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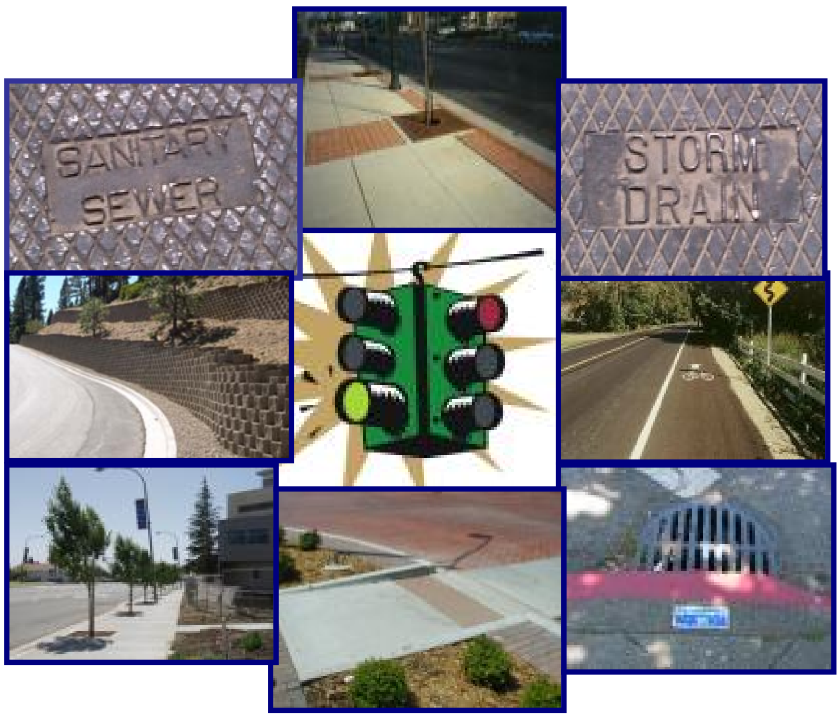
FINAL REPORT

Non Pavement Needs Assessment



Submitted to:

Metropolitan Transportation Commission
Joseph P. Bort Metro Center
101 Eight Street
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1. Introduction

Over the past decades, the public has invested through federal, state, and local government, in the construction, maintenance, and operation of the Nation's transportation system. The expectation is that governments will be responsible stewards of this investment. Toward that end, MTC is committed to making investment and maintenance decisions that are rational and understandable to the various stakeholders.

A significant challenge for MTC's Local Streets and Road Program is managing the asset base while funding expansion of the network to meet increasing demands. To meet this challenge, a thorough analysis of the non-pavement asset portion of the 2004 and 2006 Local Streets and Roads (LS&R) survey data was undertaken. The objective of this data analysis was to develop a methodology for predicting non-pavement needs to incorporate in the Regional Transportation Plan. In addition, a synthesis of relevant information on non-pavement asset management from the literature and public agencies is presented.

Background – Asset Management

Today's transportation environment is characterized by high user demand, budgets stretched by significant and growing requirements, staff shortages, and a mature system that is experiencing ongoing deterioration. The combination of changes in the transportation environment and public expectations has created a strong motivation for aligning transportation agency business practices with asset management principles.

A still-emerging concept in the highway industry, asset management may be defined as a "systematic process of maintaining, upgrading and operating physical assets cost-effectively." It combines engineering, economic principles and sound business practices to support decision-making at the network, project and field/operational level. Thus, asset management provides a framework for handling both short- and long-range planning.

Asset management links user expectations for system condition, performance, and availability with system management and investment strategies. This broad approach to resource allocation and programming decisions can provide greater value to the system and overall satisfaction for end-users. Asset management not only aids in the decision-making process, but also facilitates a fact-based dialogue between system users and other stakeholders, government officials, and managers concerned with day-to-day operations. Asset management can provide ready access to quantitative and qualitative data allowing decision-makers to more readily identify and focus on key issues.

The Federal Highway Administration (FHWA), American Association of State Highway and Transportation Officials (AASHTO) and the National Cooperative Highway Research Program (NCHRP) have sponsored numerous studies of asset management experience, techniques and processes both here and abroad. In these studies it as been noted that asset management, as an organizational culture and decision-making process, is critical to transportation programs facing significant capital renewal and preservation needs and that successful programs require top-level commitment. Also, it has been observed that agencies use asset management to obtain funding for transportation infrastructure. This is particularly significant for MTC.

Transportation asset management encompasses all phases of infrastructure life including public policy, planning, maintenance, preservation and rehabilitation. The key components to any comprehensive asset management system include the following:

1) goals and policies;
2) asset inventory;
3) condition assessment and performance monitoring;
4) a process to determine short- and long-term needs; and
5) methods to evaluate the strategies employed.

Although each element is essential, the key building blocks for any asset management system are a comprehensive inventory and condition rating for assets.

The data may be used for various purposes: planning, budgeting, scheduling and performance evaluation. Data collection requirements should be compatible with the intended use of the data. Asset management data collection should support the decision-making processes of the intended user. Asset management principles can be applied to each level of the management, operation and analysis of transportation assets. Similarly, data collection requirements must reflect how the data will be used at the network, project and field/operational level. The network level may be used to determine the overall scope of an agency's needs and may allow for general budget allocations. The focus is narrowed when applied to project level, where emphasis is placed on a geographic region and used to develop and overall workplan for meeting performance measures. The field/operational level is intended to provide tools to optimize the actual work accomplished. To ensure that appropriate data will be collected, critical thought must be given to how the data will be used.

In general, asset data collection is categorized as follows: 1) location; 2) physical attribute; and 3) condition. Physical attributes collected vary from asset to asset. General attributes that are consistent across assets include material type, size and length. Condition assessment is dependent upon the specified performance criteria for the asset. Data can be broad for some assets requiring a qualitative rating of only "good," "fair," or "bad," whereas others may require a more detailed approach set forth by national or regionally accepted practices or standards. Shown in Table 1.1 are basic inventory attributes for transportation assets.

Data for principal transportation assets may be collected for various purposes including inventory, inspection, tort liability, performance monitoring and funding allocation. Considerations when determining the data collection plan should include the following:

Table 1.1 Basic Inventory Attributes for Transportation Assets[1]

Asset Group	Asset Type	Inventory Attributes										
		Point Asset	Linear Asset	Type	Linear dimensions	Size/area	Material	Number	Depth of cover	Install date/history	Direction	Traffic
Drainage	Culvert	*		*	*	*	*	*	*	*		*
	Curb & Gutter		*	*	*					*		*
	Sidewalk		*		*		*			*	*	*
	Ditch		*	*	*					*	*	*
	Drop Inlet	*					*	*				*
	Stormwater Pond	*									*	
	Underdrain	*					*					
Roadside	Fence		*		*		*			*	*	
	Grass Mowing		*	*		*						
	Brush		*	*		*						
	Slope (Erosion Control)		*									
	Litter			*		*					*	
	Landscaping	*		*		*					*	
	Sound Barrier		*		*		*			*	*	*
Pavement	Shoulders		*	*	*	*	*			*	*	*
	Paved Surfaces		*	*	*	*	*	*		*	*	*
	Unpaved Surfaces		*		*		*			*		*
Bridge	Bridge	*		*	*	*	*			*	*	*
	Paint	*				*				*		
	Joint	*						*		*		
	Retaining Wall	*			*	*	*			*		*
Traffic Items	Signal	*								*		*
	Sign	*		*		*		*		*	*	*
	Pavement Marketing	*			*	*	*			*	*	*
	Pavement Marker	*						*		*		*
	Guardrail (End)	*			*		*			*	*	*
	Guardrail	*			*		*			*	*	*
	Overhead Sign	*		*						*	*	*
	Impact Attenuator	*		*						*		*
	Traffic Barriers		*		*		*			*	*	*
	Highway Lighting	*		*						*	*	*
Special Facilities	Movable Bridges	*		*	*	*	*			*	*	*
	Rest Areas	*		*		*				*	*	*
	Tunnels	*		*						*	*	*
	Weigh Stations	*								*	*	*
	Traffic Monitoring Systems	*	*							*	*	*

[1] American Association of State Highway and Transportation Officials, *Asset Management Data Collection Guide*, Task Force 45 Report, June 2006.

- typical use of the data;
- resources available vs volume of assets;
- level of detail and desired accuracy; and
- life expectancy and deterioration rate.

In summary, when a data collection plan is being developed, the following questions should be asked.

- What is the intended use of the data (eg, network, project, field level)?
- What data collection method(s) provides the level of detail needed to support the intended use of the data?
- Which assets will be included in the data collection plan?
- What is the best method available to collect data for the selected assets?
- What resources are available to collect the data?

Typically, the cost of data collection increases with the level of detail in the information collected about an asset.

In applying the elements of asset management, most transportation agencies have systems in place for pavements and bridges. These include relatively sophisticated management systems, detailed and comprehensive periodic inspections, as well as planning, programming and budgeting procedures to resolve investment priorities and program tradeoffs. Comparable systems are not typically available or deployed for other transportation assets in the US, at least not to the scale seen for pavements and bridges. There is at least one notable exception, however – the City of Portland, Oregon (This is discussed in further detail below.). To gain a better understanding of the state-of-the-practice for managing "other" assets, i.e., non-pavement assets, NCHRP has funded a "synthesis" project to identify "best practices"[2]. As part of this project a questionnaire was distributed to state transportation agencies. The six asset types that are the focus of this questionnaire include the following:

- traffic signals, including structural components;
- lighting, including structural components;
- signs, both ground-mounted and overhead, including structural components;
- pavement markings and lane striping;
- drainage culverts and pipes (but not bridges); and
- sidewalks.

[2] National Cooperative Highway Research Program, Project 20-5, Synthesis of Highway Practice 37-03, *Managing Selected Transportation Infrastructure Assets*, Transportation Research Board, January 2006.

The questions posed include the following:

1) What is your management approach for the asset?
2) How do you determine condition of the asset?
3) How do you determine where an asset is in its life span?
4) How do you forecast future resource needs for preserving and/or achieving a service level objective?
5) What service life models and/or assumptions do you use to forecast maintenance/rehabilitation/replacement?
6) What tools and technologies are used to collect, analyze, predict, map, and maintain asset information?
7) What are major knowledge gaps and what research needs to be done to improve the validity of service life estimates for the six named transportation asset?
8) Are there other non-pavement/bridge assets for which management approaches have been developed?

The draft report was recently submitted to the project panel for review with publication of the final report anticipated in January 2008. Of particular interest to MTC are the responses to questions 3, 4 and 5; i.e., those related to life span and forecasting future needs.

As noted above, the City of Portland, Oregon is a notable exception to managing "other" assets as it has tracked the number, condition, value and unmet needs of its transportation assets since 1986[4]. As articulated in its 2004 strategic plan, PDOT's (Portland Department of Transportation) goals are to preserve the investment at a sustainable level, optimize its use, and help to realize community goals through system improvements.

PDOT's needs are similar to the needs of many other urban transportation systems. Facing the problem of deteriorating streets, bridges and other capital facilities, it is examining the causes of deterioration and seeking alternative funding for repair and replacement of existing facilities. Like many other jurisdictions, at current funding levels Portland is unable to keep existing facilities in good condition. Many facilities are reaching the end of their useful life and maintenance has been deferred due to inadequate funding.

In response to the 1999 GASB requirements for state and local governments to report the value of their infrastructure assets, and as part of its overall annual reporting strategy, PDOT publishes a "Status and Condition Report" which is organized into six sections:

1. Summary of Environment, Condition and Unmet Need

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[4] Portland Office of Transportation, *City of Portland Transportation System: Status and Condition Report*, July 2004.

(defines the transportation system; summarizes the status, condition and replacement value of PDOT's major capital facilities; and establishes the context in which the system operates)

2. Status and Condition of the Existing System
   (describes the present condition of each major capital inventory in the system)
4. Operational Performance Measures
   (describes and reports on operational indicators of system performance)
5. Financing the Transportation System
   (identifies funding requirements for current and desired levels of maintenance of Portland's transportation system)
6. Technical Appendix
   (provides data, a glossary of terms, and a list of staff contacts)

Shown in Table 1.2 is a summary of PDOT's transportation assets from the 2004 report. Note that it identifies the "replacement value" as well as "unmet need". The **replacement value** does not imply that the entire system needs replacing, it merely directs which course of action the City will pursue: maintain its capital facilities or defer maintenance. The **total unmet needs** are defined as the cost to bring all assets up to standard or "good" condition.

Although PDOT classifies 31 different transportation assets, it has written seven strategic asset management plans that identify not only historic budget and expenditures, but also what is working well and where work is needed[5]. Currently, asset management plans have been written for the following:

- pavements;
- structures;
- traffic signals;
- street lights;
- traffic signs;
- pavement markings; and
- sidewalks, corners and curbs.

