Final Report

California Statewide Local Streets and Roads Needs Assessment

Sponsored by

LEAGUE® OF CALIFORNIA CITIES

Rural Counties Task Force
Regional Transportation Planning Agencies

October 2016

Prepared by

NCE
501 Canal Boulevard, Suite I
Point Richmond, CA 94804
Phone: 510.215.3620

Final Report

California Statewide Local Streets and Roads Needs Assessment

October 2016

Submitted By:

NCE

501 Canal Boulevard, Suite I
Point Richmond, CA 94804
Phone: 510.215.3620

In Collaboration With:

QUINCY ENGINEERING

spy pond partners, llc

Table of Contents

List of Figures

List of Tables

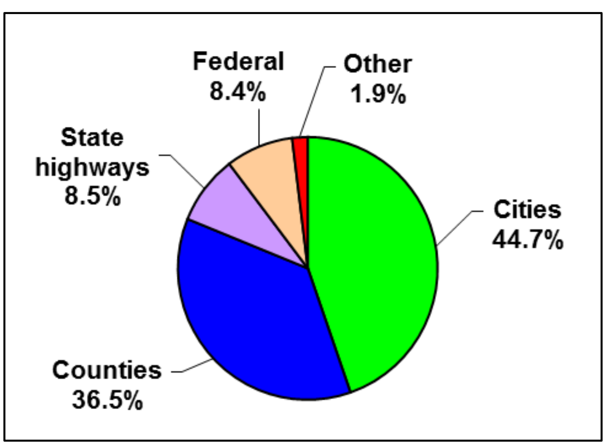
Executive Summary

California's local street and road system continues to be in crisis.

Nearly every trip begins on a city street or county road. Whether traveling by bicycle, bus, rail, truck or family automobile, Californians need a reliable and well-maintained local street and road system. Unfortunately, these continue to be challenging times due to increased demand and unreliable funding. There is a significant focus on climate change and building sustainable communities, yet sustainable communities cannot function without a well-maintained local street and road system. The need for multi-modal opportunities on the local system has never been more essential. Every component of California's transportation system is critical to providing a seamless, interconnected system that supports the traveling public and economic vitality throughout the state.

The first comprehensive statewide study of California's local street and road system in 2008 provided critical analysis and information on the local transportation network's condition and funding needs. Conducted biennially, the needs assessment provides another look at this vital component of the state's transportation system and once again finds a significant funding shortfall.

The 2016 study sought answers to important questions: What are the current pavement conditions of local streets and roads? What will it cost to repair all streets and roads? What are the needs for the essential components to a functioning system? How large is the funding shortfall? What are the solutions?



Breakdown of Road Centerline Miles by Agency

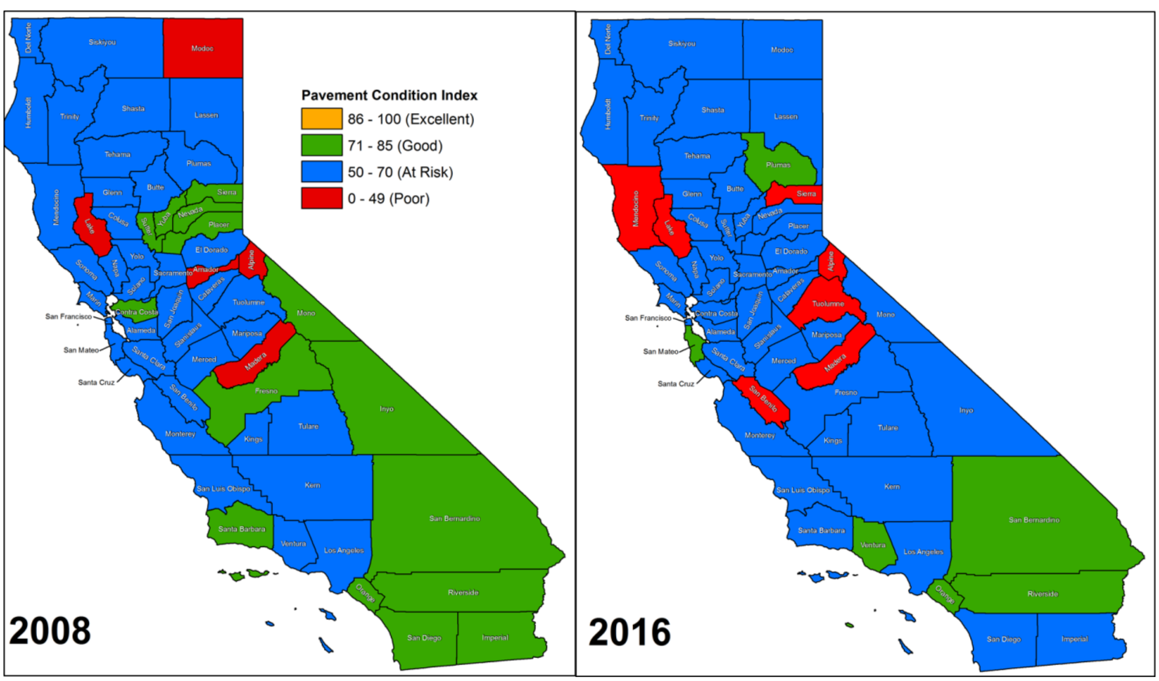
Responsible for over 81 percent of California's roads, cities and counties find this study of critical importance for several reasons. While federal and state governments regularly assess their system needs, no such data existed for the local component of California's transportation network prior to 2008. Historically, statewide transportation funding investment decisions have been made without local pavement condition data. This biennial assessment provides a critical piece in providing policy makers with a more complete picture of California's transportation system funding needs.

The goal is to use the results to educate policymakers at all levels of government and the public about the infrastructure investments needed to provide California with a seamless, multi-modal transportation system. The findings provide a credible and defensible analysis to support a dedicated, stable funding source for maintaining the local system at an optimum level. The study also provides the rationale for the most effective and efficient investment of public funds, potentially saving taxpayers from paying significantly more to fix local streets and roads into the future.

This update surveyed all of California's 58 counties and 482 cities in 2016. The information captured data from more than 99 percent of the state's local streets and roads – a level of participation that makes clear the local interest in addressing the growing problems of crumbling streets and roads.

Pavements

The conditions of California's local streets and roads are rolling off the edge of a cliff. On a scale of zero (failed) to 100 (excellent), the statewide average Pavement Condition Index (PCI) has deteriorated to 65 ("at risk" category) in 2016. Even more alarming, 52 of 58 counties are either at risk or have poor pavements (the maps illustrate the changes in condition since 2008). If the current funding remains the same, the unfunded backlog will swell from $39 billion to $59 billion by 2026.



In order to use taxpayer money wisely, it makes more sense to preserve and maintain our roads in good condition, than to let them crumble further and cost more to fix. The costs developed in this study are based on achieving a roadway pavement condition called Best Management Practices (BMP). At this condition level, preventive maintenance treatments (i.e., slurry seals, chip seals, thin overlays) are most cost-effective. Preventive maintenance interferes less with commerce and the public's mobility and is more environmentally friendly than rehabilitation and reconstruction.

The importance of this approach is significant. As roadway pavement conditions deteriorate, the cost to repair them increases exponentially. For example, it costs as much as fourteen times more to reconstruct a pavement than to preserve it when it is in good condition. Even a modest resurfacing is four times more expensive than maintenance in the BMP condition. Or to put it another way, employing maintenance practices consistent with BMP results in treating as much as fourteen times more road area for the same cost.

By bringing the local roadway system to BMP conditions, cities and counties will be able to maintain streets and roads at the most cost-effective level. It is a goal that is not only optimal, but also necessary. This study examines three funding scenarios in order to determine their impacts on the condition of the roads over the next decade. Note that these are in constant 2016 dollars.

1. **Existing funding levels of $1.98 billion/year** – this is the current funding level available to cities and counties from federal, state and local sources.
2. **Funding to maintain existing conditions ($3.5 billion/year)** – this is the funding level required to maintain the pavement conditions at its current PCI of 65.
3. **Funding required to reach Best Management Practices ($7.0 billion/year)** – the optimal scenario is to bring all pavements into a state of good repair so that best management practices can prevail. To reach BMP levels, $70 billion is needed over the next ten years. This is an estimated funding shortfall of $50.2 billion. *After that, it will only require $2.5 billion a year to maintain the pavements at that level.*

Scenarios	Annual Budget ($B)	PCI in 2026	Condition Category	% Pavements in Failed Condition	% Pavements in Good Condition
Current Conditions (2016)	-	65	At Risk	6.9%	54.8%
1. Existing Funding	$ 1.98	56	At Risk	22.2%	47%
2. Maintain PCI = 65	$ 3.5	65	At Risk	21.8%	74%
3. Best Mgmt. Practices	$7.5	87	Excellent	0.0%	100%

Essential Components

The transportation network also includes essential safety and traffic components such as curb ramps, sidewalks, storm drains, streetlights and signals. These components will require $32.1 billion to maintain over the next 10 years, and there is an estimated funding shortfall of $21.1 billion.

Bridges

Local bridges are also an integral part of the local streets and roads infrastructure. There are 12,501 local bridges (approximately 48 percent of the total) in California. There is an estimated shortfall of $1.7 billion to maintain the safety and integrity of the bridge infrastructure.

Total Funding Shortfall

The table below shows the total funding shortfall of $73 billion (*constant 2016 dollars*) over the next 10 years. For comparison, the results from the previous updates are also included.

Transportation Asset	Needs ($B)				2016		
	2008	2010	2012	2014	Needs	Funding	Shortfall
Pavement	$ 67.6	$ 70.5	$ 72.4	$ 72.7	$ 70.0	$ 19.8	$ (50.2)
Essential Components	$ 32.1	$ 29.0	$ 30.5	$ 31.0	$ 32.1	$ 11.0	$ (21.1)
Bridges	-	$ 3.3	$ 4.3	$ 4.3	$ 4.6	$ 2.9	$ (1.7)
Totals	$ 99.7	$ 102.8	$ 107.2	$ 108.0	$ 106.7	$ 33.7	$ (73.0)

What are the Solutions?

The conclusions from this study are inescapable. Given existing funding levels available to cities and counties, California's local streets and roads will continue to deteriorate over the next 10 years. It is alarming that local streets and roads have decayed to the point that funding will need to almost double just to maintain current conditions.

Investing in California's local streets and roads sooner will reduce the need for exponentially more spending in the future. To reach that level – at which taxpayer money can be spent most cost-effectively – will require an additional $50.2 billion for pavements alone, or $73 billion total for a functioning transportation system, over the next decade. ***Only $2.5 billion per year will be needed to maintain the pavements after they reach a level at which they can be maintained with best management practices.***

To bring the local system back into a cost-effective condition, thereby preserving the public's $168 billion pavement investment and stopping further costly deterioration, $7.3 billion annually in new funds are needed – that's equivalent to a 49-cent-per-gallon gas tax increase.

Failure to invest would be disastrous – not only for local streets and roads but for California's entire interrelated transportation system. Failure to invest will impact our ability to increase alternative modes, active bicycle and pedestrian options, transit needs, meet air quality impacts, greenhouse gas reduction policies, and other environmental policies.

It is imperative that cities and counties receive a stable and dedicated revenue stream for cost-effective maintenance of the local system in order to reverse this crisis.

1 Introduction

California's 58 counties and 482 cities[1] own and maintain over 143,000 centerline-miles of local streets and roads[2]. This is an impressive 81.2 percent of the state's total publicly maintained centerline miles (see Figure 1.1 below). Conservatively, this network is valued at over $168 billion.

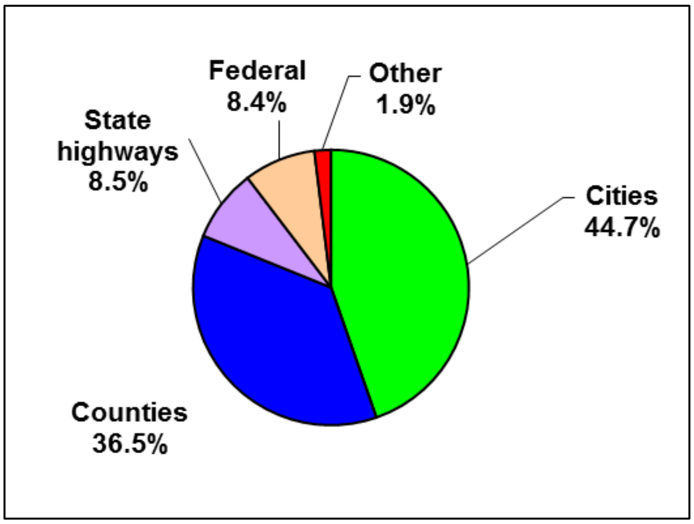


Figure 1.1 Breakdown of Maintained Road Centerline Miles by Agency[2]

Because lane-miles are more commonly used in pavement management analyses (the costs derived are based on areas, and lane-miles are a more accurate indicator of pavement areas), Table 1.1 shows the breakdown of lane-miles for local streets and roads by functional classification, as well as for unpaved roads. Major streets or roads are those that are classified as arterials or collectors, and local streets or roads are those that are classified as residentials and alleys. Unpaved roads are defined as those that have either dirt or gravel surfaces.

In addition, streets and roads are separated into urban and rural classifications. The distinction between urban and rural roads is defined by the U.S. Census Bureau: rural areas have population centers less

[1] Four new Cities, Wildomar, Menifee, Eastvale and Jurupa Valley were incorporated after the original 2008 study. The first two were included in the 2010 updates, and all were included in 2016. Note too that San Francisco is traditionally counted as both a city and a county, but for purposes of this analysis, their data have been included as a city only.
[2] *2014 California Public Road Data – Statistical Information Derived from the Highway Performance Monitoring System*, State of California Department of Transportation, Division of Transportation System Information, July 2016. The total miles come from a combination of this reference and survey results.

than 5,000, or are areas with a population density below 1,000 persons per square mile. Urban areas have population centers with more than 5,000 people. However, an urbanized or rural area may or may not contain an incorporated city and the urban boundary does not necessarily follow city corporation lines. Ultimately, however, the decision to determine the miles in either category was left to the individual city or county.

Table 1.1 Breakdowns of Functional Classification & Unpaved Roads

Lane-Miles by Functional Class						
	Urban		Rural		Unpaved	Total
	Major	Local	Major	Local		
Cities	81,412	105,764	1,943	3,496	1,176	193,792
Counties	15,274	27,085	29,970	42,148	16,393	130,870
Totals	**96,686**	**132,849**	**31,913**	**45,644**	**17,569**	**324,662**

Note: San Francisco is included as a city only.

Lane-Miles by Functional Class						
	Urban		Rural		Unpaved	Total
	Major	Local	Major	Local		
Cities	81,412	105,764	1,943	3,496	1,176	193,792
Counties	15,274	27,085	29,970	42,148	16,393	130,870
Totals	**96,686**	**132,849**	**31,913**	**45,644**	**17,569**	**324,662**

Note: San Francisco is included as a city only.

From Table 1.1, it can be seen that almost 75 percent of the total paved lane miles are in urban areas. It should also come as no surprise that more than 93 percent of rural roads belong to the counties. Conversely, 81.5 percent of urban roads belong to the cities. Finally, unpaved roads comprise approximately 5.4 percent of the total network, and over 93 percent of this belongs to the counties.

1.1 Study Objectives

In 2008, a study was conducted to assess the statewide needs for the local streets and roads network and the final report released in October 2009[3]. The intent of the 2008 study was to determine the funding required to maintain the local streets and roads system for the next 10 years, so that the information could be reported to the Governor, State Legislature, the California Transportation Commission (CTC), and Caltrans, as well as other stakeholders.

The specific objectives of the 2008 study were summarized as a series of questions:

- What are the conditions of local streets and roads?
- What will it cost to bring them up to an acceptable condition?
- How much will it cost to maintain them in an acceptable condition for the next 10 years?
- Similarly, what are the needs for other essential components, such as safety, traffic and regulatory items?
- Is there a funding shortfall? If so, how much is it?
- What are the impacts of different funding scenarios?

Since then, updates have been performed every two years, and the objectives have been essentially the same. The report also highlights the consequences of inaction. This report is the culmination of the 2016 update, and in addition to addressing the same objectives above, also includes a discussion on funding scenarios for 12,105 local bridges.

Finally, since the development of the pavement methodology to answer these questions was well documented in Appendix B of the 2008 study, they have not been included in this report. Copies of all previous reports dating back to 2008 are available on www.SaveCaliforniaStreets.org.

[3] *California Statewide Local Streets & Roads Needs Assessment*, by Nichols Consulting Engineers, Chtd., October 2009.

1.2 Study Assumptions

As before, there were some important assumptions that were made during the analyses of the data received from cities and counties. Most are consistent with those used in the Caltrans 2015 State Highway Operation and Protection Program (SHOPP)[4]. The assumptions include (see Table 1.2):

- The analysis period used in this study is 10 years, which is consistent with the SHOPP.
- All numbers reported in this study are in constant 2016 dollars – this is consistent with the SHOPP.
- The pavement condition goal was to reach a condition where best management practices (BMP) can occur. This translates to a PCI in the 80s (on a scale of 0 to 100, where zero is failed and 100 is excellent) and where there are no failed pavements. Caltrans SHOPP defines performance goals quite differently, e.g. achieve 90 percent "good pavement" by reducing distressed lane miles to 10 percent, or to achieve 95 percent bridge health index. This is further discussed in Section 4.7.
- It is assumed that no new streets or roads are added within the analysis period. In addition, capital improvement or expansion projects are not included, e.g. realignments, widenings, grade separations, etc. This is also consistent with the SHOPP.
- The inclusion of safety, traffic and regulatory components of the roadway system, such as sidewalks, curb ramps, storm drains, etc., is consistent with the SHOPP. Bicycle and pedestrian facilities are also included.
- A detailed bridge needs assessment was included in this study, including the needs and the results of various funding scenarios.

Table 1.2 Summary of Assumptions Used in 2016 Statewide Study and SHOPP

Assumptions	2014 Statewide Study	Caltrans SHOPP
Analysis Period	10 years	10 years
Cost Basis	2016 dollars	2015 dollars
Goals	Best management practices (PCI = 80 & no failed pavements)	% of distressed pavements < 10%
Total Scenarios Evaluated	3	1
Capital Improvement Projects	No	Only related to operational improvement
Essential Components	Yes	Yes
Bridges	Yes	Yes

[4] *2016 Ten-Year State Highway Operation & Protection Program (SHOPP Plan)*, Caltrans, April 2015.

1.3 Study Sponsors

This study was sponsored by the cities and counties of California and has been managed by a coalition of Cities, Counties and Regional Transportation Planning Agencies (RTPAs). Representatives of each have managed this project. The Oversight Committee is composed of representatives from the following:

- League of California Cities (League)
- California State Association of Counties (CSAC)
- County Engineers Association of California (CEAC)
- Regional Transportation Planning Agencies (RTPA)
- Rural Counties Task Force (RCTF)

The Oversight Committee members include:

- Charles Herbertson, City of Culver City, (Project Manager)
- Steve Castleberry, Nevada County
- Keith Cooke, City of San Leandro
- Greg Kelley, Los Angeles County
- Sarkes Khachek, Santa Barbara County Association of Governments
- Dave Leamon, Stanislaus County
- Mike Penrose, Sacramento County
- William Ridder, Los Angeles County Metropolitan Transportation Authority
- Theresa Romell, Metropolitan Transportation Commission
- Mike Sartor, City of Palo Alto
- Bonnie Teaford, City of Burbank
- Mike Woodman, Nevada County Transportation Commission (representing the Rural Counties Task Force)

Staff members include:

- Meghan McKelvey, League
- Rony Berdugo, League
- Kiana Valentine, CSAC
- Chris Lee, CSAC
- Merrin Gerety, CEAC

Appendix A includes a list of all the agencies that made a financial contribution to this study.

2 Pavement Needs Assessment

In this chapter, the methodology and assumptions used for the pavement needs assessment are discussed, and the results of our analyses presented. The data collection efforts are described in more detail in Appendix B, but briefly, an online survey was made available on the www.SaveCaliforniaStreets.org website between January 18th and March 26th, 2016. All cities and counties were contacted and asked to participate in the survey. A total of 462 agencies responded to the survey and either updated or confirmed the data that was provided in previous surveys. This is a response rate of 85 percent.

2.1 Methodology and Assumptions

Since not all 539 cities and counties responded to the survey, a methodology had to be developed to estimate the pavement needs of the missing agencies. The following paragraphs describe in detail the methodology that was used in the study (note that this is consistent with previous updates).

2.1.1 Filling in the Gaps

Inventory Data

Briefly, this process was to determine the total miles (both centerline and lane-miles) and pavement areas, as this is crucial in estimating the pavement needs for an agency. Missing inventory data were populated based on the following rules:

- If no updated inventory data were provided, then previous survey data were used.
- If the inventory data provided was incomplete, Table 2.1 was used to populate the missing information. The average number of lanes and average lane width are summarized from agencies who submitted complete inventory data in the previous surveys.

Pavement Condition Data

To assist those agencies who had no pavement condition data, the online survey provided a table with the average pavement condition index (PCI) collected in the 2014 study. They were then encouraged to look at the data from neighboring cities or counties to make their best estimate of the pavement condition in their agency. For those agencies that have never provided any condition data, the average condition of the county they belong to was used.

Table 2.1 Assumptions for Populating Missing Inventory Data

Functional Class	Average Number of Lanes	Average Lane Width (feet)
Urban Major Roads	3.0	14.6
Urban Residential/Local Roads	2.1	15.1
Rural Major Roads	2.0	13.3
Rural Residential/Local Roads	2.0	11.9
Unpaved Roads	1.9	11.0

The surveys also asked for condition data for different functional classifications, and additional rules were developed to populate the missing data:

- If the PCI is provided for one but not the other functional classes, the same PCI was used for all functional classes.
- If no pavement condition data were provided in 2016, the last PCI provided was used, but it was extrapolated based on the statewide PCI trend i.e. if the statewide average deteriorated one point, then it was also assumed to have deteriorated one point.
- The only exception was for San Francisco Bay area agencies, where the data came from the Metropolitan Transportation Commission (MTC).

2.1.2 Pavement Needs Assessment Goal

The same needs assessment goal from previous studies was used in the 2016 update. To reiterate, the goal is for pavements to reach a condition where best management practices (BMP) can occur, so that only the most cost-effective pavement preservation treatments are needed. Other benefits such as a reduced impact to the public in terms of delays and environment (dust, noise, energy usage) would also be realized.

Our goal is to bring streets and roads to a condition where best management practices (BMP) can occur.

In short, the BMP goal is to reach a PCI in the 80s and the elimination of the unfunded backlog. The deferred maintenance or "unfunded backlog" is defined as work that is needed, but is not funded. To perform these analyses, MTC's StreetSaver® pavement management system program was used. This program was selected because the analytical modules were able to perform the required analyses, and the default pavement performance curves were based on data from California cities and counties. This is described in detail in Appendix B of the 2008 report, which may be downloaded at www.SaveCaliforniaStreets.org.

2.1.3 Maintenance and Rehabilitation Treatment Types and Costs

Assigning the appropriate maintenance and rehabilitation (M&R) treatment is a critical component of the needs assessment. It is important to know both the ***type*** of treatment, as well as ***when*** to apply it. This is typically outlined in a decision tree. Pavement preservation concepts and their efficacy have been widely researched by the Federal Highway Administration[5] and the National Highway Institute has several training courses available. In addition, the National Center for Pavement Preservation[6] at Michigan State University maintains a technical library available to the public.

Asphalt Pavements

Figure 2.1 summarizes the types of asphalt treatments assigned in this study. Briefly, good to excellent pavements (PCI>70) are best suited for pavement preservation techniques, (e.g., preventive maintenance treatments such as chip seals or slurry seals). These are usually applied at intervals of five to seven years depending on the type of road and their traffic volumes. Note that if a pavement section has a PCI between 90 and 100, no treatment is applied.

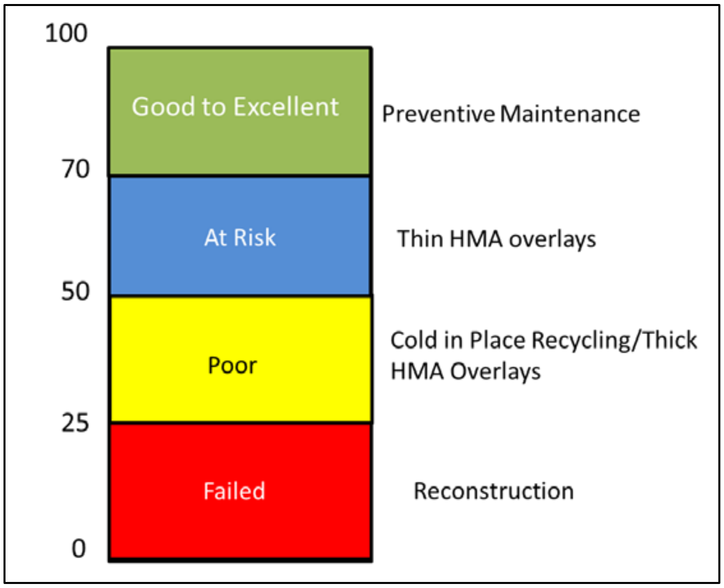


Figure 2.1 PCI Thresholds & Treatments Assigned for Asphalt Pavements

[5] http://www.fhwa.dot.gov/pavement/pres.cfm
[6] https://www.pavementpreservation.org/

As pavements deteriorate, treatments that address structural adequacy are required. Between a PCI of 25 to 69, hot mix asphalt (HMA) overlays are usually applied at varying thicknesses. This may be combined with milling or recycling techniques.

Finally, when the pavement has failed (PCI<25), reconstruction is typically required. The descriptions used for each category are typical of most agencies, although there are many variations on this theme. For example, it is not unusual for local streets to have slightly lower thresholds indicating that they are held to lower standards. The PCI thresholds shown in Figure 2.1 are generally accepted industry standards.

Concrete Pavements

Similarly, concrete pavements have numerous strategies available. Good to excellent pavements (PCI>70) are also best suited for preventive maintenance, such as diamond grinding to remove a thin surface layer of concrete improving friction, smoothing the pavement, and reducing noise. Partial and full depth slab repairs are also used as preventive maintenance to restore isolated panels that have cracked or failed.

Concrete overlays have two different options that cover a wide range of pavement repair conditions. Bonded concrete overlays of asphalt are applied on roadways in fair or better condition (PCI>70) to add structure or provide a more permanent maintenance solution to the road. Unbonded concrete overlays of asphalt are typically applied on roadways in fair to significantly deteriorated condition (PCI of 20 to 69) and will restore structural capacity while treating the existing roadway as a structural base layer.

When the pavement has failed (PCI<25), reconstruction with concrete pavement is an alternative. This may be accompanied by recycling techniques. Concrete pavements typically last 20-25 years prior to needing their first preventive maintenance treatment.

Unit cost data for asphalt treatments from 355 agencies (both 2016 and prior survey data were used) were summarized and averaged for the analysis (see Table 2.2). Again, there was a large range in costs, but for purposes of this analysis, the average was used. The costs for each treatment is separated by functional class i.e., major roads have a higher cost than local roads. There were small increases (less than 10 percent) in the unit costs for all categories EXCEPT for reconstruction on major roads, where the unit cost dropped by approximately 23 percent from 2008 levels. This is possibly due to the increased use of recycling techniques (discussed in Section 2.3.)

Table 2.2 Unit Costs Used for Different Treatments & Road Classifications

Classification	Unit Costs ($/square yard)			
	Preventive Maintenance	Thin HMA Overlay	Thick HMA Overlay	Reconstruction
Major Roads	$4.85	$21.10	$31.50	$70.60
Local Roads	$4.30	$19.60	$29.10	$61.50

It should be noted that the costs for preventive maintenance treatments (e.g., seals) increased significantly in 2010 and 2012 and appears to have stabilized since then. The initial increase is attributed to the higher demand for seals between 2008 and 2012. There could be two reasons for this:

- Financial constraints force many agencies to use less expensive treatments such as seals compared to overlays or reconstruction; and/or
- More agencies understand the advantages and cost-effectiveness of seals, and therefore their use is more widespread.

Interestingly, the cost for overlays and reconstruction actually declined in 2010 by approximately 5 percent for overlays, and as much as 30 percent for reconstruction. However, the overlays have steadily increased since then and are now approaching 2008 levels. For reconstruction, they have continued to be lower than 2008 levels, which may be attributable to using recycling technologies such as full depth reclamation. Figures 2.2 to 2.5 illustrate the trends in the unit costs for different maintenance strategies, respectively.

Finally, it should be noted that only asphalt concrete roads were considered in this analysis. The percentage of Portland cement concrete pavements was so small (approximately 1.1 percent of the total network), that it was deemed not significant for this study.

2.1.4 Escalation Factors

As with the previous studies, no escalation factors were used in this analysis. All numbers are in constant 2016 dollars, and this is consistent with the SHOPP as well as many Regional Transportation Plans (RTPs).

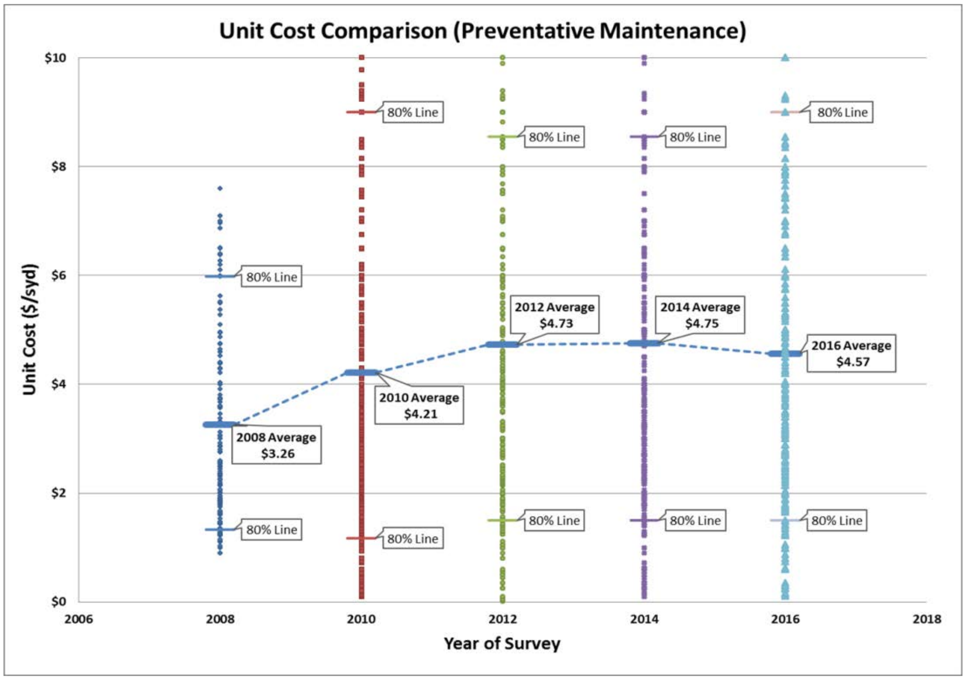


Figure 2.2 Unit Price Trends for Preventive Maintenance Treatments

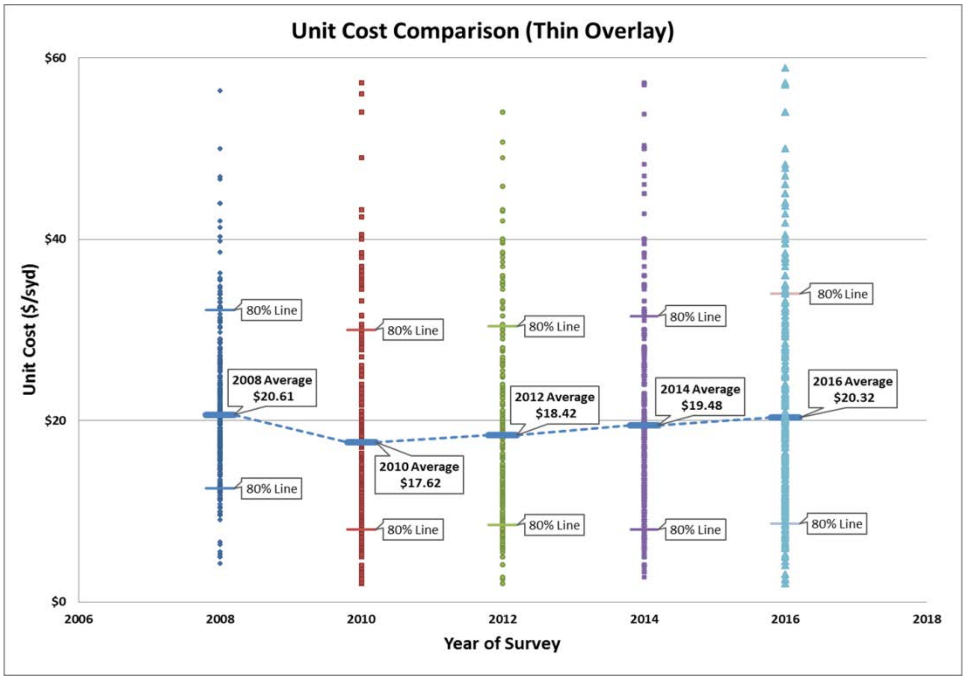


Figure 2.3 Unit Price Trends for Thin HMA Overlays

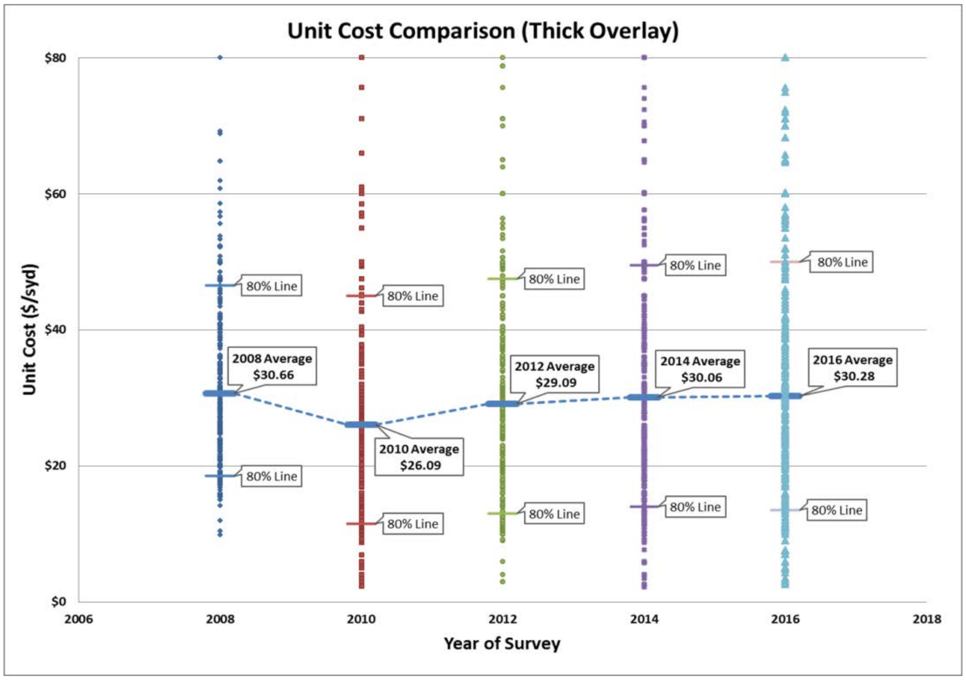


Figure 2.4 Unit Price Trends for Thick HMA Overlays

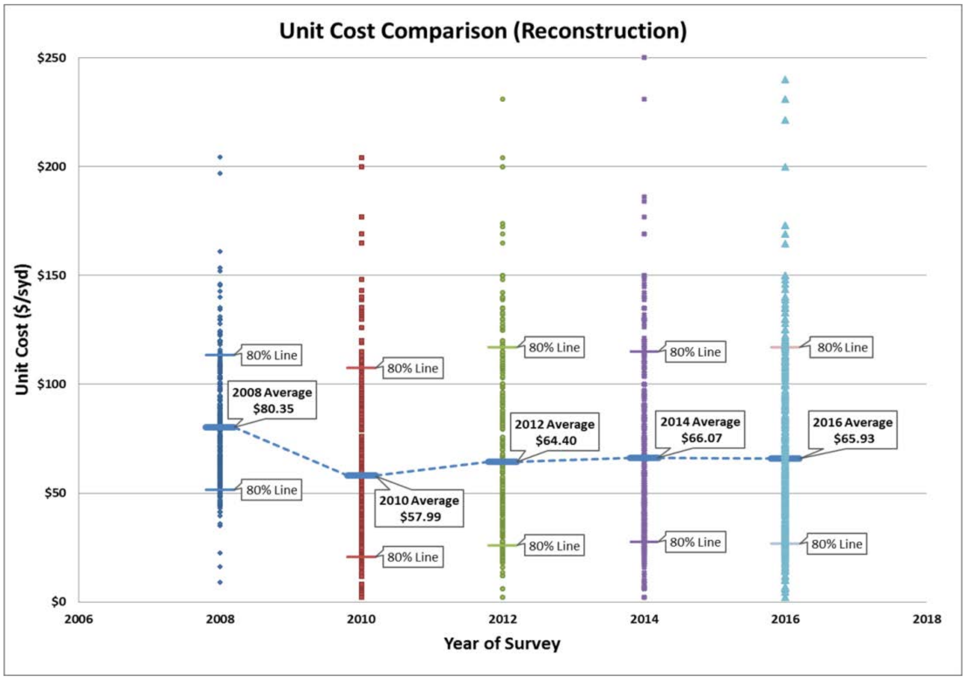


Figure 2.5 Unit Price Trends for Reconstruction

2.2 Average Network Condition

Based on the results of the surveys, the current (as of April 2016) pavement condition statewide is 65, a three point drop from 2008, when it was estimated to be 68. There is less than a one point drop from 2014. The average for cities is 67.5 and that for counties is 61.1.

Table 2.3 indicates that major streets or roads continue to be in better condition than local roads. In fact, rural local roads have the lowest PCI than any other category.

Table 2.3 Average 2016 PCI by Type of Road

Type	Average 2016 PCI	
	Major	Local
Urban Streets	68	66
Rural Roads	65	55

Table 2.4 includes the current pavement condition index (PCI) for each county (includes cities within the County). Again, this is based on a scale of 0 (failed) to 100 (excellent). This is weighted by the pavement area, i.e., longer roads have more weight than short roads when calculating the average PCI.

It needs to be emphasized that the PCI reported is only the ***weighted average*** for each county and ***includes*** the cities within the county. This means that Amador County and the cities may well have pavement sections that have a PCI of 100, although the average is 56.

The average PCI trend since 2008 is slightly downward, although some counties do show improvements. This is attributed to better data collection (more agencies are updating their pavement data), better use of pavement preservation treatments, or the increased availability of additional funds such as local sales taxes or bonds.

From this table, we can see that the statewide ***weighted average*** PCI for all local streets and roads is 65. Orange County maintains its position with the best pavements, at an average PCI of 79. Unfortunately, Mendocino and Lake Counties remain the lowest ranked counties, with an average PCI of 35 and 40, respectively. Appendix C includes maps that illustrates the PCI for each city and county.

The average pavement condition index for streets and roads statewide is 65. This rating is considered to be in the “at risk” category.

Table 2.4 Summary of PCI Data by County (includes Cities) for 2008-2016

County (Cities Included)	Center Line Miles	Lane Miles	Area (sq. yd.)	Average Weighted PCI*				
				2008	2010	2012	2014	2016
Alameda County	3,557	8,054	76,546,278	66	67	68	66	68
Alpine County	135	270	1,900,800	40	45	45	44	44
Amador County	477	945	5,908,703	31	34	33	33	56
Butte County	1,844	3,702	29,335,888	70	67	65	66	65
Calaveras County	717	1,333	8,937,332	55	53	51	51	51
Colusa County	987	1,524	12,503,304	61	60	60	62	63
Contra Costa County	3,388	7,074	63,103,914	72	70	71	68	69
Del Norte County	434	864	6,244,480	70	68	64	63	63
El Dorado County	1,408	2,806	22,277,095	62	58	63	63	62
Fresno County	6,213	12,669	107,568,743	74	70	69	69	64
Glenn County	910	1,822	13,917,626	68	68	68	68	68
Humboldt County	1,471	2,933	24,221,118	61	56	64	64	63
Imperial County	3,017	6,102	76,815,366	74	72	57	57	58
Inyo County	1,146	1,933	13,732,980	75	57	60	62	62
Kern County	5,495	12,519	111,410,008	66	63	64	64	63
Kings County	1,346	2,826	20,281,497	63	62	62	62	59
Lake County	753	1,494	9,974,991	33	31	40	40	40
Lassen County	431	879	6,282,324	55	69	66	66	63
Los Angeles County	21,015	57,404	457,128,791	68	67	66	66	67
Madera County	1,822	3,680	23,490,290	48	48	47	47	46
Marin County	1,012	2,050	16,233,715	61	61	61	63	64
Mariposa County	362	719	5,334,893	53	44	44	53	65
Mendocino County	1,124	2,256	15,980,516	51	49	37	35	35
Merced County	2,335	4,881	38,705,388	57	58	58	58	56
Modoc County	1,489	2,979	16,657,259	42	40	56	46	59
Mono County	737	1,473	9,613,552	71	68	66	67	64
Monterey County	1,783	3,756	33,423,503	63	45	50	50	50
Napa County	739	1,508	12,821,673	53	60	59	59	59
Nevada County	805	1,623	10,440,643	72	71	72	71	70

County (Cities Included)	Center Line Miles	Lane Miles	Area (sq. yd.)	Average Weighted PCI*				
				2008	2010	2012	2014	2016
Orange County	6,575	16,854	147,790,232	78	76	77	77	79
Placer County	2,010	4,203	34,143,785	79	77	71	69	68
Plumas County	705	1,411	9,090,224	71	66	66	64	72
Riverside County***	7,732	17,619	161,162,595	71	72	70	70	71
Sacramento County	5,053	11,285	95,918,441	68	66	64	62	62
San Benito County	452	916	5,951,814	68	66	66	48	46
San Bernardino County***	8,953	22,318	180,641,761	72	70	70	71	71
San Diego County	7,787	18,831	170,727,319	74	69	67	66	65
San Francisco County	941	2,140	21,224,769	62	63	65	66	68
San Joaquin County	3,229	6,795	61,416,088	70	70	67	73	70
San Luis Obispo County	1,848	3,850	30,096,673	64	64	63	64	63
San Mateo County	1,866	3,905	33,069,272	69	70	71	70	71
Santa Barbara County	1,596	3,261	29,429,220	72	70	67	66	63
Santa Clara County	4,661	10,463	97,789,614	70	69	73	68	67
Santa Cruz County	873	1,788	14,190,208	52	48	48	57	50
Shasta County	1,683	3,472	26,243,076	64	67	57	60	57
Sierra County**	399	800	5,566,517	73	71	71	45	44
Siskiyou County	1,566	3,199	20,233,539	57	57	57	57	58
Solano County	1,715	3,653	31,591,323	66	66	67	65	68
Sonoma County	2,390	4,970	39,879,923	53	50	50	52	55
Stanislaus County	2,916	6,020	52,993,373	60	51	52	55	55
Sutter County	1,011	2,041	16,410,771	73	56	56	65	70
Tehama County	1,197	2,401	15,479,180	69	65	65	62	53
Trinity County	693	1,114	11,757,354	52	50	50	60	62
Tulare County	3,931	8,119	60,118,041	66	68	68	68	60
Tuolumne County	558	1,110	8,214,336	62	62	62	47	41
Ventura County***	2,505	6,085	52,631,737	64	66	69	70	71
Yolo County	1,329	2,457	21,137,105	69	67	63	60	55
Yuba County	724	1,504	12,862,584	74	56	56	60	60
TOTALS	143,850	324,662	2,718,553,544	68	66	66	66	65

* PCI is weighted by area. ** Sierra County's PCI in 2008, 2010 and 2012 were not accurately reported.
*** Average PCI was rounded up to 71.

As was discussed in the 2014 study, an average pavement condition of 65 is not especially good news. While it seems just a few points shy of the "good/excellent" category, it has significant implications for the future. Figure 2.6 illustrates the rapid pavement deterioration at this point in the pavement life cycle; if repairs are delayed by just a few years, the costs of the proper treatment may increase significantly, as much as ten times. The financial advantages of maintaining pavements in good condition are many, including saving the taxpayers' dollars with less disruption to the traveling public, as well as environmental benefits.

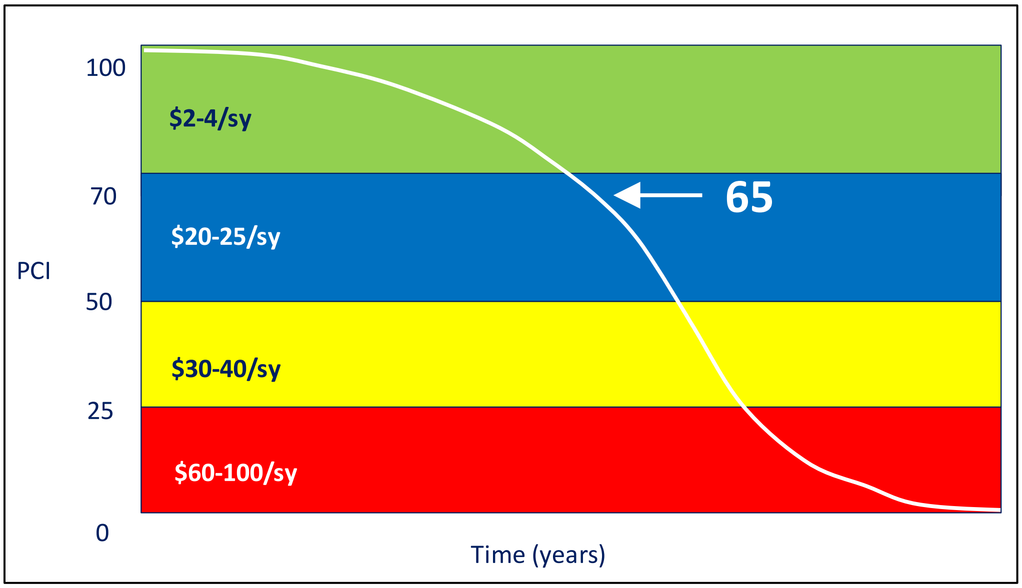


Figure 2.6 Generalized Pavement Life Cycle Curve

Many factors contribute to this rapid deterioration in pavement condition and they include:

- More traffic and heavier vehicles;
- More transit and more frequent bus trips, including heavier buses;
- Heavier and more garbage collection trucks (recycling and green waste trucks are new weekly additions to the traditional weekly garbage truck);
- More street sweeping for National Pollutant Discharge Elimination System (NPDES) requirements; and
- More freight and delivery trucks when the economy is thriving.

Therefore, a PCI of 65 should be viewed with caution – it indicates that our local streets and roads are, as it were, poised on the edge of a cliff. Figure 2.7 is an example of a local street with an average condition of 65.

Figure 2.7 Example of Local Street with PCI = 65

Figure 2.8 shows the distribution of pavement conditions by county for both 2008 and 2016. As can be seen, a majority of the counties in the state have pavement conditions that are either "At Risk" (blue) or in "Poor" (red) condition. There has been an increase in the "blue" and "red" counties from 2008. Of the 58 counties, all but six are in either "At Risk" or in "Poor" condition.

Note that Riverside, San Bernardino and Ventura counties have an average PCI of 70.8, which when rounded, is 71 as shown in Table 2.4 and Figure 2.8.

Only 54.8% of California's local streets and roads are in good condition.

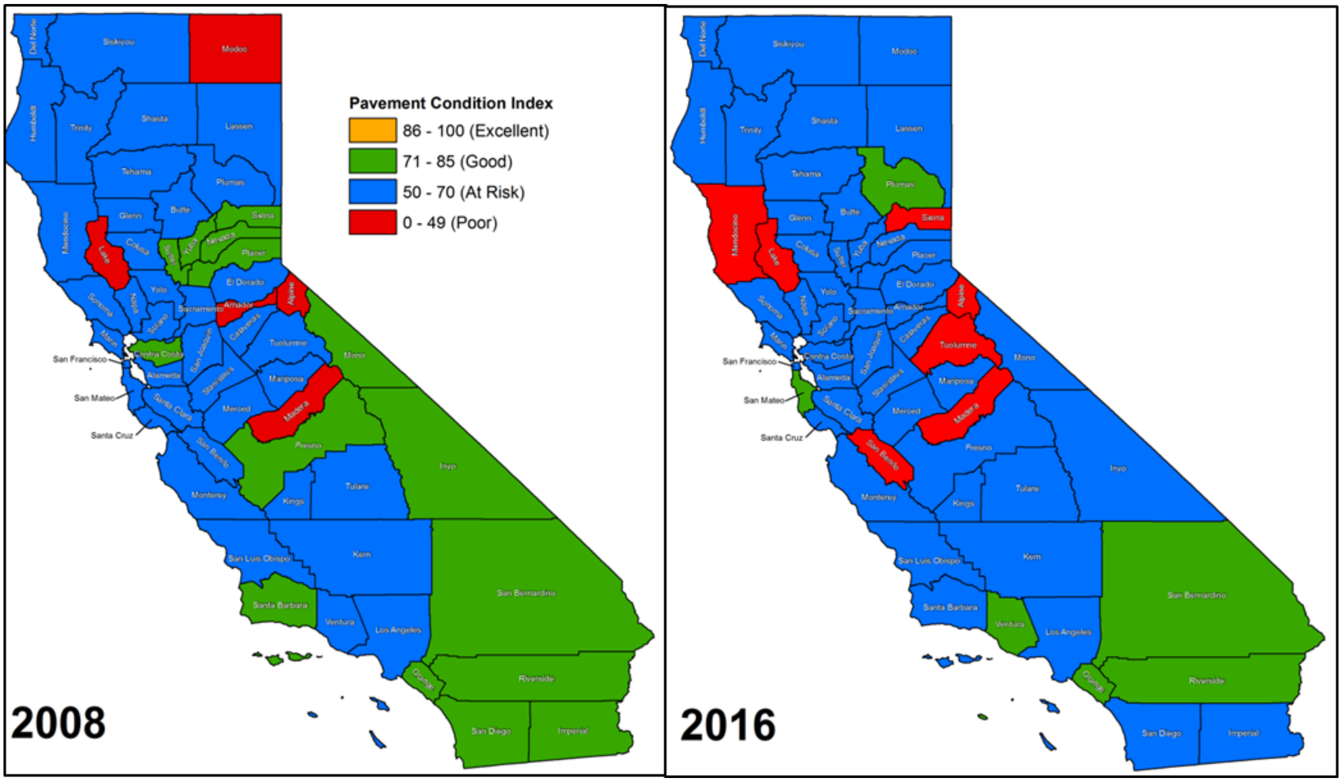


Figure 2.8 Average PCI by County for 2008 and 2016

2.3 Sustainable Pavement Practices

Sustainability continues to be a growing factor to be considered for many local agencies, particularly if it saves costs. Cities and counties were asked for information on any sustainable pavement practices employed and the estimated cost savings, if any. The types of sustainable practices that were mentioned included:

- Reclaimed asphalt pavement (RAP)
- Cold-in-place recycling (CIR)
- Hot-in-place recycling (HIR)
- Cold central plant recycling
- Full depth reclamation (FDR)
- Pavement preservation strategies
- Warm mix asphalt (WMA)
- Rubberized hot mix asphalt (RHMA)
- Porous/pervious pavements
- Subgrade stabilization

Some sustainable pavement strategies may save up to 30%.

In general, the trends continue to be in the positive direction; over 428 agencies (almost 80 percent) responded with some information on the types of sustainable practices used. Table 2.5 summarizes these responses; in general, more agencies reported using some form of recycling compared to 2014.

Table 2.5 Summary of Responses on Sustainable Pavement Strategies

Sustainable Pavement Strategies	No. of Agencies			Average % Savings	Average % Additional costs
	No. of Responses	Savings	Add'l Costs		
Reclaimed AC Pavement (RAP)	133	41	6	33%	
Cold in place recycling (CIR)	83	33	8	26%	
Hot in place recycling (HIPR)	16	3	1	25%	
Cold central plant recycling	26	8	1	24%	
Warm mix AC	75	7	6	18%	23%
Porous/Pervious pavements	28	1	4		106%
Full depth reclamation (FDR)	129	28	12	28%	
Subgrade Stabilization	53	4	7		19%
Rubberized AC (RAC)	203	13	71		19%
Pavement Preservation	309	68	29	49%	

Recycling and pavement preservation strategies were reported to have the highest cost savings when compared with conventional treatments; on average 28 percent. Other sustainable treatments incurred additional costs, particularly rubber hot mix asphalt (RHMA), which had 19 percent higher costs (an increase from the 12 percent reported in 2014). The responses for warm mix asphalt and porous/pervious pavements were insufficient to draw any conclusions.

The most common reasons cited for using sustainable practices were:

- Cost savings or cost-effectiveness;
- Environmental benefits e.g. fewer greenhouse gas emissions, reduced energy consumption, uses less natural resources, reduces landfills, reuses existing pavement materials, recycles tires, etc. (Note that every lane-mile that is recycled in-place is equivalent to removing approximately 11 cars off the road for a year)[7,8];

Every lane-mile that is recycled in-place is the equivalent of removing 11 cars off the road for a year.

7 Bilal, Julian; Chappat, Michael; COLAS Group; Sustainable Development: The Environmental Road of the Future; 2003
8 www.epa.gov/otaq/climate/420f05004.htm

- Extends pavement life;
- Positive community benefits e.g., quieter pavements;
- City Council policies support or requires sustainable pavements;
- Partnering with other agencies ensures bigger projects and lower unit prices; and
- Lower traffic impact (less construction traffic).

The most common reasons cited for not using sustainable practices were:

- Agency too small (lack of experienced personnel);
- Higher construction costs (mostly related to RHMA) or higher up-front costs;
- Not enough technical information available – design, specifications, etc.;
- Lack of experienced contractors to bid on projects;
- Constructability (large equipment on narrow or small streets);
- Not all streets are good candidates for these treatments e.g. limited right of way;
- More inspections required from agency staff; and
- Uncertainty over pavement performance.

The fact that almost 80 percent of the cities and counties in California reported using some form of sustainable pavement practices was very encouraging, particularly when one considers the potential cost savings involved. This is clearly evidence of local agencies using newer technologies to "stretch the dollar". The overwhelming majority (85 percent of respondents) also indicated that they will continue to use some form of sustainable strategy in the future.

2.4 Complete Streets

A complete streets policy ensures that transportation planners and engineers consistently design and operate the entire roadway with all users in mind - including bicyclists, public transportation vehicles and riders, and pedestrians of all ages and abilities. California state law (adopted in 2008 and effective 2011)[9] requires that cities and counties *".. plan for a balanced, multimodal transportation network that meets the needs of all users of streets, roads, and highways, defined to include motorists, pedestrians, bicyclists, children, persons with disabilities, seniors, movers of commercial goods, and users of public transportation, in a manner that is suitable to the rural, suburban, or urban context of the general plan."*

[9] ftp://www.leginfo.ca.gov/pub/07-08/bill/asm/ab_1351-1400/ab_1358_bill_20080930_chaptered.pdf

For purposes of this study, the focus is on bicycle and pedestrian facilities. Figure 2.9 is an example of a complete street that considers alternative modes of transportation i.e. pedestrians, bicyclists, buses and drivers, as well as curb ramps that are in compliance with the American Disabilities Act (ADA).

Figure 2.9 Elements of a Complete Street (Kings Beach, Placer Co.)

There were 421 responses in 2016, significantly more than in previous surveys. Of these, 187 indicated that they had a complete streets policy, which is a tripling of the number from 2012. An additional 190 indicated they had none, and 31 indicated they did not know. Of the 190 who did not have a policy, 173 indicated that they had elements of a complete street policy in place. Table 2.6 shows the different elements that are utilized by agencies.

Figure 2.10 illustrates the number of agencies (106) who have recently completed a complete street project; they have been constructed across all agency sizes i.e. small, medium and large agencies.

Table 2.6 Elements of Complete Streets Policy

Element	No. of Agencies
Pedestrian facilities	228
Bicycle facilities	225
Curb Ramps	219
Signs	201
Landscaping	182
Medians	179
Traffic Calming e.g. reducing lane widths	176
Lighting	172
Roundabouts	111
Transit elements	100

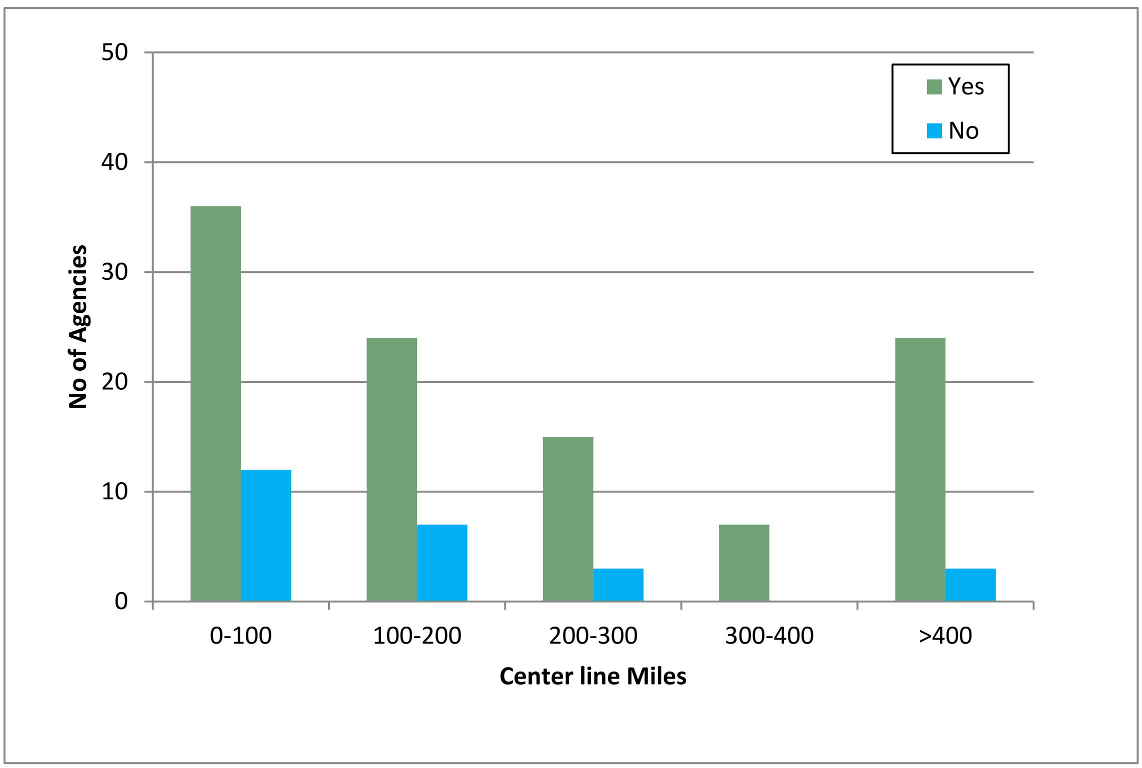


Figure 2.10 Number of Agencies With Complete Street Projects

On average, the respondents also indicated that 12 percent of their street network were eligible for including some of the above elements, and that the average additional costs were $117 per square yard. However, there was a large range in the cost data provided, from less than $1/square yard to over $700/square yard. This is largely due to the wide range of elements that can be considered part of a complete street policy e.g. restriping a road to add bicycle lanes is relatively inexpensive, but purchasing right-of-way for widening projects to include pedestrians/bicyclists/transit will be much more expensive.

The three examples shown in Figure 2.11 illustrate the range and type of complete projects possible, and also their incremental costs, which ranges from $45/sy to $230/sy. Clearly, it is challenging to assume one average unit cost for a "complete street" project.

There are challenges to implementing a complete street policy, and the most common ones cited were (in order of frequency of responses):

1. Insufficient funding
2. Insufficient right of way
3. Existing structures
4. Trees or environmental features

Finally, complete streets may have very different applications on a rural road vs. an urban street. Many rural roads are long, in remote areas and may have as little as 50 vehicles a day, with no pedestrians or bicyclists. Obviously, these will not be candidates for a complete street approach. The typical examples tend to be focused on urban roads, where the population supports multiple modes of transportation.

2.5 Additional Regulatory Requirements

In addition to the many pavement and safety policies, cities and counties identified many additional regulatory requirements they have to comply with, including:

1. American Disabilities Act of 1990 (ADA);
2. National Pollutant Discharge Elimination System (NPDES);
3. Traffic sign retroreflectivity requirements;
4. Complete streets; and
5. Others e.g. Endangered Species Act, air emissions, sanitary/wastewater management plans, etc.

As with previous surveys, the first three categories had the most responses, with 268 responses on ADA, 244 on NPDES and 217 on traffic sign retroreflectivity. These responses reflect, on average, a 50 percent increase from 2014. In addition, almost half indicate that they now track these costs separately which is a huge shift from 2014. This is an indicator of the improving quality of the data provided in this category.

City of Glendale

Population: 191,719

Street network: 336 miles

Complete street elements:
- Bulb outs and traffic circles
- Traffic signals
- Street trees
- Interpretive signing

Incremental cost: $45/sy

City of Pleasant Hill

Population: 33,152

Street network: 109 miles

Complete street elements:
- ADA upgraded and sidewalks
- Bike lanes
- Landscaping
- LED lighting and signal

Incremental cost: $88/sy

City of Concord

Population: 122,067

Street network: 310 miles

Complete street elements:
- Bicycle lanes
- Curb & gutters
- Sidewalks

Incremental cost: $230/sy

Figure 2.11 Examples of Complete Street Projects

Finally, the respondents identified $6.35 billion in needs and only $3.98 billion in funding, and a resulting shortfall of $2.37 billion (see Table 2.7).

Table 2.7 Additional Regulatory Requirements (Ten Year Needs and Funding)

Regulatory Requirements	Needs ($M)	Funding ($M)	Shortfall ($M)
ADA	$ 1,571	$ 888	$ (683)
NPDES	$ 4,021	$ 2,952	$ (1,068)
Traffic Sign Retroreflectivity	$ 191	$ 104	$ (86)
Complete Streets	$ 502	$ 17	$ (485)
Other	$ 68	$ 22	$ (46)
Total	**$ 6,351**	**$ 3,983**	**$ (2,368)**

2.6 National Highway System (NHS) Proposed Requirements

As a sidebar for potential future requirements, the survey also asked cities and counties for their current data collection practices with respect to the National Highway System (NHS)[10], which includes the Interstate Highway System as well as all Principal Arterials. These are roadways that are important to the nation's economy, defense, and mobility.

California's cities and counties own approximately 5,100 centerline miles that are designated part of the NHS. MAP-21 requires new performance measures for all highways and roadways on the NHS, and a proposed rule was released by the FHWA in January 2015. As of September 2016, no final rule has been adopted. However, the *proposed* rule[11] requires that the data in Table 2.8 be collected on all NHS pavements.

Table 2.8 Proposed NHS Performance Measures

Pavement Type	Measure	Test Method
Asphalt	International Roughness Index (IRI)	AASHTO R57-14, using device in accordance with AASHTO M328-14
	Cracking_Percent	Manual: AASHTO R55-10 (2013) OR
		Automated: AASHTO PP67-14 and PP68-14
	Rutting	AASHTO R48-10 (2013) (5-Point Method) OR
		AASHTO PP69-14 and PP70-14 (Automated transverse profile)
Jointed Concrete Pavement (JCP)	IRI	AASHTO R57-14, using device in accordance with AASHTO M328-14
	Cracking_Percent	Manual: AASHTO R55-10 (2013) OR
		Automated: AASHTO PP67-14 and PP68-14
	Faulting	AASHTO R36-13
Continuously Reinforced Concrete Pavement (CRCP)	IRI	AASHTO R57-14, using device in accordance with AASHTO M328-14
	Cracking_Percent	HPMS field manual

[10] http://dot.ca.gov/hq/tsip/hseb/nhs.html

[11] https://www.federalregister.gov/articles/2015/01/05/2014-30085/national-performance-management-measures-assessing-pavement-condition-for-the-national-highway

From the survey results (see Table 2.9), over 80 percent of the agencies indicated that they do **NOT** currently collect this information. Caltrans has committed to collecting this data for non-highway NHS roadways that are owned by cities and counties in the first two years of implementation of this rule. However, in the future, local agencies may be responsible for collecting this information.

Table 2.9 Agencies Who Collect NHS Performance Measures Data

NHS Performance Measures	No. of Agencies	
	Collected	Not Collected
International Roughness Index (IRI)	14	440
Percent Cracking	30	424
Rutting	37	417
Faulting	10	529

2.7 Unpaved Roads

Unpaved roads (gravel or dirt surfaced) are not a large component of the local transportation network statewide, and only comprises 5.3 percent of the total area. Nonetheless, they are important in many rural counties, where unpaved roads can form a significant percentage. For example, in Mono County, unpaved roads comprise more than 60 percent of the road system!

The needs assessment for unpaved roads is not complicated – 100 agencies reported a total unpaved road network of 9,370 centerline miles. The average cost of maintenance is $9,800 per centerline mile per year. Since pavement management software like StreetSaver® only analyzes paved roads, the average cost for unpaved roads from the survey was used for those agencies that did not report any funding needs. This results in a total 10-year need of $918 million for the next 10 years.

Unpaved roads need $918 million over the next 10 years.

Figure 2.12 Examples of Unpaved Roads

2.8 Pavement Needs

The determination of pavement needs and unfunded backlog were described in detail in Appendix B of the 2008 report and is therefore not duplicated here, but to briefly summarize, it requires four main elements for the analysis:

- Existing condition, i.e., PCI;
- Appropriate treatment(s) to be applied from decision tree and unit costs;
- Performance models; and
- Funding available during analysis period.

Pavement needs are $70 billion over the next ten years.

The calculation of the pavement needs is conceptually quite simple. Once the PCI of a pavement section is known, a treatment and unit cost can be applied. This is performed for all sections within the 10-year analysis period. A section may receive multiple treatments within this time period, e.g., Walnut Avenue may be overlaid in Year 1, and then sealed in Year 5 and again in Year 10.

As before, the deferred maintenance or "unfunded backlog" is defined as work that is needed, but is not funded. It is possible to fully fund ***all*** the needs in the first year, thereby reducing the backlog to zero. However, the funding constraint for the scenario is to achieve our BMP goal within 10 years. Assuming a constant annual funding level for each scenario, the backlog will gradually decrease to zero by the end of the analysis period.

The results are summarized in Table 2.10 and indicate that $70 billion is required to achieve the BMP goals in 10 years. Again, this is in constant 2016 dollars. Detailed results by county are included in Appendix C.

Table 2.10 Cumulative Pavement Needs

Cumulative Needs (2016 dollars)		
Year No.	Year	Reach BMP Goal in 10 Years ($ Billion)
1	2017	$7.0
2	2018	$14.0
3	2019	$21.0
4	2020	$28.0
5	2021	$35.0
6	2022	$42.0
7	2023	$49.0
8	2024	$56.0
9	2025	$63.0
10	2026	$70.0

In 2014, the total 10-year needs was $72.7 billion, so this is a reduction of $2.7 billion. In reviewing the data, the reduction is due primarily to the drop in reconstruction costs.

