

Implementation Plan



**M-0446 Ramp Metering Feasibility Study
for Durham and Wake Counties**

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Introduction

This report details the work involved in formulating strategies for the implementation of ramp metering within the study area.

The principles used in formulating strategy options rely on first calculating benefit-to-cost ratios (BCR) for each site, and then establishing those sites that are financially viable. These financially viable sites will be compared to a list of currently planned State Transportation Implementation Plan (STIP) and Mobility Fund projects, to ensure that a conflict does not limit the ability of a particular site to deliver a benefit.

The information for the potential costs of each site originates from Task 8 – Typical Cost Estimates. That task identified typical ramp metering cost estimates for various layouts, alternatives, and optional features, and documented the assumptions and unit costs used. The typical costs were then used to produce a cost estimate for each site. Program costs, including procurement and integration of the control software and the controller firmware, were also estimated.

The information for the potential benefits of each site originates from Task 9 – Performance Measures. That task established the expected benefits for each of the 21 sites recognized as being suitable for ramp metering, as shown in Figure 1 on the following page. Potential benefits are quantified as a value of time saved, through the reduction of vehicle hours delay (VHD) annually in each location because of the introduction of ramp metering.

This report contains the following sections:

- Recommended Improvements
- Estimated Costs
- Estimated Delay Benefits
- Cost-Benefit Analysis for Individual Sites
- STIP Projects and Freeway-to-Freeway (F2F) Sites
- Strategies for Implementation
- Summary and Recommendations

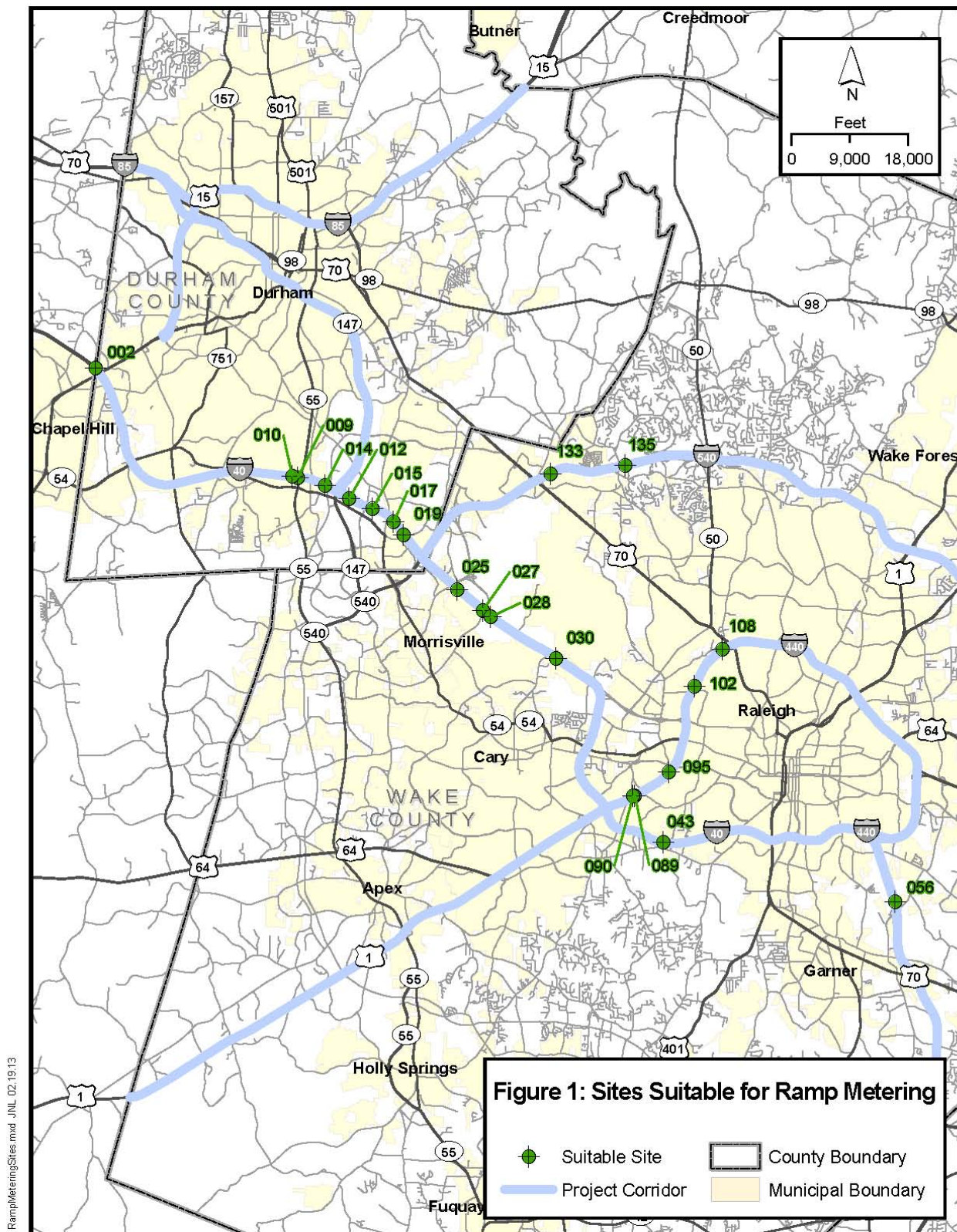


Figure 1: Sites Suitable for Ramp Metering

1. Recommended Improvements

Table 1 presents the recommended ramp meter improvements for each of the 21 sites, based on traffic congestion and the geometric conditions. The recommended improvement includes ramp meter equipment, signing, pavement markings, drainage improvements, guardrail, roadway resurfacing or widening, and related earthwork. Details of the assumptions for each site are included in Appendix A.

Table 1: Recommended Ramp Meter Configurations

Log	Freeway	Cross Street	Exit	Direction	Ramp Meter Configuration
002	I-40	US-15 / US-501	270	WB	Single Lane
009	I-40	NC-55 / Apex Hwy	278	EB	Single Lane Loop
010	I-40	NC-55 / Apex Hwy	278	WB	Single Lane
012*	I-40	NC-147 / Durham Fwy	279	EB-M2 (SB to EB)	Single Lane F2F
014*	I-40	NC-147 / Durham Fwy	279	WB-M2 (SB to WB)	Single Lane F2F
015	I-40	Davis Dr	280	EB	Two Lane
017	I-40	S Miami Blvd	281	EB	Single Lane
019	I-40	Page Rd	282	EB	Two Lane Loop
025	I-40	SR 3015 - Airport Blvd	284	EB	Single Lane
027	I-40	SR 1002 - Aviation Pkwy	285	EB-M1 (SB to EB)	Single Lane Loop
028	I-40	SR 1002 - Aviation Pkwy	285	EB-M2 (NB to EB)	Single Lane
030	I-40	SR 1652 - N Harrison Ave	287	EB	Single Lane
043	I-40	SR 1571 - Gorman St	295	WB	Single Lane
056	I-40	SR 5220 - Jones Sausage Rd	303	WB	Single Lane
089	I-440	SR 1319 - Jones Franklin Rd	1C	NB	Single Lane
090	I-440	SR 1319 - Jones Franklin Rd	1C	SB	Single Lane Loop
095	I-440	SR 1012 - Western Blvd	2	SB-M2 (EB to SB)	Single Lane
102	I-440	Lake Boone Trail	5	NB	Single Lane
108	I-440	US-70 / NC-50 / Glenwood Ave	7	WB-M2 (SB to WB)	Single Lane
133*	I-540	US-70	4	EB	Two Lane F2F
135	I-540	SR 1829 - Leesville Rd	7	EB	Single Lane

* Freeway-to-Freeway site

For Sites 015 and 019 the ramp meter would be two lanes and would include some ramp widening.

2. Estimated Costs

Three types of costs can be associated with the implementation and operation of a ramp metering site:

- Implementation cost
- Annual maintenance and operations cost
- Program cost

More information on how the estimated costs were derived can be found in Task 8 – Typical Cost Estimates Report, which breaks each cost into its component parts and describes how they were calculated.

2.1. Estimated Implementation Cost

The implementation cost estimate is a dependent variable, based on the site requirements. This estimate includes the installed cost of equipment, its design, and construction administration. Construction includes ramp meter equipment, signing, pavement markings, drainage improvements, guardrail, roadway resurfacing or widening, and related earthwork. The prorated cost of the controller firmware is also included in the site-specific costs. The estimated implementation cost for each site is shown in Table 2, and details for each site can be found in Appendix A.

Table 2: Estimated Implementation Costs for Each Site

Log	Free-way	Cross Street	Exit	Direction	Implementa-tion Cost
002	I-40	US-15 / US-501	270	WB	\$105,000
009	I-40	NC-55 / Apex Hwy	278	EB	\$105,000
010	I-40	NC-55 / Apex Hwy	278	WB	\$107,000
012*	I-40	NC-147 / Durham Fwy	279	EB-M2 (SB to EB)	\$574,000
014*	I-40	NC-147 / Durham Fwy	279	WB-M2 (SB to WB)	\$331,000
015	I-40	Davis Dr	280	EB	\$284,000
017	I-40	S Miami Blvd	281	EB	\$107,000
019	I-40	Page Rd	282	EB	\$195,000
025	I-40	SR 3015 - Airport Blvd	284	EB	\$113,000
027	I-40	SR 1002 - Aviation Pkwy	285	EB-M1 (SB to EB)	\$103,000
028	I-40	SR 1002 - Aviation Pkwy	285	EB-M2 (NB to EB)	\$113,000
030	I-40	SR 1652 - N Harrison Ave	287	EB	\$106,000
043	I-40	SR 1571 - Gorman St	295	WB	\$113,000
056	I-40	SR 5220 - Jones Sausage Rd	303	WB	\$113,000

Log	Free-way	Cross Street	Exit	Direction	Implementa-tion Cost
089	I-440	SR 1319 - Jones Franklin Rd	1C	NB	\$112,000
090	I-440	SR 1319 - Jones Franklin Rd	1C	SB	\$101,000
095	I-440	SR 1012 - Western Blvd	2	SB-M2 (EB to SB)	\$116,000
102	I-440	Lake Boone Trail	5	NB	\$107,000
108	I-440	US-70 / NC-50 / Glenwood Ave	7	WB-M2 (SB to WB)	\$101,000
133*	I-540	US-70	4	EB	\$405,000
135	I-540	SR 1829 - Leesville Rd	7	EB	\$109,000

* Freeway-to-Freeway site

2.2. Estimated Annual Cost

The estimated annual cost for each site includes maintenance, operations, and annual software support, and has been calculated as \$7,491 per site.

2.3. Estimated Equipment Replacement Cost

Typically, certain equipment would be replaced when its useful life has been reached. Types of equipment include controllers, servers, communications hardware, technology, and LED signal heads. Since the replacement period is typically 10 years, replacement costs do not need to be considered and have not been included in this analysis.

2.4. Estimated Program Cost

The estimated program cost is a fixed cost. It includes the procurement and integration of the control software, software drivers, training, servers, and miscellaneous central communications hardware. This is a one-time cost when implementing ramp metering for the first time. The cost remains the same and is not related to the number of sites being implemented. The program cost has been estimated at \$404,998 which will be divided proportionately among each group of sites considered in the Strategies for Implementation section.

2.5. Basis of Costs

During this task, costs have been expressed in 2012 prices. The estimated costs have not been discounted to a base year, nor subjected to anticipated inflation.

3. Estimated Delay Benefits

The benefits used are based on the value of time potentially saved through the introduction of a ramp metering site. These benefits are quantified in financial terms based on a 20 percent savings in delay time as presented in the Performance Measures Report. Annual benefits can be calculated as follows:

$$\text{Annual benefits} = \text{Annual vehicle delay} \times \text{Percentage reduction} \times \text{Weighted cost per hour of delay}$$

$$\text{Weighted cost per hour of vehicle delay} = \% \text{ passenger vehicles} \times \text{passenger cost per hour of vehicle delay} + \% \text{ trucks vehicles} \times \text{truck cost per hour of delay}$$

The expected annual benefit for each site is shown in Table 3.

Additional information on how benefits have been derived can be found in Task 9 – Performance Measures Report, which describes the process of how the benefits were calculated for each site.

Although the analysis uses only travel time benefits, other benefits will accrue (e.g., crash, emissions, and travel time reliability). These have not been quantified—the complexity and variability of such analysis and the contract time limitations did not permit us to expand on these benefits.

Table 3: Annual Financial Benefit of Ramp Metering for Each Site

Log	Free-way	Cross Street	Exit	Direction	Annual Benefit
002	I-40	US-15 / US-501	270	WB	\$51,635
009	I-40	NC-55 / Apex Hwy	278	EB	\$115,973
010	I-40	NC-55 / Apex Hwy	278	WB	\$130,436
012*	I-40	NC-147 / Durham Fwy	279	EB-M2 (SB to EB)	\$100,713
014*	I-40	NC-147 / Durham Fwy	279	WB-M2 (SB to WB)	\$156,859
015	I-40	Davis Dr	280	EB	\$153,237
017	I-40	S Miami Blvd	281	EB	\$367,370
019	I-40	Page Rd	282	EB	\$405,096
025	I-40	SR 3015 - Airport Blvd	284	EB	\$22,653
027	I-40	SR 1002 - Aviation Pkwy	285	EB-M1 (SB to EB)	\$71,480
028	I-40	SR 1002 - Aviation Pkwy	285	EB-M2 (NB to EB)	\$70,095
030	I-40	SR 1652 - N Harrison Ave	287	EB	\$145,506
043	I-40	SR 1571 - Gorman St	295	WB	\$125,664
056	I-40	SR 5220 - Jones Sausage Rd	303	WB	\$141,856

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Log	Free-way	Cross Street	Exit	Direction	Annual Benefit
089	I-440	SR 1319 - Jones Franklin Rd	1C	NB	\$22,170
090	I-440	SR 1319 - Jones Franklin Rd	1C	SB	\$27,183
095	I-440	SR 1012 - Western Blvd	2	SB-M2 (EB to SB)	\$227,845
102	I-440	Lake Boone Trail	5	NB	\$138,361
108	I-440	US-70 / NC-50 / Glenwood Ave	7	WB-M2 (SB to WB)	\$150,287
133*	I-540	US-70	4	EB	\$48,162
135	I-540	SR 1829 - Leesville Rd	7	EB	\$120,917

* Freeway-to-Freeway site

4. Cost-Benefit Analysis for Individual Sites

Cost-benefit ratios have been calculated for each of the potential ramp metering sites annually for periods of 5 and 10 years. This analysis uses the estimated costs described in Section 3, Estimated Costs, and the estimated delay benefits based on a 20 percent savings in delay outlined in Task 9 – Performance Measures.

The purpose of this analysis is to allow comparison of the relative economic conditions of each site. Therefore, only the costs directly associated with each individual site have been included (i.e., implementation cost and annual cost). The one-time program cost is a fixed cost for the first implementation in each area, so it will be added to the total costs for each scenario (see Section 7, Strategies for Implementation).

A benefit-cost ratio analysis is an established method to compare the cumulative benefits versus cumulative costs. If that ratio is greater than 1.0, then the project has positive net benefits over the analysis period. For purposes of this analysis, the program cost of \$404,998 includes all the central software, training, integration, and hardware.

Benefit Cost Ratio = Cumulative Benefits / (Capital Cost Cumulative + Annual Cost + Prorated Share of Program Costs)

4.1. 5-Year and 10-Year Benefit-to-Cost Ratios

The period of time used for economic analysis normally should be the period of the useful lifetime of the assets included for the options under consideration. Therefore, the recommended period for the main benefit-cost analysis is 10 years. The 10-year analysis will determine if additional sites will be financially feasible in the second 5 years, if they were not in the first 5 years. This gives the opportunity to review the site after 10 years and decide if the investment is worthwhile to continue.

A second analysis period of 5 years has been used. This confirms to NCDOT normal practice for calculating benefit-cost of this type of project. If a site “pays back” within 5 years, then it should also be economically suitable for implementation.

The difference between the 5- and 10-year costs is the additional 5 years of annual maintenance costs and an extra 5 years of benefits.

4.1.1. 5-Year Benefit-Cost Results

Table 4 shows the expected cost and benefit of each site for 5 years. These are listed in descending order of the BCR.

The 5-year BCRs of the 21 sites considered suitable for ramp metering range from 12.72 to 0.54. The total 5-year BCR of all 21 sites is 3.24.

16 of the sites have a 5-year BCR of greater than a ratio of 1.0, i.e., offering payback within the first 5 years of implementation.

