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Investigation of an Innovative Maintenance Contracting Strategy: The Performance-Based Maintenance Contract (PBMC)

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16. Abstract

One of the major responsibilities of state Departments of Transportation (DOTs) is to maintain their road assets so that road users can travel cost effectively, safely, and in a timely manner. Maintenance projects can be performed either by using the DOT's own workforce or by outsourcing to private contractors. Recently, some state DOTs have started using performance-based contracting for maintenance projects. In this study, benefits of these types of maintenance contracts were collected by conducting a national survey. Moreover, this study compared the use of the state force (SF) and private contractors in Nevada regarding the cost and quality of such maintenance activities as chip seal, striping, culvert cleaning, and sweeping. Results showed that state DOTs were highly satisfied with work performed by the state force, followed by private contractors when using method-based contracting and performance-based contracting. The cost comparison showed that chip seal, striping, culvert cleaning, and street sweeping performed by SF was less expensive than when performed by private contractors. Similarly, the quality of chip seal, culvert cleaning, and street sweeping was better when performed by SF versus contractors. However, the quality of striping work performed by contractors using the performance-based contracting (PBC) method was better than when performed by the SF. Recommendations for future study include collecting comprehensive cost and quality data for stretches of roads that are similar.

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FINAL REPORT

INVESTIGATION OF AN INNOVATIVE MAINTENANCE CONTRACTING STRATEGY: THE PERFORMANCE-BASED MAINTENANCE CONTRACT (PBMC) PHASE I – CONCEPT STAGE

Prepared for:
Nevada Department of Transportation (NDOT)
Carson City, Nevada

Pramen P. Shrestha, Aly Said, and Kishor Shrestha
Department of Civil & Environmental Engineering and Construction
Howard R. Hughes College of Engineering
University of Nevada, Las Vegas
4505 Maryland Parkway
Las Vegas, NV 89154-4054

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ABSTRACT

One of the major responsibilities of state Departments of Transportation (DOTs) is to maintain their road assets so that road users can travel cost effectively, safely, and in a timely manner. Maintenance projects can be performed either by using the DOT's own workforce or by outsourcing to private contractors. Recently, some state DOTs have started using performance-based contracting for maintenance projects. In this study, benefits of these types of maintenance contracts were collected by conducting a national survey. Moreover, this study compared the use of the state force (SF) and private contractors in Nevada regarding the cost and quality of such maintenance activities as chip seal, striping, culvert cleaning, and sweeping. Results showed that state DOTs were highly satisfied with work performed by the state force, followed by private contractors when using method-based contracting and performance-based contracting. The cost comparison showed that chip seal, striping, culvert cleaning, and street sweeping performed by SF was less expensive than when performed by private contractors. Similarly, the quality of chip seal, culvert cleaning, and street sweeping was better when performed by SF versus contractors. However, the quality of striping work performed by contractors using the performance-based contracting (PBC) method was better than when performed by the SF. Recommendations for future study include collecting comprehensive cost and quality data for stretches of roads that are similar.

EXECUTIVE SUMMARY

State Departments of Transportation (DOTs) use either their own workforce or hire private contractors to perform the road maintenance in their jurisdictions. They use their own equipment, manpower, and materials to perform road-maintenance projects. In order to outsource these projects, they either can hire private contractors based on method-based contracting (MBC) or performance-based contracting (PBC). With MBC, the contractors are given specifications to perform the maintenance. In PBC, the specifications are performance-based, and the private contractor is allowed to use innovative ideas to perform their maintenance work.

Recently, PBC has been used by several state DOTs to maintain their road assets. When setting up a performance-based contract, the state DOT specifies the performance criteria of the work during the contract-procurement phase, and the contractor must fulfill that performance benchmark. This contracting method ties the payment of the contractor to their work performance. If the contractor does not meet the performance standard set by the state DOT, either the contractor has to redo the work or their payment is reduced based on the payment reduction criteria set by the owner.

The literature review and the national survey conducted during this study with state DOTs revealed that all the states who responded used their state force (SF) and MBC private contractors to maintain their road assets. However, the survey results also showed that there were 14 states, including Nevada that used some form of PBC while performing road maintenance. Other states are California, Florida, Georgia, Kentucky, Maine, North Carolina, North Dakota, New Hampshire, Pennsylvania, South Dakota, Tennessee, and Virginia. District of Columbia has also performed maintenance work using PBC. In addition, the survey found that state DOTs used PBC for maintaining the following road activities:

1. Resurfacing, chip seal, and striping.
2. Activities related to traffic safety, e.g., road signs and marking, traffic attenuators, guard rails, barriers, and street lights.
3. Shoulder maintenance.
4. Side slope and median maintenance.
5. Right-of-way maintenance and fencing.
6. Sidewalk and curb maintenance.

When the state DOTs were asked about the main reasons for using their state force to maintain the road, they gave the following as the top three reasons:

1. Availability of DOT staff to accomplish additional projects,
2. DOT personnel have specific knowledge/skills for the job, and
3. Budget constraints.

State DOTs identified three primary reasons to use private contractors for their maintenance projects as:

1. Lack of DOT staff to accomplish additional projects,
2. DOT personnel have no specific knowledge/skills for the job, and
3. To complete the task on schedule.

When state DOTs were asked about their satisfaction with overall performance, cost effectiveness, schedule advantage, and quality of work performed by state force or contractors under the MBC and PBC methods, they were more satisfied with SF, followed by MBC and PBC.

The major lessons learned from using SF to perform maintenance work were that:

1. The work should be clearly understood by the staff;
2. The department should hire qualified personnel; and
3. SF can easily respond to unanticipated maintenance projects as well as monitor and track cost.

Similarly, the lessons learned from contracting out maintenance projects to private contractors were:

1. Specifications and contract documents should be clearly written;
2. The inspectors and the administration should clearly understand and embrace PBC; and
3. The PBC contract should be a long-term contract.

In addition, the study compared the unit maintenance cost spent on chip seal, striping, culvert cleaning, and sweeping performed by SF and private contractors. Results showed that the average cost of chip seal performed by SF ($1.67/SY) was about one half less than that performed by private contractors ($3.14/SY). Similarly, for striping, the unit cost per year of SF performed work ($457.60/LM/yr) was about one half less than that performed by private contractors ($945.14/ LM/yr). When the cost of striping performed by SF was compared with that performed by PBC contractors, the cost was about 3.8 times higher for work performed using PBC. The cost of culvert cleaning performed by SF ($4,482.72/mi/yr) was found to be 30% less than that performed by private contractors ($6,593.00/mi/yr). The cost of sweeping performed by contractors was also found to be significantly higher than that performed by SF ($64.13/ C-mile/yr vs. $43.78/ C-mile/yr). Based on available data and on the assumptions made during the cost calculations, the state force performed maintenance activities more inexpensively than did private contractors.

Assessments by the research team and road users on quality of work indicated that the quality of selected road sections regarding chip seal and street sweeping performed by SF was better than that performed by private contractors. However, the quality of striping was found to be better when done by private contractors compared to SF. The quality of striping done by a PBC contractor was found to be best in compared to SF and MBC private contractors. The evaluation of culvert

cleaning by researchers on selected road sections showed that SF performed the job better than the contractors.

In conclusion, some road maintenance activities can be performed using PBC contracts. However, the quality of the maintenance work and the cost effectiveness seemed to be better when performed by state force rather than MBC private contractors. Keep in mind that only four activities were evaluated – chip seal, striping, culvert cleaning, and street sweeping. When compared with the quality and cost effectiveness of striping performed by PBC contractor, the cost effectiveness is better for state force and vice versa for quality. According to results from the national survey, the state force should perform maintenance work of those activities in which they have expertise, for example, chip seal and street sweeping. However, some maintenance activities in which private contractors have developed expertise – e.g. striping or maintenance of traffic posts – should be outsourced to private contractors to get better results.

For future study, it is recommended that cost data be collected for similar stretches of road on which SF and private contractors had performed maintenance in order to conduct a reasonable cost comparison. Similarly, during the quality assessment, the quantitative measured data should be used rather than qualitative in order to make more accurate comparisons.

CHAPTER 1: INTRODUCTION

1.1 Background

The United States Interstate System has 46,726 miles of road, and more than four million miles of non-highway public roads (FHWA 2014, USDOT 2012), as shown in Figure 1-1. However, most of the U.S. highways were constructed prior to 1990. Therefore, every year, the U.S. Department of Transportation (USDOT) allocates a significant amount of their budget in order to maintain the national highway system.

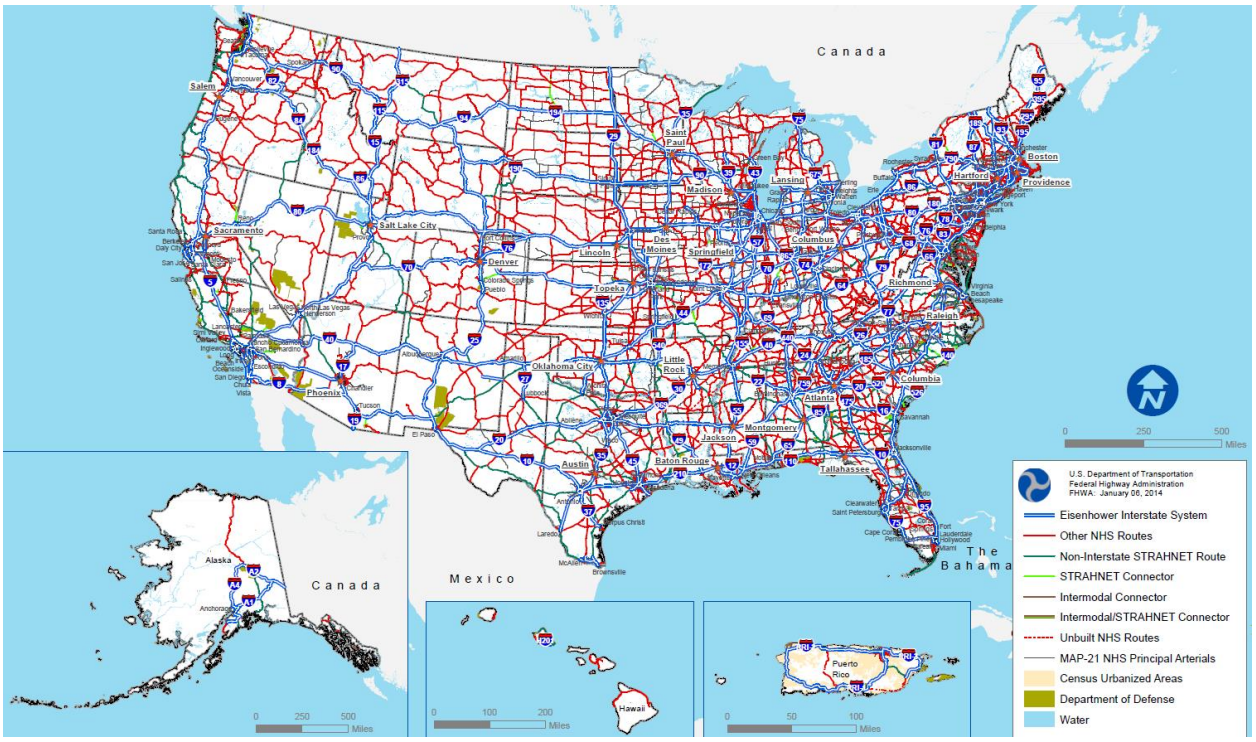


FIGURE 1-1. National Highway System in the United States (USDOT, Federal Highway Administration 2014).

For maintenance projects, state DOTs use either state forces (SF) or outsource by hiring private contractors. The selection of the method used depends on site conditions, availability of a skilled workforce, the scope of work, budget constraints, time constraints, time and schedule complexity, cost effectiveness, availability of long-term funding, risk transfer, increased level of service (LOS), and bundling of maintenance activities (Anastasopoulos et al. 2010, NCHRP 2003, NCHRP 2009, Ribreau 2003, Zietlow 2004, and Zietsman 2004).

Under the SF method, state DOTs use in-state resources to maintain the roads, which allows them to plan and execute maintenance projects based on their requirements. For example, the SF is more suitable for activities requiring an immediate response (Anastasopoulos et al. 2010) as well as for bridge and tunnel maintenance, shoulder maintenance, landscape works, and litter and debris pick-up works (Anastasopoulos et al. 2010, NCHRP 2009, and Ribreau 2003).

Two types of outsourcing are used: 1) method-based contracting (MBC), also known as prescriptive-based contracting; and 2) performance-based contracting (PBC), also known as warranty-based contracting or outcome-based contracting. The MBC method specifies to the contractor "what to do, when to do it, how to do it" and it specifies the quality of materials to be used (Stankevich et al. 2009, p. 3). In the MBC, the contractor submitting the lowest bid is chosen to complete the given task. Most state DOTs prefer this method when the scope of work is beyond the capacity of their in-state force, if the DOT does not have the skilled workforce for the project, or when there are time constraints (NCHRP 2003). The state DOTs pay the MBC contractor based on the amount of work completed.

The PBC method offers incentives and disincentives to ensure that the contractor achieves specified results. Unlike the MBC, a PBC contractor is free to execute "what to do," "when to do it," and "how to do it". The PBC first was used in 1988 for maintenance of road systems and bridges in British Columbia, Canada (Zietlow 2004). This method selects a contractor based on qualifications. Specifications used in the PBC are based on the performance of the contractor's work, and focus on the outcomes of the contractor rather than the method of execution (Stankevich et al. 2009). Benefits in using the PBC are that the risk is transferred to the contractor, availability of a maintenance fund for a longer duration (more than three years), an improved level of service (LOS), flexibility in bundling the maintenance activities, and cost-effectiveness (NCHRP 2003, NCHRP 2009, Ribreau 2003, Zietlow 2004, Zietsman 2004). Payment to the contractor is based on the quality of the work performed, and is made on a monthly basis.

The Nevada Department of Transportation (NDOT) performs their road maintenance activities using both state force as well as private contractors. Recently, NDOT used the PBC for a striping project.

1.2 Study Objectives

The main objective of this research was to evaluate road maintenance activities performed by NDOT's SF and private contractors. The following tasks were performed to achieve the objective:

1. Determine the satisfaction ratings of benefits of SF and outsourcing methods using the national survey.
2. Collect information on lessons learned by state DOTs that have used SF, MBC, and PBC.
3. Identify factors that affect the selection of SF and private contractors to perform road maintenance using the national survey.
4. Compare the cost and quality of chip seal, striping, culvert cleaning, and sweeping performed by SF and private contractors in Nevada.
5. Provide recommendations of road activities that should be maintained by using PBC contracting method.

1.3 Literature Review

Various studies were reviewed that were pertinent to this research. The literature review mainly focused on:

1. Outsourcing road maintenance activities to private contractors,
2. Cost analysis comparing the use of SF versus outsourcing, and
3. Performance-Based contracts for road maintenance.

1.3.1 Outsourcing Road Maintenance Activities to Private Contractors

The National Cooperative Highway Research Program (NCHRP 2003) identified a trend of state DOTs outsourcing work to private contractors, and identified the reasons. The study, which surveyed state DOTs on specific engineering and design elements that were outsourced, indicated that the outsourcing of road design, right-of-way maintenance, operations, and planning of road networks had increased. The three main reasons of outsourcing were lack of in-house staff, lack of skilled workers, and cost effectiveness.

Ribreau (2004) identified advantages and disadvantages of outsourcing highway maintenance by conducting case studies of five states – Massachusetts, Virginia, Oklahoma, Texas, Florida – as well as British Columbia, Canada. In Florida, it was reported that cost savings resulted from by outsourcing the maintenance projects to private contractors. Florida DOT (FDOT) gave a contractor a routine maintenance contract for 15 years in order to save costs; by doing this, they reduced the number of in-house employees and transferred the risks to the private contractor. FDOT claimed that outsourcing saved $5.9 million in maintenance project.

In contrast, Ribreau (2004) stated that the major disadvantages of outsourcing were increased costs, deterioration of service, and inefficient administration and supervision (Ribreau 2004). For example, in 1992, Massachusetts DOT (MDOT) started a pilot project to outsource a highway maintenance project; however, the contractor's performance was poor. Due to an inadequate cost analysis, the State of Massachusetts lost over $1 million in this contract. Similarly, in 1996, Virginia DOT (VDOT) outsourced a 246-mile maintenance project to a private contractor by using the PBC, and estimated a cost savings of $23 million. However, this estimate was not supported by the proper documentation, and the cost saving was calculated as the difference between the engineer's estimate and the contract cost. VDOT did not mentioned how much it would have cost if the work had been completed by private contractor using MBC. In 2001, Oklahoma DOT (ODOT) outsourced road maintenance for a project involving 2,576 lane-miles of highway for snow removal. Due to payment issues, the contractor did not clear the roads after a storm left seven inches of snow on the roads; as a result, this state faced negative public criticism. In Texas, the contractor did not remove the snow and ice for three years due to a payment issue. In addition, the contractor had poor knowledge of the materials needed for snow and ice removal; as a result, the state terminated the contract. In the late 1980s, British Columbia

contracted a highway maintenance project to a private contractor; however, over time, the cost increased from $15 million to $29 million per year.

1.3.2 Cost Analyses Comparing the Use of State Force versus Outsourcing

1.3.2.1 Outsourced Road Maintenance Activities.

Halcrow (2011) conducted a unit cost analysis of outsourcing road maintenance activities in Nevada. This researcher collected data on road maintenance costs from NDOT, Texas DOT (TxDOT), and FDOT as well as from several private contractors. In order to compare costs among agencies and contractors, the direct and indirect cost of each activity was calculated. The direct cost was defined as the expenditure of materials, labor, and equipment directly associated with an activity. The indirect costs included the overhead charges by the DOT, the division, the district as well as the cost for maintenance station management. The actual cost of the DOT staff was calculated as the percentage of time allocated to a specific maintenance project. Other indirect costs included the costs of advertisement and quality-control inspection.

Because minimal data was available from NDOT, in order to compare in-house maintenance costs with that of private contractors, cost data from the other states mentioned earlier were collected. Total costs of each activity were calculated by adding direct and indirect costs. Activities were compared against the highest expenditures for eight NDOT projects in 2009 and with 2009 costs for projects in TxDOT and FDOT. The results indicated that the average costs in Nevada for chip seal, debris removal, crack filling, and fog seal were higher than for Texas, and the cost of cut & fill in Nevada was lower than for Florida. However, no documentation was provided on how the data for indirect costs were collected.

1.3.2.2 Cost Determination Methodology

Martin (1993) conducted a study to determine the true cost of using in-house and outsourced services. For in-house services, direct costs were defined as fully dedicated costs for a target service; indirect costs were those that benefited from more than one target service. The indirect costs for personnel must be proportionally allocated to target services in the ones involved. The total cost for in-house services is the sum of the direct costs and a proportional share of the indirect costs.

According to Martin (1993), three types of costs were associated with private contracts: contract administration, one-time conversion, and new revenue. A ‘contract administration cost’ referred to all the expenditures that occurred during the contract start to the contract end. ‘One-time conversion cost’ were costs incurred when converting a target service from in-house to a contract service delivery and were required to be amortized over an effective duration. For example, the salary of workers was a ‘one-time conversion cost’ because the workers could not be removed immediately due to the contract clauses. ‘New revenue cost’ was defined as when the services were contracted out, and the agency did not need to use some of the resources or

equipment; the owner would sell out these resources or equipment. The total cost incurred in a private contract was the sum of the 'contract administration cost' and the 'one-time conversion cost' minus 'new revenue cost.'

The NCHRP (2011) developed a process to calculate the total cost of a highway maintenance activity. Total cost consisted of the line activity cost, the program support cost, and the enterprise support cost. Line activity costs were direct costs. Program support costs were those costs that did not deliver any specific work product of construction or maintenance, but did support one or more line activities, such as district maintenance staff, office stationery, and utilities. Enterprise support costs were head office administration, information technology, planning and research, and legal advice.

NCHRP used five processes to determine the respective shares of a support cost to the direct costs:

1. Collect and separate maintenance program costs;
2. Determine a share of support program costs to the line activities;
3. Collect and separate enterprise support costs;
4. Determine a share of enterprise support costs to the line activities; and
5. Add line activities, a share of support program, and a share of enterprise support costs to determine full cost.

A percentage share of both the costs for the support program activity and the enterprise-support activity to a line activity was calculated based on the ratio of the amount of the line activity costs over the total line-activity cost.

1.3.3 Performance-Based Contracts for Road Maintenance

Numerous studies conducted on using PBC for road-maintenance projects have focused on four aspects:

1. The PBC contracting process,
2. Advantages and disadvantages of PBC,
3. Development of performance measures for PBC, and
4. Lessons learned using PBC for road maintenance.

The details about these studies are summarized below.

1.3.3.1 The Performance-Based Contracting Process

The World Bank (2002) prepared a sample-contract document for PBC to be used for road-maintenance projects. This document included samples for performance specifications, criteria for service quality, inspection methods for the levels of service quality, timeliness, payment reductions, and liquidated damages. These specifications were provided for both paved and

unpaved roads. The quality inspections of paved and unpaved roads were quite similar; for each, inspections were to be carried out as directed by the project manager.

Several studies recommended that pay reductions be applied for non-compliance regarding the quality of the LOS provided in PBC contracts (Stankevich et al. 2009, Zietsman 2004, Gharaibeh 2011). The pay reduction applied in this study was a percentage of the monthly lump-sum amount of the contractor's pay. As an example, for an unpaved road, if the contractor could not meet the 'road usability' criterion or if the road is closed for traffic, 1% of the monthly lump-sum amount for the entire project or for the road section that was affected would be reduced (The World Bank 2002). Pay reductions for all the criteria were set as a percentage of the contractor's monthly payment.

Stankevich et al. (2009) differentiated PBC from traditional contracts. When using the PBC, the contractor was paid based on work performance, and the agency did not specify either the methods or the materials to be used by the contractor. During the contract selection process, the 'best value' method normally is used for PBC, whereas traditional contracts use low bid. These authors identified two types of PBC: the Pure PBC, also called PBC; and the Hybrid PBC, which is a combination of Pure PBC and MBC. According to the authors, Pure PBC contracts are based entirely on the outcome of the projects; in Hybrid PBC contracts, some activities are paid based on the PBC and the remaining are paid based on the MBC or SF.

1.3.3.2 Advantages and Disadvantages of Performance-Based Contracts

Various studies have identified the advantages of PBC used for road maintenance work. The main advantages are reduced maintenance costs and improved LOS (NCHRP 2009, Zietlow 2004, McCullouch et al. 2009, Liautaud 2004; Anastasopoulos et al. 2010). The NCHRP (2009) surveyed state DOTs of the U.S. and 10 provincial agencies of Canada, and found that using the PBC method reduced road-maintenance costs and improved LOS. According to Zietlow (2004), VDOT achieved approximately 16% reduced costs by switching from MBC to PBC because of innovative practices used in PBC, better resource allocation, and the training provided to subcontractors. McCullouch et al. (2009) interviewed state DOTs to determine the cost savings when using the PBC; results indicated that cost savings varied from 10% to 50%. In an analysis of 449 PBC contracts from 49 countries, Anastasopoulos et al. (2010) showed that the cost savings depended on spatial variables, such as high savings / low savings of the surrounding countries, contract duration, and contract size. If a country was surrounded by countries with high-cost savings, the country itself would have high cost savings. These results showed that cost savings were positively correlated with the contract duration and size.

From historical PBC projects, two studies found that the PBC provided transparency to road users, road administrators, and contractors with regard to the road conditions (Zietlow 2004, McCullouch et al. 2009). Another advantage of PBC was that it promoted innovation (Zietlow 2004, NCHRP 2009, McCullouch et al. 2009, Liautaud 2004, Zeitsman 2004). In a mowing activity in rural Virginia, a PBC contractor trained local people to complete the work at low cost (McCullouch et al. 2009).

Argentina shifted from using traditional input-based contracting methods to an outcome-based contracting method in order to fulfill four objectives in 1995 (Liautaud 2004):

1. Cut administrative costs associated with input-based contracts,
2. Encourage innovation and cost effectiveness by providing more responsibilities to the contractors,
3. Meet the needs of road users in an improved way, and
4. Develop more stable funding for road maintenance.

However, when these contracts were reviewed after three years, only the first three objectives had been met.

According to Berkland and Bell (2007), the main four disadvantages of the PBC are lack of controllability, lack of budget, poor performance by the contractors, and lack of job security for DOT personnel. According to NCHRP (2009), the main disadvantages of the PBC were that the procurement process was expensive and lengthy, there was less competition among the contractors, it resulted in uncertainty associated with long-term contracting, and there were challenges in mobilizing the contractor, a lack of controllability. In some states, PBC projects were initiated by political interests, and these were not cost effective (McCullouch et al. 2009). Liataud (2004) mentioned that contractors need to be financially strong in order to complete a PBC project successfully. Zietlow (2004) suggested for proper implementation of the PBC; otherwise, it would produce adverse effects. Another study found that the disadvantages of PBC were the inability to deal with change, a loss of flexibility, an adverse effect on smaller contractors, and less competition among the contractors (Zeitsman 2004).

1.3.3.3 Development of Performance Measures for Performance-Based Contracts

Science Applications International Corporation (SAIC, 2006) developed a framework for PBC contracts, and described two types of performance measurements, a performance goal menu and a process for performance measurement. The performance measurements would possibly answer the questions: who will measure and when to measure the performance factors, and how to analyze the results. SAIC categorized the performance goals into pass / fail measures and multi-level performance measures. They developed a process that included performance measurements for safety (injuries to workers, vehicular crash, and speed band), construction congestion, quality of pavement smoothness, quality of pavement noise, and customer satisfaction, among others. Additionally, this study discussed how frequently the performance measurements needed to be taken, either by 1) continuous measurements, 2) cyclic measurements (hourly, daily, quarterly, weekly, monthly, and annually), 3) at the start and end of a project and/or at project milestones, or 4) long-term measurements.

Pakkala (2005) and Baker (1999) identified four common performance measures for maintenance of road pavements: the International Roughness Index (IRI), skid resistance, rutting, and cracking. Pakkala (2005) included the deflection of the pavement as a performance measure;

however, Baker did not. Pakkala (2005) did not mention the target values. However, Baker (1999) specified the performance target values for various performance measures of road-pavement maintenance:

1. The IRI should be equal to or less than 181 (for roads reconstructed in past five years ago);
2. Skid resistance should be equal to or more than 40;
3. Rutting depth should be equal to or less than 0.5 inch; and
4. 95% of all cracks that were more than 0.25-in wide must be sealed for roads constructed two to five years ago.
5. Similarly, the performance targets were specified for maintenance activities of shoulders, manholes, roadway cleaning, drainage, roadside, traffic safety, roadside cleaning, roadside vegetation, snow and ice removal, traffic safety signs, and traffic safety lightings.

For unpaved roads, Hartwig et al. (2005) designed four performance measures that could be used in PBC contracts: pass-ability, attainment of average speed, user comfort, and durability (long-term sustainability). Pass-ability determined whether the road section was open and vehicles were able to go through. This study did not indicate performance target values for the average speed, users' comfort, and durability. For monitoring purposes, the contracts used two mechanisms:

1. The contractor conducted internal monitoring and prepared monthly reports that were submitted with a monthly invoice to the government office, or
2. A third-party consultant checked that the contractor was monitoring reports by the means of monthly inspections.
3. If the contractor failed to maintain the road conditions, a fixed-dollar amount was deducted from the billed invoice. If that failure was repeated, then the contract would be suspended.

Florida DOT developed a Maintenance Rating Program (MRP) that evaluated the work of a PBC contractor (FDOT 2007). The performance of the contractor could be assessed by two methods in PBC maintenance contracts:

1. The department could perform MRP in the presence of a contractor, or
2. The contractor could perform MRP following "MRP handbook and procedures." (FDOT 2007, p. 6)

1.3.3.4 Lessons Learned in using Performance-Based Contracts

Various studies have collected lessons learned when using the PBC.

1. One of the major lessons learned was that the performance criteria when using PBC should be simple (Ellevest 2001, Hartwig 2005, Menches 2010).

2. The LOS must be clearly defined in the bid document, and it was necessary that the distribution of risks between owner and contractor was equitable.
3. The PBC contractor should have experience in the PBC process and should be financially and technically qualified (Ellevest 2001, Zietlow 2004).
4. The contractor should be selected using best-value procurement (Menches 2010).
5. All the project staff should be early involved in the PBC contract process so that they will be aware of the agency goals (SAIC 2006).
6. It is better to have multi-level performance measures than pass/fail measures (SAIC 2006).

Berkland and Bell (2007) recommended that annual training be implemented to owner staffs so that all district offices would have a common understanding of the PBC contract. SAIC (2006) suggested that the performance goals of PBC contract should be specific, measurable, achievable, result-oriented, and timely (SMART). Ellevest (2001) and Menches (2010) suggested including only maintainable roads in the PBC contracts. Zietlow (2004) mentioned that the contract period should be longer than that of a traditional contract period in order to receive full benefits of the PBC.

CHAPTER 2: RESEARCH APPROACH

To achieve the objectives of the research, this study used a survey, collected and analyzed hard data, and used on-site evaluation methods. Figure 2-1 shows the research approach used in the study.

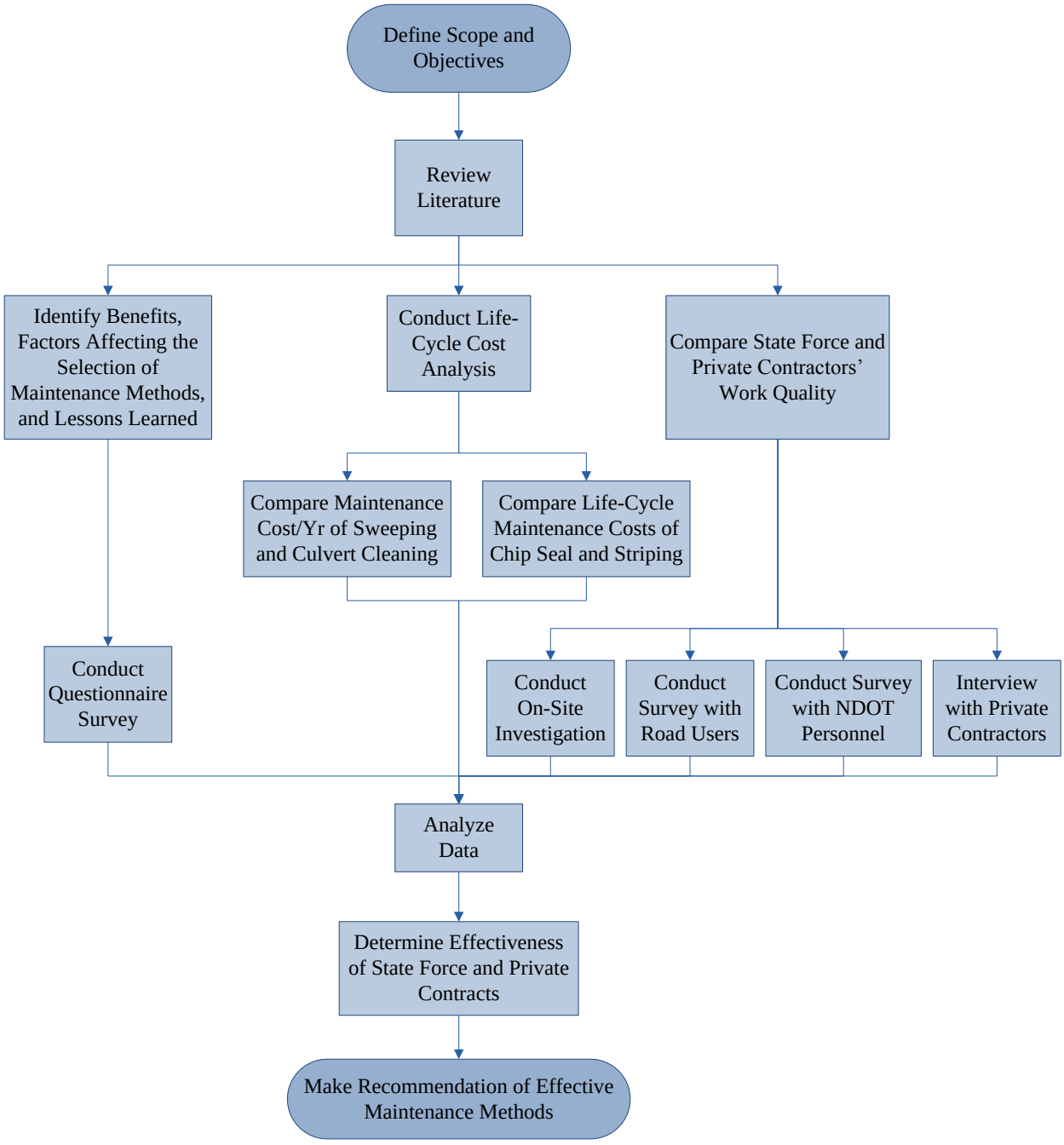


FIGURE 2-1. Overview of the research approach.

