REPORT BY THE

OFFICE OF THE CITY AUDITOR

CITY OF PORTLAND, OREGON

STREET MAINTENANCE:

OPPORTUNITIES TO IMPROVE QUALITY
AND LOWER COSTS

BARBARA CLARK, C.P.A.
CITY AUDITOR

FEBRUARY 1988

REPORT BY THE
INTERNAL AUDIT DIVISION
OFFICE OF THE CITY AUDITOR

STREET MAINTENANCE:
OPPORTUNITIES TO IMPROVE QUALITY AND LOWER COSTS

INTERNAL AUDIT REPORT
#1-88

FEBRUARY, 1988

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PORTLAND, OREGON

OFFICE OF CITY AUDITOR

Barbara Clark, City Auditor
1220 S.W. 5th, Rm. 202
Portland, Oregon 97204
(503) 248-4078

DATE: February 25, 1988

To: J.E. Bud Clark, Mayor
Earl Blumenauer, Commissioner
Dick Bogle, Commissioner
Mike Lindberg, Commissioner
Robert Koch, Commissioner
Felicia Trader, Director, Office of Transportation
Mary Nolan, Manager, Bureau of Maintenance

SUBJECT: Audit on Street Maintenance Operations of the Bureau of Maintenance.

Attached is our Internal Audit Report #1-88 covering our review of Street Maintenance Operations within the Bureau of Maintenance. A summary of our findings is contained at the beginning of the report.

We have discussed our findings and recommendations with Commissioner Blumenauer and with managers in the Office of Transportation and Bureau of Maintenance. They are in general agreement with our findings. Their written responses are included at the end of the report.

We would appreciate receiving a written status report from the Bureau of Maintenance in six months indicating what actions have been taken on our audit findings. This response should be circulated to City Council and the Director of the Office of Transportation.

We appreciate the cooperation and assistance we received from Bureau of Maintenance personnel during the course of our audit.

Barbara Clark

Barbara Clark, CPA
City of Portland Auditor

Audit Team: Richard Tracy
Lloyd Hayne
Gary Blackmer
Eric Hofeld

BC:LH:sos

Enc.

IAR #1-88
MAINTENANCE
February, 1988

TABLE OF CONTENTS

SUMMARY i

INTRODUCTION 1

BACKGROUND 1

AUDIT SCOPE AND METHODOLOGY 9

AUDIT RESULTS 11

I BUREAU HAS ACCURATELY ASSESSED STREET MAINTENANCE NEEDS 11

Recommendations 20

II IMPROVEMENTS NEEDED IN PAVEMENT QUALITY 21

Recommendations 28

III CONTRACTING PAVING WORK MAY REDUCE MAINTENANCE COSTS 29

Recommendations 34

RESPONSES TO AUDIT REPORT

Commissioner Earl Blumenauer 35

Mary Nolan, Director, Bureau of Maintenance 37

IAR #1-88
MAINTENANCE
February, 1988

SUMMARY

The Bureau of Maintenance of the Office of Transportation is responsible for maintaining City of Portland streets. One of the Bureau's major goals is to effectively preserve 1732 miles of City streets at the lowest reasonable cost. The Bureau has 424 personnel and an annual budget of approximately $26 million. We reviewed the Bureau's systems for assessing street conditions and repair needs, and evaluated the quality and efficiency of Bureau maintenance work.

Maintenance Needs Accurately Identified

The Bureau has identified 476 miles or 27% of City streets that require major repairs. This work is estimated to cost approximately $37 million. Due to the lack of detailed history on city streets, we could not determine whether average street conditions are worsening or improving. However, we believe street maintenance needs will increase in the future due to east Portland sewering projects.

Our engineering consultants, Centrac and Associates, independently inspected and rated a sample of 196 city blocks. They found that the Bureau has correctly assessed existing street conditions and selected appropriate repair methods. The Bureau can further improve the effectiveness of its Pavement Management System by including information on more types of repairs.

Substandard Street Maintenance Work

Streets paved by City crews do not meet pavement density standards. Twenty-four of twenty-nine recently paved streets we tested (83%) had low density which will cause faster deterioration and result in higher maintenance costs for the City. We found problems with the type of

asphalt mix used and the methods employed by City work crews. The Bureau should use a quality control program to detect substandard work.

We also found that the Bureau has established a program to reduce utility construction work on newly paved streets. However, more can be done by the Office of Transportation to reduce instances of utility cuts on new streets and to track the cost impact of utility construction work.

Contracting Out May Reduce Paving Costs

The Bureau's in-house paving program costs more than similar work performed by private sector contractors. Paving performed by City crews in FY 1986-87 cost $30.35 per ton while Multnomah County contracted for paving at $27.42 per ton. Based on these costs, the City could have saved approximately $190,000 in FY 1986-87. In addition, contractors must meet established quality standards and provide two year paving warranties on all paving work.

Despite these cost advantages, contracting for paving work presents a variety of risks. Principally, elimination of an in-house paving program leaves the City vulnerable to unwarranted price increases. For example, asphalt vendors have not always passed on savings resulting from fluctuations in wholesale asphalt prices to the City.

Recommendations

In order to improve methods for selecting appropriate street maintenance treatments, extend the life of city streets, and lower costs,

we recommend that the Office of Transportation and the Bureau of Maintenance:

- Include in the Pavement Management System data on repairs such as crack sealing and base repair in order to improve decisions on repair methods.

- Establish a strong quality control program to identify problems and improve City crew paving work. Evaluate the asphalt mix purchased for City paving projects.

- Better coordinate paving program with City bureaus to minimize cutting of newly paved streets and encourage cuts prior to repaving.

- Explore contracting out portions of City street paving work, monitor contractors' performance, and enforce the terms of asphalt supply and paving contracts.

INTRODUCTION

This report covers our review of City street maintenance operations performed by the Office of Transportation's Bureau of Maintenance. The review was scheduled by the City Auditor for the Internal Audit Division's Fiscal Year 1987-88 work plan. We conducted this audit in accordance with generally accepted governmental auditing standards and limited our work to those areas specified in the scope and methodology section of this report.

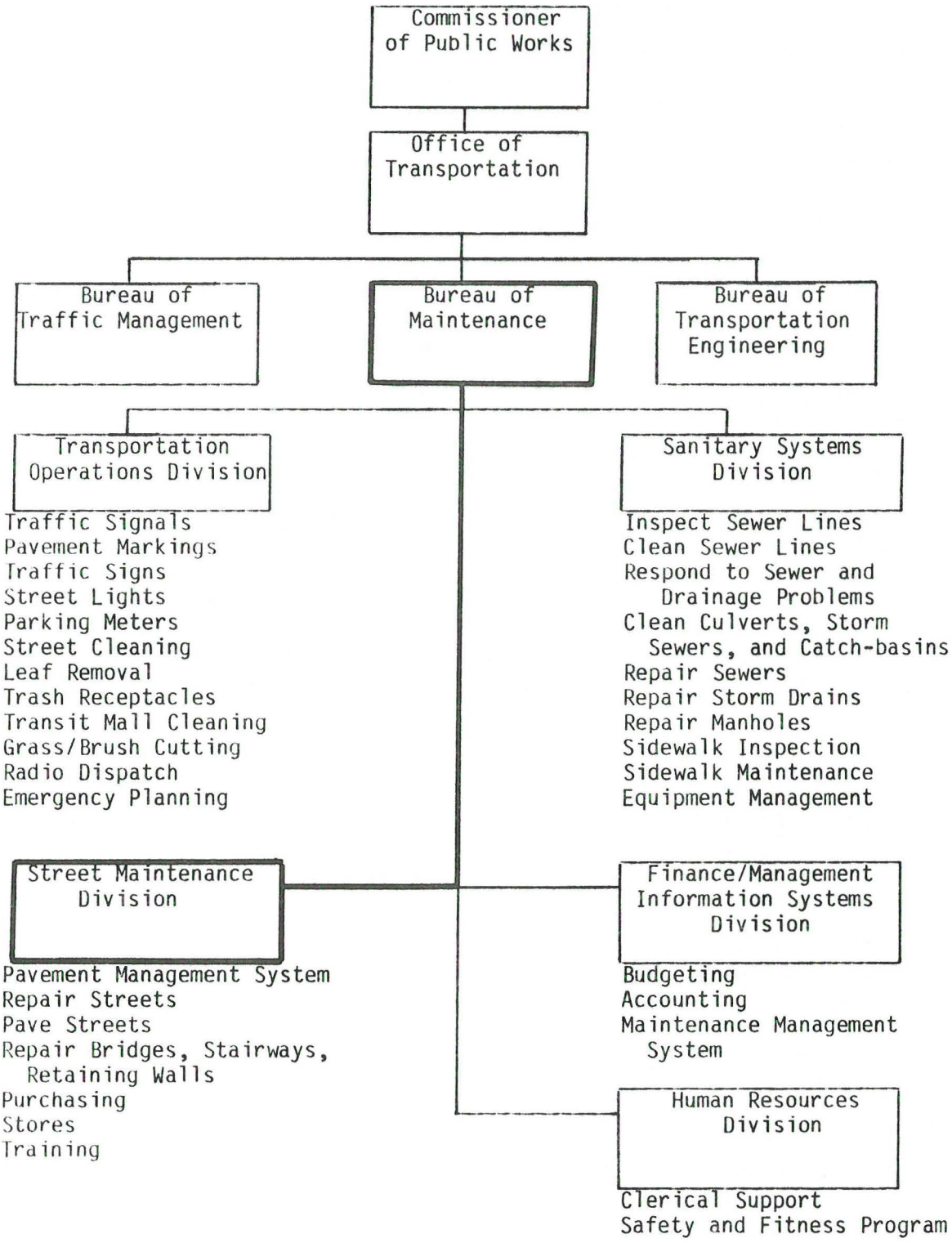
BACKGROUND

The Office of Transportation is composed of three bureaus: Maintenance, Traffic Management, and Transportation Engineering. The largest of these is the Bureau of Maintenance with 424 total staff and a FY 1987-88 budget of $26 million.

