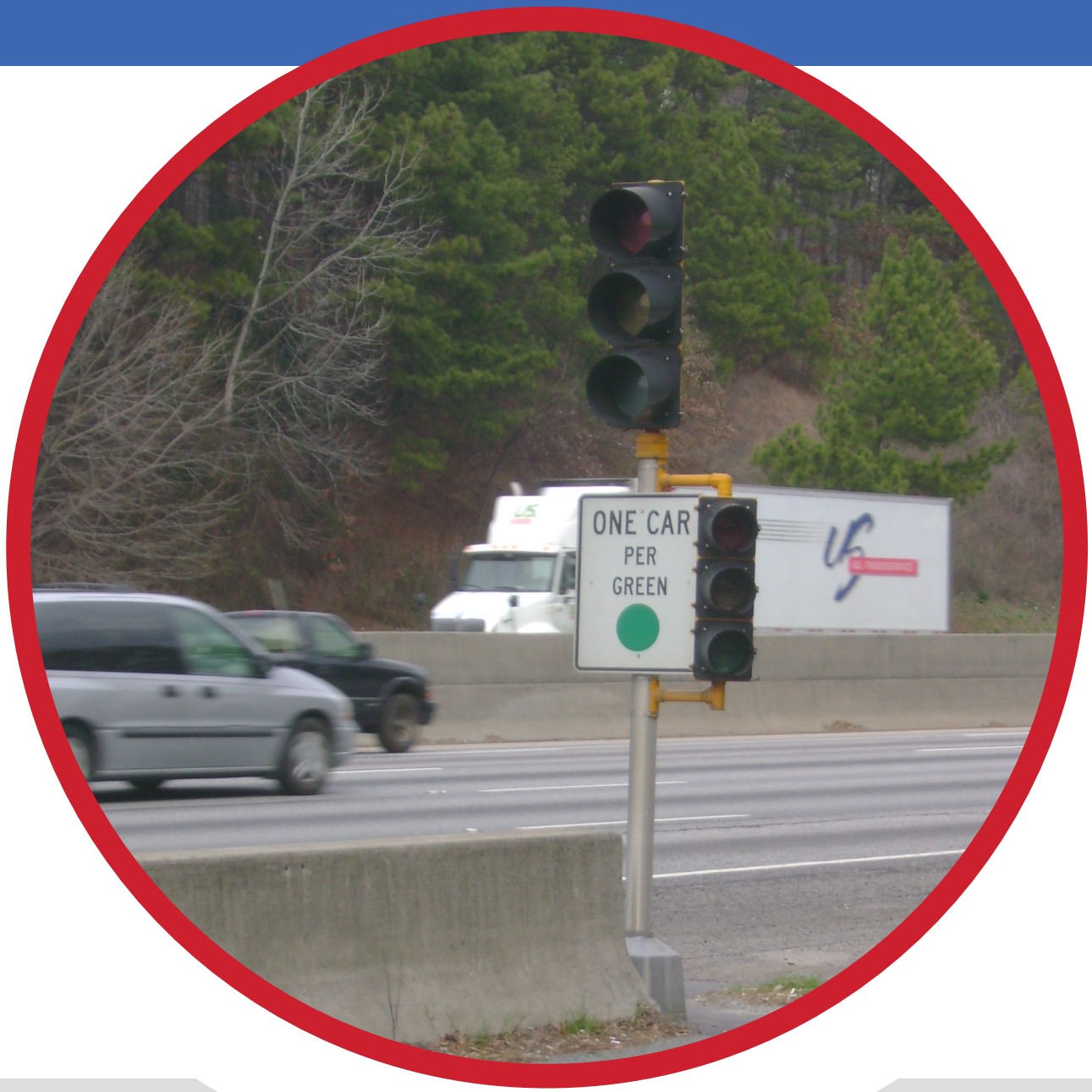
Detailed Analysis



M-0468 Ramp Metering Feasibility Study for Cabarrus, Gaston, Iredell and Mecklenburg Counties

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1. Detailed Review

This section outlines the work undertaken and the provisional results of the Detailed Review, covered under the following subsections:

- 1.1 Grouping by Congestion Problem,
- 1.2 Site Visits,
- 1.3 Traffic Counts,
- 1.4 Crash Data,
- 1.5 Traffic Signal Data, and
- 1.6 Categorization of Sites.

The relationship of these tasks is shown in Figure 1.

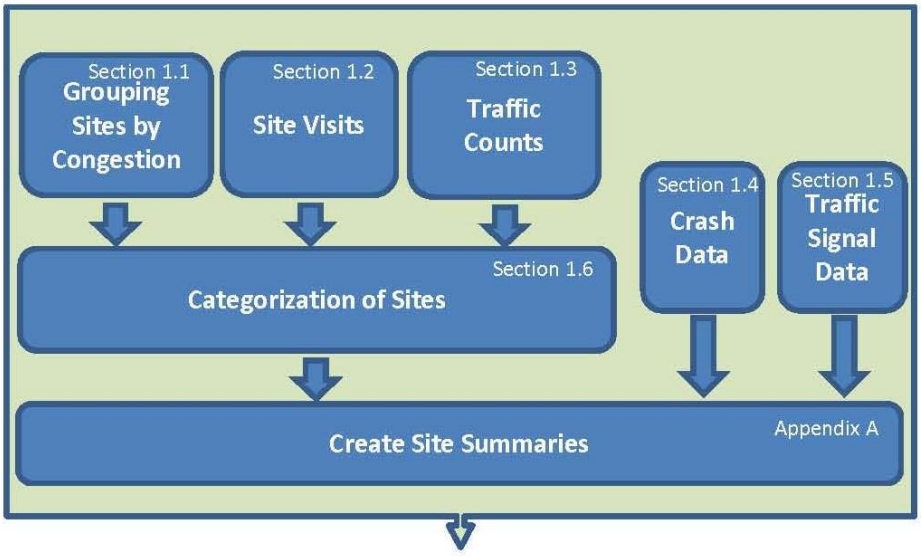


Figure 1. Relationship of Detailed Review Subtasks

In order to capture and present all of the information gathered during the detailed analysis, Site Summaries in Appendix C were created for each site and grouped accordingly.

1.1. Grouping of Sites by Congestion Problem

Sites have been grouped according to their related congestion problems so that decisions made about each site, which are sometimes linked to decisions for other sites, can be placed into context. Grouping is based on the following four general classifications:

- **Uncongested sites** involve sites that are not adjacent to significant congestion but were retained as per the Steering Committee meeting on 02/19/16 (see Table 1).
- **Individual sites** involve one congestion problem that is related to only one candidate ramp metering site (see Table 2).
- **Multiple sites** involve one congestion problem that is related to, or adjacent to, a number of candidate ramp metering sites (see Table 3).
- **Groups of congestion** involve a number of congestion problems that exist and overlap on a stretch of freeway. For example, the spillback from a downstream congestion problem overlaps the flow breakdown point of an upstream congestion

problem, or congestion problems exist at different times of the day. In this analysis, eight such groups of congestion can be found (see Table 4). Each of these contain multiple candidate sites.

Table 1. Uncongested Sites

Site Log	TO Freeway	Freeway Direction	Cross Street	Approx. Exit	County
148	I-77	SB	Langtree Rd.	31	Iredell
149	I-77	NB	Langtree Rd.	31	Iredell

Table 2. Individual Sites

Congestion Reference No.	Primary Site Log	TO Freeway	Freeway Direction	Cross Street	Approx. Exit	County
M007	045	I-85	NB	Little Rock Rd.	32	Mecklenburg
M011	067	I-85	NB	Sugar Creek Rd.	41	Mecklenburg
M013	075	I-85	NB	Mallard Creek Rd.	46	Mecklenburg
M037	146	I-77	SB	Goodrum Rd / Griffith St.	30	Mecklenburg
M039	180	I-485	Outer	West Blvd.	6	Mecklenburg
M040	181	I-485	Inner	West Blvd.	6	Mecklenburg
M041	182	I-485	Outer	US 74 / US 29 (Wilkinson Blvd.)	9	Mecklenburg
M058	250	US 74/ Independence Blvd.	WB	Briar Creek Rd.	244	Mecklenburg

Table 3. Multiple Sites

Congestion Reference No.	Primary Site Log	TO Freeway	Freeway Direction	Cross Street	Approx. Exit	County
M005	030	I-85	NB	Cox Rd.	21	Gaston
M005	032	I-85	NB	S Main St.	22	Gaston
M005	034	I-85	NB	McAdenville Rd.	23	Gaston
M048	150	I-77	SB	Williamson Rd. / US 21 (Charlotte Hwy.)	33	Iredell
M048	153	I-77	SB	SR 1100 (Brawley School Rd.)	35	Iredell
M049	175	I-485	Inner	Arrowood Rd.	3	Mecklenburg
M049	177	I-485	Inner (Loop)	Steele Creek Rd.	4	Mecklenburg
M049	179	I-485	Outer	Steele Creek Rd.	4	Mecklenburg

Table 4. Groups of Congestion and Sites in each Group

Congestion Group No.	Primary Site Log	TO Freeway	Freeway Direction	Cross Street	Approx. Exit	County
Group 1 (M004, M006)	033	I-85	SB	McAdenville Rd.	23	Gaston
	035	I-85	SB	Belmont-Mt. Holly Rd.	26	Gaston
	037	I-85	SB	Beatty Dr. / Park St.	27	Gaston
Group 2 (M008, M009, M012)	064	I-85	SB (Loop)	Graham St.	40	Mecklenburg
	069	I-85	SB	University City Blvd.	43	Mecklenburg
	072	I-85	SB	Harris Blvd.	45	Mecklenburg
Group 3 (M020, M021, M023, M027, M044, M029)	093	I-77	SB	Westinghouse Blvd.	1A	Mecklenburg
	097*	I-77	SB	I-485	1B	Mecklenburg
	099	I-77	SB	Arrowood Rd.	3	Mecklenburg
	102	I-77	SB	Nations Ford Rd.	4	Mecklenburg
	104	I-77	SB	Tyvola Rd.	5	Mecklenburg
	109	I-77	SB	Clanton Rd.	7	Mecklenburg
	111	I-77	SB	Remount Rd.	8	Mecklenburg
	117	I-77	SB (Loop)	West Trade St.	10	Mecklenburg
Group 4 (M028, M026, M025, M024, M022)	105	I-77	NB	Tyvola Rd.	5	Mecklenburg
	103	I-77	NB	Nations Ford Rd.	4	Mecklenburg
	101	I-77	NB	Arrowood Rd.	3	Mecklenburg
Group 5 (M031, M045)	129*	I-77	NB	I-85 SB	13	Mecklenburg
Group 6 (M038, M036, M035, M033)	147	I-77	NB	Goodrum Rd. / Griffith St.	30	Mecklenburg
	145	I-77	NB	US 21 (Catawba Ave.)	28	Mecklenburg
	143	I-77	NB	NC 73 (Sam Furr Rd.)	25	Mecklenburg
	140	I-77	NB	Gilead Rd.	23	Mecklenburg
Group 7 (M051, M053, M055)	230	I-485	Outer	NC 16 (Providence Rd.)	57	Mecklenburg
	232	I-485	Outer (Loop)	NC 16 (Providence Rd.)	57	Mecklenburg
	234	I-485	Outer	Rea Rd.	59	Mecklenburg
	235	I-485	Outer (Loop)	Rea Rd.	59	Mecklenburg
	238	I-485	Outer	US 521 (Johnston Rd.)	61	Mecklenburg
	239	I-485	Outer (Loop)	US 521 (Johnston Rd.)	61	Mecklenburg
Group 8 (M054, M052)	237	I-485	Inner	Rea Rd.	59	Mecklenburg
	236	I-485	Inner (Loop)	Rea Rd.	59	Mecklenburg

Congestion Group No.	Primary Site Log	TO Freeway	Freeway Direction	Cross Street	Approx. Exit	County
	233	I-485	Inner (Loop)	NC 16 (Providence Rd.)	57	Mecklenburg
	231	I-485	Inner (Loop)	NC 16 (Providence Rd.)	57	Mecklenburg
	229	I-485	Inner	E John St.	52	Mecklenburg

* Freeway to Freeway (F2F) sites that have been included in the detailed analysis to help understand the characteristics; currently, there are no plans to implement ramp metering at these sites.

Assumptions made about the congestion that could be reduced by each potential ramp metering site depend on whether the site has been classified as Individual, Multiple or Group. These assumptions, as well as the calculations performed for Multiple and Group sites, are described in Appendix B.

1.2. Site Visits

Each potential ramp metering site has been visited to gather the following information, summarized in the Observations section of the Site Summaries in Appendix C:

- General description of location;
- Confirmation of findings from the high-level geometric data analysis;
- Sight line distances;
- Ramp gradient;
- Pavement condition;
- Position of guardrail;
- Presence of shoulder or other facility for parking of maintenance/enforcement vehicles;
- Potential for altering layouts (e.g., increasing number of lanes on the entrance ramp if required);
- Closed-circuit television (CCTV) coverage;
- Presence of existing NCDOT fiber-optic communications cable; and
- Other general observations pertinent to the feasibility of a ramp meter at that location.

1.3. Traffic Counts

In order to assess whether a site is feasible for the implementation of ramp metering, it is important to understand the traffic volumes on the ramp and on the freeway, both directly upstream and downstream of the merge. Maximum and minimum volumes in each of these locations are outlined in the Typical Design Criteria, produced as part of this study, and are used to determine if the traffic volumes are within acceptable limits for each site during the times of day when congestion is observed. Traffic counts were collected to ascertain upstream, downstream, and entrance ramp volumes at each of the 51 sites.

The results of the traffic counts analysis can be found in the Traffic Volumes section of the Site Summaries. Results are detailed for each hour between 6:00 AM and 8:00 PM to determine if the volumes are feasible for the operation of ramp metering. For ramp metering to be successful, the hours during which volumes are feasible must correspond

with the hours during which congestion is observed. The Site Selection Comments section in the Site Summaries notes these results. If the volumes on the entrance ramp are too high, the comments also contain information on increasing the number of lanes on the entrance ramp to increase its suitability for ramp metering. Most ramps proposed to move forward in this study have medium to heavy amounts of congestion, especially during the peak hours. These locations would see the most benefit to the implementation of metering the ramp. Those with lower volumes, for the most part, would not see a benefit in the reduction of congestion. Therefore implementing ramp metering at these locations is not recommended.

1.4. Crash Data

NCDOT provided crash data covering a period of 5 years from March 2011 to February 2016 in the vicinity of each of the potential ramp metering sites. These data have been analyzed to identify rear-end, slow, or stop as well as sideswipe or same-direction crashes. These types of accidents are associated with congestion and can potentially be corrected with the implementation of ramp metering. A look at the possible benefits from implementing Ramp Metering at the proposed locations could see congestion related accidents reduced between 25% and 75%.

The results of the crash data analysis are expressed as a number and a percentage of overall crashes at each location, and can be found in the Crash Data section of the Site Summaries in Appendix C.

1.5. Traffic Signal Data

Where traffic signals on the surface street feed to a potential ramp metering site, it is important to know how long the platoons of traffic released by signals onto the ramp are, especially where ramp volumes are high or the entrance ramp is short. This information is used to assess whether the queue management system will become overwhelmed and to address any related recommendations. Table 5 shows which sites have signals on the surface street with relatively high volumes, and require queue management evaluation. Platoon lengths for these sites were calculated for the relevant peak hour based upon the actual signal cycle length.

Table 5. Platoon Length Analysis

Site Log	FROM Cross Street	TO Freeway	Freeway Direction	Approx. Exit	County	Peak Hour Cycle Length (sec.)	Vehicles Per Cycle	Platoon Length (ft.) per Cycle
064	Graham St.	I-85	SB (Loop)	40	Mecklenburg	120	22	550
075	Mallard Creek Rd.	I-85	NB	46	Mecklenburg	140	43	1075
093	Westinghouse Blvd.	I-77	SB	1A	Mecklenburg	120	40	1000
103	Nations Ford Rd.	I-77	NB	4	Mecklenburg	110	20	500
140	Gilead Rd.	I-77	NB	23	Mecklenburg	105	20	500
143	NC 73 (Sam Furr Rd.)	I-77	NB	25	Mecklenburg	130	23	575
145	US 21 (Catawba Ave.)	I-77	NB	28	Mecklenburg	120	43	1075
146	Goodrum Rd. / Griffith St.	I-77	SB	30	Mecklenburg	120	22	550
230	NC 16 (Providence Rd.)	I-485	Outer	57	Mecklenburg	120	12	300
231	NC 16 (Providence Rd.)	I-485	Inner (loop)	57	Mecklenburg	120	31	775
233	NC 16 (Providence Rd.)	I-485	Inner	57	Mecklenburg	120	26	650
236	Rea Rd. (Loop)	I-485	Inner	59	Mecklenburg	120	35	875
239	US 521 (Johnston Rd.)	I-485	Outer (Loop)	61	Mecklenburg	150	29	725

1.6. Categorization of Sites

The analysis performed during the detailed review determined the following:

- Any serious physical issues that may exist at each potential ramp metering location,
- Whether these issues can be rectified,
- How much congestion is at the site and whether traffic volumes are feasible for metering, and
- Other useful factors that influence the site's suitability for ramp metering.

Each candidate ramp metering site has been considered in detail and in relation to any other candidate ramp metering locations, and all comments and observations are noted in the Site Summaries.

From this information, it is possible to further categorize sites into the following groups:

- **Not Feasible** - a critical issue has been identified that makes the site not feasible for ramp metering, such as very low entrance ramp volumes. This could include, but not be limited to, traffic volumes are too high or too low, geometric issues, site might be secondary to another site that needs correcting first, etc.
- **Review in Future** - in some locations with "multiple sites" or "groups of congestion", the analysis attributed the main cause of congestion to one or two of the downstream sites. In this case, sites further upstream may cease to be congested once the downstream sites are implemented, so it has been noted that the site should be further evaluated once the downstream sites have been implemented and operating for a period of time. Sites in this category may also have traffic volumes that are marginal for being feasible
- **Feasible for Taking Forward** - these sites demonstrate good characteristics and the potential to reduce observed congestion. These sites will be taken forward into the next stage of the process: an economic analysis will outline the implementation of ramp metering and the sites will be prioritized for implementation.

The following diagrams show the locations of the various sites in their associated categories.

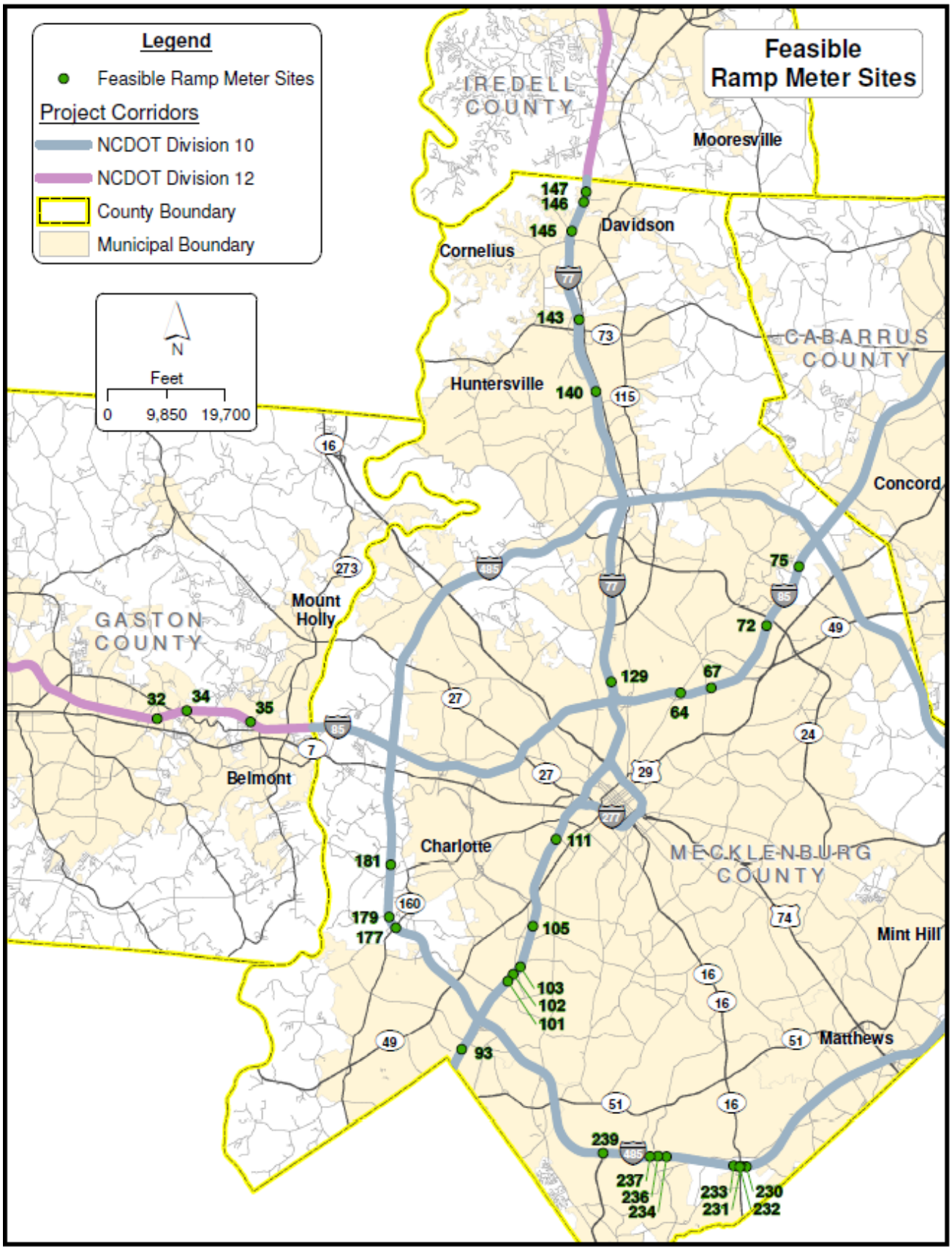


Figure 2. Feasible Ramp Meter Sites

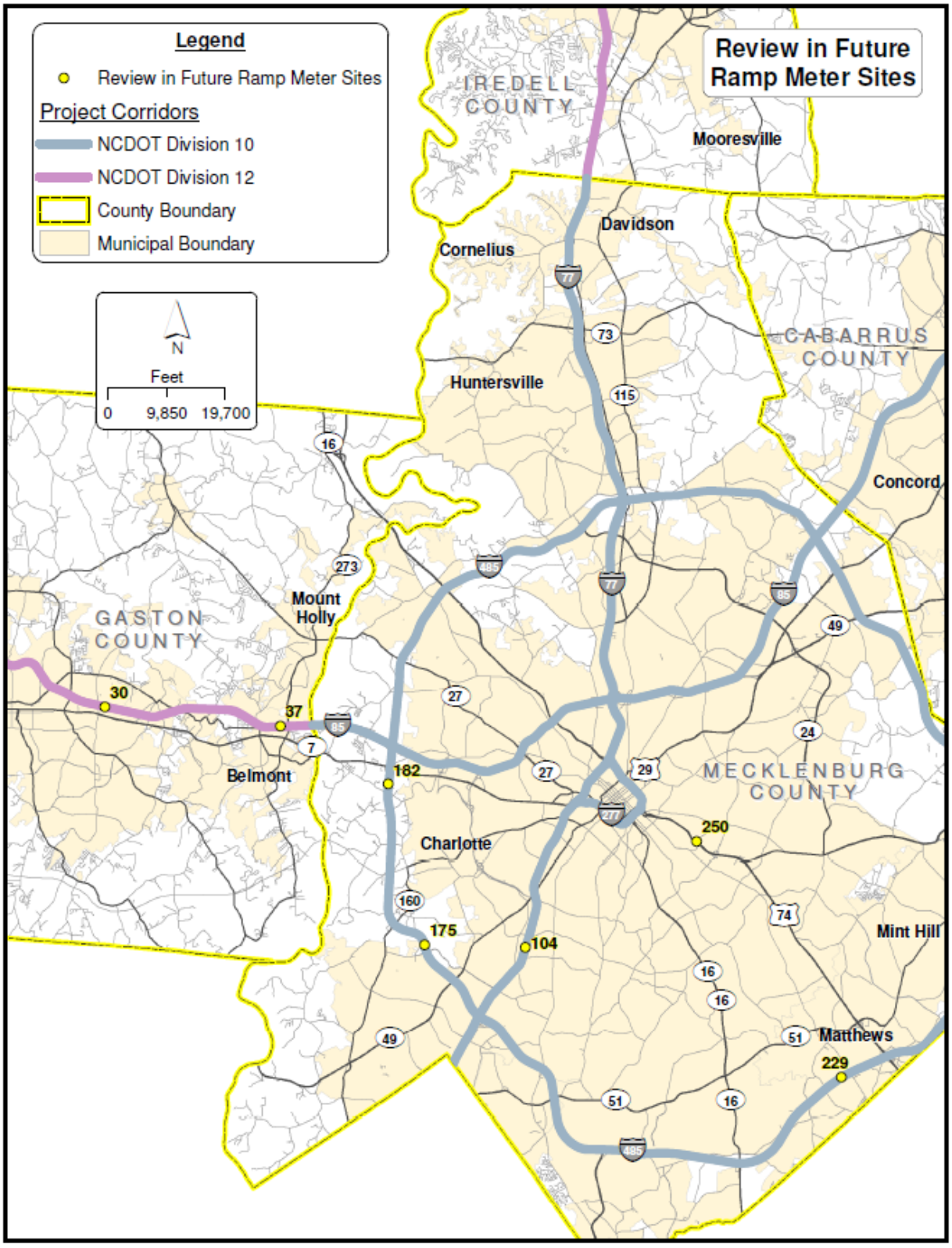


Figure 3. Review in Future Ramp Meter Sites

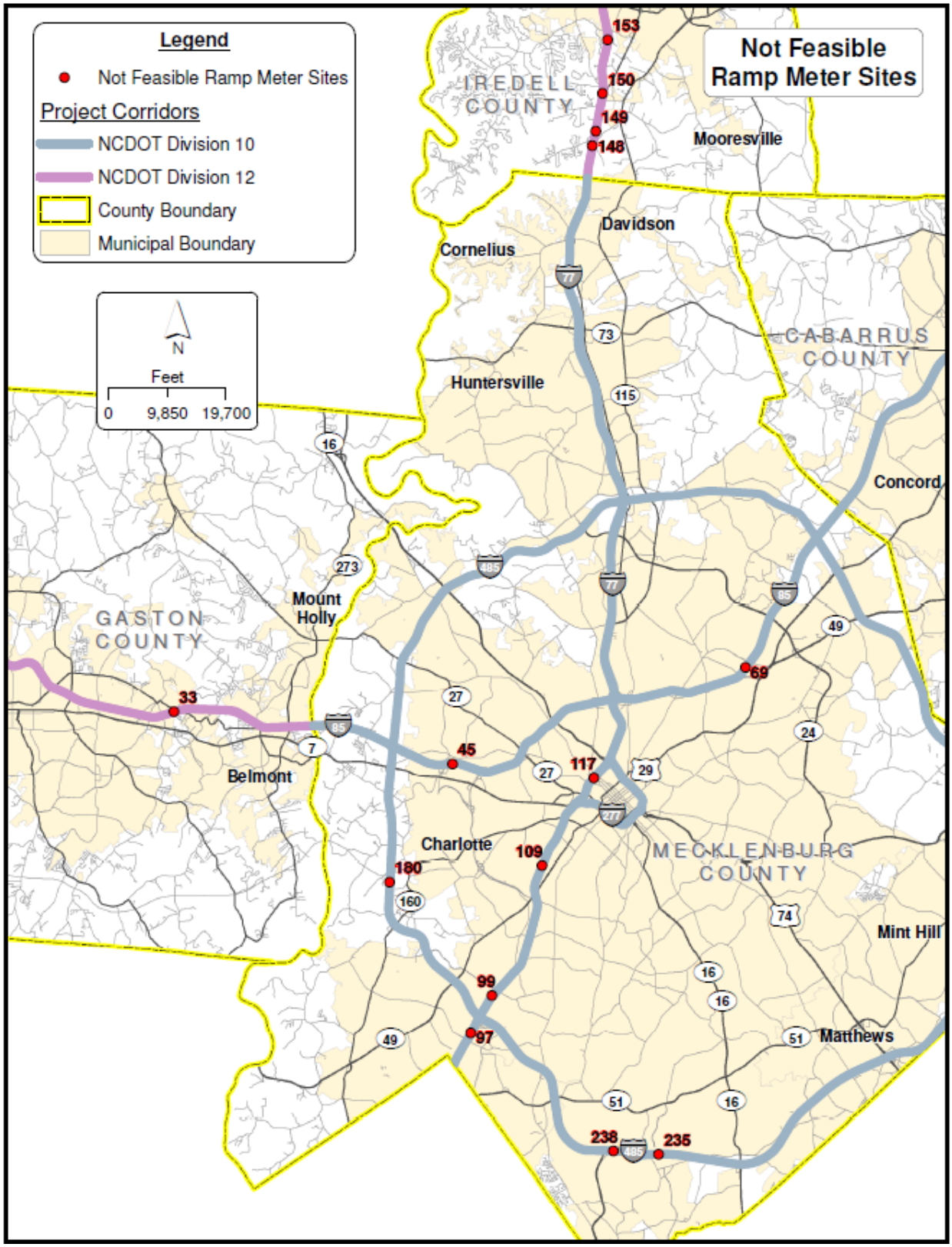


Figure 4. Not Feasible Ramp Meter Sites

1.7. Summary

Recommendations based on the results of the detailed analysis are shown in Table 6. The table is ordered as follows:

- **Individual sites** - where a single identified congestion problem is adjacent to one site only,
- **Multiple sites** - where a single identified congestion problem is adjacent to a number of sites, and
- **Group sites** - where multiple congestion problems overlap and form a larger congestion problem, which is adjacent to a number of sites.

The order that these are shown in the table below is not intended to show an order of implementation of sites, nor is it meant to suggest that sites grouped together should be implemented at the same time. The prioritization of site implementation will come in a later stage.

For more information about specific individual sites, including the rationale for the selection or ruling out of sites, please refer to the Site Selection Comments section in the Site Summaries.

Table 6. Recommendations For Each Site

Site Log	To Freeway	Cross Street	Approx. Exit	Direction	County	Categorization
Individual Sites						
045	I-85	Little Rock Rd.	32	NB	Mecklenburg	Not Feasible
067	I-85	Sugar Creek Rd.	41	NB	Mecklenburg	Feasible for Taking Forward
075	I-85	Mallard Creek Rd.	46	NB	Mecklenburg	Feasible for Taking Forward
146	I-77	Goodrum Rd. / Griffith St.	30	SB	Mecklenburg	Feasible for Taking Forward
180	I-485	West Blvd.	6	Outer	Mecklenburg	Not Feasible
181	I-485	West Blvd.	6	Inner	Mecklenburg	Feasible for Taking Forward
182	I-485	US 74 / US 29 (Wilkinson Blvd.)	9	Outer	Mecklenburg	Review in Future
250	US 74/ Indepen-dence Blvd.	Briar Creek Rd.	244	WB	Mecklenburg	Review in Future (although site does not meet criteria, will continue analysis per SC request)
Multiple Sites (M005)						
030	I-85	Cox Rd.	21	NB	Gaston	Review in Future
032	I-85	S Main St.	22	NB	Gaston	Feasible for Taking Forward
034	I-85	McAdenville Rd.	23	NB	Gaston	Feasible for Taking Forward
Multiple Sites (M048)						
150	I-77	Williamson Rd. / US 21 (Charlotte Hwy.)	33	SB	Iredell	Not Feasible

Site Log	To Freeway	Cross Street	Approx. Exit	Direction	County	Categorization
153	I-77	SR 1100 (Brawley School Rd.)	35	SB	Iredell	Not Feasible
Multiple Sites (M049)						
175	I-485	Arrowood Rd.	3	Inner	Mecklenburg	Review in Future
177	I-485	Steele Creek Rd.	4	Inner	Mecklenburg	Feasible for Taking Forward
179	I-485	Steele Creek Rd.	4	Inner	Mecklenburg	Feasible for Taking Forward
Group 1						
033	I-85	McAdenville Rd.	23	SB	Gaston	Not Feasible
035	I-85	Belmont-Mt. Holly Rd.	26	SB	Gaston	Feasible for Taking Forward
037	I-85	Beatty Dr. / Park St.	27	SB	Gaston	Review in Future
Group 2						
064	I-85	Graham St.	40	SB (Loop)	Mecklenburg	Feasible for Taking Forward
069	I-85	University City Blvd.	43	SB	Mecklenburg	Not Feasible
072	I-85	Harris Blvd.	45	SB	Mecklenburg	Feasible for Taking Forward
Group 3						
093	I-77	Westinghouse Blvd.	1A	SB	Mecklenburg	Feasible for Taking Forward
097*	I-77	I-485	1B	SB	Mecklenburg	Not Feasible
099	I-77	Arrowood Rd.	3	SB	Mecklenburg	Not Feasible
102	I-77	Nations Ford Rd.	4	SB	Mecklenburg	Feasible for Taking Forward
104	I-77	Tyvola Rd.	5	SB	Mecklenburg	Review in Future
109	I-77	Clanton Rd.	7	SB	Mecklenburg	Not Feasible
111	I-77	Remount Rd.	8	SB	Mecklenburg	Feasible for Taking Forward
117	I-77	West Trade St.	10	SB (Loop)	Mecklenburg	Not Feasible
Group 4						
105	I-77	Tyvola Rd.	5	NB	Mecklenburg	Feasible for Taking Forward
103	I-77	Nations Ford Rd.	4	NB	Mecklenburg	Feasible for Taking Forward
101	I-77	Arrowood Rd.	3	NB	Mecklenburg	Feasible for Taking Forward
Group 5						
129*	I-77	I-85 SB	13	NB	Mecklenburg	Feasible for Taking Forward

Site Log	To Freeway	Cross Street	Approx. Exit	Direction	County	Categorization
Group 6						
147	I-77	Goodrum Rd. / Griffith St.	30	NB	Mecklenburg	Feasible for Taking Forward
145	I-77	US 21 (Catawba Ave.)	28	NB	Mecklenburg	Feasible for Taking Forward
143	I-77	NC 73 (Sam Furr Rd.)	25	NB	Mecklenburg	Feasible for Taking Forward
140	I-77	Gilead Rd.	23	NB	Mecklenburg	Feasible for Taking Forward
Group 7						
230	I-485	NC 16 (Providence Rd.)	57	Outer	Mecklenburg	Feasible for Taking Forward
232	I-485	NC 16 (Providence Rd.)	57	Outer	Mecklenburg	Feasible for Taking Forward
234	I-485	Rea Rd.	59	Outer	Mecklenburg	Feasible for Taking Forward
235	I-485	Rea Rd.	59	Outer	Mecklenburg	Not Feasible
238	I-485	US 521 (Johnston Rd.)	61	Outer	Mecklenburg	Not Feasible
239	I-485	US 521 (Johnston Rd.)	61	Outer (Loop)	Mecklenburg	Feasible for Taking Forward
Group 8						
237	I-485	Rea Rd.	59	Inner	Mecklenburg	Feasible for Taking Forward
236	I-485	Rea Rd.	59	Inner	Mecklenburg	Feasible for Taking Forward
233	I-485	NC 16 (Providence Rd.)	57	Inner	Mecklenburg	Feasible for Taking Forward
231	I-485	NC 16 (Providence Rd.)	57	Inner (Loop)	Mecklenburg	Feasible for Taking Forward
229	I-485	E John St.	52	Inner	Mecklenburg	Review in Future

* F2F sites that have been included in the detailed analysis to help understand the characteristics. Currently there are no plans to implement ramp metering at these sites.

2. Conclusions

This report outlines the process carried out to conduct the Detailed Analysis. The findings indicate the sites that have been ruled out because of specific characteristics that make them unfeasible, sites that should be reviewed again in future, and sites that are feasible and should be taken forward to the next stage.

Table 7 summarizes the results of the detailed analysis. Recommendations for the 51 sites subject to detailed analysis are shown in Table 6 in the preceding section, and the number of sites in each category is summarized in Table 7.

Table 7. Number of Sites following Screening and Detailed Analysis

Site Categorization	Number of Sites
Total Sites	251
Sites in Detailed Analysis	51
Not Feasible	14
Review in Future	7
Feasible for Taking Forward	30

The sites selected as feasible for taking forward for ramp metering have demonstrated appropriate geometry, acceptable traffic volumes that will allow the system to work, and are located in a position to improve existing observed traffic problems.

The sites identified for future review (locations where ramp metering installation would result in reduced effectiveness) should be reconsidered after the first ramp meter sites have been installed and operated for a period of time to re-evaluate the observed congestion.

The next stage of the feasibility study is to use the information already collected to perform a high-level cost-benefit analysis for each site. The results will be added to the Costs and Benefits section of the Site Summaries. Following this, the most beneficial sites will be identified and prioritized for implementation. Future tasks are shown in Figure 5.

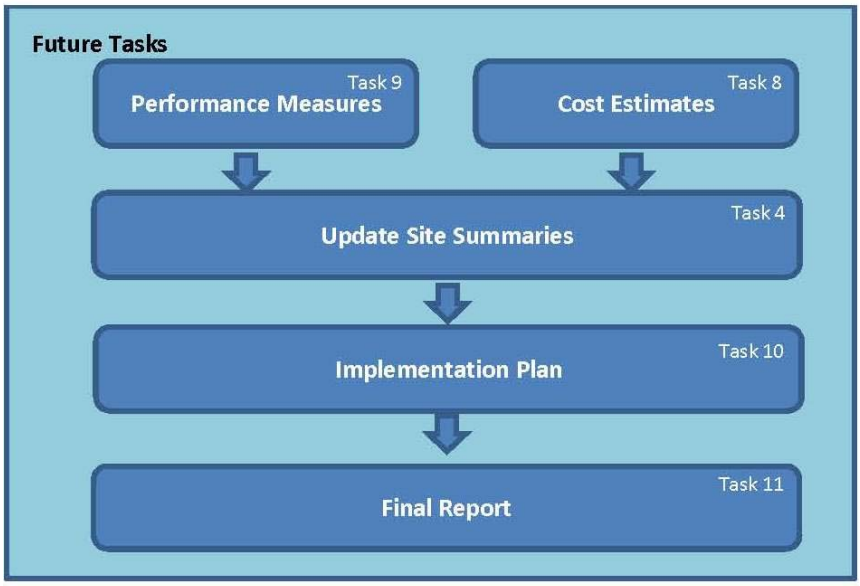


Figure 5. Relationship of Future Tasks

Appendices

Appendix A: Summary Recommendations for All Sites

Table 8 outlines the current status of all 251 entrance ramps that were initially identified in the study area. It shows the reasons why some sites will not be considered further in the current Feasibility Study and those that will be taken forward into the next stages.