The purpose of each plan is to create an internal management tool for day-to-day asset management; increase the understanding of the demands on different parts of the organization; provide a forum to ensure that process improvements are incorporated across transportation; and increase teamwork and collaboration. The framework for each asset plan is as follows:

[5] Portland Office of Transportation, Asset Management Plans

a. *Structures* – June 2001
b. *Traffic Signals* – September 2001
c. *Street Lights* – September 2001
d. *Pavement* – June 2001, April 2006
e. *Signs* – April 2002
f. *Pavement Marking* – April 2003
g. *Sidewalk System* – March 2004
h. *Parking* – November 2005

Table 1.2 PDOT 2004 Status, Condition and Value Report[6]

FACILITY	GASB34	STATUS	REPLACEMENT VALUE	CONDITION**						TOTAL NEED	ANNUAL UNMET NEED
				VG	G	F	P	VP	TBD		
PAVEMENT											
Improved Streets	X	3,943 lane miles	$4,312,122,065	29%	27%	22%	18%	3%		$70,000,000	$8,800,000
Unimproved Streets		131 lane miles*	N/A					100%		N/A	N/A
			$4,312,122,065							$70,000,000	$8,800,000
SIDEWALK SYSTEM											
Sidewalks	X	8,582,418 sq yds	$772,417,620						X	N/A	N/A
Curbs	X	3,200 miles	540,672,000		75%	15%	10%			TBD	TBD
Corners											
Improved Corners	X	37,192	61,366,800		80%	15%	5%			$44,184,096	$874,000
Corners with Ramps	X	10,588	N/A							N/A	N/A
Unimproved Corners		5,062	N/A							N/A	N/A
			$1,374,456,420							$44,184,096	$874,000
BICYCLE NETWORK			(included with Pavement)								
Bikeways		194 miles							X	TBD	TBD
STRUCTURES											
Bridges	X	157	$250,114,216	26%	17%	21%	17%	19%		$48,475,146	$500,000
Retaining Walls	X	494	45,316,292	94%	5%	1%	0%	0%		TBD	TBD
Stairways	X	174	4,321,212						X	TBD	TBD
Guardrails	X	25 miles	11,921,223						X	TBD	TBD
Harbor Wall	X	5,133 feet	166,140,891		100%					$0	$0
			$477,813,834							$48,475,146	$500,000
TRAFFIC SIGNALS											
Hardware	X	989	$98,900,000		29%	35%	36%			$35,800,000	$5,100,000
Controllers	X	989	7,912,000		44%	46%	10%			840,000	TBD
Other Equipment	X	230	1,610,000						X	TBD	TBD
ITS Equipment		TBD	TBD						X	TBD	TBD
			$108,422,000							$36,640,000	$5,100,000
STREETCAR											
Streetcars		7	$16,100,000	100%						$0	$0
Tracks	X	TBD	TBD						X	TBD	TBD
Maintenance Facilities	X	TBD	TBD						X	TBD	TBD
			$16,100,000							$0	$0
TRAFFIC CALMING											
Calming Devices	X	1,340	$7,804,084						X	TBD	TBD
STREET LIGHTS											
Option B (City Own & PGE Maintain)	X	43,830	$30,900,000		16%	76%	8%			$2,320,000	$0
Option C (City Own & Maintain)	X	9,309	$62,300,000		49%	34%	17%			$5,300,000	$1,200,000
		53,139	$93,200,000							$7,620,000	$1,200,000
STREET SIGNS											
Street Name	X	40,817	$2,110,229						X	TBD	TBD
Parking	X	42,632	901,835						X	TBD	TBD
Traffic Control	X	44,599	3,682,722						X	TBD	TBD
Stop Signs Only	X	13,824		44%	41%	10%	5%			$60,000	TBD
Guide Signs	X	6,436	598,750						X	TBD	TBD
Sign Mounts	X	86,233	5,352,909						X	$290,887	$30,000
			$12,646,445							$350,887	$30,000
PAVEMENT MARKINGS											
Center Lines		737 pass-miles	$206,400						X	TBD	TBD
Traffic Lane Lines		96 pass miles	$41,400						X	TBD	TBD
Bike Lane Lines		457 pass-miles	$127,900						X	TBD	TBD
Edge Lines		278 pass-miles	$77,500						X	TBD	TBD
Crosswalks		3,828	$586,500						X	TBD	TBD
Stop Bars		2,287	$55,300						X	TBD	TBD
Symbols & Words		11,747	$2,054,600						X	TBD	TBD
Island Markings		592	$201,596						X	TBD	TBD
Parking		1,239	$224,810						X	TBD	TBD
			$3,576,006								
PARKING METERS											
Double	X	698	$918,568		80%	10%	10%			$0	$0
Single	X	208	$141,024		80%	10%	10%			$0	$0
SmartMeter	X	959	$8,480,437	100%						$0	$0
		1,865	$9,540,029								
FACILITIES SUBTOTAL			$6,415,680,883							$207,270,129	$16,504,000
RIGHT-OF-WAY		2,001 miles	$4,608,510,720							$0	$0
TOTAL			$11,024,191,603							$207,270,129	$16,504,000

* same as 65 center-line miles
** not all assets are categorized using a 5-level condition assessment
Notes: N/A= Not Applicable, TBD= To Be Determined, VG= Very Good, G= Good, F= Fair, P= Poor, VP= Very Poor

[6] Portland Office of Transportation, *City of Portland Transportation System: Status and Condition Report*, July 2004.

- Asset Trends and Updates
    - Asset description: inventory, growth, value, condition, unmet need
    - Budget and expenditure history
    - Service level and performance
- Standards, Roles and Responsibilities
- Effectiveness/Efficiency
    - Comparison of service with other jurisdictions
    - Efficiencies and innovations
- Forecast Conditions
    - Emerging issues
    - Predicting condition for various service levels
    - Financial and other impacts
- Next Steps
    - Strategic direction & recommendations
        - Budget changes
        - Policy/goal changes
        - Opportunity for collaboration

Though Portland is light-years ahead of most cities, it should be noted that these plans are at various stages of implementation. The preceding discussion on asset management in general, and the City of Portland, in particular, is relevant for several reasons. It underscores the fact that asset management can be an effective decision-making tool at several levels: network, project and field/operational level. Also, asset management provides a framework for handling both short- and long-range planning. As is evident from the PDOT approach, asset management facilitates dialogue between users, other stakeholders, government officials and management concerned with day-to-day operations. Its system will help "establish sustainable funding for a sustainable infrastructure"[7]. Finally, the 20-year City of Portland experience highlights the critical importance of data collection – inventory as well as condition – to quantify the "unmet need."

[7] Portland Office of Transportation, *City of Portland Transportation System: Status and Condition Report*, July 2004.

2. Local Street and Road (LS&R) Survey Data

2004 and 2006 Survey Responses

In October 2004, MTC, through Berryman & Henigar, solicited information on non-pavement assets from the 109 Bay Area cities and counties. As noted in the Berryman & Henigar report[8], all but one (Sonoma) of the nine counties responded. Of the 109 surveyed, 87 responded with varying degrees of information. Twenty-two agencies did not submit any information. Approximately 80 of the agencies responded. These responses account for approximately 80% of the total.

In 2006, the same 109 agencies were surveyed by MTC. This time 88 responded, accounting for approximately 88% of the total. Figure 2.1 shows the comparison in response for the 2004 and 2006 surveys.

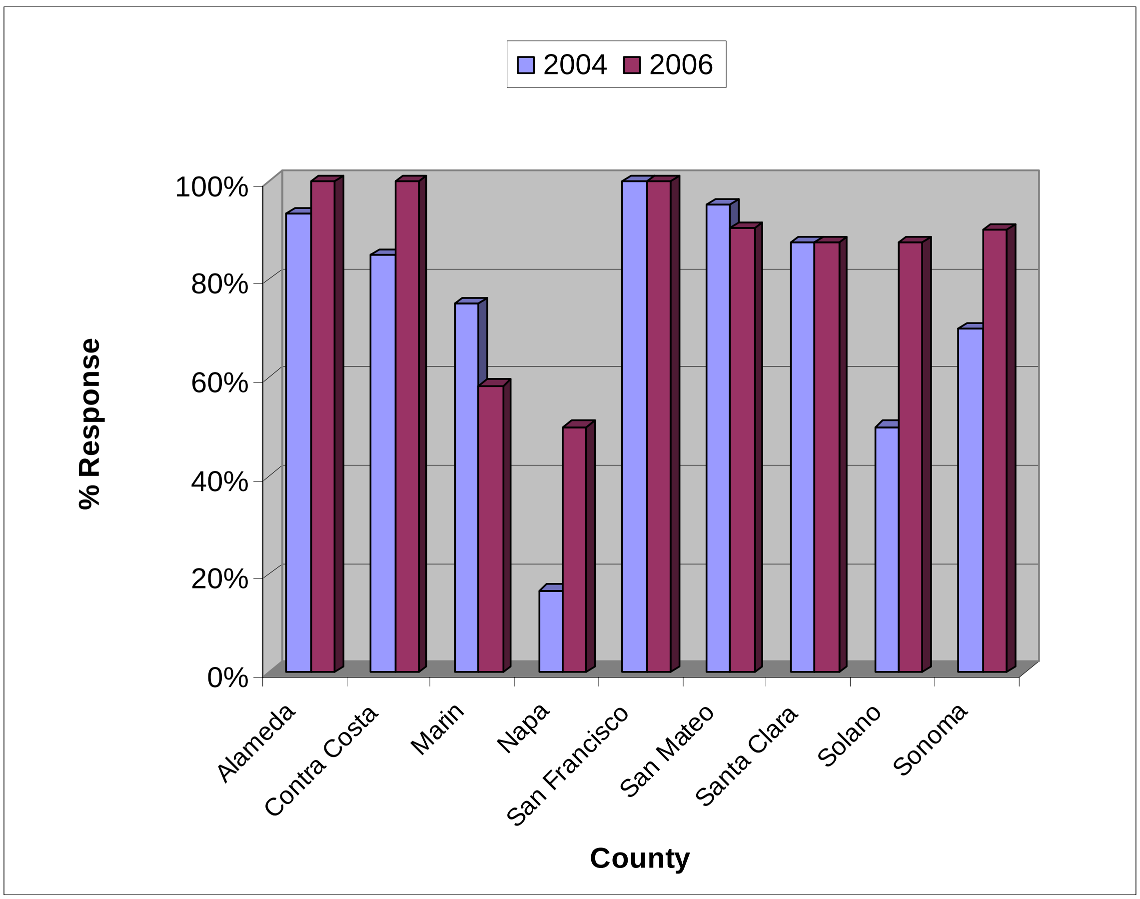


Figure 2.1 Percent Response for LS&R Survey (2004 & 2006)

[8] Berryman & Henigar, Memo to J Gerbracht from J Hoang on Task 2 (Compile and Analyze Survey Responses) and Task 3 (Identify Agency Study Lists), 30 November 2005.

Data Analysis

Table 2.1 shows the total replacement cost by county. The percent distribution of total replacement cost by county is shown in Figure 2.2. Overall, the total asset cost for all counties remained relatively constant. Still, there are significant differences reported for some of the counties between 2004 and 2006. For example, Santa Clara County, reported approximately five and a half billion dollars less in asset cost than it did in 2004, causing a dramatic change in the percent distribution of cost by county.

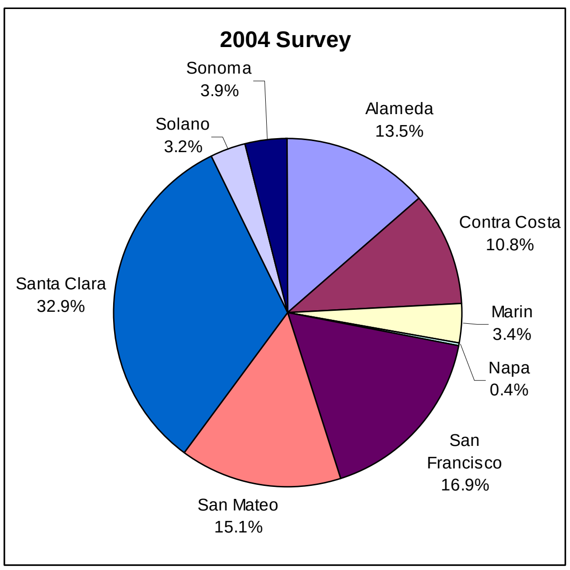
Table 2.1 Total Replacement Costs

County	Asset Cost 2004	Asset Cost 2006	Difference (2006 cost – 2004 cost)
Alameda	$3,284,737,249	$4,968,282,622	$1,683,545,373
Contra Costa	$2,613,840,617	$2,975,705,965	$361,865,348
Marin	$832,778,496	$918,586,481	$85,807,985
Napa	$93,600,000	$197,491,483	$103,891,483
San Francisco	$4,095,382,350	$6,366,557,516	$2,271,175,166
San Mateo	$3,662,335,111	$2,981,571,475	-$680,763,636
Santa Clara	$7,979,579,400	$2,716,833,865	-$5,262,745,535
Solano	$777,535,829	$1,828,055,408	$1,050,519,579
Sonoma	$955,779,369	$1,886,588,352	$930,808,983
Total	**$24,295,568,421**	**$24,839,673,167**	**$544,104,746**

Table 2.2 shows the total replacement cost data for the Santa Clara county agencies. It can be seen that in 2004, the city of San Jose reported a total asset cost of nearly six billion dollars, while in 2006 this number dropped to only one hundred million dollars (see highlighted row). However, the 2006 survey response did specify that most non-pavement assets are funded through funding sources other than the city, which explains the decrease in cost from 2004 to 2006. For the rest of the counties, the difference in cost may be due to an increase in construction costs, a change in the percent response, or a combination of both.