Table 4: Benefit-Cost Analysis over 5-Year Period for Each Site

Log	Freeway	Cross Street	Exit	Direction	5 Year Total Cost	5 Year Total Benefit	5 Year BCR
017	I-40	S Miami Blvd	281	EB	\$144,455	\$1,836,848	12.72
019	I-40	Page Rd	282	EB	\$232,455	\$2,025,478	8.71
095	I-440	SR 1012 - Western Blvd	2	SB-M2 (EB to SB)	\$153,455	\$1,139,223	7.42
108	I-440	US-70 / NC-50 / Glenwood	7	WB-M2 (SB to WB)	\$138,455	\$751,436	5.43
030	I-40	SR 1652 - N Harrison Ave	287	EB	\$143,455	\$727,529	5.07
102	I-440	Lake Boone Trail	5	NB	\$144,455	\$691,807	4.79
056	I-40	SR 5220 - Jones Sausage Rd	303	WB	\$150,455	\$709,280	4.71
010	I-40	NC-55 / Apex Hwy	278	WB	\$144,455	\$652,178	4.51
043	I-40	SR 1571 - Gorman St	295	WB	\$150,455	\$628,322	4.18
135	I-540	SR 1829 - Leesville Rd	7	EB	\$146,455	\$604,585	4.13
009	I-40	NC-55 / Apex Hwy	278	EB	\$142,455	\$579,864	4.07
027	I-40	SR 1002 - Aviation Pkwy	285	EB-M1 (SB to EB)	\$140,455	\$357,399	2.54
015	I-40	Davis Dr	280	EB	\$321,455	\$766,186	2.38
028	I-40	SR 1002 - Aviation Pkwy	285	EB-M2 (NB to EB)	\$150,455	\$350,476	2.33
014*	I-40	NC-147 / Durham Fwy	279	WB-M2 (SB to WB)	\$368,455	\$784,294	2.13
002	I-40	US-15 / US-501	270	WB	\$142,455	\$258,176	1.81
090	I-440	SR 1319 - Jones Franklin Rd	1C	SB	\$138,455	\$135,915	0.98
012*	I-40	NC-147 / Durham Fwy	279	EB-M2 (SB to EB)	\$611,455	\$503,565	0.82
025	I-40	SR 3015 - Airport Blvd	284	EB	\$150,455	\$113,266	0.75
089	I-440	SR 1319 - Jones Franklin Rd	1C	NB	\$149,455	\$110,849	0.74
133*	I-540	US-70	4	EB	\$442,455	\$240,811	0.54

* Freeway-to-Freeway site

4.1.2. 10-Year Benefit-Cost Results

Table 5 shows the expected cost and benefit of each site for 10 years.

The 10-year BCRs of the 21 sites considered suitable for ramp metering range from 20.20 to 1.00. The total 10-year BCR of all 21 sites is 5.48.

Twenty-one sites have a 10-year BCR of greater than 1.00, i.e., offering payback within the first 10 years of implementation.

4.2. First-Year Rate of Return

The first-year rate of return (FYRR) is a measure to determine if a site pays for itself in the first year of operation. This analysis ascertains the highest performing sites from a financial perspective. The FYRR is calculated as follows:

$$\text{FYRR} = (\text{Annual Benefits (1 year)} - \text{Capital Cost} + \text{Annual Cost (first year)}) / (\text{Capital Cost} + \text{Annual Cost (1 year)})$$

4.2.1. First-Year Rate of Return Results

Eleven sites have a positive FYRR, i.e., they pay for themselves within the first year of operation. These sites, which exhibit strong financial feasibility, are shown in Table 6.

4.3. Summary

These overall positive results offer confidence that the installation of ramp metering at the 21 sites should provide positive benefits; however, selecting a subset of the sites would increase the overall benefit.

Table 5: Benefit-Cost Analysis over 10-Year Period for Each Site

Log	Freeway	Cross Street	Exit	Direction	10 Year Total Cost	10 Year Total Benefit	10 Year BCR
017	I-40	S Miami Blvd	281	EB	\$181,910	\$3,673,695	20.20
019	I-40	Page Rd	282	EB	\$269,910	\$4,050,957	15.01
095	I-440	SR 1012 - Western Blvd	2	SB-M2 (EB to SB)	\$190,910	\$2,278,447	11.93
108	I-440	US-70 / NC-50 / Glenwood	7	WB-M2 (SB to WB)	\$175,910	\$1,502,872	8.54
030	I-40	SR 1652 - N Harrison Ave	287	EB	\$180,910	\$1,455,058	8.04
102	I-440	Lake Boone Trail	5	NB	\$181,910	\$1,383,614	7.61
056	I-40	SR 5220 - Jones Sausage Rd	303	WB	\$187,910	\$1,418,561	7.55
010	I-40	NC-55 / Apex Hwy	278	WB	\$181,910	\$1,304,356	7.17
043	I-40	SR 1571 - Gorman St	295	WB	\$187,910	\$1,256,645	6.69
135	I-540	SR 1829 - Leesville Rd	7	EB	\$183,910	\$1,209,170	6.57
009	I-40	NC-55 / Apex Hwy	278	EB	\$179,910	\$1,159,728	6.45
027	I-40	SR 1002 - Aviation Pkwy	285	EB-M1 (SB to EB)	\$177,910	\$714,798	4.02
015	I-40	Davis Dr	280	EB	\$358,910	\$1,532,373	4.27
028	I-40	SR 1002 - Aviation Pkwy	285	EB-M2 (NB to EB)	\$187,910	\$700,952	3.73
014*	I-40	NC-147 / Durham Fwy	279	WB-M2 (SB to WB)	\$405,910	\$1,568,587	3.86
002	I-40	US-15 / US-501	270	WB	\$179,910	\$516,352	2.87
090	I-440	SR 1319 - Jones Franklin Rd	1C	SB	\$175,910	\$271,829	1.55
012*	I-40	NC-147 / Durham Fwy	279	EB-M2 (SB to EB)	\$648,910	\$1,007,131	1.55
025	I-40	SR 3015 - Airport Blvd	284	EB	\$187,910	\$226,532	1.21
089	I-440	SR 1319 - Jones Franklin Rd	1C	NB	\$186,910	\$221,697	1.19
133*	I-540	US-70	4	EB	\$479,910	\$481,622	1.00

* Freeway-to-Freeway site

4.4. Sensitivity Testing

Some basic sensitivity analysis has been performed to test the impact of any excessive optimism in the benefits calculations. This analysis assumes that the delays are reduced by only 10 percent instead of 20 percent to determine if fewer sites should be implemented because of the reduced financial benefit of 10 percent reduction in delay.

The site-by-site results of the sensitivity testing are shown in Tables 6 and 7 on pages 19 and 20.

In this scenario, only two of the sites (Site 017, I-40 eastbound at Miami Boulevard, and Site 019, I-40 eastbound at Page Road) have a positive FYRR. This indicates these two sites should have an excellent return on investment, and the benefits of 1 year exceed the capital and first-year operating costs in the first year of operation.

Fifteen sites have a 5-year BCR of greater than 1.00. The total 5-year BCR of all 21 sites is reduced from 6.36 to 0.27.

For the 10-year scenario, only two of the sites have a positive FYRR; however, 16 of the sites have a 5-year BCR of greater than 1.00. The total 10-year BCR of all 21 sites is reduced from 10.10 to 0.50.

4.5. Conclusions

From this financial analysis of benefit-cost ratios and the first-year rate of return, some logical groups have emerged. These groups are listed below in descending first-year rate of return order:

- Sites with positive first-year rate of return:
 - Site 017: I-40 eastbound at S. Miami Blvd.
 - Site 019: I-40 eastbound at Page Rd.
- Sites with benefit-cost ratio greater than 1.0 in the first 5 years:
 - Site 002: I-40 westbound at US 15/501.
 - Site 009: I-40 eastbound at NC 55, Apex Highway.
 - Site 010: I-440 westbound at NC 55, Apex Highway.
 - Site 014: NC 147 westbound at NC 147 southbound.
 - Site 015: I-40 eastbound at Davis Dr.
 - Site 027: I-40 eastbound at SR 1002, Aviation Parkway southbound.
 - Site 028: I-40 eastbound at SR 1002, Aviation Parkway northbound.
 - Site 030: I-40 eastbound at SR 1652, N. Harrison Avenue.
 - Site 043: I-40 westbound at SR 1571, Gorman Street.
 - Site 056: I-40 westbound at SR 5220, Jones Sausage Rd.
 - Site 095: I-440 eastbound at SR 1002, Aviation Blvd. southbound.
 - Site 102: I-40 northbound at Lake Boone Trail.
 - Site 108: I-440 westbound at US 70/NC 50, Glenwood Ave. southbound.
 - Site 135: I-540 westbound at SR 1829, Leesville Rd.
- Sites with benefit-cost ratio greater than 1.0 in the second 5 years:

- Site 012: I-40 eastbound at NC 147 southbound.
- Site 025: I-40 eastbound at SR 3015, Airport Blvd.
- Site 089: I-440 northbound at SR 1319, Jones Franklin Rd.
- Site 090: I-440 eastbound at SR 1319, Jones Franklin Rd.
- Site 133: I-540 eastbound at US 70.

Table 6: Benefit Cost Appraisal over 5-Year Period for Each Site – 10% Delay Reduction

Log	Freeway	Cross Street	Exit	Direction	Cumulative Cost in Period	Cumulative Benefit in Period	BCR in Period	FYRR
017	I-40	S Miami Blvd	281	EB	\$144,455	\$918,424	6.36	60%
019	I-40	Page Rd	282	EB	\$232,455	\$1,012,739	4.36	0%
095	I-440	SR 1012 - Western Blvd	2	SB-M2 (EB to SB)	\$153,455	\$569,612	3.71	-8%
108	I-440	US-70 / NC-50 / Glenwood	7	WB-M2 (SB to WB)	\$138,455	\$375,718	2.71	-31%
030	I-40	SR 1652 - N Harrison Ave	287	EB	\$143,455	\$363,764	2.54	-36%
102	I-440	Lake Boone Trail	5	NB	\$144,455	\$345,903	2.39	-40%
056	I-40	SR 5220 - Jones Sausage Rd	303	WB	\$150,455	\$354,640	2.36	-41%
010	I-40	NC-55 / Apex Hwy	278	WB	\$358,455	\$326,089	0.91	-43%
043	I-40	SR 1571 - Gorman St	295	WB	\$150,455	\$314,161	2.09	-48%
135	I-540	SR 1829 - Leesville Rd	7	EB	\$146,455	\$303,292	2.07	-48%
009	I-40	NC-55 / Apex Hwy	278	EB	\$142,455	\$289,932	2.04	-48%
027	I-40	SR 1002 - Aviation Pkwy	285	EB-M1 (SB to EB)	\$150,455	\$178,700	1.19	-68%
015	I-40	Davis Dr	280	EB	\$321,455	\$383,093	1.19	-74%
028	I-40	SR 1002 - Aviation Pkwy	285	EB-M2 (NB to EB)	\$150,455	\$175,238	1.16	-71%
014*	I-40	NC-147 / Durham Fwy	279	WB-M2 (SB to WB)	\$366,455	\$392,147	1.07	-77%
002	I-40	US-15 / US-501	270	WB	\$142,455	\$129,080	0.91	-77%
090	I-440	SR 1319 - Jones Franklin Rd	1C	SB	\$138,455	\$67,957	0.49	-87%
012*	I-40	NC-147 / Durham Fwy	279	EB-M2 (SB to EB)	\$611,455	\$251,783	0.41	-91%
025	I-40	SR 3015 - Airport Blvd	284	EB	\$150,455	\$56,633	0.38	-91%
089	I-440	SR 1319 - Jones Franklin Rd	1C	NB	\$149,455	\$55,424	0.37	-91%
133*	I-540	US-70	4	EB	\$442,455	\$120,405	0.27	-94%

* Freeway-to-Freeway sites

Table 7: Benefit Cost Appraisal over 10-Year Period for Each Site – 10% Delay Reduction

Log	Freeway	Cross Street	Exit	Direction	Cumulative Cost in Period	Cumulative Benefit in Period	BCR in Period	FYRR
017	I-40	S Miami Blvd	281	EB	\$181,910	\$1,836,848	10.10	60%
019	I-40	Page Rd	282	EB	\$269,910	\$2,025,478	7.50	0%
095	I-440	SR 1012 - Western Blvd	2	SB-M2 (EB to SB)	\$190,910	\$1,139,223	5.97	-8%
108	I-440	US-70 / NC-50 / Glenwood	7	WB-M2 (SB to WB)	\$175,910	\$751,436	4.27	-31%
030	I-40	SR 1652 - N Harrison Ave	287	EB	\$180,910	\$727,529	4.02	-36%
102	I-440	Lake Boone Trail	5	NB	\$181,910	\$691,807	3.80	-40%
056	I-40	SR 5220 - Jones Sausage Rd	303	WB	\$187,910	\$709,280	3.77	-41%
010	I-40	NC-55 / Apex Hwy	278	WB	\$181,910	\$652,178	3.59	-43%
043	I-40	SR 1571 - Gorman St	295	WB	\$187,910	\$628,322	3.34	-48%
135	I-540	SR 1829 - Leesville Rd	7	EB	\$183,910	\$604,585	3.29	-48%
009	I-40	NC-55 / Apex Hwy	278	EB	\$179,910	\$579,864	3.22	-48%
027	I-40	SR 1002 - Aviation Pkwy	285	EB-M1 (SB to EB)	\$177,910	\$357,399	2.01	-68%
015	I-40	Davis Dr	280	EB	\$358,910	\$766,186	2.13	-74%
028	I-40	SR 1002 - Aviation Pkwy	285	EB-M2 (NB to EB)	\$187,910	\$350,476	1.87	-71%
014*	I-40	NC-147 / Durham Fwy	279	WB-M2 (SB to WB)	\$405,910	\$784,294	1.93	-77%
002	I-40	US-15 / US-501	270	WB	\$179,910	\$258,176	1.44	-77%
090	I-440	SR 1319 - Jones Franklin Rd	1C	SB	\$175,910	\$135,915	0.77	-87%
012*	I-40	NC-147 / Durham Fwy	279	EB-M2 (SB to EB)	\$648,910	\$503,565	0.78	-91%
025	I-40	SR 3015 - Airport Blvd	284	EB	\$187,910	\$113,266	0.60	-91%
089	I-440	SR 1319 - Jones Franklin Rd	1C	NB	\$186,910	\$110,849	0.59	-91%
133*	I-540	US-70	4	EB	\$479,910	\$240,811	0.50	-94%

* Freeway-to-Freeway sites

5. STIP Projects and F2F Sites

5.1. STIP Projects

The State Transportation Implementation Plan (STIP) can be found at:
<https://connect.ncdot.gov/projects/planning/Pages/Breakdown-Maps.aspx>

The STIP has been reviewed to identify any planned projects in the vicinity of a potential ramp metering site. The information compiled in Table 8 includes an indication as to whether or not there is a short-term impact on ramp metering.

Table 8: List of STIP Projects

Log	STIP Project Number	Description	Anticipated Construction	Funding Status	Short-Term Impact on RM?	Agency
002	I-3306A	Widening I-40 for additional lanes from US 15/501 to I-85 in Division 7	2020	Funded	No	Div. 7
043	I-5338	I-40 pavement rehabilitation. Project includes auxiliary lanes between interchange ramp.	2013	Funded	Likely	Div. 5
056	I-5111A	Widening I-40 for additional lanes	2018	Funded	Yes	Div. 5
089, 090, 095	U-2719	Widening I-440 for additional lanes. There also is a pavement preservation project anticipated for 2016 or 2017 on this section.	2018	Funded	No	Div. 5

The two potential ramp metering installations that could be affected by STIP projects in the near term are shown in Table 9. Site 043 will be deleted from the analysis of the implementation strategies because its benefits cannot be assured. Site 056 will remain due to some uncertainty of its construction date and the potential for that site to make an interim improvement in the congestion.

Table 9: Sites Affected by STIP Projects in the List of Suitable Locations

Log	Free-way	Cross Street	Exit	Direction	5-Year BCR
043	I-40	SR 1571 - Gorman St	295	WB	4.18
056	I-40	SR 5220 - Jones Sausage Rd	303	WB	4.71

5.2. Freeway-to-Freeway Sites

Early stages of the NCDOT Ramp Metering Feasibility Study included a number of freeway-to-freeway (F2F) sites for evaluation. This was to satisfy a desire to know how feasible F2F sites would be and the issues in implementing ramp metering at such sites, but there was no intention to install ramp metering at an F2F intersection in the first round of implementation.

Of five initially requested, three F2F sites were found to be potentially feasible for ramp metering based on the analysis of congestion, traffic, and geometric characteristics. They were therefore included in the list of 21 locations subject to financial analysis. Because there is no intention to install them at this stage, from this point forward these F2F sites will be removed from the analysis of the implementation strategies.

Table 10 identifies the three F2F sites and their relative 5-year BCRs. Only Site 014 has a benefit-cost ratio greater than 1.00.

Table 10: Freeway-to-Freeway Sites Applicable to the Suitable Locations

Log	Free-way	Cross Street	Exit	Direction	5-Year BCR
012	I-40	NC-147 / Durham Fwy	279	EB-M2 (SB to EB)	0.82
014	I-40	NC-147 / Durham Fwy	279	WB-M2 (SB to WB)	2.13
133	I-540	US-70	4	EB	0.54

6. Strategies for Implementation

6.1. Introduction

This section presents two strategies for ramp meter implementation based on the congestion and benefit costs. The ultimate choice of strategy will be based on available funds, timescales, attitude toward risk, desire to learn from the first stage of implementation, and other factors.

The four sites identified in Section 5, those impacted by the STIP projects and freeway-to-freeway sites, will not be included in this analysis (Site 043: Westbound I-40 at SR 1571 – Gorman St., Site 012: Eastbound I-40 at Southbound NC-147/Durham Fwy, Site 014: Westbound I-40 at Southbound NC-147/Durham Fwy, and Site 133: Eastbound I-540 at US 70).

A number of factors must be considered for each site, beyond just the economics. These factors include such things as primary versus secondary causes of congestion, reduced effectiveness factors, and whether sites need to be included as part of a group to ensure the level of benefit predicted. For additional details, refer to the Screening and Detailed Analysis Task Report, Table 10: Groups of Congestion and Sites in Each Group.

6.1.1. Site 002 (Westbound I-40 at US 15/501)

Site 002 is not recommended for implementation in the 5-year program due to its low benefit-cost ratio.