Table 8. Summary Recommendations for all Sites

Site Log	Cross Street	TO Freeway	Direction	Approx. Exit	County	Screening Analysis Stage 1 (Congestion)	Screening Analysis - Stage 2 (Geometric)	Detailed Analysis	Site Status at End of Detailed Analysis
80	Concord Mills / Bruton Smith Blvd.	I-85	NB	49	Cabarrus	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
79	Concord Mills / Bruton Smith Blvd.	I-85	SB (Loop)	49	Cabarrus	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
78	Concord Mills / Bruton Smith Blvd.	I-85	SB	49	Cabarrus	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
83	Kannapolis Pkwy./ George Liles Pkwy.	I-85	7SB	52	Cabarrus	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
82	Poplar Tent Rd.	I-85	NB	52	Cabarrus	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
81	Poplar Tent Rd.	I-85	SB	52	Cabarrus	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
84	Kannapolis Pkwy./ George Liles Pkwy.	I-85	NB	54	Cabarrus	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
86	NC 73 (Davidson Hwy.)	I-85	NB	55	Cabarrus	01/05/16 - Site is at the extreme back of the congestion - JE	-	-	No Further Study
85	NC 73 (Davidson Hwy.)	I-85	SB	55	Cabarrus	02/19/2016 - Construction works caused congestion - AB	-	-	Review in Future
88	US 29-601 (Concord Pkwy.)	I-85	NB	58	Cabarrus	01/31/2016 - Construction works caused congestion -AB	-	-	No Further Study
87	US 29-601 (Concord Pkwy.)	I-85	SB	58	Cabarrus	01/31/2016 - Construction works caused congestion -AB	-	-	No Further Study

Site Log	Cross Street	TO Freeway	Direction	Approx. Exit	County	Screening Analysis Stage 1 (Congestion)	Screening Analysis - Stage 2 (Geometric)	Detailed Analysis	Site Status at End of Detailed Analysis
90	Dale Earnhardt Blvd.	I-85	NB	60	Cabarrus	01/31/2016 - Construction works caused congestion -AB	-	-	No Further Study
89	Dale Earnhardt Blvd.	I-85	SB (Loop)	60	Cabarrus	01/31/2016 - Construction works caused congestion -AB	-	-	No Further Study
92	Lane St.	I-85	NB	63	Cabarrus	01/31/2016 - Construction works caused congestion -AB	-	-	No Further Study
91	Lane St.	I-85	SB	63	Cabarrus	01/25/2016 - Construction works caused congestion - JE	-	-	Review in Future
24	N Chester St.	I-85	NB (Loop)	17	Gaston	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
23	N Chester St.	I-85	SB	17	Gaston	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
26	Ozark Ave.	I-85	NB	19	Gaston	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
25	Ozark Ave.	I-85	SB	19	Gaston	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
28	New Hope Rd.	I-85	NB	20	Gaston	01/05/16 - Site is at the extreme back of the congestion - JE	-	-	No Further Study
27	New Hope Rd.	I-85	SB	20	Gaston	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
30	Cox Rd.	I-85	NB	21	Gaston	-	-	5/13/16 - Review in Future from Detailed Analysis - JE	Review in Future
29	Cox Rd.	I-85	SB	21	Gaston	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
32	S Main St.	I-85	NB	22	Gaston	-	-	-	Detailed Analysis

Site Log	Cross Street	TO Freeway	Direction	Approx. Exit	County	Screening Analysis Stage 1 (Congestion)	Screening Analysis - Stage 2 (Geometric)	Detailed Analysis	Site Status at End of Detailed Analysis
31	S Main St.	I-85	SB (Loop)	22	Gaston	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
34	McAdenville Rd.	I-85	NB	23	Gaston	-	-	-	Detailed Analysis
33	McAdenville Rd.	I-85	SB	23	Gaston	-	-	5/13/16 - Not feasible from Detailed Analysis - JE	No Further Study
36	Belmont-Mt. Holly Rd.	I-85	NB	26	Gaston	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
35	Belmont-Mt. Holly Rd.	I-85	SB	26	Gaston	-	-	-	Detailed Analysis
38	Beatty Dr. / Park St.	I-85	NB	27	Gaston	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
37	Beatty Dr. / Park St.	I-85	SB	27	Gaston	-	-	5/13/16 - Review in Future from Detailed Analysis - JE	Review in Future
149	Langtree Rd.	I-77	NB	31	Iredell	02/19/16 - Retain per SC Mtg. - AB	-	5/13/16 - Not feasible from Detailed Analysis - JE	No Further Study
148	Langtree Rd.	I-77	SB	31	Iredell	02/19/16 - Retain per SC Mtg. - AB	-	5/13/16 - Not feasible from Detailed Analysis - JE	No Further Study
152	Williams Rd. / US 21 (Charlotte Hwy.)	I-77	NB	33	Iredell	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
151	Williams Rd. / US 21 (Charlotte Hwy.)	I-77	SB	33	Iredell	-	02/18/16 AB - No Overpass	-	Review in Future
150	Williams Rd. / US 21 (Charlotte Hwy.)	I-77	SB	33	Iredell	-	-	5/13/16 - Not feasible from Detailed Analysis - JE	Review in Future
154	SR 1100 (Brawley School Rd.)	I-77	NB	35	Iredell	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
153	SR 1100 (Brawley School Rd.)	I-77	SB	35	Iredell	-	-	5/13/16 - Not feasible from Detailed Analysis - JE	Review in Future
156	NC 150 (W Plaza Dr.)	I-77	NB	36	Iredell	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study

Site Log	Cross Street	TO Freeway	Direction	Approx. Exit	County	Screening Analysis Stage 1 (Congestion)	Screening Analysis - Stage 2 (Geometric)	Detailed Analysis	Site Status at End of Detailed Analysis
155	NC 150 (W Plaza Dr.)	I-77	SB	36	Iredell	-	02/18/16 AB - No Downstream Ramp	-	Review in Future
158	US 21-NC 115 (Main St. / Charlotte Hwy.)	I-77	NB	42	Iredell	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
157	US 21-NC 115 (Main St. / Charlotte Hwy.)	I-77	SB	42	Iredell	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
160	Amity Hill Rd.	I-77	SB	45	Iredell	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
159	Amity Hill Rd.	I-77	NB	45	Iredell	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
164	Salisbury Rd.	I-77	NB	49	Iredell	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
163	Salisbury Rd.	I-77	SB (Loop)	49	Iredell	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
162	US 70 (Garner Bagnal Blvd.)	I-77	NB (Loop)	49	Iredell	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
161	US 70 (Garner Bagnal Blvd.)	I-77	SB	49	Iredell	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
166	East Broad St.	I-77	SB (Loop)	50	Iredell	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
165	East Broad St.	I-77	NB (Loop)	50	Iredell	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
170	I-40 WB	I-77	NB	51	Iredell	01/05/16 - Not adjacent to significant congestion - JE	3/10/16 - Not sig. congest. - AB	-	No Further Study
169	I-40 WB	I-77	SB (Loop)	51	Iredell	01/05/16 - Not adjacent to significant congestion - JE	3/10/16 - Not sig. congest. - AB	-	No Further Study
168	I-40 EB	I-77	NB (Loop)	51	Iredell	01/05/16 - Not adjacent to significant congestion - JE	3/10/16 - Not sig. congest. - AB	-	No Further Study

Site Log	Cross Street	TO Freeway	Direction	Approx. Exit	County	Screening Analysis Stage 1 (Congestion)	Screening Analysis - Stage 2 (Geometric)	Detailed Analysis	Site Status at End of Detailed Analysis
167	I-40 EB	I-77	SB	51	Iredell	01/05/16 - Not adjacent to significant congestion - JE	3/10/16 - Not sig. congest. - AB	-	No Further Study
3	I-77 NB	I-277	Outer	1	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	3/10/16 - Not sig. congest. - AB	-	No Further Study
2	Clarkson St.	I-277	Outer	1	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
1	I-77 NB	I-277	Inner (Loop)	1	Mecklenburg	01/05/16 - F2F site - JE	3/10/16 - Sight distance AB	-	No Further Study
18	N Graham St.	I-277	Outer (Loop)	4	Mecklenburg	01/05/16 - Primary site for congestion is F2F - JE	-	-	No Further Study
21	I-77 NB	I-277	Outer	5	Mecklenburg	01/05/16 - F2F site - JE	3/10/16 - Bridge widening AB	-	No Further Study
7	South Blvd.	I-277	Outer	1E	Mecklenburg	01/13/16 - Site is at the extreme back of the congestion - JC	-	-	Review in Future
6	Church St.	I-277	Outer	1E	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
5	South Blvd.	I-277	Inner	1E	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
4	Church St.	I-277	Inner	1E	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
12	E 3rd St. / 4th St.	I-277	Outer	2A	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
10	Stonewall St.	I-277	Outer	2A	Mecklenburg	02/24/16 - Drop per SC Mtg. - AB	-	-	Review in Future
9	E 3rd St ./ E 4th St.	I-277	Inner	2A	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
8	Stonewall St.	I-277	Inner	2A	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
13	US 74 (Independence Blvd.)	I-277	Outer	2B	Mecklenburg	01/05/16 - F2F site - JE	3/10/16 - lack of clear zone protection AB	-	No Further Study

Site Log	Cross Street	TO Freeway	Direction	Approx. Exit	County	Screening Analysis Stage 1 (Congestion)	Screening Analysis - Stage 2 (Geometric)	Detailed Analysis	Site Status at End of Detailed Analysis
11	US 74 (Independence Blvd.)	I-277	Inner	2B	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	3/10/16 - Not sig. congest. - AB	-	No Further Study
16	N Caldwell St.	I-277	Outer	3A	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
15	N Brevard St.	I-277	Inner	3A	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
14	N Davidson St.	I-277	Inner	3A	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
17	N Church St.	I-277	Outer	3B	Mecklenburg	01/05/16 - Primary site for congestion is F2F - JE	-	-	No Further Study
22	I-77 SB	I-277	Outer	5A	Mecklenburg	01/05/16 - F2F site - JE	3/10/16 Mod./Light Traffic AB	-	No Further Study
20	I-77 SB	I-277	Inner	5A	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	3/10/16 - Not sig. congest. - AB	-	No Further Study
19	I-77 NB	I-277	Inner	5A	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	3/10/16 - Not sig. congest. - AB	-	No Further Study
173	S Tryon St.	I-485	Inner	1	Mecklenburg	01/05/16 - Site is at the extreme back of the congestion - JE	-	-	No Further Study
172	S Tryon St.	I-485	Outer	1	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
171	S Tryon St.	I-485	Outer	1	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
175	Arrowood Rd.	I-485	Inner	3	Mecklenburg	-	-	5/13/16 - Review in Future from Detailed Analysis - JE	Review in Future
174	Arrowood Rd.	I-485	Outer	3	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
179	Steele Creek Rd.	I-485	Inner	4	Mecklenburg	-	-	-	Detailed Analysis

Site Log	Cross Street	TO Freeway	Direction	Approx. Exit	County	Screening Analysis Stage 1 (Congestion)	Screening Analysis - Stage 2 (Geometric)	Detailed Analysis	Site Status at End of Detailed Analysis
178	Steele Creek Rd.	I-485	Outer	4	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
177	Steele Creek Rd.	I-485	Inner	4	Mecklenburg	-	-	-	Detailed Analysis
176	Steele Creek Rd.	I-485	Outer	4	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
181	West Blvd.	I-485	Inner	6	Mecklenburg	-	-	-	Review in Future
180	West Blvd.	I-485	Outer	6	Mecklenburg	-	-	5/13/16 - Not feasible from Detailed Analysis - JE	Review in Future
182	US 74 / US 29 (Wilkinson Blvd.)	I-485	Outer	9	Mecklenburg	-	-	5/13/16 - Review in Future from Detailed Analysis - JE	Review in Future
184	I-85	I-485	Inner	10	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	3/10/16 - Not sig. congest. - AB	-	No Further Study
183	I-485 CD (Wilkinson Blvd.)	I-485	Inner	10	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	3/10/16 - Not sig. congest. - AB	-	No Further Study
186	Moores Chapel Rd.	I-485	Inner	12	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
185	Moores Chapel Rd.	I-485	Outer	12	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
187	Mt Holly Rd.	I-485	Outer	12	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
188	Mt Holly Rd.	I-485	Inner	14	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
192	NC 16	I-485	Inner	16	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
191	NC 16	I-485	Outer	16	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
190	NC 16	I-485	Inner	16	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study

Site Log	Cross Street	TO Freeway	Direction	Approx. Exit	County	Screening Analysis Stage 1 (Congestion)	Screening Analysis - Stage 2 (Geometric)	Detailed Analysis	Site Status at End of Detailed Analysis
189	NC16	I-485	Outer	16	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
195	WT Harris Blvd.	I-485	Inner	21	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
194	WT Harris Blvd.	I-485	Outer	21	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
193	WT Harris Blvd.	I-485	Outer	21	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
200	Old Statesville Rd.	I-485	Inner	23	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
199	Old Statesville Rd.	I-485	Outer	23	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
198	I-77 (North)	I-485	Inner	23	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	3/10/16 - Not sig. congest. - AB	-	No Further Study
197	I-77 (North)	I-485	Outer	23	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	3/10/16 - Not sig. congest. - AB	-	No Further Study
196	I-77 (North)	I-485	Outer	23	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	3/10/16 - Not sig. congest. - AB	-	No Further Study
202	Prosperity Church Rd.	I-485	Inner	26	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
201	Prosperity Church Rd.	I-485	Outer	26	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
204	Mallard Creek Rd.	I-485	Inner	28	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
203	Mallard Creek Rd.	I-485	Outer	28	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
206	I-85	I-485	Inner	31	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	3/10/16 - Not sig. congest. - AB	-	No Further Study

Site Log	Cross Street	TO Freeway	Direction	Approx. Exit	County	Screening Analysis Stage 1 (Congestion)	Screening Analysis - Stage 2 (Geometric)	Detailed Analysis	Site Status at End of Detailed Analysis
205	I-85	I-485	Outer	31	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	3/10/16 - Not sig. congest. - AB	-	No Further Study
209	US 29	I-485	Inner	32	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
208	US 29	I-485	Inner	32	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
207	US 29	I-485	Outer	32	Mecklenburg	02/05/2016 - Construction works caused congestion - JE	-	-	Review in Future
211	University City Blvd.	I-485	Inner	33	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
210	University City Blvd.	I-485	Outer	33	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
213	Rocky River Rd.	I-485	Inner	36	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
212	Rocky River Rd.	I-485	Outer	36	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
215	Harrisburg Rd.	I-485	Inner	39	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
214	Harrisburg Rd.	I-485	Outer	39	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
217	NC 24-27 Albemarle Rd.	I-485	Inner	41	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
216	NC 24-27 Albemarle Rd.	I-485	Outer	41	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
219	NC 51	I-485	Inner	43	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study

Site Log	Cross Street	TO Freeway	Direction	Approx. Exit	County	Screening Analysis Stage 1 (Congestion)	Screening Analysis - Stage 2 (Geometric)	Detailed Analysis	Site Status at End of Detailed Analysis
218	NC 51	I-485	Outer	43	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
221	NC 218 (Fairview Rd.)	I-485	Inner	44	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
220	NC 218 (Fairview Rd.)	I-485	Outer	44	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
223	Lawyers Rd.	I-485	Inner	47	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
222	Lawyers Rd.	I-485	Outer	47	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
225	Idlewild Rd.	I-485	Inner	49	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
224	Idlewild Rd.	I-485	Outer	49	Mecklenburg	02/19/16 - Drop per SC Mtg. - AB	-	-	Review in Future
227	US 74	I-485	Inner	51	Mecklenburg	01/05/16 - Site is at the extreme back of the congestion - JE	-	-	No Further Study
226	US 74	I-485	Outer	51	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
229	E John St.	I-485	Inner	52	Mecklenburg	-	-	5/13/16 - Review in Future from Detailed Analysis - JE	Review in Future
228	E John St.	I-485	Outer	52	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
233	NC 16 (Providence Rd.)	I-485	Inner	57	Mecklenburg	-	-	-	Detailed Analysis
232	NC 16 (Providence Rd.)	I-485	Outer	57	Mecklenburg	-	-	-	Detailed Analysis
231	NC 16 (Providence Rd.)	I-485	Inner (Loop)	57	Mecklenburg	-	-	-	Detailed Analysis
230	NC 16 (Providence Rd.)	I-485	Outer	57	Mecklenburg	-	-	-	Detailed Analysis
237	Rea Rd.	I-485	Inner	59	Mecklenburg	-	-	-	Detailed Analysis
236	Rea Rd.	I-485	Inner	59	Mecklenburg	-	-	-	Detailed Analysis

Site Log	Cross Street	TO Freeway	Direction	Approx. Exit	County	Screening Analysis Stage 1 (Congestion)	Screening Analysis - Stage 2 (Geometric)	Detailed Analysis	Site Status at End of Detailed Analysis
235	Rea Rd.	I-485	Outer	59	Mecklenburg	-	-	5/13/16 - Not feasible from Detailed Analysis - JE	No Further Study
234	Rea Rd.	I-485	Outer	59	Mecklenburg	-	-	-	Detailed Analysis
240	US 521 (Johnston Rd.)	I-485	Inner	61	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
239	US 521 (Johnston Rd.)	I-485	Outer (Loop)	61	Mecklenburg	-	-	-	Detailed Analysis
238	US 521 (Johnston Rd.)	I-485	Outer	61	Mecklenburg	-	-	5/13/16 - Not feasible from Detailed Analysis - JE	No Further Study
242	NC 51	I-485	Inner	64	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
245	Pineville Rd. / South Blvd.	I-485	Inner	65	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
244	Pineville Rd. / South Blvd.	I-485	Inner	65	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
243	Pineville Rd. / South Blvd.	I-485	Outer	65	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
241	NC 51	I-485	Outer	66	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
249	I-77 SB CD / Arrowood Rd.	I-485	Inner	67	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	3/10/16 - Not sig. congest. - AB	-	No Further Study
248	I-77 NB CD / Westinghouse Rd.	I-485	Inner	67	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	3/10/16 - Not sig. congest. - AB	-	No Further Study
247	I-77 SB CD / Arrowood Rd.	I-485	Outer	67	Mecklenburg	01/05/16 - F2F site - JE	3/10/16 - Not sig. congest. - AB	-	No Further Study
246	I-77 NB CD / Westinghouse Rd.	I-485	Outer	67	Mecklenburg	01/05/16 - F2F site - JE	3/10/16 - Not sig. congest. - AB	-	No Further Study
101	Arrowood Rd.	I-77	NB	3	Mecklenburg	-	-	-	Detailed Analysis

Site Log	Cross Street	TO Freeway	Direction	Approx. Exit	County	Screening Analysis Stage 1 (Congestion)	Screening Analysis - Stage 2 (Geometric)	Detailed Analysis	Site Status at End of Detailed Analysis
99	Arrowood Rd.	I-77	SB	3	Mecklenburg	-	-	5/13/16 - Not feasible from Detailed Analysis - JE	No Further Study
103	Nations Ford Rd.	I-77	NB	4	Mecklenburg	-	-	-	Detailed Analysis
102	Nations Ford Rd.	I-77	SB	4	Mecklenburg	-	-	-	Detailed Analysis
105	Tyvola Rd.	I-77	NB	5	Mecklenburg	-	-	-	Detailed Analysis
104	Tyvola Rd.	I-77	SB	5	Mecklenburg	-	-	5/13/16 - Review in Future from Detailed Analysis - JE	Review in Future
110	Clanton Rd.	I-77	NB	7	Mecklenburg	01/05/16 - Primary site for congestion is F2F - JE	-	-	No Further Study
109	Clanton Rd.	I-77	SB	7	Mecklenburg	-	-	5/13/16 - Not feasible from Detailed Analysis - JE	No Further Study
111	Remount Rd.	I-77	SB	8	Mecklenburg	-	-	-	Detailed Analysis
112	I-77 CD (US 74 (Wilkinson Blvd)/ Freedom Dr. / I-277 (John Belk Fwy.)	I-77	SB	9	Mecklenburg	01/05/16 - F2F site - JE	3/10/16 - Not sig. congest. - AB	-	No Further Study
118	5th St.	I-77	NB	10	Mecklenburg	01/05/16 - Primary site for congestion is F2F - JE	-	-	No Further Study
117	West Trade St.	I-77	SB	10	Mecklenburg	-	-	5/13/16 - Not feasible from Detailed Analysis - JE	No Further Study
116	West Trade St.	I-77	SB	10	Mecklenburg	-	02/18/16 AB - No Downstream Ramp	-	No Further Study
115	US 29-NC 27 (Morehead St.)	I-77	NB	10	Mecklenburg	01/05/16 - Primary site for congestion is F2F - JE	-	-	No Further Study
122	I-277 Outer	I-77	NB	11	Mecklenburg	01/05/16 - F2F site - JE	3/10/16 - Not sig. congest. - AB	-	No Further Study
121	NC 16 (Brookshire Fwy.)	I-77	NB	11	Mecklenburg	01/05/16 - F2F site - JE	3/10/16 - Not sig. congest. - AB	-	No Further Study
120	I-277 Outer	I-77	SB	11	Mecklenburg	01/05/16 - F2F site - JE	3/10/16 - Bridge widening AB	-	No Further Study

Site Log	Cross Street	TO Freeway	Direction	Approx. Exit	County	Screening Analysis Stage 1 (Congestion)	Screening Analysis - Stage 2 (Geometric)	Detailed Analysis	Site Status at End of Detailed Analysis
119	NC 16 (Brookshire Fwy.)	I-77	SB	11	Mecklenburg	01/05/16 - F2F site - JE	3/10/16 - lack of clear zone protection AB	-	No Further Study
124	LaSalle St. / Atando Ave.	I-77	NB	12	Mecklenburg	01/05/16 - Primary site for congestion is F2F - JE	-	-	No Further Study
123	LaSalle St./ Atando Ave.	I-77	SB	12	Mecklenburg	01/05/16 - Primary site for congestion is F2F - JE	-	-	No Further Study
129	I-85 SB	I-77	NB	13	Mecklenburg	2/18/16 Retain F2F Site	-	-	No Further Study
128	I-85 NB	I-77	NB	13	Mecklenburg	01/05/16 - F2F site - JE	3/10/16 - Left hand merge AB	-	No Further Study
127	I-85 SB / Statesville Rd.	I-77	SB	13	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	3/10/16 - Not sig. congest. - AB	-	No Further Study
126	I-77 SB HOV	I-77	SB	13	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	3/10/16 - Not sig. congest. - AB	-	No Further Study
125	I-85 NB	I-77	SB	13	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	3/10/16 - Not sig. congest. - AB	-	No Further Study
135	WT Harris Blvd.	I-77	NB	18	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
133	WT Harris Blvd.	I-77	NB	18	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
132	WT Harris Blvd.	I-77	SB	18	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
131	Sunset Rd.	I-77	NB	18	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
130	Sunset Rd.	I-77	SB	18	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
138	I-485 Outer	I-77	NB	19	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	3/10/16 - Not sig. congest. - AB	-	No Further Study
137	I-485 Outer	I-77	SB	19	Mecklenburg	01/05/16 - F2F site - JE	3/10/16 - Loop Ramp AB	-	No Further Study

Site Log	Cross Street	TO Freeway	Direction	Approx. Exit	County	Screening Analysis Stage 1 (Congestion)	Screening Analysis - Stage 2 (Geometric)	Detailed Analysis	Site Status at End of Detailed Analysis
136	I-485 Inner	I-77	SB	19	Mecklenburg	01/05/16 - F2F site - JE	3/10/16 Mod./Light Traffic AB	-	No Further Study
134	WT Harris Blvd.	I-77	SB	19	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
140	Gilead Rd..	I-77	NB	23	Mecklenburg	-	-	-	Detailed Analysis
143	NC 73 (Sam Furr Rd)	I-77	NB	25	Mecklenburg	-	-	-	Detailed Analysis
139	Gilead Rd.	I-77	SB	25	Mecklenburg	01/05/16 - Primary site for congestion is F2F - JE	-	-	No Further Study
142	NC 73 (Sam Furr Rd.)	I-77	SB	26	Mecklenburg	01/05/16 - Primary site for congestion is F2F - JE	-	-	No Further Study
141	NC 73 (Sam Furr Rd.)	I-77	SB	26	Mecklenburg	01/05/16 - Primary site for congestion is F2F - JE	-	-	No Further Study
145	US 21 (Catawba Ave.)	I-77	NB	28	Mecklenburg	-	-	-	Detailed Analysis
144	US 21 (Catawba Ave.)	I-77	SB	29	Mecklenburg	01/05/16 - Primary site for congestion is F2F - JE	-	-	No Further Study
147	Goodrum Rd. / Griffith St.	I-77	NB	30	Mecklenburg	-	-	-	Detailed Analysis
146	Goodrum Rd. / Griffith St.	I-77	SB	30	Mecklenburg	-	-	-	Detailed Analysis
96	Westinghouse Blvd.	I-77	NB	1A	Mecklenburg	-	02/18/16 AB - No Downstream Ramp	-	Review in Future
93	Westinghouse Blvd.	I-77	SB	1A	Mecklenburg	-	-	-	Detailed Analysis
100	I-485	I-77	NB	1B	Mecklenburg	01/05/16 - F2F site - JE	3/10/16 - Not sig. congest. - AB	-	No Further Study
98	Welcome Center	I-77	NB	1B	Mecklenburg	01/05/16 - Site is at the extreme back of the congestion - JE	-	-	No Further Study
97	I-485	I-77	SB	1B	Mecklenburg	2/18/16 Retain F2F Site	-	5/13/16 - Not feasible from Detailed Analysis - JE	No Further Study
106	Woodlawn Rd.	I-77	SB	6A	Mecklenburg	-	02/18/16 AB - No Overpass	-	No Further Study

Site Log	Cross Street	TO Freeway	Direction	Approx. Exit	County	Screening Analysis Stage 1 (Congestion)	Screening Analysis - Stage 2 (Geometric)	Detailed Analysis	Site Status at End of Detailed Analysis
108	S Tryon St.	I-77	SB	6B	Mecklenburg	-	02/18/16 AB - No Downstream Ramp	-	No Further Study
107	S Tryon St.	I-77	NB	6B	Mecklenburg	01/05/16 - Primary site for congestion is F2F - JE	-	-	No Further Study
113	West Blvd.	I-77	NB	9A	Mecklenburg	01/05/16 - Primary site for congestion is F2F - JE	-	-	No Further Study
114	I-77 CD (US 74 (Wilkinson Blvd.)/ Freedom Dr. / I-277 (John Belk Fwy.))	I-77	NB	9B	Mecklenburg	01/05/16 - F2F site - JE	3/10/16 - Bridge widening AB	-	No Further Study
95	Westinghouse Blvd.	I-77 CD	NB	1A	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
94	Westinghouse Blvd.	I-77 CD	NB	1B	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
39	Sam Wilson Rd.	I-85	SB	29	Mecklenburg	01/13/16 - Site is at the extreme back of the congestion - JC	-	-	Review in Future
43	I-485 Inner	I-85	NB	30	Mecklenburg	01/05/16 - F2F site - JE	3/10/16 Mod./Light Traffic AB	-	No Further Study
42	I-485 Outer	I-85	NB (Loop)	30	Mecklenburg	01/05/16 - F2F site - JE	3/10/16 - Sight distance AB	-	No Further Study
41	Sam Wilson Rd.	I-85	NB	30	Mecklenburg	01/05/16 - Primary site for congestion is F2F - JE	-	-	No Further Study
40	I-485 Inner / Wilkinson Blvd.	I-85	SB	30	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	3/10/16 - Not sig. congest. - AB	-	No Further Study
45	Little Rock Rd.	I-85	NB	32	Mecklenburg	-	-	5/13/16 - Not feasible from Detailed Analysis - JE	Review in Future
44	Little Rock Rd.	I-85	SB	32	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study

Site Log	Cross Street	TO Freeway	Direction	Approx. Exit	County	Screening Analysis Stage 1 (Congestion)	Screening Analysis - Stage 2 (Geometric)	Detailed Analysis	Site Status at End of Detailed Analysis
48	Billy Graham Pkwy.	I-85	NB	33	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
47	Billy Graham Pkwy.	I-85	SB (Loop)	33	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
46	Billy Graham Pkwy.	I-85	SB	33	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
51	Freedom Dr.	I-85	NB	34	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
50	Freedom Dr.	I-85	SB	34	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
49	Tuckaseegee Rd.	I-85	SB	34	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
53	Glenwood Dr.	I-85	NB	35	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
52	Glenwood Dr.	I-85	SB	35	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
55	NC 16 (Brookshire Blvd.)	I-85	NB	36	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
54	NC 16 (Brookshire Blvd.)	I-85	SB	36	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
57	Beatties Ford Rd.	I-85	NB (Loop)	37	Mecklenburg	01/05/16 - Site is at the extreme back of the congestion - JE	-	-	No Further Study
56	Beatties Ford Rd.	I-85	SB	37	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
62	I-77 NB	I-85	NB	38	Mecklenburg	01/05/16 - F2F site - JE	3/10/16 - Not sig. congest. - AB	-	No Further Study
60	I-77 SB	I-85	NB (Loop)	38	Mecklenburg	01/05/16 - F2F site - JE	3/10/16 - Sight distance AB	-	No Further Study
59	I-77 NB	I-85	SB (Loop)	38	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	3/10/16 - Not sig. congest. - AB	-	No Further Study

Site Log	Cross Street	TO Freeway	Direction	Approx. Exit	County	Screening Analysis Stage 1 (Congestion)	Screening Analysis - Stage 2 (Geometric)	Detailed Analysis	Site Status at End of Detailed Analysis
58	I-77 SB	I-85	SB	38	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	3/10/16 - Not sig. congest. - AB	-	No Further Study
63	Statesville Ave.	I-85	NB	39	Mecklenburg	-	02/18/16 AB - No Wall	-	Review in Future
61	Statesville Ave.	I-85	SB	39	Mecklenburg	-	02/18/16 AB - No Overpass	-	No Further Study
66	Sugar Creek Rd.	I-85	SB	40	Mecklenburg	-	02/18/16 AB - No Wall	-	Review in Future
65	Graham St.	I-85	NB	40	Mecklenburg	-	02/18/16 AB - No Wall	-	No Further Study
64	Graham St.	I-85	SB (Loop)	40	Mecklenburg	-	-	-	Detailed Analysis
67	Sugar Creek Rd.	I-85	NB	41	Mecklenburg	-	-	-	Detailed Analysis
68	US 29 Connector (US 29/49)	I-85	SB	42	Mecklenburg	-	02/18/16 AB - No Wall	-	No Further Study
71	University City Blvd.	I-85	NB	43	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
70	University City Blvd.	I-85	SB	43	Mecklenburg	-	02/18/16 AB - No Overpass	-	Review in Future
69	University City Blvd.	I-85	SB	43	Mecklenburg	-	-	5/13/16 - Not feasible from Detailed Analysis - JE	Review in Future
73	Harris Blvd.	I-85	NB	45	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
72	Harris Blvd.	I-85	SB	45	Mecklenburg	-	-	-	Review in Future
75	Mallard Creek Rd.	I-85	NB	46	Mecklenburg	-	-	-	Detailed Analysis
74	Mallard Creek Rd.	I-85	SB	46	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	-	-	No Further Study
77	I-485 Inner	I-85	NB	48	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	3/10/16 - Not sig. congest. - AB	-	No Further Study
76	I-485 Outer	I-85	SB	48	Mecklenburg	01/05/16 - Not adjacent to significant congestion - JE	3/10/16 - Not sig. congest. - AB	-	No Further Study
250	Briar Creek Rd.	US 74/ Independence Blvd.	WB	244	Mecklenburg	-	9/2/16 - Not sig. congest. - AT	9/27/16 - Not feasible from Detailed Analysis - JO	Review in Future (although site does not meet criteria, will continue analysis per SC request)

Appendix B: Analysis of Congestion

B.1 Assumptions made about the Potential Benefits of Ramp Metering

The congestion reduction that can be attributed to each site has been considered and recorded in the Congestion section of the Site Summaries. The method used depends on whether it is classified as individual, multiple or group (see Section 1.1). The potential impact of congestion reduction has been identified by determining the length, duration, and number of occurrences of congestion which can be impacted on by each site. These figures will be used in the next phase to determine the number of vehicle-hours delay (VHD) associated with each site and an assumption will be made about the potential percentage reduction achieved by ramp metering.

The figures used in the calculations that have been performed using the methods described below for Multiple and Group sites are contained in Section B.2.

B.1.1 Individual Sites

It is assumed that ramp metering at such a site could provide a benefit relating to the whole congestion problem. Therefore, the length, duration, and occurrences of congestion are the same as for the associated congestion problem.

B.1.2 Multiple Sites

Because a number of sites are in the vicinity of a particular congestion problem, it cannot be assumed that they can all have an equally significant impact. There are two reasons for this:

- The application of ramp metering at one of the sites could completely or substantially resolve the congestion problem, meaning no further installations are justified.
- However, where there is a significant congestion problem, ramp metering at a second site in the vicinity could provide a similar percentage delay reduction to the first, on the remaining congestion.

A site that is a significant distance upstream of a bottleneck may not have a significant impact on the traffic downstream of the site.

The following rules have been applied to weight the potential impacts of sites related to a particular congestion problem:

- For the primary site, it is assumed that ramp metering could provide a benefit relating to the whole congestion problem. Therefore, the length, duration, and occurrences of congestion are the same as for the associated congestion problem.
- For each secondary site, it is assumed that ramp metering would only provide a reduction in the congestion that occurs upstream of the site. While this is a simplification, it is considered a sensible application of engineering judgement. It builds in some allowance for the fact that secondary sites might not have such a

significant impact as the primary site which is likely to be the prime cause of a congestion problem. However, it allows for the fact that where the problem is large, secondary sites can provide significant benefits. This assumption is applied as follows:

- The length of congestion is the distance from the site to the back of the queue;
- The number of occurrences is the same;
- The duration of congestion is reduced by the same proportion as the length, to reflect the fact that the queue upstream of the secondary site has a shorter duration, as it reaches the site later and dissipates to this point sooner.
- Where the primary site has been deemed unfeasible for ramp metering (e.g. because ramp volumes are too low) then it is assumed that the secondary site could provide a benefit relating to the whole congestion problem. Therefore, the length, duration, and occurrences of congestion are the same as for the associated congestion problem.

B.1.3 Group Sites

For sites classified in groups, each congestion problem might have an associated primary site; it is assumed that each primary site could provide a benefit relating to the whole congestion problem. Therefore, the length, duration, and occurrences of congestion are the same as for the associated congestion problem. However, the same site could also be a secondary site for a congestion problem which starts further downstream, in which case it could provide some additional benefits.

The assumptions used for group sites are the same as for multiple sites to attribute congestion reduction to primary and secondary sites. Then where a particular site relates to two congestion problems in the group, the following additional rules are applied:

- The length of congestion is the weighted average of the lengths associated with the two congestion problems;
- The number of occurrences is the sum of the occurrences associated with the two congestion problems (because the site can potentially impact on both);
- The duration of congestion is the weighted average of the durations associated with the two congestion problems.

In this way the resulting length, duration and occurrences of congestion give a representative picture of the total potential impact of the site.

The Congestion Review data for the Metrolina Ramp Metering sites can be found in Table 9. This data is used in the calculations of the multiple and group sites found in Appendix B.2. Please refer to Appendix C and D in the Screening Analysis Report for the congestion/bottleneck scans and the aggregation of the congestion scan data.

Table 9. NCDOT Ramp Metering Feasibility Study - Congestion Review

					September Congestion					April Congestion					Average				
TO Freeway	Direction	Bottleneck Reference Number	Mainline Primary Log 1	FROM Cross Street (from Congestion Scan)	Average duration (minutes)	Average max length (miles)	Occurrences	Impact factor	Ave Impact Factor	Average Duration (minutes)	Average Max Length (miles)	Occurrences	Impact Factor	Ave Impact Factor	Average Duration (minutes)	Average Max Length (miles)	Occurrences	Impact factor	Merged Congestion Reference Number
I-277	SB	C046	1	I-77/US-21 Exit 1						34	0.76	54	1,395		33.03	0.70	52.50	1,208	M001
I-277	SB	C269	1	I-77/US-21 Exit 1	32	0.63	51	1,029											
I-277	NB	C083	10	NC-16 W 2nd St/Kenilworth Ave Exit 2A						34	0.59	14	281					281	M002
I-277	NB	C094	13	Davidson St Exit 3						33	0.5	13	215	548	46.90	0.55	20.33	526	M003
I-277	NB	C058	13	US-74 Exit 2						44	0.57	28	702						
I-277	NB	C281	13	US-74 Exit 2	60	0.56	20	671											
I-85	SB	C021	33	NC-7 Exit 23						98	5.42	17	9,030		117.64	5.69	14.00	9,367	M004
I-85	SB	C230	33	NC-7 Exit 23	148	6.1	11	9,935											
I-85	NB	C033	34	NC-7 Exit 23						65	3.21	16	3,338		62.16	3.60	18.50	4,142	M005
I-85	NB	C238	34	NC-7 Exit 23	60	3.9	21	4,919											
I-85	SB	C026	35	Belmont-Mt Holly Exit 26						83	4.31	17	6,081					6,081	M006
I-85	NB	C275	45	Billy Graham Pkwy Exit 33	42	1.77	12	893										893	M007
I-85	SB	C027	61	Statesville Ave Exit 39						74	5.86	14	6,071		71.11	4.99	13.50	4,794	M008
I-85	SB	C241	61	Statesville Ave Exit 39	68	4.06	13	3,592											
I-85	SB	C042	64	Graham St Exit 40						41	2.82	18	2,081					2,081	M009
I-85	NB	C036	65	Graham St Exit 40						72	2.21	17	2,705					2,705	M010
I-85	NB	C014	67	Sugar Creek Rd Exit 41						112	4.4	23	11,334		100.18	3.81	16.50	6,291	M011

					September Congestion					April Congestion					Average				
TO Freeway	Direction	Bottleneck Reference Number	Mainline Primary Log 1	FROM Cross Street (from Congestion Scan)	Average duration (minutes)	Average max length (miles)	Occurrences	Impact factor	Ave Impact Factor	Average Duration (minutes)	Average Max Length (miles)	Occurrences	Impact Factor	Ave Impact Factor	Average Duration (minutes)	Average Max Length (miles)	Occurrences	Impact factor	Merged Congestion Reference Number
I-85	NB	C259	67	Sugar Creek Rd Exit 41	73	2.44	10	1,780											
I-85	SB	C037	68	US-29 Connector Exit 42						50	3.38	15	2,535					2,535	M012
I-85	NB	C065	75	Mallard Creek Church Rd Exit 46						50	1.14	10	570		41.00	1.29	9.50	503	M013
I-85	NB	C285	75	Mallard Creek Church Rd Exit 46	31	1.46	9	407											
I-85	SB	C215	84	NC-73 Exit 55	178	11.22	18	35,961										35,961	M014
I-85	NB	C032	86	US-29 Alt Exit 58						76	3.62	13	3,577		73.11	3.14	23.50	5,399	M015
I-85	NB	C233	86	US-29 Alt Exit 58	72	2.96	34	7,244											
I-85	SB	C008	87	US-29 Alt Exit 58						101	5.78	43	25,103		82.04	4.58	40.00	15,021	M016
I-85	SB	C234	87	US-29 Alt Exit 58	60	3.18	37	7,060											
I-85	SB	C280	89	Dale Earnhardt Blvd Exit 60	38	1.9	10	721										721	M017
I-85	NB	C051	90	Dale Earnhardt Blvd Exit 60						48	2.45	9	1,058		52.48	2.66	12.50	1,746	M018
I-85	NB	C248	90	Dale Earnhardt Blvd Exit 60	55	2.78	16	2,445											
I-85	NB	C015	92	Lane St Exit 63						119	5.88	16	11,196	19,125	135.31	8.84	18.00	21,525	M19

					September Congestion					April Congestion					Average				
TO Freeway	**Direction**	**Bottleneck Reference Number**	**Mainline Primary Log 1**	**FROM Cross Street (from Congestion Scan)**	**Average duration (minutes)**	**Average max length (miles)**	**Occurrences**	**Impact factor**	**Ave Impact Factor**	**Average Duration (minutes)**	**Average Max Length (miles)**	**Occurrences**	**Impact Factor**	**Ave Impact Factor**	**Average Duration (minutes)**	**Average Max Length (miles)**	**Occurrences**	**Impact factor**	**Merged Congestion Reference Number**
I-85	NB	C218	92	Lane St Exit 63	141	8.33	23	27,000											
I-85	NB	C007	92	NC-152 Exit 68						144	12.77	15	27,583						
I-77	SB	C006	93	Westinghouse Blvd Exit 1						101	6.7	38	25,715		109.03	6.34	36.00	24,870	M020
I-77	SB	C219	93	Westinghouse Blvd Exit 1	118	5.93	34	23,775											
I-485	Outer	C097	76	I-85						30	0.51	12	184					184	M042
I-77	SB	C012	102	Nations Ford Rd Exit 4						116	4.9	27	15,347		112.57	4.85	26.50	14,456	M021
I-77	SB	C225	102	Nations Ford Rd Exit 4	109	4.79	26	13,581											
I-77	NB	C043	103	Nations Ford Rd Exit 4						60	3.1	10	1,860					1,860	M022
I-77	SB	C028	104	Tyvola Rd Exit 5						83	3.64	20	6,042		66.94	3.26	17.00	3,711	M023
I-77	SB	C261	104	Tyvola Rd Exit 5	44	2.72	14	1,673											
I-77	NB	C024	105	Tyvola Rd Exit 5						63	3.79	30	7,163						
I-77	NB	C236	105	Tyvola Rd Exit 5	64	3.25	26	5,410	3,397					14,351	86.07	4.34	28.00	10,453	M024
I-77	NB	C010	105	Woodlawn Rd Exit 6						124	5.79	30	21,539						
I-77	NB	C229	105	Woodlawn Rd Exit 6	91	4.38	26	10,365											
I-77	NB	C029	107	NC-49/Tryon St Exit 6						128	4.46	9	5,138		89.05	3.23	9.50	2,736	M025
I-77	NB	C265	107	NC-49/Tryon St Exit 6	54	2.13	10	1,148											