Table 2.2 Replacement Costs for Santa Clara County Agencies

Agency	2004	2006	Difference
Campbell	$116,800,000	$138,887,000	$22,087,000
Cupertino	$122,998,000	$129,700,000	$6,702,000
Gilroy	N/A	$1,071,125	$1,071,125
Los Altos	$68,050,000	$80,210,000	$12,160,000
Los Altos Hills	$38,726,000	$174,425,000	$135,699,000
Los Gatos	N/A	N/A	N/A
Milpitas	$170,197,300	$173,115,938	$2,918,638
Monte Sereno	$3,898,000	N/A	-$3,898,000
Morgan Hill	$86,772,480	$81,697,520	-$5,074,960
Mountain View	$299,631,000	$260,775,000	-$38,856,000
Palo Alto	$294,003,611	$373,325,611	$79,322,000
San Jose	**$5,751,615,246**	**$108,640,000**	**-$5,642,975,246**
Santa Clara	$351,900,000	$371,400,000	$19,500,000
Saratoga	$144,875,000	$80,421,250	-$64,453,750
Sunnyvale	$477,499,321	$664,965,421	$187,466,100
Unincorp. County	$52,078,125	$78,200,000	$26,121,875
Total	**$7,926,965,958**	**$2,638,633,865**	**-$5,288,332,093**



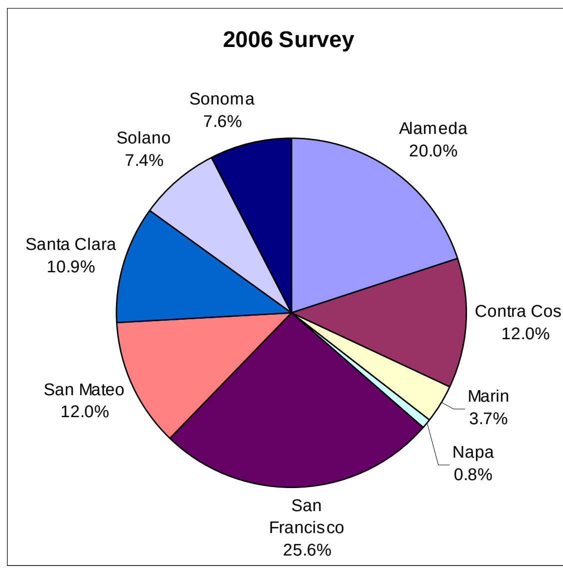


Figure 2.2 Total Replacement Cost Distribution by County

Another aspect of interest is the cost distribution by asset. Shown in Figure 2.3 is the composite for the nine-counties. Note that in both cases, there are 3 categories that account for nearly 80% of the total replacement cost (storm drain, curb and gutter, and sidewalk). Furthermore, those three categories plus traffic signals and street lights account for approximately 87% of the total replacement cost, as shown in Table 2.3.

Table 2.3 Total Replacement Costs by Category

Category	2004		2006	
Storm Drain	$10,894,292,610		$9,342,246,481	
Curb & Gutter	$4,370,168,161		$5,720,592,542	
Sidewalk	$3,874,555,490	78.8%	$4,349,386,855	78.2%
Traffic Signals	$1,277,797,609		$1,282,084,625	
Street Lights	$875,487,497	87.6%	$835,934,728	86.7%
Bicycle Paths	$1,752,400			
Bridges	$86,208,360		$984,345,000	
Corporate Yard	$752,541,679		$482,339,631	
Curb Medians	$269,727,664		$23,689,796	
Curb Ramps	$421,091,731		$536,034,744	
Guardrails	$40,901,099		$18,367,114	
Heavy Equipment	$174,654,512		$111,264,764	
Parking Lots	$603,245			
Pathways	$4,292,121			
Public Parks			$36,979,989	
Sewer - Pipelines	$661,019,161			
Sound/Retaining Walls	$395,244,243		$915,521,668	
Speed Bump	$200,000			
Storm Damage			$2,715,000	
Traffic Circles	$750,000			
Traffic Signs	$182,503,924		$182,335,232	
Trees			$1,045,000	
Other	$11,776,915		$14,790,000	
Total	**$24,295,568,421**	**100%**	**$24,839,673,167**	**100%**

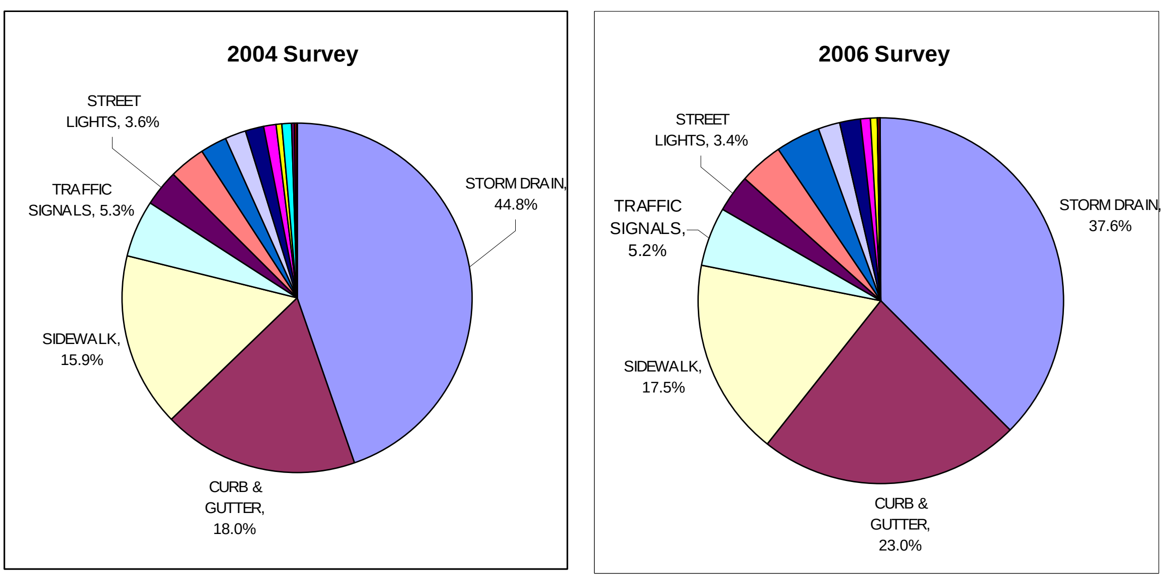


Figure 2.3 Total Non-Pavement Asset Cost by Category for All Counties

Tables 2.4 and 2.5 show the top 5 assets by county. It can be seen that most counties follow the general trend shown in Figure 2.1. Also, in most cases the top categories from the 2004 survey were maintained in 2006.

The total response for the all county top 5 categories is shown in Figure 2.4. The high percent response for each of the categories, especially for the 2006 survey, suggests that these data may be readily available or easily obtained such that these would be sufficient for estimating the total agency replacement cost.

From Figure 2.3, the major differences between the 2004 and 2006 data are in storm drain (44% vs 37%) and curb and gutter (18% vs 23%). Some "fine tuning" of the nomenclature in future surveys might help to reconcile these differences.

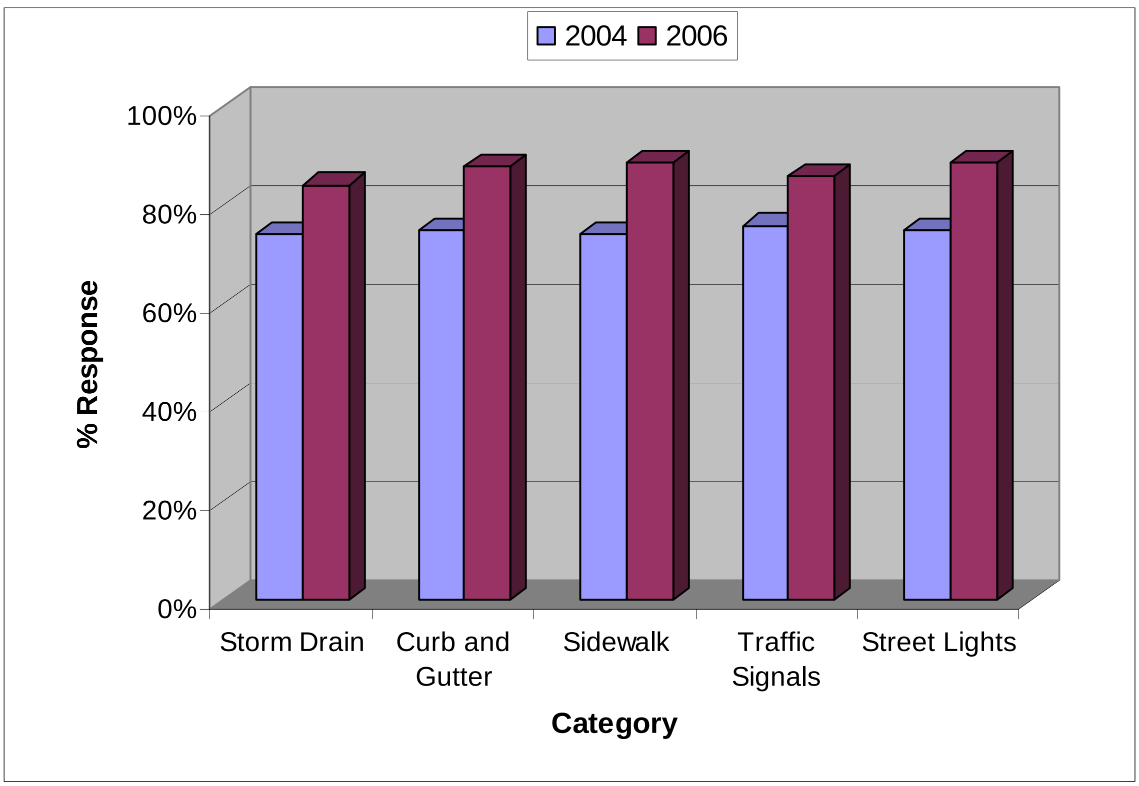


Figure 2.4 All County Responses for Top Categories

Table 2.4 Top Five Non-Pavement Asset Costs by County (2004 Survey Data)

Asset	Alameda	Contra Costa	Marin	Napa	San Francisco	San Mateo	Santa Clara	Solano	Sonoma
Storm Drain	22.6%	35.5%	41.9%	74.8%	57.4%	29.0%	58.7%	31.4%	48.7%
Curb & Gutter	24.6%	12.6%	18.6%	3.2%	24.2%	16.0%	15.2%	22.2%	11.4%
Sidewalk (Public)	28.5%	16.2%	18.7%			20.8%	15.3%	27.0%	15.3%
Traffic Signals	9.9%	6.6%	3.7%		5.3%		4.5%		8.0%
Street Lights	6.4%		5.7%				3.1%		6.7%
Corporate Yard				8.5%	2.7%	10.1%		4.5%	
Sewer - Pipelines		19.9%							
Curb Ramps					4.7%			4.1%	
Sound/Retaining Walls						9.0%			
Heavy Equipment				7.5%					
Guardrails				3.7%					
Total for Top 5 Assets	**92.0%**	**90.8%**	**88.6%**	**97.7%**	**94.3%**	**84.9%**	**96.8%**	**89.2%**	**90.1%**

Table 2.5 Top Five Non-Pavement Asset Costs by County (2006 Survey Data)

Asset	Alameda	Contra Costa	Marin	Napa	San Francisco	San Mateo	Santa Clara	Solano	Sonoma
Storm Drain	25.5%	33.9%	58.7%	51.4%	44.1%	41.9%	37.8%	42.5%	29.8%
Curb & Gutter	32.4%	26.5%	14.8%	11.1%	21.2%	13.8%	25.0%	15.3%	23.5%
Sidewalk (Public)	25.7%	27.6%	13.3%	11.5%		22.7%	15.5%	17.5%	33.6%
Traffic Signals	7.0%	4.7%	4.1%		5.4%		7.9%		3.9%
Street Lights	3.9%	2.4%	3.4%				6.5%	4.3%	
Corporate Yard				5.1%		9.2%			
Sewer - Pipelines									
Curb Ramps									
Sound/Retaining Walls				5.8%	5.0%	4.2%		10.1%	3.9%
Heavy Equipment									
Guardrails									
Bridges					15.2%				
Total for Top 5 Assets	**94.5%**	**95.1%**	**94.3%**	**84.9%**	**90.9%**	**91.8%**	**92.7%**	**89.7%**	**94.7%**

3. Life Cycle Analyses

The data collected through the survey were used to estimate the range of service life of the assets. The average values were compared to industry standards to assess the validity of the data. Figures 3.1 through 3.5 show the life cycle values for the top 5 assets. Although there is a wide range of service life values for the top categories, in general, the average service life reported for each asset compares favorably to industry standards. Table 3.1 shows the life cycle of the top 5 categories reported as industry standards by several agencies.

