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The Cost of Roadway Construction and Maintenance in New Jersey

FINAL REPORT

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16. Abstract
In today's fiscally constrained funding environment, cost efficiency in highway construction and maintenance is an important goal for transportation agencies nationwide. This research study estimated the average cost per-lane mile for roadway construction projects on State-owned roadways during a four-year analysis period; benchmarked New Jersey roadway construction costs against those of other states; identified factors that appear to influence construction costs; and identified leading practices that can improve the cost efficiency of roadway construction projects. The study found that the statewide average total project cost per lane-mile was $191,175, which is in line with costs estimated in other states. The analysis showed that projects funded using Federal funding were more expensive. Costs were also higher when projects were constructed on Interstate Highways, Other Freeways and Expressways as well as two-lane, lower-volume roads. Longer projects were much more likely to be low or very low cost while projects that were less than six miles long tended to be higher cost. Given these findings, NJDOT should further examine projects constructed on two-lane, lower-volume, undivided roadways to determine why project costs are higher on these roads and if bid specifications can be adjusted to reduce costs. Further, NJDOT should examine how project limits are currently defined to determine if there are opportunities to extend the length of projects to increase the total lane-miles of pavement addressed in each project. This can optimize the value received from construction mobilization efforts under each contract. There are other ideas for reducing costs published by FHWA. NJDOT should work with its research partners and vendors to determine which, if any of these or other recommended leading practices related to 3R projects are not currently being used but could be adopted to reduce the cost of capital construction projects in New Jersey.

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TABLE OF CONTENTS

Page

EXECUTIVE SUMMARY 1
INTRODUCTION 4
PHASE 1 FINDINGS 5
RESEARCH 2 REASEACH OBJECTIVES 6
ANALYSIS APPROACH AND METHODS 7
- **Overview of Project Analyzed** 8

ANALYSIS RESULTS 9
- **Average Project Cost Per Lane mile** 9
- **Variation in Project Cost by Location** 11
  - ***Cost Variation by NJDOT Region*** 11
  - ***Cost Variation by Population Density Place Type*** 12
- **Variation in Project Cost based on Funding Source** 15
- **Variation in Project Cost based on Roadway Characteristics** 16
  - ***Cost Variation based on Roadway Functional Classification and Cross-Section*** 16
  - ***Cost Variation based on Roadway Traffic Volume*** 20
- **Variation in Project Cost based on Project Characteristics** 22
- **Variation in Project Cost based on Construction Project Components** 24
- **Analysis of Special Case Projects** 25

BENCHMARKING NEW JERSEY COSTS AGAINST THOSE OF OTHER STATES 26
SUMMARY FINDINGS, DISCUSSION AND CONCLUSIONS 31
REFERENCES 33

LIST OF FIGURES **Page**

Figure 1. Map of NJDOT Regions 7
Figure 2. Variation in Average Project Cost Per Lane-Mile by Region 10
Figure 3. Map of New Jersey Population Densities... 13
Figure 4. Cost Range Distribution by Density Place Type... 14
Figure 5. Cost Range Distribution by Funding Source 15
Figure 6. Cost Range Distribution by Roadway Functional Classification 17
Figure 7. Cost Range Distribution by Number of Lanes 18
Figure 8. Cost Range Distribution by Roadway Traffic Volume (AADT)....................... 21
Figure 9. Cost Range Distribution by Project Length.. 20

LIST OF TABLES **Page**

Table 1 – Summary of Phase 1 Results 6
Table 2 – Overview of Sample Projects by NJDOT Region 8
Table 3 – Project Costs by NJDOT Region 9
Table 4 – Variation in Project Costs by Region 12
Table 5 – Variation in Project Cost by Population Density Place Type 14
Table 6 – Cost Variation by Project Funding Source.. 15
Table 7 – Cost Variation by Roadway Functional Classification.................................. 17
Table 8 – Cost Variation by Number of Lanes.. 18
Table 9 – Cost Variation by Presence of Shoulders... 19
Table 10 – Cost Variation by Presence of Median/Barrier 21
Table 11 – Cost Variation by Roadway Traffic Volume (AADT) 21
Table 12 – Cost Variation by Duration of Project 22
Table 13 – Cost Variation by Project Length.. 19
Table 14 – Cost Variation by Presence of Ramps and Bridges 24
Table 15 – Typical Costs per Lane Mile for Rural Roadways Assumed in HERS by Type of Improvement 29
Table 16 – Typical Costs per Lane Mile for Urban Roadways Assumed in HERS by Type of Improvement 30
Table 17 – Per Lane-Mile Cost Range Estimates for 3R Projects 31

EXECUTIVE SUMMARY

The statewide average total project cost per lane-mile, including pre-construction costs for New Jersey Department of Transportation (NJDOT) capital projects completed from Fiscal Year 2013 through Fiscal Year 2016 was estimated to be $191,175. This falls squarely within the range of costs estimated by FHWA and other State DOTs for pavement resurfacing, rehabilitation and reconstruction projects. The estimated per lane-mile cost based on project-specific data, is about 54 percent higher than the $123,755 cost per lane-mile estimated for capital construction projects derived from the program-level analysis conducted as part of Phase 1 of the study. Most of this variation is likely due to differences in calculation methods; however, part of the variation is also due to the fact that the project-level analysis conducted as part of Phase 2 included pre-construction costs, which average about $10,000 per lane mile for the projects analyzed.

The project-based analysis yielded a number of interesting insights regarding NJDOT's capital program and the factors that appear to be most associated with higher per lane-mile project costs. The following observations can be made from the analysis:

- The vast majority of capital projects undertaken and completed by NJDOT in the four-year analysis period were preventive maintenance and pavement resurfacing, rehabilitation or reconstruction projects (aka 3R projects). Consequently, pre-construction costs for projects included in the sample pool were generally limited to expenses associated with final project design. Only one project involved right-of-way acquisition and four involved utility relocation.
- Overall, there was notable variation in total project cost among the projects in the sample pool. Twenty-six projects had average costs that were above the mean, including 14 projects with costs 20 percent or more above the mean. Twenty-two projects had average costs below the mean, with 10 projects having average costs 20 percent or more below the mean. Some of the differences were significant, as much as 67 percent above and 40 percent below average per lane-mile project cost.
- Projects constructed in the South Region averaged $156,398 per lane mile, about 18 percent lower than the statewide average. North Region projects averaged $204,131 per lane mile, approximately seven percent higher than the statewide average; and projects constructed in the Central Region averaged $196,459, about three percent higher than the statewide average. However, the differences between average cost across regions may not be as great as the regional averages imply. More detailed analysis of the project pool showed that two very low-cost South Region projects, which had average costs per lane-mile more than 30 percent below the mean, lowered the regional average significantly. More than half of the eleven projects constructed in the South

Region were categorized as very high cost projects. Each had average costs per lane mile more than 30 percent above the regional mean.

- In New Jersey, it does not appear that the location of projects vis-à-vis population density is strongly associated with cost variation. The cost distribution in high and moderate density areas is very similar to the overall cost distribution for projects statewide.
- Project funding source explains at least some of the cost variation observed in the project pool. Projects funded using 100 percent State funding appear to be on average less expensive than those funded using Federal dollars. However, it is not possible from the analysis to determine if this differential is due to the types of projects typically funded with State vs. Federal funds or if using federal funds leads to more expensive projects.
- Based on the analysis it appears that there is at least some relationship between project cost and roadway functional classification. Project costs tend to be higher when associated with Interstate Highways and Other Freeways and Expressways and Minor Arterials. In both cases, 38-40 percent of projects in the sample pool had average per lane-mile costs that exceeded the regional mean by more than 30 percent.
- There also appears to be a relationship between higher project cost and number of lanes. Interestingly, the most significant cost variation is associated with two-lane roadways. Forty-four percent of construction projects involving two-lane roads had project costs per lane mile more than 30 percent above the regional mean. This is consistent with the findings related to roadway classification which showed that roadway construction projects on minor arterials tended to be more expensive.
- There does not appear to be evidence to support the conclusion that roadways with a greater number of travel lanes involve more expensive capital construction projects. To the contrary, the average cost per lane-mile for projects on roadways with four or more lanes were more likely to be in the average range or lower cost when compared to the project pool as a whole.
- The presence of shoulders does not appear to increase the likelihood that projects will be more expensive. Once again, there is evidence that the opposite is true. Projects on roadways without shoulders were more likely to have per lane-mile project costs more than 30 percent above the regional mean. With that said, it should be noted that the vast majority of the project analyzed as part of this study were constructed on roadways with shoulders. This makes drawing conclusions regarding project cost and the presence of shoulders difficult.
- Based on the analysis there appears to be a relationship between roadway volume and project cost. Half of all projects constructed on very high volume

roadways had project costs that were more than 30 percent above the regional mean. This finding is consistent with the input received from NJDOT subject matter experts and intuitively logical given the complexity of traffic management on very high volume roadways as well as the fact that construction activities on high volume roadways are most often staged at night when traffic volumes tend to be lower. Night-time construction activities are thought to have higher labor costs.

- Interestingly, average project cost per lane-mile were also higher on low-volume roadways. This is consistent with the findings related to roadway classification and cross-section which showed that roadway construction projects on minor arterials, two-lane roads and undivided roadways tended to be more expensive.
- There appears to be a strong relationship between overall project length and project cost. Longer projects were much more likely to be low or very low cost when average per lane-mile project costs were compared to regional mean project costs. In fact, a full 50 percent of projects six or more miles long were below average cost. This compares to 21 percent statewide for all projects. Projects that were less than six miles long tended to be higher cost.
- Finally, as one might expect, the analysis confirms that there is a direct positive relationship between project cost and project components. Projects that involved a greater number of elements such as traffic signal repair and replacement, temporary traffic signal systems, drainage components, more extensive landscaping and tree trimming/removal, and the inclusion of guide rail and crash cushion components were more likely to cost more.

One of the more compelling findings from this study is the fact that projects constructed on lower-order, less-trafficked, two-way undivided roadways consistently had per-lane mile costs higher than the average range. While the evidence regarding this relationship is strong, the underlying reasons why this is true are less clear. NJDOT should seek to understand this relationship in more detail by closely tracking costs for these types of projects over time, interviewing construction vendors, and revisiting the procurement process for this type of project to determine if bid specifications can be adjusted to reduce costs.