The goal of the Bureau of Maintenance is to efficiently and effectively preserve Portland's capital structures. The Bureau is responsible for cleaning, repairing and replacing street lights and traffic signals, sewers, streets and sidewalks, and City-owned bridges. The Bureau also provides emergency response to storm and other citywide maintenance problems.

TABLE 1

BUREAU OF MAINTENANCE ORGANIZATION CHART



Over the last eight years the Bureau has experienced increases in budget and staffing. The budget increased from $18.2 million in FY 1980-81 to $26 million in FY 1987-88, a 5% increase when corrected for inflation. During this time, the City assumed responsibility for 360 miles of streets in unincorporated Multnomah County, increasing City street miles by 29%. The Bureau also had a 3% increase in the number of budgeted positions during this time period. Table 2 below illustrates budget and staffing increases.

TABLE 2

BUREAU OF MAINTENANCE
BUDGET AND POSITIONS
FY 1980-81 to FY 1987-88

Year	Revised Budget	Budget in Constant Dollars*	Positions
1980-81	$18,170,749	$18,170,749	411
1981-82	19,765,933	18,200,443	410
1982-83	17,773,105	15,514,781	404
1983-84	18,954,726	16,326,841	378
1984-85	21,503,133	17,828,645	382
1985-86	22,033,665	17,519,534	382
1986-87	24,818,456	19,128,544	418
1987-88	25,968,712**	19,040,921	424
% Increase	+43%	+5%	+3%

Source: Approved Budgets, FMS Reports.

* Bureau personnel costs adjusted by cost of living allowances in City/District Council of Trade Unions collective bargaining agreement; other costs adjusted by consumer price index.

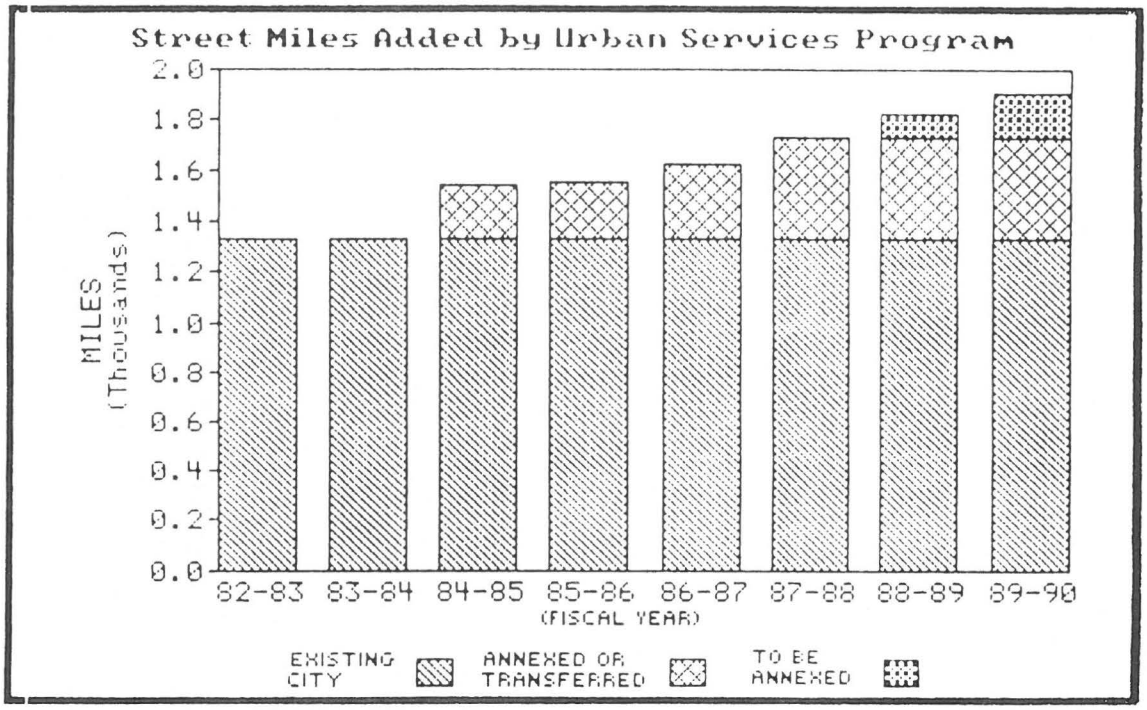
** Bureau of Maintenance Approved Budget.

Portland's Street Maintenance Program

One of the major programs conducted by the Bureau is the repair and maintenance of 1732 miles of City streets. The Office of Transportation estimates the replacement value of these streets at $1.25 billion dollars, which represents 83% of the total replacement value of all the transportation-related facilities in the City, including equipment such as bridges, traffic signals, and street lights.

The number of streets maintained by the Bureau's Street Maintenance Division has increased significantly since 1984 as a result of the annexation program carried out by the City. An Intergovernmental Agreement with Multnomah County transferred over 360 miles of road from the County to the City since FY 1984-85. Graph 1 shows the additional street miles assumed by the City from FY 1982-83 through FY 1989-90.

GRAPH 1

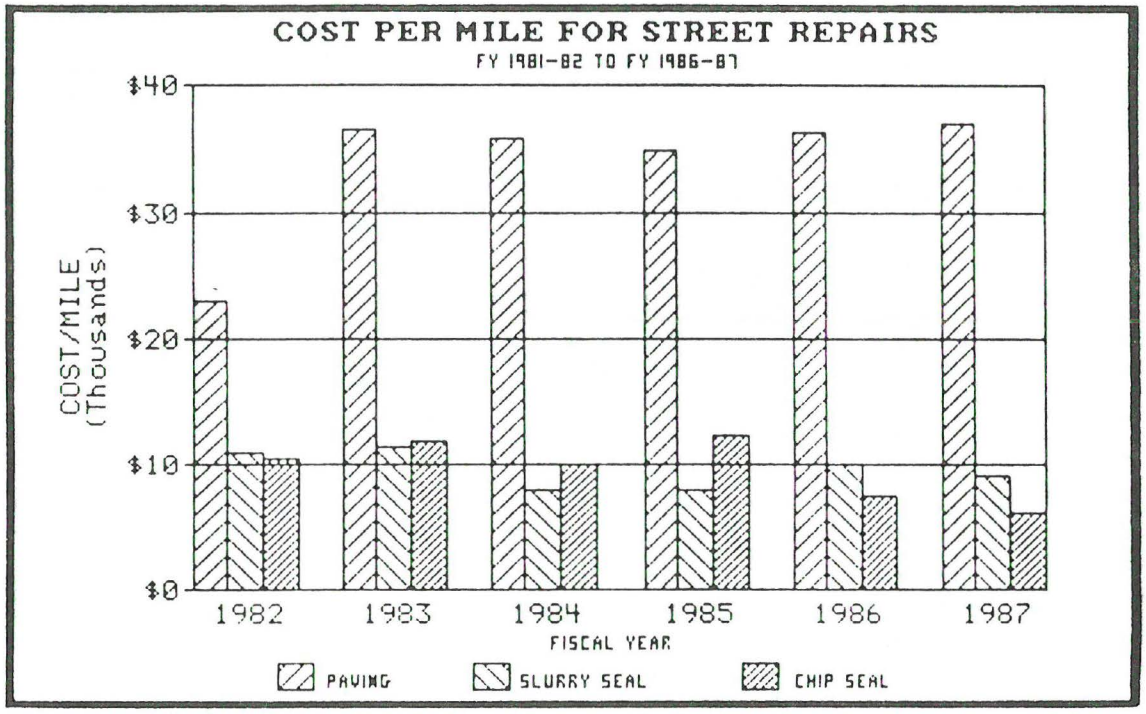


Source: Bureau of Maintenance.

The Street Maintenance Division conducts a variety of activities to prolong the useful lives of City streets, to slow deterioration, and to restore or replace worn-out roadways. The Division has adopted a variety of maintenance treatments depending on the nature of the street problem. In addition to low cost routine repairs such as pot hole filling and crack sealing, the Bureau employs three surface repair methods - paving, slurry seal and chip seal. Paving involves placing a layer of hot asphalt mix on worn streets. Slurry sealing is the application of a thin layer of fine rock and asphalt to cover the street surface. Finally, a chip seal repair involves spraying liquid asphalt on the street then spreading gravel on the

street surface.[1] The City also reconstructs severely deteriorated streets but generally contracts this work to private vendors. Illustrated in the table below, are the Bureau's major treatment methods, and the cost per mile for each treatment.