2.1 NDOT and State DOT Surveys

A survey was conducted with NDOT personnel to determine the list of maintenance activities performed by in-house and private contractors in Nevada in the summer of 2014. In Nevada, the term *State Force* (SF) is used instead of 'in-house'. The questionnaire used in this survey is shown in Appendix B.

In addition, a survey was conducted with 50 state DOTs to determine the advantages and disadvantages of contracting methods using SF and private contractors. This survey collected data related to:

1. The satisfaction ratings of benefits of three road-maintenance methods (SF, MBC, and PBC);
2. Satisfaction levels of the DOT personnel with these three methods with regard to cost effectiveness, schedule advantage, the quality of the delivered project, and risk transfer;
3. Lessons learned using these methods; and
4. Factors that influence the selection of these methods

This second survey, shown in Appendix C, was distributed in July 2013. The research team conducted follow-up telephone inquiries to those who did not respond within a month.

2.2 Unit Maintenance Costs

The research team visited NDOT's Maintenance and Asset Management Division in Carson City, NV, to collect cost data of maintenance projects performed by SF and private contractors. The cost record for road maintenance performed by State Force was downloaded from the Maintenance Management Reporting System (MMS); in addition, cost data was collected for using private contractors with the MBC and PBC methods. The cost data performed by SF were collected from 1990 to 2014, and the cost data for private contractors were collected from 2009 to 2014. Cost data for four maintenance activities – chip seal, striping, culvert cleaning, and street sweeping – were used in the analysis, as shown in Table 2-1.

TABLE 2-1 Range of Years for Collecting Cost Data for Maintenance Activities

S. N.	Name of the Activities	Year of Maintenance Performed	
		State Force	Private Contractors
1	Chip Seal	1990-2013	2010-2013
2	Striping	1990-2013	2010-2013
3	Culvert Cleaning	1990-2009	2009-2011
4	Street Sweeping	1990-2012	2012-2014

The unit cost was compared for these four activities. For a life-cycle cost analysis, road sections were selected in which this maintenance occurred multiple times since 1990. However,

the only activities performed under these criteria were chip seal and striping, and therefore were the only activities compared. For culvert cleaning and street sweeping, only unit maintenance costs were compared.

Additionally, traffic volume or annual average daily traffic (AADT) might have had an effect on the frequency of maintenance related to chip seal, striping, and street sweeping. Therefore, AADT data from the NDOT website were collected to compare unit cost per 1,000 AADT.

2.2.1 Maintenance Costs per Year

The total cost expended in a maintenance activity was calculated by adding direct and indirect costs. In maintenance activities performed by SF, the direct cost was the summation of costs for labor, materials, and equipment that was expended in the line activities. In maintenance work performed by contractors, the direct cost was the bid cost of each line activity. In both cases, the indirect cost was a percentage of the salary of the NDOT staff directly or indirectly involved in the maintenance activities. The total maintenance cost was calculated using Equation 2-1.

$$Total\ Maintenance\ Cost = Direct\ Cost + Indirect\ Cost \quad (2\text{-}1)$$

The indirect cost was the administrative costs expended in NDOT district offices as well as headquarters in Carson City. Data for total administrative costs for NDOT was available on the website for 2009 and after. To determine the indirect cost spent in the maintenance division, the ratio of the total maintenance budget (part of NDOT's total budget) and NDOT's total budget was determined. The sample calculation of indirect cost is shown in Table 2-2. The indirect cost of NDOT's maintenance division for 2009 was calculated as:

Total Maintenance and Construction Budget	= \$605.80 M
Total Maintenance Division Budget	= \$119.80 M
Percentage of Maintenance Budget with Total Budget	= (\$119.80 M/ \$605.80 M) x 100
	= 19.8%

Similar calculations were carried out to determine the percentage of maintenance budget as part of the total budget 2010 to 2013. The average indirect cost of maintenance division was calculated as 16.57% of the total administrative cost for NDOT.

TABLE 2-2 Administrative Costs for NDOT's Maintenance Division

Year	Administrative Cost ($M)	Maintenance Division Budget ($M)	New Construction Budget ($M)	Total Maint. & Const. Budget ($M)	Percentage of Maint. Division Budget (%)
2009	134.70	119.80	486.00	605.80	19.8
2010	127.90	136.40	594.30	730.70	18.7
2011	125.80	111.70	651.40	763.10	14.6
2012	120.40	132.90	748.10	881.00	15.1
2013	123.80	113.80	661.00	774.80	14.7
Average	**126.52**	**122.92**	**628.16**	**751.08**	**16.57**

From FY 2009 to 2013, on average, 16.57% of the total budget is expended on maintenance activities. Based on this percentage, the indirect cost spent on maintenance activities can be determined as follows

Average administrative cost for Maintenance Division = $126.52 M x 16.57%
= $20.96 M

Percentage of Indirect (Administrative) Cost of Maintenance Division
= ($20.92M /$122.92M) x 100
= 17.06% of Maintenance Budget

Figure 2-2 shows the steps used to calculate unit maintenance cost per year for culvert cleaning and street sweeping. The unit maintenance cost for these two activities were calculated as follows.

1. The maintenance cost data of culvert cleaning and street sweeping performed by SF and private contractors from 1990 to 2014 were collected to determine their direct costs for each year.
2. The total costs were calculated by adding direct costs and indirect costs for each year, and unit costs per year were calculated by dividing the total cost by the quantity of work.
3. The unit cost per year was adjusted to a 2014 base cost, using the *Engineering News Record* (*ENR*) cost index, and then the average unit cost per year was calculated.
4. For the private contracts, the calculated unit costs were divided by the contract duration to determine the unit cost per year.
5. Finally, the unit cost of street sweeping per year was divided by the AADT of the road section in question, multiplied by 1,000 to determine unit cost per year per 1,000 AADT.

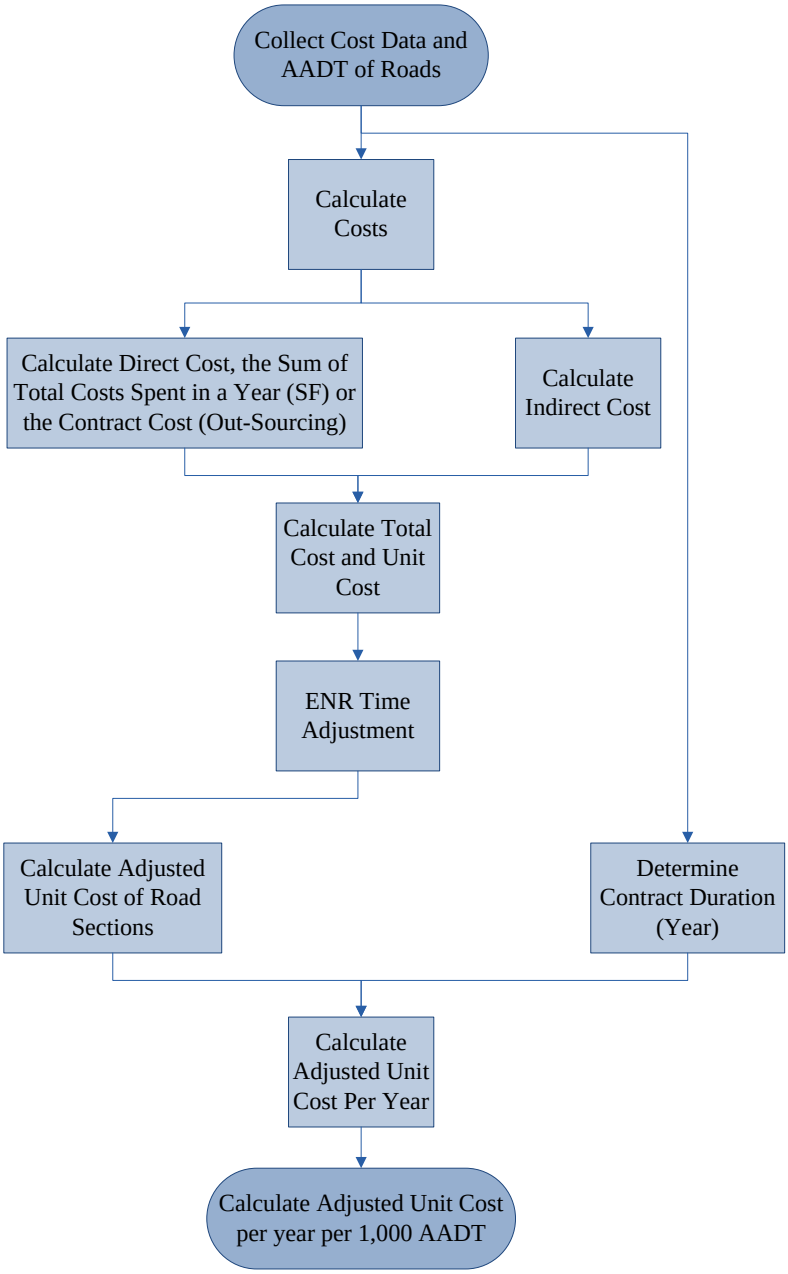


FIGURE 2-2. Steps to determine the maintenance costs per year.

2.2.2 Determination of Life-Cycle Maintenance Costs

A life-cycle cost analysis (LCCA) was used to determine the most cost-effective method among various alternatives. In this study, the total life-cycle maintenance cost was calculated for chip seal and striping by adding the maintenance cost expended for the entire life of the road. The study used maintenance costs and frequency data of chip seal and striping activities to determine the life-cycle maintenance costs (LCMC). **Error! Reference source not found.**

To calculate the LCMC of these activities, it was necessary to determine the number of times (frequency) the road section had been chip sealed or striped after it had been constructed. To calculate the average frequency of maintenance on roads maintained by SF and private contractors, maintenance data were identified and collected for 1990 to 2013.

The frequency of maintenance on each road section during these 23 years was calculated, and the average frequency of maintenance was determined. Figure 4-1 shows the steps to calculate the LCMC of chip seal and striping activities, which are as follows.

1. The cost data from 1990 to 2013 for chip seal and striping performed by SF were analyzed to determine direct costs (labor, equipment, and material costs) spent in each year.
2. The indirect costs associated with these direct costs were calculated as explained in section 2.2.1.
3. The total cost was calculated by adding direct and indirect costs. A unit cost was determined by dividing the total cost with the quantity of work performed. In case of chip seal, the thickness of the pavement varied. For most roads, a chip seal of 3/8-in thickness was used; however, for some road sections, 1/2-in or 7/8-in was used. All unit costs for these two thicknesses of chip seals were converted to an equivalent unit cost for a 3/8″ thickness.
4. The average unit cost of maintenance activities performed in various years was determined and adjusted to a 2014 base cost, using the *ENR* cost index.
5. The average frequency of maintenance for each of the road sections was determined.
6. The unit cost spent per year was calculated by dividing the unit cost with the frequency of the work performed per year.
7. The average unit cost per year per 1,000 AADT was calculated by dividing the unit cost per year by the average AADT in 1,000.

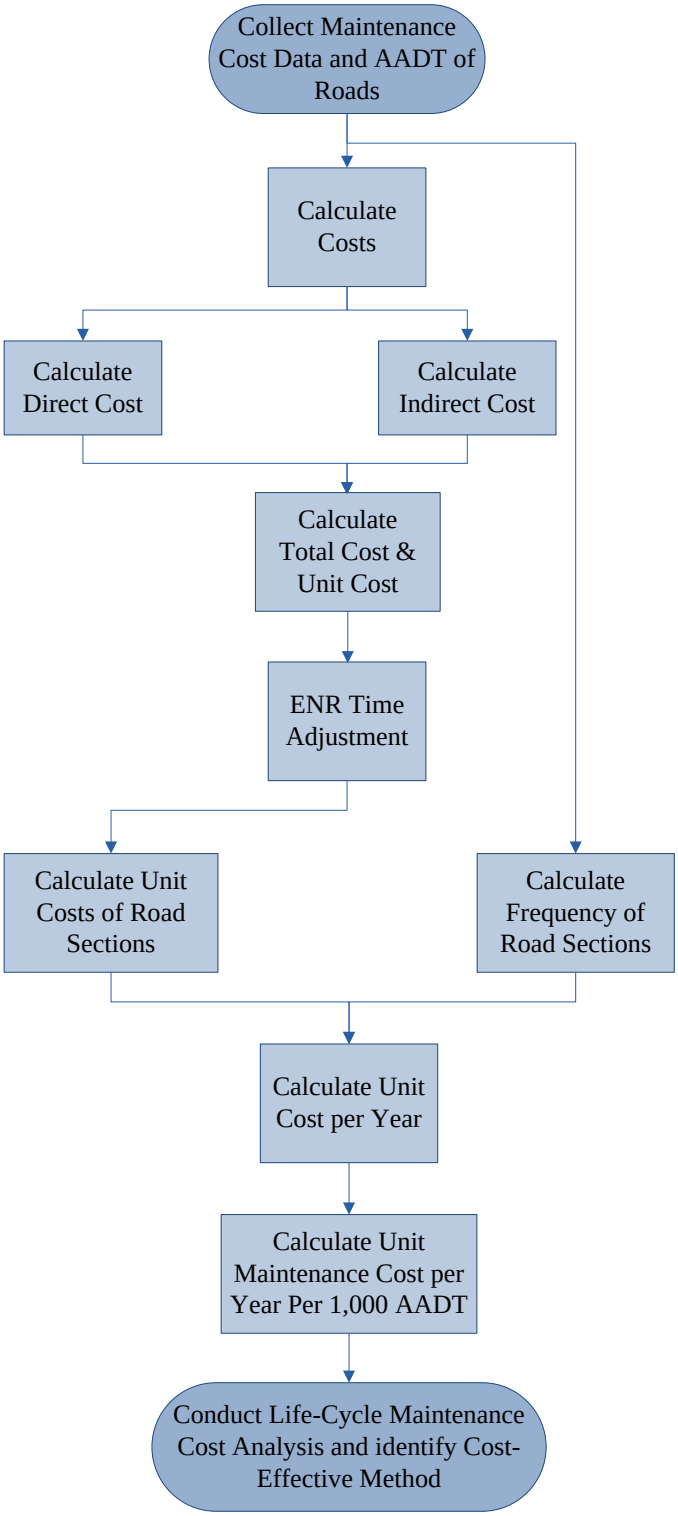


FIGURE 2-3. Determination of life-cycle maintenance costs.

2.3 Quality Assessment of Activities Performed by SF and Private Contractors

To determine the quality of these four road-maintenance activities, on-site quality evaluations were conducted and surveys were taken that rated the satisfaction of road users, NDOT maintenance personnel, and private contractors. Details of the process for the on-site quality evaluation and the surveys are described in the following sub-sections.

2.3.1 Process for On-Site Quality Evaluation of Maintenance Activities

Various performance measures were developed for on-site evaluation of the quality of work performed of these four maintenance activities. Five performance measures were developed chip seal: the presence of potholes, the loss of aggregate, the presence of cracks on the surface, the presence of rutting, and uniform distribution of the aggregate on the surface. These metrics were measured on sample road sections, and quantitative measurements were converted into a subjective scale. The measures were rated on a scale of 1 to 5, '5' being 'very satisfied' and '1' being 'very dissatisfied.''

For striping, three performance measures were used to visually monitor and rate the quality of work: visibility of the striping by day, visibility of the striping at night, and alignment of the striping. The measurements were visual, and rated on a scale of 1 to 5. For culvert cleaning, the three performance measures were cleanliness of the pipe culvert downstream, upstream, and inside the pipe. The researchers conducted a visual inspection, and gave a rating from between 1 and 5. The roadside cleaning was measured by identifying the cleanliness on left shoulder, right shoulder, and median; these measures were rated from 1 to 5 as well. The performance data sheet for these four road maintenance activities is provided in Appendix D.

To conduct the on-site evaluation for quality, at least four road sections were selected for each of the activities performed by SF and private contractors under the MBC. NDOT had performed only one PBC striping contract, and this PBC contract on striping was evaluated as well. The following factors were considered when selecting the road sections:

1. All roads were maintained in the same year.
2. The roads had similar AADT.
3. The roads had similar terrain and weather conditions.
4. The length of the road sections was between 3 and 40 miles.
5. For the on-site evaluation, each road section was divided into 0.10-mile-long samples.

Random stratified sampling was used to select a minimum of 30 samples from each road section. If the road was 3-miles long, the road section was divided into 30 samples of 0.10 miles in length. The entire lengths of the road sections were evaluated. If the road section was 6-miles long, then 60 sample sizes were available, and every other sample was evaluated. In some road sections, however, more than 30 samples were taken because the during site visit, it was found

that the actual length of the road was longer than previously estimated. Table 2-3 shows the selected road sections selected for on-site quality evaluation.

TABLE 2-3 Road Sections Selected for On-Site Quality Evaluations

S. N.	Maintenance Activities	Name of Selected Road Sections		
		State Force	MBC	PBC
1	Chip Seal	2 sections of US 93, US 06, SR 266	2 sections of US 93, SR 121, SR 305, SR 447, SR 225	-
2	Striping	2 sections of US 95, SR 163, SR 160	2 sections of: US 93 2 sections of US 95	US 95
3	Culvert Cleaning	US 93, US 95, SR 160, SR 163	US 50, 2 sections of SR 28, SR 431	-
4	Street Sweeping	2 sections of SR 592, SR 574, SR 596	SR 159, SR 573, SR 593, SR 612	-

2.3.2 Rating Surveys for Quality Satisfaction of Maintenance Activities

To assess the quality of maintenance work performed by SF and private contractors, a survey was conducted with road users for the selected road section, NDOT maintenance personnel, and private contractors. The detailed of these surveys are described below.

2.3.2.1 Surveying Users of Selected Road Sections

In the survey, provided in Appendix E, a minimum of 30 responses from road users was collected for each selected road section. This survey was distributed to road users during the site visit. During the questionnaire distribution, the road users were not aware of whether the road was maintained by the SF or by private contractors. The research team used the following five ways to collect survey responses:

1. Standing at a gas station that was within the road section or nearest to that section.
2. Standing along the road section to request road users to participate in the survey.
3. Visiting local offices and business centers to request that they participate in the survey.

4. Dropping empty pre-paid envelops in mailboxes of the road users.
5. Distributing empty pre-paid envelopes to the road users.

2.3.2.2 Quality Satisfaction Rating Survey with NDOT Personnel

In addition, a survey was conducted with personnel working in NDOT's maintenance division. The respondents were asked about the overall quality of these four maintenance activities performed by SF and private contractors. The questions were similar to the survey given to road users and the rating scale was same. However, in this survey, the NDOT personnel evaluated their overall satisfaction with the performance of SF and private contractor for these four activities, and was not specific to the selected road sections. This survey was web-based and used an online survey tool, Qualtrics. The link to the survey was sent to the respondents by email. The questionnaire is shown in Appendix F.

2.3.2.3 Quality Satisfaction Rating Survey with Private Contractors

Finally, a survey was sent to private contractors regarding the overall quality of work performed by SF and private contractors for these four maintenance activities. These private contractors were the ones who had performed one of these four maintenance contracts with NDOT. The survey was web-based, and used the online survey tool, Qualtrics. The link to the survey was sent to the respondents by email. The questionnaire is shown in Appendix G.

CHAPTER 3: RESEARCH RESULTS

In this study, surveys were conducted with state DOTs to identify the current practices, advantages, disadvantages, and factors affecting whether to select the in-house workforce or outsource maintenance. The first questionnaire was sent to NDOT in order to identify the contracting methods used for various road maintenance activities. A second questionnaire was sent by email to 49 state DOTs in the summer of 2013.

The research team collected cost data of chip seal, striping, culvert cleaning, and street sweeping performed by SF and private contractors from NDOT. The data from 1991 to 2013 were collected to determine the life-cycle cost and unit maintenance cost of these four activities.

To assess the quality of work conducted by SF and private contractors, the research team conducted on-site visits to selected road sections of Nevada. Then, a survey was conducted with road users of those road sections. A separate survey was sent to NDOT maintenance personnel and private contractors to rate the quality of work performed by SF and private contractors. The results of the surveys, cost analysis, and quality assessment are described below.

3.1 Survey Results for NDOT and State DOTs

Results of questionnaire survey with NDOT maintenance division personnel are described below.

3.1.1 Survey Results of NDOT Personnel

When asked about the types of maintenance work performed by NDOT using their own state force, NDOT personnel identified these activities, as described in Table 3-1. NDOT personnel reported that activities described in Table 302 were performed by private contractors using the MBC method. NDOT personnel stated that they only performed striping by using the PBC method. They did not suggest any activities provided in the survey list to be performed using the PBC method.

TABLE 3-1 Maintenance Activities Performed by NDOT State Force

PAVEMENT SURFACES		
Paved Surfaces		
Asphalt Pavement	Patch the potholes Fill up rutting Seal the cracks Provide chip seal Provide slurry seal	Provide thin overlays of asphalt Provide and maintain road striping Sweep and clean pavement
Concrete Pavement	Patch the concrete pavement Seal/repair joints	Repair spalls Sweep and clean pavement
Unpaved Gravel Surfaces		
Patch potholes	Blade gravel surface	

	Provide thin overlays of gravel material	
SHOULDER MAINTENANCE		
Paved Shoulders	Patch the potholes Fill up rutting Provide crack sealing Provide chip seal Provide slurry seal Provide thin asphalt/concrete overlays	Seal joints between pavement and shoulder Patch the shoulder Provide thin overlays on shoulders Seal/repair joints Repair spalls Sweep and clean shoulders
Unpaved Shoulders	Blade shoulders Patch potholes Provide thin overlays of gravel materials	
MANHOLES	Adjust and maintain manholes Replace covers as necessary	
DRAINAGE SYSTEM		
Paved Drains	Clean and maintain ditches Clean and maintain swales Remove debris and silt from inlet and within catch basin Clean and maintain culverts and storm drains Clean and maintain drains Clean and maintain inlets of cross drainages Clean and maintain cross drainage pipes Clean and maintain box culverts Clean and maintain paved ditches Clean and maintain entrance pipes	Clean and maintain under drains Clean and maintain upstream of cross drainage Clean and maintain downstream of cross drainage Clean and maintain edge drains Clean and maintain curbs and gutters Clean and maintain storm water pipes Clean and maintain storm water management ponds Clean and maintain roadside drainage
Unpaved drains	Clean and maintain unpaved roadside drainage Repair slopes/grades of unpaved drains Repair alignment of ditches	
SIDE SLOPES	Repair and maintain slopes Drift sand or erosion Repair and maintain riprap Repair and maintain bulkheads	Repair and maintain erosion control structures Repair, fill, and cut slopes
CURBS	Repair and maintain granite and concrete curbs and gutters	
SIDEWALKS	Repair and maintain sidewalks	
MEDIANS	Repair and maintain paved medians Repair and maintain unpaved medians	
FENCING	Repair and maintain fences	
ROADSIDE	Control weeds Pick up debris and litter	Remove graffiti from the roadside

	Clean up (emergency) after storms Mow and maintain grass	Repair and maintain sound barriers
RIGHT OF WAY (ROW)	Maintain vegetation Pick up foreign elements Maintain stockpiles on Right of Way Remove encroachments Repair and maintain object markers and delineators Repair and maintain glare foils Repair and maintain emergency facilities Repair and maintain rest areas	
SNOW AND ICE REMOVAL	Remove and plow snow from the road pavement and shoulders	
TRAFFIC SAFETY		
Road Signs and Markings	Repair and maintain road signs Clean and maintain paint striping Maintain reflective pavements markings	Maintain raised pavement markings Repair and maintain illuminations
Traffic Attenuators, Guardrails, and Barriers	Repair, reconstruct, and maintain damaged guardrails Repair and maintain attenuators of various types/designs, including their platforms Repair and maintain anchorages and bolted bases Repair and maintain retaining walls Repair and maintain median barriers Repair and maintain concrete barriers	
Traffic Lights	Repair and maintain street lights Repair and maintain lighting systems Repair and maintain group of incandescent lamping Repair and maintain mercury-vapor lamps and high-pressure sodium vapor lamps Replace broken glassware Repair and maintain photoelectric controls and all other parts of lighting fixtures Repair and maintain incandescent and mercury fixtures to high-pressure sodium fixtures, as directed Respond to citizens' requests for streetlight repairs Repair and replace sign lights (warning and regulatory information/guide and parking) Repair and maintain variable message signs Repair and maintain traffic detector loops Repair and maintain the electrical cable system.	

TABLE 3-2 Maintenance Activities Outsourced to MBC Contractors

PAVEMENT SURFACES		
Paved Surfaces		
Asphalt Pavement	Provide chip seal Provide slurry seal Provide thin overlays of asphalt	Provide and maintain road striping Sweep and clean pavement
Concrete Pavement	Provide thin overlays of asphalt concrete Sweep and clean pavement	
Unpaved Gravel Surfaces		
Patch potholes		
SHOULDER MAINTENANCE		
Paved Shoulders	Provide chip seal Provide slurry seal	Sweep and clean shoulders
Unpaved Shoulders		
MANHOLES	Adjust and maintain manholes	
DRAINAGE SYSTEM		
Paved Drains	Remove debris and silt from inlet and within catch basin Clean and maintain culverts and storm drains Clean and maintain drains Clean and maintain inlets of cross drainages Clean and maintain cross drainage pipes Clean and maintain box culverts	Clean and maintain entrance pipes Clean and maintain under drain Clean and maintain upstream of cross drainage Clean and maintain downstream of cross drainage Clean and maintain edge drains Clean and maintain storm water pipes
Unpaved drains		
SIDE SLOPES	Repair and maintain erosion control structures	
CURBS		
SIDEWALKS		
MEDIANS		
FENCING		
ROADSIDE	Control weeds Pick up debris and litter	Clean-up (emergency) after storms Repair and maintain sound barriers
RIGHT OF WAY (ROW)	Repair and maintain rest areas	
SNOW AND ICE REMOVAL		
TRAFFIC SAFETY		
Road Signs and Markings		

Traffic Attenuators, Guardrails, and Barriers	Repair and maintain anchorages and bolted bases Repair and maintain retaining walls Repair and maintain median barriers Repair and maintain concrete barriers
Traffic Lights	Repair and maintain variable message signs

3.1.2 Survey Results of State DOTs

As shown in Table 3-3, 34 states responded to the survey, and 15 states did not fill out the questionnaire. The response rate was 69%.

TABLE 3-3 Questionnaire Survey Responses

Detail	Count	Percentage
Number of responses	34	69%
Number of non-responses	15	31%
Total questionnaire sent	49	100%

The survey consisted of five sections: 1) General information; 2) Road maintenance contracting methods and satisfaction levels when using these methods; 3) Performance assessment of using SF as well as MBC and PBC methods; 4) Cost analysis; and 5) Information about the use of the PBC method. The general information collected was the name of the agency, the names of the respondents, telephone numbers, and email addresses.

Figure 3-1 shows that there were 14 states that have had experience with using the PBC method, including Nevada. District of Columbia has also performed maintenance work using PBC. All the states that responded use SF for road maintenance projects.

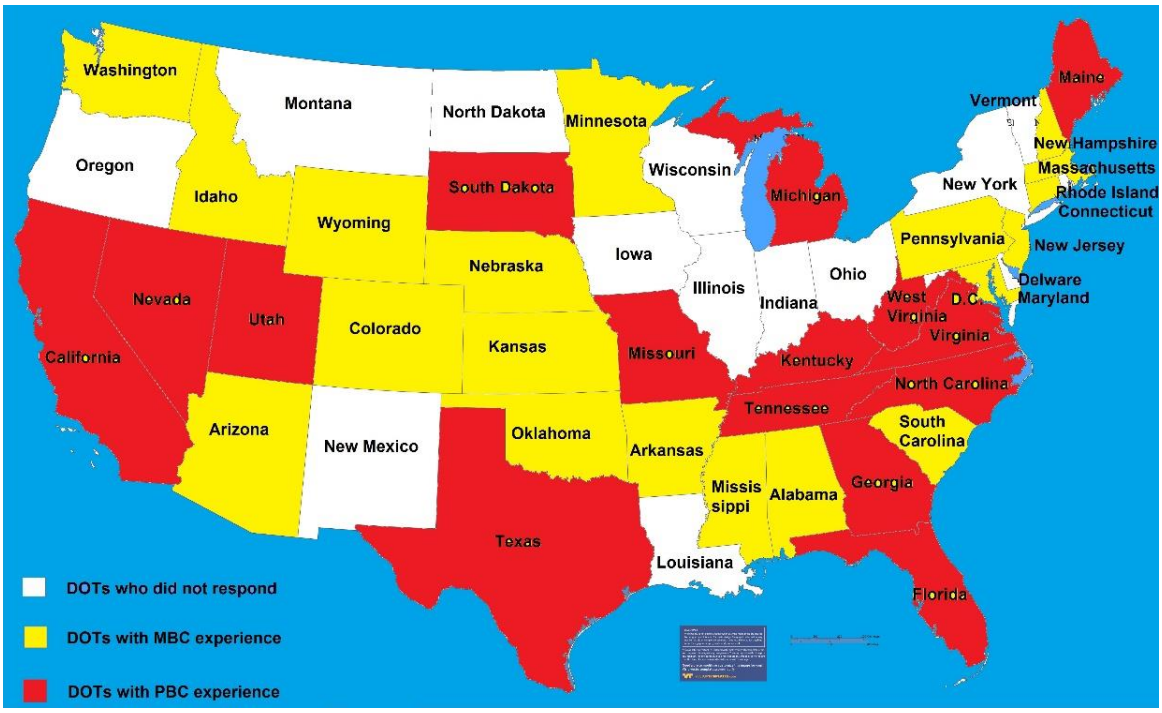


FIGURE 3-1. States with MBC and PBC experience. Red indicates states that had experience with the PBC and MBC methods. Yellow signifies states that had experience with MBC only. White color signifies states that did not respond to the questionnaire.

The state DOTs were asked about experiences with SF and private contractor-performed MBC and PBC road maintenance. The survey results in Figure 3-2 shows that all state DOTs had maintained the roads with SF, 91% had maintained the road through MBC, and 38% through PBC. Although PBC is a new method, more than one-third of the states had experience with the use of the method.

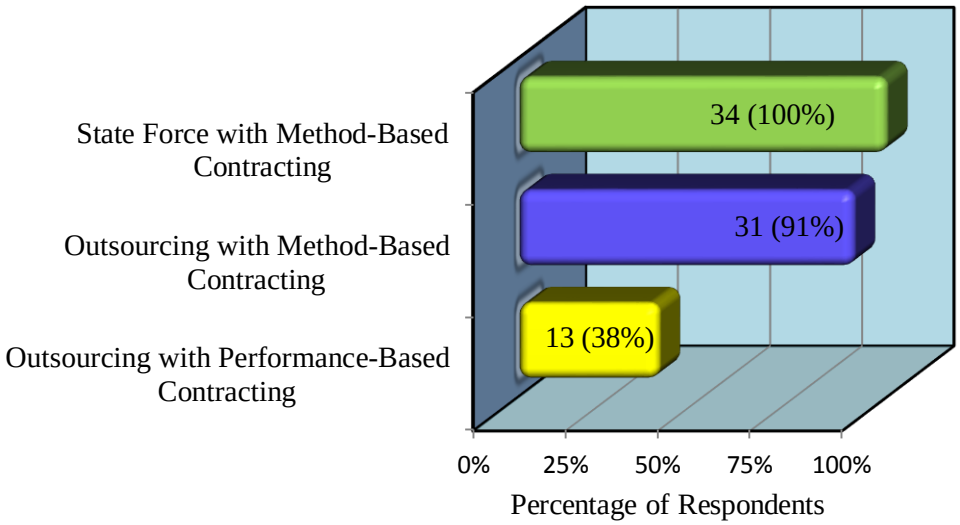


FIGURE 3-2. Use of road maintenance contracting methods by state DOTs.

The state DOTs were asked to check the appropriate box(es) for the listed maintenance activities as to whether they were performed by using SF, MBC, and/or PBC. Figure 3-3 shows the results of their responses. All respondents used SF for snow and ice removal. For other road maintenance activities, most respondents used SF to maintain traffic safety, side slopes and medians, shoulders, road pavements, sidewalks and curbs, and right of way, and fencing. A few state DOTs used PBC to maintain these road activities.