Also compelling is the finding that project length impacts cost positively. There appear to be beneficial economies of scale that play a role in reducing costs. Construction activities require significant mobilization efforts to get equipment in place, hire workers and stage the construction zone. These costs are similar for small and large projects, so there are benefits to advancing projects in a way that can make the most of mobilization efforts. NJDOT should examine how project limits are currently defined to determine if there are opportunities to expand the length of projects to increase the total lane-miles of pavement addressed. This can optimize the value received from construction mobilization efforts under each contract.

In addition to the above, FHWA recommends that State DOTs use a range of highway construction and maintenance cost control ideas, which are published on the agency's website. These recommended practices were developed by the Texas DOT's Cost Control Task Force. Recommendations address pavement maintenance and preservation, pavement design considerations, use of alternative materials in construction projects, pavement markings standards and ways to increase completion in the contract bidding process [(1)]. NJDOT should work with its research partners and vendors to determine which, if any of these or other recommended leading practices related to 3R projects are not currently being used but could be adopted to reduce the cost of capital construction projects.

INTRODUCTION

New Jersey's transportation system comprises a vast array of infrastructure, including more than 38,000 centerline miles of roadways and thousands of bridges under State and local jurisdiction; more than 3,000 buses operating on 262 bus routes; 12 commuter rail lines serving 165 stations in 117 municipalities; 3 light rail lines serving 62 station/stops; 350+ park-and-ride lots; 3 commercial airports, 46 general aviation airports; 225 miles of commercial navigation channels; the largest seaport on the east coast; two Class I rail freight carriers and 14 regional and short line railroads [(2)]. Well-maintained transportation infrastructure is necessary to support the needs of the traveling public and goods movement and other economic activity. In today's fiscally constrained funding environment, cost efficiency in highway construction and maintenance is an important goal for transportation agencies nationwide.

NJDOT retained the Alan M. Voorhees Transportation Center at Rutgers University to conduct a study of roadway construction, operations and maintenance costs in New Jersey. The purpose of the study was to provide NJDOT with short-term insight into the average cost of roadway construction and maintenance projects in New Jersey and longer-term understanding of the factors that influence construction and maintenance costs and what can be done to ensure the cost efficiency in the delivery of roadway projects. The study was conducted in two phases.

The primary research objective for Phase I of the study was to estimate how much it costs on average to plan, construct, operate and maintain the roadways and bridges under NJDOT jurisdiction based on a programmatic review of NJDOT expenditures. Phase 1 was completed in May of 2016. A summary of key findings from Phase 1 are presented in the section that follows. Phase 2 of the study involved a more detailed analysis of project-specific costs as well as a review of leading practices being used to increase the cost-efficiency of roadway construction projects.

PHASE 1 FINDINGS

The costs associated with planning, constructing, operating and maintaining New Jersey's transportation infrastructure is significant. New Jersey's total transportation expenditures can vary significantly from year to year (see Table 1). From FY2010 to FY2014, total annual expenditures–excluding expenditures by toll road authorities–ranged from a low of approximately $3.4 billion in FY2012 to a high of more than $4 billion in FY2014. On average, 59 percent of total transportation-related expenditures are for activities not directly associated with planning, constructing, operating, and maintaining roads and bridges under NJDOT's jurisdiction. These include: grants and other expenditures related to the NJDOT Local Aid program and other grants made to local governments; capital project and operating support to NJ TRANSIT; debt service on bonds issued to finance transportation projects; funds passed through to MPOs and TMAs; and expenditures associated with NJDOT's Bureau of Aeronautics, Office of Maritime Resources and activities related to rail freight planning.

Overall spending in FY2014 was approximately $300 million dollars greater than the average for the five-year analysis period. This increase in spending was at least partially due to the level of available funding and the complexity of projects undertaken. In FY2014, capital construction expenditures included a number of complex and expensive projects including but not limited to reconstruction of the Pulaski Skyway in northern New Jersey and the post-Sandy reconstruction of Route 35 in Monmouth County. In 2014, atypical funding sources included Federal funds made available to support Hurricane Sandy recovery and funding made available by the Port Authority of New York and New Jersey for the Pulaski Skyway rehabilitation project.

As shown in Table 1, costs averaged around $1.5 billion annually. This equates to an average cost of $183,757 per lane mile, excluding debt service, to plan, construct, operate and maintain the roadways and bridges under NJDOT jurisdiction. When interest payments on bonds is added in, the total cost increases to an average of $212,927 per lane mile. Detailed tables for each fiscal year analyzed for this study are presented in Appendix 1 of the Phase 1 Final Report. The results of Phase I provide a baseline understanding of average aggregate costs associated with NJDOT roadways and bridges [3].

Table 1 – Summary of Phase 1 Results

	2010	2011	2012
Total Transportation-related Expenditures[1]	$3,834,521,409	$3,742,385,422	$3,417,528,066
Expenditures directly related to planning, constructing, operating and maintaining roadways and bridges under NJDOT jurisdiction	$1,653,454,212	$1,626,844,479	$1,318,747,115
Percent of Total Expenditures	43%	43%	39%
Cost Per Lane Mile Estimates:			
Administration, Planning & Research	$7,282	$7,261	$8,491
Capital Construction	$151,756	$131,713	$101,004
Operations & Maintenance	$37,567	$54,468	$47,312
Subtotal	$196,606	$193,442	$156,807
Interest Payments on Bonds	$23,884	$25,233	$31,091
Full Cost Total per Lane Mile	**$220,490**	**$218,674**	**$187,898**
	2013	**2014**	**Average**
Total Transportation-related Expenditures[1]	$3,685,825,313	$4,069,813,267	$3,750,014,695
Expenditures directly related to planning, constructing, operating and maintaining roadways and bridges under NJDOT jurisdiction	$1,375,402,580	$1,752,544,686	$1,545,398,614
Percent of Total Expenditures	37%	43%	41%
Cost Per Lane Mile Estimates:			
Administration, Planning & Research	$9,167	$5,924	$7,625
Capital Construction	$96,305	$137,999	$123,755
Operations & Maintenance	$58,072	$64,465	$52,377
Subtotal	$163,544	$208,388	$183,757
Interest Payments on Bonds	$31,768	$33,872	$29,170
Full Cost Total	**$195,312**	**$242,261**	**$212,927**

Notes: 1 – Cash expenses, excluding toll road authority expenditures.

PHASE 2 RESEARCH OBJECTIVES

The research objectives for Phase 2 of the study were to:

1. Estimate the average cost per-lane mile for roadway construction projects on State-owned roadways using project-specific data;
2. Benchmark New Jersey roadway construction costs against those of other states;
3. Identify the factors that may influence the cost efficiency of roadway construction projects in New Jersey; and
4. Identify leading practices that can be used to improve the cost efficiency of roadway construction projects.

ANALYSIS APPROACH AND METHODS

To achieve these research objectives, the Rutgers research team conducted a detailed project-by-project analysis of costs associated with all roadway construction projects approved as complete during Fiscal Years 2013 through 2016 that were managed through the NJDOT capital projects unit. Data used to complete the analysis was drawn from a variety of sources, including the U.S. Census Bureau, NJDOT Straight Line Diagrams, project bid sheets and data exported from the NJDOT Financial Management System. In addition to estimating total construction cost per lane-mile, costs associated with other phases of project development were also examined. These included:

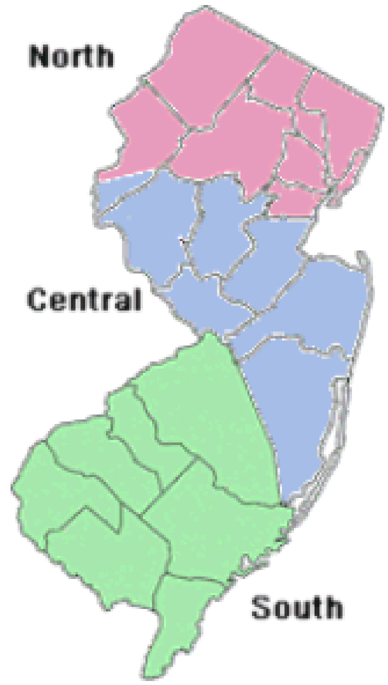

Figure 1. NJDOT Regions

- Preliminary Engineering and Design;
- Final Design;
- ROW Acquisition; and
- Utility Relocation.

To explore how potential cost drivers may explain project cost variation, the research team compiled and analyzed data on the following:

- Project location – NJDOT Region (i.e., Central, North or South) and population density;
- Funding source – Federal vs. State;
- Roadway characteristics – Functional Classification, Cross-section, and Annual Average Daily Traffic (AADT);
- Project characteristics – length of project, project duration, and involvement of structures such as ramps, bridges, culverts, etc.; and
- Construction project components – construction materials used; inclusion of temporary and permanent traffic control and safety elements; roadway markings; sidewalks and curbs, including islands; inclusion of permanent barriers such as guard rails and crash cushions; inclusion of electric and lighting systems; erosion control methods and equipment used, inclusion of utility and drainage elements, inclusion of complete streets elements, ADA elements, inclusion of lighting and traffic signal components; inclusion of landscaping and streetscape components.

The data available for this study did not include information on the number of lane miles affected by each project. Therefore, in order to calculate per lane-mile costs, the number of lane miles had to be estimated. After consulting with subject matter experts at NJDOT, the research team developed a simple formula for calculating affected lane miles using data provided on project bid sheets. Estimated total square yards of millage to be generated by each project was divided by 7,040 to approximate one lane mile based on milling an average of 3 inches of pavement.

Overview of Projects Analyzed

The pool of sample projects analyzed for this study included a total of 48 projects – 13 were located in NJDOT North Region, 24 in NJDOT Central Region, and 11 in NJDOT South Region. Twenty-seven of the projects were funded with 100 percent State funding and 21 were federally funded. Forty-six of the projects were described as pavement resurfacing or rehabilitation projects, while three were listed as preventive maintenance projects.

It should be noted that the description of all of the projects in the database provided by NJDOT was very similar. Although project classifications varied, all of the projects involved milling of the existing pavement and installing new asphalt mix pavement in the areas milled. Some project descriptions noted involvement of structures such as bridges, culverts, ADA improvements, signal upgrades and/or drainage, while others did not. More detailed examination of project bid sheets was undertaken to understand better the components included in each project.