Figure 2.13 illustrates a map of California with the 10 year pavement needs by county. From this, we can see that the preponderance of the needs are in Southern California, the San Francisco Bay area and portions of the Central Valley.

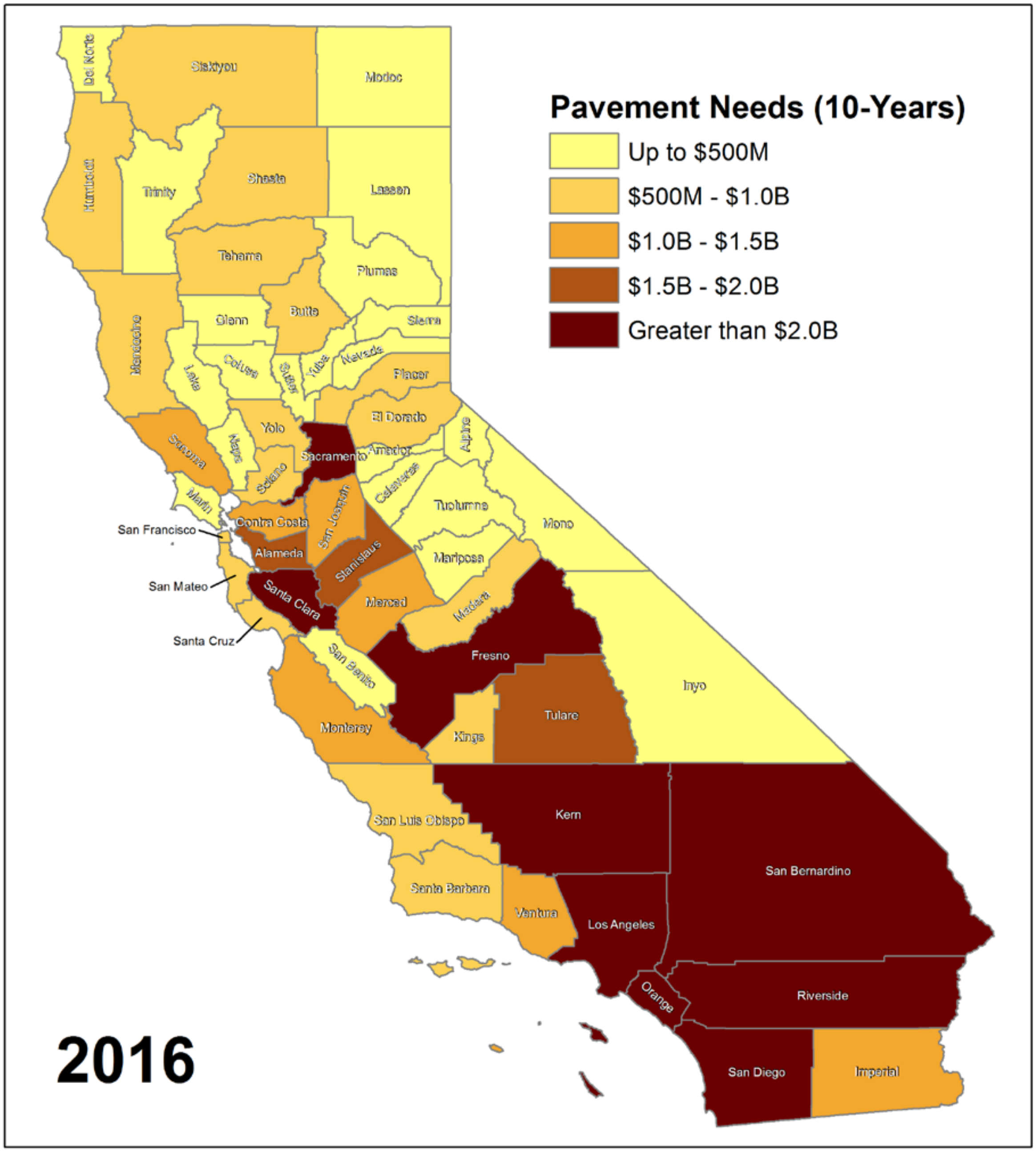


Figure 2.13 Map Illustrating Pavement Needs (10 Years) by County

3 Essential Components' Needs Assessment

The transportation system includes other essential components (i.e., safety, traffic and regulatory elements) apart from pavements and bridges. The safety of the traveling public is the highest priority for local agencies, so components such as traffic signals, street lights and signs, while not the most expensive, are critical. Since the transportation system is intended to serve all modes of travel (pedestrians, bicyclists, buses, people with disabilities etc.) and not just vehicles, local streets and roads must consider their needs as well.

Storm drains, which are mostly invisible since they tend to be underground, are also needed to remove excess water from the surface to facilitate both pavement structural integrity as well as safety. In removing water, trash and other pollutants inevitably drain into creeks, rivers, lakes, bays and the ocean, so environmental considerations come into play. Cities and counties have the responsibility of removing these pollutants as part of the maintenance costs of the transportation system.

Underground pipes, since they are often invisible, are often overlooked when establishing priorities, yet their failure can have disastrous consequences. The failure of a 90-year old water main near UC Los Angeles in July 2014 illustrates how much damage can occur. By the time emergency crews patched the pipe, an estimated 20 million gallons of water had flooded the UCLA campus (see Figure 3.1).

Figure 3.1 Water Main Break on Sunset Blvd, Los Angeles – July 2014
(Courtesy of Los Angeles Times)

3.1 Data Collection

As with past surveys, agencies were asked to provide specific information on the inventory and replacement costs for the following twelve asset categories:

Asset Category	Essential Components
1	Storm drains - pipelines
2	Curb and gutter
3	Sidewalk (public)
4	Curb ramps
5	Traffic signals
6	Street Lights
7	Sound Walls/Retaining walls
8	Traffic signs
9	Other storm drain elements e.g. manholes, inlets, culverts, pump stations, etc.
10	NPDES
11	Other ADA compliance needs
12	Other physical assets or expenditures

A total of 197 survey responses were received compared to 152 in 2014. Data from the previous surveys were also included in the analysis, which resulted in data points from 386 agencies. Table 3.1 illustrates the reliability of the data collected from the 2016 survey as determined by the city or county. That is to say, in the case of **street lights**, the survey responses indicate that:

1. 14.3% of agencies had accurate replacement costs.
2. 38.9% of agencies estimated the replacement costs.
3. 7.5% of agencies guessed the replacement cost.
4. 39.3% did not respond.

Overall, a little over half the agencies indicate that they either have accurate data or were able to provide estimates of the replacement costs for these asset categories. In Table 3.1, three major essential components (storm drains, curb and gutters, and sidewalks) have reasonably "good" data i.e. approximately two-thirds of the agencies have some data on their replacement costs, which is a key factor in estimating the needs.

Table 3.1 Percentage of Agencies Responding with Data on Essential Components

Category	Percentage of Agencies			
	Accurate	Informed Estimate	Guess	No Response
Storm Drains - pipelines	11.7%	40.9%	9.7%	37.6%
Other elements e.g. manholes, inlets, culverts, pump stations etc	8.4%	37.8%	9.5%	44.2%
Curb and gutter	9.9%	43.5%	10.3%	36.3%
Pedestrian facilities: Sidewalk (public)	9.4%	42.0%	10.5%	38.2%
Other pedestrian facilities, e.g. over-crossings	3.9%	8.1%	4.4%	83.7%
* Bicycle facilities: Class I bicycle path	6.1%	17.4%	4.8%	71.7%
Other bicycle facilities, e.g. bike shelters/lockers, etc.	4.8%	5.5%	2.8%	87.0%
Curb ramps	6.8%	31.6%	13.9%	47.7%
Traffic signals	24.2%	36.1%	4.6%	35.0%
Street Lights	14.3%	38.9%	7.5%	39.3%
Sound Walls/Retaining walls	7.2%	14.9%	12.8%	65.1%
Traffic signs	7.2%	36.0%	13.6%	43.3%
Other physical assets/expenditures that constitute >5% of non-pavement asset costs e.g. heavy equipment, corp. yards etc.)	2.9%	17.2%	11.9%	67.9%

Data on essential components are especially challenging to obtain, mostly because very few agencies have the resources to implement and maintain an asset inventory or management system. For example, unincorporated Orange County, with a road network of 320 miles, has over 18,000 signs, over 6,200 drainage inlets and 2,500 miles of storm drains, over 2,400 traffic signals, almost 10,000 miles of curbs and more than 10,000 miles of paint striping. The cost of inventorying these components can be very high, and is not financially possible for many agencies.

3.2 Needs Methodology

The analyses for the essential components are quite different from that for pavements and bridges. In 2008, a regression equation was developed to determine first the replacement costs, and from that, the ten-year needs were calculated. In 2012, the regression equation was re-evaluated and minor adjustments made. In this update, the methodology was reviewed by Dr. Bor Wen Tsai from the University of California, Berkeley. A new model based on geography (Geographically Weighted Regression or GWR), was developed (see Appendix D for a more detailed discussion). While previous models were reasonably accurate in the aggregate, large variations existed for individual agencies.

There are many factors that affect the replacement costs of these elements, most of which are caused by geography. For instance, most would agree that it is much more expensive to install a curb ramp in San Francisco than it is in Ceres, and the number of signs that exist in an urban city environment is significantly higher than in a rural county. The reasons that measured relationships vary spatially can also be attributed to sampling variation, relationships intrinsically different across space (for instance, different administrative or policies produce different responses), traffic patterns, road network attributes, or socio-demographic characteristics.

If there is spatial non-stationarity, it can be only seen through the residuals. One obvious way is to map the residuals from the regression to determine whether there are any spatial patterns. The essence of GWR modeling is to address the issue of spatial non-stationarity directly and allow the measured relationships to vary over space. Appendix D explains how the 2016 model below was developed:

$$Ln\ Cost = C_{tm3} \times tm^{1/3} + C_{tm} \times tm + C_{isrural} \times isrural + C_{iscounty} \times iscounty + Intercept$$

Where:

Cost = total replacement cost, dollars;
Total miles (tm) = total centerline miles of roads or streets;
isrural = indicator variable and is equal to 1 if agency is rural, 0 otherwise; and
iscounty = indicator variable and is equal to 1 if agency is county, 0 otherwise

Typically, the model is used only for those agencies that did not provide any replacement costs. However, some agencies reported extremely low costs that were considered anomalies; in these cases, the model was used instead.

Table 3.2 indicates the percentage of needs predicted by the model for each county. For example, in El Dorado County, 87 percent of the agencies provided data, and therefore, only 13 percent of the costs were estimated by the model. Overall, the model was used to estimate the replacement costs of approximately 28 percent of the agencies.

3.3 Determination of Essential Components' Needs

Similar to previous models, the 2016 regression model estimates the total replacement cost for only the first eight components. To estimate the needs, this cost needs to be converted to an annual amount based on the estimated service life of the different assets. The costs of the remaining four components (other storm drain elements, NPDES, ADA and other physical assets) are then added. This procedure was described in detail in Appendix D of the 2008 report and has not been duplicated here.

The 10-year needs figure was estimated to be $32.1 billion, which is a 3% increase from the $31 billion reported in 2014. Appendix E summarizes the essential components' needs for each county. Figure 3.2 is a map illustrating the distribution of needs by county. It should not be any surprise that the bulk of the needs are in the urban regions of the state.

The funding needs for essential components is $32.1 billion.

Table 3.2 Percentage of Agencies Using Model to Estimate Replacement Costs

County	% of Agencies Using Model
Alameda	0%
Alpine	100%
Amador	67%
Butte	50%
Calaveras	50%
Colusa	100%
Contra Costa	0%
Del Norte	50%
El Dorado	67%
Fresno	44%
Glenn	33%
Humboldt	63%
Imperial	75%
Inyo	0%
Kern	67%
Kings	60%
Lake	67%
Lassen	100%
Los Angeles	34%
Madera	33%
Marin	17%
Mariposa	0%
Mendocino	40%
Merced	29%
Modoc	50%
Mono	100%
Monterey	62%
Napa	0%
Nevada	75%

County	% of Agencies Using Model
Orange	34%
Placer	43%
Plumas	50%
Riverside	24%
Sacramento	38%
San Benito	33%
San Bernardino	36%
San Diego	21%
San Francisco	0%
San Joaquin	25%
San Luis Obispo	63%
San Mateo	10%
Santa Barbara	22%
Santa Clara	6%
Santa Cruz	40%
Shasta	50%
Sierra	100%
Siskiyou	70%
Solano	0%
Sonoma	30%
Stanislaus	50%
Sutter	33%
Tehama	25%
Trinity	0%
Tulare	78%
Tuolumne	50%
Ventura	27%
Yolo	20%
Yuba	67%
Total	**28%**

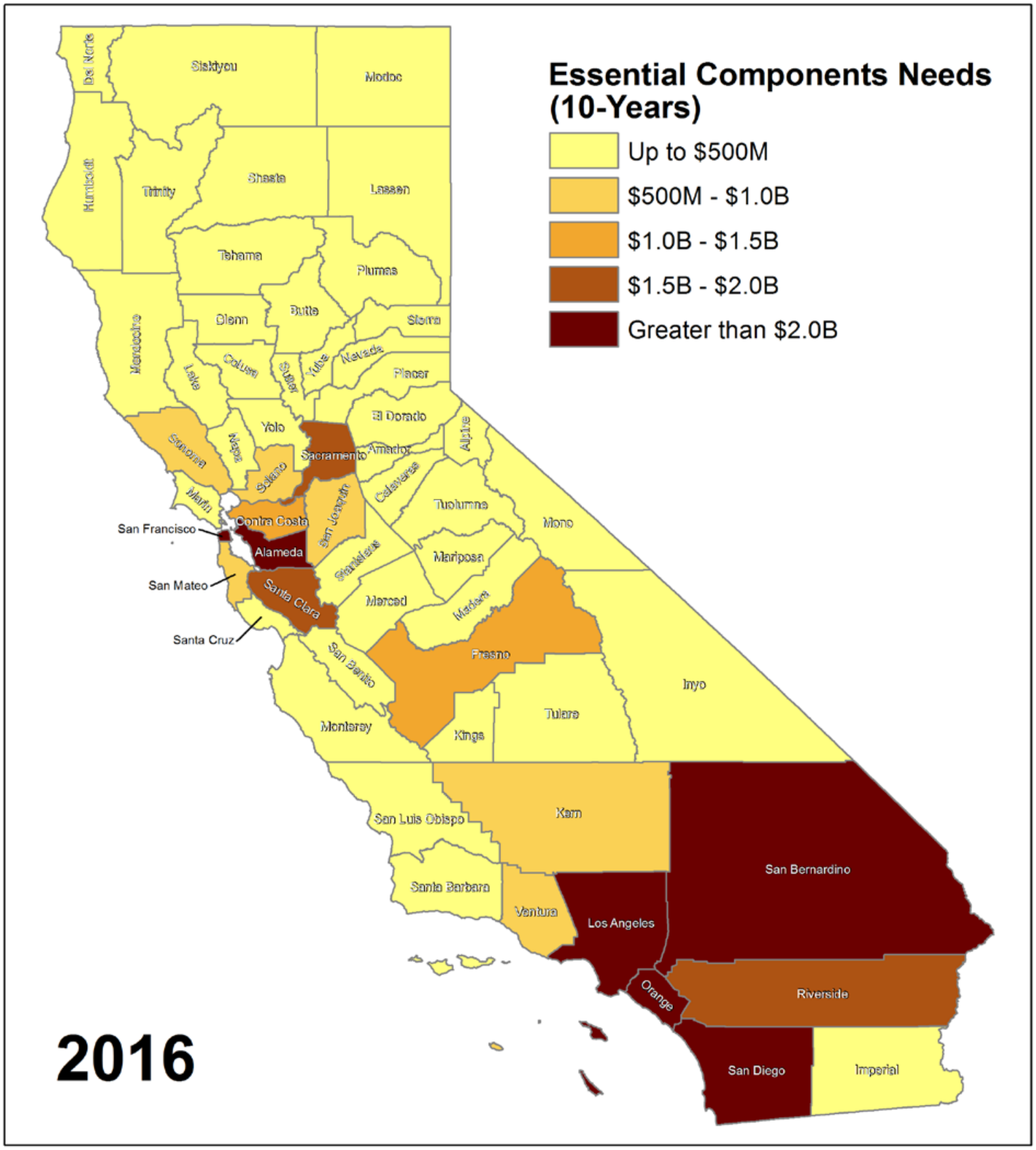


Figure 3.2 Map Illustrating Essential Components' Needs by County

4 Funding Analyses

4.1 Pavement Revenue Sources

The online survey asked agencies to provide both their revenue sources and pavement expenditures for 2014/15, 2015/16, as well as estimating an annual average for future years. A total of 340 agencies responded with financial data this year; this is an improvement over the 276 responses received in 2014.

As before, cities and counties identified a myriad of sources of funds for their pavement expenditures, broadly categorized into federal, state, or local. For local funds alone, more than a hundred different sources were identified. They included the following examples (this is by no means an exhaustive list and some funding sources have been changed with the advent of the FAST Act[12] which became law in December 2015):

Federal Funding Sources

- Community Development Block Grants (CDBG)
- Congestion Mitigation & Air Quality Improvement (CMAQ)
- Secure Rural Schools and Community Self-Determination Act
- Surface Transportation Block Grant Program
- Highway Safety Improvement Program (HSIP)
- HSIP High Risk Rural Roads Set-Aside (HR3)
- National Highway Performance Program
- Others such as emergency relief

State Funding Sources

- Gas taxes (Highway User Tax Account or HUTA)
- Active Transportation Program (ATP) which now includes the Bicycle Transportation Account (BTA) and Safe Routes to Schools (SR2S)
- State Transportation Improvement Program (STIP)
- AB 2766 (vehicle surcharge)
- Vehicle License Fees (VLF)
- CalRecycle grants

[12] http://www.fhwa.dot.gov/fastact/

- State Water Resource Control Board
- Transportation Development Act (TDA)
- Traffic Safety Fund
- Transportation Uniform Mitigation Fee (TUMF)

Local Funding Sources

- Local sales taxes
- Development impact fees
- General funds
- Various assessment districts – lighting, maintenance, flood control, special assessments, community facility districts
- Traffic impact fees
- Traffic safety/circulation fees
- Utilities e.g., stormwater, water, wastewater enterprise funds
- Transportation mitigation fees
- Parking and various permit fees
- Flood Control Districts
- Enterprise Funds (solid waste and water)
- Investment earnings
- Parcel/property taxes
- Indian reservation roads
- Indian gaming funds
- Vehicle registration fees
- Vehicle code fines
- Underground impact fees
- Solid waste funds
- Transient Occupancy Taxes (TOT)
- Capital Improvement Program (CIP) Reserves/Capital Funds

The funding data was first reviewed to ensure that the description matched the funding source (i.e. federal, state or local). In cases where the source did not match the description, the source was modified appropriately. Funds were also further categorized as gas tax, sales tax, general fund or other, based on the description. Funds and expenditures were then summed by agency and year. Agencies that reported funding or expenditures for some years, but not others were further reviewed, and the data for reported years was used to estimate the data for unreported years.

Funds and expenditures for each agency were then divided by the number of lane-miles of roadway in that agency. The funding and expenditures data per lane-mile results were then reviewed for outliers. With the outliers removed, funding and expenditure data per lane mile were then averaged for urban counties, rural counties, urban cities and rural cities. These averages were used to determine the estimated total funds and expenditures for all cities and counties. Then the total expenditures and funds for these categories were then summed to determine the statewide total values.

Table 4.1 and Figure 4.1 summarize the total pavement funding available as well as the percentage of funding sources from the different categories since 2008/09. Note that there is a small increase in funding reported in 2012/13 and 2013/14 compared to the previous years. One reason is the annual revenue neutrality adjustment on a portion of the state gas tax as a source of revenue, which resulted in a temporary spike in the gasoline excise tax revenues. In addition, there are bond measures that have essentially “front-loaded” the pavement expenditures. However, based on the survey responses, future funding is projected to drop slightly overall.

Table 4.1 Funding Sources for Pavements

	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16	Future
Pavement Funding ($M)	$1,453	$1,571	$1,557	$1,530	$1,691	$1,836	$1,938	$1,967	$1,846
Federal	10%	23%	18%	16%	10%	11%	9%	9%	11%
State	62%	49%	53%	53%	52%	50%	44%	41%	40%
Local	28%	27%	29%	30%	38%	38%	47%	50%	49%

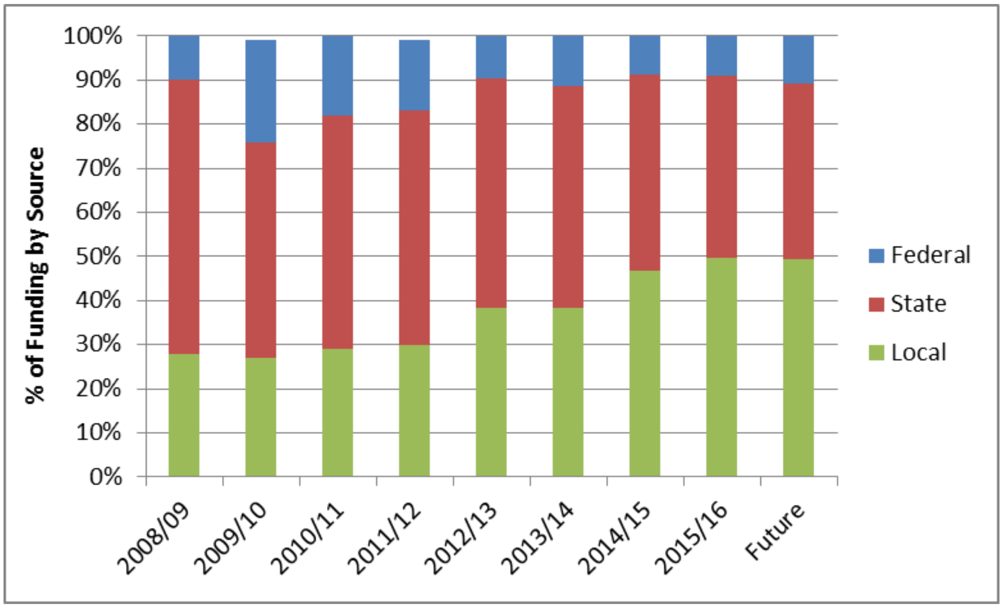


Figure 4.1 Percent of Pavement Funding By Source

In terms of the breakdown by revenue sources, there is a significant trend indicating that local agencies are relying more on local sources and less on state funding.

Note that federal funding was a significant component in 2009/10 and 2010/11, reflecting the influx of American Recovery and Reinvestment Act (ARRA) funding which occurred during the recession. Since then, the percentage of federal funds has fluctuated between 9 to 11 percent. This is an important item

to note since it indicates that cities and counties, in general, do not rely heavily on federal funds. Rather, state and local funds typically make up almost 90 percent of pavement funding.

The Highway User Tax Account (HUTA), more commonly known as the state gas tax, is still the single largest funding source for cities and counties. However, Table 4.2 shows a revenue source that is declining. This is partly due to declining gas consumption due to more gas-efficient and electric vehicles, and partly due to the additional responsibilities for most cities and counties e.g. compliance with the American Disabilities Act (ADA) in the form of curb ramps and sidewalks, which reduces the amount of funding available for pavements. Table 4.2 indicates that gas tax funds are projected to be around $910 million a year.

The gas tax is the single largest funding source for cities and counties, yet this is projected to decline statewide and nationally.

Table 4.2 Gas Tax Trends for Pavements

	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16	Future
Total Gas Tax ($M)	$ 1,115	$ 911	$ 861	$ 907	$ 1,096	$ 1,137	$ 891	$ 904	$ 910
% of State funding	66%	69%	75%	78%	93%	91%	86%	88%	90%
% of total funding	41%	34%	40%	41%	48%	46%	38%	36%	36%

Traditionally, cities and some counties have been able to rely on the General Fund for pavement funding. However, as Table 4.3 illustrates, the number of agencies who receive General Funds has markedly declined since 2008, and they are projected to continue to decrease in the future.

Of final interest is the trend in local sales tax measures. Table 4.4 shows an increasing reliance on the revenues from this source. Although it was only 10 percent of total pavement revenues in 2008/09, this has steadily increased and reached 19 percent in 2015/16.

Table 4.3 General Funds for Pavement Funding

	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16	Future
Total General Fund ($M)	$ 201	$ 120	$ 175	$ 168	$ 166	$ 232	$ 322	$ 406	$ 383
# of agencies	132	62	77	72	88	94	104	104	89
% of local funding	27%	16%	28%	25%	19%	24%	29%	33%	31%
% of total funding	7%	4%	8%	8%	7%	9%	14%	16%	15%

Table 4.4 Local Sales Tax Trends

	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16	Future
Total Sales Tax ($M)	$ 285	$ 258	$ 256	$ 279	$ 374	$ 455	$ 364	$ 475	$ 424
% of local funding	38%	35%	41%	42%	43%	48%	32%	39%	35%
% of total funding	10%	10%	12%	13%	17%	18%	16%	19%	17%

4.2 Pavement Expenditures

The survey also asked for a breakdown of pavement expenditures in four categories:

- Preventive maintenance, such as slurry seals;
- Rehabilitation and reconstruction, such as overlays;
- Other pavement related activities such as curbs and gutters; and
- Operations and maintenance.

Table 4.5 shows the breakdown in extrapolated pavement expenditures for cities, counties and cities/counties combined. There was a drop in expenditures reported in 2010/2011, reflecting the recession. However, since 2012/13, expenditures have gradually increased to 2008 levels.

Table 4.5 Breakdown of Pavement Expenditures ($M)

	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16	Future
Preventive Maintenance	$ 394	$ 375	$ 273	$ 273	$ 333	$ 367	$ 373	$ 378	$ 448
Rehabilitation & Reconst.	$ 1,224	$ 1,400	$ 817	$ 794	$ 1,132	$ 1,208	$ 1,178	$ 1,194	$ 936
Other	$ 200	$ 172	$ 84	$ 82	$ 104	$ 109	$ 194	$ 167	$ 173
Operations & Maintenance	$ 573	$ 543	$ 383	$ 381	$ 578	$ 615	$ 619	$ 631	$ 798
Totals	**$ 2,391**	**$ 2,489**	**$ 1,557**	**$ 1,530**	**$ 2,147**	**$ 2,298**	**$ 2,365**	**$ 2,370**	**$ 2,354**

Figure 4.2 illustrates the trends for all pavement expenditures graphically. Preventive maintenance continues to be a robust category, and appears to be stabilized around 16 percent. This indicates that many agencies continue to be cognizant of the need to preserve pavements. In contrast, rehabilitation and reconstruction appear to be dropping, to as low as 50 percent and is predicted to continue dropping to 40 percent in the future.

Note that the "Operations and Maintenance" category are expenditures that are related to the pavements, such as filling potholes, sealing cracks, street sweeping, etc. This category has grown significantly since 2008 and is expected to continue to grow due to regulatory requirements such as street sweeping to comply with NPDES requirements, compliance with new traffic sign retroreflectivity standards and upgrading curb ramps in compliance with the American Disabilities Act (ADA).

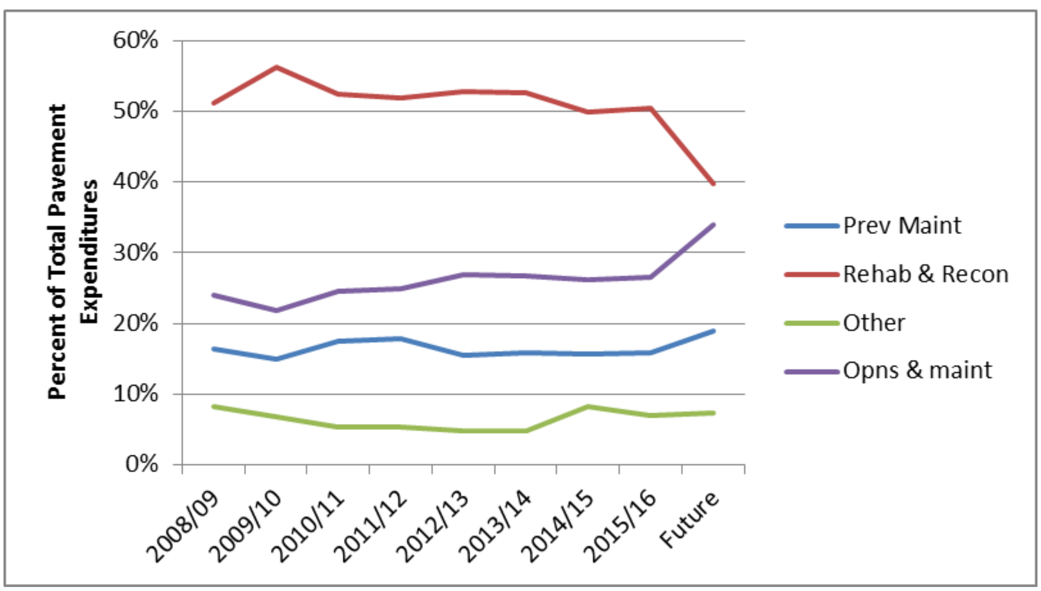


Figure 4.2 Trends in Pavement Expenditures (2008-2016)

Finally, projected pavement expenditures for the next ten years are shown in Table 4.6. As expected, counties indicate lower projected expenditures than cities, and similarly, rural agencies project lower expenditures when compared to urban agencies.

Table 4.6 Projected Pavement Expenditures Per Lane-Mile

	Pavement Expenditures ($/lane-mile)	
	Rural	Urban
County	$3,676	$8,224
City	$9,280	$7,577

The resulting total pavement expenditures for all 540 cities and counties were therefore estimated to be $1.846 billion annually. To put this funding level in perspective, $1.846 billion/year is approximately one percent of the total investment in the pavement network, the value of which is estimated at $168 billion.

Cities and counties are estimated to spend $1.846 billion annually on pavements. This is approximately 1% of the total invested in the pavement network.

However, our observations on the predicted vs. actual expenditures revealed an interesting trend, as illustrated in Figure 4.3. Generally, local agencies are receiving 10 to 25 percent <u>more</u> revenue (blue line) than predicted (red line). From discussions with some respondents, it appears that the predicted expenditures are conservative and reflects a reluctance to rely on federal and state grants/sources in the future as well as the inability to predict how the economy will perform. The latter is important, since local sales taxes (a good indicator of economic robustness) now comprise almost 20 percent of total funding. However, given the large pavement needs (green line), the difference is not overly significant.

Nonetheless, we projected that future expenditures may be $1.976 billion instead of $1.846 billion (15 percent difference). This number was used in our analysis in Section 4.6.

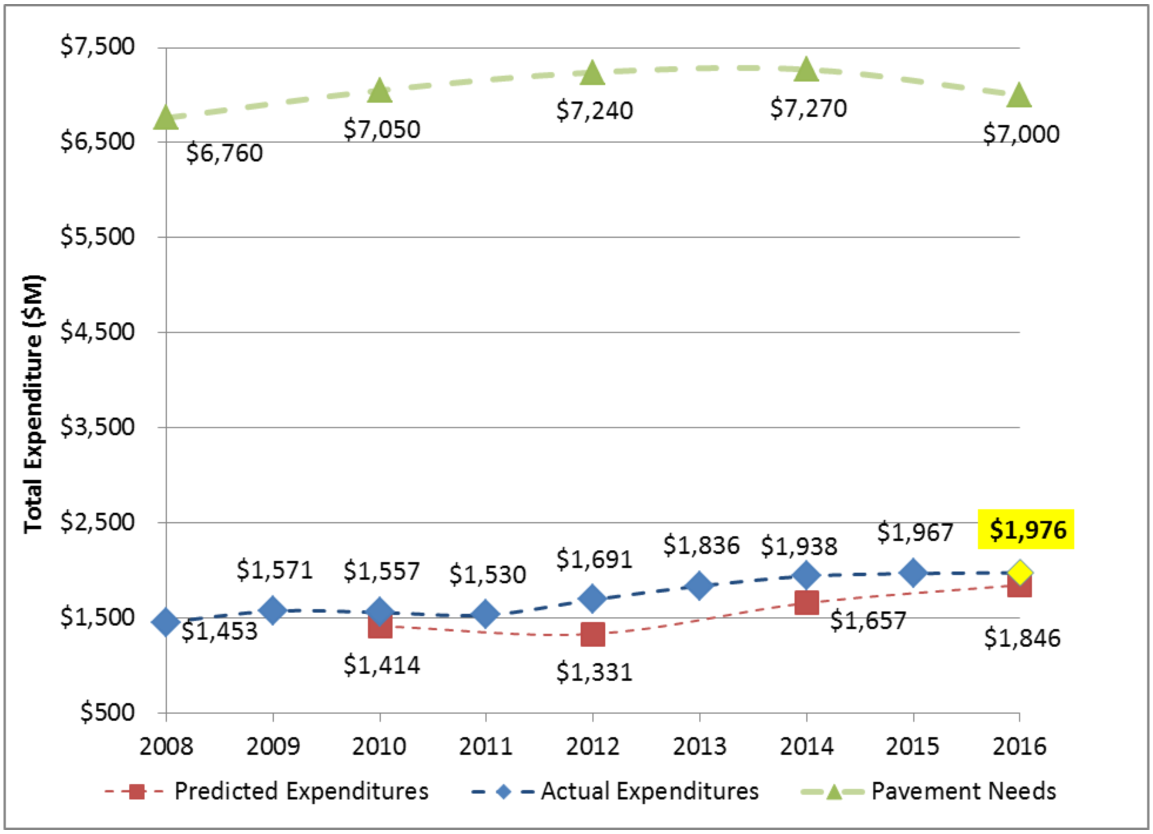


Figure 4.3 Differences Between Predicted and Actual Expenditures

4.3 Essential Components' Revenue Sources

Similarly to the analysis in Section 4.1, the revenue sources for essential components are shown in Table 4.7. Again, federal funds make only a small contribution to the cities and counties, in the order of 11 to 17 percent. However, unlike pavements, local sources now account for almost 70 percent of total funding, with state sources accounting for less than 20 percent. In addition, there is no one single funding source like the gas tax.

Since local revenues form the majority of the funding, Table 4.8 explores the five main funding sources: general funds, local sales taxes, lighting district funds, development impact fees, and other. The last category includes stormwater, sanitary and NPDES related sources. Future funding projections indicate a decrease from existing levels is expected, down from 2013/14 levels.

Table 4.7 Funding Sources for Essential Components ($M)

Funding type	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16	Future
Funding Available ($M)	$885	$903	$1,204	$1,332	$1,111	$1,184	$1,100
Federal	16%	16%	12%	13%	11%	17%	13%
State	31%	31%	28%	23%	18%	17%	18%
Local	53%	53%	60%	65%	70%	66%	70%

Table 4.8 Local Revenue Sources for Essential Components ($M)

Funding type	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16	Future
General Fund	$ 104	$ 124	$ 83	$ 93	$ 398	$ 420	$ 409
Sales Tax	$ 112	$ 114	$ 129	$ 148	$ 98	$ 132	$ 121
Lighting District Funds	-	-	-	-	$ 39	$ 40	$ 42
Development Impact Fees	$ 34	$ 37	$ 24	$ 32	$ 27	$ 23	$ 20
Other	$ 249	$ 255	$ 460	$ 556	$ 219	$ 163	$ 173
Totals	$ 498	$ 530	$ 696	$ 830	$ 781	$ 779	$ 766

4.4 Essential Components' Expenditures

Table 4.9 details the expenditures by category. Storm drains and traffic signals continue to be the largest components. Overall, expenditures appear to fluctuate between $900 million to $1 billion.

On average, anticipated expenditures for essential components over the next ten years are shown in Table 4.10. As before, rural counties and cities are expected to have lower expenditures than their urban counterparts.

The resulting total expenditures for all 539 cities and counties were estimated to be over $891 million annually.

Table 4.9 Breakdown of Expenditures for Essential Components

Essential Components	Annual Expenditures ($M)							% of total
	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16	Future	
Storm Drains	$224	$243	$241	$341	$147	$131	$112	13%
*Storm drain related	-	-	-	-	$37	$46	$48	5%
Curb and Gutter	$44	$47	$69	$68	$55	$67	$67	7%
Sidewalk (public)	$118	$117	$117	$153	$110	$129	$89	10%
Other Pedestrian Facilities	$12	$13	$13	$18	$5	$22	$13	1%
Class 1 Bicycle Path	$14	$25	$22	$19	$24	$40	$46	5%
Other Bicycle Facilities	$16	$13	$27	$14	$4	$6	$12	1%
Curb Ramps	$51	$51	$59	$61	$47	$54	$42	5%
Traffic Signals	$232	$240	$215	$215	$210	$258	$212	24%
Street Lights	$104	$108	$106	$98	$122	$121	$97	11%
Sound/Retaining Walls	$9	$8	$9	$17	$4	$7	$5	1%
Traffic Signs	$54	$54	$72	$63	$61	$68	$67	7%
*Tunnels	-	-	-	-	$0	$0	$0	0%
Other	$62	$82	$112	$117	$122	$102	$81	9%
Totals	**$940**	**$1,001**	**$1,062**	**$1,184**	**$949**	**$1,052**	**$891**	**100%**

*New Item in 2016 Survey

Table 4.10 Breakdown of Expenditures for Essential Components

	Expenditures on Essential Components	
	Rural	Urban
County	$1,035	$6,637
City	$3,790	$4,011

4.5 Funding Shortfalls

One of the primary objectives of this study was to determine if a funding shortfall existed for the next ten years, and if so, what that shortfall was. Chapters 2 and 3 described the analysis to determine the funding needs for both the pavement and essential components, respectively. The preceding sections of this chapter analyzed the revenues and expenditures as well.

Table 4.11 summarizes the results of all the preceding analyses and determines the funding shortfall to be $71.3 billion for pavements and essential components. This does not include any expenditures from the additional regulatory requirements (e.g. NPDES, ADA and sign retroreflectivity), which was estimated to have a shortfall of $2.4 billion (see Table 2.7). However, those numbers were not included in Table 4.11 since only half the agencies had data, and half of those indicated that they were "informed estimates" or "guesses" at best.

Table 4.11 Summary of 10 Year Needs & Shortfall (2016 $ Billion)

Transportation Asset	Needs ($B)				2016		
	2008	2010	2012	2014	Needs	Funding	Shortfall
Pavement	$ 67.6	$ 70.5	$ 72.4	$ 72.7	$ 70.0	$ 19.8	$ (50.2)
Essential Components	$ 32.1	$ 29.0	$ 30.5	$ 31.0	$ 32.1	$ 11.0	$ (21.1)
Totals	$ 99.7	$ 99.5	$ 102.9	$ 103.7	$ 102.1	$ 30.8	$ (71.3)

In the 2014 study, the funding shortfall identified was $77 billion, so this is a decrease of $5.7 billion (a reduction driven largely by decreased construction costs), or approximately 7.4 percent.

The shortfall for local streets and roads is estimated at $71.3 billion!

4.6 Pavement Funding Scenarios

California, together with the rest of the nation, faced severe economic challenges during the recession that began in 2008, with reductions in revenues, multi-billion dollar deficits and a high unemployment rate. While economic growth and tax increases have helped stabilize state and local revenues for many programs, transportation funding levels have not similarly recovered. Reductions in gas tax revenue due to stagnated tax rates, improving vehicle fuel economy, and low fuel prices, paint a sobering picture for transportation funding. The preceding sections described a general declining trend in funding, yet the needs continue to increase.

Over the past eight years, the results of the previous statewide needs studies have helped educate policy makers and prevented severe cuts to road funding. To further assist policy makers on how potential cuts will affect pavement conditions; this update includes the impacts from three different funding scenarios:

1. Existing funding, estimated at $1.98 billion/year;
2. Funding to maintain current pavement condition at PCI = 65; and
3. Funding to achieve best management practices (BMP) in ten years.

As noted in Chapter 1, an analysis period of 10 years was selected, not just for consistency with the SHOPP, but also because this was a reasonable time period to accomplish the BMP goal. Even if local agencies received $50.2 billion to erase the 10-year pavement shortfall today, it would not be possible to build or construct this large number of projects in one year, or two or even five. Few, if any, agencies will have the resources to design, manage or inspect this quantity of work in such a short time frame, and the contracting community is also unlikely to have the resources to construct them. In discussions with the Oversight Committee, a 10 year timeframe was deemed to be reasonable and practical.

Scenario 1: Existing Funding ($1.98 billion/year)

In this scenario, the most cost-effective treatments are funded first, and these are typically preventive maintenance or preservation strategies, such as seals. This approach generally treats a larger percent of pavement network resulting in optimizing the use of limited funds. At the existing funding level of $1.98 billion/year, the pavement condition is expected to deteriorate to 56 by 2026, and the unfunded backlog will increase by more than 50 percent to $59 billion. Again, these are in constant 2016 dollars. Figure 4.4 graphically illustrates these two trends.

Scenario 2: Maintain PCI at 65 ($3.5 billion/year)

In order to maintain the pavement condition and unfunded backlog at existing conditions (i.e., PCI = 65) an annual funding level of $3.5 billion is required (see Figure 4.5). This funding level is significantly higher than the current funding level of $1.98 billion/year. The unfunded backlog is stabilized at around $42.5 billion.

Scenario 3: Reach Best Management Practices ($7.0 billion/year)

One of the objectives of this study was to determine what funding level would be required to reach a pavement condition where best management practices can be applied. This occurs when the PCI reaches an optimal level in the mid-80s, and the unfunded backlog will be eliminated by 2027.

For this scenario, $7.0 billion/year is required to achieve this level (see Figure 4.6). The PCI will reach 84 by 2026 and the unfunded backlog is eliminated by 2027. **Once eliminated, the cost of maintenance thereafter is significantly lower, requiring approximately $2.5 billion a year.**

Once the backlog has been eliminated, only $2.5 billion/year is required to maintain the network at BMP levels.

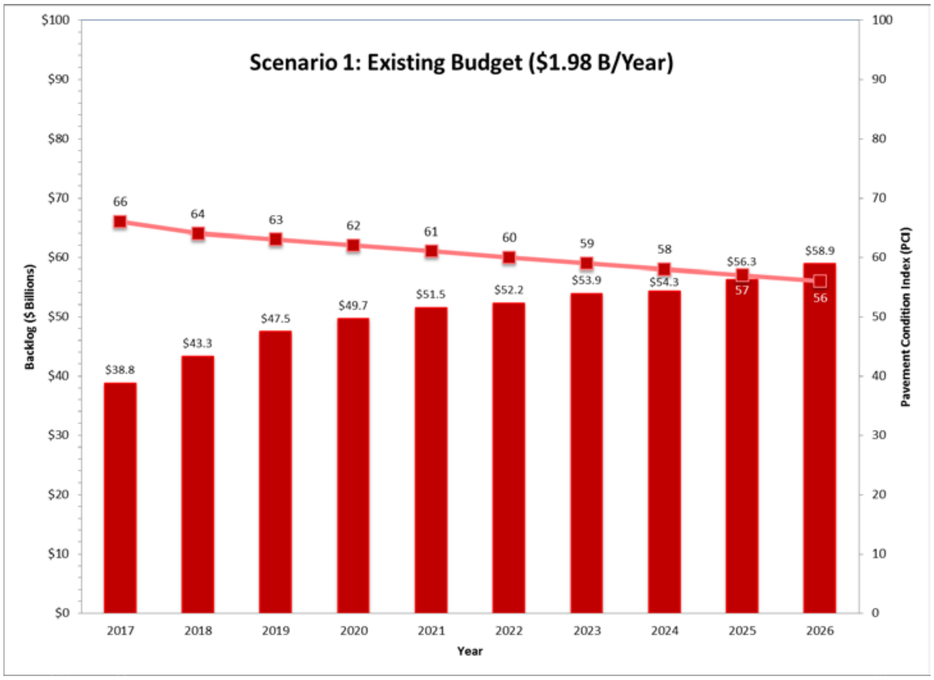


Figure 4.4 Results of Scenario 1: Existing Budget ($1.98 billion/year)

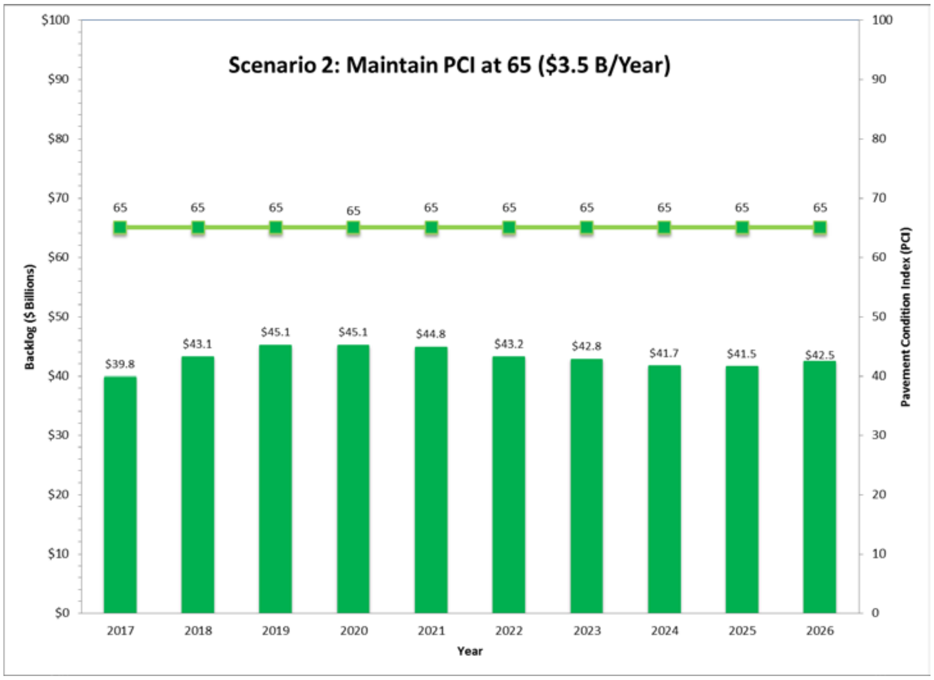


Figure 4.5 Results of Scenario 2 (Maintain PCI at 65; $3.5 billion/year)

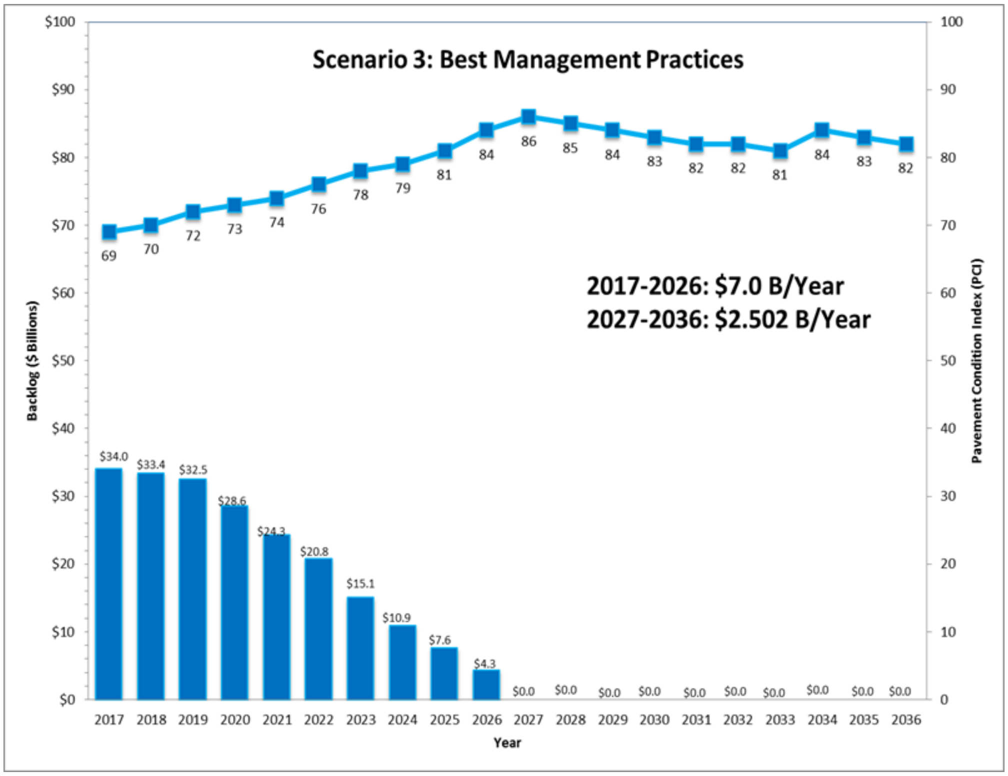


Figure 4.6 Results of Scenario 3 (BMP in 10 years = $7 billion/year)

4.7 Other Performance Measures

Although both PCI and the unfunded backlog are common performance measure for cities and counties, there are others that may be used. One such measure is the percentage of pavement area in different condition categories. Table 4.12 illustrates the breakdown in pavement area for each funding scenario.

The biggest factor that jumps out is that the percentage of pavements in failed condition today is estimated to be approximately 6.9 percent; however, under Scenarios 1 and 2, this will grow to between 22.2 to 21.8 percent by 2026, respectively. Or to be blunt, almost a quarter of local streets and roads will be considered "failed" by 2026 under existing funding levels. Figure 4.7 show examples of "failed" local streets.

Almost a quarter of California's streets will be in failed condition by 2026 under existing funding levels.

Table 4.12 Percent of Area by Condition Category in 2026 for Each Scenario

Condition Category	Current Breakdown (2016)	Scenario 1 Existing Budget ($1.98 B/yr)	Scenario 2 Maintain PCI at 65 ($3.5 B/yr)	Scenario 3 BMP in 10 Years ($7.0 B/yr)
PCI 70-100 (Good to Excellent)	54.8%	47.0%	74.0%	100.0%
PCI 50-69 (At Risk)	21.9%	18.8%	1.3%	0.0%
PCI 25-49 (Poor)	16.4%	12.0%	2.9%	0.0%
PCI 0-24 (Failed)	6.9%	22.2%	21.8%	0.0%
Totals	100.0%	100.0%	100.0%	100.0%

Figure 4.7 Examples of Failed Streets

Another trend of note is that while Scenario 2 maintains the existing condition and unfunded backlog, there is still a significant growth in the percentage of pavements that are "failed" (from 6.9 percent to 21.8 percent). The good news is that the preservation strategies will also dramatically improve the percent of pavements in the "good to excellent" category from 54.8 percent to 74 percent.

Finally, a short note on the definitions of a "distressed highway." As was mentioned in Chapter 1, Caltrans has a goal of reducing the percentage of distressed highways to 10 percent. Distressed highways in this definition are those highways that require capital preventive maintenance and rehabilitation. When applied to a local street or road, this includes all the streets in the "At Risk" category and below. Applying the Caltrans definition would mean that currently, 45.2 percent of local streets and roads are “distressed”. Clearly, the definitions used by Caltrans are applicable for highways but not for local streets and roads; this is only logical since the types of facilities are so different.

4.8 How Did We Get Here?

For those who do not work with transportation issues every day, it can be difficult to understand how California’s cities and counties have reached this situation. Yet the factors that have led us here can be quickly summarized as:

- The population of California was approximately 30 million in 1990; it is now approximately 39 million, an increase of 30 percent. Attendant with that increase in population are increases in traffic, housing and new roads.
- There are many new regulations which have increased the responsibilities of cities and counties, such as ADA, NPDES, and new traffic sign retroreflectivity standards.
- Greenhouse gas emissions reduction policies and other policies designed to improve air quality together with ADA standards have also had an unexpected impact on streets and roads. One example is the use of heavy new buses that exceed the legal highway limits because they have been upgraded to reduce GHG and other particulate air emissions and meet ADA standards. These higher loads will inevitably result in a premature pavement failures and therefore higher maintenance costs.
- The public demands a higher quality of life e.g. complete streets or active transportation policies.
- Cities and counties need to consider, build and maintain a transportation system that has multiple transportation modes e.g. bicycles, pedestrians, trucks, and buses.
- The cost of road repairs and construction has steadily increased, at rates that are significantly higher than that of inflation. In the last 15 years, paving costs have increased much more so than revenues.
- The state based gasoline excise tax has not increased in over 20 years and yet it remains the single most important funding source for transportation. This means that cities and counties are relying on a diminishing revenue source for a transportation system that is aging and deteriorating rapidly, and which continues to shoulder additional demands from the public.

4.9 Summary

From the results of the surveys as well as the funding scenarios, it is apparent that:

- Total funding for pavements is projected at $1.98 billion annually over the next ten years. Of this, 40 percent will come from state funds (almost all gas tax), 11 percent from federal sources, and the remainder from local sources (mostly sales taxes).

- Total funding for essential components is projected to decrease to approximately $1.1 billion annually. The majority of the funding comes from local sources (70%) with the state contributing approximately 18%.
- Given the existing funding levels, the total funding shortfall for pavements and essential components is a staggering $71.3 billion over the next ten years!
- Under the existing funding for pavements ($1.98 billion/year), it is projected that the statewide PCI will decrease from 65 to 56 and the unfunded backlog will increase to almost $59 billion. In addition, almost a quarter of the pavement network will be in "failed' condition by 2026.
- In order to maintain the existing pavement condition (Scenario 2), it will require a funding level of $3.5 billion/year. This would dramatically improve the percentage of pavements in the "good to excellent" category from 55 percent to 74 percent. Unfortunately, the percentage of pavements in the "failed" category also grows from 6.9 percent to 21.8 percent.
- The best management practice scenario would require approximately $7 billion annually to eliminate the backlog of work and raise the PCI to 84.
- Once the BMP goal has been reached, it will only require $2.5 billion/year to maintain the condition of the pavement network.

5 Bridge Needs and Funding Analysis

Bridges are an integral part of the transportation system, and therefore a study such as this one would be incomplete without a discussion of their needs. The catastrophic nature of a bridge failure is exemplified by the collapse of the I-35W bridge in Minneapolis during rush hour in August 2007. Thirteen people were killed and 145 injured. Failures in local bridges can also have significant consequences. Many rural bridges provide the only access to homes and communities, and if a bridge collapses, access to help is limited or not available. In other cases, detours of more than four hours may be necessary.

Addressing bridge investment needs is both a local and national challenge. In its report *Bridging the Gap*, the American Association of State Highway and Transportation Officials (AASHTO) describes age and deterioration as the first of five top problems facing the nation's bridge population[13]. Other problems include congestion, increased construction costs, maintaining bridge safety, and addressing new bridge needs. The U.S. Federal Highway Administration (FHWA) estimates the national backlog of bridge investment needs to be $106.4 billion in 2010. A national investment level of $12.2 billion, which is slightly less than the funding level in 2010 ($17.1 billion), is needed to keep the backlog from rising, setting aside consideration of addressing congestion or other new bridge needs[14]. California's bridge population is one of the largest in the country, and thus California bridge conditions have a significant bearing on any national-level analyses.

Although one can make a compelling case for making needed investments in California's local bridges, the simple truth is that local budgets are tightly constrained, there is significant uncertainty about future funding, and there are many different competing needs for available funds. Thus, bridge owners, taxpayers, and legislators need the most accurate information available to make the best decisions about how to allocate scarce resources.

---

[13] AASHTO. *Bridging the Gap: Restoring and Rebuilding the Nation's Bridges.* 2008.

[14] FHWA *2013 Status of the Nation's Highways, Bridges, and Transit: Conditions & Performance*. Report to the United States Congress. http://www.fhwa.dot.gov/policy/2013cpr/pdfs.cfm

For the 2016 update, both **Quincy Engineering (QE)** and **Spy Pond Partners (SPP)** collaborated to provide the analysis to determine both the bridge needs and funding scenarios, respectively. These results are shown in Appendix F.

5.1 Bridge Inventory Data

Two bridge inventory data sets were used for this study. The first is the National Bridge Inventory database (NBI), which is collected by Caltrans on behalf of local agencies on a biennial basis and provided to Federal Highway Administration (FHWA) to be included in the NBI database. The second type of bridge inventory data used is the local agency bridge inventory data gathered from the Statewide survey to collect data on short (less than 20 feet in length) and non-vehicular bridges which are excluded from the NBI database.

The NBI database contains detailed bridge information such as general geometry (length, width, number of supports), year built, various conditional ratings and designations. It also contains Structurally Deficient (SD) and Functionally Obsolete (FO) designations, and the Sufficiency Ratings (SR) that are used to determine the general condition of a bridge.

> **Functionally Obsolete (FO)** is a designation used to describe a bridge that is no longer functionally adequate for its task. Major reasons for this classification include inadequate bridge width for the volume of traffic accommodated, inadequate vertical clearances for traffic, and inadequate clearances over waterways. By far, the biggest driver of this classification is inadequate bridge width for traffic. This typically occurs in older bridges that may have been initially built with an adequate number of lanes and shoulder width to meet standards of the day but have experienced a significant growth in traffic volumes over their lifetimes. The Functionally Obsolete classification does not necessarily imply deficiencies of a structural nature. A Functionally Obsolete bridge may be perfectly safe and structurally sound, but may be a source of traffic congestion or may not have a high enough clearance to allow an oversized vehicle traffic.
>
> **Structurally Deficient (SD)** is a designation used to describe a bridge that has one or more structural defects that require attention. It is determined based on the structural evaluation and the condition ratings of the bridge deck, substructure, and superstructure. These component evaluations and ratings are listed in the NBI database documents along with the details of the nature and severity of the defects.
>
> The **Sufficiency Rating (SR)** is a method of evaluating a bridge by calculating multiple factors to obtain a numeric value which is indicative of bridge sufficiency to remain in service. The result of this method is a percentage in which 100 percent would represent an entirely sufficient bridge and zero percent would represent an entirely insufficient or deficient bridge. The Sufficiency

Rating is essentially an overall rating of a bridge's fitness for the duty that it performs based on factors derived from multiple NBI data fields, including fields that describe its structural evaluation, functional obsolescence, and its essentiality to the public. A low Sufficiency Rating may be due to structural defects, narrow lanes, low vertical clearance, or any of many possible issues.

A total of 12,105 local agency bridges in California were assessed from the 2015 NBI database. This is approximately 48 percent of the total of 25,318 bridges. Local agency bridges are defined as bridges that are owned by local agencies such as counties and cities and are typically not on the State Highway system. Other owners such as State, Bay Area Rapid Transit, private, railroad and federal bridges are not considered as Local Agency bridges and were not included in this study.

There are 12,105 local bridges in California, which represents 48% of the total.

Figure 5.1 represents a breakdown of local bridge count by county. Most counties (including city bridges within the county) have a few hundred bridges, averaging about 200 bridges per county. In general, the larger populated counties have a significantly higher number of bridges than the lower populated counties. Los Angeles County has the most locally owned bridges, with over 1,400 bridges.

Figure 5.2 illustrates the age distribution of all the statewide local bridges. The largest age group are bridges 40 years or older, followed by bridges that are 50 years or older. As bridges age, the need for rehabilitation or replacement becomes greater. As with streets and roads, it is more cost effective to maintain bridges in good condition than it is to allow those bridges to deteriorate at a faster rate and require replacement sooner. Figure 5.2 also shows that there are a significant number of bridges that are over 80 years old (most bridges are designed to last 50 years). Most of those bridges are at the end of their life and will require replacement soon.

Current bridge design codes (AASHTO Load Resistance Factor Design Bridge Design Specifications) are designed with a minimum lifespan of 75 years. However, older bridges may not have been designed and constructed to such high standards. The bridges that are older now are not likely to be as durable as newer bridges will be when they reach age of 75 years. It is anticipated that a significant portion of bridges over 80 years old will likely require replacement soon.

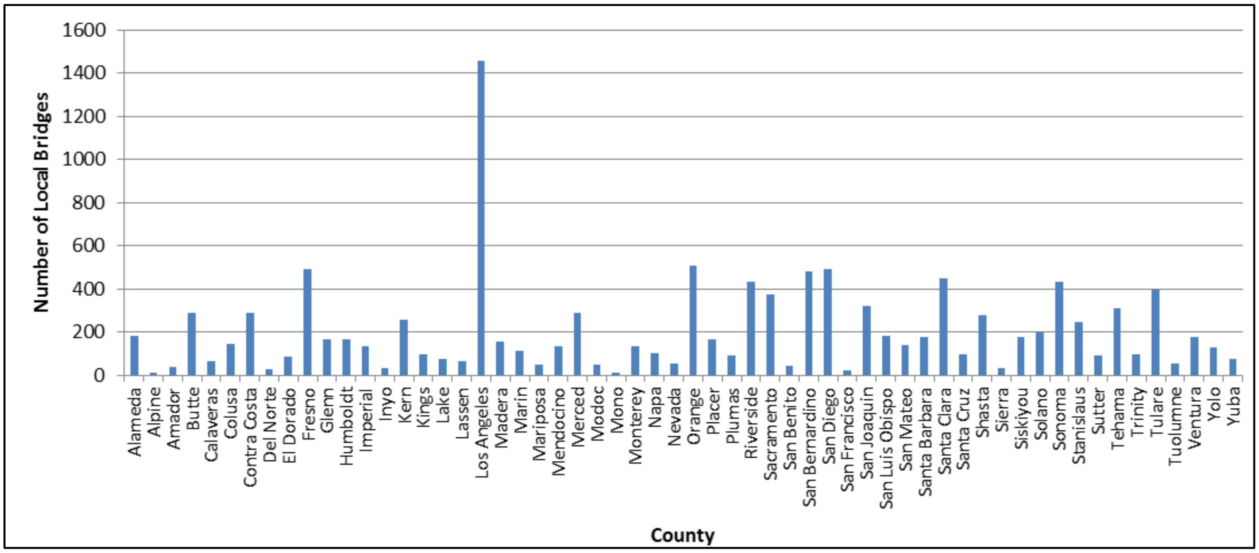


Figure 5.1 Number of Local Bridges by County (includes Cities within County)

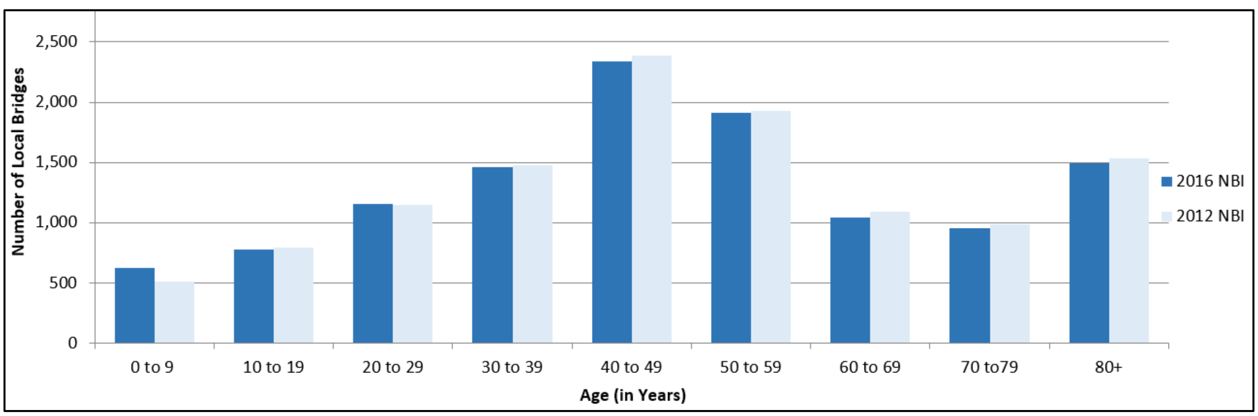


Figure 5.2 Age Distribution of Local Bridges

Figure 5.3 is a scatter plot that shows the SR for all local bridges. Although the average SR is 81, there are a significant number of bridges with a SR less than 50. County specific charts are available on the www.SaveCaliforniaStreets.org website.

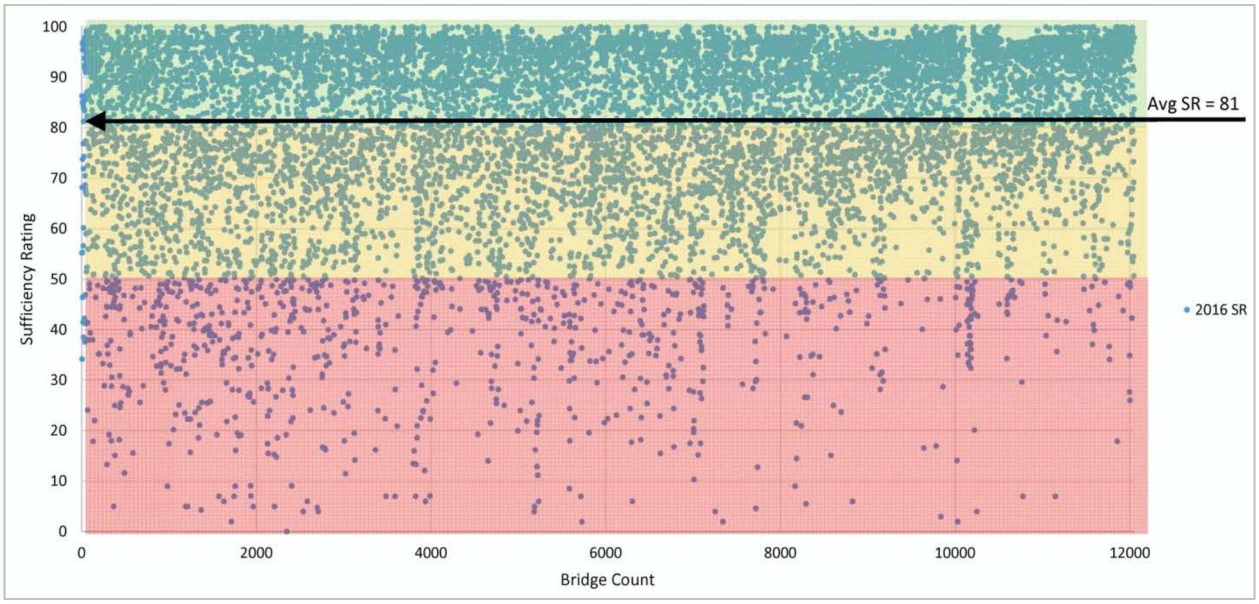


Figure 5.3 Scatter Plot of Sufficiency Ratings for Local Bridges

Of the 12,105 local agency bridges, 6,315 bridges are considered "on-system" and 5,494 are "off-system". "On-system" bridges are listed in the National Highway System or are bridges with the following functional classifications:

- Urban Principal Arterial – Interstate
- Urban Principal Arterial – Other Freeways or Expressways
- Urban Other Principal Arterial
- Urban Minor Arterial
- Urban Collector
- Rural Principal Arterial – Interstate
- Rural Principal Arterial – Other
- Rural Major Arterial
- Rural Major Collector

Off-system bridges are bridges that are not on the National Highway System and have the following functional classifications:

- Urban Local
- Rural Minor Collector
- Rural Local

Recent Caltrans Inspection Methodology Changes

There is one significant change from the 2012 assessment. Caltrans has recently modified its bridge inspection practice to perform element level inspections. The goal of this method is to more accurately assess the overall condition of bridges by evaluating the individual structural elements that comprise larger bridge components.

Bridge ***components*** fall under one of three major categories: deck, superstructure, and substructure and are assessed and recorded in the Structure Inventory and Appraisal record of the NBI. Bridge ***elements*** vary based on bridge type and materials. Several elements usually comprise one component. For example, the *superstructure* component of a steel girder bridge may be composed of steel girder elements, bearing system elements, and joint seal elements. In addition to assessing the condition of global components, element level inspection also provides understanding of how individual elements are faring in the bridge's exposure environment and how best to improve the performance of a structure with targeted maintenance of its individual elements.