Table 3.1 Industry Standards for Life Cycles

Asset	Service Life (years)
Strom drain[9]	50
Curb and gutter[10]	
• Concrete	35
• Asphalt	10-15
Sidewalk[9]	
• Asphalt	15
• Concrete	35
• Brick Pavers	25
• Concrete Pavers	25
• Flagstone	20
Traffic Signals[11]	
• Installed 1960's-1970's	25
• Installed after 1970's	40
Street Lights[10]	30

For traffic signals, it would be reasonable to assume that if devices installed in the 1960s and 1970s have a service life of 25 years, these devices would have been replaced such that the average service life of the current assets is approximately 40 years. However, as seen in Figure 2.5, the average of each county is closer to 25 years. This difference might be attributed to outdated standards.

[9] Plastics Pipe Institute
[10] Handbook of Facility Assessment
[11] Portland Transportation Asset Management

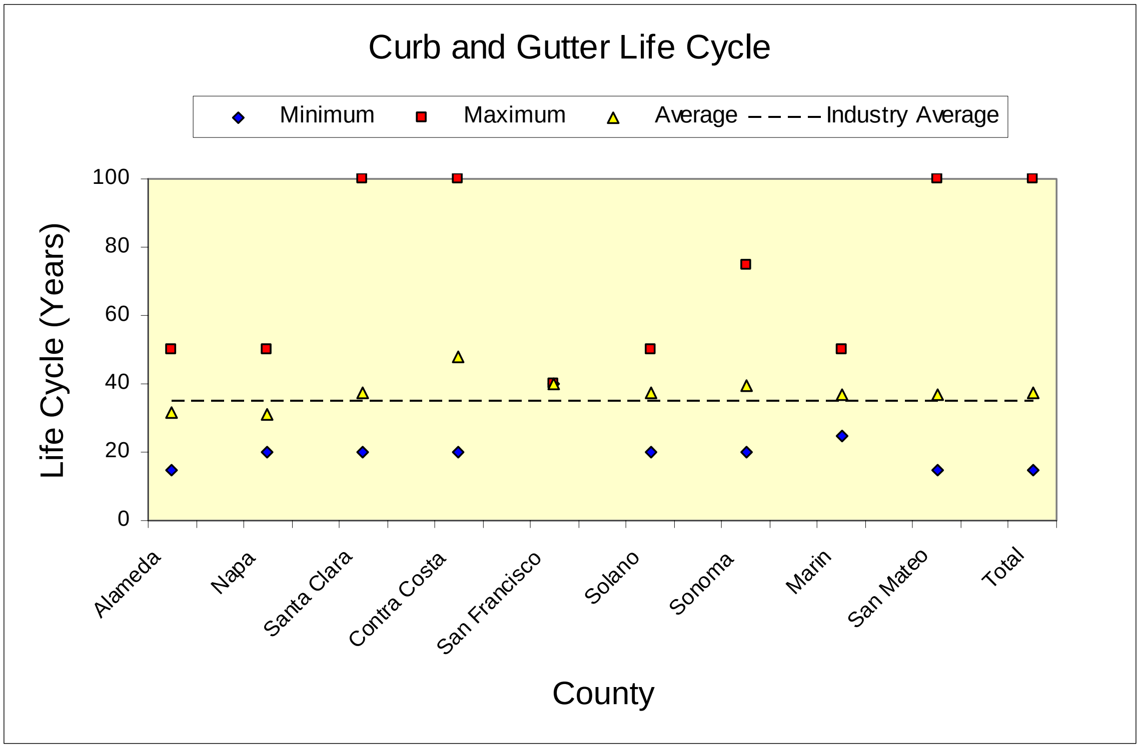


Figure 3.1 Curb and Gutter Life Cycle

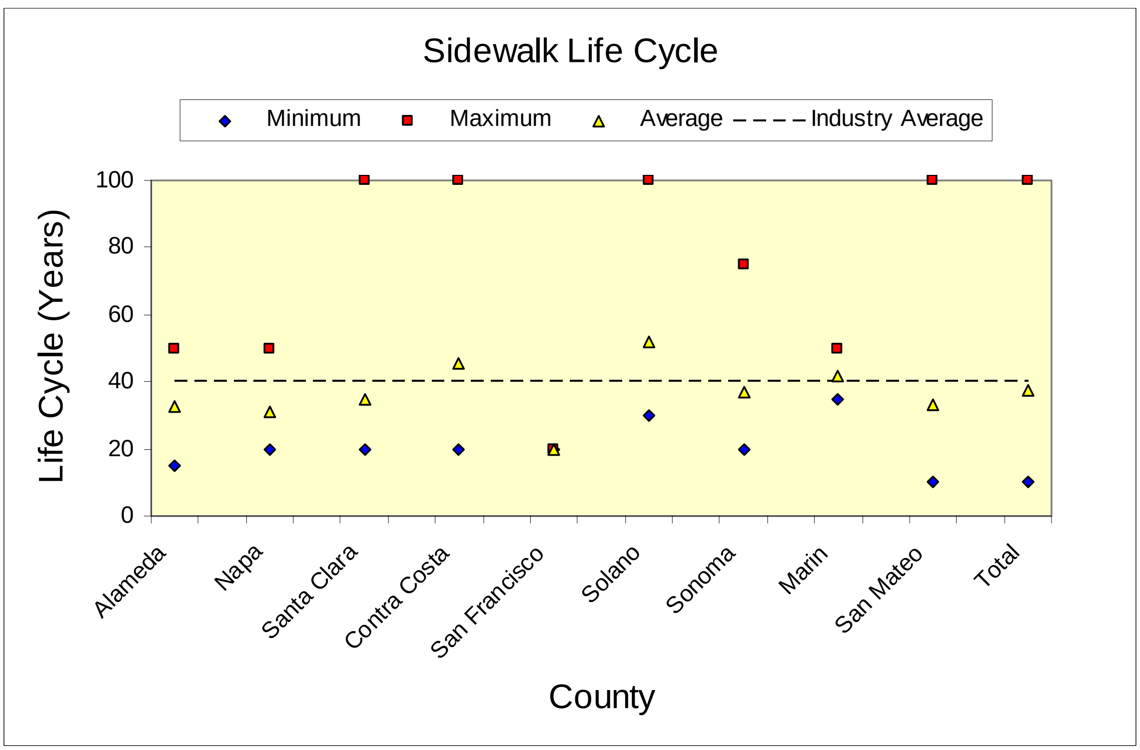


Figure 3.2 Sidewalk Life Cycle

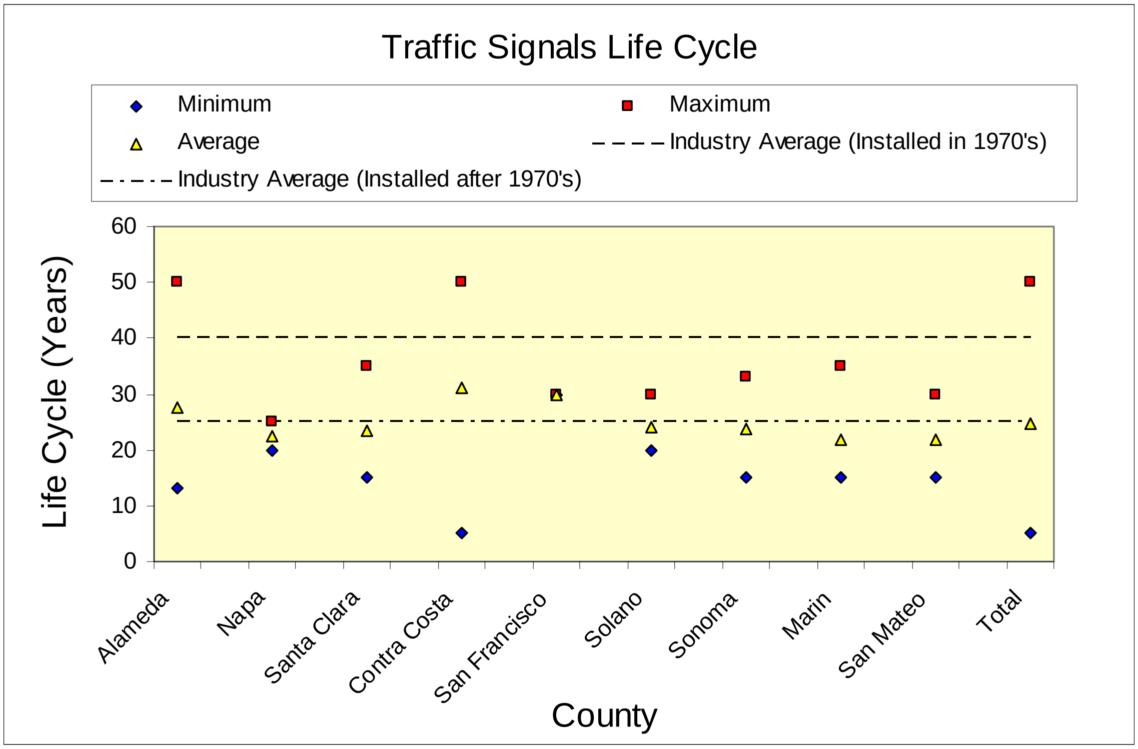


Figure 3.3 Traffic Signals Life Cycle

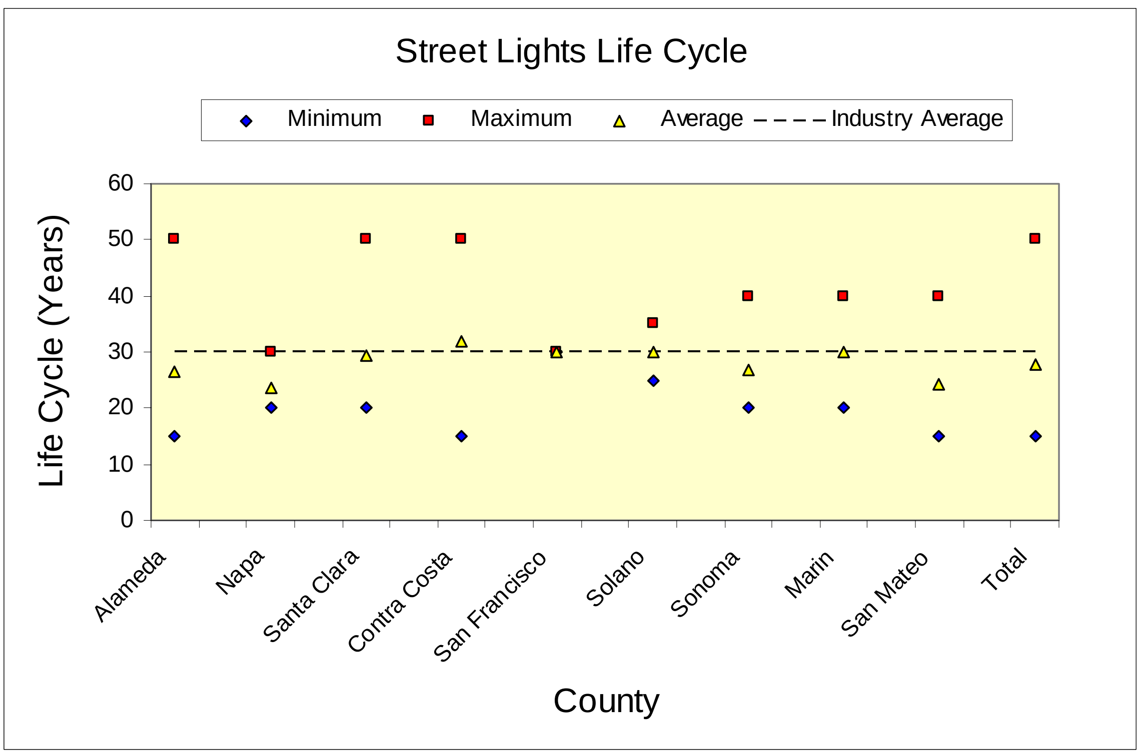


Figure 3.4 Street Lights Life Cycle

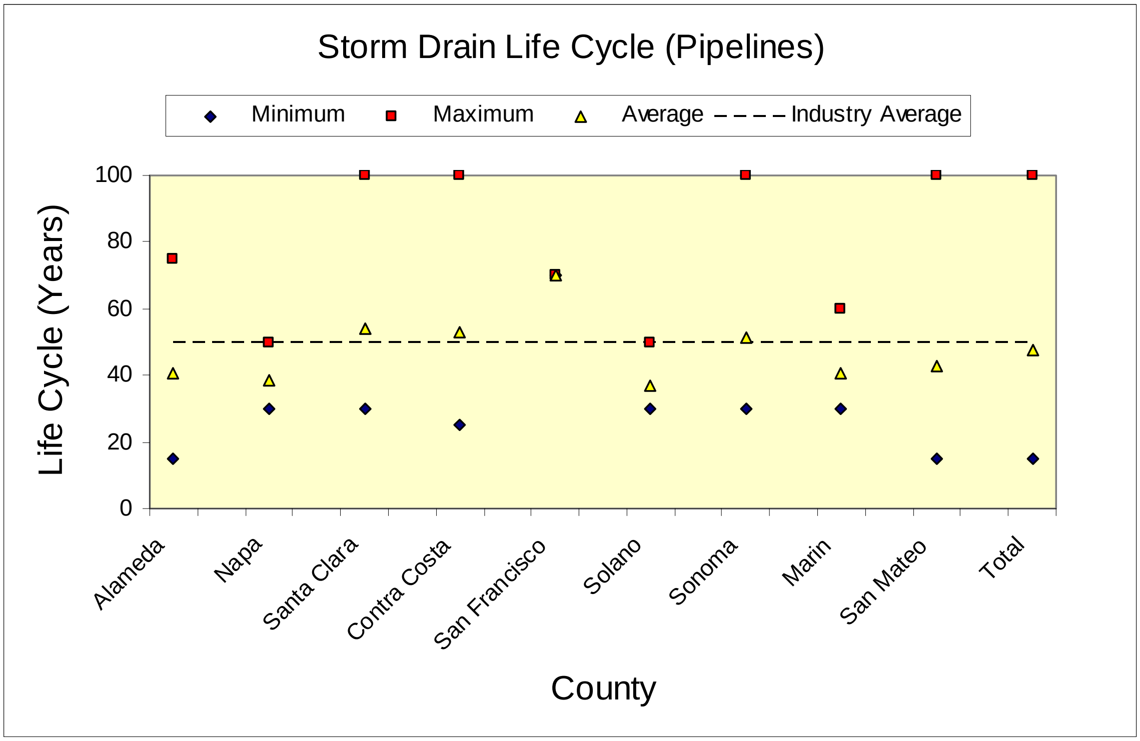


Figure 3.5 Storm Drain Life Cycle

As discussed previously, storm drains represent a significant percentage of the total replacement cost. This category is composed of several items (e.g. pipelines, structures, man holes, drainage ditches, etc.), each of which is measured differently. This makes it difficult to quantify the entire storm drain as a whole. Figure 3.6 shows the percent distribution for the cost of the storm drain subcategories. Since pipelines represent the majority of the cost, this item was considered the most critical component in storm drains.

