AGENDA NO: D-3

MEETING DATE: June 28, 2011

Staff Report

TO: Honorable Mayor and City Council **DATE:** June 20, 2011

FROM: Rob Livick, PE/PLS – Public Services Director/City Engineer

SUBJECT: Discussion and Adoption of the Pavement Management Plan

RECOMMENDATION:

Staff recommends the City Council review and adopts Morro Bay's Pavement Management Plan (PMP) as a tool for the maintenance to the City's streets.

FISCAL IMPACT:

Ideally, an annual budget of $900,000 for the street program will be sufficient to improve the street system beyond its current level and that the average PCI will reach the goal of 70 in ten years. While an annual budget of $900,000 is the optimal funding level in order to improve the City's average pavement condition index to 70, this amount may be unrealistic given today's financial climate; and lower annual budgets will have less effective results. The budgets outlined in the plan range from $250,000 to $900,000 per year. The level of funding will be set in each year's annual budget.

SUMMARY:

In order to effectively utilize the City's limited street maintenance budget, staff has prepared a Pavement Management Plan (PMP) that outlines the steps needed to both rehabilitate and preserve the pavement condition of this valuable City asset. Currently the present value of the City's street system is approximately $40,000,000. Once adopted, the PMP will serve as the roadmap for future street maintenance..

BACKGROUND/DISCUSSION:

The attached PMP has been developed by staff to implement a systematic program of maintenance, repair and improvement of the streets of Morro Bay. The plan is based on American Public Works Association's (APWA) MicroPaver Program, the PMP sets out optimal strategies and estimated costs for overall improvement to pavement conditions within City limits.

Four general maintenance and rehabilitation categories were used for this PMP program; reconstruction, overlays (heavy and light), maintenance (street sealing) and no action. Annual pavement maintenance and rehabilitation projects were developed for the next five years as part of the program. Care was taken to select streets using a critical PCI (Pavement Condition Index) approach and to group streets geographically to promote reduced construction costs using budget ranges of $250,000 to

Prepared By: RL Dept Review: RL

City Manager Review: ________

City Attorney Review: ________

$900,000 per year.

An evaluation of the overall street system was also performed as part of this scope of work. The analysis showed that the City's overall weighted average PCI is 63. This is below the PCI value of 70 that most California cities try to maintain. The City's arterial system PCI is better than average, but the other three street categories (collectors, commercial/industrial, and residential) rank below the 70 PCI benchmark.
The City's arterial system PCI is better than average, while the other three street categories (collectors, commercial/industrial, and residential) rank below this benchmark as shown in the table below.

Street Category	Miles	PCI
Arterial	7.9	78
Collector	3.2	60
Local Commercial/Industrial	5.5	64
Local/Residential	36.2	59
Total	53.4	63

TOP POLICY RECOMMENDATIONS

1. Achieve and maintain a PCI of 70 for all City streets
2. Regularly update the MicroPaver street condition database

TOP PROGRAM RECOMMENDATIONS

1. Institute a regular global maintenance (street sealing) program
2. Implement an effective pothole repair program
3. Implement a regular crack sealing program
4. Create a comprehensive 10-year Pavement Maintenance and Rehabilitation Program

ATTACHMENT

City of Morro Bay's - Pavement Management Plan, June 2011

PAVEMENT MANAGEMENT PLAN (PMP)
FOR
THE CITY OF MORRO BAY

Prepared by:

Barry Rands, P.E., Associate Engineer and

Rob Livick, P.E./P.L.S., City Engineer/Director of Public Services

June 2011

EXECUTIVE SUMMARY

This Pavement Management Plan (PMP) has been developed for the City to implement a systematic program of maintenance, repair and improvement of the streets of Morro Bay. Based on American Public Works Association's (APWA) MicroPaver Program, the PMP sets out optimal strategies and estimated costs for overall improvement to pavement conditions within City limits.

Four general maintenance and rehabilitation categories were used for this PMP program; reconstruction, overlays (heavy and light), maintenance (street sealing) and no action. Annual pavement maintenance and rehabilitation projects were developed for the next five years as part of the program. Care was taken to select streets using a critical PCI (Pavement Condition Index) approach and to group streets geographically to promote reduced construction costs using budget ranges of $250,000 to $900,000 per year.

An evaluation of the overall street system was also performed as part of this scope of work. The analysis showed that the City's overall weighted average PCI is 63. This is below the PCI value of 70 that most California cities try to maintain. The City's arterial system PCI is better than average, while the other three street categories (collectors, commercial/industrial, and residential) rank below this benchmark as shown in the table below.

Street Category	Miles	PCI
Arterial	7.9	78
Collector	3.2	60
Local Commercial/Industrial	5.5	64
Local/Residential	36.2	59
Total	53.4	63

POLICY RECOMMENDATIONS

1. Achieve and maintain a PCI of 70 for all City streets
2. Regularly update the MicroPaver street condition database
3. Encourage use of new technologies and materials in pavement design

PROGRAM RECOMMENDATIONS

1. Institute a regular global maintenance (street sealing) program
2. Implement an effective pothole repair program
3. Implement a regular crack sealing program
4. Create a Green Streets program
5. Implement a street subsurface evaluation program
6. Upgrade or Install ADA curb ramps
7. Modify and/or enforce trench cut standards
8. Coordinate with other programs and departments
    a. Utility Master Planning and scheduled repairs
    b. City Trees

c. Bicycle Traffic
d. Non-City Utilities (Cayucos, AT&T, PG&E, etc
e. Fire
f. Police
g. Businesses and Residents

9. Create a comprehensive 10-year Pavement Maintenance and Rehabilitation Program

Ideally, an annual budget of $900,000 for the street program will be sufficient to improve the street system beyond its current level and that the average PCI will reach the goal of 70 in ten years. While an annual budget of $900,000 is the optimal funding level in order to improve the City's average pavement condition index to 70, this amount may be unrealistic given today's financial climate; and lower annual budgets will have less effective results. A more realistic compromise is proposed with initial expenditures of $500,000 during the first year and $250,000 annually thereafter, with the intention of supplementing with grants and other external resources. The actual amount will be approved with each annual budget process.

DEVELOPMENT
OF A
PAVEMENT MANAGEMENT SYSTEM
FOR
THE CITY OF MORRO BAY

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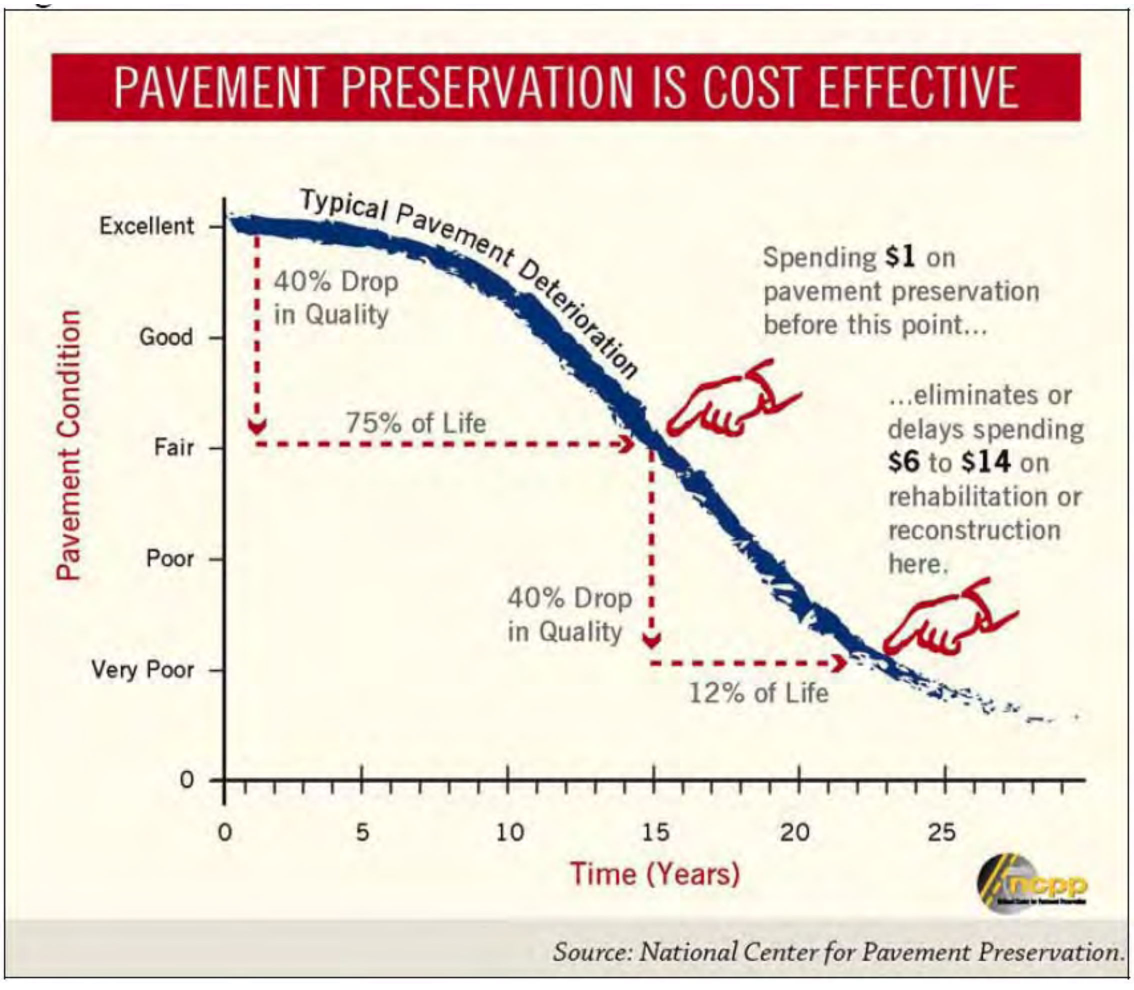
SECTION I: INTRODUCTION