Caltrans current practice is to use mathematical formulas and logic charts to compute major component NBI condition ratings based on the bridge element level ratings.

It is important to note that the modification has resulted in changes to the NBI bridge component ratings that are not necessarily the result of physical changes to the condition of assessed bridges. ***In general, the resulting trend of implementing the element level inspection procedures is an increase in Sufficiency Ratings for individual bridges.*** As a result of higher Sufficiency Ratings on specific individual bridges, the total bridge needs increase is small compared to what one might have anticipated based on increased age and use of the bridge inventory since the previous assessment in 2012.

5.2 Survey Results

As noted previously, the online statewide survey was conducted to verify NBI bridges and obtain non-NBI bridge inventory and funding level information from local agencies. Of all the local agencies surveyed, 51 of 58 counties (88%) responded to the survey and 337 of 480 cities (70%) responded to the survey. This is a significant increase from the 2012 survey, when only 49 counties and 128 cities responded.

The results indicate that 2,663 bridges require rehabilitation or replacement!

Of the 12,105 local agency bridges in California, 1,448 bridges (12%) are Structurally Deficient, and 1,930 bridges (16%) are Functionally Obsolete. The results indicate that 829 bridges (7%) require replacement and 1,834 bridges (15%) require rehabilitation.

5.3 Cost Data

Several sources were utilized to develop the costs for determining the bridge needs i.e. local agencies, Caltrans Office of Local Assistance, Caltrans Structures Maintenance and Investigations and Quincy Engineering's project contractor bid history. Information obtained from Caltrans includes the Highway Bridge Program (HBP)'s historical funding application data from the Federal Authorization Database (FMIS), the current HBP funding level of outstanding bridge list, and Caltrans remaining Local Bridge Seismic Retrofit Program funding list (LBSRP).

Bridge rehabilitation costs include design cost, associated roadway costs such as traffic control, and construction management cost. Replacement cost includes construction costs, approach roadway construction, preliminary and final engineering, environmental compliance and right-of-way certification and acquisition, and construction engineering and contract management costs. As such, replacement costs account for the majority of bridge needs.

The time value of money also plays an important role in estimating the bridge needs. The historical costs are important because the value of dollar changes over time, typically depreciating with inflation. For this study, the bridge needs are assessed in 2016 dollars. The Caltrans Construction Cost Index was used to adjust inflation for construction of bridge and approach roadway work. Figure 5.4 shows the Caltrans Construction Cost Index over time. The Consumer Price Index was also considered when adjusting historical costs to account for inflation.

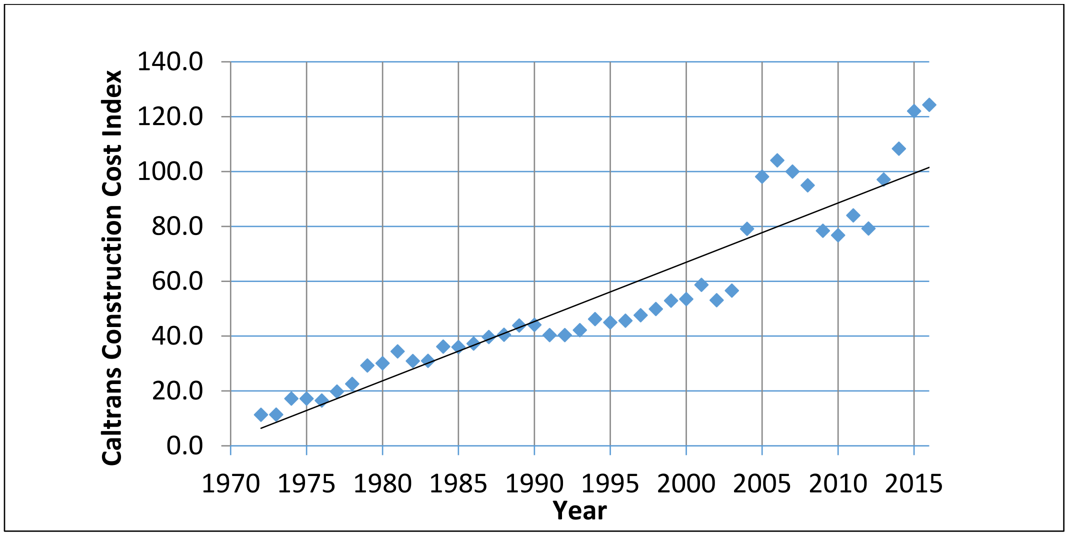


Figure 5.4 Caltrans Construction Cost Index

5.4 Needs Assessment

The bridge needs assessment methodology used in this study was extensively described in the 2012 report and a brief summary is included herein. Briefly, it follows the FHWA guidelines as listed below:

- A bridge is defined as eligible for <u>replacement</u> per FHWA if the Sufficiency Rating is less than 50 *and* the bridge is structurally deficient or functionally obsolete (SR<50 & bridge is SD or FO).
- A bridge is defined as eligible for <u>rehabilitation</u> per FHWA if the Sufficiency Rating is greater than or equal to 50 but less than or equal to 80 *and* the bridge is structurally deficient or functionally obsolete (50≤SR ≤ 80 & bridge is SD or FO).

Figures 5.5 to 5.7 illustrate examples of structurally deficient and functionally obsolete bridges.

Figure 5.5 Structurally Deficient – Poor Superstructure Condition
(Rumsey Bridge, Yolo County)

Figure 5.6 Structurally Deficient – Poor Deck Condition
(Jibboom Bridge, Sacramento County)

Figure 5.7 Functionally Obsolete – Low Approach Roadway Alignment Appraisal Rating
(Ackerman Bridge, Mendocino County)

Two large bridges were excluded from this study; the *Golden Gate-San Francisco Bay Bridge (*Bridge #27 0052) is owned by a local toll authority and is not considered a local bridge. Secondly, the *Los Angeles River Bridge on Sixth Street (*Bridge #53C1880), is owned by the City of Los Angeles, has a Sufficiency Rating of 11.7 and is classified as Structurally Deficient. However, this bridge is already programmed and federally obligated for $230 million dollars for construction and $105 million dollars for right-of-way, and is currently under construction. Therefore, both bridges were not included in this assessment.

5.4.1 Historically Significant Bridges

Historically significant bridges are structures that are on or are eligible to be on the National Register of Historic Places and are a special category. Typically, historic bridges are unique types that are no longer constructed today as they are not as cost-effective as more modern designs. An example is the historic steel truss bridge in Figure 5.8. Historically significant bridges require more effort to rehabilitate or replace. These added efforts include special design considerations, environmental analysis and mitigation measures and public outreach. Due to the additional effort required to work on historically significant bridges, these bridge replacement types were classified into their own category requiring a higher level of engineering design, environmental compliance and higher construction costs.

Figure 5.8 Historically Significant Steel Truss Bridge
(Klamath River Bridge, Siskiyou County)

5.4.2 Bridge Replacement

Figure 5.9 shows the average bridge replacement unit cost (dollars per square foot) of all the bridges that are assessed to require replacement. This cost is based on site characteristics and includes the new bridge and bridge removal costs. It does not include approach roadway and other bridge project costs.

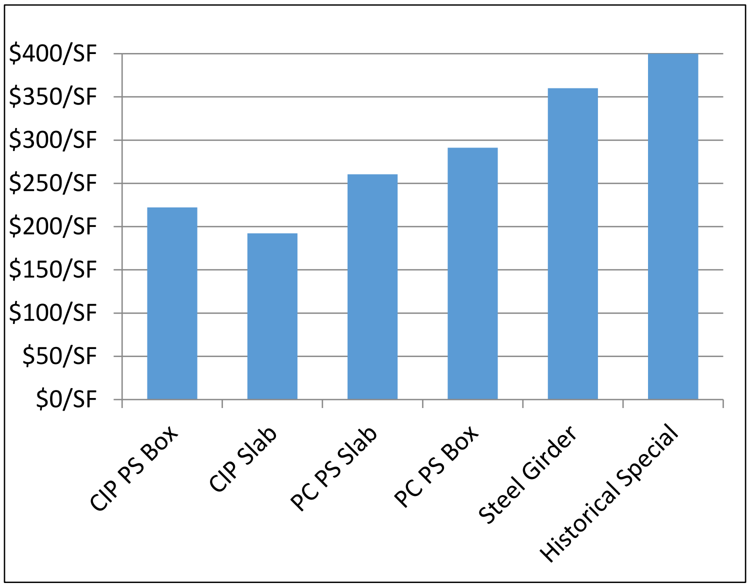


Figure 5.9 Average Bridge Replacement Unit Cost

Figure 5.10 shows the different components of the bridge replacement associated cost. In addition to the cost of replacing the bridge, the other associated costs include costs for roadway approaches, right-of-way, design engineering and environmental, construction mobilization, construction contingency, and construction management. **A total of 829 bridges require replacement at a cost of approximately $3.1 billion.**

Of the 1,891 bridges eligible for rehabilitation, approximately 587 bridges require either deck rehabilitation or deck replacement at a cost of $360 million. Figure 5.11 is an example of a bridge deck that requires replacement.

5.4.3 Bridge Rehabilitation

As mentioned previously, rehabilitation is categorized into the following three categories:

1. Bridge deck rehabilitation and deck replacement (deck improvement);
2. Bridge strengthening; and
3. Bridge widening.

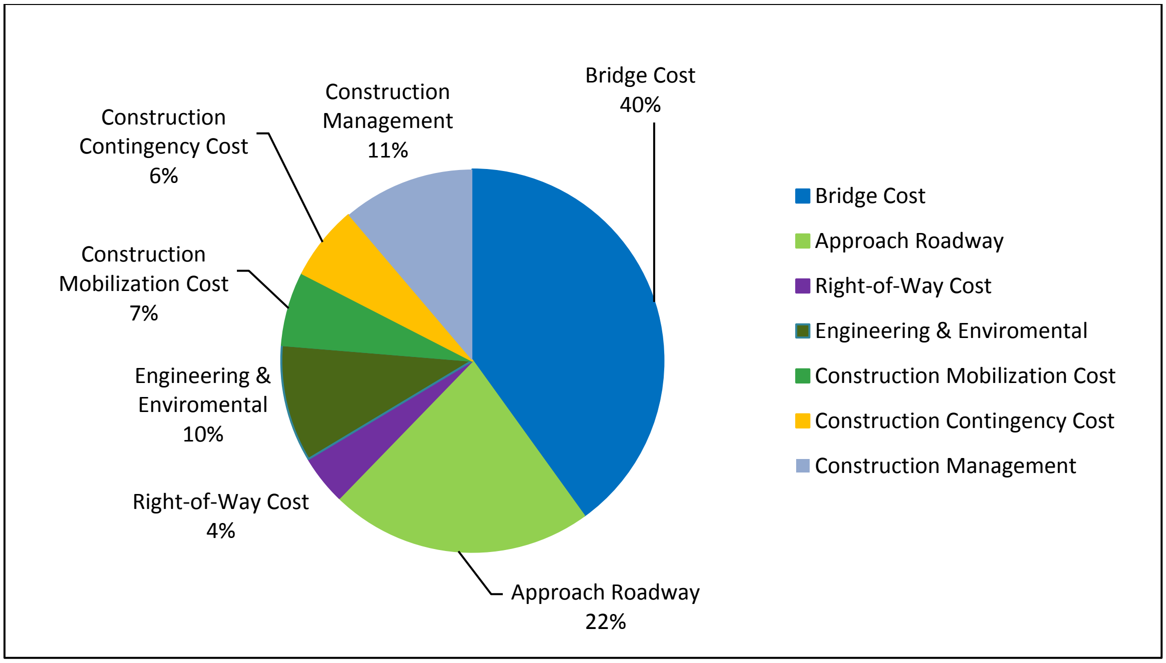


Figure 5.10 Total Bridge Replacement Associated Costs

Figure 5.11 Bridge Deck Requiring Replacement

Bridge deck rehabilitation is the most common bridge rehabilitation, and contributes to the majority of the bridge rehabilitation costs in California. Because it accounts for the majority of bridge rehabilitation cost, a refined assessment of the unit cost of bridge decks was required. A unit cost of $12/sf for deck rehabilitation and $110/sf for deck replacement was used. The unit prices are based on Caltrans and Quincy Engineering's historical design and construction support data. The unit cost is conservatively estimated to include common preservation needs such as rehabilitation of expansion joints and bridge bearings.

5.4.4 Bridge Strengthening

Bridge strengthening project costs vary widely depending on individual projects. For example, to strengthen an older steel bridge built before 1970, lead abatement and environmental mitigation will be required. Depending on the amount of work involved in bridge strengthening, the cost of lead abatement can vary from a local containment to a full bridge containment system which tends to be very costly.

The cost associated with bridge strengthening was obtained from bridge improvement data within the NBI database. To scale the improvement needs to 2016 dollars, a Construction Cost Index was used. This methodology was considered to be more accurate because local bridge inspectors and agencies have more site specific information on a project by project basis. The weighted average cost per area is $150/sf. It was estimated that **approximately 400 bridges required bridge strengthening at a total cost of $600 million.**

5.4.5 Bridge Widening

Similarly to bridge strengthening, bridge widening costs are highly dependent on specific project needs. Note that widening projects are to bring bridges up to current width standards, and are not for adding capacity i.e. adding lanes. Figure 5.12 illustrates the bridge widening cost distribution over all the local agency bridges. Most bridges that require widening are located in Los Angeles County due to the high Average Daily Traffic (ADT) count in comparison to the traveling capacity of the existing bridge. LA county bridges also have a higher project cost due to site specific variables such as higher right-of-way acquisition costs and construction limitations due to congested conditions. From the NBI data, **there are approximately 140 bridges that require widening at a cost of $370 million.**

5.4.6 Bridge Seismic Retrofit

Seismic retrofit needs are also project specific with costs varying greatly between individual projects. The Caltrans Local Bridge Seismic Retrofit Program (LBSRP) list provides remaining projects that are eligible for LBSRA Funds. Since the 2012 study, several bridges with seismic retrofit needs have been addressed. As a result, **the total seismic needs have decreased to $83 million.**

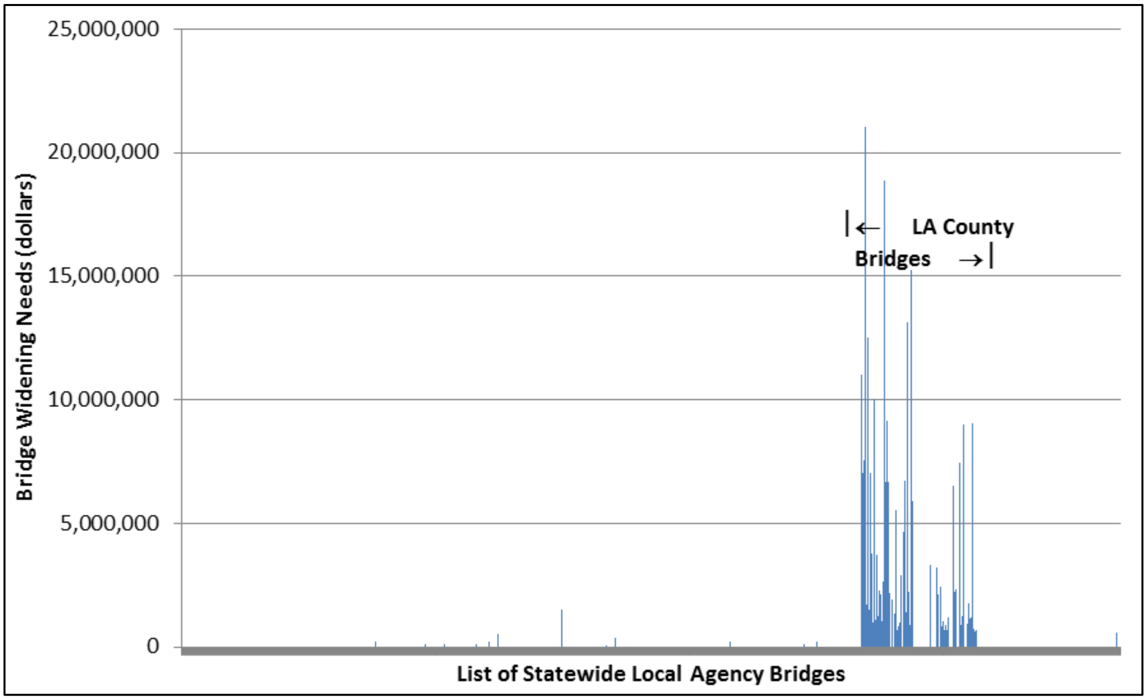


Figure 5.12 Distribution of Bridge Widening Projects

5.4.7 Non-NBI Bridges

Non-NBI Bridges are non-vehicular bridges or vehicular bridges less than 20 feet long. While a bridge may be considered non-NBI due to its limited length or because of its pedestrian and/or bicycle designation, these bridges are still of significant importance to our communities. For instance, there are many local short vehicular bridges that provide the only access for fire trucks in case of emergencies. The need for non-NBI bridges should not be neglected.

Unlike NBI bridges, non-NBI bridges do not have a state or national database that document these bridges. Therefore, the survey information was the only source available. Because not all agencies responded to the survey, a method of approximation had to be developed to estimate the non-NBI bridge counts. Briefly, the methodology to estimate the missing or unknown county bridge data was to consider geography, adjacent county data, and population. For instance, based on the 2010 United States Census, Sutter County, Yuba County, and Nevada County have similar population size. Based on geography, the three counties have similar rivers characteristics. Since bridge survey data is available for Sutter and Nevada County, Yuba County’s missing data can be estimated similar to that of Sutter and Nevada County’s.

The method to estimate city non-NBI bridges was based on available data from adjacent cities. However, not all cities within a county are similar; some cities have larger population than smaller cities. This method assumes that cities within a county had a similar bridge to population ratio. Within a given county, the geographical characteristics of its land and rivers are assumed to be similar. Therefore, the number of bridges per population should be similar.

Based on the assumptions above, the total number of non-NBI bridges was estimated to be approximately 4,000, which is more than the 3,500 estimated in 2012. **The non-NBI bridge needs are estimated to range from $80 to $100 million.**

5.4.8 Summary of Local Bridge Needs

The total statewide local agency bridge needs is estimated to be $4.6 billion over the next ten years. The breakdowns are as follows:

- Bridge replacement needs are approximately $3.1 billion.
- Bridge deck rehabilitation and deck replacement costs are approximately $360 million.
- Bridge structural strengthening requires approximately $600 million.
- Bridge widening requires approximately $370 million.
- Bridge seismic retrofit needs are approximately $83 million.
- Non-NBI bridge needs are estimated at $80 to $100 million.

The total statewide local bridge needs are estimated at $4.6 billion over the next ten years.

Appendix F contains a summary of the bridge needs by County as well as a map.

5.5 Funding Sources

Several funding data sources were obtained for this study; the historical funding data from the Federal Authorization Database (FMIS), the current HBP funding level of outstanding bridge list, and Caltrans remaining Local Bridge Seismic Retrofit Program funding list (LBSRP). The local agency funding data was obtained from the survey.

A significant factor is that effective October 2016, Caltrans will no longer use the Functionally Obsolete category. As a result, bridges that are Functionally Obsolete due to bridge deck geometries are no longer eligible for federal funding through the Highway Bridge Program as administered by Caltrans unless they are also structurally deficient.

However, bridges that are Functionally Obsolete still have a need for replacement or rehabilitation. Removing the FO designation does not change their physical characteristics nor eliminate their needs. For this study, the methodology of assessing bridge needs is consistent with the guidelines set by FHWA, and is consistent with the methodology used in the 2012 bridge needs assessment and was described in detail in the 2012 report.

The 2015 NBI data indicates that there are 1,639 bridges that have a sufficiency rating less than 80 and are designated as Functionally Obsolete. While HBP is not the sole source of bridge funding, most counties and cities do not have other reliable funding sources available. Removing the FO criteria has a significant effect on the bridge shortfall as shown in Table 5.1.

Table 5.1 Total Bridge Needs, Funding and Shortfall (10 years)

Bridge Repair Type	Total Bridge Needs ($M)	Estimated Funding* ($M)	Shortfall ($M)
Replacement	$ 3,100	$ 2,900	$ 1,713
Deck Improvement	$ 360		
Widening	$ 370		
Strengthening	$ 600		
Seismic Retrofit	$ 83		
Non-NBI Bridges	$ 100		
Totals	**$ 4,613**	**$ 2,900**	**$ 1,713**

* FO bridges not considered eligible for funding.

5.6 Funding Analysis

The funding analysis by Spypond considered maintenance, repair, rehabilitation actions required to preserve existing structures. Also, it included needs to perform seismic retrofits, strengthen bridges, raise bridges to increase vertical clearance, and widen bridges (without adding lanes) to address clearance or safety issues. Bridge replacement was considered in the analysis when it was projected to be more cost effective than preservation or functional improvement, or when other actions were deemed to be infeasible. The analysis did not consider costs associated with adding lanes to existing structures to relieve congestion.

To develop the projections, the FHWA's National Bridge Investment Analysis System (NBIAS)[15] was used. FHWA uses NBIAS to develop its biannual Conditions and Performance Report[16]. NBIAS has a modeling approach similar to that of the AASHTO Pontis Bridge Management System (BMS) which is used by Caltrans for managing its bridges. However, NBIAS requires only publically-available NBI data to run, in contrast to Pontis, which requires detailed element data that are not part of the NBI. ***(Note that the***

[15] Cambridge Systematics, Inc. *NBIAS 3.3 Technical Manual.* Technical Report prepared for FHWA. 2007.

[16] FHWA and FTA. *2010 Status of the Nation's Highways, Bridges, and Transit: Conditions & Performance*. Report to the United States Congress. 2012.

4,000 non-NBI bridges were not included in this analysis. However, their needs are only approximately 2 percent of the total, so were not considered to be significant.)

Though NBIAS is populated with default costs, deterioration models, and other parameters, it is important to calibrate the system results so that they provide as realistic a projection as possible. The costs in NBIAS were calibrated using data provided by Quincy Engineers (as described in earlier sections). Consequently, the calculation of initial needs corresponds to that developed independently by Quincy Engineers. Further, seismic retrofit needs, which are not modeled by NBIAS, were calculated by Quincy Engineers. The deterioration models used in the system were originally developed by Caltrans, and are included in NBIAS, along with models from other states. A set of calibration runs was previously performed during the 2012 assessment to confirm the deterioration models.

The results obtained from NBIAS provide a projection of bridge investment needs over time for different budget assumptions. Investment needs are funds that should be invested to minimize bridge costs over time and address economically-justified functional improvements. To the extent that projected funds are insufficient for addressing all needs, the system simulates what investments will occur with an objective of maximizing benefits given an available budget. The system also predicts what new needs may arise considering deterioration and traffic growth, and projects a range of different physical measures of bridge condition, as described further in the next section.

5.6.1 Projected Statewide Bridge Conditions and Needs

Table 5.2 presents the summary results for 10 years in the statewide analysis. The table shows results for annual budgets from $0 to $600 million. For each budget level shown the table shows results by year for 10 years for the following measures. The key measure predicted by the system is the investment needs – the funds that should be invested to minimize bridge costs over time and address economically-justified functional improvements. This is the measure that FHWA reports. Closely related to this measure is the backlog, or difference between the need and the amount of money spent on the bridge population.

- **Needs:** investment need as of the beginning of the year, shown in billions of dollars. The projections include costs for replacement, functional improvement, rehabilitation, minor preservation activities, and seismic retrofits.

- **Cumulative Work Done:** total spending over time, shown in billions of dollars. Typically this measure increases by the budgeted amount each year, but in some cases may increase by less than the budgeted amount if no needs remain to be met, or if during the program simulation the available budget was less than the cost of the next recommended action.

- **Average Health Index:** average calculated from predicted element conditions, where a value of 75 or less for an individual bridge generally indicates the bridge is in fair or poor condition (in need of rehabilitation) and a value of 90 or greater for an individual bridges indicates the bridge is in good condition.

- **Average Sufficiency Rating:** average rating calculated based on FHWA definitions unlike the Health Index Sufficiency Rating which includes adjustments for functional characteristics of a bridge.

- **Percent Structurally Deficient:** percent of bridges classified as Structurally Deficient based on FHWA definitions, weighted by deck area.

Note that the current level of spending is approximately $290 million/year. Figure 5.13 shows total cumulative unfunded backlog of needs over time and Figures 5.14, 5.15 and 5.16 show the average Health Index, average Sufficiency Rating, and percent Structurally Deficient, respectively. In the case of the Health Index, the results show a decline over time even when the needs are addressed. To some extent, this is due to the aging bridge population.

Table 5.2 Summary Bridge Funding Analysis (2016 to 2025)

	Value by Year										
Description	**Base**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**
Annual Budget: $0M											
Needs ($B)		4.5	5.0	5.7	6.2	6.9	7.3	8.0	9.4	10.9	12.4
Work Done ($B)		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Avg. Health Index	92.14	91.23	90.32	89.40	88.48	87.56	86.63	85.71	84.78	83.84	82.91
Avg. Sufficiency Rating	81.59	80.84	80.08	79.13	78.27	77.51	75.90	73.94	71.63	69.53	67.36
% Structurally Deficient	19.23	22.15	24.89	28.53	31.85	35.12	41.16	47.41	55.72	62.18	66.52
Annual Budget: $100M											
Needs ($B)		4.5	4.8	5.4	5.8	6.2	6.6	7.0	8.1	9.3	10.6
Work Done ($B)		0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
Avg. Health Index	92.14	91.28	90.43	89.58	88.75	87.95	87.13	86.35	85.64	84.98	84.28
Avg. Sufficiency Rating	81.59	80.94	80.28	79.47	78.75	78.12	76.78	75.14	73.18	71.53	69.74
% Structurally Deficient	19.23	22.09	24.20	27.56	30.04	32.26	36.81	41.05	46.90	50.65	54.10
Annual Budget: $200M											
Needs ($B)		4.5	4.7	5.2	5.5	5.8	6.0	6.3	7.1	7.5	8.3
Work Done ($B)		0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0
Avg. Health Index	92.14	91.30	90.50	89.71	88.98	88.33	87.66	87.08	86.70	86.53	86.63
Avg. Sufficiency Rating	81.59	81.02	80.45	79.73	79.14	78.72	77.69	76.39	75.00	74.10	73.65
% Structurally Deficient	19.23	22.06	23.90	26.87	28.81	29.94	33.71	36.40	38.56	40.91	41.11
Annual Budget: $300M											
Needs ($B)		4.5	4.6	5.0	5.1	5.3	5.3	5.4	5.5	5.7	5.9
Work Done ($B)		0.3	0.6	0.9	1.2	1.5	1.8	2.1	2.4	2.7	3.0
Avg. Health Index	92.14	91.34	90.59	89.95	89.30	88.87	88.85	89.00	89.47	89.50	89.34
Avg. Sufficiency Rating	81.59	81.09	80.62	80.06	79.62	79.42	79.02	78.65	78.31	77.62	76.75
% Structurally Deficient	19.23	21.94	23.44	25.77	27.13	28.00	30.82	31.64	30.53	31.91	33.04
Annual Budget: $400M											
Needs ($B)		4.5	4.5	4.7	4.7	4.7	4.6	4.5	4.4	4.5	4.6
Work Done ($B)		0.4	0.8	1.2	1.6	2.0	2.4	2.8	3.2	3.6	4.0
Avg. Health Index	92.14	91.38	90.72	90.14	89.95	90.09	90.59	90.58	90.41	90.21	90.00
Avg. Sufficiency Rating	81.59	81.17	80.81	80.45	80.30	80.34	80.31	80.02	79.31	78.57	77.92
% Structurally Deficient	19.23	21.74	22.81	25.06	26.00	26.04	27.15	27.41	28.19	29.30	30.20
Annual Budget: $500M											
Needs ($B)		4.5	4.4	4.5	4.3	4.2	3.9	3.7	3.6	3.6	3.6
Work Done ($B)		0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0
Avg. Health Index	92.14	91.42	90.84	90.55	90.71	91.19	91.20	91.07	90.89	90.72	90.54
Avg. Sufficiency Rating	81.59	81.24	81.03	80.87	80.92	81.11	81.00	80.80	80.21	79.65	79.13
% Structurally Deficient	19.23	21.67	22.22	24.31	24.48	24.26	26.03	26.04	26.41	26.59	27.33
Annual Budget: $600M											
Needs ($B)		4.5	4.3	4.3	3.9	3.7	3.3	3.1	2.8	2.7	2.6
Work Done ($B)		0.6	1.2	1.8	2.4	3.0	3.6	4.2	4.8	5.4	6.0
Avg. Health Index	92.14	91.46	90.98	90.94	91.54	91.65	91.54	91.41	91.22	91.06	90.93
Avg. Sufficiency Rating	81.59	81.32	81.22	81.31	81.49	81.64	81.55	81.50	80.99	80.50	80.02
% Structurally Deficient	19.23	21.48	21.85	23.49	23.24	23.47	25.00	24.82	24.98	24.92	25.41

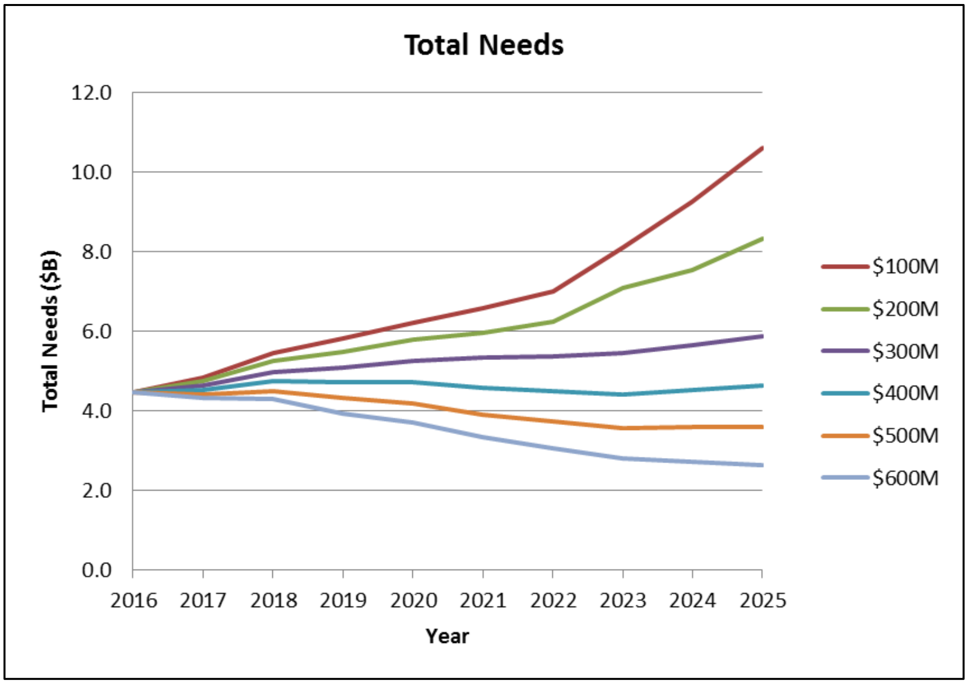


Figure 5.13 Projected Cumulative Unfunded Backlog of Local Bridge Needs (2016-2025)

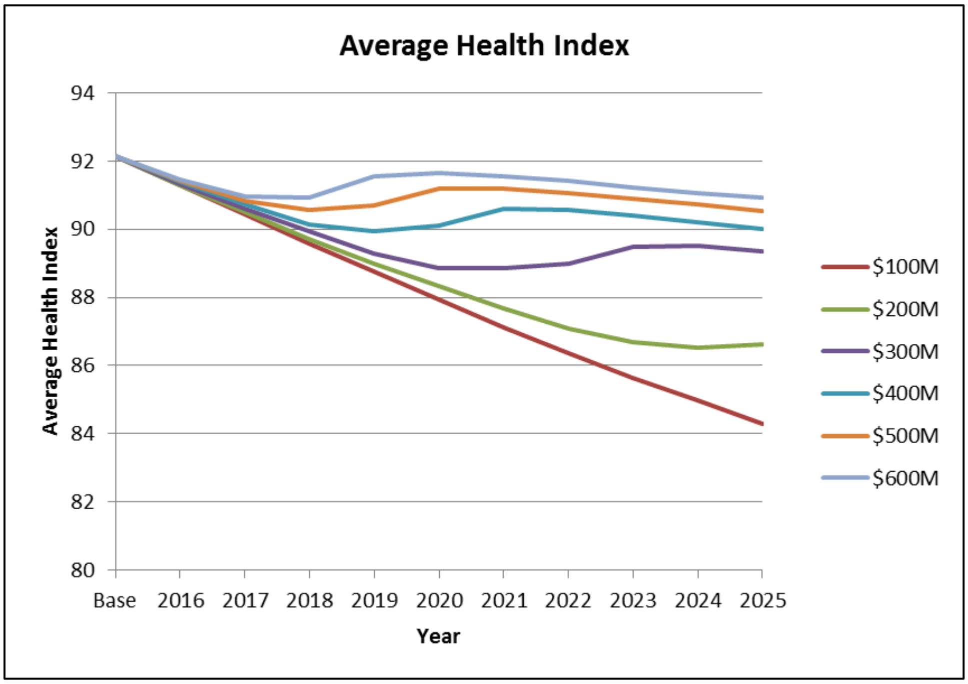


Figure 5.14 Projected Health Index (2016-2025)

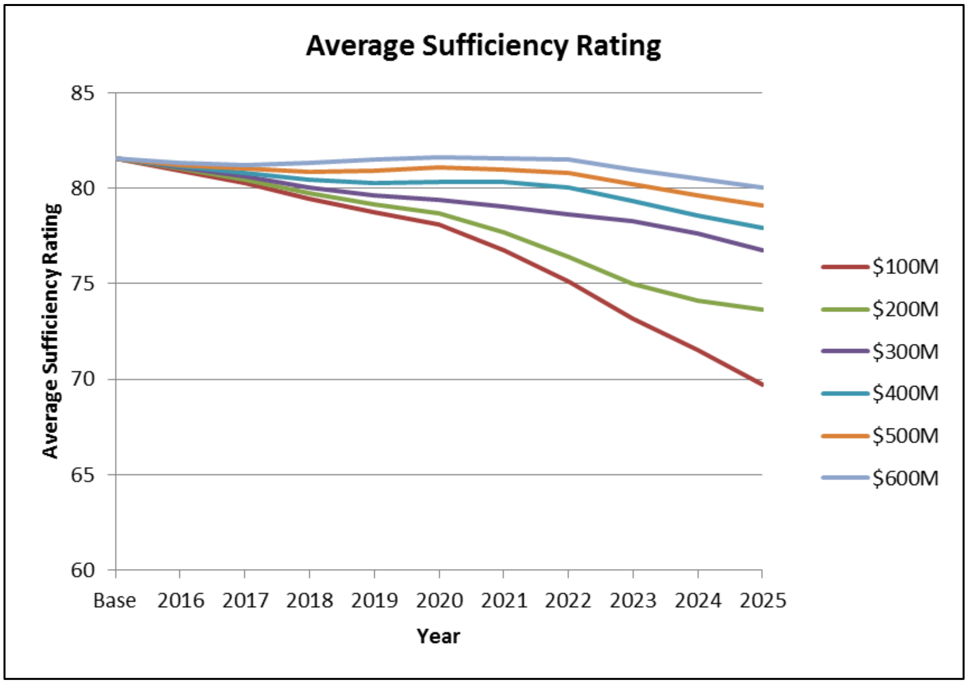


Figure 5.15 Projected Sufficiency Rating (2016-2025)

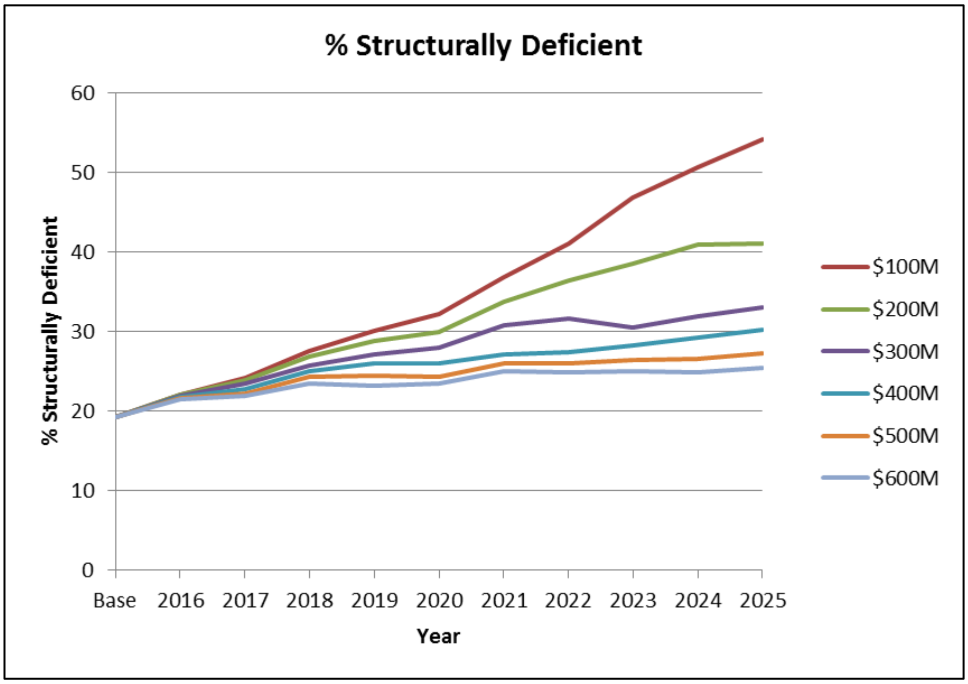


Figure 5.16 Projected Percent Structurally Deficient (2016-2025)

5.7 Summary

The total estimated needs for the local bridges is estimated to be $4.6 billion over the next ten years, which includes rehabilitation, replacement and seismic retrofit costs. Appendix F summarizes the bridge needs by county.

$4.2 billion is needed to maintain bridge investment needs at current levels.

The analysis shows that an annual budget of $420 million would be required to maintain the level of investment need over a 10-year period for California's local bridges. The average investment level required to maintain conditions is greater over longer periods, though results depend upon the measure and scope of bridges included in the analysis. Current funding levels are approximately $290 million annually.

While the analysis shows the funds required to achieve a given target condition, it does not recommend a specific level of funding. Given that the investment needs in NBIAS are based on consideration of what work is economically justified, ideally a bridge owner would address all needs rather for their bridge inventory, rather than simply maintaining conditions. However, doing this in the short term would require a substantial increase in budget, and is not practical in this case. Another approach to setting a target level of investment is to base the investment level on a specific target condition. There are several issues with this approach in the case of California's local bridges. First, it isdifficult to summarize conditions using an average Health Index or Sufficiency Rating, as an average may mask the extent of bridges in very poor condition requiring immediate attention. An average is a good measure for illustrating trends, but less useful for characterizing the distribution of conditions.

The percent of bridges classified as Structurally Deficient is a better measure than an average condition index for illustrating bridges in poor condition. However, some caution is needed in interpreting this measure. The calculation of Structurally Deficient classification is based upon the condition ratings defined in the NBI. In California, unlike other states, these ratings are not explicitly captured. Instead, they are calculated based on element-level data using an algorithm developed by FHWA. The impact of this approach is that counts of Structurally Deficient bridges for California bridges tend to be high compared to other states, but this is based more upon the inspection approach than actual differences in condition[17]. For future NBI submittals, Caltrans is shifting to use explicit inspection results rather than calculated values for condition ratings.

For lack of a better alternative, we recommend using the level of investment needed as the best measure for use in establishing target investment levels for California's local bridges. Absent budget

[17] Spy Pond Partners, LLC and Arora and Associates, Inc. NCHRP 20-24(37)E: *Measuring Performance Among State DOTs, Sharing Best Practices - Comparative Analysis of Bridge Condition.* Technical report prepared for NCHRP Project 20-24-37(E). 2010.

constraints, an organization seeking to maximize economic efficiency would address all investment needs. Considering budget constraints, a reasonable goal is to at least keep needs from increasing by addressing new investment needs as they arise, if not to lower the backlog of needs over time. Even with the goal of gradually lowering needs, however, one faces a situation in which needed work is being deferred, potentially increasing the work that must be performed on a given bridge.

6 Potential Solutions for Funding Gap

From the previous chapters, it is clear that there exists a significant funding gap between the existing funding available and what is needed to maintain the pavement conditions (an additional $1.52 billion a year) or to improve the local streets and roads system to a state of good repair (an additional $5.02 billion a year). This chapter explores various options, or combination of options, that may be employed to fill in the gap. They include:

- Technological cost savings or efficiencies
- Increasing revenues by:
  - Indexing the gas tax to inflation
  - Increasing the gas tax
  - Additional fees/taxes, many of which have been discussed in various local, state and national forums, such as the vehicle license fee, sales taxes, and road user charges.

Each is briefly discussed in the paragraphs below.

6.1 Technological Efficiencies

Full Depth Reclamation in Berkeley, CA

As with many economic trends in the United States, productivity gains from new technologies are also applicable in the transportation sector. In the case of pavements, the most obvious is the reuse or recycling of existing materials in pavement rehabilitation. Section 2.3 discussed various sustainable pavement practices; more than 150 agencies indicated that they have employed one or more recycling techniques such as the use of RAP (reclaimed asphalt pavement), cold-in-place recycling and full depth reclamation. These techniques are reported to have cost savings ranging from 24 to 33 percent when compared to conventional mill and fill overlays, or reconstruction.

Although not all streets and roads are good candidates for recycling (reasons include shallow utilities, inadequate pavement sections, geometric factors, etc.), a conservative estimate (it was assumed that only 50 percent of all eligible streets can utilize recycling technologies) indicates that ***agencies can save as much as $823 million a year. This essentially stretches the existing paving budget of $1.98 billion to $2.8 billion, an increase of 41 percent.***

Recycling technologies can save as much as $823 million a year.

6.2 Increasing Revenues

Much of the discussion in transportation policy forums, not just in California but also nationally, has been on the failing infrastructure and declining transportation revenues. For instance, the federal Highway Trust Fund was projected to be insolvent by August 2014[18] and this was only averted when the President signed a bill that transferred $10.8 billion from the General Fund. The last surface transportation authorization law, (Fixing America's Surface Transportation Act or FAST Act), which was signed in December 2015, also set spending levels significantly above revenues, resulting in a structural funding gap.

Section 4.1 indicated that the state gas tax is the single largest funding source for cities and counties, and it is well worth recapitulating the history of this revenue source. The state gas tax is currently at 27.8 cents a gallon, of which 18 cents is static and 9.8 cents is adjusted annually (see side bar on next page.) The static gas tax was first approved by voters in 1923, and the last time it was increased to its current level was in 1994, more than 20 years ago. The price of regular unleaded gasoline then was approximately $1.20 per gallon, compared to the average $2.74 per gallon in September 2016. In effect, gas prices have more than doubled, but the static gas tax has stayed the same at 18 cents. Of course, during this 20 year period, gas prices have fluctuated considerably, reaching as high as $5.59 a gallon in Bishop, CA in October 2012.

Price of Gas in Bishop, CA (October 2012)

Between 1994 and 2016, the buying power of the gas tax has also dropped significantly from inflation. In addition, declining gas consumption due to vehicles with higher efficiency standards contributes to declining gas consumption and thereby revenues. Figure 6.1 illustrates what the static 18-cent gas tax is worth today; it is essentially half the value it was in 1994.

[18] *http://www.dot.gov/highway-trust-fund-ticker*

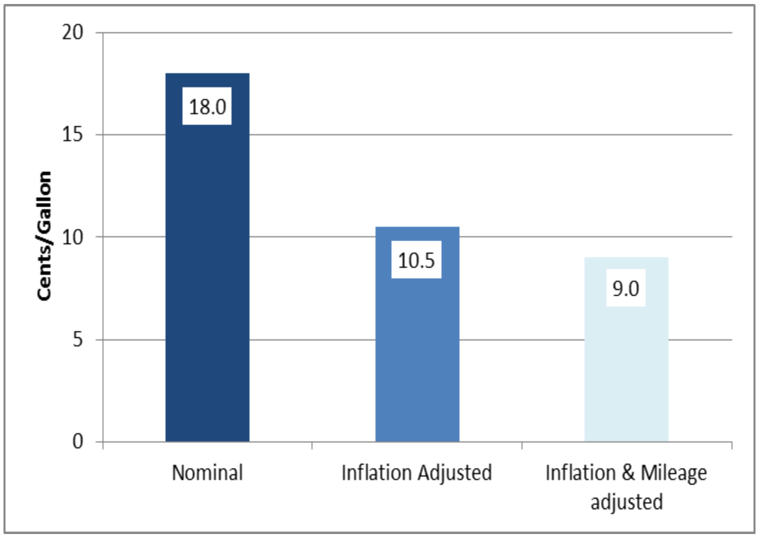


Figure 6.1 Value of 18-cent Gas Tax in 2014
(Source: Caltrans, Division of Budgets)

6.2.1 Raising the Gas Tax

For the gas tax to continue to be a relevant source for transportation means that it has to be increased. If the gas tax is not increased, the projected value is expected to decline rapidly due to the improved fuel economy standards. The Caltrans Division of Budgets, in a presentation to the California Transportation Commission (CTC) in January 2014, projected a loss of as much as $16.1 billion by 2030 due to new fuel economy standards, while the annual vehicle miles travelled (VMT) will continue to grow.

California's Gas Tax

Prior to 2010, California levied a constant rate 18-cent excise tax AND a sales tax on every gallon of gasoline.

The constant rate 18-cent excise tax stayed the same regardless of the price of gas at the pump. The sales tax increased or decreased based on the price of fuel.

However, in 2010, the sales tax was replaced with an additional increment of the excise tax. Intended to be revenue neutral, this "price based" excise tax is adjusted annually to generate what a sales tax would have otherwise generated and naturally keeps pace with inflation.

Figure 6.1 depicts the inflation adjusted value of the constant rate excise tax that was last increased in 1994.

Note that the federal excise tax is 18.4 -cents per gallon, which is separate from the state's tax.

Currently, the 18-cent state gas tax raises approximate $2.4 billion a year[19], which is allocated by formula to Caltrans, cities and counties. Raising the gas tax to 1994 levels could immediately increase the funding by an additional $1.7 billion a year (considering inflation only). This would be, of course, be distributed to Caltrans as well as cities and counties, if the allocation formula remained the same.

Finally, some regions in the state have the authority to go to the voters and increase the gas tax by as much as ten cents per gallon. If this increase were to occur, it would raise approximately $1.3 billion a year.

[19] *http://www.lao.ca.gov/handouts/transportation/2014/Overview-of-Transportation-Funding-3-13-14.pdf*

6.2.2 Indexing the Gas Tax

Indexing the gas tax in other states has proven to be a feasible and workable solution; the Governor of Nevada signed into law Assembly Bill 516 in October 2013, which resulted in Washoe County (Reno) fuel taxes indexed to the Consumer Price Index (CPI). The Regional Transportation Commission (RTC) – Washoe County staff report that with these revenues, they have been able to conduct an aggressive maintenance work plan, to the extent that currently, less than one percent of the eligible local street network needs rehabilitation in 2014. However, the CPI is lower than the rising cost of paving construction, so the buying power of this revenue stream is expected to continue to erode. [20]

Indexing the gas tax to the CPI (assuming two percent a year)[21] will raise approximately $54 million a year. This is a modest increase, and will not have a significant impact on the current shortfall, but does at least partly mitigate future increases in construction costs, which have grown at a rate greater than two percent a year.

6.2.3 Returning Vehicle Weight Fees

Various legislative proposals in recent years have sought to return vehicle weight fees to the State Highway Account, rather than diverting the revenues to the Transportation Debt Service Fund, thereby providing an additional $1 billion annually to local streets and roads, the state highway system, and other State Transportation Improvement Program Projects, including transit. None of these measures has been successful to date, as they would require the General Fund to resume making debt service payments on state transportation-related general obligation bonds.

6.2.4 Vehicle License Fees

Another option that has been discussed is an increase in the vehicle license fee. According to the Legislative Analyst's Office, each additional one-percent increase in the vehicle license fee rate would raise between $3.5 billion and $4 billion per year.

6.2.5 California Road Charge Program

Yet another option being discussed is a road user charge. SB 1077 (DeSaulnier) was passed by the California State Legislature and signed by the Governor in 2014. The bill created a pilot project (commenced in January 2016) that aims to identify and evaluate issues related to the potential implementation of a statewide vehicle-miles-traveled fee.

This is the first road charge pilot program in California, modeled after similar programs in Oregon and Washington. The intent is to charge a fee for all users of local roads and state highways, regardless of whether the vehicle is powered by gasoline, diesel, alternative fuels, or electricity. The pilot program will

[20] 2035 Regional Transportation Plan, Regional Transportation Commission of Washoe County, November 2008.
[21] *http://www.bls.gov/news.release/pdf/cpi.pdf*

assess the road user charge as a replacement to the gas tax, and the results are expected to be reported to the State Legislature by June 2018.

6.2.6 Legislative Transportation Session

The Governor convened a special session on Transportation in mid-2015, and although several proposals have been discussed, none have yet been passed. The most current proposal is a combined transportation funding and reform proposal from Assembly Member Frazier and Senator Beall[22]. In brief, this would:

- Raise $7.4 billion annually to repair and maintain state and local roads, improve trade corridors and support public transit and active transportation;
- Index transportation taxes and fees to the California Consumer Price Index to keep pace with inflation;
- Streamline transportation project delivery;
- Protect transportation revenue from being diverted for non-transportation purposes; and
- Help local governments raise revenues to meet the needs of their communities.

Local agencies would receive $2.5 billion annually for maintenance and rehabilitation of local streets and roads. Up to $80 million annually would also be available for bicycle and pedestrian projects. The new funding sources would include the gasoline excise tax ($2.5 billion = 17.5 cent per gallon increase).

6.2.7 Sales Taxes

Currently, there are 20 so-called "Self-Help Counties" that have passed sales tax measures specifically for transportation. These counties include over 83% of California's population, and the measures are estimated to fund over $95 billion of voter-approved transportation investments by 2050[23]. They include $23.9 billion for local streets and roads, and $1.3 billion for bicyclists and pedestrians.

There are an additional 16 "Aspiring Counties" who are either exploring similar sales tax measures, or who have recently failed to pass them, some very narrowly. It is estimated that if a sales tax measure were to pass in all of them, an estimated $399.6 million a year would be generated for transportation needs. Table 6.1 summarizes who the "Aspiring Counties" are and their revenue estimates.

Table 6.2 summarizes the potential solutions from all the options discussed above. Note too that some are statewide revenues, so only a portion will be allocated to local streets and roads under the existing distribution formulae.

[22] CSAC Analysis, August 24, 2016
[23] http://selfhelpcounties.org/Brochure_Self-HelpCounties_011813.pdf

Table 6.1 Aspiring Counties and Potential Revenue Estimates

Aspiring County	Revenue Estimates ($M/year)
Butte	$ 13.7
El Dorado	$ 8.9
Humboldt*	$ 10.0
Kern	$ 72.6
Kings	$ 7.0
Lake	$ 2.7
Merced*	$ 15.0
Monterey*	$ 20.0
Placer*	$ 53.3
San Benito	$ 8.0
San Luis Obispo*	$ 25.0
Santa Cruz*	$ 16.7
Shasta	$ 13.2
Solano	$ 33.7
Stanislaus*	$ 30.0
Ventura*	$ 70.0
Totals	**$ 399.6**

* Tax measures on November 2016 ballot

Table 6.2 Estimate of Potential Revenues from Different Options

Potential Solutions	Potential Revenues ($M/year)	Potential Local Streets & Roads Share
Technological Efficiencies	$ 823	$ 823
Adjust base gas tax for inflation & fuel economy changes (14 cpg increase)	$ 2,100	$ 1,050
Restore price-based excise tax to 17.3 cpg (7.5 cpg increase)	$ 1,125	$ 495
Index Gas Tax to CPI (2% annually)	$ 54	$ 27
Vehicle Registration Fee ($60)	$ 2,040	$ 1,020
Vehicle License Fee(increase by 1% of value)	$ 3,500	$ 1,750
Return Weight Based Fees to Projects	$ 1,000	$ 440
Mile-Based Fee (Replace or Supplement Gas Tax)	Unknown	Unknown
Aspiring Counties Sales Tax Measures	$ 399.6	$ 150

7 Summary and Conclusions

The results of this study continue to be sobering. It is clear that California's local streets and roads network are not just at risk; they continue to be on the edge of a cliff with an average PCI of 65. With this pavement condition and the existing funding climate, there is a clear downward trend projected for the next ten years.

By 2026, with the current funding of $1.98 billion/year, the pavement condition index will continue to deteriorate to 56. Even more critically, the backlog will increase from $38.8 billion to $59 billion. This is assuming that construction costs do not outstrip the anticipated revenues. Further, it is estimated that almost a quarter of California's local streets and roads will be in "failed" condition.

Table 7.1 summarizes the results from Chapters 3, 4 and 5. The total funding needs over the next 10 years is $106.7 billion, and the resulting shortfall is $50.2 billion for pavements, $21.1 billion for essential components and $1.7 billion for bridges. The total shortfall is $73 billion over the next 10 years.

Table 7.1 Summary of 10-Year Needs and Shortfall Calculations (2016 $ Billion)

Transportation Asset	Needs ($B)				2016		
	2008	2010	2012	2014	Needs	Funding	Shortfall
Pavement	$ 67.6	$ 70.5	$ 72.4	$ 72.7	$ 70.0	$ 19.8	$ (50.2)
Essential Components	$ 32.1	$ 29.0	$ 30.5	$ 31.0	$ 32.1	$ 11.0	$ (21.1)
Bridges	-	$ 3.3	$ 4.3	$ 4.3	$ 4.6	$ 2.9	$ (1.7)
Totals	$ 99.7	$102.8	$107.2	$108.0	$ 106.7	$ 33.7	$ (73.0)

The conclusions drawn from this study are inescapable. Given existing funding levels, California's local streets and roads can be expected to deteriorate rapidly within the next 10 years. In addition, the costs of any deferred maintenance will only continue to grow. The additional funding scenarios analyzed only serve to emphasize this point.

To bring the transportation network to a level where best management practices can occur will require more than four times the existing level of funding. For pavements, that will require an increase of at least $50.2 billion. However, once this has been achieved, it will only require $2.5 billion/year after that to maintain the pavement network.

For essential components, it will require an additional $21.1 billion to address the ten year needs, and for bridges, it will require an additional $1.7 billion for a total of $73 billion.

To just maintain the existing pavement condition at 66 will require $3.5 billion/year.

To put the shortfall in perspective, $73 billion over 10 years translates to an additional 49 cents per gallon per year at the pump (based on an estimated 14.9 billion gallons of fuel purchased in California in 2015)[24]. For the average driver (10,000 miles a year driving a 20 mpg vehicle), this translates to an average of 67 cents a day.

Another perspective is to compare what motorists pay at the pump with basic day to day amenities. Or, to be more succinct (see Figure 7.1), the annual costs of cable television, cell phone, coffee or internet access far outstrip the current prices paid for gas by the typical consumer.

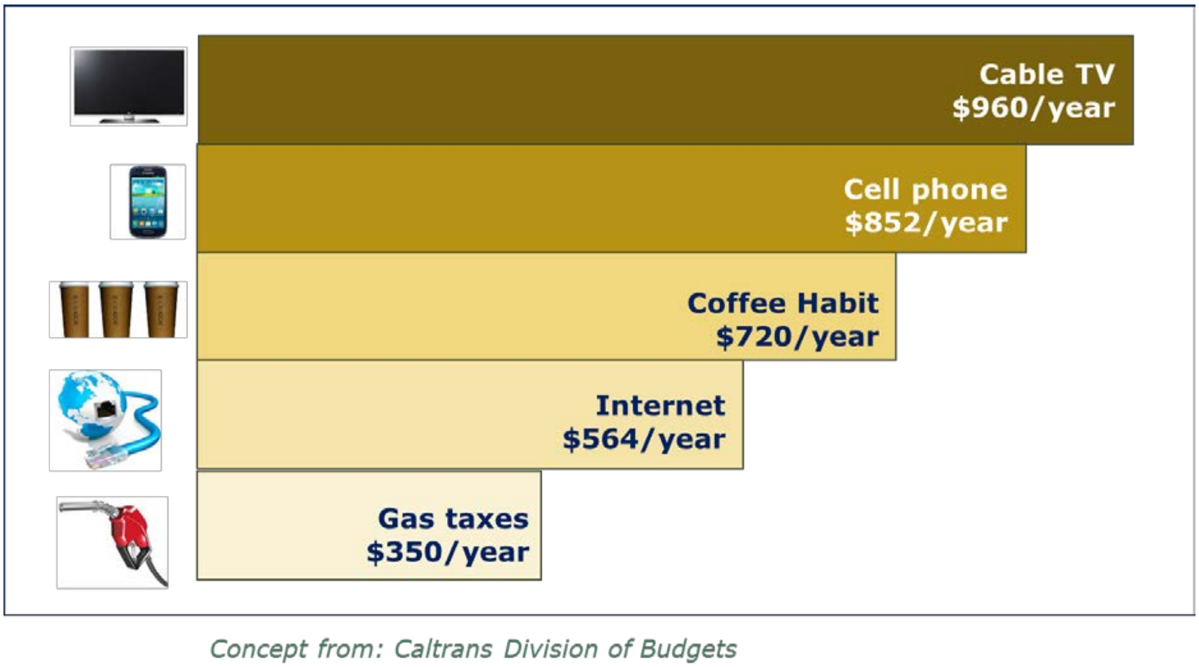


Figure 7.1 Average Annual Cost of Select Items

[24] http://www.boe.ca.gov/sptaxprog/spftrpts.htm

Appendix A

List of Fiscal Sponsors

FISCAL SPONSORS COUNTIES	
Alameda	Orange
Alpine	Placer
Amador	Plumas
Butte	Riverside
Calaveras	Sacramento
Colusa	San Benito
Contra Costa	San Bernardino
Del Norte	San Diego
El Dorado	San Joaquin
Fresno	San Luis Obispo
Glenn	San Mateo
Humboldt	Santa Barbara
Imperial	Santa Clara
Inyo	Santa Cruz
Kern	Shasta
Kings	Sierra
Lake	Siskiyou
Los Angeles	Solano
Madera	Sonoma
Marin	Stanislaus
Mariposa	Sutter
Mendocino	Tehama
Merced	Trinity
Modoc	Tulare
Mono	Tuolumne
Monterey	Ventura
Napa	Yolo
Nevada	Yuba

FISCAL SPONSORS CITIES		
Agoura Hills	Calistoga	El Monte
Alhambra	Carmel-by-the-Sea	El Segundo
Aliso Viejo	Carpinteria	Elk Grove
Alturas	Cathedral City	Emeryville
American Canyon	Cerritos	Encinitas
Angels Camp	Chico	Escalon
Antioch	Chino	Escondido
Arcata	Chino Hills	Eureka
Atascadero	Citrus Heights	Fairfax
Atwater	Claremont	Fairfield
Auburn	Clearlake	Ferndale
Avenal	Clovis	Firebaugh
Azusa	Coachella	Folsom
Bakersfield	Colfax	Fontana
Banning	Colma	Fort Jones
Barstow	Colusa	Fortuna
Bell	Compton	Fowler
Bell Gardens	Concord	Fremont
Bellflower	Corcoran	Fresno
Belmont	Corning	Fullerton
Belvedere	Corona	Galt
Berkeley	Coronado	Garden Grove
Beverly Hills	Corte Madera	Gardena
Big Bear Lake	Costa Mesa	Gilroy
Biggs	Cotati	Glendale
Bishop	Covina	Glendora
Blythe	Cudahy	Goleta
Bradbury	Culver City	Gonzales
Brea	Cupertino	Greenfield
Brentwood	Dana Point	Gridley
Brisbane	Danville	Grover Beach
Buena Park	Delano	Half Moon Bay
Burbank	Dunsmuir	Hayward
Burlingame	El Cajon	Healdsburg
Calabasas	El Centro	Hercules
California City	El Cerrito	Hermosa Beach

FISCAL SPONSORS CITIES		
Hesperia	Lodi	Novato
Highland	Lomita	Oakdale
Hillsborough	Lompoc	Oakland
Hollister	Long Beach	Oakley
Hughson	Loomis	Ojai
Huntington Beach	Los Altos	Orange Cove
Huron	Los Banos	Orinda
Imperial	Los Gatos	Orland
Indian Wells	Madera	Oroville
Indio	Manhattan Beach	Oxnard
Inglewood	Maricopa	Pacific Grove
Irvine	Marysville	Pacifica
La Canada Flintridge	Mendota	Palm Desert
La Habra Heights	Menifee	Palm Springs
La Mesa	Menlo Park	Palmdale
La Mirada	Millbrae	Palo Alto
La Puente	Mission Viejo	Paramount
La Quinta	Modesto	Parlier
La Verne	Monrovia	Paso Robles
Lafayette	Montague	Patterson
Laguna Beach	Monte Sereno	Petaluma
Laguna Hills	Montebello	Piedmont
Laguna Niguel	Monterey	Pinole
Lake Forest	Monterey Park	Pismo Beach
Lakeport	Moorpark	Pittsburg
Lakewood	Moraga	Placerville
Lancaster	Moreno Valley	Pleasant Hill
Larkspur	Morro Bay	Pleasanton
Lathrop	Mountain View	Plymouth
Lawndale	Napa	Point Arena
Lemon Grove	National City	Porterville
Lincoln	Newark	Portola
Lindsay	Newman	Poway
Live Oak	Newport Beach	Rancho Cordova
Livermore	Norco	Rancho Cucamonga
Livingston	Norwalk	Rancho Mirage

FISCAL SPONSORS CITIES		
Rancho Palos Verdes	Santa Fe Springs	Truckee
Redding	Santa Maria	Tulare
Redondo Beach	Santa Monica	Twentynine Palms
Redwood City	Santa Rosa	Ukiah
Reedley	Santee	Upland
Richmond	Saratoga	Vacaville
Rio Vista	Sausalito	Vallejo
Ripon	Scotts Valley	Ventura
Riverbank	Seal Beach	Vernon
Rocklin	Seaside	Victorville
Rohnert Park	Selma	Walnut Creek
Rolling Hills Estates	Shafter	Waterford
Rosemead	Shasta Lake	Weed
Roseville	Signal Hill	West Hollywood
Sacramento	Simi Valley	West Sacramento
Salinas	Solana Beach	Wheatland
San Anselmo	Soledad	Whittier
San Carlos	Solvang	Wildomar
San Dimas	Sonoma	Williams
San Gabriel	South El Monte	Willits
San Joaquin	South Gate	Windsor
San Juan Capistrano	South Pasadena	Winters
San Leandro	South San Francisco	Woodlake
San Luis Obispo	Stanton	Woodland
San Marcos	Stockton	Yountville
San Marino	Suisun City	Yreka
San Mateo	Susanville	Yuba City
San Pablo	Sutter Creek	Yucaipa
San Rafael	Taft	Yucca Valley
San Ramon	Tehachapi	
Sand City	Tehama	
Sanger	Temecula	
Santa Barbara	Temple City	
Santa Clara	Thousand Oaks	
Santa Clarita	Tiburon	
Santa Cruz	Tracy	

FISCAL SPONSORS REGIONAL TRANSPORTATION PLANNING AGENCIES (RTPA)	
Alpine Co. Local Transportation Commission	Mono Co. Local Transportation Commission
Amador Co. Transportation Commission	Nevada Co. Transportation Commission
Butte Co. Association of Governments	Orange Co. Transportation Authority
Calaveras Council of Governments	Placer Co. Transportation Planning Agency
Colusa Co. Transportation Commission	Plumas Co. Transportation Commission
Council of San Benito Co. Governments	Riverside Co. Transportation Commission
Del Norte Local Transportation Commission	Sacramento Area Council of Governments
El Dorado Co. Transportation Commission	San Bernardino Associated Governments
Fresno Council of Governments	San Diego Association of Governments
Glenn Co. Transportation Commission	San Joaquin Council of Governments
Humboldt Co. Association of Governments	San Luis Obispo Council of Governments
Imperial Co. Transportation Commission	Santa Barbara Co. Association of Governments
Inyo Co. Local Transportation Commission	Santa Cruz Co. Regional Transportation Commission
Kern Council of Governments	Sierra Co. Transportation Commission
Kings Co. Association of Governments	Siskiyou Co. Local Transportation Commission
Lake Co./City Area Planning Council	Tahoe Regional Planning Agency
Lassen Co. Transportation Commission	Tehama Co. Transportation Commission
Los Angeles Co. Metropolitan Transportation Authority	Transportation Agency for Monterey Co.
Madera Co. Transportation Commission	Trinity Co. Transportation Commission
Mendocino Council of Governments	Tulare Co. Association of Governments
Merced Co. Association of Governments	Tuolumne Co. Transportation Council
Metropolitan Transportation Commission	Ventura Co. Transportation Commission
Modoc Co. Transportation Commission	

As of October 10, 2016.

Appendix B

Data Collection

This appendix describes in detail the data collection efforts for this update. The goal was to ensure participation by all 58 Counties and 481 Cities.

B.1 Outreach Efforts

As with the previous studies, significant efforts were made to reach all 539 agencies in January-March 2016. This included letters sent out by NCE on behalf of the League and CEAC/CSAC. The contact database had almost 2,500 contacts for all the cities and counties. This was compiled from a variety of sources including contacts from the previous surveys in 2014, the memberships of both CSAC and the League, the email listserv for the Regional Transportation Agencies (RTPA) and NCE's client contacts.

The contacts included Public Works staff (Directors of Public Works, City Engineers or engineers responsible for pavement/asset management), Directors of Finance, City Managers, County Administrative Officers, RTPAs (Regional Transportation Planning Agencies), and MPOs (Metropolitan Planning Agencies).

Almost 2,500 contact letters were mailed out in mid-January 2016 (see Exhibit B-1) with instructions on how to access the online survey and a fact sheet explaining the project. The deadline for responding to the survey was March 18th, 2016, but this was later extended to March 26th, 2016, as there were numerous requests from agencies for more time to respond. MTC also sent numerous emails to its 109 member agencies. The League and CSAC/CEAC spread the word via their email listservs, and as before, publicized the survey at the annual Public Works Officers Institute conference in March 2016.

B.2 Project Website

The website at www.SaveCaliforniaStreets.org (see Figure B.1) was originally designed and developed for the 2008 study. This was subsequently modified to accommodate the 2016 survey. The intent of this website was to act as both an information resource on this study and as a repository of related reports that might be of interest to cities and counties. More importantly, it was a portal to the online survey described in Section B.3. CSAC currently hosts the website.