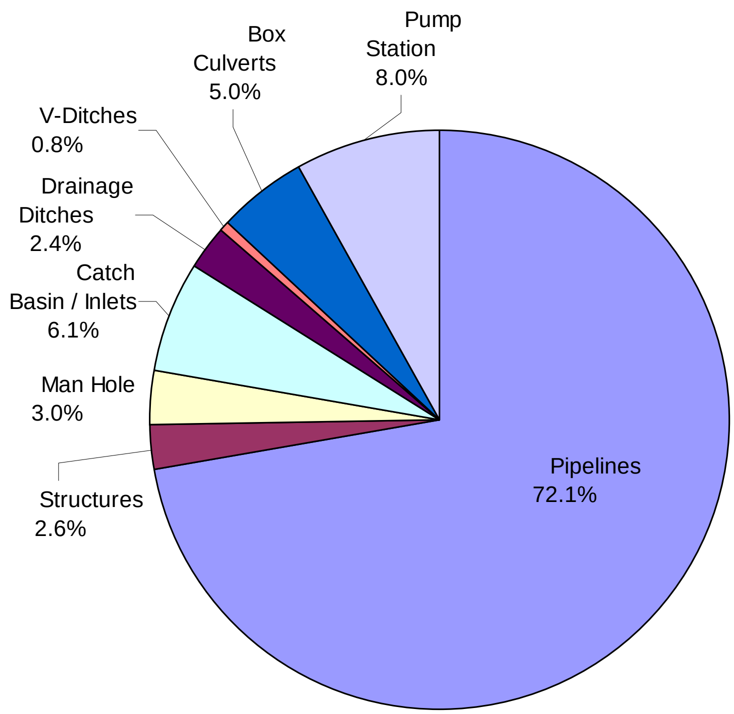


Figure 3.6 Percent Distribution of Cost for Storm Drain Components

Non-Pavement Needs

One aspect of interest is the needs assessment for each of the categories. The results from the 2004 and 2006 surveys represent the total replacement cost of the assets and do not consider the annual costs associated with repairs and maintenance. One way to estimate these costs could be to take the total replacement cost and divide it by the number of years of service life. Figures 3.7 through 3.11 show the annual cost per unit for the top categories, with the averages represented by dashed lines. Note that cities and unincorporated areas are shown separately. This distinction was made because there is a significant difference in the percentage of urban and rural miles maintained by each. As figure 3.12 shows, unincorporated counties maintain mostly rural roads, while cities are almost entirely dedicated to urban roads. Dividing the data may reduce the variability.