6.1.2. Site 009 (Eastbound I-40 at NC 55/Apex Hwy)

Site 009 is in a group with Sites 012 and 011 (see Figure 2), which cover C082 and C060. Site 009 is the downstream site for congestion reference C060, so it is likely to be the primary cause of that congestion. This means that it can be implemented on its own without needing to revise the effectiveness factor.

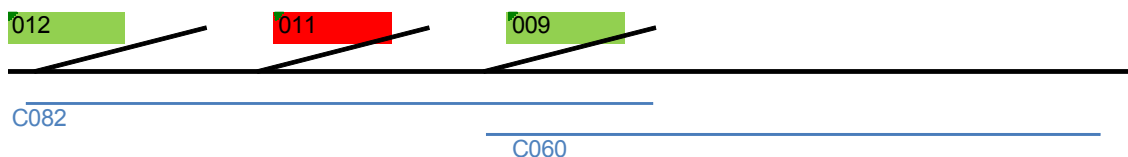


Figure 2: Congestion Site C060 and C082

6.1.3. Site 010 (Westbound I-40 at NC 55/Apex Hwy)

Site 010 is the downstream site for congestion reference C051, so it is likely to be the primary cause of that congestion. Therefore, Site 010 should be implemented first in this group.

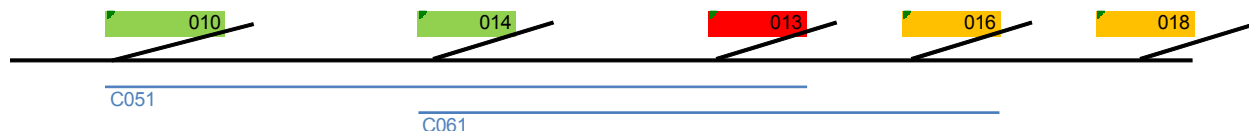


Figure 3: Congestion Site C051

6.1.4. Site 015 (Eastbound I-40 at Davis Dr)

Site 015 is a secondary site for congestion reference C006; the downstream sites are Sites 017 and 019. It is vital that the primary and downstream sites are included if Site 015 is implemented; otherwise, the effectiveness factor for Site 015 will need to be reduced.

This grouping of the sites represents an opportunity to investigate linked sites; the congestion might be completely resolved by implementing just the downstream site. Therefore, Site 015 should not be implemented initially.

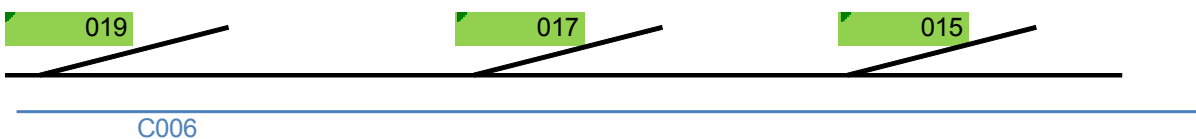


Figure 4: Congestion Site C006

6.1.5. Site 017 (Eastbound I-40 at S. Miami Blvd)

Site 017 is a secondary site in the middle of C006, as shown in Figure 4. It is vital that the primary Site 019 is included if Site 017 is implemented; otherwise, the effectiveness factor for Site 017 will need to be reduced. The success of Site 017 is dependent upon first implementing Site 019. Therefore, it is recommended to implement Site 017 after Site 019.

6.1.6. Site 019 (Eastbound I-40 at Page Rd)

Site 019 is the most downstream site of C006, as shown in Figure 4, and could be implemented on its own, if necessary. Therefore, Site 019 should be implemented first in this group.

6.1.7. Site 025 (Eastbound I-40 at SR 3015 – Airport Blvd)

Site 025 is not recommended for implementation in the 5-year program due to its low benefit-cost ratio.

6.1.8. Site 027 (Eastbound I-40 at Southbound SR 1002 – Aviation Pkwy)

Site 027 is a secondary site in C062—the primary site is Site 028. It is vital that the primary Site 028 is included if 027 is implemented; otherwise, the effectiveness factor for Site 027 will need to be reduced. The Site 027 ramp is short and curved, and storage is approximately 47 vehicles; therefore, benefits may be slightly reduced. Due to slight reduction in the site’s ability to process entrance ramp traffic, the effectiveness factor is already reduced by 25 percent. This site should only be installed if the ramp metering system includes an effective queue management system (not just queue override).



Figure 5: Congestion Site C062

6.1.9. Site 028 (Eastbound I-40 at Northbound SR 1002 – Aviation Pkwy)

Site 028 is the primary site for congestion reference C062. Lower than threshold entrance-ramp volumes during part of the congested period may limit the amount of benefits achievable by ramp metering at this location. Ramp metering will only be effective during the worst part of the congestion, and not during the build-up or recovery; consequently, the effectiveness factor will be reduced by 50 percent.

6.1.10. Site 030 (Eastbound I-40 at SR 1652 – N Harrison Ave)

Site 030 is an individual site and the primary site for congestion reference C005. Therefore, it can be implemented without regard to other sites.

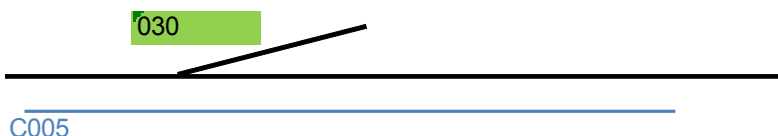


Figure 6: Congestion Site C030

6.1.11. Site 056 (Eastbound I-40 at SR 5220 – Jones Sausage Rd)

Site 056 is an individual site and the primary site for congestion reference C054. Therefore, it can be implemented without regard to other sites.

6.1.12. Site 089 (Northbound I-40 at SR 1319 – Jones Franklin Rd)

Site 089 is not recommended for implementation in the 5-year program due to its low benefit-cost ratio.

6.1.13. Site 090 (Southbound I-40 at SR 1319 – Jones Franklin Rd)

Site 090 is not recommended for implementation in the 5-year program due its low benefit-cost ratio.

6.1.14. Site 095 (Southbound I-440 at Eastbound SR 1012 – Western Blvd)

Site 095 is in a group with Site 090. It is upstream, but is the primary site for congestion references C030 and C011. This means that it can be implemented on its own without needing to revise the effectiveness factor. Low entrance-ramp volumes, although within thresholds, may limit the amount of benefits achievable by ramp metering at this location; therefore, the effectiveness factor has been reduced by 25 percent.

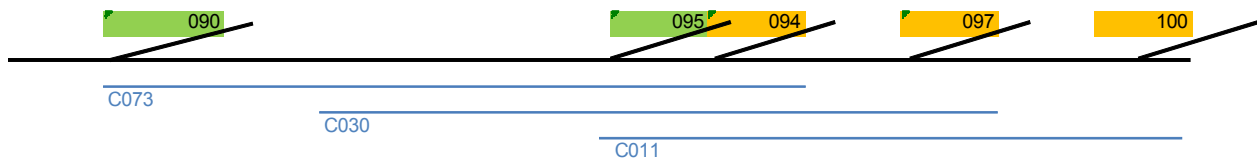


Figure 7: Congestion Sites C030 & C011

6.1.15. Site 102 (Northbound I-440 at Lane Boone Trail)

Site 102 is a secondary site in C014, but the downstream site has been identified in the screening task as not suitable for ramp metering. In order to account for this, the effectiveness factor has been reduced to 50 percent in the Performance Measures task report, which means it can be implemented on its own without having to revise the level of benefits.

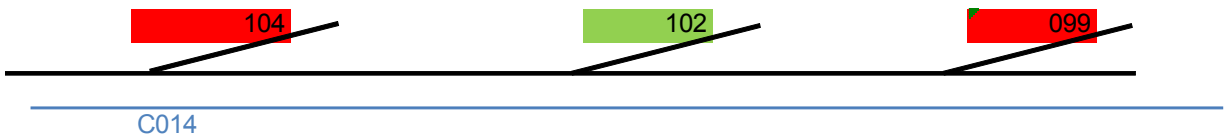


Figure 8: Congestion Site C014

6.1.16. Site 108 (Westbound I-440 at Southbound US-70/NC-50/Glenwood Ave)

Site 108 is an individual site, and is the primary site for congestion reference C016. Therefore, it can be implemented without regard to other sites.

6.1.17. Sites 133 (Eastbound I-540 at US 70 and 135 Eastbound I-540 SR 1829 – Leesville Rd)

Site 133 (a freeway-to-freeway site) is in a group with Site 135. Site 133 is the primary for congestion reference C032. This means that Site 133 can be implemented on its own without needing to revise the effectiveness factor. The effectiveness of Site 135 is dependent upon first implementing Site 133.

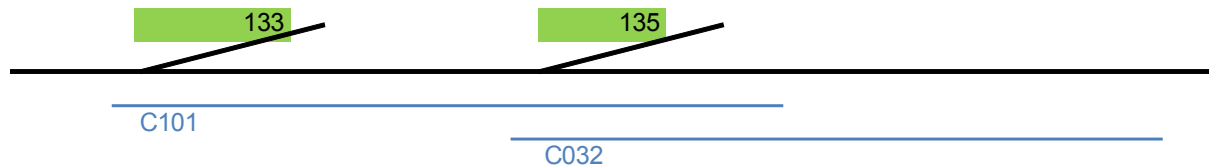


Figure 9: Congestion Sites C101 and C032

6.2. Strategy 1: All Sites with Return on Investment in 5 Years

There was consensus within the Steering Committee that a site with a benefit-to-cost ratio greater than 1.0 within 5 years would be economically suitable for implementation. The first strategy presented, therefore, is to build all sites with a return on investment within 5 years in one program. In this strategy, 14 sites are included (in order by site number), and consist of non-freeway-to-freeway sites *not* in conflict with other STIP projects:

- Site 002: Southbound I-40 at US 15/501
- Site 009: Eastbound I-40 at NC 55/Apex Hwy
- Site 010: Westbound I-40 at NC 55/Apex Hwy
- Site 015: Eastbound I-40 at Davis Dr
- Site 017: Eastbound I-40 at S. Miami Blvd
- Site 019: Eastbound I-40 at Page Rd
- Site 027: Eastbound I-40 at Southbound SR 1002 – Aviation Pkwy
- Site 028: Eastbound I-40 at Northbound SR 1002 – Aviation Pkwy
- Site 030: Eastbound I-40 at Harrison Avenue
- Site 056: Westbound I-40 at Jones Sausage Road
- Site 095: Southbound I-40 at SR 1012 – Western Blvd
- Site 102: Northbound I-440 at Lane Boone Trail
- Site 108: Westbound I-440 at Southbound US-70/NC-50/Glenwood Ave
- Site 135: Eastbound I-540 at SR 1829 – Leesville Rd

These 14 sites are shown in Figure 10.

Seven of the 21 sites have a benefit-cost ratio less than 1.0, or are freeway-to-freeway sites, or are in conflict with an STIP project, and are not installed at this stage:

- Site 012: Eastbound I-40 at Southbound NC-147 / Durham Fwy
- Site 014: Westbound I-40 at Northbound NC-147 / Durham Fwy
- Site 025: Eastbound I-40 at SR 3015 - Airport Blvd
- Site 043: Westbound I-40 at SR 1571 – Gorman St
- Site 089: Northbound I-40 at SR 1319 - Jones Franklin Rd
- Site 090: Southbound I-40 at SR 1319 - Jones Franklin Rd
- Site 133: Eastbound I-540 at Eastbound US 70

For the 14 sites, dividing the estimated total program cost of \$404,998 among the costs of these sites would add \$28,928 to the cost of each.

These results are shown in Table 11. Over a 10-year period the estimated total cost of implementing these sites would be \$3,210,274 and the estimated total benefits would be \$22,900,932 providing an overall BCR of 7.13. However, it can be seen that some sites would contribute far more (Sites 017, 019, and 095 have BCRs greater than 10), where others would contribute less (Sites 002, 015, 027, and 028 have BCRs less than 5).

It should be remembered that these figures relate to just delay time benefits, while other benefits, including accidents and emissions, will also be accrued.

This option includes some sites in groups, providing the opportunity to analyze the performance of the chosen system on grouped sites. It also includes some sites with low entrance-ramp volumes, allowing investigation of whether or not these succeed. Finally, this option includes some sites with short ramps, allowing analysis of whether the chosen system's queue management method is effective for such sites. The inclusion of these sites brings with it the risk that one or more sites might not perform as well as expected; if chosen, this strategy would allow lessons to be learned.

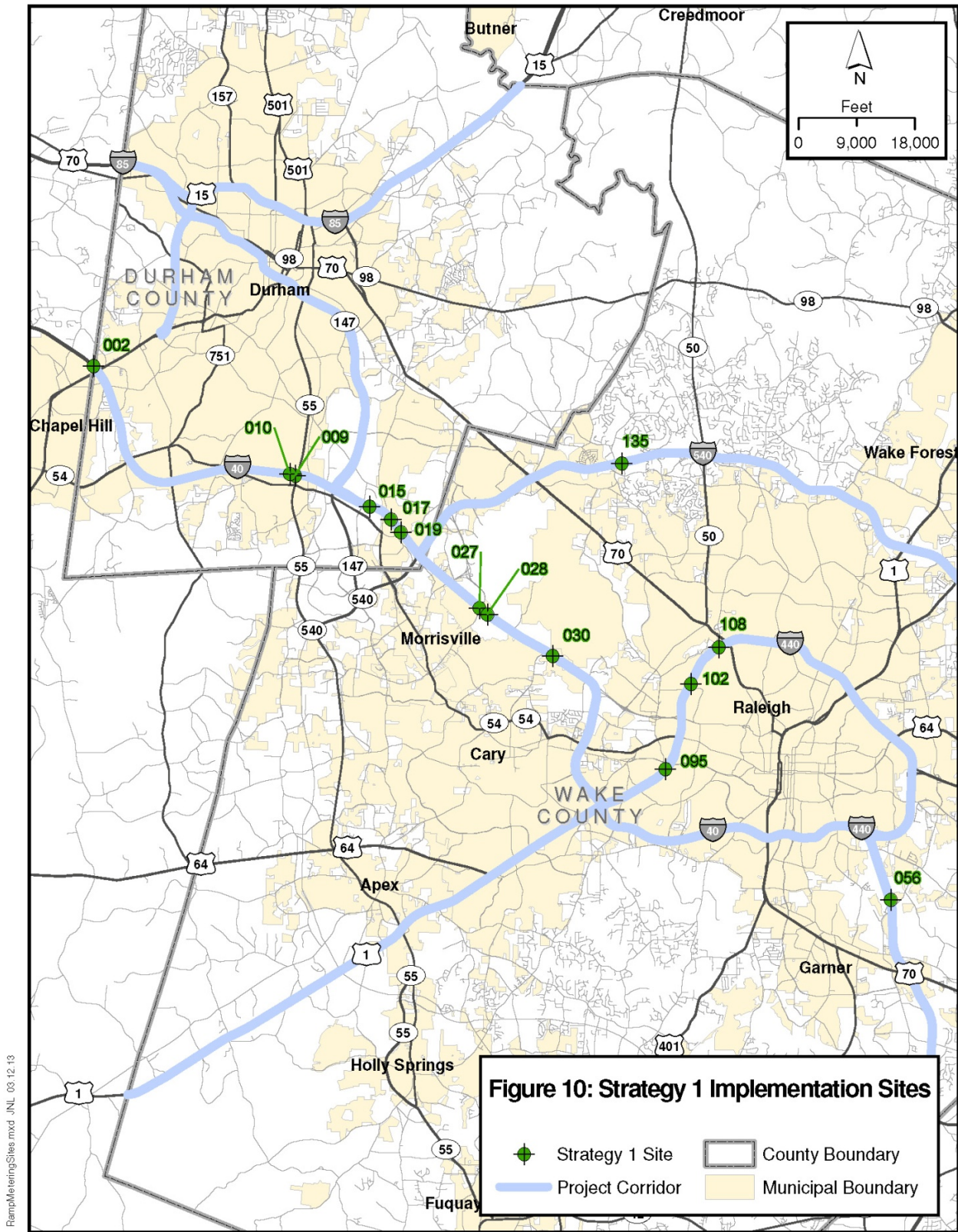


Figure 10: Strategy 1 Implementation Sites

Table 11: Costs, Benefits, and BCRs for Strategy 1 Sites

Log	Freeway	Cross Street	Exit	Direction	10 Year Total Cost with Pro-rated Program	10 Year Total Benefit	10 Year BCR with Pro-rated Program
002	I-40	US-15 / US-501	270	WB	\$208,838	\$516,352	2.47
009	I-40	NC-55 / Apex Hwy	278	EB	\$208,838	\$1,159,728	5.55
010	I-40	NC-55 / Apex Hwy	278	WB	\$210,838	\$1,304,356	6.19
015	I-40	Davis Dr	280	EB	\$387,838	\$1,532,373	3.95
017	I-40	S Miami Blvd	281	EB	\$210,838	\$3,673,695	17.42
019	I-40	Page Rd	282	EB	\$298,838	\$4,050,957	13.56
027	I-40	SR 1002 - Aviation Pkwy	285	EB-M1 (SB to EB)	\$206,838	\$714,798	3.46
028	I-40	SR 1002 - Aviation Pkwy	285	EB-M2 (NB to EB)	\$216,838	\$700,952	3.23
030	I-40	SR 1652 - N Harrison Ave	287	EB	\$202,838	\$1,455,058	7.17
056	I-40	SR 5220 - Jones Sausage Rd	303	WB	\$219,838	\$1,418,561	6.45
095	I-440	SR 1012 - Western Blvd	2	SB-M2 (EB to SB)	\$210,838	\$2,278,447	10.81
102	I-440	Lake Boone Trail	5	NB	\$204,838	\$1,383,614	6.75
108	I-440	US-70 / NC-50 / Glenwood	7	WB-M2 (SB to WB)	\$212,838	\$1,502,872	7.06
135	I-540	SR 1829 - Leesville Rd	7	EB	\$215,064	\$1,209,170	5.62

6.3. Strategy 2: 5-Year Payback and Reduced Risk

Some sites identified as suitable might achieve lower than average benefits (e.g., some secondary sites and some sites with less than ideal geometry). These have been given a reduced effectiveness factor as described in Task 9 – Performance Measures, and outlined previously in Section 6.1.