B.3 Online Survey Questionnaire

A survey questionnaire was prepared and finalized in early December 2015, and a blank example is included in Exhibit B-1. Briefly, it included a request for the following information:

1. Contact name and information for both pavements and financial data
2. Streets and pavements data (including sustainable pavements and complete streets)
3. Essential components (safety, traffic, and regulatory) data
4. Bridge data
5. Additional regulatory requirements
6. Funding and expenditure data

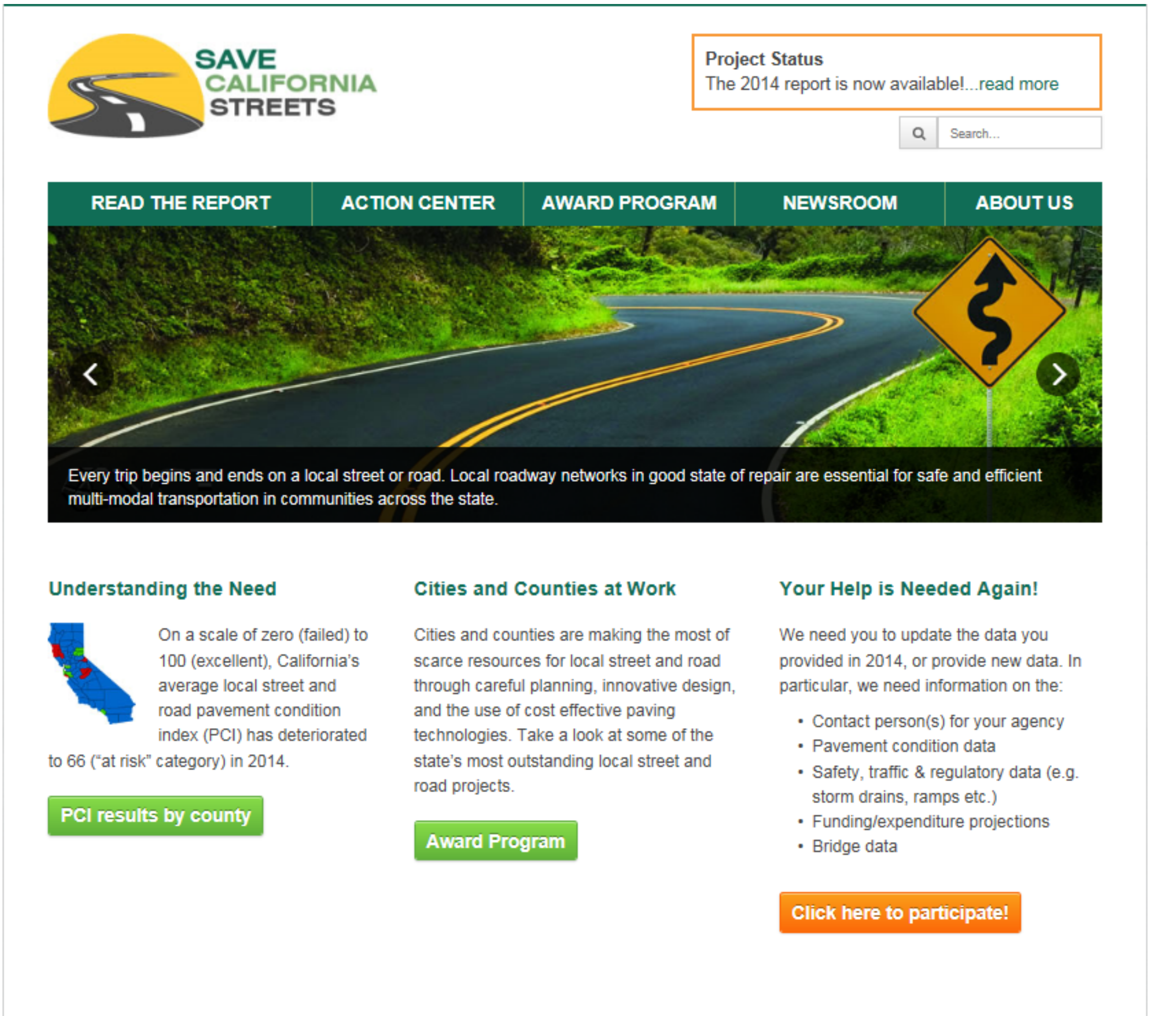


Figure B.1 Home Page of www.SaveCaliforniaStreets.org Website

Like the previous studies, no hardcopy surveys were available to the cities and counties, thus requiring all data entry to be made online. The online survey made data aggregation much simpler and faster. The custom database previously designed and developed in 2014 was updated for 2016.

Data from 99% of the state's local streets and roads are included in this study.

B.4 Results of Data Collection

A total of 462 agencies (85 percent) responded to the survey, which was an increase from the 399 agencies in 2014. In fact, this year's response rate is the highest ever in the history of the assessment! When these were added to the agencies who responded in 2008, 2010, 2012 and 2014, they represented 99.7 percent of the total centerline miles of local streets and roads in the state (see Figure B.2). It also represented 98 percent of the state's population.

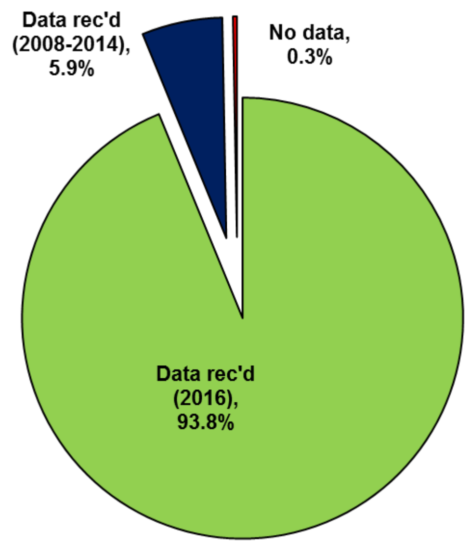


Figure B.2 Responses to Survey (% centerline miles)

Only 9 agencies have not responded to this or any previous survey; of these, 8 have less than 100 centerline miles, and all have populations less than 50,000.

Table B.1 illustrates the survey responses by type of data. The pavement data had the most responses (454), but the remaining data elements all showed increased responses compared to previous years. Note that the cells with blanks indicated that those data elements were not requested during the applicable survey years.

B.4.1 Are Data Representative?

Throughout the data collection phase, it was important to ensure that the data received were representative in nature. This was critical for the analyses – as with the previous studies, the criterion used was network size.

Table B.1 Number of Agencies Responding by Data Type

Data Type	2008	2010	2012	2014	2016
Pavement data	314	344	273	371	454
Unit costs	50	260	211	177	187
Sustainable practices	-	-	280	269	428
Complete streets	-	-	269	250	421
Safety, Traffic & Regulatory	188	296	159	152	197
Bridges	-	-	177	-	400
Additional Regulatory Requirements	-	-	220	199	382
Financial	137	300	238	276	340

The distribution of responses with respect to network size is shown in Figure B.3. Small agencies are those that have less than 100 centerline miles; medium between 101 to 300 miles, and large agencies have more than 300 miles. Figure B.3 shows all the agencies who responded in 2016 (green), those who responded in previous surveys but not 2016 (blue) and the ones who have never responded in red. Clearly, the bulk of the agencies who did not respond had less than 100 miles of pavement network (small cities), but we still had 255 responses in this category, so our confidence in the responses were validated.

An important point to note too is that small agencies account for a very small percentage of the state's pavement network. There are 262 cities with less than 100 centerline miles of streets, and 159 cities with less than 50 centerline miles of streets. However, they comprise only 8.2 percent and 2.9 percent of the total miles in the state, respectively. Their impact on the statewide needs is consequently minimal.

B.4.2 PMS Software

The survey responses also indicated that 83 percent of the responding agencies had a pavement management system (PMS) in place (see Figure B.4). The StreetSaver® (48 percent) and MicroPAVER (20 percent) software programs are the two main ones in the state, which is not surprising given their reasonable costs. StreetSaver® was developed and supported by the Metropolitan Transportation Commission (MTC) and MicroPAVER is supported by the American Public Works Association (APWA).

Due to the widespread use of a PMS, the quality of the pavement data received contributed immensely to the validity of this study's results.

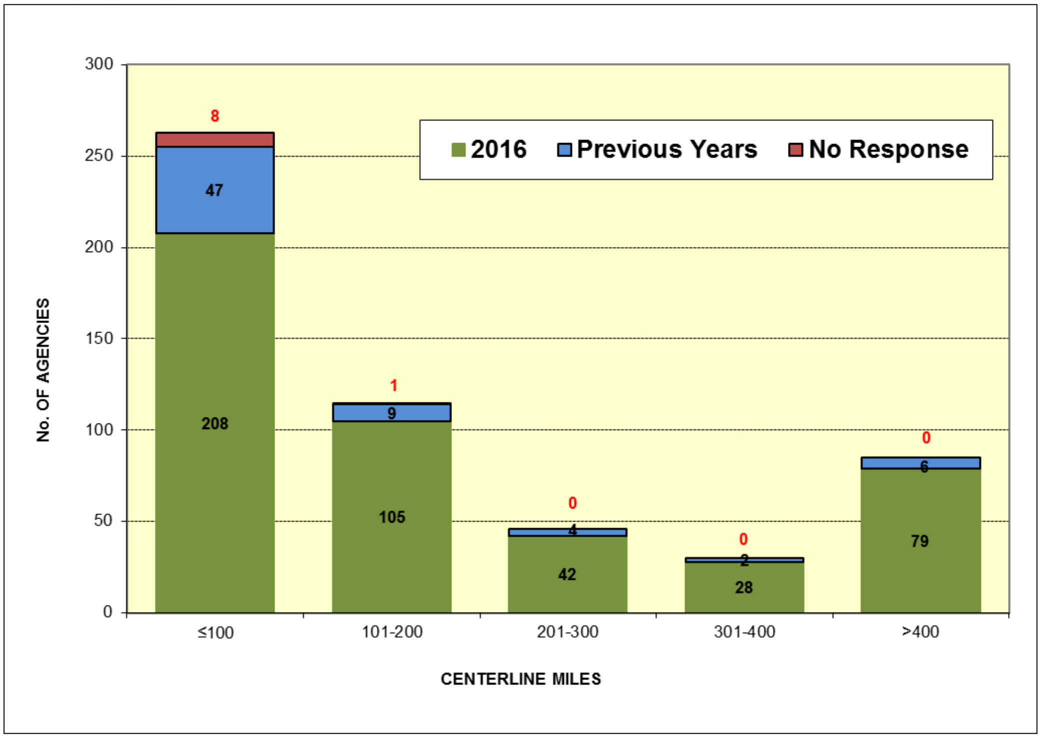


Figure B.3 Distribution of Agency Responses by Network Size (centerline miles)

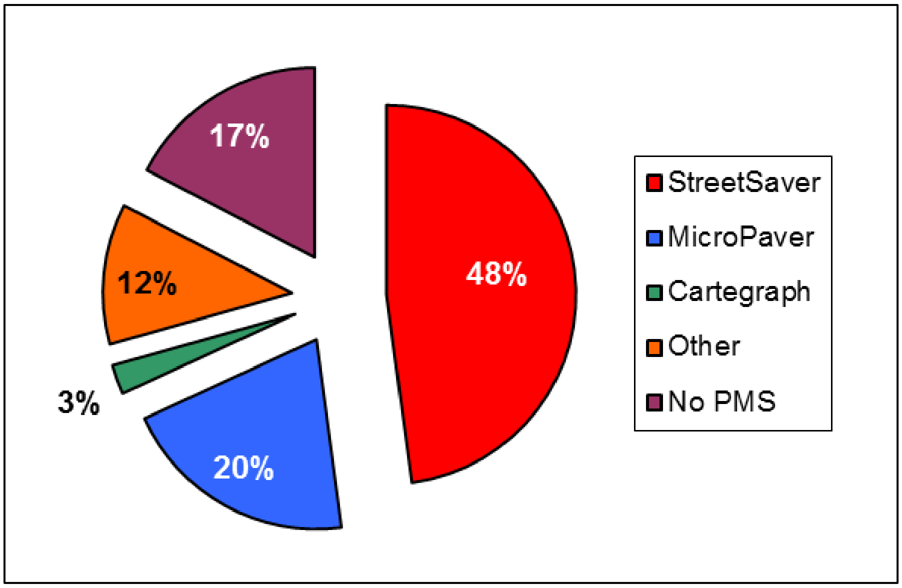


Figure B.4 PMS Software Used from Survey Responses

What is more important is that approximately 94 percent of the total miles in the state are included in a pavement management system, which lead to a high confidence in the data submitted.

B.5 Summary

Overall, the number and quality of the survey responses received again exceeded expectations and more than met the needs of this study. To obtain data on more than 99 percent of the state's local streets and roads network was a remarkable achievement. That 83 percent of agencies had a pavement management system in place removed many obstacles in the technical analyses. In particular, the consistency in the pavement conditions reported contributed enormously to the validity of the study.

Exhibit B-1

Contact Letter, Instructions for Online Survey, Fact Sheet & Survey Questionnaire

January 15, 2016

NAME
TITLE
AGENCY
ADDRESS #1
ADDRESS #2

SUBJECT: 2016 CALIFORNIA STATEWIDE LOCAL STREETS AND ROADS NEEDS ASSESSMENT

Dear XXX:

Your help in responding to our survey in 2014 made a difference! We are asking for your help again in updating the information you provided two years ago.

Since 2008, the California Statewide Local Streets and Roads Needs Assessment Report has been invaluable to the California State Association of Counties (CSAC) and the League of California Cities (League) on a number of transportation efforts at both the state and federal level. We have used the findings to educate elected officials, policy- and decision-makers, and the public about the condition of the local transportation network and the funding needed to bring the system into a state of good repair. CSAC and the League have also used the findings to advocate against, and ultimately avoid, what could have been devastating cuts to local transportation funding over several state budget cycles (the 2014 report is available at www.SaveCaliforniaStreets.org).

In addition to deterring negative policies and budget decisions, CSAC and the League have used the findings in proactive efforts including SB 375 implementation, seeking revenues for Cap and Trade funding, and other sustainable transportation efforts. Another positive outcome was the special legislative session on transportation last summer. Although no final solution has yet been proposed, it is promising to see the visibility that transportation has achieved in recent years.

In 2017-18, we will continue to use the findings of the 2016 assessment to emphasize the importance of *increasing* funding for maintenance of our local streets and roads.

As in the past, this project is being funded through contributions from stakeholders. Regional Transportation Planning Agencies (RTPAs) have provided half the cost, with cities and counties sharing equally in the remaining cost. It is essential that each agency contribute toward this study in order to demonstrate how critical this issue is to sustaining our state's transportation infrastructure.

An ongoing effort is needed to update the local streets and roads needs on a regular, consistent basis, much like the State does in preparing the State Highway Operation and Protection Program (SHOPP). NCE will assist us in performing the 2016 update of the Statewide Needs Assessment.

YOU CAN CONTINUE TO MAKE A DIFFERENCE!

We need your immediate assistance on the following items:

1. To ensure a widespread dissemination of this request, this letter has been sent to the City Manager/County Administrative Officer, Public Works Director, City/County Engineer, and Finance Director. We recognize that the data may come from multiple sources, so we ask

your agency to coordinate among yourselves to ensure that the most recent and accurate information is entered. Please provide NCE with your agency's contact information if you are not the appropriate contact. This person(s) should be able to provide all the information requested in the survey. We need information on two main areas:

a. Technical – pavement, bridges and safety, regulatory and traffic needs.
b. Financial – projected funding revenues/expenditures.

2. Fill out the online survey at www.SaveCaliforniaStreets.org. Instructions for filling out the survey are enclosed. Your agency's login and password are:

Login: Password:

It is essential that we have this data no later than March 18th, 2016. Should you have any questions, please do not hesitate to contact:

Ms. Margot Yapp, P.E. Vice President/Project Manager NCE 501 Canal Blvd, Suite I Pt. Richmond, CA 94804 (510) 215-3620 myapp@ncenet.com

We appreciate your help in providing this information.

Sincerely,

Charles D. Herbertson, P.E., L.S.
Director of Public Works/City Engineer
Project Manager of Statewide Needs Assessment
City of Culver City/League of California Cities

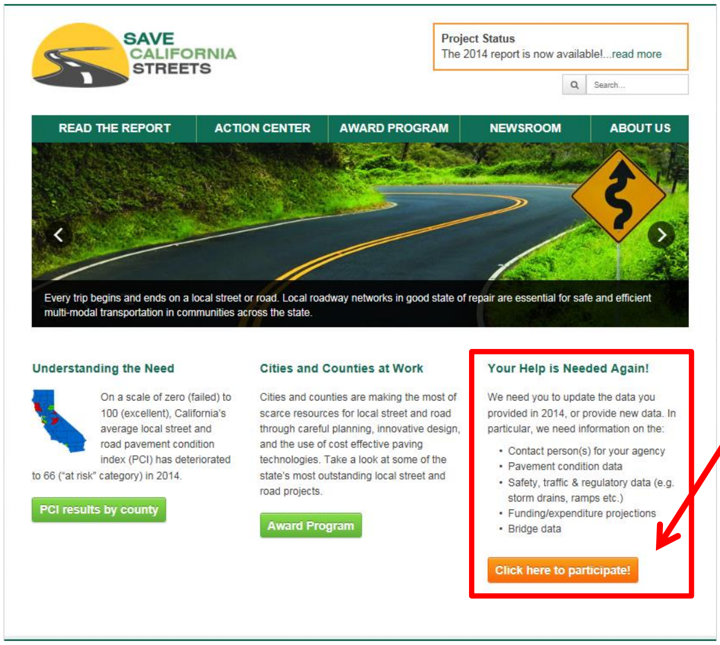
Matt Machado, President
County Engineers Association of California
Director of Public Works
County of Stanislaus

Timm Borden, President
Public Works Officers Department
League of California Cities
Director of Public Works
City of Cupertino

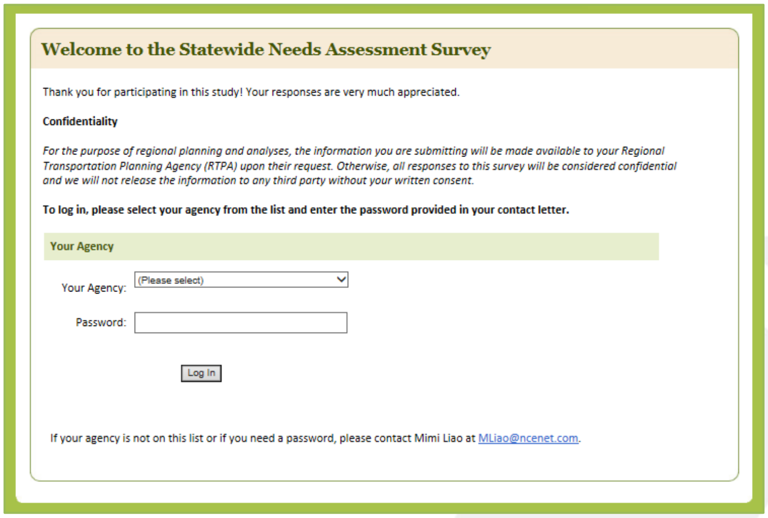
Enclosures: Fact Sheet
Instructions for Online Survey

Instructions for Online Survey

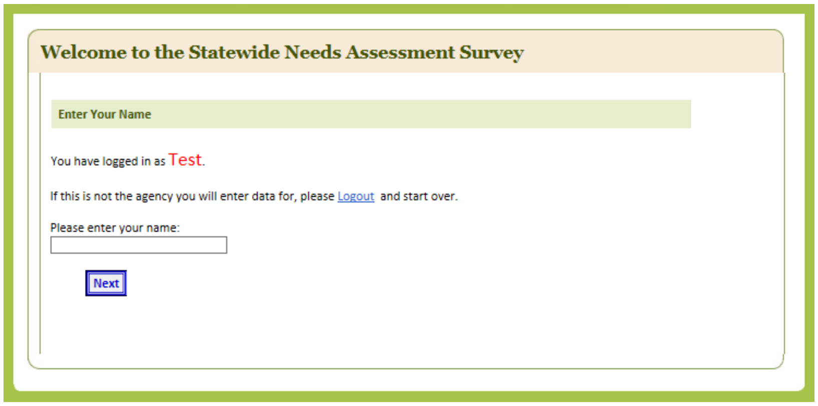
Step 1. Go to http://www.savecaliforniastreets.org. Click on the button that says "Click here to participate".



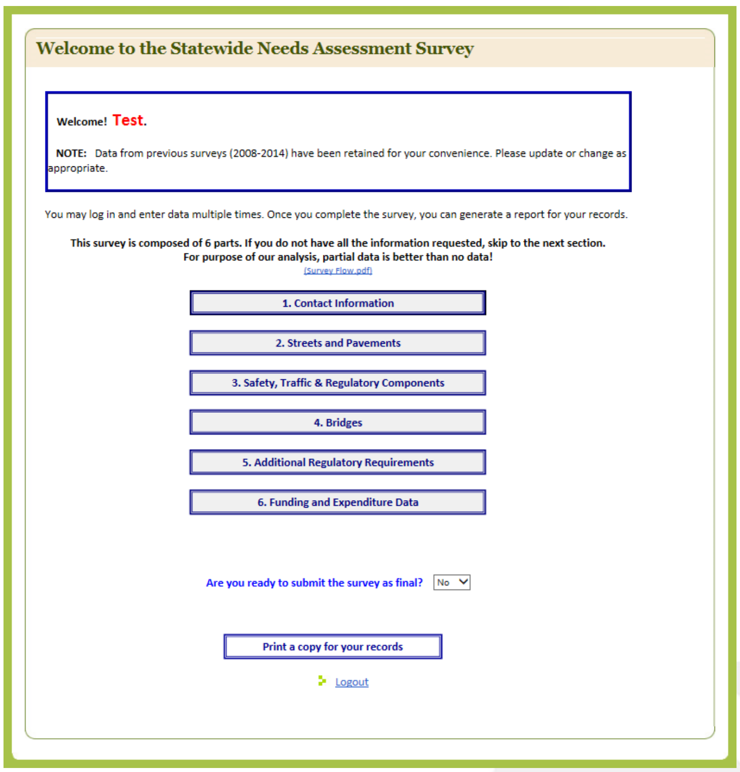
Step 2. On the login page, select the name of your agency from the dropdown list. If you responded to the 2014 or earlier surveys, the information you entered at that time will be shown so that you can update it. You will need your agency's login and password, which was mailed to you. If you do not have this information, please contact Mimi Liao at (510) 215-3620 or at mliao@ncenet.com.



Step 3. Enter your name, then click "Next" to the main survey page.



Step 4. There are six (6) parts in this survey (see image below). Click on each button to enter the relevant information. <u>If you do not have all the information requested, skip to the next section.</u>



Step 5. Once data entry is complete, you can view and print your entry by clicking on the "Print a copy for your records" button. If there are no more changes, select "Yes" on the "Are you ready to submit the survey as final?" question.

Step 6. Click "Logout" button when done.

THANK YOU FOR YOUR PARTICIPATION!

California Statewide Needs Assessment Project

www.SaveCaliforniaStreets.org

FACT SHEET

Why are we updating the 2014 study?

Transportation funding for Cities and Counties continue to be at risk.

The 2014 statewide needs study identified a funding shortfall of almost $80 billion for local streets and roads (the final report is available on the www.SaveCaliforniaStreets.org website).

This update will help us once again with our efforts not just to protect our transportation funds, but to advocate for *increased* funding for local street and road maintenance.

Why is this update important?

Performing a needs assessment biennially will provide updated information to maintain and obtain transportation funding, similar to Caltrans. Hopefully, the information from this study will embed into the decision makers' minds the importance of maintaining sufficient transportation funding for local streets and roads. Additionally, we need to make it clear what the detrimental consequences are for deferring or reducing local street and road funds. This study is the only comprehensive and systematic statewide approach to quantify the needs for local streets and roads.

Study Achievements

The findings have been used to:

- Educate elected officials, policy- and decision-makers, and the public about the condition of the local transportation network and the funding needed. This study has been cited by many media sources and reports.
- Advocate against, and ultimately avoid, potential devastating cuts to local transportation funding over several state budget cycles.
- Proactively advocate for funding from the SB 375 implementation, Cap and Trade, and other sustainable transportation efforts.

How can Cities and Counties help?

Your help in 2014 made a difference; and we need your input again!

Please go to www.SaveCaliforniaStreets.org and login to our online survey to provide updates in the following categories:

- Contact Person from your Agency
- Pavement condition data
- Bridge data
- Safety, traffic, and regulatory data
- Funding/expenditure projections

FACT SHEET

We are anxious to begin the study, so please provide us with the contact person who is responsible for both the technical and funding information in your agency (see our contact information below). We will be in touch with them soon to obtain this information. The deadline for responding to this survey is **March 18th, 2016**.

Who is sponsoring this project?

Many cities and counties contributed funding to this study. The agencies listed below have accepted the leadership responsibility for completing this study on behalf of the cities and counties in California.

- California State Association of Counties (CSAC)
- League of California Cities (League)
- County Engineers Association of California (CEAC)
- County of Los Angeles
- City of Culver City
- California Regional Transportation Planning Agencies (RTPA)
- Metropolitan Transportation Commission (MTC)
- California Rural Counties Task Force (RCTF)

The Oversight Committee is composed of representatives from each organization, with the City of Culver City (representing the League of California Cities) acting as the Project Manager. NCE is the consultant who will be performing the update. Oversight Committee members include:

Jim Biery, City of Buena Park
Keith Cooke, City of San Leandro
Charles Herbertson, City of Culver City
Greg Kelley, Los Angeles County
Sarkes Khachek, Santa Barbara County Association of Governments
Steve Kowalewski, Contra Costa County
William Ridder, LA Metro
Theresa Romell, MTC
Mike Sartor, City of Palo Alto
Mike Woodman, Nevada County Transportation Commission

Staff

Meghan McKelvey, League of California Cities
Rony Berdugo, League of California Cities
Merrin Gerety, CEAC
Chris Lee, CSAC

Who should I contact for more information?

Margot Yapp, Vice President
NCE
501 Canal Blvd., Suite I
Pt. Richmond, CA 94804
Tel: (510) 215-3620

Charles Herbertson, Director of Public Works/City Engineer
Project Manager
City of Culver City
9770 Culver Blvd.
Culver City, CA
Tel: (310) 253-5630

Statewide Needs Assessment Online Survey Report (2016)

Agency Name:

1. CONTACT INFORMATION

Contact Type	Salutation	Name	Title	Department	Address Line 1	Address Line 2	City	Zip Code	Email	Phone
Main Contact Person										
Alternative Contact Person										
Contact Person for Financial Data										
Alternative Contact Person for Financial Data										

2. STREETS AND PAVEMENTS

2.1 Pavement Management System and Pavement Distress Survey Procedures

1. Does your agency use Pavement Management System (PMS) software?
   (Go to Question 1a if "Yes"; Go to Question 1b if "No".)

   1a. Select your agency's PMS software:

   Enter your agency's PMS software name (if "Other" is selected above):

   1b. Select the reason your agency does not use a PMS:

   Enter the reason your agency does not use a PMS (if "Other" is selected above):

2. What pavement distresses do you collect for Asphalt Concrete (AC)? If you collect distresses that are not listed below, please enter in the "Other AC Distresses" box.

   1) Alligator Cracking
   2) Block Cracking
   3) Distortions
   4) Long. & Trans. Cracking
   5) Patch & Util. Cut Patch
   6) Rutting/Depression
   7) Weathering & Raveling

   Other AC distresses your agency collects, if any:

3. Does your agency have Portland Cement Concrete (PCC) pavements?

   If yes, what pavement distresses do you collect for PCC? If you collect distresses that are not listed below, please enter in the "Other PCC Distresses" box.

   1) Corner Break
   2) Divided Slab
   3) Faulting
   4) Linear Cracking
   5) Patching & Utility Cuts
   6) Scaling/Map Cracking/Crazing
   7) Spalling

Other PCC distresses your agency collects, if any:

4. What other condition data do you collect?
   - Deflection
   - Ride Quality e.g. International Roughness Index (IRI)
   - Friction
   - Drainage
   - Structure/Core
   - Complaints
   - Pavement Age

Other condition data your agency collects, if any:

5. What is the scale of the pavement condition index/rating used (e.g. 0-100, A-F)?

   Lowest possible rating(e.g. 0)

   Highest possible rating(e.g. 100)

6. How much will you require annually to maintain existing conditions (e.g. if your current PCI is 70, indicate the annual funding required to maintain the pavement network at 70.)

   $

7. For the roads/streets that are included in the National Highway System (NHS), do you collect the following information as per the proposed rule from FHWA?
   1) International Roughness Index (IRI)
   2) Percent cracking (as measured by the HPMS)
   3) Rutting
   4) Faulting

8. If you currently do not collect the above information, how will you plan on collecting it? E.g. in-house staff, consultant, Caltrans, etc.

9. If known, please estimate the cost for data collection for roads/streets in the NHS.

$

10. Any notes you would like to add regarding your pavement distress survey procedures (e.g. collected by consultant, in-house, frequency of collection, etc.), or any comments/notes you have regarding any portion of this survey/your data:

11. Are larger/heavier vehicles (e.g. buses, refuse/recycling trucks, snow removal vehicles, etc) impacting pavement performance or your maintenance practices? If so, please explain the type of vehicles and how they impact performance:

2.2 Sustainable Pavement Practices

1. What sustainable pavement practices does your agency utilize?

Sustainable Pavement Practice	Does your agency utilize?	Unit Cost ($/sy)	Additional Costs or Savings	Percentage of Additional Costs or Savings
Use of Reclaimed Asphalt Pavement (RAP) in pavements				%
Cold In-place Recycling (CIR)				%
Hot In-place Recycling (HIPR)				%
Cold Central Plant Recycling				%
Warm Mix Asphalt				%
Porous/Pervious Pavements				%
Full Depth Reclamation (FDR)				%
Subgrade Stabilization				%
Rubberized Asphalt Concrete (RAC)				%
Pavement Preservation Strategies e.g. chip seals, fog seals, microsurfacing, cape seals				%
Other (please explain below)				%

if "Other" is used in the above table, please describe below:

2. Will you continue applying sustainable pavement practices?

3. If you do not employ sustainable practices, please indicate the reason(s) why (check all that apply):

1) High construction cost

2) Lack of knowledge

3) No local contractors

4) No street/road candidates

5) Other (please explain below)

4. Other comments regarding sustainable pavement practices:

2.3 Inventory and condition Information

Functional Class/Road Type	Year of Last Inspection	Pavement Condition Rating (Weighted Average)	Center Line Miles	Lane Miles	Area(sq. yd.)	PCC (as % of the area)	Center Line Miles included in NHS
Urban Major Roads							
Urban Residential/Local Roads							
Rural Major Roads							
Rural Residential/Local Roads							
Unpaved Roads							

2.4 Pavement Treatment Policy and Unit Costs

Urban Major Roads:

Pavement Treatment	PCI Range	Unit Cost ($/sq. yd.)
Do Nothing	90 - 100	
Preventive Maintenance (e.g. slurry, chip seal, cape seal)	70 - 89	
Thin overlay (e.g. less than or equal to 2 inches)	50 - 69	
Thick overlay (e.g. more than 2 inches)	25 - 49	
Reconstruction (e.g. remove & replace)	0 - 24	

Urban Residential/Local Roads:

Pavement Treatment	PCI Range	Unit Cost ($/sq. yd.)
Do Nothing	90 - 100	
Preventive Maintenance (e.g. slurry, chip seal, cape seal)	70 - 89	
Thin overlay (e.g. less than or equal to 2 inches)	50 - 69	
Thick overlay (e.g. more than 2 inches)	25 - 49	
Reconstruction (e.g. remove & replace)	0 - 24	

Rural Major Roads:

Pavement Treatment	PCI Range	Unit Cost ($/sq. yd.)
Do Nothing	90 - 100	
Preventive Maintenance (e.g. slurry, chip seal, cape seal)	70 - 89	
Thin overlay (e.g. less than or equal to 2 inches)	50 - 69	
Thick overlay (e.g. more than 2 inches)	25 - 49	
Reconstruction (e.g. remove & replace)	0 - 24	

Rural Residential/Local Roads:

Pavement Treatment	PCI Range	Unit Cost ($/sq. yd.)
Do Nothing	90 - 100	
Preventive Maintenance (e.g. slurry, chip seal, cape seal)	70 - 89	
Thin overlay (e.g. less than or equal to 2 inches)	50 - 69	
Thick overlay (e.g. more than 2 inches)	25 - 49	
Reconstruction (e.g. remove & replace)	0 - 24	

2.5 Complete Streets Policy

1. Has your agency adopted a "Complete Streets Policy"?
   If your answer is "No" or "Don't know", skip this section. Please explain below why not if known.

2. What complete streets elements are included or assumed in the policy? Check all that apply.

   - Bicycle facilities ☐
   - Pedestrian facilities ☐
   - Landscaping ☐
   - Medians ☐
   - Lighting ☐
   - Roundabouts ☐
   - Traffic Calming e.g. reducing lane widths ☐
   - Signs ☐
   - Curb Ramps ☐
   - Transit elements ☐

   Comments/Additional items:

3. Do you have other plans that incorporate these elements even if you do not have a Complete Streets policy?

4. What percentage of roads will have Complete Streets elements? (e.g. enter 10 for 10%)

   %

5. What is the estimated average incremental costs to provide Complete Street enhancements ($/sq. yd) i.e. in addition to conventional costs?

   $ /sq. yd

6. Do you have a representative project that included Complete Streeets elements that was recently constructed? If no, please provide a brief description.

7. Do you anticipate more of these projects in the future? If so, approximately how many?

8. What are the major challenges you face in implementing a Complete Streets Policy? Check all that apply.

- Insufficient right-of-way ☐
- Trees/environmental features ☐
- Existing structures ☐
- Insufficient funding ☐
- Other (please explain) ☐

If "Other" is checked, please describe below:

9. Other comments or notes you would like to add regarding Complete Streets:

3. SAFETY, TRAFFIC AND REGULATORY COMPONENTS (as related to the road network)

Category	Inventory (Quantity)	Unit	Total Replacement Cost	Accuracy
Storm Drains - pipelines		mile		
Other elements e.g. manholes, inlets, culverts, pump stations etc		ea		
Curb and gutter		ft		
Pedestrian facilities: Sidewalk (public)		sq. ft.		
Other pedestrian facilities, e.g. over-crossings		ea		
* Bicycle facilities: Class I bicycle path		mile		
Other bicycle facilities, e.g. bike shelters/lockers, etc.		ea		
Curb ramps		ea		
Traffic signals		ea		
Street Lights		ea		
Sound Walls/Retaining walls		sq. ft.		
Traffic signs		ea		
Tunnels		ft		
Other physical assets or expenditures that constitute >5% of total non-pavement asset costs e.g. heavy equipment, corporation yards etc. Note: Do NOT include bridges (handled separately)		ea		

4. BRIDGE DATA

4.1 Local Agency Owned/Maintained Bridges (LAB's)

1. Total Number of LAB's within / not within the National Bridge Inventory (NBI):

Number of LAB's within the NBI	Number of LAB's NOT within the NBI

2. Number of LAB's by maintenance expenditures in last two years:

	Maintenance Expenditures per Bridge in Last Two Years		
	None	<$1000/Bridge	>=$1000/Bridge
Number of LAB's			

3. Number of LAB's posted for live load restriction:

4. Has Agency developed a Scour Mitigation Plan of Action (POA) for LAB's?

5. If so, number of LAB's that the Agency has completed Scour Mitigation POA's over last 5 years:

6. Has Agency submitted Bridge Preventative Maintenance Program (BPMP) Plan to Caltrans for review / approval?

4.2 Short Span Vehicular Bridges (SSB's)

1. Total Number of SSB's

4.3. Non-Vehicular Bridges (NVB's)

1. Total Number of NVB's

2. Number of NVB's by Maintenance Expenditures in last two years

	Maintenance Expenditures per Bridge in Last Two Years		
	None	<$1000/Bridge	>=$1000/Bridge
Number of NVB's			

4.4 Low Water Crossings (LWC's)

Total Number of LWC's	Number of LWC's replaced over last 5 years	Total Number of LWC's that should be replaced with bridges

5. ADDITIONAL REGULATORY REQUIREMENTS

Does your agency have additional regulatory requirements such as Americans with Disabilities Act (ADA), National Pollutant Discharge Elimination System (NPDES) requirements or Traffic Sign Retroreflectivity?

If you answered "Yes" above, please fill out the table at the bottom of this page. Otherwise, skip this section.

May we contact you if we have follow-up questions?

Additional comments regarding "Additional Regulatory Requirements":

Regulatory Requirements	Do you track costs separately?	Estimated 10-Year Needs	Estimated 10-Year Expenditures	Accuracy
ADA				
Traffic Sign Retroreflectivity				
NPDES				

6. FUNDING AND EXPENDITURE DATA

6.1 Actual/Estimated Revenues for Pavement-Related Activities

Funding Source	Type	Amount (FY14/15)	Amount (FY15/16)	Annual Average (FY16/17 to 25/26)

6.2 Actual/Estimated Revenues for Safety, Traffic & Regulatory Components

Funding Source	Type	Amount (FY14/15)	Amount (FY15/16)	Annual Average (FY16/17 to 25/26)

6.3 Expenditures on Pavements

Name	Amount (FY14/15)	Amount (FY15/16)	Annual Average (FY16/17 to 25/26)
Preventive Maintenance e.g. crack seals, slurry seals etc			
Rehabilitation & reconstruction e.g. overlays			
Other (pavement related)			
Other Operations & Maintenance (non-pavement related e.g. vegetation, cleaning ditches, sweeping, markings, signs, etc.)			

Of the totals reported above, what percentages are due to "Sustainable Pavement Practices", "Complete streets Policy" and "Additional Regulatory Requirements"? Enter in table below.

Name	% of Amount (FY14/15) Total	% of Amount (FY15/16) Total	% of Annual Average (FY16/17 to 25/26) Total
Sustainable Pavement Practices			
Complete Streets Components			
Additional Regulatory Requirements			

6.4 Expenditures on Safety, Traffic & Regulatory Components

Name	Amout (FY14/15)	Amount (FY15/16)	Annual Average (FY16/17 to 25/26)
Storm Drains - pipelines			
Other elements e.g. manholes, inlets, culverts, pump stations etc			
Curb and gutter			
Pedestrian facilities: Sidewalk (public)			
Other pedestrian facilities, e.g. over-crossings			
* Bicycle facilities: Class I bicycle path			
Other bicycle facilities, e.g. bike shelters/lockers, etc.			
Curb ramps			
Traffic signals			
Street Lights			
Sound Walls/Retaining walls			
Traffic signs			
Tunnels			
Other physical assets or expenditures that constitute >5% of total non-pavement asset costs e.g. heavy equipment, corporation yards etc. Note: Do NOT include bridges (handled separately)			

Of the above total expenditures, what percentages are due to a "Complete Streets Policy"?

Name	% of Amount (FY14/15) Total	% of Amount (FY15/16) Total	% of Annual Average (FY16/17 to 25/26) Total
Complete Streets Components			

6.5 Bridge Needs, Funding and Expenditures

1. Please provide bridge maintenance expenditures:

Bridge Type	Total maintenance expenditures over last 2 years
Local Agency Owned/Maintained Bridges (LAB's)	$
Non-vehicular Bridges (NVB's)	$

2. If your agency has developed a Scour Mitigation Plan of Action (POA) for LAB's, provide total project costs of Scour Mitigation POA's over last 5 years:
   $

3. If you agency has submitted Bridge Preventative Maintenance Program (BPMP) Plan to Caltrans, provide cost of developing the BPMP Plan:
   $

4. Please provide your estimated bridge needs and available funding for the next ten (10) years:

Activity	Anticipated funding needs in the next 10 years	Available funding currently identified in the next 10 years
Bridge Maintenance	$	$
Bridge Rehabilitation	$	$
Bridge Replacement	$	$

6.6 Financial Questions

1. What innovative methods is your agency doing to “stretch” the dollar? e. g. new technologies, use of recycling techniques, partnering with other agencies for lower bids, preventive maintenance, etc.

2. Are there new revenues sources that your agency is considering?

3. Is there a city/county wide sales tax solely for transportation?

4. Is there a city/county wide sales tax that is partially used for transportation?

5. If you answered "Yes" above, please describe how it is used.
(e.g. local match for highways, local streets & roads only, transit, etc).

Appendix C

Pavement Condition* & Needs by County

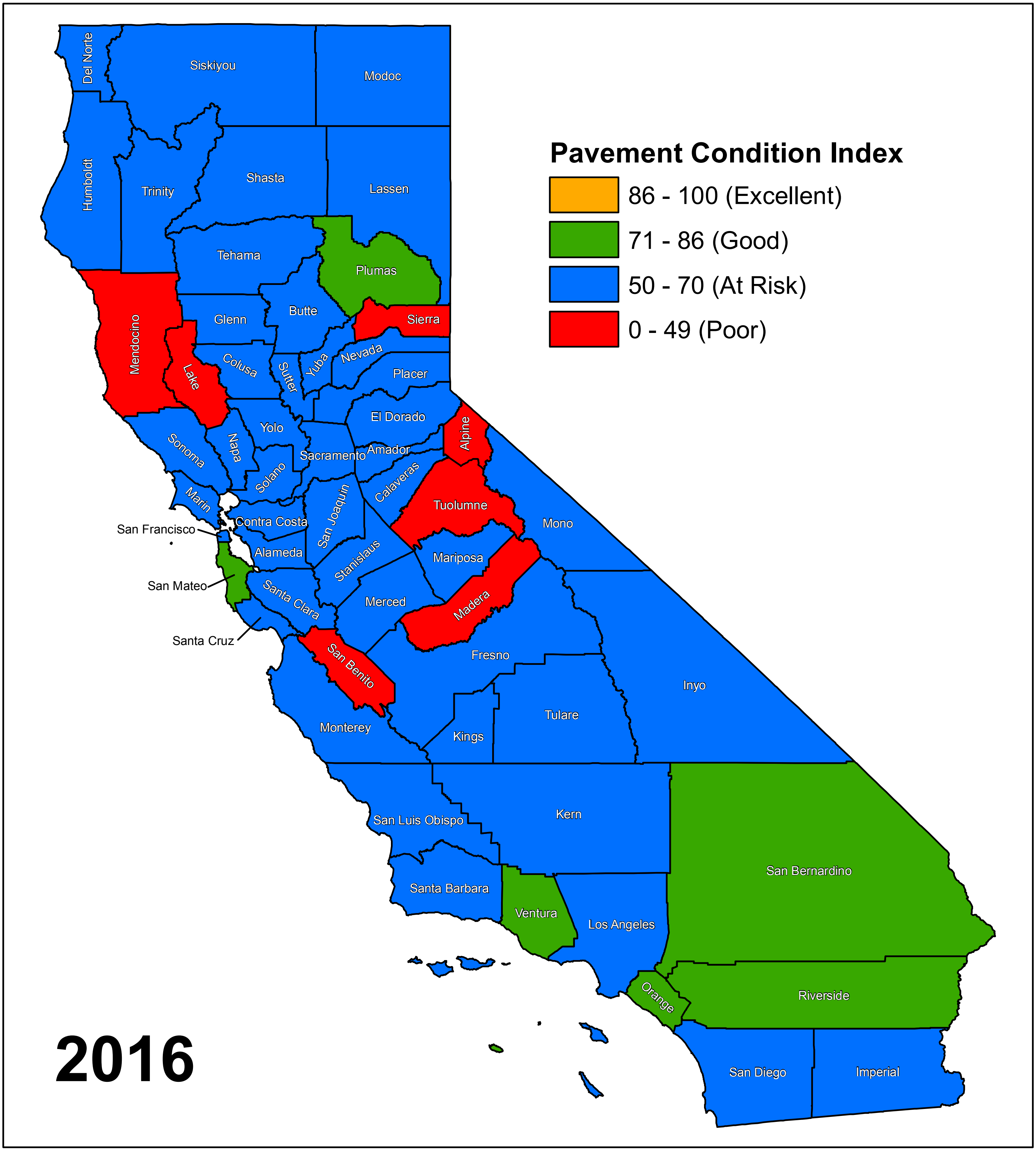
*Pavement condition data for the MTC region provided by MTC in 2016.

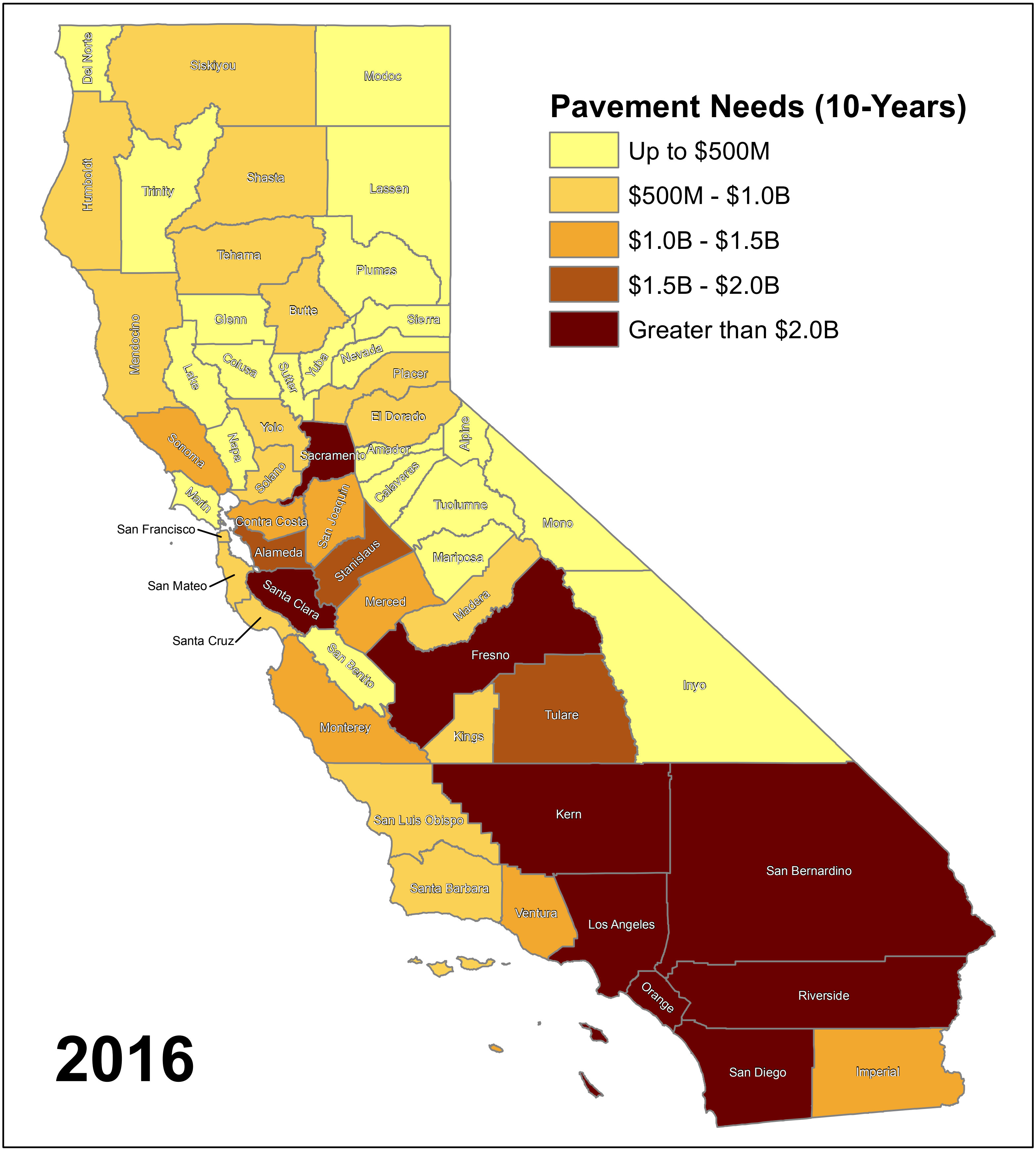
Table C.1 Pavement Needs by County* (2016 $)

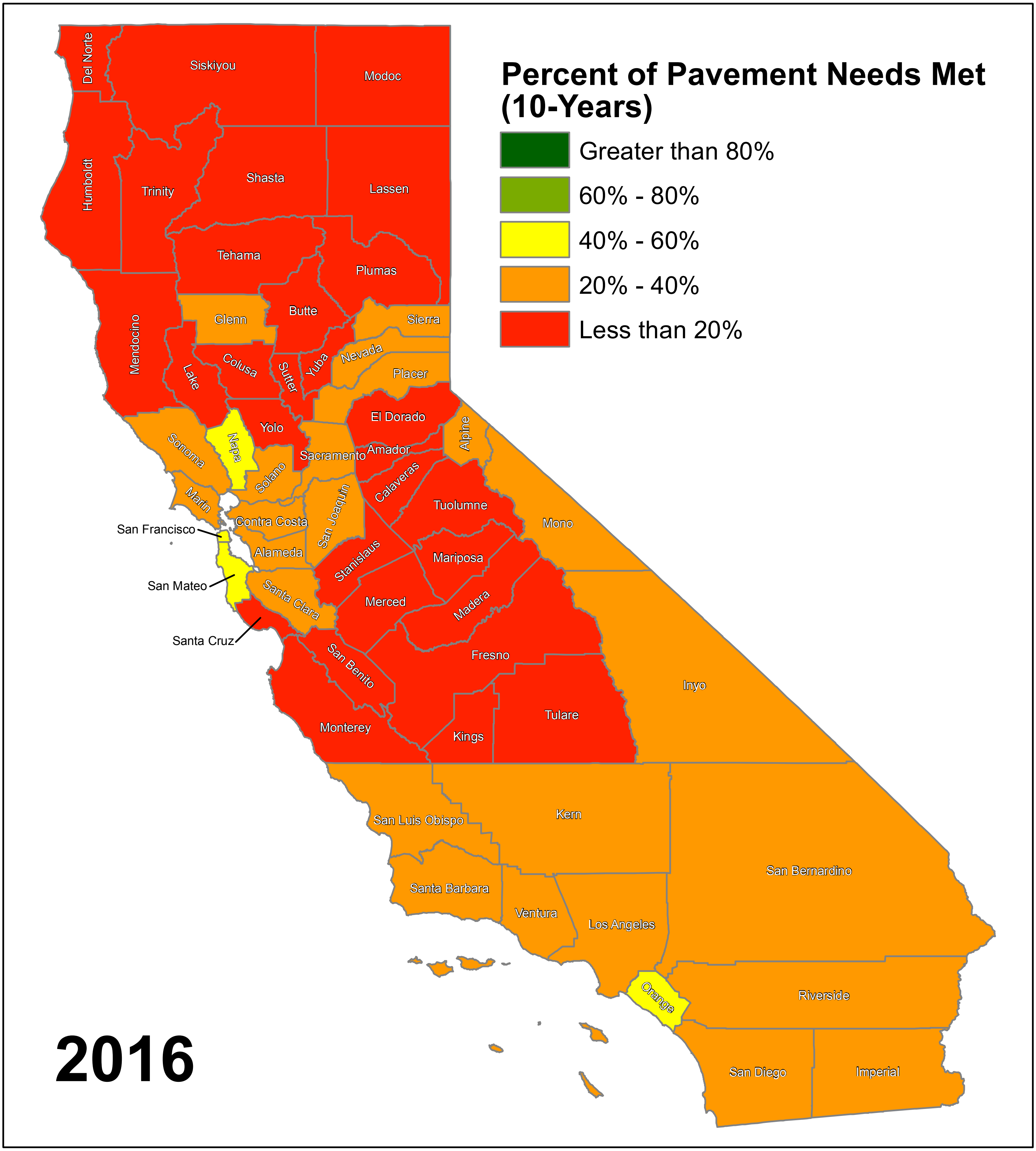
County (Cities included)	Center Line Miles	Lane Miles	Area (sq. yd.)	2016 PCI	10 Year Needs (2016 $M)
Alameda County	3,557	8,054	76,546,278	68	$ 1,879
Alpine County	135	270	1,900,800	44	$ 43
Amador County	477	945	5,908,703	56	$ 200
Butte County	1,844	3,702	29,335,888	65	$ 720
Calaveras County	717	1,333	8,937,332	51	$ 337
Colusa County	987	1,524	12,503,304	63	$ 301
Contra Costa County	3,388	7,074	63,103,914	69	$ 1,453
Del Norte County	434	864	6,244,480	63	$ 145
El Dorado County	1,408	2,806	22,277,095	62	$ 631
Fresno County	6,213	12,669	107,568,743	64	$ 2,959
Glenn County	910	1,822	13,917,626	68	$ 337
Humboldt County	1,471	2,933	24,221,118	63	$ 663
Imperial County	3,017	6,102	76,815,366	58	$ 1,075
Inyo County	1,146	1,933	13,732,980	62	$ 291
Kern County	5,495	12,519	111,410,008	63	$ 3,088
Kings County	1,346	2,826	20,281,497	59	$ 626
Lake County	753	1,494	9,974,991	40	$ 409
Lassen County	431	879	6,282,324	63	$ 187
Los Angeles County	21,015	57,404	457,128,791	67	$ 11,705
Madera County	1,822	3,680	23,490,290	46	$ 964
Marin County	1,012	2,050	16,233,715	64	$ 458
Mariposa County	362	719	5,334,893	65	$ 149
Mendocino County	1,124	2,256	15,980,516	35	$ 602
Merced County	2,335	4,881	38,705,388	56	$ 1,271
Modoc County	1,489	2,979	16,657,259	59	$ 408
Mono County	737	1,473	9,613,552	64	$ 156
Monterey County	1,783	3,756	33,423,503	50	$ 1,296
Napa County	739	1,508	12,821,673	59	$ 408
Nevada County	805	1,623	10,440,643	70	$ 221
Orange County	6,575	16,854	147,790,232	79	$ 2,413
Placer County	2,010	4,203	34,143,785	68	$ 798
Plumas County	705	1,411	9,090,224	72	$ 163
Riverside County	7,732	17,619	161,162,595	71	$ 3,564
Sacramento County	5,053	11,285	95,918,441	62	$ 2,813
San Benito County	452	916	5,951,814	46	$ 246

County (Cities included)	Center Line Miles	Lane Miles	Area (sq. yd.)	2016 PCI	10 Year Needs (2016 $M)
San Bernardino County	8,953	22,318	180,641,761	71	$ 3,902
San Diego County	7,787	18,831	170,727,319	65	$ 4,795
San Francisco County	941	2,140	21,224,769	68	$ 516
San Joaquin County	3,229	6,795	61,416,088	70	$ 1,390
San Luis Obispo County	1,848	3,850	30,096,673	63	$ 804
San Mateo County	1,866	3,905	33,069,272	71	$ 723
Santa Barbara County	1,596	3,261	29,429,220	63	$ 845
Santa Clara County	4,661	10,463	97,789,614	67	$ 2,485
Santa Cruz County	873	1,788	14,190,208	50	$ 540
Shasta County	1,683	3,472	26,243,076	57	$ 816
Sierra County	399	800	5,566,517	44	$ 166
Siskiyou County	1,566	3,199	20,233,539	58	$ 547
Solano County	1,715	3,653	31,591,323	68	$ 741
Sonoma County	2,390	4,970	39,879,923	55	$ 1,384
Stanislaus County	2,916	6,020	52,993,373	55	$ 1,836
Sutter County	1,011	2,041	16,410,771	70	$ 346
Tehama County	1,197	2,401	15,479,180	53	$ 511
Trinity County	693	1,114	11,757,354	62	$ 309
Tulare County	3,931	8,119	60,118,041	60	$ 1,783
Tuolumne County	558	1,110	8,214,336	41	$ 379
Ventura County	2,505	6,085	52,631,737	71	$ 1,181
Yolo County	1,329	2,457	21,137,105	55	$ 696
Yuba County	724	1,504	12,862,584	60	$ 374
California	**143,850**	**324,662**	**2,718,553,544**	**65**	**$ 70,047**

* Includes Cities within County

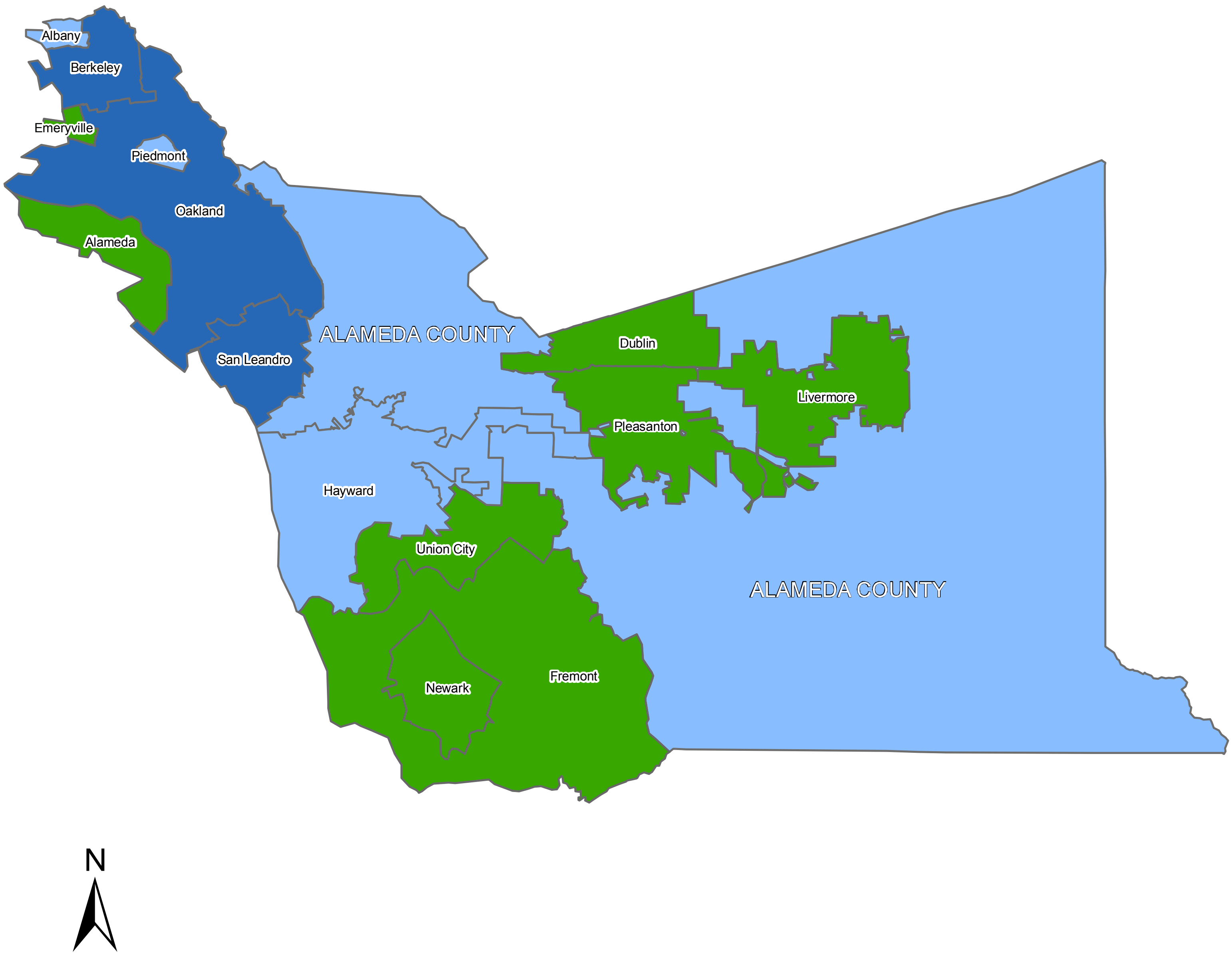

Pavement Condition Index
86 - 100 (Excellent)
71 - 86 (Good)
50 - 70 (At Risk)
0 - 49 (Poor)
2016
Del Norte
Siskiyou
Modoc
Humboldt
Trinity
Shasta
Lassen
Tehama
Plumas
Mendocino
Glenn
Butte
Sierra
Lake
Colusa
Sutter
Yuba
Nevada
Placer
El Dorado
Yolo
Sonoma
Napa
Alpine
Sacramento
Amador
Solano
Calaveras
Marin
San Joaquin
Tuolumne
Mono
Contra Costa
San Francisco
Alameda
Stanislaus
Mariposa
San Mateo
Santa Clara
Merced
Madera
Santa Cruz
San Benito
Fresno
Inyo
Tulare
Monterey
Kings
San Luis Obispo
Kern
San Bernardino
Santa Barbara
Ventura
Los Angeles
Orange
Riverside
San Diego
Imperial


Pavement Needs (10-Years)
Up to $500M
$500M - $1.0B
$1.0B - $1.5B
$1.5B - $2.0B
Greater than $2.0B
2016
Del Norte
Siskiyou
Modoc
Humboldt
Trinity
Shasta
Lassen
Tehama
Plumas
Mendocino
Glenn
Butte
Sierra
Lake
Colusa
Sutter
Yuba
Nevada
Placer
El Dorado
Yolo
Sonoma
Napa
Sacramento
Amador
Alpine
Solano
Calaveras
Marin
Tuolumne
Mono
San Joaquin
Contra Costa
San Francisco
Alameda
Stanislaus
Mariposa
San Mateo
Santa Clara
Merced
Madera
Santa Cruz
Fresno
San Benito
Inyo
Tulare
Monterey
Kings
Kern
San Luis Obispo
San Bernardino
Santa Barbara
Ventura
Los Angeles
Orange
Riverside
San Diego
Imperial



Percent of Pavement Needs Met (10-Years)
Greater than 80%
60% - 80%
40% - 60%
20% - 40%
Less than 20%
Del Norte
Siskiyou
Modoc
Humboldt
Trinity
Shasta
Lassen
Tehama
Plumas
Glenn
Butte
Sierra
Mendocino
Lake
Colusa
Sutter
Yuba
Nevada
Placer
Yolo
El Dorado
Sonoma
Napa
Solano
Sacramento
Amador
Alpine
Marin
Calaveras
Tuolumne
San Joaquin
Contra Costa
Mono
San Francisco
Alameda
Stanislaus
Mariposa
San Mateo
Santa Clara
Merced
Madera
Santa Cruz
San Benito
Fresno
Inyo
Tulare
Monterey
Kings
San Luis Obispo
Kern
San Bernardino
Santa Barbara
Ventura
Los Angeles
Orange
Riverside
San Diego
Imperial
2016

Alameda County

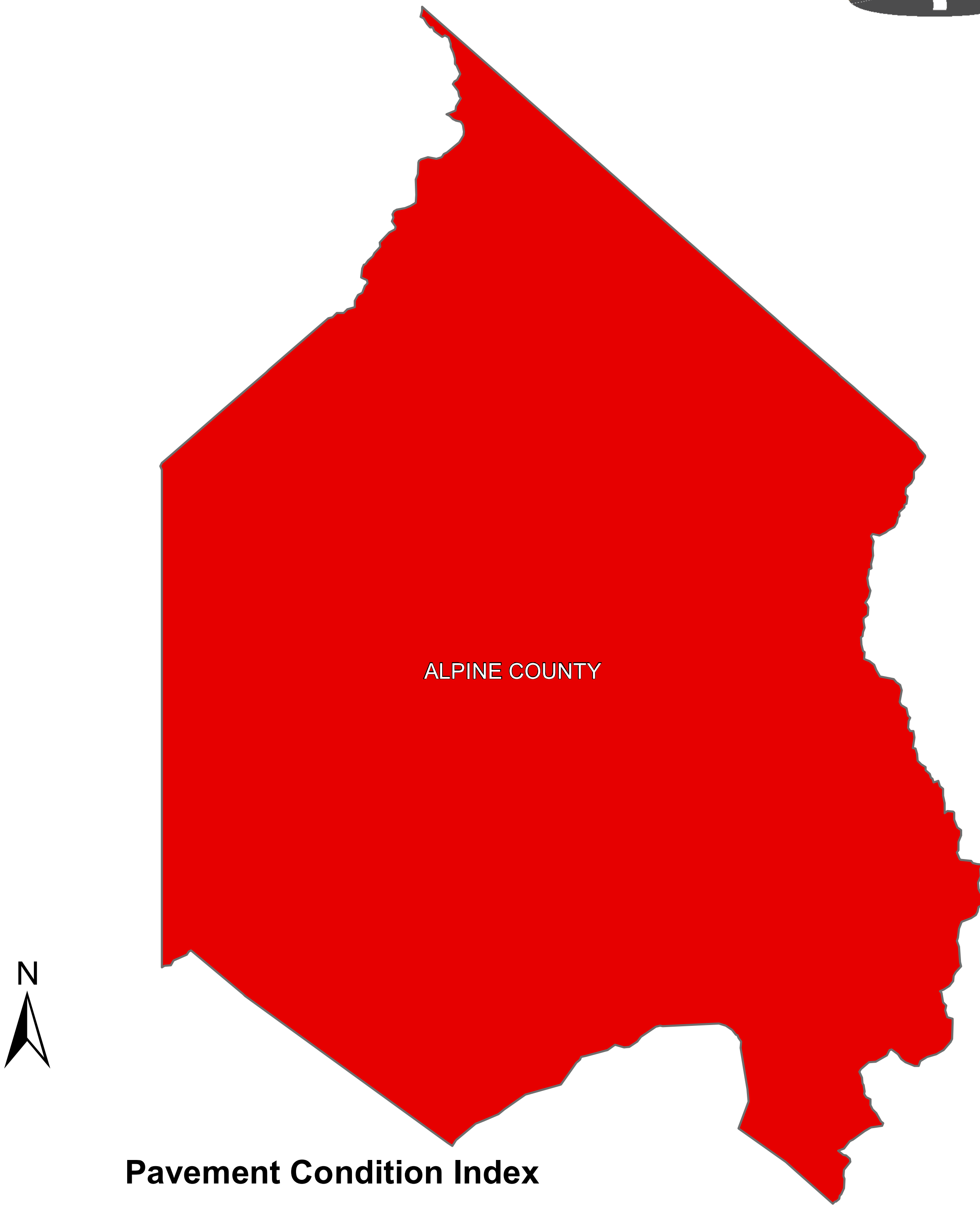


Pavement Condition Index

Reported	Estimated
Good (71-100)	Good (71-100)
At Lower Risk (61-70)	At Lower Risk (61-70)
At Higher Risk (50-60)	At Higher Risk (50-60)
Poor (0-49)	Poor (0-49)

Boundaries represent incorporated city limits from U.S. Census data and are approximate in shape and area.