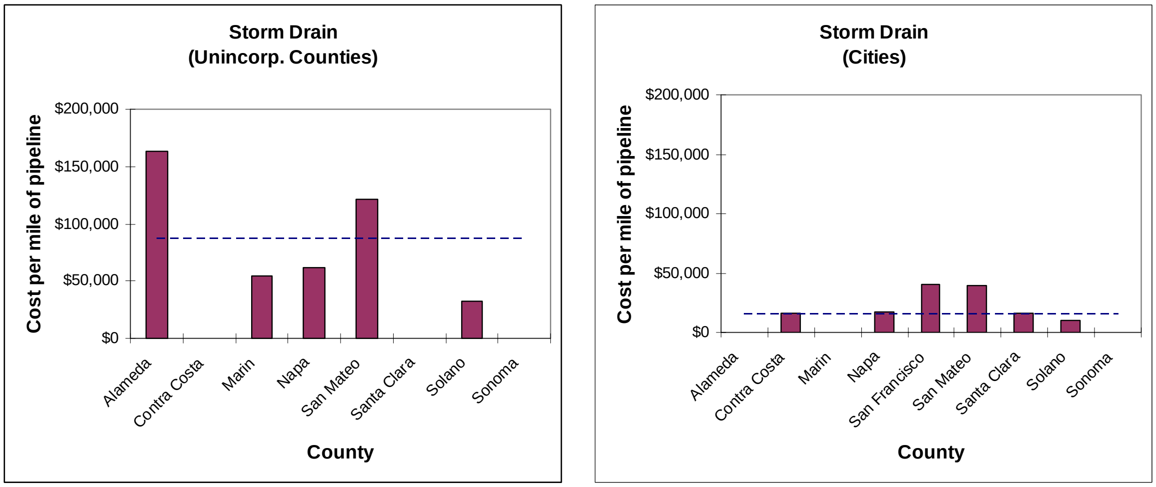


Figure 3.7 Annual Cost per Mile of Storm Drainage

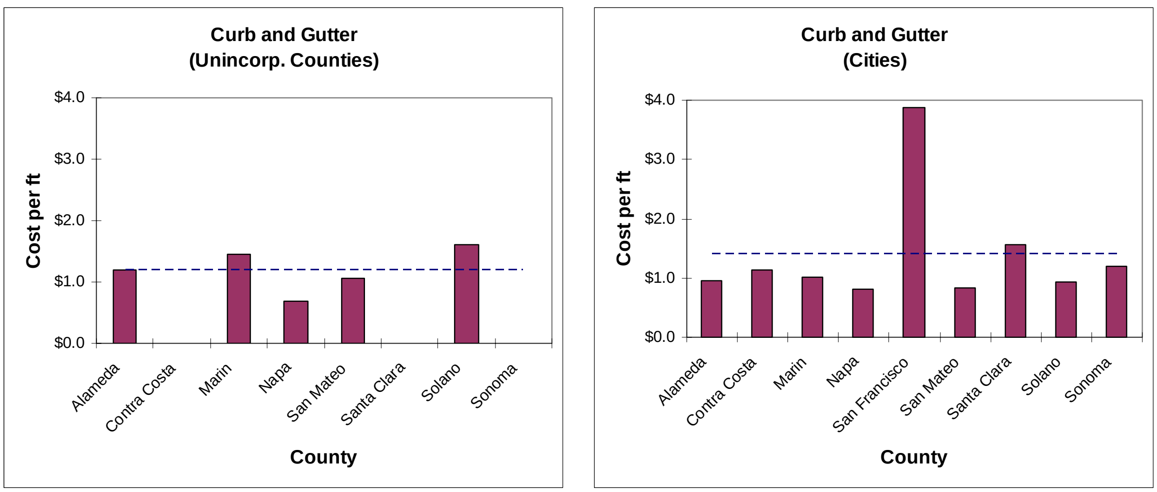


Figure 3.8 Annual Cost per Linear Foot of Curb and Gutter

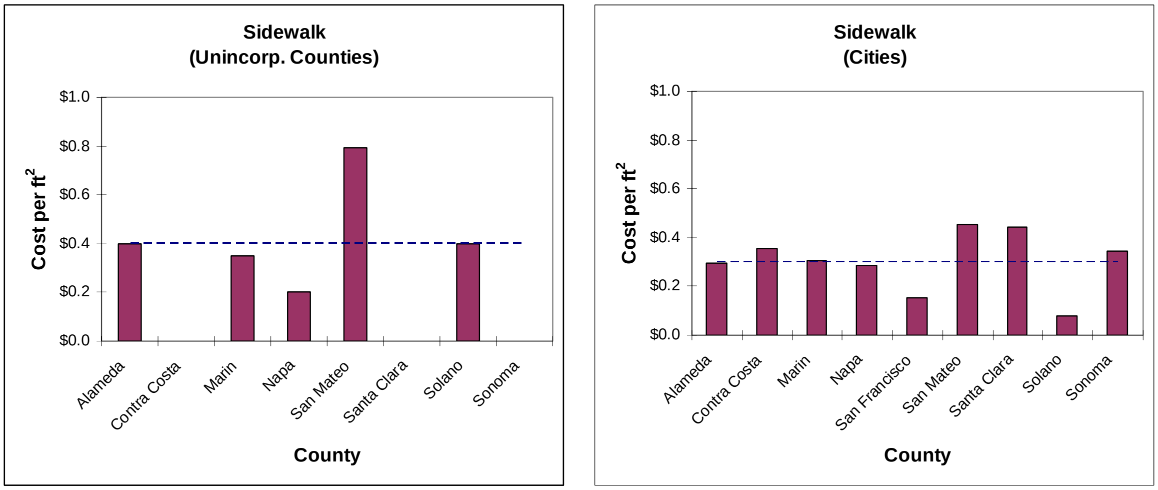


Figure 3.9 Annual Cost per Square Foot of Sidewalk

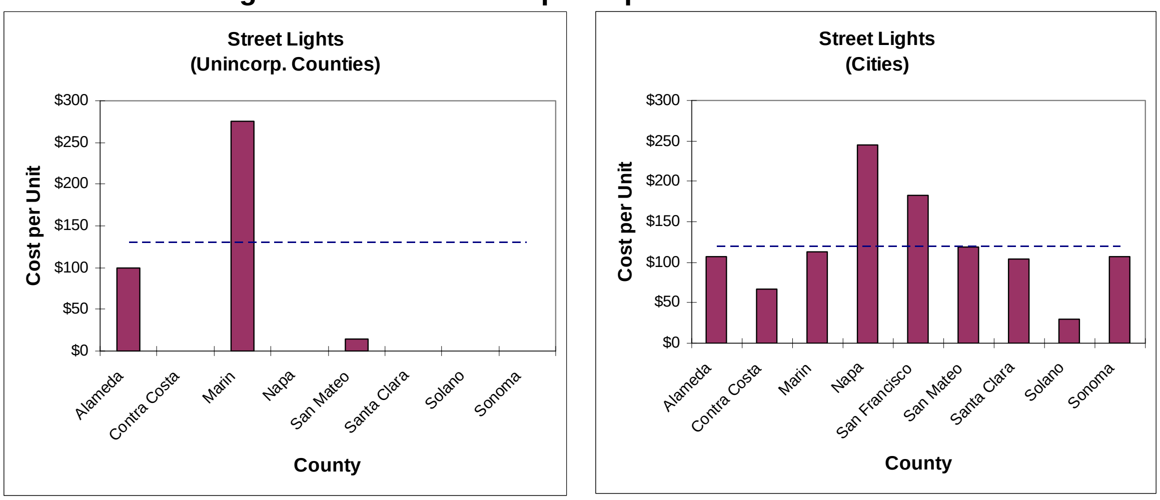


Figure 3.10 Annual Cost per Street Light

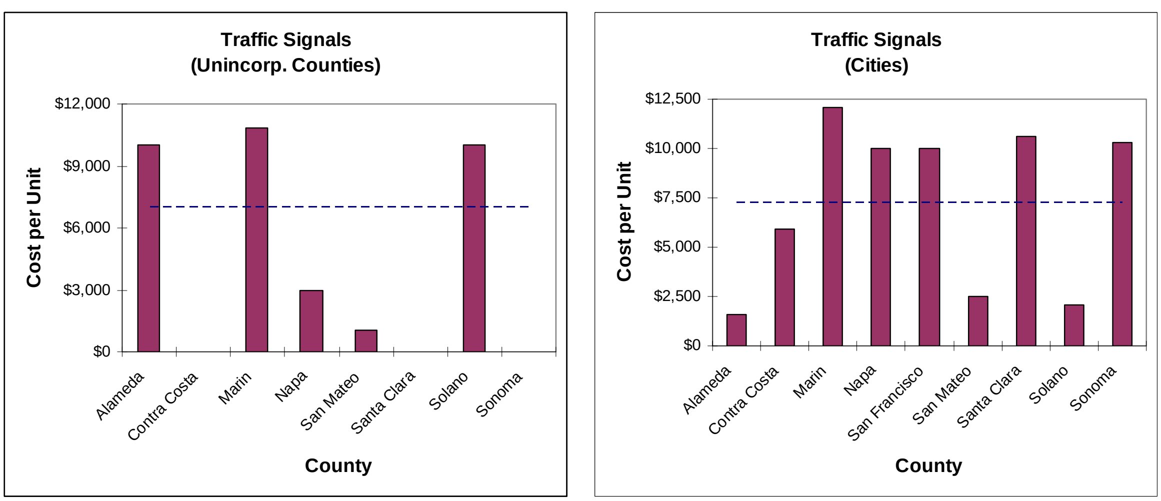


Figure 3.11 Annual Cost per Traffic Signal

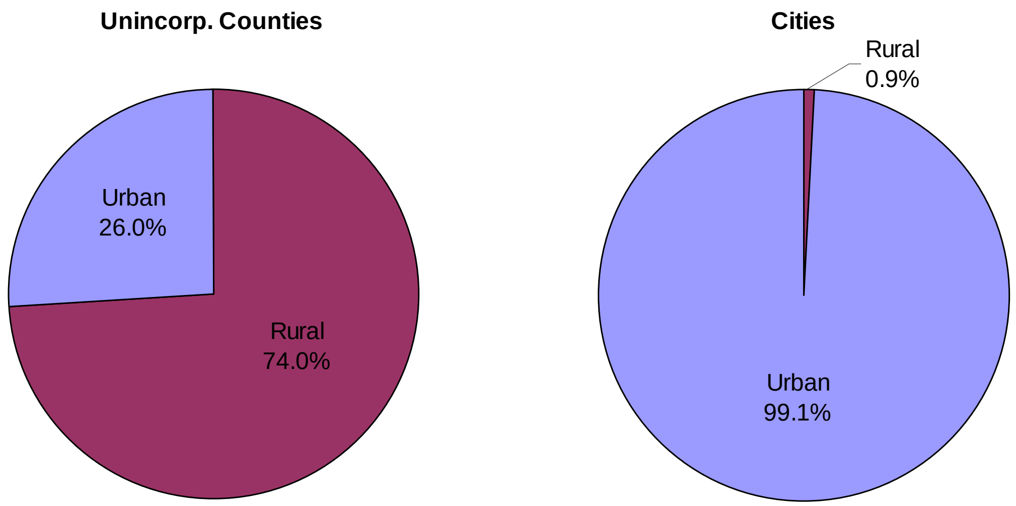


Figure 3.12 Percent Distribution of Miles Maintained

Table 3.2 shows the average annual costs for the top 5 categories. Most items have similar estimates for cities and unincorporated counties. However, there is a large difference between the average costs for storm drains, which are much higher for unincorporated counties than cities. To reconcile this disparity, further discussion with agency personnel may be required.

Table 3.2 Average Annual Costs

Category	Units	Average Annual Cost	
		Unincorp. Counties	Cities
Storm Drain	mi	$86,837	$15,507
Curb and Gutter	ft	$1.20	$1.40
Sidewalk	ft^2	$0.40	$0.30
Street Lights	ea.	$130	$119
Traffic Signals	ea.	$6,963	$7,226

4. Prediction Models

To develop a strategy for projecting future non-pavement asset needs, several models were considered. Intuitively, one would anticipate some relationship between non-pavement costs and some element of the following: pavements; demographics; and/or infrastructure assets. Accordingly, mathematical relationships between these various “predictor variables” were explored.

First, the relationship between non-pavement cost and pavement needs was evaluated. This model has the distinct advantage of accounting for “time,” i.e., the change in pavement condition with time (and/or traffic). However, no significant regressions were obtained with either pavement needs or PCI (pavement condition index). Even though a preliminary model resulted in a quadratic fit with R^2 = 87%, the analysis revealed the presence of an influence point, which corresponds to San Francisco (Figure 4.1). If this data point is not eliminated, the model assumptions of normality and constant variance are not met, therefore, this is not an appropriate model to predict non pavement costs.

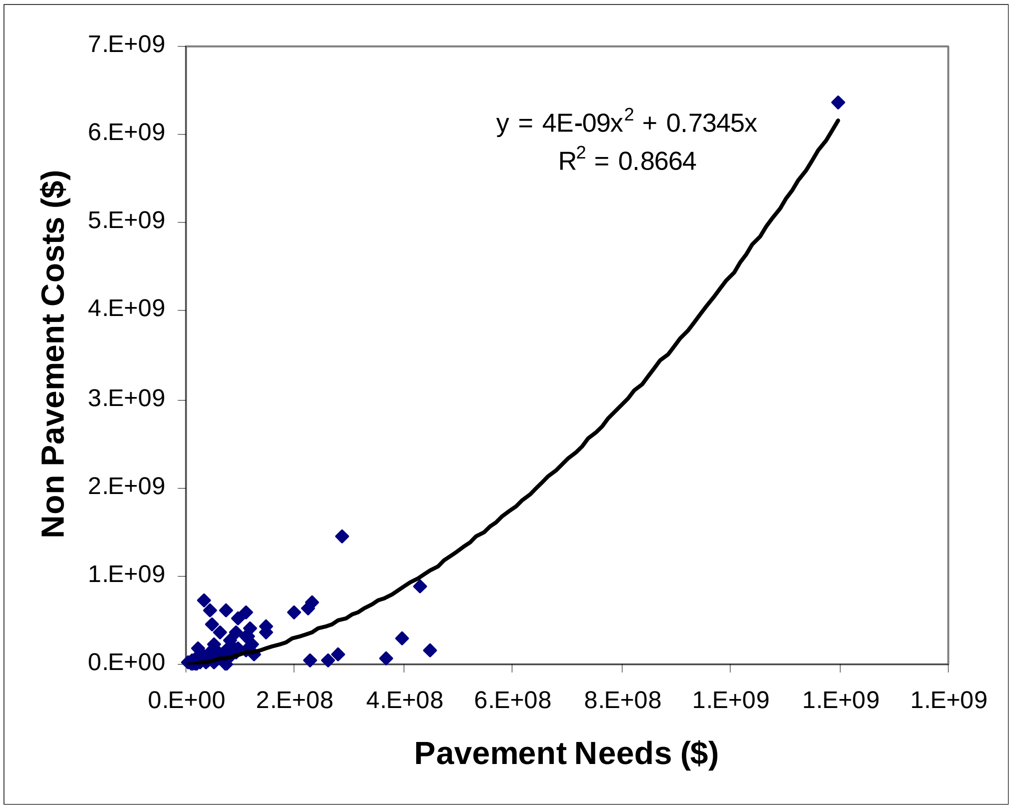


Figure 4.1 Relationship Between Pavement Needs and Non Pavement Costs

The second model considered the demographics of each agency: miles maintained (urban and rural) and population. In this case, the final model included only the urban miles as a predictor (R^2 = 45.5%), as shown in Figure 4.2. A log transformation on the response was necessary to correct normality problems. Area and population density were also explored as predictor variables but these were eventually dropped from the analyses as there was no correlation.

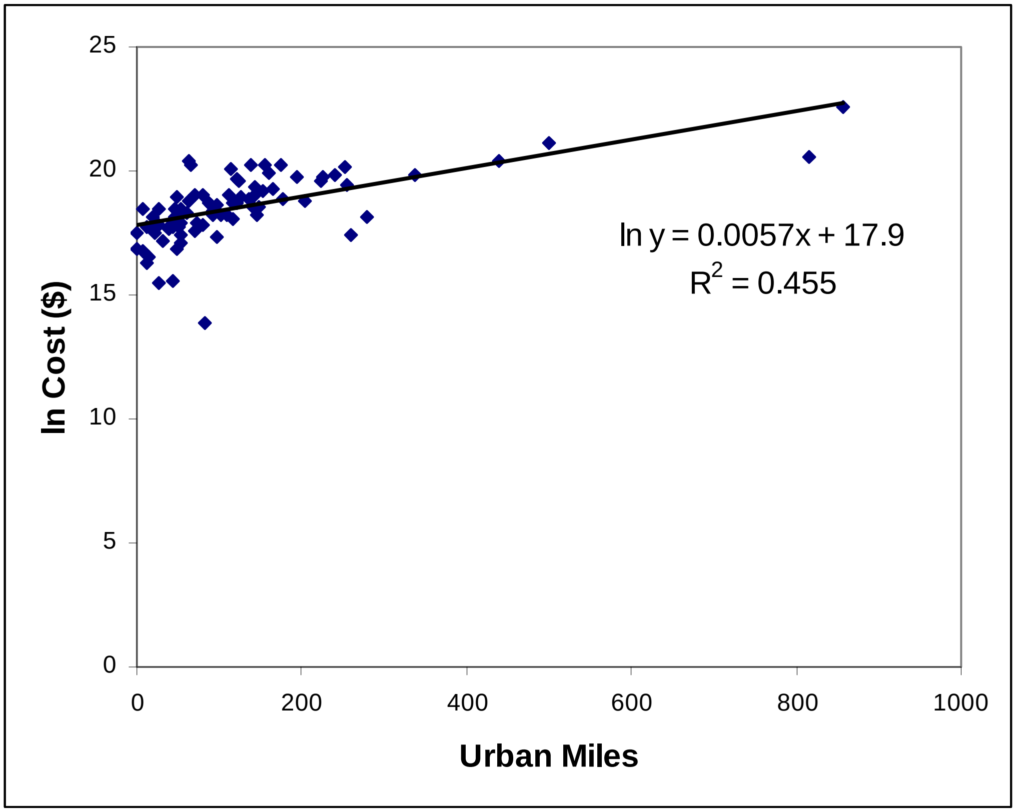


Figure 4.2 Relationship Between Urban Miles and Non Pavement Costs

Finally, the third model considered the inventory of the top 5 categories as predictors:

- pipeline in the storm drain (miles)
- curb and gutter (linear feet)
- sidewalk (square feet)
- Number of street lights and
- number of traffic signals

The final model included length of curb and gutter and number of street lights, and it also required a log transformation to correct non-normality. This resulted in the best of the three proposed relationships (R^2 = 65.0%). To assess the applicability of this model, the data were divided into rural and urban agencies. Those agencies with more than 50% rural miles were considered rural and are shown in Table 4.1.

Table 4.1 Rural Agencies

Agency	Rural Miles	Urban Miles	Total Miles	% Rural Miles
Calistoga	16.7	0	16.7	100
Cloverdale	24.3	0	24.3	100
Napa County	443.6	6.3	449.9	98.6
Solano County	589.3	11.5	600.8	98.1
Santa Clara County	418	278.8	696.8	60.0
San Mateo County	176.9	139.1	316	56.0
Marin County	217.2	203.9	421.1	51.6

Figure 4.3 shows the comparison between reported and actual cost for the urban model. The best fit line indicates that in general, the model overestimates the replacement cost. However, there is one influence point (San Francisco) that causes this difference in the results. By removing this data point, the best fit line between actual and calculated cost has a slope of almost 1 (Figure 4.4), which indicates a better approximation of the cost.

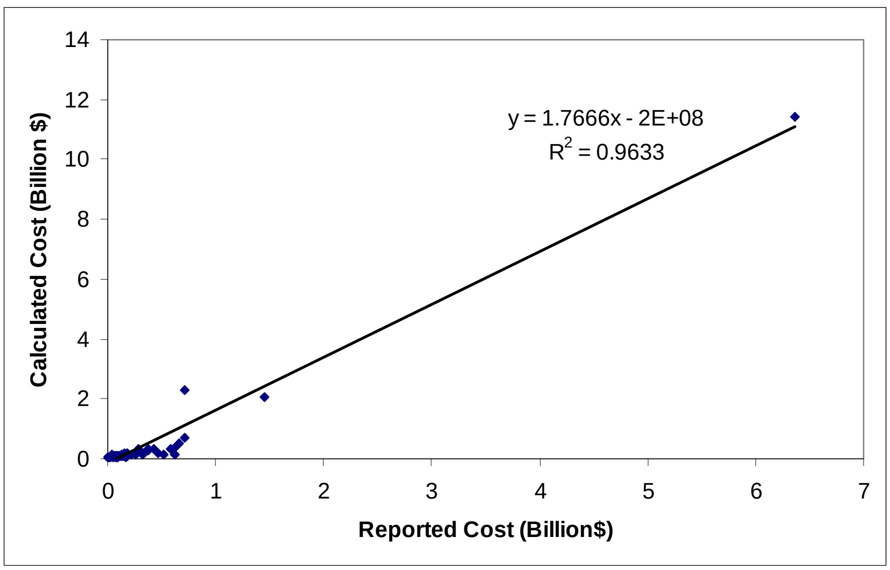


Figure 4.3 Cost Comparison for Urban Model

Figure 4.5 shows that the rural model is very accurate for predicting the replacement cost. However, the amount of data used to develop the model is limited. Caution should be taken when applying the model to a different data set.