In addition to the 48 projects referenced above, three other projects were reviewed but were treated as "outliers" due to the nature of the projects and the fact that the estimated cost per lane-mile for these projects were more than twice the statewide average. The three projects that were analyzed separately, were:

- Route 46 from Main Street to Frederick Place (North Region). This project included safety improvements, widening of Route 46 and signalized intersection upgrades.
- Route 80 EB resurfacing from MP 45.6 to 53 (North Region). This project included resurfacing as well as removal of substandard guardrails and installation of a new berm area to restore drainage.
- Route 45 from Carpenter Street to Red Bank (Central Region). This project included cross-section changes and associated streetscape improvements.

All three of these projects were federally funded. A brief analysis of these projects appears in a separate section below.

Table 2 – Overview of Sample Projects by NJDOT Region

	NJDOT Region			**Total**
	North	Central	South	
Number of Projects	13	24	11	48
Funding Source				
Federal	5	10	6	21
State	8	14	5	27
Functional Classification				
Freeway/Expressway	3	3	2	8
Principal Arterial	9	16	5	30
Minor Arterial	1	5	4	10
Project Type				
Preventative Maintenance	3	0	0	3
Pavement Resurfacing/Rehabilitation	10	24	11	45

ANALYSIS RESULTS

Average Project Cost Per Lane Mile

To estimate average project costs per lane-mile the research team analyzed data exported from NJDOT's Financial Management System for each project in the sample pool. These data included costs associated with preliminary engineering, final design, utility relocation, right-of-way acquisition, construction, and costs associated with settling vendor claims. All costs were considered including in-house NJDOT salaries, "other in-house" expenses, and the costs associated with vendor contracts for each project. As noted previously, the number of lane miles associated with each project was calculated based on millage estimates from each project bid sheet.

As shown in Table 3, the total cost of the 48 projects analyzed for this study was approximately $236.3 million. These projects affected approximately 1,236 lane miles of roadway. The vast majority of the costs associated with the sample projects was for construction phase work. None of the projects involved right-of-way acquisition and a limited number of projects involved minor utility relocations. As shown in Table 3, the statewide average total project cost per lane-mile for the capital projects in the sample pool was $191,175.

Overall, there was notable variation in total project cost among the projects in the sample pool (See Figure 2). Twenty-six projects had average costs that were above the mean. Fourteen projects had average costs 20 percent or more above the mean. Twenty-two projects had average costs below the mean, with 10 projects having average costs 20 percent or more below the mean. Some of the differences were significant, as much as 67 percent above and 40 percent below average per lane-mile project cost.

Table 3 – Project Costs by NJDOT Region

	NJDOT Region			Statewide
	North	Central	South	
Pre-Construction Costs				
Preliminary Engineering	$315,988	$447,517	$174,069	$937,574
Final Design	$3,558,454	$6,447,225	$1,311,164	$11,316,843
Utility Relocation	$15,380	$74,081	$0	$89,461
Right-of-Way Acquisition	$0	$0	$0	$0
Subtotal Pre-Construction	$3,889,822	$6,968,823	$1,485,233	$12,343,878
Construction Costs	$75,353,807	$112,869,539	$35,643,654	$223,867,000
Vendor Claims	$0	$119,622	$0	$119,622
Total Project Costs	$79,243,630	$119,957,984	$37,128,886	$236,330,500
Estimated Total Lane Miles for all Projects	388.2	610.6	237.4	1236.2
Average Per Lane Mile Project Costs				
Pre-Construction	$10,020	$11,413	$6,256	$9,985
Construction + Vendor Claims	$194,111	$185,046	$150,142	$181,190
Total Project Costs	$204,131	$196,459	$156,398	$191,175

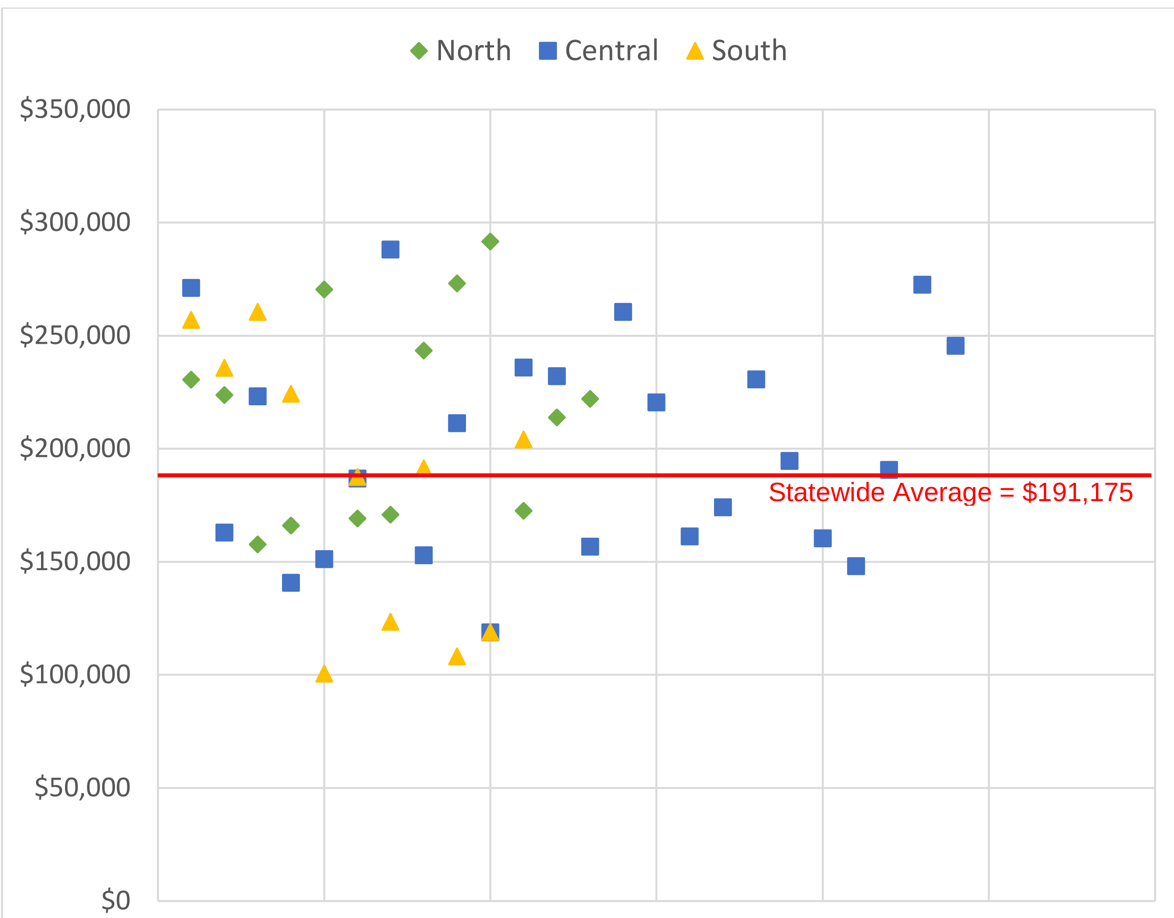

Figure 2. Variation in Average Project Cost Per Lane mile by Region

Variation in Project Costs by Location

One of the factors thought to influence project cost is the location where the project is undertaken. Interviews with NJDOT subject matter experts revealed a basic assumption that projects constructed in certain parts of New Jersey are likely to be more expensive than others. For example, experts opined that projects constructed in more densely populated parts of the State where roadways are more congested are likely to be more expensive. Other opinions included the belief that projects in southern New Jersey are less expensive than projects completed in northern and central New Jersey. This is thought to be true for a variety of reasons, including the fact that winter weather conditions in the southern part of the State are often less severe, labor and material costs are thought to be lower and southern New Jersey is less congested.

To understand better how project cost varies in different parts of New Jersey, the research team categorized projects based how much total project costs per lane-mile varied from regional weighted mean costs. Projects were considered in the average range if costs varied +/- 20 percent from the regional mean. Projects with average costs more than 20 percent above the regional mean were considered in the high cost range. Projects with average costs more than 20 percent below the regional mean were considered to be in the low cost range. Once categorized, variation in project costs was then compared across NJDOT regions and in the context of population density.

Cost Variation by NJDOT Region

As shown in Table 3, in the aggregate, there was some evidence to support the notion that projects constructed in southern Jersey counties cost less than projects constructed in central and northern New Jersey. Projects constructed in the South Region averaged $156,398 per lane-mile, about 18 percent lower than the statewide average. North Region projects averaged $204,131 per lane-mile, approximately seven percent higher than the statewide average; and projects constructed in the Central Region averaged $196,459, about three percent higher than the statewide average. However, the apparent regional variation in average cost may not be as great as the regional averages imply (see Table 4).

While average project cost per lane-mile in the South Region were lowest ($156,391), more detailed analysis of the project pool showed some revealing patterns that challenge the notion that south Jersey projects are less expensive. For example, only two projects constructed in the South Region fell within the average range. Also, two very low cost South Region projects, which had average costs per lane-mile more than 30 percent below the mean, lowered the regional average significantly. More than half of the eleven projects constructed in the South Region were categorized as very high cost projects. Each had average costs per lane-mile more than 30 percent above the regional mean. In fact, these six projects had average costs per lane-mile that were well above even the statewide average.

Some additional observations that can be made include the following:

- There was less variation in project cost per lane-mile in the North Region than in the other two regions. More than two-thirds (69 percent) of North Region projects fell within the average cost range. Among the projects falling outside the average range, nearly one-quarter (23 percent) were very high cost projects, while eight percent were low cost projects.

- More than half the projects constructed in the Central Region (54 percent) fell within the average cost range. The remaining projects were almost evenly split between higher and lower cost projects.

Table 4 – Variation in Project Cost by Region

	Number of Projects in Each Category							
	North Region		Central Region		South Region		Statewide	
	No.	%	No.	%	No.	%	No.	%
Very High Cost	3	23%	4	17%	6	55%	13	27%
High Cost	0	0%	1	4%	1	9%	2	4%
High Average Cost	2	15%	5	21%	1	9%	8	17%
Average Cost	3	23%	4	17%	0	0%	7	15%
Low Average Cost	4	31%	4	17%	0	0%	8	17%
Low Cost	1	8%	5	21%	2	18%	8	17%
Very Low Cost	0	0%	1	4%	1	9%	2	4%
Total	13		24		11		48	
High + Very High		23%		21%		64%		31%
Average Range		69%		54%		9%		48%
Low + Very Low		8%		25%		27%		21%

Notes: Very High Cost (≥ + 30%); High Cost (+ 20.1 to 29.9%); High Average Cost (+ 10.1 to 20%); Average Cost (+/- 10%); Low Average Cost (- 10.1 to 20%); Low Cost (- 20.1 to 29.9%); and Very Low Cost (≤ - 30%)

Cost Variation by Population Density Place Type

Another dimension of project location is whether projects are constructed in high-, moderate- or low-density areas. To explore if and how project cost may vary depending on the type of place it is constructed, the research team compiled population density data for the municipalities in which the projects were constructed. Locations were characterized as high-, moderate- or low-density based on the number of persons per square mile in the area. Figure 3 provides a map of the New Jersey showing variation in population density statewide by census tract. Average project cost per lane-mile were then compared between density place types.