Alpine County

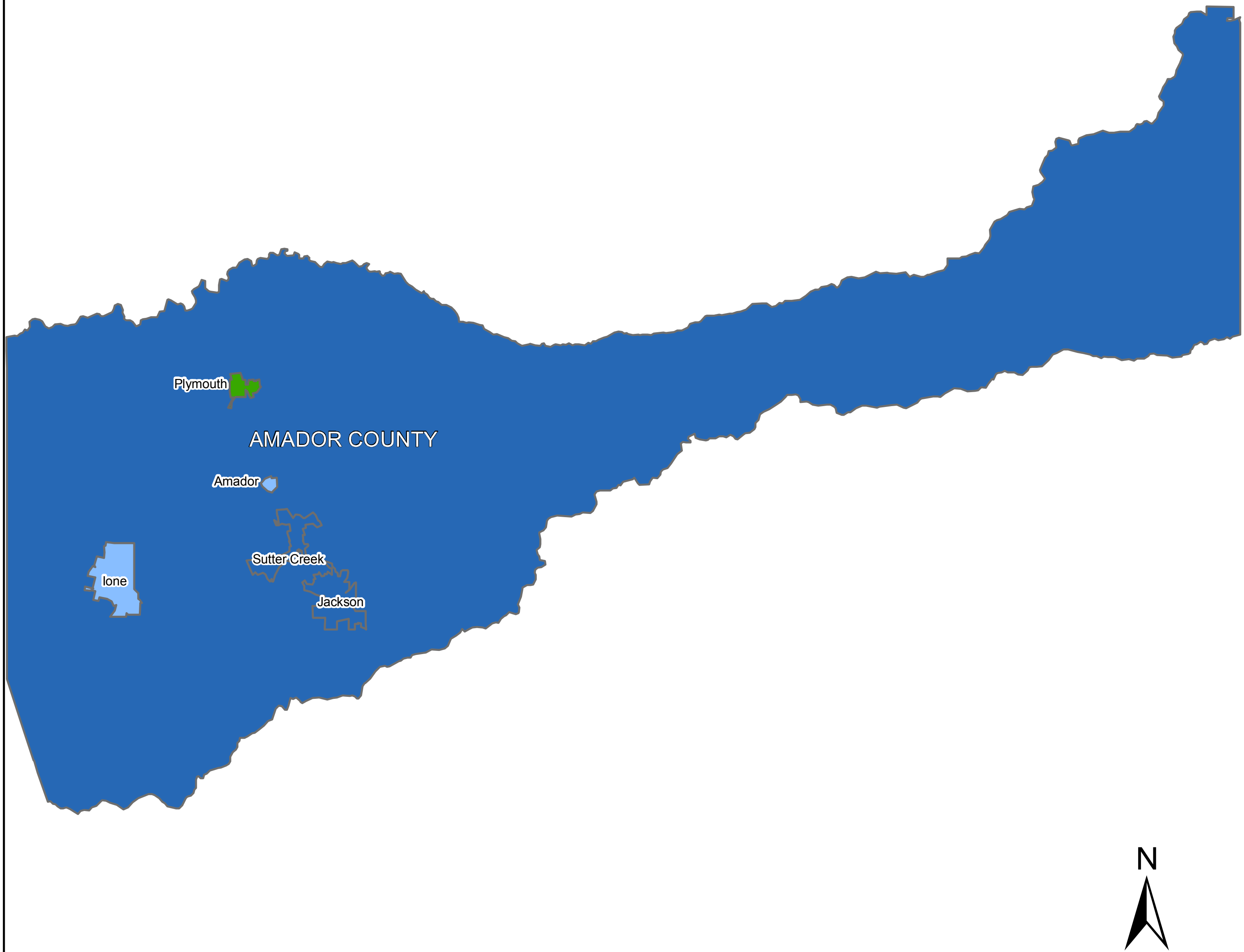


Pavement Condition Index

Reported
- Good (71-100)
- At Lower Risk (61-70)
- At Higher Risk (50-60)
- Poor (0-49)

Estimated
- Good (71-100)
- At Lower Risk (61-70)
- At Higher Risk (50-60)
- Poor (0-49)

Amador County

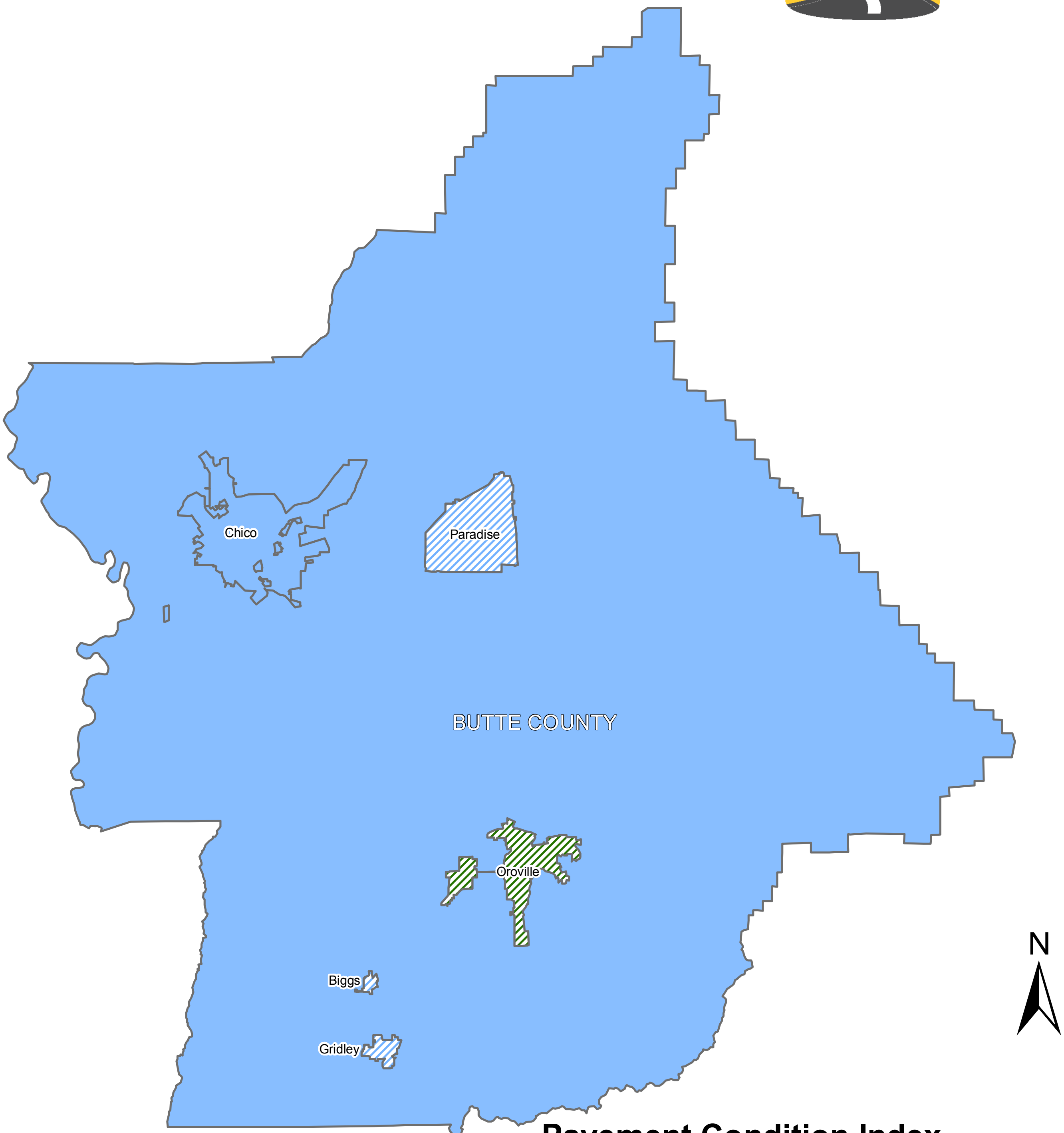


Pavement Condition Index

Reported	Estimated
Good (71-100)	Good (71-100)
At Lower Risk (61-70)	At Lower Risk (61-70)
At Higher Risk (50-60)	At Higher Risk (50-60)
Poor (0-49)	Poor (0-49)

NCE

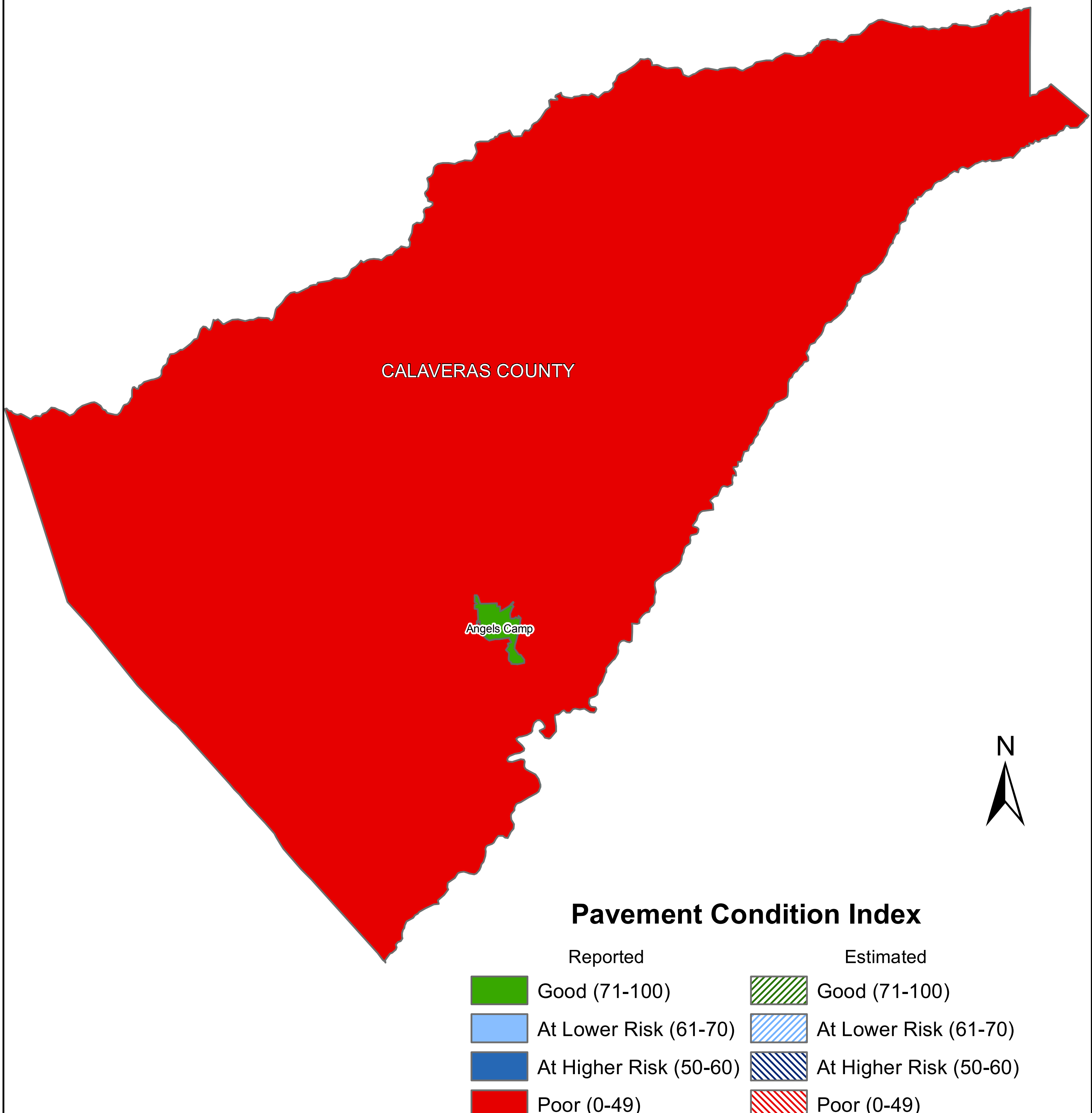
Butte County



Pavement Condition Index

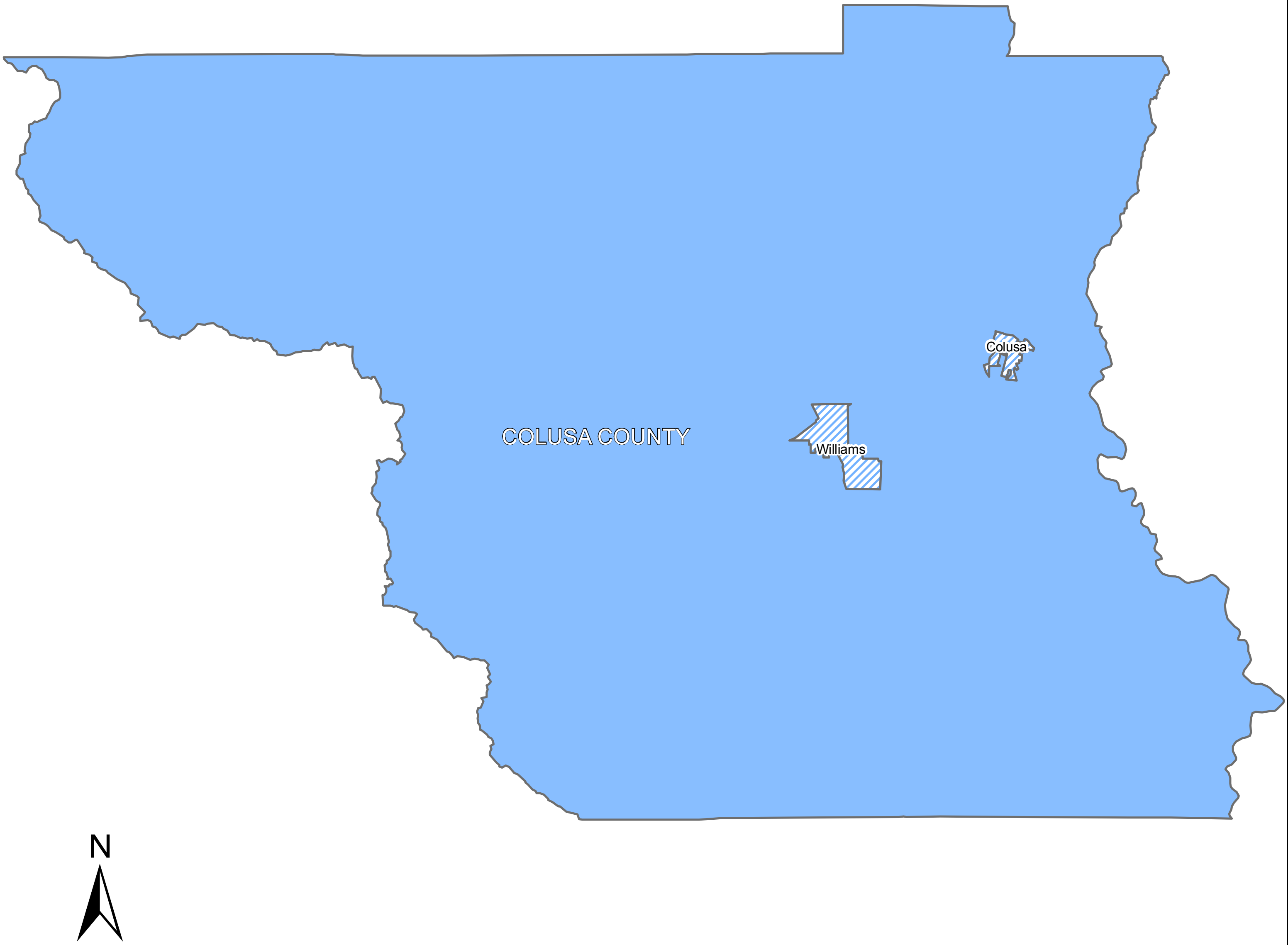
Reported	Estimated
Good (71-100)	Good (71-100)
At Lower Risk (61-70)	At Lower Risk (61-70)
At Higher Risk (50-60)	At Higher Risk (50-60)
Poor (0-49)	Poor (0-49)

Calaveras County



Boundaries represent incorporated city limits from U.S. Census data and are approximate in shape and area.

Colusa County



Pavement Condition Index

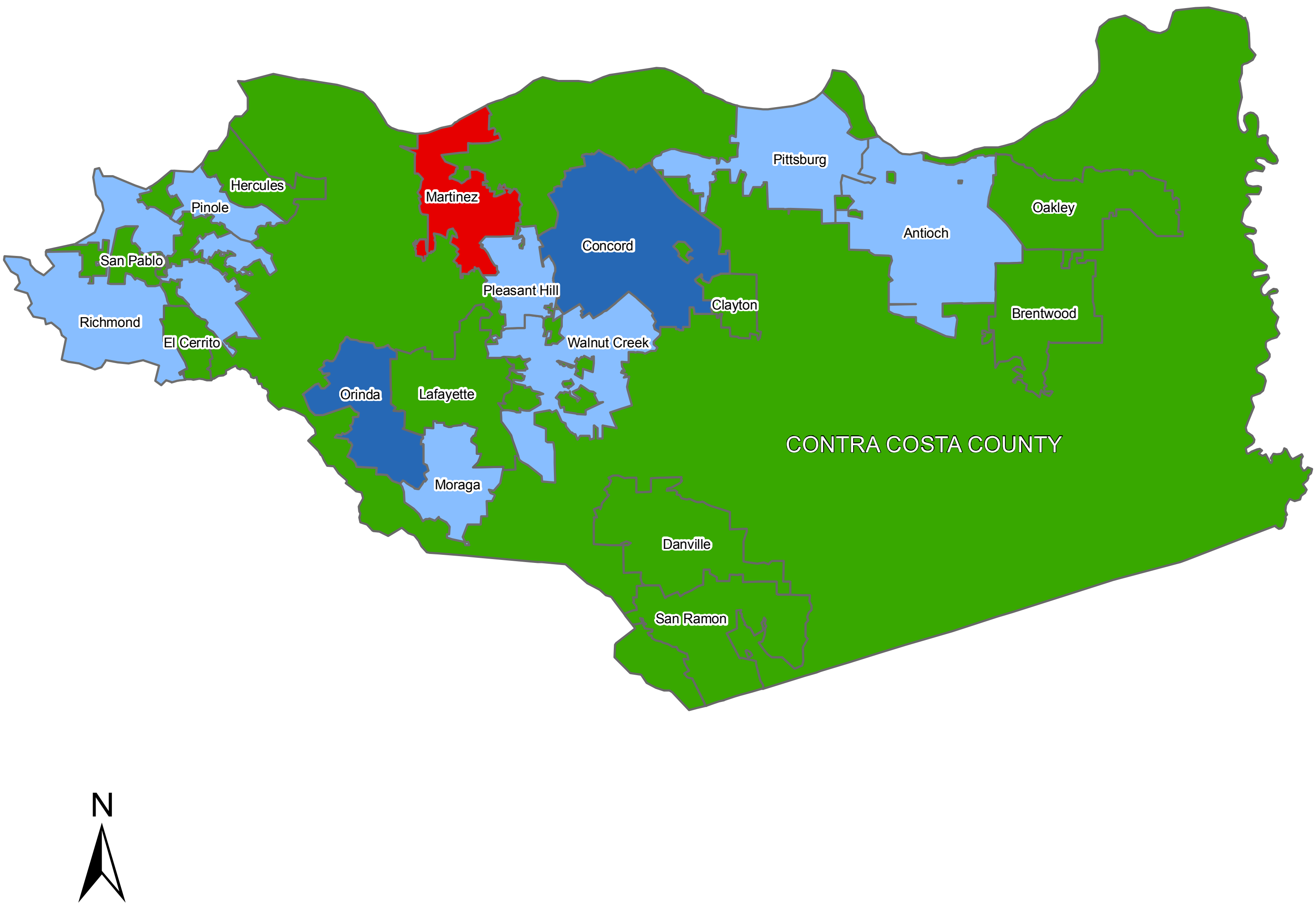
Reported	Estimated
Good (71-100)	Good (71-100)
At Lower Risk (61-70)	At Lower Risk (61-70)
At Higher Risk (50-60)	At Higher Risk (50-60)
Poor (0-49)	Poor (0-49)

NCE

Boundaries represent incorporated city limits from U.S. Census data and are approximate in shape and area.

Contra Costa County

SAVE CALIFORNIA STREETS

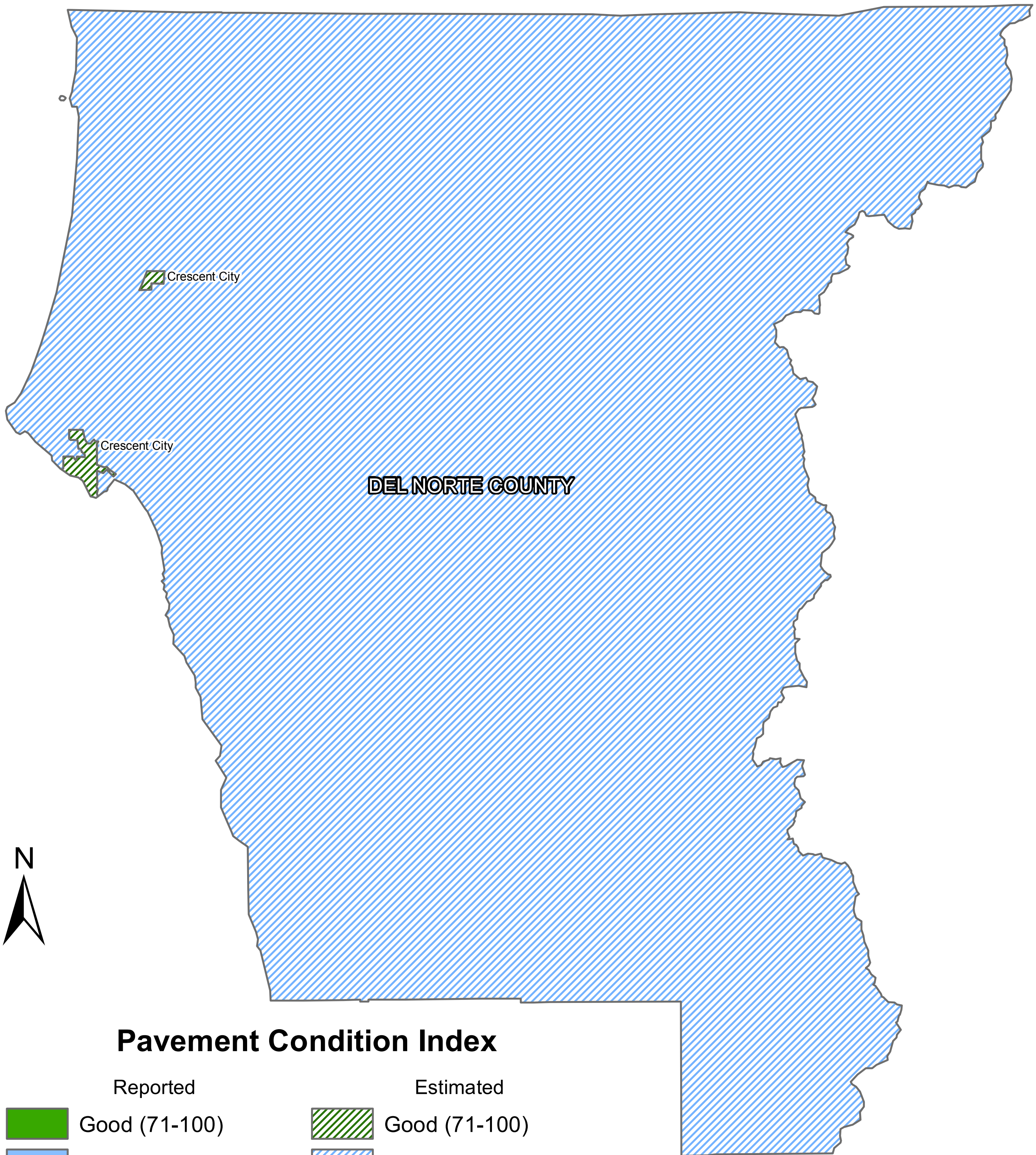


Pavement Condition Index

Reported	Estimated
Good (71-100)	Good (71-100)
At Lower Risk (61-70)	At Lower Risk (61-70)
At Higher Risk (50-60)	At Higher Risk (50-60)
Poor (0-49)	Poor (0-49)

NCE

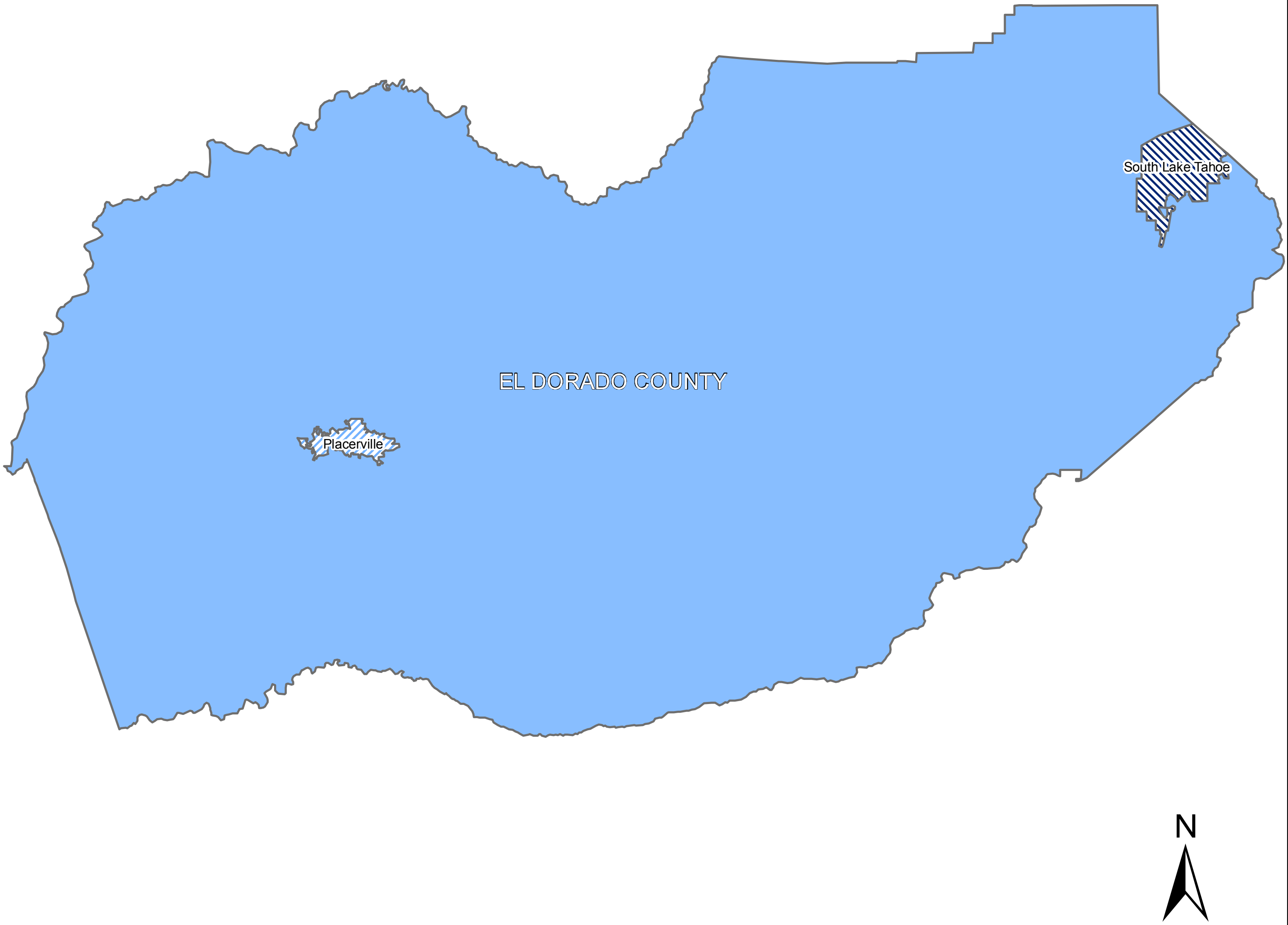
Del Norte County



Pavement Condition Index

Reported	Estimated
Good (71-100)	Good (71-100)
At Lower Risk (61-70)	At Lower Risk (61-70)
At Higher Risk (50-60)	At Higher Risk (50-60)
Poor (0-49)	Poor (0-49)

El Dorado County



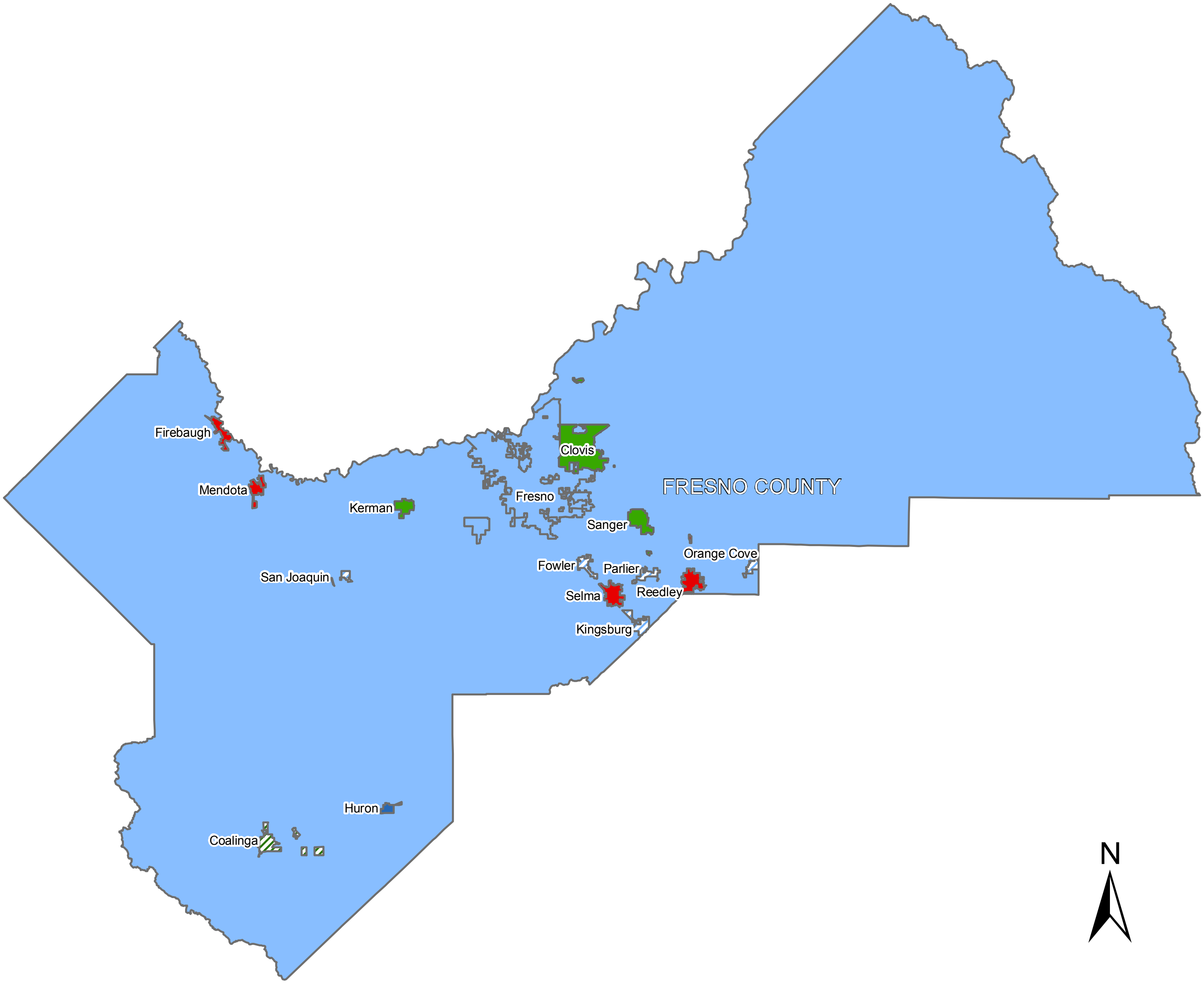
Pavement Condition Index

Reported	Estimated
Good (71-100)	Good (71-100)
At Lower Risk (61-70)	At Lower Risk (61-70)
At Higher Risk (50-60)	At Higher Risk (50-60)
Poor (0-49)	Poor (0-49)

NCE

Boundaries represent incorporated city limits from U.S. Census data and are approximate in shape and area.

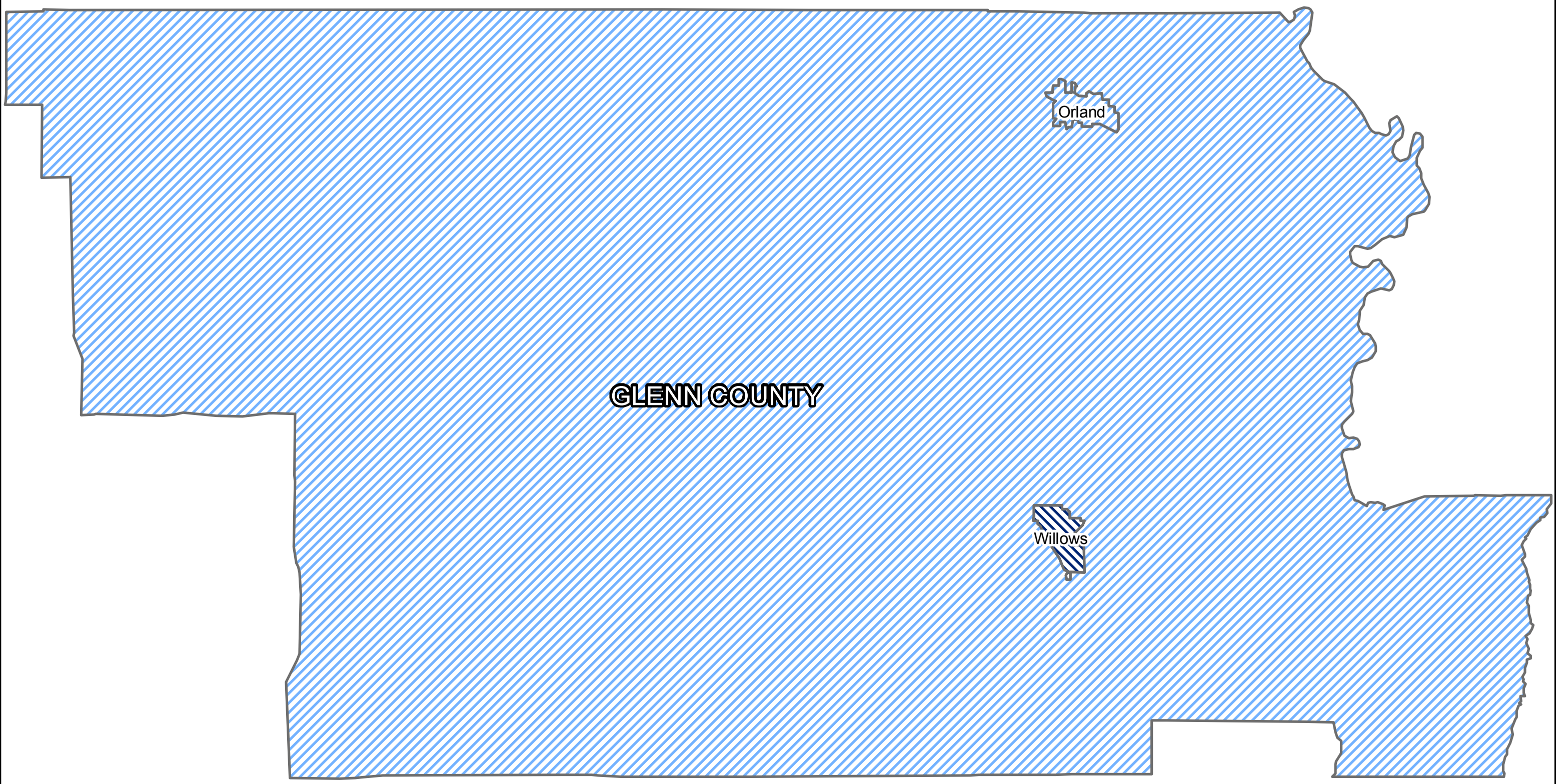
Fresno County



Pavement Condition Index

Reported	Estimated
Good (71-100)	Good (71-100)
At Lower Risk (61-70)	At Lower Risk (61-70)
At Higher Risk (50-60)	At Higher Risk (50-60)
Poor (0-49)	Poor (0-49)

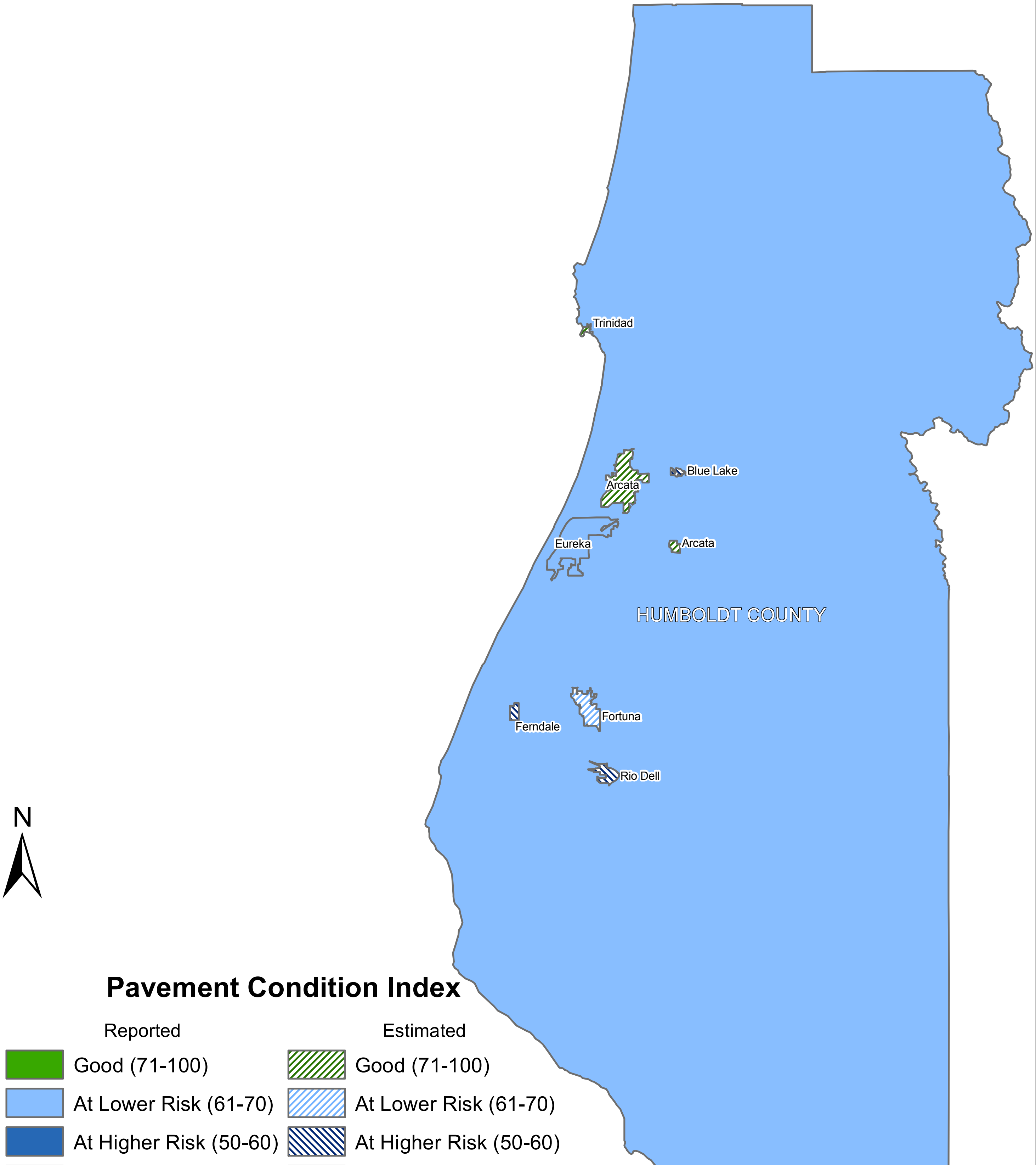
Glenn County



Pavement Condition Index

Reported	Estimated
Good (71-100)	Good (71-100)
At Lower Risk (61-70)	At Lower Risk (61-70)
At Higher Risk (50-60)	At Higher Risk (50-60)
Poor (0-49)	Poor (0-49)

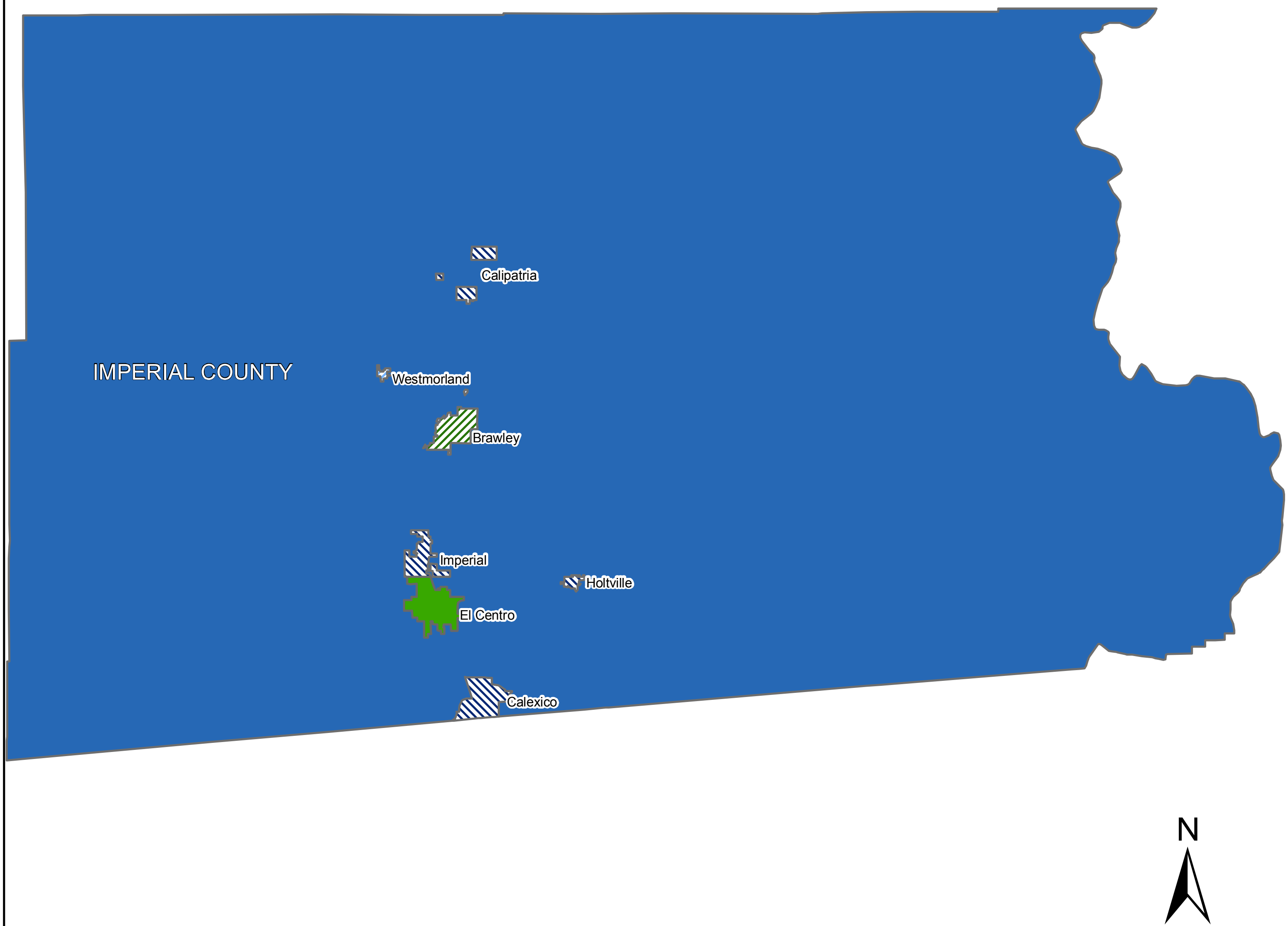
Humboldt County



Pavement Condition Index

Reported		Estimated	
(solid green)	Good (71-100)	(green hatched)	Good (71-100)
(solid light blue)	At Lower Risk (61-70)	(light blue hatched)	At Lower Risk (61-70)
(solid blue)	At Higher Risk (50-60)	(dark blue hatched)	At Higher Risk (50-60)
(solid red)	Poor (0-49)	(red hatched)	Poor (0-49)

Imperial County

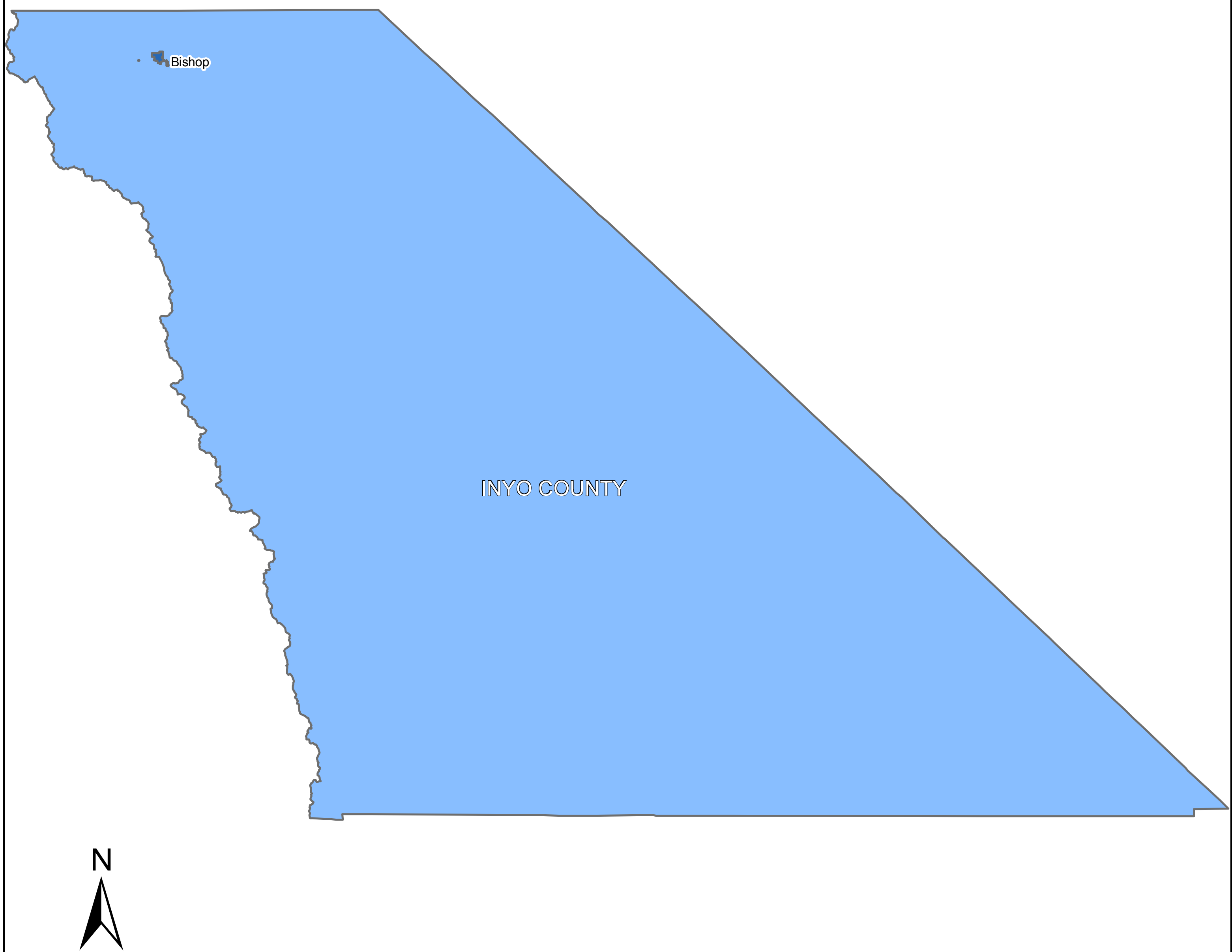


Pavement Condition Index

Reported		Estimated	
	Good (71-100)		Good (71-100)
	At Lower Risk (61-70)		At Lower Risk (61-70)
	At Higher Risk (50-60)		At Higher Risk (50-60)
	Poor (0-49)		Poor (0-49)

NCE

Inyo County

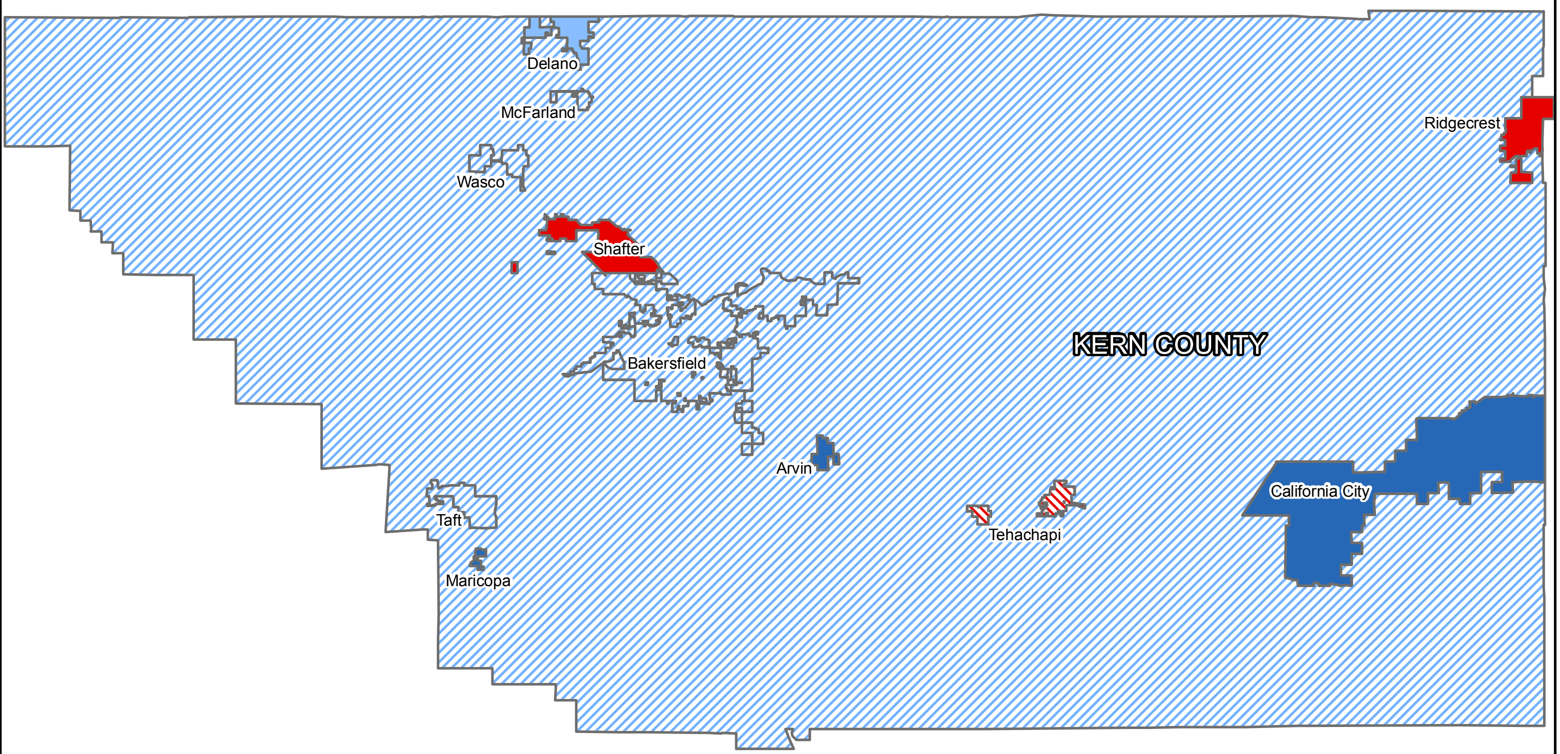


Pavement Condition Index

Reported	Estimated
Good (71-100)	Good (71-100)
At Lower Risk (61-70)	At Lower Risk (61-70)
At Higher Risk (50-60)	At Higher Risk (50-60)
Poor (0-49)	Poor (0-49)

Boundaries represent incorporated city limits from U.S. Census data and are approximate in shape and area.

Kern County



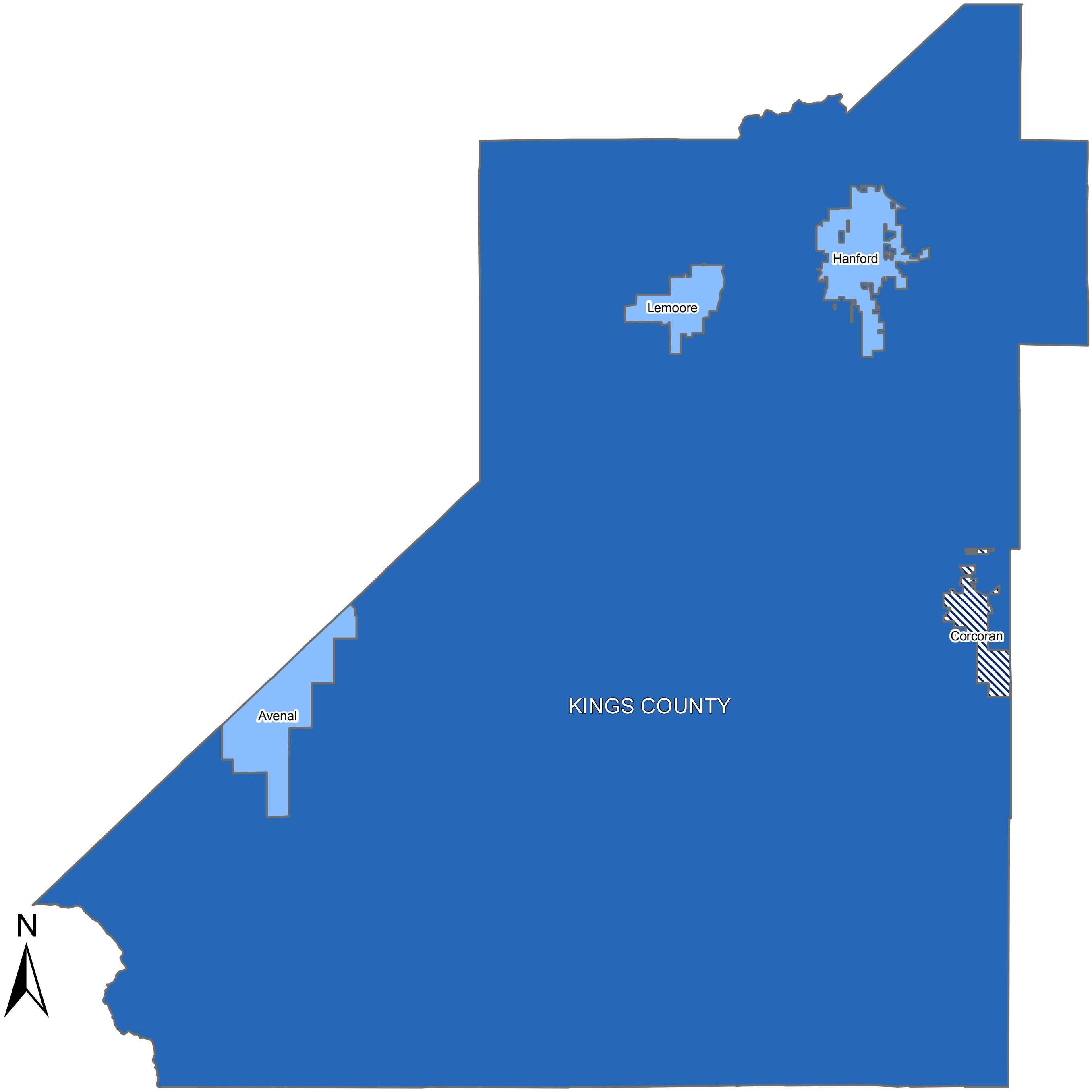
N

Pavement Condition Index

Reported	Estimated
Good (71-100)	Good (71-100)
At Lower Risk (61-70)	At Lower Risk (61-70)
At Higher Risk (50-60)	At Higher Risk (50-60)
Poor (0-49)	Poor (0-49)

Kings County

SAVE CALIFORNIA STREETS

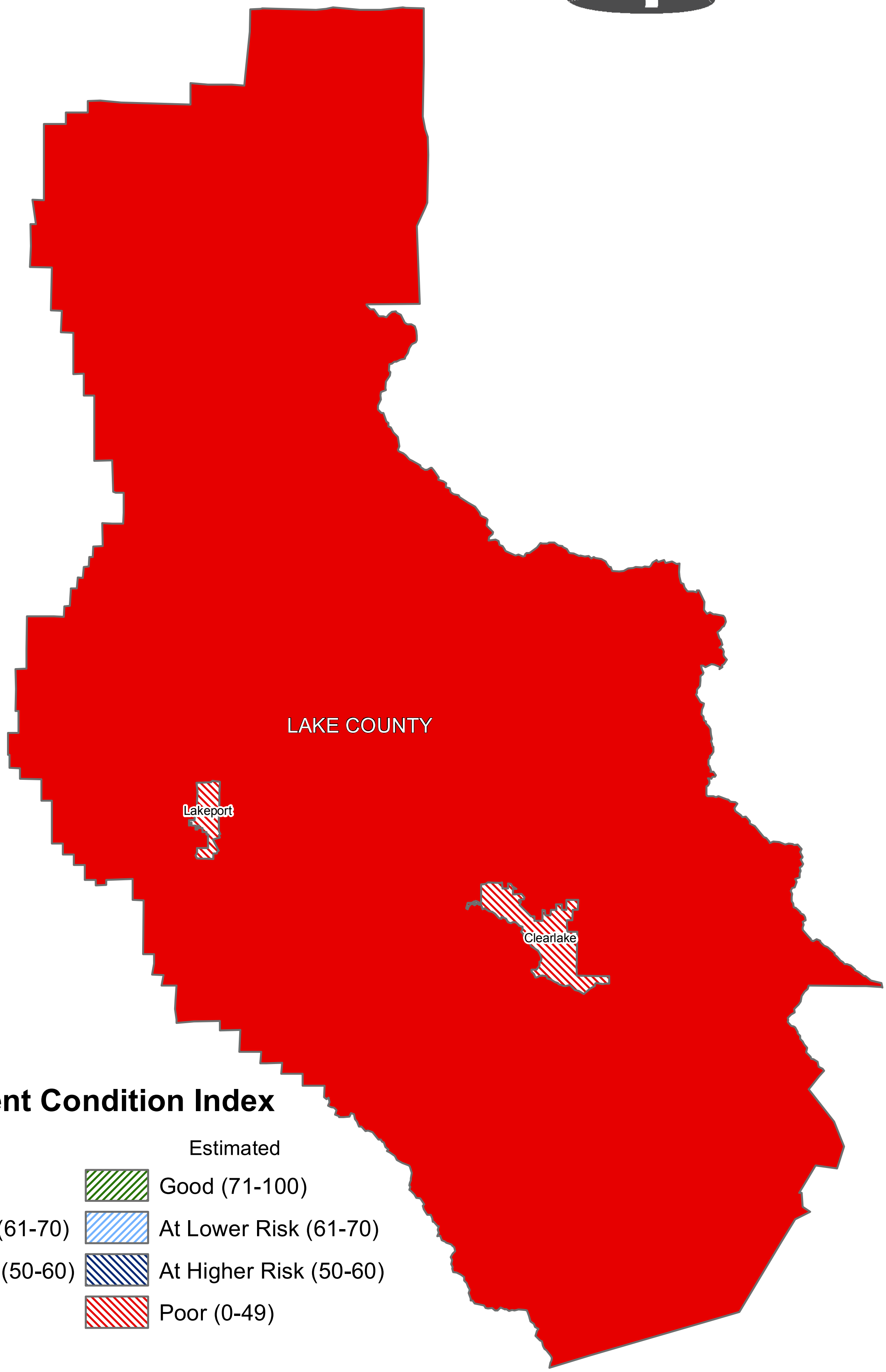


Pavement Condition Index

Reported	Estimated
Good (71-100)	Good (71-100)
At Lower Risk (61-70)	At Lower Risk (61-70)
At Higher Risk (50-60)	At Higher Risk (50-60)
Poor (0-49)	Poor (0-49)

NCE

Lake County

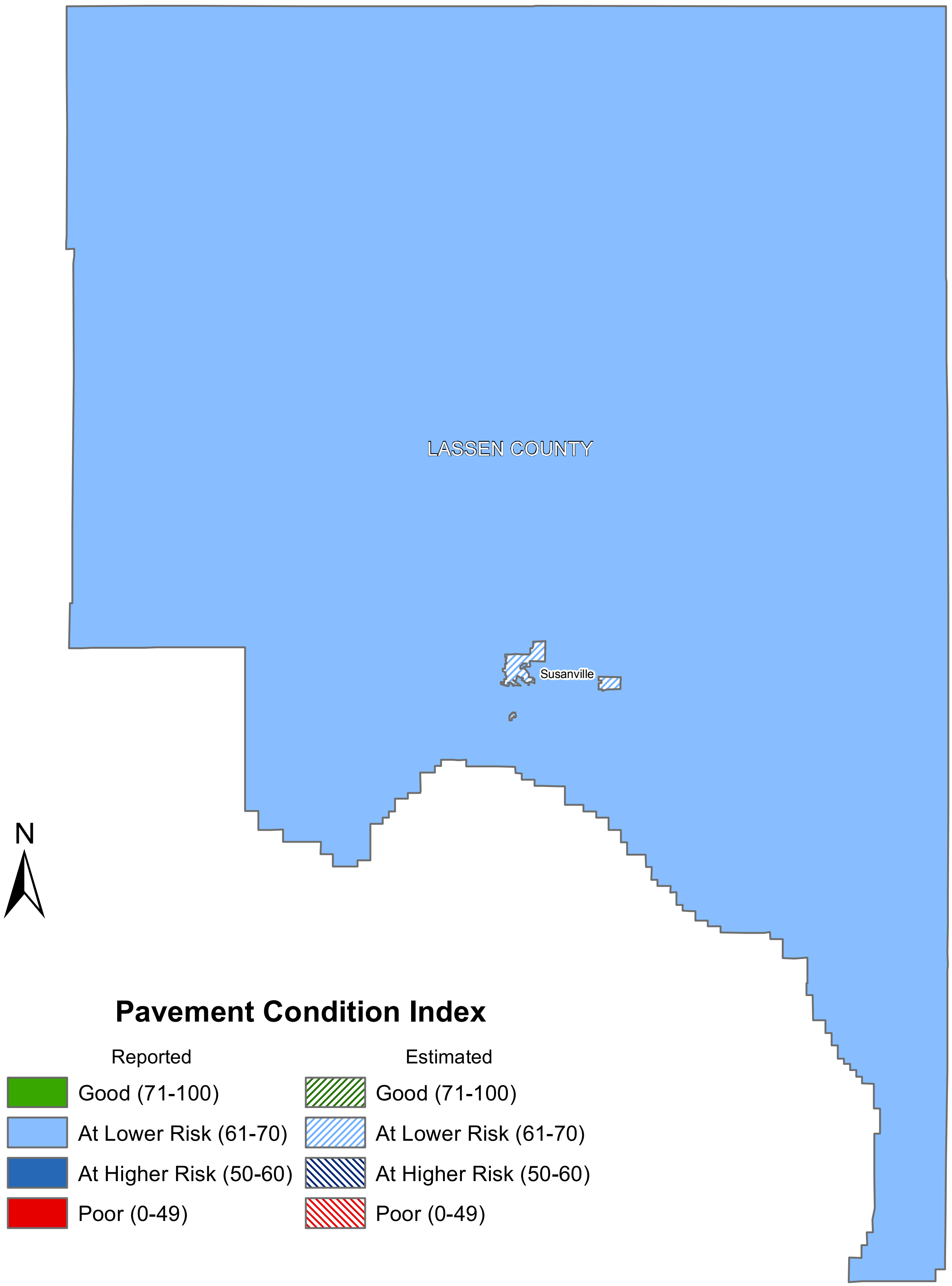


N

Pavement Condition Index

Reported	Estimated
Good (71-100)	Good (71-100)
At Lower Risk (61-70)	At Lower Risk (61-70)
At Higher Risk (50-60)	At Higher Risk (50-60)
Poor (0-49)	Poor (0-49)

Lassen County

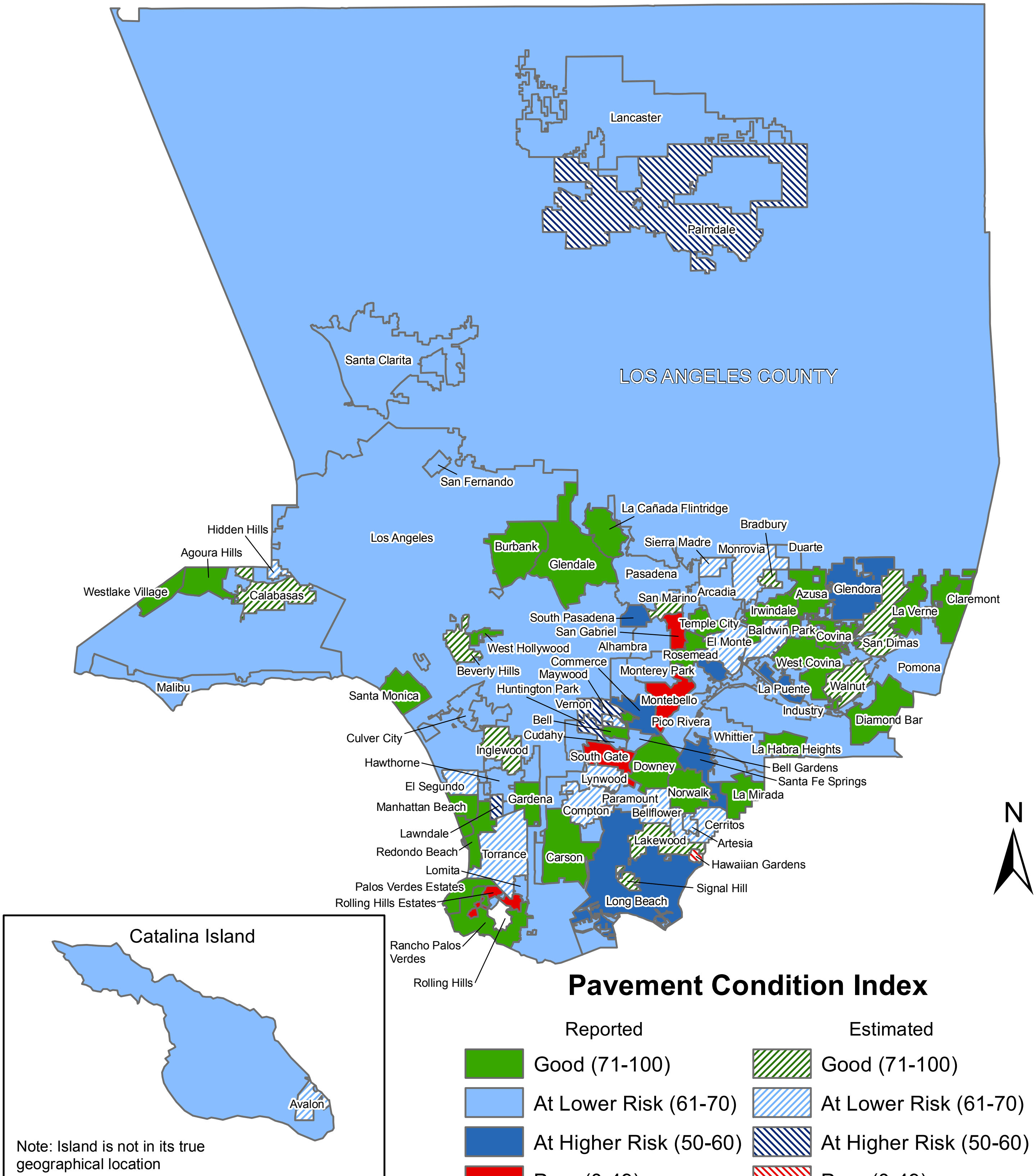


Pavement Condition Index

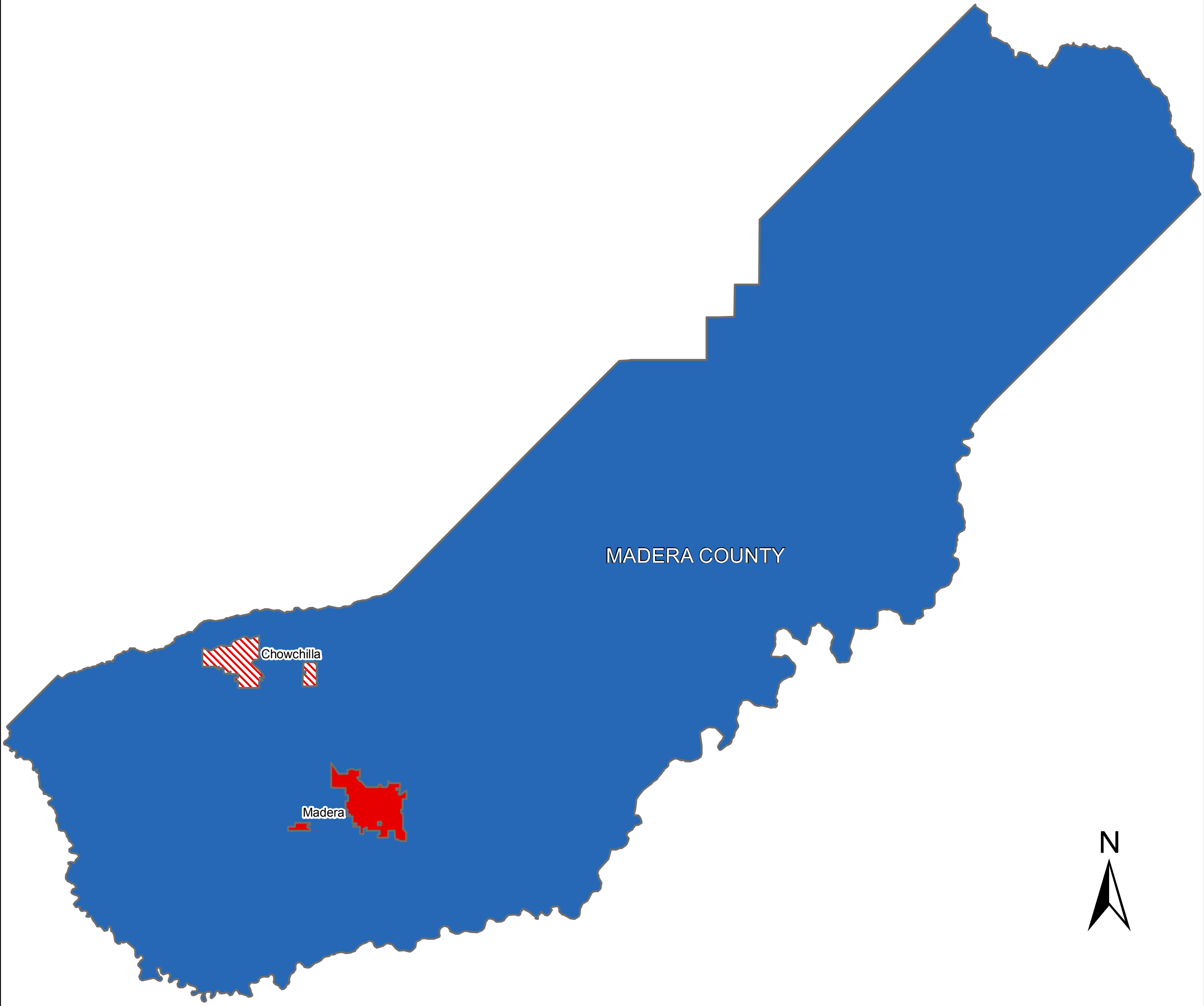
Reported	Estimated
Good (71-100)	Good (71-100)
At Lower Risk (61-70)	At Lower Risk (61-70)
At Higher Risk (50-60)	At Higher Risk (50-60)
Poor (0-49)	Poor (0-49)

Boundaries represent incorporated city limits from U.S. Census data and are approximate in shape and area.