GRAPH 2

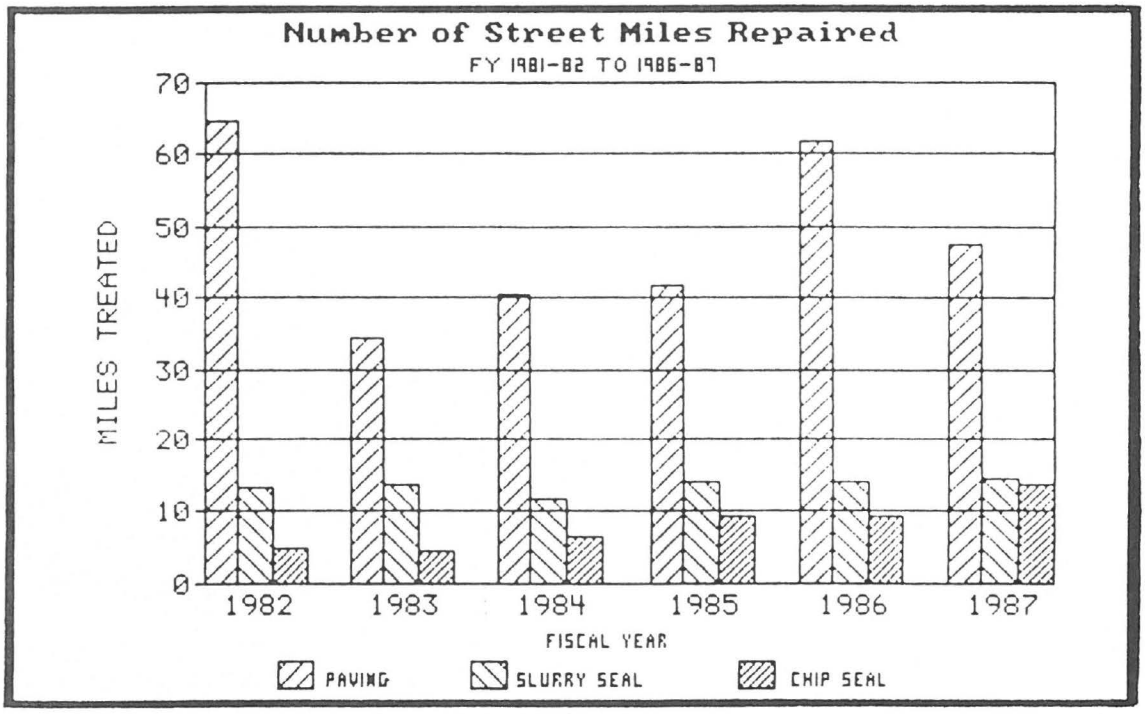


Source: Bureau Maintenance Management System.

As shown in Graph 3 below, paving is the principal method for maintaining city streets. An annual average of almost 49 miles of streets were paved over the last six years, 14 miles were slurry sealed and eight miles were chip sealed. During this same period, the paving program costs averaged $1.6 million annually. The chip seal and slurry seal programs cost an average of $131,000 and $74,000 respectively.

[1] Chip seal repairs are applied to oil and gravel streets that do not have curb or drainage improvements.

GRAPH 3



Source: Bureau of Maintenance Management System.

Automated Management Systems

To manage the street maintenance program, the Bureau of Maintenance has established two computerized management systems - the Pavement Management System (PMS) and the Maintenance Management System (MMS). The PMS is a set of procedures and computer programs to assist managers in planning street maintenance. It includes procedures for rating street conditions and maintains this information by City block on computer files. PMS programs identify maintenance needs, prioritize maintenance projects by type of treatment, and provide preliminary project lists to assist managers in scheduling annual maintenance programs.

The PMS, in use since 1983, consists of an inventory of all city streets and with information on each street's design, past treatment, and current condition. The data base is updated annually based on visual inspection, condition ratings, and physical testing of half the arterial streets and one-fourth the local streets. The first condition survey of City streets was completed in 1984.

Each fall the managers use the PMS to generate lists of streets requiring chip seal, slurry seal, or paving. The Street Maintenance Division distributes the list to utilities and other organizations who can notify the Bureau regarding their planned repair activities. Streets which utilities are planning to excavate are then removed from the paving list. In addition, foremen inspect the streets before the paving season to verify conditions and identify any necessary preparatory work to be completed during the winter months.

The Maintenance Management System (MMS) is used to track programs, allocate resources, and monitor accomplishments. This system is used to schedule seasonal activities and provides detailed information about personnel and equipment use. Managers use the MMS in their annual Management By Objectives (MBO) process to establish performance goals and to track accomplishments each accounting period.

SCOPE AND METHODOLOGY

The objectives of this audit were to evaluate the efficiency and effectiveness of the City of Portland's street maintenance operations. Specifically, we reviewed the accuracy of systems for determining maintenance needs and recommending appropriate treatment methods. We also evaluated the quality and cost of the City's pavement program.

We hired an independent engineering consulting firm, Centrac and Associates, to assist us in the technical aspects of pavement rating and treatment decisions. The consultants also provided technical assistance regarding the impact of quality control on the effectiveness of street maintenance operations.

We used the City's Bureau of Environmental Services testing laboratory personnel and equipment to test the quality of the City's paving repairs. The lab tested a sample of 29 streets with a nuclear densitometer to determine the relative density of recently paved streets. In addition, we had 5 cores cut from these streets to identify whether the City's paving program met specifications required of outside contractors. These tests were conducted in conformance with asphalt engineering guidelines.

We had tachographs installed in one of the City's paving machines and on three asphalt trucks to monitor delays in paving operations as a result of waiting times at asphalt plants. Tachographs record engine RPMs and are used to analyze equipment use.

Our review of the Bureau of Maintenance encompassed only street maintenance operations. We did not evaluate new street construction or the impact and control of overweight vehicles. We did not test the accuracy of data entry information in the Bureau's computerized Maintenance Management system.

We reviewed the available literature on utility cuts, the methods used for tracking those cuts, and the Bureau's method for coordinating its paving program with various utilities in the area.

We interviewed Bureau managers and supervisors, as well as managers from other jurisdictions on the West Coast. We met with members of the Association of General Contractors (AGC) to discuss pavement contracting issues as well as asphalt production issues. We reviewed the Bureau's cost accounting system and developed costs for the various components of pavement contracting. We reviewed the City's contracting methods for purchasing asphalt and the prices paid over the past 10 years. We interviewed other jurisdictions to obtain comparative contracting costs, and reviewed the literature on contracting benefits and risks.

AUDIT RESULTS

CHAPTER I: BUREAU HAS ACCURATELY ASSESSED STREET MAINTENANCE NEEDS

Chapter Summary

The Bureau has developed a comprehensive Pavement Management System to inventory City streets, rate their condition, determine appropriate treatment methods, and to predict future maintenance needs. The system has identified 476 miles of City streets that require major maintenance work, 27% of the City's 1732 total street miles. The total cost of these major repairs is estimated at $37 million.

Our engineering consultants, Centrac and Associates, evaluated the Bureau's systems for rating street conditions and selecting treatment methods. They found that the Bureau accurately assesses street maintenance needs and selects reasonable repair approaches. Due to the lack of sufficient historical data, we could not determine if overall street conditions are deteriorating or improving. However, sewer construction planned for east Portland during the next 20 years appears likely to increase street maintenance workload and costs.

The Bureau can further improve the effectiveness of its repair decisions by collecting additional information on crack sealing, patching, and base repairs which are not now included in the PMS. This data will help the Bureau assess the costs and benefits of treatment alternatives.

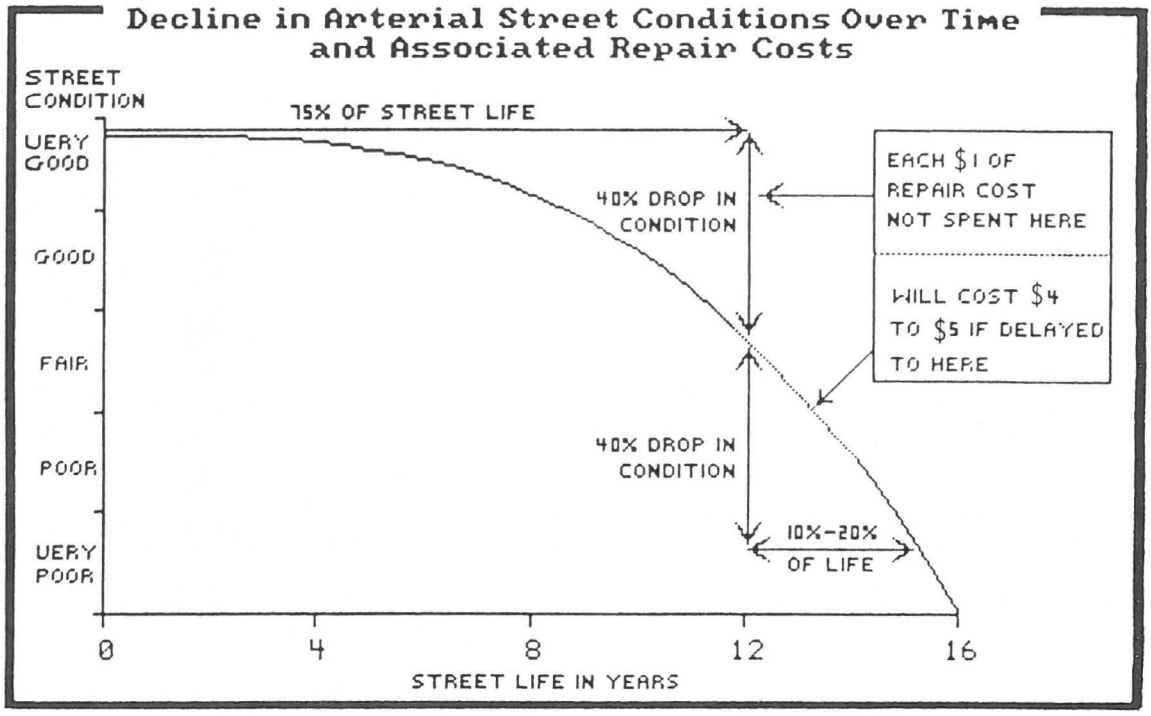
Assessing Maintenance Needs and Appropriate Repairs

To ensure the best use of resources, street maintenance managers must consider many factors when assessing street conditions and repair needs. Two important factors are the timing and type of maintenance treatment. Premature repairs or delayed treatment both contribute to higher costs.