This option includes ten sites (shown in Figure 11) that have an effectiveness factor of 1, indicating they are primary sites with low risks:

- Site 002: Southbound I-40 at US 15/501
- Site 009: Eastbound I-40 at NC 55/Apex Hwy
- Site 010: Westbound I-40 at NC 55/Apex Hwy
- Site 015: Eastbound I-40 at Davis Dr
- Site 017: Eastbound I-40 at S. Miami Blvd
- Site 019: Eastbound I-40 at Page Rd
- Site 030: Eastbound I-40 at Harrison Avenue
- Site 056: Westbound I-40 at Jones Sausage Road
- Site 108: Westbound I-440 at Southbound US-70/NC-50/Glenwood Ave
- Site 135: Eastbound I-540 at SR 1829 – Leesville Rd

If the estimated total program cost of \$404,998 is split among these sites, it adds \$40,500 to each. These results are shown in Table 12. Over a 10-year period the estimated total cost of implementing these sites would be \$2,465,848 and the estimated total benefits would be \$17,823,120, providing an overall BCR of 7.23.

Note that these figures relate only to travel time benefits, while other benefits, including accidents and emissions, will also be accrued.

This strategy also excludes four sites with effectiveness factors less than 1.0, indicating they are secondary sites and are at least partially dependent on a site downstream:

- 027: Eastbound I-40 at Southbound SR 1002 – Aviation Pkwy
- 028: Eastbound I-40 at Northbound SR 1002 – Aviation Pkwy
- 095: Southbound I-40 at SR 1012 – Western Blvd
- 102: Northbound I-440 at Lane Boone Trail

While this strategy would increase the likelihood of all chosen sites achieving very high benefits, it would allow less opportunity to test the chosen system over the full range of scenarios. This would result in less potential to learn from performance of a broader range of sites, which could provide helpful information when contemplating ramp metering implementation for other urban areas in North Carolina.

Table 12: Costs, Benefits, and BCRs for Strategy 2 Sites

Log	Freeway	Cross Street	Exit	Direction	10 Year Total Cost with Pro-rated Program	10 Year Total Benefit	10 Year BCR with Pro-rated
002	I-40	US-15 / US-501	270	WB	\$220,410	\$516,352	2.34
009	I-40	NC-55 / Apex Hwy	278	EB	\$220,410	\$1,159,728	5.26
010	I-40	NC-55 / Apex Hwy	278	WB	\$222,410	\$1,304,356	5.86
015	I-40	Davis Dr	280	EB	\$399,410	\$1,532,373	3.84
017	I-40	S Miami Blvd	281	EB	\$222,410	\$3,673,695	16.52
019	I-40	Page Rd	282	EB	\$310,410	\$4,050,957	13.05
030	I-40	SR 1652 - N Harrison Ave	287	EB	\$221,410	\$1,455,058	6.57
056	I-40	SR 5220 - Jones Sausage Rd	303	WB	\$208,410	\$1,418,561	6.81
108	I-440	US-70 / NC-50 / Glenwood	7	WB-M2 (SB to WB)	\$216,410	\$1,502,872	6.94
135	I-540	SR 1829 - Leesville Rd	7	EB	\$224,410	\$1,209,170	5.39

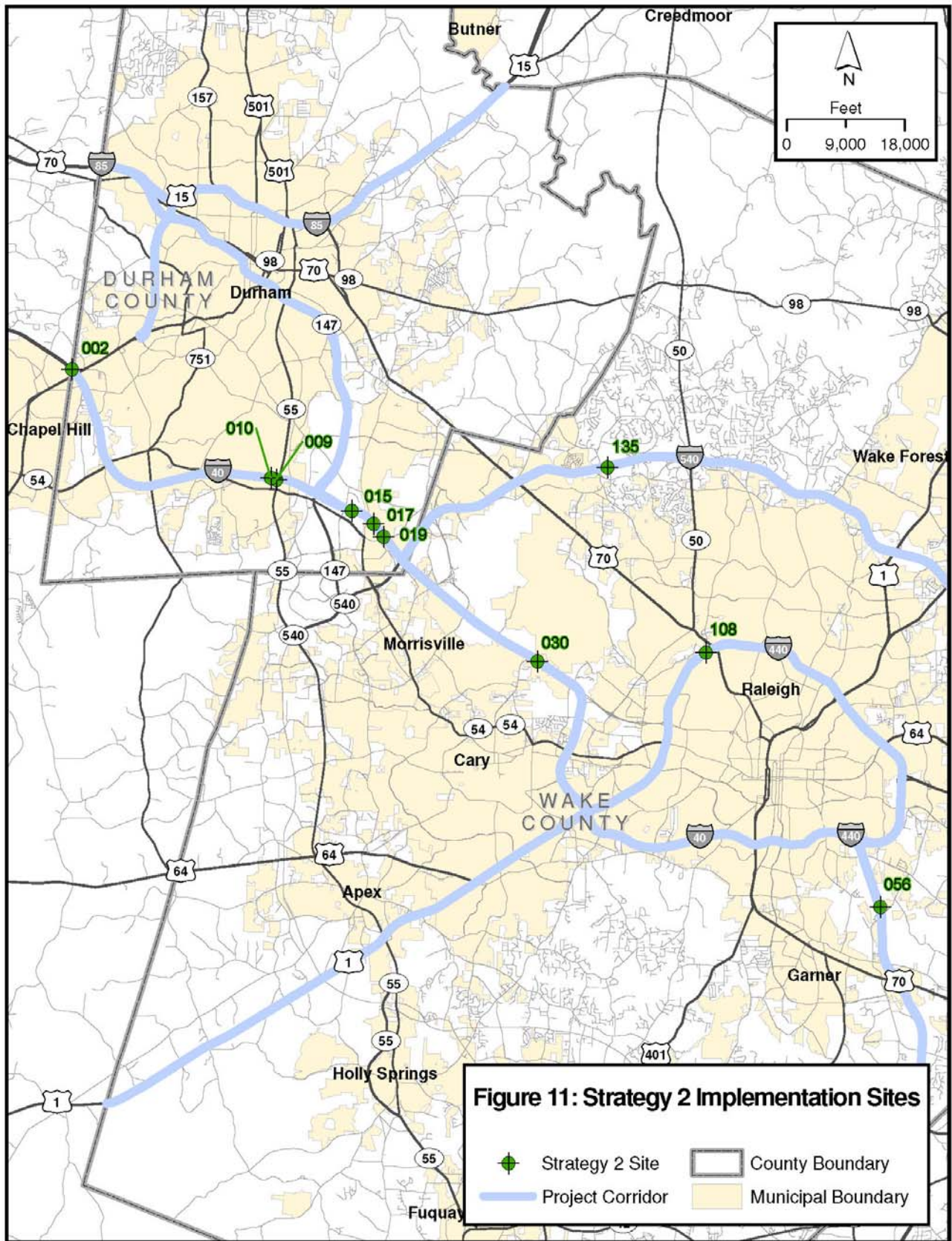


Figure 11: Strategy 2 Implementation Sites

7. Summary

Using the predicted costs and benefits of the sites taken from the list of the 21 sites, a benefit-cost analysis has been performed. This analysis takes into account implementation costs, maintenance costs, and program costs. The financial benefits are only for the reduction in travel time expected from the system.

From this analysis, two strategies have been identified:

- Strategy 1: Includes all sites suitable for ramp metering that pay back within 5 years (i.e., have a 5-year benefit-to-cost ratio greater than 1.00), does not include one site that overlaps an STIP project, and does not include three sites that are freeway-to-freeway sites.
- Strategy 2: This lower-risk strategy includes only sites with a 5-year payback that have an effectiveness factor of 1.00, does not include one site that overlaps an STIP project, and does not include three sites that are freeway-to-freeway sites.

Strategy 1 would offer more potential to learn about the performance of the system in different scenarios—knowledge that could then be used to decide where to apply ramp metering elsewhere in North Carolina.

Strategy 2 removes some sites that have a slightly higher chance of not performing as expected. The key results of these two strategies are shown in Table 13.

Table 13: Strategy Results

Strategy	Number of Sites	10-Year Total Cost	10-Year Total Benefit	10-Year BCR
1	14	\$3,210,274	\$22,900,932	7.13
2	10	\$2,465,848	\$17,823,120	7.23

It is important to consider the following:

- Care must be taken with the choice of system, particularly with Strategy 2, due to the greater need for effective queue management (although good queue management is essential at all sites in order to obtain optimum benefits).
- The analysis is based on travel time benefits only, whereas other benefits actually will accrue including safety, emissions, and reliability improvements. Some of the sites screened out during the previous phase of analysis might well provide benefits in the future.
- Following a pilot ramp-metering program using either Strategy 1 or 2 above, it might be useful to review some of those sites based on the results of the pilot to determine whether to install at those sites.

8. Recommendations

8.1. Recommended Strategy

Two implementation strategies have been presented in this report. Strategy 1 is a slightly higher-risk option that deploys more sites, with more variety, which would allow NCDOT to gain more operational experience and a broader understanding for a wider selection of sites. Strategy 2 is the lower-risk option and includes a smaller group of projects with less variability in site conditions. Low risk can be defined as those sites with an effectiveness factor of 1.0, indicating they are the primary sites of congestion not dependent on sites downstream.

The benefits were conservatively estimated based upon other states' implementations and without the benefit of estimating emissions, safety, etc. Since this a pilot study, a logical goal of the project would be to gain as much knowledge about a variety of sites. Therefore, it is recommended the Strategy 1 implementation sites be installed.

8.2. Sequence of Implementation of Strategy 1

Upon determining an overall strategy to select a group of sites, a scheme must be developed that addresses the priorities within the select group of sites. This will allow the Department to implement the sites in a variety of ways. Site prioritization must consider that this is a pilot project, which will afford the Department the opportunity to develop a knowledge base of design, operations, and maintenance issues with implementation.

All of the sites in the Strategy 1 group have good benefit-cost ratios; therefore, it can be assumed they will all offer good performance. To ensure the initial deployment provides solid results without the effects of other sites that are not suitable, it is logical to rank the highest the primary sites at the sources of the congestion. It is also beneficial to first deploy sites that will have less complicated design issues. This helps the Department learn from the experience of progressively more complicated designs. Table 14 shows the proposed order of implementation for Strategy 1.

Each site has been ranked based upon four criteria—benefit-cost ratio, congestion importance, and relative difficulty of design. Each site was graded as follows:

- For benefit-cost ranking, B/C ratio > 5 is a 1, B/C ratio > 4 is a 2, B/C ratio > 2 is a 3, and B/C ratio > 1 is a 4.
- For congestion importance ranking, each site was graded with a score—primary congestion site = 1, median site = 2, and every secondary site = 3.
- For relative difficulty of design, each site was scored—low design difficulty site = 1, medium-low difficulty design = 2, medium difficulty design = 3, and high difficulty design = 4. The lowest overall score is the highest ranking.
- Each site was given a score of 1 if there is no conflict with a STIP project, a score of 2 if there was a potential conflict, and a score of 3 if there is a definite conflict with a STIP project.

Table 14: Recommended Order of Implementation in Strategy Group 1

Log	Freeway	Cross Street	Exit	Direction	F2F?	TIP Conflict	Congesti on Location	Design Difficulty	Ramp Meter Configuration	Location Notes	TIP Conflict	B/C Ranking	Congestion ranking	Design Difficulty	Total Score	Ranking
017	I-40	S Miami Blvd	281	EB	No	No	primary	Low	Single Lane	downstream	1	1	1	1	4	1
095	I-440	SR 1012 - Western Blvd	2	SB-M2 (EB to SB)	No	No	primary	Low	Single Lane	downstream	1	1	1	1	4	1
102	I-440	Lake Boone Trail	5	NB	No	No	primary	Low	Single Lane	downstream	1	2	1	1	5	2
135	I-540	SR 1829 - Leesville Rd	7	EB	No	No	solo site	Low	Single Lane	downstream	1	2	1	1	5	2
028	I-40	SR 1002 - Aviation Pkwy	285	EB-M2 (NB to EB)	No	No	primary	Low	Single Lane	downstream	1	3	1	1	6	3
030	I-40	SR 1652 - N Harrison Ave	287	EB	No	No	secondary	Low	Single Lane	upstream of 019	1	1	3	1	6	3
108	I-440	US-70 / NC-50 / Glenwood Ave	7	WB-M2 (SB to WB)	No	No	secondary	Low	Single Lane	upstream of 019 amd 017	1	1	3	1	6	3
009	I-40	NC-55 / Apex Hwy	278	EB	No	No	secondary	Low	Single Lane Loop	(F2F) and 011 (unsuitable)	1	2	3	1	7	4
010	I-40	NC-55 / Apex Hwy	278	WB	No	No	secondary	Low	Single Lane	upstream of 028	1	2	3	1	7	4
019	I-40	Page Rd	282	EB	No	No	secondary	Medium	Two Lane Loop	upstream of F2F one and non-suitable one	1	1	3	3	8	5
027	I-40	SR 1002 - Aviation Pkwy	285	EB-M1 (SB to EB)	No	No	secondary	Low	Single Lane Loop	upstream of 028	1	3	3	1	8	5
056	I-40	SR 5220 - Jones Sausage Rd	303	WB	No	Potential	secondary	Low	Single Lane	TIP Conflict	2	2	3	1	8	5
002	I-40	US-15 / US-501	270	WB	No	No	secondary	Low	Single Lane	upstream of non-suitable site 104	1	4	3	1	9	6
015	I-40	Davis Dr	280	EB	No	No	secondary	Medium-Low	Two Lane	upstream of 019 and 017	1	3	3	2	9	6

NCDOT might not deploy ramp metering projects in the order that they are ranked, due to other considerations and constraints.

Appendices

Appendix A. Site-Specific Cost Estimates

Site-specific cost estimates were developed for the 21 sites passing the detailed analysis. These estimates are presented in this Appendix.

M-0446 Ramp Metering Feasibility Study for Durham and Wake Counties
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**Typical Design and Construction Costs
Single Lane Ramp Meter**

Log No.: 002 Ramp: US 15/501
Location: I-40 Eastbound Exit 270B

Categories	Description	Unit	Quantity	Unit Cost	Total Cost	Assumptions
Earthwork and Structures						
	Retaining Wall 5' High	LF	0	\$ 250.00	\$ -	
	Retaining Wall 10' High	LF	0	\$ 475.00	\$ -	
	Excavation	CY	0	\$ 4.00	\$ -	
	Fill	CY	0	\$ 5.00	\$ -	
	Seeding	SY	1499	\$ 2.50	\$ 3,747.50	Seeding around trench, conduit runs, pull box, and foundation areas
Subtotal					\$ 3,747.50	
Guardrail						
	Guardrail Rail	LF	250	\$ 15.00	\$ 3,750.00	
	Guardrail Approach End Treatment	EA	1	\$ 1,500.00	\$ 1,500.00	
Subtotal					\$ 5,250.00	
Drainage						
	Pipe	LF	0	\$ 44.00	\$ -	
Subtotal					\$ -	
Signalization						
	6'x6' loops	EA	5	\$ 394.50	\$ 1,972.50	One queue, three passage and one clearance
	Detector Lead-in Cable	EA	390	\$ 1.50	\$ 585.00	Assumed setback distance 350'
	MVDS detector	EA	1	\$ 1,800.00	\$ 1,800.00	Mainline detection
	Detector pole	EA	1	\$ 6,000.00	\$ 6,000.00	
	Pullbox (Std.)	EA	6	\$ 300.00	\$ 1,800.00	
	Conduit (Trenched)	LF	2200	\$ 6.00	\$ 13,200.00	All purposes
	Conduit (Directional Drilled)	LF	50	\$ 14.00	\$ 700.00	One ramp crossing, multiple conduits
	Electrical Service	EA	1	\$ 1,500.00	\$ 1,500.00	
	Electrical Conductors	LF	850	\$ 5.00	\$ 4,250.00	
	2070 Controller and Cabinet	EA	1	\$ 14,000.00	\$ 14,000.00	
	Firmware/Calibration	EA	1	\$ 5,300.00	\$ 5,300.00	
	Cabinet Foundation	EA	1	\$ 450.00	\$ 450.00	
	45' Mast Arm Poles and Foundation	EA	0	\$ 15,000.00	\$ -	
	Pedestal Pole	EA	1	\$ 1,000.00	\$ 1,000.00	
	Three Section Signal Head	EA	2	\$ 1,000.00	\$ 2,000.00	
	One Section Signal Head	EA	2	\$ 500.00	\$ 1,000.00	Ramp meter advance signal
	Signal Cable	LF	400	\$ 2.75	\$ 1,100.00	
Subtotal					\$ 56,657.50	
Communications						
	Serial Communications	EA	350	\$ 2.00	\$ 700.00	Link to MVDS
	Splice Enclosure	EA	1	\$ 1,000.00	\$ 1,000.00	Link to SMFO
	Pullbox (Special Size)	EA	1	\$ 1,750.00	\$ 1,750.00	For splice enclosure
	Interconnect Center	EA	1	\$ 1,500.00	\$ 1,500.00	In cabinet
	Fiber-optic Drop Cable (six strands)	LF	500	\$ 1.50	\$ 750.00	Drop cable to controller cabinet
	Ethernet Switch	EA	1	\$ 1,700.00	\$ 1,700.00	
Subtotal					\$ 7,400.00	
Pavement Marking						
	Pavement Marking Removal	LF	640	\$ 0.62	\$ 396.80	40 mph design speed. 110' transitions, 100' narrowed lane