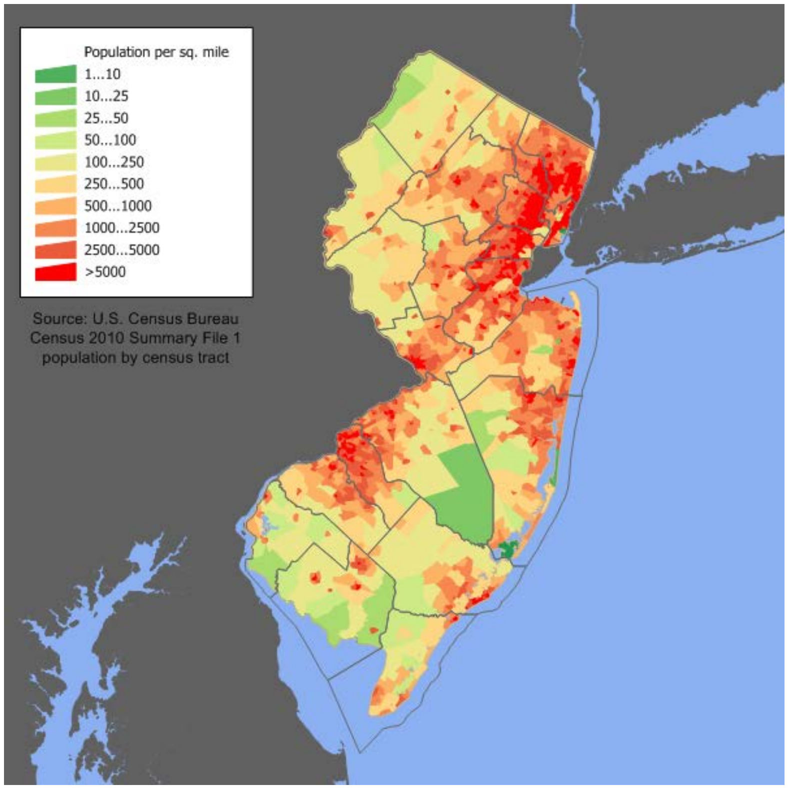

Figure 3. Map of New Jersey Population Densities

As shown in Table 5 and Figure 4, the location of projects vis-à-vis population density does not appear to be strongly associated with cost variation. The cost distribution in high- and moderate-density areas is very similar to the overall cost distribution for projects statewide. However, the analysis seems to indicate that projects constructed in low-density areas tend to have higher average costs per lane-mile. Nearly half (46 percent) of the projects constructed in low-density areas had average costs more than 20 percent above the regional mean. Less than one-third of projects statewide (31 percent) were high or very high cost projects. This finding appears to at least partially contravene the conventional wisdom expressed by NJDOT subject matter experts that projects are less expensive when constructed in lower density areas.

The following additional observations can be made from the analysis:

- Projects constructed in moderately dense areas are more consistently within the average range of cost. More than half (54 percent) of project constructed in moderately dense parts of the State fell within this range. Twenty-seven percent of the remaining projects were higher cost, while 19 percent were lower cost.

- The distribution of project costs in higher density areas was almost perfectly symmetrical. Fifty-six percent of projects fell within the average range, while 22 percent were higher cost and 22 percent were lower cost.

Table 5 – Cost Variation in Project Cost by Population Density Place Type

	Number of Projects in Each Category							
	High Density (> 4,000 Persons per Sq. Mile)		**Moderate Density** (500-4000 Persons per Sq. Mile)		**Low Density** (< 500 Persons per Sq. Mile)		**Statewide**	
	No.	%	No.	%	No.	%	No.	%
Very High Cost	2	22%	5	19%	6	46%	13	27%
High Cost	0	0%	2	8%	0	0%	2	4%
High Average Cost	2	22%	5	19%	1	8%	8	17%
Average Cost	2	22%	4	15%	1	8%	7	15%
Low Average Cost	1	11%	5	19%	2	15%	8	17%
Low Cost	2	22%	4	15%	2	15%	8	17%
Very Low Cost	0	0%	1	4%	1	8%	2	4%
Total	9		26		13		48	
High + Very High		22%		27%		46%		31%
Average Range		56%		54%		31%		48%
Low + Very Low		22%		19%		23%		21%

Notes: Very High Cost (≥ + 30%); High Cost (+ 20.1 to 29.9%); High Average Cost (+ 10.1 to 20%); Average Cost (+/- 10%); Low Average Cost (- 10.1 to 20%); Low Cost (- 20.1 to 29.9%); and Very Low Cost (≤ - 30%)

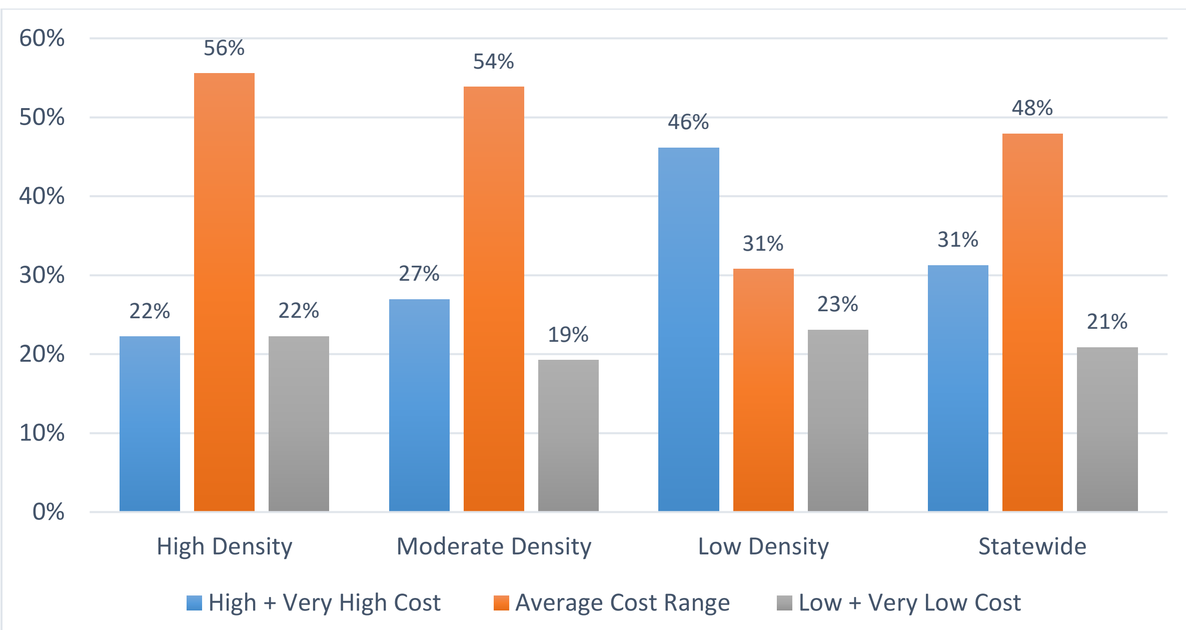

Figure 4. Cost Range Distribution by Density Place Type

Variation in Project Cost Based on Funding Source

NJDOT subject matter experts interviewed for this study universally expressed the opinion that projects funded with Federal transportation funds are likely to be more expensive because generally, projects funded with federal dollars take longer and require higher levels of documentation and oversight. To explore this premise, the research team analyzed project costs based on the source of project funding. The analysis provides some evidence that project funding source explains at least some of the cost variation observed in the project pool (see Table 6 and Figure 5).

Table 6 – Cost Variation by Project Funding Source

	Number of Projects in Each Category					
	State		Federal		All Projects	
	No.	%	No.	%	No.	%
Very High Cost	5	18%	8	40%	13	27%
High Cost	0	0%	2	10%	2	4%
High Average Cost	5	18%	3	15%	8	17%
Average Cost	4	14%	3	15%	7	15%
Low Average Cost	7	25%	1	5%	8	17%
Low Cost	5	18%	3	15%	8	17%
Very Low Cost	2	7%	0	0%	2	4%
Total	28		20		48	
High + Very High		18%		50%		31%
Average Range		57%		35%		48%
Low + Very Low		25%		15%		21%

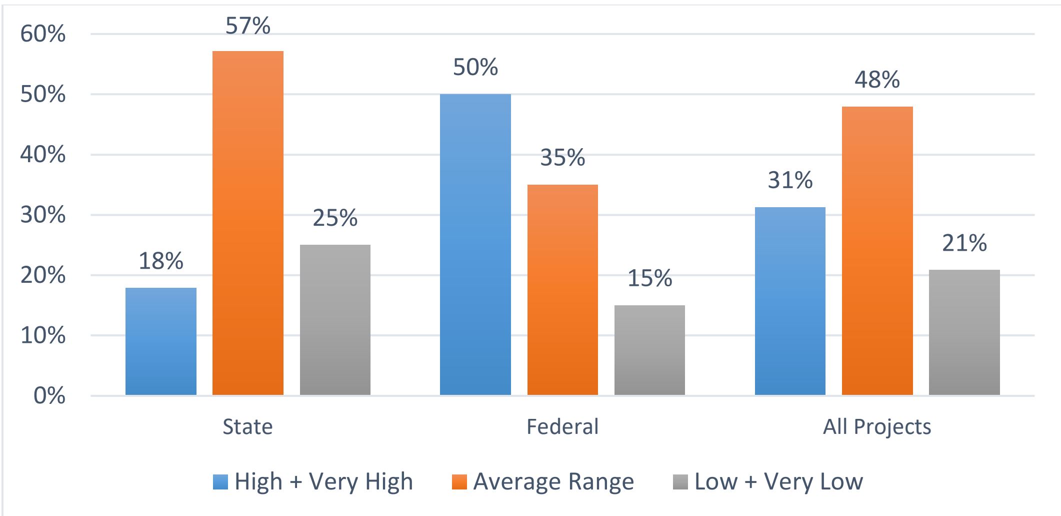

Figure 5. Cost Range Distribution by Funding Source

Projects funded with 100 percent State funding appear to be on average less expensive than those funded using Federal dollars. Of the 28 projects in the sample pool that were funded with 100 percent State funding, 16 projects or 57 percent had costs that fell within the average range. Another 25 percent had average per lane-mile costs more than 20 percent lower than the regional mean. Half of the projects funded through federal programs, had project costs that were in the high or very high range. Eight of the 20 projects had average costs per lane mile 30 percent or more above the regional mean. It must be noted however that it is not possible from the analysis to determine if this differential is due to the types of projects typically funded with State vs. Federal funds or if using federal funds leads to more expensive projects.