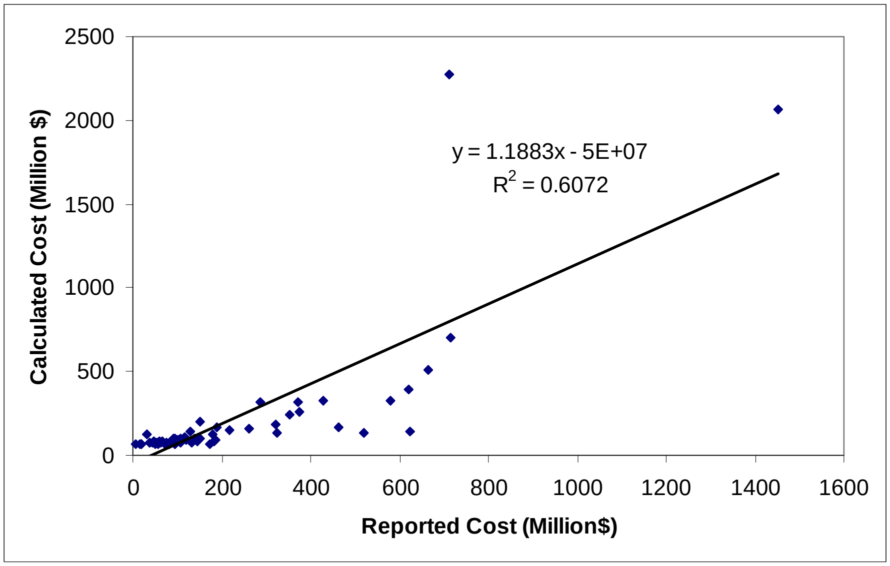


Figure 4.4 Cost Comparison for Urban Model (Not Including San Francisco)

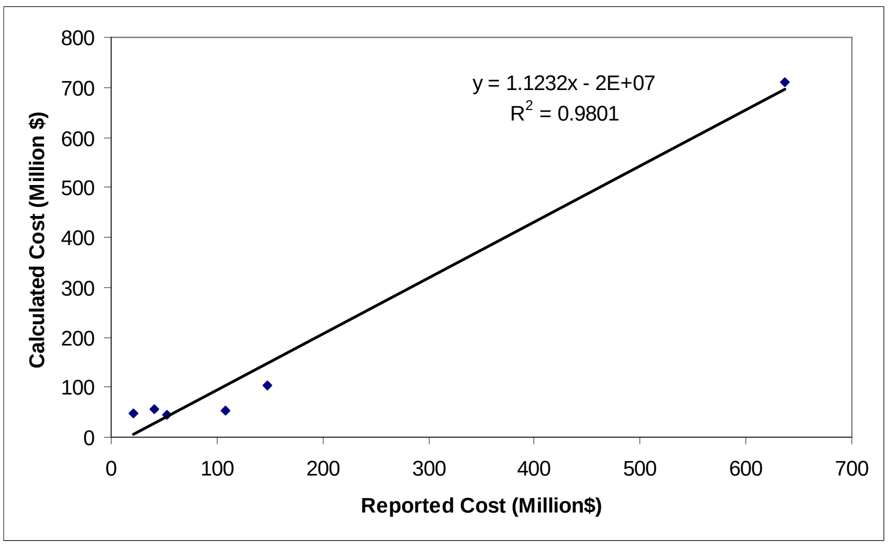


Figure 4.5 Cost Comparison for Rural Model

Table 4.2 shows a summary of results for the regression models studied. It can be seen that while the urban model has the same predictors than the overall model, the rural model depends only on the curb and gutter variable. Even though the R^2 is higher for the rural model, it is important to consider that this model was developed with significantly less data points (only six). Overall, the models are adequate to predict the total non pavement costs, but may present significant variations at the individual level.

Table 4.2 Prediction Models for Non Pavement Costs

Equation Number	Predictor(s)	Final Model	R^2 p-value
1	Pavement needs or PCI	No significant model	N/A
2	Urban Miles Rural Miles Population	ln Cost = = 17.9 + 0.00566*Urban Miles	R^2 = 45.5% p-value < 0.001
3	Miles of pipeline Feet of curb and gutter Square feet of sidewalk Number of street lights Number of traffic signals	ln Cost = 18 + 9E-7*Curb and gutter + 0.000196*Street Lights	R^2 = 65.0% p-value < 0.001
4	Urban	ln Cost = 17.97 + 8.037E-8*Curb and gutter + 0.0001996*Street Lights	R^2 = 65.8% p-value < 0.001
5	Rural	ln Cost = 17.58 + 8.246E-7*Curb and gutter	R^2 = 74.8% p-value = 0.016

Note: "ln Cost" refers to the natural logarithm of Cost.

Agencies with No Data

For agencies with no data on either curb and gutter or streetlights, a methodology was developed to predict the non-pavement costs. It was found that there was a linear relationship between both these variables and the urban miles in an agency. Figures 4.6 and 4.7 show these relationships, and the equations are summarized below. The relationship between these variable are highly correlated, with an R^2 greater than 0.8.

Curb & Gutter = 9883.3*Urban Miles – 138057 Eq. 7

Street Lights = 27.867*Urban Miles – 441.65 Eq. 8

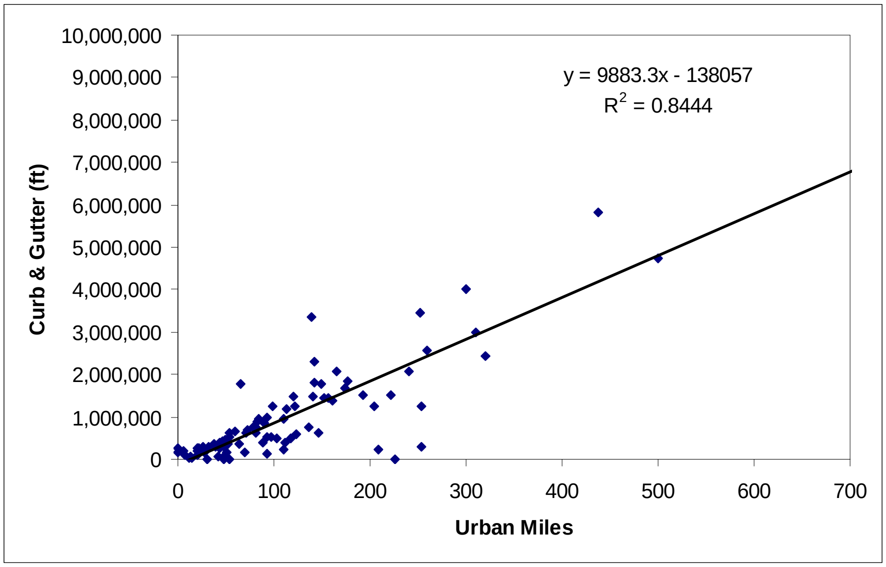


Figure 4.6 Relationship Between Feet of Curb and Gutter and Urban Miles

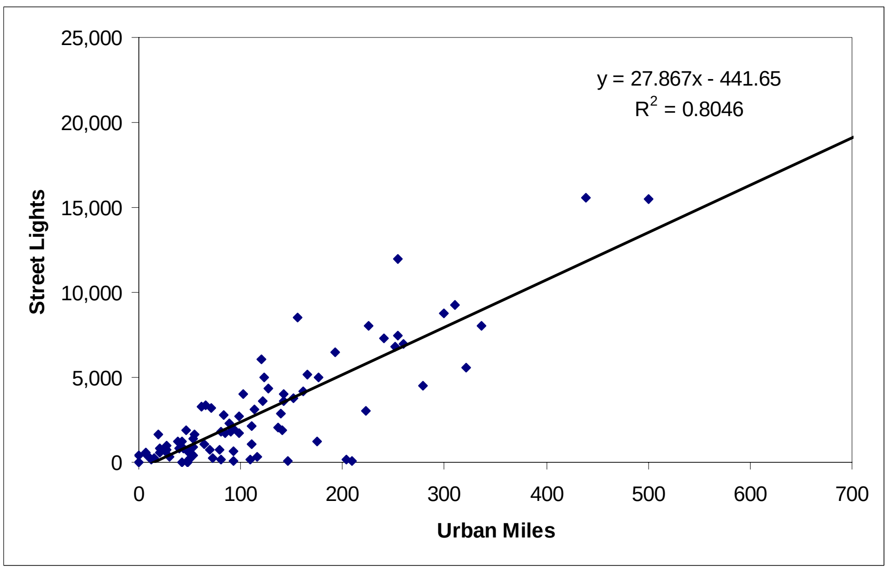


Figure 4.7 Relationship Between Street Lights and Urban Miles

5. Conclusions and Recommendations

Based on the literature review and an extensive analysis conducted on the survey data the following conclusions are drawn:

1) Since most road-related work falls within the realm of maintenance, rehabilitation and reconstruction - as opposed to new construction - the emphasis within the transportation community has shifted from “build it” to “improve system performance.” Thus, transportation agencies are under renewed pressure to demonstrate improvements in the performance of the transportation system and are being held increasingly accountable for funding decisions. To help ease the transition from building new infrastructure to improving the performance of the existing system, many agencies are turning to Transportation Asset Management (TAM), which provides agencies with the tools and structure necessary to set goals, identify priorities, improve processes, and measure results to demonstrate improved performance. Asset management is a decision-making process for allocating resources. It relies on tools and information to analyze tradeoffs among investment options.

2) Though the asset management framework and systems for pavements and bridges are well-established, widely-used and in most cases quite sophisticated, similar systems are not typically available or deployed for other transportation assets in the US. Unlike pavement and bridge management systems where national standards for condition assessment and performance monitoring are readily available, comparable, quantitative standards for non-pavement assets are non-existent or evolving.

3) The key building blocks for any asset management system are a comprehensive inventory and condition rating for assets. Although the data may be used for various purposes – planning, budgeting, scheduling and performance evaluation - the data collection requirements should be compatible with the intended use of the data. The data collection requirements must reflect how the data will be used at the network, project and field/operational level.

4) For the San Francisco Bay area, the top three non-pavement asset costs include the following: storm drain, curb and gutter and sidewalk.

5) Five categories, storm drain, curb and gutter, sidewalk, traffic signals and street lights, account for nearly 88% of the total non-pavement asset costs. The remaining 14 categories account for approximately 12% of the total non-pavement asset costs.

6) Total replacement cost and service life data may be used to estimate the annual non-pavement costs. This estimate may be dependent on the nature of the area being serviced (urban or rural).

7) The MTC non-pavement cost data, when compared with other cities' data, seem reasonable.

Based on the preceding, the following recommendations are made:

1) Assuming that the MTC LS&R survey data are used for policy purposes and budget allocations, the emphasis should be on thorough and accurate data in fewer categories. Specifically, MTC is encouraged to limit the non-pavement asset categories to those noted in Table 2.5. To that end, it is recommended that MTC continue to work with the agencies to clearly define the terminology used in the survey: e.g., replacement value and unmet needs.

2) If MTC is to be integrally involved with the development and implementation of an asset management plan for the Counties and Cities, it is recommended that MTC work with them to develop a consistent approach for data collection, condition assessment and performance monitoring.

3) Of the top 5 non-asset pavement categories, the variables curb and gutter and street lights can be used to predict the total replacement cost in a model that explains 65% of the variation in non-pavement costs. Equations 4 and 5 are recommended for urban and rural agencies, respectively.

4) For agencies with no information on either curb and gutter or street lights, it is recommended that the correlation equations developed. Equations 6 and 7 are recommended.

APPENDIX A

Source Data

Table A.1 Demographic Data

Agency	Population*	Rural Miles**	Urban Miles**	Total Miles
Alameda County	143,900	224.5	253.7	478.2
Alameda	75,400	0	120.9	120.9
Albany	16,800	0	26.8	26.8
Berkeley	105,300	0	222.3	222.3
Dublin	40,700	3.8	61.9	65.7
Emeryville	8,000	0	19.8	19.8
Fremont	211,100	0	438.2	438.2
Hayward	146,300	0	240	240
Livermore	78,000	0.8	251.9	252.7
Newark	44,400	0	98	98
Oakland	414,100	0	814.8	814.8
Piedmont	11,100	0	43.6	43.6
Pleasanton	68,200	3.5	165.4	168.9
San Leandro	82,400	0	176.7	176.7
Union City	71,400	0	151.8	151.8
Contra Costa County	160,700	410.1	327.8	737.9
Antioch	102,300	0	225.9	225.9
Brentwood	44,300	0	65	65
Clayton	10,900	0	37.8	37.8
Concord	123,900	0	336.6	336.6
Danville	43,100	0	141	141
El Cerrito	23,200	0	73	73
Hercules	22,400	0	52.3	52.3
Lafayette	24,100	0	92.3	92.3
Martinez	36,500	0	110.8	110.8
Moraga	16,300	0	53	53
Oakley	28,300	3	115.9	118.9
Orinda	17,700	0	93	93
Pinole	19,300	0	53	53
Pittsburg	61,300	1.7	136.8	138.5
Pleasant Hill	33,200	0	116.7	116.7
Richmond	100,500	0	259.8	259.8
San Pablo	30,900	0	49	49
San Ramon	52,200	0	142.3	142.3
Walnut Creek	65,200	0	174.4	174.4
Marin County	69,100	217.2	203.9	421.1
Belvedere	2,150	0	12.5	12.5
Corte Madera	9,400	0	27.2	27.2
Fairfax	7,300	0	28.5	28.5
Larkspur	12,000	0	39.2	39.2
Mill Valley	13,600	0	70.2	70.2
Novato	50,900	0	142.9	142.9
Ross	2,350	0	15	15
San Anselmo	12,400	0	47.2	47.2
San Rafael	56,200	0	160.7	160.7
Sausalito	7,300	0	25.6	25.6
Tiburon	8,700	0	30	30
Napa County	28,600	443.6	6.3	449.9
American Canyon	14,200	1.3	26.7	28
Calistoga	5,200	16.7	0	16.7

Table A.1 Demographic Data (cont.)