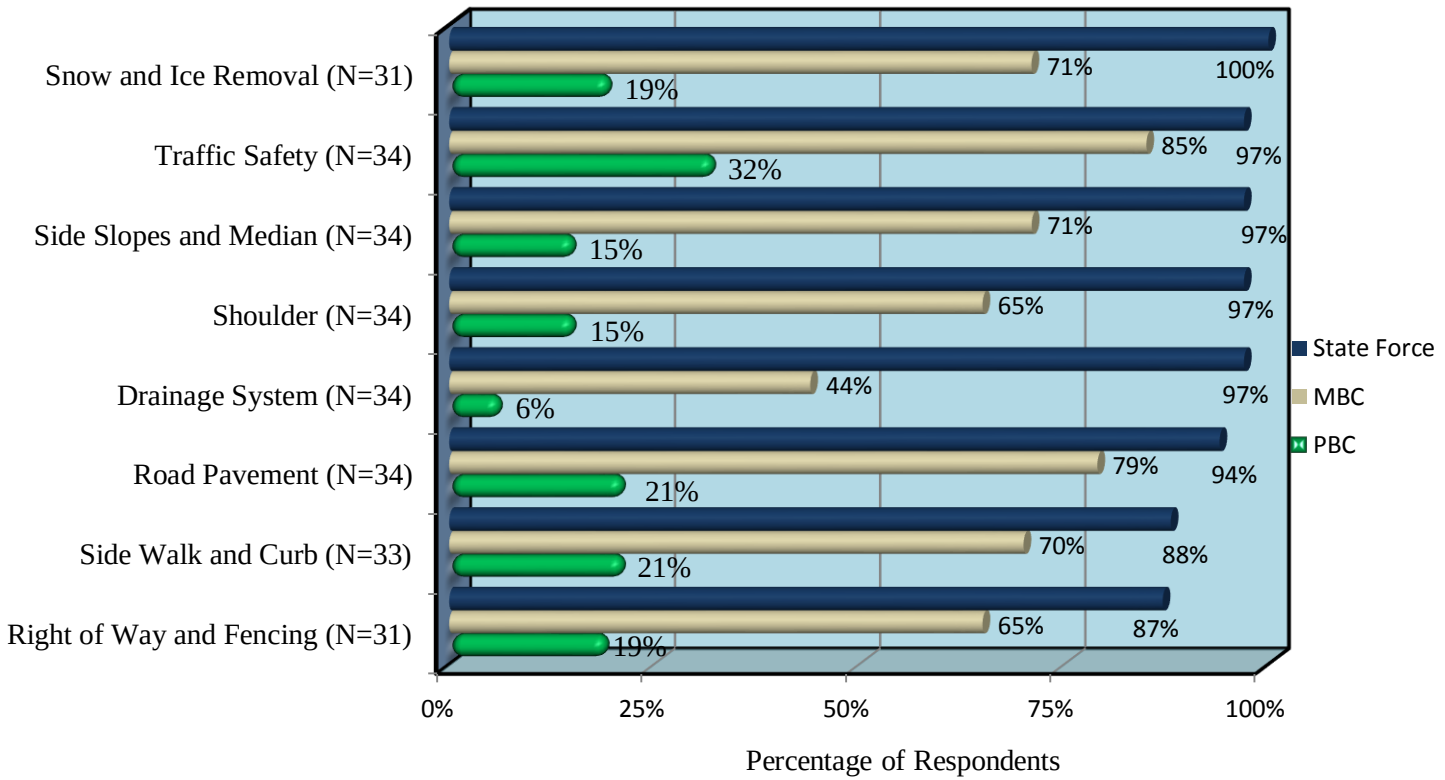


FIGURE 3-3. Eight road maintenance activities maintained by three methods: the use of state force (in-house) and the use of MBC and PBC contractors.

The state DOTs were asked which specification methods they used in 2012 for most of their road-maintenance activities. Figure 3-4 shows that most DOTs used the SF method (74%), 32% used MBC, and 3% used PBC to maintain their roads.

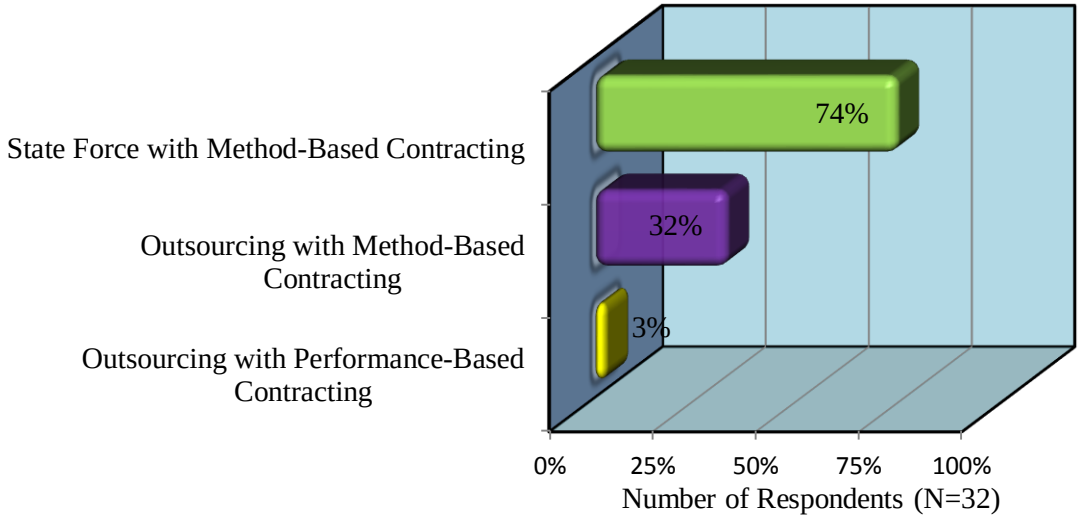


FIGURE 3-4. Types of contracting methods used in maintaining roads during 2012.

The state DOTs were asked to estimate the percentage of their maintenance budget allocated to SF, MBC, and PBC methods in 2012. Table 3-4 shows that, on average, most DOT budgets were expended on road maintenance using SF. Some DOTs allocated up to 45% of the budget to perform road maintenance by private contractors using PBC.

TABLE 3-4 Distribution of Estimated State DOTs' Road Maintenance Budget (N=33)

S.N.	Methods of Road Maintenance	Mean Budget (%)	Minimum Budget (%)	Maximum Budget (%)
1	State Force	63	10	100
2	Maintenance-based Contracting (MBC)	37	1	85
3	Performance-based Contracting (PBC)	10	1	45

The state DOTs were asked to rate their satisfaction levels regarding their experiences using SF, MBC, and PBC methods, rated on a scale of 1 to 5, '1' being 'very dissatisfied' and '5' being 'very satisfied.' The results showed that the SF method was rated high, followed by MBC and PBC methods (Figure 3-5).

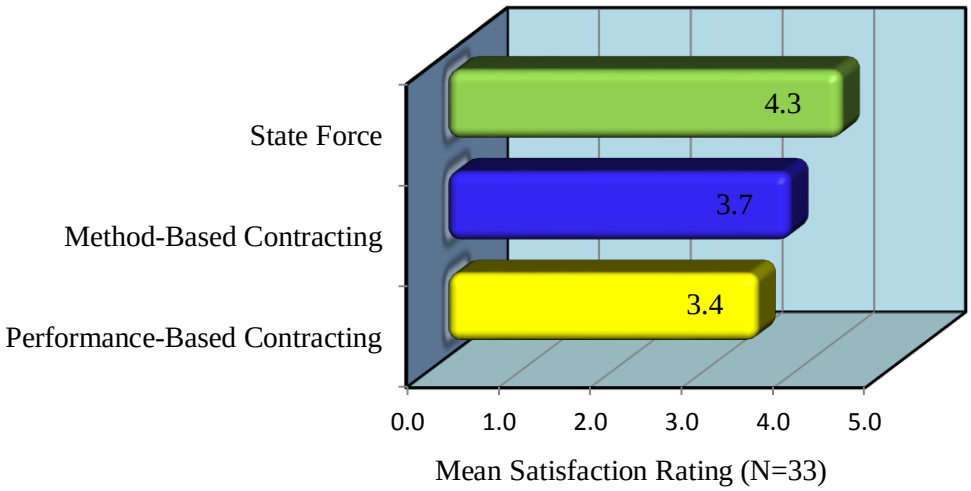


FIGURE 3-5. Satisfaction level of state DOTs regarding their experience with SF, MBC, and PBC methods.

The state DOTs were asked to rate satisfaction levels regarding five benefits of using the SF method, as shown in Figure 3-6. The results showed that the benefit 'quick response for emergency activities' were rated highest, followed by 'schedule advantage' and 'cost effectiveness'.

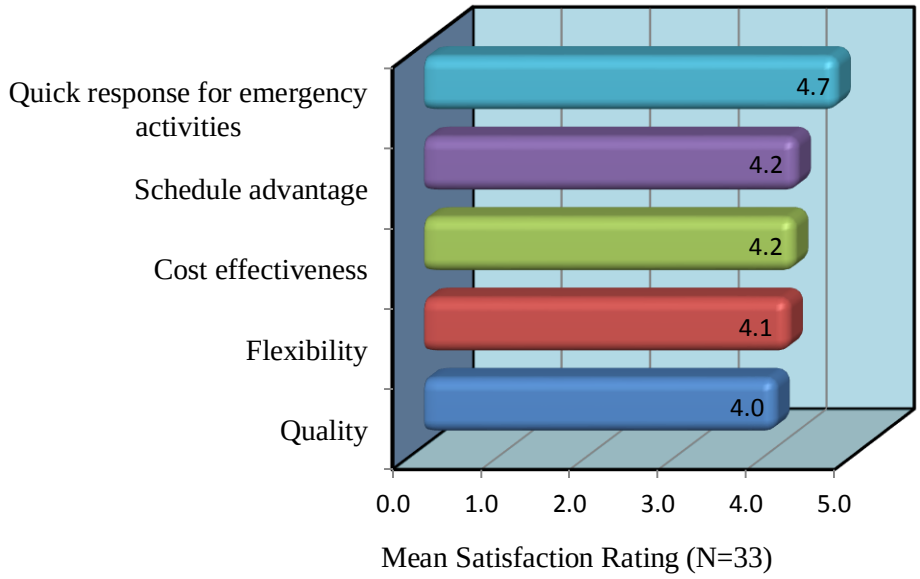


FIGURE 3-6. Satisfaction level of state DOTs regarding five benefits of using State Force (SF) to maintain roads.

In addition, the state DOTs were asked to rate five benefits of contracting projects to private contractors (Figure 3-7). They rated 'quality' the highest, followed by 'cost

effectiveness', and 'schedule advantage'. When compared with ratings of these benefits when using SF to maintain roads, SF outperformed using MBC contractors.

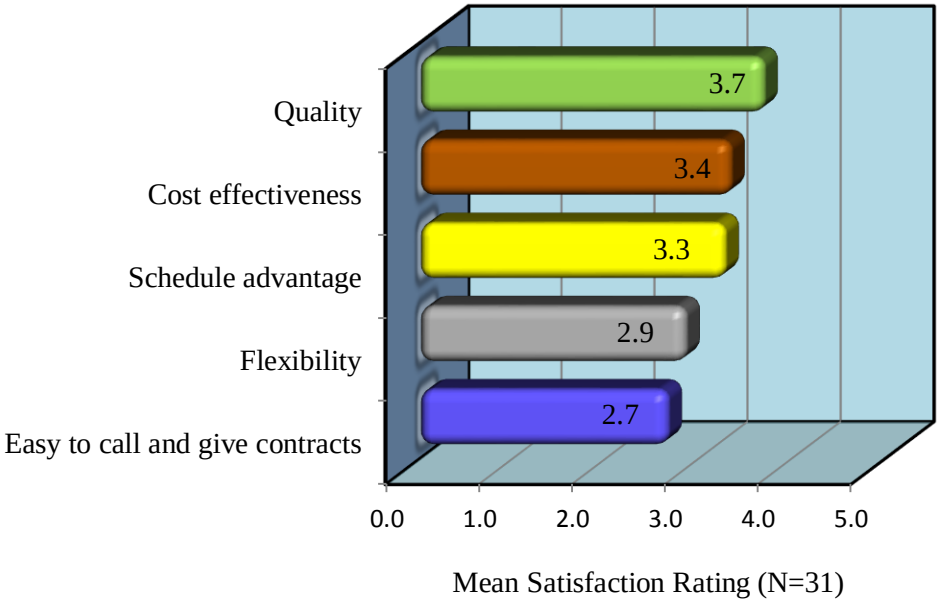


FIGURE 3-7. Satisfaction ratings of state DOTS regarding benefits of contracting out road maintenance to MBC contractors.

The state DOTs were asked to rank the three methods for maintaining emergency road work (e.g., snow removal). They ranked the SF method as the most preferred method to conduct that type of work, followed by MBC and PBC. Of the 33 respondents, 29 provided ranked the SF method first.

The state DOTs were asked to provide the 'lessons learned' from using SF and outsourcing methods. The top two lessons learned from using SF method were 1) 'the work should be clear and easy to understand' and 2) 'the department should hire qualified personnel and/or multi-skilled workforce' (Table 3-5).

TABLE 3-5 Lessons Learned from Using State Force

S.N.	Description	Percent of Respondents
1	The work should be clear and easy to understand	18%
2	The department should hire qualified personnel and/or multi-skilled workforce	18%
3	It is easier to respond to unanticipated maintenance works, monitor, and track cost.	12%

The state DOTs were asked to describe lessons learned from outsourcing road maintenance projects to private contractors. The major lessons learned from using contractors was that the state DOTs should ensure that the specifications and the contract documents are clearly written (Table 3-6). In addition, 17% of the state DOTs stated that inspectors and administrators should clearly understand and embrace the use of performance-based contracts.

TABLE 3-6 Lessons Learned from Outsourcing to Private Contractors

S.N.	Lessons Learned	Percent of Respondents
1	Ensure specification and contract documents are clearly written.	44%
2	For PBC, inspectors and administrators clearly understand and embrace the contract.	17%
3	The PBC should be long-term contract. The scope should be dynamic so that the contract always follows the current policies set.	11%

The state DOTs that had experience using PBC were asked to provide lessons learned during the implementation of that method. These were collected from four phases of the project: 1) the contract procurement phase, 2) the initial baseline measurement phase, 3) the performance measurement phase, and 4) the payment phase. Table 3-7 shows the top three lessons learned during these four phases.

TABLE 3-7 Lessons learned using Performance-Based Contracts

S.N.	Description	Percent of Respondents
Contract procurement phase (N=7)		
1	Hold pre-bid meetings	43%
2	Develop detailed measures of all assets	29%
3	Set the duration of contract as long as you are comfortable.	29%
Initial baseline measurement phase (N=4)		
1	Make sure you have a good baseline	50%
2	Decide who performs baseline evaluations	50%
3	Contractors will do their own baseline to make sure you are accurate	25%
Performance measurement phase (N=7)		
1	Performance measures should be clearly defined, and an independent third party should conduct performance measurements	100%
2	Performance targets should align with your expectations and payments	29%
3	Use pre-existing performance standards, if possible, and provide training regarding PBC	14%

Payment phase (N=7)		
1	Certain measures include timeliness and are tied to the scheduled payment	43%
2	Payment should be based on performance	29%
3	It is a good idea to front-load a contract with higher payments early, and then move to the same amount each month.	14%

Twenty-three state DOTs did not use PBC, and were asked to identify the reasons for not using that method for road maintenance. The main reason was due to their satisfaction with current outsourcing methods. The respondents stated that they had enough expertise, skilled workers, and equipment within the state force to perform maintenance projects. Some respondents reported that there was a lack of long-term budget commitment from their state governments for road maintenance performed using PBC.

3.1.2.1 Satisfaction Levels of State Force, MBC, and PBC Methods

The state DOTs were asked to rate their satisfaction levels with overall performance when using the three maintenance contracting methods. The results showed that they were highly satisfied when using SF, followed by MBC and PBC (Figure 3-8).

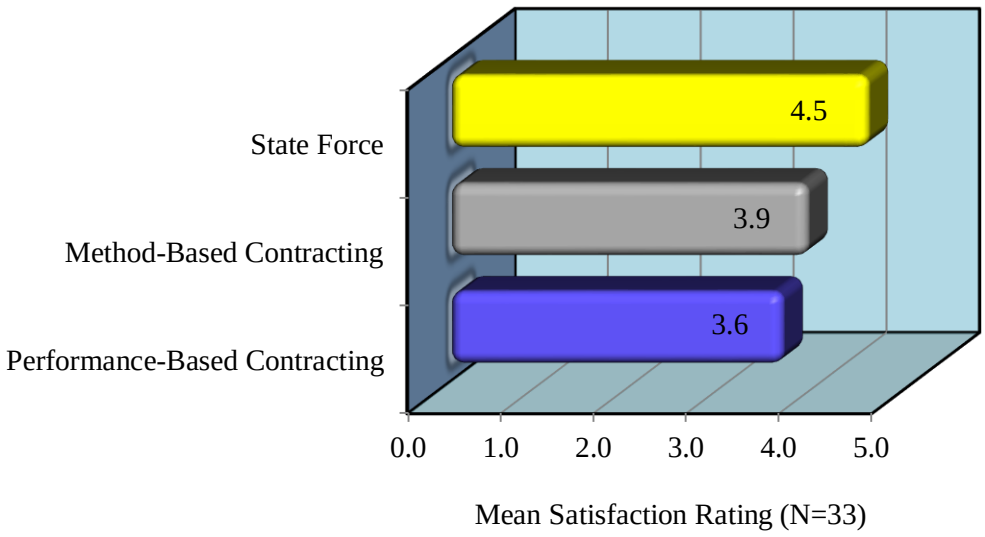


FIGURE 3-8. Satisfaction level of overall performance when using the three methods (SF, MBC, and PBC).

When rating their level of satisfaction regarding cost effectiveness for the three maintenance contracting methods, results showed that state DOTs were mostly satisfied with cost effectiveness provided by SF (Figure 3-9). They were equally satisfied with MBC and PBC when considering cost effectiveness.

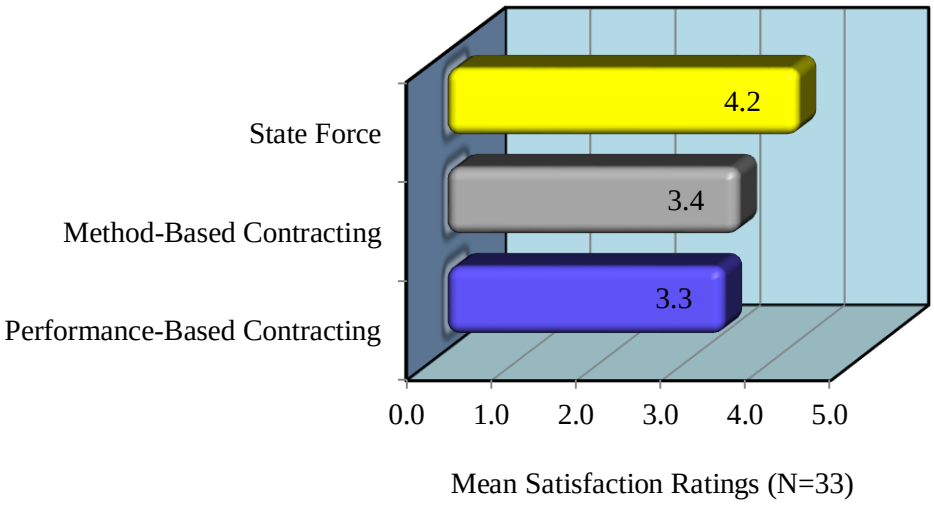


FIGURE 3-9. Satisfaction levels with the cost effectiveness of the three methods.

When rating their satisfaction level with schedule advantages of the three maintenance contracting methods, state DOTs were highly satisfied with the schedule advantage provided by SF, followed by MBC and PBC (Figure 3-10).

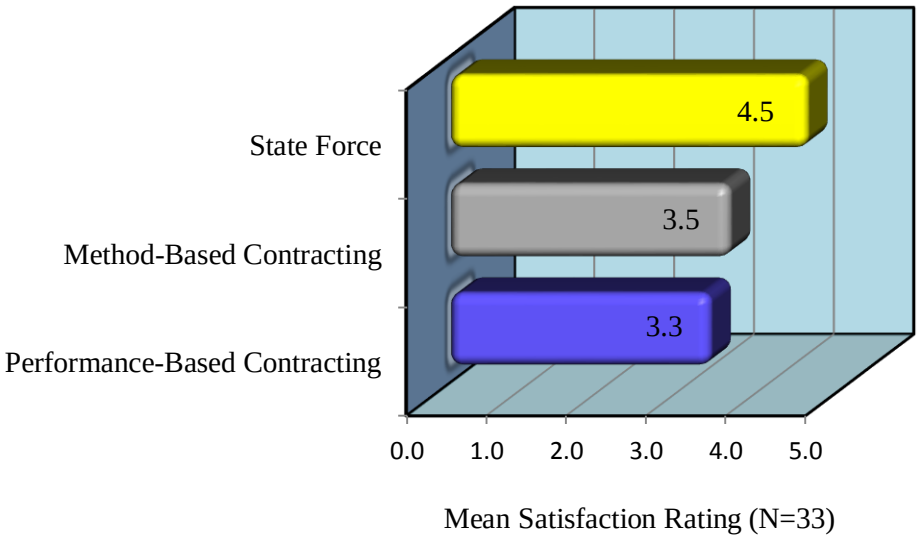


FIGURE 3-10. Satisfaction levels with schedule advantages of the three methods.

When rating the satisfaction level of state DOTs with the quality of work delivered by the three methods, the quality of work delivered by SF method was higher than that of MBC and PBC (Figure 3-11).

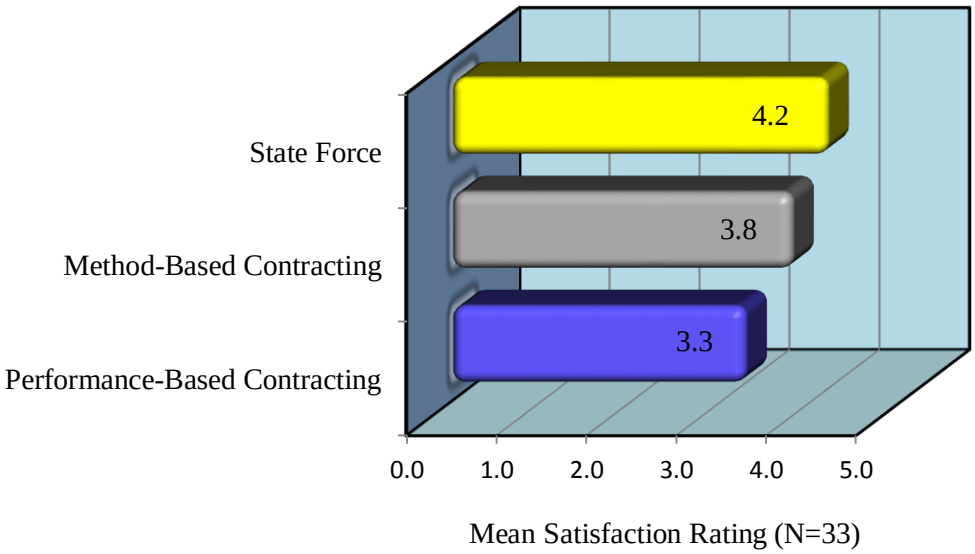


FIGURE 3-11. Satisfaction levels with the quality of work delivered by the three methods.

When rating their satisfaction level with risk transfer between the MBC and PBC methods, most state DOTs agreed that the PBC was better than MBC in terms of transferring the risk to private contractors (Figure 3-12).

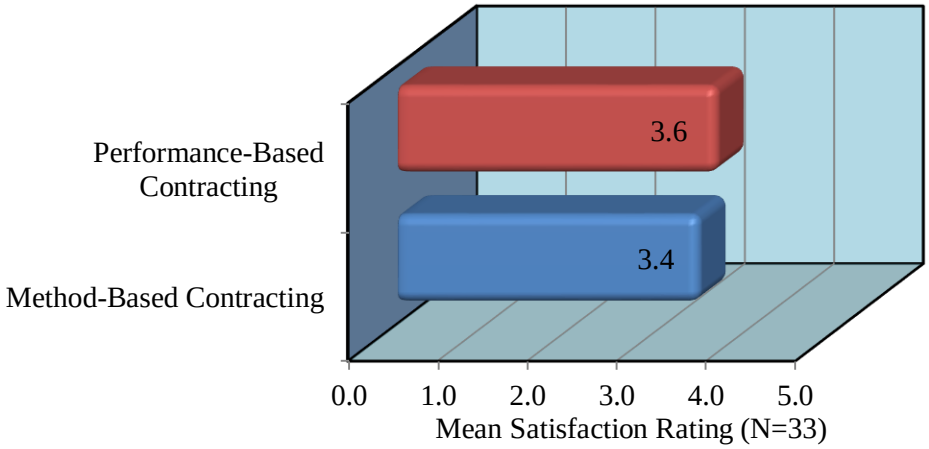


FIGURE 3-12. Satisfaction levels with risk transfer when using MBC and PBC methods.

The state DOTs were asked to rate the importance of five cost parameters that should be included when determining the maintenance costs of road activities using SF. The results showed that the most important cost parameter for determining maintenance cost was 'labor, material, and equipment costs'. Other cost parameters to be included in the cost analysis of maintenance projects are shown in Figure 3-13.

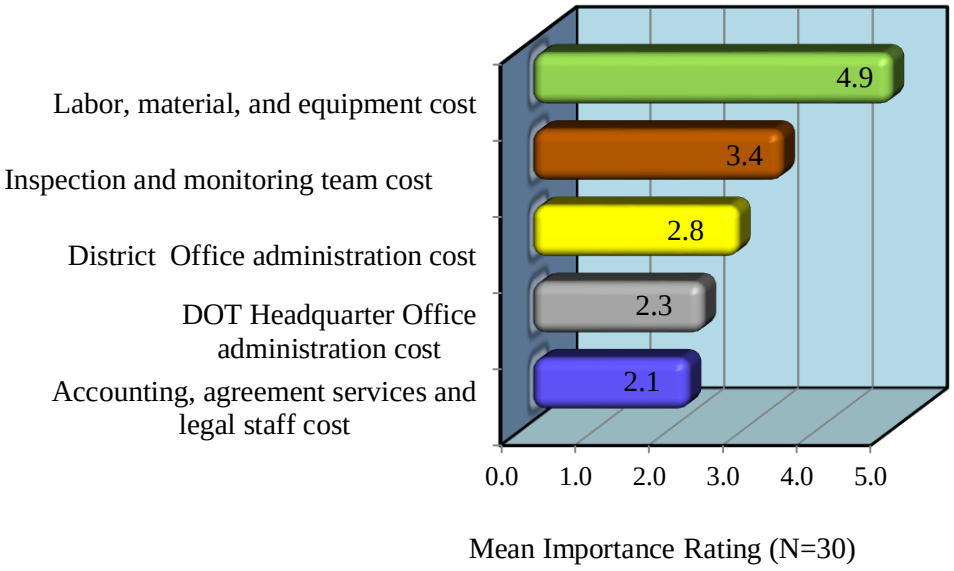


FIGURE 3-13. Cost parameters considered when using the State Force method.

Regarding cost parameters for outsourcing maintenance projects, the results were similar (Figure 3-14). However the mean importance rating of 'inspection and monitoring team cost' was higher than that of SF method.

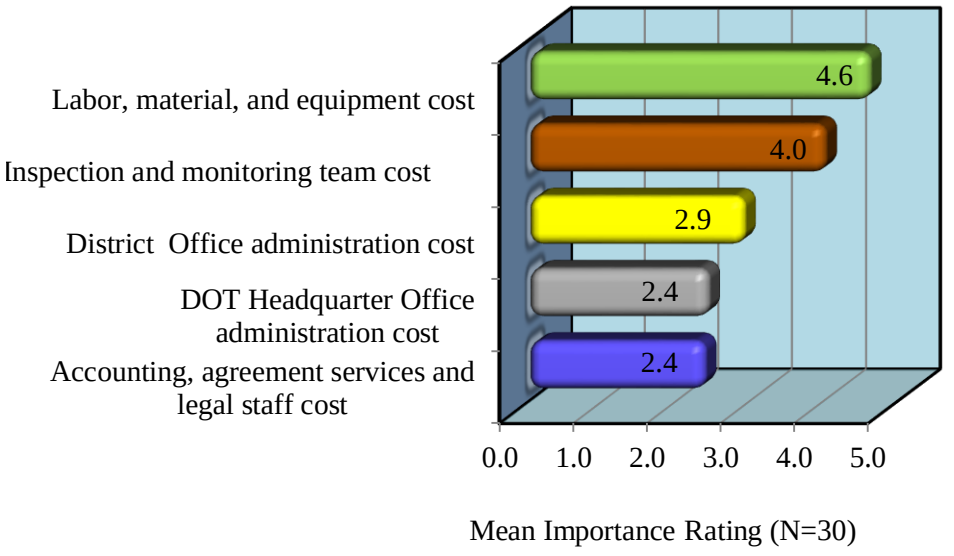


FIGURE 3-14. Cost parameters considered when outsourcing projects.

When the state DOTs were asked about cost analyses conducted by their DOTs to compare SF and outsourcing methods for road maintenance, 12 (35%) stated that they performed such a cost analysis. Based on follow-up questions to these DOTs regarding to the

cost effectiveness comparison between the two methods (MBC and PBC), 42% responded that comparing costs of the two methods were difficult; however, 33% stated that SF method was more cost effective than outsourcing projects (Figure 3-15).

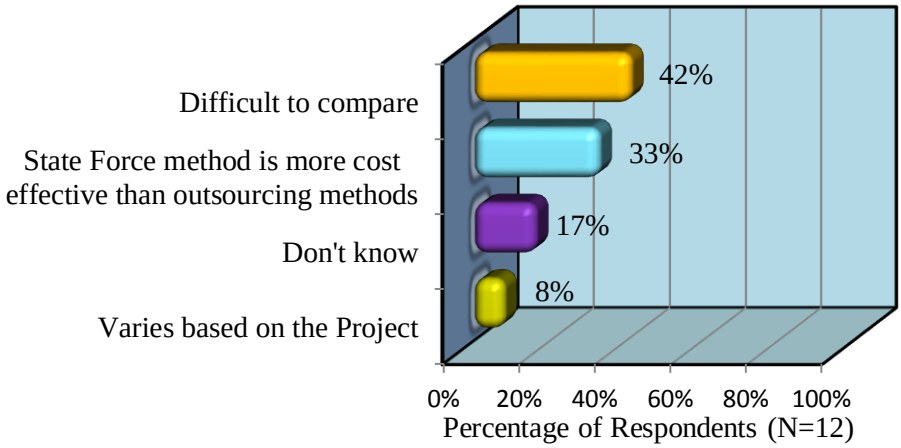


FIGURE 3-15. Result of cost comparison between State Force and outsourcing methods.

The state DOTs were asked whether the quality of the work performed should be considered while comparing the cost of SF and outsourcing methods. All the respondents stated that the quality of work should be factored in during the cost comparison.

3.1.2.2 Factors Affecting the Selection of Contracting Methods

State DOTs were asked to rate the selection criteria of SF and outsourcing methods for road maintenance activities on a scale of 1 to 5, 5 being 'very important' and 1 being 'least important'. A summary of the responses are shown in Table 3-8 for SF and Table 3-9 for outsourcing methods. Based on mean value of rating, the top three selection criteria for the SF method were 1) availability of DOT staff to accomplish additional works, 2) the DOT has the specific knowledge/skills for the job, and 3) budget constraints. For outsourcing, the top three were 1) lack of DOT staff to accomplish additional works, 2) the DOT has specific knowledge/skills for the job, and 3) to complete the task on schedule.

TABLE 3-8 Selection Criteria When Using State Force (N=33)

S.N.	Selection Criteria	Mean	Median
1	Availability of DOT staff to accomplish additional works	4.48	5.00
2	DOT has specific knowledge/skills for the job	4.16	4.00
3	Budget constraints	3.97	4.00
4	To complete the task on budget or to save money	3.86	4.00
5	Quality of work	3.69	4.00
6	Time constraints (N=30)	3.63	4.00
7	To complete the task on schedule (N=28)	3.43	3.50

TABLE 3-9 Selection Criteria for Outsourcing (N=32)

S.N.	Selection Criteria	Mean	Median
1	Lack of DOT staff to accomplish additional projects	4.37	5.00
2	DOT has no specific knowledge/skills for the job	3.55	4.00
3	To complete the task on schedule	3.43	3.00
4	To complete the task on budget or to save money	3.19	3.00
5	Time constraints	3.18	3.50
6	Quality of work	3.14	3.00
7	Long-term budget availability	2.89	3.00

3.2 Maintenance Costs

The maintenance cost of chip seal, striping, street sweeping, and culvert cleaning was calculated for work performed by SF and private contractors on various road sections of Nevada. Cost data was collected from 1990 to 2013. During this period, only chip seal and striping maintenance were performed repeatedly on the same section of roads.

The life-cycle maintenance cost (LCMC) for these two activities were calculated. Limited cost data were available for street sweeping and culvert cleaning, so only the unit maintenance cost per annum was calculated.