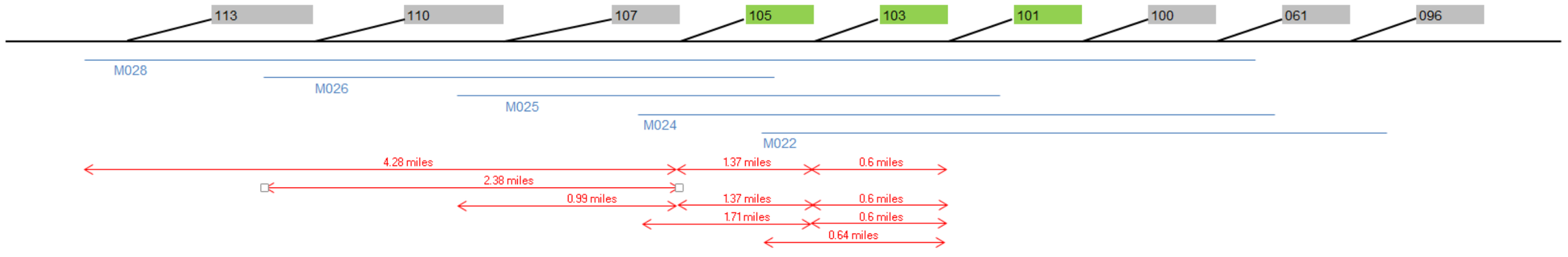
					September Congestion					April Congestion					Average				
TO Freeway	**Direction**	**Bottleneck Reference Number**	**Mainline Primary Log 1**	**FROM Cross Street (from Congestion Scan)**	**Average duration (minutes)**	**Average max length (miles)**	**Occurrences**	**Impact factor**	**Ave Impact Factor**	**Average Duration (minutes)**	**Average Max Length (miles)**	**Occurrences**	**Impact Factor**	**Ave Impact Factor**	**Average Duration (minutes)**	**Average Max Length (miles)**	**Occurrences**	**Impact factor**	**Merged Congestion Reference Number**
I-77	NB	C022	110	Clanton Rd Exit 7						97	3.72	27	9,743		159.43	3.51	18.50	10,366	M026
I-77	NB	C231	110	Clanton Rd Exit 7	328	2.96	10	9,697											
I-77	SB	C017	111	Remount Rd Exit 8						73	2.87	49	10,266		77.90	3.81	48.00	14,227	M027
I-77	NB	C221	111	Remount Rd Exit 8	83	4.78	47	18,665											
I-77	NB	C009	114	I-277/US-74 Exit 9						107	8.19	25	21,908		93.39	7.98	35.50	26,445	M028
I-77	NB	C216	114	I-277/US-74 Exit 9	86	7.86	46	31,095											
I-77	SB	C053	123	I-277/NC-16/W 11th St/ Brookshire Exit 12						50	1.14	16	912					912	M029
I-77	NB	C237	124	LaSalle St Exit 12	62	5.75	15	5,347										5,347	M030
I-77	NB	C002	129	I-85/ Statesville Ave Exit 13						128	8.76	56	62,792					62,792	M031
I-77	SB	C003	139	Gilead Rd Exit 23						131	5.69	74	55,159		128.83	7.62	57.00	55,959	M032
I-77	SB	C214	139	Gilead Rd Exit 23	102	7.13	64	46,536	30,630										
I-77	SB	C213	139	I-485 Exit 19	176	12.9	33	74,906											
I-77	NB	C077	140	Gilead Rd Exit 23						30	0.96	13	374		49.59	1.56	16.00	1,238	M033
I-77	NB	C250	140	Gilead Rd Exit 23	63	1.97	19	2,355											
I-77	SB	C273	141	NC-73 Exit 25	31	1.91	16	949										949	M034

					September Congestion					April Congestion					Average				
TO Freeway	**Direction**	**Bottleneck Reference Number**	**Mainline Primary Log 1**	**FROM Cross Street (from Congestion Scan)**	**Average duration (minutes)**	**Average max length (miles)**	**Occurrences**	**Impact factor**	**Ave Impact Factor**	**Average Duration (minutes)**	**Average Max Length (miles)**	**Occurrences**	**Impact Factor**	**Ave Impact Factor**	**Average Duration (minutes)**	**Average Max Length (miles)**	**Occurrences**	**Impact factor**	**Merged Congestion Reference Number**
I-77	NB	C048	143	NC-73 Exit 25						46	1.88	14	1,211		54.80	2.72	12.50	1,863	M035
I-77	NB	C245	143	NC-73 Exit 25	66	3.79	11	2,752											
I-77	NB	C005	145	US-21 Exit 28						81	5.36	67	29,089		72.61	5.14	51.50	19,207	M036
I-77	NB	C232	145	US-21 Exit 28	57	4.72	36	9,678											
I-77	SB	C034	146	Griffith St Exit 30						69	1.77	24	2,931		63.03	1.74	17.50	1,914	M037
I-77	SB	C274	146	Griffith St Exit 30	50	1.66	11	914											
I-77	NB	C018	147	Griffith St Exit 30						103	6.45	15	9,965	118,736	190.80	8.92	27.25	46,401	M038
I-77	NB	C001	147	Iredell/Mecklenburg County Line						238	9.83	62	145,051						
I-77	NB	C220	147	Iredell/ Mecklenburg County Line	148	8.1	16	19,171	10,483										
I-77	NB	C222	147	Griffith St Exit 30	133	8.56	16	18,216											
I-485	Outer	C258	180	West Blvd/Garrison Rd Exit 6	39	2.45	19	1,818										1,818	M039
I-485	Inner	C266	181	West Blvd/Garrison Rd Exit 6	45	1.26	20	1,135										1,135	M040
I-485	Outer	C057	182	US-74/US-29/Wilkinson Blvd/Exit 6						49	0.82	18	723		57.22	1.38	18.50	1,460	M041
I-485	Outer	C249	182	US-74/US-29/Wilkinson Blvd/Exit 6	65	1.91	19	2,357											
I-485	Outer	C277	224	Idlewild Rd Exit 49	38	1.49	13	737										737	M043

					September Congestion					April Congestion					Average				
TO Freeway	**Direction**	**Bottleneck Reference Number**	**Mainline Primary Log 1**	**FROM Cross Street (from Congestion Scan)**	**Average duration (minutes)**	**Average max length (miles)**	**Occurrences**	**Impact factor**	**Ave Impact Factor**	**Average Duration (minutes)**	**Average Max Length (miles)**	**Occurrences**	**Impact Factor**	**Ave Impact Factor**	**Average Duration (minutes)**	**Average Max Length (miles)**	**Occurrences**	**Impact factor**	**Merged Congestion Reference Number**
I-77	SB	C268	119	I-277/NC-16/W 11th St/Brookshire Exit 11	61	1.62	11	1,086										1,086	M044
I-77	NB	C226	128	I-85/ Statesville Ave Exit 13	97	6.77	20	13,137										13,137	M045
I-77	SB	C004	136	I-485 Exit 19						160	9.88	23	36,358					36,358	M046
I-77	SB	C039	141	NC-73 Exit 25						58	3.31	13	2,496					2,496	M047
I-77	SB	C020	150	US-21 Exit 33						106	3.57	26	9,839					9,839	M048
I-485	Inner	C030	177	NC-160/Steele Creek Rd Exit 4						62	2.98	23	4,249		65.51	2.85	20.50	3,831	M049
I-485	Inner	C243	177	NC-160/Steele Creek Rd Exit 4	70	2.69	18	3,390											
I-277	NB	C025	21	W 5Th St Exit 5						67	1.17	83	6,506		61.78	1.15	73.50	5,233	M050
I-277	NB	C239	21	W 5Th St Exit 5	55	1.13	64	3,980											
I-485	Outer	C019	230	NC-16 Providence Rd Exit 57						118	6.48	13	9,940		119.28	6.24	18.00	13,391	M051
I-485	Outer	C223	230	NC-16 Providence Rd Exit 57	120	6.1	23	16,824											
I-485	Inner	C011	231	NC-16 Providence Rd Exit 57						76	6.56	34	16,951		77.69	6.17	29.50	14,132	M052

					September Congestion					April Congestion					Average				
TO Freeway	**Direction**	**Bottleneck Reference Number**	**Mainline Primary Log 1**	**FROM Cross Street (from Congestion Scan)**	**Average duration (minutes)**	**Average max length (miles)**	**Occurrences**	**Impact factor**	**Ave Impact Factor**	**Average Duration (minutes)**	**Average Max Length (miles)**	**Occurrences**	**Impact Factor**	**Ave Impact Factor**	**Average Duration (minutes)**	**Average Max Length (miles)**	**Occurrences**	**Impact factor**	**Merged Congestion Reference Number**
I-485	Inner	C227	231	NC-16 Providence Rd Exit 57	80	5.63	25	11,254											
I-485	Outer	C016	234	Rea Rd Exit 59						101	4.26	25	10,757		89.08	3.59	18.00	5,753	M053
I-485	Outer	C262	234	Rea Rd Exit 59	62	2.06	11	1,407											
I-485	Inner	C023	236	Rea Rd Exit 59						89	6.74	13	7,798		72.93	5.52	14.00	5,640	M054
I-485	Inner	C240	236	Rea Rd Exit 59	59	4.47	15	3,960											
I-485	Outer	C038	238	US-521 Exit 61						52	2.2	22	2,517					2,517	M055
I-485	Outer	C044	246	I-77/US-21 Exit 67						53	1.32	25	1,749		53.94	1.23	23.50	1,554	M056
I-485	Outer	C263	246	I-77/US-21 Exit 67	55	1.12	22	1,360											
I-85	NB	C059	42	I-485 Exit 30						41	1.88	9	694					694	M057
US 74	WB			Briar Creek Rd./Television Lane						82	2.17	26	4,623		82.83	2.72	18.00	4,056	
US 74	WB			Hawthorne Road						85	4.15	10	3,526						
US 74	EB			I-277	22	1.03	6	136											

Figure 6. Example showing Calculation of Multiple and Group Sites
(Continued on Next Page)



Congestion	Average Max Length (miles) (F_T)	No. of Occurrences (G)	Average Duration (min) (J)
M028	7.98	36	93.39
M026	3.51	19	159.43
M025	3.23	10	89.05
M024	4.34	28	86.07
M022	3.10	10	60.00

All data in these cells comes from Table 9

Site 105	Average Max Length (miles) (F)= F_T - E	No. of Occurrences (G)	Average Duration (min) (H) = F/F_T x J	Impact (I) = FxGxH		Distance from Primary Site (E)
M028	3.70	36	43.30	5767.71		4.28
M026	1.13	19	51.33	1101.98		2.38
M025	2.24	10	61.76	1383.34		0.99
M024	4.34	28	86.07	10459.23	start of bottleneck	0
Total	3.21	93	59.80	17856.21		
	((F*G)$_{M028}$+ (F*G)$_{M026}$+ (F*G)$_{M025}$+ (F*G)$_{M024}$)/ Total G	SUM of G	((H*G)$_{M028}$+ (H*G)$_{M026}$+ (H*G)$_{M025}$+ (H*G)$_{M024}$)/ Total G			

Site 103	Average Max Length (miles) (F)= F_T - E	No. of Occurrences (G)	Average Duration (min) (H) = F/F_T x J	Impact (I) = FxGxH		Distance from Primary Site (E)
M028	2.33	36	27.27	2287.24		4.28+1.37
M025	0.87	10	23.99	208.67		.99+1.37
M024	2.63	28	52.16	3840.89		1.71
M022	3.10	10	60.00	1860.00	start of bottleneck	0
Total	2.35	84	39.07	7705.47		
	((F*G)$_{M028}$+ (F*G)$_{M026}$+ (F*G)$_{M025}$+ (F*G)$_{M024}$)/ Total G	SUM of G	((H*G)$_{M028}$+ (H*G)$_{M026}$+ (H*G)$_{M025}$+ (H*G)$_{M024}$)/ Total G			

Site 101	Average Max Length (miles) (F)= F_T - E	No. of Occurrences (G)	Average Duration (min) (H) = F/F_T x J	Impact (I) = FxGxH	Distance from Primary Site (E)
M028	1.73	36	20.25	1260.93	4.28+1.37+0.6
M025	0.27	10	7.44	20.10	0.99+1.37+0.6
M024	2.03	28	40.26	2288.30	1.71+0.6
M022	2.46	10	47.61	1171.28	0.64
Total	1.74	84	28.65	4195.05	
	((F*G)$_{M028}$+ (F*G)$_{M026}$+ (F*G)$_{M025}$+ (F*G)$_{M024}$)/ Total G	SUM of G	((H*G)$_{M028}$+ (H*G)$_{M026}$+ (H*G)$_{M025}$+ (H*G)$_{M024}$)/ Total G		

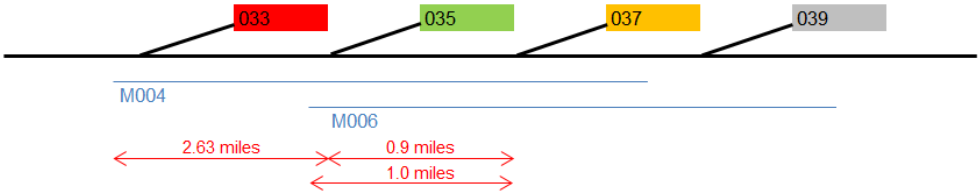
B.2 Calculations Performed for Multiple and Group Sites

The following figures show the calculations made for each Multiple and Group site using the assumptions above.

The information shown on the diagrams that follow represent the congestion sites and respective delays. The red lines beneath the line diagrams represent the distances in miles used to calculate the length of congestion over which benefits from ramp metering can be realized. For example in the first diagram, the distance between sites 033 and 035 is 2.63 miles, the distance between sites 035 and 037 is 0.9 miles and the distance between the start of congestion M006 and site 037 is 1 mile. These figures feed data into the calculations beneath the line diagram.

The sites are color coded to represent how they have been categorized. The following legend shows the respective categories:

Site Category:	
Feasible	
Review in Future	
Not Feasible	
Not included in Detailed Analysis	



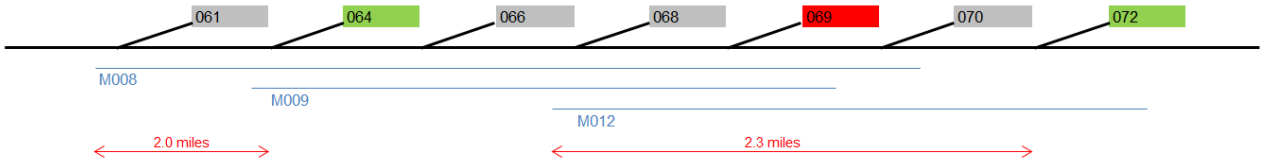
Congestion	Average max length (miles)	No. of occurrences	Average duration (min)
M004	5.69	14	117
M006	4.31	17	83

Site 035	Average max length (miles)	No. of occurrences	Average duration (min)	Impact	
M004	3.06	14	62.92	2695.53	
M006	4.31	17	83.00	6081.41	start of bottleneck
Total	3.75	31	73.93	8584.25	

Site 037	Average max length (miles)	no. of occurrences	Average duration (min)	impact
M004	2.16	14	44.41	1343.10
M006	3.31	17	63.74	3586.79
Total	2.79	31	55.01	4759.25

Site 033	Not Feasible

Figure 7. Congestion Group 1



Congestion	Average max length (miles)	No. of occurrences	Average duration (min)
M008	4.99	14	71.11
M009	2.82	18	41.00
M012	3.38	15	50.00

Site 064	Average max length (miles)	No. of occurrences	Average duration (min)	Impact	
M008	2.99	14	42.63	1722.63	
M009	2.82	18	41.00	2081.16	start of bottleneck
Total	2.89	32	41.70	3801.61	

Site 072	Average max length (miles)	No. of occurrences	Average duration (min)	Impact
M012	1.08	15	15.98	258.82

Site 069	Not Feasible

Figure 8. Congestion Group 2

Congestion	Average max length (miles)	No. of occurrences	Average duration (min)
M020	6.34	36	109.03
M021	4.85	27	112.57
M023	3.26	17	66.94
M027	3.81	48	77.90

Site 93	Average max length (miles)	No. of occurrences	Average duration (min)	
M020	6.34	36	109.03	start of bottleneck

Site 097	Average max length (miles)	no. of occurrences	Average duration (min)	impact	
M020	5.80	36	99.74	20811.95	F2F

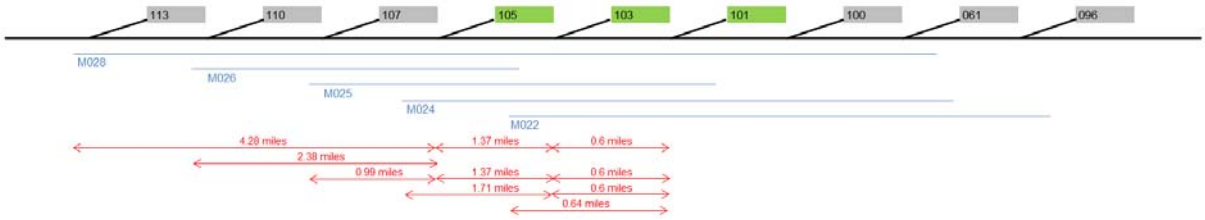
Site 102	Average max length (miles)	No. of occurrences	Average duration (min)	Impact	
M020	3.42	36	58.78	7229.90	
M021	4.85	27	112.57	14455.73	start of bottleneck
Total	4.02	63	81.59	20512.00	

Site 104	Average max length (miles)	no. of occurrences	Average duration (min)	impact
M020	2.42	36	41.58	3616.86
M021	3.75	27	87.01	8637.95
M023	3.26	17	66.94	3711.22
Total	3.04	80	62.15	15020.95

Site 111	Average max length (miles)	No. of occurrences	Average duration (min)	Impact	
M021	0.10	27	2.23	5.68	
M027	3.81	48	77.90	14227.28	start of bottleneck
Total	2.49	75	50.98	9441.25	

Site 099	Not Feasible
Site 109	Not Feasible
Site 117	Not Feasible

Figure 9. Congestion Group 3



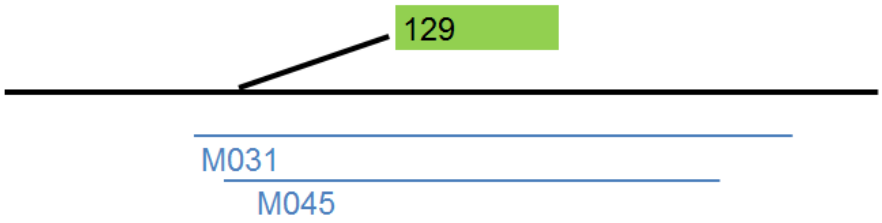
Congestion	Average max length (miles)	No. of occurrences	Average duration (min)
M028	7.98	36	93.39
M026	3.51	19	159.43
M025	3.23	10	89.05
M024	4.34	28	86.07
M022	3.10	10	60.00

Site 105	Average max length (miles)	No. of occurrences	Average duration (min)	Impact	
M028	3.70	36	43.28	5678.89	
M026	1.13	19	51.47	1080.33	
M025	2.24	10	61.79	1317.03	
M024	4.34	28	86.07	10452.94	start of bottleneck
Total	3.22	92	59.95	17683.64	

Site 103	Average max length (miles)	No. of occurrences	Average duration (min)	Impact	
M028	2.33	36	27.24	2249.29	
M025	0.87	10	24.06	199.70	
M024	2.63	28	52.14	3835.50	
M022	3.10	10	60.00	1860.00	start of bottleneck
Total	2.35	83	39.22	7665.60	

Site 101	Average max length (miles)	no. of occurrences	Average duration (min)	Impact
M028	1.73	36	20.21	1238.61
M025	0.27	10	7.54	19.60
M024	2.03	28	40.23	2283.71
M022	2.46	10	47.61	1171.28
Total	1.75	83	28.82	4185.39

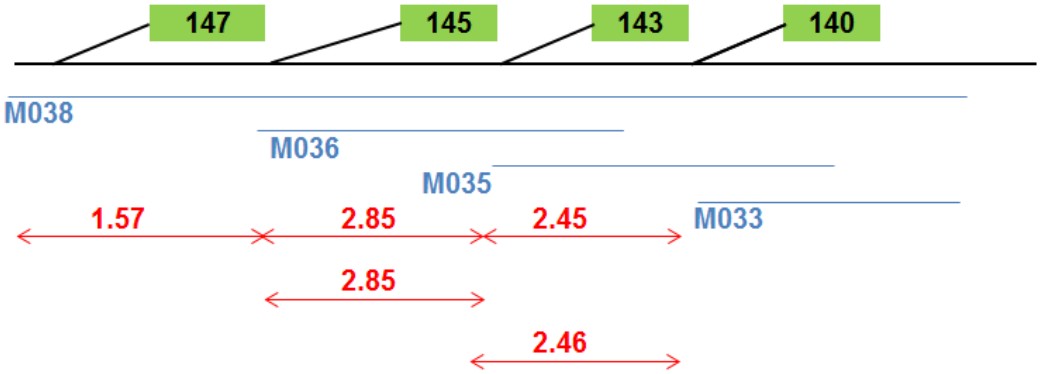
Figure 10. Congestion Group 4



Congestion	Average max length (miles)	No. of occurrences	Average duration (min)	
M031	8.76	56	128.00	F2F
M045	6.77	20	97.00	F2F

Site 129	Average max length (miles)	No. of occurrences	Average duration (min)	Impact	
M031	8.76	56	128.00	62791.68	start of bottleneck
M045	6.77	20	97.00	13133.80	start of bottleneck
Total	8.24	76	119.84	75016.36	

Figure 11. Congestion Group 5



Congestion	Average max length (miles)	No. of occurrences	Average duration (min)
M038	8.92	27	190.80
M036	5.14	52	72.61
M035	2.72	13	54.80
M033	1.56	16	49.59

Site 147	Average max length (miles)	No. of occurrences	Average duration (min)	
M038	8.92	27	190.80	Start of bottleneck

Site 145	Average max length	No. of occurrences	Average duration (min)	Impact	
M038	7.35	27	157.23	31511.04	
M036	5.14	52	72.61	19207.23	Start of bottleneck
Total	5.90	79	101.89	47373.25	

Site 143	Average max length (miles)	No. of occurrences	Average duration (min)	Impact	
M038	4.50	27	96.30	11820.87	
M036	2.29	52	32.32	3805.68	
M035	2.72	13	54.80	1863.47	Start of bottleneck
Total	3.01	91	54.51	14962.11	

Site 140	Average max length	No. of occurrences	Average duration (min)	Impact
M033	1.56	16	49.59	1237.61
M038	2.05	27	43.92	2459.05
M035	0.26	13	5.25	17.07
Total	1.51	56	36.88	3104.99

Figure 12. Congestion Group 6

Congestion	Average max length (miles)	No. of occurrences	Average duration (min)
M051	6.24	18	119.28
M053	3.59	18	89.08
M055	2.20	22	52.00

Site 230	Average max length (miles)	No. of occurrences	Average duration (min)	
M051	6.24	18	119.28	start of bottleneck

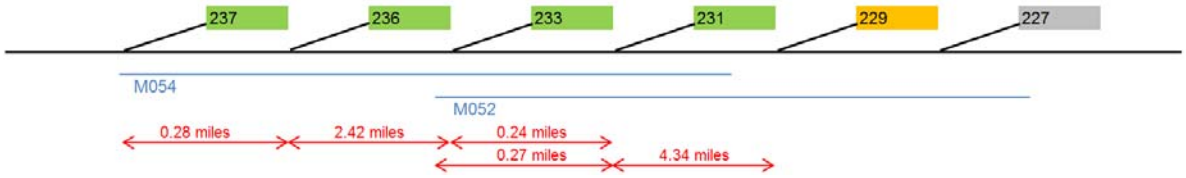
Site 232	Average max length (miles)	No. of occurrences	Average duration (min)	Impact
M051	5.99	18	114.50	12339.33

Site 234	Average max length (miles)	No. of occurrences	Average duration (min)	Impact	
M051	3.65	18	69.75	4578.94	
M053	3.59	18	89.08	5753.00	start of bottleneck
Total	3.62	36	79.42	10342.29	

Site 239	Average max length (miles)	No. of occurrences	Average duration (min)	Impact
M051	1.62	18	30.93	900.29
M053	1.52	18	37.69	1029.58
M055	1.85	22	43.73	1779.70
Total	1.67	58	37.88	3679.27

Site 235	Not Feasible
Site 238	Not Feasible

Figure 13. Congestion Group 7



Congestion	Average max length (miles)	No. of occurrences	Average duration (min)
M054	5.52	14	72.93
M052	6.17	30	77.69

Site 237	Average max length (miles)	No. of occurrences	Average duration (min)	
M054	5.52	14	72.93	start of bottleneck

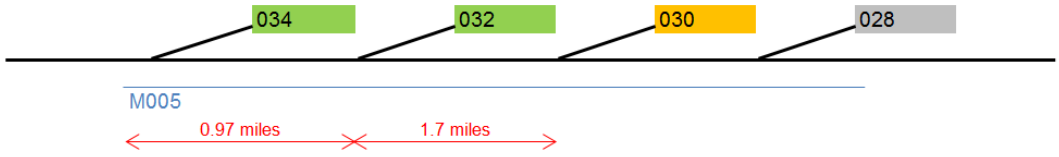
Site 236	Average max length (miles)	No. of occurrences	Average duration (min)	Impact
M054	5.24	14	69.23	5082.66

Site 233	Average max length (miles)	No. of occurrences	Average duration (min)	Impact	
M054	2.82	14	37.28	1473.96	
M052	6.17	30	77.69	14132.32	start of bottleneck
Total	5.09	44	64.69	14323.99	

Site 231	Average max length (miles)	No. of occurrences	Average duration (min)	Impact
M054	2.58	14	34.11	1234.07
M052	5.90	30	74.29	12921.73
Total	4.83	44	61.36	12892.38

Site 229	Average max length (miles)	no. of occurrences	Average duration (min)	impact
M052	1.56	30	19.61	899.91

Figure 14. Congestion Group 8



Congestion	Average max length (miles)	No. of occurrences	Average duration (min)
M005	3.60	19	62.16

Site 034	Average max length (miles)	No. of occurrences	Average duration (min)	Impact	
M005	3.60	19	62.16	4251.74	start of bottleneck

Site 032	Average max length (miles)	No. of occurrences	Average duration (min)	Impact
M005	2.63	19	45.41	2269.20

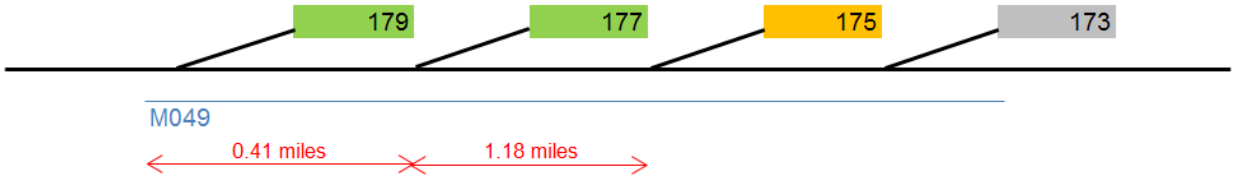
Site 030	Average max length (miles)	no. of occurrences	Average duration (min)	impact
M005	0.93	19	16.06	283.74

Figure 15. Multiple Site Congestion M005

Congestion	Average max length (miles)	No. of occurrences	Average duration (min)
M048	3.57	26	106.00

Site 150	Not Feasible
Site 153	Not Feasible

Figure 16. Multiple Site Congestion M048



Congestion	Average max length (miles)	No. of occurrences	Average duration (min)
M049	2.85	21	65.51

Site 179	Average max length (miles)	No. of occurrences	Average duration (min)	Impact	
M049	2.85	21	65.51	3831.15	start of bottleneck

Site 177	Average max length (miles)	No. of occurrences	Average duration (min)	Impact
M049	2.44	21	56.10	2809.03

Site 175	Average max length (miles)	no. of occurrences	Average duration (min)	impact
M049	1.26	21	29.00	750.60

Figure 17. Multiple Site Congestion M049

Appendix C: Site Summaries

The Site Summaries are live documents and are presented here as they currently stand. The costs and benefits have yet to be completed; this will be done in the next phase of the project. At the end of the project, the final versions will include information on costs, benefits, and resulting place in the prioritized order for the implementation plan.

C.1 Individual Sites

Site Summaries 045, 067, 075, 146, 180, 181, 182, and 250 have been included in this section.

NCDOT Ramp Metering Feasibility Study
Site Summary Document

045

Site Details

Site Number	045
Freeway	I-85
Cross Street	Little Rock Road
Exit	32
Direction	Northbound
County	Mecklenburg

Physical Characteristics Overview

Origin of Entrance Ramp	Free Flow Link
Lane Addition onto Main Freeway length (feet)	400
Number of Entrance Ramp Lanes	1
Lane Drop on Entrance Ramp Before Merge	Yes
Number of Freeway Lanes Before Merge	4
Number of Freeway Lanes After Merge	4
Entrance Ramp Length to Back of Gore (feet)	840
Entrance Ramp Length to Tip of Gore (feet)	1,188
Merge Length (feet)	720
Entrance Ramp Horizontal Alignment	Straight
Entrance Ramp Vertical Alignment	Slight uphill
Entrance Ramp Shoulder (Paved Full Width)	Yes
Main Freeway Vertical Alignment Downstream	Level
Main Freeway Shoulder	Yes
Number of Vehicles Storage	34
Guardrail	Yes
Pipe Crossing	Yes; Concrete drainage ditch located 8’ from edge of travel lane

Signalization Overview

Upstream Signal	3-way signal; Ramp entry from: dual left turn and right turn
Nearest Power Source	Distribution pole at intersection at overpass

Signing Overview

Existing Signing	Dual left lane ends - 54' & 70' from grass island "No Trucks 3 Axles" – 360' from grass island (21' off edge of travel lane)

Traffic Volumes

Period Beginning	Upstream Hourly Volume Rate	Downstream Hourly Volume Rate	Entrance Ramp Hourly Volume Rate	Downstream Volume per Lane	Entrance Ramp Volume per Lane	Entrance Ramp % of Downstream Volume	Hour Meets Acceptable Criteria for Ramp Metering
06:00	4,603	4,984	381	1,246	381	8	Yes
07:00	7,965	8,373	408	2,093	408	5	No
08:00	7,830	8,280	450	2,070	450	5	Yes
09:00	5,774	6,191	417	1,548	417	7	Yes
10:00	4,115	4,566	451	1,142	451	10	Yes
11:00	3,720	4,120	400	1,030	400	10	Yes
12:00	3,636	4,086	450	1,022	450	11	Yes
13:00	3,835	4,254	419	1,064	419	10	Yes
14:00	4,052	4,496	444	1,124	444	10	Yes
15:00	4,460	5,057	597	1,264	597	12	Yes
16:00	4,543	5,105	562	1,276	562	11	Yes
17:00	4,778	5,328	550	1,332	550	10	Yes
18:00	4,333	4,805	472	1,201	472	10	Yes
19:00	3,265	3,786	521	947	521	14	Yes
20:00	2,483	2,898	415	725	415	14	Yes

Capacity Analysis

Downstream Freeway Peak Volume	8,748
Corresponding Ramp Volume	396
Corresponding Upstream Freeway Peak Volume	8,352
Peak Hour Factor	0.936
Ramp Merge Level of Service	F

Congestion

Congestion	M007
Ave Length of Congestion (Miles)	1.77
Duration of Congestion (Minutes)	42
Calculated Number of Occurrences per Year	146
Typical Times of Congestion	07:30 - 09:30

Crash Data

The total number of accidents from March 2011 to February 2016 was: 42
Of these, 29 were accidents which can be associated with congestion:
Type 21-Rear end, slow or stop: 19 (45%)
Type 28- Sideswipe, same direction: 10 (24%)

Observations

Log 45 is a direct ramp with no sight distance issues. The grade is slightly uphill with an average slope of 1.73%. Both the travel lane and shoulder are made of asphalt and transitions to concrete at 185' from grass island. The pavement and shoulder condition were considered to be fair. The left shoulder has a width of 8' and the right shoulder has a width of 8'. There is a run of guardrail/barrier wall 351' from the grass island with an offset of 14' from edge of travel lane, guardrail is 64' long and transitions to barrier wall. There is a concrete drainage ditch running along the entrance ramp 8' from edge of travel lane. Utility light poles located directly behind guardrails.

Small PM peak of congestion in traffic count

Site Selection Comments

This is a single lane direct ramp from a free-volume intersection. It has storage for approximately 34 vehicles.

This is a primary site for congestion problem M007. This is a reasonably serious congestion problem, however it appears that it is caused by traffic queueing to leave the freeway at a downstream off ramp. This is not a problem that ramp metering can address.

Downstream volumes and ideal and ramp volumes are acceptable during the congested period.

This is not a feasible site for ramp metering as it will not address the congestion problem which is caused by traffic queuing for a downstream off ramp.

Site Categorization

Not feasible

NCDOT Ramp Metering Feasibility Study
Site Summary Document

067

Site Details

Site Number	067
Freeway	I-85
Cross Street	Sugar Creek Road
Exit	41
Direction	Northbound
County	Mecklenburg

Physical Characteristics Overview

Origin of Entrance Ramp	Signalized Intersection
Lane Addition onto Main Freeway length (feet)	660
Number of Entrance Ramp Lanes	1
Lane Drop on Entrance Ramp Before Merge	None
Number of Freeway Lanes Before Merge	4
Number of Freeway Lanes After Merge	4
Entrance Ramp Length to Back of Gore (feet)	570
Entrance Ramp Length to Tip of Gore (feet)	595
Merge Length (feet)	640
Entrance Ramp Horizontal Alignment	Straight
Entrance Ramp Vertical Alignment	Slight Downhill
Entrance Ramp Shoulder (Paved Full Width)	Yes
Main Freeway Vertical Alignment Downstream	Slight uphill
Main Freeway Shoulder	Yes
Number of Vehicles Storage	23
Guardrail	Yes
Pipe Crossing	None Present

Signalization Overview

Upstream Signal	3-way signal; Ramp entry from: left turn and right turn
Nearest Power Source	Traffic Signal

Signing Overview

Existing Signing	No Signs

Traffic Volumes

Period Beginning	Upstream Hourly Volume Rate	Downstream Hourly Volume Rate	Entrance Ramp Hourly Volume Rate	Downstream Volume per Lane	Entrance Ramp Volume per Lane	Entrance Ramp % of Downstream Volume	Hour Meets Acceptable Criteria for Ramp Metering
06:00	3,869	4,191	322	1,048	322	8	Yes
07:00	5,735	6,179	444	1,545	444	7	Yes
08:00	6,387	6,906	519	1,727	519	8	Yes
09:00	5,910	6,287	377	1,572	377	6	Yes
10:00	5,535	5,920	385	1,480	385	7	Yes
11:00	5,502	5,933	431	1,483	431	7	Yes
12:00	5,600	6,073	473	1,518	473	8	Yes
13:00	5,898	6,337	439	1,584	439	7	Yes
14:00	6,289	6,758	469	1,690	469	7	Yes
15:00	6,830	7,370	540	1,843	540	7	Yes
16:00	7,700	8,310	610	2,078	610	7	Yes
17:00	7,881	8,456	575	2,114	575	7	Yes
18:00	6,951	7,422	471	1,856	471	6	Yes
19:00	5,654	6,013	359	1,503	359	6	Yes
20:00	4,266	4,541	275	1,135	275	6	No

Capacity Analysis

Downstream Freeway Peak Volume	8,577
Corresponding Ramp Volume	606
Corresponding Upstream Freeway Peak Volume	7,971
Peak Hour Factor	0.955
Ramp Merge Level of Service	D

Congestion

Congestion	M011
Ave Length of Congestion (Miles)	3.81
Duration of Congestion (Minutes)	100.18
Calculated Number of Occurrences per Year	201
Typical Times of Congestion	15:00 - 19:00

Crash Data

The total number of accidents from March 2011 to February 2016 was: 76
Of these, 51 were accidents which can be associated with congestion:
Type 21-Rear end, slow or stop: 27 (36%)
Type 28- Sideswipe, same direction: 24 (32%)

Observations

Log 67 is a direct ramp with no sight distance issues. The grade is slightly downhill with an average slope of -1.17%, and merges to a slight uphill grade on the mainline. The travel lane and shoulders are asphalt. The pavement and shoulder condition were considered to be poor to fair. The left shoulder has a width of 4.5' and the right shoulder has a width of 9.5'. There is a run of guardrail 464' from the crosswalk at start of the ramp that transitions to barrier wall at 602' from the crosswalk at start of the ramp. Concrete curbing gutter runs length of Entrance Ramp to barrier wall at 12' offset from edge of travel lane. Road behind barrier/retaining wall so there is no room to expand outside of ramp.

Site Selection Comments

This is a single lane direct ramp from a signalized intersection. It has capacity to store approximately 23 vehicles on the ramp.

This is the primary site for congestion problem M011 and is congested during the PM peak. It is an individual site, meaning it is not associated with any other congestion problems.

Downstream and ramp volumes are with the ideal range during the congested period. The entrance ramp volumes are toward the lower end of the range for ideal conditions but will still provide a benefit.

There is scope for ramp metering to provide a benefit here. It would operate best as a single lane at the ramp metering stop line, however if additional storage is required, it would be possible to widen the entrance ramp and have a lane drop before the signals.

No specific implementation problems have been identified.

Site Categorization

Feasible for taking forward

NCDOT Ramp Metering Feasibility Study
Site Summary Document

075

Site Details

Site Number	075
Freeway	I-85
Cross Street	Mallard Creek Church Road
Exit	46
Direction	Northbound
County	Mecklenburg

Physical Characteristics Overview

Origin of Entrance Ramp	Free Flow Link
Lane Addition onto Main Freeway length (feet)	1,450
Number of Entrance Ramp Lanes	1
Lane Drop on Entrance Ramp Before Merge	None
Number of Freeway Lanes Before Merge	4
Number of Freeway Lanes After Merge	4
Entrance Ramp Length to Back of Gore (feet)	1,235
Entrance Ramp Length to Tip of Gore (feet)	1,510
Merge Length (feet)	5,025
Entrance Ramp Horizontal Alignment	Straight
Entrance Ramp Vertical Alignment	Downhill
Entrance Ramp Shoulder (Paved Full Width)	No
Main Freeway Vertical Alignment Downstream	Level
Main Freeway Shoulder	Yes
Number of Vehicles Storage	49
Guardrail	Yes
Pipe Crossing	None Present

Signalization Overview

Upstream Signal	Two-way signal; Ramp entry from single left and right turns
Nearest Power Source	Power Pole from signal at start of ramp

Signing Overview

Existing Signing	No Signs

Traffic Volumes

Period Beginning	Upstream Hourly Volume Rate	Downstream Hourly Volume Rate	Entrance Ramp Hourly Volume Rate	Downstream Volume per Lane	Entrance Ramp Volume per Lane	Entrance Ramp % of Downstream Volume	Hour Meets Acceptable Criteria for Ramp Metering
06:00	1,918	2,118	200	530	200	9	No
07:00	3,019	3,358	339	840	339	10	Yes
08:00	3,387	3,726	339	932	339	9	Yes
09:00	3,292	3,579	287	895	287	8	No
10:00	3,560	3,877	317	969	317	8	Yes
11:00	4,058	4,451	393	1,113	393	9	Yes
12:00	4,291	4,780	489	1,195	489	10	Yes
13:00	4,264	4,713	449	1,178	449	10	Yes
14:00	4,615	5,093	478	1,273	478	9	Yes
15:00	5,396	6,048	652	1,512	652	11	Yes
16:00	5,899	6,825	926	1,706	926	14	Yes
17:00	6,025	7,116	1,091	1,779	1,091	15	Yes
18:00	5,396	6,069	673	1,517	673	11	Yes
19:00	4,075	4,565	490	1,141	490	11	Yes
20:00	3,298	3,614	316	904	316	9	Yes

Capacity Analysis

Downstream Freeway Peak Volume	7,116
Corresponding Ramp Volume	1,091
Corresponding Upstream Freeway Peak Volume	6,025
Peak Hour Factor	0.981
Ramp Merge Level of Service	F

Congestion

Congestion	M013
Ave Length of Congestion (Miles)	1.29
Duration of Congestion (Minutes)	41
Calculated Number of Occurrences per Year	122
Typical Times of Congestion	17:00 - 18:00

Crash Data

The total number of accidents from March 2011 to February 2016 was: 56
Of these, 48 were accidents which can be associated with congestion:
Type 21-Rear end, slow or stop: 26 (46%)
Type 28- Sideswipe, same direction: 22 (39%)

Observations

Log 075 is a direct ramp. The grade is level with an average slope of -2.23%. Both the travel lane and shoulder are made of asphalt. The pavement and shoulder condition were considered to be poor. The left shoulder has a width of 3'' and the right shoulder had a width of 4'. There is a guardrail that runs the length of the ramp with an offset of 13' from edge of travel lane. Drop-off directly behind guardrail. Trees on inside of ramp may pose minor sight distance issue.

Site Selection Comments

This is a single lane direct ramp from an un-signalized intersection. It has capacity to store approximately 49 vehicles on the ramp.

This is the primary site for congestion problem M013 and is congested during the PM peak. It is an individual site, meaning it is not associated with any other congestion problems. The level of congestion is relatively low.

Downstream and ramp volumes are acceptable during congestion. The ramp volume is on the high side for a single lane, so ramp metering would operate better if this site was metered as two lanes. However this is not absolutely necessary for some benefit to be gained.

This site is primary to congestion problem to M013. The site has potential to ease weaving movements downstream. The site would operate more effectively if increased to two entrance ramp lanes, although this will present increased costs. While it is desirable to have a second lane, the system will work in the current single lane configuration with more limited effect.

This site should be easy to implement, although if the second lane option is chosen, this could add significantly to the cost.

