Analysis of TAMC Investment Reporting Data for Network Level Modeling on the Locally Owned Road System in Michigan

Michigan Transportation Asset Management Council

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ABSTRACT

The Michigan Transportation Asset Management Council (TAMC) has been collecting data on pavement maintenance and construction activities via the Investment Reporting Tool (IRT) for several years now. IRT data provides a rich set of infrastructure investment data that can be used for modeling and strategy analysis efforts both on a state and local level. This study evaluates IRT data from 2017 and 2016 for use in modeling efforts.

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EXECUTIVE SUMMARY

Michigan Public Act 499 established the Transportation Asset Management Council (TAMC) to collect, analyze, and report on Michigan's public road network. To accomplish this mission, TAMC has worked with state and local agencies to develop tools, systems, and processes that help roadway owners collect and use roadway asset information. The Investment Reporting Tool (IRT) is of these systems that captures road and bridge construction and maintenance activity from Michigan's 656 local road owning agencies and MDOT.

Road agencies are required to report road and bridge planned and completed construction and maintenance activity annually using the IRT. The IRT data is the most complete source of data for state level condition modeling of Michigan's public roads and bridges. This report analyzes the IRT data collected during 2017 and 2016, and makes recommendations for use of this data at state and local levels for project planning and condition modeling.

The project evaluated data in the IRT data to produce average cost per lane mile figures for four classes of treatments: reconstruction, rehabilitation, heavy preventive maintenance and light preventive maintenance for large cities, counties and small cities. The IRT data was also used to develop estimates of the total quantity of these four treatment classes on local agency roads. The data analysis suggests that IRT data is resilient to common errors in reporting, and produces consistent data that can be used for state and local level modeling and planning.

This study compared reconstruction and rehabilitation projects reported in the IRT, against the against actual bid costs for the reported projects. This analysis indicates that there may need to be clarification on the basis of cost reporting as it relates to preliminary engineering, construction engineering and right of way purchase costs. Overall the impact of these costs appear to be relatively small, effecting primarily the cost of reconstruction and rehabilitation projects. However, more clearly defining the basis of cost with guidance and education would eliminate a source of variability in the IRT data.

1 INTRODUCTION

The Michigan Transportation Asset Management Council (TAMC) was appointed by the State Transportation Commission on September 26, 2002 as required in Public Act (PA) 499. Their mission as defined by this act is to report the condition of the Michigan public road network to the Michigan Legislature [1]. The TAMC's mission is taken directly from PA 499 and states:

> "In order to provide a coordinated, unified effort by the various roadway agencies within the state, the transportation asset management council is hereby created within the state transportation commission and is charged with advising the commission on a statewide asset management strategy and the processes and necessary tools needed to implement such a strategy beginning with the federal-aid eligible highway system, and once completed, continuing on with the county road and municipal systems, in a cost-effective and efficient manner."

The TAMC outlined many tasks necessary to meet the mission of PA 499 and developed these tools, systems, and processes to complete reporting and analysis tasks:

- Investment Reporting Tool (IRT) is the procedure and system developed by the TAMC to meet reporting requirements of Act 499 of 2002 and subsequent amendments. IRT is a statewide road and bridge reporting tool offering a web-based data entry or online reporting from the widely used Roadsoft Asset Management software.
- Act 51 Distribution and Reporting System (ADARS) receives data from the IRT. Local road agencies also report the disposition of funds appropriated, apportioned, or allocated to them under Act 51 on an annual basis using ADARS.
- Pavement Condition Forecasting System (PCFS) receives data from IRT, ADARS, and other sources to help forecast and understand regional and statewide road condition trends.

These systems and tools help local agencies meet reporting requirements while providing road owners, managers, engineers, policy makers, and the public with valuable information on road condition.

Investment reporting data from the Michigan Department of Transportation (MDOT) for state-owned roads were not included in this study because MDOT already has processes in place to report, analyze, and model pavement project data for state-owned roads. Data for state-owned roads are provided as a modeling input for TAMC's pavement model for the state trunk line system under a separate analysis process that is internal to the MDOT.

The IRT study was developed to create modeling inputs for the PCFS system from data reported to TAMC by Michigan's local agencies as part of their annual PA 51 project and financial

reporting. Outputs from this study will also provide data that can be used by local agencies in their own modelling or planning efforts. This study provides the following outputs:

1) A subdivided table of average treatment costs per lane mile that can be used for planning the cost of future projects or modeling the state and local road networks;
2) A subdivided project volume for each treatment class that is extrapolated to account for incomplete reporting and can then be used as model input for TAMC's network-level model;
3) Recommendations for the implementation of processes that will routinely produce these results from the raw data in future years.

2 BACKGROUND

Michigan's public road network is owned by 656 local government units (cities, counties and villages) and the State of Michigan, however, a group that is commonly referred to as the "Big 124" owns approximately 92% of the road network. The Big 124 is comprised of Michigan's 83 county road commissions, its 40 largest cities, and the Michigan Department of Transportation (MDOT). The remaining 8% of Michigan's public roads are owned by 533 smaller cities and villages. Most transportation initiatives focus on the Big 124 because this group's behavior can greatly influence transportation sector outcomes for the whole state.

An important part of the asset management process is forecasting asset condition so that maintenance and construction can be planned well into the future and "what if" scenarios can be contemplated. Asset managers typically use condition modeling which helps improve condition forecasts to guide maintenance and construction strategies, rather than relying purely on professional judgement or historic trends. Pavement condition modeling is important on the state level, and is a critical process to fulfill the TAMC's mission to advise the state legislature on the current and future condition of Michigan's transportation assets.

The TAMC has been using network-level models to predict pavement condition on Michigan's public roads for over a decade. The current pavement condition forecast model is called the Pavement Condition Forecast System (PCFS), which was developed by the MDOT. The PCFS is a network-level model that converts broad state-level budgets into discrete categories of maintenance and construction work. The model estimates pavement condition given a planned course of maintenance and construction activity and anticipated annual deterioration rates.

The TAMC has defined four classifications of construction and maintenance work which are the basis for reporting by road owning agencies. These classifications as defined by the TAMC are as follows:

Reconstruction is the removal and replacement of the majority of the structure of a pavement. This includes additions to the base or sub-base of the road. Examples of reconstruction would be crush and shape with the addition of base materials, or the construction of a new road. In concrete pavements, reconstruction includes rubblizing or crushing existing concrete pavement surfaces for use as added base material followed by the construction of a new concrete surfaces.

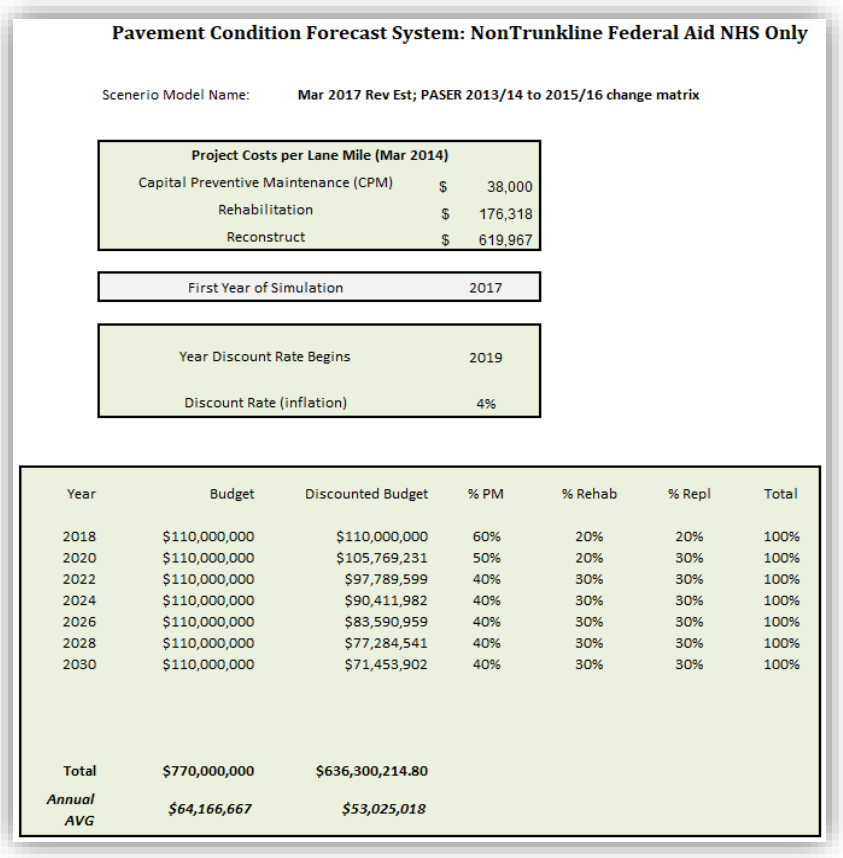
Rehabilitation is the salvage of the majority of the structure of the pavement, either by adding additional structural components (>1.5-inch overlay) to replace failing ones, or by recycling structural components (crush and shape, warm in-place recycling) for the majority of the pavement. Generally speaking, rehabilitation does not include the addition or replacement of base or subbase material other than recycling of failed layers. In concrete pavements, rehabilitation includes extensive full-depth patching and limited full-slab replacement or overlay with hot mix asphalt (HMA).

Heavy Capital Preventive Maintenance (CPM) are bituminous surface treatments such as slurry seal, chip seal, or thin (<1.5 inch) overlays designed to protect the pavement from water intrusion or environmental weathering without adding significant structural strength. In concrete pavements, patching or repair that is less than 1/3 of the depth of the pavement (partial depth repair) are included in this treatment.

Light CPM are treatments primarily designed to seal isolated areas of the pavement from water (crack and joint sealing), or protect and restore surface oxidation with limited surface thickness materials (fog seal). Generally speaking, light CPM will not provide a corresponding increase in PASER rating when applied.

The PCFS can model three of the four TAMC construction and maintenance classifications: Reconstruction, rehabilitation, and heavy preventive maintenance (shortened to preventive maintenance in PCFS). These three construction and maintenance classifications directly impact road condition ratings when they are applied, resulting in an increase in condition rating. The fourth construction and maintenance classification defined by the TAMC is light preventive maintenance, which is not modeled by the PCFS since these treatments do not directly increase the condition of a pavement as measured by the Pavement Surface Evaluation Rating (PASER) condition system. Light preventive maintenance does provide a material benefit when it is applied to pavements, however this benefit is not readily apparent in the relatively course PASER 10 to 1 rating system.

The main user input page for the PCFS system is illustrated in Figure 1 below.



Pavement Condition Forecast System: NonTrunkline Federal Aid NHS Only

Scenerio Model Name: **Mar 2017 Rev Est; PASER 2013/14 to 2015/16 change matrix**

Project Costs per Lane Mile (Mar 2014)		
Capital Preventive Maintenance (CPM)	$	38,000
Rehabilitation	$	176,318
Reconstruct	$	619,967

First Year of Simulation	2017
Year Discount Rate Begins	2019
Discount Rate (inflation)	4%

Year	Budget	Discounted Budget	% PM	% Rehab	% Repl	Total
2018	$110,000,000	$110,000,000	60%	20%	20%	100%
2020	$110,000,000	$105,769,231	50%	20%	30%	100%
2022	$110,000,000	$97,789,599	40%	30%	30%	100%
2024	$110,000,000	$90,411,982	40%	30%	30%	100%
2026	$110,000,000	$83,590,959	40%	30%	30%	100%
2028	$110,000,000	$77,284,541	40%	30%	30%	100%
2030	$110,000,000	$71,453,902	40%	30%	30%	100%
Total	**$770,000,000**	**$636,300,214.80**				
Annual AVG	***$64,166,667***	***$53,025,018***				

Figure 1: User input page for the TAMC's Pavement Condition Forecasting System (PCFS) illustrating the construction and maintenance cost and budget inputs present in the model. Data Sources

3 DATA SOURCES

3.1 Investment Reporting Tool (IRT)

Michigan Public Act 199 of 2007 requires "The department, each county road commission, and each city and village of this state shall annually submit a report to the transportation asset management council… (which) shall be reported consistent with categories established by the transportation asset management council." This act requires the reporting of all maintenance and construction activity completed during the year, and requires the reporting of planned maintenance and construction projects for the upcoming three-year window for the entire public road system. The act also requires the reporting of pavement condition data on the federal aid eligible road system, and bridge asset condition data for the entire public road system.

The TAMC developed a web-based system called the Investment Reporting Tool (IRT) to manage the process of reporting planned and completed maintenance and construction activity for roads and bridges. The IRT collects the location, type, and status of individual road and bridge projects as a direct export from the Roadsoft Asset Management system, or manually using a web interface. This versatility is intended to meet the business processes of various sized local agencies while minimizing duplicated effort. The MDOT also provides data to TAMC on state trunkline road and bridge projects through and export of their data management system to the IRT database.