In order to determine the best timing for various types of intervention as a street deteriorates, managers should evaluate street conditions, relative costs of treatment methods, and the number of years a treatment will add to street life. While the treatment costs are easily determined, the relative benefit of the various repair methods is difficult to estimate.

Street maintenance literature indicates that delays in maintaining streets can result in a faster deterioration and require more extensive and costly treatments. Graph 4 shows the relative condition of a street throughout its expected life. It indicates that the streets deteriorate more rapidly toward the end of their useful lives and that repairs delayed only a few years can cost four to five times more than the cost of earlier intervention. Street maintenance experts agree that available resources are best allocated to earlier repairs than later reconstruction.

GRAPH 4



Source: Based upon graph in Management of Public Works, ICMA, 1986.

City Street Conditions and Maintenance Needs

The Bureau's PMS has identified 476 miles out of a total of 1732 miles (27%) of City streets that need some type of major repair work. Over the last six years the Bureau's maintenance program has resurfaced approximately 63 miles of street each year. Consequently, this additional workload represents the equivalent of over seven years of maintenance work for the Bureau. The actual length of time to complete these repairs depends on the amount of new repair needs identified each year and on the level of funding. Table 4 below displays the recommended treatment for each mile of street and the current cost estimates for completing this work.

TABLE 4

1987 BUREAU ESTIMATE OF STREET
SURFACE TREATMENT NEEDS AND COSTS*

Treatment	Number of Miles	Cost
Slurry Seal	142	$ 2,279,000
Paving		
o Minor Base Repair	233	$15,344,000
o Major Base Repair	101	$19,950,000
TOTAL	476	$37,573,000

* Chip Seal repairs are not included in the above estimates. These repairs represent 45 miles and are estimated to cost $270,000.

Source: PMS Bureau estimates

We could not determine if the average condition of City streets is improving or worsening because the Bureau's computer system has been in place less than four years and is not yet able to predict street deterioration rates. Because of recent enhancements in the PMS program we also cannot analyze changes in the types of repair needs by comparing annual trends in the number of streets needing paving or slurry seal. As a result, it is difficult to determine if the Bureau is keeping pace with its street repairs needs. Moreover, because of differences in climate, street construction methods, and data collection systems, we are unable to determine if the workload is high or low compared to other cities.

However, the Bureau faces significant additional work over the next 20 years as a result of 350 miles of sewers that will be installed in the recently annexed areas of east Portland. According to Multnomah County road maintenance personnel, most maintenance activities were suspended in this area over five years ago when it appeared that sewers would be installed.

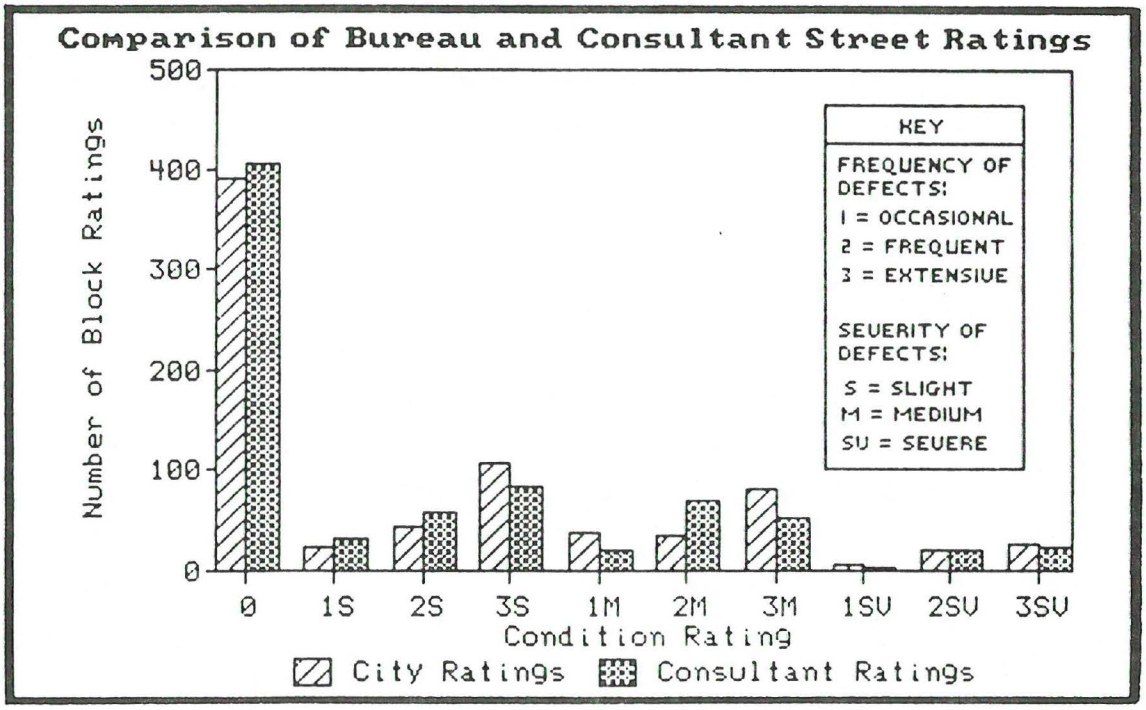
Since annexation, the City has continued this practice to avoid having newly paved streets excavated for sewer installation. In addition, streets with installed sewers are likely to deteriorate more quickly. Research from other cities indicates that utility cuts can shorten the expected life of streets considerably. The additional maintenance needs and costs resulting from mid-county sewering has not been estimated by the Bureau nor included in the current maintenance workload.

Verification of Pavement Management System

In order to determine if the Bureau has accurately analyzed City street conditions and repair needs, we contracted with Centrac and Associates, a Portland engineering consulting firm. We provided the consultants with a sample of City blocks which reflected the range of defects found on streets. Centrac independently inspected and rated the condition of 196 City blocks that had recently been rated by Bureau personnel and compared their ratings with the Bureau's. Centrac also made recommendations on treatment methods for each type of street defect.

Centrac found general agreement between their ratings of street conditions and the Bureau's rating. Graph 5 below shows the Bureau's rating of street condition compared to our consultant's rating of street condition. The ratings show a consistently similar pattern, indicating general agreement as to the condition of the sample streets.

GRAPH 5



Source: Bureau PMS and Centrac consultants.

The PMS recommends appropriate repairs for the defects found in the City's streets. As illustrated in Table 5, for each type of street defect, our consultants and the Bureau agreed as to the appropriate means of repair. To verify that the PMS computer program also selects appropriate repair decisions, we analyzed the treatments recommended for our 196 block sample and found that there were no significant differences from the maintenance practices recommended by our consultants.

TABLE 5

COMMON STREET DEFECTS AND RECOMMENDED TREATMENTS

DEFECT	CONSULTANT TREATMENT RECOMMENDATION	BUREAU TREATMENT RECOMMENDATION
Transverse Cracking These cracks run perpendicular to the centerline of the street and are caused by temperature fluctuations or by old cracks under a new overlay which "reflect" up through the new surface.	Crack Sealing consists of the injection of a rubber-asphalt compound into the cracks to prevent water from penetrating the surface.	SAME
Ravelling is the wearing away of the pavement surface by the loss of the asphalt binder and dislodged aggregate particles. It is usually caused by brittle asphalt or a poor quality mixture.	Sealcoats are thin applications of asphalt and fine aggregate mixtures which protect the pavement.	SAME
Longitudinal Cracking These cracks run parallel to the centerline of the street in the wheelpath areas. Longitudinal cracking can be caused by temperature fluctuations, failure of the street base, or reflection of cracks up from beneath the surface.	Base Repairs and an Overlay may be required to restore the structural strength of the street. This involves excavation of the area around the crack, rebuilding that portion of the street, and paving the area of the crack.	Same, except Bureau does not do base repairs on reflective cracks from an underlying concrete surface.
Rutting is the depressions in the wheelpaths of the street caused by compression of the pavement under traffic loads, or inadequate design strength for the traffic loads.	Base Repairs and an Overlay may be required to eliminate the rutting. This may involve excavation if there is an inadequate base and paving of the street.	SAME
Alligator Cracking consists of a network of interconnected cracks in the wheelpath of the street which resemble the pattern of alligator skin. The pavement begins cracking as a result of repeated loads, from the base up to the surface of the street.	Base Repairs and an Overlay are also required to restore the structural strength of the street. This involves excavation of the area around the crack, rebuilding that portion of the street, and paving the area of the crack.	SAME

Source: Bureau personnel and Centrac consultants.