Site Categorization

Feasible for taking forward

NCDOT Ramp Metering Feasibility Study
Site Summary Document

146

Site Details

Site Number	146
Freeway	I-77
Cross Street	Goodrum Road / Griffith Street
Exit	30
Direction	Southbound
County	Mecklenburg

Physical Characteristics Overview

Origin of Ramp	Stop-controlled Intersection with free flow right turn
Lane Addition onto Main Freeway length (feet)	440
Number of Entrance Ramp Lanes	1
Lane Drop on Entrance Ramp Before Merge	None
Number of Freeway Lanes Before Merge	2
Number of Freeway Lanes After Merge	2
Entrance Ramp Length to Back of Gore (feet)	885
Entrance Ramp Length to Tip of Gore (feet)	1,125
Merge Length (feet)	770
Entrance Ramp Horizontal Alignment	Straight
Entrance Ramp Vertical Alignment	Slight Downhill
Entrance Ramp Shoulder (Paved Full Width)	No
Main Freeway Vertical Alignment Downstream	Level
Main Freeway Shoulder	Yes
Number of Vehicles Storage	35
Guardrail	None Present
Pipe Crossing	None Present

Signalization Overview

Upstream Signal	No Signal
Nearest Power Source	Power pole at start of ramp 60’ from edge of travel lane inside of ramp

Signing Overview

Existing Signing	No Signs

Traffic Volumes

Period Beginning	Upstream Hourly Volume Rate	Downstream Hourly Volume Rate	Entrance Ramp Hourly Volume Rate	Downstream Volume per Lane	Entrance Ramp Volume per Lane	Entrance Ramp % of Downstream Volume	Hour Meets Acceptable Criteria for Ramp Metering
06:00	3,665	3,905	240	1,953	240	6	No
07:00	2,984	3,231	247	1,616	247	8	No
08:00	2,865	3,181	316	1,591	316	10	Yes
09:00	3,254	3,574	320	1,787	320	9	Yes
10:00	3,458	3,808	350	1,904	350	9	Yes
11:00	3,418	3,873	455	1,937	455	12	Yes
12:00	3,429	3,883	454	1,942	454	12	Yes
13:00	3,605	4,011	406	2,006	406	10	Yes
14:00	3,498	3,894	396	1,947	396	10	Yes
15:00	3,713	4,244	531	2,122	531	13	Yes
16:00	3,768	4,355	587	2,178	587	13	Yes
17:00	3,991	4,644	653	2,322	653	14	Yes
18:00	3,767	4,186	419	2,093	419	10	Yes
19:00	2,419	2,688	269	1,344	269	10	No
20:00	2,168	2,378	210	1,189	210	9	No

Capacity Analysis

Downstream Freeway Peak Volume	4,644
Corresponding Ramp Volume	653
Corresponding Upstream Freeway Peak Volume	3,991
Peak Hour Factor	0.940
Ramp Merge Level of Service	F

Congestion

Congestion	M037
Ave Length of Congestion (Miles)	1.74
Duration of Congestion (Minutes)	63.03
Calculated Number of Occurrences per Year	213
Typical Times of Congestion	13:00 - 17:30

Crash Data

The total number of accidents from March 2011 to February 2016 was: 37
Of these, 31 were accidents which can be associated with congestion:
Type 21-Rear end, slow or stop: 26 (70%)
Type 28- Sideswipe, same direction: 5 (14%)

Observations

Log 146 is a long direct ramp. There are no sight distance issues. The grade is slightly downhill with an average slope of -1.27%. The pavement and shoulder type are asphalt. The pavement and shoulder condition were considered to be poor. The left and right side of both shoulders have a width of 2' along the ramp. Concrete drainage structure 12' from edge of travel lane. The tree line occurs at 28' from edge of travel lane.

Peak flow greater than 2,000 vehicles per hour per lane.

Site Selection Comments

This is a direct single lane ramp with storage for approximately 35 vehicles, fed from a partially stop-controlled, partially free-flow link.

There is quite a lot of congestion at this location and it is the primary site for M037. Ramp metering should provide congestion benefits at this location.

Downstream and ramp volumes are ideal during the congested period.

This site seems to be a good candidate for ramp metering. The limited storage is a concern, however RM would not operate effectively using a two lane stop line because the ramp volumes are too low most of the time. There could be some scope for widening the storage area with a lane drop approaching the stop line, but this is not necessary.

No specific implementation problems have been identified, however adding an extra lane for storage, but not metering, might be beneficial.

Site Categorization

Feasible for taking forward

NCDOT Ramp Metering Feasibility Study
Site Summary Document

180

Site Details

Site Number	180
Freeway	I-485
Cross Street	West Boulevard
Exit	6
Direction	Outer
County	Mecklenburg

Physical Characteristics Overview

Origin of Entrance Ramp	Stop Controlled Intersection with Free Flow Right Turn
Lane Addition onto Main Freeway length (feet)	475
Number of Entrance Ramp Lanes	1
Lane Drop on Entrance Ramp Before Merge	No
Number of Freeway Lanes Before Merge	3
Number of Freeway Lanes After Merge	3
Entrance Ramp Length to Back of Gore (feet)	1,400
Entrance Ramp Length to Tip of Gore (feet)	1,610
Merge Length (feet)	1,350
Entrance Ramp Horizontal Alignment	Straight
Entrance Ramp Vertical Alignment	Slightly Downhill
Entrance Ramp Shoulder (Paved Full Width)	Yes
Main Freeway Vertical Alignment Downstream	Uphill
Main Freeway Shoulder	Yes
Number of Vehicles Storage	56
Guardrail	None
Pipe Crossing	None

Signalization Overview

Upstream Signal	No Signal; Stop Controlled
Nearest Power Source	Power Poles across street (exit ramp side)

Signing Overview

Existing Signing	None

Traffic Volumes

Period Beginning	Upstream Hourly Volume Rate	Downstream Hourly Volume Rate	Entrance Ramp Hourly Volume Rate	Downstream Volume per Lane	Entrance Ramp Volume per Lane	Entrance Ramp % of Downstream Volume	Hour Meets Acceptable Criteria for Ramp Metering
06:00	4,478	4,609	131	1,536	131	3	No
07:00	7,200	7,459	259	2,486	259	3	No
08:00	6,999	7,201	202	2,400	202	3	No
09:00	4,729	4,848	119	1,616	119	2	No
10:00	3,886	3,989	103	1,330	103	3	No
11:00	3,696	3,845	149	1,282	149	4	No
12:00	3,917	4,063	146	1,354	146	4	No
13:00	4,444	4,593	149	1,531	149	3	No
14:00	4,753	4,938	185	1,646	185	4	No
15:00	5,298	5,558	260	1,853	260	5	No
16:00	5,990	6,298	308	2,099	308	5	No
17:00	5,695	6,014	319	2,005	319	5	Yes
18:00	4,878	5,111	233	1,704	233	5	No
19:00	3,957	4,056	99	1,352	99	2	No
20:00	2,741	2,802	61	934	61	2	No

Capacity Analysis

Downstream Freeway Peak Volume	7,565
Corresponding Ramp Volume	267
Corresponding Upstream Freeway Peak Volume	7,298
Peak Hour Factor	0.965
Ramp Merge Level of Service	F

Congestion

Congestion	M039
Ave Length of Congestion (Miles)	2.45
Duration of Congestion (Minutes)	39
Calculated Number of Occurrences per Year	19
Typical Times of Congestion	07:30 - 09:00

Crash Data

The total number of accidents from March 2011 to February 2016 was: 12
Of these, 1 was an accident which can be associated with congestion:
Type 21-Rear end, slow or stop: 0 (0%)
Type 28- Sideswipe, same direction: 1 (8%)

Observations

Log 180 is a direct ramp with no sight distance issues. The grade is slightly downhill with an average slope of -1.5%. The ramp has one lane and has entry from a single left turn, a thru movement and a yield controlled right turn. The travel lane and shoulders are asphalt. Both the travel lane and shoulder switch to concrete at the end of the ramp. The pavement condition was considered to be fair. The left shoulder has a width of 4' and the right shoulder had a width of 10'. Drainage structures are located 27' from the edge of travel lane at the start and end of the ramp. The tree line occurs 25' from the edge of travel lane.

Peak volume is greater than 2,000 vehicles per hour per lane.

Typical times of congestion from the Bottleneck Ranking tool doesn't match the suitability criteria from the Traffic Count analysis (see 'Flow Summary' tab of Traffic Data spreadsheet).

Site Selection Comments

This is a single lane direct ramp from a stop controlled intersection with free-flow right turn. It has storage for approximately 56 vehicles.

This is a primary site for congestion problem M039.

Ramp volumes are too low during the congested period for ramp metering to operate effectively.

Although this is a primary site, the ramp volumes are too low for RM to operate effectively during congestion. There would be no congestion benefit from RM at its location.

Site Categorization

Not feasible

NCDOT Ramp Metering Feasibility Study
Site Summary Document

181

Site Details

Site Number	181
Freeway	I-485
Cross Street	West Boulevard
Exit	6
Direction	Inner
County	Mecklenburg

Physical Characteristics Overview

Origin of Entrance Ramp	Stop controlled with Free Flow Right Turn
Lane Addition onto Main Freeway length (feet)	1,700
Number of Entrance Ramp Lanes	1
Lane Drop on Entrance Ramp Before Merge	No
Number of Freeway Lanes Before Merge	3
Number of Freeway Lanes After Merge	3
Entrance Ramp Length to Back of Gore (feet)	1,490
Entrance Ramp Length to Tip of Gore (feet)	1,700
Merge Length (feet)	1,700
Entrance Ramp Horizontal Alignment	Straight
Entrance Ramp Vertical Alignment	Slight downhill
Entrance Ramp Shoulder (Paved Full Width)	Yes
Main Freeway Vertical Alignment Downstream	Uphill
Main Freeway Shoulder	Yes
Number of Vehicles Storage	60
Guardrail	Yes
Pipe Crossing	None

Signalization Overview

Upstream Signal	No Signal
Nearest Power Source	Power poles at start of the ramp

Signing Overview

Existing Signing	No Signs

Traffic Volumes

Period Beginning	Upstream Hourly Volume Rate	Downstream Hourly Volume Rate	Entrance Ramp Hourly Volume Rate	Downstream Volume per Lane	Entrance Ramp Volume per Lane	Entrance Ramp % of Downstream Volume	Hour Meets Acceptable Criteria for Ramp Metering
06:00	1,802	1,894	92	631	92	5	No
07:00	2,794	2,969	175	990	175	6	No
08:00	3,241	3,379	138	1,126	138	4	No
09:00	1,583	1,714	131	571	131	8	No
10:00	1,507	1,650	143	550	143	9	No
11:00	1,507	1,652	145	551	145	9	No
12:00	1,632	1,774	142	591	142	8	No
13:00	1,683	1,856	173	619	173	9	No
14:00	1,884	2,103	219	701	219	10	No
15:00	2,234	2,624	390	875	390	15	Yes
16:00	2,470	3,104	634	1,035	634	20	Yes
17:00	2,404	3,089	685	1,030	685	22	Yes
18:00	1,885	2,211	326	737	326	15	Yes
19:00	1,466	1,602	136	534	136	8	No
20:00	1,060	1,152	92	384	92	8	No

Capacity Analysis

Downstream Freeway Peak Volume	3,658
Corresponding Ramp Volume	149
Corresponding Upstream Freeway Peak Volume	3,509
Peak Hour Factor	0.912
Ramp Merge Level of Service	B

Congestion

Congestion	M040
Ave Length of Congestion (Miles)	45
Duration of Congestion (Minutes)	1.26
Calculated Number of Occurrences per Year	243
Typical Times of Congestion	15:30 - 18:30

Crash Data

The total number of accidents from March 2011 to February 2016 was: 22
Of these, 6 were accidents which can be associated with congestion:
Type 21-Rear end, slow or stop: 2 (9%)
Type 28- Sideswipe, same direction: 4 (18%)

Observations

Log 181 is a direct ramp with no sight distance issues. The grade is slightly downhill with an average slope of -0.467%. The ramp has one lane and has entry from a single left turn, a thru movement and right turn. The travel lane and shoulders are asphalt. Both the travel lane and shoulder switch to concrete at the end of the ramp. The pavement condition was considered to be fair. The left shoulder has a width of 4' and the right shoulder had a width of 11'. Guardrail is located towards the end of the ramp 192' from the concrete/asphalt pavement break. Drainage structures are located 30' from the edge of travel lane throughout the ramp. The drop-off/tree line occurs 10' behind the guardrail.

Site Selection Comments

This is a single lane direct ramp fed by a signalized intersection with free-flow right turn. It has approximately 60 vehicle storage and the physical characteristics appear to be good for RM.

This is the primary site for M040, it has a comparatively small amount of congestion during the PM peak, although some benefits could be gained from ramp metering.

Downstream volumes are acceptable and ramp volumes are slightly low to ideal during the congested period if metered as a single lane.

This site offers the potential for benefits and there do not appear to be any implementation issues although the level of congestion is relatively low.

No specific implementation problems have been identified.

Site Categorization

Feasible for taking forward

NCDOT Ramp Metering Feasibility Study
Site Summary Document

182

Site Details

Site Number	182
Freeway	I-485
Cross Street	Wilkinson Boulevard (US 74/529)
Exit	9
Direction	Outer
County	Mecklenburg

Physical Characteristics Overview

Origin of Entrance Ramp	Free Flow Link
Lane Addition onto Main Freeway length (feet)	2,975
Number of Entrance Ramp Lanes	3
Lane Drop on Entrance Ramp Before Merge	Yes
Number of Freeway Lanes Before Merge	3
Number of Freeway Lanes After Merge	3
Entrance Ramp Length to Back of Gore (feet)	2,600
Entrance Ramp Length to Tip of Gore (feet)	3,050
Merge Length (feet)	2,975
Entrance Ramp Horizontal Alignment	Straight
Entrance Ramp Vertical Alignment	Slightly uphill
Entrance Ramp Shoulder (Paved Full Width)	Yes
Main Freeway Vertical Alignment Downstream	Slight uphill
Main Freeway Shoulder	Yes
Number of Vehicles Storage	312
Guardrail	Yes; 440’ from concrete median
Pipe Crossing	None

Signalization Overview

Upstream Signal	3-way signal; Ramp entry from: left turn and right turn
Nearest Power Source	Power Poles at signal

Signing Overview

Existing Signing	Wrong Way sign located in concrete median

Traffic Volumes

Period Beginning	Upstream Hourly Volume Rate	Downstream Hourly Volume Rate	Entrance Ramp Hourly Volume Rate	Downstream Volume per Lane	Entrance Ramp Volume per Lane	Entrance Ramp % of Downstream Volume	Hour Meets Acceptable Criteria for Ramp Metering
06:00	1,412	1,908	496	636	165	26	No
07:00	2,345	3,214	869	1,071	290	27	No
08:00	2,470	3,122	652	1,041	217	21	No
09:00	1,192	1,583	391	528	130	25	No
10:00	1,104	1,507	403	502	134	27	No
11:00	1,131	1,507	376	502	125	25	No
12:00	1,089	1,632	543	544	181	33	No
13:00	1,203	1,683	480	561	160	29	No
14:00	1,320	1,884	564	628	188	30	No
15:00	1,586	2,234	648	745	216	29	No
16:00	1,743	2,476	733	825	244	30	No
17:00	1,837	2,549	712	850	237	28	No
18:00	1,456	1,900	444	633	148	23	No
19:00	716	1,238	522	413	174	42	No
20:00	631	881	250	294	83	28	No

Capacity Analysis

Downstream Freeway Peak Volume	3,705
Corresponding Ramp Volume	821
Corresponding Upstream Freeway Peak Volume	2,884
Peak Hour Factor	0.963
Ramp Merge Level of Service	A

Congestion

Congestion	M041
Ave Length of Congestion (Miles)	1.38
Duration of Congestion (Minutes)	57.22
Calculated Number of Occurrences per Year	225
Typical Times of Congestion	07:30 - 09:00

Crash Data

The total number of accidents from March 2011 to February 2016 was: 52
Of these, 30 were accidents which can be associated with congestion:
Type 21-Rear end, slow or stop: 19 (37%)
Type 28- Sideswipe, same direction: 11 (21%)

Observations

Log 182 is a direct ramp with no sight distance issues. The grade is slightly uphill with an average slope of 0.967%. The ramp starts as one lane, then joins with two existing collector lanes along I-485. The ramp has entry from a single left turn and right turn. The travel lane and shoulders are asphalt. Both the travel and shoulder switch to concrete towards the end of the ramp The pavement condition was considered to be fair. The left shoulder has a width of 4' and the right shoulder has a width of 10'. There is a run of guardrail 440' from the start of the concrete median and is offset 10.5' from the edge of travel lane. The drop-off/tree line occurs directly behind the guardrail so there is not room to move it back. A CCTV camera/cabinet is located 96' prior to the change in pavement type on the inside of the ramp.

Typical times of congestion from the Bottleneck Ranking tool doesn't match the suitability criteria from the Traffic Count analysis (see 'Flow Summary' tab of Traffic Data spreadsheet).

Site Selection Comments

This is a triple lane on-ramp where dropping to two lanes before it joins the main freeway. It is made up from a collector distributor road that comes through an upstream F2F location and a single lane entrance ramp from street level. This has a complicated geometry and would need careful consideration although there is a large potential for vehicle storage, approximately 312 vehicles.

This is a primary site for congestion problem M041 in the AM peak.

An issue has been identified with the traffic volume data collected; the entrance ramp volume is only for the single lane ramp from street level.

This site could have potential for congestion benefits, although it would be a complicated site to install across three lanes. The main problem is that traffic volumes on the ramp still need to be ascertained.

This site would require a three lane meter and the CDR comes from a F2F junction so vehicles are travelling at high speed. Safety aspects would need very careful consideration in design.

Site Categorization

Review in future

NCDOT Ramp Metering Feasibility Study
Site Summary Document

250

Site Details

Site Number	250
Freeway	US 74/ Independence Blvd.
Cross Street	Briar Creek Rd.
Exit	244
Direction	Westbound
County	Mecklenburg

Physical Characteristics Overview

Origin of Entrance Ramp	Free Flow Link
Lane Addition onto Main Freeway length (ft)	77
Number of Entrance Ramp Lanes	1
Lane Drop on Entrance Ramp Before Merge	None
Number of Freeway Lanes Before Merge	3
Number of Freeway Lanes After Merge	3
On Ramp Length to Back of Gore (ft)	820
On Ramp Length to Tip of Gore (ft)	1,050
Merge Length (ft)	275
Entrance Ramp Horizontal Alignment	Straight
Entrance Ramp Vertical Alignment	Downhill
Entrance Ramp Shoulder (Paved Full Width)	No
Main Freeway Vertical Alignment Downstream	Level
Main Freeway Shoulder	Yes
Number of Vehicles Storage	33
Guardrail	None Present
Pipe Crossing	None Present

Signalization Overview

Upstream Signal	No Signal
Nearest Power Source	Power pole at beginning of ramp immediately behind guardrail on inside of interchange loop, 30' from end of median.

Signing Overview

Existing Signing	None

Traffic Volumes

Period Beginning	Upstream Hourly Volume Rate	Downstream Hourly Volume Rate	On-Ramp Hourly Volume Rate	Downstream Volume per Lane	On-Ramp Volume per Lane	On-Ramp % of Downstream Volume	Hour Meets Acceptable Criteria for Ramp Metering
06:00	5,144	5,308	164	1,769	164	3	No
07:00	5,311	5,526	215	1,842	215	4	No
08:00	4,903	5,112	209	1,704	209	4	No
09:00	4,055	4,238	183	1,413	183	4	No
10:00	3,384	3,596	212	1,199	212	6	No
11:00	3,074	3,294	220	1,098	220	7	No
12:00	3,688	3,915	227	1,305	227	6	No
13:00	3,793	4,025	232	1,342	232	6	No
14:00	3,828	4,036	208	1,345	208	5	No
15:00	3,750	3,964	214	1,321	214	5	No
16:00	3,683	3,880	197	1,293	197	5	No
17:00	3,641	3,848	207	1,283	207	5	No
18:00	3,380	3,610	230	1,203	230	6	No
19:00	2,658	2,842	184	947	184	7	No
20:00	2,375	2,573	162	846	162	6	No

Capacity Analysis

Downstream Freeway Peak Volume	5,526
Corresponding Ramp Volume	215
Corresponding Upstream Freeway Peak Volume	5,311
Peak Hour Factor	0.979
Ramp Merge Level of Service	D

Congestion

Congestion	M058
Ave Length of Congestion (Miles)	2.17
Duration of Congestion (Min)	82.00
Calculated Number of Occurrences per Year	316
Typical Times of Congestion	07:00 - 09:00

Crash Data

The total number of accidents from March 2011 to February 2016 was: 14
Of these, 9 were accidents which can be associated with congestion:
Type 21-Rear end, slow or stop: 5 (36%)
Type 28- Sideswipe, same direction: 4 (29%)

Observations

Log 250 is a direct ramp. There will be sight distance issues as there is an earth mound between the ramp and mainline. The total average length of the entrance ramp has an average downhill grade that flattens out near the merge location. The pavement and shoulder type are asphalt. Pavement condition is poor to fair with several cracks along the ramp. Shoulder width for the left side is approximately 4' along the entrance ramp. There is no shoulder on the right side of the ramp, only concrete curb and gutter and a concrete paved ditch.

Site Selection Comments

This is a single lane direct ramp from a free flow link. It has capacity to store approximately 33 vehicles on the ramp.

This is a primary site to congestion problem M058. It is congested during the AM peak.

Downstream volumes are ideal during the congested period, but ramp volumes are too low for ramp metering to provide any benefits.

No specific implementation problems have been identified.

This site does not meet the typical design criteria for installing ramp metering due to low ramp volumes. However, the Steering Committee has requested that this site be taken forward and therefore this site is categorized as 'Review in future'.

Site Categorization

Review in future

C.2 Multiple Sites

Site Summaries 030, 032, 034, 150, 153, 175, 177, and 179 have been included in this section.

NCDOT Ramp Metering Feasibility Study
Site Summary Document

030

Site Details

Site Number	030
Freeway	I-85
Cross Street	Cox Road
Exit	21
Direction	Northbound
County	Gaston

Physical Characteristics Overview

Origin of Entrance Ramp	Signalized Intersection with Free Flow Right Turn
Lane Addition onto Main Freeway length (feet)	320
Number of Entrance Ramp Lanes	1
Lane Drop on Entrance Ramp Before Merge	None
Number of Freeway Lanes Before Merge	3
Number of Freeway Lanes After Merge	3
Entrance Ramp Length to Back of Gore (feet)	640
Entrance Ramp Length to Tip of Gore (feet)	945
Merge Length (feet)	600
Entrance Ramp Horizontal Alignment	Straight
Entrance Ramp Vertical Alignment	Slight Uphill
Entrance Ramp Shoulder (Paved Full Width)	No
Main Freeway Vertical Alignment Downstream	Slight Uphill
Main Freeway Shoulder	Yes
Number of Vehicles Storage	26
Guardrail	Yes
Pipe Crossing	None Present

Signalization Overview

Upstream Signal	3-way signal; Ramp entry from: left turn, and right turn
Nearest Power Source	Traffic Signal Cabinet

Signing Overview

Existing Signing	“No Trucks 3 Axles or More Left Lane” – 583’ from concrete island (19’ from edge of travel lane)

Traffic Volumes

Period Beginning	Upstream Hourly Volume Rate	Downstream Hourly Volume Rate	Entrance Ramp Hourly Volume Rate	Downstream Volume per Lane	Entrance Ramp Volume per Lane	Entrance Ramp % of Downstream Volume	Hour Meets Acceptable Criteria for Ramp Metering
06:00	2,603	2,945	342	982	342	12	Yes
07:00	3,416	3,756	340	1,252	340	9	Yes
08:00	2,424	2,762	338	921	338	12	Yes
09:00	2,465	2,883	418	961	418	14	Yes
10:00	2,442	2,879	437	960	437	15	Yes
11:00	2,490	2,942	452	981	452	15	Yes
12:00	2,489	2,984	495	995	495	17	Yes
13:00	2,769	3,330	561	1,110	561	17	Yes
14:00	2,859	3,453	594	1,151	594	17	Yes
15:00	2,820	3,475	655	1,158	655	19	Yes
16:00	2,779	3,410	631	1,137	631	19	Yes
17:00	2,658	3,284	626	1,095	626	19	Yes
18:00	2,340	2,808	468	936	468	17	Yes
19:00	1,925	2,394	469	798	469	20	Yes
20:00	1,732	2,096	364	699	364	17	Yes

Capacity Analysis

Downstream Freeway Peak Volume	3,870
Corresponding Ramp Volume	351
Corresponding Upstream Freeway Peak Volume	3,519
Peak Hour Factor	0.932
Ramp Merge Level of Service	C

Congestion

Congestion	M005
Ave Length of Congestion (Miles)	0.93
Duration of Congestion (Minutes)	16.06
Calculated Number of Occurrences per Year	231
Typical Times of Congestion	07:00 - 09:00

Crash Data

The total number of accidents from March 2011 to February 2016 was: 40
Of these, 28 were accidents which can be associated with congestion:
Type 21-Rear end, slow or stop: 18 (45%)
Type 28- Sideswipe, same direction: 10 (25%)

Observations

Log 30 is a direct ramp with no sight distance issues. The overall grade is slightly uphill with an average slope of 0.5%. The travel lane and shoulders are asphalt. The pavement condition was considered to be poor with several cracks. The left shoulder has a width of 3.5' and the right shoulder had a width of 3.5'. There is a run of guardrail 571' from the concrete island with an offset of 14' from the edge of travel lane. There is a sign "No Trucks 3 Axles" 19' from the edge of travel lane that may cause a conflict with ramp meter. Drop-off occurs 15' from the edge of travel lane. Guardrail must be moved back if more space is needed for travel lanes.

Site Selection Comments

This is a single lane direct ramp from a signalized intersection with free-flow right turn. It has storage for approximately 26 vehicles.

This is a secondary site for congestion problem M005, for which sites 032 and 034 are downstream. The congestion at this site occurs in the AM peak.

Downstream and ramp volumes are acceptable during the congested period. The volumes on the ramp are on the low side which could affect the ability of ramp metering to provide congestion benefits.

This site suffers from a relatively small amount of congestion and is a secondary site, upstream of Sites 032 and 034 which have been identified as feasible for taking forward.

No specific implementation problems have been identified.

Site Categorization

Review in future

NCDOT Ramp Metering Feasibility Study
Site Summary Document

032

Site Details

Site Number	032
Freeway	I-85
Cross Street	South Main Street
Exit	22
Direction	Northbound
County	Gaston

Physical Characteristics Overview

Origin of Entrance Ramp	Signalized Intersection with Free Flow Right Turn
Lane Addition onto Main Freeway length (feet)	250
Number of Entrance Ramp Lanes	1
Lane Drop on Entrance Ramp Before Merge	None
Number of Freeway Lanes Before Merge	3
Number of Freeway Lanes After Merge	3
Entrance Ramp Length to Back of Gore (feet)	1,020
Entrance Ramp Length to Tip of Gore (feet)	1,420
Merge Length (feet)	540
Entrance Ramp Horizontal Alignment	Slight Curve
Entrance Ramp Vertical Alignment	Slight Downhill
Entrance Ramp Shoulder (Paved Full Width)	No
Main Freeway Vertical Alignment Downstream	Level
Main Freeway Shoulder	No
Number of Vehicles Storage	41
Guardrail	Yes
Pipe Crossing	None Present

Signalization Overview

Upstream Signal	3-way signal; Ramp entry from: left turn, and right turn
Nearest Power Source	Power distribution pole at start of ramp

Signing Overview

Existing Signing	"No Trucks 3 Axles or More Left Lane" – 362' from tip of concrete median (18' from edge of travel lane)

Traffic Volumes

Period Beginning	Upstream Hourly Volume Rate	Downstream Hourly Volume Rate	Entrance Ramp Hourly Volume Rate	Downstream Volume per Lane	Entrance Ramp Volume per Lane	Entrance Ramp % of Downstream Volume	Hour Meets Acceptable Criteria for Ramp Metering
06:00	3,695	4,426	731	1,475	731	17	Yes
07:00	4,367	5,160	793	1,720	793	15	Yes
08:00	3,343	3,993	650	1,331	650	16	Yes
09:00	3,450	3,951	501	1,317	501	13	Yes
10:00	3,547	3,980	433	1,327	433	11	Yes
11:00	3,476	3,916	440	1,305	440	11	Yes
12:00	3,512	3,985	473	1,328	473	12	Yes
13:00	3,889	4,373	484	1,458	484	11	Yes
14:00	4,264	4,758	494	1,586	494	10	Yes
15:00	4,187	4,635	448	1,545	448	10	Yes
16:00	4,306	4,745	439	1,582	439	9	Yes
17:00	4,244	4,708	464	1,569	464	10	Yes
18:00	3,606	4,077	471	1,359	471	12	Yes
19:00	2,754	3,120	366	1,040	366	12	Yes
20:00	2,512	2,797	285	932	285	10	No

Capacity Analysis

Downstream Freeway Peak Volume	5,160
Corresponding Ramp Volume	793
Corresponding Upstream Freeway Peak Volume	4,367
Peak Hour Factor	0.924
Ramp Merge Level of Service	D

Congestion

Congestion	M005
Ave Length of Congestion (Miles)	2.63
Duration of Congestion (Minutes)	45.41
Calculated Number of Occurrences per Year	231
Typical Times of Congestion	07:00 - 09:00

Crash Data

The total number of accidents from March 2011 to February 2016 was: 69
Of these, 50 were accidents which can be associated with congestion:
Type 21-Rear end, slow or stop: 37 (54%)
Type 28- Sideswipe, same direction: 13 (19%)

Observations

Log 32 is a direct ramp with no sight distance issues. The grade is slightly downhill with an average slope of -0.93%. Both the travel lane and shoulder start as concrete (231' of concrete) and transitions to asphalt. The pavement and shoulder condition were considered to be fair. The left shoulder has a width of 3.5' and the right shoulder had a width of 3'. Guardrail runs entire length of ramp with an offset of 12' from edge of travel lane. No room to move guardrail back due to drop-off and tree line.

Site Selection Comments

This is a single lane direct ramp from a signalized intersection with free-flow right turn. It has capacity to store approximately 41 vehicles on the ramp.

This is a secondary site to downstream site number 034 which is primary to congestion problem M005. It is congested during the AM peak.

Downstream volumes are acceptable and ramp volumes are ideal for a single lane ramp during the congested period.

This is not a primary site but could provide benefits in supporting downstream primary site 034. There are no notable problems with the site.

No specific implementation problems have been identified.

Site Categorization

Feasible for taking forward

NCDOT Ramp Metering Feasibility Study
Site Summary Document

034

Site Details

Site Number	034
Freeway	I-85
Cross Street	McAdenville Road
Exit	23
Direction	Northbound
County	Gaston

Physical Characteristics Overview

Origin of Entrance Ramp	Signalized Intersection with Free Flow Right Turn
Lane Addition onto Main Freeway length (feet)	512
Number of Entrance Ramp Lanes	1
Lane Drop on Entrance Ramp Before Merge	None
Number of Freeway Lanes Before Merge	3
Number of Freeway Lanes After Merge	3
Entrance Ramp Length to Back of Gore (feet)	615
Entrance Ramp Length to Tip of Gore (feet)	940
Merge Length (feet)	850
Entrance Ramp Horizontal Alignment	Straight
Entrance Ramp Vertical Alignment	Slight Downhill
Entrance Ramp Shoulder (Paved Full Width)	No
Main Freeway Vertical Alignment Downstream	Slight Downhill
Main Freeway Shoulder	No
Number of Vehicles Storage	25
Guardrail	None Present
Pipe Crossing	Yes; Drainage structure at 172' from concrete island (20' offset from edge of travel lane)

Signalization Overview

Upstream Signal	3-way signal; Ramp entry from: left turn, right turn and thru
Nearest Power Source	Power distribution pole at start of ramp (Traffic Signal)

Signing Overview

Existing Signing	"No Trucks 3 Axles or More Left Lane"-182' from concrete island 14' off edge of travel lane 2 – "No Parking"

Traffic Volumes

Period Beginning	Upstream Hourly Volume Rate	Downstream Hourly Volume Rate	Entrance Ramp Hourly Volume Rate	Downstream Volume per Lane	Entrance Ramp Volume per Lane	Entrance Ramp % of Downstream Volume	Hour Meets Acceptable Criteria for Ramp Metering
06:00	2,408	2,775	367	925	367	13	Yes
07:00	3,845	4,313	468	1,438	468	11	Yes
08:00	4,291	4,544	253	1,515	253	6	No
09:00	4,165	4,321	156	1,440	156	4	No
10:00	4,463	4,591	128	1,530	128	3	No
11:00	4,631	4,755	124	1,585	124	3	No
12:00	4,880	5,023	143	1,674	143	3	No
13:00	4,839	4,981	142	1,660	142	3	No
14:00	5,318	5,469	151	1,823	151	3	No
15:00	5,884	6,042	158	2,014	158	3	No
16:00	6,291	6,460	169	2,153	169	3	No
17:00	5,943	6,117	174	2,039	174	3	No
18:00	5,844	5,982	138	1,994	138	2	No
19:00	4,326	4,466	140	1,489	140	3	No
20:00	3,292	3,371	79	1,124	79	2	No

Capacity Analysis

Downstream Freeway Peak Volume	6,460
Corresponding Ramp Volume	169
Corresponding Upstream Freeway Peak Volume	6,291
Peak Hour Factor	0.978
Ramp Merge Level of Service	F

Congestion

Congestion	M005
Ave Length of Congestion (Miles)	3.60
Duration of Congestion (Minutes)	62.16
Calculated Number of Occurrences per Year	231
Typical Times of Congestion	07:00 - 09:00

Crash Data

The total number of accidents from March 2011 to February 2016 was: 42
Of these, 29 were accidents which can be associated with congestion:
Type 21-Rear end, slow or stop: 19 (45%)
Type 28- Sideswipe, same direction: 10 (24%)

Observations

Log 34 is a direct ramp with no sight distance issues. The grade is slightly downhill with an average slope of -2.77%. The travel lane and shoulders are asphalt. The pavement and shoulder condition were considered to be poor, shoulder outside of pavement has ruts from water drainage. The left shoulder has a width of 4' and the right shoulder had a width of 3.5'. Concrete drainage structure 172' from concrete island with an offset of 20' from edge of travel lane. Tree line located at 32' from edge of travel lane.

Site Selection Comments

This is a single lane direct ramp from a signalized intersection with free-flow right turn. It has capacity to store approximately 25 vehicles on the ramp.

This is the primary site for congestion problem M005. This suffers from congestion in the AM peak.

Downstream and ramp volumes are acceptable during the congested period. The ramp volume per lane is on the low side making it only acceptable despite being a single lane.

This is the primary site for congestion problem M005 and could be supported by upstream site 032. Although the storage is limited on the ramp, the ramp volume is low so should not cause a problem. However there is scope in future to add a ramp lane if necessary, although metering currently would only be effective across one lane.

No specific implementation problems have been identified. Ramp metering should be effective with existing lane configuration.

Site Categorization

Feasible for taking forward

NCDOT Ramp Metering Feasibility Study
Site Summary Document

150

Site Details

Site Number	150
Freeway	I-77
Cross Street	Williamson Road / US 21
Exit	33
Direction	Southbound
County	Iredell

Physical Characteristics Overview

Origin of Entrance Ramp	Free Flow Link
Lane Addition onto Main Freeway length (feet)	720
Number of Entrance Ramp Lanes	1
Lane Drop on Entrance Ramp Before Merge	None
Number of Freeway Lanes Before Merge	3
Number of Freeway Lanes After Merge	3
Entrance Ramp Length to Back of Gore (feet)	950
Entrance Ramp Length to Tip of Gore (feet)	1,190
Merge Length (feet)	900
Entrance Ramp Horizontal Alignment	Straight
Entrance Ramp Vertical Alignment	Slight Uphill
Entrance Ramp Shoulder (Paved Full Width)	Discontinuous
Main Freeway Vertical Alignment Downstream	Slight Uphill
Main Freeway Shoulder	Yes
Number of Vehicles Storage	38
Guardrail	Yes
Pipe Crossing	None Present

Signalization Overview

Upstream Signal	Not signalized
Nearest Power Source	Power distribution poles from across street at start of ramp

Signing Overview

Existing Signing	No Signs

Traffic Volumes

Period Beginning	Upstream Hourly Volume Rate	Downstream Hourly Volume Rate	Entrance Ramp Hourly Volume Rate	Downstream Volume per Lane	Entrance Ramp Volume per Lane	Entrance Ramp % of Downstream Volume	Hour Meets Acceptable Criteria for Ramp Metering
06:00	3,294	3,677	383	1,226	383	10	Yes
07:00	2,908	3,241	333	1,080	333	10	Yes
08:00	2,877	3,172	295	1,057	295	9	No
09:00	3,102	3,439	337	1,146	337	10	Yes
10:00	2,955	3,309	354	1,103	354	11	Yes
11:00	3,115	3,462	347	1,154	347	10	Yes
12:00	3,253	3,627	374	1,209	374	10	Yes
13:00	3,387	3,740	353	1,247	353	9	Yes
14:00	3,316	3,685	369	1,228	369	10	Yes
15:00	3,747	4,091	344	1,364	344	8	Yes
16:00	4,525	4,819	294	1,606	294	6	No
17:00	4,481	4,775	294	1,592	294	6	No
18:00	3,801	4,074	273	1,358	273	7	No
19:00	2,185	2,410	225	803	225	9	No
20:00	2,177	2,344	167	781	167	7	No

Capacity Analysis

Downstream Freeway Peak Volume	4,841
Corresponding Ramp Volume	306
Corresponding Upstream Freeway Peak Volume	4,535
Peak Hour Factor	0.937
Ramp Merge Level of Service	C

Congestion

Congestion	M048
Ave Length of Congestion (Miles)	3.57
Duration of Congestion (Minutes)	106
Calculated Number of Occurrences per Year	316
Typical Times of Congestion	16:00-19:00

Crash Data

The total number of accidents from March 2011 to February 2016 was: 64
Of these, 52 were accidents which can be associated with congestion:
Type 21-Rear end, slow or stop: 40 (63%)
Type 28- Sideswipe, same direction: 12 (19%)

Observations

Log 150 is a direct ramp with no sight distance issues. The grade starts slightly uphill, and midway through the ramp it turns slightly downhill with an average slope of 0.13%. The travel lane and shoulders are asphalt. The pavement condition was considered to be fair. The left shoulder has a width of 3.5' and the right shoulder has a non-uniform width of 3.5' to 10' along the ramp. There is a run of guardrail 433' from the start of the ramp with an offset of 13' from edge of travel lane. Guardrail does not look to be necessary; there is a bank behind guardrail with trees that are beyond clear zone at top of bank. Concrete drainage ditch runs along the ramp at 10' from edge of travel lane.

Site Selection Comments

This is a single lane direct ramp from an un-signalized intersection. It has storage for approximately 38 vehicles.

This is the primary site for congestion problem M048 and it is congested in the PM peak.

Entrance ramp volumes are too low during the congested period for ramp metering to be able to operate effectively.

This site is not feasible for RM because the low entrance ramp volumes will not allow RM to meter effectively, so no congestion benefits are possible. Upstream site 151 is already ruled out because of its physical characteristics and the next upstream site, 153, is not feasible because the entrance ramp volume is too low.

Site Categorization

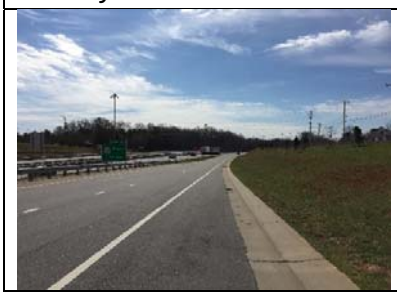
Not feasible

NCDOT Ramp Metering Feasibility Study
Site Summary Document

153

Site Details

Site Number	153
Freeway	I-77
Cross Street	Secondary Road 1100 (Brawley School Road)
Exit	35
Direction	Southbound
County	Iredell



Physical Characteristics Overview

Origin of Entrance Ramp	Signalized Intersection with Free Flow Right Turn
Lane Addition onto Main Freeway length (feet)	700
Number of Entrance Ramp Lanes	2
Lane Drop on Entrance Ramp Before Merge	Yes
Number of Freeway Lanes Before Merge	2
Number of Freeway Lanes After Merge	2
Entrance Ramp Length to Back of Gore (feet)	860
Entrance Ramp Length to Tip of Gore (feet)	1,500
Merge Length (feet)	950
Entrance Ramp Horizontal Alignment	Straight
Entrance Ramp Vertical Alignment	Slight Downhill
Entrance Ramp Shoulder (Paved Full Width)	No
Main Freeway Vertical Alignment Downstream	Slight downhill
Main Freeway Shoulder	Yes
Number of Vehicles Storage	69
Guardrail	Yes
Pipe Crossing	None Present

Signalization Overview

Upstream Signal	3-way signal; Ramp entry from: dual left turn and right turn
Nearest Power Source	Power distribution pole at start of ramp

Signing Overview

Existing Signing	Right lane ends graphical sign – 97' from end of bridge wall

Traffic Volumes

Period Beginning	Upstream Hourly Volume Rate	Downstream Hourly Volume Rate	Entrance Ramp Hourly Volume Rate	Downstream Volume per Lane	Entrance Ramp Volume per Lane	Entrance Ramp % of Downstream Volume	Hour Meets Acceptable Criteria for Ramp Metering
06:00	2,888	3,320	432	1,660	216	13	No
07:00	2,795	3,331	536	1,666	268	16	No
08:00	3,101	3,528	427	1,764	214	12	No
09:00	2,973	3,364	391	1,682	196	12	No
10:00	3,026	3,367	341	1,684	171	10	No
11:00	3,004	3,368	364	1,684	182	11	No
12:00	3,248	3,653	405	1,827	203	11	No
13:00	3,476	3,902	426	1,951	213	11	No
14:00	3,500	3,859	359	1,930	180	9	No
15:00	3,320	3,680	360	1,840	180	10	No
16:00	3,240	3,597	357	1,799	179	10	No
17:00	2,989	3,271	282	1,636	141	9	No
18:00	2,590	2,829	239	1,415	120	8	No
19:00	2,397	2,604	207	1,302	104	8	No
20:00	2,230	2,430	200	1,215	100	8	No

Capacity Analysis

Downstream Freeway Peak Volume	3,915
Corresponding Ramp Volume	423
Corresponding Upstream Freeway Peak Volume	3,492
Peak Hour Factor	0.966
Ramp Merge Level of Service	D

Congestion

Congestion	M048
Ave Length of Congestion (Miles)	1.82
Duration of Congestion (Minutes)	54.04
Calculated Number of Occurrences per Year	316
Typical Times of Congestion	16:00-19:00

Crash Data

The total number of accidents from March 2011 to February 2016 was: 24
Of these, 20 were accidents which can be associated with congestion:
Type 21-Rear end, slow or stop: 17 (71%)
Type 28- Sideswipe, same direction: 3 (13%)

Observations

Log 153 is a direct ramp with no sight distance issues. The grade is slightly downhill with an average slope of -1.9%. The travel lane and shoulders are asphalt. The pavement condition was considered to be good. The left shoulder has a width of 5' and the right shoulder has a non-uniform width of 4'-6'. There is a run of guardrail 448' from bridge wall (inside ramp) that has an offset of 8' from edge of travel lane. An existing electrical pull box was located at 16' from the edge of travel lane on outside ramp. There is a drainage concrete ditch that runs along the entrance ramp with a non-uniform offset of 4'-6' from edge of travel lane.