The IRT allows local agency users to enter data on the following fields: a unique project identifier, the date the project was open to traffic, the location of the project, and the classification of the project. Construction cost data can be linked to IRT data through a unique project identifier that connects construction and maintenance costs from the Act 51 Distribution and Reporting System (ADARS) to a respective project in the IRT (see section 3.2 for more information on ADARS reporting). Data from the IRT and ADARS are linked by the unique project identifier.

Reporting project information using the IRT is mandatory for road-owning agencies, and recently the TAMC made a concerted effort to gain compliance. Local agencies are required to check a "reporting complete" box in the IRT after completing data entry or indicating that there were no planned or completed projects.

The IRT includes user access controls to determine whether agencies have logged on to the system and whether they have finished the reporting process by marking their reporting as complete. TAMC monitors use of the IRT and works to improve compliance with agencies that do not complete the process or who have made obvious errors in reporting. Reporting compliance is high, however some of the 656 road-owning agencies do not fully complete the reporting process each year.

Any construction or maintenance project that is complete and open to traffic during the road agency's fiscal year must be reported in the IRT. The reporting deadlines for the IRT follow the individual road agency's own fiscal year definition. The typical fiscal year reporting cycles used by Michigan road owning agencies are October 1, 2016 to September 30, 2017, January 1, 2016 to December 31, 2017, and July 1, 2016 to June 30, 2017. Each of these reporting periods is considered part of the TAMC 2017 IRT reporting set. Agencies have 180 days after the end of their fiscal year to report investments, which means that 2017 was the most current and fully complete IRT data set when this report was written in mid-2018.

The 2017 and 2016 IRT reporting cycles have a higher reporting rate, which positively reflect the efforts to increase reporting. The IRT data sets were received from the Michigan Center for Shared Solutions (CSS) multiple times during this project as local agencies reported data, and reporting compliance was reviewed. Early versions of the IRT database were used for testing and analytical set up. The final production version of the IRT database used for this study was received on August 16, 2018. The database contains 10,685 projects from the 2017 and 2016 reporting cycles, of which 10,190 are local agency projects and 495 are MDOT projects.

Data was filtered from the production version of the IRT/ADARS data set to remove MDOT projects, yielding a database containing 5025 local agency projects for 2017, and 5165 local agency project from 2016. To remove likely erroneous entries, analysts discarded projects that were missing data or had project costs less than ten dollars.

In the fiscal year 2017 IRT reporting cycle, 51 of the 656 Michigan local agencies did not fully complete the required IRT reporting, or were under review at the time of analysis, and in 2016 only 45 local agencies did not complete reporting. See Section 5.4 for more detail on incomplete reporting. Project data from local agencies that did not complete reporting, or that were still under review were removed from the analysis in this study because it could not be determined if those reports were complete. Methods for estimating the volume of this missing data are discussed later in this report.

CTT staff manually reviewed the filtered local agency data set to remove bridge, culvert replacement, and gravel road projects. The resulting filtered database is expected to only contain projects on paved roads that were intended to improve pavement condition, and submitted by local agencies that had fully completed the IRT/ADARS reporting process.

Figure 2 below illustrates the process flow used to filter raw IRT/ADARS data and arrive at the final database. Appendix A includes a similar figure for the 2016 data set. In 2017 approximately 9% of the total local agency project dollar value was removed as a result of filtering. Approximately 1.7% of the 2016 local agency project dollar value was removed as a result of these filtering processes. The higher removal percentage in 2017 was several local agency submittals were still being reviewed by the TAMC staff at the time data was received, and as such does not indicate reporting compliance issues.

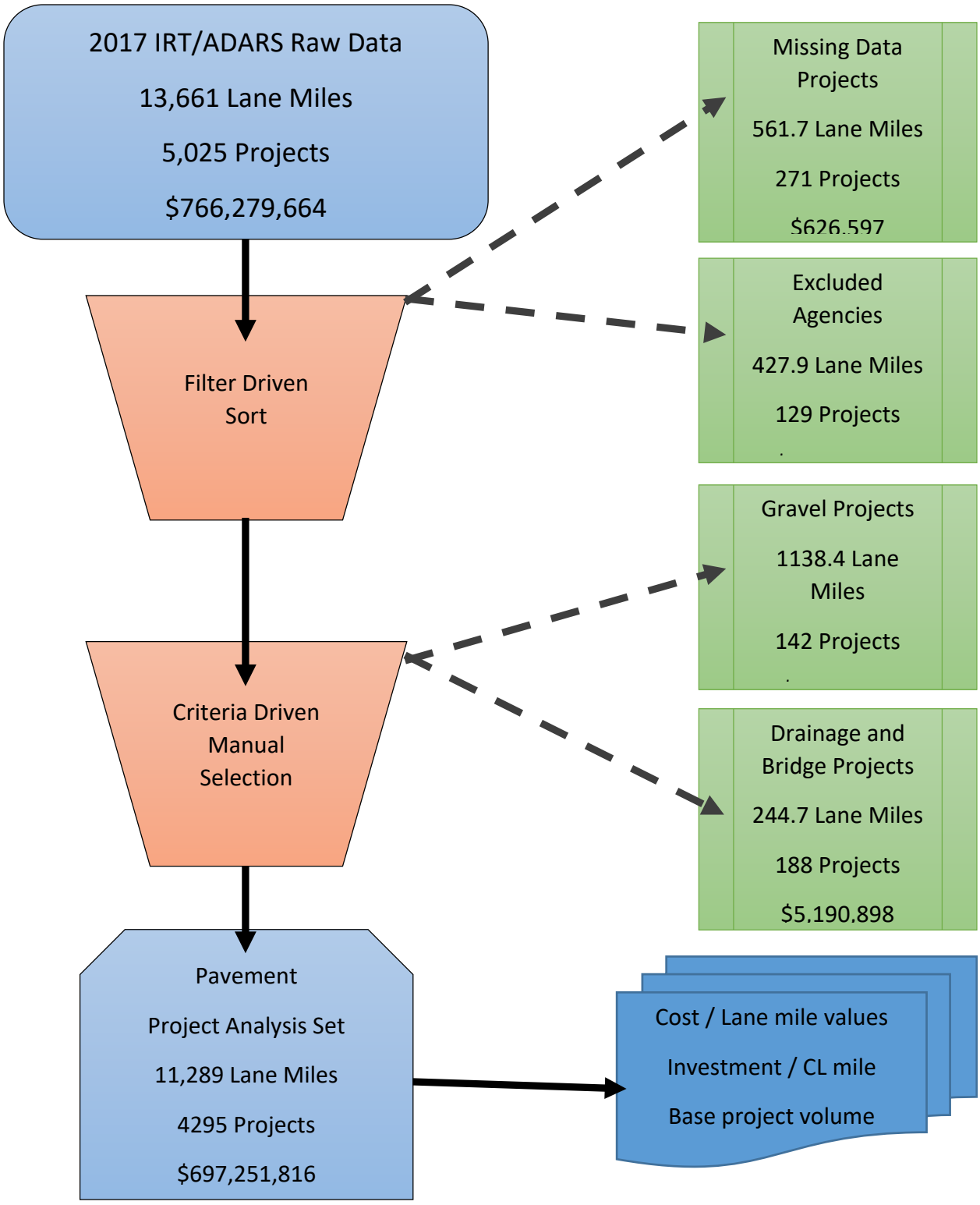


Figure 2: 2017 IRT/ADARS processing to develop analysis data set

3.2 Act 51 Distribution and Reporting System (ADARS)

Michigan local agencies are required to report their annual financial information relating to transportation spending to the Michigan Department of Transportation (MDOT). The MDOT developed the Act 51 Distribution and Reporting System (ADARS), which is a web based tool that streamlines the reporting of financial information. The ADARS system provides a link between the details of the road and bridge construction projects reported in the IRT to financial information for those individual projects. IRT and ADARS project and finance information are linked via a user entered project ID which allows joining of the information in the two databases. ADARS reporting cycles are matched with the IRT reporting cycle. See section 3.1 for details in the IRT.

ADARS data was provided by the Michigan Center for Shared Services (CSS) as a joined data set so that financial data from ADARS was linked to the respective IRT project using the unique project identifier in both data sets. CSS manages both the IRT and ADARS systems.

3.3 Michigan Department of Transportation Bid Letting System

All road construction projects in Michigan on state owned roads, and locally owned road project that use federal dollars must be processed through the MDOT bid letting system. This system processes over a billion dollars in construction and maintenance projects each year between roads owned by MDOT and local agencies. At least once per month bid openings are schedule and the resultant bid tabulations are processed through the MDOT letting system.

The MDOT bid letting systems provides very detailed information on individual projects that are put out for bid for contractor consideration. Data includes: a short description of the project detailing the work type and approximate limits, a listing of the types of pay items associated with the project, the quantity of each of the pay items, and the prices contractors bid for the respective items. The letting systems also include the total prices for each contractor that has bid for the project and an engineer's estimate of costs.

The MDOT bid letting system provides the most extensive single set of bid data for transportation construction projects in the state of Michigan. The system provides a narrative description of the work in each bid project. The bid letting systems only provides basic detail on the extent of the project with respect to the lane miles of pavement treated. Each project includes the details on the mile point of beginning and ending, however there is no data field that provides a square unit of measurement for the number of lane miles of treatment completed or the specific construction and maintenance classification of the project, however, this information can be determined from other data in the system.

Data from local agency owned projects from May 2016 to October 2017 bid lettings were analyzed to determine bid costs for local agency let projects. A total of 1,078 projects were let

during this time period in the MDOT bid letting system, which included the 238 local agency owned projects that were open to traffic in 2017.

The area of extent for each project in the bid letting system was determined by locating the project via google maps from the bid description. The width of located projects were determined by finding the number of lanes via Google Street View. The number of lanes estimated from a project was multiplied by the length of the project described in the bid description to develop an estimate of lane miles of activity for each project.

Let projects were classified into the TAMC's four construction and maintenance types based on the project description and pay items present in the bid.

Interpretation on area of extent and project classification are likely to provide a source of error since it is subject to interpretation by people not familiar with the project. This error is likely to overestimate the extent of the project work since project limits outlined in the bid system are typically the maximum extent of all the work on the project and may not actually reflect the extent of pavement work.

Project data from the MDOT's bid letting system were compared both individually and in aggregate to ADARDS and IRT reporting data as an indicator of the cost capture of ADARS reporting.

4 METHODS

4.1 Evaluation of Missing Data Due to Non-Complete Reporting

TAMC has worked with the Michigan Center for Shared Services (CSS) to develop performance metrics to measure compliance with reporting requirements which can also be helpful to estimate the impact of unreported projects from non-responsive agencies. CSS regularly reports the number of local agencies who have not logged in to the IRT system before the reporting deadline, the number of local agencies who have not marked "reporting complete" in the IRT. Both of these cases may result in unreported projects. The TAMC staff review submittals from local agencies to determine if they have met reporting requirements and looking for obvious errors after a submittal has been made.

In 2017 IRT/ADARS data set there were 51 local agencies that either did not fully complete reporting process or still had pending reviews of their submittals. In the 2016 IRT/ADARS data set this number of local agencies was 45. These local agencies are not necessarily out of compliance with reporting requirements, nor does this mean that the agencies did not report projects using the IRT. However, for the purposes of this study these agencies were excluded from the analysis to mitigate any concerns over data quality or completeness.

A summary of the 2017 and 2016 agencies that were excluded from this analysis and the centerline mileage of their respective road networks are listed in Table 1 below.

Table 1: Local agencies that were excluded from this study due to incomplete reporting or pending data review during the 2017 and 2016 IRT/ADARS reporting cycles.

2017 Excluded Agencies by Agency Type	Number of Agencies	Total Centerline Miles	Fed Aid Centerline Miles	Non Fed Aid Centerline Miles
County	8	9214	2540	6674
Top 40 Cities	2	412	119	293
Small Cities and Villages	41	537	100	436
Total	51	10162	2759	7403

2016 Excluded Agencies by Agency Type	Number of Agencies	Total Centerline Miles	Fed Aid Centerline Miles	Non Fed Aid Centerline Miles
County	0	0	0	0
Top 40 Cities	1	155	45	110
Small Cities and Villages	44	829	170	658
Total	45	984	215	769

Projects reported from local agencies excluded from this study constitute 8% by total project dollars in 2017, and 1.6% of the total project dollars reported in 2016. While this percentage is small, it is still worthwhile to estimate the loss of project volume for agencies who did not fully report to remove this as a source of error in modeling or reporting efforts.

Local road owing agencies that were responsive in reporting IRT–ADARSA data can be used as a proxy for agencies that were excluded from this study. The use of peer proxies allows IRT-ADARS data to be expanded to account for missing data in total project expenditures and total lane miles of road projects completed. Two methods for assigning peer proxies are discussed in this section. Method 1 will be demonstrated in section 5.0 of this report.