Agency	Population*	Rural Miles**	Urban Miles**	Total Miles
Napa	76,600	0	208.6	208.6
St. Helena	6,100	24.1	0	24.1
Yountville	3,400	6.8	0	6.8
San Francisco County	798,000	0	856	856
San Mateo County	63,800	176.9	139.1	316
Atherton	7,300	0	50	50
Belmont	25,300	0	64.1	64.1
Brisbane	3,750	0	20.4	20.4
Burlingame	28,200	0	80.9	80.9
Colma	1,350	0	7.8	7.8
Daly City	104,100	0	113.6	113.6
East Palo Alto	32,700	0	38.5	38.5
Foster City	29,800	0	46.4	46.4
Half Moon Bay	12,500	0	26.7	26.7
Hills- Borough	11,000	0	80.9	80.9
Menlo Park	30,800	0	97.8	97.8
Millbrae	21,200	0	53.3	53.3
Pacifica	38,500	0	89.8	89.8
Portola Valley	4,600	0	42.5	42.5
Redwood City	77,300	0	156	156
San Bruno	41,700	0	78.8	78.8
San Carlos	27,900	0	84.5	84.5
San Mateo	94,900	0	190.4	190.4
South San Francisco	61,000	0	123.1	123.1
Woodside	5,500	0	47.4	47.4
Santa Clara County	104,100	418	278.8	696.8
Campbell	38,200	0	88.5	88.5
Cupertino	54,600	0	122.3	122.3
Gilroy	46,100	0	82.5	82.5
Los Altos	27,700	0	109.5	109.5
Los Altos Hills	8,300	0	47.7	47.7
Los Gatos	28,700	0	111.4	111.4
Milpitas	65,400	0	127	127
Monte Sereno	3,600	0	12.6	12.6
Morgan Hill	35,600	0	102.2	102.2
Mountain View	71,900	0	142.3	142.3
Palo Alto	59,900	7.3	193.1	200.4
San Jose	935,300	0	1940.7	1940.7
Santa Clara	108,700	0	225.6	225.6
Saratoga	30,300	0	145.8	145.8
Sunnyvale	131,700	0	299.9	299.9
Solano County	20,900	589.3	11.5	600.8
Benicia	26,900	1.9	92.4	94.3
Dixon	16,500	0	54.2	54.2
Fairfield	105,700	2.2	253.8	256
Rio Vista	7,200	23.2	0	23.2
Suisun Valley	27,900	0	71	71
Vacaville	96,600	6.6	320.8	327.4
Vallejo	122,100	0.3	309.8	310.1
Sonoma County	153,800	1285	104.7	1389.7

Table A.1 Demographic Data (cont.)

Agency	Population*	Rural Miles**	Urban Miles**	Total Miles
Cloverdale	8,300	24.3	0	24.3
Cotati	7,200	0	20.5	20.5
Healdsburg	11,700	0	43	43
Petaluma	56,400	2.6	148.6	151.2
Rohnert Park	42,400	0	83.1	83.1
Santa Rosa	155,300	2.3	500.3	502.6
Sebastabol	7,800	0	22.3	22.3
Sonoma	9,500	0	32.6	32.6
Windsor	25,300	0	59.7	59.7

Notes:
* Source: 2000 Census data projection for 2005.
** Source: LS&R Survey 2004

Table A.2 Inventory Data

Agency	Storm Drain* (mi.)	Curb & Gutter* (ft)	Sidewalk* (sq. ft.)	Street Lights* (units)	Traffic Signals* (units)	Pavement Need** ($)	Replacement Cost* ($)
Alameda County	19.3	1,262,000	5,047,724	7,500	80	398,123,209	285,530,040
Alameda	71.0	1,470,000	6,864,000	6,100	77	61,390,388	351,749,044
Albany						15,349,844	
Berkeley	78.0	1,522,981	8,297,678	3,072	5,905	110,030,552	325,209,569
Dublin	40.4	21,785,280	4,329,600	3,250	63	34,166,624	715,072,175
Emeryville	13.3	100,300	600,000	1,600	25	12,752,325	
Fremont	410.0	5,806,000	19,080,000	15,570	158	230,236,322	710,724,000
Hayward	206.0	2,076,000	10,349,000	7,300	106	145,284,239	428,170,350
Livermore	172.0	3,464,000	10,296,000	6,800	90	109,041,562	579,645,000
Newark	56.8	1,246,100	4,984,300	2,743	42	51,105,623	32,775,452
Oakland		7,920,000	31,680,000		665	430,862,128	884,802,500
Piedmont	67,320.0	406,040	2,030,200	799	5	14,121,566	50,040,000
Pleasanton		2,059,010	9,229,505	5,200	85	121,206,058	235,020,000
San Leandro	70.1	1,830,000	9,030,000	5,000	153	94,526,075	150,759,000
Union City	76.0	1,446,720	7,233,600	3,787	57	52,111,809	218,785,492
Contra Costa County						186,333,549	
Antioch	245.0				100	145,136,563	
Brentwood	134.8	1,781,300	6,696,624	3,364	43	42,664,811	622,326,126
Clayton	15.0	348,480	844,800	1,200	12	20,910,166	46,330,000
Concord	231.0		12,463,656	8,070	156	117,971,110	404,782,455
Danville	151.0	1,490,000	500,000	1,903	48	61,223,043	116,800,000
El Cerrito	26.4	686,400	2,745,600	275	11	40,695,965	61,476,177
Hercules	53.5	364,166	1,288,444	514	14	38,811,792	38,101,800
Lafayette	78.7	516,225	226,832	625	26	53,671,540	81,145,576
Martinez	57.1	966,240	2,898,720	1,079	22	96,082,702	182,267,200
Moraga	38.5	538,333	1,923,685	936	9	36,493,998	60,956,099
Oakley						21,244,447	71,583,490
Orinda	25.0	126,497	106,450	67	15	45,146,833	
Pinole	42.7	64	128	373	17	24,479,258	95,496,000
Pittsburg	61.1	767,109	3,028,535	2,028	62	108,492,605	150,701,210
Pleasant Hill	66.7	502,940	2,015,340	358	36	58,580,866	131,199,996
Richmond		2,574,000		7,000		228,935,863	36,473,000
San Pablo	16.6	469,160	1,147,250	158	25	26,696,755	92,989,050
San Ramon	7.0	1,821,860	8,245,948	4,043	70	76,241,805	187,465,724
Walnut Creek		1,665,227	6,660,909	1,249	96	200,070,000	599,092,062
Marin County	133.0	1,240,000	4,000,000	200	8	449,966,961	147,510,000
Belvedere	5.1	55,700	108,300	157		2,242,475	11,741,600
Corte Madera	189,015.0	155,000	905,000	735	13	25,429,664	106,610,000
Fairfax						14,295,603	
Larkspur	20.0	290,000	740,333	795	7	20,792,094	50,900,000
Mill Valley	17.5	158,400	850,000	772	7	39,633,258	44,717,600
Novato						62,191,758	
Ross	7.9	27,164	108,656	259	3	8,205,004	14,770,847
San Anselmo	57.0	300,000	120,000	666	12	31,271,576	74,903,900
San Rafael	131.0	1,372,800	5,500,000	4,215	82	47,382,847	462,152,000
Sausalito	15.0			664	9	9,892,123	5,280,534
Tiburon	43.0	35	739,200	300		25,130,674	
Napa County	705.0	200,000	35,000	544	27	277,807,913	108,750,000
American Canyon	48.0	285,000	1,100,000	969	6	18,466,976	54,465,200
Calistoga	7.3	163,567	346,107	20		9,742,366	21,376,783
Napa		233,500	930,000	95		216,777,290	
St. Helena						17,305,338	
Yountville						5,318,194	
San Francisco County	1,000.0	8,701,440	18,300,000	22,500	1,154	1,198,655,000	6,366,557,516
San Mateo County	44.0	3,347,168	4,675,619	2,882	158	222,593,566	636,163,422
Atherton	26.1	150,000	6,000	250	6	19,591,436	50,464,500
Belmont	28.0	360,000	127,000	1,087	58	44,221,092	145,327,000
Brisbane	47.0	250,000	712,000	800	110	19,166,980	75,340,000
Burlingame	38.0	615,000	3,060,000	1,800	15	50,674,506	185,547,993
Colma	12.8	95,040	356,400	375	7	13,005,682	18,514,515
Daly City	46.2	1,200,000	8,400,000	3,112	461	93,878,214	519,475,000
East Palo Alto						44,456,385	
Foster City	55.0	439,857	109,400	1,918	25	28,373,632	105,710,566
Half Moon Bay						39,553,533	
Hills- Borough	33.4	748,160	1,638,924	125	1	45,659,064	56,660,668

Table A.2 Inventory Data (cont.)

Agency	Storm Drain* (mi.)	Curb & Gutter* (ft)	Sidewalk* (sq. ft.)	Street Lights* (units)	Traffic Signals* (units)	Pavement Need** ($)	Replacement Cost* ($)
Menlo Park	44.0	528,532	1,213,231	1,718	23	64,681,434	118,332,157
Millbrae	21.0	616,362	2,308,344	1,384	5	65,898,567	100,770,000
Pacifica	54.2	865,920	3,896,640	1,770	70	44,455,380	118,700,654
Portola Valley	16.5	80,000	63,000	3	0	19,878,750	5,555,000
Redwood City	67.0	1,452,000	7,128,000	8,500	58	74,151,843	621,792,000
San Bruno		766,000	3,830,000	750	16	72,508,171	
San Carlos	1,826.0	944,933	50,000	1,740	15	56,960,881	
San Mateo						174,265,407	
South San Francisco	128.0	600,000	2,400,000	5,000	320	112,878,348	320,760,000
Woodside	60.0	50,000	700,000	6	10	25,305,429	20,458,000
Santa Clara County				4,500	660	368,193,400	78,200,000
Campbell	41.7	399,600	1,601,350	2,314	42	78,468,853	138,887,000
Cupertino	102.0	1,250,000	4,005,000	3,600	55	92,570,853	129,700,000
Gilroy						72,073,916	1,071,125
Los Altos	58.0	230,000	748,500	130	14	32,119,489	80,210,000
Los Altos Hills	145.0	10,000	3,000,000	10	3	21,914,376	174,425,000
Los Gatos		400,000	1,260,000	2,095	28	67,116,543	0
Milpitas	103.5			4,354	69	89,695,538	173,115,938
Monte Sereno						13,882,663	
Morgan Hill	90.0	500,000	1,000,000	4,000		81,458,167	81,697,520
Mountain View	109.0	2,310,000	2,900,000	3,579	76	80,886,308	260,775,000
Palo Alto	107.0	1,500,000	10,000,000	6,446	98	90,899,999	373,325,611
San Jose						1,066,512,265	
Santa Clara	138.0	498	414	8,000	150	146,998,194	371,400,000
Saratoga	63.0	638,970	396,000	120	65	81,722,301	80,421,250
Sunnyvale	327.0	4,002,240	2,000,000	8,800	136	88,240,723	
Solano County	1,020.0	24,000	64,000		3	260,853,176	52,325,000
Benicia	77.0	1,000,000	3,000,000	2,000	10	47,374,359	95,200,000
Dixon			3,289,929	1,671	3	36,856,505	27,161,645
Fairfield	196.5	295,000	10,903,200	12,000	81	143,492,323	
Rio Vista						1,619,831	
Suisun Valley	51.0	633,600	792,000	3,235	14	50,160,897	179,159,800
Vacaville	217.0	2,425,632	10,277,520	5,600	68	115,148,370	
Vallejo	219.0	3,009,600	12,038,400	9,300	117	218,247,015	
Sonoma County						810,210,131	
Cloverdale	25.4	264,396	1,321,980	413	3	15,408,962	41,295,855
Cotati	26.9	196,161	888,542	567	7	10,850,631	52,802,700
Healdsburg	22.0	250,000	1,100,000	1,200	12	22,508,342	66,375,000
Petaluma		1,789,920	7,159,680			126,702,542	115,842,136
Rohnert Park	42.0	897,600	4,488,000	2,800	33	60,393,778	
Santa Rosa	371.0	4,752,000	28,512,000	15,520	221	285,039,171	1,452,263,900
Sebastabol	16.4	253,440	1,140,480	628	10	15,131,708	39,198,963
Sonoma	13.0	300,000	2,200,000	360		17,016,617	28,905,000
Windsor	335,757	669,424	3,314,867	1,927	14	31,261,773	89,904,798

Notes:
* Source: LS&R Survey 2006
** Source: MTC 2005 LS&R Data