Los Angeles County



Madera County

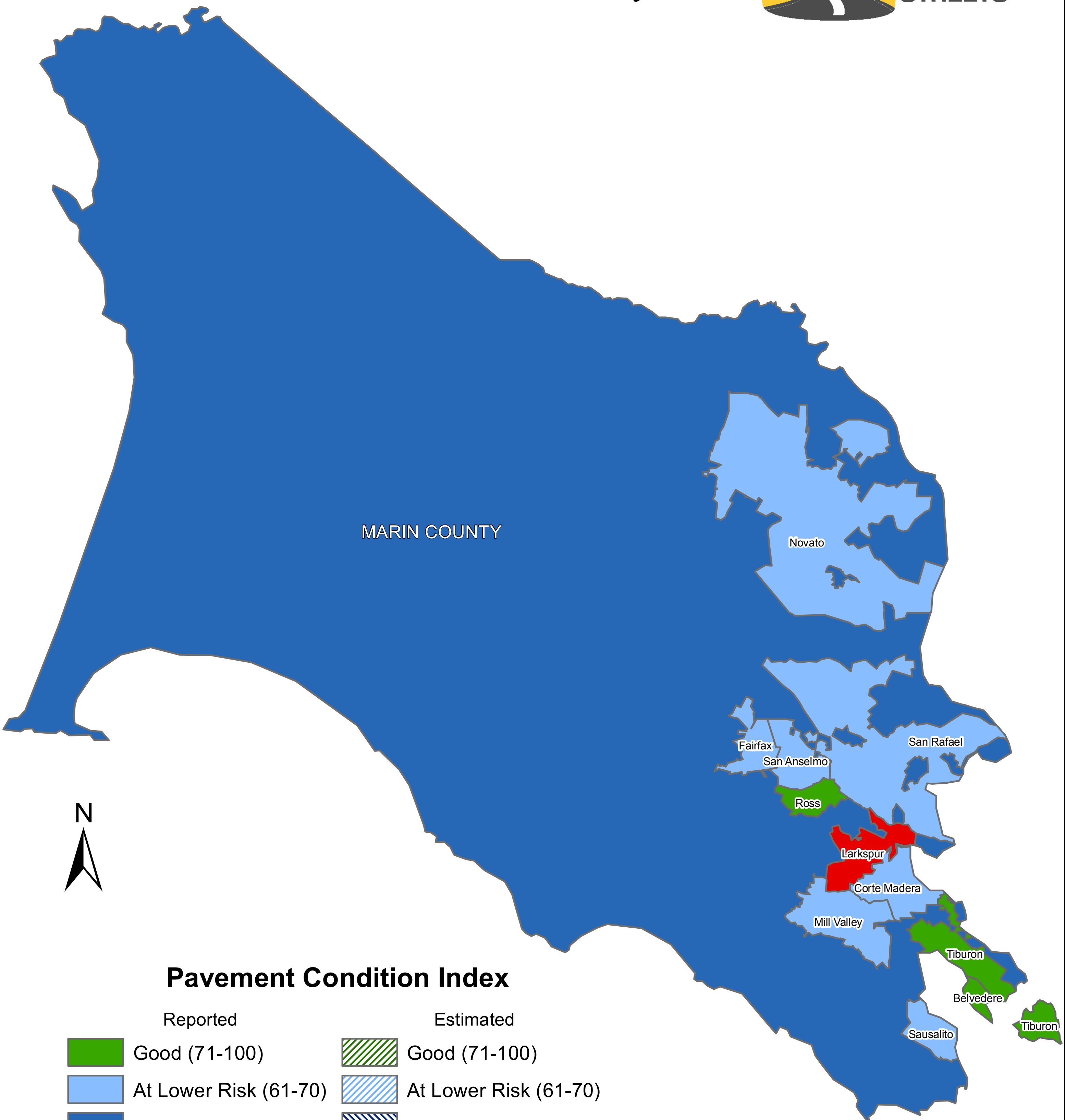


Pavement Condition Index

Reported	Estimated
Good (71-100)	Good (71-100)
At Lower Risk (61-70)	At Lower Risk (61-70)
At Higher Risk (50-60)	At Higher Risk (50-60)
Poor (0-49)	Poor (0-49)

Boundaries represent incorporated city limits from U.S. Census data and are approximate in shape and area.

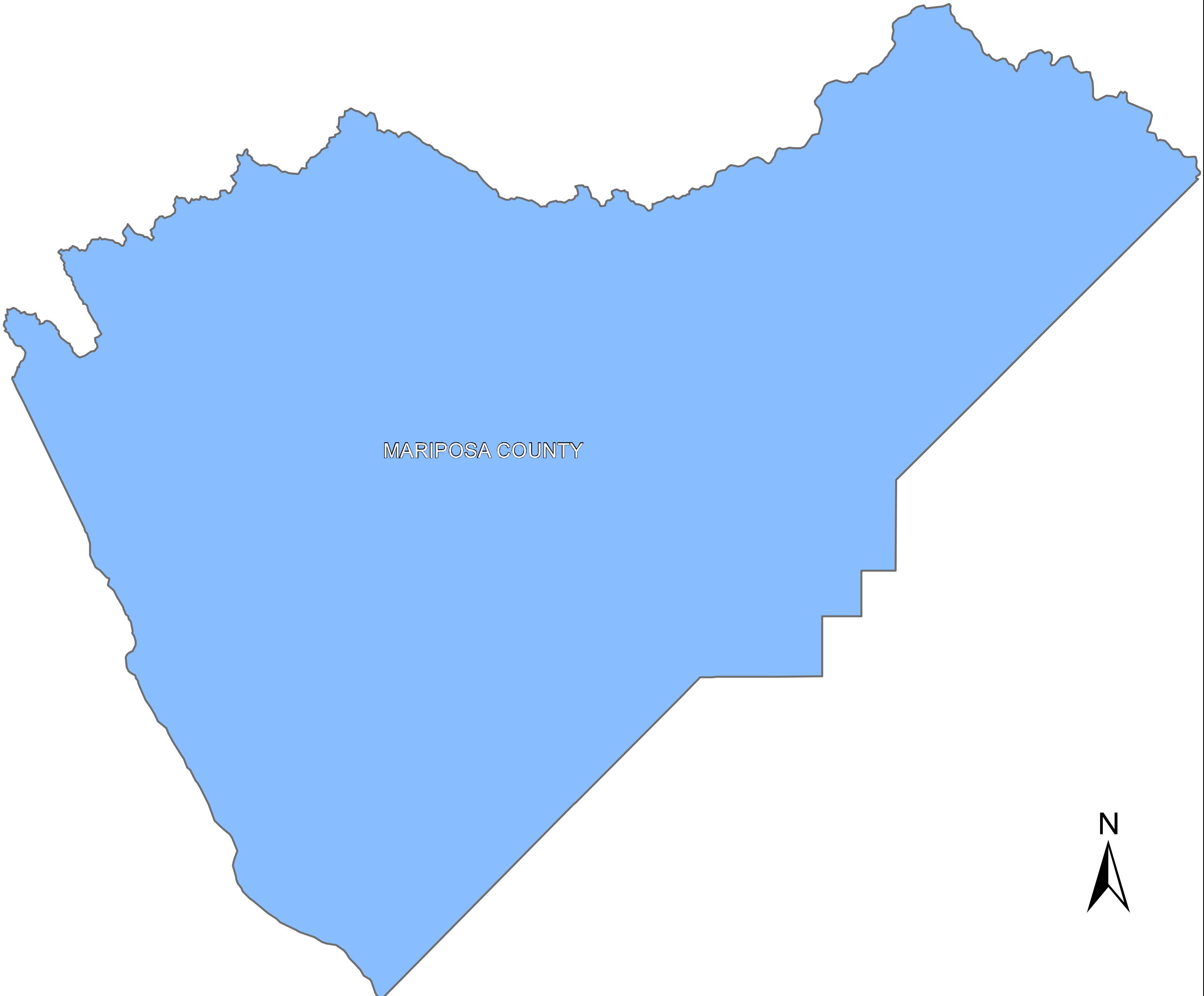
Marin County



Pavement Condition Index

Reported	Estimated
Good (71-100)	Good (71-100)
At Lower Risk (61-70)	At Lower Risk (61-70)
At Higher Risk (50-60)	At Higher Risk (50-60)
Poor (0-49)	Poor (0-49)

Mariposa County



Pavement Condition Index

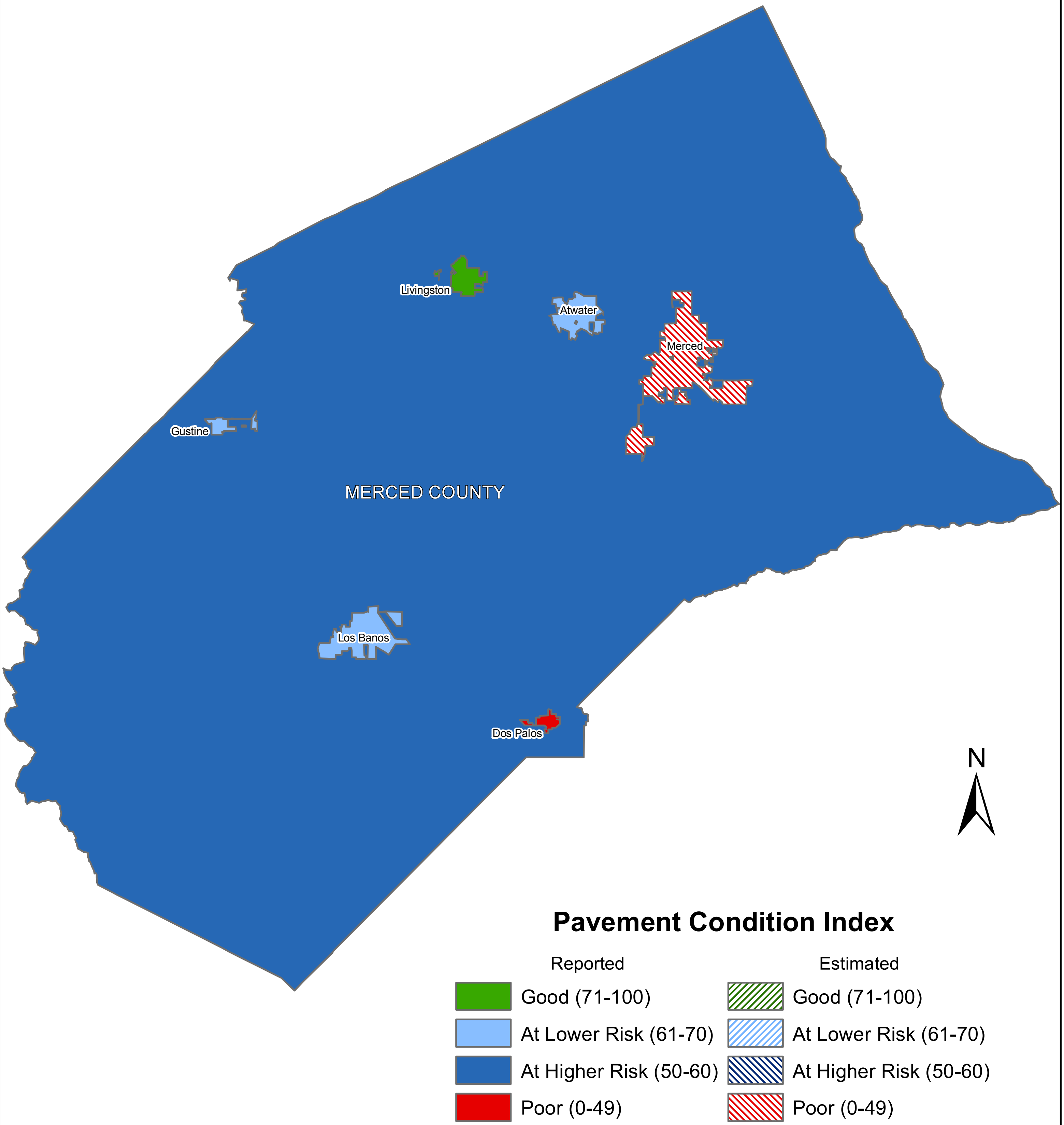
Reported	Estimated
Good (71-100)	Good (71-100)
At Lower Risk (61-70)	At Lower Risk (61-70)
At Higher Risk (50-60)	At Higher Risk (50-60)
Poor (0-49)	Poor (0-49)

Mendocino County

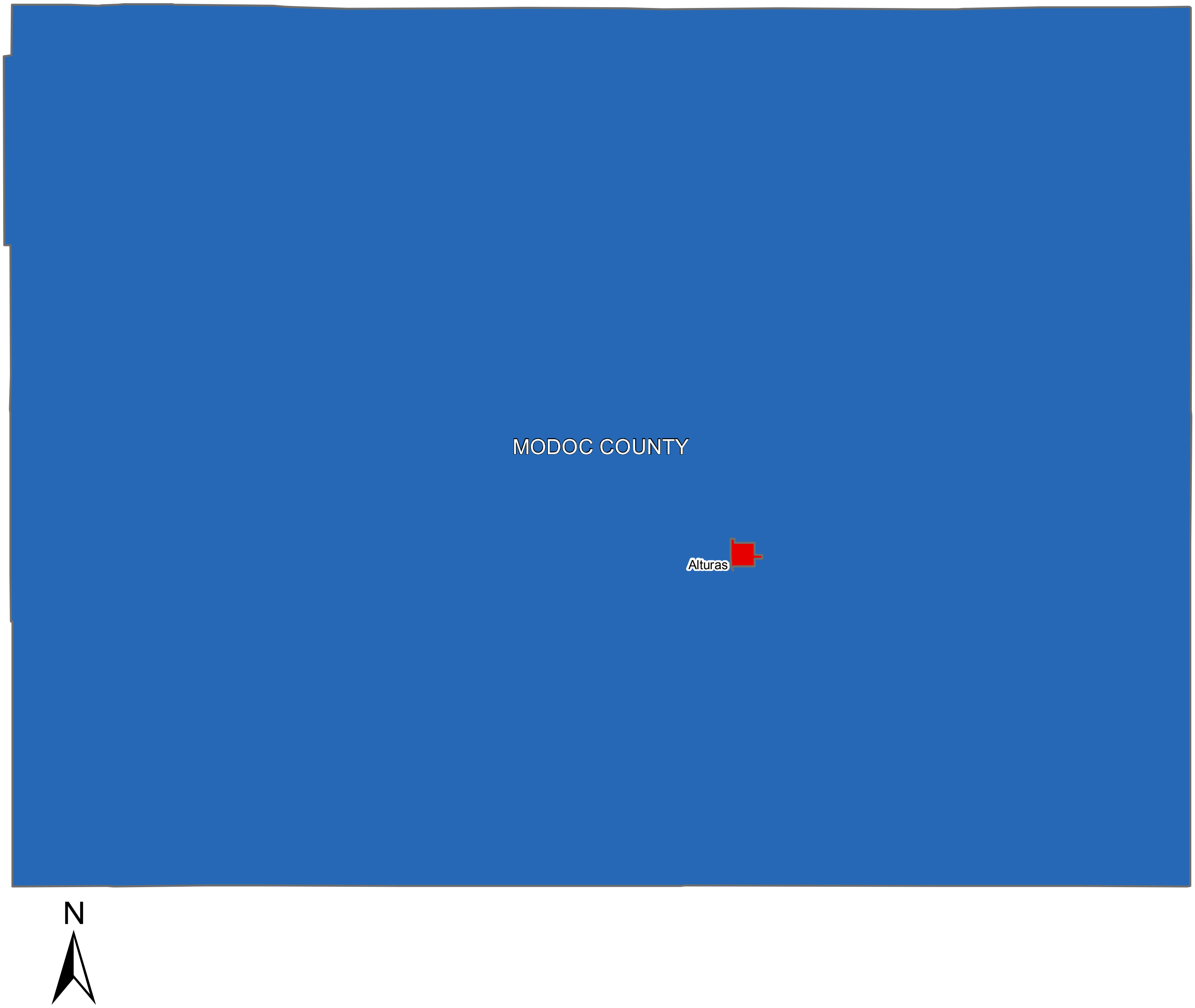
Pavement Condition Index

Reported	Estimated
Good (71-100)	Good (71-100)
At Lower Risk (61-70)	At Lower Risk (61-70)
At Higher Risk (50-60)	At Higher Risk (50-60)
Poor (0-49)	Poor (0-49)

Merced County



Modoc County

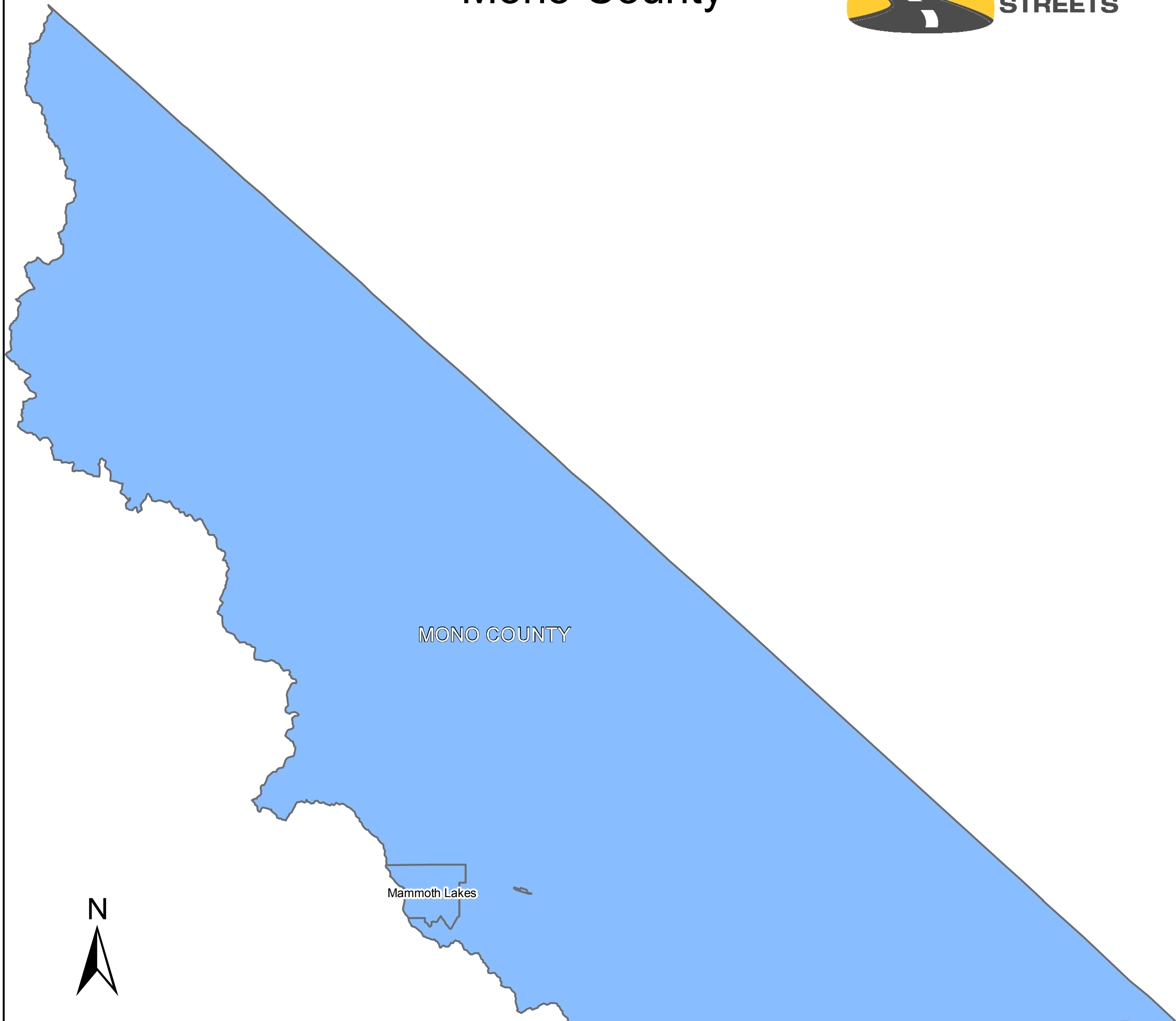


Pavement Condition Index

Reported	Estimated
Good (71-100)	Good (71-100)
At Lower Risk (61-70)	At Lower Risk (61-70)
At Higher Risk (50-60)	At Higher Risk (50-60)
Poor (0-49)	Poor (0-49)

NCE

Mono County

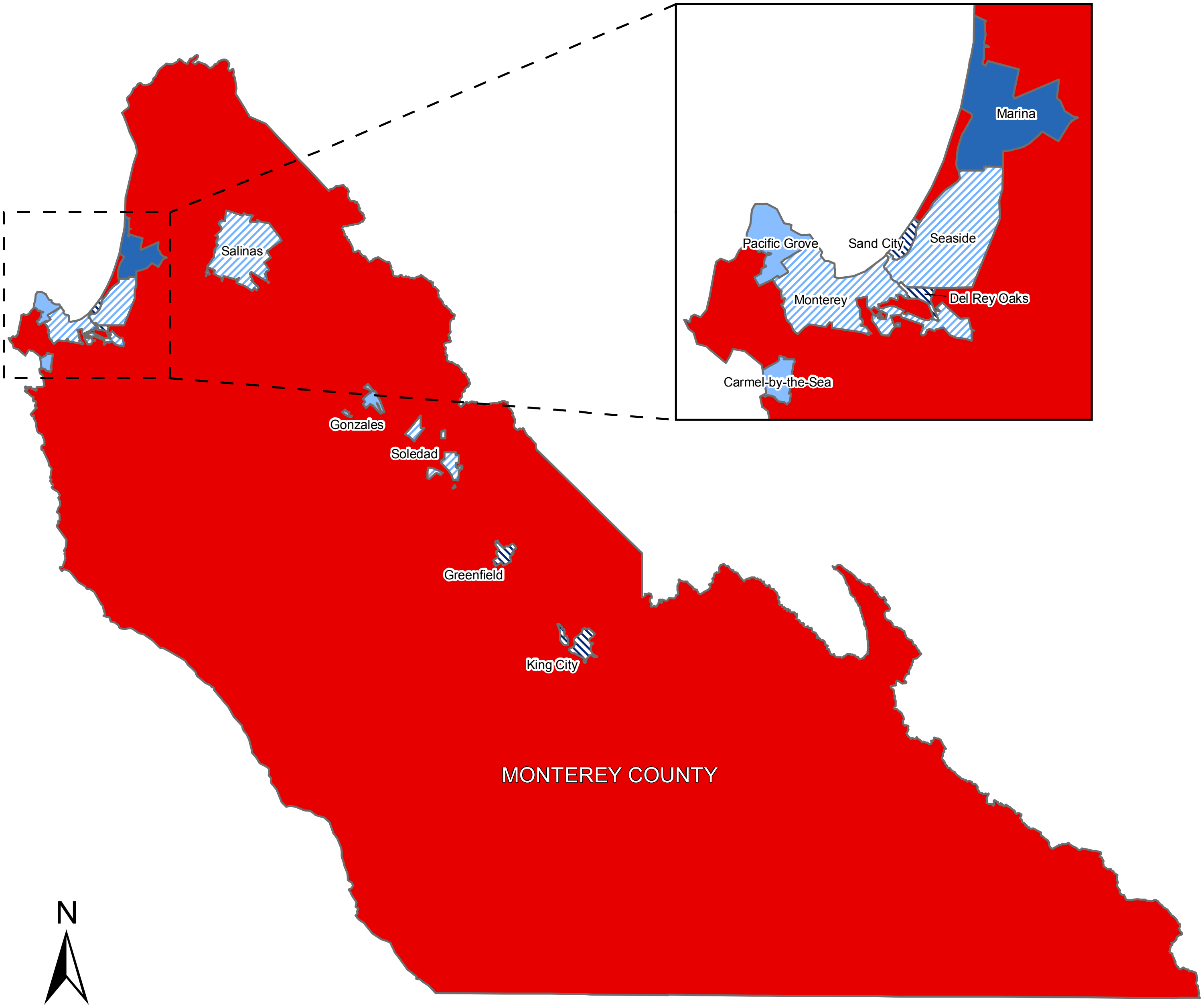


Pavement Condition Index

Reported	Estimated
Good (71-100)	Good (71-100)
At Lower Risk (61-70)	At Lower Risk (61-70)
At Higher Risk (50-60)	At Higher Risk (50-60)
Poor (0-49)	Poor (0-49)

Boundaries represent incorporated city limits from U.S. Census data and are approximate in shape and area.

Monterey County

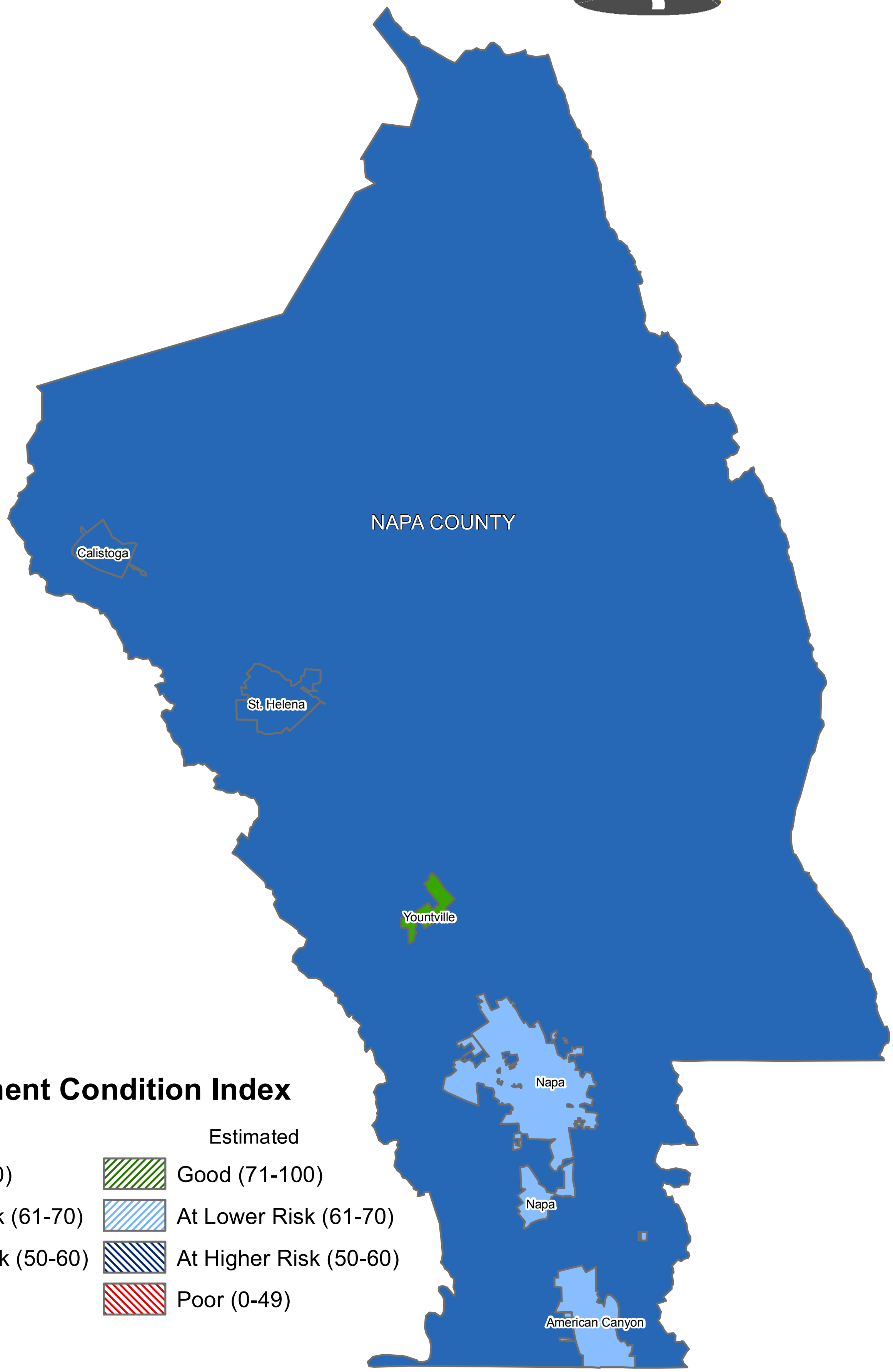


Pavement Condition Index

Reported	Estimated
Good (71-100)	Good (71-100)
At Lower Risk (61-70)	At Lower Risk (61-70)
At Higher Risk (50-60)	At Higher Risk (50-60)
Poor (0-49)	Poor (0-49)

Boundaries represent incorporated city limits from U.S. Census data and are approximate in shape and area.

Napa County



N

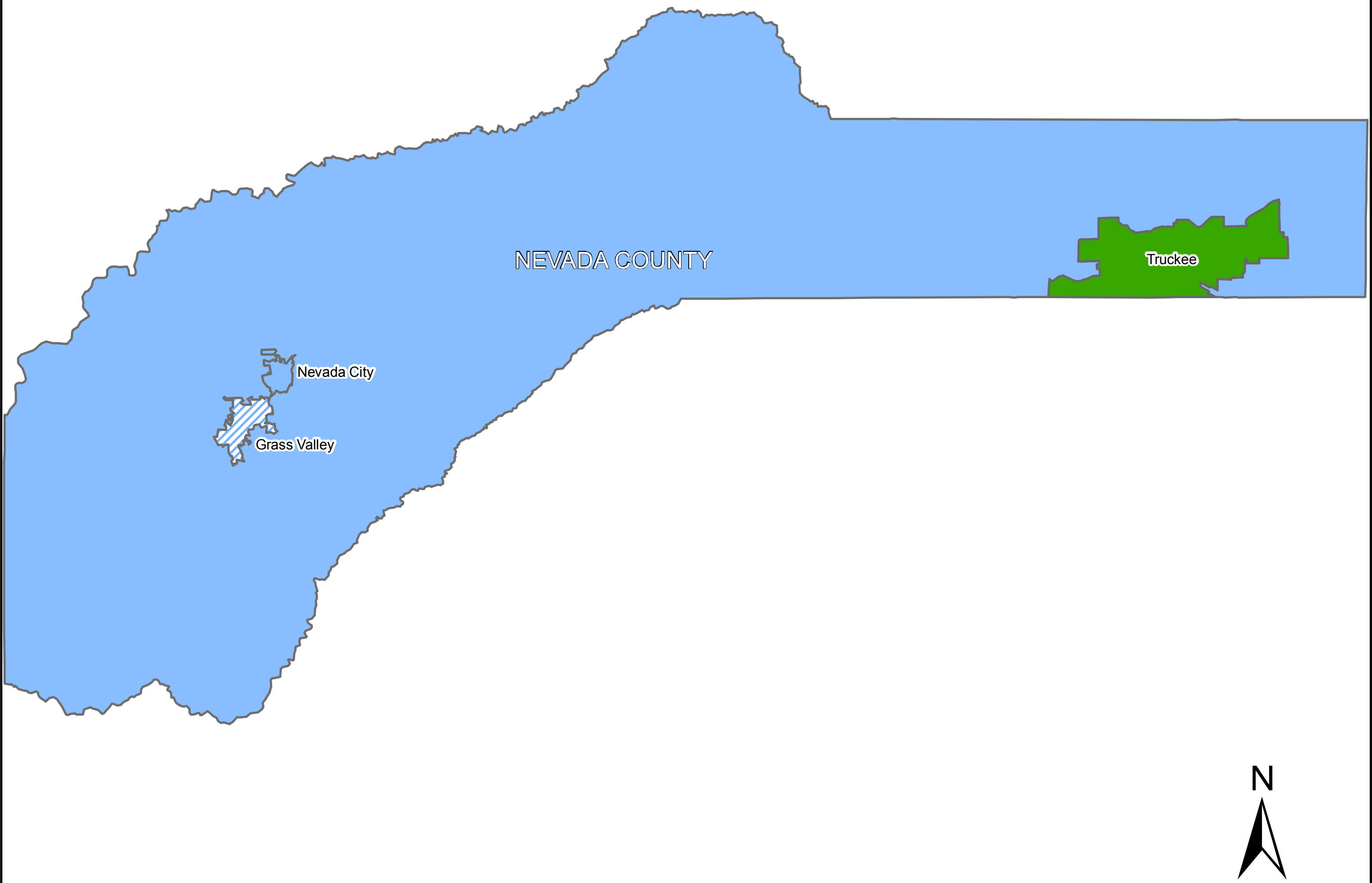
Pavement Condition Index

Reported	Estimated
Good (71-100)	Good (71-100)
At Lower Risk (61-70)	At Lower Risk (61-70)
At Higher Risk (50-60)	At Higher Risk (50-60)
Poor (0-49)	Poor (0-49)

Boundaries represent incorporated city limits from U.S. Census data and are approximate in shape and area.

Nevada County

SAVE CALIFORNIA STREETS



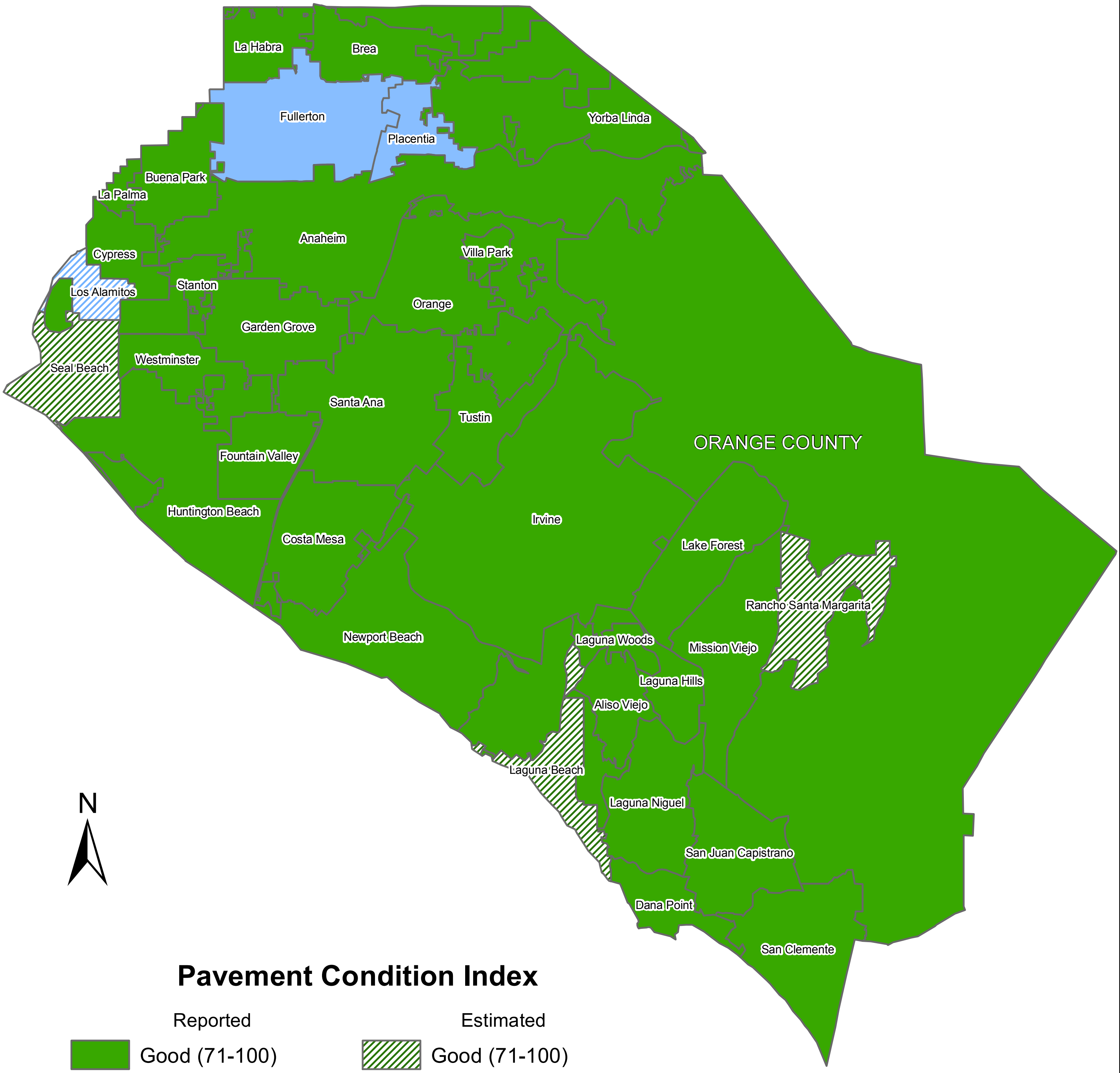
Pavement Condition Index

Reported	Estimated
Good (71-100)	Good (71-100)
At Lower Risk (61-70)	At Lower Risk (61-70)
At Higher Risk (50-60)	At Higher Risk (50-60)
Poor (0-49)	Poor (0-49)

NCE

Boundaries represent incorporated city limits from U.S. Census data and are approximate in shape and area.

Orange County

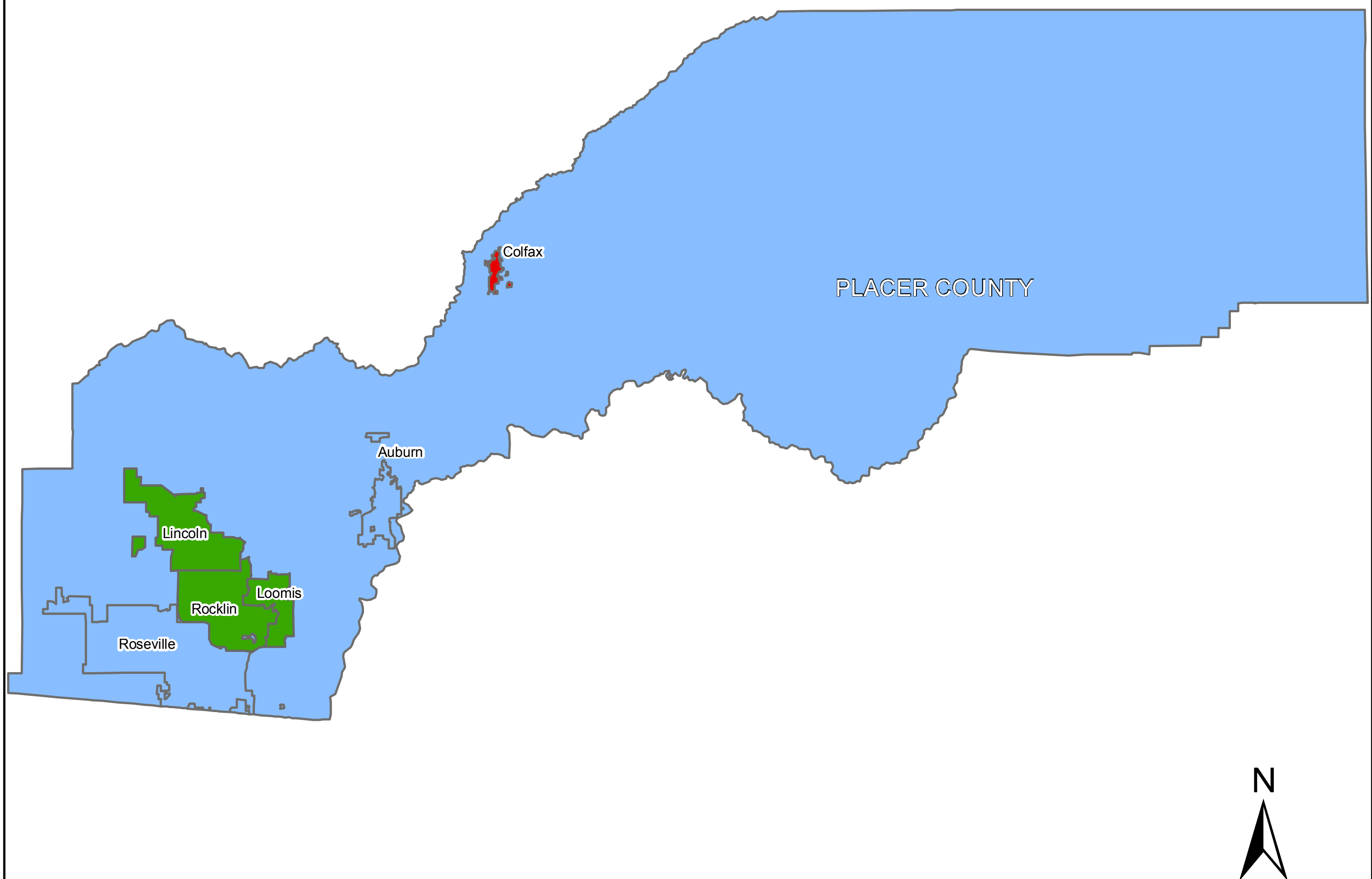


Pavement Condition Index

Reported	Estimated
Good (71-100)	Good (71-100)
At Lower Risk (61-70)	At Lower Risk (61-70)
At Higher Risk (50-60)	At Higher Risk (50-60)
Poor (0-49)	Poor (0-49)

Boundaries represent incorporated city limits from U.S. Census data and are approximate in shape and area.

Placer County



Pavement Condition Index

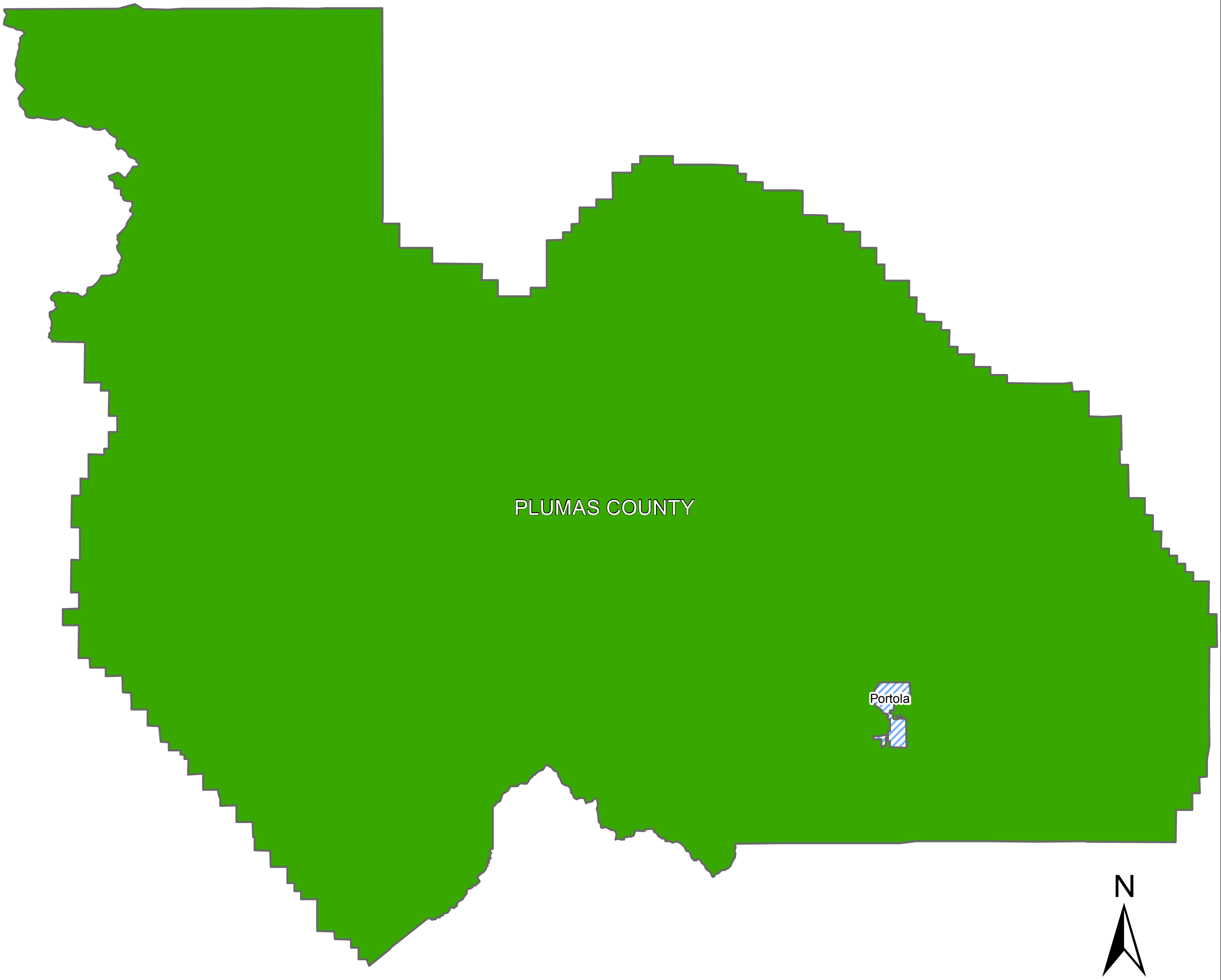
Reported	Estimated
Good (71-100)	Good (71-100)
At Lower Risk (61-70)	At Lower Risk (61-70)
At Higher Risk (50-60)	At Higher Risk (50-60)
Poor (0-49)	Poor (0-49)

NCE

Boundaries represent incorporated city limits from U.S. Census data and are approximate in shape and area.

Plumas County

SAVE CALIFORNIA STREETS



Pavement Condition Index

Reported	Estimated
Good (71-100)	Good (71-100)
At Lower Risk (61-70)	At Lower Risk (61-70)
At Higher Risk (50-60)	At Higher Risk (50-60)
Poor (0-49)	Poor (0-49)

NCE

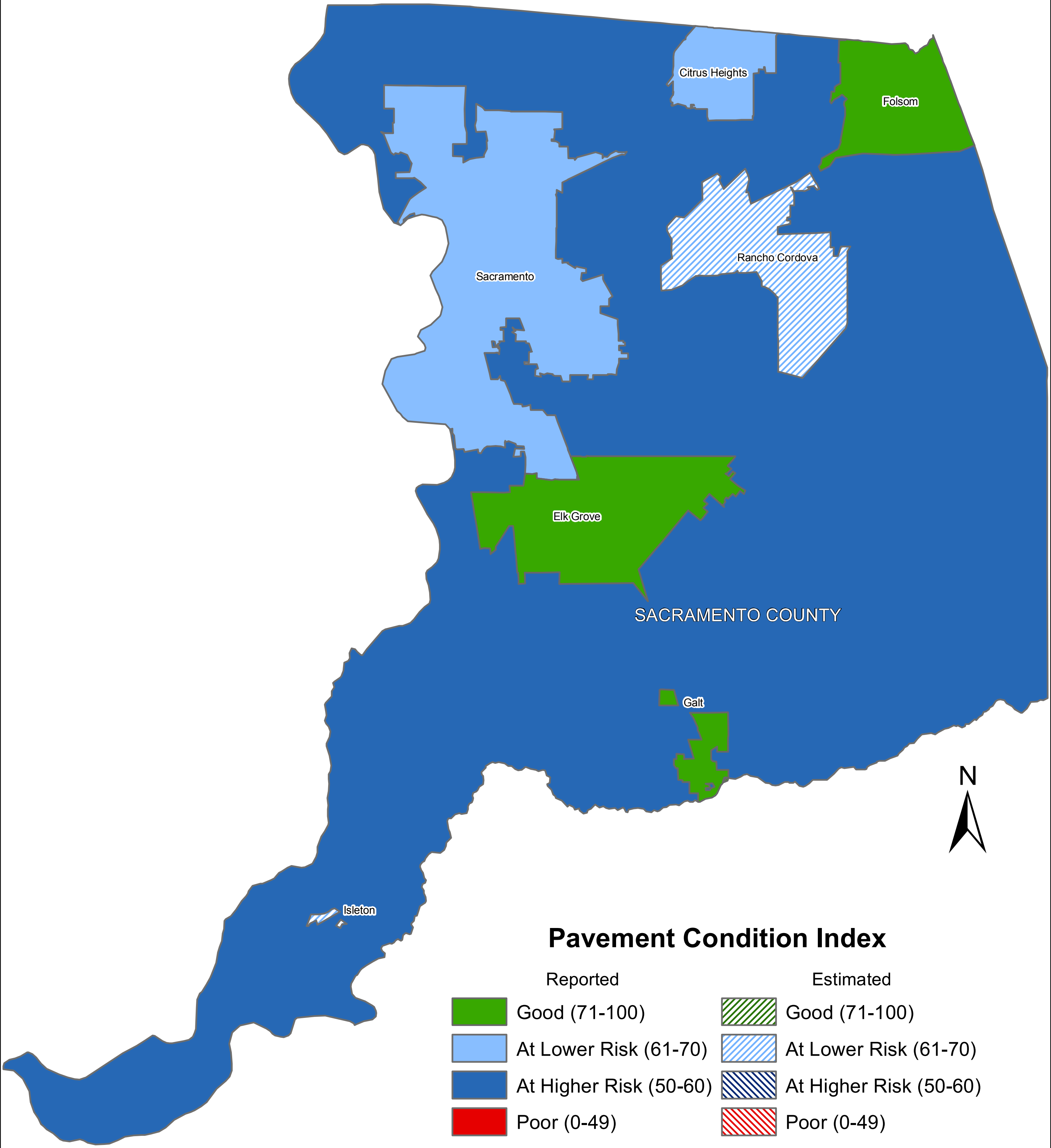
Riverside County

N

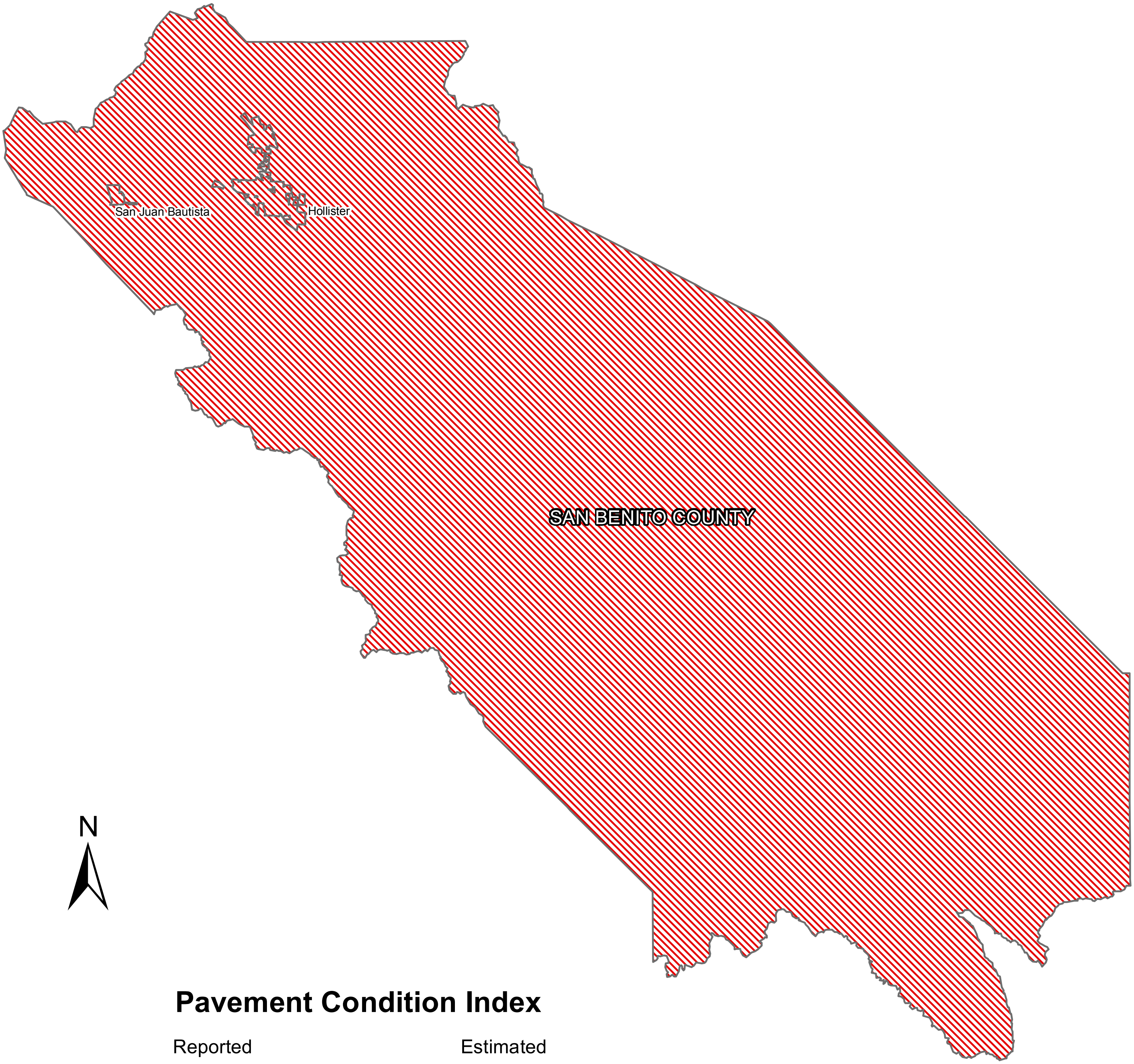
Pavement Condition Index

Reported	Estimated
Good (71-100)	Good (71-100)
At Lower Risk (61-70)	At Lower Risk (61-70)
At Higher Risk (50-60)	At Higher Risk (50-60)
Poor (0-49)	Poor (0-49)

Sacramento County



San Benito County

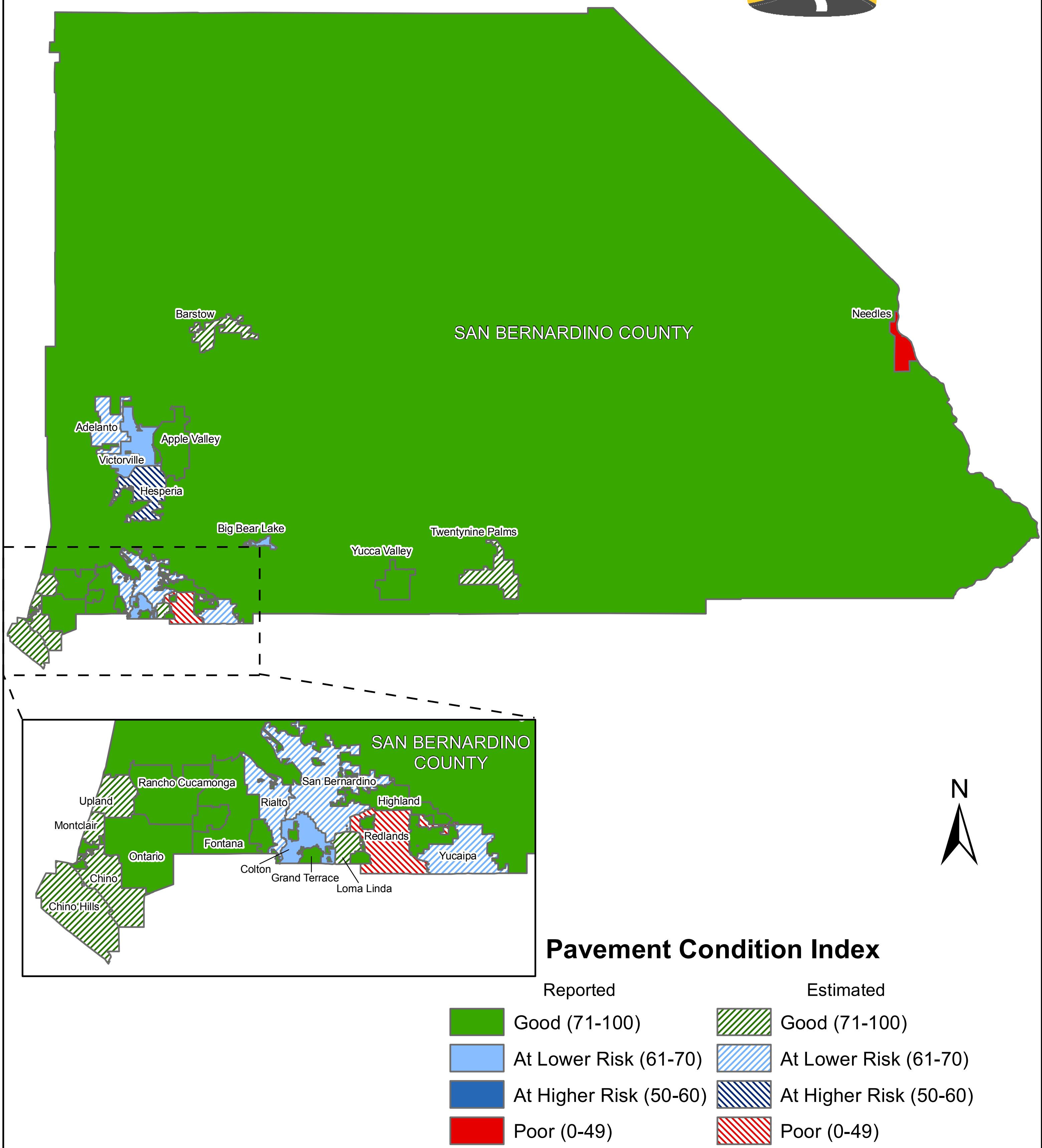


Pavement Condition Index

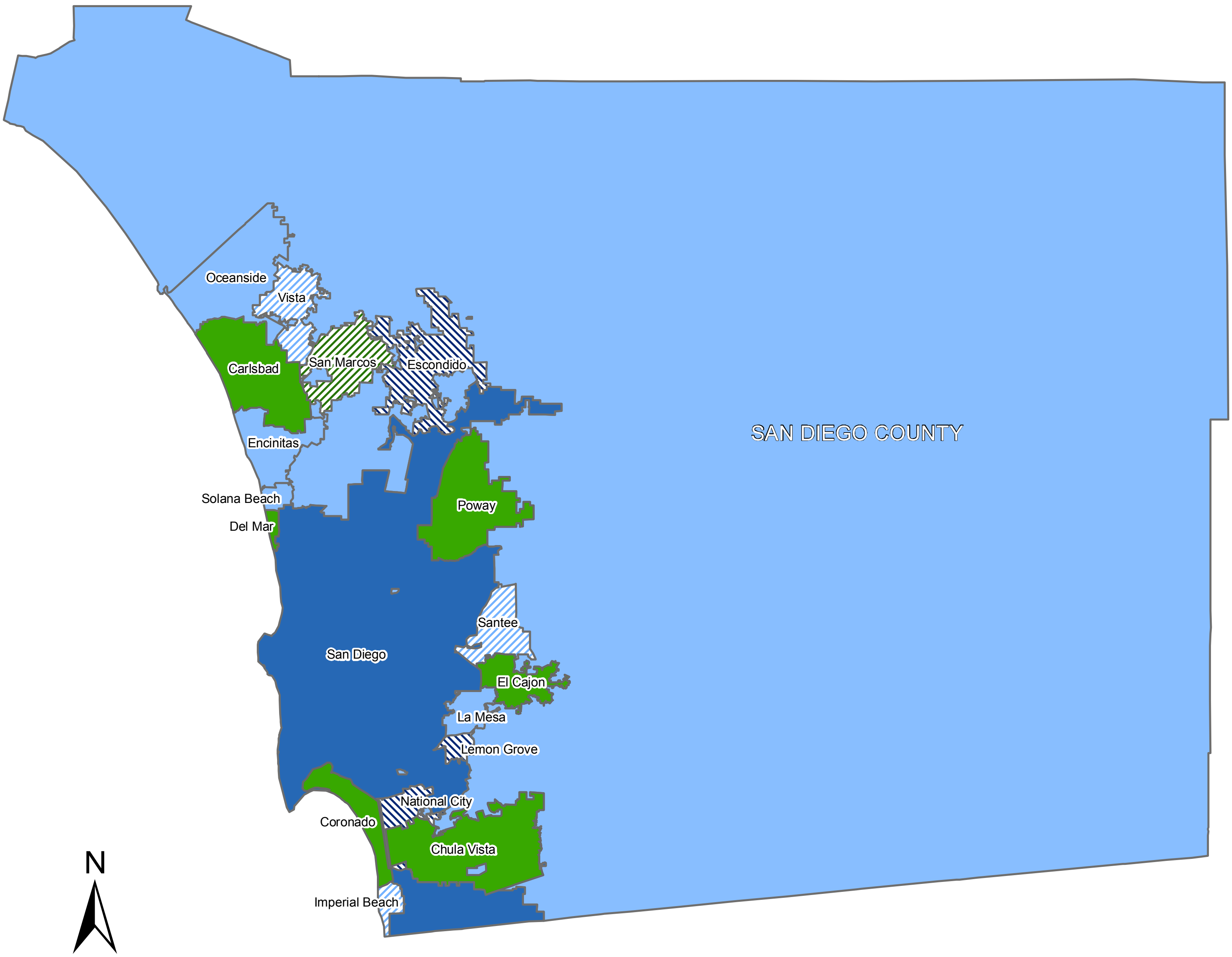
Reported	Estimated
Good (71-100)	Good (71-100)
At Lower Risk (61-70)	At Lower Risk (61-70)
At Higher Risk (50-60)	At Higher Risk (50-60)
Poor (0-49)	Poor (0-49)

 GIS mapping data modified from US Census Bureau TIGER Cartographic Boundary Shapefiles (http://www.census.gov/geo/maps-data/data/tiger.html), accessed August 2016. Boundaries represent incorporated city limits from U.S. Census data and are approximate in shape and area.

San Bernardino County



San Diego County



Pavement Condition Index

Reported		Estimated	
	Good (71-100)		Good (71-100)
	At Lower Risk (61-70)		At Lower Risk (61-70)
	At Higher Risk (50-60)		At Higher Risk (50-60)
	Poor (0-49)		Poor (0-49)

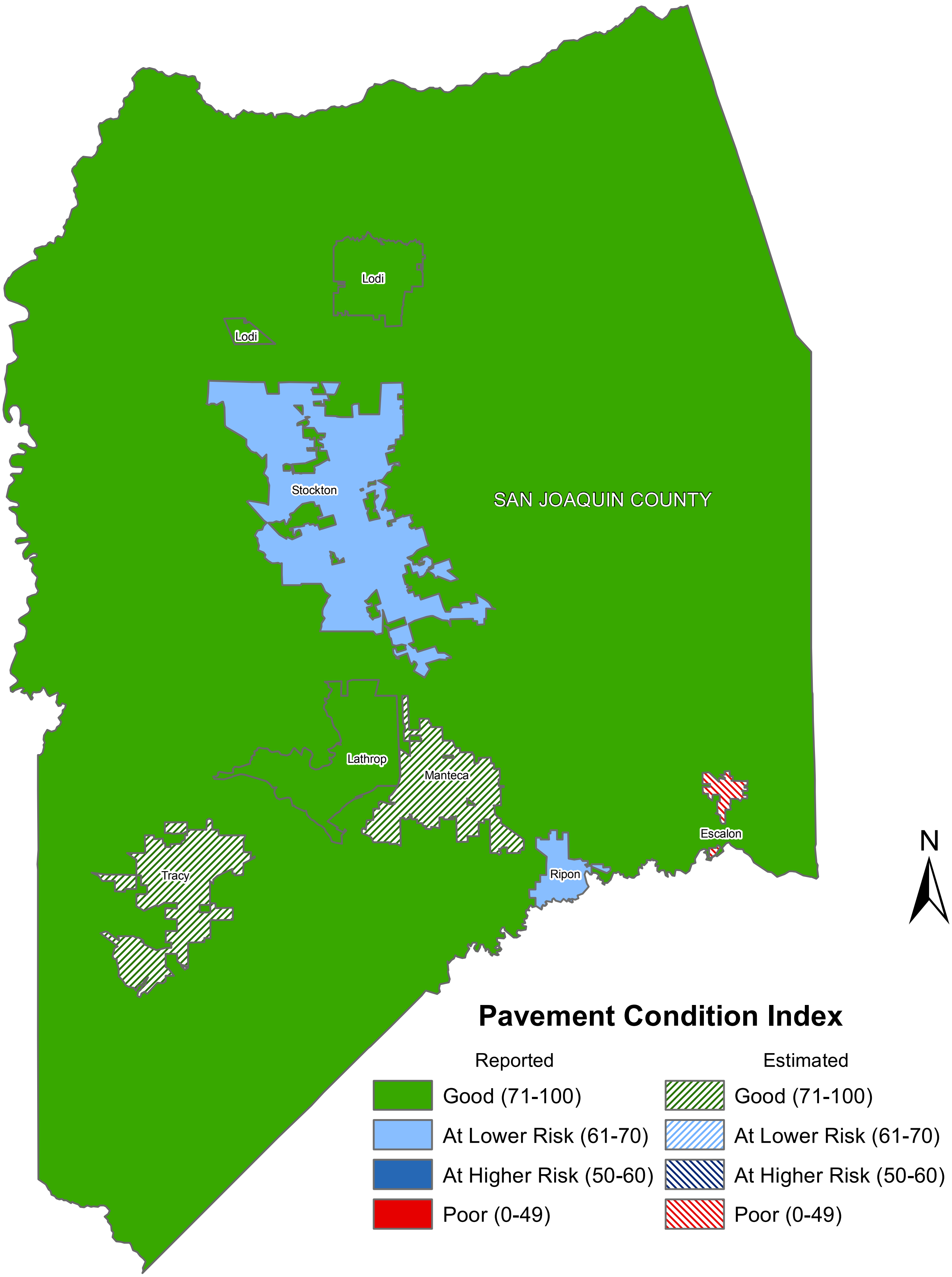
Boundaries represent incorporated city limits from U.S. Census data and are approximate in shape and area.