4.1.1 Method 1: State Average Agency Spending

This method subdivides local agencies in to three groups; Counties, Top 40 Cities, and Small Cities and Villages. These subdivisions are based on the relative proportion of road ownership in Michigan and have a significance in transportation spending. Average project investments per agency owned centerline mile of road were calculated for each of the three local agency groups from investment data that was reported in the IRT. Local agencies that did not complete reporting in the IRT were removed from the calculation of average project investment per centerline mile. The investment rate (average project investment per centerline mile) can be multiplied by the centerline road network size from agencies that did not complete reporting to make an estimate the total missing investments in each of the four TAMC project classifications.

Table 2 below summarizes average annual dollars of project investments per centerline mile as reported in the 2017 IRT-ADARD database.

Table 2: Average annual spending per centerline mile according to 2017 IRT/ADARS reporting.

TAMC	County		Top 40 City		Small City or Village	
Treatment Class	Federal Aid	Non Fed Aid	Federal Aid	Non Fed Aid	Federal Aid	Non Fed Aid
Light CPM	$ 231	$ 32	$ 865	$ 84	$ 348	$ 77
Heavy CPM	$ 2,439	$ 527	$ 4,263	$ 1,149	$ 3,288	$ 847
Rehabilitation	$ 6,208	$ 897	$ 26,303	$ 4,334	$ 8,652	$ 2,618
Reconstruction	$ 2,940	$ 381	$ 15,288	$ 8,474	$ 11,518	$ 4,059

A similar trend is apparent when analyzing 2016. Table 3 illustrates investment spending per centerline mile analysis from 2016 IRT/ADARS reports.

Table 3: Average annual spending per centerline mile according to 2016 IRT/ADARS reporting

TAMC	County		Top 40 City		Small City or Village	
Treatment Class	Federal Aid	Non Fed Aid	Federal Aid	Non Fed Aid	Federal Aid	Non Fed Aid
Light CPM	$ 81	$ 14	$ 977	$ 104	$ 372	$ 95
Heavy CPM	$ 2,569	$ 418	$ 5,574	$ 1,648	$ 2,997	$ 1,035
Rehabilitation	$ 6,443	$ 861	$ 18,828	$ 4,874	$ 11,581	$ 1,969
Reconstruction	$ 5,407	$ 577	$ 12,318	$ 5,657	$ 14,205	$ 2,926

This method produces reasonable estimates of unreported project activity by using all agencies in a given year as a proxy for agencies that were excluded from the study. It is specifically usefully when not much is known about the history or level of activity of the excluded agency. Average spending per year should be aggregated over several years as a longer history of these spending trends becomes available. Multiyear averaging minimizes yearly variance in

Reconstruction investments that may be swayed by a few high cost projects on an annual basis. Multiyear averaging is a best practice, but will not significantly impact investment calculations on a state level if it is not completed in the next few years.

4.1.2 Method 2: Planned Projects

IRT reporting data can be estimated for agencies that did not report in a given year or were excluded from the study, but have been responsive in the past. Historic reporting of planned projects provides a reasonable estimate of missing investment data. Previously reported planned projects provide an estimate of the work that likely occurred in a year that no data was reported or where there are concerns over data quality. This method should be used in cases where data is available before considering the use of state average investments from Method 1. The drawback from this method is that most agencies that are unresponsive in a given year, may be more likely not to have provided accurate planned project information in past years. As the TAMC continues to collect and use planned project data this method will become more viable and will likely be the preferred method.

4.2 Basis of Project Cost

Determining the basis of project costs is an important step in any financial reporting and modeling where budgets are used as the basis for determining the lane mile extent of a future work program. The basis of cost for projects used in a modeling or planning effort should always be the same as the budget being modeled to avoid over or under estimation of the value of a given funding level.

The basis of costs determines what is considered included and excluded on when reporting a project cost or a budget. A basis of cost can be all inclusive “agency total cost” by adding non-construction costs for a project such as the cost of right of way purchase, construction and design engineering, construction testing and surveying along with the costs of the physical construction activity.

Costs outside of physical construction costs are more likely to be a significant factor with reconstruction and rehabilitation projects due to their complexity, and are not likely to be as significant on light and heavy capital preventive maintenance projects, which usually do not require significant engineering, testing or surveying services.

The document titled “Instructions for Preparing the Act 51 Street Report for Cities and Villages on the ADARS” provides guidance for the basis of costs of construction and maintenance project reporting. This same guidance is echoed in the ADARS training and the fact sheet “Investment Reporting 101, Key Points on IRT/ADARS – 4/4/2016”. This guidance says:

> “Enter all expenditures for street construction on Major and Local Streets. This category should include expenditures that can be directly assigned to a construction project, (i.e.,

engineering fees, ROW acquisition, etc.). Include charges for payroll, related fringe benefits, equipment rentals, materials, and contractual services that were charged to a project."

This guidance appears to be all inclusive of expenses for road and bridge projects, however, it unclear if these costs specifically include only construction phase services, or if pre-construction costs such as preliminary design engineering included.

One county finance officers that spoke to the research team indicated that they believed that this guidance may be interpreted differently among local agencies. The finance officer believed that this provision limits reporting of costs to only the current year that a construction project is completed. This understanding of this guidance would exclude design services, and may have a significant impact on the reporting of multiple year construction projects, since only the costs in the final year would be reported.

Correspondence and phone calls with MDOT's Bureau of Transportation Planning indicates that data for IRT/ ADARS reports for MDOT's road projects include construction phase costs only.

"MDOT only reports on the Construction Costs (This does not include costs associated with Early Preliminary Engineering, Preliminary Engineering, Environmental Clearance, Permitting or Real Estate purchases). It does include Construction Engineering so we are confirming it includes testing, surveying, equipment and materials."

At a minimum it appears that the basis of cost being reported by the MDOT and the local agencies differs in how right of way costs are included or excluded in IRT/ADARS reporting. There also appears to be anecdotal evidence that the open nature of the cost guidance may be interpreted broadly by local agencies. Neither of these items are catastrophic in nature, but are sources of "noise" in the cost per lane mile data.

4.2.1 Impact of Design and Construction Services on Project Costs

Design and construction services are a significant percentage of the total cost of transportation projects. Typically, these costs are expressed as "preliminary engineering" or PE, and "construction engineering" or CE.

Preliminary Engineering is commonly defined as:

"[P]lanning and design of a highway project first receives funding authorization for planning and/or design activities. The delivery of the construction documents used for solicitation of construction contract bids (known as project letting) marks the end of PE." (Hollar, 2011)

Construction engineering or CE includes professional services necessary for the contractor to construct the job. This can include surveying, field engineering, inspection and testing by the project owner.

PE and CE are most often these costs are expressed as a percentage of the physical cost to construct the transportation project. A literature review of states that have published data on

design and construction cost contributions to total project cost indicate that the project size, complexity and work type all contribute to the relative expense of design and construction services necessary to deliver a project.

In 2002 Washington Department of Transportation (WashDOT) completed a national survey of PE and CE costs on specific road construction projects which included bridge and road components (Highway Construction Cost Comparision Survey, 2002). This survey remains one of the most cited pieces on the topic of PE and CE costs. Analysis of the data from 24 state departments of transportation that responded to the WashDOT survey indicated PE costs typically averaged about 10.3% of physical construction costs and CE averaged 11% of construction costs. The MDOT response to this survey indicated that PE was 8% of physical construction costs and CE ranges from 0 to 15% of physical construction costs.

CE and PE costs conservatively add between 21 to 27 percent of the physical construction cost for DOT projects that are of a similar size typical local agency reconstruction and rehabilitation projects. In Michigan on the federal aid eligible road system it is reasonable to expect that these PE and CE percentage would be similar for local agency owned reconstruction and Rehabilitation projects.

5 RESULTS

5.1 IRT/ADARS Project Cost Results

Raw data from the 2017 IRT/ADARS submittals were processed to isolate local-agency road projects by removing any bridge projects and removing any projects on state-owned roads. The local-agency road data set was then filtered to remove projects from local agencies that had not fully completed the report process, or whose data was still under review by the TAMC. See section 4.1 for details. Projects which did not contain cost data were also removed from the analysis set.

The data from the analysis set was subdivided into the four TAMC treatment classifications and separated based on road system category. The total dollars of projects in each of these subdivided categories were divided by the total lane miles of projects in that respective category to produce a weighted average cost per lane mile for each specific class of projects. This technique of weighting projects by the number of lane miles assigns more significance for bigger projects rather than assuming all projects are of equal value. Weighting by lane miles makes it less likely that data errors or small, high cost projects will influence the calculated cost per lane mile figures.

The percentage on a dollar basis was calculated for each of the specific treatment classifications. The summarized IRT/ADARS average cost per lane mile data at the statewide level for 2017 are presented in Table 4. This table provides inputs for the PCFS model.

Table 4: Statewide IRT/ADARS project cost data for 2017.

All Projects Statewide					
	# of Projects	Lane Miles	Total Dollars	% of Total	Dollars/LM
Light CPM	837	2,264.2	$ 10,840,529	1.55%	$ 4,788
Heavy CPM	1,756	5,547.3	$ 115,921,824	16.63%	$ 20,897
Rehabilitation	1,218	2,766.2	$ 321,777,460	46.15%	$ 116,326
Reconstruction	484	711.5	$ 248,712,003	35.67%	$ 349,545
Totals	***4,295***	***11,289.1***	***$ 697,251,816***		
Federal Aid Projects Statewide					
	# of Projects	Lane Miles	Total Dollars	% of Totals	Dollars/LM
Light CPM	400	1,672.5	$ 7,551,626	2%	$ 4,515
Heavy CPM	572	3,343.0	$ 67,114,433	17%	$ 20,076
Rehabilitation	419	1,600.7	$ 208,974,236	52%	$ 130,552
Reconstruction	168	350.7	$ 120,087,742	30%	$ 342,451
Totals	***1,559***	***6,966.9***	***$ 403,728,036***	100%	
Non Federal Aid Projects Statewide					
	# of Projects	Lane Miles	Total Dollars	% of Totals	Dollars/LM
Light CPM	437	591.6	$ 3,288,903	1%	$ 5,559
Heavy CPM	1,184	2,204.2	$ 48,807,391	17%	$ 22,143
Rehabilitation	799	1,165.5	$ 112,803,224	38%	$ 96,787
Reconstruction	316	360.9	$ 128,624,260	44%	$ 356,439
Totals	***2,736***	***4,322.2***	***$ 293,523,779***	100%	

The weighted average cost data used for this study contained a number of projects that appeared to be outliers from a cost per lane mile standpoint. Many of these outliers were projects with very short segment lengths, which led to a large cost per lane mile calculation. At least one of these outliers appears to be a representation of an agency wide crack sealing program that was placed on a single segment of road because the individual locations were not known. The impact of these outlier projects was investigated by performing a sensitivity analysis.

The sensitivity analysis removed projects with a total size of less than 0.2 lane miles, which equates to approximately 528 feet long by two lanes. This length was chosen because it is less than a typical city block. Projects that appear to be in the wrong treatment classification were also removed from the analysis to test the impact of data errors. Comparison of the altered data set used for the sensitivity analysis with the statewide average for light CPM, heavy CPM, rehabilitation, and reconstruction found in Table 4 reduced weighted average cost per lane mile results by 1.91%, 1.07%, 1.80%, and 2.58%, respectively. Changes in results of this magnitude were not considered to be significant considering other sources of variation.

The weighted average cost per lane mile calculations of the four project classifications have been further subdivided by agency type (County, Top 40 City and Small City) and are included in Appendix B. Data tables in Appendix B include data for 2017 and 2016.

Several trends were apparent from the IRT/ADARS project cost per lane mile data. County road commission projects typically had the lowest cost per lane mile, followed by small cities and villages, with the Top 40 Cities having the largest cost per lane mile. Federal aid projects were typically cost more per lane mile than non-federal aid eligible projects with the exception of light CPM in all city categories, and reconstruction for the top 40 cities. Figure 3 below graphically illustrates the calculated cost per lane mile data from 2017.