This project consisted of setting up a Pavement Management System (PMS) for the City of Morro Bay. MicroPAVER, version 6.1, an American Public Works supported PMS software package, was used for this project.

A PMS program has several distinctive uses as a budgeting and inventory tool, while also providing a record of pavement condition. The primary use of any PMS is a budgeting tool with the aim of maximizing the cost effectiveness of every dollar spent on city streets The graphic below illustrates how critical it is to allocate funds for street repair in a timely manner The system provides project rehabilitation costs and timing based on nationwide research which provides average pavement deterioration rates. Unit costs are based on recently bid projects. As an inventory tool, it provides a quick and easy reference on pavement areas and usages. As a pavement condition record, it provides age, load-related, non-load related and climate related pavement condition and deterioration information.



A PMS is not capable of providing detailed engineering designs for each street. The PMS instead helps to identify potential repair and maintenance candidate streets. Further investigation, or project level analysis, of these candidate streets is used to optimize the City's pavement management dollars. Project level pavement analysis and engineering is an essential feature of future pavement maintenance and rehabilitation projects. Project level engineering examines the pavements in significantly more detail than the visual evaluation required for the

PMS system and provides optimization of the design given all of the peculiar constraints of the project streets.

The PMS software assumes average construction and material quality. Pavement life is very sensitive to materials and workmanship quality. Poor quality new construction may result in up to a 50 percent loss in the pavement life. In other words, poor quality new construction may last 10 to 15 years, whereas excellent quality construction may last 20 to 30 years. Investing in quality, both in design and construction, provides significant returns in extended pavement life resulting in lowered annual maintenance costs.

The PMP for the City of Morro Bay has five primary goals as follows:

1. Provide an accurate and complete inventory of the City's pavements and condition.
2. Identify and quantify maintenance and rehabilitation needs for the street system.
3. Identify prioritization and optimization criteria for the street system.
4. Develop a set of pavement management policy guidelines.
5. Develop a ten year plan and budget for the City street system.

A full appreciation of a pavement management system and the value of its data and cost projections depends on a basic understanding of pavement design basics. These are provided in Section II: Background. Section III provides information on the PMS Program Specifics incorporated into the program. Section IV provides Summarized System Information in the form of easy to read tables and figures. Section V provides a set of policy and program recommendations for future pavement management. Two appendices detail the proposed ten-year pavement management program and a list of description of pavement distresses.

SECTION II: BACKGROUND

This section is intended to introduce important pavement design definitions and calculations as a background for understanding the Pavement Management System (PMS) assumptions.

PAVEMENT DESIGN BASICS

Pavements are a structural support system generally considered to act like a beam. But unlike beams in buildings which generally have static loads, the pavement structure is flexed many times from traffic loading. Cars and light trucks have little impact on the pavement structure. Larger/Heavier trucks have very significant impacts to the pavement due to the high axle weights. The impact of trucks is measured in equivalent single 18,000 pound axle loads (ESALs). The total ESALs are converted into a design Traffic Index (TI) by an exponential formula. For example, a design TI of 5 is equal to 7,160 ESALs. A design TI of 8 is equal to 372,000 ESALs. Therefore, the design TI is related to the total number of ESALs that the pavement will support before it begins to fail, regardless of the passage of time. Normally for a new pavement, the ESALs over a 20-year period are used. For rehabilitation procedures such as overlays, 10 years is generally used.

The other element of pavement design is the support of the beam. The support is provided by the subgrade soils. The support value is designated by the R-value test, which is performed by a soils engineer.

Using the design TI and R-value, the pavement designer chooses various materials to construct the structural section. The most common pavement section is a thin layer of asphalt concrete over aggregate base(s)

Many options are available depending on specific project requirements and conditions.

The design method used in California is based on a 50 percent reliability. This means that the average pavement life of all pavements constructed using the design procedure will last the design life. It also means that about half will not last that long and the other half will last longer. To express this concept, a design life is often expressed in a span of years, such as 17 to 23 years for 20-year design life.

PAVEMENT DETERIORATION

Pavement deteriorates from two processes: fatigue and aging. The processes occur simultaneously. In a well designed and constructed pavement, the two processes result in the need to rehabilitate the pavement at approximately the same time. This is called the design life. The design life for most new pavements is 20 years. Each aging process has its own set of pavement defects which are related to the process.

Fatigue

The first deterioration process is fatigue from heavy axle loads. As the pavement structure flexes or bends from heavy wheel loads, the asphalt concrete layer's ability to flex is consumed. With sufficient bending, the asphalt concrete layer begins to break at the bottom. This cracking progresses upward until it reaches the surface and appears as alligator cracking. If left unattended, they will produce a pothole. These areas are repaired by removal and replacement of the asphalt concrete in the affected areas. These repairs are commonly called digouts.

Pavement structure and durability are also impacted by utility trenches. When total cumulative quantity of digouts and utility patches reaches approximately 5 percent of the total area, the pavement is considered to have reached its design life and requires major rehabilitation.

Aging

The major element of the pavement structure which ages is the asphalt concrete layer. To a minor extent, aggregate bases can age if contaminated by fine soil particles which are transported from the subsoil into the aggregate base.

Asphalt concrete is composed of aggregates and asphalt cement. The aggregates used are generally of fair quality and do experience some breakdown over time. Aggregate aging problems need to be addressed in maintenance procedures. The asphalt concrete binder ages as well. As the asphalt binder ages, it loses volume through loss of volatile components in the asphalt. As the volume decreases, the pavement will progressively crack from the resulting tensile strain in the layer. Normally, these cracks first show up as transverse cracks. They also show up at weak areas such as paving joints. These cracks widen and increase over time until the pavement has a checkerboard appearance.

The aging process also causes the pavement to become more brittle. The increased stiffness results in additional cracking from loaded vehicles. This load induced cracking from the brittleness of the asphalt concrete is very similar to fatigue cracking in appearance. The major agent for deterioration of the asphalt concrete binder is oxygen. The carrier of the oxygen is water. Water enters the pavement either from the surface or as water vapor from underneath.

TYPICAL PAVEMENT DEFECTS

MicroPAVER identifies nineteen different distress types. Some of these distress types are not applicable to the City of Morro Bay. Using our knowledge of California coastal streets, we have reduced the number of distress types to fifteen. These fifteen are:

1. Alligator Cracking (Fatigue)
2. Block Cracking
3. Bumps and Sags
4. Depressions
5. Edge Cracking
6. Joint Reflection Cracking
7. Lane/Shoulder Drop-off
8. Longitudinal and Transverse Cracking
9. Patching and Utility Cut Patching
10. Polished Aggregate
11. Potholes
12. Rutting
13. Shoving
14. Swell
15. Weathering and Raveling

These defects are common to virtually all of the pavements as aging progresses.

For purposes of understanding the character and levels of these distresses, the pavement defect descriptions from the rating manual are included in Appendix 2.

PAVEMENT MAINTENANCE PROCEDURES

Pavement maintenance procedures are designed to slow the pavement aging process. Mainly, the procedures are designed to protect the pavement from the adverse effects of water and to some extent vehicle traffic.

Maintenance procedures which protect the pavement from aging are crack sealing, digouts, slurry seals, and cape seals. When pavements have extensive cracking and are beyond their design life, sealing can also be used as an interim holding measure or stop gap prior to major rehabilitation.