San Francisco County

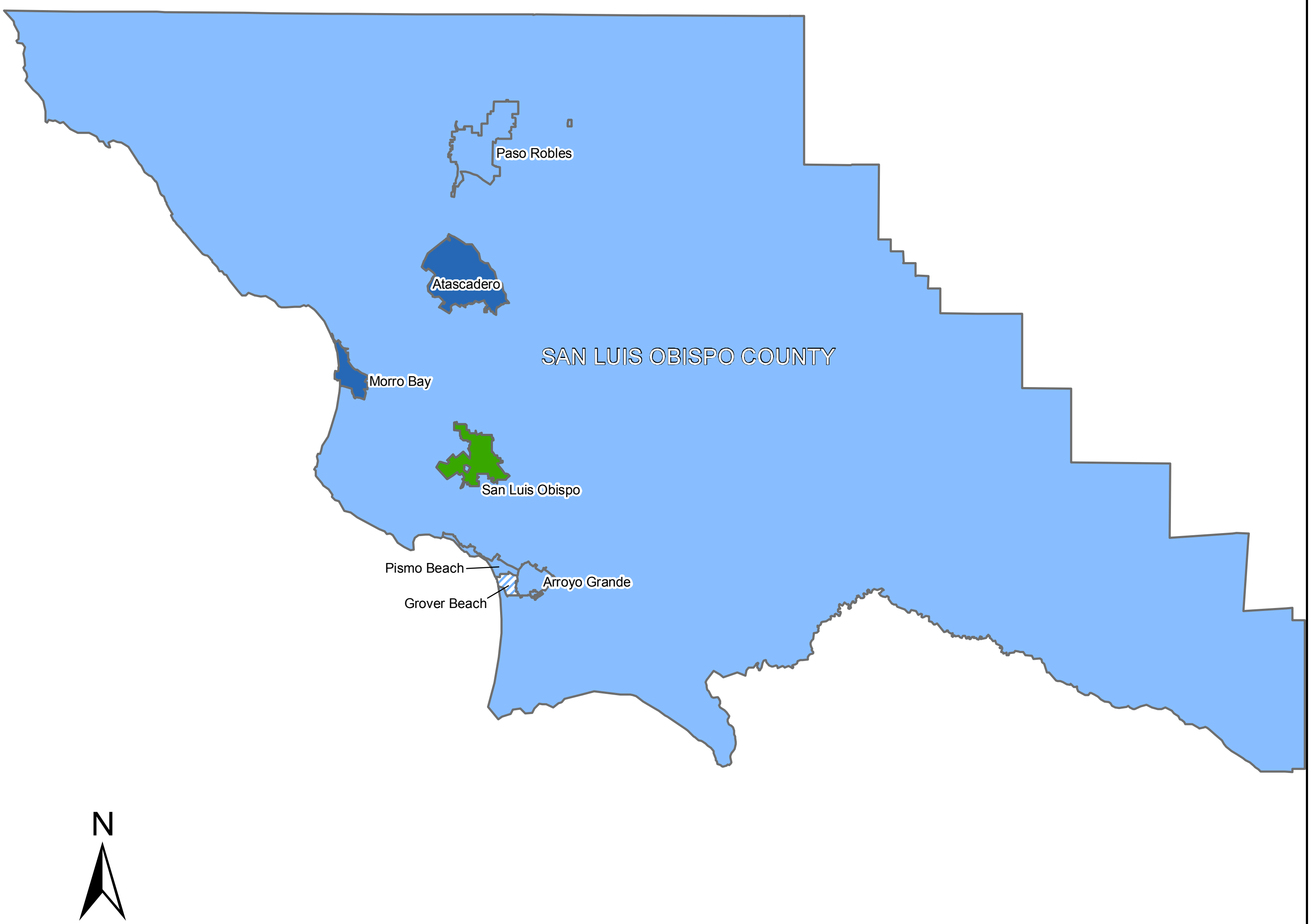
Pavement Condition Index

Reported	Estimated
Good (71-100)	Good (71-100)
At Lower Risk (61-70)	At Lower Risk (61-70)
At Higher Risk (50-60)	At Higher Risk (50-60)
Poor (0-49)	Poor (0-49)

San Joaquin County



San Luis Obispo County

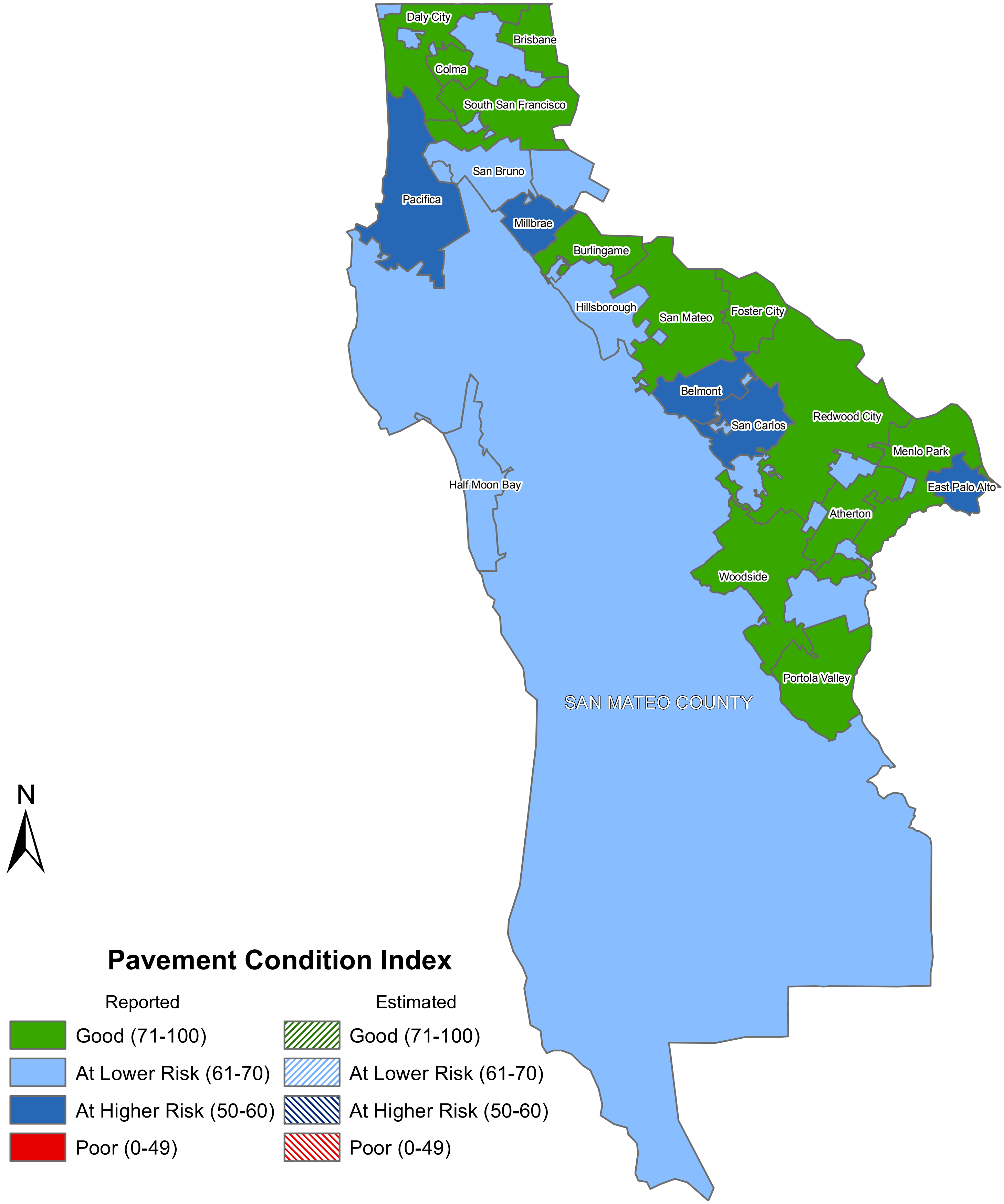


Pavement Condition Index

Reported	Estimated
Good (71-100)	Good (71-100)
At Lower Risk (61-70)	At Lower Risk (61-70)
At Higher Risk (50-60)	At Higher Risk (50-60)
Poor (0-49)	Poor (0-49)

Boundaries represent incorporated city limits from U.S. Census data and are approximate in shape and area.

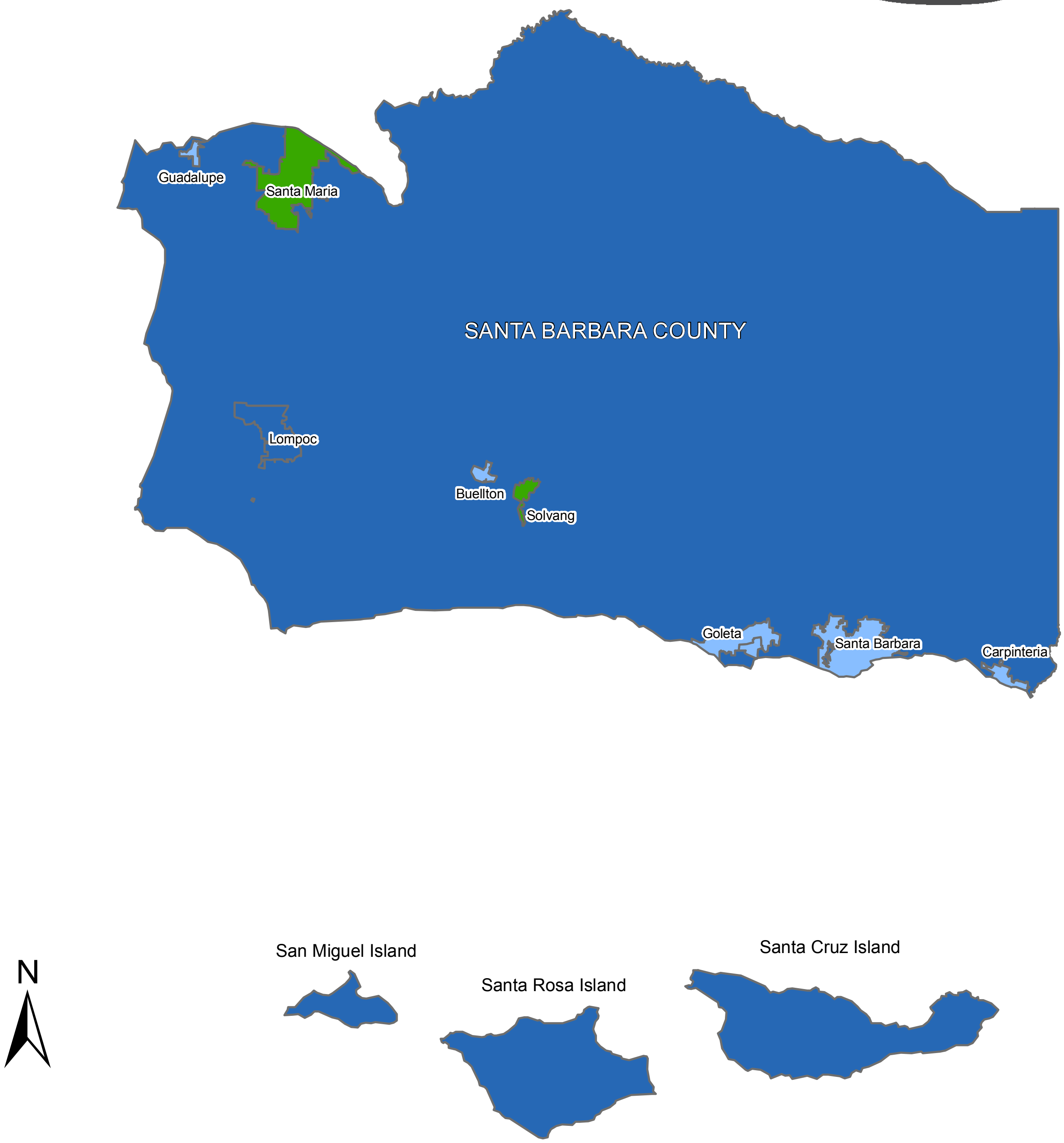
San Mateo County



Pavement Condition Index

Reported	Estimated
Good (71-100)	Good (71-100)
At Lower Risk (61-70)	At Lower Risk (61-70)
At Higher Risk (50-60)	At Higher Risk (50-60)
Poor (0-49)	Poor (0-49)

Santa Barbara County

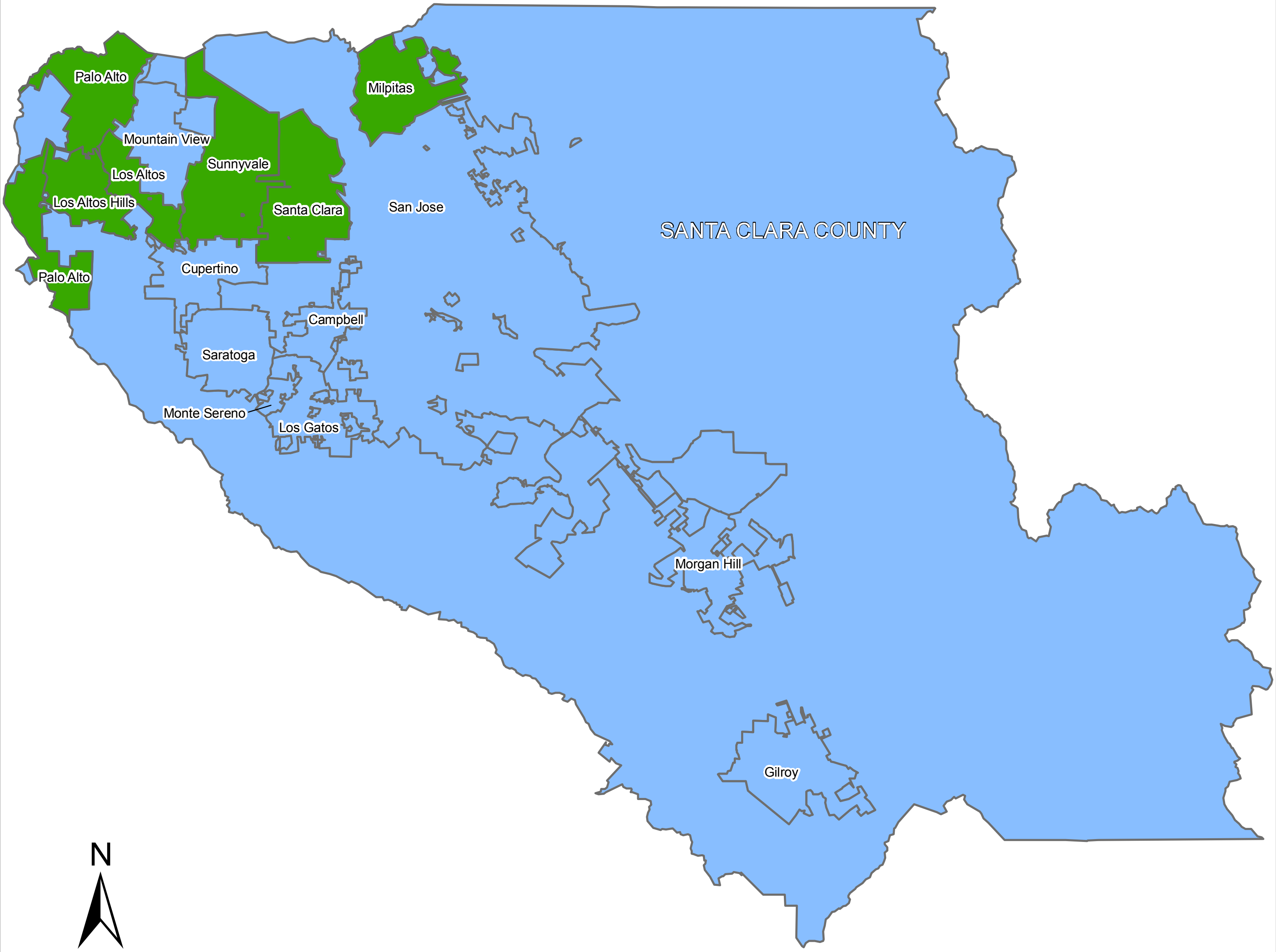


Pavement Condition Index

Reported	Estimated
Good (71-100)	Good (71-100)
At Lower Risk (61-70)	At Lower Risk (61-70)
At Higher Risk (50-60)	At Higher Risk (50-60)
Poor (0-49)	Poor (0-49)

Boundaries represent incorporated city limits from U.S. Census data and are approximate in shape and area.

Santa Clara County

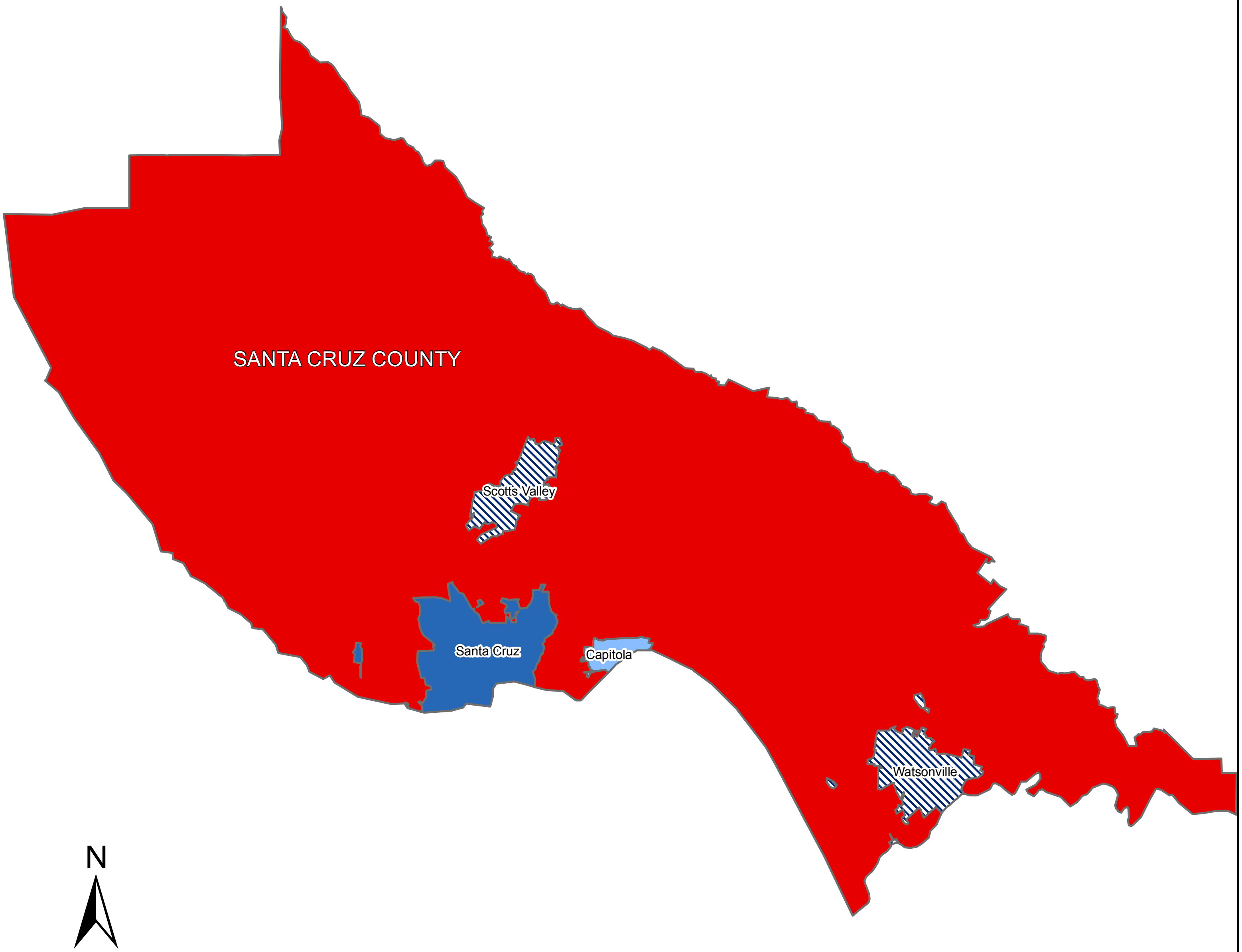


Pavement Condition Index

Reported	Estimated
Good (71-100)	Good (71-100)
At Lower Risk (61-70)	At Lower Risk (61-70)
At Higher Risk (50-60)	At Higher Risk (50-60)
Poor (0-49)	Poor (0-49)

Boundaries represent incorporated city limits from U.S. Census data and are approximate in shape and area.

Santa Cruz County

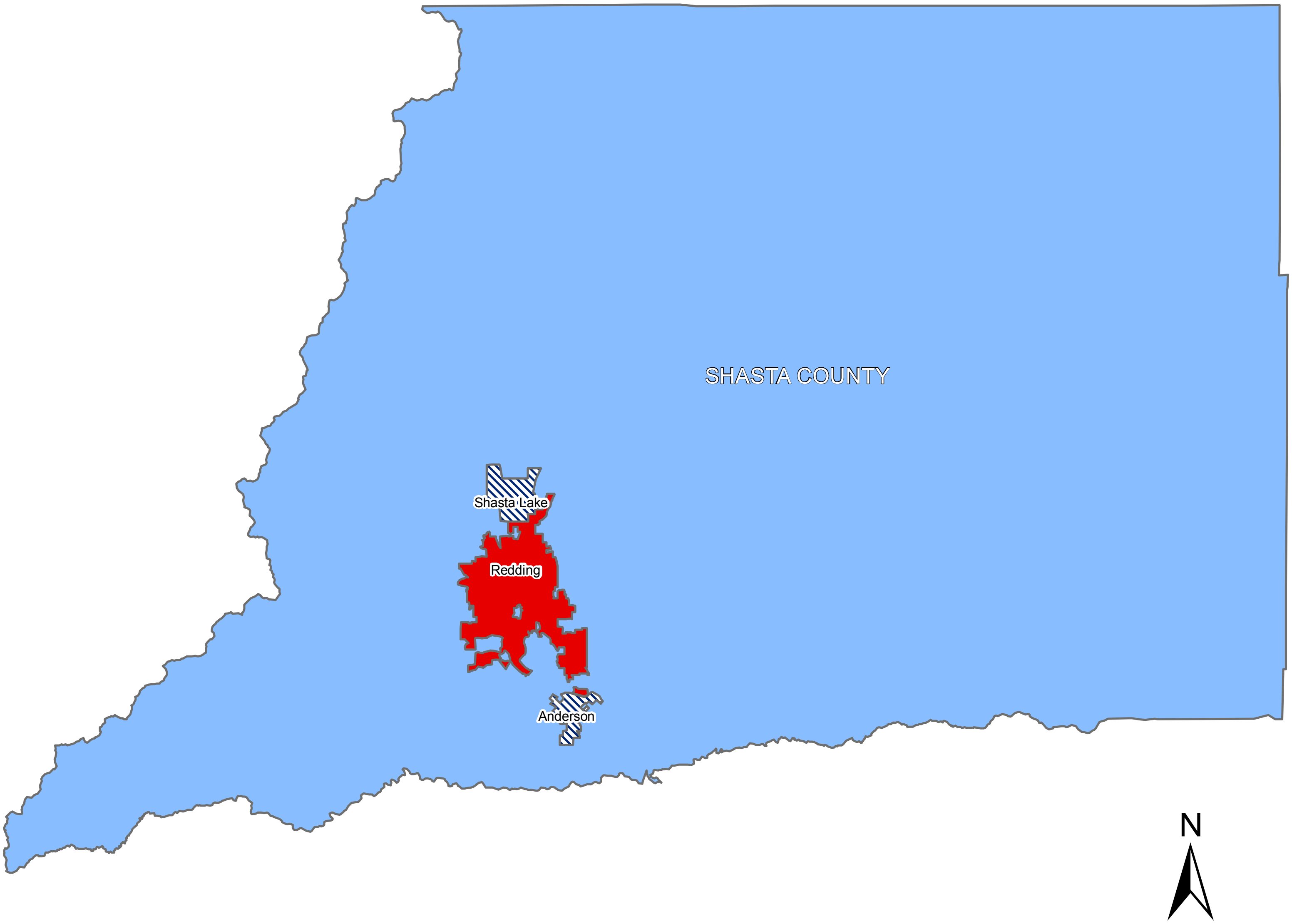


Pavement Condition Index

Reported	Estimated
Good (71-100)	Good (71-100)
At Lower Risk (61-70)	At Lower Risk (61-70)
At Higher Risk (50-60)	At Higher Risk (50-60)
Poor (0-49)	Poor (0-49)

Boundaries represent incorporated city limits from U.S. Census data and are approximate in shape and area.

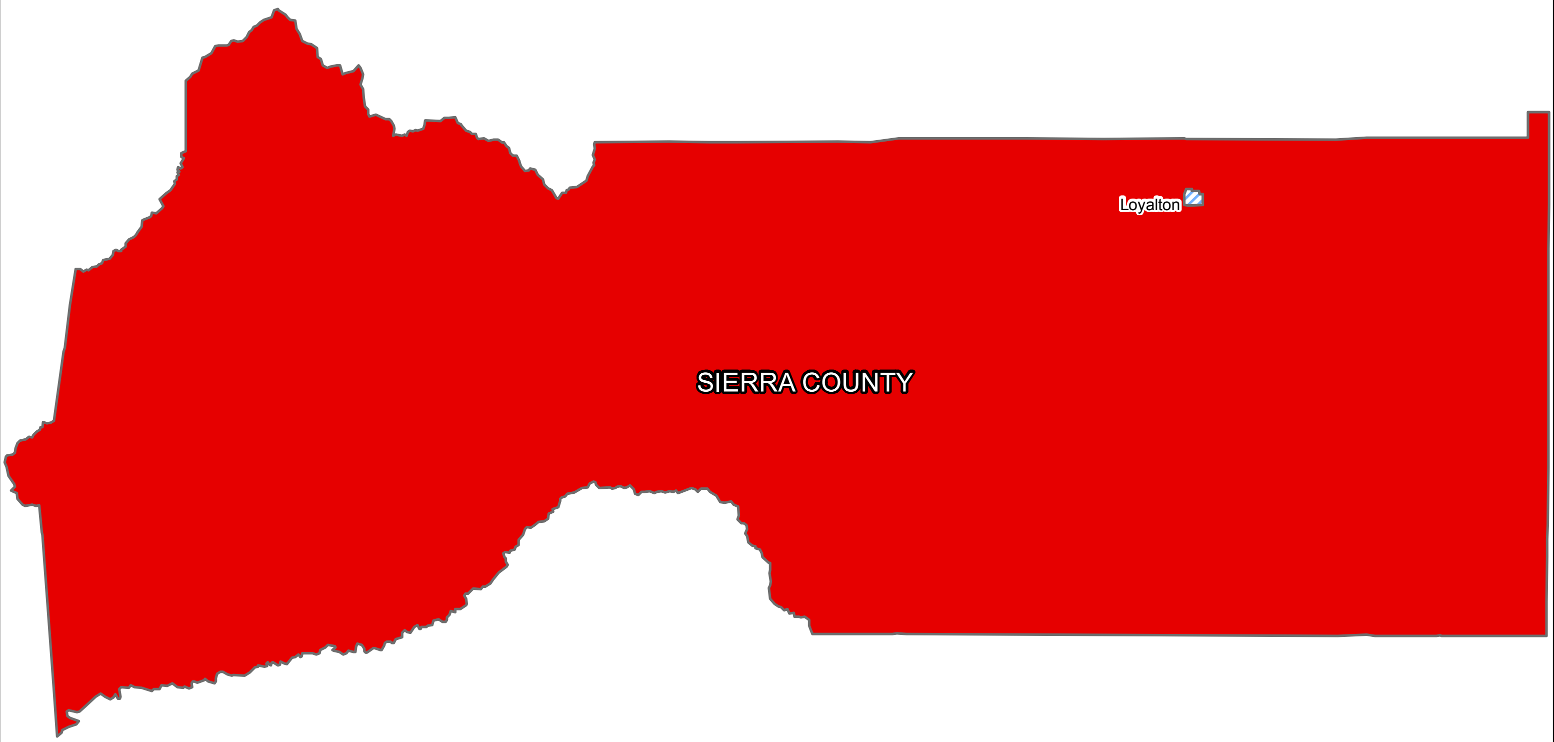
Shasta County



Pavement Condition Index

Reported	Estimated
Good (71-100)	Good (71-100)
At Lower Risk (61-70)	At Lower Risk (61-70)
At Higher Risk (50-60)	At Higher Risk (50-60)
Poor (0-49)	Poor (0-49)

Sierra County



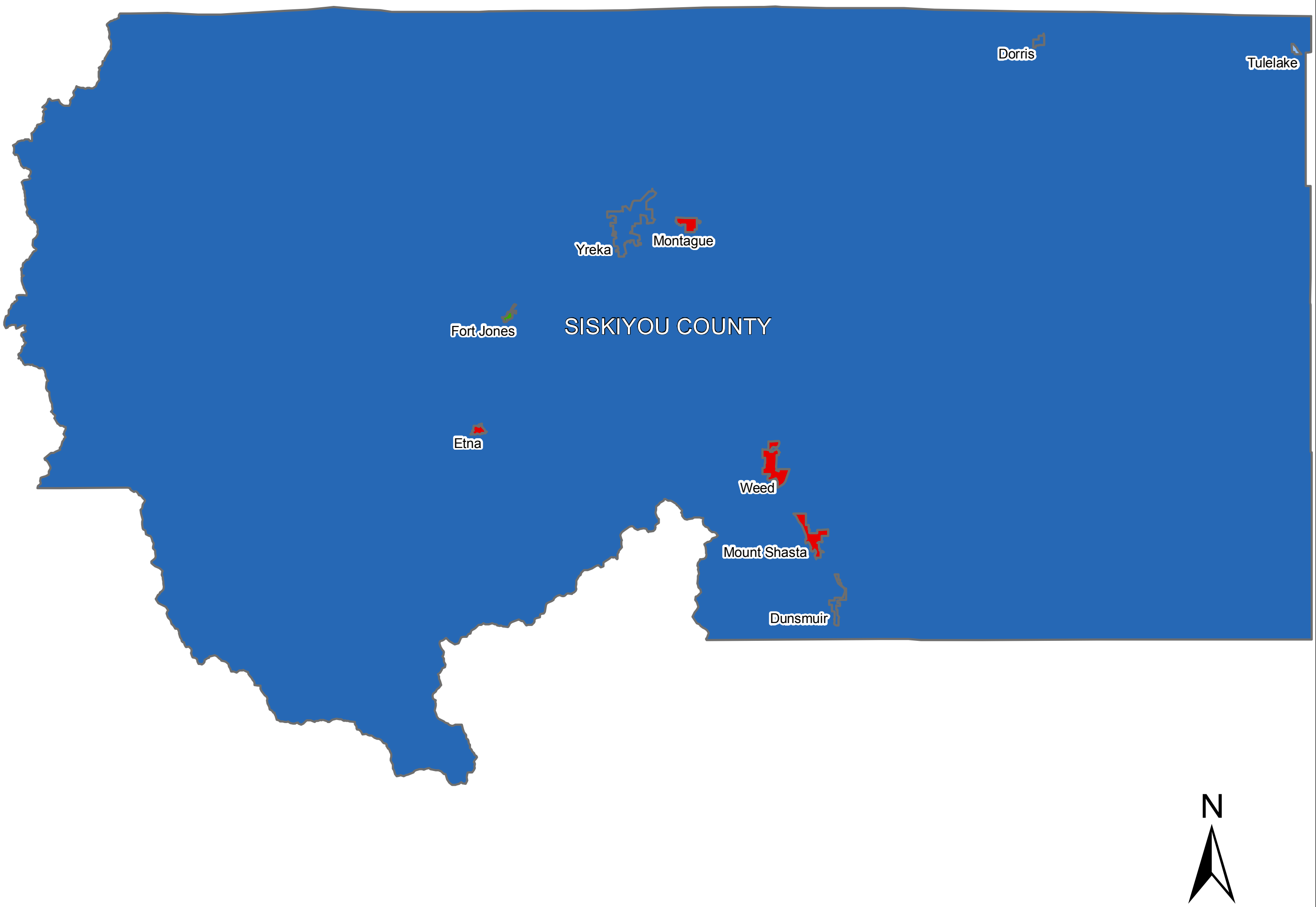
N

Pavement Condition Index

Reported	Estimated
Good (71-100)	Good (71-100)
At Lower Risk (61-70)	At Lower Risk (61-70)
At Higher Risk (50-60)	At Higher Risk (50-60)
Poor (0-49)	Poor (0-49)

Boundaries represent incorporated city limits from U.S. Census data and are approximate in shape and area.

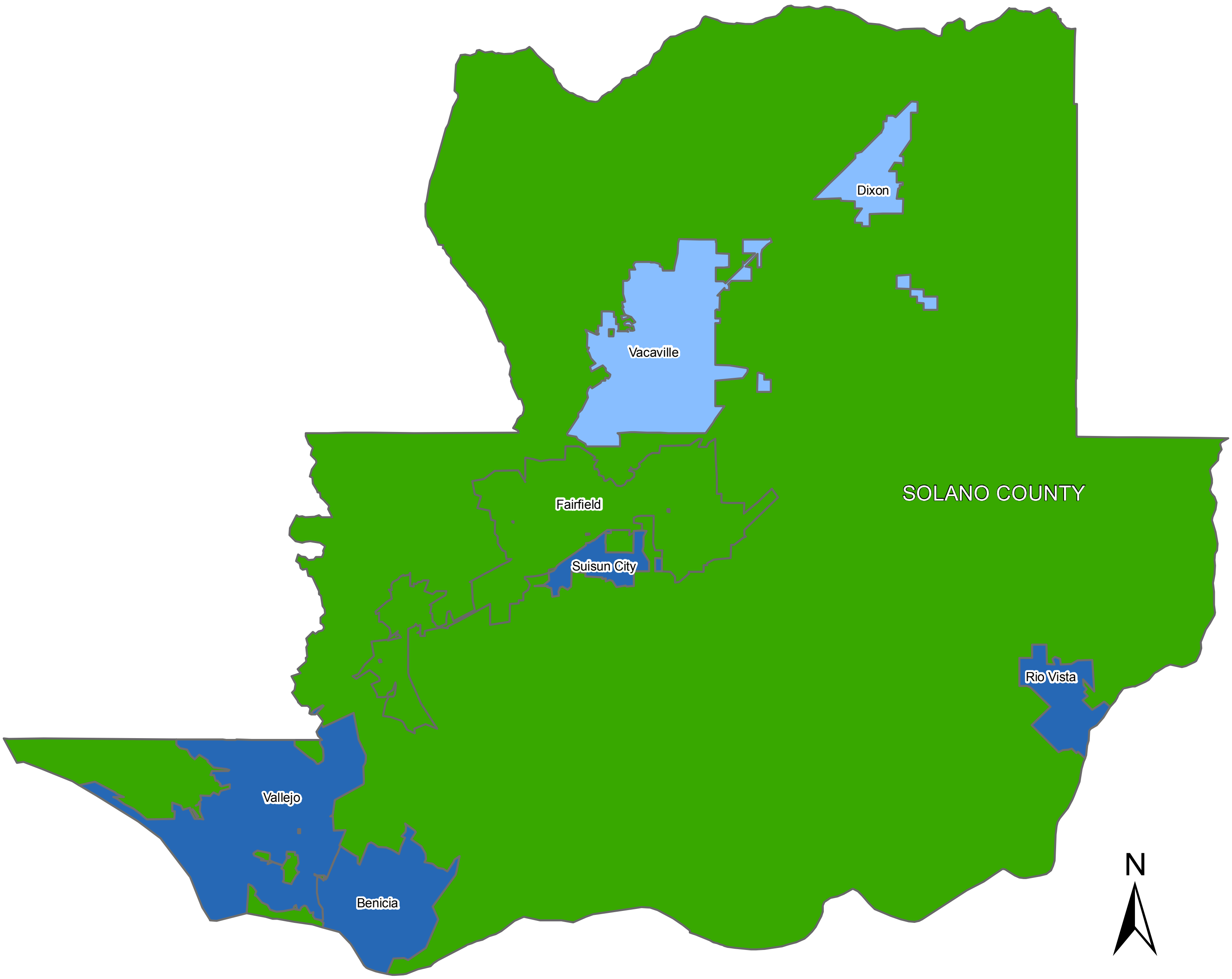
Siskiyou County



Pavement Condition Index

Reported	Estimated
Good (71-100)	Good (71-100)
At Lower Risk (61-70)	At Lower Risk (61-70)
At Higher Risk (50-60)	At Higher Risk (50-60)
Poor (0-49)	Poor (0-49)

Solano County



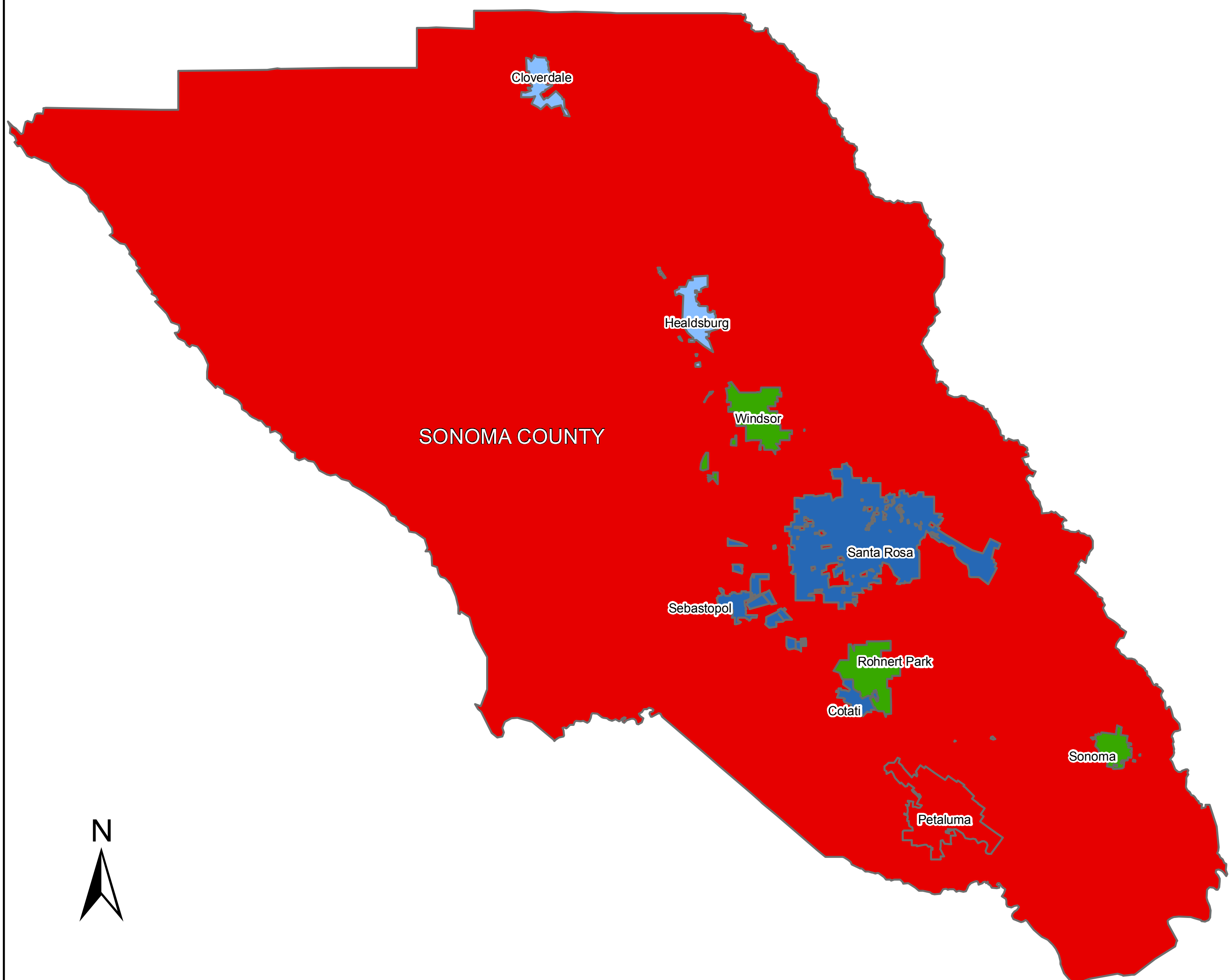
Pavement Condition Index

Reported		Estimated	
	Good (71-100)		Good (71-100)
	At Lower Risk (61-70)		At Lower Risk (61-70)
	At Higher Risk (50-60)		At Higher Risk (50-60)
	Poor (0-49)		Poor (0-49)

Boundaries represent incorporated city limits from U.S. Census data and are approximate in shape and area.

Sonoma County

SAVE CALIFORNIA STREETS



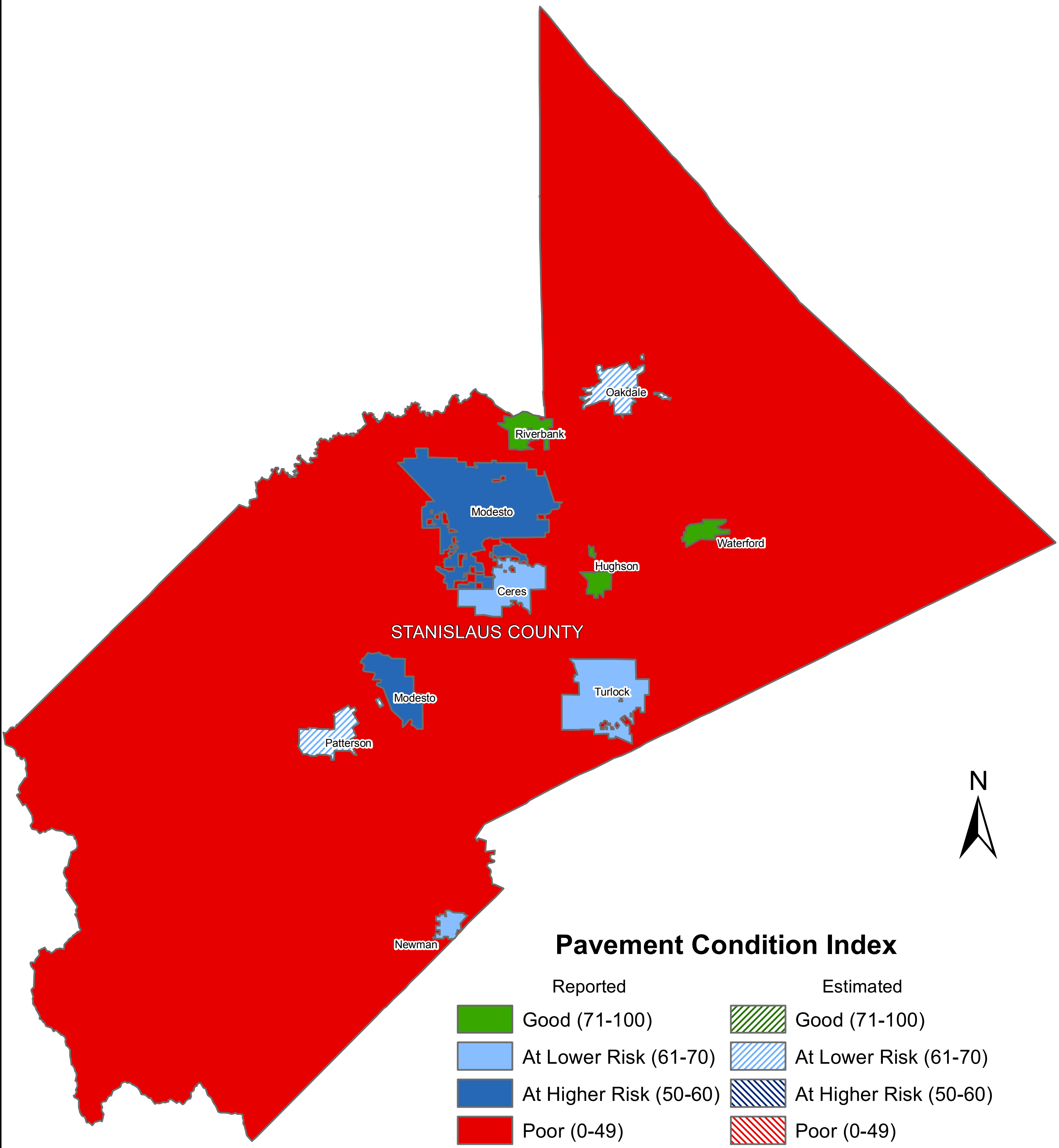
Pavement Condition Index

Reported	Estimated
Good (71-100)	Good (71-100)
At Lower Risk (61-70)	At Lower Risk (61-70)
At Higher Risk (50-60)	At Higher Risk (50-60)
Poor (0-49)	Poor (0-49)

NCE

Boundaries represent incorporated city limits from U.S. Census data and are approximate in shape and area.

Stanislaus County

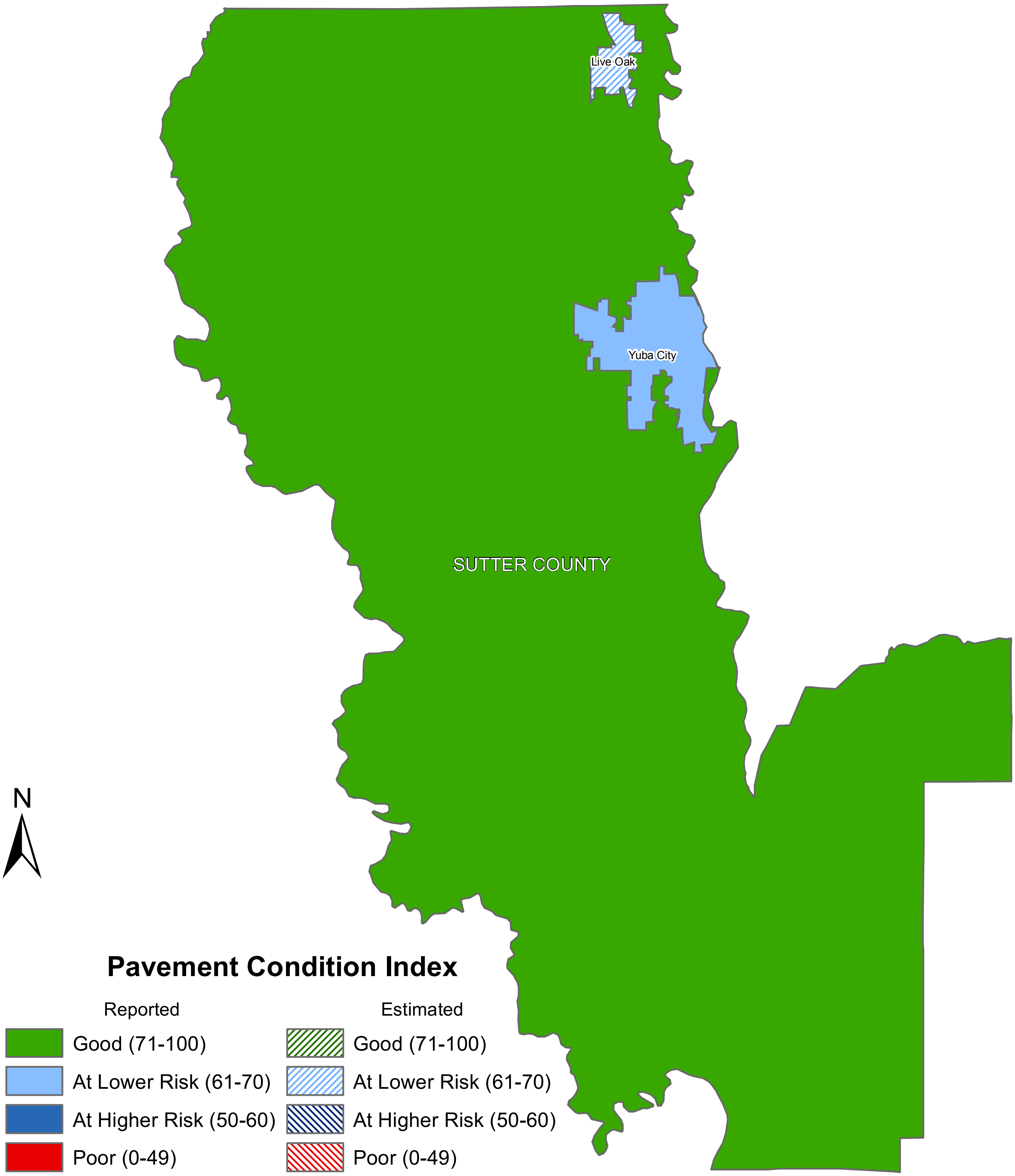


Pavement Condition Index

Reported	Estimated
Good (71-100)	Good (71-100)
At Lower Risk (61-70)	At Lower Risk (61-70)
At Higher Risk (50-60)	At Higher Risk (50-60)
Poor (0-49)	Poor (0-49)

Boundaries represent incorporated city limits from U.S. Census data and are approximate in shape and area.

Sutter County

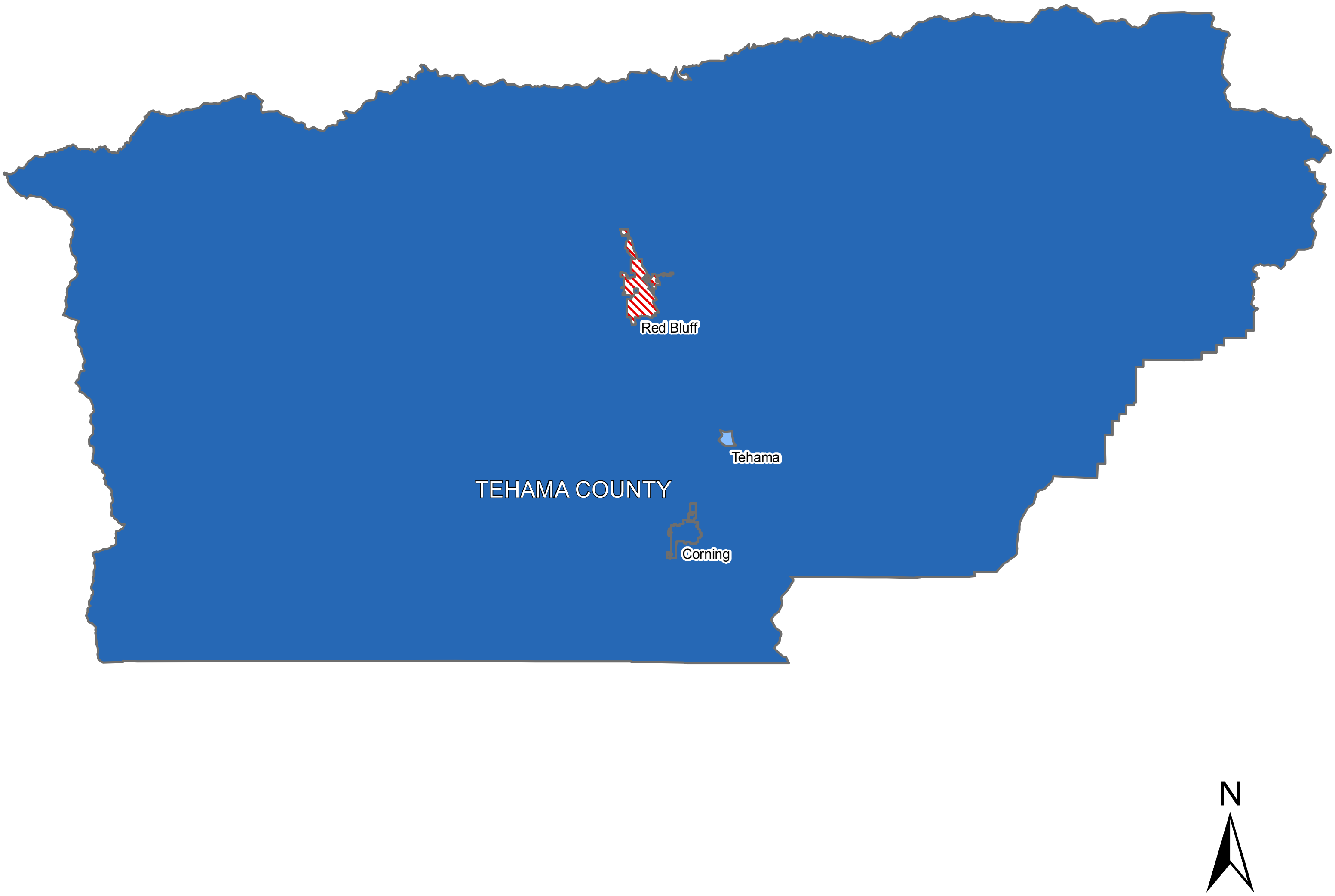


Pavement Condition Index

Reported	Estimated
Good (71-100)	Good (71-100)
At Lower Risk (61-70)	At Lower Risk (61-70)
At Higher Risk (50-60)	At Higher Risk (50-60)
Poor (0-49)	Poor (0-49)

Boundaries represent incorporated city limits from U.S. Census data and are approximate in shape and area.

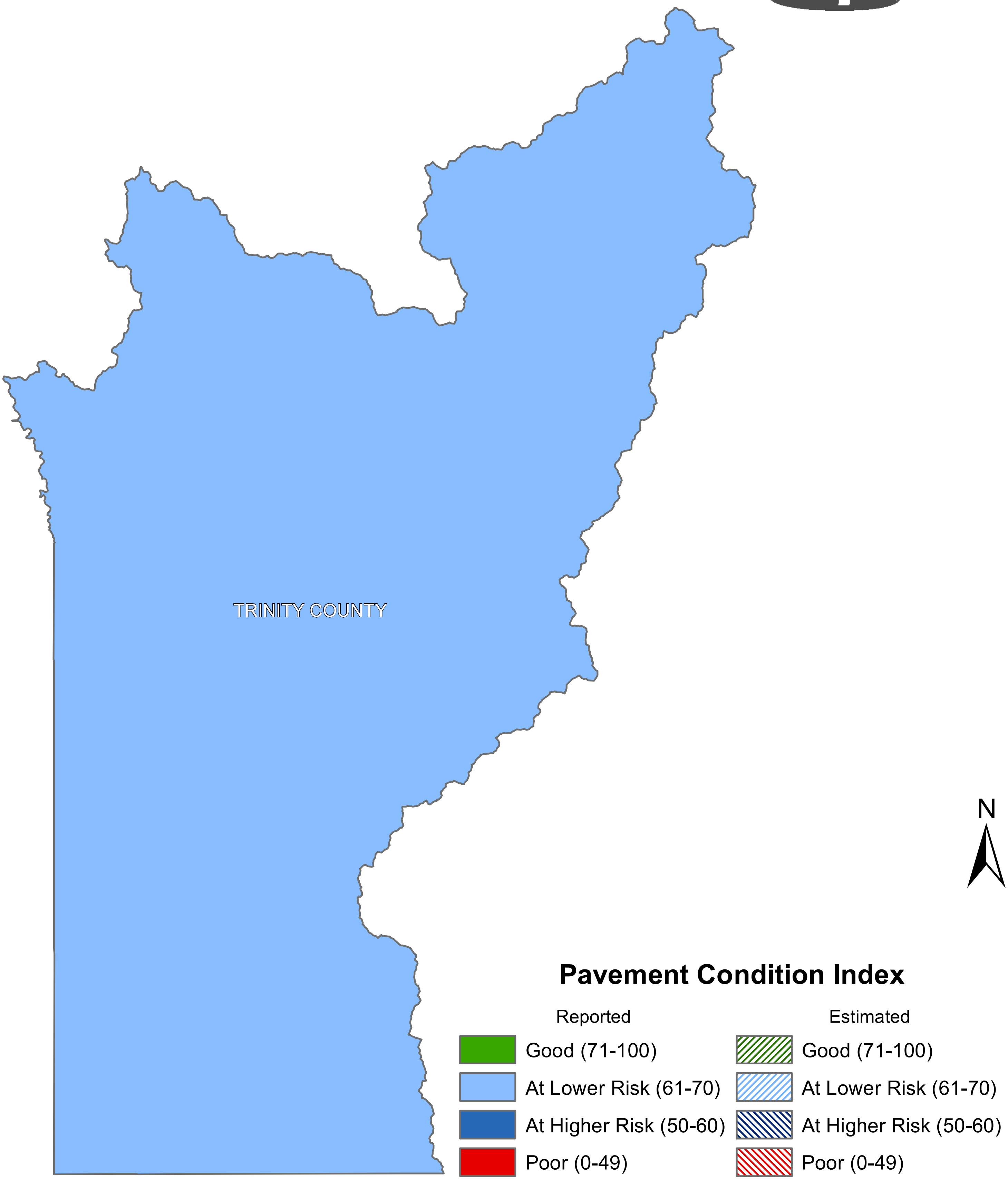
Tehama County



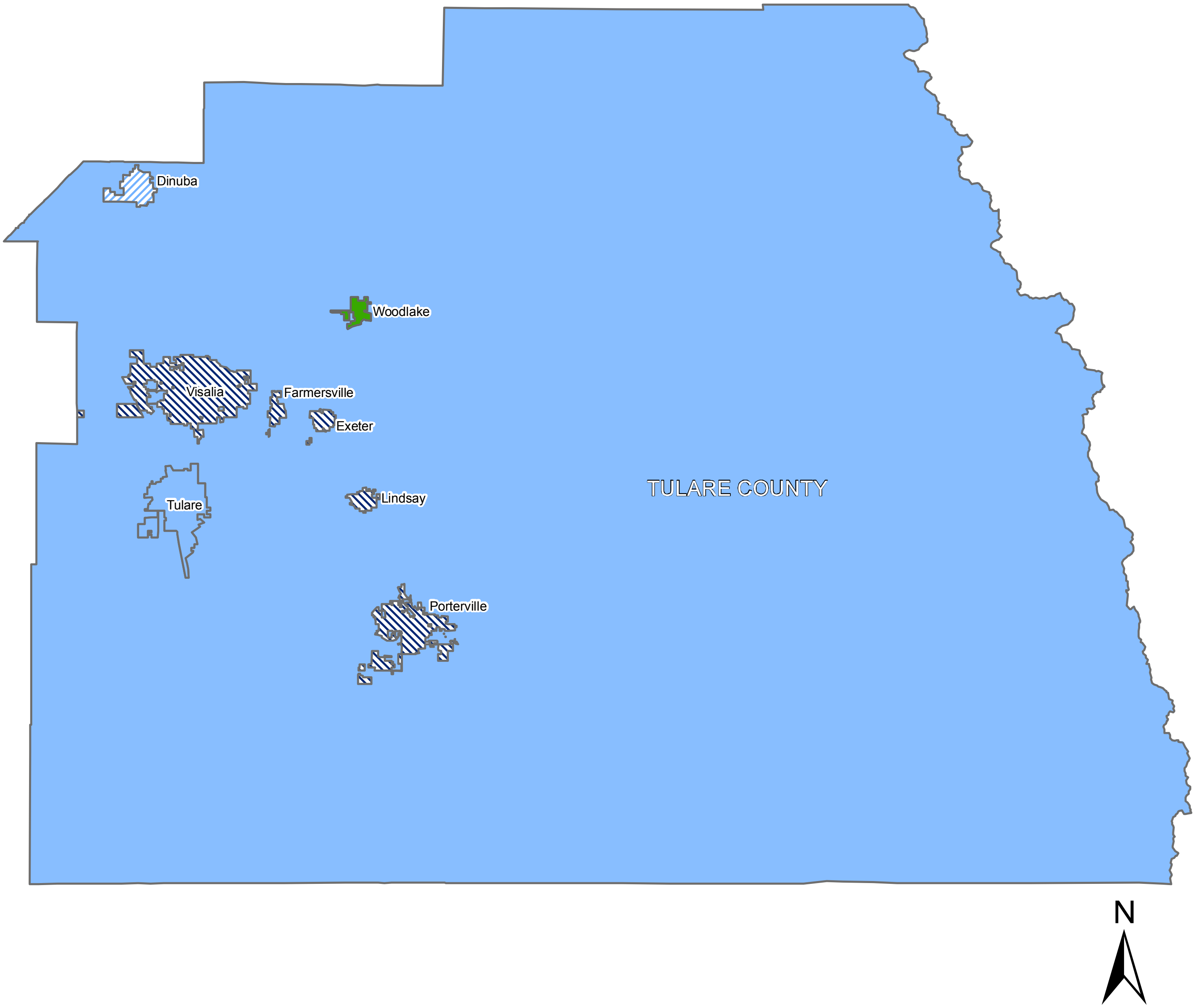
Pavement Condition Index

Reported	Estimated
Good (71-100)	Good (71-100)
At Lower Risk (61-70)	At Lower Risk (61-70)
At Higher Risk (50-60)	At Higher Risk (50-60)
Poor (0-49)	Poor (0-49)

Trinity County



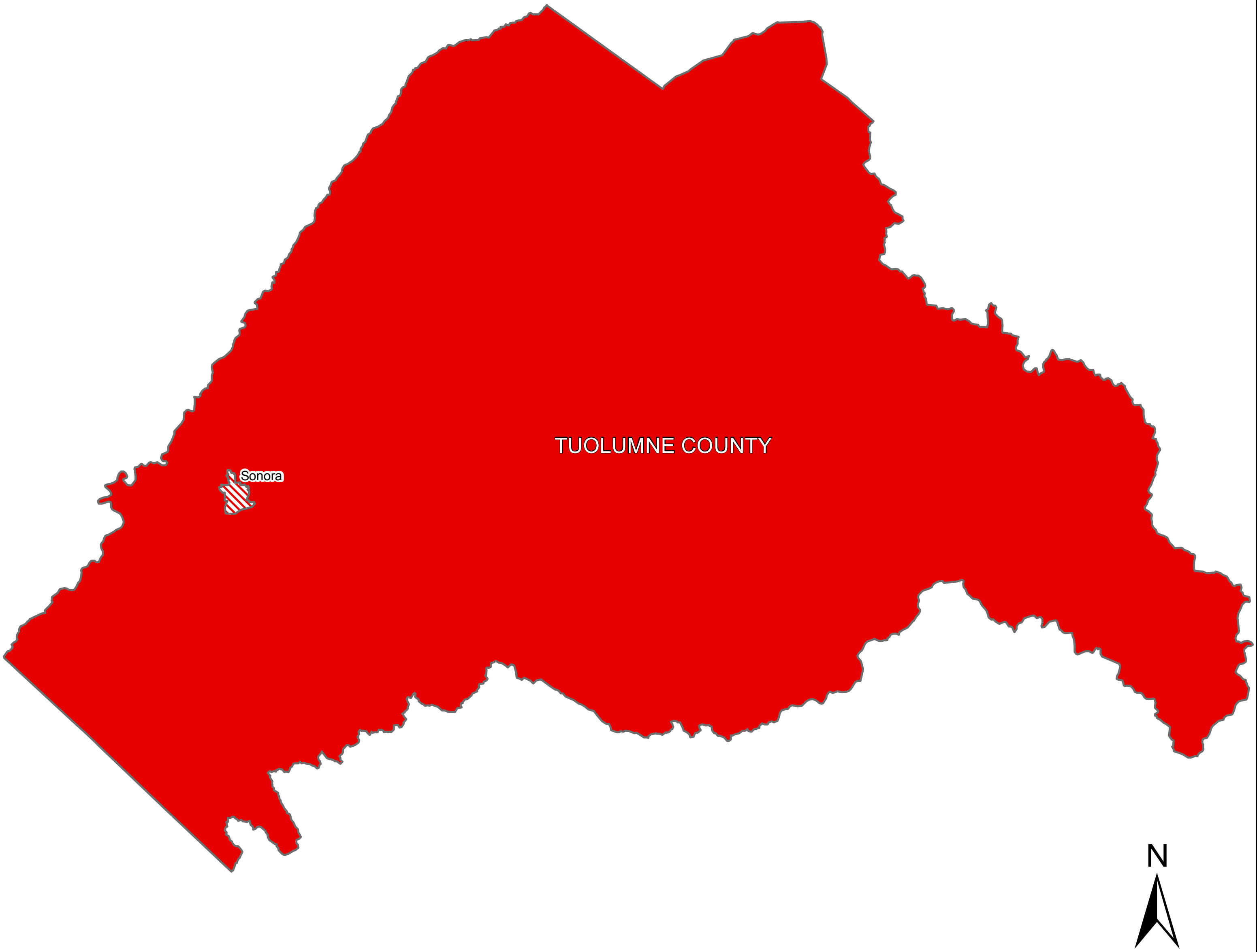
Tulare County



Pavement Condition Index

Reported	Estimated
Good (71-100)	Good (71-100)
At Lower Risk (61-70)	At Lower Risk (61-70)
At Higher Risk (50-60)	At Higher Risk (50-60)
Poor (0-49)	Poor (0-49)

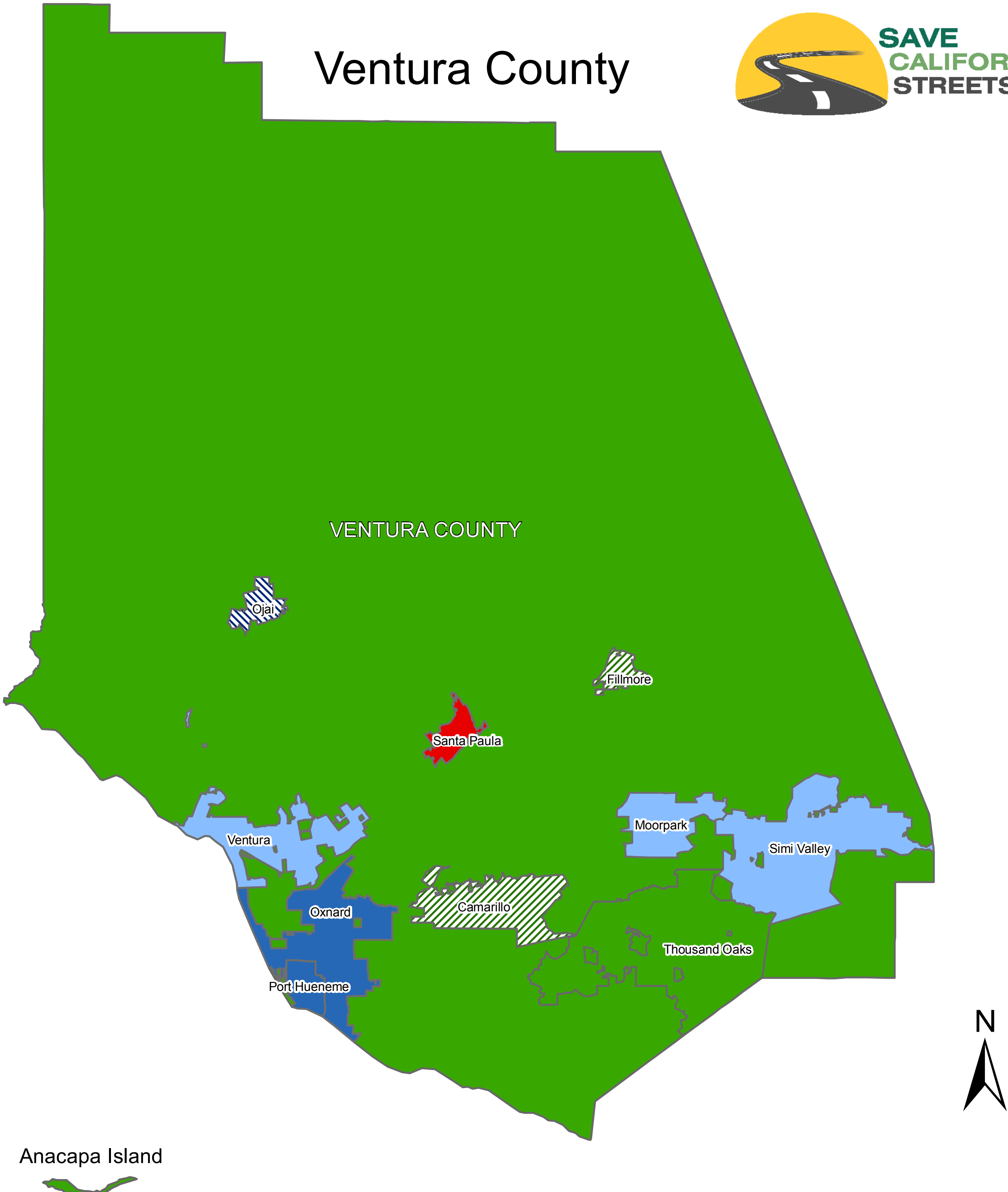
Tuolumne County

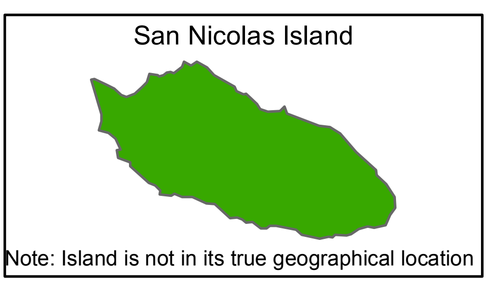


Pavement Condition Index

Reported	Estimated
Good (71-100)	Good (71-100)
At Lower Risk (61-70)	At Lower Risk (61-70)
At Higher Risk (50-60)	At Higher Risk (50-60)
Poor (0-49)	Poor (0-49)

Ventura County





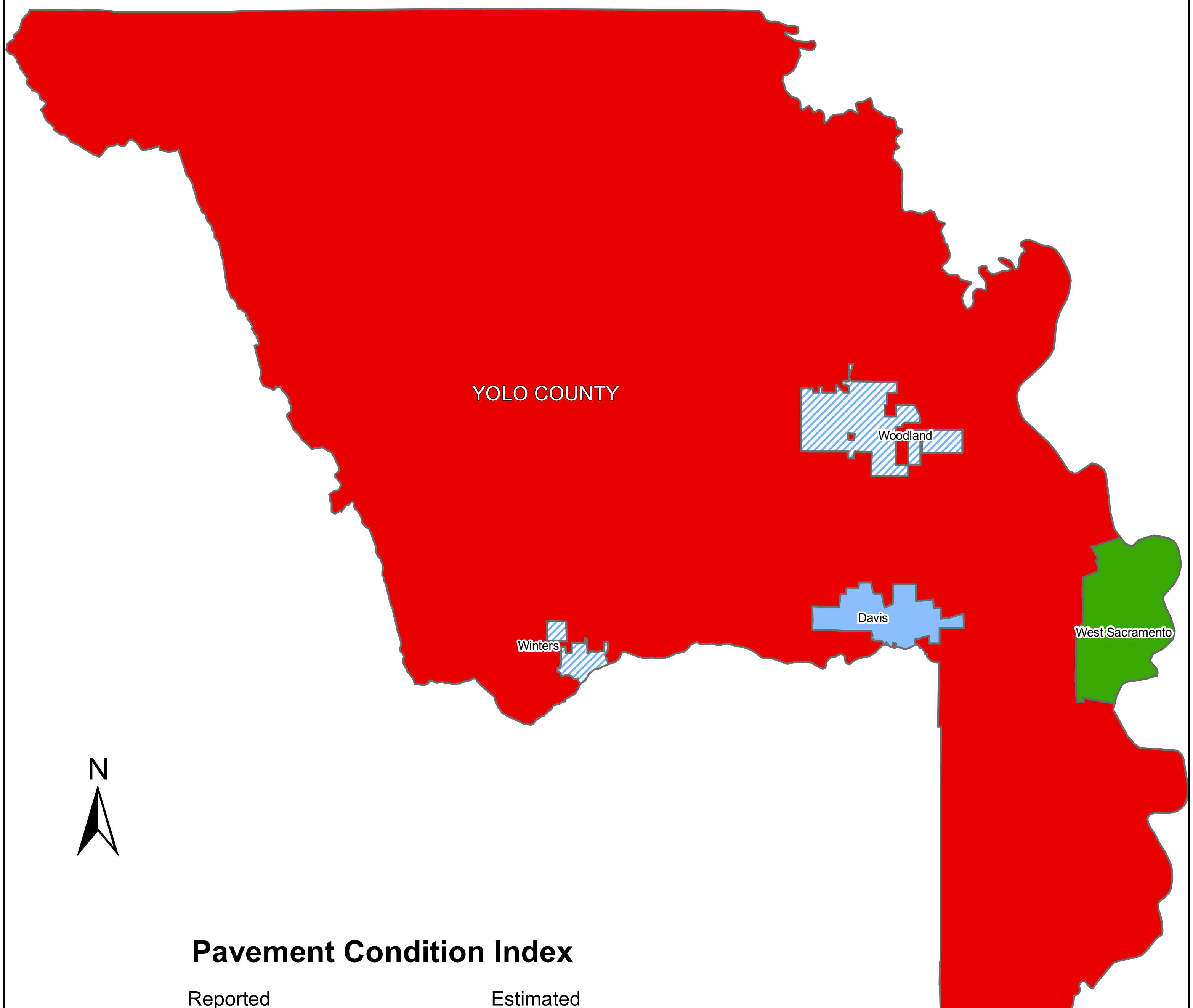
Pavement Condition Index

Reported	Estimated
Good (71-100)	Good (71-100)
At Lower Risk (61-70)	At Lower Risk (61-70)
At Higher Risk (50-60)	At Higher Risk (50-60)
Poor (0-49)	Poor (0-49)

Boundaries represent incorporated city limits from U.S. Census data and are approximate in shape and area.