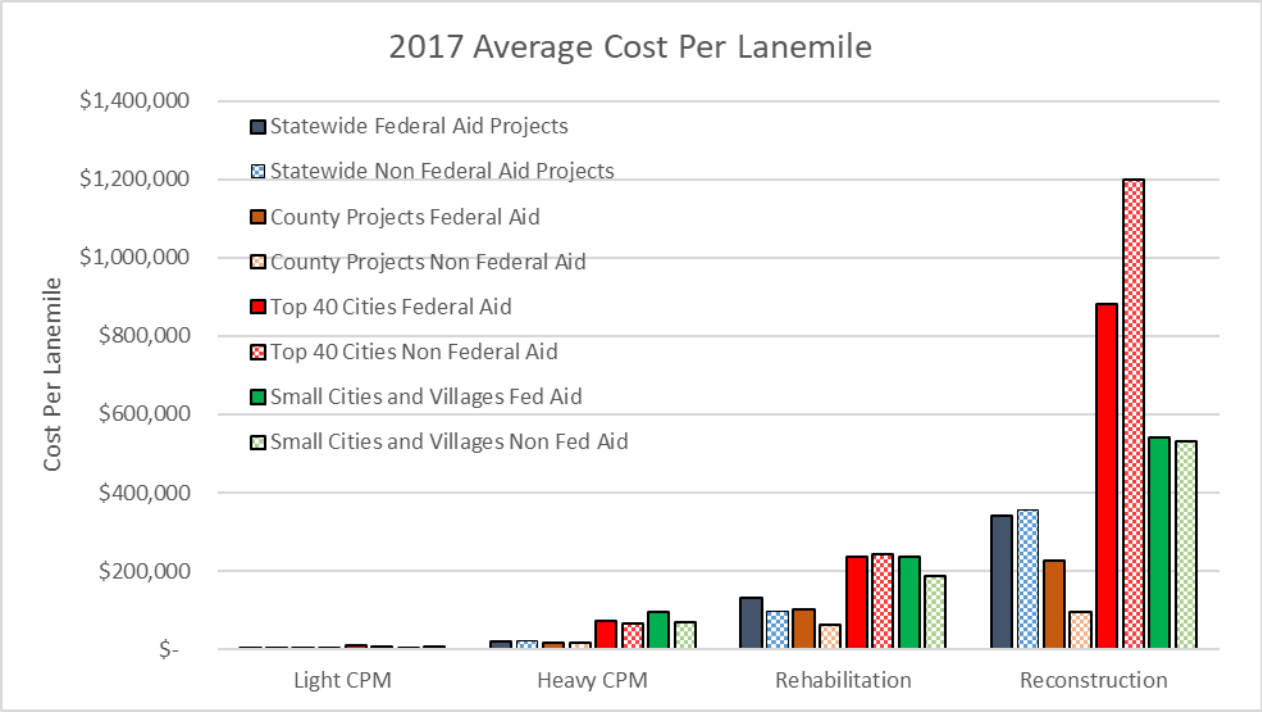


Figure 3: 2017 Weighted average project cost per lane mile data from IRT/ADARS system

Figure 4 below illustrates the total lane miles of local agency projects in the 2017 IRT data set after filtering described in Section 3.1. As previously discussed, this data is a subset of all the reported data which represents about 92% of the 2017 IRT/ADARS local agency submittal. This figure illustrates the relative impact that county road commissions activities have on the overall local agency own system due to their high volume of project work. Data from 2016 exhibits a similar pattern.

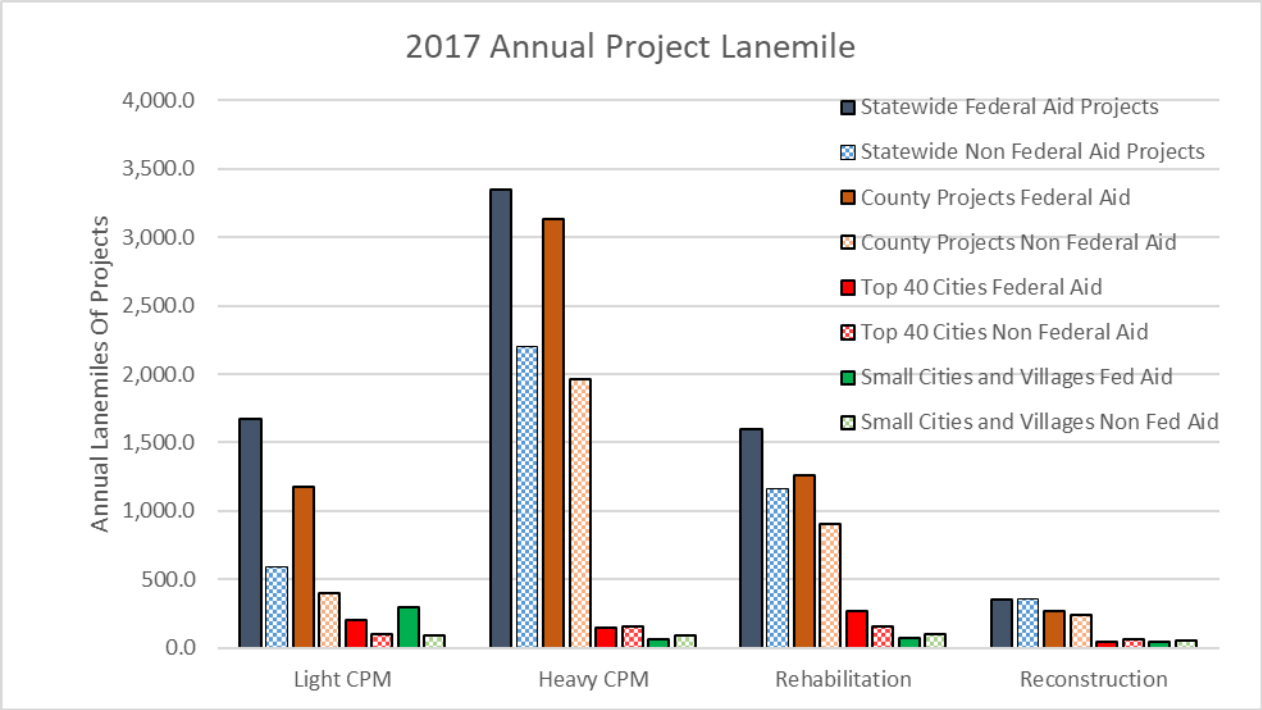


Figure 4: 2017 Total lane miles of road projects in the analysis set separated by agency type from IRT/ADARS reporting

Figure 5 below illustrates the total dollars in the analysis set and in each project classification respective of local agency type after filtering described in Section 3.1. County road commission spending in rehabilitation and light and heavy preventive maintenance represent the majority of the dollars in these categories. However, reconstruction dollars for counties and the top 40 cities are almost identical in total volume.

The project cost per lane mile and total volume differential between cities and counties are both significant for state level modeling efforts. Reconstruction and rehabilitation in cities are a small portion of the total miles of road work completed every year, however, they constitute a very significant total dollar volume.

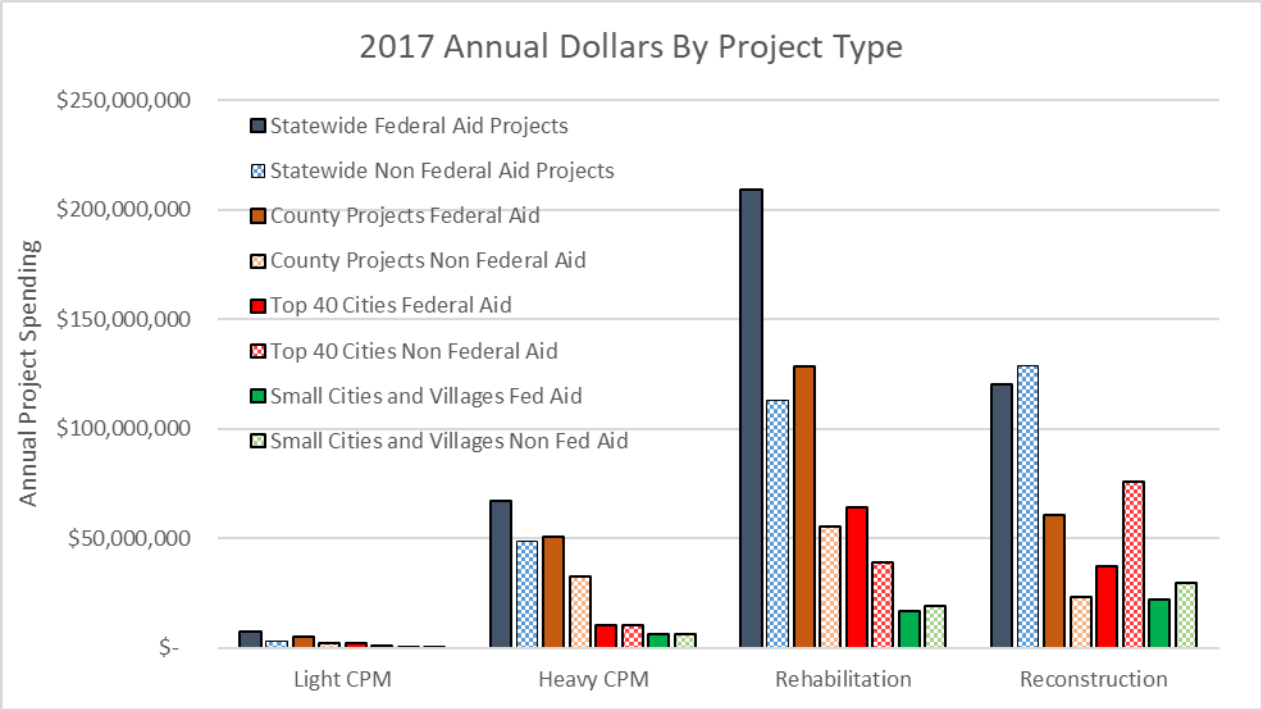


Figure 5: 2017 Total dollars of projects by agency type contained in the analysis set from IRT/ADARS Reporting

Data shown in Figure 3, Figure 4, and Figure 5 for 2016 IRT/ADARS reporting are included in Appendix B.

5.1.1 Analysis of IRT/ ADARS Data for Common Treatments

The IRT-ADARS data set was analyzed using the common treatment name to break down the four treatment classifications into their component treatment types. Projects with similar common treatment names were aggregated and compared as a group. Projects that did not include a common treatment name or where the intent of the common treatment name was unclear were excluded from the analysis. Groups of common treatment names that did not include over 40 individual projects were aggregated with another similar group when possible.

Table 5 and Figure 6 below illustrate the average weighted cost per lane mile data for common treatments identified in the combined 2017 and 2016 IRT/ADARS data set. The cost per lane mile calculations of the common treatments have been further subdivided agency type (County, Top 40 City and Small City) and are included in Appendix C. Calculations in Appendix C include data for 2017 and 2016.

Table 5: 2017 and 2016 IRT/ADARS average weighted cost per lane mile calculations for common local agency treatments at a state level.

2016 & 2017 Statewide Projects					
TAMC Class	Project Subcategory	# of Projects	Lane Miles	Total Project Dollars	$/LM
Heavy CPM	Chip Seal	1918	7937.2	$ 97,255,143	$ 12,253
Heavy CPM	Slurry or Cape Seal	112	510.1	$ 9,961,373	$ 19,528
Heavy CPM	Micro Surfacing	233	270.7	$ 8,739,353	$ 32,281
Heavy CPM	Ultra Thin Overlay	115	288.1	$ 10,595,521	$ 36,780
Heavy CPM	Mill and Fill - Non Structural	412	437.0	$ 44,946,306	$ 102,855
Heavy CPM	Overlay - Non Structural	652	1133.0	$ 63,980,522	$ 56,468
Rehabilitation	Mill and Fill - Structural	180	284.8	$ 38,887,034	$ 136,538
Rehabilitation	Overlay - Structural	566	1044.3	$ 101,343,033	$ 97,046
Rehabilitation	Crush and Shape	474	940.6	$ 143,728,966	$ 152,804
Rehabilitation	Minor Rehab	142	308.2	$ 20,769,477	$ 67,393
Rehabilitation	Major Rehab	101	373.0	$ 62,881,715	$ 168,567
Rehabilitation	Resurfacing	810	1762.1	$ 242,868,181	$ 137,825
Reconstruction	Reconstruction	766	1126.9	$ 435,638,749	$ 386,598