Variation in Project Cost based on Roadway Characteristics

NJDOT subject matter experts suggested that roadway characteristics such as functional classification, cross-section (i.e., number of lanes, shoulders, grade separation, medians, etc.), and AADT may affect project costs. In general, the experts expressed the opinion that projects constructed on higher order roadways (e.g., Interstates, freeways and other principal arterials) and roadways with a higher AADT might have higher project costs. To test this theory, the research team assembled and analyzed data on project roadway characteristics for each project in the sample pool to see which if any characteristics might be associated with variation in project costs.

Cost Variation based on Roadway Functional Classification and Cross-Section

The first component of the analysis examined cost variation in the context of roadway functional classification. The sample pool included eight roadways classified as either Interstate Highways or Other Freeways and Expressways; 30 roadways classified as Other Principal Arterials; and 10 Minor Arterials. Based on the analysis it appears that there is at least some relationship between project cost and functional classification (see Table 7 and Figure 6). Although the cost range distribution of projects constructed on Other Principal Arterials closely matches the distribution for all roadway types, project costs skew higher for Interstate Highways and Other Freeways and Expressways and Minor Arterials. In both cases, 38-40 percent of projects had average per lane-mile costs that exceed the regional mean by more than 30 percent.

Closely related to a roadway's functional classification is its cross-section, which is another defining characteristic. A roadway cross-section typically includes a number of elements. Depending on the location, nature and function of the roadway, cross-section elements will usually include two or more travel lanes and may include shoulders, a median strip or barrier, acceleration and deceleration lanes, parking, sidewalks and other elements. For the purpose of this study, the research team compiled and analyzed data on the number of travel lanes and shoulders involved in the construction project, as well as information on the type of median, if applicable.

Table 7 – Cost Variation by Roadway Functional Classification

	Number of Projects in Each Category							
	Interstates & Other Freeways/ Expressways		Other Principal Arterial		Minor Arterial		All Roadway Types	
	No.	%	No.	%	No.	%	No.	%
Very High Cost	3	38%	6	20%	4	40%	13	27%
High Cost	0	0%	2	7%		0%	2	4%
High Average Cost	1	13%	4	13%	3	30%	8	17%
Average Cost	0	0%	6	20%	1	10%	7	15%
Low Average Cost	3	38%	5	17%		0%	8	17%
Low Cost	1	13%	6	20%	1	10%	8	17%
Very Low Cost	0	0%	1	3%	1	10%	2	4%
Total	8		30		10		48	
High + Very High		38%		27%		40%		31%
Average Range		50%		50%		40%		48%
Low + Very Low		13%		23%		20%		21%

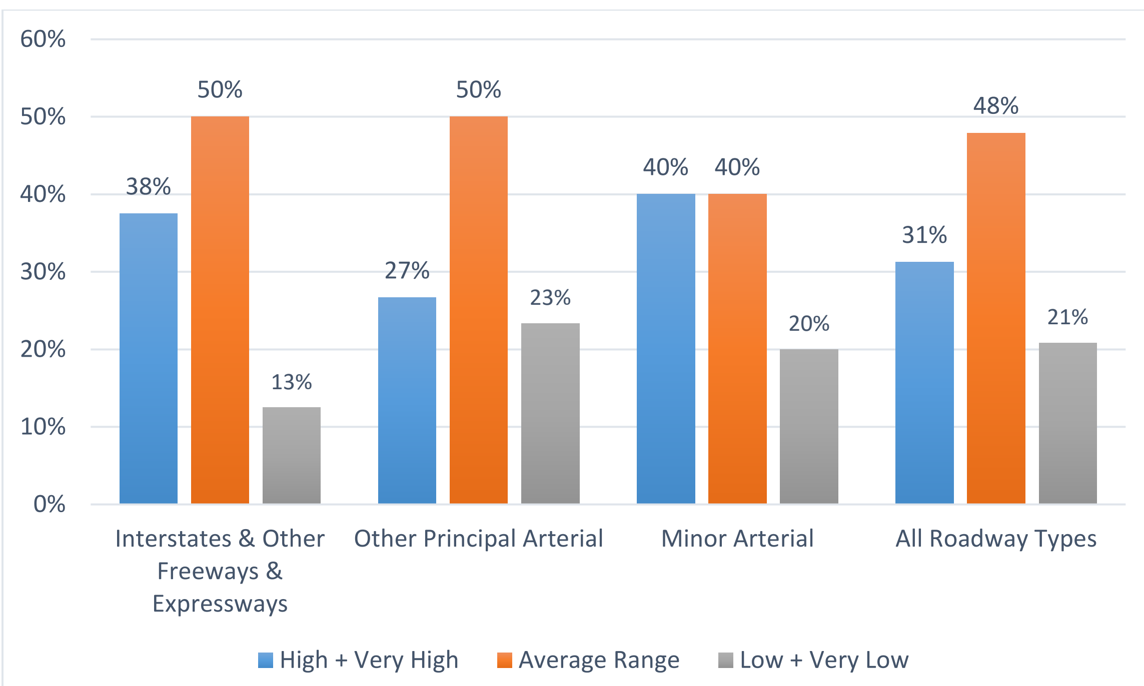

Figure 6. Cost Range Distribution by Roadway Functional Classification

Table 8 – Cost Variation by Number of Lanes

	Number of Projects in Each Category							
	2-lane		4-lane		6 + lanes		All Roadways	
	No.	%	No.	%	No.	%	No.	%
Very High Cost	7	44%	4	17%	2	22%	13	27%
High Cost	1	6%	0	0%	1	11%	2	4%
High Average Cost	4	25%	2	9%	2	22%	8	17%
Average Cost	1	6%	4	17%	2	22%	7	15%
Low Average Cost	0	0%	6	26%	2	22%	8	17%
Low Cost	3	19%	5	22%	0	0%	8	17%
Very Low Cost	0	0%	2	9%	0	0%	2	4%
Total	16		23		9		48	
High + Very High		50%		17%		33%		31%
Average Range		31%		52%		67%		48%
Low + Very Low		19%		30%		0%		21%

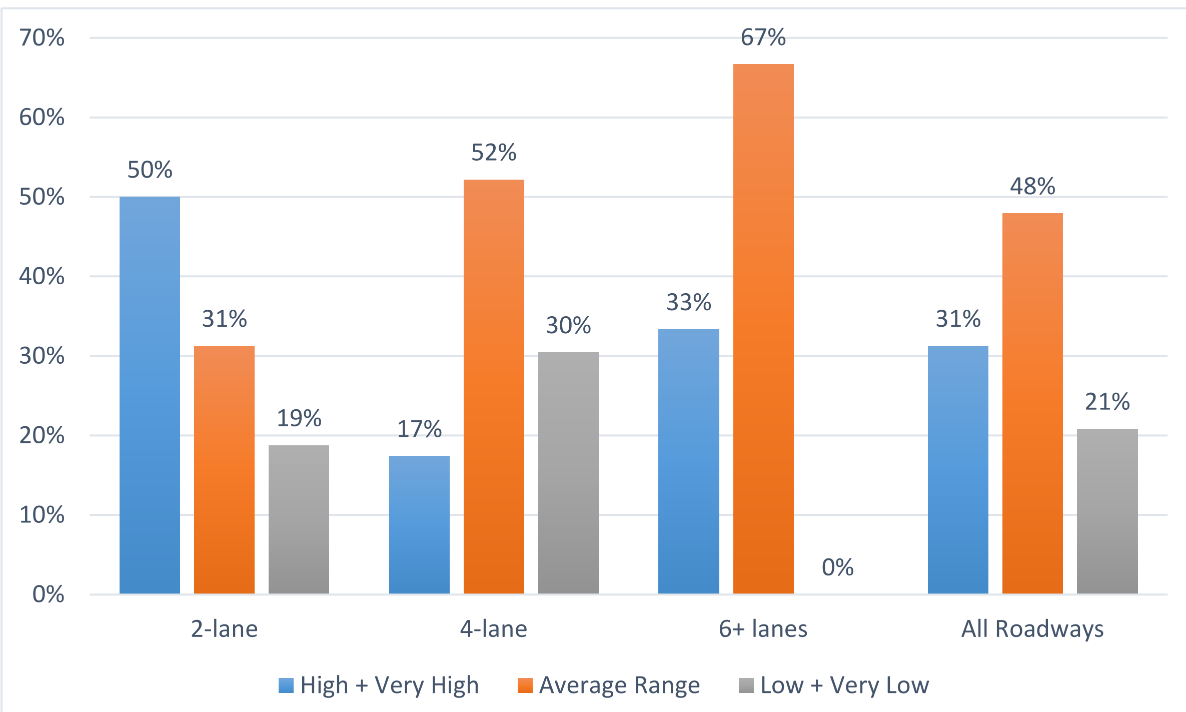

Figure 7. Cost Range Distribution by Number of Lanes

The sample pool included 16 projects constructed on two-lane roadways, 23 projects constructed on four-lane roadways and nine projects constructed on roadways with six or more lanes. Interestingly, the analysis showed that the most significant cost variation is associated with two-lane roadways (see Table 8 and Figure 6). Forty-four percent of construction projects involving two-lane roads had project costs per lane-mile more than 30 percent above the regional mean. This is consistent with the findings related to roadway classification which showed that roadway construction projects on minor arterials tended to be more expensive. Minor arterials generally have fewer lanes and, in fact, seven of the ten minor arterials where projects were constructed also had a two-lane cross-section.