Crack Sealing

Crack sealing prevents surface water from getting beneath the asphalt concrete layer into the aggregate bases. Crack sealing is generally performed using hot rubberized crack sealing material. The procedure includes routing small cracks, cleaning and sealing. The City owns and operates its own crack sealing equipment.

Digouts (Patching)

Digouts are small areas of deteriorated pavements (usually potholes) which are removed and replaced with new asphalt concrete. Pavement removal is accomplished by cold planing or sawcutting and excavation. New asphalt is installed in at least two lifts. The digout depth is determined depending on the severity and type of distress, as well as street type and construction. Shallow patching is often used on low to medium severity distressed areas of pavement where the underlying base is sound, while a full depth digout is required when the failure of the base material is detected. Digouts are generally performed by the City crew, though digouts repairs are often required in preparation for a contracted slurry seal.

Slurry Seals and Micro-surfacing

Slurry seals consist of a combination of fine aggregate and emulsified oil used on relatively good streets to preserve and extend pavement life. Slurry seals are also a cost effective treatment for streets whose major form of distress is severe weathering or raveling. Micro-surfacing is similar to a slurry seal with added polymers that allow the application of thicker layers and added service life. The added thickness of micro-surfacing makes it a good choice to correct rutting. Micro-surfacing is used exclusively by the City of San Luis Obispo for routine street sealing providing excellent results with a life expectancy of 8 years. The City of Morro Bay used micro-surfacing for the first time in November, 2010 on a one-mile stretch of North Main Street between Atascadero Road and San Jacinto.

Cape Seals

Cape seals consist of a chip seal overcoated with a slurry seal. A chip seal is an application of small angular rock (chips) approximately 1/4” to 3/8” in maximum size embedded into a thick application of asphalt emulsion. Most chips seals incorporate polymer modified binders.

Cape seals are used on residential and collector streets to maintain a pavement which may need an overlay, but there are not sufficient funds available. Chip seals are placed over low to moderate alligator cracks and block shrinkage cracking. Due to the distress covered by the chip seal, small areas of disbonding or failure may occur and will require patching.

Cape sealed surfaces are fairly coarse compared to new paving. Due to this characteristic, they may not be acceptable to some segments of the public.

Though chip seals were used extensively in Morro Bay prior to incorporation, many of the streets that received this treatment did not have a stable base and subsequent deterioration has resulted. Cape seals have never been used in Morro Bay but are being considered as a pavement treatment option in the near future on streets with a stable base. They may also be used as an interim holding measure to "hold" the pavement together until funds become available for major rehabilitation.

PAVEMENT REHABILITATION PROCEDURES

Pavement rehabilitation consists of procedures used to restore the existing pavement quality or to add additional structural support to the pavement. Rehabilitation procedures include conventional overlays; heavy overlays; and reconstruction.

Conventional Overlays

Conventional overlays generally consist of surface preparation, the optional installation of pavement fabric, followed by the application of varying thicknesses of asphalt concrete. Surface preparation can consist of crack filling, pavement repairs of base failures and leveling courses.

Pavement fabric is often used as a water inhibiting membrane and to retard reflective cracking. Care must be used with fabric to avoid intersections with heavy truck braking, steep grades (generally over 8 percent), and areas where subsurface water might be trapped.

The overlay thickness is determined by the structural requirement of the deflection analysis and reflective cracking criteria. The reflective cracking criteria requires the thickness of the overlay to be a minimum 1/2 the thickness of the existing bonded layers. Pavement fabric can account for 0.10 ft of asphalt for reflective cracking criteria if the structural requirements from the deflection analysis are met.

Conventional overlays have an expected service life of 7 to 13 years if they are designed to meet structural and reflective cracking criteria and are well constructed.

Heavy Overlay: Pulverization and Resurfacing

Pulverization and resurfacing (also known as Cold in-Place Recycling) is an alternative to conventional overlays for streets that are structurally adequate but exhibit sufficient cracking to warrant improvement to the asphalt surface. Pulverization and resurfacing is an intermediate step between overlays and reconstruction. The existing asphalt concrete is pulverized, mixed with an engineered emulsion and reapplied over the existing aggregate base. The total structural section is increased by the recycled base. A final seal coat or thin overlay completes the resurfacing process. This method eliminates the stress history and cracking of the old asphalt concrete pavement, thus eliminating negative impacts on the new asphalt concrete surface.

Pulverization and resurfacing has a life expectancy of 13 to 18 years. The life expectancy is slightly less than full reconstruction because some residual deficiencies in thickness or quality of the unaffected layers may still exist. Additional testing is necessary to determine if pulverization is a viable alternative. This testing includes measuring the existing structural section and testing the native soil for bearing capacity (R-value).

Heavy Overlay: AC Removal and Replacement (Mill and Fill)

On some thick asphalt concrete pavements, the most economical approach to rehabilitating the pavement is to remove some of the existing asphalt concrete surface by cold planing and to place new asphalt concrete surface which matches the existing profile. This method may be required if the pavement profile is already so thick that the additional thickness obtained from recycling the existing pavement is unacceptable due to drainage, street geometry, or other concerns. The removed asphalt can often be recycled and reused on other streets if concurrent projects are planned appropriately. Depending on existing conditions, this method should have a life of 15 to 20 years.

Reconstruction

When the pavement has severe cross section deficiencies or requires significant structural strengthening, reconstruction may be the only alternative. Generally, existing pavement materials are recycled and incorporated into the new pavement structure in a process called Full Depth Reclamation. This method minimizes the importation of new base material and virtually eliminates export of material to landfill sites. Engineered emulsion binders are mixed with the existing materials to form a base that is equal to or superior in strength to new aggregate base. The final surface is then applied, typically 3 to 4 inches of hot mix asphalt. Many of the residential streets on the north side of town require reconstruction due to the poor quality of the original construction prior to incorporation.

SECTION III: THE PMS PROGRAM

This section discusses the characteristics of the PMS program and its application to the City of Morro Bay.

BACKGROUND

During the early years of PMS software development, many companies developed private PMS software packages focused on management of municipal street systems. Though these programs were versatile and sophisticated, the user was also dependent upon the software vendor for training, program updates, and software servicing. Many of the vendors had difficulty maintaining their software, leaving agencies stranded after making a substantial investment.

The American Public Works Association identified the need for a publicly supported PMS program independent of private vendors. The association chose the Paver program as a basis for a municipal version. The original Paver PMS program was developed by the Army Corp of Engineers for management of military pavements, particularly air fields. Working with the Army Corp of Engineers, APWA-MicroPAVER was developed.

The program has features which make it applicable for a wide range of municipal pavements throughout the country. In order to make it user friendly, the program lacks much of the sophistication of private programs. However, it does provide good system wide models and budgeting capacity. It also provides an inventory of pavements.

For this project, the City decided to update their MicroPAVER software to the latest version, 6.1. It is also used by many other municipalities and counties in the region, including the Cities of Pismo Beach and San Luis Obispo and the County of San Luis Obispo.

SYSTEM ASSUMPTIONS

The PMS program makes several basic assumptions regarding the degradation of pavements. The basis of the system is the Pavement Condition Index (PCI). New pavements with no defects receive a score of 100. From this score, the program deducts points based on defect type and severity identified during the visual review. After the initial PCI for a street segment is determined, the program reduces the PCI on an annual basis using preset deterioration curves. Placement on the deterioration curve is determined by the date of original construction or most recent overlay. The PCI is increased when a maintenance or rehabilitation activity is performed.

The APWA-MicroPAVER PMS program does not have the capacity to include much historic information beyond the date of original construction or most recent overlay in determining the current PCI or initial score. Thus, a pavement without defects is scored at 100, regardless of age. Most pavements within the first 5 to 8 years of their life have few if any defects. Therefore, a PCI of 100 may be applied to pavements from 0 to 8 years old. At 8 years, the pavement is approximately 1/3 through its initial life. As the system is maintained with maintenance activity and condition updates, the system adjusts itself to correct for these initial input variances.

The system uses standard treatments to raise the PCI based on the original PCI. The treatment strategies include localized maintenance, global maintenance, and major rehabilitation. Localized maintenance includes such activities as digouts and crack sealing. Global maintenance includes activities such as slurry, micro-surfacing and cape seals. Major rehabilitation activities include overlays and reconstruction.

The system ratings do not take into account geometric constraints in the system such as excessive crowns or lack of median curb height. These geometric constraints often make some procedures inapplicable. An example is lack of curb height. At some point, the pavement will have to be milled off prior to placement of a new surface layer. The system does not contain this alternate. Neither does the system include miscellaneous costs, such as associated concrete repairs or sidewalk improvements.