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**Typical Design and Construction Costs
Single Lane Loop Ramp Meter**

Log No.: 009 Ramp: NC 55
Location: I-40 Eastbound Exit 278

Categories	Description	Unit	Quantity	Unit Cost	Total Cost	Assumptions
Earthwork and Structures						
	Retaining Wall 5' High	LF	0	\$ 250.00	\$ -	
	Retaining Wall 10' High	LF	0	\$ 475.00	\$ -	
	Excavation	CY	0	\$ 4.00	\$ -	
	Fill	CY	0	\$ 5.00	\$ -	
	Seeding	SY	1499	\$ 2.50	\$ 3,747.50	Seeding around trench, conduit runs, pull box, and foundation areas
Subtotal					\$ 3,747.50	
Guardrail						
	Guardrail Rail	LF	250	\$ 15.00	\$ 3,750.00	
	Guardrail Approach End Treatment	EA	1	\$ 1,500.00	\$ 1,500.00	
Subtotal					\$ 5,250.00	
Drainage						
	Pipe	LF	0	\$ 44.00	\$ -	
Subtotal					\$ -	
Signalization						
	6'x6' loops	EA	5	\$ 394.50	\$ 1,972.50	One queue, three passage and one clearance
	Detector Lead-in Cable	EA	390	\$ 1.50	\$ 585.00	Assumed setback distance 350'
	MVDS detector	EA	1	\$ 1,800.00	\$ 1,800.00	Mainline detection
	Detector pole	EA	1	\$ 6,000.00	\$ 6,000.00	
	Pullbox (Std.)	EA	6	\$ 300.00	\$ 1,800.00	
	Conduit (Trenched)	LF	2200	\$ 6.00	\$ 13,200.00	All purposes
	Conduit (Directional Drilled)	LF	50	\$ 14.00	\$ 700.00	One ramp crossing, mult. conduits
	Electrical Service	EA	1	\$ 1,500.00	\$ 1,500.00	
	Electrical Conductors	LF	850	\$ 5.00	\$ 4,250.00	
	2070 Controller and Cabinet	EA	1	\$ 14,000.00	\$ 14,000.00	
	Firmware/Calibration	EA	1	\$ 5,300.00	\$ 5,300.00	
	Cabinet Foundation	EA	1	\$ 450.00	\$ 450.00	
	45' Mast Arm Poles and Foundation	EA	0	\$ 15,000.00	\$ -	
	Pedestal Pole	EA	1	\$ 1,000.00	\$ 1,000.00	
	Three Section Signal Head	EA	2	\$ 1,000.00	\$ 2,000.00	
	One Section Signal Head	EA	2	\$ 500.00	\$ 1,000.00	Ramp meter advance signal
	Signal Cable	LF	400	\$ 2.75	\$ 1,100.00	
Subtotal					\$ 56,657.50	
Communications						
	Serial Communications	EA	350	\$ 2.00	\$ 700.00	Link to MVDS
	Splice Enclosure	EA	1	\$ 1,000.00	\$ 1,000.00	Link to SMFO
	Pullbox (Special Size)	EA	1	\$ 1,750.00	\$ 1,750.00	For splice enclosure
	Interconnect Center	EA	1	\$ 1,500.00	\$ 1,500.00	In cabinet
	Fiber-optic Drop Cable (six strands)	LF	500	\$ 1.50	\$ 750.00	Drop cable to controller cabinet
	Ethernet Switch	EA	1	\$ 1,700.00	\$ 1,700.00	
Subtotal					\$ 7,400.00	
Pavement Marking						

**Typical Design and Construction Costs
Site Assumptions Checklist**

Log No.:	012	Ramp:	NC 147
Location:	I-40 Eastbound Exit 279		Southbound to Eastbound
Two Lane Ramp Widening (Y/N):		<input type="text" value="Y"/>	
Length of Two Lane Ramp Widening (ft.):		<input type="text" value="2000"/>	
Distance from Stopbar to W3-8 sign (ft.):		<input type="text" value="1000"/>	
Pipe Crossings (Y/N):		<input type="text" value="N"/>	
Retaining Walls (Y/N):		<input type="text" value="N"/>	
Fill (Y/N):		<input type="text" value="N"/>	
Guardrail Other than for Ramp Meter Equipment (Y/N):		<input type="text" value="N"/>	
Nearest Power Source (ft.):		<input type="text" value="3200"/>	

Notes
No nearby power source. This estimate assumes pulling power from CCTV at Davis Dr. Possible closer power source could be from the nearby office park. Install equipment on left side only, protect with guardrail

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**Typical Design and Construction Costs
Two Lane Freeway to Freeway Ramp Meter**

Log No.: 012
Location: I-40 Eastbound Exit 279

Ramp: NC 147 Southbound to Eastbound

Categories	Description	Unit	Quantity	Unit Cost	Total Cost	Assumptions
Earthwork and Structures						
	Retaining Wall 5' High	LF	0	\$ 250.00	\$ -	
	Retaining Wall 10' High	LF	0	\$ 475.00	\$ -	
	Excavation	CY	0	\$ 4.00	\$ -	
	Fill	CY	0	\$ 5.00	\$ -	
	Seeding	SY	4922	\$ 2.50	\$ 12,305.00	Seeding along pavement widening and around trench, conduit, pull box, and foundation areas
Subtotal					\$ 12,305.00	
Guardrail						
	Guardrail Rail	LF	1250	\$ 15.00	\$ 18,750.00	
	Guardrail Approach End Treatment	EA	5	\$ 1,500.00	\$ 7,500.00	
Subtotal					\$ 26,250.00	
Paving						
	Traffic Separator, 4' Wide	LF	0	\$ 32.00	\$ -	
	Ramp Widening	SY	3556	\$ 32.00	\$ 113,792.00	
	Pavement Resurfacing	SY	3556	\$ 12.00	\$ 42,672.00	
Subtotal					\$ 156,464.00	
Drainage						
	Pipe	LF	0	\$ 44.00	\$ -	
Subtotal					\$ -	
Signalization						
	6'x6' loops	EA	10	\$ 394.50	\$ 3,945.00	One queue, three passage and one clearance
	Detector Lead-in Cable	EA	390	\$ 1.50	\$ 585.00	Assumed setback distance 350'
	MVDS detector	EA	1	\$ 1,800.00	\$ 1,800.00	Mainline detection
	Detector pole	EA	1	\$ 6,000.00	\$ 6,000.00	
	Pullbox (Std.)	EA	10	\$ 300.00	\$ 3,000.00	
	Conduit (Trenched)	LF	5310	\$ 6.00	\$ 31,860.00	All purposes
	Conduit (Directional Drilled)	LF	125	\$ 14.00	\$ 1,750.00	One ramp crossing, mult. Conduits, electrical conduit across interstate
	Electrical Service	EA	1	\$ 1,500.00	\$ 1,500.00	
	Electrical Conductors	LF	3200	\$ 5.00	\$ 16,000.00	
	2070 Controller and Cabinet	EA	1	\$ 14,000.00	\$ 14,000.00	
	Firmware/Calibration	EA	1	\$ 5,300.00	\$ 5,300.00	
	Cabinet Foundation	EA	1	\$ 450.00	\$ 450.00	
	45' Mast Arm Poles and Foundation	EA	1	\$ 15,000.00	\$ 15,000.00	
	Pedestal Pole	EA	0	\$ 1,000.00	\$ -	
	Three Section Signal Head	EA	2	\$ 1,000.00	\$ 2,000.00	
	One Section Signal Head	EA	6	\$ 500.00	\$ 3,000.00	Ramp meter advance signal
	Signal Cable	LF	1386	\$ 2.75	\$ 3,811.50	
Subtotal					\$ 110,001.50	
Communications						
	Serial Communications	EA	350	\$ 2.00	\$ 700.00	Link to MVDS
	Splice Enclosure	EA	1	\$ 1,000.00	\$ 1,000.00	Link to SMFO
	Pullbox (Special Size)	EA	1	\$ 1,750.00	\$ 1,750.00	For splice enclosure
	Interconnect Center	EA	1	\$ 1,500.00	\$ 1,500.00	In cabinet
	Fiber-optic Drop Cable (six strands)	LF	500	\$ 1.50	\$ 750.00	Drop cable to controller cabinet

**Typical Design and Construction Costs
Site Assumptions Checklist**

Log No.:	014	Ramp:	NC 147
Location:	I-40 Westbound Exit 279		Southbound to Westbound
Two Lane Ramp Widening (Y/N):		<input type="text" value="N"/>	
Length of Two Lane Ramp Widening (ft.):		<input type="text" value="N"/>	
Distance from Stopbar to W3-8 sign (ft.):		<input type="text" value="1000"/>	
Pipe Crossings (Y/N):		<input type="text" value="N"/>	
Retaining Walls (Y/N):		<input type="text" value="N"/>	
Fill (Y/N):		<input type="text" value="N"/>	
Guardrail Other than for Ramp Meter Equipment (Y/N):		<input type="text" value="N"/>	
Nearest Power Source (ft.):		<input type="text" value="1800"/>	

Notes
Nearest Power source is CCTV at 147 interchange. Install equipment on right side only, protect with guardrail

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Typical Design and Construction Costs
Two Lane Ramp Meter

Log No.: 015
Location: I-40 Eastbound Exit 280

Ramp: Davis Drive

Categories	Description	Unit	Quantity	Unit Cost	Total Cost	Assumptions
Earthwork and Structures						
	Retaining Wall 5' High	LF	0	\$ 250.00	\$ -	
	Retaining Wall 10' High	LF	0	\$ 475.00	\$ -	
	Excavation	CY	0	\$ 4.00	\$ -	
	Fill	CY	0	\$ 5.00	\$ -	
	Seeding	SY	1760	\$ 2.50	\$ 4,400.00	Seeding along pavement widening and around trench, conduit, pull box, and foundation areas
Subtotal					\$ 4,400.00	
Guardrail						
	Guardrail Rail	LF	500	\$ 15.00	\$ 7,500.00	
	Guardrail Approach End Treatment	EA	2	\$ 1,500.00	\$ 3,000.00	
Subtotal					\$ 10,500.00	
Paving						
	Ramp Widening	SY	2667	\$ 32.00	\$ 85,344.00	
	Pavement Resurfacing	SY	2667	\$ 12.00	\$ 32,004.00	
Subtotal					\$ 117,348.00	
Drainage						
	Pipe	LF	0	\$ 44.00	\$ -	
Subtotal					\$ -	
Signalization						
	6'x6' loops	EA	10	\$ 394.50	\$ 3,945.00	One queue, three passage and one clearance
	Detector Lead-in Cable	EA	390	\$ 1.50	\$ 585.00	Assumed setback distance 350'
	MVDS detector	EA	1	\$ 1,800.00	\$ 1,800.00	Mainline detection
	Detector pole	EA	1	\$ 6,000.00	\$ 6,000.00	
	Pullbox (Std.)	EA	6	\$ 300.00	\$ 1,800.00	
	Conduit (Trenched)	LF	2585	\$ 6.00	\$ 15,510.00	All purposes
	Conduit (Directional Drilled)	LF	250	\$ 14.00	\$ 3,500.00	One ramp crossing, mult. conduits
	Electrical Service	EA	1	\$ 1,500.00	\$ 1,500.00	
	Electrical Conductors	LF	1200	\$ 5.00	\$ 6,000.00	
	2070 Controller and Cabinet	EA	1	\$ 14,000.00	\$ 14,000.00	
	Firmware/Calibration	EA	1	\$ 5,300.00	\$ 5,300.00	
	Cabinet Foundation	EA	1	\$ 450.00	\$ 450.00	
	45' Mast Arm Poles and Foundation	EA	0	\$ 15,000.00	\$ -	
	Pedestal Pole	EA	2	\$ 1,000.00	\$ 2,000.00	dual pedestals
	Three Section Signal Head	EA	2	\$ 1,000.00	\$ 2,000.00	
	One Section Signal Head	EA	2	\$ 500.00	\$ 1,000.00	Ramp meter advance signal
	Signal Cable	LF	505	\$ 2.75	\$ 1,388.75	
Subtotal					\$ 66,778.75	
Communications						
	Serial Communications	EA	350	\$ 2.00	\$ 700.00	Link to MVDS
	Splice Enclosure	EA	1	\$ 1,000.00	\$ 1,000.00	Link to SMFO
	Pullbox (Special Size)	EA	1	\$ 1,750.00	\$ 1,750.00	For splice enclosure
	Interconnect Center	EA	1	\$ 1,500.00	\$ 1,500.00	In cabinet
	Fiber-optic Drop Cable (six strands)	LF	500	\$ 1.50	\$ 750.00	Drop cable to controller cabinet
	Ethernet Switch	EA	1	\$ 1,700.00	\$ 1,700.00	

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Typical Design and Construction Costs
Two Lane Ramp Meter

Log No.: 015
Location: I-40 Eastbound Exit 280

Ramp: Davis Drive

Categories	Description	Unit	Quantity	Unit Cost	Total Cost	Assumptions
Subtotal					\$ 7,400.00	
Pavement Marking						
	Pavement Marking Removal	LF	640	\$ 0.62	\$ 396.80	40 mph design speed, 110' transitions, 100' narrowed lane
	Raised Pavement Markers	EA	19	\$ 4.50	\$ 85.50	Along skip line only
	White Edge Line	LF	320	\$ 0.95	\$ 304.00	110' transitions, 100' narrowed lane
	Yellow Edge Line	LF	320	\$ 0.95	\$ 304.00	110' transitions, 100' narrowed lane
	White Skip Line	LF	1500	\$ 0.24	\$ 356.25	
	24" Stop Bar	LF	12	\$ 7.00	\$ 84.00	
Subtotal					\$ 1,530.55	
Signing						
	W3-8, Ramp Metered When Flashing	EA	2	\$ 650.00	\$ 1,300.00	Sign and post only
	W3-4, Be Prepared to Stop	EA	1	\$ 650.00	\$ 650.00	Sign and post
	R10-6, Stop Here on Red	EA	1	\$ 175.00	\$ 175.00	Pedestal mounted
	R10-28, XX Vehicles Per Green	EA	1	\$ 175.00	\$ 175.00	Pedestal mounted
	W4-1L, Merge Left	EA	1	\$ 650.00	\$ 650.00	
Subtotal					\$ 2,950.00	
Subtotal Construction					\$ 211,000.00	
Traffic Control				3%	\$ 7,000.00	
Contingencies				10%	\$ 22,000.00	
Total Construction					\$ 240,000.00	
Design				8%	\$ 20,000.00	
Construction Administration				10%	\$ 24,000.00	
Total Design and Construction					\$ 284,000.00	

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**Typical Design and Construction Costs
Single Lane Ramp Meter**

Log No.: 017
Location: I-40 Eastbound Exit 281

Ramp: S. Miami Blvd.