Yolo County

SAVE CALIFORNIA STREETS

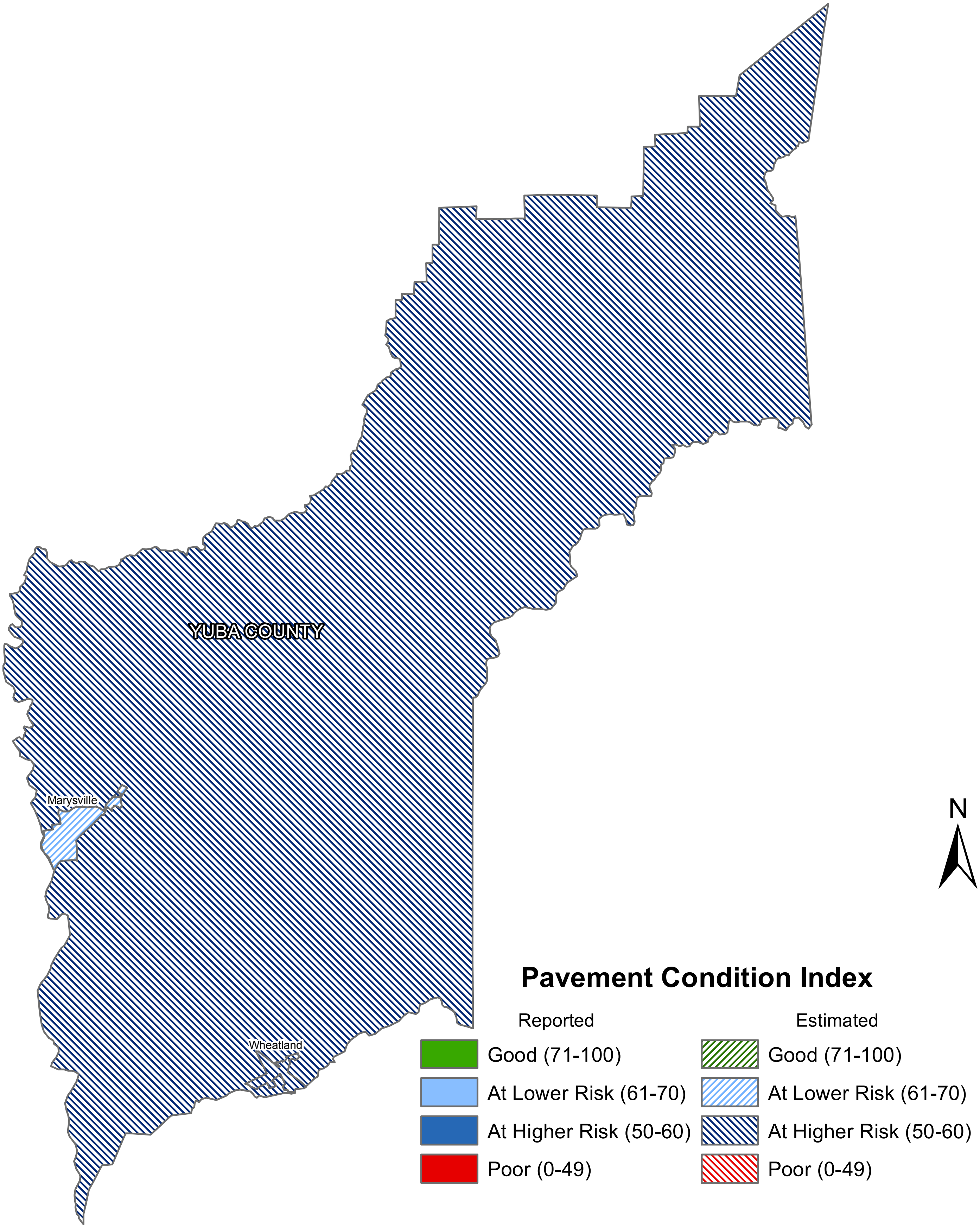


Pavement Condition Index

Reported	Estimated
Good (71-100)	Good (71-100)
At Lower Risk (61-70)	At Lower Risk (61-70)
At Higher Risk (50-60)	At Higher Risk (50-60)
Poor (0-49)	Poor (0-49)

NCE

Yuba County



Boundaries represent incorporated city limits from U.S. Census data and are approximate in shape and area.

Appendix D

Regression Modeling for Essential Components

Application of Geographically Weighted Regression in R to California Statewide Local Streets and Roads Needs Assessment Project

05May2016 by Bor-Wen Tsai

D1. INTRODUCTION

The purpose of this memorandum is to improve the regression model developed in 2012 [*1*] that was used to estimate the safety, traffic and regulatory needs. Notice that the replacement cost is calculated based on the first eight asset categories (storm drains, curb and gutter, sidewalk (public), curb ramps, traffic signals, street lights, sound walls/retaining walls, and traffic signs). The needs of remaining four categories (other elements, NPDES, other ADA compliance needs, and other physical assets or expenditures) [*1*] were considered as a percentage of the replacement cost of the first eight asset categories. The multiple regression model of replacement cost established in 2012 has the following formula with three indicator variables, *Type_Rural*, *Climate_Central*, and *Large*.

$$LnCost = 15.0 + 0.726 Total\ Miles^{1/3} - 0.00268 Total\ Miles - 2.13 Type\_Rural + 0.329 Climate\_Central + 3.5\ Large$$

where, $LnCost =$ replacement cost in natural logarithm,

$$Type\_Rural = \begin{cases} 1 \text{ if the agency is rural} \\ 0 \text{ oerthwise} \end{cases},$$

$$Climate\_Central = \begin{cases} 1 \text{ if the agency is central} \\ 0 \text{ oerthwise} \end{cases}, \text{ and}$$

$$Large = \begin{cases} 1 \text{ for large agencies with network greater than 1,900 miles} \\ 0 \text{ oerthwise} \end{cases}.$$

Noticed that, in this formula, the covariates *Type_Rural* and *Climate_Central* are geographically associated. Hereafter, the covariates $Total\ Miles^{1/3}$, *Total Miles*, *Type_Rural*, and *Climate_Central* will be denoted as *tm3*, *tm*, *isrural*, and *central* respectively. In order to improve current 2012 regression model, it is necessary to re-visit multiple linear regression (MLR) model, validate the regression model with newly collected data, and explore state-of-the-art methodology that can better explain the spatial variation of residuals, such as the geographically weighted regression (GWR) model as introduced below.

D2. DATA

With the newly collected data, four datasets (**safe_6u**, **safe_ee3**, **safe_ee2**, and **safe_ee1**) were selected to evaluate the effect of data integrity on the modelling results.

The primary dataset discussed in the following is **safe_6u**, which includes agencies that their replacement costs were calculated based on six or more components of the first eight categories and each component was within middle 80 percent of data, i.e., from 10^{th} percentile to 90^{th} percentile. It is recognized that the three most important categories that consist of replacement cost are storm drains, curb and gutter, and sidewalk.

The dataset of **safe_ee3** contains agencies that replacement costs were evaluated with the most three important categories [storm drains, curb and gutter, and sidewalk (public)] and more. All the components were validated within middle 80 percent of data. The dataset of **safe_ee2** includes agencies that replacement costs were computed with two of the three most important categories (storm drains, curb and gutter) and more. The dataset of **safe_ee1** has agencies that replacement costs were calculated with one of the three most important categories (storm drains) and more.

The sample sizes of **safe_6u**, **safe_ee3**, **safe_ee2**, and **safe_ee1** are 272, 107, 139, and 202 respectively. For **safe_6u**, 97 out of 272 agencies contain the three most important categories; 120 agencies have storm drains and curb categories; and 168 agencies include only storm drains.

In the following, the **safe_6u** dataset will be used to demonstrate/examine both MLR and GWR models.

D3. METHODOLOGY

D3.1 Multiple Linear Regression (MLR)

D3.1.1 Statistic Terms

The following definitions of statistic terms [*2*] are provided to understand the output and diagnosis plots from R software.

Residual: $e_i = y_i - \hat{y}_i$, the residual describes the error (difference) in the fit of the model to the *i*th observation y_i.
***t*-test**: testing hypotheses about individual regression coefficients based on the *t* distribution. The null hypothesis is $H_0: \beta_j = 0$. If the null hypothesis is not rejected, this indicates that the covariate x_j can be deleted from the model.
Multiple R-squared (R-squared): $R^2 = \frac{SS_R}{SS_T} = 1 - \frac{SS_E}{SS_T}$, where regression sum of squares $SS_R = \sum_{i=1}^{n}(\hat{y}_i - \bar{y})^2$, total sum of squares $SS_T = \sum_{i=1}^{n}(y_i - \bar{y})^2$, and error sum of squares $SS_E = \sum_{i=1}^{n}(y_i - \hat{y}_i)^2$.
Outliers: an observation with large residual.
Leverage: an observation with an extreme value on a predictor variable. The leverage of an observation measures the amount by which the predicted value would change if the observation was shifted one unit in the y-direction.
Standardized residual: $d_i = \frac{e_i}{\sqrt{\hat{\sigma}^2}}$, is computed by dividing the ordinary residual by the square root of the residual mean square and thus produces scaled residuals that have a unit variance.
Cook's distance is a measure of the influence of each individual observation on the estimates of the regression model parameters. It expresses the distance that the vector of model parameter estimates with the ith observation removed lies from the vector of model parameter estimates based on all observations. Large values of Cook's distance indicate that the observation is influential.

D3.1.2 Coefficient of Determination R^2 and Correlation Coefficient ρ

The correlation coefficient is defined in terms of the covariance. If X and Y are jointly distributed random variables and the variances and covariances of both X and Y exist and the variances are nonzero, then the correlation of X and Y, denoted by ρ, is

$$\rho = \frac{Cov(X,Y)}{\sqrt{Var(X)Var(Y)}}$$

Note that if X and Y are two jointly distributed random variables with a standard normal distribution $N(0,1)$, then the, $Var(X) = Var(Y) = 1$, and $\rho = Cov(X,Y)$.

Figure D-1 presents a series of scatterplots of 500 independent pairs of bivariate normal random variables with several correlation coefficients so as to give the reader an indication of how the scatterplots look if two normal random variables exist with a certain correlation coefficient/coefficient of determination. The clouds of points are roughly elliptical in shape. From Figure D-1, the subjective threshold to marginally/visually identify the linear strength of two variables can be set at a correlation coefficient value of roughly 0.4. The algorithm to generate two jointly distributed random variables with a certain correlation coefficient is not discussed herein.

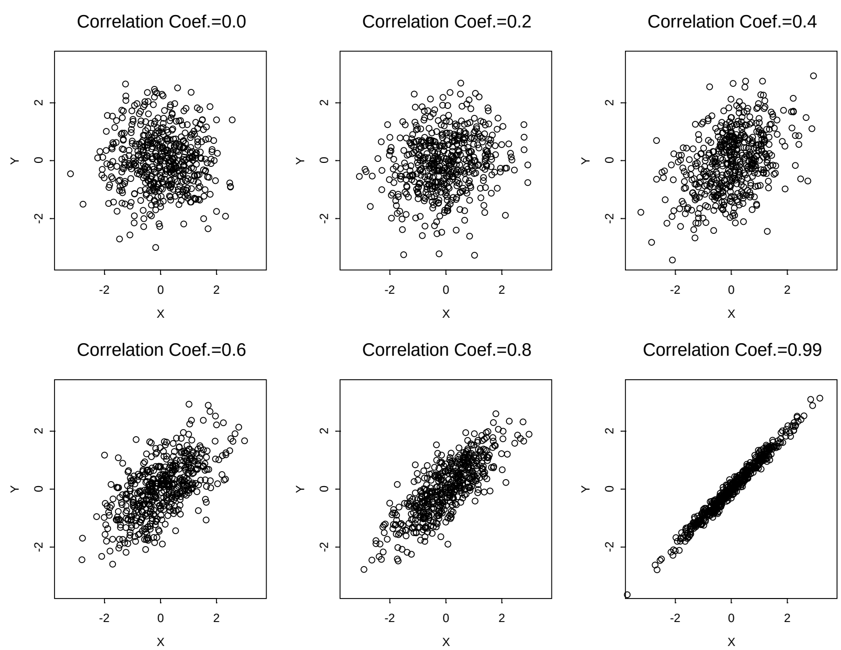


Figure D-1. Scatterplots of 500 independent pairs of bivariate normal random variables with correlation coefficients ρ = 0.0, ρ = 0.2, ρ = 0.4, ρ = 0.6, ρ = 0.8 and ρ = 0.99.

Notice that the coefficient of determination R^2 is just the square of the correlation coefficient between Y and X [2], that is, $R^2 = \rho^2$. Hence, the corresponding R^2s for Figure D-1 are 0.00, 0.04, 0.16, 0.36, 0.64, and 0.98.

D3.2 Geographically weighted regression (GWR)

The reasons that measured relationships vary spatially could be attributed to sampling variation, relationships intrinsically different across space (for instance, different administrative or political effects produce different responses to the stimuli), traffic patterns, road network attributes, or socio-demographic characteristics. If there is spatial non-stationarity, it can be only seen through the residuals. One obvious way is to map the residuals from the regression to determine whether there are any spatial patterns. The essence of GWR modeling is to address the issue of spatial non-stationarity directly and allow the measured relationships to vary over space.

In a GWR, the replacement costs are predicted by a set of covariates of which the parameters are allowed to vary over space. The model specification, that is,

$$y_i = \beta_0(i) + \beta_1(i)x_{1i} + \beta_2(i)x_{2i} + \cdots + \beta_n(i)x_{ni} + \varepsilon_i$$

with the coefficients, $\boldsymbol{\beta}'(i) = (\boldsymbol{X}'\boldsymbol{W}(i)\boldsymbol{X})^{-1}\boldsymbol{X}'\boldsymbol{W}(i)\boldsymbol{Y},$ where $\boldsymbol{W}(i)$ is a matrix of weights specific to location *i* such that observations close to *i* are given greater weight than observations further away.

In the linear regression, the strength and direction of association is indicated by the regression coefficients, with one coefficient given for each covariate in the dataset. Main output of GWR is a set of location-specific parameter estimates which can be mapped and analyzed to provide information on spatial non-stationarity in relationships. Thus, in GWR, instead of one global coefficient for each covariate, coefficients are able to vary spatially.

The GWR modeling was carried out using R package **`spgwr`**. First, we will calibrate the bandwidth of the kernel that will be used to capture the points for each regression and then run the GWR model.

D3.3 Measures of goodness of fit

The measures of goodness of fit used for model comparison are (1) the mean absolute deviation (MAD) and (2) the mean squared prediction error (MSPE). A smaller value of MAD or MPSE, in an average sense, suggests that the model predicts the observed data better. These measures are defined as follows:

$$MAD = \frac{\sum_{i=1}^{N}\left|Y_i - \hat{Y}_i\right|}{N}$$

$$MSPE = \frac{\sum_{i=1}^{N}\left(Y_i - \hat{Y}_i\right)^2}{N}$$

where Y_i is the observed value of replacement cost in natural logarithm for agency $\hat{Y}_i$ is the predicted value of replacement cost in mnatural logarith for agency, and N is the number of agencies.

D3.4 Moran's I statistics

Moran's I is a measure of spatial autocorrelation – how related the value of a variable are based on the location they were measured – developed by Moran (1950) [*3*]. Herein, the Moran's I test was introduced to investigate whether the residuals of replacement cost of different models are spatially correlated among adjacent area. Values of Moran's I range from -l (perfect dispersion) to +1 (perfect correlation). Notice that a zero value indicates a random spatial pattern. The Moran's I tests were conducted using R package **ape**. The Moran's I coefficient is computed using the formula:

$$I = \frac{n}{S_0} \frac{\sum_{i=1}^{n} \sum_{j=1}^{n} w_{i,j} (y_i - \bar{y})(y_j - \bar{y})}{\sum_{i=1}^{n} (y_i - \bar{y})^2}$$

where y_i = observations; $w_{i,j}$ = distance weigh; n = number of observations; $S_0 = \sum_{i=1}^{n} \sum_{j=1}^{n} w_{i,j}$. The matrix weight is used as "neighborhood" weights. Based on the results, we can reject the null hypothesis that there is zero spatial autocorrelation present in the residuals of replacement cost at a specified significance level. The calculation of Moran's I statistic uses R package **ape**.

D4. MODEL IMPROVEMENT USING SAFE_6U DATASET AS AN EXAMPLE

In the following, the general process introduced to improve 2012 regression model will be applied not only to **safe_6u** dataset but to all the other datasets defined in this study. The major difference resides in the influential observations/outliers that need to remove to improve fitting (step 3). In addition, to simplify the model, the covariate *central* was eliminated since the GWR modeling will take into account the spatial variation using the geo-coordinates of agencies; the covariate *large* will be substituted by the covariate *iscounty* (step 4). Two GWR models, city-based and county-based models, will be assessed. The process to improve 2012 MLR model adapts the following steps:

Step 1 (mod1.lm): run 2012 MLR model

Figure D-2 presents the MLR output and its diagnosis plots as well. Several points can be addressed from this figure: (1) the multiple R-squared value 0.38 is pretty low; (2) t-statistic shows that all the estimations of parameter coefficients are significant at level 0.01; (3) normal Q-Q plot indicates the distribution of prediction error is skew to left; (4) Cook's distance, leverage, and normal Q-Q plots all reveal the possibility of influential observations/outliers.


```
> summary(mod1.lm)

Call:
lm(formula = log(cost) ~ tm + tm3 + isrural + central + large,
    data = df)

Residuals:
    Min      1Q  Median      3Q     Max
-8.3249 -0.4440  0.1683  0.7264  3.1451

Coefficients:
              Estimate Std. Error t value Pr(>|t|)
(Intercept) 14.9489017  0.4259926  35.092  < 2e-16 ***
tm          -0.0024666  0.0006309  -3.910 0.000117 ***
tm3          0.6560646  0.0960042   6.834 5.63e-11 ***
isrural     -2.0204575  0.2828640  -7.143 8.76e-12 ***
central      0.6201246  0.1986173   3.122 0.001993 **
large        2.6952875  0.9252350   2.913 0.003883 **
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 1.323 on 266 degrees of freedom
Multiple R-squared:  0.3784,	Adjusted R-squared:  0.3667
F-statistic: 32.38 on 5 and 266 DF,  p-value: < 2.2e-16

>
```

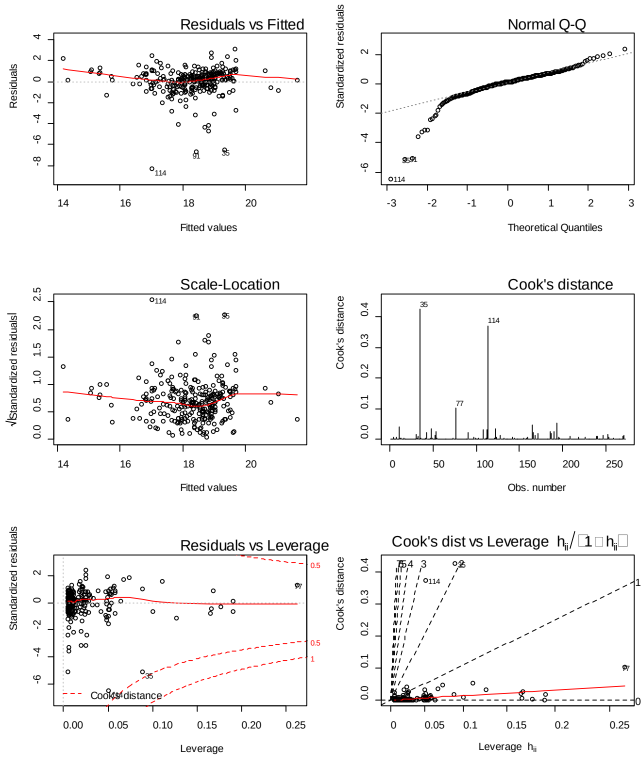


Figure D-2. MLR output and diagnosis plots of prediction errors of 2012 MLR model (Step 1) using safe_6u dataset.

Step 2 (mod2.lm): evaluate the addition of covariate iscounty

By adding one more covariate *iscounty*, the R-squared value raises up slightly from 0.38 to 0.42. The new covariate *iscounty* is an indicator variable that is defined as follows:

$$iscounty = \begin{cases} 1 \text{ if the agency is county} \\ 0 \text{ oerthwise} \end{cases}$$

Step 3 (mod3.lm): remove possible influential observations/outliers

Viewing from the Cook's distance, leverage, and normal Q-Q plots of step 2, it identifies that the replacement costs obtained from the agencies Fresno (Fresno county), Los Angeles county, Temple city (Los Angeles county), and Mono county require further verification and it is not necessary to say that these agencies are bad observations or outliers. After removing these agencies, the R-squared value showed a considerable increase from 0.42 to 0.55. Figure D-3 presents the MLR output and the corresponding diagnosis plots of prediction errors. Notice that t-statistic shows that the estimation of parameter *large* is not significant at all and the residual analysis is not unacceptable.


```
> summary(mod3.lm)

Call:
lm(formula = log(cost) ~ tm + tm3 + isrural + central + large +
    iscounty, data = df[!(df$n %in% outs), ])

Residuals:
    Min      1Q  Median      3Q     Max
-4.8819 -0.4461  0.1146  0.5606  2.7799

Coefficients:
              Estimate Std. Error t value Pr(>|t|)
(Intercept) 14.5991648  0.3398680  42.955  < 2e-16 ***
tm          -0.0018941  0.0005357  -3.535 0.000481 ***
tm3          0.7697884  0.0790898   9.733  < 2e-16 ***
isrural     -1.2824245  0.2393854  -5.357 1.86e-07 ***
central      0.3612106  0.1558696   2.317 0.021257 *
large        0.9326553  0.7388421   1.262 0.207960
iscounty    -1.7702885  0.2796463  -6.330 1.06e-09 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 1.001 on 261 degrees of freedom
Multiple R-squared:  0.5484,    Adjusted R-squared:  0.538
F-statistic: 52.82 on 6 and 261 DF,  p-value: < 2.2e-16

> df[df$n %in% c(35,77,91,114),]$name
[1] "Fresno (Fresno County)"
[2] "Los Angeles County (Los Angeles County)"
[3] "Temple City (Los Angeles County)"
[4] "Mono County (Mono County)"
>
```

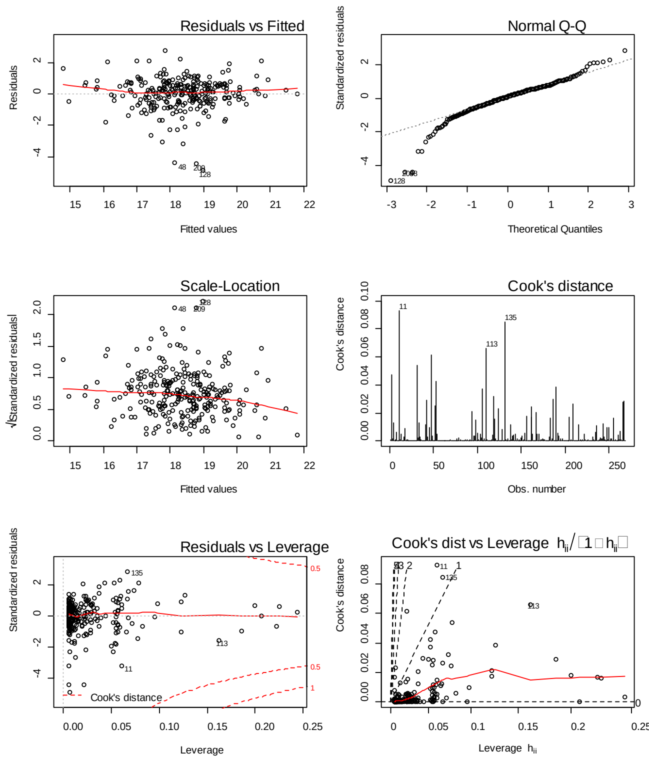


Figure D-3. MLR output and diagnosis plots of prediction errors (Step 3) using safe_6u dataset.

Step 4 (mod4.lm): remove central and large covariates

As mentioned before, the covariate *central* was removed because it is geographically-associated and will be considered in GWR modeling; the covariate *large* was eliminated and substituted by the covariate *iscounty*. As a result, the penalty of model simplification is pretty minor and the R-squared value decreases to an acceptable level from 0.55 to 0.54.

Step 5 (mod1.gwr): develop city-based GWR model

The same model specification of mod4.lm (Step 4) will be utilized as partial input to develop GWR models including the city-based and the following county-based GWR models. When compared with mod4.lm, the GWR modeling provides a surpassingly better model than MLR model in terms of R-squared value (0.62 versus 0.54), measures of goodness of fit (MAD: 0.62 versus 0.72; MSPE: 0.83 versus 1.00) and Moran’s I statistic as shown in Table D-1. Inspection of p-values of mod4.lm and mod1.gwr models indicates that we are not going to reject the null hypothesis that there is zero spatial autocorrelation for the prediction errors of mod1.gwr (p-value = 0.98) whereas we have to reject the null hypothesis that there is zero spatial autocorrelation for mod4.lm (p-value = 0.06) at significance level 0.10. In other words, the prediction errors of MLR model show apparent spatial pattern whereas the prediction errors of GWR model present no spatial pattern.

Table D-1. Measures of goodness of fit and Moran's I statistics for residuals of predictions in the MLR and GWR models.

Dataset	Model	R^2/ Quasi-Global R^2	Goodness of Fit		Moran's I[1]			
			MAD	MSPE	Observed	Expected	SD	*P*-value
Safe_6u	mod1.lm	0.38	0.8404	1.7127	0.04408	-0.00369	0.03079	0.12079
	mod2.lm	0.42	0.7827	1.6005	0.05803	-0.00369	0.03065	0.04406
	mod3.lm	0.55	0.6992	0.9752	0.06148	-0.00375	0.03131	0.03725
	mod4.lm	0.54	0.7193	1.0005	0.05492	-0.00375	0.03131	0.06099
	mod1.gwr	0.62	0.6194	0.8297	-0.00443	-0.00375	0.03121	0.98262
	mod2.gwr	0.61	0.6231	0.8367	-0.00458	-0.00375	0.03121	0.97858
Safe_ee3	mod1.lm	0.63	0.5884	0.8068	-0.00329	-0.00943	0.06031	0.91880
	mod2.lm	0.71	0.5647	0.6260	0.02781	-0.00943	0.06105	0.54187
	mod3.lm	0.79	0.4662	0.3429	0.05748	-0.00971	0.06475	0.29948
	mod4.lm	0.79	0.4656	0.3450	0.05695	-0.00971	0.06473	0.30307
	mod1.gwr	0.81	0.4311	0.3117	0.01841	-0.00971	0.06466	0.66364
	mod2.gwr	0.81	0.4316	0.3122	0.01531	-0.00971	0.06467	0.69887
Safe_ee2	mod1.lm	0.57	0.6466	0.8262	0.11681	-0.00725	0.05074	0.01449
	mod2.lm	0.66	0.6037	0.6608	0.13623	-0.00725	0.05107	0.00497
	mod3.lm	0.72	0.5363	0.4449	0.12942	-0.00741	0.05299	0.00982
	mod4.lm	0.71	0.5472	0.4566	0.12480	-0.00741	0.05298	0.01258
	mod1.gwr	0.72	0.5185	0.4296	0.09656	-0.00741	0.05295	0.04959
	mod2.gwr	0.73	0.5169	0.4287	0.09421	-0.00741	0.05295	0.05496
Safe_ee1	mod1.lm	0.46	0.7340	1.0528	0.08514	-0.00498	0.04073	0.02692
	mod2.lm	0.53	0.6860	0.9219	0.11153	-0.00498	0.04060	0.00411
	mod3.lm	0.62	0.6196	0.6440	0.13285	-0.00505	0.04164	0.00093
	mod4.lm	0.60	0.6407	0.6818	0.13034	-0.00505	0.04162	0.00114
	mod1.gwr	0.71	0.5203	0.4987	0.06305	-0.00505	0.04162	0.10177
	mod2.gwr	0.71	0.5200	0.4902	0.05806	-0.00505	0.04161	0.12931

Note:

1. Observed: the computed Moran's I; expected: the expected value of I under the null hypothesis; SD: the standard deviation of I under the null hypothesis; *P*-value: the *p*-value of the test of the null hypothesis against the alternative hypothesis specified in alternative; null hypothesis H_0: there is zero spatial autocorrelation.

Step 6 (mod2.gwr): establish county-based GWR model

According to analysis results in Table D-1, mod1.gwr is slightly better than mod2.gwr in terms of different performance measures. However, from the viewpoint of practical application, county-based GWR model (mod2.gwr) makes more sense. Table D-2 lists the estimations of parameters of the county-based GWR model (mod2.gwr) for each county using **safe_6u** dataset. Due to incompleteness of data collection, Table D-2 contains only 52 counties, except Alpine, Colusa, Lassen, Modoc, Mono, and Sierra counties.

Figure D-4 presents the city-based GWR coefficients of variables in a color scale relative to the estimations of parameters of mod4.lm (white color). Gradient red or blue colors indicate that the GWR coefficients are greater or smaller than the coefficients of mod4.lm. The coefficients of mod4.lm are intercept (14.981574), *tm3* (0.740290), *tm* (-0.001491), *isrural* (-1.341778), and *iscounty* (-1.991640).

Figure D-5 shows the choropleth maps of the county-based GWR coefficients of variables. As can be seen from Figures D-4 and D-5, it is apparent that the coefficients (estimations of parameters) of variables in the GWR varied spatially suggesting the effects of covariates on replacement cost were different between northern California and southern California.

Figure D-6 gives the spatial variations and histograms of the residuals of replacement cost for one MLR model (mod4.lm) and two GWR models (mod1.gwr and mod2.gwr). The residuals of GWR models distribute more evenly than MLR model does. The histograms of residuals indicate that (1) the histograms of GWR models are close to bell-shaped normal distribution whereas the histogram of MLR is apparently skew to left; (2) the histogram of city-based GWR model is slightly better than that of county-based GWR model.

D5. CONCLUSIONS

Based on analysis results of different datasets, the following conclusions are offered:

1. The results showed that the geographically weighted regression (GWR) successfully captured the spatially non-stationary relationships between replacement cost and the associated covariates, which multiple linear regression (MLR) fails to explain.
2. From Figures D-4 and D-5, it is apparent that the coefficients (estimations of parameters) of variables in the GWR varied spatially suggesting the effects of covariates on replacement cost were different between northern California and southern California, especially in San Francisco Bay Area and Los Angeles Area,
3. According to the measures of MAD and MSPE shown in Table D-1, geographically weighted regression performs superbly over multiple linear regression no matter which dataset is selected.
4. The values of quasi-global R^2/R^2 and goodness of fit (MAD and MSPE) for each model depend on how the dataset was sampled. While the agencies were selected such that the replacement costs were calculated by including the most three important categories, i.e., **safe_ee3**, it gives the best performance measures. To aware that data sampling is able to affect model fitting significantly, it is strongly recommended that data collection should contain the information of storm drains, curb and gutter, and sidewalk (public) as much as possible no matter how difficult the data collection will be.
5. By summarizing the model fitting results, it is suggested that the model specification should be county-based GWR model, rather than city-based GWR model, with the formulation of $LnCost = f\left(utm, utm^{1/3}, rural, mycounty\right)$ so as to keep the model as practical and simple as possible. Notice that the downside of GWR modeling is that the developed models are not spatially transferable since they produce a set of local parameters for a specific geographic region.

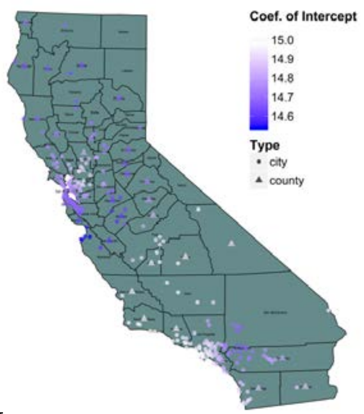
D6. REFERENCES

1. Engineering & Environmental Services, Nichols Consulting Engineers, Chtd., *California Statewide Local Streets and Roads Needs Assessment*, Final Report, January 2013.
2. Montgomery, D. C. and G. C. Runger. *Applied Statistics and Probability for Engineers*. John Wiley & Sons, Inc. Fifth Edition, 2010.
3. Moran, P.A.P., Notes on continuous stochastic phenomena. Biometrika 37 (1), 17-23, 1950.

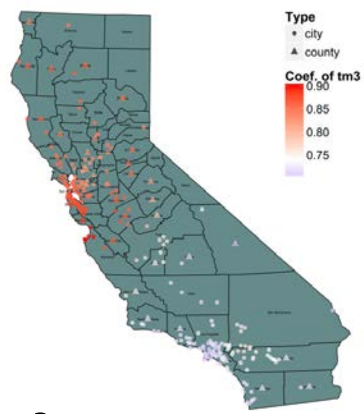
Table D-2. Estimations of parameters of the county-based GWR model (mod2.gwr) using safe_6u dataset.

County	Intercept	*tm3*	*tm*	*isrural*	*iscounty*
Alameda	14.951943	0.823950	-0.001668	-1.474594	-1.725067
Amador	14.692445	0.847607	-0.001730	-1.019572	-3.018222
Butte	14.683179	0.850587	-0.001733	-0.995800	-2.886857
Calaveras	14.680732	0.850200	-0.001752	-1.018081	-3.033804
Contra Costa	14.964169	0.815019	-0.001551	-1.472243	-2.066141
Del Norte	14.696651	0.843193	-0.001907	-1.003560	-2.491808
El Dorado	14.669853	0.849910	-0.001755	-1.001867	-2.998694
Fresno	14.907841	0.768560	-0.001636	-1.227668	-2.379635
Glenn	14.709118	0.847486	-0.001672	-1.013976	-2.827333
Humboldt	14.648657	0.861380	-0.001950	-0.978660	-2.566992
Imperial	14.897179	0.718726	-0.001431	-1.963983	-1.173713
Inyo	14.999453	0.710267	-0.001395	-1.503208	-1.975829
Kern	15.046698	0.709182	-0.001593	-1.536991	-1.619161
Kings	14.959486	0.753944	-0.001616	-1.287754	-2.213079
Lake	14.715750	0.851774	-0.001692	-1.060343	-2.751696
Los Angeles	15.039804	0.712716	-0.001674	-1.930626	-0.319629
Madera	14.823044	0.795049	-0.001710	-1.151881	-2.576092
Marin	14.749860	0.857775	-0.001664	-1.270258	-2.329730
Mariposa	14.758223	0.816073	-0.001760	-1.103721	-2.712322
Mendocino	14.659918	0.864479	-0.001848	-1.010342	-2.663102
Merced	14.641040	0.864312	-0.001933	-1.090522	-2.841942
Monterey	14.724818	0.844532	-0.001953	-1.190610	-2.515264
Napa	14.823442	0.834793	-0.001548	-1.222329	-2.672645
Nevada	14.666431	0.851102	-0.001768	-0.994372	-2.941659
Orange	14.908911	0.724885	-0.001572	-1.934951	-0.177979
Placer	14.674813	0.849467	-0.001744	-0.998706	-2.978346
Plumas	14.659120	0.851015	-0.001829	-0.986074	-2.817844
Riverside	14.812009	0.733428	-0.001506	-2.045890	-0.952513
Sacramento	14.817346	0.828055	-0.001589	-1.122881	-2.891993
San Benito	14.670651	0.860829	-0.001985	-1.161927	-2.642340
San Bernardino	14.815893	0.730826	-0.001480	-1.994607	-1.129561
San Diego	14.824067	0.734126	-0.001539	-2.094002	-0.699978
San Francisco	14.782372	0.853118	-0.001684	-1.393526	-1.964925
San Joaquin	14.896751	0.818871	-0.001593	-1.189494	-2.739548
San Luis Obispo	14.981351	0.752389	-0.001635	-1.320472	-2.096367
San Mateo	14.781961	0.854342	-0.001733	-1.405538	-1.713859
Santa Barbara	15.048053	0.727537	-0.001669	-1.399212	-1.746989
Santa Clara	14.826726	0.851449	-0.001895	-1.351795	-2.070942
Santa Cruz	14.736176	0.866139	-0.001940	-1.327264	-2.268571
Shasta	14.641355	0.859528	-0.001904	-0.963225	-2.698684
Siskiyou	14.675394	0.848204	-0.001911	-0.984743	-2.569740
Solano	14.931198	0.813370	-0.001485	-1.334765	-2.556903
Sonoma	14.747700	0.851335	-0.001612	-1.136903	-2.650863
Stanislaus	14.717028	0.856462	-0.001847	-1.113862	-2.830694
Sutter	14.790092	0.829036	-0.001539	-1.078146	-2.931923
Tehama	14.654637	0.859056	-0.001824	-0.972352	-2.772816
Trinity	14.637991	0.863943	-0.001938	-0.966387	-2.628343
Tulare	14.981725	0.728783	-0.001551	-1.331229	-2.139191

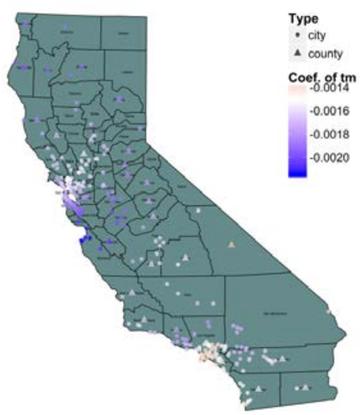
County	Intercept	*tm3*	*tm*	*isrural*	*iscounty*
Tuolumne	14.700672	0.833594	-0.001788	-1.055615	-2.843902
Ventura	15.085803	0.707705	-0.001696	-1.666002	-1.106515
Yolo	14.893846	0.812058	-0.001414	-1.211272	-2.837071
Yuba	14.715717	0.843200	-0.001667	-1.018811	-2.947135



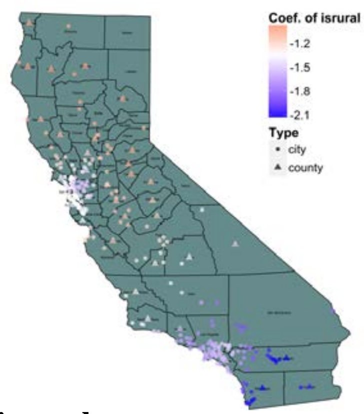
(a) Intercept



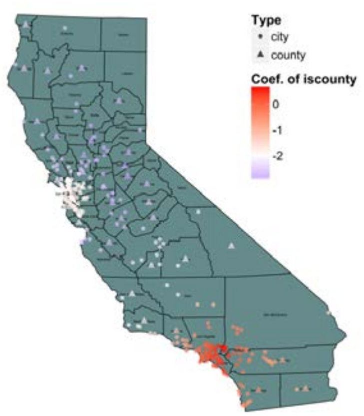
(b) tm3



(c) tm

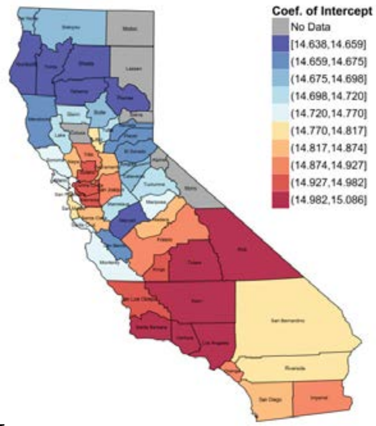


(d) isrural

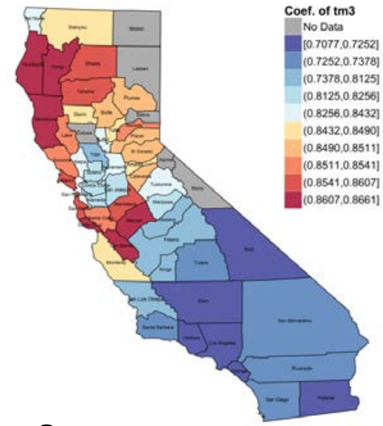


(e) iscounty

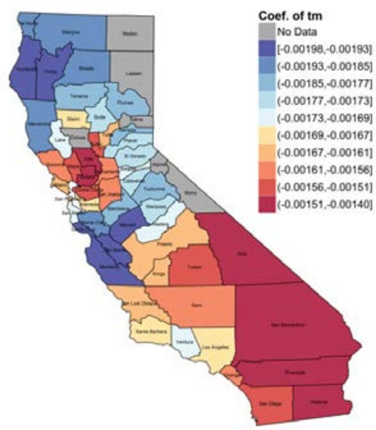
Figure D-4. City-based GWR coefficients of variables (safe_6u dataset): (a) intercept; (b) *tm3*; (c) *tm*; (d) is*rural*; and (e) *iscounty*. [Note: White stripe of legend for each covariate represents the regression coefficient of mod4.lm. The coefficients of mod4.lm are intercept (14.981574), *tm3* (0.740290), *tm* (-0.001491), *isrural* (-1.341778), and *iscounty* (-1.991640).]



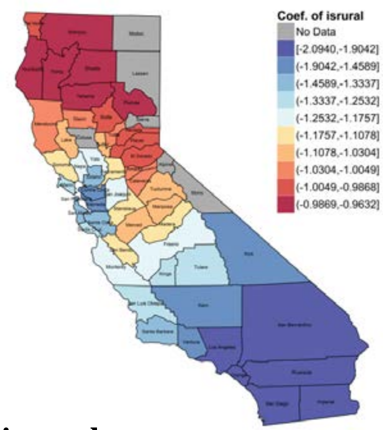
(a) Intercept



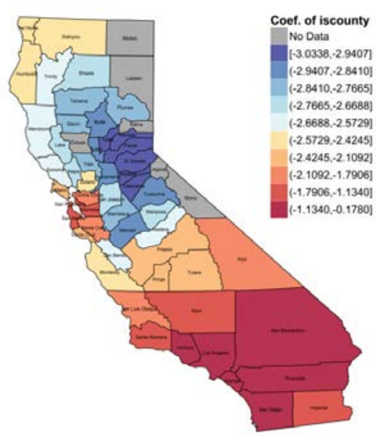
(b) tm3



(c) tm

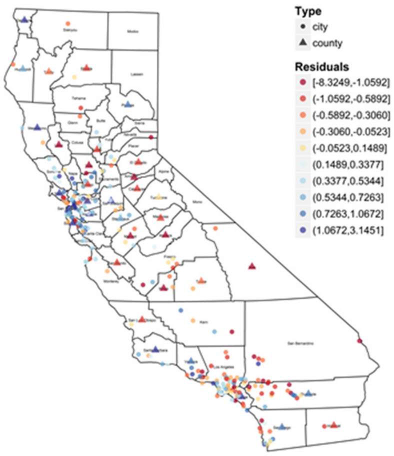


(d) isrural

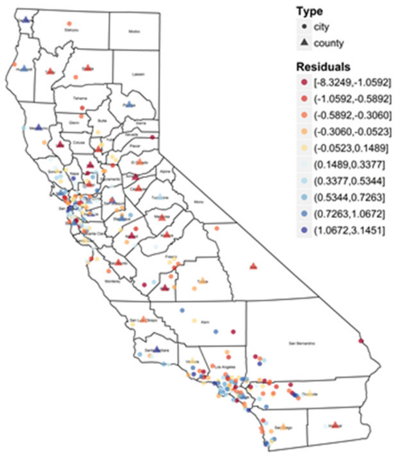


(e) iscounty

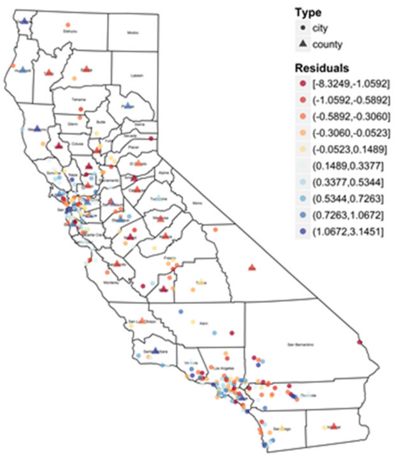
Figure D-5. Choropleth maps of county-based GWR coefficients of variables (safe_6u dataset): (a) intercept; (b) *tm3*; (c) *tm*; (d) *isrural*; and (e) *iscounty*.



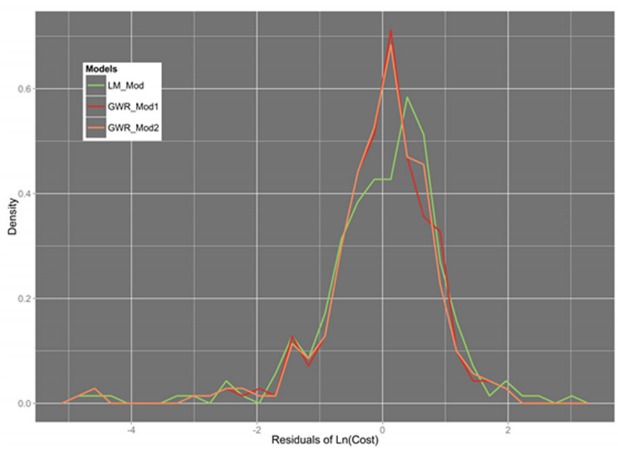
(a) Multiple Linear Regression Model (LM_Mod)



(b) City-Based GWR Model (GWR_Mod1)



(c) County-Based GWR Model (GWR_Mod2)



(d) Model Comparison

Figure D-6. Spatial variations and histograms of residuals of replacement cost (LnCost) using safe_6u dataset: (a) multiple linear regression model; (b) city-based GWR model; (c) county-based GWR model; (d) model comparison.

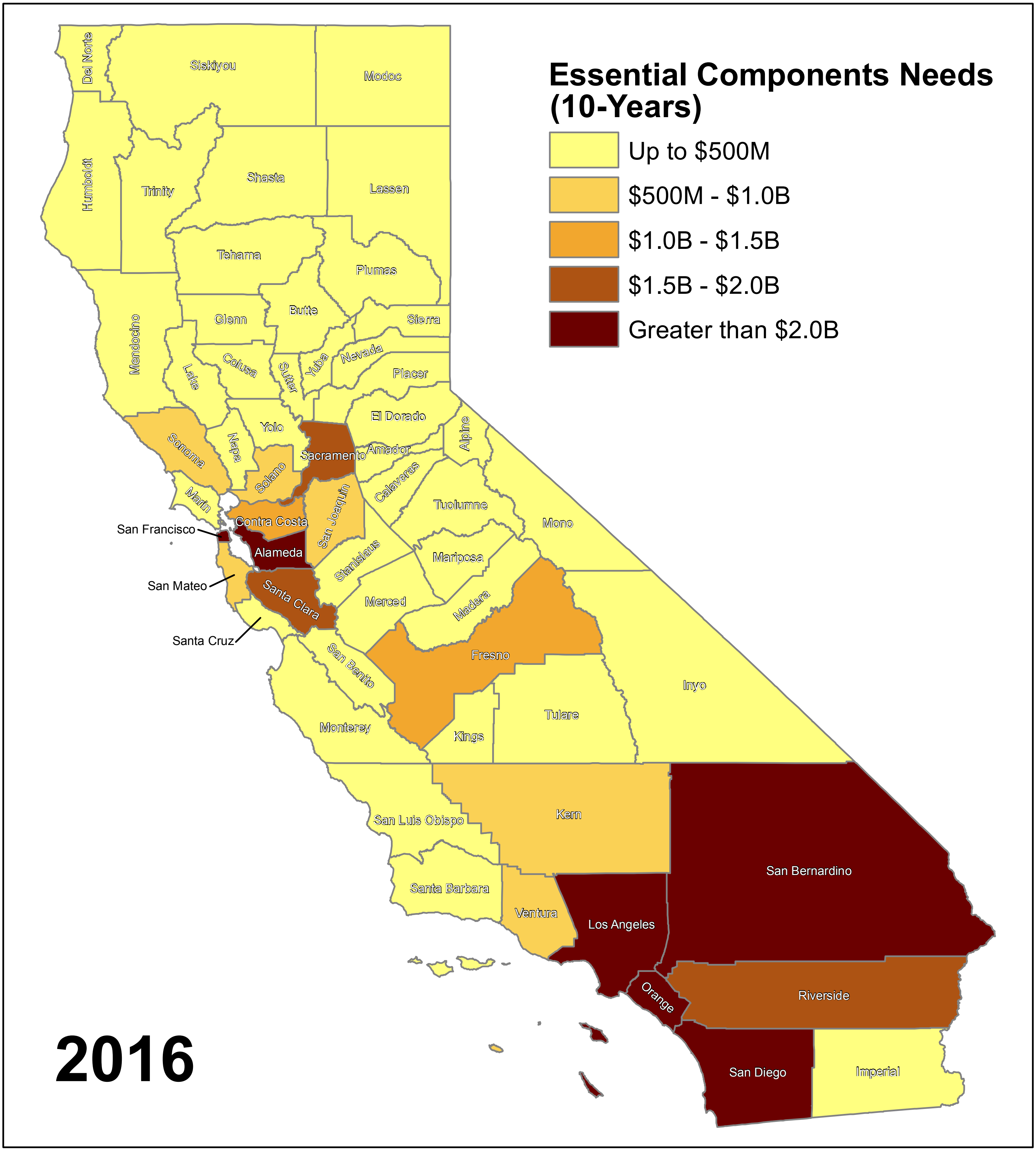
Appendix E

Essential Component Needs by County

Table E.1 Summary of Essential Components Needs by County*

County	10 year Needs ($M)	County	10 year Needs ($M)
Alameda	$ 2,169	Orange	$ 2,017
Alpine	$ 1	Placer	$ 392
Amador	$ 27	Plumas	$ 27
Butte	$ 200	Riverside	$ 1,590
Calaveras	$ 8	Sacramento	$ 1,799
Colusa	$ 26	San Benito	$ 10
Contra Costa	$ 1,392	San Bernardino	$ 2,011
Del Norte	$ 32	San Diego	$ 2,083
El Dorado	$ 66	San Francisco	$ 2,597
Fresno	$ 1,488	San Joaquin	$ 672
Glenn	$ 28	San Luis Obispo	$ 140
Humboldt	$ 172	San Mateo	$ 764
Imperial	$ 113	Santa Barbara	$ 271
Inyo	$ 8	Santa Clara	$ 1,829
Kern	$ 679	Santa Cruz	$ 124
Kings	$ 106	Shasta	$ 179
Lake	$ 37	Sierra	$ 6
Lassen	$ 19	Siskiyou	$ 64
Los Angeles	$ 4,408	Solano	$ 519
Madera	$ 96	Sonoma	$ 741
Marin	$ 309	Stanislaus	$ 459
Mariposa	$ 6	Sutter	$ 109
Mendocino	$ 126	Tehama	$ 62
Merced	$ 96	Trinity	$ 7
Modoc	$ 83	Tulare	$ 273
Mono	$ 19	Tuolumne	$ 31
Monterey	$ 298	Ventura	$ 790
Napa	$ 165	Yolo	$ 237
Nevada	$ 32	Yuba	$ 46
		Totals	**$ 32,057**

* Includes cities within County



Essential Components Needs (10-Years)
Up to $500M
$500M - $1.0B
$1.0B - $1.5B
$1.5B - $2.0B
Greater than $2.0B
Del Norte
Siskiyou
Modoc
Humboldt
Trinity
Shasta
Lassen
Tehama
Plumas
Mendocino
Glenn
Butte
Sierra
Colusa
Lake
Sutter
Yuba
Nevada
Placer
El Dorado
Alpine
Yolo
Sonoma
Napa
Sacramento
Amador
Solano
Marin
Calaveras
Tuolumne
Mono
Contra Costa
San Joaquin
San Francisco
Alameda
Stanislaus
Mariposa
San Mateo
Santa Clara
Merced
Madera
Santa Cruz
San Benito
Fresno
Inyo
Monterey
Kings
Tulare
Kern
San Luis Obispo
San Bernardino
Santa Barbara
Ventura
Los Angeles
Orange
Riverside
San Diego
Imperial
2016

Appendix F

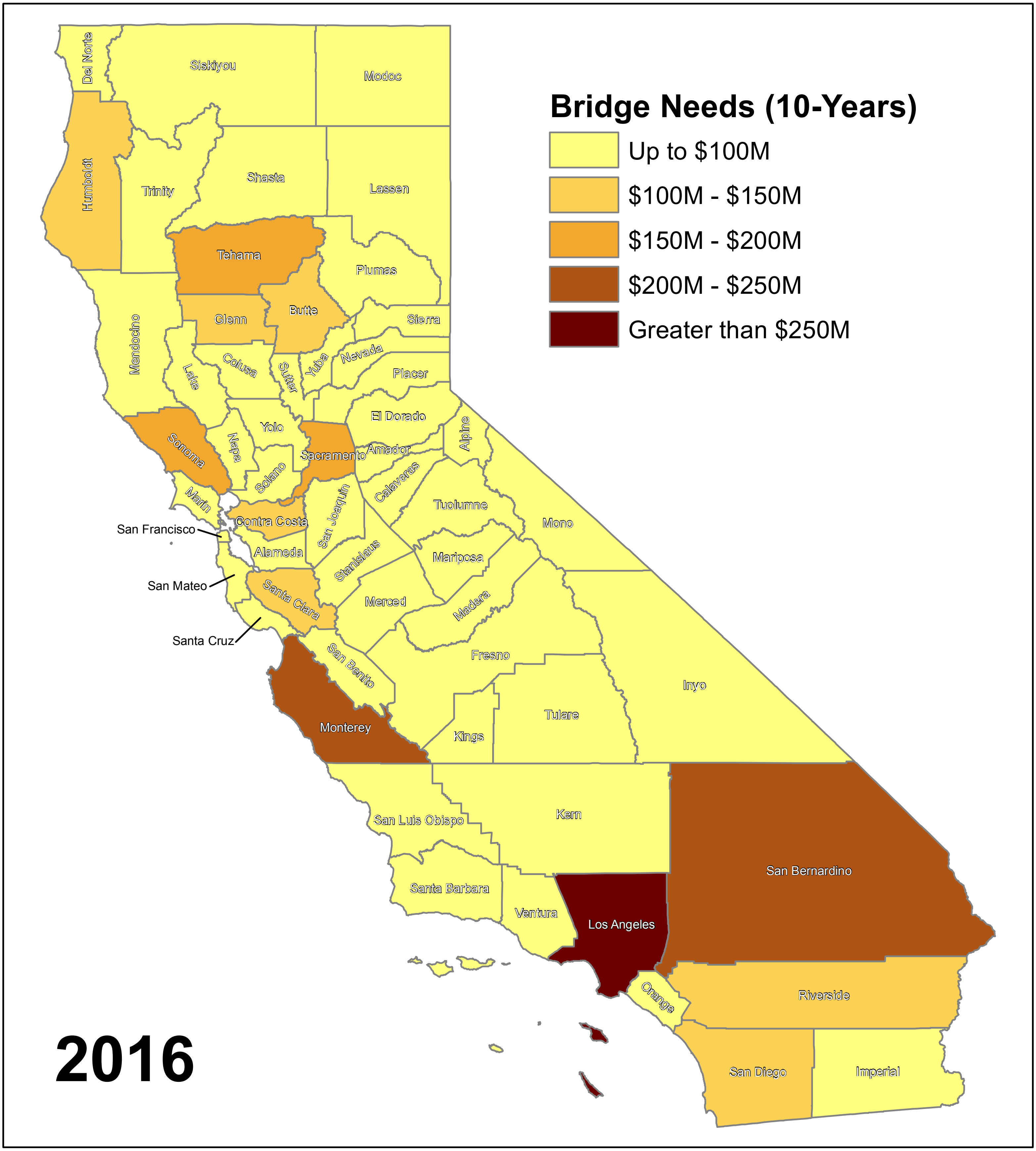
Local Bridge Needs Assessment

Table F.1 Bridge Needs by County* (2016 $)

County	Number of Bridges	Average Sufficiency Rating, SR	Structures with SR ≤ 80	Structures with SR ≤ 50	Total Bridge Need
	EA	%	EA	EA	$ Million
Alameda	205	83	58	7	$ 55
Alpine	11	74	6	1	$ 2
Amador	39	69	19	8	$ 7
Butte	293	75	100	40	$ 110
Calaveras	68	73	24	12	$ 18
Colusa	148	85	28	10	$ 12
Contra Costa	294	83	86	14	$ 105
Del Norte	28	76	9	4	$ 12
El Dorado	86	68	47	14	$ 36
Fresno	494	80	164	33	$ 84
Glenn	168	77	56	24	$ 105
Humboldt	167	72	59	33	$ 129
Imperial	134	77	43	20	$ 25
Inyo	34	82	10	2	$ 1
Kern	283	87	65	2	$ 29
Kings	99	87	28	0	$ 2
Lake	80	72	28	14	$ 23
Lassen	65	75	26	7	$ 13
Los Angeles	1,470	84	456	38	$ 1,232
Madera	155	83	37	14	$ 57
Marin	113	75	45	12	$ 33
Mariposa	53	67	24	11	$ 19
Mendocino	139	74	56	21	$ 77
Merced	298	80	117	15	$ 27
Modoc	49	88	9	2	$ 1
Mono	12	78	5	1	$ 1
Monterey	137	69	53	32	$ 205
Napa	103	73	48	14	$ 40
Nevada	62	75	16	11	$ 21
Orange	514	83	174	17	$ 59
Placer	177	79	51	23	$ 37
Plumas	91	73	34	15	$ 45
Riverside	438	87	91	8	$ 138

County	Number of Bridges	Average Sufficiency Rating, SR	Structures with SR ≤ 80	Structures with SR ≤ 50	Total Bridge Need
	EA	%	EA	EA	$ Million
Sacramento	403	85	87	21	$ 185
San Benito	45	75	18	5	$ 17
San Bernardino	487	79	159	53	$ 219
San Diego	527	87	112	13	$ 137
San Francisco	24	73	11	3	$ 23
San Joaquin	324	85	85	11	$ 53
San Luis Obispo	201	77	90	15	$ 30
San Mateo	140	76	69	12	$ 97
Santa Barbara	188	80	52	20	$ 55
Santa Clara	458	81	128	39	$ 120
Santa Cruz	99	68	40	22	$ 40
Shasta	283	80	101	15	$ 62
Sierra	32	77	12	5	$ 16
Siskiyou	178	82	39	17	$ 31
Solano	201	88	42	6	$ 44
Sonoma	440	77	166	44	$ 160
Stanislaus	247	78	121	13	$ 88
Sutter	90	79	35	8	$ 6
Tehama	305	76	96	47	$ 159
Trinity	92	78	21	12	$ 27
Tulare	400	81	153	9	$ 37
Tuolumne	55	68	25	12	$ 21
Ventura	182	82	65	6	$ 83
Yolo	123	77	49	12	$ 21
Yuba	74	74	29	10	$ 25

*Cities included within County


Bridge Needs (10-Years)
Up to $100M
$100M - $150M
$150M - $200M
$200M - $250M
Greater than $250M
2016
Del Norte
Siskiyou
Modoc
Humboldt
Trinity
Shasta
Lassen
Tehama
Plumas
Glenn
Butte
Sierra
Mendocino
Colusa
Lake
Sutter
Yuba
Nevada
Placer
El Dorado
Yolo
Alpine
Sonoma
Napa
Sacramento
Amador
Solano
Calaveras
Marin
Tuolumne
Mono
San Francisco
Contra Costa
San Joaquin
Alameda
Stanislaus
Mariposa
San Mateo
Santa Clara
Merced
Madera
Santa Cruz
Fresno
San Benito
Inyo
Tulare
Monterey
Kings
San Luis Obispo
Kern
San Bernardino
Santa Barbara
Ventura
Los Angeles
Orange
Riverside
San Diego
Imperial