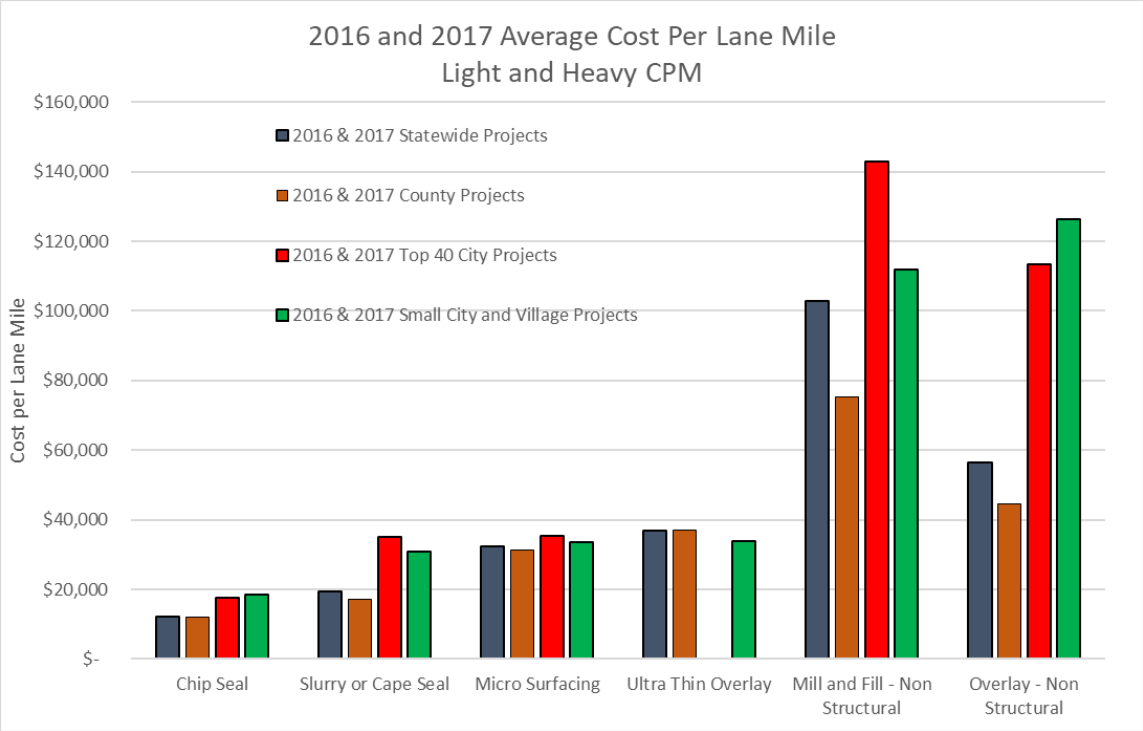


Figure 6: Weighted average cost per lane mile for common preservation treatments

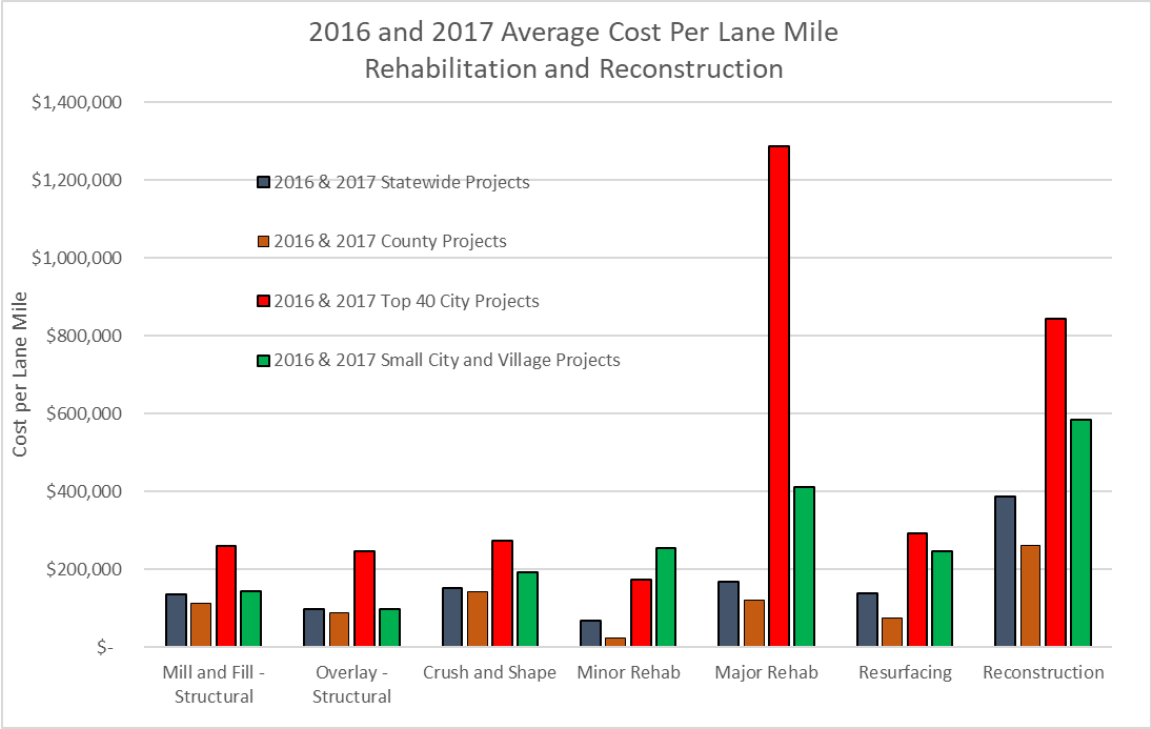


Figure 7: Weighted average cost per lane mile for common structural treatments

5.2 Treatment Volume Results

Analysis of IRT/ADARS reporting compliance from 2017 indicates that a very small number of local agencies did not fully complete reporting of completed projects in the IRT, and only a few of these agencies were still being reviewed by TAMC staff. These local agencies and the data that they submitted were removed from the analysis of this study to avoid any concerns over data quality or completeness.

The local agencies that were responsive to reporting can be used as a proxy for non-responsive agencies by the use of average project investments per centerline mile as previously calculated in Table 2 and Table 3. The excluded agencies and the centerline miles of road that they represent by agency type and project classification are illustrated in Table 1. Multiplying unreported lane miles in Table 1 by the respective investment per centerline mile factors from Table 2 and Table 3 results in an estimate of unreported dollars in each project classification for the respective years. Table 6 illustrates the estimated unreported investments for 2017 as a result of excluding local agencies from this study. This data is the product of Table 2Table 1 and Table 2. This unreported investment is $57 million total dollars, which is 8.2% of the total local agency spending in 2017.

Table 6: Estimate of unreported investments from agencies not completing reporting in 2017.

TAMC	County		Top 40 City		Small City or Village	
Treatment Class	Federal Aid	Non Fed Aid	Federal Aid	Non Fed Aid	Federal Aid	Non Fed Aid
Light CPM	$ 586,931	$ 215,494	$ 102,969	$ 24,514	$ 34,968	$ 33,555
Heavy CPM	$ 6,194,322	$ 3,520,297	$ 507,646	$ 336,328	$ 329,966	$ 369,599
Rehabilitation	$ 15,765,603	$ 5,984,480	$ 3,132,299	$ 1,268,697	$ 868,104	$ 1,142,333
Reconstruction	$ 7,465,396	$ 2,544,172	$ 1,820,615	$ 2,480,701	$ 1,155,760	$ 1,771,034
Total	**$ 30,012,252**	**$ 12,264,442**	**$ 5,563,529**	**$ 4,110,240**	**$ 2,388,797**	**$ 3,316,521**

Unreported investments for 2016 were calculated using this same technique using the product of Table 1 and Table 3, and are illustrated in Table 7 below, with an unreported investment total of $11.9 million.

Table 7: Estimate of unreported investments from agencies not completing reporting in 2016.

TAMC	County		Top 40 City		Small City or Village	
Treatment Class	Federal Aid	Non Fed Aid	Federal Aid	Non Fed Aid	Federal Aid	Non Fed Aid
Light CPM	$ -	$ -	$ 43,744	$ 11,501	$ 63,356	$ 62,783
Heavy CPM	$ -	$ -	$ 249,506	$ 181,776	$ 510,018	$ 681,377
Rehabilitation	$ -	$ -	$ 842,735	$ 537,740	$ 1,971,084	$ 1,296,647
Reconstruction	$ -	$ -	$ 551,353	$ 624,102	$ 2,417,723	$ 1,926,282
Total	**$ -**	**$ -**	**$ 1,687,339**	**$ 1,355,119**	**$ 4,962,181**	**$ 3,967,088**

The unreported local agency spending from Table 6 and Table 7 is added to the results of the IRT/ADARS reported spending to produce a total estimated spending for each of the four treatment categories and the three agency classifications, and are illustrated in Table 8 and Table 9 below. These two tables represent the suggested modeling inputs for the PCFS model.

Table 8: Total estimated local agency spending in 2017 adjusted for agencies that did not fully report IRT/ADARS data

TAMC	County		Top 40 City		Small City or Village	
Treatment Class	Federal Aid	Non Fed Aid	Federal Aid	Non Fed Aid	Federal Aid	Non Fed Aid
Light CPM	$ 5,365,296	$ 2,198,684	$ 2,207,720	$ 774,144	$ 703,478	$ 589,638
Heavy CPM	$ 56,624,000	$ 35,917,636	$ 10,884,206	$ 10,621,264	$ 6,638,160	$ 6,494,715
Rehabilitation	$ 144,117,718	$ 61,059,729	$ 67,158,246	$ 40,065,532	$ 17,464,277	$ 20,073,473
Reconstruction	$ 68,243,244	$ 25,958,222	$ 39,035,009	$ 78,340,718	$ 23,251,260	$ 31,121,229
Total	**$ 274,350,258**	**$ 125,134,271**	**$ 119,285,181**	**$ 129,801,657**	**$ 48,057,176**	**$ 58,279,054**

Table 9: Total estimated local agency spending in 2016 adjusted for agencies that did not fully report IRT/ADARS data.

TAMC	County		Top 40 City		Small City or Village	
Treatment Class	Federal Aid	Non Fed Aid	Federal Aid	Non Fed Aid	Federal Aid	Non Fed Aid
Light CPM	$ 1,879,283	$ 947,122	$ 2,448,788	$ 940,715	$ 769,151	$ 752,266
Heavy CPM	$ 59,631,151	$ 28,481,745	$ 13,967,270	$ 14,868,057	$ 6,191,721	$ 8,164,327
Rehabilitation	$ 149,574,769	$ 58,654,699	$ 47,176,165	$ 43,983,560	$ 23,929,362	$ 15,536,552
Reconstruction	$ 125,519,185	$ 39,280,005	$ 30,864,655	$ 51,047,438	$ 29,351,645	$ 23,080,899
Total	**$ 336,604,387**	**$ 127,363,571**	**$ 94,456,878**	**$ 110,839,770**	**$ 60,241,879**	**$ 47,534,044**

5.3 Evaluation of Local Agency Basis of Cost

Project cost data from the MDOT bid letting system is a resilient source of information on bid costs for federal aid road projects both at the state and local levels. This information can provide a useful comparison to IRT/ADARS cost data.

Information from MDOT's bid letting system provides project cost data that only represents contractor low bid cost for specific projects. The bid letting data does not include construction over or under-runs in the construction phase of the project. Current professional practice in Michigan indicates that low bid costs are routinely within +-10% of the final physical construction costs for most projects. While there may be outliers, +-10% is a typical planning threshold.

Bid letting data from local agency projects from 2016 were collected from MDOT's bid letting system. Projects identified as local agency projects were classified based on the project description into one of the TAMC's four project categories (reconstruction, rehabilitation, heavy preventive maintenance, light preventive maintenance). The total length of the project was estimated using the start and end point locations included in the project description. Google Earth and Google Street view were used to determine the number of pavement lanes within each project boundary to calculate a lane mile number for each project. Summary data from bid analysis is presented below in Table 10 below.

Table 10: Bid letting costs from 2016 lettings for locally owned federal aid eligible projects matched to ADARS projects in 2017.

	# of Projects	Lane Miles	Total Dollars	Dollars/LM	% of Total
Light CPM	1	$ 306.1	$ 622,610	$ 2,034	0.29%
Heavy CPM	22	$ 385.6	$ 12,174,076	$ 31,575	5.71%
Rehabilitation	136	$ 576.5	$ 98,348,397	$ 170,599	46.10%
Reconstruction	73	$ 140.0	$ 102,170,859	$ 729,844	47.90%
Totals	***232***	***1408.2***	***$ 213,315,943***		100%

The cost per lane mile averages for heavy CPM, rehabilitation, and reconstruction generated from bid letting exceed the averages generated for the federal aid network using IRT/ADARS reporting data. See section 5.1 and Appendix A for details on IRT/ADARS costs. This analysis is not a one-to-one comparison of projects, and it is likely that projects present in the MDOT bid letting system are of a more complex subset of the projects that are submitted in the IRT/ADARS system. These more complex projects would likely have a higher cost per lane mile. While this particular analysis is not conclusive, it is a trend that was investigated further with other techniques.

The relationship between IRT/ADARS costs and bid letting data was investigated by finding and comparing individual projects that were bid, constructed, and reported to TAMC through the IRT/ADARS system. Projects in the 2017 IRT data set were matched to their respective 2016 bid letting data. Project matches were identified based on the project's description in the bid letting system and the PR and mile point data from the IRT/ADARS system.