3.2.1 Life-Cycle Maintenance Cost

3.2.1.1 Chip Seal

To calculate the LCMC of chip seal conducted by SF, all costs spent on chip seal was collected from the inception of its maintenance. The average cost per square yard (SY) spent on the road section was calculated using the steps described in Section 2.2.2. The sample calculation of a unit cost of chip seal performed by SF in an SR 361 MI road section since 2001 is shown in Table 3-10.

TABLE 3-10 Details of Direct Cost for Chip Seal of SR 361 MI

Maintenance Year	Material Cost ($)	Labor Cost ($)	Equipment Cost ($)	Total Direct Cost ($)	Total Direct Cost (2014) ($)	Indirect Cost (17.06% Direct Cost) ($)	Total Cost of Chip Seal ($)	Unit Cost ($/SY)
2001	142,547	22,885	28,509	193,941	301,107	51,369	352,477	0.64
2009	313,199	59,154	206,870	582,223	668,096	113,977	7782,073	1.51
2011	481,565	39,384	105,185	626,134	678,951	115,829	794,779	2.34
				Average Unit Cost				**1.49**

The average unit cost spent in chip seal on a particular road section was divided by the average frequency of maintenance conducted by SF to determine the average unit cost spent per year. The average frequency of maintenance was calculated with the use of the steps mentioned in Chapter 3. It was determined from the cost data since 1990 that, on average, NDOT's SF performed chip seal on the road sections every 5.4 years. It was assumed that the frequency of maintenance of the chip seal would increase as the AADT of the road increased. Therefore, the average unit cost per year was divided by 1,000 AADT to determine the unit cost spent in chip seal per year per 1,000 AADT.

Table 3-11 shows the average chip seal cost per SY, average cost per SY per year, and average cost per SY per year per 1,000 AADT of 17 road sections. The detailed cost calculation is shown in Appendix H-1. The results show that the average cost per SY of chip seal performed by SF varied from $1.20 to $3.12. The average cost per SY per year for chip seal on road sections performed by SF was $0.31. When this value was normalized with AADT, the average cost per SY per year per 1,000 AADT was $0.97.

TABLE 3-11 Cost of Chip Seal Performed by State Force for Various Road Sections

S.N.	Name of Roads	Average Cost/SY ($)	Average Cost/SY/YR ($)	AADT	Average Cost/SY/YR/ 1000 AADT ($)
1	SR 361 MI	1.49	0.28	100	2.76
2	SR 361 NY	1.75	0.32	275	1.17
3	SR 375 LN	1.37	0.25	250	1.01
4	SR 375 NY	1.39	0.26	200	1.28
5	US 06 ES	1.32	0.24	625	0.39
6	US 06 MI	1.64	0.30	675	0.45
7	US 06 NY	1.61	0.30	450	0.66
8	SR 447 WA	2.50	0.46	933	0.49
9	SR 854 PE	3.12	0.58	700	0.82
10	SR 140 HU	1.43	0.26	370	0.72
11	SR 226 EL	1.38	0.26	250	1.02
12	SR 229 EL	1.95	0.36	137	2.62
13	SR 278 EL	1.32	0.24	160	1.53
14	SR 278 EU	1.60	0.29	700	0.42
15	SR 305 LA	1.36	0.25	1650	0.15
16	SR 400 PE	1.20	0.22	250	0.88
17	US 95 HU	1.95	0.36	3175	0.11
	Average	**1.67**	**0.31**		**0.97**

Similar procedures were followed to calculate the average unit cost of chip seal performed by private contractors for nine road sections. In the chip seal contracts, the striping is also included. Therefore the cost of striping should be taken out before calculating the chip seal cost. However, in the bid documents, the cost of chip seal and striping is combined. Therefore, the researchers investigated three chip seal contracts estimated cost and found that the striping cost is about 12.3% of the total estimated contract cost. The calculation is shown in Appendix H-2. For the road sections whose chip seal was performed by private contractors, the frequency of maintenance was found to be 3.16 years (shown in Appendix H-2). Detailed calculation of the unit costs for chip seal performed by private contractor are shown in Appendix H-2. The average cost per SY, average cost per SY per year, and average cost per SY per year per 1,000 AADT of MBC performed chip seal of nine road sections were calculated and shown in Table 3-12. The average of average costs per SY, average cost per SY per year, and average cost per SY per year per 1,000 AADT of chip seal performed by private contractor under MBC method were $3.14, $0.99, and $0.86 respectively.

TABLE 3-12 Cost of Chip Seal Performed by Private Contractors for Various Road Sections

S.N.	Name of Roads	Average Cost/SY ($)	Average Cost/SY/YR ($)	AADT	Average Cost/SY/YR/ 1000 AADT ($)
1	US 93 EL	3.29	1.04	1,450	0.72
2	SR 225 EL	3.29	1.04	633	1.64
3	SR 305 LA	3.29	1.04	1,650	0.63
4	SR 140 HU	3.29	1.04	370	2.81
5	SR 893 WP	3.29	1.04	-	-
6	US 93 CL	3.16	1.00	4,425	0.23
7	SR 147 CL	3.16	1.00	14,875	0.07
8	SR 341 LY	2.75	0.87	2,100	0.41
9	US 95 LY	2.75	0.87	3,233	0.35
	Average	**3.14**	**0.99**		**0.86**

Table 3-13 shows the average costs of chip seal performed by SF and private contractors. The average cost of chip seal per SY per year and the average cost per SY per year per 1,000 AADT performed by SF were $0.31 and $0.97, respectively; when performed by MBC contractors the costs were $0.99 and $0.86, respectively. The results showed that the average unit cost of chip seal per SY and unit cost per SY per year performed by SF are lower than that of performed private contractors. However, when the average unit cost was normalized with AADT, then the average unit cost of chip seal performed by private contractors was lower than that which was performed by SF.

TABLE 3-13 Cost Comparison of SF- and Private Contractor- Performed Chip Seal

Cost of Chip Seal	State Force	Private Contractors
Average Cost/SY ($)	1.67	3.14
Average Frequency of Maintenance (yrs)	5.42	3.16
Average Cost / SY/Yr ($)	0.31	0.99
Average Cost/SY/ Yr./ 1,000 AADT ($)	0.97	0.86

3.2.1.2 Striping

Similar procedures used in the previous section were followed to determine the LCMC of striping work performed by SF on six road sections. The striping maintenance is not affected by the AADT of the road section; therefore, the average unit cost was not normalized with AADT data. The cost data showed that, on average, NDOT's SF performed striping on these road sections every 1.39 years. The average cost per lane-mile (L-mile) per year for striping were calculated as $457.60 for SF-performed road sections (Table 3-14). The detailed cost calculation for each road section is shown in Appendix I-1.

TABLE 3-14 Cost of Striping of Road Sections When Performed by State Force

S.N.	Roads	Average Cost/ L-Mile ($)	Average Cost/ L-Mile/YR ($)
1	IR 15 CL	443.51	319.07
2	IR 215 CL	1400.33	1007.43
3	US 95 CL	489.75	352.34
4	US 95 ES	271.60	195.40
5	US 95 MI	962.92	692.75
6	US 95 NY	248.25	178.60
	Average	**636.06**	**457.60**

The average cost per L-mile and average cost per L-mile per year of striping work, performed by private contractors under MBC and PBC methods, was determined. Table 3-15 shows an average cost per lane mile per year for an individual road section. Striping was performed by private contractors in 9 road sections under MBC method, and one road section under PBC method. In MBC projects, the combined cost of chip seal and striping is found in the contract. Therefore, similar method used in the calculation of chip seal amount is used to calculate the cost of striping. The cost of striping is calculated as 12.3% of the total contract cost of chip seal and striping. When the unit cost of striping was calculated for these road sections, all the road sections unit striping cost was very similar, however for road section SR

140 HU, the unit cost of striping was coming about 3 times more than the average. Therefore this outlier data was removed. The cost data shows that on average, private contractors were performing striping on these road sections every 1.89 years under MBC. Under PBC, there was only one road section and the contract duration was 5 years. The data analysis results showed that the average cost per L-mile and average cost per L-mile per year of striping work performed by MBC method was $1,786.31 and $945.14 respectively, and that performed under PBC was $8,741.60 and $1,748.32 respectively. The detailed cost calculation for each road section is shown in Appendix I-2 for MBC and in Appendix I-3 for PBC.

TABLE 3-15 Average Cost Calculation for Striping of Roads Performed by Private Contractors (MBC and PBC)

S.N.	Road	Average Cost / L-Mile ($)	Average Cost / L-Mile /Yr ($)
PRIVATE CONTRACTORS UNDER MBC			
1	US 93 EL	1880.94	995.21
2	SR 225 EL	1880.94	995.21
3	SR 305 LA	1880.94	995.21
4	SR893 WP	1880.94	995.21
5	US 93 CL	1808.01	956.62
6	SR 147 CL	1808.01	956.62
7	SR 341 LY	1575.34	833.52
8	US 95 LY	1575.34	833.52
	Average Cost	**1,786.31**	**945.14**
PRIVATE CONTRACTOR UNDER PBC			
1	US 95 CL	8,741.60	1,748.32

Table 3-16 compares the average costs of striping performed by SF and private contractors under the MBC and PBC methods. The results showed that the average frequency of striping works performed by these methods were 1.39, 1.89, and 5.00 years respectively. The average cost per L-mile per year of striping work performed by SF and private contractors under MBC and PBC methods were $317.68, $659.65, and $1,748.32 respectively. It showed that average cost of striping work performed by SF was lower than that performed by private contractors under MBC and PBC.

TABLE 3-16 Striping Work Unit Cost per Year with SF, MBC, and PBC Methods

Description	SF Method	MBC Method	PBC Method
Average Cost/L-mi ($)	636.06	1,786.31	8,734.22
Average Frequency (yr)s	1.39	1.89	5.00
Average Cost/L-mi/yr ($)	457.60	945.14	1,746.84

3.2.2 Unit Maintenance Cost per Annum

3.2.2.1 Culvert Cleaning

In order to compare the culvert cleaning cost performed by SF and private contractors, five road sections were selected: SR 28 (DO 0.00-1.23, CC 0.00-3.95, WA 0.00-10.99), SR 207 (DO 0.00-3.20), SR 431 (WA 0.00-6.50), SR 760 (DO 0.00-0.61), and US 50 (DO 0.00-13.00). In these sections of road, culvert cleaning was performed by SF from 1990 to 2008. After that, from 2009 to 2011, culvert cleaning was contracted out to a private contractor. Therefore, to calculate the average cost spent per mile per year in these five road sections under SF and private contract, the total cost spent was divided by total miles and total number of years. The length of these five road sections was 39.48 miles. The cost was adjusted to a 2014 base cost, using the *ENR* cost index. Table 3-17 summarizes the total cost per year and the average cost per mile per year for culvert cleaning of five road sections performed by SF and private contractors. Detailed cost calculations are shown in Appendix J. The results show that the average cost spent per year by SF was lower than that spent by private contractors.

TABLE 3-17 Cost Comparison of Culvert Cleaning Performed by SF and Private Contractors

S.N.	Road Names	SF Method		MBC Method	
		Total Cost/Yr	Average Cost/ Mile/Yr	Total Cost/Yr	Average Cost/ Mile/Yr
1	SR 28				
2	SR 207				
3	SR 431	$176.978	$4,482.72	$260,292	$6,593.00
4	SR 760				
5	US 50				

3.2.2.2 Street Sweeping

The average cost per C-mile, cost per C-mile per year, and cost per C-mile per year per 1,000 AADT of street sweeping performed by SF in three road sections were determined, as shown in Table 3-18. The detailed cost calculation is shown in Appendix K-1. The cost data indicated that street sweeping was conducted in these road sections every year, and was performed by SF from 1990 to 2013. The total (direct + indirect) cost spent on these road sections during this period was added and divided by the total number of curb miles to get the average cost per C-mile per year. The cost was adjusted to a 2014 base cost by using the *ENR* cost index. From these data, the average cost per C-mile per year and the average cost

per C-mile per year per 1,000 AADT of SF-performed street sweeping was found to be $43.78 and $1.29, respectively; the average cost /C-mile/yr ranged from $42.50 to $46.25.

TABLE 3-18 Cost of Street Sweeping Performed by State Force (1990 – 2003)

S.N.	Road Names	Average Cost / C-Mile / Yr	AADT	Average Cost/ C-Mile/ Yr / 1,000 AADT
1	US 93 CL	$42.91	44,425	$0.97
2	SR 574 CL	$43.46	33,900	$1.28
3	SR 592 CL	$42.50	42,000	$1.01
4	SR 596 CL	$46.25	24,500	$1.89
	Average =	**$43.78**		**$1.29**

Table 3-19 shows the average cost per C-mile, the average cost per C-mile per year, and the average cost per C-mile per year per 1,000 AADT of street sweeping performed by private contractors under the MBC method. Street sweeping was performed from 2012 to 2014 by a single private contractor with a single bid in the road sections shown in this table. It was determined that the frequency of sweeping performed by private contractors on these road sections varied from every week to every month. Out of the seven roads under contract, the frequency of street sweeping for one road was every week, for five roads was every other week, and for the final road was every month. The total annual curb mile to be swept is 6,237. The average cost per C-mile per year and average cost per C-mile per year per 1,000 AADT of street sweeping performed by private contractors was found to be $64.13, and $1.70, respectively. Detailed cost calculations are shown in Appendix K-2.

TABLE 3-19 Cost of Street Sweeping Performed by Private Contractors (2012 – 2014)

S.N.	Road Names	Average Cost / C-Mile / Yr	AADT	Average Cost / C-Mile / Yr/ 1,000 AADT
1	SR 595	$64.13	39,445	$1.63
2	SR 593	$64.13	31,875	$2.01
3	SR 612	$64.13	33,155	$1.93
4	SR 573	$64.13	61,500	$1.04
5	SR 599	$64.13	39,445	$1.62
6	SR 159	$64.13	31,250	$2.05
7	SR 589	$64.13	39,445	$1.63
	Average =	**$64.13**		**$1.70**

The average cost of street sweeping performed by SF and private contractors is summarized in Table 3-20. The MMS data shows that the frequencies of street sweeping performed by SF were not consistent. All costs for street sweeping a road incurred in a year were summed up, and the average frequency of street sweeping was presented for one year. For the contract work, since the contract period was two years and 10 months, the average frequency of the work performed by the private contractor was presented as 2.83 years. The average costs of street sweeping per mile per year and average cost per mile per year per 1,000 AADT of SF and private contractors was $43.78, $1.29, $64.13, and $1.70, respectively. Results indicate that the unit cost of street sweeping performed by SF was lower than that performed by private contractors.

TABLE 3-20 Unit Cost for Street Sweeping When Using SF and MBC Contractors

DESCRIPTION	SF METHOD	MBC METHOD
Average Cost/C-mi/yr	$43.78	$64.13
Average Cost/C-mi/yr/ 1000 AADT	$1.29	$1.70

3.3 Quality Assessment of Road Maintenance Activities Performed by State Force and Private Contractors

The on-site quality evaluation consisted of two parts, researchers' evaluations and road users' evaluations. The results of these evaluations are described below.

3.3.1 Process of On-Site Quality Evaluation of Maintenance Activities

The on-site quality evaluation of chip seal are discussed below.

3.3.1.1 Chip Seal

Chip seal is a common pavement maintenance practice in which hot asphalt is spread over a prepared road surface, followed by spreading chips (crushed aggregates). The chip seal is compacted immediately by a rubber-tired roller.

In this study, chip seals performed by only SF and MBC contractors were evaluated because NDOT did not have a PBC contract for this maintenance activity. TABLE 3-21 shows details of the road sections that were evaluated by researchers during a site visit. The four road sections selected for this study whose chip seals were performed by SF were US 93 in Lincoln County (LN), SR 266 in Esmeralda County (ES), US 93 in Elko County (EL), and US 06 in Nye County (NY). Six road sections performed by MBC private contractors were selected for an on-site evaluation. These road sections were SR 121 in Churchill County (CH), US 93 in Clark County (CL), US 93 in Lincoln Country (LN), SR 305 in Landar County (LA), SR 447 in Washoe County (WA), SR 225 in Elko County (EL). AADT data for 2012 was available and collected for each of the road sections. Four different contractors performed chip seal on these road sections. The road sections selected were each maintained by different contractors.

TABLE 3-21 Evaluation of Chip Seal Performed by SF and MBC Contractors

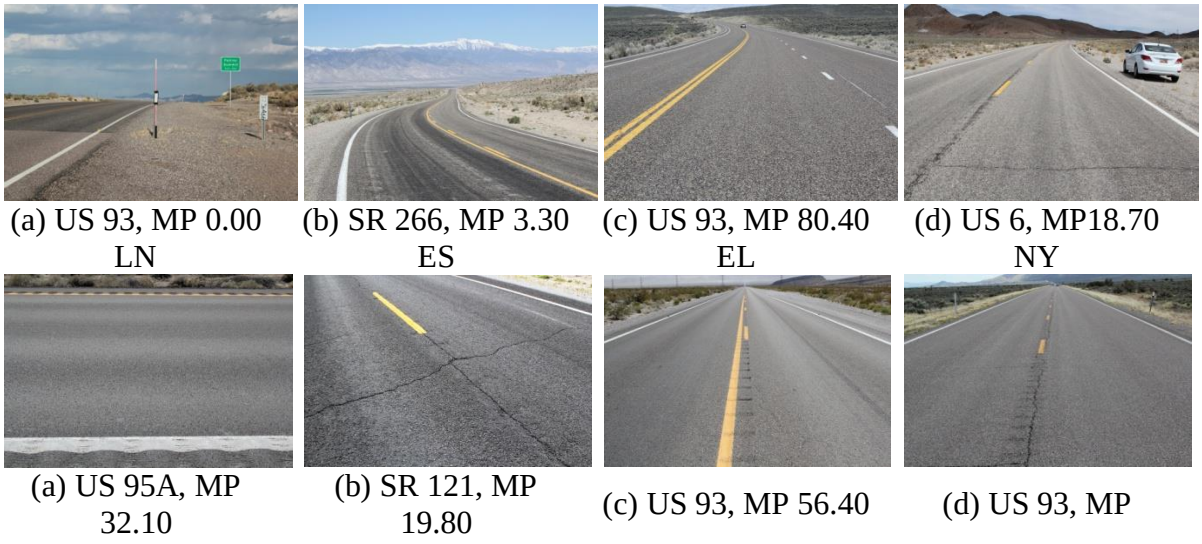
Method	Road Names	County	Mileage	AADT	Contract Date
State Force	US 93	LN	64-80	2,100	2012
	SR 266	ES	0-25	250	2012
	US 93	EL	74-83	1,450	2011
	US 06	NY	2-26	625	2011
MBC	SR 121	CH	0-27	60	2014
	US 93	CL	52-68	2,250	2012
	US 93	LN	109-132	1,200	2012
	SR 305	LA	69-97	1,650	2012
	SR 447	WA	10-25	933	2013
	SR 225	EL	112.9-127.5	633	2014

Table 3-22 shoes the average on-site evaluation ratings of these roads when performed by SF and MBC contractors. The mean rating for the loss of aggregates and the presence of cracks when SF performed the work was significantly higher than for MBC contractors. This means that a road section maintained by SF had a lower number of cracks and lower loss of aggregates than when private contractors maintained the roads. However, there was little difference between SF and private contractors in terms of road maintenance for potholes, rutting, and the distribution of aggregates. The overall mean rating for SF-maintained roads was higher than for roads maintained by private contractors.

TABLE 3-22 Researchers' Evaluations of Chip Seal Performed by SF and MBC Contractors

S.N.	Description	Methods	N	Mean	Std. Dev.
1	Presence of pot holes	State Force	120	5.00	0.00
		MBC	186	5.00	0.00
2	Loss of aggregate	State Force	120	4.98	0.16
		MBC	186	4.82	0.68
3	Presence of bleeding and cracks on the surface	State Force	120	4.62	0.55
		MBC	186	3.51	1.38
4	Presence of rutting	State Force	120	4.97	0.18
		MBC	186	4.96	0.23
5	Uniform distribution of aggregate on the surface	State Force	120	5.00	0.00
		MBC	186	4.97	0.31
Average		State Force	120	4.91	0.12
		MBC	186	4.65	0.10

Figure 3-16 shows chip-seal road surfaces maintained by SF and private contractors. The first row of pictures show four road-sections maintained by SF. The second row pictures displays roads maintained by private contractor. This figure indicates the milepost (MP) where each photo was taken during the site visit. The detailed photographs are located in Appendix L.



(a) US 93, MP 0.00 LN (b) SR 266, MP 3.30 ES (c) US 93, MP 80.40 EL (d) US 6, MP18.70 NY

(a) US 95A, MP 32.10 (b) SR 121, MP 19.80 (c) US 93, MP 56.40 (d) US 93, MP

FIGURE 3-16. Photos of state force and private contractors-performed chip seal roads. Mileposts (MP) where the photos were taken are indicated.

3.3.1.2 Striping

A striping is a pavement marking line of either white or yellow color used to guide drivers. The study evaluated striping performed by SF and private contractors under MBC and PBC methods. Table 3-23 provides details of the road sections that were evaluated onsite. Four SF-maintained road sections located in Clark County were chosen. Similarly, four road sections maintained by MBC private contractors were selected for on-site evaluation in CL, CH, LN, and Mineral (MI) counties. US 95 located in CL was selected for on-site evaluation in which a PBC private contractor maintained the striping.

TABLE 3-23 Road Sections Selected for Onsite Evaluation of Striping

METHODS	NAME OF ROADS	COUNTY	MILEPOST	AADT	CONTRACT DATE
State Force	US 95	CL	21-56	6,600	2012
	SR 163	CL	0-9	6,250	2012
	SR 160	CL	22-43	41,000	2013
	US 95	CL	97-132	3,300	2013
MBC	US 93	CL	52-68	2,250	2011
	US 95	CH	0-15	2,600	2011
	US 93	LN	109-132	1,200	2011
	US 95	MI	83-92	2,500	2011
PBC	US 95	CL	0-21	6,600	2012-2017

The quality of the striping activity was evaluated under three criteria:

1. The striping on the road is visible during the day,
2. The striping on the road is visible at night, and
3. The striping on the road is continuous and has straight alignment.

Table 3-24 shows the mean ratings of these three criteria for road sections maintained by SF as well as MBC and PBC private contractors. The result showed that the visibility of the striping line during the day was higher when done by PBC and MBC contractors than when performed by SF. However, there was no difference between striping performed by private contractors under MBC and PBC methods. When evaluating the visibility of striping at night, the PBC contractors performed this task better than SF or MBC contractors; however, there was no difference between SF and MBC contractors. In evaluating the third criteria – the line was continuous and at the right alignment – MBC contractors performed this work significantly better than SF or PBC contractors; however, there was no significant difference between SF and PBC contractors in performing this work. Overall, striping work performed by PBC contractors was performed better than by MBC contractors and SF. Similarly, striping performed by MBC contractors was better than work done by SF.

TABLE 3-24 Results of Researchers' Evaluation of Striping Works

S.N.	Description	Methods	N	Mean	Std. Dev.
1	The striping on the road is visible during the day	State Force	132	4.77	0.42
		MBC	122	5.00	0.00
		PBC	32	5.00	0.00
2	The striping on the road is visible at night	State Force	132	4.00	0.00
		MBC	122	4.00	0.00
		PBC	32	5.00	0.00
3	The striping on the road is continuous and has straight alignment	State Force	132	4.91	0.31
		MBC	122	5.00	0.00
		PBC	32	4.90	0.30
	Average	State Force	132	4.56	0.17
		MBC	122	4.67	0.01
		PBC	32	4.97	0.10

Figure 3-17 shows the photos of striping maintained by SF and private contractors under MBC and PBC. The first row of photographs were from four road sections maintained

by SF, and second and third rows' photographs were from private contractor-maintained roads under MBC and PBC respectively. It also shows the milepost (MP) where the photographs were taken during site visit. The detailed photographs have been shown in the Appendix M.

(a) US 95 CL, MP 21.00 (b) SR 163 CL, MP 8.90 (c) SR 160 CL, MP 33.70 (d) US 95 CL, MP 98.60

(a) US 93 CL, MP 67.30 (b) US 95 CH, MP 7.90 (c) US 93 LN, MP 130.80 (d) US 95 CL, MP 91.10

(a) US 95 CL, MP 0.00 (b) US 95 CH, MP 7.90 (c) US 93 LN, MP 110.00 (d) US 95 CL, MP 0.00

FIGURE 3-17. Photos of striping performed by SF and private contractors under MBC and PBC.

3.3.1.3 Culvert Cleaning

Table 3-25 shows the details of eight road sections whose quality of culvert cleaning was evaluated. Four road sections whose culvert cleaning was performed by SF method were selected for evaluation – US 95, SR 160, SR 163, and US 93, all located in CL County. Similarly, other four sections whose culvert cleaning was performed by private contractors under the MBC method were selected – SR 28, SR 431, US 50, and SR 28. The first two road sections were located in WA County, and the third and fourth road sections were located in DO and CC counties, respectively. The AADTs for these road sections were not available.

TABLE 3-25 Details of Road Sections Evaluated for Culvert Cleaning

Methods	Road Name	County	Mileage	Length	Date	AADT
State Force	US 95	CL	MP 10-56, 91.5, and 91.9	N/A	Need Base	N/A
	SR 160	CL	MP 24.50	N/A	Need Base	N/A
	SR 163	CL	MP 15.50	N/A	Need Base	N/A
	US 93	CL	MP 0-9.50	N/A	Need Base	N/A
MBC	SR 28	WA	WA 0-10.99	10.99	N/A	N/A
	SR 431	WA	0-6.5	6.5	N/A	N/A
	US 50	DO	0-13	13	N/A	N/A
	SR 28	CC	CC0-CC3.95	3.95	N/A	N/A

Table 3-26 shows the mean ratings of culvert cleaning performed by SF and private contractors under the MBC method. Cleanliness upstream, downstream, and inside the pipe was evaluated during on-site visits. The result showed that SF performed the work better than did MBC private contractors.

TABLE 3-26 Researcher's Rating of Culvert Cleaning

S.N.	Description	Methods	N	Mean	Std. Dev.
1	Debris that effects drainage was cleared on the upstream side of the culvert	State Force	40	4.60	0.74
		MBC	38	4.87	0.66
2	Debris that effects drainage was cleared on the downstream side of the culvert	State Force	40	4.83	0.45
		MBC	38	4.53	1.16
3	The inside pipe of the culvert was clear	State Force	40	4.52	0.82
		MBC	38	4.58	1.08
	Average	State Force	40	4.69	0.51
		MBC	39	4.65	0.85

Figure 3-18 shows the photographs of street sweeping performed by SF and private contractors under the MBC methods. The first row shows work done on four road sections maintained by SF, and the second row shows work done by private contractors under the

MBC method. The mileposts (MP) indicate where the photos were taken during the site visit. Detailed photos are located in the Appendix N.

(a) SR 160 CL (Upstream) (b) SR 596 CL (Upstream) (c) US 95 CL, MP 92.50 (Upstream) (d) US 95 CL, MP 92.50 (Downstream)

(a) SR 28 WA, MP 2.20 (Upstream) (b) SR 28 WA, MP 2.20 (Downstream)

FIGURE 3-18. Culvert cleaning performed by SF and MBC private contractors.

3.3.1.4 Street Sweeping

Table 3-27 shows details of eight road sections where the quality of street sweeping was evaluated. Among them, four road sections – SR 574, SR 592, and two sections of SR 596 located in CL county – were maintained by SF method; and four sections – SR 159, SR 573, SR 593, and SR 612, located in CL – were maintained by private contractors under the MBC method. AADT data of the road section collected in 2012 is shown in the table.

TABLE 3-27 Road Section Details of Street Sweeping Work

Methods	Road Name	County	From-To	Length	Date	AADT
State Force	SR 574 (Cheyenne Ave)	CL	0-10.67	10.67	2014	33,900
	SR 596 (Jones Road)	CL	0-7.16	7.16	2014	24,500
	SR 592 (Flamingo Rd.)	CL	5.05-9.92	4.87	2014	42,000
	SR 592 (Flamingo Rd.)	CL	0-3.61	3.61	2014	55,000
MBC	SR 593 (Tropicana Blvd.)	CL	Dean Martin Dr - Boulder Hwy	7.40	2012-2014	31,875
	SR 159 (Charleston Blvd)	CL	Rainbow Blvd - Nellis Blvd	10.15	2012-2014	31,250
	SR 612 (Nellis Road)	CL	SR 604 - Tropicana Ave	10.10	2012-2014	33,155
	SR 573 (Craig Road)	CL	US 95 - Nellis Blvd, two sections	10.00	2012-2014	61,500

Table 3-28 shows the mean ratings of how well street sweeping – in terms of cleanliness of roadway median and shoulders – was performed by SF and private contractors under the MBC method. The mean ratings for SF were a little higher than for MBC private contractors.

TABLE 3-28 Results of Researchers' Evaluation of Street Sweeping Works

S.N.	Description	Methods	N	Mean	Std. Dev.
1	The roadway and median are clear of debris	State Force	122	4.96	0.20
		MBC	123	4.93	0.26
2	The displeasing materials on the shoulder, gutter, and ditches are removed	State Force	122	4.89	0.32
		MBC	123	4.80	0.46
	Average	State Force	122	4.92	0.23
		MBC	123	4.87	0.31

Figure 3-19 shows photographs of street sweeping performed by SF and private contractors under MBC. The first row of photographs was from four road sections

maintained by SF, and the second row was from roads maintained by MBC private contractors. Mileposts are indicated where the photographs were taken during the site visit. Detailed photos are located in Appendix P.

(a) SR 574 CL, MP 4.40 (b) SR 596 CL, MP 4.40 (c) SR 592 CL, MP 0.70 k (d) SR 592 CL, MP 9.20

(a) SR 593 CL, MP 1.40 (b) SR 159 CL, MP 1.80 (c) SR 573 CL, MP 8.10 (d) SR 589 CL, MP 1.00

FIGURE 3-19. Photos of street sweeping performed by SF as well as private contractors using the MBC method.

3.3.2 Rating Surveys for Quality Satisfaction of Maintenance Activities

To evaluate the quality satisfaction of overall road sections, three surveys were conducted. They were surveying with users of selected road sections, quality satisfaction rating with NDOT personnel, and quality satisfaction rating survey with private contractors.

3.3.2.1 Surveying with Users of Selected Road Sections

The road users of selected road sections were asked to rate the quality of chip seal, striping, street sweeping, and culvert cleaning worked performed by SF and private contractors under MBC and PBC. The road users, those who commute everyday on those selected road sections whose on-site quality investigation was conducted, were asked to rate the quality of the maintenance activities. The road users were not aware whether the SF or private contractors performed the maintenance work of the selected road sections. The results of the survey are described below.

3.3.2.1.1 Chip Seal

Table 3-29 shows the mean rating of the quality of chip seal performed by SF and private contractors under MBC. Road users were asked to rate smoothness, comfort, and traffic control during construction. The mean ratings for all the criteria when SF performed the

work were higher than for private contractors. The overall mean rating for work performed by SF was higher than for work performed by private contractors.

TABLE 3-29 Evaluation by Road Users of the Quality of Chip Seal

S.N.	Description	Methods	N	Mean	Std. Dev.
1	The surface of chip-sealed roads are smooth and have little loose aggregate	State Force	123	4.82	0.44
		MBC	87	4.56	0.73
2	The ride quality of the road is comfortable at posted speeds	State Force	123	4.75	0.49
		MBC	87	4.29	0.90
3	Proper traffic control was provided during construction	State Force	25	4.96	0.20
		MBC	22	4.63	0.58
	Average	State Force	126	4.79	0.40
		MBC	119	4.44	0.75

3.3.2.1.2 Striping

Table 3-30 shows the mean rating of the quality of striping performed by SF and private contractors. NDOT hired a PBC contractor for striping; therefore, the road users were asked to rate striping work performed by SF as well as by MBC and PBC private contractors. The mean rating for the visibility of striping during the day and at night when performed by the PBC contractor was higher than by SF and MBC contractors. However, traffic management performed by private contractors was higher than by SF. Striping was rated higher when performed by the PBC contractor than for work done by SF and MBC contractors.

TABLE 3-30 Road Users' Evaluations of Striping Work

S.N.	Description	Methods	N	Mean	Std. Dev.
1	The striping on the road is visible during the day	State Force	124	4.69	0.71
		MBC	136	4.84	0.37
		PBC	31	5.00	0.00
2	The striping on the road is visible during wet weather and at night	State Force	121	4.29	1.07
		MBC	120	4.27	0.73
		PBC	31	4.71	0.46
3	Provided proper traffic control or warning signs during striping	State Force	64	4.64	0.74
		MBC	66	4.88	0.37
		PBC	12	5.00	0.00
	Average	State Force	124	4.56	0.71
		MBC	136	4.64	0.43
		PBC	31	4.85	0.23

3.3.2.1.3 Street Sweeping

Table 3-31 shows the mean rating of the quality of street sweeping performed by SF and MBC private contractors. The mean rating for cleanliness of drains and roadways as well as traffic management during construction was higher when performed by SF than by private contractors. The overall mean rating for work done by SF was higher than by private contractors as well.