Maintenance treatment recommendations are based on certain PCI and pavement distress level thresholds, some of which are adjustable by the user and others are not. Due to these assumptions and program simplifications, the PMS program designated maintenance treatment for a given street may not be precisely what that particular street requires. For example, the program suggests major rehabilitation if the surface area of alligator cracking exceeds 0.5% of the total street surface. Such streets can often be patched and resurfaced at a lower cost. Making these determinations is project level engineering. The PMS program identifies candidate streets for various treatment types. The project engineer then visually reviews the streets. Depending on the condition, a specific maintenance treatment can be specified, or in the case of major rehabilitation, additional testing may need to be performed to identify which specific maintenance or rehabilitation approach may be most economical.

The goal of the PMS program is to furnish budgetary amounts in order to achieve system wide improvements in the overall pavement condition. The goal of project engineering is to obtain the maximum economical impact for a given subset of the system to be maintained. Using the PMS program, management is able to realistically budget for economically maintaining the City's pavement system. Annually updating maintenance activity and costs keep the system current.

PAVEMENT MAINTENANCE PRIORITIES

Though the initial selection of streets, scheduling of work, and choice of treatment is made by the MicroPAVER program with the goal of maximizing the impact of pavement management dollars, several user-defined criteria guide the program in the way it processes data. These key criteria include:

1. Achieve and maintain an average PCI of 70 or higher for all city streets with no street below a PCI of 55.
2. Give priority to more heavily traveled streets. The order of priority has been set as arterial, collector, industrial, and residential, in that order.
3. Preventative maintenance on streets with a low surface area percentage of distresses is the best use of funds. Digout repairs followed by cape seals or micro-surfacing treatment measures can be used as appropriate. Priority is given to streets that are in the lower PCI range to prevent them from dropping down into a distress category that requires more expensive rehabilitation.
4. Rehabilitation measures are generally required for streets with a PCI in the range of 55 to 70 or high surface area percentage of distresses. Priority is given to streets that are in the lower PCI range to prevent them from dropping down into a distress category that requires more expensive reconstruction.
5. Streets that have fallen below a critical PCI level of 55 and have known base deficiencies shall be scheduled for reconstruction on a "worst first" basis. Stopgap measures shall be used to keep streets safe for travel until reconstruction can take place.

SYSTEM INVENTORY

The street classifications (arterial, collector, industrial, and residential) assigned in this report were determined by city staff. Since pavement life is directly proportional to the types and weight of vehicles, the City should periodically review and upgrade the classification of streets so the PMP can correctly identify rehabilitation and maintenance strategies and account for the increased truck traffic.

All streets were measured using a vehicle mounted measuring device for length and a hand held measuring wheel for width. Length was measured from center of intersection to center of intersection on residential and collector streets. Intersections of arterials and collectors were measured in only one direction unless two arterials adjoined each other, in which case the intersection length was included in both directions. Measuring from centerline to centerline creates an increased area in the program. This increase helps adjust for additional costs of maintaining intersections. In the case of cul-de-sacs, lengths were adjusted to account for the additional pavement area in the cul-de-sacs bulbs. Widths were measured from face of curb to face of curb to provide a small amount of contingency. Widths of collectors and arterials were adjusted to account for pavement in turn pockets.

PAVEMENT MAINTENANCE AND REHABILITATION UNIT COSTS

The following costs were used to develop the indicated budget numbers for each street segment reviewed. The costs include miscellaneous work such as transitions, striping, digouts, etc.

The costs are averages. Small programs will have higher unit costs and large programs will have lower unit costs. The larger the annual program size, the better the economies of scale. Timing is also important. Bidding the work in early spring will result in significantly lower prices than bids solicited in the late summer or fall. If small packages are used, costs could be 25 to 50 percent higher.

The costs reflect prices for work completed within the county over the past few years, including data from within the City and estimated costs from other agencies using MicroPaver. The developed unit costs include striping and other lump sum project costs for each street. The costs per street were then averaged and rounded to produce the indicated unit costs. The unit costs include a 10% contingency and a 15% allowance to account for engineering design fees and inspection. These prices are in today's dollars (December, 2010) and do not account for inflation.

PAVEMENT MAINTENANCE & REHABILITATION UNIT COSTS

Treatment Description	Street Classification (Cost/SF*)		
	Arterial	Collector	Residential
Reconstruct	$5.00	$5.00	$4.50
Thick Overlay	$3.50	$3.50	$3.00
Thin overlay	$2.50	$2.50	$2.00
Heavy Maintenance (Cape Seal)	$0.60	$0.60	$0.60
Light Maintenance(Micro-surface)	$0.38	$0.38	$0.38

*All Costs Include Surface Preparation, Design and Inspection

Since life cycle cost analysis is part of developing annual maintenance and rehabilitation programs, some general life expectancies should be identified. For a typical light maintenance treatment, a service life of 5 to 8 years can be assumed. A heavy maintenance treatment may provide a service life of 7 to 10 years. A typical conventional overlay, whether light or heavy, has an expected service life of 8 to 13 years. Depending on the existing pavement and soil conditions, other rehabilitation options can be applied that will provide a service life of up to 18 years. A reconstructed pavement is expected to provide a service life of 20 years.

Depending on the existing conditions, the identified service life may vary. The projections of future life are given to provide a broad outline for pavement maintenance budgeting. They should not be interpreted as providing definitive predictions of future pavement performance.

VISUAL EVALUATIONS

All of the pavements were evaluated by a Cal Poly student working as an intern for the City. The streets were rated based on the *Paver Asphalt Distress Manual*, which is part of the APWA--MicroPAVER system described in Section II. Once the data were entered into the program, Rob Livick completed a quality assurance review of the system and verified the results in the field. The street inventory was based on visual evaluations. Recent street maintenance procedures could be masking the pavement's true condition. For this reason, the City should commit to maintaining the PMP by reviewing the system's pavements at least every three years.

SYSTEM UPDATES

The Pavement Management System is a dynamic program. It is expected that the City will continue to visually rate the street network and update the database at least every three years. It is recommended that the arterial, collector and industrial streets be re-rated annually. This constant review of the system will refine the deterioration curves used to predicate future work. In addition to the visual review, the City should update the database by adding new streets incorporated into the City as well as and new maintenance work performed to a particular street segment.

SECTION IV: SUMMARIZED SYSTEM INFORMATION

The City of Morro Bay currently maintains approximately 53.4 centerline miles of roadways (approximately 8,030,178 square feet of pavement). This represents an asset with a replacement value of approximately $40,000,000.

Data were collected for the entire street system using MicroPAVER PMS version 6.1. An alphabetical listing is provided in Section V. The current weighted average PCI (Pavement Condition Index) for the street system is 63.4. While it is up to the City of Morro Bay to determine at what condition level (PCI) they want their pavements to be, most cities in California are trying to maintain their entire street system with an average PCI of 70 or above.

The street system for the City of Morro Bay currently breaks down as follows:

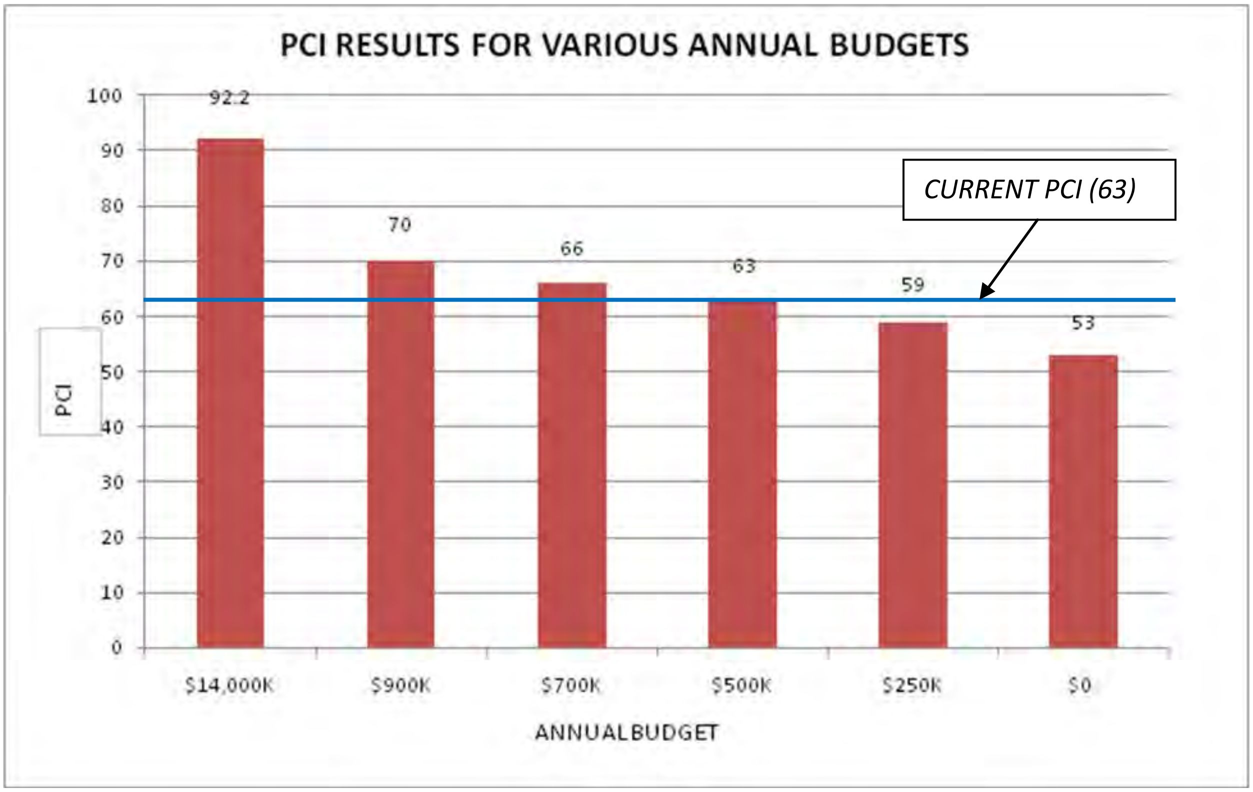
Street Classification	Centerline Miles	Area (Square Feet)	Percent of System	Average PCI
Arterials	7.9	1,531,968	19%	78
Collectors	3.2	526,700	7%	60
Local Industrial/Commercial	5.5	1,016,700	13%	64
Local Residential	36.9	4,954,810	62%	59
Total	53.4	8,030,178	100%	63