Bureau managers estimate that it would cost about $37 million to treat the 476 miles of streets identified as needing major repairs. We reviewed the methodology used to estimate this cost and found that it is based on a variety of engineering judgments concerning the best way to maintain City streets. Key assumptions include:

- Streets scheduled for routine paving will be reconstructed if curb heights or crowning are outside Bureau standards;[2]
- Streets will be maintained to accommodate heavier than average traffic loads in order to prolong street life; and
- Streets in the annexed areas will require the same proportion of slurry seal, paving, and reconstruction as the remainder of the city.

In our opinion, the Bureau's cost estimate and underlying assumptions appear to be reasonable. Assumptions are consistent with maintenance goals of allocating resources to preventative repairs rather than later reconstruction. According to Bureau managers, actual maintenance costs depend on final repair methods selected and the level of funding approved by Council.

Tracking the Cost-Effectiveness Of Maintenance Decisions

The Bureau's Pavement Management System provides managers with excellent information on street conditions but only partial information on maintenance practices. The system tracks slurry seal and paving repairs but does not track crack sealing, patching, and base repair activities.

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[2] Curb height is the distance between the pavement and the top of the curb. If insufficient, water runoff will spill onto adjoining property. Crowning is the condition where the street is substantially higher at the center than at the curbs.

Managers therefore cannot determine how much patching, crack sealing and other maintenance has been performed on a particular street. Street repair histories would help management to more fully analyze the cost-benefit ratios of different treatment approaches.

For example, without complete information on the various repairs applied to a street, the Bureau lacks full information to determine whether it is more cost effective to pave in a given year or to provide routine maintenance for additional years before repaving. Similarly, the Bureau cannot determine the impact a slurry sealing has on other maintenance requirements over the life of the street, or the long term benefits of a new treatment method.

Although Bureau managers have not quantified the costs of tracking this information by block, they state that the value of this additional information may be less than the costs of record-keeping to track the information. However, we found that some foremen already keep these records manually, but do not now integrate the data into the PMS. Managers also cite national studies now underway to develop evaluation methods for alternative treatments as good sources of information on appropriate treatment methods.

RECOMMENDATIONS

1. The Bureau should begin tracking its base repair, patching, and crack sealing repairs on the PMS to enable it to further improve future decisions on the timing of various repair methods.

CHAPTER II: NEED FOR IMPROVED STREET PAVEMENT QUALITY

Chapter Summary

The Bureau of Maintenance can extend the life of streets by improving the quality of City paving work and better coordinating paving with utility construction. We tested 29 recently paved City streets and found that 24 (or 83%) failed to meet the quality standards established for contracted paving work. Deficiencies exist in both the type of asphalt used and work procedures. Additionally, while efforts are made to reduce utility construction work on newly paved streets, such work still occurs. As a result of both these problems, some streets paved by City crews will fail sooner and will cost more to maintain.

The Bureau can extend the life of City streets by establishing a strong quality control program to identify and correct problems. Paving work should be systematically tested and asphalt quality closely monitored. Additionally, current procedures for coordinating work between utility and City maintenance crews can be strengthened.

Street Deterioration

A variety of factors affect the rate at which streets deteriorate. Harsh weather, poor sub-soils, and heavy traffic loads are some major causes of street wear. The effective life of a street is also reduced if poor quality materials or construction methods are used, and if a street is cut into to repair or install gas, sewer, water, and other utility services.

Street pavement will last longer if the asphalt mix and compaction methods produce a dense surface. Asphalt mix design[1] and compaction (rolling) determine the density of pavement. Optimum density indicates proper mix and compaction, whereas lower density indicates either improper asphalt mix or inadequate compaction. Both improper asphalt mix and low compaction will reduce pavement strength and durability.

Utility construction work on streets can also cause substantial damage by disturbing the sub-surface. Improperly filled cuts sink under traffic load, and improperly patched cuts allow water into the subgrade, causing premature failure of the pavement. Although the Bureau does not track the percentage of workload directly related to failed utility cut patches, managers state that poor quality utility cuts substantially increase street maintenance workload.

The City has developed stringent specifications for paving work contracted to the private sector. For contracted paving, City inspectors test the asphalt mix and monitor construction practices to ensure pavement quality. Contractors may be penalized a percentage of their contract fee if their work fails to meet contract specifications. The amount of the penalty offsets the estimated decrease in pavement life due to the substandard work. City transportation engineers require contracted paving to be a minimum density of 91%.

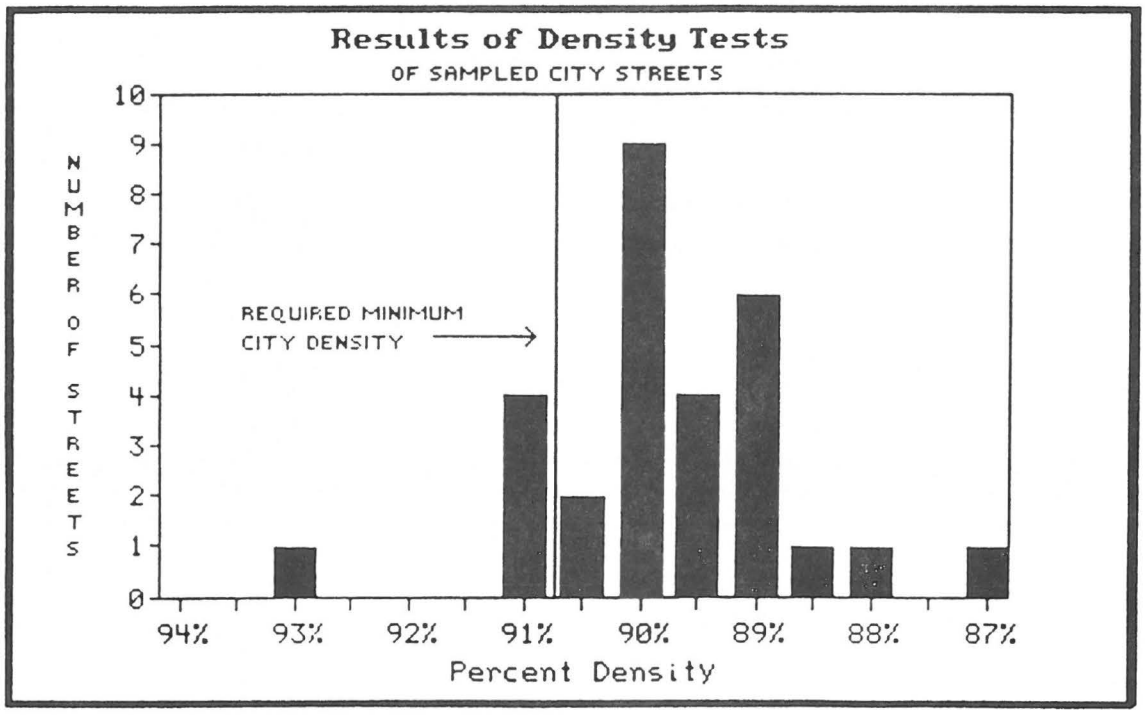
Substandard Paving Work

In order to determine if City paving crews are producing streets with appropriate density, we tested 29 streets with the assistance of the City's Bureau of Environmental Services testing laboratory. Under our direction, the laboratory technicians used portable instruments called nuclear densitometers to test pavement density. We performed density tests on each of 29 streets paved by City crews in 1987, for a total of 143 tests. As

[1] "Mix Design" includes the type and size of the rock and the amount of liquid asphalt combined to create the asphalt mixture.

shown on Graph 6, the tests showed that 24 of the sampled streets failed to meet the density standards required of contracted paving work.

GRAPH 6



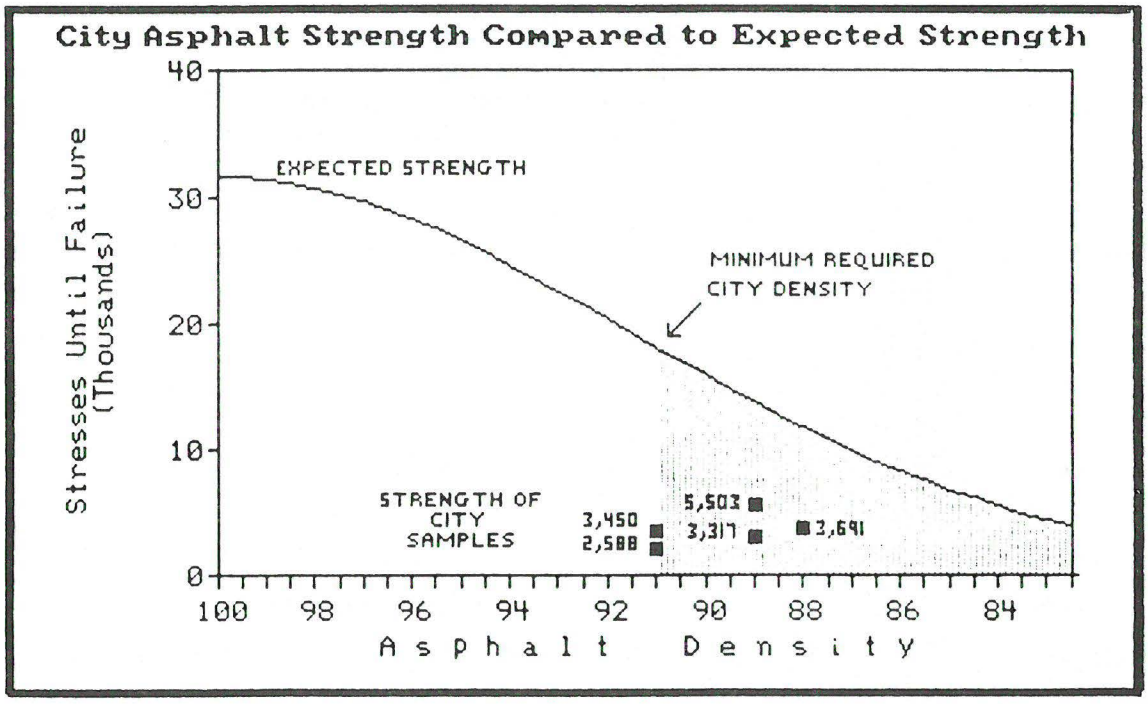
Source: Internal Audit Division density tests.