Only 57 reconstruction or rehabilitation projects are present in both the 2016 bid letting data and the 2017 IRT / ADARS data, which was expected since many federal aid project are bid several years before they would be reported in the IRT.

Matched pairs of bid letting data and IRT/ADARS data are presented in Table 11. The trend observed in the aggregate comparison of letting vs ADARS cost was again apparent when comparing the total let cost of these matched pairs of projects with their respective IRT/ADARS costs. The let costs of the matched pairs exceed the reported ADARS project costs for these projects.

Table 11: Bid letting costs and ADARS costs for matched reconstruction and rehabilitation pairs on locally owned, federal aid eligible projects.

Project Type	Number of projects	Total Let Cost	Total ADARS Cost
Reconstruction	21	27,199,199	23,149,232
Rehabilitation	36	25,629,326	24,807,865

The reported IRT/ADARS cost for each of the matched 57 projects were subtracted from the respective let cost to calculate a project by project cost difference. This cost difference was

expressed as a percentage of the let cost for each of the 57 matching projects. Analysis of the magnitude of the difference between let-cost data and IRT-ADARS cost data for matched pairs of projects is illustrated in Figure 8 below.

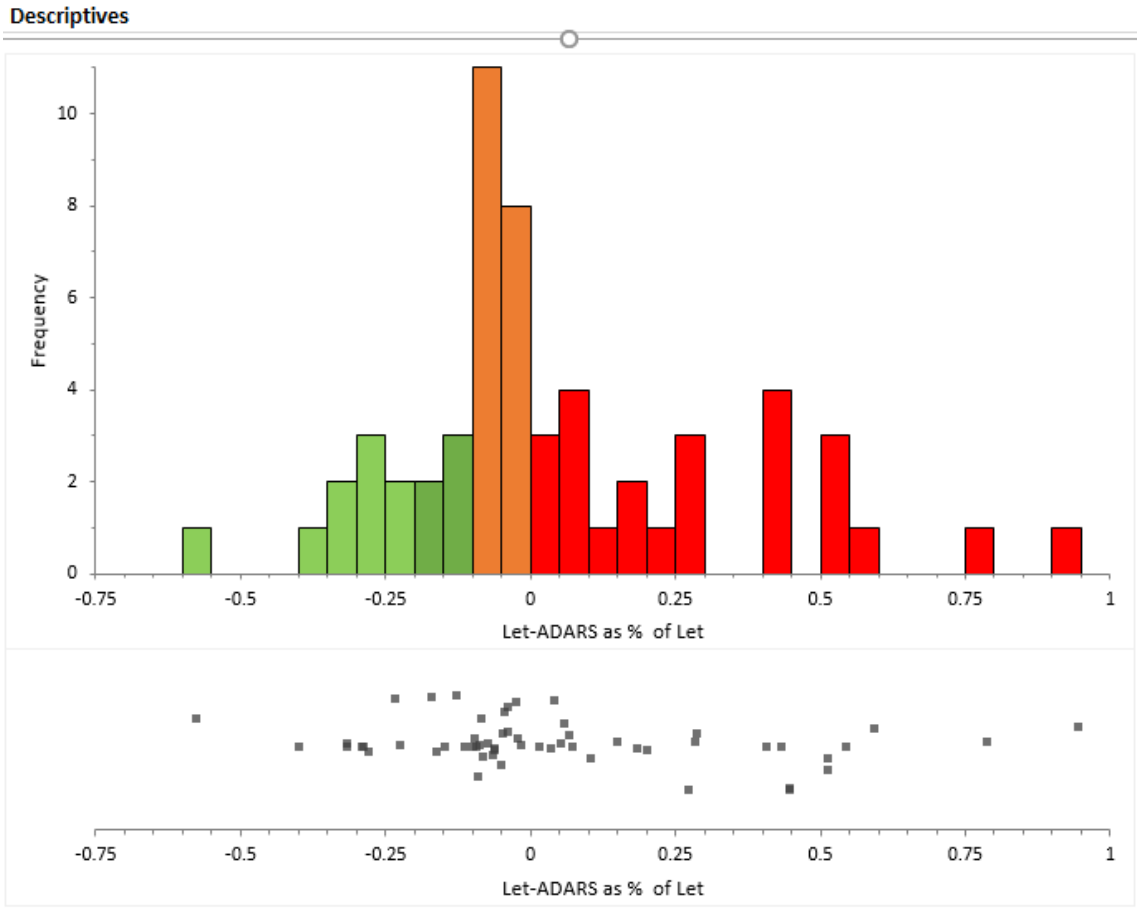


Figure 8: Frequency and box plot chart illustrating the percentage difference between let cost data and IRT/ADARS Cost data for matched pairs of projects.

NOTE: Negative scale means LET data is lower than IRT/ADARS data, positive scale means LET data is higher than IRT/ADARS data. Projects illustrated in green are within the expected range exceeding let costs. Projects illustrated in red are lower than expected IRT/ADARS costs when compared to Let data.

It is surprising to see the large portion of projects that had bid lettings in excess of the reported ADARS costs for the project. Some of these projects may be the result of bid savings, meaning the total quantity of pay items was less than estimated by the bid package, resulting in a lower total cost than the contractors bid. However, this would typically account for at most at 10% bid savings.

Bid letting costs do not include PE and CE costs for normal project delivery, so some or all of those costs should be included in IRT/ADARS reports depending on how cost reporting guidance is interpreted. Conservatively estimating PE may range from 10% to 16% of physical construction costs on reconstruction or rehabilitation projects. CE can account for an additional 11% to 16% on top of physical construction costs.

Interpreting the data shown in Figure 8 requires the creation of a reasonable threshold for comparison of let costs to final project costs considering sources of additive and subtractive expenses. It is feasible that project underruns could account for a savings of 10%, so the lowest reasonably expected physical construction cost could be 10% lower than the let cost. Including PE costs would add 10% or more to the physical construction costs, and CE would add another 11% or more to the physical construction cost. Therefore, let costs should be at least 1% under ADARS cost if only CE is included (ADARS cost = Let cost – 10% bid savings, +11% CE cost) and let cost should be 11% under the ADARS cost (ADARS cost = Let cost – 10% bid savings, +10 PE cost, + 11% CE cost) if both CE and PE are included.

Projects that have IRT/ADARS reported costs lower than their let costs are shown in red in Figure 8. These projects constitute 42% of the matched projects in this study. The criteria developed in the previous paragraph would indicate that these projects are outliers if CE costs were included in IRT/ADARS costs that were reported.

Matched pair projects that are shown in orange in Figure 8 constitute 33% of the total projects. These projects, in addition to the projects shown in red, constitute 75% of the matched pairs, and are considered to be outliers if both CE and PE are included in the IRT/ADARS costs.

At the far end of the spectrum there are 10% of the matched pair project that have IRT/ADARS costs that are less than half the let cost. These projects may be reporting errors that are a misunderstanding of the basis of cost, or they may represent data entry errors.

6 CONCLUSIONS AND RECOMMENDATIONS

6.1.1 Project Cost Per Lane Mile

IRT data provides a wealth of cost information and project volume information that is useful for local agency, regional, and state planning. Compliance with the project reporting requirements are high, with an estimated 92% of the reported data useful for analysis without quality or completeness concerns. This should not be misconstrued as a measure of compliance, but rather a measure of data used by this study for analysis.

Project cost per lane mile data calculated from the IRT/ADARS data set appears to be resilient to the level of errors and inconsistencies observed in the entered data. This was tested by performing a sensitivity analysis on the cost per lane mile data.

Project cost per lane mile data from this study is comparable to the TAMC Treatment Cost Survey that was completed in 2008. The 2008 survey asked local agency staff to provide their planning costs for projects on a lane mile basis but did not evaluate any actual project data, and the definitions for preventive maintenance were slightly different than the current TAMC project classifications.

Data from the statewide project cost tables and project volume table from this report should be used as the basis for modeling local agency road networks. This data represents the best source of cost and treatment volume data available at the state level. The data should be calculated annually and combined in a three year rolling average data set to eliminate year to year changes that may occur due to a few large projects.

6.1.2 Basis of Cost Reporting

Analysis of MDOT bid letting system and IRT-ADARS total project costs for local agency projects indicates that it is likely that CE and PE costs are not being captured by local agency project reporting. This may be due to a misunderstanding of the basis of costs, or it could be due to the specifics of the accounting systems that local agencies use and how they track time and expenses. Work is therefore needed to better define and communicate to local agencies the basis of project cost reporting for ADARS, and specifically whether CE and PE should be included.

MDOT currently excludes right of way costs in their reporting to TAMC, whereas these costs are included in local agency data. These costs may not be significant at the state level, and MDOT likely has the ability to either estimate or directly report these costs. While this may not be a serious concern for the use of the data, the issue underlines the confusion over the basis of costs that are to be reported.

There is no right or wrong answer as far as including or excluding CE and PE costs, since methods exist for estimating their impact to an overall budget. However, agencies should be

instructed to either include or exclude these costs to ensure consistency among agencies and between reporting systems.

6.1.3 Repeat Analysis

The TAMC's focus on gaining compliance with reporting requirements appears to be paying off in terms of the data that is being produced in the IRT. Successive years of IRT data will allow TAMC to separate year to year trends from background noise much like successive years of PASER data have done for forecasting on the overall trajectory of the paved federal aid eligible road system.

It is recommended that the analysis in this study be rerun every two years as normal TAMC business process. Data handling routines should be set up with the help of CSS to automate data processing following the general form of the analysis in this report.

7 REFERENCES

WashDOT (2002). *Highway Construction Cost Comparision Survey.* Washington State Department of Transportation.

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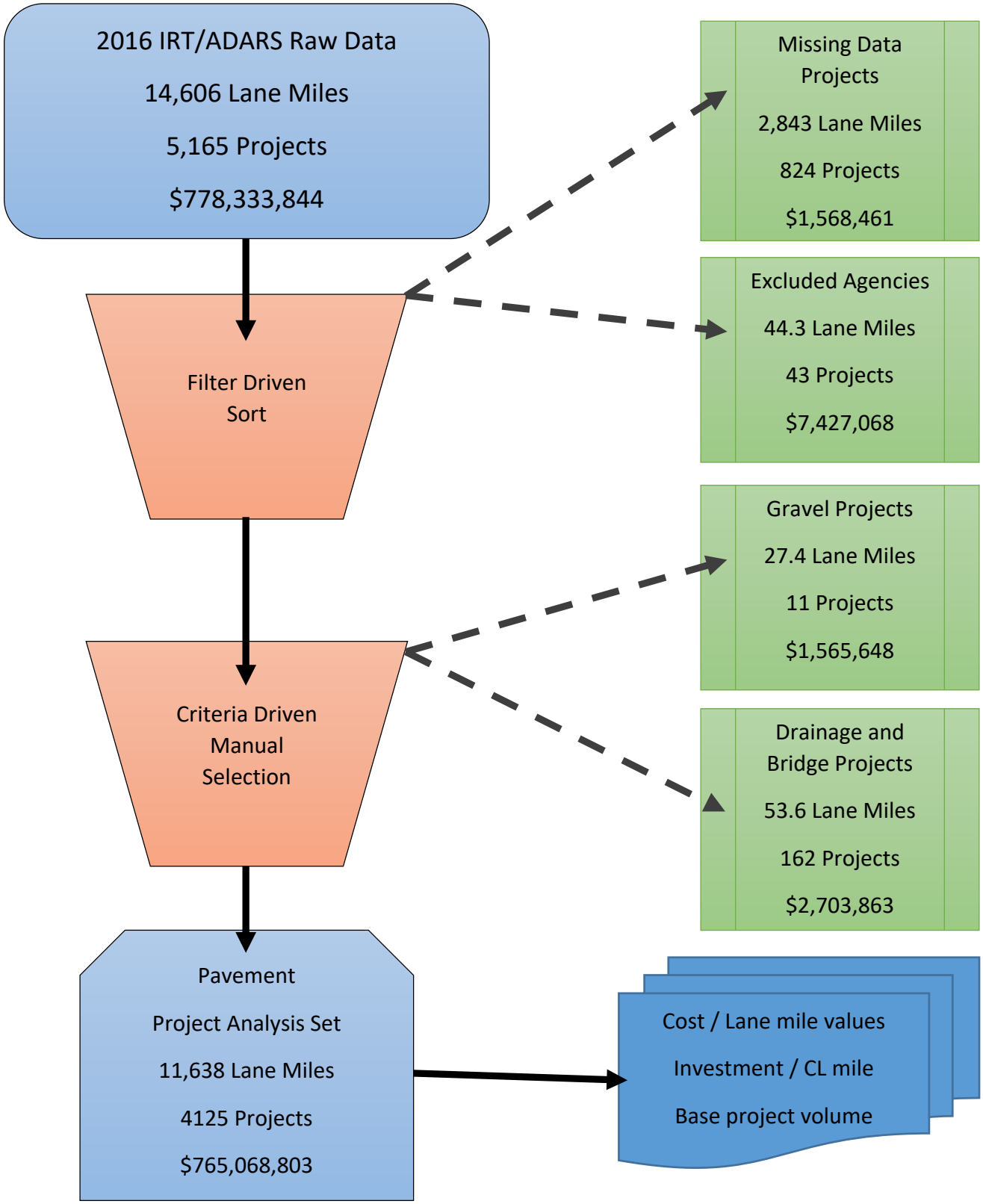
Hummer, J. E., Liu, M., & Rasdorf, W. J. (2011). *Preliminary Engineering Cost Trends for Highway Projects.* Raleigh Corth Carolina: North Carolina State University.