There does not appear to be evidence to support the conclusion that roadways with a greater number of lanes involve more expensive capital construction projects. To the contrary, the average cost per lane-mile for projects on roadways with four or more lanes were more likely to be in the average range or lower cost when compared to the project pool as a whole. Similarly, the presence of shoulders does not appear to increase the likelihood that projects will be more expensive (see Table 9). Once again, there is evidence that the opposite is true. Projects on roadways without shoulders were more likely to have per lane-mile project costs more than 30 percent above the regional mean. It should be noted however that the vast majority (83 percent) of the projects analyzed as part of this study were constructed on roadways with shoulders. This makes drawing conclusions from the analysis somewhat difficult.

Table 9 – Cost Variation by Presence of Shoulders

	Number of Projects in Each Category					
	No Shoulders		With Shoulders		All Roadways	
	No.	%	No.	%	No.	%
Very High Cost	4	50%	9	23%	13	27%
High Cost	0	0%	2	5%	2	4%
High Average Cost	1	13%	7	18%	8	17%
Average Cost	1	13%	6	15%	7	15%
Low Average Cost	1	13%	7	18%	8	17%
Low Cost	1	13%	7	18%	8	17%
Very Low Cost	0	0%	2	5%	2	4%
Total	8		40		48	
High + Very High		50%		28%		31%
Average Range		38%		50%		48%
Low + Very Low		13%		23%		21%

Finally, the research team investigated whether costs varied if roadways were divided or not. The analysis indicated that there is an apparent relationship between project cost and whether the roadway is divided. It does not appear to matter if the division is a concrete barrier or median strip. As shown in Table 10, projects constructed on undivided roadways had average per lane mile costs above the average range when compared to the regional mean project cost.

Table 10 – Cost Variation by Presence of Median/Barrier

	Number of Projects in Each Category							
	Concrete Barrier		Median		No Barrier or Median		All Roadways	
	No.	%	No.	%	No.	%	No.	%
Very High Cost	3	21%	3	23%	7	33%	13	27%
High Cost	1	7%	0	0%	1	5%	2	4%
High Average Cost	1	7%	1	8%	6	29%	8	17%
Average Cost	3	21%	1	8%	3	14%	7	15%
Low Average Cost	4	29%	4	31%	0	0%	8	17%
Low Cost	2	14%	3	23%	3	14%	8	17%
Very Low Cost	0	0%	1	8%	1	5%	2	4%
Total	14		13		21		48	
High + Very High		29%		23%		38%		31%
Average Range		57%		46%		43%		48%
Low + Very Low		14%		31%		19%		21%

Cost Variation based on Roadway Traffic Volume

In addition to roadway classification, the research team also analyzed project costs in the context of AADT. For the purpose of this study, the following criteria were used to categorize the traffic volume classification of roadways based on AADT.

Roadway Classification	AADT
Very Low Volume	less than 2,000
Low Volume	2,001-10,000
Moderate Volume	10,001-40,000
High Volume	40,001-80,0000
Very High Volume	more than 80,000

The analysis demonstrated some relationship between roadway volume and project cost (see Table 11 and Figure 8). Half of all projects constructed on very high-volume roadways had project costs that were more than 30 percent above the regional mean. This finding is consistent with the input received from NJDOT subject matter experts and intuitively logical given the complexity of traffic management on very high-volume roadways as well as the fact that construction activities on high-volume roadways are very often staged at night when traffic volumes tend to be lower. Night-time construction activities are thought to have higher labor costs.

Table 11 – Cost Variation by Roadway Traffic Volume (AADT)

	Number of Projects in Each Category									
	Low Volume		Moderate Volume		High Volume		Very High Volume		All Roadways Types	
	No.	%	No.	%	No.	%	No.	%	No.	%
Very High Cost	4	44%	5	19%	2	22%	2	50%	13	27%
High Cost	0	0%	1	4%	1	11%	0	0%	2	4%
High Average Cost	2	22%	5	19%	1	11%	0	0%	8	17%
Average Cost	0	0%	5	19%	1	11%	1	25%	7	15%
Low Average Cost	0	0%	5	19%	3	33%	0	0%	8	17%
Low Cost	3	33%	3	12%	1	11%	1	25%	8	17%
Very Low Cost	0	0%	2	8%	0	0%	0	0%	2	4%
Total	9		26		9		4		48	
High + Very High		44%		23%		33%		50%		31%
Average Range		22%		58%		56%		25%		48%
Low + Very Low		33%		19%		11%		25%		21%

Note: There were no sample projects on very low volume roadways

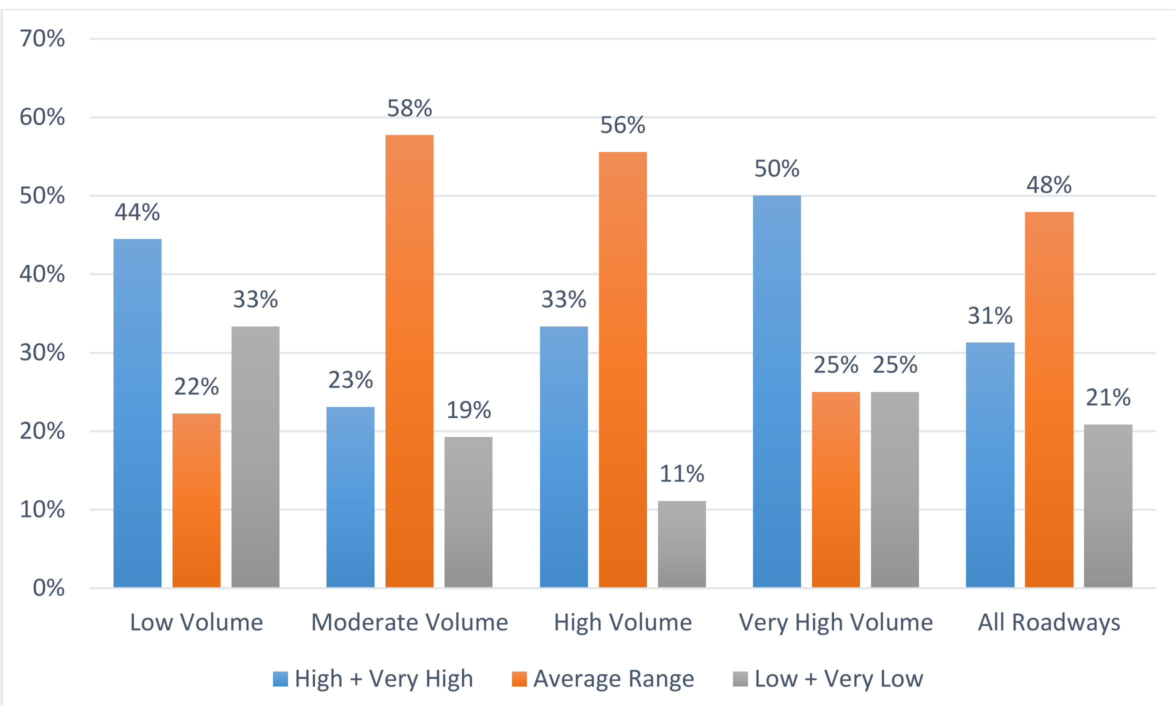

Figure 8. Cost Range Distribution by Roadway Traffic Volume (AADT)

Interestingly, average project cost per lane-mile was also higher on low-volume roadways. This is consistent with the findings related to roadway classification and cross-section which showed that roadway construction projects on minor arterials, two-lane roads and undivided roadways tended to be more expensive. As one might expect, minor arterials and two-lane roadways generally have lower volumes of daily traffic. In fact, six of the ten minor arterials where sample pool projects were constructed were also classified as low-volume roadways; and eight out of nine low-volume roadways where projects were constructed were undivided.

Variation in Project Cost based on Project Characteristics

Some NJDOT subject matter experts expressed the opinion that project characteristics such as the overall length of the project, project duration, and involvement of ramps, bridges and culverts, which can make projects more complex, may affect project costs. Project duration appears to have a marginal effect on overall project cost. As shown in Table 12, projects that are longer duration (more than 18 months) were somewhat more likely to have higher average project costs per lane-mile than shorter duration projects.

Table 12 – Cost Variation by Duration of Project

	Number of Projects in Each Category					
	Short Duration		Long Duration		All Roadways	
	No.	%	No.	%	No.	%
Very High Cost	4	20%	9	32%	13	27%
High Cost	1	5%	1	4%	2	4%
High Average Cost	2	10%	6	21%	8	17%
Average Cost	3	15%	4	14%	7	15%
Low Average Cost	5	25%	3	11%	8	17%
Low Cost	4	20%	4	14%	8	17%
Very Low Cost	1	5%	1	4%	2	4%
Total	20		28		48	
High + Very High		25%		36%		31%
Average Range		50%		46%		48%
Low + Very Low		25%		18%		21%

There appears to be a strong relationship between project length and project cost. As shown in Table 13 and Figure 9, longer projects were much more likely to be low- or very low-cost when average per lane-mile project costs were compared to regional mean project costs. In fact, a full 50 percent of projects six or more miles in length were below average cost. This compares to 21 percent statewide for all projects. Projects that were less than six miles long tended to be higher cost.