Research has shown that streets with inadequate density will fail sooner and require more repairs than streets with optimal asphalt density. A research report prepared by Oregon State University and the Oregon Department of Transportation calculated the relation between pavement density and structural strength based on a sample of State highways. The researchers found a strong relation between pavement density and structural strength as measured by the asphalt's ability to withstand simulated traffic loads as measured in 'stresses'.

To confirm that density also affects City street strength, we tested 5 core samples of City streets representing the full range of densities found in our 143 samples. The five samples were subjected to stress tests at the Oregon State testing laboratory until each failed.

Graph 7 shows the expected fatigue life for asphalt as calculated by the OSU-ODOT study in comparison with the actual fatigue life of the City samples. Based on sample densities, samples should have had a fatigue life of between 14,000 and 20,000 stresses. However, as shown, the samples performed even less favorably than would been expected, in the range of 2,600 to 5,500 stresses.

GRAPH 7



Source: OSU-ODOT study, Internal Audit Division test samples.

There are several possible causes for low densities found on city streets: The City's mix of asphalt ingredients may not be appropriate; the asphalt plants may be providing substandard asphalt mix; the asphalt may not be sufficiently compacted by the paving crews; or, the temperature of the mix at the time of compaction may be too low, caused either by the asphalt plant producing insufficiently heated mix, or by the paving crews allowing the asphalt to cool too much in the paving truck. Our consultants and a paving engineer with the State of Oregon suspect, on preliminary observation, that the City's asphalt mix is improper, and is a major factor contributing to low density. The Bureau's asphalt mix, which was changed several years ago, differs from that used by the state and by private contractors for City streets. According to the Bureau, the mix design was changed in 1978 to reduce street ravelling.

Inadequate Quality Control Procedures

Although the Bureau has developed comprehensive procedures to identify maintenance needs and design appropriate treatments, the in-house maintenance program lacks adequate quality control systems to ensure asphalt overlays meet required density standards. The Bureau does not monitor the quality of its overlay work nor regularly test the mix design or temperature of the asphalt put on the streets. Although private paving contractors' work is subject to density and other quality control tests, City crew paving work is not tested. Had a quality control program been in place, managers would have been aware of the low density and structural weaknesses of City pavement.

The Bureau does not ensure that purchased asphalt meets the "mix" specifications required by vendor contracts. During the audit, the Bureau accepted asphalt which was outside contract specifications on at least two occasions. In one instance, City crews accepted Class "B" asphalt rather than the Class "C" as specified by contract. In another case, crews accepted asphalt 100 degrees hotter than specifications. Improper asphalt mix and wrong asphalt temperatures reduce the strength of the pavement.

Although the City has the right to refuse out-of-specification asphalt, we found no instance of the City returning or refusing asphalt.

Several factors have contributed to the incomplete quality controls over paving operations. Foremost, we found a Bureau perception that City paving crews do an excellent job and that testing is not needed. We were also told that in the past the Bureau did test City paving but that testing was discontinued when it appeared that pavement quality was satisfactory.

We also found that paving crews may not be completely aware of all factors affecting pavement quality nor have access to testing equipment. Paving crews, including foremen, are primarily trained on the job and none have had recent training in paving operations. The crews we observed did not have asphalt thermometers or equipment to test pavement density. While pavement density testing has historically been costly and time consuming, new equipment now allows density tests to be accomplished in about two minutes. If tests are done while the new pavement is still hot, paving crews often can correct inadequate densities with additional rolling.

More Coordination of Utility Street Work

The Office of Transportation and the Bureau of Maintenance have taken several steps to control damage caused by street cuts. Permits are required before cutting a City street, and utilities are required to warrant utility cut patches for two years. Additionally, the City imposes a 2-year moratorium on street cutting for newly overlayed streets. The Bureau of Maintenance also coordinates with outside utilities (gas, water, and electric) so that they will not pave a street which will undergo utility construction work. Bureau managers told us the Bureau postpones treatment on between 15 and 50% of originally scheduled paving and slurry sealing projects because of pending utility work.

Although the Bureau has developed systems for coordinating City paving with utility street work, we found the Bureau could better coordinate with other city Bureaus.

The Street Systems Management section of the Office of Transportation is responsible for utility cut permits and imposes a two year moratorium on permits after paving. However, it does not always receive timely notice that streets have been paved. Also, Maintenance managers are not aware of previously issued permits. Street Systems Management managers stated that this lack of information results in newly paved streets being cut. We were unable to determine the magnitude of this problem due to the lack of reliable information.

Utility cut data are maintained by several bureaus on several systems. Environmental Services, Bureau of Maintenance, Street Systems Management, and the Water Bureau each track a portion of the cuts. This information is not part of the Pavement Management System. Because utility cut data are not maintained on the PMS, the Bureau cannot quantify the impact of utility cuts on street condition, impairing the City's ability to determine the sufficiency of the utility cut permit fees. The inability to tie utility cuts to the Pavement Management System also makes it difficult for managers to determine responsibility for defective cuts.

Additional opportunities exist for the Bureau of Maintenance to minimize the cutting of new streets by informing residents of proposed repaving in advance of actual work. Currently, the Bureau notifies residents of repaving within a week of the actual work. This does not provide residents who are considering installation of gas or other underground utilities sufficient time to perform the work prior to repaving.[2]

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[2] Street Systems Management managers told us that the two-year no-cutting moratorium does not apply to residents who wish to install underground utilities.

RECOMMENDATIONS:

To ensure the quality of paving work performed by City crews, the Bureau of Maintenance should:

1. Set asphalt paving quality standards for in-house paving program. At a minimum, in-house standards should be set at the same level required for contracted paving work.

2. Regularly test paved streets to identify pavement quality problems.

3. Analyze the City's asphalt mix design to determine if it provides an acceptable quality of pavement.

4. Evaluate training needs for City paving crews.

To minimize the damage caused by utility cuts in City streets, the Office of Transportation should:

1. Better coordinate with other City agencies to ensure that it does not pave streets for which utility cut permits are outstanding.

2. Study the feasibility of consolidating utility cut information on the PMS data system.

3. Consider revising the utility cut permit fee structure to encourage street cuts prior to repaving. Also, explore methods for informing residents earlier when paving work will be done.

CHAPTER III: CONTRACTING PAVING WORK MAY REDUCE MAINTENANCE COSTS

Chapter Summary

Although the Bureau has developed effective systems for identifying streets which need treatment, its paving program costs more than work performed by private sector contractors. In FY 1986-87, the Bureau spent about $190,000 more for paving than Multnomah County did for similar work contracted to private contractors. In addition, the Bureau can reduce the current paving backlog at a lower cost by using private contractors rather than scheduling in-house crews on higher cost overtime. Moreover, unlike in-house crews, private sector contractors can be penalized for failure to meet City quality standards and must provide warranties on all work.

Although contracting for paving work offers cost advantages, it also presents risks. Vigilant enforcement of contract terms is required if the advantages of contracting are to be realized. We found that lax enforcement of existing asphalt supply contracts may have increased the City's paving costs. Also, experts warn that elimination of in-house paving programs can leave jurisdictions vulnerable to unwarranted price increases.

Benefits of Contracting for Repaving

We found that paving by private contractors was less costly than by the City crews. We analyzed the cost of the City's asphalt overlay program in FY 1986-87 and compared these costs with the contracted price paid by other local jurisdictions for similar work. If the City could have contracted for in-place asphalt at a cost equal to that paid by Multnomah County, the City could have saved approximately $190,000 of the $1.9 million expended on asphalt paving in FY 1986-87.

The City's average 1986-87 cost per ton was $30.35, whereas Multnomah County paid about $27.42 for comparable work. We used Multnomah County for comparison because it receives bids from many of the same contractors as would bid for City overlay work. It should be noted that approximately two-thirds of City paving costs is attributed to the cost of the asphalt mix. Asphalt mix is acquired through a competively bid annual supply contract with private vendors.

Table 7 below shows the relative costs of in-place asphalt paid by Portland and other jurisdictions.