APPENDIX A: DATABASE FILTERING STATISTICS FOR 2016


2016 IRT/ADARS Raw Data
14,606 Lane Miles
5,165 Projects
$778,333,844
Filter Driven Sort
Criteria Driven Manual Selection
Pavement Project Analysis Set
11,638 Lane Miles
4125 Projects
$765,068,803
Missing Data Projects
2,843 Lane Miles
824 Projects
$1,568,461
Excluded Agencies
44.3 Lane Miles
43 Projects
$7,427,068
Gravel Projects
27.4 Lane Miles
11 Projects
$1,565,648
Drainage and Bridge Projects
53.6 Lane Miles
162 Projects
$2,703,863
Cost / Lane mile values
Investment / CL mile
Base project volume

APPENDIX B COST PER LANE MILE TABLES AND GRAPHS

2017 IRT/ADARD Data

All Projects Statewide					
	# of Projects	Lane Miles	Total Dollars	% of Total	Dollars/LM
Light CPM	837	2,264.2	$ 10,840,529	1.55%	$ 4,788
Heavy CPM	1,756	5,547.3	$ 115,921,824	16.63%	$ 20,897
Rehabilitation	1,218	2,766.2	$ 321,777,460	46.15%	$ 116,326
Reconstruction	484	711.5	$ 248,712,003	35.67%	$ 349,545
Totals	***4,295***	***11,289.1***	***$ 697,251,816***		
Federal Aid Projects Statewide					
	# of Projects	Lane Miles	Total Dollars	% of Totals	Dollars/LM
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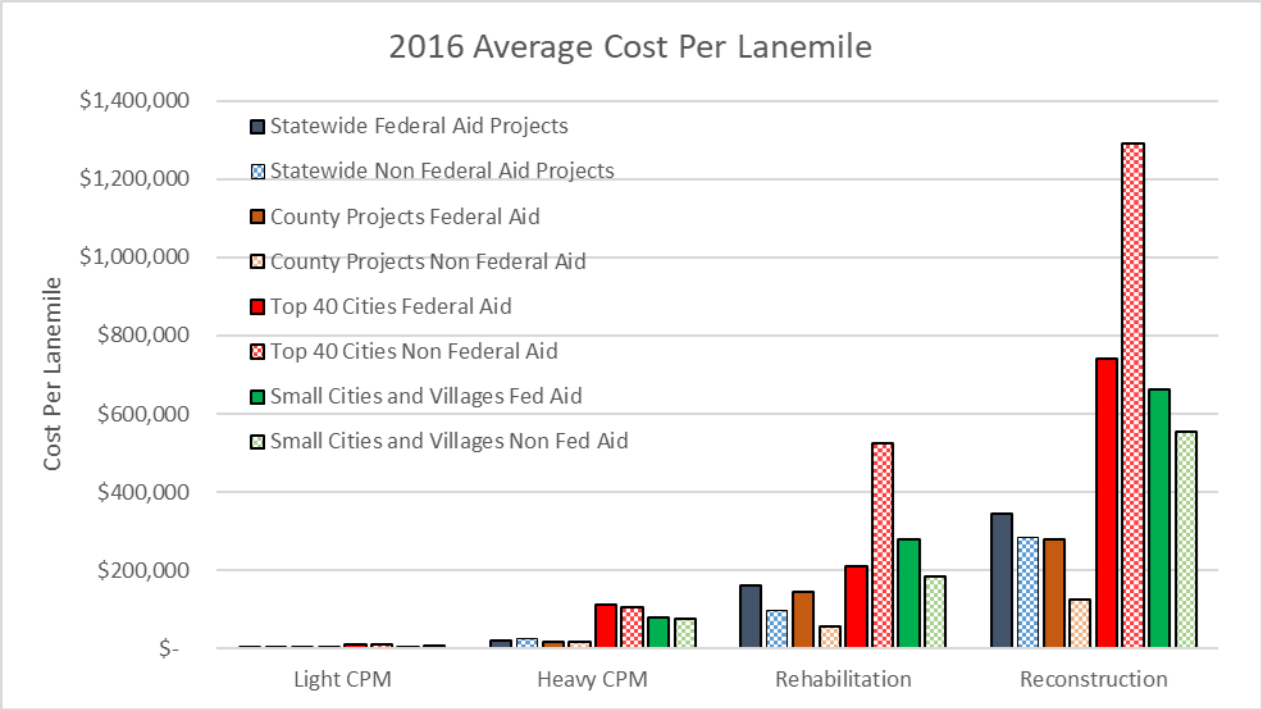
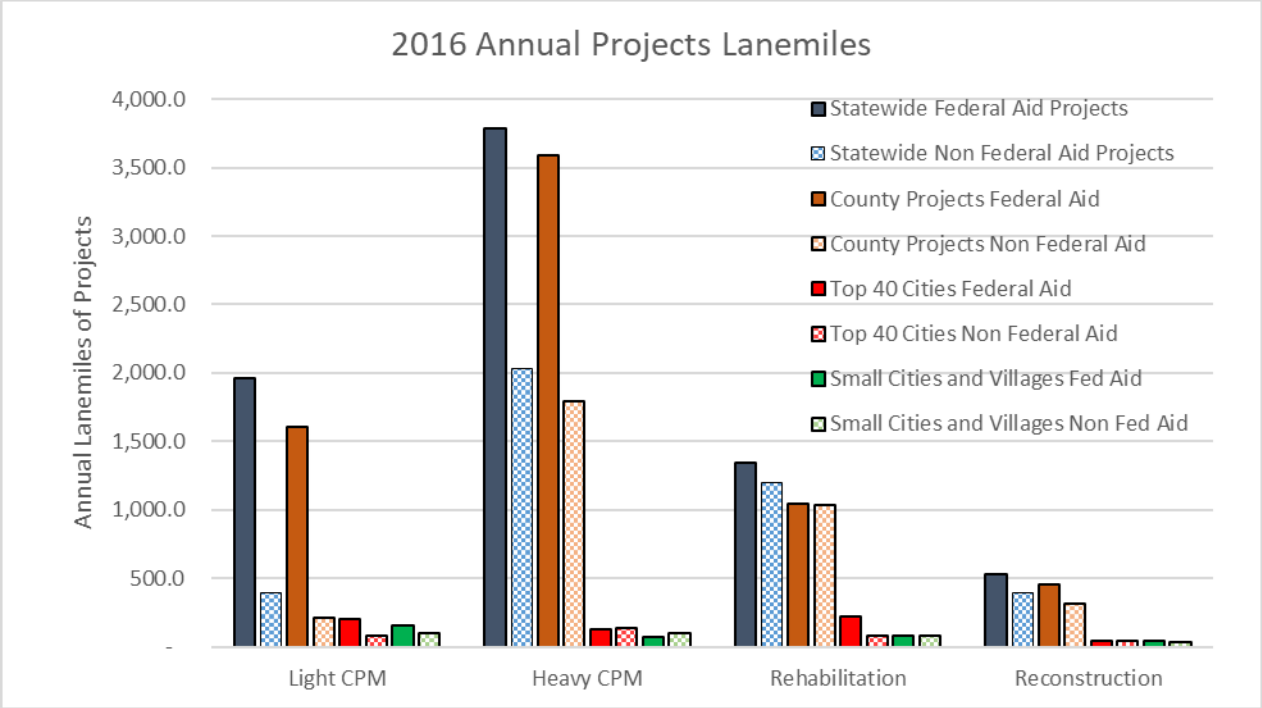
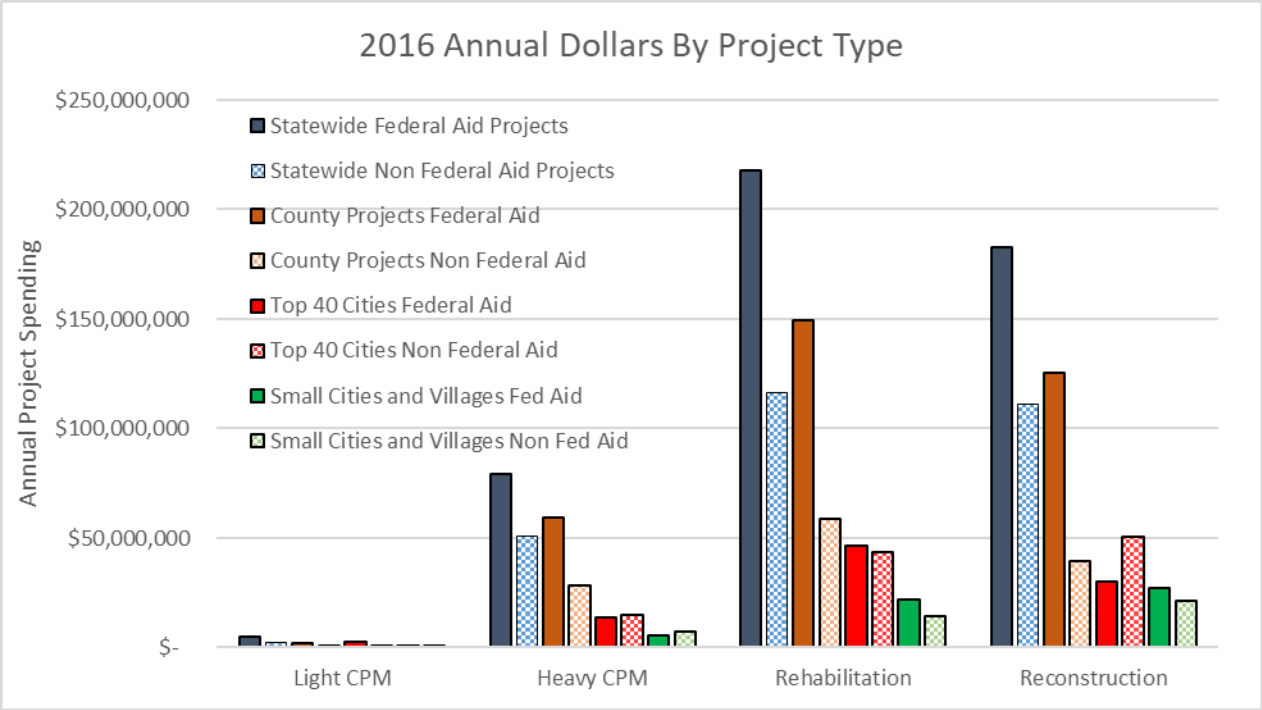
Totals	***1,559***	***6,966.9***	***$ 403,728,036***	100%	
Non Federal Aid Projects Statewide					
	# of Projects	Lane Miles	Total Dollars	% of Totals	Dollars/LM
Light CPM	437	591.6	$ 3,288,903	1%	$ 5,559
Heavy CPM	1,184	2,204.2	$ 48,807,391	17%	$ 22,143
Rehabilitation	799	1,165.5	$ 112,803,224	38%	$ 96,787
Reconstruction	316	360.9	$ 128,624,260	44%	$ 356,439
Totals	***2,736***	***4,322.2***	***$ 293,523,779***	100%	
County Projects					
Federal Aid Projects					
	# of Projects	Lane Miles	Total Dollars	% of Totals	Dollars/LM
Light CPM	245	1,178.2	$ 4,778,365	2%	$ 4,056
Heavy CPM	456	3,133.3	$ 50,429,678	21%	$ 16,095
Rehabilitation	300	1,260.8	$ 128,352,115	53%	$ 101,801
Reconstruction	88	267.7	$ 60,777,848	25%	$ 227,066
Totals	***1,089***	***5,840.0***	***$ 244,338,006***	100%	
Non Federal Aid Projects					
	# of Projects	Lane Miles	Total Dollars	% of Totals	Dollars/LM
Light CPM	161	400.4	$ 1,983,191	2%	$ 4,953
Heavy CPM	719	1,963.9	$ 32,397,339	29%	$ 16,496
Rehabilitation	481	903.2	$ 55,075,249	49%	$ 60,978
Reconstruction	137	242.4	$ 23,414,050	21%	$ 96,597
Totals	***1,498***	***3,509.9***	***$ 112,869,829***	100%	
Top 40 Cities					
Federal Aid Projects					
	# of Projects	Lane Miles	Total Dollars	% of Totals	Dollars/LM
Light CPM	72	199.4	$ 2,104,751	2%	$ 10,555
Heavy CPM	59	144.3	$ 10,376,560	9%	$ 71,891
Rehabilitation	52	269.6	$ 64,025,947	56%	$ 237,462
Reconstruction	26	42.3	$ 37,214,394	33%	$ 880,752
Totals	***209***	***655.6***	***$ 113,721,652***	100%	
Non Federal Aid Projects					
	# of Projects	Lane Miles	Total Dollars	% of Totals	Dollars/LM
Light CPM	128	104.1	$ 749,630	1%	$ 7,201
Heavy CPM	316	152.9	$ 10,284,936	8%	$ 67,251
Rehabilitation	164	160.9	$ 38,796,835	31%	$ 241,170
Reconstruction	68	63.3	$ 75,860,016	60%	$ 1,198,534
Totals	***676***	***481.2***	***$ 125,691,417***	100%	
Small Cities and Villages					
Federal Aid Projects					
	# of Projects	Lane Miles	Total Dollars	% of Totals	Dollars/LM
Light CPM	83	294.9	$ 668,510	1%	$ 2,267
Heavy CPM	57	65.4	$ 6,308,195	14%	$ 96,526
Rehabilitation	67	70.3	$ 16,596,174	36%	$ 236,204
Reconstruction	54	40.8	$ 22,095,500	48%	$ 542,194
Totals	***261***	***471.3***	***$ 45,668,378***	100%	
Non Federal Aid Projects					
	# of Projects	Lane Miles	Total Dollars	% of Totals	Dollars/LM
Light CPM	148	87.1	$ 556,083	1%	$ 6,385
Heavy CPM	149	87.4	$ 6,125,116	11%	$ 70,115
Rehabilitation	154	101.4	$ 18,931,140	34%	$ 186,685
Reconstruction	111	55.2	$ 29,350,195	53%	$ 531,947
Totals	***562***	***331.0***	***$ 54,962,533***	100%	