TABLE 3-31 Results of Road Users' Evaluation of Street Sweeping

S.N.	Description	Methods	N	Mean	Std. Dev.
1	The roadway and median are clear of debris	State Force	120	4.89	0.34
		MBC	120	4.85	0.38
2	The displeasing materials on the shoulder, gutter, and ditches are removed	State Force	120	4.51	0.69
		MBC	120	4.29	0.82
3	Used proper signs/warning flashers on the sweeper truck to make drivers aware of the maintenance work	State Force	30	4.93	0.25
		MBC	40	4.73	0.51
	Average	State Force	120	4.70	0.46
		MBC	120	4.56	0.52

3.3.2.2 Quality Satisfaction Rating with NDOT Personnel

NDOT maintenance personnel were asked to rate the overall performance of contractors and SF on the above-mentioned four maintenance activities, but were not asked about any specific road sections. Therefore, the results of this survey cover the overall performance of SF and contractors.

3.3.2.2.1 Chip Seal

Table 3-32 shows the results of the survey conducted with NDOT maintenance personnel regarding the quality of chip seal performed by SF as well as private contractors. The quality ratings under all the criteria of chip seal performed by SF were higher than that of private contractors.

TABLE 3-32 Chip Seal Ratings Provided by NDOT Personnel

S. N	DESCRIPTION	METHODS	N	MEAN	STD. DEVIATION
1	The surface of chip sealed roads are smooth and have little loss of aggregates	State Force	35	4.74	0.44
		MBC	36	2.14	1.02
2	The ride quality of road is comfortable at posted speed	State Force	35	4.71	0.46
		MBC	36	2.92	0.94
3	Provided proper traffic control during construction	State Force	35	4.89	0.32
		MBC	36	2.75	1.16
4	Quality of materials used	State Force	35	4.60	0.55
		MBC	36	3.17	1.16
5	Quality of workmanship	State Force	35	4.91	0.28
		MBC	36	1.94	0.80
	Average	State Force	35	4.77	0.33
		MBC	36	2.58	0.86

3.3.2.2.2 Striping

Table 3-33 shows the results of the survey with NDOT maintenance personnel regarding the quality of striping work performed by SF and private contractors. The quality ratings of striping performed by SF were higher than for private contractors.

TABLE 3-33 Striping Ratings Provided by NDOT Personnel

S.N.	Description	Methods	N	Mean	Std. Dev.
1	The striping on the road is visible during the day	State Force	30	4.50	0.68
		MBC	30	3.83	0.95
2	The striping on the road is visible during wet weather and at night	State Force	30	4.20	0.85
		MBC	29	3.66	0.94
3	Provided proper traffic or warning signs control during striping	State Force	30	4.33	0.88
		MBC	29	3.28	0.96
4	Quality of materials used	State Force	29	4.21	0.77
		MBC	30	3.43	1.00
5	Quality of workmanship	State Force	30	4.37	0.89
		MBC	30	3.33	0.96
	Average	State Force	30	4.33	0.75
		MBC	30	3.49	0.89

3.3.2.2.3 Culvert Cleaning

Table 3-34 displays the results of the survey conducted with NDOT maintenance personnel regarding the quality of culvert cleaning work performed by SF and private contractors. The quality ratings of culvert cleaning performed by SF were higher than that of private contractors.

TABLE 3-34 Culvert Cleaning Ratings Provided by NDOT Personnel

S.N.	Description	Methods	N	Mean	Std. Dev.
1	Debris that effects drainage are cleared on the upstream side	State Force	30	4.47	0.94
		MBC	22	2.95	0.84
2	Debris that effects drainage are cleared on the downstream side	State Force	30	4.40	0.93
		MBC	22	3.00	0.87
3	The inside of the culvert is cleaned	State Force	30	4.70	0.47
		MBC	22	3.05	0.95
4	Placed proper signs to make drivers aware of the maintenance work or to detour traffic	State Force	30	4.77	0.43
		MBC	22	3.00	0.87
	Average	State Force	30	4.58	0.63
		MBC	22	3.00	0.87

3.3.2.2.4 Street Sweeping

Table 3-35 shows survey results of NDOT maintenance personnel regarding the quality of street sweeping performed by SF and private contractors. The average quality rating of chip seal performed by SF was higher than that performed by private contractors.

TABLE 3-35 Street Sweeping Ratings Provided by NDOT Personnel

S.N.	Description	Methods	N	Mean	Std. Dev.
1	The roadway and median are clear of debris	State Force	32	4.44	0.56
		MBC	21	2.90	1.09
2	The displeasing materials on the shoulder, gutter, and ditches are removed	State Force	32	4.50	0.57
		MBC	21	2.81	1.03
3	Used proper signs/warning flashers on the sweeper truck to make commuters aware of the maintenance work	State Force	32	4.56	0.72
		MBC	21	3.00	1.00
	Average	State Force	32	4.50	0.55
		MBC	21	2.90	1.00

3.3.2.3 Rating Survey for Quality Satisfaction with Private Contractors

The survey was sent to private contractors to determine the quality of work performed by private companies and SF. The contractors included those that recently performed chip seal, striping, culvert cleaning, and street sweeping with NDOT. The results of the survey are described below.

3.3.2.3.1 Chip Seal

Table 3-36 shows the survey results conducted with private contractors regarding the quality of chip seal performed by the companies and SF. The ratings under all the criteria of chip seal performed by private contractor were higher than that performed by SF.

TABLE 3-36 Chip Seal Ratings Provided by Private Contractors

S.N.	Description	Methods	N	Mean	Std. Dev.
1	The surface of roads are smooth and have little loss of chips	State Force	5	4.00	0.71
		MBC	5	4.40	0.55
2	The ride quality of road is comfortable at posted speed	State Force	5	4.00	0.71
		MBC	5	4.40	0.55
3	Provided proper traffic control during construction	State Force	5	3.20	0.84
		MBC	4	4.75	0.50
4	Quality of materials used	State Force	5	3.80	0.84
		MBC	4	4.50	0.58
5	Quality of workmanship	State Force	5	4.00	0.71
		MBC	5	4.40	0.55
	Average	State Force	5	3.80	0.53
		MBC	5	4.44	0.52

3.3.2.3.2 Striping

Table 3-37 shows the survey results of contractor personnel regarding the quality of striping work performed by the companies and SF. The average quality ratings under all the criteria of striping performed by private contractors was higher than that performed by SF.

TABLE 3-37 Results of Striping Ratings Provided by Private Contractors

S.N.	Description	Methods	N	Mean	Std. Dev.
1	The striping on the road is visible during the day	State Force	4	3.50	1.29
		MBC	4	4.00	1.41
2	The striping on the road is visible during wet weather and at night	State Force	4	3.50	1.29
		MBC	4	4.00	1.41
3	Provided proper traffic or warning signs control during striping	State Force	4	4.00	0.81
		MBC	4	4.75	0.50
4	Quality of materials used	State Force	4	4.00	0.82
		MBC	4	4.75	0.50
5	Quality of workmanship	State Force	4	4.00	0.82
		MBC	4	4.75	0.50
	Average	State Force	4	3.80	0.91
		MBC	4	4.45	0.85

3.3.2.3.3 Culvert Cleaning

Table 3-38 shows the results of the survey conducted with private contractors regarding the quality of culvert cleaning performed by the companies and SF. The quality of work performed by private contractors seemed to exceed the work performed by SF.

TABLE 3-38 Results for Culvert Cleaning Ratings Provided by Private Contractors

S.N.	Description	Methods	N	Mean
1	Debris that effects drainage are cleared on the upstream side	State Force	1	3.00
		MBC	1	5.00
2	Debris that effects drainage are cleared on the downstream side	State Force	1	3.00
		MBC	1	5.00
3	The inside of the culvert is cleaned	State Force	1	3.00
		MBC	1	5.00
4	Place proper signs to make drivers aware of the maintenance work or to detour traffic	State Force	1	3.00
		MBC	1	5.00
	Average	State Force	1	3.00
		MBC	1	5.00

3.4 Limitations of the Study

The findings of this study when comparing the cost and quality of four road maintenance activities performed by SF and private contractors have several limitations.

3.4.1 Limitations Regarding Cost

Results regarding cost have the following limitations.

1. The cost data were obtained from the NDOT database for work performed from 1990 to 2013; this data were collected and analyzed.
2. Cost data from private contractors were not available from 1990 because it has been only recently that NDOT started contracting these maintenance activities to private contractors. Therefore, in order to make reasonable comparisons, the entire cost data were converted to base cost 2014 using the *ENR* cost index. However, these conversions might not reflect the true cost due to a large difference in the maintenance year.
3. During the analysis of life-cycle maintenance costs, the frequency of the maintenance performed by SF was calculated based on how many times during those 23 years, the work was performed on same sections of road. However, the duration of maintenance activities for some road sections was very high; therefore, the frequency of maintenance calculated might not reflect the actual frequency.
4. A few road sections were maintained by private contractors more than once. Therefore, the frequency calculations might not reflect the actual frequency of maintenance work.

3.4.2 Limitations Regarding Quality

The results regarding quality have the following limitations.

1. The road sections were selected for evaluations on quality based on discussions with NDOT personnel. Therefore, these were not random selections.
2. The survey was given to road users during the site visits. These surveys were conducted over a small period of time, and not during the entire year.
3. Data from the survey given to contractors were limited because there was very limited number of contractors who performed maintenance work for NDOT.

CHAPTER 4: CONCLUSIONS AND RECOMMENDATIONS

The main objective of this study was to assess the cost effectiveness and the quality of the road maintenance performed by NDOT state force as well as private contractors hired by NDOT. Further, the study conducted surveys with NDOT personnel and other state DOTs to identify which maintenance activities were performed by their state force and by private contractors. They were asked to rate the level of satisfaction with maintenance work performed by state force and private contractor, and the results were assessed.

The survey given to state DOTs showed that most states used their own workforce to maintain their roadways. Every DOT who responded to the questionnaire revealed that their workforce did most of the maintenance work. However, outsourcing road-maintenance activities was increasing. On average, about 62% of each state's maintenance budget was allocated to work done by their workforce; the rest of the budget was allocated for outsourcing to private contractors. The main reasons for outsourcing the maintenance work was due to the unavailability of skilled workforce within their state's DOT agency.

This survey to state DOTs also revealed that performance-based contracting was not as widely used in the U.S. for road maintenance work as for other countries. Only 14 state DOTs had experience working with the PBC method for road maintenance. Moreover, the survey revealed that this method was not used by state DOTs because these agencies had enough skilled labor to maintain the roadways using their state workforce. According to the state DOTs, one of the major reasons to use PBC was 1) when they lacked the expertise in that area of maintenance or 2) when a contractor could provide innovation in that type of maintenance work.

Based on this survey, this study recommends that the PBC method be used for the following road-maintenance activities:

1. Activities related to the road pavement, e.g., resurfacing, chip seal, rehabilitation, and striping.
2. Activities that are related to traffic safety, e.g., road signs and marking, traffic attenuators, guard rails, barriers, and street lights.
3. Shoulder maintenance activities.
4. Activities related to side slope and median maintenance.
5. Right-of-way maintenance and fencing.
6. Sidewalk and curb maintenance.

When the respondents were asked about their level of satisfaction with work done by the state workforce versus private contractors, most respondents were more satisfied with work done by state force than with private contractors. In particular, the performance of private contractors using the PBC method were rated poorly when compared to private

contractors using MBC methods. Regarding work done by the state workforce, the major lesson learned was that the scope of the work should be clearly understood by the state workers. Another lesson learned was when outsourcing maintenance work, DOTs must write very clear and specific contracts and specifications.

When asked to analyze the cost effectiveness between maintenance activities performed by the state workforce versus outsourcing, most state DOTs said they have not conducted this type of cost analysis; however, they thought that it was important to consider doing. When they were asked which component of the cost was most important when calculating cost effectiveness, most said that the cost of material, labor, and equipment were the most important cost factors. While conducting the survey, the research team was not able to determine whether any state DOTs conducted any comprehensive cost analyses of maintenance work done by state force versus outsourcing to private contractors.

The major objectives of this study were to compare maintenance costs and the quality of four road maintenance activities performed by SF and private contractors, namely, chip seal, striping, culvert cleaning, and street sweeping. Cost comparisons always are difficult because it is necessary to make an 'apples-to-apples' comparison. Based on data available from NDOT, the life-cycle maintenance costs of the chip seal performed by state force ($0.31/SY/Yr) were found to be three times lower than performed by private contractors ($0.99/SY/yr). However, when the cost was normalized with AADT for chip seal, the LCMC of chip seal was found to be lower for private contractors ($0.86/SY/yr) compared to work performed by SF ($0.97/SY/yr). This shows that the maintenance cost spent per 1,000 AADT in maintaining the road surface by conducting chip seal seems to be less expensive when a contractor performed the work.

The LCMC cost of striping was lower for work performed by SF ($457.60/LM/yr) compared to private contractors: $945.14/LM/yr when using the MBC method and $1,741.60/LM/yr when using the PBC method. The unit maintenance cost of culvert cleaning was $4,482.72/mi/yr when maintained by SF and $6,593.00/ mi/yr when a private contractor performed the work. Similarly the unit maintenance cost of street sweeping was found to be $43.78/mi/yr for work done by SF and $64.13/mi/yr for private contractors. Overall, the unit costs for each of these activities were less when SF maintained the road sections compared to private contractors. When compared with maintenance work performed by contractors using the PBC method, the unit cost of striping was about four times higher as compared to SF; the unit cost of striping using private contractors who were not using the PBC method were two times higher than that for SF.

The results of the quality assessment showed that SF maintained chip seal, culvert cleaning, and sweeping at better quality compared to private contractors. However, the quality of stripping seemed to be better when performed by private contractors, especially when using the PBC method. Regarding the quality assessments by researchers and road users, these assessments agrees with each other. However, overall quality assessment by

NDOT maintenance personnel and private contractors seemed to be biased because both groups assessed their work better than their counterparts.

The results derived in this study regarding the maintenance cost of these four maintenance activities were based on data available from NDOT. Therefore, the results obtained from this study should not be generalized, and should be taken in context. The comparison of cost and quality between SF and outsourced maintenance work is valid only if the work was performed in a similar stretch of road and under similar work specifications. Therefore, this study recommends that data be collected for maintenance by SF and contractors that are performed on the same stretch of road in the same year with same specifications. This can eliminate a significant amount of bias. Regarding the evaluation of the quality of work, this study recommends using more quantitative approaches than qualitative approaches in the future.

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APPENDIX A:

Acronyms

ADOT	Arizona Department of Transportation
AM	Asset Management
CE	Cost Efficiency
DCDPW	District of Columbia Department of Public Works
DOT	Department of Transportation
ENR	*Engineering News Record*
ESALs	Equivalent Single Axle Loads
ESDA	Exploratory Spatial Data Analysis
FDOT	Florida Department of Transportation
FHWA	Federal Highway Administration
FY	Fiscal Year
INDOT	Illinois Department of Transportation
IRI	International Roughness Index
JLARC	Joint Legislative Audit and Review Commission
LCCA	Life Cycle Cost Analysis
LOS	Level of Service
MBC	Method-Based Contracting
MDOT	Massachusetts Department of Transportation
MMS	Maintenance Management Reporting System
MQA	Maintenance Quality Assurance
MRP	Maintenance Rating Program
NCDOT	North Carolina Department of Transportation
NCHRP	National Cooperative Highway Research Program
NDOT	Nevada Department of Transportation
NJDOT	New Jersey Department of Transportation
NHS	National Highway System
ODOT	Oklahoma Department of Transportation
PBC	Performance-Based Contracting
PBMMR	Performance-Based Contracts for Management and Maintenance of Roads

QOS	Quality of Service
RM	Rehabilitation Maintenance
RP	Relative Performance
SAIC	Science Applications International Corporation
SCDOT	South Carolina Department of Transportation
SF	State Force
SP	Safety Procedures
TxDOT	Texas Department of Transportation
TOR	Timeliness of Response
USDOT	United States Department of Transportation
VDOT	Virginia Department of Transportation
WSDOT	Washington State Department of Transportation

APPENDIX B:

Survey of NDOT Personnel on Road Maintenance in Nevada

We would like to thank you in advance for the time and effort involved in your agency's participation in this research.

This questionnaire is designed to collect information regarding procurement methods of road maintenance activities in your state, and is divided into fifteen sections:

- General Information
- Pavement Surface
- Shoulder
- Drainage System
- Side Slopes
- Curb
- Side Walk
- Median
- Fencing
- Roadside
- Right of Way
- Snow & Ice Removal
- Traffic Safety-Road Signs and Markings
- Traffic/Safety – Traffic Attenuators, Guardrails, and Barriers
- Traffic/Safety – Street Lights

If not enough space is provided to answer questions, please feel free to attach extra sheets. Please do what you can to provide this information as fully as possible. Your detailed sponses will help us in a study entitled, "An Investigation of Innovative Contracting Methods". The results of the current survey will be backbone of our study to select which activities of the road maintenance in the State of Nevada could be maintained by performance-based specifications and which not.

We appreciate your cooperation. Please return this questionnaire by email, fax, or mail to the following address:

Dr. Pramen P. Shrestha, Assistant Professor
Department of Civil and Environmental Engineering & Construction
University of Nevada, Las Vegas
4505 S. Maryland Pkwy., Las Vegas, NV 89154
Phone: 702-895-3841; Fax Number: 702-895-3936; Email: pramen.shrestha@unlv.edu

1. General Information

1.1. Name of the Department of Transportation (DOT) Nevada Dept. of Transportation

1.2. State: Nevada

1.3. Name of the maintenance engineer (respondent): _____

1.4. Contact person's phone number: _____

1.5. Contact person's E-mail address: _____

2. Road Maintenance Activities

2.1 Pavement Surface

2.1.1 Paved Surface

Select the road maintenance contracting methods that NDOT has been using for last 10 years:

Maintenance Activities	In-House		Out-Sourcing			N/A
	Prescriptive-Based Specification	Performance-Based Specification	Prescriptive-Based Specification	Performance-Based Specification	Other Innovative Methods	
Asphalt Pavement						
a) Patch the potholes	☐	☐	☐	☐	☐	☐
b) Fill up rutting	☐	☐	☐	☐	☐	☐
c) Seal the cracks	☐	☐	☐	☐	☐	☐
d) Provide chip seal	☐	☐	☐	☐	☐	☐
e) Provide slurry seal	☐	☐	☐	☐	☐	☐
f) Provide thin overlays of asphalt	☐	☐	☐	☐	☐	☐
g) Provide and maintain road striping	☐	☐	☐	☐	☐	☐
h) Sweep and clean pavement	☐	☐	☐	☐	☐	☐
Concrete Pavement						
i) Patch the concrete pavement	☐	☐	☐	☐	☐	☐
j) Seal/repair joints	☐	☐	☐	☐	☐	☐
k) Repair spalls	☐	☐	☐	☐	☐	☐
l) Provide thin overlays of asphalt concrete	☐	☐	☐	☐	☐	☐
m) Sweep and clean pavement	☐	☐	☐	☐	☐	☐

Please specify other maintenance activities:

.....

.....

Please specify other innovative methods:

……

……

2.1.2 Unpaved Gravel Surfaces

Select the road maintenance contracting methods that NDOT has been using for last 10 years:

Maintenance Activities	In-House		Out-Sourcing			N/A
	Prescriptive-Based Specification	Performance-Based Specification	Prescriptive-Based Specification	Performance-Based Specification	Other Innovative Methods	
Gravel Surfaces						
a) Patch the potholes	☐	☐	☐	☐	☐	☐
b) Blade gravel surface	☐	☐	☐	☐	☐	☐
c) Provide thin overlays of gravel material	☐	☐	☐	☐	☐	☐

Please specify other maintenance activities:

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Please specify other innovative methods:

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2.2 Shoulders Maintenance

Select the road maintenance contracting methods that NDOT has been using for last 10 years:

Maintenance Activities	In-House		Out-Sourcing			N/A
	Prescriptive-Based Specification	Performance-Based Specification	Prescriptive-Based Specification	Performance-Based Specification	Other Innovative Methods	
Paved Shoulder						
a) Patch the potholes	☐	☐	☐	☐	☐	☐
b) Fill up rutting	☐	☐	☐	☐	☐	☐
c) Provide crack sealing	☐	☐	☐	☐	☐	☐
d) Provide chip seal	☐	☐	☐	☐	☐	☐
e) Provide slurry seal	☐	☐	☐	☐	☐	☐
f) Provide thin asphalt/concrete overlays	☐	☐	☐	☐	☐	☐
g) Seal joints between pavement and shoulder	☐	☐	☐	☐	☐	☐
h) Patch the shoulder	☐	☐	☐	☐	☐	☐

Maintenance Activities	In-House		Out-Sourcing			N/A
	Prescriptive-Based Specification	Performance-Based Specification	Prescriptive-Based Specification	Performance-Based Specification	Other Innovative Methods	
i) Provide thin overlays on shoulders	☐	☐	☐	☐	☐	☐
j) Seal/repair joints	☐	☐	☐	☐	☐	☐
k) Repair the spalls	☐	☐	☐	☐	☐	☐
l) Sweep and clean shoulders	☐	☐	☐	☐	☐	☐
Unpaved Shoulder						
m) Blade shoulders	☐	☐	☐	☐	☐	☐
n) Patch the potholes	☐	☐	☐	☐	☐	☐
o) Provide thin overlays of gravel materials	☐	☐	☐	☐	☐	☐

Please specify other maintenance activities:

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Please specify other innovative methods:

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2.3 Manholes

Select the road maintenance contracting methods that NDOT has been using for last 10 years:

Maintenance Activities	In-House		Out-Sourcing			N/A
	Prescriptive-Based Specification	Performance-Based Specification	Prescriptive-Based Specification	Performance-Based Specification	Other Innovative Methods	
a) Adjust and maintain manholes	☐	☐	☐	☐	☐	☐
b) Replace covers as necessary	☐	☐	☐	☐	☐	☐

Please specify other maintenance activities:

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Please specify other innovative methods:

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2.4 Drainage Systems

Select the road maintenance contracting methods that NDOT has been using for last 10 years:

Maintenance Activities	In-House		Out-Sourcing			N/A
	Prescriptive-Based Specification	Performance-Based Specification	Prescriptive-Based Specification	Performance-Based Specification	Other Innovative Methods	
Paved Drains						
a) Clean and maintain ditches	☐	☐	☐	☐	☐	☐
b) Clean and maintain swales	☐	☐	☐	☐	☐	☐
c) Remove debris and silt from inlet and within catch basin	☐	☐	☐	☐	☐	☐
d) Repair and maintain drainage structures structurally	☐	☐	☐	☐	☐	☐
e) Clean and maintain culverts and storm drains	☐	☐	☐	☐	☐	☐
f) Clean and maintain drains	☐	☐	☐	☐	☐	☐
g) Clean and maintain inlets of cross drainages	☐	☐	☐	☐	☐	☐
h) Clean and maintain cross drainage pipes	☐	☐	☐	☐	☐	☐
i) Clean and maintain box culverts	☐	☐	☐	☐	☐	☐
j) Clean and maintain paved ditches	☐	☐	☐	☐	☐	☐
k) Clean and maintain entrance pipes	☐	☐	☐	☐	☐	☐
l) Clean and maintain under drains	☐	☐	☐	☐	☐	☐
m) Clean and maintain upstream of cross drainage	☐	☐	☐	☐	☐	☐
n) Clean and maintain downstream of cross drainage	☐	☐	☐	☐	☐	☐
o) Clean and maintain edge drains	☐	☐	☐	☐	☐	☐
p) Clean and maintain curbs and gutters	☐	☐	☐	☐	☐	☐
q) Clean and maintain storm water pipes	☐	☐	☐	☐	☐	☐
r) Clean and maintain storm water management ponds	☐	☐	☐	☐	☐	☐

Maintenance Activities	In-House		Out-Sourcing			N/A
	Prescriptive-Based Specification	Performance-Based Specification	Prescriptive-Based Specification	Performance-Based Specification	Other Innovative Methods	
s) Clean and maintain roadside drainage	☐	☐	☐	☐	☐	☐
Unpaved Drains						
t) Clean and maintain unpaved roadside drainage	☐	☐	☐	☐	☐	☐
u) Repair slopes/grades of unpaved drains	☐	☐	☐	☐	☐	☐
v) Repair alignment of ditches	☐	☐	☐	☐	☐	☐

Please specify other maintenance activities:

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Please specify other innovative methods:

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2.5 Side Slopes

Select the road maintenance contracting methods that NDOT has been using for last 10 years:

Maintenance Activities	In-House		Out-Sourcing			N/A
	Prescriptive-Based Specification	Performance-Based Specification	Prescriptive-Based Specification	Performance-Based Specification	Other Innovative Methods	
a) Repair and maintain slopes	☐	☐	☐	☐	☐	☐
b) Drift sand or erosion	☐	☐	☐	☐	☐	☐
c) Repair and maintain riprap	☐	☐	☐	☐	☐	☐
d) Repair and maintain bulkheads	☐	☐	☐	☐	☐	☐
e) Repair and maintain erosion control structures	☐	☐	☐	☐	☐	☐
f) Repair, fill, and cut slopes	☐	☐	☐	☐	☐	☐

Please specify other maintenance activities:

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Please specify other innovative methods:

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2.6 Curbs

Select the road maintenance contracting methods that NDOT has been using for last 10 years:

Maintenance Activities	In-House		Out-Sourcing			N/A
	Prescriptive-Based Specification	Performance-Based Specification	Prescriptive-Based Specification	Performance-Based Specification	Other Innovative Methods	
a) Repair and maintain granite and concrete curbs and gutters	☐	☐	☐	☐	☐	☐
b) Replace curb stones	☐	☐	☐	☐	☐	☐

Please specify other maintenance activities:

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Please specify other innovative methods:

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2.7 Sidewalks

Select the road maintenance contracting methods that NDOT has been using for last 10 years:

Maintenance Activities	In-House		Out-Sourcing			N/A
	Prescriptive-Based Specification	Performance-Based Specification	Prescriptive-Based Specification	Performance-Based Specification	Other Innovative Methods	
a) Repair and maintain sidewalks	☐	☐	☐	☐	☐	☐

Please specify other maintenance activities:

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Please specify other innovative methods:

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2.8 Medians

Select the road maintenance contracting methods that NDOT has been using for last 10 years:

Maintenance Activities	In-House		Out-Sourcing			N/A
	Prescriptive-Based Specification	Performance-Based Specification	Prescriptive-Based Specification	Performance-Based Specification	Other Innovative Methods	
a) Repair and maintain paved medians	☐	☐	☐	☐	☐	☐
b) Repair and maintain unpaved medians	☐	☐	☐	☐	☐	☐

Please specify other maintenance activities:

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Please specify other innovative methods:

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2.9 Fencing

Select the road maintenance contracting methods that NDOT has been using for last 10 years:

Maintenance Activities	In-House		Out-Sourcing			N/A
	Prescriptive-Based Specification	Performance-Based Specification	Prescriptive-Based Specification	Performance-Based Specification	Other Innovative Methods	
a) Repair and maintain fences	☐	☐	☐	☐	☐	☐

Please specify other maintenance activities:

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Please specify other innovative methods:

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2.10 Roadside

Select the road maintenance contracting methods that NDOT has been using for last 10 years:

Maintenance Activities	In-House		Out-Sourcing			N/A
	Prescriptive-Based Specification	Performance-Based Specification	Prescriptive-Based Specification	Performance-Based Specification	Other Innovative Methods	
a) Control weed	☐	☐	☐	☐	☐	☐
b) Pick up debris and litter	☐	☐	☐	☐	☐	☐
c) Clean-up (emergency) after storms	☐	☐	☐	☐	☐	☐
d) Mow and maintain grass	☐	☐	☐	☐	☐	☐
e) Remove graffiti from the roadside	☐	☐	☐	☐	☐	☐
f) Repair and maintain sound barriers	☐	☐	☐	☐	☐	☐

Please specify other maintenance activities:

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Please specify other innovative methods:

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2.11 Right of Way

Select the road maintenance contracting methods that NDOT has been using for last 10 years:

Maintenance Activities	In-House		Out-Sourcing			N/A
	Prescriptive-Based Specification	Performance-Based Specification	Prescriptive-Based Specification	Performance-Based Specification	Other Innovative Methods	
a) Maintain vegetation	☐	☐	☐	☐	☐	☐
b) Pick up foreign elements	☐	☐	☐	☐	☐	☐
c) Maintain stockpiles on Right of Way (ROW)	☐	☐	☐	☐	☐	☐
d) Remove encroachments	☐	☐	☐	☐	☐	☐
e) Repair and maintain object markers and delineators	☐	☐	☐	☐	☐	☐
f) Repair and maintain glare foils	☐	☐	☐	☐	☐	☐
g) Repair and maintain emergency facilities	☐	☐	☐	☐	☐	☐
h) Repair and maintain rest areas	☐	☐	☐	☐	☐	☐

Please specify other maintenance activities:

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Please specify other innovative methods:

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2.12 Snow & Ice Removal

Select the road maintenance contracting methods that NDOT has been using for last 10 years:

Maintenance Activities	In-House		Out-Sourcing			N/A
	Prescriptive-Based Specification	Performance-Based Specification	Prescriptive-Based Specification	Performance-Based Specification	Other Innovative Methods	
a) Remove and plow snow from the road pavement and shoulder	☐	☐	☐	☐	☐	☐

Please specify other maintenance activities:

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Please specify other innovative methods:

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2.13 Traffic Safety

2.13.1 Traffic Safety: Road Signs and Markings

Select the road maintenance contracting methods that NDOT has been using for last 10 years:

Maintenance Activities	In-House		Out-Sourcing			N/A
	Prescriptive-Based Specification	Performance-Based Specification	Prescriptive-Based Specification	Performance-Based Specification	Other Innovative Methods	
a) Repair and maintain road signs	☐	☐	☐	☐	☐	☐
b) Clean and maintain paint striping	☐	☐	☐	☐	☐	☐
c) Maintain reflective pavements markings	☐	☐	☐	☐	☐	☐
d) Maintain raised pavement markings	☐	☐	☐	☐	☐	☐
e) Repair and maintain illuminations	☐	☐	☐	☐	☐	☐

Please specify other maintenance activities:

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Please specify other innovative methods:

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2.13.2 Traffic Safety: Traffic Attenuators, Guardrails, and Barriers

Select the road maintenance contracting methods that NDOT has been using for last 10 years:

Maintenance Activities	In-House		Out-Sourcing			N/A
	Prescriptive-Based Specification	Performance-Based Specification	Prescriptive-Based Specification	Performance-Based Specification	Other Innovative Methods	
a) Repair, reconstruct, and maintain damaged guardrail	☐	☐	☐	☐	☐	☐
b) Repair and maintain attenuators of various types/designs, including their platforms	☐	☐	☐	☐	☐	☐
c) Repair and maintain anchorages and bolted bases	☐	☐	☐	☐	☐	☐
d) Repair and maintain retaining walls	☐	☐	☐	☐	☐	☐
e) Repair and maintain median barriers	☐	☐	☐	☐	☐	☐
f) Repair and maintain concrete barriers	☐	☐	☐	☐	☐	☐

Please specify other maintenance activities:

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Please specify other innovative methods:

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2.13.3 Traffic Safety: Traffic Lights

Select the road maintenance contracting methods that NDOT has been using for last 10 years:

Maintenance Activities	In-House		Out-Sourcing			N/A
	Prescriptive-Based Specification	Performance-Based Specification	Prescriptive-Based Specification	Performance-Based Specification	Other Innovative Methods	
a) Repair and maintain street lights	☐	☐	☐	☐	☐	☐
b) Repair and maintain traffic lights	☐	☐	☐	☐	☐	☐
c) Repair and maintain lighting systems	☐	☐	☐	☐	☐	☐
d) Repair and maintain group of incandescent lamping	☐	☐	☐	☐	☐	☐
e) Repair and maintain mercury-vapor lamps and high-pressure sodium vapor lamps	☐	☐	☐	☐	☐	☐
f) Replace broken glassware	☐	☐	☐	☐	☐	☐
g) Repair and maintain photoelectric controls and all other parts of lighting fixtures	☐	☐	☐	☐	☐	☐
h) Repair and maintain incandescent and mercury fixtures to high-pressure sodium fixtures, as directed	☐	☐	☐	☐	☐	☐
i) Respond to citizens' requests for streetlight repairs	☐	☐	☐	☐	☐	☐
j) Repair and replace sign lights (warning and regulatory information/guide and parking)	☐	☐	☐	☐	☐	☐
k) Repair and maintain variable message signs	☐	☐	☐	☐	☐	☐
l) Repair and maintain traffic detector loops	☐	☐	☐	☐	☐	☐
m) Repair and maintain the electrical cable system	☐	☐	☐	☐	☐	☐

Please specify other maintenance activities:

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Please specify other innovative methods:

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APPENDIX C:

Survey of In-house and Outsourced Maintenance Contracts Conducted with 50 State DOTs

I would like to thank you in advance for your time and effort involved in your agency's participation in this research. This questionnaire is designed to collect in-depth information related to the procurement process and benefits of In-House and Out-Sourced road maintenance activities in your state. It is divided into five sections:

1. General Information
2. Road Maintenance Specifications Methods and Satisfaction Level
3. Performance Assessment of In-House, MBC, and PBC methods
4. Cost Analysis (In-House versus Out-Sourcing)
5. Performance Based Contract

If not enough space is provided to answer questions, please feel free to attach extra sheets. In the questions, we ask you to indicate how the road maintenance activities are performed in your state. Please provide this information as fully as possible. Your detailed responses will help us in a study of Performance-Based Road Maintenance Contracting funded by the Nevada Department of Transportation (NDOT).