To assist with further analysis and project development, the City was divided into four zones: North, EastCentral, Downtown and South (see attached zone map). A summary of the pavements in these zones is presented in the table below:

Zone	Centerline Miles	Area (Square Feet)	Percent of System	Average PCI
North	11.8	1,435,800	18%	56.7
EastCentral	16.3	2,479,460	31%	59.9
Dowtown	12.6	2,427,950	30%	68.6
South	12.8	1,686,968	21%	66.1
Total	53.4	8,030,178	100%	63.3

For this PMP, each street was assigned a treatment action and budget based on the pavement's current rating and construction history. The cost or need has been calculated at $14.4 million to provide the recommended treatments to all streets. Spending this amount would result in the total system having an average PCI of well over 70. While it is recognized that the City of Morro Bay does not have the means, budget or resources to spend that amount of money, the number provides a bench mark for future analysis.

As part of the analysis, the anticipated PCI at various budget levels over 10 years was projected using the MicroPAVER software. The analysis showed that a yearly funding level of about $500,000 is required to maintain the street system at its current average condition and it would require $900,000 annually to increase the overall PCI to 70. Anything less than $500,00 will mean continued degradation of pavement conditions in the City. The analysis is summarized on the graph below.



- The $14 Million budget amount is the total expenditure required to provide all recommended repairs.

SECTION V: PAVEMENT MANAGEMENT PLAN RECOMMENDATIONS

POLICY RECOMMENDATIONS

1. **Achieve and maintain a PCI of 70 for all City streets**: The current level of 63.3 is below the average condition that most California cities try to maintain. It is also evident from the level of citizen complaints that our streets need improvement. Achieving an average PCI of 70 will not eliminate all poor streets, but it will reduce citizen complaints and provide a more attractive and efficient transportation network.
2. **Regularly update the MicroPaver street condition database**: All maintenance, repair and rehabilitation activities should be entered into the MicroPaver database so that current street conditions can be tracked and project planning facilitated. Coordination with the Streets Department, who are responsible for pothole repairs and other minor maintenance activities, will be necessary. A complete reevaluation of the entire street system should be performed every five years.
3. **Encourage use of new technologies and materials in pavement design**: For example, pavement recycling technologies have greatly improved in the last decade, providing street rehabilitation treatments that are durable, economical and less damaging to the environment. Micro-surfacing is a relatively new form of slurry seal that has proven to work well in nearby cities. In Morro Bay, it was used as a maintenance treatment on North Main Street in November 2010. Staff should keep abreast of new developments in pavement technologies and incorporate them in future work where feasible.

PROGRAM RECOMMENDATIONS

1. **Institute a regular global maintenance (street sealing) program**: The expected life of a good micro-surface treatment is eight years and a cape seal can be expected to last 10 years. Every street in the City should be sealed every 8 to 10 years unless it is scheduled for major rehabilitation. Such a maintenance program will need to be phased in over time, as there are many streets that already exceed this interval and budget does not allow to treat them all immediately.
2. **Implement an effective pothole repair program**: Pothole repair prevents water intrusion into the supporting soil and can also serve as a “stop gap” repair until major maintenance can be performed. Pothole repair can sometimes involve a simple removal and replacement of the top layer of asphalt, but more often requires full digout of the underlying base and reconstruction of the entire pavement profile. Once the area of pothole patch repairs exceeds 5% of the street area, the street is a candidate for major rehabilitation. The Streets Division is responsible for pothole repair, which can be performed either by City crews or by private contractors. Pothole repair requests usually originate from citizens but a more pro-active approach coordinated with the street sealing program will enhance both the life of the pothole repair and the seal coat.
3. **Implement a regular crack sealing program**: Older pavements tend to crack even if the subgrade is stable. Cracks, however, will allow water to enter the supporting soil and destabilize the pavement base. A regular crack sealing program will increase the longevity of streets and delay more costly maintenance and repairs. The Streets Division has the equipment to perform this task. Unlike potholes, which are often reported by citizens, cracks are best identified during periodic inventories. The MicroPaver PMS catalogues cracks that need attention. Sealing cracks prior to microsurfacing or chip

seals will extend the life of the new surface.

4. **Create a Green Streets program**: Street reconstruction is an opportunity to "go green" through the use of recycled pavement materials and in redesigning drainage to reduce the amount of polluted runoff that enters our creeks and the storm drain system. Green streets usually have bike and pedestrian-friendly components. Such a program is often a good candidate for external grant funding to help stretch City budget dollars. A City Council- approved grant application to develop a Green Streets program was submitted to Caltrans in early 2011.
5. **Implement a street subsurface evaluation program**: Streets that are scheduled for reconstruction may have adequate materials in the pavement profile to warrant full-depth reclamation of these materials. Depending on the quality and thickness of the existing materials that make up the pavement profile, and a suitable binder material can be designed to be added during the reclamation process to form a strong base. An evaluation of the pavement profile will provide the necessary data for engineering design of the recycled base.
6. **Install or Upgrade ADA curb ramps**: Street repairs are also a good time to update and add ADA curb ramps to current standards. In some cases, requirements attached to funding sources or the project is a significant improvement, ADA ramps need to be updated. Typically, when a street rehabilitation project requires ¾-inch or greater overlay, then curb ramp upgrades are installed.
7. **Modify and/or enforce trench cut standards:** Trench cuts can have a significant impact on street durability. Internal coordination with utility master plan projects will help reduce damage to recently paved streets due to planned activities, but trenching for emergency repairs and new developments are inevitable. Diligent enforcement of current engineering standards for trench backfill including the one-year warranty against settlement will help minimize trenching impacts to the pavement. The City standards should also be updated to conform to current material specifications and trench repair technologies.
8. **Coordinate with other programs and departments:** Street repair and maintenance often impacts other activities, programs and City operations. At a minimum, the following activities should be coordinated with street repair and maintenance:
    a. **Utility Master Planning and scheduled repairs**: Coordination of proposed street and utility work can avoid counterproductive efforts such as trenching in newly repaved streets.
    b. **City Trees:** Urban trees are a valuable resource and often the object of passionate feelings in the City of Morro Bay. Street work may require trimming or removal of trees to accommodate repairs or work within the drip line. All street work should comply with the City Tree Regulations within the Municipal Code.
    c. **Bicycle Traffic:** Class 2 bicycle lanes share the paved area of City streets, often on the outside edge or shoulder. Pavement maintenance and overlays should be performed such that sharp edges and ridges in the bicycle lane are avoided. Pavement repair may also present an opportunity to correct or enhance bicycle lane markings.
    d. **Non-City Utilities (Cayucos, AT&T, PG&E, etc.):** Street work often requires excavation into the underlying soil or impacts utility poles and holes. Coordination with impacted utilities is a must.
    e. **Fire:** The Fire department must be notified of street closures during construction and should be consulted when street work may impact fire hydrants. Blue

reflectors adjacent to fire hydrants may need to be replaced where maintenance or repair results in their damage or removal.

f. **Police:** The police department must be notified of street closures and parking restrictions during construction and any long-term changes to parking restrictions or traffic flow due to street work.

g. **Businesses and Residents:** Notification of street work should be made well in advance of the project, especially if any long-term changes are to be made (e.g parking restrictions). Feedback from impacted business owners and residents can often be more easily incorporated into the design phase rather than in the middle of project implementation. Typically, work on streets within the business district that impacts parking shall be conducted between Labor Day and Memorial Day.