Table 13 – Cost Variation by Project Length

	Number of Projects in Each Category							
	0-3 Miles		3.1-5.9 Miles		6 + miles		All Roadways	
	No.	%	No.	%	No.	%	No.	%
Very High Cost	4	31%	7	33%	2	14%	13	27%
High Cost	1	8%	1	5%	0	0%	2	4%
High Average Cost	3	23%	3	14%	2	14%	8	17%
Average Cost	3	23%	3	14%	1	7%	7	15%
Low Average Cost	2	15%	4	19%	2	14%	8	17%
Low Cost	0	0%	3	14%	5	36%	8	17%
Very Low Cost	0	0%	0	0%	2	14%	2	4%
Total	13		21		14		48	
High + Very High		38%		38%		14%		31%
Average Range		62%		48%		36%		48%
Low + Very Low		0%		14%		50%		21%

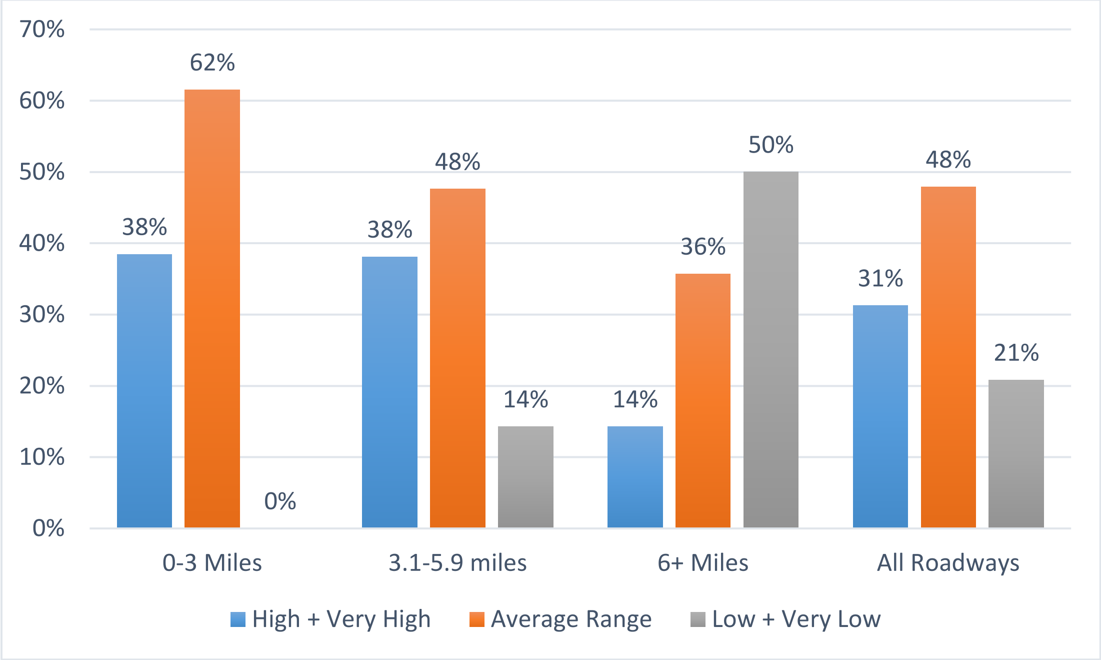

Figure 9. Cost Range Distribution by Project Length

Finally, it does not appear that projects that involve structures such as ramps and bridges are significantly more costly. Table 14 shows cost variation among projects based on whether or not the project limits included interchange ramps and how many bridges were located on the roadway within the limits of the project. As shown in the table, projects constructed on roadways with ramps are marginally more likely to cost more. Similarly, projects that have two or more bridges located on the roadways within the limits of the project are somewhat more likely to have project costs higher than the average range. It should be noted that in some cases the project analyzed included minor repairs to bridge decks, but none of the projects in the project pool included significant bridge work.

Table 14 – Cost Variation by Presence of Ramps and Bridges

	Number of Projects in Each Category									
	Ramps		No Ramps		0-1 Bridges		2+ Bridges		All Roadways	
	No.	%	No.	%	No.	%	No.	%	No.	%
Very High Cost	3	18%	10	32%	5	23%	8	36%	13	27%
High Cost	1	6%	1	3%	2	9%	0	0%	2	4%
High Average Cost	5	29%	3	10%	4	18%	4	18%	8	17%
Average Cost	1	6%	6	19%	4	18%	3	14%	7	15%
Low Average Cost	4	24%	4	13%	5	23%	3	14%	8	17%
Low Cost	2	12%	6	19%	2	9%	6	27%	8	17%
Very Low Cost	1	6%	1	3%	0	0%	2	6%	2	4%
Total	17		31		22		26		48	
High + Very High		24%		35%		32%		36%		31%
Average Range		59%		42%		59%		45%		48%
Low + Very Low		18%		23%		9%		34%		21%

Variation in Project Cost based on Construction Project Components

The final analysis conducted for this study involved a qualitative examination of construction project components such as construction materials used; inclusion of temporary and permanent traffic control and safety elements; roadway markings; sidewalks and curbs, including islands; inclusion of permanent barriers such as guard rails and crash cushions; inclusion of electric and lighting systems; erosion control methods and equipment used, inclusion of utility and drainage elements, inclusion of complete streets elements, ADA elements, inclusion of lighting and traffic signal components; and inclusion of landscaping and streetscape components. For this analysis the research team assembled information from project bid sheets and compared the components included for higher cost projects to those included for average range and lower cost projects to determine what, if any, patterns emerged.

Given the extensive nature of information contained on the project bid sheets and the unique characteristics of each project in terms of detail, it was challenging to discern any clear patterns. With that said, a couple of observations can be made:

- **There are many basic construction components that were common to virtually all of the projects analyzed**. Examples include but are not limited to: performance bonds; insurance; and traffic control equipment such as breakaway barriers, drums traffic cones, construction signs, variable message boards, temporary traffic striping and others. Many projects also included traffic directors, flaggers and the like. Virtually all the projects in the sample pool included milling of pavement, hot mix asphalt repair tack coat, hot mix asphalt 12.5 M 64 surface course, and HMA patch. Many, but not all projects, included a hot mix asphalt base course as well. Most projects included permanent traffic striping and raised pavement markers, and depending on the nature of the roadway, many included rumble strips. Most, but not all, projects included at least some length of concrete sidewalks and curbs.

- **Project costs add up**. As one might expect, projects that include a greater number of components cost more. For example, while there were a couple of exceptions, projects that included traffic signal repair and replacement were consistently in the high average-, high- and very high-cost range. Typical traffic signal components included foundation, meter cabinets, traffic signal standards, mast arms, cable, and signal heads. Many of the projects in the very high-cost range also included temporary traffic signal systems. Some less common components that also contributed to higher project cost include drainage pipe clean-out, having to reconstruct/repair drainage inlets and pipes, more extensive landscaping and tree trimming/removal; and the inclusion of guide rail and crash cushion components.

Other than these intuitive observations, no clear pattern emerged from the analysis.

Analysis of Special Case Project

As noted above, three projects were reviewed but were treated as special cases. These projects are briefly discussed below.

- **Route 46 from Main Street to Frederick Place (North Region).** This project included safety improvements, widening of Route 46 and signalized intersection upgrades involving 2.7 lane miles of roadway. Given the nature of this project, it involved significant pre-construction activity and costs that added dramatically to the per lane-mile cost of the project. Pre-construction activities and costs included:

Final Design	$2,014,567
Utility Relocation	$1,079,199
Right-of-Way Acquisition	$5,374,919
Total Pre-Construction Costs	$8,468,685

The cost of constructing this project was $8,570,608. The construction project included extensive traffic signal work, drainage, electrical and other utility work. The total per lane-mile cost of constructing this project was approximately $6.3 million per lane-mile.

- **Route 80 EB resurfacing from MP 45.6 to 53 (North Region).** This project included resurfacing approximately 34.3 lane miles of roadway as well as removal of substandard guardrails and installation of a new berm area to restore drainage. This project also involved $925,397 in final design costs that added significantly to overall project cost. The combined pre-construction and construction cost of this project was $14,208,467, which works out to $414,241 per lane mile, approximately two times the North Region mean cost per lane-mile, but as detailed in the next section, still within the range of costs estimated in other states for similar projects. The project included 8-inch thick, dense graded aggregate base course, temporary crash cushions, grading, top soil, and drainage work.

- **Route 45 from Carpenter Street to Red Bank (Central Region).** This project included cross-section changes and associated streetscape improvements involving approximately 4.2 lane miles of roadway. Pre-construction activities and costs included:

Final Design	$119,669
Utility Relocation	$275,875
Total Pre-Construction Costs	$395,544

Total construction cost for this project was $1,927,236. Combined costs totaled $2,322,780, which works out to $553,042 per lane-mile. This was almost three times the Central Region mean cost per lane-mile, but again as shown in the next section, within the range of project constructed in other States. Construction included extensive traffic signal work, significant sidewalk construction or reconstruction, installation of concrete paver crosswalks, concrete driveway aprons, and use of interim traffic signals.

BENCHMARKING NEW JERSEY COSTS AGAINST THOSE OF OTHER STATES

Although detailed data on specific project costs in nearby states could not be obtained for this study, the literature on accurately estimating construction costs for capital project budgeting purposes and several studies conducted by other state DOTs provide useful points of reference for this study’s findings. In particular, the Federal Highway Administration’s Highway Investment Analysis Methodology, a tool used by State DOTs to estimate the cost of various types of highway construction projects, can be used to benchmark New Jersey costs against a nationally published resource.

The Highway Investment Analysis Methodology utilizes a representative project sample of construction projects completed in six states to develop a typical project cost matrix that presents cost per-lane mile estimates for different types of roadway construction projects. Cost per lane-mile estimates are derived from modeling highway resurfacing and reconstruction and highway and bridge capacity expansion projects using the Highway Economic Requirements System (HERS). The cost matrix differentiates between construction projects on different types of rural roads in various terrains from those constructed in more urbanized areas. Project types in urban areas are broken down by population area size and type of highway.

According to the methodology, the costs presented in the tables "are intended to reflect the typical values for these types of projects…and thus do not reflect the large variation in cost among projects of the same type that is evident in the project-level data on which the typical values are based." The authors attribute the variation to location-specific factors. Among other factors that could make costs unusually high are complicated interchanges, major environmental issues, and other extreme engineering issues." [(4)]

As shown in Tables 15 and 16, the FHWA HERS analysis estimates that the typical cost to resurface an existing lane or roadway in a rural setting ranges from $247,000 per lane mile for a Minor Arterial in flat terrain to $457,000 for an Interstate Highway in mountainous terrain. The typical cost to resurface an existing lane of roadway in an urban setting ranges from $252,000 for a Minor Arterial/Collector in a small urban area to as much as $1.078 million for a Freeway/Expressway/Interstate in a major urbanized area.

In addition to the estimates published by FHWA, several State DOT's have completed studies designed to help project engineers estimate per lane-mile costs for roadway construction projects. West Virginia Division of Highways (WVDOH) estimates the cost for resurfacing a single 12-foot wide travel lane to be $125,000, or about half the FHWA estimate. The WVDOH estimate assumes a typical two-inch pavement overlay with associated milling of the existing deteriorated pavement surface[(5)]. New Jersey projects typically include pavement milling and overlays that exceed two inches.