The confidentiality of this questionnaire will be maintained. The questionnaire data will not be placed in any permanent record and will be destroyed when no longer needed by the researcher. The identity of respondents who provided all this information will remain anonymous. The data obtained during this questionnaire will not be linked in any way to the participants' names. The results of the current survey will assist us to select the best methods for maintaining the roads in Nevada.

I greatly appreciate your assistance. Please return this questionnaire by email, fax, or mail to the following address:

Pramen P. Shrestha, Ph.D., P.E., Associate Professor
Department of Civil and Environmental Engineering and Construction
Howard R. Hughes College of Engineering
University of Nevada, Las Vegas
4505 S. Maryland Pkwy., Las Vegas, NV 89154
Phone: 702-895-3841; Fax Number: 702-895-3936
Email: pramen.shrestha@unlv.edu

1. General Information

1.1. Name of your Agency: _____
1.2. Name of your State: _____
1.3. Name of the maintenance engineer (respondent): _____
1.4. Respondent's phone number: _____
1.5. Respondent's E-mail address: _____

2. Road Maintenance Specifications Methods and Satisfaction Level

From our literature review, most DOTs maintained roads using prescriptive specifications. While out-sourcing maintenance works to private contractors, DOTs choose the prescriptive specification or the performance specification. Please check the appropriate box (es) for the listed maintenance activity, performed by In-House staff and/or Out-Sourced contracts. Select the specifications method that is used, Method-Based (traditional prescriptive specifications), Performance-Based or other methods.

Maintenance Activities	**In-House Methods**	**Out-Sourcing Methods**			**N/A**
	Method-Based	Method - Based	Performanc e-Based	Other methods	
a) Road Pavement	☐	☐	☐	☐	☐
b) Shoulder	☐	☐	☐	☐	☐
c) Drainage System	☐	☐	☐	☐	☐
d) Side Slopes and Median	☐	☐	☐	☐	☐
e) Right of Way and Fencing	☐	☐	☐	☐	☐
f) Snow and Ice Removal	☐	☐	☐	☐	☐
g) Side Walk and Curb	☐	☐	☐	☐	☐
h) Traffic Safety-Road Signs and markings, Traffic Attenuators, Guard Rails, Barriers, and Street Lights	☐	☐	☐	☐	☐

2.1. If your DOT maintains any road activities by in-house staff using performance based specifications criteria, write the name of the maintenance activities and performance targets below (or attach any documents you would like to share.)

Name of the maintenance activities **Performance Targets**

1.
2.
3.
4.
5.

2.2. Which specification methods did you use in your DOT last year for the majority of road maintenance activities?

☐ In-House
☐ Out-Sourcing with Method-Based Contracts (MBC)
☐ Out-Sourcing with Performance-Based Contracts (PBC)
☐ Out-Sourcing with other methods

2.3. Please estimate the percentage of your maintenance budget that is allocated to the following type of methods for your DOT maintenance activities in last year.

In-House	……%
Out-Sourcing with MBC	……%
Out-Sourcing with PBC	……%
Other Out-Sourcing methods	……%
Total	**100 %**

Please rate (1-5 scale, 5 being "very important" and 1 being "least important") for the selection criteria of In-House and Out-Sourced methods for maintenance work in your DOT:

In-House Method Selection Criteria	Out-Sourcing Method Selection Criteria
_ Availability of DOT staff to accomplish additional works	_ Lack of DOT staff to accomplish additional works
_ To complete the task on schedule	_ To complete the task on schedule
_ To complete the task on budget or to save money	_ To complete the task on budget or to save money
_ DOT have specific knowledge/skill for the job	_ DOT does not have specific knowledge/skill for a particular job
_ Budget constraint	_ Long-term budget availability
_ Time constraint	_ Time constraint
_ Quality of work	_ Quality of work

2.4. Based on your experience, rate on a scale of 1 to 5, 5 being "very satisfied" and 1 being "very unsatisfied", the benefits received for the following methods.

	Maintenance methods	**Rating**
2.	In-House work	_____
3.	MBC	_____
4.	PBC	_____
5.	Other Contracting Method; please specify ……	_____

2.5. Please rate (1-5) the benefits of In-House maintenance work.

Cost effective _____
Schedule advantage _____
Quick response for emergency activities _____
Quality _____
Flexibility _____
Others, please specify ……..._____

2.6. Please rate (1-5) the benefits of Out-Sourced maintenance work.

Cost effective _____
Schedule advantage _____
Quality _____
Flexibility _____
Easy to call and give contracts _____

2.7. Rank 1 to 3 (3 as highest ranking) the maintenance methods that is best suitable for emergency work, like snow removal.

In-House _____
MBC _____
PBC _____

2.8. Identify lessons learned from the In-House contracting processes for maintenance work.

a) ……
b) ……
c) ……

2.9. Identify lessons learned from the Out-Sourced contracting methods for maintenance work.

a) ……
b) ……
c) ……

3. Performance Assessment of In-House, MBC, and PBC (If your DOT has not used the listed method, please leave the column blank.)

3.1. Rate the satisfaction level for the overall experience of In-House, MBC, and PBC methods for road maintenance activities.

	In-House work	MBC	PBC
Highly Satisfied	☐	☐	☐
Satisfied	☐	☐	☐
Neutral	☐	☐	☐
Unsatisfied	☐	☐	☐
Highly Unsatisfied	☐	☐	☐

3.2. Rate the satisfaction level for the cost effectiveness of In-House, MBC, and PBC methods for road maintenance activities.

	In-House work	MBC	PBC
Highly Satisfied	☐	☐	☐
Satisfied	☐	☐	☐
Neutral	☐	☐	☐
Unsatisfied	☐	☐	☐
Highly Unsatisfied	☐	☐	☐

3.3. Rate the satisfaction level for the schedule advantage of In-House, MBC, and PBC methods for road maintenance activities.

	In-House work	MBC	PBC
Highly Satisfied	☐	☐	☐
Satisfied	☐	☐	☐
Neutral	☐	☐	☐
Unsatisfied	☐	☐	☐
Highly Unsatisfied	☐	☐	☐

3.4. Rate the satisfaction level for the quality delivered of In-House, MBC, and PBC methods for road maintenance activities.

	In-House work	MBC	PBC
Highly Satisfied	☐	☐	☐
Satisfied	☐	☐	☐
Neutral	☐	☐	☐
Unsatisfied	☐	☐	☐
Highly Unsatisfied	☐	☐	☐

3.5. Rate the satisfaction level for the risk transfer to the MBC and PBC contractor.

	MBC	PBC
Highly Satisfied	☐	☐
Satisfied	☐	☐
Neutral	☐	☐
Unsatisfied	☐	☐
Highly Unsatisfied	☐	☐

4. Cost Analysis (In-House versus Out-Sourcing)

Please rate on a scale of 1-5, 5 being "very important" and 1 being "least important", the following cost items that should be included while analyzing the cost of In-House and Out-Sourced maintenance work.

In-House Maintenance Work	Out-Sourced Maintenance Work
_ Labor, Material, and Equipment cost	_ ____ Labor, Material, and Equipment cost
_ DOT Headquarter Office administration cost	_ ____ DOT Headquarter Office administration cost
_ District Office administration cost	_ District Office administration cost
_ Accounting, agreement services and legal staff cost	_ Accounting, agreement services and legal staff cost
_ Inspection and monitoring team cost	_ Inspection and monitoring team cost
_ Others, please specify ……..	_ Others, please specify ……..

4.1 Did your DOT perform a cost analysis to compare In-House versus Out-Sourced maintenance work?

☐ Yes (If yes, please provide the report or if it available online, please provide the web link)

_____

☐ No (Go to **Q. No. 4.4**)

4.2 If the cost analysis was performed, what were the findings?

☐ In-House method is more cost effective than other Out-Sourced methods
☐ In-House method is not as cost effective as other Out-Sourced methods
☐ Neutral
☐ Difficult to compare
☐ Do not know

4.3 In your opinion, should the quality of work be considered while comparing the cost effectiveness of In-House and Out-Sourced methods of maintenance work?

☐ Yes
☐ No
☐ Not Sure

5. Performance-Based Contracts (PLEASE STOP, if your DOT had not used PBC)

Please list the most important lessons learned from PBC method for road maintenance in the following phases that might be useful for other states.

5.1 Contract Procurement Phase

a. ……
b. ……
c. ……
d. ……

5.2 Initial Baseline Measurement Phase

a. ……
b. ……
c. ……
d. ……

5.3 Performance Measurement Phase

a. ……
b. ……
c. ……
d. ……

5.4 Payment Phase

a. ……
b. ……
c. ……
d. ……

5.5 If your DOT has <u>not</u> used Performance-Based contracts for maintenance work, please check the reasons that apply

a. We are satisfied with current Out-Sourced methods. ☐
b. There is a leadership resistance, as it measures the performance ☐
c. of both the contractor and the DOT. ☐
d. There is fear PBC will lay-off many workers. ☐
Union is not in the favor of PBC. ☐
e. Our DOT has enough expertise, skilled workers, and equipment. ☐
f. Our DOT tried and moved back from PBC, please explain the reasons ☐
……
g. Other, please specify …… ☐

5.6 Please rate (1-5) the following factors affecting your DOT's decision to use PBC method for road maintenance.

<u>Name of factors</u>	**<u>Rating</u>**
Availability of staffs in DOT	_____
Degree of schedule complexity of the work	_____
Requirement of specific knowledge/skill	_____
To save money (with life-cycle cost consideration)	_____
To save time	_____
Contractors' capability to perform works	_____
Permission from state statute	_____
Types of maintenance activities	_____
Guaranteed funding availability for a long period of time	_____
Innovation	_____

5.7 Does your DOT prepare Performance-Based road maintenance specifications?

☐ Yes. (If yes, please provide a copy or if it is available in web, please provide the web link) _____

☐ No

THANK YOU FOR YOUR HELP AND COOPERATION

APPENDIX D

On-Site Road Section Evaluation by the Research Team: Questionnaire on Chip Seal, Striping, Street Sweeping, and Culvert Cleaning

Researcher's Evaluation Form

Name of the Road:

Road Mile Post: From To

Road maintenance activities		Very	Satisfied	Neutral	Dissatisfied	Very
A.	**Chip Seal**					
A.1	**Presence of Pot holes** • 5 for < 2#-64 sq. in.x 1 in. deep potholes per 0.1 lane mile • 4 for 2 to 3#-64 sq. in.x 1 in. deep potholes per 0.1 lane mile • 3 for 4 to 5#-64 sq. in.x 1 in. deep potholes per 0.1 lane mile • 2 for 6 to 7#-64 sq. in.x 1 in. deep potholes per 0.1 lane mile • 1 for > 8#-64 sq. in.x 1 in. deep potholes per 0.1 lane mile	5	4	3	2	1
A.2	**Loss of aggregate** • 5 for < 10% aggregate loss • 4 for 10-20% aggregate loss • 3 for 20-30% aggregate loss • 2 for 30-40% aggregate loss • 1 for > 40% aggregate loss	5	4	3	2	1
A.3	**Presence of bleeding and cracks on the surface** • 5 for insignificant amount of bleeding and cracks width < 1/7-1/8 in. • 4 for insignificant amount of bleeding and cracks width < 1/6 -1/7 in. • 3 for insignificant amount of bleeding and cracks width < 1/5-1/6 in. • 2 for significant amount of bleeding and cracks width < 1/4-1/5 in. • 1 for significant amount of bleeding and cracks width > ¼ in.	5	4	3	2	1

A.4	**Presence of rutting** • 5 for < 7/8 in • 4 for 7/8-6/8 in. • 3 for 6/8-5/8 in. • 2 for 5/8-1/2 in. • 1 for > ½ in	5	4	3	2	1
A.5	**Uniform distribution of aggregate on the surface** • 5 for 90-100% aggregate are uniformly distributed • 4 for 80-90% aggregate are uniformly distributed • 3 for 70-80% aggregate are uniformly distributed • 2 for 60-70% aggregate are uniformly distributed • 1 for <60% aggregate are uniformly distributed	5	4	3	2	1
B.	**Striping**					
B.1	***The striping on the road is visible during the DAY***	5	4	3	2	1
B.2	***The striping on the road is visible at NIGHT***	5	4	3	2	1
B.3	***The striping on the road is continuous and has straight alignment***	5	4	3	2	1
C.	**Street Sweeping**					
C.1	***The roadway and median are clear of debris*** • 5 for roadway and median are 90-100% clear of debris • 4 for roadway and median are 80-90% clear of debris • 3 for roadway and median are 70-80% clear of debris • 2 for roadway and median are 60-70% clear of debris • 1 for roadway and median are <60% clear of debris	5	4	3	2	1
C.2	***The displeasing materials on the shoulder, gutter, and ditches are removed*** • 5 for shoulder, gutter, and ditches are 90-100% clear • 4 for shoulder, gutter, and ditches are 80-90% clear • 3 for shoulder, gutter, and ditches are 70-80% clear • 2 for shoulder, gutter, and ditches are 60-70% clear • 1 for shoulder, gutter, and ditches are <60% clear	5	4	3	2	1
D.	**Culvert Cleaning**					
D.1	***Debris that effects drainage was cleared on the upstream side of the culvert*** • 5 for >50% upstream side is not clear • 4 for 40-50% upstream side is not clear • 3 for 30-40% upstream side is not clear • 4 for 20-30% upstream side is not clear • 4 for <20% upstream side is not clear	5	4	3	2	1
D.2	***Debris that effects drainage was cleared on the downstream side of the culvert*** • 5 for >50% downstream side is not clear	5	4	3	2	1

	• 4 for 40-50% downstream side is not clear • 3 for 30-40% downstream side is not clear • 4 for 20-30% downstream side is not clear • 4 for <20% downstream side is not clear					
D.3	***The inside pipe of the culvert was clear*** • 5 for 90 to 100% open • 4 for 80 to 90% open • 3 for 70 to 80% open • 2 for 50 to 60% open • 1 for Less than 50% open	5	4	3	2	1

APPENDIX E

A Survey of Road Users to Evaluate Chip Seal, Striping, Street Sweeping, and Culvert Cleaning

Road Users Evaluation Form

Name of the Road:

Road Section:

Please rate (1-5 scale, 5 being "very satisfied" and 1 being "very dissatisfied") for the following activities:

1. Road Maintenance activities		Very Satisfied	Satisfied	Neutral	Dissatisfied	Very Dissatisfied
1.	**CHIP SEAL**					
a.	The surface of chip-sealed roads are smooth and have little loose aggregates	5	4	3	2	1
b.	The ride quality of road is comfortable at posted speeds	5	4	3	2	1
c.	Proper traffic control was provided during construction	5	4	3	2	1
2.	**STRIPING**					
a.	The striping on the road is visible during the DAY	5	4	3	2	1
b.	The striping on the road is visible during WET weather and NIGHTS	5	4	3	2	1
c.	Provided proper traffic control or warning signs during striping	5	4	3	2	1
3.	**SWEEPING**					
a.	The roadway and median are clear of debris	5	4	3	2	1

b.	The displeasing materials on the shoulder, gutter, and ditches are removed	5	4	3	2	1
c.	Used proper signs/ warning flashers on the sweeper truck to make drivers aware of the maintenance work	5	4	3	2	1

Comments:

_____

Thank You.
Please put this form in the envelope provided and post it.

APPENDIX F

A Survey of NDOT Personnel to Evaluate Chip Seal, Striping, Street Sweeping, and Culvert Cleaning

Satisfaction Rating of In-House & Out-sourced Road Maintenance Works

Title of the Evaluator: ……..
District: ……..

1. Are you involved in overseeing CHIP SEAL performed by NDOT In-House workers?
   ☐ YES
   ☐ NO

Please rate your satisfaction level with the following issues related to CHIP SEAL work performed by NDOT In-house workers (1-5 scale, 5 being "very satisfied" and 1 being "very unsatisfied").

Chip seal performed by NDOT		Very Satisfied	Satisfied	Neutral	Dissatisfied	Very Dissatisfied
A.	The surface of chip sealed roads are smooth and have little loss of aggregate	5	4	3	2	1
B.	The ride quality of road is comfortable at posted speed	5	4	3	2	1
C.	Provided proper traffic control during construction	5	4	3	2	1
D.	Quality of materials used	5	4	3	2	1
E.	Quality of workmanship	5	4	3	2	1

2. Are you involved in overseeing CHIP SEAL performed by private contractors?
   ☐ YES
   ☐ NO

Please rate your satisfaction level with the following issues related to CHIP SEAL work performed by private contractors.

Chip seal performed by private contractors		Very Satisfied	Satisfied	Neutral	Dissatisfied	Very Dissatisfied
A.	The surface of roads are smooth and have little loss of aggregate	5	4	3	2	1
B.	The ride quality of road is comfortable at posted speed	5	4	3	2	1
C.	Provided proper traffic control during construction	5	4	3	2	1
D.	Quality of materials used	5	4	3	2	1
E.	Quality of workmanship	5	4	3	2	1

3. Are you involved in overseeing STRIPING work performed by NDOT In-house workers?
   ☐ YES
   ☐ NO

Please rate your satisfaction level with the following items related to pavement STRIPING work performed by NDOT In-house workers.

Striping work performed by NDOT		Very Satisfied	Satisfied	Neutral	Dissatisfied	Very Dissatisfied
A.	The striping on the road is visible during the DAY	5	4	3	2	1
B.	The striping on the road is visible during WET weather and NIGHTS	5	4	3	2	1
C.	Provided proper traffic or warning signs control during striping	5	4	3	2	1
D.	Quality of material used	5	4	3	2	1
E.	Quality of workmanship	5	4	3	2	1

4. Are you involved in overseeing STRIPING work performed by private contractors?
   ☐ YES
   ☐ NO

Please rate your satisfaction level with the following items related to pavement STRIPING work performed by private contractors.

Striping work performed by private contractors		Very Satisfied	Satisfied	Neutral	Dissatisfied	Very Dissatisfied
A.	The striping on the road is visible during the DAY	5	4	3	2	1
B.	The striping on the road is visible during WET weather and NIGHTS	5	4	3	2	1
C.	Provided proper traffic or warning signs control during striping	5	4	3	2	1
D.	Quality of material used	5	4	3	2	1
E.	Quality of workmanship	5	4	3	2	1

5. Are you involved in overseeing CULVERT CLEANING work performed by NDOT In-house workers?
   ☐ YES
   ☐ NO

Please rate your satisfaction level with the following items related to CULVERT CLEANING work performed by NDOT In-house workers.

Culvert cleaning work performed by NDOT		Very Satisfied	Satisfied	Neutral	Dissatisfied	Very Dissatisfied
A.	Debris that effects drainage are cleared on the upstream side of the culvert	5	4	3	2	1
B.	Debris that effects drainage are cleared on the downstream side of the culvert	5	4	3	2	1
C.	The inside of the culvert is cleaned	5	4	3	2	1
D.	Placed proper signs to make drivers aware of the maintenance work or to detour traffic	5	4	3	2	1

6. Are you involved in overseeing CULVERT CLEANING work performed by private contractors?
   ☐ YES
   ☐ NO

Please rate your satisfaction level with the following items related to CULVERT CLEANING work performed by private contractors.

Culvert cleaning work performed by private contractors		Very Satisfied	Satisfied	Neutral	Dissatisfied	Very Dissatisfied
A.	Debris that effects drainage are cleared on the upstream side of the culvert	5	4	3	2	1
B.	Debris that effects drainage are cleared on the downstream side of the culvert	5	4	3	2	1
C.	The inside of the culvert was cleaned	5	4	3	2	1
D.	Placed proper signs to make drivers aware of the maintenance work or to detour traffic	5	4	3	2	1

7. Are you involved in overseeing SWEEPING work performed by NDOT In-house workers?
   ☐ YES
   ☐ NO

Please rate your satisfaction level with the following items related to SWEEPING work performed by NDOT In-house workers.

Sweeping work performed by NDOT		Very Satisfied	Satisfied	Neutral	Dissatisfied	Very Dissatisfied
A.	The roadway and median are clear of debris	5	4	3	2	1
B.	The displeasing materials on the shoulder, gutter, and ditches are removed	5	4	3	2	1
C.	Used proper signs / warning flashers on the sweeper truck to make commuters aware of the maintenance work	5	4	3	2	1

8. Are you involved in overseeing SWEEPING work performed by private contractors?
   ☐ YES
   ☐ NO

Please rate your satisfaction level with the following issues related to SWEEPING work performed by private contractors.

Sweeping work performed by private contractors		Very Satisfied	Satisfied	Neutral	Dissatisfied	Very Dissatisfied
A.	The roadway and median are clear of debris	5	4	3	2	1
B.	The displeasing materials on the shoulder, gutter, and ditches are removed	5	4	3	2	1
C.	Used proper signs / warning flashers on the sweeper truck to make commuters aware of the maintenance work	5	4	3	2	1

APPENDIX G

A Survey of Private Contractors to Evaluate Chip Seal, Striping, Street Sweeping, and Culvert Cleaning

Satisfaction Rating of In-House & Out-sourced Road Maintenance Works

Title of the Evaluator: ……..

Name of the firm: ……..

1. Are you involved in overseeing CHIP SEAL performed by your firm?
   ☐ YES
   ☐ NO

Please rate your satisfaction level with the following issues related to CHIP SEAL work performed by your firm (1-5 scale, 5 being "very satisfied" and 1 being "very dissatisfied").

Chip seal performed by private contractor		Very Satisfied	Satisfied	Neutral	Dissatisfied	Very Dissatisfied
A.	The surface of roads are smooth and have little loss of aggregates	5	4	3	2	1
B.	The ride quality of road is comfortable at posted speed	5	4	3	2	1
C.	Provided proper traffic control during construction	5	4	3	2	1
D.	Quality of materials used	5	4	3	2	1
E.	Quality of workmanship	5	4	3	2	1

2. Have you seen CHIP SEAL performed by NDOT In-House workers?
   ☐ YES
   ☐ NO

Please rate your satisfaction level with the following issues related to CHIP SEAL work performed by NDOT In-house workers.

Chip seal performed by NDOT		Very Satisfied	Satisfied	Neutral	Dissatisfied	Very Dissatisfied
A.	The surface of roads are smooth and have little loss of aggregates	5	4	3	2	1
B.	The ride quality of road is comfortable at posted speed	5	4	3	2	1
C.	Provided proper traffic control during construction	5	4	3	2	1

D.	Quality of materials used	5	4	3	2	1
E.	Quality of workmanship	5	4	3	2	1

3. Are you involved in overseeing STRIPING work performed by your firm?
   ☐ YES
   ☐ NO

Please rate your satisfaction level with the following issues related to STRIPING work performed by your firm.

Striping work performed by private contractor		Very Satisfied	Satisfied	Neutral	Dissatisfied	Very Dissatisfied
A.	The striping on the road is visible during the DAY	5	4	3	2	1
B.	The striping on the road is visible during WET weather and NIGHTS	5	4	3	2	1
C.	Provided proper traffic or warning signs control during striping	5	4	3	2	1
D.	Quality of material used	5	4	3	2	1
E.	Quality of workmanship	5	4	3	2	1

4. Have you seen STRIPING work performed by NDOT In-House workers?
   ☐ YES
   ☐ NO

Please rate your satisfaction level with the following issues related to STRIPING work performed by NDOT In-house workers.

Striping work performed by NDOT		Very Satisfied	Satisfied	Neutral	Dissatisfied	Very Dissatisfied
A.	The striping on the road is visible during the DAY	5	4	3	2	1
B.	The striping on the road is visible during WET weather and NIGHTS	5	4	3	2	1
C.	Provided proper traffic or warning signs control during striping	5	4	3	2	1
D.	Quality of material used	5	4	3	2	1
E.	Quality of workmanship	5	4	3	2	1

5. Are you involved in overseeing CULVERT CLEANING work performed by your firm?
   ☐ YES
   ☐ NO

Please rate your satisfaction level with the following issues related to CULVERT CLEANING work performed by your firm.

Culvert cleaning work performed by private contractor		Very Satisfied	Satisfied	Neutral	Dissatisfied	Very Dissatisfied
A.	Debris that effects drainage are cleared on the upstream side of the culvert	5	4	3	2	1
B.	Debris that effects drainage are cleared on the downstream side of the culvert	5	4	3	2	1
C.	The inside of the culvert was cleaned	5	4	3	2	1
D.	Placed proper signs to make drivers aware of the maintenance work or to detour traffic	5	4	3	2	1

6. Have you seen CULVERT CLEANING work performed by NDOT In-House workers?
   ☐ YES
   ☐ NO

Please rate your satisfaction level with the following issues related to CULVERT CLEANING work performed by NDOT In-house workers.

Culvert cleaning work performed by NDOT		Very Satisfied	Satisfied	Neutral	Dissatisfied	Very Dissatisfied
A.	Debris that effects drainage are cleared on the upstream side of the culvert	5	4	3	2	1
B.	Debris that effects drainage are cleared on the downstream side of the culvert	5	4	3	2	1
C.	The inside of the culvert was cleaned	5	4	3	2	1
D.	Placed proper signs to make drivers aware of the maintenance work or to detour traffic	5	4	3	2	1

7. Are you involved in overseeing SWEEPING work performed by your firm?
   ☐ YES
   ☐ NO

If yes, please rate your satisfaction level with the following issues related to SWEEPING work performed by your firm.

Sweeping work performed by private contractor		Very Satisfied	Satisfied	Neutral	Dissatisfied	Very Dissatisfied
A.	The roadway and median are clear of debris	5	4	3	2	1
B.	The displeasing materials on the shoulders, gutter, and ditches are removed	5	4	3	2	1
C.	Used proper signs / warning flashers on the sweeper truck to make commuters aware of the maintenance work	5	4	3	2	1

8. Are you involved in overseeing SWEEPING work performed by NDOT In-House workers?
   ☐ YES
   ☐ NO

Please rate your satisfaction level with the following issues related to SWEEPING work performed by NDOT In-house workers.

Sweeping work performed by NDOT		Very Satisfied	Satisfied	Neutral	Dissatisfied	Very Dissatisfied
A.	The roadway and median are clear of debris	5	4	3	2	1
B.	The displeasing materials on the shoulders, gutter, and ditches are removed	5	4	3	2	1
C.	Used proper signs / warning flashers on the sweeper truck to make commuters aware of the maintenance work	5	4	3	2	1

APPENDIX H

H-1: Chip Seal Cost Calculations (Performed by State Force)

TABLE H 1-1 Chip Seal Cost Calculation of SR 361 MI

SR 361 MI

Year	ENR Factor	Direct Cost	Adjusted Cost	Indirect Cost (%)	Indirect cost	Total Cost	Quantity (SY)	Unit Rate
2001	1.552573413	$ 193,941	$ 301,108	17.06	$ 51,369	$ 352,477	549,246	$ 0.64
2009	1.147491249	$ 582,223	$ 668,096	17.06	$ 113,977	$ 782,073	519,349	$ 1.51
2011	1.084353291	$ 626,134	$ 678,950	17.06	$ 115,829	$ 794,779	340,317	$ 2.34
							Average Rate=	$ 1.49

TABLE H 1-2 Chip Seal Cost Calculation of SR 361 NY

SR 361 NY

Year	ENR Factor	Direct Cost	Adjusted Cost	Indirect Cost (%)	Indirect cost	Total Cost	Quantity (SY)	Unit Rate
2001	1.552573413	$ 33,891	52,618	17.06	$ 8,977	$ 61,594.96	92,577	$ 0.67
2005	1.320709106	$ 456,142	602,431	17.06	$ 102,775	$ 705,206.28	418,926	$ 1.68
2007	1.234341659	$ 65,103	80,360	17.06	$ 13,709	$ 94,069.08	68,515	$ 1.37
2009	1.147491249	$ 112,621	129,232	17.06	$ 22,047	$ 151,279.14	61,592	$ 2.46
2010	1.1175	$ 446,956	499,473	17.06	$ 85,210	$ 584,683.62	244,617	$ 2.39
2011	1.084353291	$ 71,683	77,730	17.06	$ 13,261	$ 90,990.23	47,615	$ 1.91
							Average Rate=	$ 1.75

TABLE H 1-3 Chip Seal Cost Calculation of SR 375 LN

SR 375 LN

Year	ENR Factor	Direct Cost	Adjusted Cost	Indirect Cost (%)	Indirect cost	Total Cost	Quantity (SY)	Unit Rate
1992	1.972718154	$ 43,032	$ 84,889	17.06	$ 14,482	$ 99,371	68,640	$ 1.45
1997	1.687950566	$ 600,735	$ 1,014,011	17.06	$ 172,990	$ 1,187,001	875,542	$ 1.36
2002	1.504129703	$ 204,456	$ 307,529	17.06	$ 52,464	$ 359,993	317,269	$ 1.13
2003	1.468857356	$ 432,011	$ 634,562	17.06	$ 108,256	$ 742,818	427,532	$ 1.74
2005	1.320709106	$ 549,368	$ 725,555	17.06	$ 123,780	$ 849,335	692,502	$ 1.23
2007	1.234341659	$ 367,873	$ 454,081	17.06	$ 77,466	$ 531,548	401,455	$ 1.32
							Average Rate=	$ 1.37

TABLE H 1-4 Chip Seal Cost Calculation of SR 375 NY

SR 375 NY

Year	ENR Factor	Direct Cost	Adjusted Cost	Indirect Cost (%)	Indirect cost	Total Cost	Quantity (SY)	Unit Rate
1992	1.972718154	$ 163,338	$ 322,220	17.06	$ 54,971	$ 377,191	213,129	$ 1.77
2002	1.504129703	$ 141,093	$ 212,222	17.06	$ 36,205	$ 248,427	242,464	$ 1.02
2008	1.183393502	$ 801,400	$ 948,372	17.06	$ 161,792	$ 1,110,164	810,076	$ 1.37
							Average Rate=	$ 1.39

TABLE H 1-5 Chip Seal Cost Calculation of US 06 ES

US 06 ES

Year	ENR Factor	Direct Cost	Adjusted Cost	Indirect Cost (%)	Indirect cost	Total Cost	Quantity (SY)	Unit Rate
1991	2.033919338	$ 121,003	$ 246,110	17.06	$ 41,986	$ 288,097	219,644	$ 1.31
1992	1.972718154	$ 148,681	$ 293,306	17.06	$ 50,038	$ 343,344	282,303	$ 1.22
1997	1.687950566	$ 250,745	$ 423,245	17.06	$ 72,206	$ 495,451	285,129	$ 1.74
2001	1.552573413	$ 169,581	$ 263,287	17.06	$ 44,917	$ 308,204	457,773	$ 0.67
2005	1.320709106	$ 4,743	$ 6,264	17.06	$ 1,069	$ 7,332	4,800	$ 1.53
2006	1.268739517	$ 551,293	$ 699,447	17.06	$ 119,326	$ 818,773	573,540	$ 1.43
							Average Rate=	$ 1.32

TABLE H 1-6 Chip Seal Cost Calculation of US 06 MI

US 06 MI

Year	ENR Factor	Direct Cost	Adjusted Cost	Indirect Cost (%)	Indirect cost	Total Cost	Quantity (SY)	Unit Rate
2007	1.234341659	$ 211,323	$ 260,845	17.06	$ 44,500	$ 305,345	249,686	$ 1.22
2012	1.069145466	$ 411,770	$ 440,242	17.06	$ 75,105	$ 515,347	249,686	$ 2.06
							Average Rate=	$ 1.64