9. **Create a comprehensive 10-year Pavement Maintenance and Rehabilitation Program**: Based on the above policy recommendations, pavement management system reports, and preliminary field evaluations of the City street system, a comprehensive plan should be prepared for the upkeep, maintenance and rehabilitation of the streets of Morro Bay. The program should have several budget alternatives including the use of current budget amounts projected forward. City Council can then choose amongst the alternatives with an understanding of how the adopted program will impact the long term condition of City streets. Though the Program lists projects over a five-year period, budgeting should plan for ten years of work.

   A preliminary street maintenance and repair plan has been created and is included in Appendix 1 to illustrate how recommended policies and priorities will translate into a comprehensive program.

APPENDIX 1

TEN-YEAR PAVEMENT MAINTENANCE AND REHABILITATION PROGRAM

The annual programs were developed utilizing the MicroPAVER calculated PCI and pavement management priorities outlined above. An effort was also made to group streets by treatment type and geographical location. The optimal annual budget for a program that complies with the policy recommendations of this report is $900,000. Plans for a $500,000 and $250,000 annual budget have also been developed, as well as a budget that spends $900,000 in the first year, followed by $250,000 annually thereafter.

The street maintenance and repair plan for the next ten years is based on the policy that seeks to maximize the impact for every dollar spent on street improvements. Since it is less costly to maintain good streets than to repair failed streets, the plan initially targets streets that can be brought up to a very good condition (PCI > 80) at the least unit cost. In later years, streets that are more severely degraded can be repaired or reconstructed as budget permits.

ANNUAL BUDGET: $900,000

Year One:

The focus of the first year will be on pavement maintenance (micro-surfacing and cape seals) on streets with minimal to moderate level of distress. The streets selected for the first year of the program are located in the south and downtown zones of the City. By targeting a constrained geographic area and using only two treatment methods, we can expect more favorable bids. Most of the streets to be treated will also require crack sealing and/or site-specific digout repairs in preparation for the seal coat. Cost of these site-specific repairs are included in the budget.

In addition to pavement maintenance, a “Green Streets” program for reconstruction of streets in the north side residential areas will be started. It is expected that grant funding will be available to partially fund this program.

Year Two:

The second year plan is similar to the first, targeting the remaining streets to be given micro-surface treatment maintenance in the south and downtown zones and doing cape seals of streets in the north and eastcentral zones. One street is scheduled for an overlay.

Year Three to Year Five

The next three years will target streets that are due for overlays.

Years Six to Ten

At the end of Year Five, the entire street system will be reevaluated and projects will be prioritized based on that evaluation.

5-Year Plan @ 900,000/year									
2011		2012		2013		2014		2015	
Street	Treatment	Street	Treatment	Street	Treatment	Street	Treatment	Street	Treatment
Marina3	CapeSeal	Toro1	CapeSeal	Beach2	HOverlay	Bonita1	HOverlay	Greenwood1	HOverlay
Oak1	CapeSeal	Formosa1	CapeSeal	Pacific2	HOverlay	Bernardo1	HOverlay	Marina1	HOverlay
Olive3	CapeSeal	Java2	CapeSeal	Main8	HOverlay	Kern1	Overlay	Elena2	HOverlay
Pacific1	CapeSeal	Clarabell1	CapeSeal	Hemlock1	Overlay	Ironwood1	Overlay	Seaview1	HOverlay
Napa1	CapeSeal	Sequoia1	CapeSeal	Cedar	Overlay	Beachcomb2	Overlay	Market2	HOverlay
Shasta1	CapeSeal	Capri1	CapeSeal	Ironwood3	Overlay				
Estero1	CapeSeal	Tahiti2	CapeSeal	West1	Overlay				
Quintana3	CapeSeal	Downing1	CapeSeal	Casitas1	Overlay				
Harbor1	CapeSeal	SunsetCt1	CapeSeal	Errol1	Overlay				
Butte1	CapeSeal	Damar1	CapeSeal	Dunbar1	Overlay				
Barlow1	CapeSeal	Koa1	CapeSeal	Norwich1	Overlay				
Madera1	CapeSeal	Main7	CapeSeal	Avalon1	Overlay				
Pecho1	CapeSeal	Sandalwoo2	CapeSeal						
Ridgeway1	CapeSeal	Hillcrest1	CapeSeal						
Center1	MicroSurf	Azure1	CapeSeal						
Merengo1	MicroSurf	SequoiaCt1	CapeSeal						
SurfAlley1	MicroSurf	Sunset3	CapeSeal						
Dana1	MicroSurf	Park1	CapeSeal						
Fresno1	MicroSurf	Mimosa1	CapeSeal						
Marina2	MicroSurf	Monterey4	MicroSurf						
Bayshore1	MicroSurf	QuintanaP1	MicroSurf						
Quintana2	MicroSurf	BellaVist1	MicroSurf						
Scott1	MicroSurf	Dunes2	MicroSurf						
South2	MicroSurf	Acacia1	MicroSurf						
Embarcade1	MicroSurf	Walnut1	MicroSurf						
Alta1	MicroSurf	Scott2	MicroSurf						
Balboa1	MicroSurf	Vista1	MicroSurf						
LasTunas	MicroSurf	Driftwood2	MicroSurf						
Morro2	MicroSurf	Monterey3	MicroSurf						
Dunes1	MicroSurf	Main10	MicroSurf						
Quintana4	MicroSurf	Beach1	MicroSurf						
Quintana1	MicroSurf	Morro5	MicroSurf						
		Fairview1	MicroSurf						
		PineyLn1	MicroSurf						
		Bay1	MicroSurf						
		Luista1	MicroSurf						
		Embarcadr3	MicroSurf						
		Carmel1	MicroSurf						
		Main13	MicroSurf						
		Olive2	MicroSurf						
		Driftwood1	MicroSurf						
		Main9	MicroSurf						
		Bradley1	MicroSurf						
		Monterey2	MicroSurf						
		Main12	MicroSurf						
		Palm1	MicroSurf						
		Morro1	MicroSurf						
		Kings1	Overlay						

ANNUAL BUDGET: $500,000

Years One and Two:

The focus of the first two years will be on pavement maintenance (micro-surfacing and cape seals) on streets with minimal to moderate level of distress. The streets selected for the first year of the program are located in the south and downtown zones of the City. By targeting a constrained geographic area and using only two treatment methods, we can expect more favorable bids. Most of the streets to be treated will also require crack sealing and/or site-specific digout repairs in preparation for the seal coat. Cost of these site-specific repairs are included in the budget.

In addition to pavement maintenance, a “Green Streets” program for reconstruction of streets in the north side residential areas will be started. It is expected that grant funding will be available to partially fund this program.

Year Three to Year Five

The next three years will target streets that are due for overlays and Microsurfacing on Main Street in the downtown area.

Years Six to Ten

At the end of Year Five, the entire street system will be reevaluated and projects will be prioritized based on that evaluation.

5-Year Plan @ 500,000/year									
2011		2012		2013		2014		2015	
Street	**Treatment**	**Street**	**Treatment**	**Street**	**Treatment**	**Street**	**Treatment**	**Street**	**Treatment**
Marina3	CapeSeal	Butte1	CapeSeal	Beach2	HOverlay	Greenwood1	HOverlay	Ironwood1	Overlay
Oak1	CapeSeal	Barlow1	CapeSeal	Bonita1	HOverlay			Beachcomb2	Overlay
Olive3	CapeSeal	Madera1	CapeSeal	Marina1	HOverlay			Beach1	MicroSurf
Pacific1	CapeSeal	Pecho1	CapeSeal	Pacific2	HOverlay			Main7	MicroSurf
Napa1	CapeSeal	Ridgeway1	CapeSeal	Main8	HOverlay			Main9	MicroSurf
Shasta1	CapeSeal	Center1	MicroSurf					Main10	MicroSurf
Estero1	CapeSeal	Merengo1	MicroSurf					Main11	MicroSurf
Quintana3	CapeSeal	SurfAlley1	MicroSurf					Main12	MicroSurf
Harbor1	CapeSeal	Dana1	MicroSurf					Main13	MicroSurf
		Fresno1	MicroSurf						
		Marina2	MicroSurf						
		Bayshore1	MicroSurf						
		Quintana2	MicroSurf						
		Scott1	MicroSurf						
		South2	MicroSurf						
		Embarcade1	MicroSurf						
		Alta1	MicroSurf						
		Balboa1	MicroSurf						
		LasTunas	MicroSurf						
		Morro2	MicroSurf						
		Dunes1	MicroSurf						
		Quintana4	MicroSurf						
		Quintana1	MicroSurf						
		Monterey4	MicroSurf						
		QuintanaP1	MicroSurf						
		BellaVist1	MicroSurf						
		Dunes2	MicroSurf						
		Acacia1	MicroSurf						
		Walnut1	MicroSurf						
		Scott2	MicroSurf						
		Vista1	MicroSurf						
		Driftwood2	MicroSurf						

ANNUAL BUDGET: $250,000

Years One to Four:

The focus of the first four years will be on pavement maintenance (micro-surfacing and cape seals) on streets with minimal to moderate level of distress. The streets selected are located in the south and downtown zones of the City. By targeting a constrained geographic area and using only two treatment methods, we can expect more favorable bids. Most of the streets to be treated will also require crack sealing and/or site-specific digout repairs in preparation for the seal coat. Cost of these site-specific repairs are included in the budget.