The Maine Department of Transportation estimates the average cost per-lane mile for a typical resurfacing project to be $135,000 to $430,000 depending on project details[(6)]. Guidance from the Ohio Department of Transportation references paving costs per lane-mile ranging from $120,000 for two-lane roads to $502,000 for four-lane roads. The Ohio DOT guidance notes that these estimates do not include "…other appurtenances such as lighting, pavement markings, guard rails, and noise walls." [(7)] As described in the previous sections, many of the NJDOT projects analyzed for this study included pavement markings, lighting, guide rails, traffic signals and other items, that increased the cost per lane-mile estimates.

Finally, a study conducted by the California Department of Transportation analyzed pavement management expenditures for Fiscal Years 2010 through 2014. Project spending data was used to calculate costs per lane-mile for capital pavement and rehabilitation projects during those years. The study found that cost ranged from $276,529 to $747,787 per lane-mile, on average, for projects on the state highway system(8). The lower range estimate was for typical capital pavement maintenance projects such as resurfacing, while the higher range estimate was for projects involving more extensive pavement reconstruction.

Table 15 – Typical Costs per Lane Mile for Rural Roadways Assumed in HERS by Type of Improvement

Category	Typical Costs (Thousands of 2012 Dollars per Lane Mile)								
	Reconstruct and Widen Lane	Reconstruct Existing Lane	Resurface and Widen Lane	Resurface Existing Lane	Improve Shoulder	Add Lane, Normal Cost	Add Lane, Equivalent, High Cost	New Alignment, Normal Cost	New Alignment, High Cost
Rural Roadways									
Interstate									
Flat	$1,496	$977	$847	$347	$65	$1,923	$2,666	$2,666	$2,666
Rolling	$1,677	$1,003	$975	$370	$106	$2,085	$3,374	$3,374	$3,374
Mountainous	$3,180	$2,195	$1,615	$547	$223	$6,492	$7,600	$7,600	$7,600
Other Principal Arterial									
Flat	$1,169	$782	$706	$279	$43	$1,541	$2,205	$2,205	$2,205
Rolling	$1,319	$804	$803	$310	$72	$1,650	$2,662	$2,662	$2,662
Mountainous	$2,562	$1,810	$1,556	$438	$95	$5,824	$6,706	$6,706	$6,706
Minor Arterial									
Flat	$1,069	$687	$658	$247	$41	$1,400	$1,966	$1,966	$1,966
Rolling	$1,290	$761	$819	$266	$75	$1,605	$2,532	$2,532	$2,532
Mountainous	$2,143	$1,405	$1,556	$365	$168	$4,916	$5,900	$5,900	$5,900
Major Collector									
Flat	$1,125	$728	$680	$252	$52	$1,455	$1,965	$1,965	$1,965
Rolling	$1,232	$739	$765	$267	$70	$1,486	$2,418	$2,418	$2,418
Mountainous	$1,869	$1,157	$1,113	$365	$108	$3,147	$4,111	$4,111	$4,111

Source: Highway Economic Requirements System. U.S. Department of Transportation, Federal Highway Administration, Office of Policy and Government Affairs. Highway Investment Analysis Methodology, Appendix A. 2015. Accessed online: https://www.fhwa.dot.gov/policy/2015cpr/appendixa.cfm

Notes: 1) The values shown in the table for adding a lane at "Normal Cost" reflect costs of projects for which sufficient right-of-way is available or readily obtained to accommodate additional lanes. The values for adding lane equivalents at "High Cost" are intended to reflect situations in which conventional widening is infeasible and alternative approaches are required to add capacity to a given corridor. Such alternatives include the construction of parallel facilities, double decking, tunneling, or the purchase of extremely expensive right-of-way. HERS models these lane equivalents as though they are part of existing highways, but some of this capacity could be from new highways or other modes of transportation.

Table 16 – Typical Costs per Lane Mile for Urban Roadways Assumed in HERS by Type of Improvement

Category	Typical Costs (Thousands of 2012 Dollars per Lane Mile)								
	Reconstruct and Widen Lane	Reconstruct Existing Lane	Resurface and Widen Lane	Resurface Existing Lane	Improve Shoulder	Add Lane, Normal Cost	Add Lane Equivalent, High Cost	New Alignment, Normal Cost	New Alignment, High Cost
Urban Roadways									
Freeway/Expressway/Interstate									
Small Urban	$2,440	$1,690	$1,923	$410	$75	$3,061	$10,022	$4,126	$14,085
Small Urbanized	$2,623	$1,704	$1,989	$485	$99	$3,345	$10,991	$5,562	$18,986
Large Urbanized	$4,184	$2,790	$3,081	$651	$376	$5,598	$18,777	$8,158	$27,849
Major Urbanized	$8,368	$5,580	$5,979	$1,078	$752	$11,197	$46,691	$16,315	$62,414
Other Principal Arterial									
Small Urban	$2,127	$1,436	$1,760	$344	$76	$2,602	$8,500	$3,253	$11,102
Small Urbanized	$2,275	$1,453	$1,840	$406	$102	$2,819	$9,244	$4,013	$13,698
Large Urbanized	$3,251	$2,129	$2,692	$511	$328	$4,126	$13,786	$5,509	$18,804
Major Urbanized	$6,501	$4,259	$5,384	$825	$656	$8,252	$31,988	$11,018	$47,693
Minor Arterial/Collector									
Small Urban	$1,567	$1,084	$1,331	$252	$55	$1,922	$6,225	$2,347	$8,011
Small Urbanized	$1,642	$1,097	$1,343	$286	$68	$2,025	$6,580	$2,880	$9,830
Large Urbanized	$2,210	$1,466	$1,837	$351	$184	$2,807	$9,321	$3,748	$12,792
Major Urbanized	$4,421	$2,932	$2,779	$585	$368	$5,614	$31,988	$7,496	$39,585

Source: Highway Economic Requirements System. U.S. Department of Transportation, Federal Highway Administration, Office of Policy and Government Affairs. Highway Investment Analysis Methodology, Appendix A. 2015. Accessed online: https://www.fhwa.dot.gov/policy/2015cpr/appendixa.cfm

Notes: 1) The values shown in the table for adding a lane at "Normal Cost" reflect costs of projects for which sufficient right-of-way is available or readily obtained to accommodate additional lanes. The values for adding lane equivalents at "High Cost" are intended to reflect situations in which conventional widening is infeasible and alternative approaches are required to add capacity to a given corridor. Such alternatives include the construction of parallel facilities, double decking, tunneling, or the purchase of extremely expensive right-of-way. HERS models these lane equivalents as though they are part of existing highways, but some of this capacity could be from new highways or other modes of transportation; 2) Four population groupings are used: small urban (populations of 5,000 to 49,999), small urbanized (populations of 50,000 to 200,000), large urbanized (populations of more than 200,000); and major urbanized areas (populations of more than 1 million).

SUMMARY RESULTS, DISCUSSION AND RECOMMENDATIONS

The vast majority of capital projects undertaken and completed by NJDOT in Fiscal Years 2013 through 2016 were preventive maintenance or 3R projects that involved, resurfacing, rehabilitation or reconstruction of existing pavement. The statewide average total project cost per lane-mile, including pre-construction costs for NJDOT capital projects completed during the four-year analysis period was $191,175. Overall, there was notable variation in total project cost among the projects in the sample pool, including across NJDOT regions.

Projects constructed in the South Region averaged $156,398 per lane-mile. North Region projects averaged $204,131 per lane-mile; and projects constructed in the Central Region averaged $196,459. As shown in Table 17, New Jersey's cost structure falls squarely within the range of costs estimated by FHWA and other State DOTs for pavement resurfacing, rehabilitation and reconstruction projects.

Table 17 – Per Lane-Mile Project Cost Range Estimates for 3R Projects

Source	Low-Range	Mid-Range	High-Range
FHWA	$252,000	$665,000	$1.078 m
California	$276,529	$512,158	$747,787
Ohio	$120,000	$311,000	$502,000
Maine	$135,000	$282,500	$430,000
West Virginia	n/a	$125,000	n/a

Based on the analysis the following factors appear to be associated with project cost variation:

- ***Project funding source*** – Projects funded using State dollars appear to be on average less expensive than those funded using Federal funding.

- ***Roadway functional classification and cross-section*** – Project costs tend to be higher when associated with projects constructed on Interstate Highways and Other Freeways and Expressways and Minor Arterials. Construction projects involving two-lane roads were also more expensive. Projects on roadways with four or more lanes were more likely to be in the average range or lower cost when compared to the project pool as a whole. Projects on roadways without shoulders were more likely to have higher per lane-mile project costs.

- ***Roadway traffic volume*** – Half of all projects constructed on very high-volume roadways had project costs that were more than 30 percent above the regional mean. At the same time, average project cost per lane-mile were also higher on low-volume roadways.

- ***Project length*** – Longer projects were much more likely to be low or very low cost when compared to regional mean project costs. Projects that were less than six miles long tended to be higher cost.

- ***Project components*** – Projects that involved a greater number of elements such as traffic signal repair and replacement, temporary traffic signal systems, drainage components, more extensive landscaping and tree trimming/removal, and the inclusion of guide rail and crash cushion components are more likely to cost more.

One of the more compelling findings from this study is the fact that projects constructed on lower-order, less-trafficked, two-way undivided roadways consistently had per-lane mile costs higher than average. While the evidence regarding this relationship is strong, the underlying reasons why this is true are less clear. NJDOT should seek to understand this relationship in more detail by closely tracking costs over time, interviewing construction vendors, and revisiting the procurement process for this type of project to determine if bid specifications can be adjusted to reduce costs.

Also compelling is the finding that project length impacts cost positively. There appear to be beneficial economies of scale that play a role in reducing costs. Construction activities require significant mobilization efforts to get equipment in place, hire workers and stage the construction zone. These costs are similar for small and large projects, so there are benefits to advancing projects in a way that can make the most of mobilization efforts. NJDOT should examine how project limits are currently defined to determine if there are opportunities to expand the length of projects to increase the total lane-miles of pavement addressed in each project. This can optimize the value received from construction mobilization efforts under each contract.

In addition to the above, FHWA offers a range of highway construction and maintenance cost control ideas on it’s website. These recommended practices were developed by the Texas DOT’s Cost Control Task Force. Recommendations address pavement maintenance and preservation, pavement design considerations, use of alternative materials in construction projects, pavement markings standards and ways to increase completion in the contract bidding process[1]. NJDOT should work with its research partners and vendors to determine which, if any of these or other recommended leading practices related to 3R projects are not currently being used but could be adopted to reduce the cost of capital construction projects in New Jersey.

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