TABLE H 1-7 Chip Seal Cost Calculation of US 06 NY

US 06 NY

Year	ENR Factor	Direct Cost	Adjusted Cost	Indirect Cost (%)	Indirect cost	Total Cost	Quantity (SY)	Unit Rate
1990	2.07819104	$ 134,311	$ 279,123	17.06	$ 47,618	$ 326,742	257,570	$ 1.27
1991	2.033919338	$ 167,907	$ 341,509	17.06	$ 58,261	$ 399,770	275,692	$ 1.45
1992	1.972718154	$ 65,907	$ 130,017	17.06	$ 22,181	$ 152,198	114,359	$ 1.33
1995	1.797477609	$ 115,936	$ 208,393	17.06	$ 35,552	$ 243,945	185,383	$ 1.32
1999	1.623040106	$ 196,623	$ 319,126	17.06	$ 54,443	$ 373,569	213,122	$ 1.75
2001	1.552573413	$ 9,119	$ 14,158	17.06	$ 2,415	$ 16,574	22,823	$ 0.73
2002	1.504129703	$ 258,664	$ 389,064	17.06	$ 66,374	$ 455,438	335,400	$ 1.36
2003	1.468857356	$ 556,101	$ 816,833	17.06	$ 139,352	$ 956,184	569,398	$ 1.68
2006	1.268739517	$ 40,451	$ 51,322	17.06	$ 8,755	$ 60,077	95,791	$ 0.63
2007	1.234341659	$ 766,748	$ 946,429	17.06	$ 161,461	$ 1,107,890	685,516	$ 1.62
2008	1.183393502	$ 60,647	$ 71,769	17.06	$ 12,244	$ 84,013	39,775	$ 2.11
2009	1.147491249	$ 126,684	$ 145,369	17.06	$ 24,800	$ 170,168	44,670	$ 3.81
2011	1.084353291	$ 935,742	$ 1,014,675	17.06	$ 173,104	$ 1,187,779	645,642	$ 1.84
							Average Rate=	$ 1.61

TABLE H 1-8 Chip Seal Cost Calculation of SR 447 WA

SR 447 WA

Year	ENR Factor	Direct Cost	Adjusted Cost	Indirect Cost (%)	Indirect cost	Total Cost	Quantity (SY)	Unit Rate
1996	1.749822064	$ 21,028	$ 36,796	17.06	$ 6,277	$ 43,073	$ 15,253	$ 2.82
2001	1.552573413	$ 1,121,473	$ 1,741,170	17.06	$ 297,044	$ 2,038,213	$ 1,092,066	$ 1.87
2002	1.504129703	$ 269,776	$ 405,778	17.06	$ 69,226	$ 475,004	$ 243,501	$ 1.95
2007	1.234341659	$ 80,045	$ 98,802	17.06	$ 16,856	$ 115,658	$ 76,266	$ 1.52
2008	1.183393502	$ 847,138	$ 1,002,497	17.06	$ 171,026	$ 1,173,523	$ 300,191	$ 3.91
2009	1.147491249	$ 271,566	$ 311,620	17.06	$ 53,162	$ 364,782	$ 124,350	$ 2.93
							Average Rate=	$ 2.50

TABLE H 1-9 Chip Seal Cost Calculation of SR 854 PE

SR 854 PE

Year	ENR Factor	Direct Cost	Adjusted Cost	Indirect Cost (%)	Indirect cost	Total Cost	Quantity (SY)	Unit Rate
1998	1.661148649	$ 79,434	$ 131,952	17.06	$ 22,511	$ 154,463	49,445	$ 3.12
							Average Rate=	$ 3.12

TABLE H 1-10 Chip Seal Cost Calculation of SR 140 HU

SR 140 HU

Year	ENR Factor	Direct Cost	Adjusted Cost	Indirect Cost (%)	Indirect cost	Total Cost	Quantity (SY)	Unit Rate
1990	2.07819104	$ 118,349	$ 245,952	17.06	$ 41,959	$ 287,911	225,280	$ 1.28
1992	1.972718154	$ 165,337	$ 326,164	17.06	$ 55,644	$ 381,808	201,987	$ 1.89
1999	1.623040106	$ 458,977	$ 744,937	17.06	$ 127,086	$ 872,024	604,661	$ 1.44
2000	1.580774795	$ 235,209	$ 371,813	17.06	$ 63,431	$ 435,244	251,593	$ 1.73
2002	1.504129703	$ 352,711	$ 530,524	17.06	$ 90,507	$ 621,031	455,627	$ 1.36
2003	1.468857356	$ 435,828	$ 640,169	17.06	$ 109,213	$ 749,382	864,778	$ 0.87
2005	1.320709106	$ 325,676	$ 430,123	17.06	$ 73,379	$ 503,502	622,412	$ 0.81
2007	1.234341659	$ 550,242	$ 679,186	17.06	$ 115,869	$ 795,055	622,391	$ 1.28
2008	1.183393502	$ 427,050	$ 505,368	17.06	$ 86,216	$ 591,584	656,140	$ 0.90
2009	1.147491249	$ 513,656	$ 589,415	17.06	$ 100,554	$ 689,970	247,967	$ 2.78
							Average Rate=	$ 1.43

TABLE H 1-11 Chip Seal Cost Calculation of SR 226 EL

SR 226 EL

Year	ENR Factor	Direct Cost	Adjusted Cost	Indirect Cost (%)	Indirect cost	Total Cost	Quantity (SY)	Unit Rate
1990	2.07819104	$ 293,519	$ 609,988	17.06	$ 104,064	$ 714,052	575,225	$ 1.24
1991	2.033919338	$ 2,164	$ 4,402	17.06	$ 751	$ 5,153	4,200	$ 1.23
1992	1.972718154	$ 183,637	$ 362,263	17.06	$ 61,802	$ 424,065	321,844	$ 1.32
1997	1.687950566	$ 285,240	$ 481,471	17.06	$ 82,139	$ 563,610	332,522	$ 1.69
2004	1.382150387	$ 541,717	$ 748,734	17.06	$ 127,734	$ 876,469	607,775	$ 1.44
2006	1.268739517	$ 575,507	$ 730,168	17.06	$ 124,567	$ 854,735	616,492	$ 1.39
							Average Rate=	$ 1.38

TABLE H 1-12 Chip Seal Cost Calculation of SR 229 EL

SR 229 EL

Year	ENR Factor	Direct Cost	Adjusted Cost	Indirect Cost (%)	Indirect cost	Total Cost	Quantity (SY)	Unit Rate
2001	1.552573413	$ 469,162	$ 728,409	17.06	$ 124,267	$ 852,676	612,681	$ 1.39
2005	1.320709106	$ 228,930	$ 302,349	17.06	$ 51,581	$ 353,930	205,405	$ 1.72
2006	1.268739517	$ 389,117	$ 493,688	17.06	$ 84,223	$ 577,911	383,278	$ 1.51
2007	1.234341659	$ 234,191	$ 289,072	17.06	$ 49,316	$ 338,388	174,715	$ 1.94
2009	1.147491249	$ 757,335	$ 869,036	17.06	$ 148,257	$ 1,017,293	320,320	$ 3.18
							Average Rate=	$ 1.95

TABLE H 1-13 Chip Seal Cost Calculation of SR 278 EL

SR 278 EL

Year	ENR Factor	Direct Cost	Adjusted Cost	Indirect Cost (%)	Indirect cost	Total Cost	Quantity (SY)	Unit Rate
1991	2.033919338	$ 27,417	$ 55,764	17.06	$ 9,513	$ 65,278	45,689	$ 1.43
2005	1.320709106	$ 121,358	$ 160,279	17.06	$ 27,344	$ 187,623	153,752	$ 1.22
							Average Rate=	$ 1.32

TABLE H 1-14 Chip Seal Cost Calculation of SR 278 EU

SR 278 EU

Year	ENR Factor	Direct Cost	Adjusted Cost	Indirect Cost (%)	Indirect cost	Total Cost	Quantity (SY)	Unit Rate
1991	2.033919338	$ 9,325	$ 18,967	17.06	$ 3,235.74	$ 22,203	12,906	$ 1.72
1994	1.81841716	$ 323,285	$ 587,867	17.06	$ 100,290.07	$ 688,157	412,592	$ 1.67
1996	1.749822064	$ 142,604	$ 249,532	17.06	$ 42,570.16	$ 292,102	189,375	$ 1.54
1999	1.623040106	$ 385,570	$ 625,796	17.06	$ 106,760.83	$ 732,557	414,734	$ 1.77
2001	1.552573413	$ 151,150	$ 234,672	17.06	$ 40,035.05	$ 274,707	212,000	$ 1.30
2003	1.468857356	$ 718,914	$ 1,055,982	17.06	$ 180,150.61	$ 1,236,133	1,095,369	$ 1.13
2005	1.320709106	$ 132,326	$ 174,764	17.06	$ 29,814.69	$ 204,578	236,274	$ 0.87
2008	1.183393502	$ 1,105,071	$ 1,307,734	17.06	$ 223,099.37	$ 1,530,833	549,888	$ 2.78
							Average Rate=	$ 1.60

TABLE H 1-15 Chip Seal Cost Calculation of SR 305 LA

SR 305 LA

Year	ENR Factor	Direct Cost	Adjusted Cost	Indirect Cost (%)	Indirect cost	Total Cost	Quantity (SY)	Unit Rate
2000	1.580774795	$ 352,354	$ 556,993	17.06	$ 95,023	$ 652,016	536,014	$ 1.22
2001	1.552573413	$ 418,137	$ 649,189	17.06	$ 110,752	$ 759,940	891,433	$ 0.85
2005	1.320709106	$ 62,435	$ 82,458	17.06	$ 14,067	$ 96,526	139,761	$ 0.69
2009	1.147491249	$ 732,014	$ 839,980	17.06	$ 143,301	$ 983,280	369,131	$ 2.66
							Average Rate=	$ 1.36

TABLE H 1-16 Chip Seal Cost Calculation of SR 400 PE

SR 400 PE

Year	ENR Factor	Direct Cost	Adjusted Cost	Indirect Cost (%)	Indirect cost	Total Cost	Quantity (SY)	Unit Rate
2000	1.580774795	$ 209,601	$ 331,332	17.06	$ 56,525	$ 387,857	514,196	$ 0.75
2005	1.320709106	$ 204,716	$ 270,371	17.06	$ 46,125	$ 316,496	224,726	$ 1.41
2009	1.147491249	$ 20,797	$ 23,864	17.06	$ 4,071	$ 27,935	19,470	$ 1.43
							Average Rate=	$ 1.20

TABLE H 1-17 Chip Seal Cost Calculation of US 95 HU

US 95 HU

Year	ENR Factor	Direct Cost	Adjusted Cost	Indirect Cost (%)	Indirect cost	Total Cost	Quantity (SY)	Unit Rate
1990	2.07819104	$ 246,578	$ 512,436	17.06	$ 87,422	$ 599,858	323,392	$ 1.85
1991	2.033919338	$ 902	$ 1,834	17.06	$ 313	$ 2,147	1,600	$ 1.34
1994	1.81841716	$ 131,425	$ 238,986	17.06	$ 40,771	$ 279,756	165,829	$ 1.69
1995	1.797477609	$ 219,603	$ 394,731	17.06	$ 67,341	$ 462,072	234,230	$ 1.97
1998	1.661148649	$ 437,053	$ 726,010	17.06	$ 123,857	$ 849,867	459,687	$ 1.85
2003	1.468857356	$ 221,009	$ 324,630	17.06	$ 55,382	$ 380,012	529,033	$ 0.72
2004	1.382150387	$ 153,360	$ 211,966	17.06	$ 36,161	$ 248,127	114,346	$ 2.17
2005	1.320709106	$ 8,405	$ 11,100	17.06	$ 1,894	$ 12,994	5,467	$ 2.38
2007	1.234341659	$ 725,870	$ 895,972	17.06	$ 152,853	$ 1,048,825	692,897	$ 1.51
2009	1.147491249	$ 476,719	$ 547,031	17.06	$ 93,323	$ 640,354	158,896	$ 4.03
							Average Rate=	$ 1.95

TABLE H 1-18 Chip Seal Work Frequency of State Force-Performed Road Sections

SN	Name of the Road Sections	Frequency of Chip Seal for SF-Maintained Roads (Years)
1	SR 147 CL	7
2	SR 361 MI	2
3	SR 361 NY	3.9
4	SR 375 LN	7.84
5	SR 375 NY	2
6	US 06 MI	5
7	US 06 NY	1.44
8	US 93 LN	5.9
9	SR 208 LY	6.25
10	SR 396 PE	9
11	US 95 CH	3.52
12	SR 140	5.29
13	SR 225 EL	7.33
14	SR 226 EL	7.8
15	SR 229 EL	2.82
16	SR 278 EL	9
17	SR 278 EU	5
18	SR 305 LA	5.07
19	SR 306 EU	5
20	SR 400 PE	5
21	SR 893 WP	7
22	US 06 WP	7
23	US 50 EU	6.5
24	US 50 LA	3.38
25	US 50 WP	5.31
26	US 93 EL	5.09
27	US 93 WP	6.23
28	US 95 HU	5
	Average Frequency =	5.42

H-2: Chip Seal Cost Calculations (Performed by Private Contractor)

TABLE H 2-1 Average Striping Cost Percentage Calculation

Calculation of Striping Cost Percentage

Contract No.	Total Estimated Cost	Striping Cost	Striping Cost (%)
1	$ 2,005,607	$ 209,481	10.4
2	$ 8,492,534	$ 1,093,701	12.9
3	$ 1,627,747	$ 219,667	13.5
		Average Striping Cost(%)	12.3

Note: Striping cost percentage is calculated to deduct from a combined chip seal and striping cost of the contracts.

TABLE H 2-2 Unit Chip Seal Cost Calculation of Private Contractor-Performed Roads

Unit Cost of Chip Seal of MBC maintained Roads:

SN	Name of the Road	Year	ENR Factor	Total Contract Cost	Total Chip Seal Contract Cost	Adjusted Chip Seal Cost	Indirect Cost (17.06% of Contract Cost)	Total Chip Seal Cost	Each Road Length (Miles)	Pavement Area (SY)	Unit Cost
1	US 93 EL	2011	1.084353291	$ 1,338,336	$ 1,173,721	$ 1,272,728	$ 217,127	$ 1,489,856	32.2	453,376	$ 3.29
2	SR 225 EL	2011	1.084353291	$ 1,059,031	$ 928,771	$ 1,007,115	$ 171,814	$ 1,178,929	25.48	358,758	$ 3.29
3	SR 305 LA	2011	1.084353291	$ 1,149,224	$ 1,007,869	$ 1,092,886	$ 186,446	$ 1,279,333	27.65	389,312	$ 3.29
4	SR 140 HU	2011	1.084353291	$ 1,496,277	$ 1,312,235	$ 1,422,926	$ 242,751	$ 1,665,677	36	506,880	$ 3.29
5	SR 893 WP	2011	1.084353291	$ 1,652,139	$ 1,448,926	$ 1,571,147	$ 268,038	$ 1,839,185	39.75	559,680	$ 3.29
6	US 93 CL	2011	1.084353291	$ 1,524,154	$ 1,336,683	$ 1,449,437	$ 247,274	$ 1,696,711	38.15	537,152	$ 3.16
7	SR 147 CL	2011	1.084353291	$ 286,853	$ 251,570	$ 272,791	$ 46,538	$ 319,329	7.18	101,094	$ 3.16
8	SR 341 LY	2011	1.084353291	$ 170,573	$ 149,592	$ 162,211	$ 27,673	$ 189,884	4.9	68,992	$ 2.75
9	US 95 LY, CH, MI	2011	1.084353291	$ 968,434	$ 849,317	$ 920,960	$ 157,116	$ 1,078,075	27.82	391,706	$ 2.75
										Average Cost	$ 3.14

Note: All Roads are 2-lane-2-way

TABLE H 2-3 Chip Seal Work Frequency of Contractor-Performed Road Sections

SN	Name of the Road Sections	Frequency of Chip Seal for SF-Maintained Roads (Years)
1	SR 147 CL	3
2	SR 169 CL	4
3	SR 375 LN	1
4	SR 375 NY	4
5	US 93 CL	3
6	US 93 LN	3.65
7	US 95 NY	3
8	SR 401 PE	4
9	SR 121 CH	2
10	SR 208 LY	4
11	SR 341 LY	3
12	SR 341 ST	4
13	SR 447 WA	3
14	SR 854 PE	3
15	US 95 CH	2.49
16	SR 140	3
17	SR 225 EL	2.63
18	SR 226 EL	2
19	SR 278 EU	4
20	SR 305 LA	3
21	SR 306 EU	2
22	SR 400 PE	4
23	SR 893 WP	3
24	US 06 WP	4
25	US 50 EU	3
26	US 50 LA	4
27	US 50 WP	2.86
28	US 93 EL	2.96
29	US 95 HU	4
	Average Frequency =	3.16

APPENDIX I

I-1: Striping Cost Calculations (State Force-Performed works)

TABLE I 1-1 Striping Cost Calculation of IR 15 CL

IR 15 CL

Year	ENR Factor	Direct Cost		Indirect Cost (%)	Indirect cost	Quantity (Line Mile)	Unit Rate
		Cost	Adjusted Cost				
1990	2.08	$ 97,467	$ 202,554	17.06%	$ 34,556	389.85	$ 608.21
1991	2.03	$ 240,061	$ 488,265	17.06%	$ 83,298	427.80	$ 1,336.05
1992	1.97	$ 119,616	$ 235,969	17.06%	$ 40,256	420.90	$ 656.27
1993	1.89	$ 96,980	$ 183,052	17.06%	$ 31,229	355.35	$ 603.01
1994	1.82	$ 40,067	$ 72,859	17.06%	$ 12,430	355.35	$ 240.01
1995	1.80	$ 28,776	$ 51,724	17.06%	$ 8,824	376.05	$ 161.01
1996	1.75	$ 54,031	$ 94,544	17.06%	$ 16,129	427.80	$ 258.70
1997	1.69	$ 46,709	$ 78,843	17.06%	$ 13,451	414.00	$ 222.93
1998	1.66	$ 27,021	$ 44,885	17.06%	$ 7,657	410.55	$ 127.98
1999	1.62	$ 68,624	$ 111,380	17.06%	$ 19,001	427.80	$ 304.77
2000	1.58	$ 56,610	$ 89,488	17.06%	$ 15,267	427.80	$ 244.87
2001	1.55	$ 53,738	$ 83,433	17.06%	$ 14,234	427.80	$ 228.30
2002	1.50	$ 66,982	$ 100,750	17.06%	$ 17,188	251.85	$ 468.29
2003	1.47	$ 60,321	$ 88,602	17.06%	$ 15,116	227.70	$ 455.50
2004	1.38	$ 81,176	$ 112,197	17.06%	$ 19,141	238.05	$ 551.73
2005	1.32	$ 27,714	$ 36,603	17.06%	$ 6,244	345.00	$ 124.19
2006	1.27	$ 31,260	$ 39,661	17.06%	$ 6,766	293.25	$ 158.32
2007	1.23	$ 200,656	$ 247,678	17.06%	$ 42,254	400.20	$ 724.47
2008	1.18	$ 160,123	$ 189,489	17.06%	$ 32,327	376.05	$ 589.86
2009	1.15	$ 147,130	$ 168,830	17.06%	$ 28,802	424.35	$ 465.73
2010	1.12	$ 187,775	$ 209,838	17.06%	$ 35,798	389.85	$ 630.08
2011	1.08	$ 264,051	$ 286,325	17.06%	$ 48,847	427.80	$ 783.48
2012	1.07	$ 29,826	$ 31,889	17.06%	$ 5,440	262.20	$ 142.37
2013	1.03	$ 156,418	$ 161,188	17.06%	$ 27,499	338.10	$ 558.08
						Average Rate=	$ 443.51

TABLE I 1-2 Striping Cost Calculation of IR 215 CL

IR 215 CL

Year	ENR Factor	Direct Cost		Indirect Cost (%)	Indirect cost	Quantity (Line Mile)	Unit Rate
		Cost	Adjusted Cost				
1998	1.66	$ 1,943	$ 3,228	17.06%	$ 551	6.90	$ 547.57
1999	1.62	$ 7,486	$ 12,151	17.06%	$ 2,073	10.35	$ 1,374.28
2000	1.58	$ 767	$ 1,213	17.06%	$ 207	10.35	$ 137.19
2002	1.50	$ 14,642	$ 22,023	17.06%	$ 3,757	10.35	$ 2,490.81
2003	1.47	$ 2,860	$ 4,201	17.06%	$ 717	10.35	$ 475.10
2004	1.38	$ 1,606	$ 2,219	17.06%	$ 379	10.35	$ 251.02
2007	1.23	$ 9,800	$ 12,097	17.06%	$ 2,064	17.25	$ 820.92
2008	1.18	$ 52,380	$ 61,987	17.06%	$ 10,575	10.35	$ 7,010.77
2010	1.12	$ 13,198	$ 14,748	17.06%	$ 2,516	10.35	$ 1,668.07
2011	1.08	$ 6,865	$ 7,444	17.06%	$ 1,270	10.35	$ 841.94
2012	1.07	$ 8,100	$ 8,660	17.06%	$ 1,477	10.35	$ 979.48
2013	1.03	$ 1,774	$ 1,828	17.06%	$ 312	10.35	$ 206.77
						Average Rate=	$ 1,400.33

TABLE I 1-3 Striping Cost Calculation of US 95 CL

US 95 CL

Year	ENR Factor	Direct Cost		Indirect Cost (%)	Indirect cost	Quantity (Line Mile)	Unit Rate
		Cost	Adjusted Cost				
1990	2.078	$ 68,909	$ 143,206	17.06%	$ 24,431	403.65	$ 415.30
1991	2.034	$ 185,701	$ 377,701	17.06%	$ 64,436	441.6	$ 1,001.22
1992	1.973	$ 122,385	$ 241,432	17.06%	$ 41,188	441.6	$ 639.99
1993	1.888	$ 103,658	$ 195,656	17.06%	$ 33,379	417.45	$ 548.65
1994	1.818	$ 105,168	$ 191,239	17.06%	$ 32,625	441.6	$ 506.94
1995	1.797	$ 114,308	$ 205,466	17.06%	$ 35,052	445.05	$ 540.43
1996	1.750	$ 69,146	$ 120,994	17.06%	$ 20,642	382.95	$ 369.85
1997	1.688	$ 59,929	$ 101,156	17.06%	$ 17,257	448.5	$ 264.02
1998	1.661	$ 66,854	$ 111,055	17.06%	$ 18,946	458.85	$ 283.32
1999	1.623	$ 86,627	$ 140,599	17.06%	$ 23,986	458.85	$ 358.69
2000	1.581	$ 72,047	$ 113,890	17.06%	$ 19,430	458.85	$ 290.55
2001	1.553	$ 68,023	$ 105,610	17.06%	$ 18,017	303.6	$ 407.20
2002	1.504	$ 99,493	$ 149,651	17.06%	$ 25,530	458.85	$ 381.78
2003	1.469	$ 62,528	$ 91,844	17.06%	$ 15,669	362.25	$ 296.79
2004	1.382	$ 123,970	$ 171,345	17.06%	$ 29,231	386.4	$ 519.09
2005	1.321	$ 153,728	$ 203,030	17.06%	$ 34,637	376.05	$ 632.01
2006	1.269	$ 206,172	$ 261,579	17.06%	$ 44,625	386.4	$ 792.45
2007	1.234	$ 100,570	$ 124,137	17.06%	$ 21,178	458.85	$ 316.69
2008	1.183	$ 107,940	$ 127,736	17.06%	$ 21,792	458.85	$ 325.87
2009	1.147	$ 143,145	$ 164,258	17.06%	$ 28,022	376.05	$ 511.32
2010	1.118	$ 204,639	$ 228,684	17.06%	$ 39,014	358.8	$ 746.09
2011	1.084	$ 68,117	$ 73,863	17.06%	$ 12,601	341.55	$ 253.15
2012	1.07	$ 294,065	$ 314,398	17.06%	$ 53,636	310.5	$ 1,185.30
2013	1.03	$ 34,905	$ 35,969	17.06%	$ 6,136	251.85	$ 167.18
						Average Rate=	$ 489.75

TABLE I 1-4 Striping Cost Calculation of US 95 ES

US 95 ES

Year	ENR Factor	Direct Cost		Indirect Cost (%)	Indirect cost	Quantity (Line Mile)	Unit Rate
		Cost	Adjusted Cost				
1990	2.08	$ 33,063	$ 68,711	17.06%	$ 11,722	207.00	$ 388.57
1991	2.03	$ 57,312	$ 116,568	17.06%	$ 19,886	207.00	$ 659.20
1992	1.97	$ 41,773	$ 82,406	17.06%	$ 14,058	207.00	$ 466.01
1993	1.89	$ 32,103	$ 60,595	17.06%	$ 10,338	207.00	$ 342.67
1994	1.82	$ 24,535	$ 44,615	17.06%	$ 7,611	207.00	$ 252.30
1995	1.80	$ 14,185	$ 25,496	17.06%	$ 4,350	207.00	$ 144.18
1996	1.75	$ 21,322	$ 37,310	17.06%	$ 6,365	207.00	$ 210.99
1997	1.69	$ 30,409	$ 51,329	17.06%	$ 8,757	207.00	$ 290.27
1998	1.66	$ 31,256	$ 51,922	17.06%	$ 8,858	207.00	$ 293.62
1999	1.62	$ 32,695	$ 53,066	17.06%	$ 9,053	207.00	$ 300.09
2000	1.58	$ 29,886	$ 47,244	17.06%	$ 8,060	207.00	$ 267.17
2001	1.55	$ 11,595	$ 18,001	17.06%	$ 3,071	207.00	$ 101.80
2002	1.50	$ 9,764	$ 14,687	17.06%	$ 2,506	207.00	$ 83.06
2003	1.47	$ 13,612	$ 19,995	17.06%	$ 3,411	207.00	$ 113.07
2004	1.38	$ 79,334	$ 109,652	17.06%	$ 18,707	207.00	$ 620.09
2005	1.32	$ 68,552	$ 90,538	17.06%	$ 15,446	207.00	$ 512.00
2006	1.27	$ 15,771	$ 20,009	17.06%	$ 3,414	207.00	$ 113.15
2007	1.23	$ 38,636	$ 47,690	17.06%	$ 8,136	207.00	$ 269.69
2008	1.18	$ 36,895	$ 43,661	17.06%	$ 7,449	207.00	$ 246.90
2009	1.15	$ 37,722	$ 43,286	17.06%	$ 7,385	207.00	$ 244.78
2010	1.12	$ 46,958	$ 52,475	17.06%	$ 8,952	207.00	$ 296.75
2011	1.08	$ 17,720	$ 19,215	17.06%	$ 3,278	207.00	$ 108.66
2012	1.07	$ 31,176	$ 33,332	17.06%	$ 5,686	207.00	$ 188.49
2013	1.03	$ 850	$ 876	17.06%	$ 149	207.00	$ 4.95
						Average Rate=	$ 271.60

TABLE I 1-5 Striping Cost Calculation of US 95 MI

US 95 MI

Year	ENR Factor	Direct Cost		Indirect Cost (%)	Indirect cost	Quantity (Line Mile)	Unit Rate
		Cost	Adjusted Cost				
1990	2.08	$ 62,469	$ 129,822	17.06%	$ 22,148	89.70	$ 1,694.20
1991	2.03	$ 92,366	$ 187,866	17.06%	$ 32,050	89.70	$ 2,451.68
1992	1.97	$ 65,365	$ 128,947	17.06%	$ 21,998	89.70	$ 1,682.78
1993	1.89	$ 56,353	$ 106,367	17.06%	$ 18,146	89.70	$ 1,388.11
1994	1.82	$ 48,009	$ 87,300	17.06%	$ 14,893	89.70	$ 1,139.28
1995	1.80	$ 63,073	$ 113,372	17.06%	$ 19,341	89.70	$ 1,479.52
1996	1.75	$ 58,010	$ 101,506	17.06%	$ 17,317	89.70	$ 1,324.68
1997	1.69	$ 44,235	$ 74,667	17.06%	$ 12,738	89.70	$ 974.42
1998	1.66	$ 33,053	$ 54,906	17.06%	$ 9,367	89.70	$ 716.53
1999	1.62	$ 56,871	$ 92,303	17.06%	$ 15,747	89.70	$ 1,204.57
2000	1.58	$ 41,617	$ 65,787	17.06%	$ 11,223	89.70	$ 858.53
2001	1.55	$ 22,734	$ 35,296	17.06%	$ 6,021	89.70	$ 460.62
2002	1.50	$ 26,037	$ 39,164	17.06%	$ 6,681	89.70	$ 511.09
2003	1.47	$ 19,230	$ 28,247	17.06%	$ 4,819	89.70	$ 368.62
2004	1.38	$ 25,186	$ 34,810	17.06%	$ 5,939	89.70	$ 454.28
2005	1.32	$ 38,899	$ 51,374	17.06%	$ 8,764	89.70	$ 670.44
2006	1.27	$ 7,563	$ 9,596	17.06%	$ 1,637	89.70	$ 125.22
2007	1.23	$ 64,084	$ 79,102	17.06%	$ 13,495	89.70	$ 1,032.30
2008	1.18	$ 109,215	$ 129,244	17.06%	$ 22,049	89.70	$ 1,686.66
2009	1.15	$ 24,226	$ 27,799	17.06%	$ 4,742	89.70	$ 362.78
2010	1.12	$ 46,435	$ 51,891	17.06%	$ 8,853	89.70	$ 677.19
2011	1.08	$ 37,685	$ 40,863	17.06%	$ 6,971	NA	-
2012	1.07	$ 60,284	$ 64,452	17.06%	$ 10,995	89.70	$ 841.11
2013	1.03	$ 3,160	$ 3,256	17.06%	$ 556	89.70	$ 42.50
						Average Rate=	$ 962.92

TABLE I 1-6 Striping Cost Calculation of US 95 NY

US 95 NY

Year	ENR Factor	Direct Cost		Indirect Cost (%)	Indirect cost	Quantity (Line Mile)	Unit Rate
		Cost	Adjusted Cost				
1990	2.08	$ 27,639	$ 57,440	17.06%	$ 9,799	269.10	$ 249.87
1991	2.03	$ 106,392	$ 216,394	17.06%	$ 36,917	372.60	$ 679.85
1992	1.97	$ 47,000	$ 92,718	17.06%	$ 15,818	372.60	$ 291.29
1993	1.89	$ 38,573	$ 72,807	17.06%	$ 12,421	372.60	$ 228.74
1994	1.82	$ 42,677	$ 77,605	17.06%	$ 13,239	369.15	$ 246.09
1995	1.80	$ 44,283	$ 79,599	17.06%	$ 13,580	372.60	$ 250.08
1996	1.75	$ 48,026	$ 84,037	17.06%	$ 14,337	269.10	$ 365.57
1997	1.69	$ 23,997	$ 40,506	17.06%	$ 6,910	372.60	$ 127.26
1998	1.66	$ 43,463	$ 72,198	17.06%	$ 12,317	372.60	$ 226.82
1999	1.62	$ 20,567	$ 33,381	17.06%	$ 5,695	348.45	$ 112.14
2000	1.58	$ 56,856	$ 89,876	17.06%	$ 15,333	372.60	$ 282.36
2001	1.55	$ 12,812	$ 19,891	17.06%	$ 3,393	372.60	$ 62.49
2002	1.50	$ 14,390	$ 21,644	17.06%	$ 3,693	372.60	$ 68.00
2003	1.47	$ 55,223	$ 81,114	17.06%	$ 13,838	372.60	$ 254.84
2004	1.38	$ 84,901	$ 117,346	17.06%	$ 20,019	372.60	$ 368.67
2005	1.32	$ 103,485	$ 136,674	17.06%	$ 23,317	372.60	$ 429.39
2006	1.27	$ 31,654	$ 40,161	17.06%	$ 6,852	372.60	$ 126.17
2007	1.23	$ 50,849	$ 62,765	17.06%	$ 10,708	372.60	$ 197.19
2008	1.18	$ 58,748	$ 69,522	17.06%	$ 11,860	327.75	$ 248.31
2009	1.15	$ 56,854	$ 65,239	17.06%	$ 11,130	376.05	$ 203.08
2010	1.12	$ 101,947	$ 113,926	17.06%	$ 19,436	355.35	$ 375.30
2011	1.08	$ 64,790	$ 70,256	17.06%	$ 11,986	324.30	$ 253.60
2012	1.07	$ 58,686	$ 62,743	17.06%	$ 10,704	-	-
2013	1.03	$ 4,662	$ 4,804	17.06%	$ 820	89.70	$ 62.70
						Average Rate=	$ 248.25

TABLE I 1-7 Frequency of Striping Performed by State Force

SN	Name of the Road Sections	Frequency of Striping for SF-Maintained Roads (Years)
1	IR 15 CL	1.2
2	IR 215 CL	2.54
3	US 95 CL	1.22
4	US 95 ES	1.04
5	US 95 MI	1.26
5	US 95 NY	1.11
	Average Frequency =	1.40

I-2 Striping Cost Calculations (Performed by Private Contractor)

TABLE I 2-1 Striping Direct Cost Calculation of Road Sections Performed by MBC Contractors