Site Selection Comments

This is a two lane direct ramp from a signalized intersection with free flow right turn. It has storage for approximately 69 vehicles.

This is a secondary site for congestion problem M048, suffering from congestion during the PM peak.

Ramp volumes are not acceptable during the congested period, they are too low for ramp metering to operate effectively.

This is a secondary site upstream of primary site 150. Neither site has enough volume on the entrance ramp, by a wide margin, for ramp metering to have any effect on the congestion.

Site Categorization

Not feasible

NCDOT Ramp Metering Feasibility Study
Site Summary Document

175

Site Details

Site Number	175
Freeway	I-485
Cross Street	Arrowood Road
Exit	3
Direction	Inner
County	Mecklenburg

Physical Characteristics Overview

Origin of Entrance Ramp	Signalized Intersection with free flow right turn
Lane Addition onto Main Freeway length (feet)	1,840
Number of Entrance Ramp Lanes	1
Lane Drop on Entrance Ramp Before Merge	No
Number of Freeway Lanes Before Merge	3
Number of Freeway Lanes After Merge	4
Entrance Ramp Length to Back of Gore (feet)	895
Entrance Ramp Length to Tip of Gore (feet)	1,265
Merge Length (feet)	1,840
Entrance Ramp Horizontal Alignment	Straight
Entrance Ramp Vertical Alignment	Slightly Downhill
Entrance Ramp Shoulder (Paved Full Width)	No
Main Freeway Vertical Alignment Downstream	Level
Main Freeway Shoulder	Yes
Number of Vehicles Storage	36
Guardrail	Yes; 15’ offset from edge line
Pipe Crossing	None

Signalization Overview

Upstream Signal	3-way signal; ramp entry from: single left turn, thru, and right turn
Nearest Power Source	Power Poles from signal

Signing Overview

Existing Signing	None

Traffic Volumes

Period Beginning	Upstream Hourly Volume Rate	Downstream Hourly Volume Rate	Entrance Ramp Hourly Volume Rate	Downstream Volume per Lane	Entrance Ramp Volume per Lane	Entrance Ramp % of Downstream Volume	Hour Meets Acceptable Criteria for Ramp Metering
06:00	2,360	2,495	135	624	135	5	No
07:00	4,112	4,439	327	1,110	327	7	Yes
08:00	3,925	4,194	269	1,049	269	6	No
09:00	2,807	2,996	189	749	189	6	No
10:00	2,171	2,328	157	582	157	7	No
11:00	1,953	2,188	235	547	235	11	No
12:00	2,234	2,500	266	625	266	11	No
13:00	2,398	2,724	326	681	326	12	Yes
14:00	2,810	3,220	410	805	410	13	Yes
15:00	3,326	3,814	488	954	488	13	Yes
16:00	4,757	5,760	1,003	1,440	1,003	17	Yes
17:00	5,304	6,516	1,212	1,629	1,212	19	No
18:00	3,861	4,436	575	1,109	575	13	Yes
19:00	2,228	2,542	314	636	314	12	Yes
20:00	1,631	1,903	272	476	272	14	No

Capacity Analysis

Downstream Freeway Peak Volume	6,516
Corresponding Ramp Volume	1,212
Corresponding Upstream Freeway Peak Volume	5,304
Peak Hour Factor	0.939
Ramp Merge Level of Service	D

Congestion

Congestion	M049
Ave Length of Congestion (Miles)	1.26
Duration of Congestion (Minutes)	29
Calculated Number of Occurrences per Year	256
Typical Times of Congestion	16:30 - 18:30

Crash Data

The total number of accidents from March 2011 to February 2016 was: 13
Of these, 8 were accidents which can be associated with congestion:
Type 21-Rear end, slow or stop: 4 (31%)
Type 28- Sideswipe, same direction: 4 (31%)

Observations

Log 175 is a direct ramp with no sight distance issues. The grade is slightly downhill with an average slope of -1.1%. The ramp has a single lane with entry from a single left, thru, and right turn movement. The ramp and shoulder are both constructed of concrete which is in fair/good condition. The left shoulder is 4.5' and the right shoulder is 4.5'. A run of guardrail runs halfway down the ramp and is offset 15' from the edge of travel lane. The drop-off/hazard occurs 3.5' behind the guardrail so it is not likely that it could be moved to gain more space for added lanes.

Site Selection Comments

This is a direct single lane ramp with storage for approximately 36 vehicles.

This is a secondary site to downstream site numbers 177 and 179 which are both feasible for RM meaning that the amount of congestion is relatively small. This site is congested in the PM peak.

The volume on the entrance ramp is too high during most of the congested period. This means that metering could cause congestion if it is unable to process the number of vehicles on the ramp.

This site would require a second lane in order for ramp metering to work and have any benefit. Adding a second lane is feasible although this site is secondary to two already select downstream sites.

No major implementation problems have been identified, but widening costs would be incurred.

Site Categorization

Review in future

NCDOT Ramp Metering Feasibility Study
Site Summary Document

177

Site Details

Site Number	177
Freeway	I-485
Cross Street	Steele Creek Road
Exit	4
Direction	Inner
County	Mecklenburg

Physical Characteristics Overview

Origin of Entrance Ramp	Free Flow Link
Lane Addition onto Main Freeway length (feet)	585
Number of Entrance Ramp Lanes	1
Lane Drop on Entrance Ramp Before Merge	No
Number of Freeway Lanes Before Merge	3
Number of Freeway Lanes After Merge	3
Entrance Ramp Length to Back of Gore (feet)	1,020
Entrance Ramp Length to Tip of Gore (feet)	1,180
Merge Length (feet)	700
Entrance Ramp Horizontal Alignment	Tight Curve
Entrance Ramp Vertical Alignment	Slightly downhill
Entrance Ramp Shoulder (Paved Full Width)	No
Main Freeway Vertical Alignment Downstream	Level
Main Freeway Shoulder	Yes
Number of Vehicles Storage	41
Guardrail	None
Pipe Crossing	None

Signalization Overview

Upstream Signal	No Signal
Nearest Power Source	Signal cabinet and power poles from exit ramp signal

Signing Overview

Existing Signing	None

Traffic Volumes

Period Beginning	Upstream Hourly Volume Rate	Downstream Hourly Volume Rate	Entrance Ramp Hourly Volume Rate	Downstream Volume per Lane	Entrance Ramp Volume per Lane	Entrance Ramp % of Downstream Volume	Hour Meets Acceptable Criteria for Ramp Metering
06:00	2,666	3,181	515	1,060	515	16	Yes
07:00	3,962	4,763	801	1,588	801	17	Yes
08:00	4,239	4,826	587	1,609	587	12	Yes
09:00	3,544	3,978	434	1,326	434	11	Yes
10:00	3,109	3,449	340	1,150	340	10	Yes
11:00	2,880	3,268	388	1,089	388	12	Yes
12:00	3,124	3,548	424	1,183	424	12	Yes
13:00	3,408	3,857	449	1,286	449	12	Yes
14:00	3,742	4,225	483	1,408	483	11	Yes
15:00	4,469	5,154	685	1,718	685	13	Yes
16:00	5,126	6,007	881	2,002	881	15	Yes
17:00	4,348	5,072	724	1,691	724	14	Yes
18:00	3,845	4,428	583	1,476	583	13	Yes
19:00	2,556	2,978	422	993	422	14	Yes
20:00	2,620	2,943	323	981	323	11	Yes

Capacity Analysis

Downstream Freeway Peak Volume	6,124
Corresponding Ramp Volume	873
Corresponding Upstream Freeway Peak Volume	5,251
Peak Hour Factor	0.916
Ramp Merge Level of Service	D

Congestion

Congestion	M049
Ave Length of Congestion (Miles)	2.44
Duration of Congestion (Minutes)	56.1
Calculated Number of Occurrences per Year	255.5
Typical Times of Congestion	16:30 - 18:30

Crash Data

The total number of accidents from March 2011 to February 2016 was: 14
Of these, 7 were accidents which can be associated with congestion:
Type 21-Rear end, slow or stop: 3 (21%)
Type 28- Sideswipe, same direction: 4 (29%)

Observations

Log 177 is a loop ramp with no sight distance issues. The grade is slightly downhill with an average slope of -2.07%. The ramp has one lane and has entry from a single right turn movement. Both the travel lane and shoulder are made of asphalt, but field observations were unable to determine if both were full depth. The pavement condition was considered to be poor to fair. The inner shoulder is curb and gutter and the right shoulder had a width of 4'. A drainage structure is 28' from the edge of travel lane near the beginning of the ramp. Two additional drainage structures near the middle of the ramp are 20' and 29' from edge of travel lane. A final drainage structure occurs near the end of the ramp and is 30' from the edge of travel lane.

Site Selection Comments

This is a single lane loop ramp. Although no sight distance issues were recorded during the site visit, careful consideration should be given to this during the design of the site. This ramp is an un-signalized intersection and has storage for approximately 41 vehicles.

This is not a primary congestion site, although it could support downstream site 179 which is the primary site for congestion problem M049. The amount of congestion is low and it occurs over a three hour period during the PM peak.

Downstream volumes are acceptable and ramp volumes are ideal during the congested period for a single lane ramp meter.

There are some reservations about the loop and visibility. Congestion occurs and volumes are ideal for the current single lane layout. This site would support primary site 179 which is part of the same intersection, further downstream.

No major implementation problems have been identified, beyond ensuring that issues relating to it being a loop ramp are identified and resolved.

Site Categorization

Feasible for taking forward

NCDOT Ramp Metering Feasibility Study
Site Summary Document

179

Site Details

Site Number	179
Freeway	I-485
Cross Street	Steele Creek Road
Exit	4
Direction	Inner
County	Mecklenburg

Physical Characteristics Overview

Origin of Entrance Ramp	Signalized Intersection
Lane Addition onto Main Freeway length (feet)	390
Number of Entrance Ramp Lanes	1
Lane Drop on Entrance Ramp Before Merge	No
Number of Freeway Lanes Before Merge	3
Number of Freeway Lanes After Merge	3
Entrance Ramp Length to Back of Gore (feet)	1,395
Entrance Ramp Length to Tip of Gore (feet)	1,865
Merge Length (feet)	1,015
Entrance Ramp Horizontal Alignment	Slight Curve
Entrance Ramp Vertical Alignment	Slightly downhill
Entrance Ramp Shoulder (Paved Full Width)	Yes
Main Freeway Vertical Alignment Downstream	Slight uphill
Main Freeway Shoulder	Yes
Number of Vehicles Storage	56
Guardrail	None
Pipe Crossing	None

Signalization Overview

Upstream Signal	3-way signal; Ramp entry from: thru and right turn
Nearest Power Source	Power Poles near signal

Signing Overview

Existing Signing	None

Traffic Volumes

Period Beginning	Upstream Hourly Volume Rate	Downstream Hourly Volume Rate	Entrance Ramp Hourly Volume Rate	Downstream Volume per Lane	Entrance Ramp Volume per Lane	Entrance Ramp % of Downstream Volume	Hour Meets Acceptable Criteria for Ramp Metering
06:00	2,251	2,301	50	767	50	2	No
07:00	4,256	4,394	138	1,465	138	3	No
08:00	4,036	4,106	70	1,369	70	2	No
09:00	2,970	3,045	75	1,015	75	2	No
10:00	2,674	2,730	56	910	56	2	No
11:00	2,770	2,825	55	942	55	2	No
12:00	3,033	3,116	83	1,039	83	3	No
13:00	3,506	3,584	78	1,195	78	2	No
14:00	3,912	4,024	112	1,341	112	3	No
15:00	4,967	5,113	146	1,704	146	3	No
16:00	5,898	6,225	327	2,075	327	5	Yes
17:00	5,532	6,006	474	2,002	474	8	Yes
18:00	4,222	4,347	125	1,449	125	3	No
19:00	3,018	3,092	74	1,031	74	2	No
20:00	2,160	2,201	41	734	41	2	No

Capacity Analysis

Downstream Freeway Peak Volume	6,225
Corresponding Ramp Volume	327
Corresponding Upstream Freeway Peak Volume	5,898
Peak Hour Factor	0.991
Ramp Merge Level of Service	D

Congestion

Congestion	M049
Ave Length of Congestion (Miles)	2.85
Duration of Congestion (Minutes)	65.61
Calculated Number of Occurrences per Year	223
Typical Times of Congestion	16:30 - 18:30

Crash Data

The total number of accidents from March 2011 to February 2016 was: 26
Of these, 9 were accidents which can be associated with congestion:
Type 21-Rear end, slow or stop: 3 (12%)
Type 28- Sideswipe, same direction: 6 (23%)

Observations

Log 179 is a direct ramp with no sight distance issues. The grade is slightly downhill with an average slope of -1.4%. The ramp has one lane and has entry from a thru movement and a right turn. Both the travel lane and shoulder are made of full depth asphalt. Both the travel line and shoulder change to concrete at the end of the ramp. The pavement condition was considered to be fair. The left shoulder has a width of 4' and the right shoulder had a width of 9'. The bank on the outer edge of the ramp is 32' from the edge of travel lane.

Site Selection Comments

This is a single lane direct ramp with no sight line issues. It is fed from a signalized intersection. It has approximately 56 vehicle storage, and the physical layout appears to be good.

This is the primary site for M049. It is congested in the afternoon peak and could be linked to site 177 which would support it.

The volumes are acceptable for the two hours of usual congestion, with volumes typically being on the low side. However there is some scope for ramp metering benefit if metered as one lane.

This site could be supported by site 177 which is part of the same intersection, further upstream. This appears to be a good candidate for ramp metering in most respects although the entrance ramp volume is quite low, just acceptable during congested periods.

No specific implementation problems have been identified.

Site Categorization

Feasible for taking forward

C.3 Group Sites

Site Summaries below have been included in this section:

Group 1: 033, 035, 037

Group 2: 064, 069, 072

Group 3: 093, 097*, 099, 102, 104, 109, 111, 117

Group 4: 101, 103, 105

Group 5: 129*

Group 6: 147, 145, 143, 140

Group 7: 230, 232, 234, 235, 238, 239

Group 8: 237, 236, 233, 231, 229

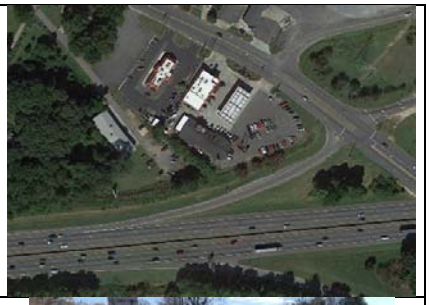
C.3.1 Site Summaries - Group 1

NCDOT Ramp Metering Feasibility Study
Site Summary Document

033

Site Details

Site Number	033
Freeway	I-85
Cross Street	McAdenville Road
Exit	23
Direction	Southbound
County	Gaston



Physical Characteristics Overview

Origin of Entrance Ramp	Free Flow Link
Lane Addition onto Main Freeway length (feet)	525
Number of Entrance Ramp Lanes	1
Lane Drop on Entrance Ramp Before Merge	No
Number of Freeway Lanes Before Merge	3
Number of Freeway Lanes After Merge	3
Entrance Ramp Length to Back of Gore (feet)	535
Entrance Ramp Length to Tip of Gore (feet)	735
Merge Length (feet)	860
Entrance Ramp Horizontal Alignment	Straight
Entrance Ramp Vertical Alignment	Slightly Downhill
Entrance Ramp Shoulder (Paved Full Width)	No
Main Freeway Vertical Alignment Downstream	Uphill
Main Freeway Shoulder	Yes
Number of Vehicles Storage	21
Guardrail	None
Pipe Crossing	Drainage structure 172’ from concrete island (20’ offset from edge of travel lane)

Signalization Overview

Upstream Signal	3-way signal; Ramp entry from: single left, yield controlled right turn, thru
Nearest Power Source	Signal Cabinet and Power Poles at start of ramp

Signing Overview

Existing Signing	“No Trucks 3 axles left lane” – 321’ from concrete island

Traffic Volumes

Period Beginning	Upstream Hourly Volume Rate	Downstream Hourly Volume Rate	Entrance Ramp Hourly Volume Rate	Downstream Volume per Lane	Entrance Ramp Volume per Lane	Entrance Ramp % of Downstream Volume	Hour Meets Acceptable Criteria for Ramp Metering
06:00	2,326	2,457	131	819	131	5	No
07:00	3,668	3,975	307	1,325	307	8	Yes
08:00	3,990	4,230	240	1,410	240	6	No
09:00	3,739	3,904	165	1,301	165	4	No
10:00	3,526	3,696	170	1,232	170	5	No
11:00	3,667	3,841	174	1,280	174	5	No
12:00	3,685	3,876	191	1,292	191	5	No
13:00	3,638	3,810	172	1,270	172	5	No
14:00	4,067	4,268	201	1,423	201	5	No
15:00	4,782	5,047	265	1,682	265	5	No
16:00	5,283	5,519	236	1,840	236	4	No
17:00	5,220	5,444	224	1,815	224	4	No
18:00	4,094	4,298	204	1,433	204	5	No
19:00	3,516	3,703	187	1,234	187	5	No
20:00	2,570	2,668	98	889	98	4	No

Capacity Analysis

Downstream Freeway Peak Volume	5,596
Corresponding Ramp Volume	248
Corresponding Upstream Freeway Peak Volume	5,348
Peak Hour Factor	0.963
Ramp Merge Level of Service	D

Congestion

Congestion	M004
Ave Length of Congestion (Miles)	5.69
Duration of Congestion (Minutes)	117.64
Calculated Number of Occurrences per Year	170
Typical Times of Congestion	15:00-19:30

Crash Data

The total number of accidents from March 2011 to February 2016 was: 17
Of these, 11 were accidents which can be associated with congestion:
Type 21-Rear end, slow or stop: 5 (29%)
Type 28- Sideswipe, same direction: 6 (35%)

Observations

Log 033 is a direct ramp with no sight distance issues. The grade is slightly downhill with a -0.76% slope. The ramp has one lane and has entry from a single left and thru movement and a yield controlled right turn movement. The travel lane and shoulders are asphalt. Field observations were unable to determine if both were full depth asphalt. The pavement condition was considered to be poor. The left shoulder has a width of 4' and the right shoulder had a width of 5.5'. There is one "No Trucks 3 Axles Left Lane" sign located 321' from the concrete island at the start of the ramp with a 13' offset from the edge of travel lane. Three "No Parking" signs are also along the ramp. A drainage structure is 13' from the edge of travel lane near the end of the ramp. The bank on the outer edge of the ramp is 19' from the edge of travel lane.

Typical times of congestion from the Bottleneck Ranking tool doesn't match the suitability criteria from the Traffic Count analysis (see 'Flow Summary' tab of Traffic Data spreadsheet).

Site Selection Comments

This is a single lane direct ramp from un-signalized intersection. It has storage for approximately 21 vehicles.

This is a primary site for congestion problem M004. The site suffers significant congestion in the PM peak.

During the congested period, entrance ramp volumes are approximately two thirds of the minimum level required for ramp metering to operate effectively.

Although this is a primary site, the level of entrance ramp volume during congestion is too low for RM to have any benefit.

Site Categorization

Not feasible

NCDOT Ramp Metering Feasibility Study
Site Summary Document

035

Site Details

Site Number	035
Freeway	I-85
Cross Street	Belmont-Mount Holly Road
Exit	26
Direction	Southbound
County	Gaston

Physical Characteristics Overview

Origin of Entrance Ramp	Signalized Intersection with Free Flow Right Turn
Lane Addition onto Main Freeway length (feet)	580
Number of Entrance Ramp Lanes	1
Lane Drop on Entrance Ramp Before Merge	No
Number of Freeway Lanes Before Merge	3
Number of Freeway Lanes After Merge	3
Entrance Ramp Length to Back of Gore (feet)	815
Entrance Ramp Length to Tip of Gore (feet)	1,260
Merge Length (feet)	850
Entrance Ramp Horizontal Alignment	Straight
Entrance Ramp Vertical Alignment	Level
Entrance Ramp Shoulder (Paved Full Width)	No
Main Freeway Vertical Alignment Downstream	Downhill
Main Freeway Shoulder	Yes
Number of Vehicles Storage	33
Guardrail	Yes; ends 147’ from conc. island
Pipe Crossing	None

Signalization Overview

Upstream Signal	3-way Signal; Ramp entry from single left and yield controlled right turn
Nearest Power Source	Signal Cabinet and Power Poles at start of ramp

Signing Overview

Existing Signing	"No Trucks 3 Axles Left Lane" – 183' from concrete island

Traffic Volumes

Period Beginning	Upstream Hourly Volume Rate	Downstream Hourly Volume Rate	Entrance Ramp Hourly Volume Rate	Downstream Volume per Lane	Entrance Ramp Volume per Lane	Entrance Ramp % of Downstream Volume	Hour Meets Acceptable Criteria for Ramp Metering
06:00	2,235	2,481	246	827	246	10	No
07:00	3,623	4,088	465	1,363	465	11	Yes
08:00	3,916	4,296	380	1,432	380	9	Yes
09:00	3,610	3,915	305	1,305	305	8	Yes
10:00	3,415	3,728	313	1,243	313	8	Yes
11:00	3,512	3,828	316	1,276	316	8	Yes
12:00	3,566	3,893	327	1,298	327	8	Yes
13:00	3,552	3,887	335	1,296	335	9	Yes
14:00	4,043	4,431	388	1,477	388	9	Yes
15:00	4,739	5,242	503	1,747	503	10	Yes
16:00	5,483	5,936	453	1,979	453	8	Yes
17:00	5,392	5,853	461	1,951	461	8	Yes
18:00	4,156	4,533	377	1,511	377	8	Yes
19:00	3,497	3,768	271	1,256	271	7	No
20:00	2,541	2,787	246	929	246	9	No

Capacity Analysis

Downstream Freeway Peak Volume	6,059
Corresponding Ramp Volume	491
Corresponding Upstream Freeway Peak Volume	5,568
Peak Hour Factor	0.972
Ramp Merge Level of Service	D

Congestion

Congestion	M004, M006
Ave Length of Congestion (Miles)	3.75
Duration of Congestion (Minutes)	73.93
Calculated Number of Occurrences per Year	377
Typical Times of Congestion	15:30 - 19:30

Crash Data

The total number of accidents from March 2011 to February 2016 was: 44
Of these, 34 were accidents which can be associated with congestion:
Type 21-Rear end, slow or stop: 19 (43%)
Type 28- Sideswipe, same direction: 15 (34%)

Observations

Log 035 is a direct ramp with no sight distance issues. The grade is fairly level with an average slope of 0.133%. There is one travel lane with ramp entry from a left turn and a yield controlled right turn. Both the travel lane and shoulder are constructed of asphalt, but field observations were unable to determine if both were full depth. The pavement condition was considered to be poor. The left shoulder width was 5’ and the right shoulder width was 3.5’. There were several ruts/holes on the shoulder outside of the pavement. Guardrail starts prior to the ramp and ends 147’ from the concrete island at the start of the ramp. One “No Trucks 3 Axles Left Lane” sign is located 183' from the concrete island and has a 10’ offset from the edge of travel lane. Two “No Parking” signs are also located towards the middle/end of the ramp. Several new “landscape” trees were planted 30’ from the edge of travel lane on the outside edge of the ramp.

Site Selection Comments

This is a single lane direct ramp from a signalized intersection with free-flow right turn. It has capacity to store approximately 33 vehicles on the ramp.

This is the primary site for congestion problem M006 which starts just downstream of the merge as well as being a secondary site for M004 as well, the primary site being 033.

Downstream and ramp volumes are ideal during the congested period for a single lane entrance ramp, although entrance ramp volumes are toward the lower end of ideal and become too low later during the congested period.

This appears to be a good site for providing congestion benefits with its current single lane configuration.

No specific implementation problems have been identified.

Site Categorization

Feasible for taking forward

NCDOT Ramp Metering Feasibility Study
Site Summary Document

037

Site Details

Site Number	037
Freeway	I-85
Cross Street	Beatty Drive / Park Street
Exit	27
Direction	Southbound
County	Gaston

Physical Characteristics Overview

Origin of Entrance Ramp	Signalized Intersection with Free Flow Right Lane
Lane Addition onto Main Freeway length (feet)	1,120
Number of Entrance Ramp Lanes	1
Lane Drop on Entrance Ramp Before Merge	Yes
Number of Freeway Lanes Before Merge	4
Number of Freeway Lanes After Merge	4
Entrance Ramp Length to Back of Gore (feet)	1,037
Entrance Ramp Length to Tip of Gore (feet)	1,565
Merge Length (feet)	1,080
Entrance Ramp Horizontal Alignment	Straight
Entrance Ramp Vertical Alignment	Slightly Downhill
Entrance Ramp Shoulder (Paved Full Width)	No
Main Freeway Vertical Alignment Downstream	Level
Main Freeway Shoulder	Yes
Number of Vehicles Storage	41
Guardrail	None
Pipe Crossing	None

Signalization Overview

Upstream Signal	3-way signal: Ramp entry from: dual lefts and a yield controlled right turn
Nearest Power Source	Power Poles from signal at start of ramp

Signing Overview

Existing Signing	Large Blue Attractions sign, “Left Lane ends 2400 FT” sign, “No Parking” sign

Traffic Volumes

Period Beginning	Upstream Hourly Volume Rate	Downstream Hourly Volume Rate	Entrance Ramp Hourly Volume Rate	Downstream Volume per Lane	Entrance Ramp Volume per Lane	Entrance Ramp % of Downstream Volume	Hour Meets Acceptable Criteria for Ramp Metering
06:00	2,150	2,363	213	591	213	9	No
07:00	3,454	3,909	455	977	455	12	Yes
08:00	3,715	4,058	343	1,015	343	8	Yes
09:00	3,538	3,791	253	948	253	7	No
10:00	3,263	3,572	309	893	309	9	Yes
11:00	3,251	3,630	379	908	379	10	Yes
12:00	3,319	3,659	340	915	340	9	Yes
13:00	3,376	3,699	323	925	323	9	Yes
14:00	3,906	4,299	393	1,075	393	9	Yes
15:00	4,667	5,138	471	1,285	471	9	Yes
16:00	5,561	5,969	408	1,492	408	7	Yes
17:00	5,491	5,843	352	1,461	352	6	Yes
18:00	4,617	4,850	233	1,213	233	5	No
19:00	3,485	3,746	261	937	261	7	No
20:00	2,390	2,619	229	655	229	9	No

Capacity Analysis

Downstream Freeway Peak Volume	6,029
Corresponding Ramp Volume	371
Corresponding Upstream Freeway Peak Volume	5,658
Peak Hour Factor	0.987
Ramp Merge Level of Service	C

Congestion

Congestion	M004, M006
Ave Length of Congestion (Miles)	2.79
Duration of Congestion (Minutes)	55.01
Calculated Number of Occurrences per Year	31
Typical Times of Congestion	15:30 - 19:30

Crash Data

The total number of accidents from March 2011 to February 2016 was: 339
Of these, 309 were accidents which can be associated with congestion:
Type 21-Rear end, slow or stop: 270 (80%)
Type 28- Sideswipe, same direction: 39 (12%)

Observations

Log 037 is a direct ramp with no sight distance issues. The grade is slightly downhill with an average slope of -0.6%. The ramp begins as two lanes that merge into one lane after about 500'. Both the travel lane and shoulder are constructed of asphalt, but field observations were unable to determine if both were full depth. The left shoulder was 6.5' and the right shoulder was 4'. The pavement condition was considered to be poor. The shoulder outside of the pavement was in poor condition with several ruts/holes. A large blue "attractions" sign was located 1085' from the concrete island with a 33' offset from the edge of travel lane. A "Left Lane Ends 2400 FT" sign was located 1095' from the concrete island with an 8' offset from the edge of travel lane. One "No Parking" sign was also observed on the ramp. There looked like there was plenty of ROW to expand on the outside edge of the ramp.

Small AM peak of congestion in traffic counts.

Site Selection Comments

This is a single lane direct ramp from a signalized intersection with free-flow right turn. It has storage for approximately 41 vehicles.

This is a secondary site for congestion problem M004 and M006. This site is congested during the PM peak.

Downstream volumes are acceptable during congestion, but entrance ramp volumes are only acceptable for three of the four hours of congestion. The entrance ramp volumes are on the low side, meaning that the site may not provide the level of congestion benefit expected, however some benefit is likely.

This location has a downstream lane drop that does not appear to be the cause of congestion. However congestion propagates through from downstream site 035 which has already been identified as feasible for taking forward. Because of the distance between the sites and the lane drop between, it is recommended that this site be reviewed in future after site 35 has been implemented.

No specific implementation problems have been identified.

Site Categorization

Review in future

C.3.2 Site Summaries - Group 2

NCDOT Ramp Metering Feasibility Study
Site Summary Document

064

Site Details

Site Number	064
Freeway	I-85
Cross Street	Graham Street
Exit	40
Direction	Southbound
County	Mecklenburg

Physical Characteristics Overview

Origin of Entrance Ramp	Signalized Intersection with Free Flow Right Turn
Lane Addition onto Main Freeway length (feet)	1,250
Number of Entrance Ramp Lanes	1
Lane Drop on Entrance Ramp Before Merge	No
Number of Freeway Lanes Before Merge	4
Number of Freeway Lanes After Merge	4
Entrance Ramp Length to Back of Gore (feet)	680
Entrance Ramp Length to Tip of Gore (feet)	885
Merge Length (feet)	1,500
Entrance Ramp Horizontal Alignment	Tight Curve
Entrance Ramp Vertical Alignment	Downhill
Entrance Ramp Shoulder (Paved Full Width)	No
Main Freeway Vertical Alignment Downstream	Level
Main Freeway Shoulder	Yes
Number of Vehicles Storage	27
Guardrail	None
Pipe Crossing	None

Signalization Overview

Upstream Signal	3-way signal; Ramp entry from: left turn, thru, and yield controlled right turn.
Nearest Power Source	Power Poles from signal

Signing Overview

Existing Signing	"No Trucks 3 Axles Left Lane" – 262' from concrete island

Traffic Volumes

Period Beginning	Upstream Hourly Volume Rate	Downstream Hourly Volume Rate	Entrance Ramp Hourly Volume Rate	Downstream Volume per Lane	Entrance Ramp Volume per Lane	Entrance Ramp % of Downstream Volume	Hour Meets Acceptable Criteria for Ramp Metering
06:00	4,185	4,776	591	1,194	591	12	Yes
07:00	5,182	5,823	641	1,456	641	11	Yes
08:00	4,365	4,919	554	1,230	554	11	Yes
09:00	5,020	5,630	610	1,408	610	11	Yes
10:00	5,159	5,673	514	1,418	514	9	Yes
11:00	5,362	5,844	482	1,461	482	8	Yes
12:00	5,421	5,925	504	1,481	504	9	Yes
13:00	5,685	6,267	582	1,567	582	9	Yes
14:00	5,676	6,337	661	1,584	661	10	Yes
15:00	5,575	6,286	711	1,572	711	11	Yes
16:00	5,672	6,319	647	1,580	647	10	Yes
17:00	5,868	6,512	644	1,628	644	10	Yes
18:00	5,677	6,145	468	1,536	468	8	Yes
19:00	5,215	5,622	407	1,406	407	7	Yes
20:00	4,804	5,097	293	1,274	293	6	No

Capacity Analysis

Downstream Freeway Peak Volume	6,512
Corresponding Ramp Volume	644
Corresponding Upstream Freeway Peak Volume	5,868
Peak Hour Factor	0.965
Ramp Merge Level of Service	C

Congestion

Congestion	M008, M009
Ave Length of Congestion (Miles)	3.75
Duration of Congestion (Minutes)	53.90
Calculated Number of Occurrences per Year	389
Typical Times of Congestion	07:00 - 09:30

Crash Data

The total number of accidents from March 2011 to February 2016 was: 205
Of these, 146 were accidents which can be associated with congestion:
Type 21-Rear end, slow or stop: 93 (45%)
Type 28- Sideswipe, same direction: 53 (26%)

Observations

Log 033 is a loop ramp with no sight distance issues. The grade is downhill with an average slope of -2.33%. The ramp has one lane and has entry from a single left and thru movement and a yield controlled right turn movement. The travel lane and shoulders are asphalt. The pavement condition was considered to be poor due to lots of “alligator” cracking. The inside shoulder is composed of curb and gutter and the outside shoulder had a width of 4’. There is one “No Trucks 3 Axles Left Lane” sign located 262’ from the concrete island at the start of the ramp with a 6’ offset from the edge of travel lane. A drainage structure is 15’ from the inside of the curb near the middle of the ramp. Bushes line the outside shoulder of the ramp.

Site Selection Comments

This is a single lane loop ramp is fed from a signalized intersection with free flow right turn. Forward visibility could be an issue on this tightly curved ramp with vegetation on the inside of the curve. It has a relatively low storage of 27 vehicles.

This is the primary site for congestion problem M009 and it suffers reasonably high levels of congestion during the AM peak period. It is also a secondary site for congestion problem M008, which is associated with downstream primary F2F site 061 which is F2F.

Downstream volumes are acceptable and ramp volumes are ideal during congestion for a single lane entrance ramp.

This is the primary site for congestion problem M009. During the course of the AM peak it will become swamped by the downstream congestion from an F2F site meaning that benefits could be limited. However ramp metering should provide some benefits in the lead up to the later congestion.

This is a loop ramp so forward visibility will need to be considered during design, removal of vegetation on the inside of the curve would help.

Site Categorization

Feasible for taking forward

NCDOT Ramp Metering Feasibility Study
Site Summary Document

069

Site Details

Site Number	069
Freeway	I-85
Cross Street	University City Boulevard
Exit	43
Direction	Southbound
County	Mecklenburg

Physical Characteristics Overview

Origin of Entrance Ramp	Stop Controlled Intersection
Lane Addition onto Main Freeway length (feet)	680
Number of Entrance Ramp Lanes	1
Lane Drop on Entrance Ramp Before Merge	No
Number of Freeway Lanes Before Merge	5
Number of Freeway Lanes After Merge	5
Entrance Ramp Length to Back of Gore (feet)	960
Entrance Ramp Length to Tip of Gore (feet)	1,260
Merge Length (feet)	960
Entrance Ramp Horizontal Alignment	Straight
Entrance Ramp Vertical Alignment	Level
Entrance Ramp Shoulder (Paved Full Width)	No
Main Freeway Vertical Alignment Downstream	Level
Main Freeway Shoulder	Yes
Number of Vehicles Storage	38
Guardrail	Yes; ends 233’ from start of ramp
Pipe Crossing	None

Signalization Overview

Upstream Signal	Stop Controlled Intersection
Nearest Power Source	No obvious power source, CCTV near mainline underpass

Signing Overview

Existing Signing	None

Traffic Volumes

Period Beginning	Upstream Hourly Volume Rate	Downstream Hourly Volume Rate	Entrance Ramp Hourly Volume Rate	Downstream Volume per Lane	Entrance Ramp Volume per Lane	Entrance Ramp % of Downstream Volume	Hour Meets Acceptable Criteria for Ramp Metering
06:00	5,018	5,092	74	1,018	74	1	No
07:00	7,505	7,718	213	1,544	213	3	No
08:00	6,174	6,371	197	1,274	197	3	No
09:00	5,306	5,409	103	1,082	103	2	No
10:00	4,529	4,609	80	922	80	2	No
11:00	4,709	4,763	54	953	54	1	No
12:00	4,709	4,792	83	958	83	2	No
13:00	4,928	5,010	82	1,002	82	2	No
14:00	5,025	5,152	127	1,030	127	2	No
15:00	5,100	5,343	243	1,069	243	5	No
16:00	5,375	5,705	330	1,141	330	6	Yes
17:00	5,850	6,285	435	1,257	435	7	Yes
18:00	5,411	5,639	228	1,128	228	4	No
19:00	4,134	4,211	77	842	77	2	No
20:00	3,229	3,294	65	659	65	2	No

Capacity Analysis

Downstream Freeway Peak Volume	7,718
Corresponding Ramp Volume	213
Corresponding Upstream Freeway Peak Volume	7,505
Peak Hour Factor	0.900
Ramp Merge Level of Service	C

Congestion

Congestion	M008, M009, M012
Ave Length of Congestion (Miles)	0.62
Duration of Congestion (Minutes)	8.98
Calculated Number of Occurrences per Year	389
Typical Times of Congestion	07:30 - 09:00

Crash Data

The total number of accidents from March 2011 to February 2016 was: 49
Of these, 29 were accidents which can be associated with congestion:
Type 21-Rear end, slow or stop: 13 (27%)
Type 28- Sideswipe, same direction: 16 (33%)

Observations

Log 069 is a direct ramp with no sight distance issues. While the ramp starts at a slight downgrade, the grade overall is nearly level with an average slope of -0.033%. The ramp has one lane and has entry from a single left turn, a thru movement and right turn. Both the travel lane and shoulder are made of asphalt, but field observations were unable to determine if both were full depth. The pavement condition was considered to be poor to fair. The left shoulder has a width of 4-4.5' and the right shoulder had a width of 4-14'. Guardrail starts prior to the ramp and ends 233' down the ramp. A concrete ditch runs beside the guardrail and ends 225' from the start of the ramp. Three light poles are present on the outside shoulder of the ramp and are offset 14' from the edge of travel lane.

Site Selection Comments

This is a single lane direct ramp from a stop controlled intersection. It has storage for approximately 38 vehicles.

This is a secondary site for congestion problems M008, M009 and M012.

Ramp volumes are too low during the congested period, by a large margin, for ramp metering to have any positive benefit on the congestion.

This location has too few vehicles entering the entrance ramp for ramp metering to have an effect on the congestion problem.

Site Categorization

Not feasible

NCDOT Ramp Metering Feasibility Study
Site Summary Document

072

Site Details

Site Number	072
Freeway	I-85
Cross Street	Harris Boulevard
Exit	45
Direction	Southbound
County	Mecklenburg

Physical Characteristics Overview

Origin of Entrance Ramp	Signalized Intersection
Lane Addition onto Main Freeway length (feet)	3,000
Number of Entrance Ramp Lanes	2
Lane Drop on Entrance Ramp Before Merge	No
Number of Freeway Lanes Before Merge	4
Number of Freeway Lanes After Merge	5
Entrance Ramp Length to Back of Gore (feet)	1,200
Entrance Ramp Length to Tip of Gore (feet)	1,570
Merge Length (feet)	4,055
Entrance Ramp Horizontal Alignment	Straight
Entrance Ramp Vertical Alignment	Level
Entrance Ramp Shoulder (Paved Full Width)	No
Main Freeway Vertical Alignment Downstream	Slight Uphill
Main Freeway Shoulder	Yes
Number of Vehicles Storage	96
Guardrail	Yes; 135’ from ramp start
Pipe Crossing	None

Signalization Overview

Upstream Signal	Two-way signal; Ramp entry from single left and right turns
Nearest Power Source	Power Poles from signal at start of ramp

Signing Overview

Existing Signing	None

Traffic Volumes

Period Beginning	Upstream Hourly Volume Rate	Downstream Hourly Volume Rate	Entrance Ramp Hourly Volume Rate	Downstream Volume per Lane	Entrance Ramp Volume per Lane	Entrance Ramp % of Downstream Volume	Hour Meets Acceptable Criteria for Ramp Metering
06:00	4,888	5,343	455	1,336	228	9	No
07:00	6,924	7,683	759	1,921	380	10	Yes
08:00	4,802	5,546	744	1,387	372	13	Yes
09:00	4,436	5,169	733	1,292	367	14	Yes
10:00	3,815	4,434	619	1,109	310	14	Yes
11:00	3,695	4,438	743	1,110	372	17	Yes
12:00	3,910	4,735	825	1,184	413	17	Yes
13:00	4,115	4,961	846	1,240	423	17	Yes
14:00	4,062	4,995	933	1,249	467	19	Yes
15:00	3,786	4,866	1,080	1,217	540	22	Yes
16:00	3,598	4,988	1,390	1,247	695	28	Yes
17:00	3,775	5,289	1,514	1,322	757	29	Yes
18:00	3,934	5,005	1,071	1,251	536	21	Yes
19:00	3,791	4,527	736	1,132	368	16	Yes
20:00	3,417	4,028	611	1,007	306	15	Yes

Capacity Analysis

Downstream Freeway Peak Volume	7,809
Corresponding Ramp Volume	746
Corresponding Upstream Freeway Peak Volume	7,063
Peak Hour Factor	0.966
Ramp Merge Level of Service	B

Congestion

Congestion	M012
Ave Length of Congestion (Miles)	1.08
Duration of Congestion (Minutes)	15.98
Calculated Number of Occurrences per Year	183
Typical Times of Congestion	07:30 - 08:30

Crash Data

The total number of accidents from March 2011 to February 2016 was: 36
Of these, 24 were accidents which can be associated with congestion:
Type 21-Rear end, slow or stop: 12 (33%)
Type 28- Sideswipe, same direction: 12 (33%)

Observations

Log 072 is a direct ramp with no sight distance issues. The grade is level with an average slope of 0.333%. The ramp has two lanes and has entry from a single left turn, a thru movement and right turn. Both the travel lane and shoulder are made of asphalt, but field observations were unable to determine if both were full depth. The pavement condition was considered to be poor. The left shoulder has a width of 2' and the right shoulder had a width of 4'. A run of guardrail begins 135' from the start of the ramp and has an offset of 14'. A row of trees occurs 6' behind the guardrail. Three light poles are located 14' from the edge of travel lane towards the end of the ramp.