In addition to pavement maintenance, a “Green Streets” program for reconstruction of streets in the north side residential areas will be started. It is expected that grant funding will be available to partially fund this program.

Year Five:

The fifth year targets two arterial streets due for heavy overlays.

Years Six to Ten

At the end of Year Five, the entire street system will be reevaluated and projects will be prioritized based on that evaluation.

5-Year Plan @ 250,000/year									
2011		**2012**		**2013**		**2014**		**2015**	
Street	**Treatment**	**Street**	**Treatment**	**Street**	**Treatment**	**Street**	**Treatment**	**Street**	**Treatment**
Marina3	CapeSeal	Shasta1	CapeSeal	Butte1	CapeSeal	Bayshore1	MicroSurf	Pacific2	HOverlay
Oak1	CapeSeal	Quintana3	CapeSeal	Barlow1	CapeSeal	Alta1	MicroSurf	Main8	HOverlay
Olive3	CapeSeal	Harbor1	CapeSeal	Madera1	CapeSeal	Balboa1	MicroSurf		
Pacific1	CapeSeal			Pecho1	CapeSeal	LasTunas	MicroSurf		
Napa1	CapeSeal			Ridgeway1	CapeSeal	Morro2	MicroSurf		
Estero1	CapeSeal			Center1	MicroSurf	Dunes1	MicroSurf		
				Merengo1	MicroSurf	Quintana4	MicroSurf		
				SurfAlley1	MicroSurf	Quintana1	MicroSurf		
				Dana1	MicroSurf	Monterey4	MicroSurf		
				Fresno1	MicroSurf	QuintanaP1	MicroSurf		
				Marina2	MicroSurf	BellaVist1	MicroSurf		
				Quintana2	MicroSurf	Dunes2	MicroSurf		
				Scott1	MicroSurf	Acacia1	MicroSurf		
				South2	MicroSurf	Walnut1	MicroSurf		
				Embarcade1	MicroSurf	Scott2	MicroSurf		
						Vista1	MicroSurf		
						Driftwood2	MicroSurf		

ANNUAL BUDGET: $500,000/$250,000

This budget, which includes a high level of expenditures in the first year, uses accumulated Measure Q funds during the first year to maximize impact on high use streets. Following years are funded with general funds.

Year One:

The focus of the first year will be on pavement maintenance (micro-surfacing and cape seals) on streets with minimal to moderate level of distress. The streets selected for the first year of the program are located in the south and downtown zones of the City. By targeting a constrained geographic area and using only two treatment methods, we can expect more favorable bids. Most of the streets to be treated will also require crack sealing and/or site-specific digout repairs in preparation for the seal coat. Cost of these site-specific repairs are included in the budget.

In addition to pavement maintenance, a “Green Streets” program for reconstruction of streets in the north side residential areas will be started. It is expected that grant funding will be available to partially fund this program.

Year Two to Year Five:

The remaining year plans are similar to the first, targeting the remaining streets to be given micro-surface treatment maintenance in the south and downtown zones and doing cape seals of streets in the north and eastcentral zones.

Years Six to Ten

At the end of Year Five, the entire street system will be reevaluated and projects will be prioritized based on that evaluation.

5-Year Plan @ 500,000 in Year 1, $250,00 in Years 2-5									
2011		2012		2013		2014		2015	
Street	**Treatment**	**Street**	**Treatment**	**Street**	**Treatment**	**Street**	**Treatment**	**Street**	**Treatment**
Marina3	CapeSeal	Harbor1	CapeSeal	Madera1	CapeSeal	Main10	MicroSurf	Toro1	CapeSeal
Oak1	CapeSeal	Butte1	CapeSeal	Pecho1	CapeSeal	Beach1	MicroSurf	Formosa1	CapeSeal
Olive3	CapeSeal	Barlow1	CapeSeal	Ridgeway1	CapeSeal	Morro5	MicroSurf	Java2	CapeSeal
Pacific1	CapeSeal	Scott1	MicroSurf	Dunes1	MicroSurf	Fairview1	MicroSurf	Clarabell1	CapeSeal
Napa1	CapeSeal	South2	MicroSurf	Quintana4	MicroSurf	PineyLn1	MicroSurf	Sequoia1	CapeSeal
Shasta1	CapeSeal	Embarcade1	MicroSurf	Quintana1	MicroSurf	Bay1	MicroSurf	Capri1	CapeSeal
Estero1	CapeSeal	Alta1	MicroSurf	Monterey4	MicroSurf	Luista1	MicroSurf	Tahiti2	CapeSeal
Quintana3	CapeSeal	Balboa1	MicroSurf	QuintanaP1	MicroSurf	Embarcadr3	MicroSurf	Downing1	CapeSeal
Center1	MicroSurf	LasTunas	MicroSurf	BellaVist1	MicroSurf	Carmel1	MicroSurf	SunsetCt1	CapeSeal
Merengo1	MicroSurf	Morro2	MicroSurf	Dunes2	MicroSurf	Main13	MicroSurf	Damar1	CapeSeal
SurfAlley1	MicroSurf			Acacia1	MicroSurf	Olive2	MicroSurf	Koa1	CapeSeal
Dana1	MicroSurf			Walnut1	MicroSurf	Driftwood1	MicroSurf	Main7	CapeSeal
Fresno1	MicroSurf			Scott2	MicroSurf	Main9	MicroSurf	Azure1	CapeSeal
Marina2	MicroSurf			Vista1	MicroSurf	Bradley1	MicroSurf	Monterey2	MicroSurf
Bayshore1	MicroSurf			Driftwood2	MicroSurf	Palm1	MicroSurf	Main12	MicroSurf
Quintana2	MicroSurf			Monterey3	MicroSurf			Morro1	MicroSurf

APPENDIX 2: PAVEMENT DEFECT DESCRIPTIONS

1. Alligator Cracking (Fatigue)

Description:

Alligator or fatigue cracking is a series of interconnecting cracks caused by fatigue failure of the asphalt concrete surface under repeated traffic loading. Cracking begins at the bottom of the asphalt surface (or stabilized base) where tensile stress and strain are highest under a wheel load. The cracks propagate to the surface initially as a series of parallel longitudinal cracks. After repeated traffic loading, the cracks connect, forming many sided, sharp-angled pieces that develop a pattern resembling chicken wire or the skin of an alligator. The pieces are generally less than 0.5 m (1.5 ft) on the longest side. Alligator cracking occurs only in areas subjected to repeated traffic loading, such as wheel paths. (Pattern-type cracking that occurs over an entire area not subjected to loading is called “block cracking,” which is not a load-associated distress.)

Severity Levels:

- L Fine, longitudinal hairline cracks running parallel to each other with no, or only a few interconnecting cracks. The cracks are not spalled.
- M Further development of light alligator cracks into a pattern or network of cracks that may be lightly spalled.
- H Network or pattern cracking has progressed so that the pieces are well defined and spalled at the edges. Some of the pieces may rock under traffic.

2. Block Cracking

Description:

Block cracks are interconnected cracks that divide the pavement into approximately rectangular pieces. The blocks may range in size from approximately 0.3 by 0.3 m (1 by 1 ft) to 3 by 3 m (10 by 10 ft). Block cracking is caused mainly by shrinkage of the asphalt concrete and daily temperature cycling (which results in daily stress/strain cycling). It is not load-associated. Block cracking usually indicates that the asphalt has hardened significantly. Block cracking normally occurs over a large portion of the pavement area, but sometimes will occur only in non-traffic areas. This type of distress differs from alligator cracking in that alligator cracks form smaller, many-sided pieces with sharp angles.