Categories	Description	Unit	Quantity	Unit Cost	Total Cost	Assumptions
Earthwork and Structures						
	Retaining Wall 5' High	LF	0	\$ 250.00	\$ -	
	Retaining Wall 10' High	LF	0	\$ 475.00	\$ -	
	Excavation	CY	0	\$ 4.00	\$ -	
	Fill	CY	0	\$ 5.00	\$ -	
	Seeding	SY	1549	\$ 2.50	\$ 3,872.50	Seeding around trench, conduit runs, pull box, and foundation areas
Subtotal					\$ 3,872.50	
Guardrail						
	Guardrail Rail	LF	250	\$ 15.00	\$ 3,750.00	
	Guardrail Approach End Treatment	EA	1	\$ 1,500.00	\$ 1,500.00	
Subtotal					\$ 5,250.00	
Drainage						
	Pipe	LF	0	\$ 44.00	\$ -	
Subtotal					\$ -	
Signalization						
	6'x6' loops	EA	5	\$ 394.50	\$ 1,972.50	One queue, three passage and one clearance
	Detector Lead-in Cable	EA	390	\$ 1.50	\$ 585.00	Assumed setback distance 350'
	MVDS detector	EA	1	\$ 1,800.00	\$ 1,800.00	Mainline detection
	Detector pole	EA	1	\$ 6,000.00	\$ 6,000.00	
	Pullbox (Std.)	EA	6	\$ 300.00	\$ 1,800.00	
	Conduit (Trenched)	LF	2275	\$ 6.00	\$ 13,650.00	All purposes
	Conduit (Directional Drilled)	LF	175	\$ 14.00	\$ 2,450.00	One ramp crossing, multiple conduits
	Electrical Service	EA	1	\$ 1,500.00	\$ 1,500.00	
	Electrical Conductors	LF	925	\$ 5.00	\$ 4,625.00	
	2070 Controller and Cabinet	EA	1	\$ 14,000.00	\$ 14,000.00	
	Firmware/Calibration	EA	1	\$ 5,300.00	\$ 5,300.00	
	Cabinet Foundation	EA	1	\$ 450.00	\$ 450.00	
	45' Mast Arm Poles and Foundation	EA	0	\$ 15,000.00	\$ -	
	Pedestal Pole	EA	1	\$ 1,000.00	\$ 1,000.00	
	Three Section Signal Head	EA	2	\$ 1,000.00	\$ 2,000.00	
	One Section Signal Head	EA	2	\$ 500.00	\$ 1,000.00	Ramp meter advance signal
	Signal Cable	LF	400	\$ 2.75	\$ 1,100.00	
Subtotal					\$ 59,232.50	
Communications						
	Serial Communications	EA	350	\$ 2.00	\$ 700.00	Link to MVDS
	Splice Enclosure	EA	1	\$ 1,000.00	\$ 1,000.00	Link to SMFO
	Pullbox (Special Size)	EA	1	\$ 1,750.00	\$ 1,750.00	For splice enclosure
	Interconnect Center	EA	1	\$ 1,500.00	\$ 1,500.00	In cabinet
	Fiber-optic Drop Cable (six strands)	LF	500	\$ 1.50	\$ 750.00	Drop cable to controller cabinet
	Ethernet Switch	EA	1	\$ 1,700.00	\$ 1,700.00	
Subtotal					\$ 7,400.00	
Pavement Marking						
	Pavement Marking Removal	LF	440	\$ 0.62	\$ 272.80	40 mph design speed. 110' transitions, 100' narrowed lane

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Typical Design and Construction Costs
Two Lane Ramp Meter

Log No.: 019
Location: I-40 Eastbound Exit 282

Ramp: Page Road

Categories	Description	Unit	Quantity	Unit Cost	Total Cost	Assumptions
Earthwork and Structures						
	Retaining Wall 5' High	LF	0	\$ 250.00	\$ -	
	Retaining Wall 10' High	LF	0	\$ 475.00	\$ -	
	Excavation	CY	0	\$ 4.00	\$ -	
	Fill	CY	0	\$ 5.00	\$ -	
	Seeding	SY	1393	\$ 2.50	\$ 3,482.50	Seeding along pavement widening and around trench, conduit, pull box, and foundation areas
Subtotal					\$ 3,482.50	
Guardrail						
	Guardrail Rail	LF	500	\$ 15.00	\$ 7,500.00	
	Guardrail Approach End Treatment	EA	2	\$ 1,500.00	\$ 3,000.00	
Subtotal					\$ 10,500.00	
Paving						
	Ramp Widening	SY	1334	\$ 32.00	\$ 42,688.00	
	Pavement Resurfacing	SY	1334	\$ 12.00	\$ 16,008.00	
Subtotal					\$ 58,696.00	
Drainage						
	Pipe	LF	0	\$ 44.00	\$ -	
Subtotal					\$ -	
Signalization						
	6'x6' loops	EA	10	\$ 394.50	\$ 3,945.00	One queue, three passage and one clearance
	Detector Lead-in Cable	EA	390	\$ 1.50	\$ 585.00	Assumed setback distance 350'
	MVDS detector	EA	1	\$ 1,800.00	\$ 1,800.00	Mainline detection
	Detector pole	EA	1	\$ 6,000.00	\$ 6,000.00	
	Pullbox (Std.)	EA	6	\$ 300.00	\$ 1,800.00	
	Conduit (Trenched)	LF	2035	\$ 6.00	\$ 12,210.00	All purposes
	Conduit (Directional Drilled)	LF	150	\$ 14.00	\$ 2,100.00	One ramp crossing, mult. conduits
	Electrical Service	EA	1	\$ 1,500.00	\$ 1,500.00	
	Electrical Conductors	LF	650	\$ 5.00	\$ 3,250.00	
	2070 Controller and Cabinet	EA	1	\$ 14,000.00	\$ 14,000.00	
	Firmware/Calibration	EA	1	\$ 5,300.00	\$ 5,300.00	
	Cabinet Foundation	EA	1	\$ 450.00	\$ 450.00	
	45' Mast Arm Poles and Foundation	EA	0	\$ 15,000.00	\$ -	
	Pedestal Pole	EA	2	\$ 1,000.00	\$ 2,000.00	dual pedestals
	Three Section Signal Head	EA	2	\$ 1,000.00	\$ 2,000.00	
	One Section Signal Head	EA	2	\$ 500.00	\$ 1,000.00	Ramp meter advance signal
	Signal Cable	LF	505	\$ 2.75	\$ 1,388.75	
Subtotal					\$ 59,328.75	
Communications						
	Serial Communications	EA	350	\$ 2.00	\$ 700.00	Link to MVDS
	Splice Enclosure	EA	1	\$ 1,000.00	\$ 1,000.00	Link to SMFO
	Pullbox (Special Size)	EA	1	\$ 1,750.00	\$ 1,750.00	For splice enclosure
	Interconnect Center	EA	1	\$ 1,500.00	\$ 1,500.00	In cabinet
	Fiber-optic Drop Cable (six strands)	LF	500	\$ 1.50	\$ 750.00	Drop cable to controller cabinet
	Ethernet Switch	EA	1	\$ 1,700.00	\$ 1,700.00	

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Implementation Plan

Typical Design and Construction Costs
Two Lane Ramp Meter

Log No.: 019
Location: I-40 Eastbound Exit 282

Ramp: Page Road

Categories	Description	Unit	Quantity	Unit Cost	Total Cost	Assumptions
Subtotal					\$ 7,400.00	
Pavement Marking						
	Pavement Marking Removal	LF	640	\$ 0.62	\$ 396.80	40 mph design speed, 110' transitions, 100' narrowed lane
	Raised Pavement Markers	EA	10	\$ 4.50	\$ 45.00	Along skip line only
	White Edge Line	LF	320	\$ 0.95	\$ 304.00	110' transitions, 100' narrowed lane
	Yellow Edge Line	LF	320	\$ 0.95	\$ 304.00	110' transitions, 100' narrowed lane
	White Skip Line	LF	750	\$ 0.24	\$ 178.13	
	24" Stop Bar	LF	12	\$ 7.00	\$ 84.00	
Subtotal					\$ 1,311.93	
Signing						
	W3-8, Ramp Metered When Flashing	EA	2	\$ 650.00	\$ 1,300.00	Sign and post only
	W3-4, Be Prepared to Stop	EA	1	\$ 650.00	\$ 650.00	Sign and post
	R10-6, Stop Here on Red	EA	1	\$ 175.00	\$ 175.00	Pedestal mounted
	R10-28, XX Vehicles Per Green	EA	1	\$ 175.00	\$ 175.00	Pedestal mounted
	W4-1L, Merge Left	EA	1	\$ 650.00	\$ 650.00	
Subtotal					\$ 2,950.00	
Subtotal Construction					\$ 144,000.00	
Traffic Control				3%	\$ 5,000.00	
Contingencies				10%	\$ 15,000.00	
Total Construction					\$ 164,000.00	
Design				8%	\$ 14,000.00	
Construction Administration				10%	\$ 17,000.00	
Total Design and Construction					\$ 195,000.00	

**Typical Design and Construction Costs
Site Assumptions Checklist**

Log No.:	027	Ramp:	Aviation Parkway
Location:	I-40 Eastbound Exit 285		Southbound to Eastbound
Two Lane Ramp Widening (Y/N):		<input type="text" value="N"/>	
Length of Two Lane Ramp Widening (ft.):		<input type="text" value="0"/>	
Distance from Stopbar to W3-8 sign (ft.):		<input type="text" value="750"/>	
Pipe Crossings (Y/N):		<input type="text" value="N"/>	
Retaining Walls (Y/N):		<input type="text" value="N"/>	
Fill (Y/N):		<input type="text" value="N"/>	
Guardrail Other than for Ramp Meter Equipment (Y/N):		<input type="text" value="N"/>	
Nearest Power Source (ft.):		<input type="text" value="775"/>	

Notes
Nearest Power source is signal cabinet. Curb and gutter on right side. Install equipment on right side only, protect with guardrail

M-0446 Ramp Metering Feasibility Study for Durham and Wake Counties
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**Typical Design and Construction Costs
Single Lane Loop Ramp Meter**

Log No.: 027

Ramp: Aviation Parkway Southbound to Eastbound

Location: I-40 Eastbound Exit 285

Categories	Description	Unit	Quantity	Unit Cost	Total Cost	Assumptions
Earthwork and Structures						
	Retaining Wall 5' High	LF	0	\$ 250.00	\$ -	
	Retaining Wall 10' High	LF	0	\$ 475.00	\$ -	
	Excavation	CY	0	\$ 4.00	\$ -	
	Fill	CY	0	\$ 5.00	\$ -	
	Seeding	SY	1449	\$ 2.50	\$ 3,622.50	Seeding around trench, conduit runs, pull box, and foundation areas
Subtotal					\$ 3,622.50	
Guardrail						
	Guardrail Rail	LF	250	\$ 15.00	\$ 3,750.00	
	Guardrail Approach End Treatment	EA	1	\$ 1,500.00	\$ 1,500.00	
Subtotal					\$ 5,250.00	
Drainage						
	Pipe	LF	0	\$ 44.00	\$ -	
Subtotal					\$ -	
Signalization						
	6'x6' loops	EA	5	\$ 394.50	\$ 1,972.50	One queue, three passage and one clearance
	Detector Lead-in Cable	EA	390	\$ 1.50	\$ 585.00	Assumed setback distance 350'
	MVDS detector	EA	1	\$ 1,800.00	\$ 1,800.00	Mainline detection
	Detector pole	EA	1	\$ 6,000.00	\$ 6,000.00	
	Pullbox (Std.)	EA	6	\$ 300.00	\$ 1,800.00	
	Conduit (Trenched)	LF	2125	\$ 6.00	\$ 12,750.00	All purposes
	Conduit (Directional Drilled)	LF	100	\$ 14.00	\$ 1,400.00	Two ramp crossing, mult. conduits
	Electrical Service	EA	1	\$ 1,500.00	\$ 1,500.00	
	Electrical Conductors	LF	775	\$ 5.00	\$ 3,875.00	
	2070 Controller and Cabinet	EA	1	\$ 14,000.00	\$ 14,000.00	
	Firmware/Calibration	EA	1	\$ 5,300.00	\$ 5,300.00	
	Cabinet Foundation	EA	1	\$ 450.00	\$ 450.00	
	45' Mast Arm Poles and Foundation	EA	0	\$ 15,000.00	\$ -	
	Pedestal Pole	EA	1	\$ 1,000.00	\$ 1,000.00	
	Three Section Signal Head	EA	2	\$ 1,000.00	\$ 2,000.00	
	One Section Signal Head	EA	2	\$ 500.00	\$ 1,000.00	Ramp meter advance signal
	Signal Cable	LF	400	\$ 2.75	\$ 1,100.00	
Subtotal					\$ 56,532.50	
Communications						
	Serial Communications	EA	350	\$ 2.00	\$ 700.00	Link to MVDS
	Splice Enclosure	EA	1	\$ 1,000.00	\$ 1,000.00	Link to SMFO
	Pullbox (Special Size)	EA	1	\$ 1,750.00	\$ 1,750.00	For splice enclosure
	Interconnect Center	EA	1	\$ 1,500.00	\$ 1,500.00	In cabinet
	Fiber-optic Drop Cable (six strands)	LF	500	\$ 1.50	\$ 750.00	Drop cable to controller cabinet
	Ethernet Switch	EA	1	\$ 1,700.00	\$ 1,700.00	
Subtotal					\$ 7,400.00	
Pavement Marking						

**Typical Design and Construction Costs
Single Lane Loop Ramp Meter**

Log No.: 027

Ramp: Aviation Parkway Southbound to Eastbound

Location: I-40 Eastbound Exit 285

Categories	Description	Unit	Quantity	Unit Cost	Total Cost	Assumptions
	Pavement Marking Removal	LF	440	\$ 0.62	\$ 272.80	30 mph design speed, 60' transitions, 100' narrowed lane
	Raised Pavement Markers	EA	0	\$ 4.50	\$ -	
	White Edge Line	LF	220	\$ 0.95	\$ 209.00	60' transitions, 100' narrowed lane
	Yellow Edge Line	LF	220	\$ 0.95	\$ 209.00	60' transitions, 100' narrowed lane
	24" Stop Bar	LF	12	\$ 7.00	\$ 84.00	
Subtotal					\$ 774.80	
Signing						
	W3-8, Ramp Metered When Flashing	EA	2	\$ 650.00	\$ 1,300.00	Sign and post only
	W3-4, Be Prepared to Stop	EA	1	\$ 650.00	\$ 650.00	Sign and post
	R10-6, Stop Here on Red	EA	1	\$ 175.00	\$ 175.00	Pedestal mounted
	R10-28, XX Vehicles Per Green	EA	1	\$ 175.00	\$ 175.00	Pedestal mounted
Subtotal					\$ 2,300.00	
Subtotal Construction					\$ 76,000.00	
Traffic Control				3%	\$ 3,000.00	
Contingencies				10%	\$ 8,000.00	
Total Construction					\$ 87,000.00	
Design				8%	\$ 7,000.00	
Construction Administration				10%	\$ 9,000.00	
Total Design and Construction					\$ 103,000.00	

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**Typical Design and Construction Costs
Single Lane Ramp Meter**

Log No.: 028

Ramp: Aviation Parkway Northbound to Eastbound

Location: I-40 Eastbound Exit 285

Categories	Description	Unit	Quantity	Unit Cost	Total Cost	Assumptions
Earthwork and Structures						
	Retaining Wall 5' High	LF	0	\$ 250.00	\$ -	
	Retaining Wall 10' High	LF	0	\$ 475.00	\$ -	
	Excavation	CY	0	\$ 4.00	\$ -	
	Fill	CY	0	\$ 5.00	\$ -	
	Seeding	SY	1732	\$ 2.50	\$ 4,330.00	Seeding around trench, conduit runs, pull box, and foundation areas
Subtotal					\$ 4,330.00	
Guardrail						
	Guardrail Rail	LF	250	\$ 15.00	\$ 3,750.00	
	Guardrail Approach End Treatment	EA	1	\$ 1,500.00	\$ 1,500.00	
Subtotal					\$ 5,250.00	
Drainage						
	Pipe	LF	0	\$ 44.00	\$ -	
Subtotal					\$ -	
Signalization						
	6'x6' loops	EA	5	\$ 394.50	\$ 1,972.50	One queue, three passage and one clearance
	Detector Lead-in Cable	EA	390	\$ 1.50	\$ 585.00	Assumed setback distance 350'
	MVDS detector	EA	1	\$ 1,800.00	\$ 1,800.00	Mainline detection
	Detector pole	EA	1	\$ 6,000.00	\$ 6,000.00	
	Pullbox (Std.)	EA	6	\$ 300.00	\$ 1,800.00	
	Conduit (Trenched)	LF	2550	\$ 6.00	\$ 15,300.00	All purposes
	Conduit (Directional Drilled)	LF	150	\$ 14.00	\$ 2,100.00	One ramp crossing, multiple conduits
	Electrical Service	EA	1	\$ 1,500.00	\$ 1,500.00	
	Electrical Conductors	LF	1200	\$ 5.00	\$ 6,000.00	
	2070 Controller and Cabinet	EA	1	\$ 14,000.00	\$ 14,000.00	
	Firmware/Calibration	EA	1	\$ 5,300.00	\$ 5,300.00	
	Cabinet Foundation	EA	1	\$ 450.00	\$ 450.00	
	45' Mast Arm Poles and Foundation	EA	0	\$ 15,000.00	\$ -	
	Pedestal Pole	EA	1	\$ 1,000.00	\$ 1,000.00	
	Three Section Signal Head	EA	2	\$ 1,000.00	\$ 2,000.00	
	One Section Signal Head	EA	2	\$ 500.00	\$ 1,000.00	Ramp meter advance signal
	Signal Cable	LF	400	\$ 2.75	\$ 1,100.00	
Subtotal					\$ 61,907.50	
Communications						
	Serial Communications	EA	350	\$ 2.00	\$ 700.00	Link to MVDS
	Splice Enclosure	EA	1	\$ 1,000.00	\$ 1,000.00	Link to SMFO
	Pullbox (Special Size)	EA	1	\$ 1,750.00	\$ 1,750.00	For splice enclosure
	Interconnect Center	EA	1	\$ 1,500.00	\$ 1,500.00	In cabinet
	Fiber-optic Drop Cable (six strands)	LF	500	\$ 1.50	\$ 750.00	Drop cable to controller cabinet
	Ethernet Switch	EA	1	\$ 1,700.00	\$ 1,700.00	
Subtotal					\$ 7,400.00	
Pavement Marking						
	Pavement Marking Removal	LF	640	\$ 0.62	\$ 396.80	40 mph design speed. 110' transitions, 100' narrowed lane

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**Typical Design and Construction Costs
Single Lane Ramp Meter**