No PM peak.

Site Selection Comments

This is a double lane direct ramp with a large amount of storage at approximately 96 vehicles.

This is the secondary site for congestion problem M012, however the downstream site is not feasible for RM due to geometric issues. The site is congested in the AM peak.

Downstream and ramp volumes are acceptable during the congested period, although entrance ramp volume is on the low side due to the current two lane physical layout. However some benefits should be available.

This site could provide some benefits, although the level of congestion here is relatively low and it is not a primary site. It is notable that the ramp volume is highest in the PM peak, but this is not when the freeway suffers congestion.

No specific implementation problems have been identified.

Site Categorization

Feasible for taking forward

C.3.3 Site Summaries - Group 3

NCDOT Ramp Metering Feasibility Study
Site Summary Document

093

Site Details

Site Number	93
Freeway	I-77
Cross Street	Westinghouse Boulevard
Exit	1A
Direction	Southbound
County	Mecklenburg

Physical Characteristics Overview

Origin of Entrance Ramp	Free Flow Link
Lane Addition onto Main Freeway length (feet)	520
Number of Entrance Ramp Lanes	1
Lane Drop on Entrance Ramp Before Merge	None
Number of Freeway Lanes Before Merge	4
Number of Freeway Lanes After Merge	4
Entrance Ramp Length to Back of Gore (feet)	930
Entrance Ramp Length to Tip of Gore (feet)	1,570
Merge Length (feet)	790
Entrance Ramp Horizontal Alignment	Straight
Entrance Ramp Vertical Alignment	Slight Uphill
Entrance Ramp Shoulder (Paved Full Width)	Discontinuous
Main Freeway Vertical Alignment Downstream	Level
Main Freeway Shoulder	Yes
Number of Vehicles Storage	37
Guardrail	Yes; 370’ from grass island
Pipe Crossing	None Present

Signalization Overview

Upstream Signal	3-way signal: ramp entry from: dual left & right turn island
Nearest Power Source	Traffic Signal Cabinet located at intersection

Signing Overview

Existing Signing	“No Trucks 3 Axles” sign at 436’ from grass island

Traffic Volumes

Period Beginning	Upstream Hourly Volume Rate	Downstream Hourly Volume Rate	Entrance Ramp Hourly Volume Rate	Downstream Volume per Lane	Entrance Ramp Volume per Lane	Entrance Ramp % of Downstream Volume	Hour Meets Acceptable Criteria for Ramp Metering
06:00	4,905	5,142	237	1,286	237	5	No
07:00	7,018	7,392	374	1,848	374	5	Yes
08:00	7,622	7,937	315	1,984	315	4	No
09:00	6,368	6,654	286	1,664	286	4	No
10:00	6,330	6,589	259	1,647	259	4	No
11:00	7,060	7,430	370	1,858	370	5	No
12:00	7,719	8,141	422	2,035	422	5	Yes
13:00	7,968	8,375	407	2,094	407	5	No
14:00	7,922	8,444	522	2,111	522	6	Yes
15:00	7,911	8,663	752	2,166	752	9	Yes
16:00	9,778	10,942	1,164	2,736	1,164	11	Yes
17:00	8,444	9,652	1,208	2,413	1,208	13	No
18:00	7,287	8,035	748	2,009	748	9	Yes
19:00	7,267	7,674	407	1,919	407	5	Yes
20:00	6,266	6,470	204	1,618	204	3	No

Capacity Analysis

Downstream Freeway Peak Volume	11,256
Corresponding Ramp Volume	1,176
Corresponding Upstream Freeway Peak Volume	10,080
Peak Hour Factor	0.907
Ramp Merge Level of Service	F

Congestion

Congestion	M020
Ave Length of Congestion (Miles)	6.34
Duration of Congestion (Minutes)	109.03
Calculated Number of Occurrences per Year	438
Typical Times of Congestion	16:30 - 18:30

Crash Data

The total number of accidents from March 2011 to February 2016 was: 70
Of these, 55 were accidents which can be associated with congestion:
Type 21-Rear end, slow or stop: 46 (66%)
Type 28- Sideswipe, same direction: 9 (13%)

Observations

Log 93 is a long direct ramp. There are no sight distance issues. The entrance ramp average a slight 0.77% uphill grade that flattens out near the merge location. The pavement and shoulder type is asphalt. Condition of the pavement seems to be good but parts of the shoulder seems to be in a fair condition with some cracks. Right shoulder has a non-uniform width of 4' to 10' along the ramp and the left side shoulder has a width of 5' along the ramp. Guardrail located 13' off edge of travel lane at 370' from grass island. Drop-off located directly behind guardrail.

Very high traffic count values throughout the day. PM peak is significantly higher than 2000 vehicles per hour per lane.

Site Selection Comments

This is a single lane direct ramp from an un-signalized intersection. It has capacity to store approximately 37 vehicles on the ramp.

This is the primary site for congestion problem M020. The site has a considerable amount of congestion in the PM peak, meaning that RM could provide good benefits.

Downstream volumes are ideal and ramp volumes are acceptable for some of the congested period, but the ramp volumes are too high per lane during the worst of the congestion. In order to operate successfully this site will need to be widened to two metered lanes in order to store and process the ramp volume adequately.

This site has the potential for very good benefits, although it will need to be widened to two entrance ramp lanes for metering.

The widening of this site will incur increased costs. However, the current shoulder could be used.

Site Categorization

Feasible for taking forward

NCDOT Ramp Metering Feasibility Study
Site Summary Document

097

Site Details

Site Number	097
Freeway	I-77
Cross Street	I-485 (Outer)
Exit	1B
Direction	Southbound
County	Mecklenburg

Physical Characteristics Overview

Origin of Entrance Ramp	Freeway
Lane Addition onto Main Freeway length (feet)	3,000
Number of Entrance Ramp Lanes	2
Lane Drop on Entrance Ramp Before Merge	Yes, exit to Westinghouse Road
Number of Freeway Lanes Before Merge	3
Number of Freeway Lanes After Merge	4, 4th lane drops at next interchange
On Ramp Length to Back of Gore (feet)	585
On Ramp Length to Tip of Gore (feet)	1,290
Merge Length (feet)	3,000
Entrance Ramp Horizontal Alignment	Very slight curve
Entrance Ramp Vertical Alignment	Slightly uphill
Entrance Ramp Shoulder (Paved Full Width)	All asphalt, left shoulder 4', right shoulder 12', 12' lanes
Main Freeway Vertical Alignment Downstream	Slightly uphill
Main Freeway Shoulder	asphalt, 12' lanes
Number of Vehicles Storage	47
Guardrail	Upstream of gore at overhead sign structure
Pipe Crossing	No

Signalization Overview

Upstream Signal	None
Nearest Power Source	1200' north in median of I-485

Signing Overview

Existing Signing	Ramp warning speed upstream end of ramp, high occupancy vehicle 2+ sign 305' upstream of gore, Overhead guide sign 285' upstream of gore

Traffic Volumes

Period Beginning	Upstream Hourly Volume Rate	Downstream Hourly Volume Rate	On-Ramp Hourly Volume Rate	Downstream Volume per Lane	Entrance Ramp Volume per Lane	Entrance Ramp % of Downstream Volume	Hour Meets Acceptable Criteria for Ramp Metering
06:00	2,209	3,709	1,500	927	750	40	Yes
07:00	2,564	4,700	2,136	1,175	1,068	45	Yes
08:00	2,237	4,318	2,081	1,080	1,041	48	Yes
09:00	2,416	4,075	1,659	1,019	830	41	Yes
10:00	2,710	4,029	1,319	1,007	660	33	Yes
11:00	2,759	4,079	1,320	1,020	660	32	Yes
12:00	2,945	4,324	1,379	1,081	690	32	Yes
13:00	2,990	4,509	1,519	1,127	760	34	Yes
14:00	3,285	4,967	1,682	1,242	841	34	Yes
15:00	3,331	5,397	2,066	1,349	1,033	38	Yes
16:00	4,005	6,848	2,843	1,712	1,422	42	No
17:00	4,506	7,098	2,592	1,775	1,296	37	No
18:00	3,465	5,400	1,935	1,350	968	36	Yes
19:00	2,757	4,120	1,363	1,030	682	33	Yes
20:00	2,425	3,409	984	852	492	29	Yes

Capacity Analysis

Downstream Freeway Peak Volume	7,219
Corresponding Ramp Volume	2,786
Corresponding Upstream Freeway Peak Volume	4,433
Peak Hour Factor	0.992
Ramp Merge Level of Service	F

Congestion

Congestion	M020
Ave Length of Congestion (Miles)	5.8
Duration of Congestion (Minutes)	99.74
Calculated Number of Occurrences per Year	438
Typical Times of Congestion	17:00 - 18:30

Crash Data

Observations

Log 97 is a direct two-lane ramp. There are no sight distance issues. The entrance ramp is slightly uphill (less than 2%). The pavement and shoulder type is asphalt. Pavement condition is good. Shoulder width for the right side is 12' along the entrance ramp and the width for the left side 4'. There is a guardrail protecting an upstream sign structure.

Upstream on this ramp the ramps from both directions of I-485 merge then 500' downstream of that the exit ramp to Westinghouse Road begins. Then 1500' downstream of that is the merge onto I-77.

Clear zone setbacks will be critical to the placement of the ramp meter equipment.

Site Selection Comments

This is a two lane F2F ramp starting with a merge from two different directions, followed by an exit to a local road exit ramp before joining the freeway. Storage of vehicles is an issue due to the complex nature of the entrance ramp, but it is estimated to be approximately 47 vehicles.

This is a secondary site for congestion problem M020, which is a significant problem. The site is congested in the PM peak. Site 093 downstream is the primary site and this has been selected as feasible for taking forward.

Ramp volume per lane is too high for metering to be able to have an effect on the congestion.

This is effectively an F2F site. Limited storage, without affecting other movements, combined with ramp volumes being too high for metering to have a positive effect on the congestion, plus the complex nature of the layout, make this site unfeasible.

Site Categorization

Not feasible

NCDOT Ramp Metering Feasibility Study
Site Summary Document

099

Site Details

Site Number	099
Freeway	I-77
Cross Street	Arrowood Road
Exit	3
Direction	Southbound
County	Mecklenburg

Physical Characteristics Overview

Origin of Entrance Ramp	Free Flow Link
Lane Addition onto Main Freeway length (feet)	1,640
Number of Entrance Ramp Lanes	1
Lane Drop on Entrance Ramp Before Merge	Yes
Number of Freeway Lanes Before Merge	2 (Collector/Distributor road)
Number of Freeway Lanes After Merge	3 (Collector/Distributor road)
Entrance Ramp Length to Back of Gore (feet)	790
Entrance Ramp Length to Tip of Gore (feet)	1,285
Merge Length (feet)	1,500
Entrance Ramp Horizontal Alignment	Slight Curve
Entrance Ramp Vertical Alignment	Discontinuous
Entrance Ramp Shoulder (Paved Full Width)	No
Main Freeway Vertical Alignment Downstream	Level
Main Freeway Shoulder	Yes
Number of Vehicles Storage	32
Guardrail	Yes; 103’ from grass island (9’ off edge of travel lane)
Pipe Crossing	None Present

Signalization Overview

Upstream Signal	3-way signal: ramp entry from: dual left & single right turn
Nearest Power Source	Power source available at beginning outside of ramp

Signing Overview

Existing Signing	"No Trucks 3 Axles or More Left Lane" sign at 468' from edge of grass island

Traffic Volumes

Period Beginning	Upstream Hourly Volume Rate	Downstream Hourly Volume Rate	Entrance Ramp Hourly Volume Rate	Downstream Volume per Lane	Entrance Ramp Volume per Lane	Entrance Ramp % of Downstream Volume	Hour Meets Acceptable Criteria for Ramp Metering
06:00	1,068	1,432	364	477	364	25	Yes
07:00	1,874	2,345	471	782	471	20	Yes
08:00	2,157	2,615	458	872	458	18	Yes
09:00	1,726	2,092	366	697	366	17	Yes
10:00	1,589	1,989	400	663	400	20	Yes
11:00	1,500	1,997	497	666	497	25	Yes
12:00	1,974	2,670	696	890	696	26	Yes
13:00	1,913	2,467	554	822	554	22	Yes
14:00	1,783	2,356	573	785	573	24	Yes
15:00	1,966	2,820	854	940	854	30	Yes
16:00	2,736	4,264	1,528	1,421	1,528	36	No
17:00	3,660	5,353	1,693	1,784	1,693	32	No
18:00	2,602	3,523	921	1,174	921	26	Yes
19:00	1,880	2,411	531	804	531	22	Yes
20:00	1,410	1,784	374	595	374	21	Yes

Capacity Analysis

Downstream Freeway (Collector/Distributor Road) Peak Volume	5,399
Corresponding Ramp Volume	1,793
Corresponding Upstream Freeway (Collector/Distributor Road) Peak Volume	3,606
Peak Hour Factor	0.948
Ramp Merge Level of Service	F

Congestion

Congestion	M020
Ave Length of Congestion (Miles)	4.44
Duration of Congestion (Minutes)	76.34
Calculated Number of Occurrences per Year	438
Typical Times of Congestion	16:30 - 18:30

Crash Data

The total number of accidents from March 2011 to February 2016 was: 24
Of these, 18 were accidents which can be associated with congestion:
Type 21-Rear end, slow or stop: 8 (33%)
Type 28- Sideswipe, same direction: 10 (42%)

Observations

Log 99 is a long direct ramp which merges onto the I-77 Collector/Distributor road. There are no sight distance issues. The entrance ramp has average a slight 1.1% uphill grade that flattens out near the merge location. The pavement and shoulder type is asphalt. Condition of the pavement and shoulder seems to be good. Right side of the shoulder has a width of 6' and the left side of the shoulder has a width of 9'. The right side of the ramp has a guardrail and a barrier wall that are located at 103' from edge of grass island with an offset of 9' from edge of travel lane. Drop-off located directly behind guardrail.

Site Selection Comments

This is a single lane direct ramp from an un-signalized intersection. It has storage for approximately 32 vehicles. It is part of a complex CDR arrangement and does not enter the freeway directly.

This is a secondary site for congestion problem M020. It is congested in the PM peak. The primary site for the congestion is 093 which is downstream beyond an F2F intersection.

Ramp volume is too high during congestion.

This location does not feed directly onto the freeway and the ramp volumes are too high to meter. It is not feasible for RM.

Site Categorization

Not feasible

NCDOT Ramp Metering Feasibility Study
Site Summary Document

102

Site Details

Site Number	102
Freeway	I-77
Cross Street	Nations Ford Road
Exit	4
Direction	Southbound
County	Mecklenburg

Physical Characteristics Overview

Origin of Entrance Ramp	Signalized Intersection
Lane Addition onto Main Freeway length (feet)	2,560
Number of Entrance Ramp Lanes	1
Lane Drop on Entrance Ramp Before Merge	None
Number of Freeway Lanes Before Merge	3
Number of Freeway Lanes After Merge	4
Entrance Ramp Length to Back of Gore (feet)	810
Entrance Ramp Length to Tip of Gore (feet)	1,060
Merge Length (feet)	1,500
Entrance Ramp Horizontal Alignment	Straight
Entrance Ramp Vertical Alignment	Slight Downhill
Entrance Ramp Shoulder (Paved Full Width)	No
Main Freeway Vertical Alignment Downstream	Level
Main Freeway Shoulder	Yes
Number of Vehicles Storage	32
Guardrail	None Present
Pipe Crossing	None Present

Signalization Overview

Upstream Signal	3-way signal: ramp entry from: single left & right turn
Nearest Power Source	Traffic Signal Cabinet: inside corner of ramp & intersection

Signing Overview

Existing Signing	"No Trucks 3 Axles" sign located at 302' from concrete island

Traffic Volumes

Period Beginning	Upstream Hourly Volume Rate	Downstream Hourly Volume Rate	Entrance Ramp Hourly Volume Rate	Downstream Volume per Lane	Entrance Ramp Volume per Lane	Entrance Ramp % of Downstream Volume	Hour Meets Acceptable Criteria for Ramp Metering
06:00	3,609	4,038	429	1,010	429	11	Yes
07:00	5,127	5,625	498	1,406	498	9	Yes
08:00	5,614	6,066	452	1,517	452	7	Yes
09:00	4,771	5,023	252	1,256	252	5	No
10:00	4,475	4,727	252	1,182	252	5	No
11:00	4,813	5,129	316	1,282	316	6	Yes
12:00	4,826	5,183	357	1,296	357	7	Yes
13:00	5,357	5,738	381	1,435	381	7	Yes
14:00	5,496	5,883	387	1,471	387	7	Yes
15:00	5,571	6,104	533	1,526	533	9	Yes
16:00	5,533	6,387	854	1,597	854	13	Yes
17:00	5,247	6,104	857	1,526	857	14	Yes
18:00	4,692	5,306	614	1,327	614	12	Yes
19:00	4,448	4,796	348	1,199	348	7	Yes
20:00	3,866	4,106	240	1,027	240	6	No

Capacity Analysis

Downstream Freeway Peak Volume	6,420
Corresponding Ramp Volume	903
Corresponding Upstream Freeway Peak Volume	5,517
Peak Hour Factor	0.958
Ramp Merge Level of Service	F

Congestion

Congestion	M020, M021
Ave Length of Congestion (Miles)	4.02
Duration of Congestion (Minutes)	81.59
Calculated Number of Occurrences per Year	767
Typical Times of Congestion	15:30 - 19:00

Crash Data

The total number of accidents from March 2011 to February 2016 was: 35
Of these, 21 were accidents which can be associated with congestion:
Type 21-Rear end, slow or stop: 13 (37%)
Type 28- Sideswipe, same direction: 8 (23%)

Observations

Log 102 is a long direct ramp. There are no sight distance issues. The entrance ramp has average a slight -1.76% downhill grade that flattens out near the merge location. The pavement and shoulder type is asphalt. Condition of the pavement and shoulder seems to be fair with some pavement cracks, especially along the shoulder line. The right side shoulder has a width of 5' and the left side shoulder has a width of 4'. The tree line towards the end of the entrance ramp has an offset of 16' from edge of travel lane before that is far enough that it will not cause conflicts with ramp metering.

Site Selection Comments

This is a single lane direct ramp from a signalized intersection with right turn yield control. It has capacity to store approximately 32 vehicles on the ramp.

This is the primary site for congestion problem M021, this is a significant congestion problem so ramp metering could offer good benefits. This site is congested during the PM peak and there is a suspected weaving movement problem downstream which ramp metering could benefit.

Downstream and ramp volumes are ideal during the congested period for a single entrance ramp lane. The entrance ramp volumes would also be feasible for a two lane metered ramp, but currently this is not required.

This site could give good benefits, addressing the downstream weaving problem. RM would work across two lanes at this location if it is found to be required, although currently it is expected that the system will work effectively as a single lane.

No specific implementation problems have been identified. It would be technically possible to widen the ramp here, although there would be cost implications.

Site Categorization

Feasible for taking forward

NCDOT Ramp Metering Feasibility Study
Site Summary Document

104

Site Details

Site Number	104
Freeway	I-77
Cross Street	Tyvola Road
Exit	5
Direction	Southbound
County	Mecklenburg

Physical Characteristics Overview

Origin of Entrance Ramp	Free Flow Link
Lane Addition onto Main Freeway length (feet)	500
Number of Entrance Ramp Lanes	1
Lane Drop on Entrance Ramp Before Merge	Yes
Number of Freeway Lanes Before Merge	3
Number of Freeway Lanes After Merge	3
Entrance Ramp Length to Back of Gore (feet)	960
Entrance Ramp Length to Tip of Gore (feet)	2,195
Merge Length (feet)	1,845
Entrance Ramp Horizontal Alignment	Straight
Entrance Ramp Vertical Alignment	Slight Downhill
Entrance Ramp Shoulder (Paved Full Width)	Discontinuous
Main Freeway Vertical Alignment Downstream	Level
Main Freeway Shoulder	Yes
Number of Vehicles Storage	38
Guardrail	Yes
Pipe Crossing	None Present

Signalization Overview

Upstream Signal	Signalized; dual left, right turn on red
Nearest Power Source	Traffic Signal Cabinet

Signing Overview

Existing Signing	“No Trucks 3 Axles” sign located 378’ from tip of grass island

Traffic Volumes

Period Beginning	Upstream Hourly Volume Rate	Downstream Hourly Volume Rate	Entrance Ramp Hourly Volume Rate	Downstream Volume per Lane	Entrance Ramp Volume per Lane	Entrance Ramp % of Downstream Volume	Hour Meets Acceptable Criteria for Ramp Metering
06:00	4,483	4,760	277	1,587	277	6	No
07:00	6,909	7,424	515	2,475	515	7	Yes
08:00	6,676	7,294	618	2,431	618	8	Yes
09:00	5,638	6,126	488	2,042	488	8	Yes
10:00	5,664	6,208	544	2,069	544	9	Yes
11:00	6,177	6,891	714	2,297	714	10	Yes
12:00	5,567	6,276	709	2,092	709	11	Yes
13:00	6,176	6,948	772	2,316	772	11	Yes
14:00	6,097	6,858	761	2,286	761	11	Yes
15:00	6,106	7,031	925	2,344	925	13	Yes
16:00	5,502	6,654	1,152	2,218	1,152	17	Yes
17:00	4,647	5,768	1,121	1,923	1,121	19	Yes
18:00	4,460	5,367	907	1,789	907	17	Yes
19:00	5,654	6,270	616	2,090	616	10	Yes
20:00	4,835	5,376	541	1,792	541	10	Yes

Capacity Analysis

Downstream Freeway Peak Volume	7,645
Corresponding Ramp Volume	635
Corresponding Upstream Freeway Peak Volume	7,010
Peak Hour Factor	0.986
Ramp Merge Level of Service	F

Congestion

Congestion	M023, M020, M021
Ave Length of Congestion (Miles)	3.87
Duration of Congestion (Minutes)	79.05
Calculated Number of Occurrences per Year	767
Typical Times of Congestion	15:30-19:00

Crash Data

The total number of accidents from March 2011 to February 2016 was: 82
Of these, 67 were accidents which can be associated with congestion:
Type 21-Rear end, slow or stop: 49 (60%)
Type 28- Sideswipe, same direction: 18 (22%)

Observations

Log 104 is a long direct ramp. There are no sight distance issues. The entrance ramp has a downhill grade that flattens out near the merge location. The pavement and shoulder type is asphalt. Condition of the pavement and shoulder seems to be good. Right side of the shoulder has a width of 9' and the left side a width of 4'. The right side of the ramp has a guardrail that runs the length of the ramp and has a 10' offset from edge of travel lane. A drop-off/wetland is directly behind the guardrail and there is no room outside of guardrail for more lanes.

Site Selection Comments

This is a direct single lane entrance ramp with approximately 38 vehicles storage. The ramp originates at a signalized intersection.

This is the primary site for congestion problem M023 and also a secondary site to M020 and M021. This site is congested in the PM peak. The amount and type of congestion are feasible for RM.

Downstream volumes are ideal but ramp volumes are high during the congested period and only just acceptable for a single lane entrance ramp.

Vehicle storage is relatively low compared to the volume on the single lane. The signalized intersection could cause platoons that would overwhelm the amount of storage available. This site has the potential for benefits, but would require an additional lane for storage and to be able to process the entrance ramp volume. In addition this location is in the tail of downstream congestion problems related to site 102. It is worth assessing the effect of implementing site 102 before committing to installing ramp metering at this site as the congestion benefits may reduce.

This site would require an additional lane on the entrance ramp.

Site Categorization

Review in future

NCDOT Ramp Metering Feasibility Study
Site Summary Document

109

Site Details

Site Number	109
Freeway	I-77
Cross Street	Clanton Road
Exit	7
Direction	Southbound
County	Mecklenburg

Physical Characteristics Overview

Origin of Entrance Ramp	Signalized Intersection with Free Flow Right Turn
Lane Addition onto Main Freeway length (feet)	960
Number of Entrance Ramp Lanes	1
Lane Drop on Entrance Ramp Before Merge	None
Number of Freeway Lanes Before Merge	3
Number of Freeway Lanes After Merge	3
Entrance Ramp Length to Back of Gore (feet)	720
Entrance Ramp Length to Tip of Gore (feet)	960
Merge Length (feet)	1,230
Entrance Ramp Horizontal Alignment	Straight
Entrance Ramp Vertical Alignment	Slight Downhill
Entrance Ramp Shoulder (Paved Full Width)	No
Main Freeway Vertical Alignment Downstream	Level
Main Freeway Shoulder	Yes
Number of Vehicles Storage	29
Guardrail	Yes
Pipe Crossing	None Present

Signalization Overview

Upstream Signal	Signalized; 3-way, single left, right turn on red, through
Nearest Power Source	Traffic Signal Cabinet: Inside corner of ramp & intersection

Signing Overview

Existing Signing	“No Trucks 3 Axles” sign at 225’ from concrete island

Traffic Volumes

Period Beginning	Upstream Hourly Volume Rate	Downstream Hourly Volume Rate	Entrance Ramp Hourly Volume Rate	Downstream Volume per Lane	Entrance Ramp Volume per Lane	Entrance Ramp % of Downstream Volume	Hour Meets Acceptable Criteria for Ramp Metering
06:00	4,912	5,116	204	1,705	204	4	No
07:00	7,165	7,505	340	2,502	340	5	No
08:00	6,991	7,299	308	2,433	308	4	No
09:00	6,080	6,337	257	2,112	257	4	No
10:00	6,261	6,516	255	2,172	255	4	No
11:00	6,643	6,907	264	2,302	264	4	No
12:00	6,005	6,278	273	2,093	273	4	No
13:00	6,231	6,538	307	2,179	307	5	No
14:00	6,202	6,486	284	2,162	284	4	No
15:00	6,176	6,472	296	2,157	296	5	No
16:00	5,532	5,858	326	1,953	326	6	Yes
17:00	5,052	5,301	249	1,767	249	5	No
18:00	5,240	5,462	222	1,821	222	4	No
19:00	5,548	5,756	208	1,919	208	4	No
20:00	4,575	4,739	164	1,580	164	3	No

Capacity Analysis

Downstream Freeway Peak Volume	7,615
Corresponding Ramp Volume	364
Corresponding Upstream Freeway Peak Volume	7,251
Peak Hour Factor	0.981
Ramp Merge Level of Service	F

Congestion

Congestion	M021, M023
Ave Length of Congestion (Miles)	0.9
Duration of Congestion (Minutes)	4.86
Calculated Number of Occurrences per Year	535
Typical Times of Congestion	14:30 - 19:00

Crash Data

The total number of accidents from March 2011 to February 2016 was: 104
Of these, 91 were accidents which can be associated with congestion:
Type 21-Rear end, slow or stop: 71 (68%)
Type 28- Sideswipe, same direction: 20 (19%)

Observations

Log 109 is a long direct ramp. There are no sight distance issues. The entrance ramp has a slight downhill grade that flattens out near the merge location. The pavement and shoulder type is asphalt. Condition of the pavement seems to fair with some cracks along the ramp. Shoulder has a width of 4’ on each side with a poor condition. The condition of the dirt shoulder seems to be very poor with several ruts. There is a guardrail located at 715’ from concrete Island with an offset of 10’ from edge of travel lane. Existing utility box located at 8’ from edge of travel lane.

No PM peak, and peak volume is greater than 2000 vehicles per hour per lane.

Site Selection Comments

This is a single lane direct ramp with storage for approximately 29 vehicles. The ramp comes from a signalized intersection with free flow right turn.

This is a secondary site which is a long way back in congestion problem M021 and M023. The amount of congestion in this location is relatively small.

Ramp volume is typically too low during the congested period.

This site has little congestion, is not a primary site and the entrance ramp volumes are too low for metering. This is not a feasible site for RM.

Site Categorization

Not feasible

NCDOT Ramp Metering Feasibility Study
Site Summary Document

111

Site Details

Site Number	111
Freeway	I-77
Cross Street	Remount Road
Exit	8
Direction	Southbound
County	Mecklenburg

Physical Characteristics Overview

Origin of Ramp	Free Flow Link
Lane Addition onto Main Freeway length (feet)	900
Number of Entrance Ramp Lanes	1
Lane Drop on Entrance Ramp Before Merge	None
Number of Freeway Lanes Before Merge	3
Number of Freeway Lanes After Merge	3
Entrance Ramp Length to Back of Gore (feet)	995
Entrance Ramp Length to Tip of Gore (feet)	1,285
Merge Length (feet)	1,170
Entrance Ramp Horizontal Alignment	Slight Curve
Entrance Ramp Vertical Alignment	Slight Downhill
Entrance Ramp Shoulder (Paved Full Width)	No
Main Freeway Vertical Alignment Downstream	Slight Uphill
Main Freeway Shoulder	Yes
Number of Vehicles Storage	40
Guardrail	Yes; 10’ from edge of travel lane
Pipe Crossing	None Present

Signalization Overview

Upstream Signal	Not signalized – Yield Controlled
Nearest Power Source	260’ Northwest from concrete island

Signing Overview

Existing Signing	“No Trucks 3 Axles or More Left Lane” sign located 275’ from concrete island

Traffic Volumes

Period Beginning	Upstream Hourly Volume Rate	Downstream Hourly Volume Rate	Entrance Ramp Hourly Volume Rate	Downstream Volume per Lane	Entrance Ramp Volume per Lane	Entrance Ramp % of Downstream Volume	Hour Meets Acceptable Criteria for Ramp Metering
06:00	6,853	7,034	181	2,345	181	3	No
07:00	9,108	9,743	635	3,248	635	7	Yes
08:00	8,631	9,201	570	3,067	570	6	Yes
09:00	8,364	8,665	301	2,888	301	3	No
10:00	8,715	8,978	263	2,993	263	3	No
11:00	9,054	9,391	337	3,130	337	4	No
12:00	8,282	8,632	350	2,877	350	4	No
13:00	8,262	8,677	415	2,892	415	5	No
14:00	7,937	8,334	397	2,778	397	5	No
15:00	8,193	8,699	506	2,900	506	6	Yes
16:00	7,062	7,645	583	2,548	583	8	Yes
17:00	5,942	6,469	527	2,156	527	8	Yes
18:00	7,106	7,494	388	2,498	388	5	Yes
19:00	7,707	8,003	296	2,668	296	4	No
20:00	6,686	6,973	287	2,324	287	4	No

Capacity Analysis

Downstream Freeway Peak Volume	9,743
Corresponding Ramp Volume	635
Corresponding Upstream Freeway Peak Volume	9,108
Peak Hour Factor	0.979
Ramp Merge Level of Service	F

Congestion

Congestion	M021, M027
Ave Length of Congestion (Miles)	2.49
Duration of Congestion (Minutes)	50.98
Calculated Number of Occurrences per Year	913
Typical Times of Congestion	07:00 - 09:30, 14:30 - 19:00

Crash Data

The total number of accidents from March 2011 to February 2016 was: 147
Of these, 122 were accidents which can be associated with congestion:
Type 21-Rear end, slow or stop: 86 (59%)
Type 28- Sideswipe, same direction: 36 (24%)

Observations

Log 111 is a direct ramp. There are no sight distance issues. The entrance ramp has a downhill grade that flattens out to a very slight uphill grade near the merge location. The pavement is paved with concrete and shows a fair condition. Shoulder is paved with asphalt and shows a very poor condition (not full width, reconstruction needed). Shoulder width for the right side is 7' and the left side is 4'. There is a guardrail with an offset of 10' from edge of travel lane that starts 310' from concrete island and stops just before merging onto the freeway. Drop-off 7' behind face of guardrail. Utility box located 12' from edge of travel lane.

Volumes decrease around 16:00-18:00 (typical PM peak times) rather than increase as would be expected. Peak volume is much greater than the 2000 vehicles per hour per lane (3247).

Site Selection Comments

This is a single lane direct ramp from an un-signalized intersection, with storage for approximately 40 vehicles.

This is the primary site for congestion M027. It has a large amount of VHD so there is the opportunity to get good congestion benefits from metering.

Ramp volumes are acceptable and downstream volumes are ideal during the congested period.

This appears to be a good site in most respects. Occasionally during congestion the entrance ramp volume is too low to be able to form a queue, but most of the time it should operate well.

No specific implementation problems have been identified.

Site Categorization

Feasible for taking forward

NCDOT Ramp Metering Feasibility Study
Site Summary Document

117

Site Details

Site Number	117
Freeway	I-77
Cross Street	West Trade Street
Exit	10
Direction	Southbound
County	Mecklenburg

Physical Characteristics Overview

Origin of Ramp	Free Flow Link
Lane Addition onto Main Freeway length (feet)	400
Number of Entrance Ramp Lanes	1
Lane Drop on Entrance Ramp Before Merge	None
Number of Freeway Lanes Before Merge	4
Number of Freeway Lanes After Merge	4
Entrance Ramp Length to Back of Gore (feet)	865
Entrance Ramp Length to Tip of Gore (feet)	1,060
Merge Length (feet)	470
Entrance Ramp Horizontal Alignment	Tight Curve
Entrance Ramp Vertical Alignment	Uphill
Entrance Ramp Shoulder (Paved Full Width)	No
Main Freeway Vertical Alignment Downstream	Slight curve
Main Freeway Shoulder	Yes
Number of Vehicles Storage	35
Guardrail	Yes
Pipe Crossing	None

Signalization Overview

Upstream Signal	None
Nearest Power Source	East Side of interchange

Signing Overview

Existing Signing	Chevron curve warnings only

Traffic Volumes

Period Beginning	Upstream Hourly Volume Rate	Downstream Hourly Volume Rate	Entrance Ramp Hourly Volume Rate	Downstream Volume per Lane	Entrance Ramp Volume per Lane	Entrance Ramp % of Downstream Volume	Hour Meets Acceptable Criteria for Ramp Metering
06:00	4,764	4,795	31	1,199	31	1	No
07:00	6,962	7,072	110	1,768	110	2	No
08:00	6,463	6,573	110	1,643	110	2	No
09:00	5,559	5,649	90	1,412	90	2	No
10:00	4,919	5,001	82	1,250	82	2	No
11:00	4,849	4,958	109	1,240	109	2	No
12:00	4,774	4,897	123	1,224	123	3	No
13:00	5,042	5,158	116	1,290	116	2	No
14:00	5,056	5,207	151	1,302	151	3	No
15:00	5,041	5,247	206	1,312	206	4	No
16:00	4,603	4,946	343	1,237	343	7	Yes
17:00	4,173	4,518	345	1,130	345	8	Yes
18:00	4,198	4,450	252	1,113	252	6	No
19:00	4,050	4,195	145	1,049	145	3	No
20:00	3,326	3,412	86	853	86	3	No

Capacity Analysis

Downstream Freeway Peak Volume	7,072
Corresponding Ramp Volume	110
Corresponding Upstream Freeway Peak Volume	6,962
Peak Hour Factor	0.972
Ramp Merge Level of Service	D

Congestion

Congestion	M027
Ave Length of Congestion (Miles)	1.48
Duration of Congestion (Minutes)	30.2
Calculated Number of Occurrences per Year	584
Typical Times of Congestion	07:00 - 09:30

Crash Data

The total number of accidents from March 2011 to February 2016 was: 141
Of these, 112 were accidents which can be associated with congestion:
Type 21-Rear end, slow or stop: 54 (38%)
Type 28- Sideswipe, same direction: 58 (41%)

Observations

No PM peak. Typical times of congestion from the Bottleneck Ranking tool do not match the suitability criteria from the Traffic Count analysis (see 'Flow Summary' tab of Traffic Data spreadsheet).

Site Selection Comments

This is a single loop ramp with storage for approximately 35 vehicles. The ramp comes from a free-flow intersection. There are concerns over the tight curve of the entrance ramp and the low visibility due to vegetation.

This is a secondary site for congestion problem M027.

Ramp volumes are significantly too low during the congested period, and consequently it would not be possible for ramp metering to operate effectively on these volumes.

Implementation would be challenging due to the tight curvature of the ramp and low volumes mean that RM would not give any congestion benefits.

Site Categorization

Not feasible

C.3.4 Site Summaries - Group 4

NCDOT Ramp Metering Feasibility Study
Site Summary Document

101

Site Details

Site Number	101
Freeway	I-77
Cross Street	Arrowood Road
Exit	3
Direction	Northbound
County	Mecklenburg

Physical Characteristics Overview

Origin of Entrance Ramp	Free Flow Link
Lane Addition onto Main Freeway length (feet)	950
Number of Entrance Ramp Lanes	1
Lane Drop on Entrance Ramp Before Merge	Yes
Number of Freeway Lanes Before Merge	3
Number of Freeway Lanes After Merge	3
On Ramp Length to Back of Gore (feet)	2,280
On Ramp Length to Tip of Gore (feet)	2,555
Merge Length (feet)	1,060
Entrance Ramp Horizontal Alignment	Straight
Entrance Ramp Vertical Alignment	Slight Uphill
Entrance Ramp Shoulder (Paved Full Width)	No
Main Freeway Vertical Alignment Downstream	Level
Main Freeway Shoulder	Yes
Number of Vehicles Storage	91
Guardrail	Yes, 6’ Off edge of travel lane, 263’ from grass island
Pipe Crossing	None Present

Signalization Overview

Upstream Signal	3-way signal; ramp entry from: dual left & right turn lane
Nearest Power Source	Power distribution pole located 8’ behind guardrail

Signing Overview

Existing Signing	“No Trucks 3 Axles”, sign located at 707’ from grass island

Traffic Volumes

Period Beginning	Upstream Hourly Volume Rate	Downstream Hourly Volume Rate	Entrance Ramp Hourly Volume Rate	Downstream Volume per Lane	Entrance Ramp Volume per Lane	Entrance Ramp % of Downstream Volume	Hour Meets Acceptable Criteria for Ramp Metering
06:00	4,104	4,357	253	1,452	253	6	No
07:00	4,569	5,256	687	1,752	687	13	Yes
08:00	4,776	5,295	519	1,765	519	10	Yes
09:00	4,389	4,735	346	1,578	346	7	Yes
10:00	4,297	4,629	332	1,543	332	7	Yes
11:00	4,269	4,748	479	1,583	479	10	Yes
12:00	4,322	4,847	525	1,616	525	11	Yes
13:00	4,330	4,782	452	1,594	452	9	Yes
14:00	4,362	4,837	475	1,612	475	10	Yes
15:00	4,471	5,019	548	1,673	548	11	Yes
16:00	4,045	4,724	679	1,575	679	14	Yes
17:00	3,557	4,446	889	1,482	889	20	Yes
18:00	3,881	4,442	561	1,481	561	13	Yes
19:00	3,991	4,398	407	1,466	407	9	Yes
20:00	2,984	3,325	341	1,108	341	10	Yes

Capacity Analysis

Downstream Freeway Peak Volume	5,423
Corresponding Ramp Volume	615
Corresponding Upstream Freeway Peak Volume	4,808
Peak Hour Factor	0.962
Ramp Merge Level of Service	D

Congestion

Congestion	M028, M025, M024, M022
Ave Length of Congestion (Miles)	1.75
Duration of Congestion (Minutes)	28.83
Calculated Number of Occurrences per Year	1,010
Typical Times of Congestion	07:00 - 10:00, 12:00 - 19:00

Crash Data

The total number of accidents from March 2011 to February 2016 was: 180
Of these, 161 were accidents which can be associated with congestion:
Type 21-Rear end, slow or stop: 136 (76%)
Type 28- Sideswipe, same direction: 25 (14%)

Observations

Log 101 is a direct ramp. There are no sight distance issues. The total average length of the entrance ramp has an average uphill grade of 2.07% that flattens out near the merge location. The pavement and shoulder type is asphalt. Pavement condition is poor to fair with several cracks along the ramp. Shoulder width for the right side is 4' along the entrance ramp and the width for the left side 9' at the beginning of the entrance ramp and after about 530' from the grass island it converts to 4'. There is a guardrail protecting the power pole on the right side before the lane drop. Power distribution pole located 8' behind guardrail (14' from edge of travel lane). An existing utility box located at 15' off the edge of travel lane and 463' from grass island.

Site Selection Comments

This starts as a two lane ramp but narrows to one before the ramp meter, which doubles the recorded storage. It has approximately 91 vehicles storage. The ramp originates at a free-flow link.

This is not a primary congestion site, but could support site 103.