Severity Levels:

- L Blocks are defined by low-severity* cracks.
- M Blocks are defined by medium-severity* cracks.
- H Blocks are defined by high-severity* cracks.

*See definitions of longitudinal transverse cracking.

3. Bumps and Sags

Description:

Bumps are small, localized, upward displacements of the pavement surface. They are different from shoves in that shoves are caused by unstable pavement. Bumps, on the other hand, can be caused by several factors, including:

1. Buckling or bulging of underlying PCC slabs in AC overlay over PCC pavement.

2. Infiltration and buildup of material in a crack in combination with traffic loading (sometimes called "tenting")

Sags are small, abrupt, downward displacements of the pavement surface. If bumps appear in pattern perpendicular to traffic flow and are spaced at less than 3 m (10 ft) , the distress is called corrugation. Distortion and displacement that occur over large areas of the pavement surface, causing large and/or long dips in the pavement should be recorded at "swelling."

Severity Levels:

L Bump or sag causes low-severity ride quality.
M Bump or sag causes medium-severity ride quality.
H Bump or sag causes high-severity ride quality.

4. Depressions

Description:

Depressions are localized pavement surface areas with elevations slightly lower than those of the surrounding pavement. In many instances, light depressions are not noticeable until after a rain, when ponded water creates a "birdbath" area; on dry pavement, depressions can be spotted by looking for stains caused by ponding water. Depressions are created by settlement of the foundation soil or are a result of improper construction. Depressions cause some roughness, and when deep enough or filled with water, can cause hydroplaning.

Severity Levels:

Maximum depth of depression

L ½ to 1 inch
M 1 to 2 inches
H more than 2 inches

5. Edge Cracking

Description:

Edge cracks are parallel to and usually within 1 to 1.5 feet of the outer edge of the pavement. This distress is accelerated by traffic loading and can be caused by a weak base or subgrade near the edge of the pavement. The area between the crack and pavement edge is classified as raveled if it is broken up.

Severity Levels:

L Low or medium cracking with no breakup or raveling.
M Medium cracks with some breakup and raveling.
H Considerable breakup or raveling along the edge.

6. Joint Reflection Cracking (from PCC slabs)

Description:

Joint reflection cracking occurs in a flexible overlay over an existing crack or joint in a PCC slab. The cracks occur directly over the underlying cracks or joints.

Severity Levels:

- L One of the following conditions exists: (1) non-filled crack width is less than 3/8 in, or (2) filled crack of any width (filler in satisfactory condition)
- M One of the following conditions exists: (1) non-filled crack width is greater than or equal to 3/8" and less than 3 in.; (2) non-filled crack is less than or equal to 3 in. surrounded by light and random cracking, or (3) filled crack is of any width surrounded by light random cracking.
- H One of the following conditions exists: (1) any crack filled or non-filled surrounded by medium- or high-severity random cracking, (2) non-filled crack greater than 3 in., or (3) a crack of any width where approximately 4 in. of pavement around the crack is severely broken.

7. Lane/Shoulder Drop-off

Description:

Lane/shoulder drop off is a difference in elevation between the pavement edge and the shoulder. This distress is caused by shoulder erosion, shoulder settlement, or by building up the roadway without adjusting the shoulder level.

Severity Levels:

- L The difference between the pavement edge and shoulder is 1 to 2 in.
- M The difference between the pavement edge and shoulder is 2 to 4 in.
- H The difference between the pavement edge and shoulder is > 4 in.

8. Longitudinal and Transverse Cracking (Non-PCC Slab Joint Reflective)

Description:

Longitudinal cracks are parallel to the pavement's centerline or laydown direction. They may be caused by:

1. A poorly constructed paving lane joint.
2. Shrinkage of the AC surface due to low temperatures or hardening of the asphalt and/or daily temperature cycling.
3. A reflective crack caused by cracking beneath the surface course, including cracks in PCC slabs (but not PCC joints)

Transverse cracks extend across the pavement at approximately right angles to the pavement centerline or direction of laydown. These types of cracks are not usually load-associated.

Severity Levels:

- L One of the following conditions exists: (1) non-filled crack width is less than 3/8 in, or (2) filled crack of any width (filler in satisfactory condition)
- M One of the following conditions exists: (1) non-filled crack width is greater than or equal to 3/8" and less than 3 in.; (2) non-filled crack is less than or equal to 3 in. surrounded by light and random cracking, or (3) filled crack is of any width surrounded by light random cracking.
- H One of the following conditions exists: (1) any crack filled or non-filled surrounded by medium- or high-severity random cracking, (2) non-filled crack greater than 3 in., or (3) a crack of any width where approximately 4 in. of pavement around the crack is severely broken.

9. Patching and Utility Cut Patching

Description:

A patch is an area of pavement that has been replaced with new material to repair the existing pavement. A patch is considered a defect no matter how well it is performing (a patched area or adjacent area usually does not perform as well as an original pavement section). Generally, some roughness is associated with this distress.

Severity Levels:

- L Patch is in good condition and satisfactory. Ride quality is rated as low severity or better.
- M Patch is moderately deteriorated and/or ride quality is rated as medium severity.
- H Patch is badly deteriorated and/or ride quality is rated as high severity. Needs replacement soon.

10. Polished Aggregate

Description:

Areas of pavement where the portion of aggregate extending above the asphalt binder is either very small or there are no rough or angular aggregate particles. A polished road surface will have a reduced level of skid resistance.

Severity Levels:

Not defined

11. Potholes

Description:

Potholes are small, usually less than 30 inches in diameter, bowl shaped depressions in the pavement surface. They generally have sharp edges and vertical sides near the top of the hole.

Severity Levels:

The levels of severity for potholes less than 30 inches in diameter are based on both the diameter and the depth of the pothole, according to the following table.

	Average Diameter (in.)

Maximum Depth of Pothole	4 to 8 in.	8 to 18 in.	18 to 30 in.
1/2 to 1 in.	L	L	M
1 to 2 in.	L	M	H
2 in.	M	M	H

12. Rutting

Description:

A rut is a surface depression in the wheel paths. Pavement uplift may occur along the sides of the rut, but, in many instances, ruts are noticeable only after a rainfall when the paths are filled with water. Rutting stems from a permanent deformation in any of the pavement layers or subgrades, usually caused by consolidated or lateral movement of the materials due to traffic load.

Severity Levels:

Mean Rut Depth;

L 1/4 to 1/2 in.
M 1/2 to 1 in.
H >1 in.

13. Shoving

Description:

Shoving is a permanent, longitudinal displacement of a localized area of the pavement surface caused by traffic loading. When traffic pushes against the pavement, it produces a short, abrupt wave in the pavement surface. This distress normally occurs only in unstable liquid asphalt mix (cutback or emulsion) pavements.

Shoves also occur where asphalt pavements abut PCC pavements; the PCC pavement increase in length and push the asphalt pavement, causing the shoving.

Severity Levels:

L Shove causes low-severity ride quality.
M Shove causes medium-severity ride quality.
H Shove causes high-severity ride quality.

14. Swell

Description:

Swell is characterized by an upward bulge in the pavement's surface. A swell may occur sharply over a small area or as a longer, gradual wave. Either type of swell can be accompanied by surface cracking. A swell is usually caused by soil swelling in the subgrade.

Severity Levels:

L Swell is barely visible and has a minor effect on the pavement's ride quality.

M Swell can be observed without difficulty and has a significant effect on the pavement's ride quality.

H Swell can be readily observed and severely affects the pavement's ride quality.

15. Weathering and Raveling

Description:

Weathering and raveling are the wearing away of the pavement surface due to a loss of asphalt or dislodged aggregate particles. These distresses indicate that either the asphalt binder has hardened appreciably or that a poor-quality mixture is present. In addition, raveling may be caused by certain types of traffic, e.g., tracked vehicles. Softening of the surface and dislodging of the aggregates due to oil spillage are also included under raveling.

Severity Levels:

L Aggregate or binder has started to wear away. In some areas, the surface is starting to pit. In the case of oil spillage, the oil spillage, the oil stain can be seen, but the surface is hard and cannot be penetrated with a coin.

M Aggregate or binder has worn away. The surface texture is moderately rough and pitted. In the case of oil spillage, the surface is soft and can be penetrated with a coin.

H Aggregate or binder has been worn away considerably. The surface texture is very rough and severely pitted. The pitted areas are less than 4 inches in diameter and less than ½ inch deep; pitted areas larger than this are counted as potholes. In the case of oil spillage, the asphalt binder has lost its binding effect and the aggregate has become loose.