Log No.: 030
Location: I-40 Eastbound Exit 287

Ramp: Harrison Avenue

Categories	Description	Unit	Quantity	Unit Cost	Total Cost	Assumptions
Earthwork and Structures						
	Retaining Wall 5' High	LF	0	\$ 250.00	\$ -	
	Retaining Wall 10' High	LF	0	\$ 475.00	\$ -	
	Excavation	CY	0	\$ 4.00	\$ -	
	Fill	CY	0	\$ 5.00	\$ -	
	Seeding	SY	1566	\$ 2.50	\$ 3,915.00	Seeding around trench, conduit runs, pull box, and foundation areas
Subtotal					\$ 3,915.00	
Guardrail						
	Guardrail Rail	LF	250	\$ 15.00	\$ 3,750.00	
	Guardrail Approach End Treatment	EA	1	\$ 1,500.00	\$ 1,500.00	
Subtotal					\$ 5,250.00	
Drainage						
	Pipe	LF	0	\$ 44.00	\$ -	
Subtotal					\$ -	
Signalization						
	6'x6' loops	EA	5	\$ 394.50	\$ 1,972.50	One queue, three passage and one clearance
	Detector Lead-in Cable	EA	390	\$ 1.50	\$ 585.00	Assumed setback distance 350'
	MVDS detector	EA	1	\$ 1,800.00	\$ 1,800.00	Mainline detection
	Detector pole	EA	1	\$ 6,000.00	\$ 6,000.00	
	Pullbox (Std.)	EA	6	\$ 300.00	\$ 1,800.00	
	Conduit (Trenched)	LF	2300	\$ 6.00	\$ 13,800.00	All purposes
	Conduit (Directional Drilled)	LF	50	\$ 14.00	\$ 700.00	One ramp crossing, multiple conduits
	Electrical Service	EA	1	\$ 1,500.00	\$ 1,500.00	
	Electrical Conductors	LF	950	\$ 5.00	\$ 4,750.00	
	2070 Controller and Cabinet	EA	1	\$ 14,000.00	\$ 14,000.00	
	Firmware/Calibration	EA	1	\$ 5,300.00	\$ 5,300.00	
	Cabinet Foundation	EA	1	\$ 450.00	\$ 450.00	
	45' Mast Arm Poles and Foundation	EA	0	\$ 15,000.00	\$ -	
	Pedestal Pole	EA	1	\$ 1,000.00	\$ 1,000.00	
	Three Section Signal Head	EA	2	\$ 1,000.00	\$ 2,000.00	
	One Section Signal Head	EA	2	\$ 500.00	\$ 1,000.00	Ramp meter advance signal
	Signal Cable	LF	400	\$ 2.75	\$ 1,100.00	
Subtotal					\$ 57,757.50	
Communications						
	Serial Communications	EA	350	\$ 2.00	\$ 700.00	Link to MVDS
	Splice Enclosure	EA	1	\$ 1,000.00	\$ 1,000.00	Link to SMFO
	Pullbox (Special Size)	EA	1	\$ 1,750.00	\$ 1,750.00	For splice enclosure
	Interconnect Center	EA	1	\$ 1,500.00	\$ 1,500.00	In cabinet
	Fiber-optic Drop Cable (six strands)	LF	500	\$ 1.50	\$ 750.00	Drop cable to controller cabinet
	Ethernet Switch	EA	1	\$ 1,700.00	\$ 1,700.00	
Subtotal					\$ 7,400.00	
Pavement Marking						
	Pavement Marking Removal	LF	640	\$ 0.62	\$ 396.80	40 mph design speed. 110' transitions, 100' narrowed lane

**Typical Design and Construction Costs
Single Lane Ramp Meter**

Log No.: 030

Ramp: Harrison Avenue

Location: I-40 Eastbound Exit 287

Categories	Description	Unit	Quantity	Unit Cost	Total Cost	Assumptions
	Raised Pavement Markers	EA	0	\$ 4.50	\$ -	
	White Edge Line	LF	320	\$ 0.95	\$ 304.00	110' transitions, 100' narrowed lane
	Yellow Edge Line	LF	320	\$ 0.95	\$ 304.00	110' transitions, 100' narrowed lane
	24" Stop Bar	LF	12	\$ 7.00	\$ 84.00	
Subtotal					\$ 1,088.80	
Signing						
	W3-8, Ramp Metered When Flashing	EA	2	\$ 650.00	\$ 1,300.00	Sign and post only
	W3-4, Be Prepared to Stop	EA	1	\$ 650.00	\$ 650.00	Sign and post
	R10-6, Stop Here on Red	EA	1	\$ 175.00	\$ 175.00	Pedestal mounted
	R10-28, XX Vehicles Per Green	EA	1	\$ 175.00	\$ 175.00	Pedestal mounted
Subtotal					\$ 2,300.00	
Subtotal Construction					\$ 78,000.00	
Traffic Control				3%	\$ 3,000.00	
Contingencies				10%	\$ 8,000.00	
Total Construction					\$ 89,000.00	
Design				8%	\$ 8,000.00	
Construction Administration				10%	\$ 9,000.00	
Total Design and Construction					\$ 106,000.00	

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**Typical Design and Construction Costs
Single Lane Ramp Meter**

Log No.: 043

Ramp: Gorman Street

Location: I-40 Westbound Exit 295

Categories	Description	Unit	Quantity	Unit Cost	Total Cost	Assumptions
Earthwork and Structures						
	Retaining Wall 5' High	LF	0	\$ 250.00	\$ -	
	Retaining Wall 10' High	LF	0	\$ 475.00	\$ -	
	Excavation	CY	0	\$ 4.00	\$ -	
	Fill	CY	0	\$ 5.00	\$ -	
	Seeding	SY	1799	\$ 2.50	\$ 4,497.50	Seeding around trench, conduit runs, pull box, and foundation areas
Subtotal					\$ 4,497.50	
Guardrail						
	Guardrail Rail	LF	250	\$ 15.00	\$ 3,750.00	
	Guardrail Approach End Treatment	EA	1	\$ 1,500.00	\$ 1,500.00	
Subtotal					\$ 5,250.00	
Drainage						
	Pipe	LF	0	\$ 44.00	\$ -	
Subtotal					\$ -	
Signalization						
	6'x6' loops	EA	5	\$ 394.50	\$ 1,972.50	One queue, three passage and one clearance
	Detector Lead-in Cable	EA	390	\$ 1.50	\$ 585.00	Assumed setback distance 350'
	MVDS detector	EA	1	\$ 1,800.00	\$ 1,800.00	Mainline detection
	Detector pole	EA	1	\$ 6,000.00	\$ 6,000.00	
	Pullbox (Std.)	EA	6	\$ 300.00	\$ 1,800.00	
	Conduit (Trenched)	LF	2650	\$ 6.00	\$ 15,900.00	All purposes
	Conduit (Directional Drilled)	LF	50	\$ 14.00	\$ 700.00	One ramp crossing, multiple conduits
	Electrical Service	EA	1	\$ 1,500.00	\$ 1,500.00	
	Electrical Conductors	LF	1300	\$ 5.00	\$ 6,500.00	
	2070 Controller and Cabinet	EA	1	\$ 14,000.00	\$ 14,000.00	
	Firmware/Calibration	EA	1	\$ 5,300.00	\$ 5,300.00	
	Cabinet Foundation	EA	1	\$ 450.00	\$ 450.00	
	45' Mast Arm Poles and Foundation	EA	0	\$ 15,000.00	\$ -	
	Pedestal Pole	EA	1	\$ 1,000.00	\$ 1,000.00	
	Three Section Signal Head	EA	2	\$ 1,000.00	\$ 2,000.00	
	One Section Signal Head	EA	2	\$ 500.00	\$ 1,000.00	Ramp meter advance signal
	Signal Cable	LF	400	\$ 2.75	\$ 1,100.00	
Subtotal					\$ 61,607.50	
Communications						
	Serial Communications	EA	350	\$ 2.00	\$ 700.00	Link to MVDS
	Splice Enclosure	EA	1	\$ 1,000.00	\$ 1,000.00	Link to SMFO
	Pullbox (Special Size)	EA	1	\$ 1,750.00	\$ 1,750.00	For splice enclosure
	Interconnect Center	EA	1	\$ 1,500.00	\$ 1,500.00	In cabinet
	Fiber-optic Drop Cable (six strands)	LF	500	\$ 1.50	\$ 750.00	Drop cable to controller cabinet
	Ethernet Switch	EA	1	\$ 1,700.00	\$ 1,700.00	
Subtotal					\$ 7,400.00	
Pavement Marking						
	Pavement Marking Removal	LF	640	\$ 0.62	\$ 396.80	40 mph design speed. 110' transitions, 100' narrowed lane

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**Typical Design and Construction Costs
Single Lane Ramp Meter**

Log No.: 056

Ramp: Jones Sausage Rd.

Location: I-40 Westbound Exit 303

Categories	Description	Unit	Quantity	Unit Cost	Total Cost	Assumptions
Earthwork and Structures						
	Retaining Wall 5' High	LF	0	\$ 250.00	\$ -	
	Retaining Wall 10' High	LF	0	\$ 475.00	\$ -	
	Excavation	CY	0	\$ 4.00	\$ -	
	Fill	CY	0	\$ 5.00	\$ -	
	Seeding	SY	1799	\$ 2.50	\$ 4,497.50	Seeding around trench, conduit runs, pull box, and foundation areas
Subtotal					\$ 4,497.50	
Guardrail						
	Guardrail Rail	LF	250	\$ 15.00	\$ 3,750.00	
	Guardrail Approach End Treatment	EA	1	\$ 1,500.00	\$ 1,500.00	
Subtotal					\$ 5,250.00	
Drainage						
	Pipe	LF	0	\$ 44.00	\$ -	
Subtotal					\$ -	
Signalization						
	6'x6' loops	EA	5	\$ 394.50	\$ 1,972.50	One queue, three passage and one clearance
	Detector Lead-in Cable	EA	390	\$ 1.50	\$ 585.00	Assumed setback distance 350'
	MVDS detector	EA	1	\$ 1,800.00	\$ 1,800.00	Mainline detection
	Detector pole	EA	1	\$ 6,000.00	\$ 6,000.00	
	Pullbox (Std.)	EA	6	\$ 300.00	\$ 1,800.00	
	Conduit (Trenched)	LF	2650	\$ 6.00	\$ 15,900.00	All purposes
	Conduit (Directional Drilled)	LF	100	\$ 14.00	\$ 1,400.00	One ramp crossing, crossing from interstate median for power, multiple conduits
	Electrical Service	EA	1	\$ 1,500.00	\$ 1,500.00	
	Electrical Conductors	LF	1300	\$ 5.00	\$ 6,500.00	
	2070 Controller and Cabinet	EA	1	\$ 14,000.00	\$ 14,000.00	
	Firmware/Calibration	EA	1	\$ 5,300.00	\$ 5,300.00	
	Cabinet Foundation	EA	1	\$ 450.00	\$ 450.00	
	45' Mast Arm Poles and Foundation	EA	0	\$ 15,000.00	\$ -	
	Pedestal Pole	EA	1	\$ 1,000.00	\$ 1,000.00	
	Three Section Signal Head	EA	2	\$ 1,000.00	\$ 2,000.00	
	One Section Signal Head	EA	2	\$ 500.00	\$ 1,000.00	Ramp meter advance signal
	Signal Cable	LF	400	\$ 2.75	\$ 1,100.00	
Subtotal					\$ 62,307.50	
Communications						
	Serial Communications	EA	350	\$ 2.00	\$ 700.00	Link to MVDS
	Splice Enclosure	EA	1	\$ 1,000.00	\$ 1,000.00	Link to SMFO
	Pullbox (Special Size)	EA	1	\$ 1,750.00	\$ 1,750.00	For splice enclosure
	Interconnect Center	EA	1	\$ 1,500.00	\$ 1,500.00	In cabinet
	Fiber-optic Drop Cable (six strands)	LF	500	\$ 1.50	\$ 750.00	Drop cable to controller cabinet
	Ethernet Switch	EA	1	\$ 1,700.00	\$ 1,700.00	
Subtotal					\$ 7,400.00	
Pavement Marking						

M-0446 Ramp Metering Feasibility Study for Durham and Wake Counties
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**Typical Design and Construction Costs
Single Lane Ramp Meter**

Log No.: 089 **Ramp:** Jones Franklin Road
Location: I-440 Northbound Exit 1C

Categories	Description	Unit	Quantity	Unit Cost	Total Cost	Assumptions
Earthwork and Structures						
	Retaining Wall 5' High	LF	0	\$ 250.00	\$ -	
	Retaining Wall 10' High	LF	0	\$ 475.00	\$ -	
	Excavation	CY	0	\$ 4.00	\$ -	
	Fill	CY	0	\$ 5.00	\$ -	
	Seeding	SY	1699	\$ 2.50	\$ 4,247.50	Seeding around trench, conduit runs, pull box, and foundation areas
Subtotal					\$ 4,247.50	
Guardrail						
	Guardrail Rail	LF	250	\$ 15.00	\$ 3,750.00	
	Guardrail Approach End Treatment	EA	1	\$ 1,500.00	\$ 1,500.00	
Subtotal					\$ 5,250.00	
Drainage						
	Pipe	LF	0	\$ 44.00	\$ -	
Subtotal					\$ -	
Signalization						
	6'x6' loops	EA	5	\$ 394.50	\$ 1,972.50	One queue, three passage and one clearance
	Detector Lead-in Cable	EA	390	\$ 1.50	\$ 585.00	Assumed setback distance 350'
	MVDS detector	EA	1	\$ 1,800.00	\$ 1,800.00	Mainline detection
	Detector pole	EA	1	\$ 6,000.00	\$ 6,000.00	
	Pullbox (Std.)	EA	6	\$ 300.00	\$ 1,800.00	
	Conduit (Trenched)	LF	2500	\$ 6.00	\$ 15,000.00	All purposes
	Conduit (Directional Drilled)	LF	150	\$ 14.00	\$ 2,100.00	One ramp crossing, power from cabinet across intersection, multiple conduits
	Electrical Service	EA	1	\$ 1,500.00	\$ 1,500.00	
	Electrical Conductors	LF	1150	\$ 5.00	\$ 5,750.00	
	2070 Controller and Cabinet	EA	1	\$ 14,000.00	\$ 14,000.00	
	Firmware/Calibration	EA	1	\$ 5,300.00	\$ 5,300.00	
	Cabinet Foundation	EA	1	\$ 450.00	\$ 450.00	
	45' Mast Arm Poles and Foundation	EA	0	\$ 15,000.00	\$ -	
	Pedestal Pole	EA	1	\$ 1,000.00	\$ 1,000.00	
	Three Section Signal Head	EA	2	\$ 1,000.00	\$ 2,000.00	
	One Section Signal Head	EA	2	\$ 500.00	\$ 1,000.00	Ramp meter advance signal
	Signal Cable	LF	400	\$ 2.75	\$ 1,100.00	
Subtotal					\$ 61,357.50	
Communications						
	Serial Communications	EA	350	\$ 2.00	\$ 700.00	Link to MVDS
	Splice Enclosure	EA	1	\$ 1,000.00	\$ 1,000.00	Link to SMFO
	Pullbox (Special Size)	EA	1	\$ 1,750.00	\$ 1,750.00	For splice enclosure
	Interconnect Center	EA	1	\$ 1,500.00	\$ 1,500.00	In cabinet
	Fiber-optic Drop Cable (six strands)	LF	500	\$ 1.50	\$ 750.00	Drop cable to controller cabinet
	Ethernet Switch	EA	1	\$ 1,700.00	\$ 1,700.00	
Subtotal					\$ 7,400.00	
Pavement Marking						

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**Typical Design and Construction Costs
Single Lane Loop Ramp Meter**

Log No.: 090

Ramp: Jones Franklin Road

Location: I-40 Southbound Exit 1C

Categories	Description	Unit	Quantity	Unit Cost	Total Cost	Assumptions
Earthwork and Structures						
	Retaining Wall 5' High	LF	0	\$ 250.00	\$ -	
	Retaining Wall 10' High	LF	0	\$ 475.00	\$ -	
	Excavation	CY	0	\$ 4.00	\$ -	
	Fill	CY	0	\$ 5.00	\$ -	
	Seeding	SY	1299	\$ 2.50	\$ 3,247.50	Seeding around trench, conduit runs, pull box, and foundation areas
Subtotal					\$ 3,247.50	
Guardrail						
	Guardrail Rail	LF	250	\$ 15.00	\$ 3,750.00	
	Guardrail Approach End Treatment	EA	1	\$ 1,500.00	\$ 1,500.00	
Subtotal					\$ 5,250.00	
Drainage						
	Pipe	LF	0	\$ 44.00	\$ -	
Subtotal					\$ -	
Signalization						
	6'x6' loops	EA	5	\$ 394.50	\$ 1,972.50	One queue, three passage and one clearance
	Detector Lead-in Cable	EA	390	\$ 1.50	\$ 585.00	Assumed setback distance 350'
	MVDS detector	EA	1	\$ 1,800.00	\$ 1,800.00	Mainline detection
	Detector pole	EA	1	\$ 6,000.00	\$ 6,000.00	
	Pullbox (Std.)	EA	6	\$ 300.00	\$ 1,800.00	
	Conduit (Trenched)	LF	1900	\$ 6.00	\$ 11,400.00	All purposes
	Conduit (Directional Drilled)	LF	100	\$ 14.00	\$ 1,400.00	Two ramp crossing, mult. conduits
	Electrical Service	EA	1	\$ 1,500.00	\$ 1,500.00	
	Electrical Conductors	LF	550	\$ 5.00	\$ 2,750.00	
	2070 Controller and Cabinet	EA	1	\$ 14,000.00	\$ 14,000.00	
	Firmware/Calibration	EA	1	\$ 5,300.00	\$ 5,300.00	
	Cabinet Foundation	EA	1	\$ 450.00	\$ 450.00	
	45' Mast Arm Poles and Foundation	EA	0	\$ 15,000.00	\$ -	
	Pedestal Pole	EA	1	\$ 1,000.00	\$ 1,000.00	
	Three Section Signal Head	EA	2	\$ 1,000.00	\$ 2,000.00	
	One Section Signal Head	EA	2	\$ 500.00	\$ 1,000.00	Ramp meter advance signal
	Signal Cable	LF	400	\$ 2.75	\$ 1,100.00	
Subtotal					\$ 54,057.50	
Communications						
	Serial Communications	EA	350	\$ 2.00	\$ 700.00	Link to MVDS
	Splice Enclosure	EA	1	\$ 1,000.00	\$ 1,000.00	Link to SMFO
	Pullbox (Special Size)	EA	1	\$ 1,750.00	\$ 1,750.00	For splice enclosure
	Interconnect Center	EA	1	\$ 1,500.00	\$ 1,500.00	In cabinet
	Fiber-optic Drop Cable (six strands)	LF	500	\$ 1.50	\$ 750.00	Drop cable to controller cabinet
	Ethernet Switch	EA	1	\$ 1,700.00	\$ 1,700.00	
Subtotal					\$ 7,400.00	
Pavement Marking						