MBC contract work for Striping

SN	Name of Road	Year	ENR Factor	Total Contract Cost	Total Chip Seal Cost	Striping Cost	Adjusted Striping Cost	Indirect Cost (17.06%)	Total Striping Cost	Curb miles	Line miles	Unit Cost
1	US 93 EL	2011	1.084353291	$ 1,338,336	$ 1,173,721	$ 164,615	$ 178,501	$ 30,452	$ 208,954	32.2	111.09	$ 1,880.94
2	SR 225 EL	2011	1.084353291	$ 1,059,031	$ 928,771	$ 130,261	$ 141,249	$ 24,097	$ 165,346	25.48	87.91	$ 1,880.94
3	SR 305 LA	2011	1.084353291	$ 1,149,224	$ 1,007,869	$ 141,355	$ 153,278	$ 26,149	$ 179,427	27.65	95.39	$ 1,880.94
4	SR 893 WP	2011	1.084353291	$ 1,652,139	$ 1,448,926	$ 203,213	$ 220,355	$ 37,593	$ 257,947	39.75	137.14	$ 1,880.94
5	US 93 CL	2011	1.084353291	$ 1,524,154	$ 1,336,683	$ 187,471	$ 203,285	$ 34,680	$ 237,965	38.15	131.62	$ 1,808.01
6	SR 147 CL	2011	1.084353291	$ 286,853	$ 251,570	$ 35,283	$ 38,259	$ 6,527	$ 44,786	7.18	24.77	$ 1,808.01
7	SR 341 LY	2011	1.084353291	$ 170,573	$ 149,592	$ 20,980	$ 22,750	$ 3,881	$ 26,631	4.9	16.91	$ 1,575.36
8	US 95 LY, CH, MI	2011	1.084353291	$ 968,434	$ 849,317	$ 119,117	$ 129,165	$ 22,036	$ 151,201	27.82	95.98	$ 1,575.34
											Average=	$ 1,786.31

TABLE I 2-2 Frequency of Striping Performed by Private Contractors

SN	Name of the Road Sections	Frequency of Striping for Private Contractor-Maintained Roads (Years)
1	US 95 MI	2.39
2	US 95 NY	1.39
	Average Frequency =	1.87

I-3 Striping Cost Calculations (Performed by PBC Private Contractors)

TABLE I 3-1 Cost Calculation of Striping Performed on US 95 CL by PBC Contractor

Name of the Road	**US 95 CL**
Total Contract Cost (TCC)	**$ 842,940**
Total Striping Cost (TSC)	**$ 802,800**
Length of Road	**90 miles**

Payment Schedule for PBC Contractor				
Year	**Payment Schedule**	**Payment Amount**	**ENR Adjustment Factor**	**Adjusted Direct Cost to 2014**
2012	40% TSC	$ 321,120	1.07	$ 343,598
2013	10% TSC	$ 80,280	1.03	$ 82,688
2014	10% TSC	$ 80,280	1	$ 80,280
2015	10% TSC	$ 80,280	0.93	$ 74,660
2016	10% TSC	$ 80,280	0.88	$ 70,646
2017	20% TSC	$ 160,560	0.84	$ 134,870
Total Payment		**$ 802,800**		**$ 786,744**
	Unit Cost of Striping			**$ 8,741.60**

APPENDIX J

J-1: Culvert Cleaning Cost Calculations (Performed by State Force)

TABLE J 1-1 Cost Calculations for Culvert Cleaning of Five Road Sections, Performed by State Force

SR 28, 431, SR 207, SR 760, US 50

SN	Year	ENR Factor	Direct Cost	Adjusted Direct Cost	Indirect Cost (17.06%)	Indirect cost	Total Cost
1	1990	2.07819104	$356,090	$ 740,023	0.170559066	$126,218	$ 866,241
2	1991	2.033919338	$414,622	$ 843,308	0.170559066	$143,834	$ 987,142
3	1992	1.972718154	$261,961	$ 516,774	0.170559066	$ 88,141	$ 604,915
4	1993	1.887523992	$ 24,995	$ 47,178	0.170559066	$ 8,047	$ 55,225
5	1994	1.81841716	$ 28,750	$ 52,279	0.170559066	$ 8,917	$ 61,195
6	1995	1.797477609	$ 17,452	$ 31,369	0.170559066	$ 5,350	$ 36,719
7	1996	1.749822064	$ 37,734	$ 66,027	0.170559066	$ 11,262	$ 77,289
8	1997	1.687950566	$ 37,397	$ 63,124	0.170559066	$ 10,766	$ 73,890
9	1998	1.661148649	$ 50,296	$ 83,549	0.170559066	$ 14,250	$ 97,799
10	1999	1.623040106	$ 18,151	$ 29,460	0.170559066	$ 5,025	$ 34,485
11	2000	1.580774795	$ 42,942	$ 67,882	0.170559066	$ 11,578	$ 79,460
12	2001	1.552573413	$ 41,189	$ 63,948	0.170559066	$ 10,907	$ 74,855
13	2002	1.504129703	$ 31,531	$ 47,427	0.170559066	$ 8,089	$ 55,516
14	2003	1.468857356	$ 17,893	$ 26,282	0.170559066	$ 4,483	$ 30,765
15	2004	1.382150387	$ 13,373	$ 18,484	0.170559066	$ 3,153	$ 21,637
16	2006	1.268739517	$ 14,029	$ 17,799	0.170559066	$ 3,036	$ 20,834
17	2007	1.234341659	$ 19,121	$ 23,602	0.170559066	$ 4,026	$ 27,628
18	2008	1.183393502	$ 63,209	$ 74,801	0.170559066	$ 12,758	$ 87,558
19	2009	1.147491249	$ 51,688	$ 59,312	0.170559066	$ 10,116	$ 69,428
					Average Rate=		**$ 176,978**

J-2: Culvert Cleaning Cost Calculations (Performed by Private Contractors)

TABLE J 2-1 Cost Calculations for Culvert Cleaning of Five Road Sections, Performed by MBC Contractors

SR 28, 431, SR 207, SR 760, US 50

SN	Year	ENR Factor	Direct Cost	Adjusted Direct Cost	Indirect Cost (%)	Indirect cost	Total Cost
1	2010	1.118	$ 201,974	$ 225,705	17.06	$ 38,505	$ 264,211
2	2011	1.084	$ 201,974	$ 219,011	17.06	$ 37,363	$ 256,374
						Average Rate	$ 260,292

APPENDIX K

K-1: Street Sweeping Cost Calculations (State Force-Performed)

TABLE K 1-1 Street Sweeping Cost Calculation of US 93 CL

US 93 CL

SN	Year	ENR Factor	Direct Cost	Adjusted Direct Cost	Indirect Cost (%)	Indirect cost	Total Cost	Length (Mile)	Length (Curb Mile)	Unit Rate
1	1990	2.078191	$ 60,129	$ 124,960	17.06	$ 21,318	$ 146,278	1,214	2,429	$ 60.22
2	1991	2.0339193	$ 101,113	$ 205,657	17.06	$ 35,085	$ 240,742	2,159	4,318	$ 55.75
3	1992	1.9727182	$ 53,710	$ 105,955	17.06	$ 18,076	$ 124,031	1,411	2,823	$ 43.94
4	1993	1.887524	$ 77,249	$ 145,809	17.06	$ 24,875	$ 170,684	1,708	3,415	$ 49.98
5	1994	1.8184172	$ 64,037	$ 116,446	17.06	$ 19,866	$ 136,312	1,505	3,011	$ 45.28
6	1995	1.7974776	$ 68,234	$ 122,650	17.06	$ 20,924	$ 143,574	1,448	2,897	$ 49.56
7	1996	1.7498221	$ 95,767	$ 167,576	17.06	$ 28,588	$ 196,164	1,587	3,175	$ 61.79
8	1997	1.6879506	$ 80,445	$ 135,788	17.06	$ 23,165	$ 158,953	1,242	2,485	$ 63.98
9	1998	1.6611486	$ 66,296	$ 110,127	17.06	$ 18,788	$ 128,915	1,100	2,200	$ 58.61
10	1999	1.6230401	$ 63,815	$ 103,574	17.06	$ 17,670	$ 121,243	1,024	2,047	$ 59.22
11	2000	1.5807748	$ 47,963	$ 75,818	17.06	$ 12,935	$ 88,753	1,279	2,558	$ 34.69
12	2001	1.5525734	$ 36,950	$ 57,368	17.06	$ 9,787	$ 67,155	1,056	2,111	$ 31.81
13	2002	1.5041297	$ 29,796	$ 44,817	17.06	$ 7,646	$ 52,463	1,107	2,213	$ 23.70
14	2003	1.4688574	$ 25,005	$ 36,729	17.06	$ 6,266	$ 42,995	1,100	2,200	$ 19.54
15	2004	1.3821504	$ 45,859	$ 63,384	17.06	$ 10,813	$ 74,198	1,948	3,896	$ 19.04
16	2005	1.3207091	$ 43,123	$ 56,953	17.06	$ 9,716	$ 66,669	1,769	3,539	$ 18.84
17	2006	1.2687395	$ 34,841	$ 44,204	17.06	$ 7,541	$ 51,745	1,318	2,635	$ 19.64
18	2007	1.2343417	$ 23,859	$ 29,450	17.06	$ 5,024	$ 34,474	922	1,843	$ 18.70
19	2008	1.1833935	$ 52,521	$ 62,153	17.06	$ 10,603	$ 72,757	791	1,582	$ 46.00
20	2009	1.1474912	$ 66,295	$ 76,073	17.06	$ 12,978	$ 89,051	731	1,461	$ 60.95
21	2010	1.1175	$ 55,608	$ 62,142	17.06	$ 10,601	$ 72,744	694	1,389	$ 52.38
22	2011	1.0843533	$ 132,090	$ 143,232	17.06	$ 24,435	$ 167,667	1,678	3,355	$ 49.97
23	2012	1.0691455	$ 73,236	$ 78,300	17.06	$ 13,358	$ 91,658	1,049	2,097	$ 43.71
24	2013	1.0304936	$ 23,982	$ 24,713	17.06	$ 4,216	$ 28,929	340	679	$ 42.59
								Average		**$ 42.91**

TABLE K 1-2 Street Sweeping Cost Calculation of SR 574 CL

SR 574 CL

SN	Year	ENR Factor	Direct Cost	Adjusted Direct Cost	Indirect Cost (%)	Indirect cost	Total Cost	Length (Mile)	Length (Curb Mile)	Unit Rate
1	1990	2.078191	$ 15,987	$ 33,224	17.06	$ 5,668	$ 38,892	314	627	$ 62.00
2	1991	2.0339193	$ 24,599	$ 50,033	17.06	$ 8,536	$ 58,568	524	1048	$ 55.90
3	1992	1.9727182	$ 16,827	$ 33,195	17.06	$ 5,663	$ 38,858	347	694	$ 55.99
4	1993	1.887524	$ 28,814	$ 54,387	17.06	$ 9,278	$ 63,666	718	1436	$ 44.33
5	1994	1.8184172	$ 29,237	$ 53,166	17.06	$ 9,070	$ 62,236	651	1302	$ 47.80
6	1995	1.7974776	$ 40,319	$ 72,473	17.06	$ 12,364	$ 84,837	791	1583	$ 53.59
7	1996	1.7498221	$ 50,381	$ 88,157	17.06	$ 15,040	$ 103,197	832	1664	$ 62.03
8	1997	1.6879506	$ 45,791	$ 77,293	17.06	$ 13,186	$ 90,479	656	1311	$ 69.01
9	1998	1.6611486	$ 34,182	$ 56,781	17.06	$ 9,687	$ 66,467	548	1095	$ 60.70
10	1999	1.6230401	$ 39,590	$ 64,256	17.06	$ 10,962	$ 75,219	619	1237	$ 60.80
11	2000	1.5807748	$ 30,800	$ 48,688	17.06	$ 8,306	$ 56,995	745	1490	$ 38.24
12	2001	1.5525734	$ 20,123	$ 31,243	17.06	$ 5,330	$ 36,573	571	1143	$ 32.01
13	2002	1.5041297	$ 15,483	$ 23,288	17.06	$ 3,973	$ 27,261	567	1135	$ 24.03
14	2003	1.4688574	$ 12,283	$ 18,041	17.06	$ 3,078	$ 21,119	594	1189	$ 17.77
15	2004	1.3821504	$ 21,293	$ 29,430	17.06	$ 5,021	$ 34,451	977	1955	$ 17.63
16	2005	1.3207091	$ 21,046	$ 27,796	17.06	$ 4,742	$ 32,538	852	1703	$ 19.10
17	2006	1.2687395	$ 19,590	$ 24,855	17.06	$ 4,240	$ 29,095	759	1517	$ 19.18
18	2007	1.2343417	$ 8,905	$ 10,992	17.06	$ 1,875	$ 12,867	331	662	$ 19.43
19	2008	1.1833935	$ 15,481	$ 18,320	17.06	$ 3,125	$ 21,445	270	540	$ 39.73
20	2009	1.1474912	$ 30,224	$ 34,682	17.06	$ 5,917	$ 40,599	342	685	$ 59.30
21	2010	1.1175	$ 19,242	$ 21,503	17.06	$ 3,668	$ 25,172	243	486	$ 51.84
22	2011	1.0843533	$ 31,719	$ 34,395	17.06	$ 5,868	$ 40,262	408	815	$ 49.39
23	2012	1.0691455	$ 32,236	$ 34,465	17.06	$ 5,880	$ 40,345	487	973	$ 41.45
24	2013	1.0304936	$ 14,801	$ 15,252	17.06	$ 2,602	$ 17,855	213	427	$ 41.83
								Average		**$ 43.46**

TABLE K 1-3 Street Sweeping Cost Calculation of SR 592 CL

SR 592 CL

SN	Year	ENR Factor	Direct Cost	Adjusted Direct Cost	Indirect Cost (%)	Indirect cost	Total Cost	Length (Mile)	Length (Curb Mile)	Unit Rate
1	1990	2.078191	$ 38,455	$ 79,917	17.06	$ 13,634	$ 93,551	762	1524	$ 61.40
2	1991	2.0339193	$ 39,240	$ 79,811	17.06	$ 13,616	$ 93,427	1145	2290	$ 40.80
3	1992	1.9727182	$ 23,492	$ 46,344	17.06	$ 7,906	$ 54,250	749	1499	$ 36.19
4	1993	1.887524	$ 31,658	$ 59,755	17.06	$ 10,194	$ 69,949	592	1185	$ 59.05
5	1994	1.8184172	$ 29,233	$ 53,158	17.06	$ 9,069	$ 62,227	638	1275	$ 48.80
6	1995	1.7974776	$ 18,820	$ 33,829	17.06	$ 5,771	$ 39,600	426	852	$ 46.47
7	1996	1.7498221	$ 27,446	$ 48,025	17.06	$ 8,193	$ 56,218	436	872	$ 64.50
8	1997	1.6879506	$ 22,780	$ 38,451	17.06	$ 6,560	$ 45,010	384	768	$ 58.63
9	1998	1.6611486	$ 18,068	$ 30,014	17.06	$ 5,120	$ 35,135	319	637	$ 55.13
10	1999	1.6230401	$ 16,197	$ 26,288	17.06	$ 4,485	$ 30,773	256	511	$ 60.17
11	2000	1.5807748	$ 8,748	$ 13,829	17.06	$ 2,359	$ 16,189	227	454	$ 35.67
12	2001	1.5525734	$ 11,454	$ 17,784	17.06	$ 3,034	$ 20,818	304	609	$ 34.21
13	2002	1.5041297	$ 6,419	$ 9,655	17.06	$ 1,647	$ 11,303	247	494	$ 22.88
14	2003	1.4688574	$ 7,802	$ 11,460	17.06	$ 1,955	$ 13,415	330	660	$ 20.33
15	2004	1.3821504	$ 15,717	$ 21,723	17.06	$ 3,706	$ 25,428	603	1207	$ 21.08
16	2005	1.3207091	$ 13,933	$ 18,402	17.06	$ 3,139	$ 21,541	587	1173	$ 18.36
17	2006	1.2687395	$ 11,181	$ 14,185	17.06	$ 2,420	$ 16,605	394	787	$ 21.09
18	2007	1.2343417	$ 9,413	$ 11,618	17.06	$ 1,982	$ 13,600	375	751	$ 18.11
19	2008	1.1833935	$ 21,457	$ 25,393	17.06	$ 4,332	$ 29,725	318	635	$ 46.79
20	2009	1.1474912	$ 29,459	$ 33,804	17.06	$ 5,767	$ 39,571	327	655	$ 60.44
21	2010	1.1175	$ 26,801	$ 29,950	17.06	$ 5,110	$ 35,060	341	682	$ 51.41
22	2011	1.0843533	$ 28,290	$ 30,676	17.06	$ 5,233	$ 35,909	385	769	$ 46.68
23	2012	1.0691455	$ 20,980	$ 22,431	17.06	$ 3,827	$ 26,257	289	579	$ 45.37
24	2013	1.0304936	$ 3,051	$ 3,144	17.06	$ 536	$ 3,681	40	79	$ 46.38
								Average		**$ 42.50**

TABLE K 1-4 Street Sweeping Cost Calculation of SR 596 CL

SR 596 CL

SN	Year	ENR Factor	Direct Cost	Adjusted Direct Cost	Indirect Cost (%)	Indirect cost	Total Cost	Length (Mile)	Length (Curb Mile)	Unit Rate
1	1990	2.078191	$ 81,513	$ 169,400	17.06	$ 28,900	$ 198,299	1093	2186	$ 90.71
2	1991	2.0339193	$ 124,137	$ 252,484	17.06	$ 43,074	$ 295,557	1643	3287	$ 89.93
3	1992	1.9727182	$ 53,495	$ 105,530	17.06	$ 18,003	$ 123,533	1165	2329	$ 53.04
4	1993	1.887524	$ 66,516	$ 125,551	17.06	$ 21,419	$ 146,970	1330	2659	$ 55.27
5	1994	1.8184172	$ 43,364	$ 78,854	17.06	$ 13,453	$ 92,307	904	1807	$ 51.07
6	1995	1.7974776	$ 40,308	$ 72,452	17.06	$ 12,360	$ 84,813	860	1720	$ 49.32
7	1996	1.7498221	$ 63,475	$ 111,070	17.06	$ 18,948	$ 130,018	1167	2334	$ 55.72
8	1997	1.6879506	$ 44,421	$ 74,980	17.06	$ 12,792	$ 87,772	774	1549	$ 56.68
9	1998	1.6611486	$ 43,592	$ 72,413	17.06	$ 12,354	$ 84,766	790	1580	$ 53.64
10	1999	1.6230401	$ 30,301	$ 49,179	17.06	$ 8,390	$ 57,569	568	1136	$ 50.69
11	2000	1.5807748	$ 29,892	$ 47,252	17.06	$ 8,061	$ 55,313	1133	2266	$ 24.41
12	2001	1.5525734	$ 19,544	$ 30,344	17.06	$ 5,177	$ 35,520	698	1396	$ 25.44
13	2002	1.5041297	$ 29,713	$ 44,692	17.06	$ 7,624	$ 52,316	1038	2076	$ 25.20
14	2003	1.4688574	$ 19,412	$ 28,514	17.06	$ 4,864	$ 33,378	713	1426	$ 23.41
15	2004	1.3821504	$ 27,875	$ 38,528	17.06	$ 6,573	$ 45,101	1188	2376	$ 18.98
16	2005	1.3207091	$ 26,266	$ 34,690	17.06	$ 5,918	$ 40,608	1069	2139	$ 18.99
17	2006	1.2687395	$ 15,834	$ 20,090	17.06	$ 3,427	$ 23,517	576	1152	$ 20.42
18	2007	1.2343417	$ 24,413	$ 30,134	17.06	$ 5,141	$ 35,275	904	1808	$ 19.51
19	2008	1.1833935	$ 59,566	$ 70,491	17.06	$ 12,026	$ 82,516	786	1572	$ 52.50
20	2009	1.1474912	$ 21,836	$ 25,057	17.06	$ 4,275	$ 29,331	207	414	$ 70.88
21	2010	1.1175	$ 39,986	$ 44,684	17.06	$ 7,623	$ 52,307	458	916	$ 57.07
22	2011	1.0843533	$ 53,784	$ 58,320	17.06	$ 9,949	$ 68,270	587	1174	$ 58.14
23	2012	1.0691455	$ 52,320	$ 55,938	17.06	$ 9,543	$ 65,481	704	1407	$ 46.53
24	2013	1.0304936	$ 14,256	$ 14,691	17.06	$ 2,506	$ 17,197	202	404	$ 42.56
								Average		**$ 46.25**

K-2: Street Sweeping Cost Calculations (Performed by Private Contractors)

TABLE K 2-1 Cost Calculation of Street Sweeping Performed by MBC Contractors

SR 595, SR 593, SR 612, SR 573, SR 599, SR 159, SR 589

SN	Year	ENR Factor	Direct Cost	Adjusted Direct Cost	Indirect Cost (%)	Indirect cost	Total Cost	Quantity (Curb Mile)	Unit Rate
1	2013	1.0304936	$ 168,274	$ 173,406	17.06	$ 29,583	$ 202,989		
2	2014	1	$ 168,274	$ 168,274	17.06	$ 28,708	$ 196,982	6237	
							$ 399,970		**$ 64.13**

APPENDIX L

L.1 Photos of Chip Seal Performed by State Force

(a)

(b)

FIGURE L 1-1 (a) (b) Chip Seal, State Force, US 93 LN County 2012.

(a)

(b)

FIGURE L 1-2 (a) (b) Chip Seal, State Force, SR 266 ES County 2012.

(a)

(b)

FIGURE L 1-3 (a) (b) Chip Seal, State Force, US 93 EL County 2011.

(a)

(b)

FIGURE L 1-4 (a) (b) Chip Seal, State Force, US 6 NY County 2011.

L.2: Photos of Chip Seal Performed by Private Contractors

(a)

(b)

FIGURE L 2-1 (a) (b) Chip Seal, Private Contract Work, SR 121 CH County 2014.

(a)

(b)

FIGURE L 2-2 (a) (b) Chip Seal, Private Contract Work, US 93 CL County 2012.

(a)

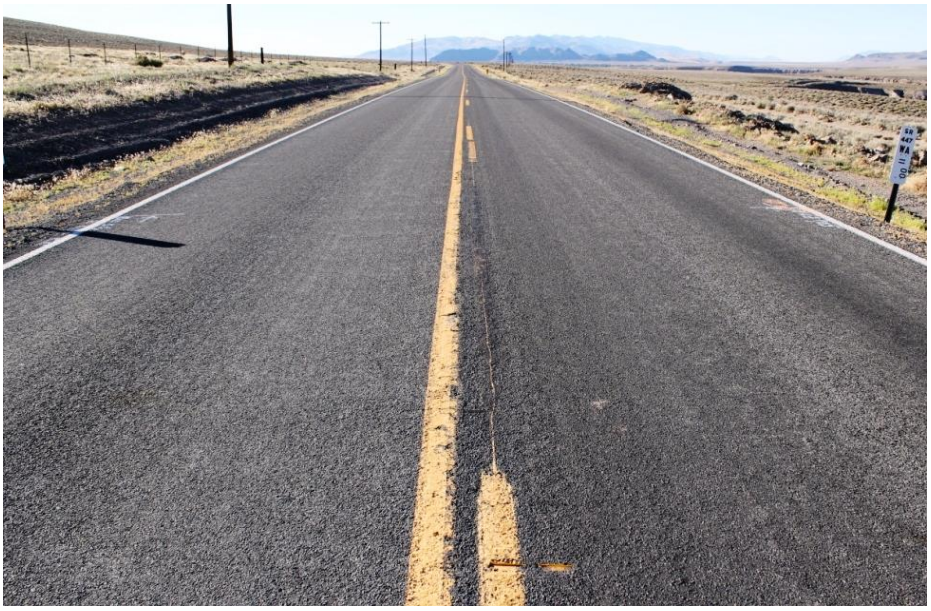
(b)

FIGURE L 2-3 (a) (b) Chip Seal, Private Contract Work, US 93 LN County 2012.

(a)

(b)

FIGURE L 2-4 (a) (b) Chip Seal, Private Contract Work, SR 305 LA County 2012.



(a)

(b)

FIGURE L 2-5 (a) (b) Chip Seal, Private Contract Work, SR 447 WA County 2013.

(a)

(b)

FIGURE L 2-6 (a) (b) Chip Seal, Private Contract Work, SR 225 EL County 2014.

APPENDIX M

M-1: Photos of Striping Performed by State Force

(a)

(b)

(c)

FIGURE M-1-1 (a) (b) (c) Striping, State Force Work, US 95 CL County 2012.

(a)

(b)

(c)

FIGURE M-1-2 (a) (b) (c) Striping, State Force Work, SR 163 CL County 2012

(a)

(b)

(c)

FIGURE M-1-3 (a) (b) (c) Striping, State Force Work, SR 160 CL County 2013.

(a)

(b)

(c)

FIGURE M-1-4 (a) (b) (c) Striping, State Force Work, US 95 CL County 2013.

M-2: Photos of Chip Seal Performed by Private Contractors

(a)

(b)

(c)

FIGURE M-2-1 (a) (b) (c) Striping, Private Contractor Work, US 93 CL County 2011.

(a)

(b)

(c)

FIGURE M-2-2 (a) (b) (c) Striping, Private Contractor Work, US 95 CH County 2011.

(a)

(b)

(c)

FIGURE M-2-3 (a) (b) (c) Striping, Private Contractor Work, US 93 LN County 2011.

(a)

(b)

(c)

FIGURE M-2-4 (a) (b) (c) Striping, Private Contractor Work, US 95 MI County 2011.

M-3: Photos of Striping Performed by PBC Private Contractors

(a)

(b)

(c)

FIGURE M-3-1 (a) (b) (c) Striping, PBC Contractor Work, US 95 CL County 2012-2017.

APPENDIX N

N-1: Photos of Culvert Cleaning Performed by State Force

(a)

(b)

FIGURE N-1-1 (a) (b) Culvert Cleaning, State Force, SR 160 CL County 2014.

(a)

(b)

FIGURE N-1-2 (a) (b) Culvert Cleaning, State Force, US 95 CL County (Las Vegas to Beatty) 2014.

(a)

(b)

FIGURE N-1-3 (a) (b) Culvert Cleaning, State Force, US 95 CL County (Searchlight to Las Vegas) 2014.

(a)

(b)

FIGURE N-1-4 (a) (b) Culvert Cleaning, State Force, SR 163 CL County 2014.

N-2: Photos of Private Contractor-Performed Culvert Cleaning

(a)

(b)

(c)

FIGURE N-2-1 (a) (b) (c) Culvert Cleaning, Private Contractor, SR 28 CC County.

(a)

(b)

FIGURE N-2-2 (a) (b) Culvert Cleaning, Private Contractor, SR 28 WA County.

(a)

(b)

(c)

FIGURE N-2-3 (a) (b) (c) Culvert Cleaning, Private Contractor, SR 431 WA County.

(a)

(b)

FIGURE N-2-4 (a) (b) Culvert Cleaning, Private Contractor, US 50 DO County.

APPENDIX P

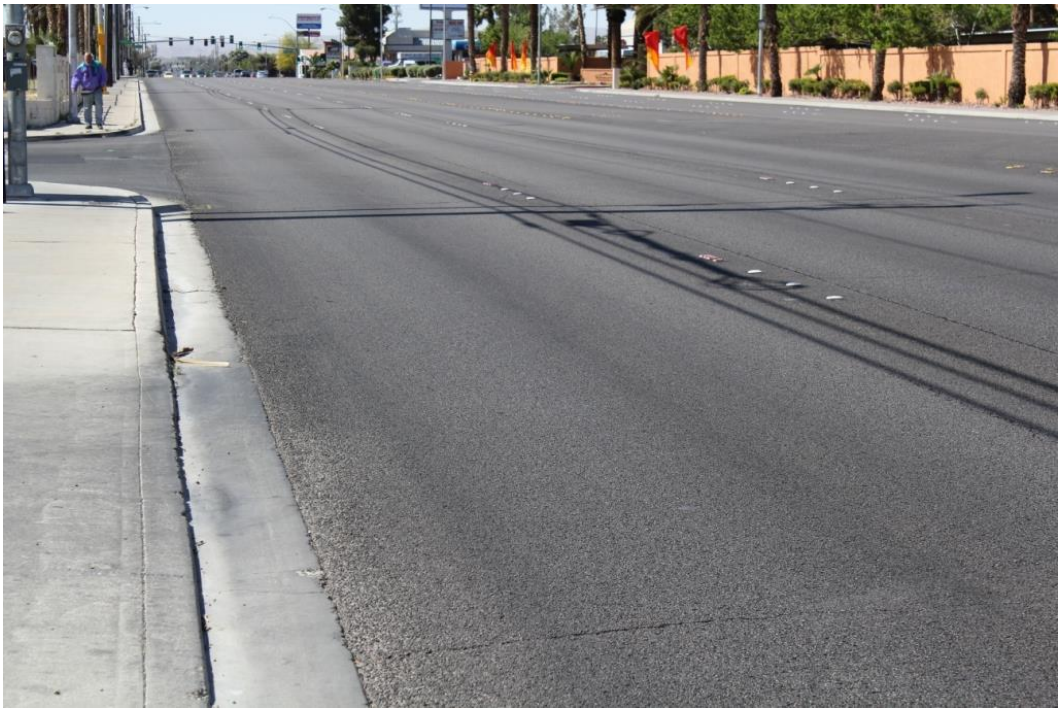
P-1: Photos of Street Sweeping Performed by State Force

(a)

(b)

FIGURE P-1-1 (a) (b) Street Sweeping, State Force, SR 574 CL County 2014.

(a)



(b)

FIGURE P-1-2 (a) (b) Street Sweeping, State Force, SR 596 CL County 2014.

(a)

(b)

FIGURE P-1-3 (a) (b) Street Sweeping, State Force, SR 592 CL County 2014.

(a)

(b)

FIGURE P-1-4 (a) (b) Street Sweeping, State Force, SR 592 CL County 2014.

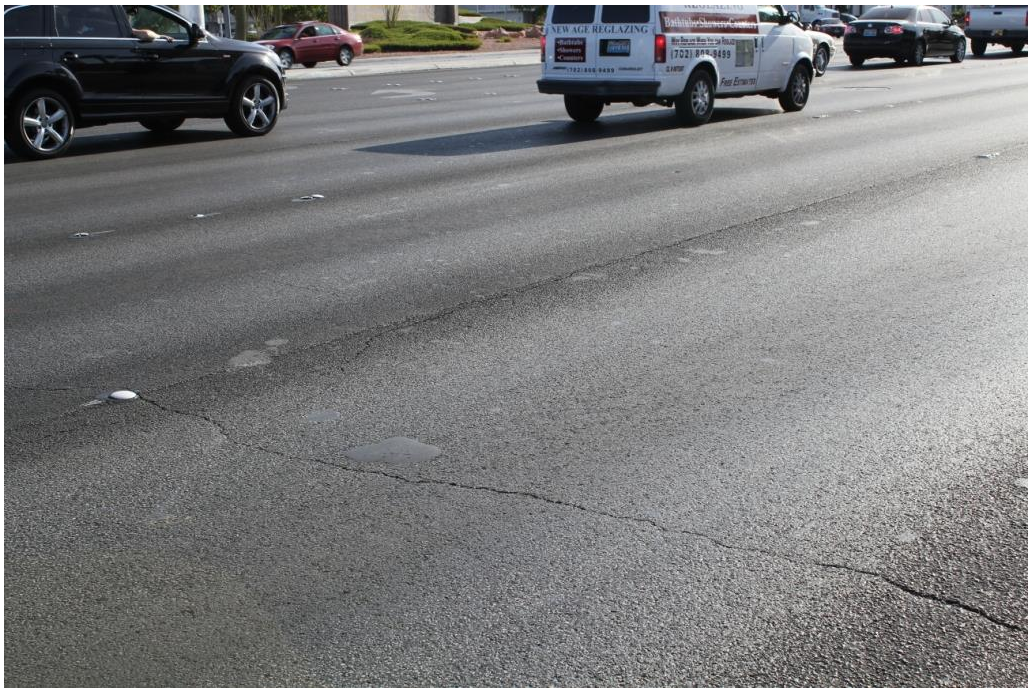
(a)

(b)

FIGURE P-1-5 (a) (b) Street Sweeping, State Force, SR 596 CL County 2014.

P-2: Photos of Street Sweeping Performed by Private Contractor

(a)



(b)

FIGURE P-2-1 (a) (b) Street Sweeping, Private Contractor, SR 596 CL County 2012-2014.

(a)

(b)

FIGURE P-2-2 (a) (b) Street Sweeping, Private Contractor, SR 592 CL County 2012-2014.

(a)

(b)

FIGURE P-2-3 (a) (b) Street Sweeping, Private Contractor, SR 573 CL County 2012-2014.

(a)

(b)

FIGURE P-2-4 (a) (b) Street Sweeping, Private Contractor, SR 612 CL County 2012-2014.

Nevada Department of Transportation
Rudy Malfabon, P.E. Director
Ken Chambers, Research Division Chief
(775) 888-7220
kchambers@dot.state.nv.us
1263 South Stewart Street
Carson City, Nevada 89712