TABLE 7
COMPARISION OF PAVING COSTS

JURISDICTION	COST PER TON*	% OF PORTLAND COST
MULTNOMAH COUNTY	$27.42	90%
CITY OF NEWBERG	$25.44	84%
CITY OF PORTLAND	$30.35	100%
CITY OF WEST LINN	$35.63	117%

Source: Contractor Bid documents and City cost data.

* Contractor Prices based on actual bid documents, adjusted upward by 6% to reflect estimated contract monitoring and quality control costs.

Both in-house and contracted prices are somewhat higher due to indirect costs not reflected in the above table. In-house overlay costs should be increased to reflect liability claims costs attributable to paving operations. Contracting costs do not reflect the cost of the bidding process. Additionally, Bureau managers cautioned against direct cost comparison between jurisdictions because smaller projects, curbed streets, and heavier traffic tend to make City paving work more expensive than other jurisdictions.

Contracting for asphalt overlay can provide several safeguards not available to the City. Contractors can face significant payment penalities if they fail to meet minimum specifications for materials and application of asphalt. If work is not done according to standards, the City can pay less, or reject the work and pay nothing. Additionally, the City requires that contractors guarantee their work for one to two years. There is no similar recourse against poor quality work performed in-house. As a result, the City pays for all additional work caused by poor quality paving. However, because City rework is not identified in Bureau records, we could not quantify associated costs.

Finally, supplementing the Bureau's in-house program with contracted work would be a less costly alternative for doing more major street repairs annually. Although the Bureau's in-house crews have usually paved more than their annual paving goals, they are unable to further expand the paving program. As a result, in their last two budget requests, the Bureau proposed using a combination of overtime labor and contracting. However, the cost of repaving with overtime labor is approximately $30.96 per ton, higher than prices available from contractors.

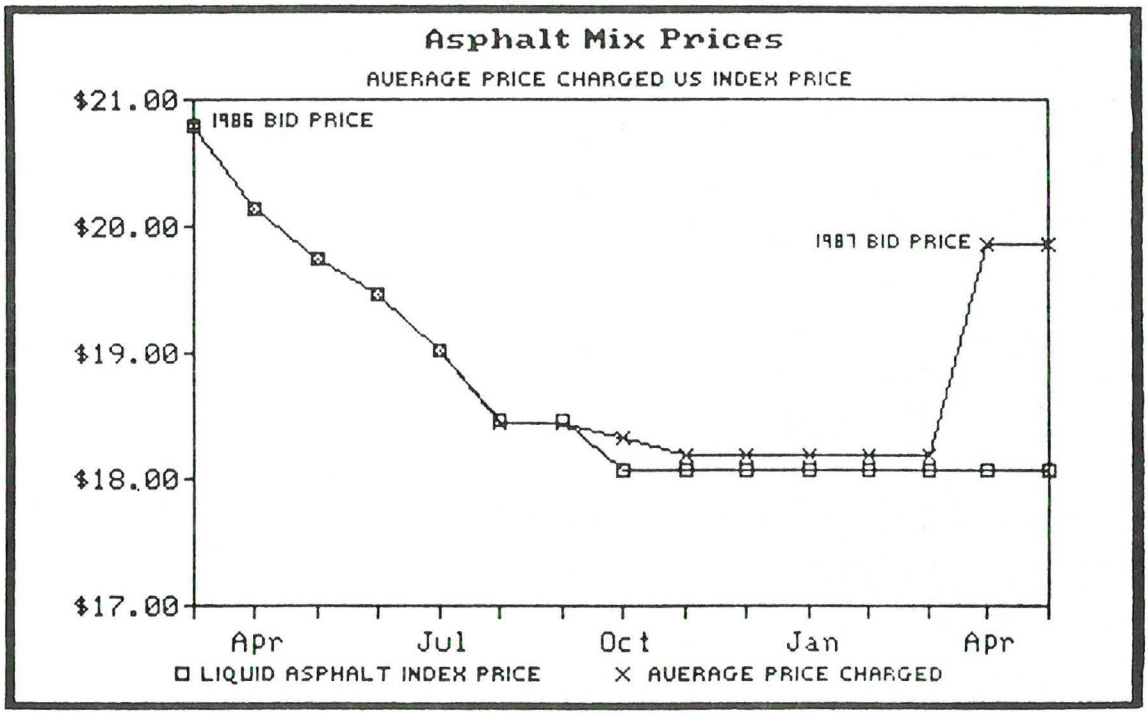
Risks of Contracting Paving

Although contracting for paving may provide some cost and quality control advantages, contracting also poses risks. The major risk should the City exclusively contract for work is the ability to ensure that costs remain low.

For example, the City purchases all hot asphalt from vendors. During our audit, asphalt contractors told us that private sector efficiencies and competition between contractors would reduce costs and protect the City from unwarranted price increases. However, we found that these same vendors did not pass on cost savings to the City when their costs for producing asphalt decreased. In April 1986, the City contracted for hot asphalt mix at an average base price of $20.80 per ton from its three major vendors. Each contract provided price adjustments as the contractors' cost for liquid

asphalt changed. As the price of liquid asphalt dropped 29% from $167 to $118 per ton during the contract year, contractors reduced the price of asphalt mix to an average of $18.18/ton in March, 1987. However, as shown in Graph 8, when the 1987 contract was re-bid in February 1987, the contractors bid an average base price of $19.85 per ton, 9% higher than they had been charging. We estimate that had asphalt mix prices followed liquid asphalt prices, allowing for inflation on other costs, the City would have saved approximately $130,000 in FY 1986-87.

GRAPH 8



Source: Internal Audit Division analysis.

City costs are also influenced by the actions of asphalt vendors that may reduce efficiency. For example, during two months of the 1987-88 paving season, we observed that City trucks waited longer at contractor-owned asphalt plants than the 10 minute maximum agreed upon by contract. City drivers waited 10 minutes 20% of the time and twenty minutes 8% of the time. During one 17 day period, we confirmed that these delays caused the paving machine to stand idle at least 5% of the workday because of a lack of asphalt, increasing City paving costs. City truck drivers have complained that some of these delays were caused by contractors allowing their trucks to cut in line ahead of City trucks. One vendor stated that cutting in line was a "conscious business decision" to keep their own paving crews operating without interruption.

The bureau also fears that without an in-house paving program and associated personnel, they would not be able to accomplish off-season maintenance tasks such as removing leaves from catch basins in the fall, and road patching and snow removal in the winter. The bureau has not, however, evaluated this problem using the Maintenance Management system to model the impact of a reduced paving workforce on other operations. Such modeling would calculate any resulting work force shortages and overtime impacts.

Authorities on the contracting of governmental services have cautioned other jurisdictions against becoming totally dependent on contracted work to perform required governmental services. Public officials in other jurisdictions have found it important to closely monitor contractor performance and to enforce contract terms, including penalty and cancellation clauses. Experts have advised local governments to retain some in-house capacity to perform services to prevent uncontrollable cost increases. For example, Phoenix, Arizona has in-house labor bid against private sector contractors for garbage collection services. Other jurisdictions reserve a portion of the workload for in-house crews. However, these authorities also emphasize the importance of using private sector services as a measure of the cost effectiveness of governmental services performed in-house.

RECOMMENDATIONS

To minimize the costs of the City's paving program, and to provide a benchmark against which to measure the cost effectiveness of the Bureau's in-house paving program, we recommend that the Office of Transportation:

1. Request bids from private sector contractors for paving which cannot be accomplished using existing Bureau of Maintenance labor capacity.

2. Evaluate the cost effectiveness of the in-house paving program by comparing in-house costs against costs available from private contractors. This evaluation should include the impact of inadequate paving quality as discussed in Chapter II.

3. Carefully monitor contractor performance and enforce the terms of existing and future contracts with private sector contractors.

CITY OF
PORTLAND, OREGON
DEPARTMENT OF PUBLIC WORKS

Earl Blumenauer, Commissioner
1220 S.W. 5th Avenue, Room 407
Portland, Oregon 97204
(503) 248-5577

February 22, 1988

Dear Ms. Clark:

I appreciate the opportunity to review your final draft audit report of street maintenance operations in the Bureau of Maintenance.

With the tremendous backlog of maintenance needs in Portland, I welcome your report and ideas on how service can be improved without increasing the cost to taxpayers. I have also been impressed throughout this process with the close cooperation between the various affected City agencies. I have reviewed Mary Nolan's response to the audit and fully support the immediate actions she has taken and her plans for specific remedies to address some of your audit findings.

There are, as always, areas that require clarification and amplification. Ms. Nolan's response highlights some of those elements that warrant further discussion and outlines how she intends to conduct further follow-up to resolve those issues.

None of this, however, detracts from the valuable service that your staff has performed in the study of our maintenance activities. I look forward to continuing this hard work and cooperation as we follow through on the audit recommendations and work to further improve the service. This is precisely what an effective internal audit program should do. You can count on my fullest cooperation and timely follow-up.