Ramp and downstream volumes are mostly ideal during congestion for the number of lanes available on the entrance ramp.

This appears to be a good site with a good amount of storage and a lane drop at the downstream end meaning that metering would take place for one lane, which is appropriate for the peak entrance ramp volumes. The site could support site 103 which is the primary site for M022.

No specific implementation problems have been identified.

Site Categorization

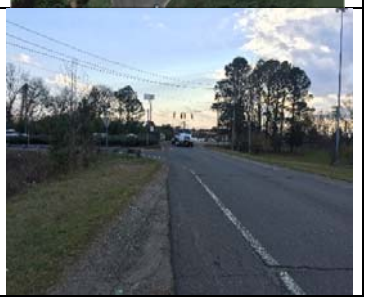
Feasible for Taking Forward

NCDOT Ramp Metering Feasibility Study
Site Summary Document

103

Site Details

Site Number	103
Freeway	I-77
Cross Street	Nations Ford Road
Exit	4
Direction	Northbound
County	Mecklenburg



Physical Characteristics Overview

Origin of Entrance Ramp	Free Flow Link
Lane Addition onto Main Freeway length (feet)	560
Number of Entrance Ramp Lanes	1
Lane Drop Entrance Ramp Before Merge	None
Number of Freeway Lanes Before Merge	3
Number of Freeway Lanes After Merge	3
Entrance Ramp Length to Back of Gore (feet)	485
Entrance Ramp Length to Tip of Gore (feet)	770
Merge Length (feet)	970
Entrance Ramp Horizontal Alignment	Straight
Entrance Ramp Vertical Alignment	Slight Downhill
Entrance Ramp Shoulder (Paved Full Width)	No
Main Freeway Vertical Alignment Downstream	Level
Main Freeway Shoulder	Yes
Number of Vehicles Storage	19
Guardrail	Yes
Pipe Crossing	None Present

Signalization Overview

Upstream Signal	3-way signal: ramp entry from: single left, single right turn lane, thru
Nearest Power Source	Traffic Signal Cabinet located at intersection

Signing Overview

Existing Signing	“No Trucks 3 Axles” sign at 210’ from concrete Island

Traffic Volumes

Period Beginning	Upstream Hourly Volume Rate	Downstream Hourly Volume Rate	Entrance Ramp Hourly Volume Rate	Downstream Volume per Lane	Entrance Ramp Volume per Lane	Entrance Ramp % of Downstream Volume	Hour Meets Acceptable Criteria for Ramp Metering
06:00	3,923	4,508	585	1,503	585	13	Yes
07:00	4,750	5,402	652	1,801	652	12	Yes
08:00	4,488	5,037	549	1,679	549	11	Yes
09:00	4,143	4,517	374	1,506	374	8	Yes
10:00	4,031	4,414	383	1,471	383	9	Yes
11:00	4,307	4,734	427	1,578	427	9	Yes
12:00	4,275	4,705	430	1,568	430	9	Yes
13:00	4,245	4,664	419	1,555	419	9	Yes
14:00	4,304	4,759	455	1,586	455	10	Yes
15:00	4,380	4,881	501	1,627	501	10	Yes
16:00	4,069	4,583	514	1,528	514	11	Yes
17:00	3,800	4,279	479	1,426	479	11	Yes
18:00	3,793	4,246	453	1,415	453	11	Yes
19:00	3,629	4,017	388	1,339	388	10	Yes
20:00	2,561	2,859	298	953	298	10	No

Capacity Analysis

Downstream Freeway Peak Volume	5,530
Corresponding Ramp Volume	654
Corresponding Upstream Freeway Peak Volume	4,876
Peak Hour Factor	0.980
Ramp Merge Level of Service	D

Congestion

Congestion	M022, M024, M025, M028
Ave Length of Congestion (Miles)	2.36
Duration of Congestion (Minutes)	39.23
Calculated Number of Occurrences per Year	83
Typical Times of Congestion	07:00 - 10:00, 12:00 - 19:00

Crash Data

The total number of accidents from March 2011 to February 2016 was: 206
Of these, 188 were accidents which can be associated with congestion:
Type 21-Rear end, slow or stop: 149 (72%)
Type 28- Sideswipe, same direction: 39 (19%)

Observations

Log 103 is a direct ramp. There are no sight distance issues. The entrance ramp has an average -0.7% grade that flattens out near the merge location. The pavement and shoulder type are Asphalt. Condition of the pavement seems to be poor to fair with some cracks. Shoulder has a width of 4' on each side. Guardrail located at the end of the acceleration lane of ramp. Existing utility box located at 8' from edge of travel lane at a distance of 272' from concrete island.

No PM peak in traffic count.

Site Selection Comments

This is a direct single lane entrance ramp with storage for approximately 19 vehicles. The ramp originates at a free volume link.

This is a primary site for M022, but it is also a secondary site for other congestion problems. This site could also be linked to site 101.

Entrance ramp volumes are ideal for single lane metering. If an extra lane was added then the volumes would be too low to meter effectively.

This appears to be a good site in all respects apart from storage capacity. An additional lane would be useful for storage, but the ramp must be metered on one lane to achieve the best benefit, so widening to two lanes with a lane drop before the signals should be considered. This location could be supported by being linked to upstream site 101.

Consideration should be given to widening to two lanes with a lane drop, so that it operates as a single lane meter.

Site Categorization

Feasible for taking forward

NCDOT Ramp Metering Feasibility Study
Site Summary Document

105

Site Details

Site Number	105
Freeway	I-77
Cross Street	Tyvola Road
Exit	5
Direction	Northbound
County	Mecklenburg

Physical Characteristics Overview

Origin of Entrance Ramp	Free Flow Link
Lane Addition onto Main Freeway length (feet)	230
Number of Entrance Ramp Lanes	2
Lane Drop on Entrance Ramp Before Merge	Yes
Number of Freeway Lanes Before Merge	3
Number of Freeway Lanes After Merge	3
Entrance Ramp Length to Back of Gore (feet)	900
Entrance Ramp Length to Tip of Gore (feet)	2,310
Merge Length (feet)	1,600
Entrance Ramp Horizontal Alignment	Straight
Entrance Ramp Vertical Alignment	Slight Downhill
Entrance Ramp Shoulder (Paved Full Width)	No
Main Freeway Vertical Alignment Downstream	Straight
Main Freeway Shoulder	Yes
Number of Vehicles Storage	72
Guardrail	None Present
Pipe Crossing	Drainage structure located at 27’ from edge of travel lane

Signalization Overview

Upstream Signal	3-way signal: ramp entry from: dual left & right turn island
Nearest Power Source	Traffic Signal Cabinet located at intersection

Signing Overview

Existing Signing	“Right Lane Ends” sign at 184’ from grass island “Right Lane Ends” signs at 576’ from grass island “No Trucks 3 Axles” sign at 382’ from grass island

Traffic Volumes

Period Beginning	Upstream Hourly Volume Rate	Downstream Hourly Volume Rate	Entrance Ramp Hourly Volume Rate	Downstream Volume per Lane	Entrance Ramp Volume per Lane	Entrance Ramp % of Downstream Volume	Hour Meets Acceptable Criteria for Ramp Metering
06:00	6,666	7,106	440	2,369	220	6	No
07:00	8,236	9,037	801	3,012	401	9	Yes
08:00	6,596	7,447	851	2,482	426	11	Yes
09:00	5,914	6,484	570	2,161	285	9	No
10:00	6,603	7,243	640	2,414	320	9	Yes
11:00	6,952	7,616	664	2,539	332	9	Yes
12:00	6,853	7,702	849	2,567	425	11	Yes
13:00	6,958	7,796	838	2,599	419	11	Yes
14:00	7,183	8,112	929	2,704	465	11	Yes
15:00	6,588	7,557	969	2,519	485	13	Yes
16:00	6,106	7,085	979	2,362	490	14	Yes
17:00	5,872	6,910	1,038	2,303	519	15	Yes
18:00	6,039	6,971	932	2,324	466	13	Yes
19:00	6,418	7,073	655	2,358	328	9	Yes
20:00	4,961	5,459	498	1,820	249	9	No

Capacity Analysis

Downstream Freeway Peak Volume	9,037
Corresponding Ramp Volume	801
Corresponding Upstream Freeway Peak Volume	8,236
Peak Hour Factor	0.982
Ramp Merge Level of Service	F

Congestion

Congestion	M024, M025, M026, M028
Ave Length of Congestion (Miles)	3.22
Duration of Congestion (Minutes)	59.95
Calculated Number of Occurrences per Year	1,119
Typical Times of Congestion	07:00 - 10:00, 12:00 - 19:00

Crash Data

The total number of accidents from March 2011 to February 2016 was: 176
Of these, 152 were accidents which can be associated with congestion:
Type 21-Rear end, slow or stop: 117 (66%)
Type 28- Sideswipe, same direction: 35 (20%)

Observations

Log 105 is a long direct ramp. There are no sight distance issues. The entrance ramp has a slight -2.5% downhill grade that flattens out near the merge location. The pavement and shoulder type are Asphalt. Condition of the pavement seems to be poor to fair with some cracks. Shoulder has a width of 4’ on each side. Utility light poles begin at the tip of the physical gore along the entrance ramp and continues to the Main Freeway with an offset of 14’ from edge of travel lane. Drainage structure were located at 27’ from the edge of travel lane. Existing utility box located at 9’ from edge of travel lane and 463’ from grass island.

Site Selection Comments

This is a two lane direct ramp from a free-flow link, with storage for approximately 72 vehicles.

Some congestion occurs in the morning, although entrance ramp volumes are low at this time. During the afternoon a more significant congestion problem arises, where the entrance ramp volumes are more ideal. This is a primary site for M024 but sites relating to congestion further downstream have been ruled out during the screening analysis.

Downstream and ramp volumes are ideal during the congested period.

This appears to be a good site in all respects. However the lane markings need to be clearer to show two lanes. This will need to be a two lane metered site.

No specific implementation problems have been identified. Entrance ramp lane markings will need to be made clearer.

Site Categorization

Feasible for taking forward

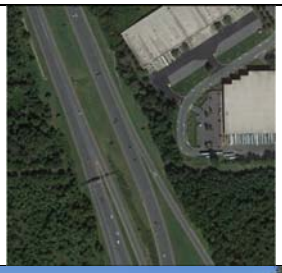
C.3.5 Site Summaries - Group 5

NCDOT Ramp Metering Feasibility Study
Site Summary Document

129

Site Details

Site Number	129
Freeway	I-77
Cross Street	I-85
Exit	13
Direction	Northbound
County	Mecklenburg



Physical Characteristics Overview

Origin of Entrance Ramp	Freeway
Lane Addition onto Main Freeway length (feet)	410
Number of Entrance Ramp Lanes	1
Lane Drop on Entrance Ramp Before Merge	Yes, 2 lane ramp ends 625’ south of back of gore
Number of Freeway Lanes Before Merge	4
Number of Freeway Lanes After Merge	4
On Ramp Length to Back of Gore (feet)	1,710
On Ramp Length to Tip of Gore (feet)	2,315
Merge Length (feet)	720
Entrance Ramp Horizontal Alignment	Very slight curve to right.
Entrance Ramp Vertical Alignment	2% downhill
Entrance Ramp Shoulder (Paved Full Width)	8’ asphalt left, 4’ asphalt right, 12’ lanes, 16’ lane after lane reduction, some transverse deep cracking (master list: No)
Main Freeway Vertical Alignment Downstream	Slight downhill
Main Freeway Shoulder	12’ asphalt (master list: Yes)
Number of Vehicles Storage	68
Guardrail	Guardrail protecting the power pole on the right side before the lane drop

Pipe Crossing	Power distribution pole located 8' behind guardrail (14' from edge of travel lane). Approximately 500' north of gore

Signalization Overview

Upstream Signal	None
Nearest Power Source	Approximately 500' north of gore

Signing Overview

Existing Signing	Numerous No Parking signs on right shoulder, W4-2 Lane Drop sign (all south of gore) and High Occupancy Vehicle lane 2+ (north of gore)

Traffic Volumes

Period Beginning	Upstream Hourly Volume Rate	Downstream Hourly Volume Rate	Entrance Ramp Hourly	Downstream Volume per Lane	Entrance Ramp Volume per Lane	Entrance Ramp % of Downstream Volume	Hour Meets Acceptable Criteria for Ramp Metering
06:00	1,472	1,691	219	423	219	13	No
07:00	2,438	2,748	310	687	310	11	Yes
08:00	2,325	2,597	272	649	272	10	No
09:00	2,156	2,467	311	617	311	13	Yes
10:00	2,381	2,657	276	664	276	10	No
11:00	2,479	2,760	281	690	281	10	No
12:00	2,561	2,914	353	729	353	12	Yes
13:00	2,687	2,995	308	749	308	10	Yes
14:00	2,840	3,192	352	798	352	11	Yes
15:00	2,928	3,311	383	828	383	12	Yes
16:00	3,579	4,032	453	1,008	453	11	Yes
17:00	4,151	4,635	484	1,159	484	10	Yes
18:00	3,489	3,824	335	956	335	9	Yes
19:00	2,493	2,761	268	690	268	10	No
20:00	2,047	2,249	202	562	202	9	No

Capacity Analysis

Downstream Freeway Peak Volume	4,635
Corresponding Ramp Volume	484
Corresponding Upstream Freeway Peak Volume	4,151
Peak Hour Factor	0.917
Ramp Merge Level of Service	B

Congestion

Congestion	M031, M045
Ave Length of Congestion (Miles)	8.24
Duration of Congestion (Minutes)	119.84
Calculated Number of Occurrences per Year	961
Typical Times of Congestion	15:30 - 19:00

Crash Data

Observations

Log 101 is a direct ramp. There are no sight distance issues. The total average length of the entrance ramp has an average uphill grade of 2.07% that flattens out near the merge location. The pavement and shoulder type is asphalt. Pavement condition is poor to fair with transverse deep cracking along the ramp. Shoulder width for the right side is 4' along the entire ramp, and the width for the left side is 9' at the beginning of the ramp. After about 530' from the grass island it converts to 4'. After the final lane drop, the entrance ramp is a single 16' lane. There is a guardrail protecting the power pole on the right side before the lane drop. Power distribution pole located 8' behind guardrail (14' from edge of travel lane). An existing utility box is located at 15' off the edge of travel lane and 463' from grass island.

No AM peak.

Site Selection Comments

This is a direct single lane ramp with storage for approximately 68 vehicles. This is an F2F site which starts as two lanes drops to one at about its mid-point, which affords an additional 40 vehicles storage being available over what has been calculated.

This is a primary site for congestion problem M031 and M045. It has a large amount of vehicles per day so there is the opportunity to get good congestion benefits from metering.

Downstream volumes are acceptable and ramp volumes are ideal during the congested period.

This appears to be a good site in most respects with significant congestion meaning that ramp metering could provide a significant benefit. There is a good amount of storage and a lane drop meaning that metering would take place for one lane, which is appropriate for the peak entrance ramp volumes. The total storage is approximately 108 vehicles including the extra 40 vehicles afforded by the extra lane upstream of the lane drop.

No specific implementation problems have been identified, although this is an F2F site so further consideration should be given.

Site Categorization

Feasible for taking forward

C.3.6 Site Summaries - Group 6

NCDOT Ramp Metering Feasibility Study
Site Summary Document

147

Site Details

Site Number	147
Freeway	I-77
Cross Street	Goodrum Road/Griffith Street
Exit	30
Direction	Northbound
County	Mecklenburg

Physical Characteristics Overview

Origin of Entrance Ramp	Free Flow Link
Lane Addition onto Main Freeway length (feet)	195
Number of Entrance Ramp Lanes	1
Lane Drop on Entrance Ramp Before Merge	None
Number of Freeway Lanes Before Merge	2
Number of Freeway Lanes After Merge	2
Entrance Ramp Length to Back of Gore (feet)	740
Entrance Ramp Length to Tip of Gore (feet)	985
Merge Length (feet)	440
Entrance Ramp Horizontal Alignment	Straight
Entrance Ramp Vertical Alignment	Slight Downhill
Entrance Ramp Shoulder (Paved Full Width)	No
Main Freeway Vertical Alignment Downstream	Level
Main Freeway Shoulder	Yes
Number of Vehicles Storage	30
Guardrail	Yes; ends 122’ from concrete island
Pipe Crossing	No

Signalization Overview

Upstream Signal	No signal
Nearest Power Source	Power distribution poles on intersection of Northbound exit ramp

Signing Overview

Existing Signing	No signs that may cause conflict with ramp metering

Traffic Volumes

Period Beginning	Upstream Hourly Volume Rate	Downstream Hourly Volume Rate	Entrance Ramp Hourly Volume Rate	Downstream Volume per Lane	Entrance Ramp Volume per Lane	Entrance Ramp % of Downstream Volume	Hour Meets Acceptable Criteria for Ramp Metering
06:00	3,142	3,216	74	1,608	74	2	No
07:00	5,881	6,094	213	3,047	213	3	No
08:00	5,961	6,158	197	3,079	197	3	No
09:00	5,819	5,922	103	2,961	103	2	No
10:00	5,662	5,742	80	2,871	80	1	No
11:00	5,706	5,760	54	2,880	54	1	No
12:00	5,598	5,681	83	2,841	83	1	No
13:00	5,740	5,822	82	2,911	82	1	No
14:00	5,493	5,620	127	2,810	127	2	No
15:00	5,502	5,745	243	2,873	243	4	No
16:00	5,746	6,076	330	3,038	330	5	Yes
17:00	5,678	6,113	435	3,057	435	7	Yes
18:00	5,127	5,355	228	2,678	228	4	No
19:00	4,174	4,267	93	2,134	93	2	No
20:00	3,415	3,480	65	1,740	65	2	No

Capacity Analysis

Downstream Freeway Peak Volume	6,436
Corresponding Ramp Volume	194
Corresponding Upstream Freeway Peak Volume	6,242
Peak Hour Factor	0.932
Ramp Merge Level of Service	F

Congestion

Congestion	M038
Ave Length of Congestion (Miles)	8.92
Duration of Congestion (Minutes)	190.8
Calculated Number of Occurrences per Year	329
Typical Times of Congestion	08:00 - 10:30, 12:30 - 19:30

Crash Data

The total number of accidents from March 2011 to February 2016 was: 37
Of these, 21 were accidents which can be associated with congestion:
Type 21-Rear end, slow or stop: 14 (38%)
Type 28- Sideswipe, same direction: 7 (19%)

Observations

Log 147 is a long direct ramp. There are no sight distance issues. The entrance ramp averages a slight -1.6% downhill grade that flattens out near the merge location. The pavement and shoulder type is asphalt. Condition of the pavement and shoulders seems to be poor, with the shoulder showing water ruts along the ramp. Shoulder has a width of 2' on each side. There is a concrete drainage ditch on the right side 15' from edge of travel lane before the ramp merges onto the main freeway. "2" utility light poles were located behind the drainage ditch at the end of the ramp before merging onto the freeway.

Peak volume is much greater than 2,000 vehicles per hour per lane (3,218).

Site Selection Comments

This is a direct single lane ramp with storage for approximately 30 vehicles, fed from an un-signalized intersection.

There is a lot of congestion at this location and it is a primary site for M038. Ramp metering should provide congestion benefits at this location.

Downstream volumes are ideal during the congested period. However, ramp volumes are only acceptable for two hours of the 9.5 hour congested period; for the rest of the time the volumes are too low. Consequently, sufficient benefits will only be realized for the two hours when volumes are acceptable. The ramp volumes are such that the system will only be effective metering on one lane at the stop line.

Downstream volumes are ideal during the congested period. However, ramp volumes are only acceptable for two hours of the 9.5 hour congested period; for the rest of the time the volumes are too low. Consequently, sufficient benefits will only be realized for the two hours when volumes are acceptable. The ramp volumes are such that the system will only be effective metering on one lane at the stop line.

No specific implementation problems have been identified.

Site Categorization

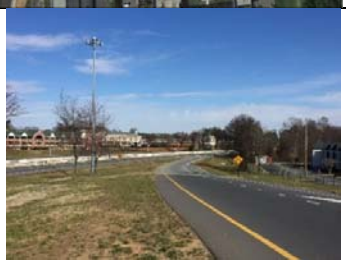
Feasible for taking forward

NCDOT Ramp Metering Feasibility Study
Site Summary Document

145

Site Details

Site Number	145
Freeway	I-77
Cross Street	Catawba Avenue
Exit	28
Direction	Northbound
County	Mecklenburg



Physical Characteristics Overview

Origin of Entrance Ramp	Signalized Intersection with Free Flow Right Turn
Lane Addition onto Main Freeway length (feet)	160
Number of Entrance Ramp Lanes	1
Lane Drop on Entrance Ramp Before Merge	Yes
Number of Freeway Lanes Before Merge	2
Number of Freeway Lanes After Merge	2
Entrance Ramp Length to Back of Gore (feet)	900
Entrance Ramp Length to Tip of Gore (feet)	1,590
Merge Length (feet)	880
Entrance Ramp Horizontal Alignment	Straight
Entrance Ramp Vertical Alignment	Slight Downhill
Entrance Ramp Shoulder (Paved Full Width)	No
Main Freeway Vertical Alignment Downstream	Level
Main Freeway Shoulder	Yes
Number of Vehicles Storage	36
Guardrail	None Present
Pipe Crossing	Yes; 43’ from edge of travel lane

Signalization Overview

Upstream Signal	3-way signal: ramp entry from: left & right turn islands (diverging diamond)
Nearest Power Source	Traffic Signal Cabinet located at intersection

Signing Overview

Existing Signing	“Right Lane Ends Graphical Sign”

Traffic Volumes

Period Beginning	Upstream Hourly Volume Rate	Downstream Hourly Volume Rate	Entrance Ramp Hourly Volume Rate	Downstream Volume per Lane	Entrance Ramp Volume per Lane	Entrance Ramp % of Downstream Volume	Hour Meets Acceptable Criteria for Ramp Metering
06:00	1,285	1,650	365	825	365	22	Yes
07:00	2,414	3,574	1,160	1,787	1,160	32	Yes
08:00	2,372	3,404	1,032	1,702	1,032	30	Yes
09:00	2,412	3,127	715	1,564	715	23	Yes
10:00	2,120	2,729	609	1,365	609	22	Yes
11:00	2,040	2,674	634	1,337	634	24	Yes
12:00	2,205	2,969	764	1,485	764	26	Yes
13:00	2,382	3,215	833	1,608	833	26	Yes
14:00	2,387	3,231	844	1,616	844	26	Yes
15:00	2,312	3,153	841	1,577	841	27	Yes
16:00	2,517	3,322	805	1,661	805	24	Yes
17:00	2,597	3,500	903	1,750	903	26	Yes
18:00	2,427	3,178	751	1,589	751	24	Yes
19:00	2,143	2,582	439	1,291	439	17	Yes
20:00	1,578	1,916	338	958	338	18	Yes

Capacity Analysis

Downstream Freeway Peak Volume	3,698
Corresponding Ramp Volume	1,272
Corresponding Upstream Freeway Peak Volume	2,426
Peak Hour Factor	0.961
Ramp Merge Level of Service	D

Congestion

Congestion	M038, M036
Ave Length of Congestion (Miles)	5.9
Duration of Congestion (Minutes)	101.89
Calculated Number of Occurrences per Year	961
Typical Times of Congestion	07:30 - 10:00, 12:30 - 19:30

Crash Data

The total number of accidents from March 2011 to February 2016 was: 57
Of these, 40 were accidents which can be associated with congestion:
Type 21-Rear end, slow or stop: 26 (46%)
Type 28- Sideswipe, same direction: 14 (25%)

Observations

Log 145 is a long direct ramp. There are no sight distance issues. The entrance ramp has a slight -2.5% downhill grade that flattens out near the merge location. The pavement and shoulder type are Asphalt. Condition of the pavement seems to be good but parts of the shoulder seems to be in a fair condition with some cracks. Right shoulder has a non-uniform width of 5' to 4' along the ramp and the left side shoulder has a width of 4' along the ramp. "1" Large utility light pole on inside of ramp at 40' from edge of travel lane and "4" utility light poles were located along the entrance ramp before merging into the freeway at 16' from edge of travel lane. Drainage pipe and structure on outside of ramp were located at 43' from the edge of travel lane with a manhole cover located at 16' from edge of travel lane.

Site Selection Comments

This is a direct single lane ramp with storage for approximately 36 vehicles, fed from a signalized intersection with free flow right turn.

This site has high vehicles per day and it is the primary site for M036. The congestion occurs in the AM and PM peaks but is worse in the PM. There appears to be potential for ramp metering to reduce congestion.

Downstream and ramp volumes are ideal during most of the congested period although at times they are high enough to support ramp metering operation across two lanes. The site could still operate across one lane, but with less benefit.

This appears to be a good site with sufficient congestion for ramp metering to provide benefits. The site could operate in its current single lane configuration, but given the high ramp volumes and relatively low storage, performance would be optimized with a two lane configuration. It may be possible to queue traffic on the surface street for a short distance in both directions to gain extra storage space.

No specific implementation problems have been identified.

Site Categorization

Feasible for taking forward

NCDOT Ramp Metering Feasibility Study
Site Summary Document

143

Site Details

Site Number	143
Freeway	I-77
Cross Street	NC 73 (Sam Furr Road)
Exit	25
Direction	Northbound
County	Mecklenburg

Physical Characteristics Overview

Origin of Entrance Ramp	Signalized intersection with Free Flow Right Turn
Lane Addition onto Main Freeway length (feet)	615
Number of Entrance Ramp Lanes	1
Lane Drop on Entrance Ramp Before Merge	None
Number of Freeway Lanes Before Merge	2
Number of Freeway Lanes After Merge	2
Entrance Ramp Length to Back of Gore (feet)	1,255
Entrance Ramp Length to Tip of Gore (feet)	1,820
Merge Length (feet)	970
Entrance Ramp Horizontal Alignment	Straight
Entrance Ramp Vertical Alignment	Slight Downhill
Entrance Ramp Shoulder (Paved Full Width)	No
Main Freeway Vertical Alignment Downstream	Level
Main Freeway Shoulder	Yes
Number of Vehicles Storage	50
Guardrail	Yes; 12.5’ From edge of travel lane
Pipe Crossing	None Present

Signalization Overview

Upstream Signal	3-way signal: ramp entry from: single left & single right turn
Nearest Power Source	Traffic Signal Cabinet located at intersection

Signing Overview

Existing Signing	Right turn Yield Sign

Traffic Volumes

Period Beginning	Upstream Hourly Volume Rate	Downstream Hourly Volume Rate	Entrance Ramp Hourly Volume Rate	Downstream Volume per Lane	Entrance Ramp Volume per Lane	Entrance Ramp % of Downstream Volume	Hour Meets Acceptable Criteria for Ramp Metering
06:00	1,767	2,182	415	1,091	415	19	Yes
07:00	3,656	4,514	858	2,257	858	19	Yes
08:00	4,200	4,847	647	2,424	647	13	Yes
09:00	3,772	4,309	537	2,155	537	12	Yes
10:00	3,012	3,541	529	1,771	529	15	Yes
11:00	2,997	3,572	575	1,786	575	16	Yes
12:00	3,231	3,859	628	1,930	628	16	Yes
13:00	3,296	3,983	687	1,992	687	17	Yes
14:00	3,606	4,245	639	2,123	639	15	Yes
15:00	3,315	3,989	674	1,995	674	17	Yes
16:00	3,672	4,324	652	2,162	652	15	Yes
17:00	3,853	4,525	672	2,263	672	15	Yes
18:00	3,596	4,167	571	2,084	571	14	Yes
19:00	3,382	3,773	391	1,887	391	10	Yes
20:00	2,311	2,691	380	1,346	380	14	Yes

Capacity Analysis

Downstream Freeway Peak Volume	4,876
Corresponding Ramp Volume	672
Corresponding Upstream Freeway Peak Volume	4,254
Peak Hour Factor	0.978
Ramp Merge Level of Service	F

Congestion

Congestion	M038, M036, M035
Ave Length of Congestion (Miles)	3.01
Duration of Congestion (Minutes)	54.51
Calculated Number of Occurrences per Year	1,107
Typical Times of Congestion	07:30 - 10:00, 12:30 - 19:30

Crash Data

The total number of accidents from March 2011 to February 2016 was: 47
Of these, 35 were accidents which can be associated with congestion:
Type 21-Rear end, slow or stop: 28 (60%)
Type 28- Sideswipe, same direction: 7 (15%)

Observations

Log 143 is a direct ramp. There are no sight distance issues. The entrance ramp has average a slight -1.87% downhill grade that flattens out near the merge location. The pavement and shoulder type are asphalt. Condition of the pavement and shoulder seems to be poor to fair with some cracks. Right shoulder has a width of 4' and the left side shoulder has a width of 3.5'. Guardrail located at 12.5' off the edge of travel lane and 675' from the end of concrete sidewalk. "4" Utility light poles were located along the entrance ramp before merging into the freeway at 19' from edge of travel. No room to move guardrail back due to utility poles and drop off.

Peak volume greater than 2,000 vehicles per hour per lane.

Site Selection Comments

This is a direct single lane ramp with storage for approximately 50 vehicles, is fed from a signalized intersection with free-flow right turn.

There is a reasonable amount of congestion at this site, but it can happen at different times during the day, meaning that ramp metering benefit could be limited. This is the primary site for M035.

Downstream and ramp volumes are ideal during the congested periods.

This appears to be a good site in terms of implementation, there is scope for ramp metering benefits, but the nature of congestion means that the benefit might be limited.

No specific implementation problems have been identified.

Site Categorization

Feasible for taking forward

NCDOT Ramp Metering Feasibility Study
Site Summary Document

140

Site Details

Site Number	140
Freeway	I-77
Cross Street	Gilead Road
Exit	23
Direction	Northbound
County	Mecklenburg

Physical Characteristics Overview

Origin of Entrance Ramp	Signalized Intersection
Lane Addition onto Main Freeway length (feet)	200
Number of Entrance Ramp Lanes	1
Lane Drop on Entrance Ramp Before Merge	None
Number of Freeway Lanes Before Merge	2
Number of Freeway Lanes After Merge	2
Entrance Ramp Length to Back of Gore (feet)	1,910
Entrance Ramp Length to Tip of Gore (feet)	2,165
Merge Length (feet)	1,025
Entrance Ramp Horizontal Alignment	Straight
Entrance Ramp Vertical Alignment	Slight Downhill
Entrance Ramp Shoulder (Paved Full Width)	No
Main Freeway Vertical Alignment Downstream	Level
Main Freeway Shoulder	Yes
Number of Vehicles Storage	76
Guardrail	None Present
Pipe Crossing	None Present

Signalization Overview

Upstream Signal	3-way signal: ramp entry from: single left & right turn
Nearest Power Source	Traffic Signal Cabinet located at intersection

Signing Overview

Existing Signing	Right Turn Yield Sign “No Parking” sign at 20’ off the edge of travel lane

Traffic Volumes

Period Beginning	Upstream Hourly Volume Rate	Downstream Hourly Volume Rate	Entrance Ramp Hourly Volume Rate	Downstream Volume per Lane	Entrance Ramp Volume per Lane	Entrance Ramp % of Downstream Volume	Hour Meets Acceptable Criteria for Ramp Metering
06:00	2,078	2,341	263	1,171	263	11	No
07:00	3,400	3,822	422	1,911	422	11	Yes
08:00	2,945	3,264	319	1,632	319	10	Yes
09:00	3,239	3,623	384	1,812	384	11	Yes
10:00	3,247	3,652	405	1,826	405	11	Yes
11:00	3,318	3,778	460	1,889	460	12	Yes
12:00	3,437	3,975	538	1,988	538	14	Yes
13:00	3,713	4,226	513	2,113	513	12	Yes
14:00	3,810	4,256	446	2,128	446	10	Yes
15:00	3,402	3,847	445	1,924	445	12	Yes
16:00	3,421	3,984	563	1,992	563	14	Yes
17:00	3,596	4,273	677	2,137	677	16	Yes
18:00	3,631	4,144	513	2,072	513	12	Yes
19:00	3,695	4,048	353	2,024	353	9	Yes
20:00	2,887	3,123	236	1,562	236	8	No

Capacity Analysis

Downstream Freeway Peak Volume	4,274
Corresponding Ramp Volume	672
Corresponding Upstream Freeway Peak Volume	3,602
Peak Hour Factor	0.975
Ramp Merge Level of Service	E

Congestion

Congestion	M033, M038, M035
Ave Length of Congestion (Miles)	1.51
Duration of Congestion (Minutes)	36.88
Calculated Number of Occurrences per Year	681
Typical Times of Congestion	08:00 - 10:30, 12:00 - 19:00

Crash Data

The total number of accidents from March 2011 to February 2016 was: 62
Of these, 47 were accidents which can be associated with congestion:
Type 21-Rear end, slow or stop: 33 (53%)
Type 28- Sideswipe, same direction: 14 (23%)

Observations

Log 140 is a long direct ramp. There are no sight distance issues. The entrance ramp has average a slight -1.83% downhill grade that flattens out near the merge location. The pavement and shoulder type is asphalt. Condition of the pavement and shoulder seems to be poor. Right side of the shoulder has a discontinuous width of 3' along the ramp due to cracking and deterioration of asphalt. Left side of the shoulder has a width of 4' with a poor condition. Tree line located at 17' from edge of travel lane.

Site Selection Comments

This is a direct single lane ramp with storage for approximately 76 vehicles, fed from a signalized intersection.

The amount of congestion at this site is not particularly high, but can happen at any time during the day, meaning that ramp metering benefit could be limited. This is the primary site for M033.

Downstream and ramp volumes are ideal during the identified congested periods.

This appears to be a good site in terms of implementation, there is scope for RM benefits, but the amount of congestion means that the benefit is limited.

No specific implementation problems have been identified.

Site Categorization

Feasible for taking forward

C.3.7 Site Summaries - Group 7

NCDOT Ramp Metering Feasibility Study
Site Summary Document

230

Site Details

Site Number	230
Freeway	I-485
Cross Street	Providence Road
Exit	57
Direction	Outer
County	Mecklenburg

Physical Characteristics Overview

Origin of Entrance Ramp	Signalized Intersection
Lane Addition onto Main Freeway length (feet)	800
Number of Entrance Ramp Lanes	1
Lane Drop on Entrance Ramp Before Merge	No
Number of Freeway Lanes Before Merge	2
Number of Freeway Lanes After Merge	2
Entrance Ramp Length to Back of Gore (feet)	890
Entrance Ramp Length to Tip of Gore (feet)	1,100
Merge Length (feet)	1,080
Entrance Ramp Horizontal Alignment	Straight
Entrance Ramp Vertical Alignment	Level
Entrance Ramp Shoulder (Paved Full Width)	No
Main Freeway Vertical Alignment Downstream	Level
Main Freeway Shoulder	Yes
Number of Vehicles Storage	24
Guardrail	None
Pipe Crossing	None

Signalization Overview

Upstream Signal	3-way signal; Ramp entry from: thru and right turn
Nearest Power Source	Power Poles from signal at start of ramp

Signing Overview

Existing Signing	None

Traffic Volumes

Period Beginning	Upstream Hourly Volume Rate	Downstream Hourly Volume Rate	Entrance Ramp Hourly Volume Rate	Downstream Volume per Lane	Entrance Ramp Volume per Lane	Entrance Ramp % of Downstream Volume	Hour Meets Acceptable Criteria for Ramp Metering
06:00	1,200	1,338	138	669	138	10	No
07:00	2,391	2,755	364	1,378	364	13	Yes
08:00	2,346	2,662	316	1,331	316	12	Yes
09:00	1,978	2,213	235	1,107	235	11	No
10:00	1,650	1,825	175	913	175	10	No
11:00	1,648	1,851	203	926	203	11	No
12:00	1,710	1,906	196	953	196	10	No
13:00	1,826	2,058	232	1,029	232	11	No
14:00	2,048	2,321	273	1,161	273	12	No
15:00	2,494	2,769	275	1,385	275	10	No
16:00	3,038	3,357	319	1,679	319	10	Yes
17:00	3,229	3,580	351	1,790	351	10	Yes
18:00	2,652	2,860	208	1,430	208	7	No
19:00	1,902	2,048	146	1,024	146	7	No
20:00	1,213	1,324	111	662	111	8	No

Capacity Analysis

Downstream Freeway Peak Volume	3,580
Corresponding Ramp Volume	351
Corresponding Upstream Freeway Peak Volume	3,229
Peak Hour Factor	0.962
Ramp Merge Level of Service	D

Congestion

Congestion	M051
Ave Length of Congestion (Miles)	6.24
Duration of Congestion (Minutes)	119.28
Calculated Number of Occurrences per Year	219
Typical Times of Congestion	16:00 - 19:00

Crash Data

The total number of accidents from March 2011 to February 2016 was: 14
Of these, 4 were accidents which can be associated with congestion:
Type 21-Rear end, slow or stop: 1 (7%)
Type 28- Sideswipe, same direction: 3 (21%)

Observations

Log 230 is a direct ramp with no sight distance issues. The grade is level with an average slope of -0.133%. The ramp has one lane and has entry from a thru movement and a right turn. The travel lane and shoulders are asphalt. The pavement condition was considered to be good. The left shoulder has a width of 4' and the right shoulder had a width of 6'. The shoulder outside of the pavement is in poor condition and has several ruts. There is a bank located 33' from the edge of travel lane near the end of the ramp.

Site Selection Comments

This is a direct single lane ramp from a signalized intersection. There is comparatively low storage at 24 vehicles although there is scope to store some vehicles on the surface street.

This is the primary site for M051. It suffers a reasonable amount of congestion in the afternoon peak and ramp metering should be able to provide some benefit.

Downstream volumes are ideal and ramp volumes are low but acceptable during the congested period.

This site appears to be good for ramp metering. Although there is fairly limited storage the volumes are quite low so the system should work. This site could be supported by upstream site 232.

This site appears to be straightforward to implement, although some consideration should be given to providing additional storage if it is deemed to be a problem.

Site Categorization

Feasible for taking forward

NCDOT Ramp Metering Feasibility Study
Site Summary Document

232

Site Details

Site Number	232
Freeway	I-485
Cross Street	Providence Road
Exit	57
Direction	Outer
County	Mecklenburg

Physical Characteristics Overview

Origin of Entrance Ramp	Free Flow Link
Lane Addition onto Main Freeway length (feet)	660
Number of Entrance Ramp Lanes	1
Lane Drop on Entrance Ramp Before Merge	No
Number of Freeway Lanes Before Merge	2
Number of Freeway Lanes After Merge	2
Entrance Ramp Length to Back of Gore (feet)	630
Entrance Ramp Length to Tip of Gore (feet)	795
Merge Length (feet)	910
Entrance Ramp Horizontal Alignment	Tight Curve
Entrance Ramp Vertical Alignment	Downhill
Entrance Ramp Shoulder (Paved Full Width)	No
Main Freeway Vertical Alignment Downstream	Level
Main Freeway Shoulder	Yes
Number of Vehicles Storage	25
Guardrail	None but has barrier wall
Pipe Crossing	None

Signalization Overview

Upstream Signal	Not signalized
Nearest Power Source	Signal Cabinet and Power Poles from exit ramp signal

Signing Overview

Existing Signing	“Exit”, “Ramp 25 MPH”, and 4 Chevrons

Traffic Volumes

Period Beginning	Upstream Hourly Volume Rate	Downstream Hourly Volume Rate	Entrance Ramp Hourly Volume Rate	Downstream Volume per Lane	Entrance Ramp Volume per Lane	Entrance Ramp % of Downstream Volume	Hour Meets Acceptable Criteria for Ramp Metering
06:00	768	1,200	432	600	432	36	Yes
07:00	1,506	2,391	885	1,196	885	37	Yes
08:00	1,493	2,346	853	1,173	853	36	Yes
09:00	1,450	1,978	528	989	528	27	Yes
10:00	1,224	1,650	426	825	426	26	Yes
11:00	1,294	1,648	354	824	354	21	Yes
12:00	1,346	1,710	364	855	364	21	Yes
13:00	1,447	1,826	379	913	379	21	Yes
14:00	1,691	2,048	357	1,024	357	17	Yes
15:00	2,037	2,494	457	1,247	457	18	Yes
16:00	2,457	3,038	581	1,519	581	19	Yes
17:00	2,515	3,229	714	1,615	714	22	Yes
18:00	2,103	2,652	549	1,326	549	21	Yes
19:00	1,616	1,902	286	951	286	15	No
20:00	1,054	1,213	159	607	159	13	No

Capacity Analysis

Downstream Freeway Peak Volume	3,229
Corresponding Ramp Volume	714
Corresponding Upstream Freeway Peak Volume	2,515
Peak Hour Factor	0.962
Ramp Merge Level of Service	C

Congestion

Congestion	M051
Ave Length of Congestion (Miles)	5.99
Duration of Congestion (Minutes)	114.5
Calculated Number of Occurrences per Year	219
Typical Times of Congestion	16:00-19:00

Crash Data

The total number of accidents from March 2011 to February 2016 was: 61
Of these, 15 were accidents which can be associated with congestion:
Type 21-Rear end, slow or stop: 12 (20%)
Type 28- Sideswipe, same direction: 3 (5%)

Observations

Log 232 is a loop ramp with no sight distance issues. The grade is downhill with an average slope of -2.67%. The ramp has one lane and has entry from a right turn. The travel lane and shoulders are asphalt. The pavement condition was considered to be good. The inner shoulder is curb and gutter and the right shoulder has a width of 3.5'. A barrier wall starts 45' from the gore and is offset 5' from the edge of travel lane. An "Exit" sign is 18' from the gore and a "Ramp 25 MPH" sign is 55' from the gore. Three chevrons are located 315', 435', and 495' from the gore. A fourth chevron (positioned 2nd from the gore) appeared to be wiped out by a vehicle. This might be an indication of a crash concern at this location.