2016 IRT/ADARS Data

All Projects Statewide					
	# of Projects	Lane Miles	Total Dollars	% of Total	Dollars/LM
Light CPM	548	2,360.8	$ 7,555,942	1%	$ 3,201
Heavy CPM	1,771	5,813.0	$ 129,681,594	17%	$ 22,309
Rehabilitation	1,305	2,541.4	$ 334,206,901	44%	$ 131,507
Reconstruction	501	923.0	$ 293,624,367	38%	$ 318,128
Totals	***4,125***	***11,638.2***	***$ 765,068,803***	100%	
Federal Aid Projects STATEWIDE					
	# of Projects	Lane Miles	Total Dollars	% of Totals	Dollars/LM
Light CPM	245	1,963.1	$ 4,990,122	1%	$ 2,542
Heavy CPM	709	3,783.3	$ 79,030,618	16%	$ 20,889
Rehabilitation	401	1,344.0	$ 217,866,477	45%	$ 162,104
Reconstruction	174	533.0	$ 182,766,408	38%	$ 342,887
Totals	***1,529***	***7,623.5***	***$ 484,653,625***	100%	
Non Federal Aid Projects STATEWIDE					
	# of Projects	Lane Miles	Total Dollars	% of Totals	Dollars/LM
Light CPM	303	397.7	$ 2,565,820	1%	$ 6,451
Heavy CPM	1,062	2,029.7	$ 50,650,976	18%	$ 24,955
Rehabilitation	904	1,197.4	$ 116,340,423	41%	$ 97,163
Reconstruction	327	390.0	$ 110,857,959	40%	$ 284,285
Totals	***2,596***	***4,014.8***	***$ 280,415,178***	100%	
County Projects					
Federal Aid Projects					
	# of Projects	Lane Miles	Total Dollars	% of Totals	Dollars/LM
Light CPM	121	1,607.4	$ 1,879,283	1%	$ 1,169
Heavy CPM	602	3,588.3	$ 59,631,151	18%	$ 16,618
Rehabilitation	283	1,045.3	$ 149,574,769	44%	$ 143,097
Reconstruction	115	451.3	$ 125,519,185	37%	$ 278,111
Totals	***1,121***	***6,692.3***	***$ 336,604,387***	100%	
Non Federal Aid Projects					
	# of Projects	Lane Miles	Total Dollars	% of Totals	Dollars/LM
Light CPM	100	212.4	$ 947,122	1%	$ 4,460
Heavy CPM	826	1,792.6	$ 28,481,745	22%	$ 15,888
Rehabilitation	664	1,037.2	$ 58,654,699	46%	$ 56,550
Reconstruction	208	312.6	$ 39,280,005	31%	$ 125,671
Totals	***1,798***	***3,354.8***	***$ 127,363,571***	100%	
Top 40 Cities					
Federal Aid Projects					
	# of Projects	Lane Miles	Total Dollars	% of Totals	Dollars/LM
Light CPM	70	200.3	$ 2,405,044	3%	$ 12,006
Heavy CPM	52	123.5	$ 13,717,764	15%	$ 111,067
Rehabilitation	56	219.8	$ 46,333,430	50%	$ 210,806
Reconstruction	21	41.0	$ 30,313,301	33%	$ 739,656
Totals	***199***	***584.6***	***$ 92,769,540***	100%	
Non Federal Aid Projects					
	# of Projects	Lane Miles	Total Dollars	% of Totals	Dollars/LM
Light CPM	85	83.0	$ 929,214	1%	$ 11,197
Heavy CPM	86	139.4	$ 14,686,281	13%	$ 105,375
Rehabilitation	90	83.1	$ 43,445,820	40%	$ 523,003
Reconstruction	46	39.1	$ 50,423,336	46%	$ 1,289,336
Totals	***307***	***344.5***	***$ 109,484,651***	100%	
Small Cities and Villages					
Federal Aid Projects					
	# of Projects	Lane Miles	Total Dollars	% of Totals	Dollars/LM
Light CPM	54	155.4	$ 705,795	1%	$ 4,542
Heavy CPM	55	71.6	$ 5,681,703	10%	$ 79,407
Rehabilitation	62	78.9	$ 21,958,278	40%	$ 278,185
Reconstruction	38	40.7	$ 26,933,922	49%	$ 661,572
Totals	***209***	***346.6***	***$ 55,279,698***	100%	
Non Federal Aid Projects					
	# of Projects	Lane Miles	Total Dollars	% of Totals	Dollars/LM
Light CPM	118	102.3	$ 689,484	2%	$ 6,737
Heavy CPM	150	97.7	$ 7,482,950	17%	$ 76,577
Rehabilitation	150	77.1	$ 14,239,905	33%	$ 184,711
Reconstruction	73	38.3	$ 21,154,618	49%	$ 552,585
Totals	***491***	***315.4***	***$ 43,566,956***	100%	


2016 Average Cost Per Lanemile
Cost Per Lanemile
$1,400,000
$1,200,000
$1,000,000
$800,000
$600,000
$400,000
$200,000
$-
Statewide Federal Aid Projects
Statewide Non Federal Aid Projects
County Projects Federal Aid
County Projects Non Federal Aid
Top 40 Cities Federal Aid
Top 40 Cities Non Federal Aid
Small Cities and Villages Fed Aid
Small Cities and Villages Non Fed Aid
Light CPM
Heavy CPM
Rehabilitation
Reconstruction


2016 Annual Projects Lanemiles
Annual Lanemiles of Projects
4,000.0
3,500.0
3,000.0
2,500.0
2,000.0
1,500.0
1,000.0
500.0
-
Statewide Federal Aid Projects
Statewide Non Federal Aid Projects
County Projects Federal Aid
County Projects Non Federal Aid
Top 40 Cities Federal Aid
Top 40 Cities Non Federal Aid
Small Cities and Villages Fed Aid
Small Cities and Villages Non Fed Aid
Light CPM
Heavy CPM
Rehabilitation
Reconstruction


2016 Annual Dollars By Project Type
$250,000,000
$200,000,000
$150,000,000
$100,000,000
$50,000,000
$-
Annual Project Spending
Statewide Federal Aid Projects
Statewide Non Federal Aid Projects
County Projects Federal Aid
County Projects Non Federal Aid
Top 40 Cities Federal Aid
Top 40 Cities Non Federal Aid
Small Cities and Villages Fed Aid
Small Cities and Villages Non Fed Aid
Light CPM
Heavy CPM
Rehabilitation
Reconstruction

APPENDIX C: AVERAGE WEIGHTED COST PER LANE MILE FOR COMMON TREATMENTS

2016 & 2017 County Projects

TAMC Class	Project Subcategory	# of Projects	Lane Miles	Total Project Dollars	$/LM
Heavy CPM	Chip Seal	1809	7775.7	$ 94,362,306	$ 12,136
Heavy CPM	Slurry or Cape Seal	68	438.3	$ 7,550,493	$ 17,228
Heavy CPM	Micro Surfacing	56	205.1	$ 6,422,093	$ 31,312
Heavy CPM	Ultra Thin Overlay	98	271.6	$ 10,034,560	$ 36,951
Heavy CPM	Mill and Fill - Non Structural	143	188.3	$ 14,153,379	$ 75,145
Heavy CPM	Overlay - Non Structural	439	946.0	$ 42,039,080	$ 44,439
Rehabilitation	Mill and Fill - Structural	88	220.2	$ 24,929,138	$ 113,215
Rehabilitation	Overlay - Structural	507	968.0	$ 85,237,119	$ 88,058
Rehabilitation	Crush and Shape	302	818.5	$ 116,191,356	$ 141,963
Rehabilitation	Minor Rehab	112	223.7	$ 5,534,475	$ 24,741
Rehabilitation	Major Rehab	48	333.9	$ 40,293,758	$ 120,660
Rehabilitation	Resurfacing	471	1222.3	$ 90,615,807	$ 74,138
Reconstruction	Reconstruction	372	814.6	$ 212,347,535	$ 260,664

2016 & 2017 Top 40 City Projects

TAMC Class	Project Subcategory	# of Projects	Lane Miles	Total Project Dollars	$/LM
Heavy CPM	Chip Seal	50	98.8	$ 1,737,572	$ 17,583
Heavy CPM	Slurry or Cape Seal	5	46.5	$ 1,629,774	$ 35,032
Heavy CPM	Micro Surfacing	175	63.3	$ 2,239,182	$ 35,376
Heavy CPM	Ultra Thin Overlay	0	0.0	$ -	
Heavy CPM	Mill and Fill - Non Structural	68	95.1	$ 13,591,431	$ 142,889
Heavy CPM	Overlay - Non Structural	147	131.8	$ 14,958,746	$ 113,476
Rehabilitation	Mill and Fill - Structural	43	39.9	$ 10,428,611	$ 261,055
Rehabilitation	Overlay - Structural	33	58.0	$ 14,307,971	$ 246,685
Rehabilitation	Crush and Shape	54	50.1	$ 13,729,087	$ 273,941
Rehabilitation	Minor Rehab	16	76.9	$ 13,290,333	$ 172,833
Rehabilitation	Major Rehab	10	7.4	$ 9,525,478	$ 1,287,923
Rehabilitation	Resurfacing	168	412.6	$ 120,693,726	$ 292,551
Reconstruction	Reconstruction	144	155.5	$ 131,429,497	$ 845,445

2016 & 2017 Small City and Village Projects

TAMC Class	Project Subcategory	# of Projects	Lane Miles	Total Project Dollars	$/LM
Heavy CPM	Chip Seal	59	62.7	$ 1,155,266	$ 18,420
Heavy CPM	Slurry or Cape Seal	39	25.3	$ 781,106	$ 30,854
Heavy CPM	Micro Surfacing	2	2.3	$ 78,078	$ 33,467
Heavy CPM	Ultra Thin Overlay	17	16.5	$ 560,961	$ 33,971
Heavy CPM	Mill and Fill - Non Structural	201	153.5	$ 17,201,496	$ 112,046
Heavy CPM	Overlay - Non Structural	66	55.2	$ 6,982,696	$ 126,489
Rehabilitation	Mill and Fill - Structural	49	24.7	$ 3,529,286	$ 143,071
Rehabilitation	Overlay - Structural	26	18.3	$ 1,797,943	$ 98,179
Rehabilitation	Crush and Shape	118	72.0	$ 13,808,523	$ 191,710
Rehabilitation	Minor Rehab	14	7.6	$ 1,944,668	$ 256,316
Rehabilitation	Major Rehab	43	31.7	$ 13,062,479	$ 412,118
Rehabilitation	Resurfacing	171	127.3	$ 31,558,648	$ 247,845
Reconstruction	Reconstruction	250	156.8	$ 91,861,717	$ 586,021