Sincerely,

Earl Blumenauer

Earl Blumenauer

Ms. Barbara Clark, Auditor
City of Portland
B131/R202

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CITY OF
PORTLAND, OREGON
OFFICE OF TRANSPORTATION

Earl Blumenauer, Commissioner
Bureau of Maintenance
2929 N. Kerby Ave.
Portland, Oregon 97227
248-5546 — Sanitary Section
248-5545 — Street Section

February 25, 1988

TO: Barbara Clark
City Auditor

FROM: Mary T. Nolan, Director
Bureau of Maintenance

RE: Audit of Street Paving Operations

The audit your staff conducted over the past nine months of the Bureau of Maintenance's paving activities has highlighted key aspects of this $1.9 million operation. I appreciate the efforts your staff members made in reviewing this important, and complex, service. Generally, I find the final report of this audit to be a fair assessment of street pavement maintenance activities.

KEY FINDINGS

While your report contains a great deal of information that we will review for applicability, three of your findings should be of immediate interest to the Council and the public.

1. **Confirmation of $37 Million Paving Backlog.** You have concluded that there is a significant backlog of critical pavement repair work. We had estimated a paving backlog of 476 miles, with a repair cost of $37 million. Your own staff and the consulting engineers you hired to assist in this audit have concurred as to both the magnitude and cost of the backlog. You point out that when policy or budget decisions are made that inhibit our ability to reduce this backlog, those decisions inevitably increase the eventual cost of street maintenance, sometimes making street repair four to five times more expensive due to delays.

2. **Need to Enforce Paving Density Standards.** Your field tests show that recent paving work has failed to meet density standards by as much as 4%. We have begun to implement steps to remedy this failure, details of which are discussed below.

3. **Apparent 9% Overcharge by Asphalt Suppliers.** Your analysis of recent bid prices for asphalt, tracked against appropriate indices for petroleum products, gives persuasive evidence that the failure of local vendors to pass along oil price reductions will cost the City $130,000 this year. This practice is by far the major factor causing the cost of our in-house paving operation to appear to be 10% higher than the cost of Multnomah County's paving operation, which is conducted almost exclusively by private contractors.

DETAILED RESPONSE

Assessment of Street Maintenance Needs (Audit Report pages 11 to 20)

Technical evaluation of pavement conditions is a complex issue, thorough evaluation of which took the City's professional engineering staff two years to complete. Your audit staff has done a worthy job in reviewing the intricate and sometimes counter-intuitive aspects of this subject. With the assistance of a consulting engineer, your staff has conducted a respectable evaluation of our Pavement Management System (PMS).

The existence and growth of the paving backlog has been a frustration for those responsible for maintaining the City's streets in safe operating condition. Your validation of the 476 mile backlog, and the overwhelming $37 million liability it represents should help focus attention on the need for a multi-year plan to eliminate the backlog.

You have recommended that we use the PMS to track and analyze data on additional activities, including crack sealing, patching and utility cuts. The volume of information that must be collected and input to monitor these work elements is extensive. In the budget request we submitted in January, we included a request for accounting, computer and analytical assistance needed to accomplish your recommendation. We agree that this information would be useful to have, and might contribute to an improvement in our PMS. However, since we are convinced that the PMS already provides us with exceptionally accurate and credible if not absolutely complete information -- doubly so, since your consultant has verified our methods and methodology -- I would not recommend that important direct service programs be curtailed to achieve this objective.

Quality Control in Paving (Audit Report pages 21 to 26, and 28)

Your audit has identified that 83% of sample paving work failed to meet established density standards by 0.5% to 4.4%. We are intent on determining and correcting the cause of this inadequate quality control. As you point out, many factors can influence the density of asphalt paving. Until thorough engineering analysis can be completed, we cannot say with certainty what causes the conditions you have identified. We therefore hesitate to endorse your conclusion that asphalt mix design is the fundamental cause. Our uncertainty about causality is compounded by our review of information on all street paving programs. Density tests conducted on street construction work performed by contractors reveal a comparable failure rate of 80%.

To combat this problem, we have proposed as an integral part of our '88-89 paving program (and budget request) routine sampling and testing of asphalt supplied to our paving crews. We will also establish procedures for testing the methods used by our crews to apply this asphalt to the street. This program will consist of:

1. Daily observation, material sampling and asphalt temperature recording at the asphalt plants.

2. Daily observation and asphalt temperature recording at each work site.

3. Daily density testing at each work site.

4. Gradation and asphalt extraction tests of each material sample.

5. Coring, bulk specific gravity, Rice specific gravity and gradation tests at select locations.

In addition to this quality control program, the Bureau will conduct an investigation into the cause of low densities on both Maintenance Bureau paving work and contracted construction work. The focus of this investigation will be the asphalt concrete mix and mix designs. Tests will be run of samples of material from a large number of projects to determine if the material meets the specification requirements. The desired outcome of these tests will be a determination of whether the density failures were primarily a result of inferior material mix designs or primarily a result of substandard materials being supplied.

Damage Caused by Utility Cuts (Audit Report pages 26 to 28)

Our experience, our instincts and the preponderance of professional literature all confirm your assertion that utility cuts cause significant long-term damage to the structural integrity of streets. A 1985 engineering study of city streets in Vermont, presented to the national Transportation Research Board, showed a 40-70% reduction in the useful life of urban streets due to the weakening effects of utility cuts. If we can extend this finding to Portland's street system, at our current service level, utility cuts absorb $ 3 to 8 million of our Street Preservation Program resources.

Awareness of this extensive problem motivated the Office of Transportation to implement a very successful utility coordination program that has nearly eliminated utility cuts for two years following street re-surfacing. As you point out, over the last two years, we have paved or sealed nearly 140 miles of street, which is roughly 2,500 blocks and 2,300,000 square yards of surface. In that two year period, utility permit records show no instances of routine utility work in newly paved streets, and only 17 instances of emergency utility work after paving. While the actions you recommend could be expected to improve this performance even further, each recommendation requires a staff intensive effort to initiate and maintain. Although we would like to operate a 100% program, it is worth noting that we have already reduced utility cuts in recently paved streets to significantly below 1%. I am not inclined to dedicate additional resources to an effort that promises only marginal returns when so many of our programs have pressing needs for resources.

Contracting Paving Work (Audit Report pages 29 through 34)

The question of how to assure the lowest long-term cost of paving services -- or any public service -- has occupied innumerable policy-makers, executives, managers and citizen activists. The Bureau of Maintenance has an ongoing commitment to evaluating and re-evaluating our policies and procedures in order to keep our costs down. A proper balance of in-house and external work is a key element in achieving efficiencies. Intuition alone suggests that a competitive environment may help keep both in-house and external crews honest.

Contracting of services can be extremely valuable in managing an operation such as paving that experiences unpredictable swings in funding. Rather than staff up when limited-term funds are available, we can and do use outside contractors to supplement our in-house paving program.

Last year, we conducted a $1.9 million in-house paving program, of which over $1.2 million was actually bid to private suppliers of asphalt. In addition, we directly vended $800,000 in street work to private contractors.

Direct comparisons of costs for paving are difficult to make. Such review should consider all the factors that influence the cost of paving work:

1. The size of individual pieces of the work. Larger, continuous jobs tend to be cheaper to perform than a series of small, separated jobs.

2. The shape of the work. Straight, level jobs tend to be cheaper than curved, hilly jobs.

3. The scope of work included for the price. Many public jurisdiction that contract for paving actually perform the preparation, notification, and clean-up activities with in-house crews. When making cost comparisons of in-house and external operations, it is critical that the costs include exactly and only the same activities.

4. The environment. Crowded urban streets with heavy vehicular and pedestrian traffic tend to be more expensive to pave than uncongested rural roads. Distance from the asphalt supply is a significant factor in the total cost of any paving operation.

Your audit showed that the average cost for the City's in-house paving operation was $30.35, and that Multnomah County contracted for some elements of a paving program at a cost of $27.42. Time, resources, or the scope of your study prevented an adequate evaluation of whether these two figures represented work that could be appropriately compared. Until such an evaluation is conducted, any conclusions about the relative efficiencies of these two operations are speculative.

If we can determine that a direct comparison between the City's average cost per ton and the County's average contracted cost per ton is appropriate, your report suggests that the City might be able to save $190,000. Achieving that

level of savings, of course, assumes that the prices bid for the City's paving work would be the same as the prices bid for the County's work. Based on our knowledge of the County's paving operation, we believe a careful evaluation will indeed show these two programs to differ in fundamental ways.

The largest piece of the potential $190,000 in savings you have identified is in the cost of our asphalt, which appears to be $130,000 too high. We must point out that the vendor employed by Multnomah County is among the 5 asphalt suppliers to the City who collectively have not passed along the oil price reductions you discovered.

The public is best served by a thorough evaluation of the sustained long-term costs of street repair work. To assure that we deliver the best value to the taxpayers, we will implement four steps:

1. We have recently called for bids for asphalt supply. We have adjusted the terms of this purchase in ways that should result in more competitive bids from local suppliers.

2. We will follow and aggressively enforce contract provisions to minimize plant delays and to ensure that we receive the quality of product that we pay for.

3. Because asphalt bid prices have not reflected reductions that would have been expected, commensurate with falling oil prices, we will evaluate the potential savings of making asphalt in-house, either with portable asphalt plants or by re-opening the municipal asphalt plant that was closed with a reliance on open competition to assure lowest prices.

4. Last fall, we scheduled paving work for this spring that exceeds the capabilities of our current work force. We have begun the design and contract preparation to let this work to private contractors. Furthermore, we have requested funding in our FY '88-89 budget for $2 million for the in-house paving program, and $3 million for additional paving to be contracted to local paving contractors.

Nolan

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