Site Selection Comments

This is a single lane loop ramp fed from a free volume un-signalized intersection at street level. Storage capacity is relatively low at 25 vehicles and there are some concerns about forward visibility.

This is just upstream of site 230 which is the primary site for M051. It is congested in the evening peak and could support site 230.

Downstream and ramp volumes are ideal during the congested period for a single lane site. Entrance ramp volumes are at the low end of ideal, so if an extra lane was added they would be too low for the system to operate effectively.

This site could offer some benefit in support of site 230 which is just downstream, part of the same intersection. However, care needs to be taken in the design due to potential visibility issues.

There are some issues with implementation, with caution required regarding the tightly curved ramp. There is little scope for widening the ramp to address the limited storage capacity, although storage could be increased to approximately 30 vehicles through use of the overpass.

Site Categorization

Feasible for taking forward

NCDOT Ramp Metering Feasibility Study
Site Summary Document

234

Site Details

Site Number	234
Freeway	I-485
Cross Street	Rea Road
Exit	59
Direction	Outer
County	Mecklenburg

Physical Characteristics Overview

Origin of Entrance Ramp	Free Flow Link
Lane Addition onto Main Freeway length (feet)	735
Number of Entrance Ramp Lanes	1
Lane Drop on Entrance Ramp Before Merge	No
Number of Freeway Lanes Before Merge	2
Number of Freeway Lanes After Merge	2
Entrance Ramp Length to Back of Gore (feet)	1,000
Entrance Ramp Length to Tip of Gore (feet)	1,205
Merge Length (feet)	1,150
Entrance Ramp Horizontal Alignment	Straight
Entrance Ramp Vertical Alignment	Slightly Downhill
Entrance Ramp Shoulder (Paved Full Width)	Yes
Main Freeway Vertical Alignment Downstream	Level
Main Freeway Shoulder	Yes
Number of Vehicles Storage	40
Guardrail	Yes; runs entire length of ramp
Pipe Crossing	None

Signalization Overview

Upstream Signal	Not Signalized; right turn movement only
Nearest Power Source	Power Pole from signal at start of ramp

Signing Overview

Existing Signing	None

Traffic Volumes

Period Beginning	Upstream Hourly Volume Rate	Downstream Hourly Volume Rate	Entrance Ramp Hourly Volume Rate	Downstream Volume per Lane	Entrance Ramp Volume per Lane	Entrance Ramp % of Downstream Volume	Hour Meets Acceptable Criteria for Ramp Metering
06:00	1,355	1,486	131	743	131	9	No
07:00	2,552	2,853	301	1,427	301	11	Yes
08:00	2,556	2,816	260	1,408	260	9	No
09:00	2,277	2,536	259	1,268	259	10	No
10:00	1,958	2,195	237	1,098	237	11	No
11:00	2,008	2,221	213	1,111	213	10	No
12:00	2,161	2,432	271	1,216	271	11	No
13:00	2,286	2,563	277	1,282	277	11	No
14:00	2,496	2,787	291	1,394	291	10	No
15:00	3,195	3,497	302	1,749	302	9	Yes
16:00	3,422	3,908	486	1,954	486	12	Yes
17:00	3,325	3,938	613	1,969	613	16	Yes
18:00	3,403	3,757	354	1,879	354	9	Yes
19:00	2,495	2,714	219	1,357	219	8	No
20:00	1,583	1,782	199	891	199	11	No

Capacity Analysis

Downstream Freeway Peak Volume	4,037
Corresponding Ramp Volume	471
Corresponding Upstream Freeway Peak Volume	3,566
Peak Hour Factor	0.931
Ramp Merge Level of Service	D

Congestion

Congestion	M051, M053
Ave Length of Congestion (Miles)	3.62
Duration of Congestion (Minutes)	79.42
Calculated Number of Occurrences per Year	438
Typical Times of Congestion	16:00 - 19:00

Crash Data

The total number of accidents from March 2011 to February 2016 was: 23
Of these, 10 were accidents which can be associated with congestion:
Type 21-Rear end, slow or stop: 8 (35%)
Type 28- Sideswipe, same direction: 2 (9%)

Observations

Log 234 is a direct ramp. There is a small cluster of trees between the ramp and mainline that may present a minor sight distance issue. The grade is slightly downhill with an average slope of -1.97%. The ramp has one lane and has entry from right turn only. The travel lane and shoulders are asphalt. The pavement condition was considered to be good. The left shoulder has a width of 4' and the right shoulder had a width of 10.5'. A single run of guardrail spans the entire ramp. There are several trees and a drop-off directly behind the guardrail. At the end of the ramp, light poles are located 5' behind the guardrail.

Site Selection Comments

This is a single lane direct ramp fed from an un-signalized intersection. No sightline issues have been identified and it has storage for about 40 vehicles.

This is the primary site for congestion M053. It suffers from moderate congestion in the AM peak and could be supported by site 235 which is just upstream.

Downstream and ramp volumes are ideal for a single lane entrance ramp during the congested period.

This site appears to be a good ramp metering candidate and could offer congestion benefits. It could be supported by upstream site 235. No specific problems noted.

No specific implementation problems have been identified.

Site Categorization

Feasible for taking forward

NCDOT Ramp Metering Feasibility Study
Site Summary Document

235

Site Details

Site Number	235
Freeway	I-485
Cross Street	Rea Road
Exit	59
Direction	Outer
County	Mecklenburg

Physical Characteristics Overview

Origin of Entrance Ramp	Free Flow Link
Lane Addition onto Main Freeway length (feet)	600
Number of Entrance Ramp Lanes	1
Lane Drop on Entrance Ramp Before Merge	No
Number of Freeway Lanes Before Merge	2
Number of Freeway Lanes After Merge	2
Entrance Ramp Length to Back of Gore (feet)	730
Entrance Ramp Length to Tip of Gore (feet)	900
Merge Length (feet)	910
Entrance Ramp Horizontal Alignment	Tight Curve
Entrance Ramp Vertical Alignment	Slightly Downhill
Entrance Ramp Shoulder (Paved Full Width)	No
Main Freeway Vertical Alignment Downstream	Level
Main Freeway Shoulder	Yes
Number of Vehicles Storage	29
Guardrail	Yes; 125’ from gore, 10’ offset
Pipe Crossing	None

Signalization Overview

Upstream Signal	Not Signalized
Nearest Power Source	Power Poles between loop ramp and exit ramp

Signing Overview

Existing Signing	“Exit” sign 28’ from gore at start of ramp

Traffic Volumes

Period Beginning	Upstream Hourly Volume Rate	Downstream Hourly Volume Rate	Entrance Ramp Hourly Volume Rate	Downstream Volume per Lane	Entrance Ramp Volume per Lane	Entrance Ramp % of Downstream Volume	Hour Meets Acceptable Criteria for Ramp Metering
06:00	1,305	1,372	67	686	67	5	No
07:00	2,333	2,528	195	1,264	195	8	No
08:00	2,337	2,504	167	1,252	167	7	No
09:00	2,095	2,204	109	1,102	109	5	No
10:00	1,801	1,925	124	963	124	6	No
11:00	1,841	1,955	114	978	114	6	No
12:00	1,916	2,075	159	1,038	159	8	No
13:00	2,044	2,231	187	1,116	187	8	No
14:00	2,308	2,474	166	1,237	166	7	No
15:00	2,932	3,103	171	1,552	171	6	No
16:00	3,164	3,440	276	1,720	276	8	No
17:00	2,691	3,009	318	1,505	318	11	Yes
18:00	2,937	3,148	211	1,574	211	7	No
19:00	2,293	2,376	83	1,188	83	3	No
20:00	1,520	1,590	70	795	70	4	No

Capacity Analysis

Downstream Freeway Peak Volume	3,505
Corresponding Ramp Volume	210
Corresponding Upstream Freeway Peak Volume	3,295
Peak Hour Factor	0.942
Ramp Merge Level of Service	D

Congestion

Congestion	M053, M051
Ave Length of Congestion (Miles)	3.36
Duration of Congestion (Minutes)	73.7
Calculated Number of Occurrences per Year	438
Typical Times of Congestion	16:00 - 19:00

Crash Data

The total number of accidents from March 2011 to February 2016 was: 49
Of these, 35 were accidents which can be associated with congestion:
Type 21-Rear end, slow or stop: 27 (55%)
Type 28- Sideswipe, same direction: 8 (16%)

Observations

Log 235 is a loop ramp. The grade is slightly downhill with an average slope of -2.47%. The ramp has one lane and has entry from a right turn. The travel lane and shoulders are asphalt. The pavement condition was considered to be good. The inner shoulder is curb and gutter and the right shoulder has a width of 4.5'. Guardrail starts 125' from the gore and is offset 10' from the edge of travel lane. An "Exit" sign is 28' from the gore. The tree line on the outside of the ramp is 25' from the edge of travel lane. The trees closest to the mainline may pose some sight distances issues for cars exiting the ramp and cars approaching the ramp on the mainline.

Site Selection Comments

This is a loop ramp from an un-signalized intersection with storage capacity for 29 vehicles. Forward visibility is poor due to vegetation.

This is a primary site for congestion problem M053 and secondary to M052. Site 234 is the primary downstream site and this has been recommended for taking forward.

Downstream volumes are ideal but ramp volumes are generally too low during the congested period.

The combination of a tightly curved ramp, poor forward visibility and low entrance ramp volumes make this site unfeasible for ramp metering.

The visibility issue would need to be addressed for this site to be implemented.

Site Categorization

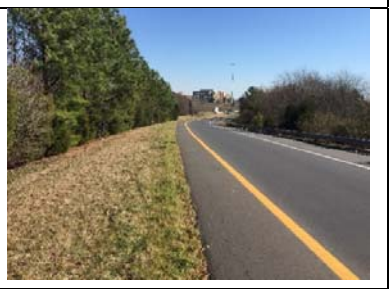
Not feasible

NCDOT Ramp Metering Feasibility Study
Site Summary Document

238

Site Details

Site Number	238
Freeway	I-485
Cross Street	Johnston Road
Exit	61
Direction	Outer
County	Mecklenburg



Physical Characteristics Overview

Origin of Entrance Ramp	Free Flow Link
Lane Addition onto Main Freeway length (feet)	700
Number of Entrance Ramp Lanes	1
Lane Drop on Entrance Ramp Before Merge	No
Number of Freeway Lanes Before Merge	3
Number of Freeway Lanes After Merge	3
Entrance Ramp Length to Back of Gore (feet)	2,735
Entrance Ramp Length to Tip of Gore (feet)	3,035
Merge Length (feet)	1,075
Entrance Ramp Horizontal Alignment	Slight Curve
Entrance Ramp Vertical Alignment	Slight downhill
Entrance Ramp Shoulder (Paved Full Width)	Full shoulder ends 710’ from Back of Gore
Main Freeway Vertical Alignment Downstream	Level
Main Freeway Shoulder	Yes
Number of Vehicles Storage	109
Guardrail	Yes; runs entire length of ramp
Pipe Crossing	None

Signalization Overview

Upstream Signal	Not Signalized
Nearest Power Source	No obvious power source close by

Signing Overview

Existing Signing	Overhead Sign Structure at start of ramp

Traffic Volumes

Period Beginning	Upstream Hourly Volume Rate	Downstream Hourly Volume Rate	Entrance Ramp Hourly Volume Rate	Downstream Volume per Lane	Entrance Ramp Volume per Lane	Entrance Ramp % of Downstream Volume	Hour Meets Acceptable Criteria for Ramp Metering
06:00	1,428	1,543	115	514	115	7	No
07:00	2,654	2,876	222	959	222	8	No
08:00	2,847	3,048	201	1,016	201	7	No
09:00	2,557	2,730	173	910	173	6	No
10:00	2,163	2,360	197	787	197	8	No
11:00	2,331	2,511	180	837	180	7	No
12:00	2,546	2,755	209	918	209	8	No
13:00	2,613	2,833	220	944	220	8	No
14:00	2,863	3,115	252	1,038	252	8	No
15:00	3,502	3,783	281	1,261	281	7	No
16:00	4,191	4,483	292	1,494	292	7	No
17:00	3,307	3,510	203	1,170	203	6	No
18:00	3,552	3,729	177	1,243	177	5	No
19:00	2,842	3,045	203	1,015	203	7	No
20:00	1,926	2,081	155	694	155	7	No

Capacity Analysis

Downstream Freeway Peak Volume	4,504
Corresponding Ramp Volume	293
Corresponding Upstream Freeway Peak Volume	4,211
Peak Hour Factor	0.947
Ramp Merge Level of Service	C

Congestion

Congestion	M055, M053, M051
Ave Length of Congestion (Miles)	2.01
Duration of Congestion (Minutes)	45.38
Calculated Number of Occurrences per Year	706
Typical Times of Congestion	16:00 - 19:00

Crash Data

The total number of accidents from March 2011 to February 2016 was: 53
Of these, 34 were accidents which can be associated with congestion:
Type 21-Rear end, slow or stop: 28 (53%)
Type 28- Sideswipe, same direction: 6 (11%)

Observations

Log 238 is a long direct ramp with no sight distance issues. The grade overall is slightly downhill with an average slope of -1.97%. The ramp has one lane and has entry from right turn only. The travel lane and shoulders are asphalt. The pavement condition was considered to be good. The left shoulder has a width of 4' and the right shoulder had a width of 10'. A single run of guardrail spans the entire ramp and is offset 14' from the edge of travel lane. There is a drop-off directly behind the guardrail. There are several drainage inlets in front of the guardrail along the ramp. A large overhead sign structure is at the beginning of the ramp.

Typical times of congestion from the Bottleneck Ranking tool doesn't match the suitability criteria from the Traffic Count analysis (see 'Flow Summary' tab of Traffic Data spreadsheet).

Site Selection Comments

This is a single lane direct ramp from an un-signalized intersection. It has storage for approximately 109 vehicles.

This is a primary site for congestion problem M055. It is congested during the PM peak.

Downstream volumes are acceptable during the congested period, but the ramp volumes are too low for ramp metering to have a positive effect.

Although this is a primary site, the entrance ramp volumes are too low for ramp metering to have any congestion benefit.

Site Categorization

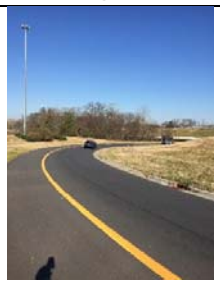
Not feasible

NCDOT Ramp Metering Feasibility Study
Site Summary Document

239

Site Details

Site Number	239
Freeway	I-485
Cross Street	Johnston Road
Exit	61
Direction	Outer
County	Mecklenburg



Physical Characteristics Overview

Origin of Entrance Ramp	Free Flow Link
Lane Addition onto Main Freeway length (feet)	505
Number of Entrance Ramp Lanes	1
Lane Drop on Entrance Ramp Before Merge	No
Number of Freeway Lanes Before Merge	3
Number of Freeway Lanes After Merge	3
Entrance Ramp Length to Back of Gore (feet)	700
Entrance Ramp Length to Tip of Gore (feet)	905
Merge Length (feet)	1,080
Entrance Ramp Horizontal Alignment	Tight Curve
Entrance Ramp Vertical Alignment	Slightly Downhill
Entrance Ramp Shoulder (Paved Full Width)	Yes
Main Freeway Vertical Alignment Downstream	Level
Main Freeway Shoulder	Yes
Number of Vehicles Storage	28
Guardrail	None
Pipe Crossing	None

Signalization Overview

Upstream Signal	Not Signalized
Nearest Power Source	Signal Cabinet and Power Poles from exit ramp

Signing Overview

Existing Signing	"Exit" sign – 81' from beginning of ramp

Traffic Volumes

Period Beginning	Upstream Hourly Volume Rate	Downstream Hourly Volume Rate	Entrance Ramp Hourly Volume Rate	Downstream Volume per Lane	Entrance Ramp Volume per Lane	Entrance Ramp % of Downstream Volume	Hour Meets Acceptable Criteria for Ramp Metering
06:00	995	1,286	291	429	291	23	No
07:00	1,927	2,396	469	799	469	20	Yes
08:00	2,115	2,542	427	847	427	17	Yes
09:00	1,751	2,203	452	734	452	21	Yes
10:00	1,472	1,893	421	631	421	22	Yes
11:00	1,630	2,052	422	684	422	21	Yes
12:00	1,742	2,212	470	737	470	21	Yes
13:00	1,938	2,377	439	792	439	18	Yes
14:00	2,077	2,541	464	847	464	18	Yes
15:00	2,694	3,300	606	1,100	606	18	Yes
16:00	3,077	3,770	693	1,257	693	18	Yes
17:00	2,091	2,789	698	930	698	25	Yes
18:00	2,824	3,352	528	1,117	528	16	Yes
19:00	2,224	2,607	383	869	383	15	Yes
20:00	1,404	1,714	310	571	310	18	Yes

Capacity Analysis

Downstream Freeway Peak Volume	3,879
Corresponding Ramp Volume	694
Corresponding Upstream Freeway Peak Volume	3,185
Peak Hour Factor	0.946
Ramp Merge Level of Service	C

Congestion

Congestion	M055, M053, M051
Ave Length of Congestion (Miles)	1.67
Duration of Congestion (Minutes)	37.88
Calculated Number of Occurrences per Year	706
Typical Times of Congestion	16:00 - 19:00

Crash Data

The total number of accidents from March 2011 to February 2016 was: 73
Of these, 51 were accidents which can be associated with congestion:
Type 21-Rear end, slow or stop: 38 (52%)
Type 28- Sideswipe, same direction: 13 (18%)

Observations

Log 239 is a loop ramp with no sight distance issues. The grade is downhill with an average slope of -1.93%. The ramp has one lane and has entry from a right turn. The travel lane and shoulders are asphalt. The pavement condition was considered to be good. The inner shoulder is curb and gutter and the right shoulder has a width of 7'. An "Exit" sign is 81' from the gore. There is a drainage structure 26' from the edge of travel lane near the middle of the loop.

Site Selection Comments

This is a single lane loop ramp fed from a free-flow intersection. Downstream visibility could be an issue on this tightly curved ramp with vegetation on the inside of the curve. It has a relatively low storage of 28 vehicles with no opportunity for storage on the local street.

It is congested in the PM peak. It is just upstream of site 238 (and is part of the same intersection). Site 238 is the primary site for congestion problem M055.

Downstream volumes are acceptable and ramp volumes are ideal during the congested period for a single lane entrance ramp. If the site was increased to two lanes on the ramp, entrance ramp volume per would still be acceptable.

This site could provide benefits for congestion in support of site 238. There is some concern with lack of forward visibility on the ramp. There is scope for operating this as a two lane site, but this would require significant re-modelling which would add to the cost, while the site would operate with some benefits as it is.

Forward visibility issues on the ramp need to be considered carefully in the design of this site.

Site Categorization

Feasible for taking forward

C.3.8 Site Summaries - Group 8

NCDOT Ramp Metering Feasibility Study
Site Summary Document

237

Site Details

Site Number	237
Freeway	I-485
Cross Street	Rea Road
Exit	59
Direction	Inner
County	Mecklenburg

Physical Characteristics Overview

Origin of Entrance Ramp	Free Flow Link
Lane Addition onto Main Freeway length (feet)	675
Number of Entrance Ramp Lanes	1
Lane Drop on Entrance Ramp Before Merge	No
Number of Freeway Lanes Before Merge	2
Number of Freeway Lanes After Merge	2
Entrance Ramp Length to Back of Gore (feet)	990
Entrance Ramp Length to Tip of Gore (feet)	1,250
Merge Length (feet)	925
Entrance Ramp Horizontal Alignment	Straight
Entrance Ramp Vertical Alignment	Slightly Downhill
Entrance Ramp Shoulder (Paved Full Width)	No
Main Freeway Vertical Alignment Downstream	Level
Main Freeway Shoulder	Yes
Number of Vehicles Storage	40
Guardrail	None
Pipe Crossing	None

Signalization Overview

Upstream Signal	3-way signal; Ramp entry from: right turn only
Nearest Power Source	Power Poles from signal at start of ramp

Signing Overview

Existing Signing	None

Traffic Volumes

Period Beginning	Upstream Hourly Volume Rate	Downstream Hourly Volume Rate	Entrance Ramp Hourly Volume Rate	Downstream Volume per Lane	Entrance Ramp Volume per Lane	Entrance Ramp % of Downstream Volume	Hour Meets Acceptable Criteria for Ramp Metering
06:00	3,097	3,225	128	1,613	128	4	No
07:00	4,522	4,919	397	2,460	397	8	Yes
08:00	4,065	4,425	360	2,213	360	8	Yes
09:00	3,501	3,760	259	1,880	259	7	No
10:00	2,626	2,837	211	1,419	211	7	No
11:00	2,562	2,762	200	1,381	200	7	No
12:00	2,394	2,615	221	1,308	221	8	No
13:00	2,531	2,775	244	1,388	244	9	No
14:00	2,542	2,766	224	1,383	224	8	No
15:00	2,610	2,851	241	1,426	241	8	No
16:00	2,915	3,118	203	1,559	203	7	No
17:00	2,977	3,216	239	1,608	239	7	No
18:00	2,590	2,746	156	1,373	156	6	No
19:00	1,943	2,097	154	1,049	154	7	No
20:00	1,521	1,616	95	808	95	6	No

Capacity Analysis

Downstream Freeway Peak Volume	4,956
Corresponding Ramp Volume	420
Corresponding Upstream Freeway Peak Volume	4,536
Peak Hour Factor	0.982
Ramp Merge Level of Service	C

Congestion

Congestion	M054
Ave Length of Congestion (Miles)	5.52
Duration of Congestion (Minutes)	72.93
Calculated Number of Occurrences per Year	170
Typical Times of Congestion	07:00 - 10:00

Crash Data

The total number of accidents from March 2011 to February 2016 was: 51
Of these, 36 were accidents which can be associated with congestion:
Type 21-Rear end, slow or stop: 24 (47%)
Type 28- Sideswipe, same direction: 12 (24%)

Observations

Log 237 is a direct ramp with no sight distance issues. The grade is slightly downhill with an average slope of -0.83%. The ramp has one lane and has entry from a single left turn, a thru movement and right turn. The travel lane and shoulders are asphalt. The pavement condition was considered to be good. The left shoulder has a width of 4' and the right shoulder had a width of 5.5'. The shoulder outside of the pavement is in poor condition with several ruts/holes. A drainage structure is located 29' from the edge of travel lane near the middle of the ramp. A sound wall is located outside of the ramp 37' from the edge of travel lane. Lastly, some light poles near the end of the ramp are located 19' from the edge of travel lane.

Peak volume is greater than 2,000 vehicles per hour per lane (2,478).

Site Selection Comments

This is a single lane direct ramp fed from an un-signalized intersection. It has no sight distance issues and has storage for about 40 vehicles.

This is the primary site for congestion problem M054, and it is just downstream from site 236 which is part of the same intersection. Congestion occurs in the AM peak. Downstream volumes are ideal and ramp volumes are acceptable during the congested period. The entrance ramp volumes are at the low end, just about acceptable during the congested period for a single lane ramp.

This site could be a reasonable ramp metering site, although the entrance ramp volumes are on the low side and the local road intersection is not signalized, but there is scope for some benefits.

No specific implementation problems have been identified.

Site Categorization

Feasible for taking forward

NCDOT Ramp Metering Feasibility Study
Site Summary Document

236

Site Details

Site Number	236
Freeway	I-485
Cross Street	Rea Road
Exit	59
Direction	Inner
County	Mecklenburg

Physical Characteristics Overview

Origin of Entrance Ramp	Free Flow Link
Lane Addition onto Main Freeway length (feet)	3,000
Number of Entrance Ramp Lanes	1
Lane Drop on Entrance Ramp Before Merge	No
Number of Freeway Lanes Before Merge	2
Number of Freeway Lanes After Merge	2
Entrance Ramp Length to Back of Gore (feet)	755
Entrance Ramp Length to Tip of Gore (feet)	950
Merge Length (feet)	850
Entrance Ramp Horizontal Alignment	Tight Curve
Entrance Ramp Vertical Alignment	Downhill
Entrance Ramp Shoulder (Paved Full Width)	No
Main Freeway Vertical Alignment Downstream	Level
Main Freeway Shoulder	Yes
Number of Vehicles Storage	30
Guardrail	Yes; 91’ from back of entry gore with 7’ offset
Pipe Crossing	None

Signalization Overview

Upstream Signal	Not Signalized; Free Flow
Nearest Power Source	Power Poles from signal at exit ramp

Signing Overview

Existing Signing	“Exit” – 15’ from gore on outside edge of ramp

Traffic Volumes

Period Beginning	Upstream Hourly Volume Rate	Downstream Hourly Volume Rate	Entrance Ramp Hourly Volume Rate	Downstream Volume per Lane	Entrance Ramp Volume per Lane	Entrance Ramp % of Downstream Volume	Hour Meets Acceptable Criteria for Ramp Metering
06:00	3,607	4,115	508	2,058	508	12	Yes
07:00	5,678	6,699	1,021	3,350	1,021	15	Yes
08:00	5,351	6,219	868	3,110	868	14	Yes
09:00	4,494	5,167	673	2,584	673	13	Yes
10:00	3,356	3,878	522	1,939	522	13	Yes
11:00	3,319	3,821	502	1,911	502	13	Yes
12:00	3,180	3,736	556	1,868	556	15	Yes
13:00	3,357	3,870	513	1,935	513	13	Yes
14:00	3,332	3,832	500	1,916	500	13	Yes
15:00	3,431	3,914	483	1,957	483	12	Yes
16:00	3,677	4,140	463	2,070	463	11	Yes
17:00	3,725	4,192	467	2,096	467	11	Yes
18:00	3,113	3,515	402	1,758	402	11	Yes
19:00	2,508	2,836	328	1,418	328	12	Yes
20:00	1,926	2,200	274	1,100	274	12	No

Capacity Analysis

Downstream Freeway Peak Volume	6,842
Corresponding Ramp Volume	1,029
Corresponding Upstream Freeway Peak Volume	5,813
Peak Hour Factor	0.985
Ramp Merge Level of Service	F

Congestion

Congestion	M054
Ave Length of Congestion (Miles)	5.24
Duration of Congestion (Minutes)	69.23
Calculated Number of Occurrences per Year	170
Typical Times of Congestion	07:00 - 10:00

Crash Data

The total number of accidents from March 2011 to February 2016 was: 67
Of these, 40 were accidents which can be associated with congestion:
Type 21-Rear end, slow or stop: 30 (45%)
Type 28- Sideswipe, same direction: 10 (15%)

Observations

Log 236 is a loop ramp with no sight distance issues. The grade is slightly downhill with an average slope of -3.17%. The ramp has one lane and has entry from a right turn. The travel lane and shoulders are asphalt. The pavement condition was considered to be good. The inner shoulder is curb and gutter and the right shoulder has a width of 4.5'. There is a run of guardrail 91' from the back of the gore at the start of the ramp. A drainage structure is located near the middle of the ramp and is 30' from the edge of travel lane. The tree line occurs 26' from the edge of travel lane at the middle/end of the ramp.

Peak volume is far greater than 2,000 vehicles per hour per lane (3,421). Very small PM peak.

Site Selection Comments

This is a single lane loop ramp fed from an un-signalized intersection at street level. It has approximately 30 vehicles storage. Forward visibility could be an issue on this tightly curved ramp because the ground is raised and there is vegetation on the inside of the curve.

This is part of the same intersection but upstream of site 237, which is the primary site for congestion problem M054. The site suffers from moderate congestion in the AM peak.

Downstream volumes are ideal and ramp volumes are ideal/acceptable during the congested period. The entrance ramp volume per lane is toward the high end of ideal, becoming only acceptable at times. These volumes would support two lane RM.

This site would support site 237 with the M054 congestion problem. It would be desirable to have an extra lane on the ramp due to ramp volumes and storage although it would operate with the current single lane.

There is a specific problem with forward visibility on the ramp and it would be desirable, though not necessary, to have an additional entrance ramp lane. But the existing geometry would not favor this, so it could be expensive. Careful consideration is required when implementing this site.

Site Categorization

Feasible for taking forward

NCDOT Ramp Metering Feasibility Study
Site Summary Document

233

Site Details

Site Number	233
Freeway	I-485
Cross Street	Providence Road
Exit	57
Direction	Inner
County	Mecklenburg

Physical Characteristics Overview

Origin of Entrance Ramp	Signalized Int.
Lane Addition onto Main Freeway length (feet)	745
Number of Entrance Ramp Lanes	1
Lane Drop on Entrance Ramp Before Merge	No
Number of Freeway Lanes Before Merge	2
Number of Freeway Lanes After Merge	2
Entrance Ramp Length to Back of Gore (feet)	905
Entrance Ramp Length to Tip of Gore (feet)	1,100
Merge Length (feet)	1,050
Entrance Ramp Horizontal Alignment	Straight
Entrance Ramp Vertical Alignment	Downhill
Entrance Ramp Shoulder (Paved Full Width)	No
Main Freeway Vertical Alignment Downstream	Level
Main Freeway Shoulder	Yes
Number of Vehicles Storage	36
Guardrail	None
Pipe Crossing	None

Signalization Overview

Upstream Signal	3-way signal; Ramp entry from: thru and right turn
Nearest Power Source	Power poles from signal at start of ramp

Signing Overview

Existing Signing	None

Traffic Volumes

Period Beginning	Upstream Hourly Volume Rate	Downstream Hourly Volume Rate	Entrance Ramp Hourly Volume Rate	Downstream Volume per Lane	Entrance Ramp Volume per Lane	Entrance Ramp % of Downstream Volume	Hour Meets Acceptable Criteria for Ramp Metering
06:00	2,218	2,721	503	1,361	503	18	Yes
07:00	2,752	3,552	800	1,776	800	23	Yes
08:00	2,752	3,497	745	1,749	745	21	Yes
09:00	2,736	3,253	517	1,627	517	16	Yes
10:00	2,436	2,843	407	1,422	407	14	Yes
11:00	2,282	2,720	438	1,360	438	16	Yes
12:00	2,206	2,684	478	1,342	478	18	Yes
13:00	2,263	2,677	414	1,339	414	15	Yes
14:00	2,318	2,713	395	1,357	395	15	Yes
15:00	2,369	2,788	419	1,394	419	15	Yes
16:00	2,648	3,032	384	1,516	384	13	Yes
17:00	2,836	3,257	421	1,629	421	13	Yes
18:00	2,622	2,982	360	1,491	360	12	Yes
19:00	1,901	2,204	303	1,102	303	14	Yes
20:00	1,442	1,652	210	826	210	13	No

Capacity Analysis

Downstream Freeway Peak Volume	3,601
Corresponding Ramp Volume	756
Corresponding Upstream Freeway Peak Volume	2,845
Peak Hour Factor	0.922
Ramp Merge Level of Service	D

Congestion

Congestion	M052, M054
Ave Length of Congestion (Miles)	5.09
Duration of Congestion (Minutes)	64.69
Calculated Number of Occurrences per Year	535
Typical Times of Congestion	07:00 - 10:00

Crash Data

The total number of accidents from March 2011 to February 2016 was: 28
Of these, 15 were accidents which can be associated with congestion:
Type 21-Rear end, slow or stop: 9 (32%)
Type 28- Sideswipe, same direction: 6 (21%)

Observations

Log 233 is a direct ramp with no sight distance issues. The grade is downhill with an average slope of -2.77%. The ramp has one lane and has entry from a thru movement and a right turn. The travel lane and shoulders are asphalt. The pavement condition was considered to be good. The left shoulder has a width of 4' and the right shoulder had a width of 5-16'. The bank on the outside of the ramp is 40' from the edge of travel lane.

Site Selection Comments

This is a single lane direct ramp fed from a signalized intersection. No sightline issues have been identified and it has storage for 36 vehicles.

This is primary site for M052 and it is congested during the morning peak. There is a reasonable amount of congestion offering good opportunity for ramp metering benefit.

Downstream and ramp volumes are ideal during the congested period for a single lane site.

This site appears to be a good candidate for ramp metering and could be supported by the upstream site 231.

No specific implementation problems have been identified.

Site Categorization

Feasible for taking forward

NCDOT Ramp Metering Feasibility Study
Site Summary Document

231

Site Details

Site Number	231
Freeway	I-485
Cross Street	Providence Road
Exit	57
Direction	Inner
County	Mecklenburg

Physical Characteristics Overview

Origin of Entrance Ramp	Free Flow Link
Lane Addition onto Main Freeway length (feet)	640
Number of Entrance Ramp Lanes	1
Lane Drop on Entrance Ramp Before Merge	No
Number of Freeway Lanes Before Merge	2
Number of Freeway Lanes After Merge	2
Entrance Ramp Length to Back of Gore (feet)	600
Entrance Ramp Length to Tip of Gore (feet)	720
Merge Length (feet)	1,015
Entrance Ramp Horizontal Alignment	Tight Curve
Entrance Ramp Vertical Alignment	Downhill
Entrance Ramp Shoulder (Paved Full Width)	No
Main Freeway Vertical Alignment Downstream	Level
Main Freeway Shoulder	Yes
Number of Vehicles Storage	24
Guardrail	None
Pipe Crossing	None

Signalization Overview

Upstream Signal	Not Signalized
Nearest Power Source	Power Poles from signal at exit ramp

Signing Overview

Existing Signing	“Exit”, “Ramp 25MPH”, 4 Chevrons

Traffic Volumes

Period Beginning	Upstream Hourly Volume Rate	Downstream Hourly Volume Rate	Entrance Ramp Hourly Volume Rate	Downstream Volume per Lane	Entrance Ramp Volume per Lane	Entrance Ramp % of Downstream Volume	Hour Meets Acceptable Criteria for Ramp Metering
06:00	2,027	2,820	793	1,410	793	28	Yes
07:00	2,295	3,172	877	1,586	877	28	Yes
08:00	2,179	2,910	731	1,455	731	25	Yes
09:00	1,997	2,634	637	1,317	637	24	Yes
10:00	1,708	2,117	409	1,059	409	19	Yes
11:00	1,620	2,107	487	1,054	487	23	Yes
12:00	1,555	2,011	456	1,006	456	23	Yes
13:00	1,658	2,107	449	1,054	449	21	Yes
14:00	1,694	2,141	447	1,071	447	21	Yes
15:00	1,877	2,301	424	1,151	424	18	Yes
16:00	2,093	2,533	440	1,267	440	17	Yes
17:00	2,193	2,705	512	1,353	512	19	Yes
18:00	1,882	2,263	381	1,132	381	17	Yes
19:00	1,317	1,563	246	782	246	16	No
20:00	891	1,070	179	535	179	17	No

Capacity Analysis

Downstream Freeway Peak Volume	3,424
Corresponding Ramp Volume	903
Corresponding Upstream Freeway Peak Volume	2,521
Peak Hour Factor	0.823
Ramp Merge Level of Service	D

Congestion

Congestion	M052, M054
Ave Length of Congestion (Miles)	4.85
Duration of Congestion (Minutes)	61.62
Calculated Number of Occurrences per Year	535
Typical Times of Congestion	07:00 - 10:00

Crash Data

The total number of accidents from March 2011 to February 2016 was: 108
Of these, 54 were accidents which can be associated with congestion:
Type 21-Rear end, slow or stop: 36 (33%)
Type 28- Sideswipe, same direction: 18 (17%)

Observations

Log 231 is a loop ramp with no sight distance issues. The grade is downhill with an average slope of -2.5%. The ramp has one lane and has entry from a single right turn. The travel lane and shoulders are asphalt. The pavement condition was considered to be good. The inner shoulder is curb and gutter and the outer shoulder has a width of 4.5'. There is a barrier wall that is 45' from the gore with a 6.5' offset from the edge of travel lane. There is one "Exit" sign located 21' from the gore at the start of the ramp and also one "Ramp 25 MPH" located 66' from the gore. Four chevrons are also positioned 313', 372', 427', and 497' from the gore.

Site Selection Comments

This is a single lane loop ramp fed from an un-signalized intersection from street level. It has storage for approximately 24 vehicles.

This is just upstream of site 233 which is the primary site for M052. It is congested in the morning peak and should be able to support site 233 to give benefits.

Downstream volumes are ideal/acceptable and ramp volumes are ideal during the congested period. Volumes on the ramp are ideal for a single lane. If the location was widened to two metered lanes the volumes during congestion would still be acceptable.

This site could offer ramp metering benefits but would need careful consideration due to the tightly curved and short entrance ramp. There is little scope for widening this site, but traffic could be stored on the approaches at street level. This site would support site 233 which is downstream and part of the same intersection.

There are some issues with implementation, with caution required regarding the tightly curved ramp. There is little scope for widening the ramp to address the limited storage capacity, although storage could be increased to approximately 58 vehicles through use of the overpass.

Site Categorization

Feasible for taking forward

NCDOT Ramp Metering Feasibility Study
Site Summary Document

229

Site Details

Site Number	229
Freeway	I-485
Cross Street	East John Street
Exit	52
Direction	Inner
County	Mecklenburg

Physical Characteristics Overview

Origin of Entrance Ramp	Signalized Int.
Lane Addition onto Main Freeway length (feet)	640
Number of Entrance Ramp Lanes	1
Lane Drop on Entrance Ramp Before Merge	No
Number of Freeway Lanes Before Merge	2
Number of Freeway Lanes After Merge	2
Entrance Ramp Length to Back of Gore (feet)	1,370
Entrance Ramp Length to Tip of Gore (feet)	1,640
Merge Length (feet)	950
Entrance Ramp Horizontal Alignment	Straight
Entrance Ramp Vertical Alignment	Slightly downhill
Entrance Ramp Shoulder (Paved Full Width)	No
Main Freeway Vertical Alignment Downstream	Level
Main Freeway Shoulder	Yes
Number of Vehicles Storage	55
Guardrail	Yes – 990’ from start of ramp
Pipe Crossing	None

Signalization Overview

Upstream Signal	3-way signal; Ramp entry from: left turn, and right turn
Nearest Power Source	Power poles at start of ramp (signal cabinet across street)

Signing Overview

Existing Signing	No Signs

Traffic Volumes

Period Beginning	Upstream Hourly Volume Rate	Downstream Hourly Volume Rate	Entrance Ramp Hourly Volume Rate	Downstream Volume per Lane	Entrance Ramp Volume per Lane	Entrance Ramp % of Downstream Volume	Hour Meets Acceptable Criteria for Ramp Metering
06:00	3,410	3,861	451	1,931	451	12	Yes
07:00	3,594	3,961	367	1,981	367	9	Yes
08:00	2,414	2,736	322	1,368	322	12	Yes
09:00	1,518	1,942	424	971	424	22	Yes
10:00	1,128	1,483	355	742	355	24	Yes
11:00	1,328	1,774	446	887	446	25	Yes
12:00	1,345	1,806	461	903	461	26	Yes
13:00	1,499	1,959	460	980	460	23	Yes
14:00	1,678	2,135	457	1,068	457	21	Yes
15:00	1,754	2,263	509	1,132	509	22	Yes
16:00	2,155	2,765	610	1,383	610	22	Yes
17:00	2,700	3,306	606	1,653	606	18	Yes
18:00	2,322	2,763	441	1,382	441	16	Yes
19:00	1,522	1,876	354	938	354	19	Yes
20:00	989	1,232	243	616	243	20	No

Capacity Analysis

Downstream Freeway Peak Volume	4,648
Corresponding Ramp Volume	440
Corresponding Upstream Freeway Peak Volume	4,208
Peak Hour Factor	0.837
Ramp Merge Level of Service	F

Congestion

Congestion	M052
Ave Length of Congestion (Miles)	1.56
Duration of Congestion (Minutes)	19.61
Calculated Number of Occurrences per Year	365
Typical Times of Congestion	07:00 - 10:00

Crash Data

The total number of accidents from March 2011 to February 2016 was: 19
Of these, 12 were accidents which can be associated with congestion:
Type 21-Rear end, slow or stop: 6 (32%)
Type 28- Sideswipe, same direction: 6 (32%)

Observations

Log 229 is a direct ramp with no sight distance issues. The grade is slightly downhill with an average slope of -0.63%. The ramp has one lane and has entry from a single left turn and a right turn. The travel lane and shoulders are asphalt. The pavement condition was considered to be good. The left shoulder has a width of 3' and the right shoulder had a width of 4'. There is a run of guardrail 990' from the start of the ramp. The tree line occurs 11' behind the guardrail so it could be moved back if more space is need for travel lanes.

Peak volume greater than 2,000 vehicles per hour per lane (2,324).

Site Selection Comments

This is a single lane direct ramp from a signalized intersection. It has storage for approximately 55 vehicles.

This is a secondary site for congestion problem M052 for which sites 231 and 233 are the primary sites. This site is congested during the AM peak.

Downstream and ramp volumes are acceptable during the congested period, although the ramp volumes are on the low side which could affect the level of benefit ramp metering could provide.

This site could have some benefits, though slightly limited by the low volumes on the ramp and the fact that it is a secondary site. The two downstream sites are feasible and if they are implemented then there is a chance that there will be no benefits available at this site.

No specific implementation problems have been identified.

Site Categorization

Review in future

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