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**Typical Design and Construction Costs
Single Lane Ramp Meter**

Log No.: 095

Ramp: US 1 Eastbound to Southbound

Location: I-440 Southbound Exit 2

Categories	Description	Unit	Quantity	Unit Cost	Total Cost	Assumptions
Earthwork and Structures						
	Retaining Wall 5' High	LF	0	\$ 250.00	\$ -	
	Retaining Wall 10' High	LF	0	\$ 475.00	\$ -	
	Excavation	CY	0	\$ 4.00	\$ -	
	Fill	CY	0	\$ 5.00	\$ -	
	Seeding	SY	1832	\$ 2.50	\$ 4,580.00	Seeding around trench, conduit runs, pull box, and foundation areas
Subtotal					\$ 4,580.00	
Guardrail						
	Guardrail Rail	LF	250	\$ 15.00	\$ 3,750.00	
	Guardrail Approach End Treatment	EA	1	\$ 1,500.00	\$ 1,500.00	
Subtotal					\$ 5,250.00	
Drainage						
	Pipe	LF	0	\$ 44.00	\$ -	
Subtotal					\$ -	
Signalization						
	6'x6' loops	EA	5	\$ 394.50	\$ 1,972.50	One queue, three passage and one clearance
	Detector Lead-in Cable	EA	390	\$ 1.50	\$ 585.00	Assumed setback distance 350'
	MVDS detector	EA	1	\$ 1,800.00	\$ 1,800.00	Mainline detection
	Detector pole	EA	1	\$ 6,000.00	\$ 6,000.00	
	Pullbox (Std.)	EA	6	\$ 300.00	\$ 1,800.00	
	Conduit (Trenched)	LF	2700	\$ 6.00	\$ 16,200.00	All purposes
	Conduit (Directional Drilled)	LF	250	\$ 14.00	\$ 3,500.00	One ramp crossing, power from cabinet across intersection, multiple conduits
	Electrical Service	EA	1	\$ 1,500.00	\$ 1,500.00	
	Electrical Conductors	LF	1350	\$ 5.00	\$ 6,750.00	
	2070 Controller and Cabinet	EA	1	\$ 14,000.00	\$ 14,000.00	
	Firmware/Calibration	EA	1	\$ 5,300.00	\$ 5,300.00	
	Cabinet Foundation	EA	1	\$ 450.00	\$ 450.00	
	45' Mast Arm Poles and Foundation	EA	0	\$ 15,000.00	\$ -	
	Pedestal Pole	EA	1	\$ 1,000.00	\$ 1,000.00	
	Three Section Signal Head	EA	2	\$ 1,000.00	\$ 2,000.00	
	One Section Signal Head	EA	2	\$ 500.00	\$ 1,000.00	Ramp meter advance signal
	Signal Cable	LF	400	\$ 2.75	\$ 1,100.00	
Subtotal					\$ 64,957.50	
Communications						
	Serial Communications	EA	350	\$ 2.00	\$ 700.00	Link to MVDS
	Splice Enclosure	EA	1	\$ 1,000.00	\$ 1,000.00	Link to SMFO
	Pullbox (Special Size)	EA	1	\$ 1,750.00	\$ 1,750.00	For splice enclosure
	Interconnect Center	EA	1	\$ 1,500.00	\$ 1,500.00	In cabinet
	Fiber-optic Drop Cable (six strands)	LF	500	\$ 1.50	\$ 750.00	Drop cable to controller cabinet
	Ethernet Switch	EA	1	\$ 1,700.00	\$ 1,700.00	
Subtotal					\$ 7,400.00	
Pavement Marking						

**Typical Design and Construction Costs
Single Lane Ramp Meter**

Log No.: 095

Ramp: US 1 Eastbound to Southbound

Location: I-440 Southbound Exit 2

Categories	Description	Unit	Quantity	Unit Cost	Total Cost	Assumptions
	Pavement Marking Removal	LF	640	\$ 0.62	\$ 396.80	40 mph design speed. 110' transitions, 100' narrowed lane
	Raised Pavement Markers	EA	0	\$ 4.50	\$ -	
	White Edge Line	LF	320	\$ 0.95	\$ 304.00	110' transitions, 100' narrowed lane
	Yellow Edge Line	LF	320	\$ 0.95	\$ 304.00	110' transitions, 100' narrowed lane
	24" Stop Bar	LF	12	\$ 7.00	\$ 84.00	
Subtotal					\$ 1,088.80	
Signing						
	W3-8, Ramp Metered When Flashing	EA	2	\$ 650.00	\$ 1,300.00	Sign and post only
	W3-4, Be Prepared to Stop	EA	1	\$ 650.00	\$ 650.00	Sign and post
	R10-6, Stop Here on Red	EA	1	\$ 175.00	\$ 175.00	Pedestal mounted
	R10-28, XX Vehicles Per Green	EA	1	\$ 175.00	\$ 175.00	Pedestal mounted
Subtotal					\$ 2,300.00	
Subtotal Construction					\$ 86,000.00	
Traffic Control				3%	\$ 3,000.00	
Contingencies				10%	\$ 9,000.00	
Total Construction					\$ 98,000.00	
Design				8%	\$ 8,000.00	
Construction Administration				10%	\$ 10,000.00	
Total Design and Construction					\$ 116,000.00	

**Typical Design and Construction Costs
Site Assumptions Checklist**

Log No.:	108	Ramp:	US 70
Location:	I-440 Westbound Exit 7		Southbound to Westbound
Two Lane Ramp Widening (Y/N):		<input type="text" value="N"/>	
Length of Two Lane Ramp Widening (ft.):		<input type="text" value="0"/>	
Distance from Stopbar to W3-8 sign (ft.):		<input type="text" value="550"/>	
Pipe Crossings (Y/N):		<input type="text" value="N"/>	
Retaining Walls (Y/N):		<input type="text" value="N"/>	
Fill (Y/N):		<input type="text" value="N"/>	
Guardrail Other than for Ramp Meter Equipment (Y/N):		<input type="text" value="N"/>	
Nearest Power Source (ft.):		<input type="text" value="650"/>	

Notes
Nearest power source is from CCTV. Install equipment on left side only, protect with guardrail

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**Typical Design and Construction Costs
Single Lane Ramp Meter**

Log No.: 108

Ramp: US 70 Southbound to Westbound

Location: I-440 Westbound Exit 7

Categories	Description	Unit	Quantity	Unit Cost	Total Cost	Assumptions
Earthwork and Structures						
	Retaining Wall 5' High	LF	0	\$ 250.00	\$ -	
	Retaining Wall 10' High	LF	0	\$ 475.00	\$ -	
	Excavation	CY	0	\$ 4.00	\$ -	
	Fill	CY	0	\$ 5.00	\$ -	
	Seeding	SY	1366	\$ 2.50	\$ 3,415.00	Seeding around trench, conduit runs, pull box, and foundation areas
Subtotal					\$ 3,415.00	
Guardrail						
	Guardrail Rail	LF	250	\$ 15.00	\$ 3,750.00	
	Guardrail Approach End Treatment	EA	1	\$ 1,500.00	\$ 1,500.00	
Subtotal					\$ 5,250.00	
Drainage						
	Pipe	LF	0	\$ 44.00	\$ -	
Subtotal					\$ -	
Signalization						
	6'x6' loops	EA	5	\$ 394.50	\$ 1,972.50	One queue, three passage and one clearance
	Detector Lead-in Cable	EA	390	\$ 1.50	\$ 585.00	Assumed setback distance 350'
	MVDS detector	EA	1	\$ 1,800.00	\$ 1,800.00	Mainline detection
	Detector pole	EA	1	\$ 6,000.00	\$ 6,000.00	
	Pullbox (Std.)	EA	6	\$ 300.00	\$ 1,800.00	
	Conduit (Trenched)	LF	2000	\$ 6.00	\$ 12,000.00	All purposes
	Conduit (Directional Drilled)	LF	50	\$ 14.00	\$ 700.00	One ramp crossing, power from cabinet across intersection, multiple conduits
	Electrical Service	EA	1	\$ 1,500.00	\$ 1,500.00	
	Electrical Conductors	LF	650	\$ 5.00	\$ 3,250.00	
	2070 Controller and Cabinet	EA	1	\$ 14,000.00	\$ 14,000.00	
	Firmware/Calibration	EA	1	\$ 5,300.00	\$ 5,300.00	
	Cabinet Foundation	EA	1	\$ 450.00	\$ 450.00	
	45' Mast Arm Poles and Foundation	EA	0	\$ 15,000.00	\$ -	
	Pedestal Pole	EA	1	\$ 1,000.00	\$ 1,000.00	
	Three Section Signal Head	EA	2	\$ 1,000.00	\$ 2,000.00	
	One Section Signal Head	EA	2	\$ 500.00	\$ 1,000.00	Ramp meter advance signal
	Signal Cable	LF	400	\$ 2.75	\$ 1,100.00	
Subtotal					\$ 54,457.50	
Communications						
	Serial Communications	EA	350	\$ 2.00	\$ 700.00	Link to MVDS
	Splice Enclosure	EA	1	\$ 1,000.00	\$ 1,000.00	Link to SMFO
	Pullbox (Special Size)	EA	1	\$ 1,750.00	\$ 1,750.00	For splice enclosure
	Interconnect Center	EA	1	\$ 1,500.00	\$ 1,500.00	In cabinet
	Fiber-optic Drop Cable (six strands)	LF	500	\$ 1.50	\$ 750.00	Drop cable to controller cabinet
	Ethernet Switch	EA	1	\$ 1,700.00	\$ 1,700.00	
Subtotal					\$ 7,400.00	
Pavement Marking						

**Typical Design and Construction Costs
Single Lane Ramp Meter**

Log No.: 108

Ramp: US 70 Southbound to Westbound

Location: I-440 Westbound Exit 7

Categories	Description	Unit	Quantity	Unit Cost	Total Cost	Assumptions
	Pavement Marking Removal	LF	640	\$ 0.62	\$ 396.80	40 mph design speed. 110' transitions, 100' narrowed lane
	Raised Pavement Markers	EA	0	\$ 4.50	\$ -	
	White Edge Line	LF	320	\$ 0.95	\$ 304.00	110' transitions, 100' narrowed lane
	Yellow Edge Line	LF	320	\$ 0.95	\$ 304.00	110' transitions, 100' narrowed lane
	24" Stop Bar	LF	12	\$ 7.00	\$ 84.00	
Subtotal					\$ 1,088.80	
Signing						
	W3-8, Ramp Metered When Flashing	EA	2	\$ 650.00	\$ 1,300.00	Sign and post only
	W3-4, Be Prepared to Stop	EA	1	\$ 650.00	\$ 650.00	Sign and post
	R10-6, Stop Here on Red	EA	1	\$ 175.00	\$ 175.00	Pedestal mounted
	R10-28, XX Vehicles Per Green	EA	1	\$ 175.00	\$ 175.00	Pedestal mounted
Subtotal					\$ 2,300.00	
Subtotal Construction					\$ 74,000.00	
Traffic Control				3%	\$ 3,000.00	
Contingencies				10%	\$ 8,000.00	
Total Construction					\$ 85,000.00	
Design				8%	\$ 7,000.00	
Construction Administration				10%	\$ 9,000.00	
Total Design and Construction					\$ 101,000.00	

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**Typical Design and Construction Costs
Two Lane Freeway to Freeway Ramp Meter**

Log No.: 133 **Ramp:** US 70
Location: I-540 Eastbound Exit 4

Categories	Description	Unit	Quantity	Unit Cost	Total Cost	Assumptions
Earthwork and Structures						
	Retaining Wall 5' High	LF	0	\$ 250.00	\$ -	
	Retaining Wall 10' High	LF	0	\$ 475.00	\$ -	
	Excavation	CY	0	\$ 4.00	\$ -	
	Fill	CY	0	\$ 5.00	\$ -	
	Seeding	SY	2388	\$ 2.50	\$ 5,970.00	Seeding along pavement widening and around trench, conduit, pull box, and foundation areas
Subtotal					\$ 5,970.00	
Guardrail						
	Guardrail Rail	LF	1250	\$ 15.00	\$ 18,750.00	
	Guardrail Approach End Treatment	EA	5	\$ 1,500.00	\$ 7,500.00	
Subtotal					\$ 26,250.00	
Paving						
	Ramp Widening	SY	0	\$ 32.00	\$ -	
	Pavement Resurfacing	SY	0	\$ 12.00	\$ -	
Subtotal					\$ -	
Drainage						
	Pipe	LF	0	\$ 44.00	\$ -	
Subtotal					\$ -	
Signalization						
	6'x6' loops	EA	10	\$ 394.50	\$ 3,945.00	One queue, three passage and one clearance
	Detector Lead-in Cable	EA	390	\$ 1.50	\$ 585.00	Assumed setback distance 350'
	MVDS detector	EA	1	\$ 1,800.00	\$ 1,800.00	Mainline detection
	Detector pole	EA	1	\$ 6,000.00	\$ 6,000.00	
	Pullbox (Std.)	EA	10	\$ 300.00	\$ 3,000.00	
	Conduit (Trenched)	LF	3510	\$ 6.00	\$ 21,060.00	All purposes
	Conduit (Directional Drilled)	LF	100	\$ 14.00	\$ 1,400.00	electrical conduit on Mt. Herman Rd
	Electrical Service	EA	1	\$ 1,500.00	\$ 1,500.00	
	Electrical Conductors	LF	1400	\$ 5.00	\$ 7,000.00	
	2070 Controller and Cabinet	EA	1	\$ 14,000.00	\$ 14,000.00	
	Firmware/Calibration	EA	1	\$ 5,300.00	\$ 5,300.00	
	Cabinet Foundation	EA	1	\$ 450.00	\$ 450.00	
	45' Mast Arm Poles and Foundation	EA	1	\$ 15,000.00	\$ 15,000.00	
	Pedestal Pole	EA	0	\$ 1,000.00	\$ -	
	Three Section Signal Head	EA	2	\$ 1,000.00	\$ 2,000.00	
	One Section Signal Head	EA	6	\$ 500.00	\$ 3,000.00	Ramp meter advance signal
	Signal Cable	LF	1786	\$ 2.75	\$ 4,911.50	
Subtotal					\$ 90,951.50	
Communications						
	Serial Communications	EA	350	\$ 2.00	\$ 700.00	Link to MVDS
	Splice Enclosure	EA	1	\$ 1,000.00	\$ 1,000.00	Link to SMFO
	Pullbox (Special Size)	EA	1	\$ 1,750.00	\$ 1,750.00	For splice enclosure
	Interconnect Center	EA	1	\$ 1,500.00	\$ 1,500.00	In cabinet
	Fiber-optic Drop Cable (six strands)	LF	500	\$ 1.50	\$ 750.00	Drop cable to controller cabinet
	Ethernet Switch	EA	1	\$ 1,700.00	\$ 1,700.00	
Subtotal					\$ 7,400.00	

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**Typical Design and Construction Costs
Two Lane Freeway to Freeway Ramp Meter**

Log No.: 133 **Ramp:** US 70
Location: I-540 Eastbound Exit 4

Categories	Description	Unit	Quantity	Unit Cost	Total Cost	Assumptions
Pavement Marking						
	Raised Pavement Markers	EA	0	\$ 4.50	\$ -	Along skip line only
	White Edge Line	LF	400	\$ 0.95	\$ 380.00	200' transitions, 100' narrowed lane, 50 MPH
	Yellow Edge Line	LF	600	\$ 0.95	\$ 570.00	300' transitions, 100' narrowed lane, 50 MPH
	24" Stop Bar	LF	24	\$ 7.00	\$ 168.00	
	White Skip Line	LF	0	\$ 0.24	\$ -	
Subtotal					\$ 1,118.00	
Signing						
	W3-8, Ramp Metered When Flashing	EA	2	\$ 650.00	\$ 1,300.00	Sign and post only
	W3-4, Be Prepared to Stop	EA	1	\$ 650.00	\$ 650.00	Sign and post
	R10-6, Stop Here on Red	EA	1	\$ 175.00	\$ 175.00	Pedestal mounted
	R10-28, XX Vehicles Per Green	EA	1	\$ 175.00	\$ 175.00	Pedestal mounted
	W4-1L, Merge Left	EA	2	\$ 650.00	\$ 1,300.00	
	Sign Structure (Cantilever)	EA	3	\$ 50,000.00	\$ 150,000.00	
	Ramp Meter On Sign (Message A)	EA	2	\$ 5,000.00	\$ 10,000.00	
	Prepare to Stop Sign (Message B)	EA	1	\$ 5,000.00	\$ 5,000.00	
Subtotal					\$ 168,600.00	
Subtotal Construction					\$ 301,000.00	
Traffic Control				3%	\$ 10,000.00	
Contingencies				10%	\$ 31,000.00	
Total Construction					\$ 342,000.00	
Design				8%	\$ 28,000.00	
Construction Administration				10%	\$ 35,000.00	
Total Design and Construction					\$ 405,000.00	

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