
1.0 Project Background and Summary

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The Minnesota Department of Transportation (Mn/DOT) uses ramp meters to manage freeway access on approximately 210 miles of freeways in the Twin Cities metropolitan area. Mn/DOT first tested ramp meters in 1969 as a method to optimize freeway safety and efficiency in the metropolitan area. Since then, approximately 430 ramp meters have been installed and used to help merge traffic onto freeways and to help manage the flow of traffic through bottlenecks.

In 2000, a bill passed by the Minnesota Legislature required Mn/DOT to study the effectiveness of ramp meters in the Twin Cities Region. As a result, a ramp meter evaluation study was conducted in the fall of 2000, with its results presented to the Legislature and the public in February 2001. This “Phase I” evaluation consisted of field observations and traveler surveys/focus groups “with” and “without” ramp metering. The Phase I field evaluation’s findings included:

- **Traffic volumes and throughput:** After the meters went off there was an average nine percent traffic volume reduction on freeways and no significant traffic volume change on parallel arterials. Also, during peak traffic conditions, freeway mainline throughput declined by an average of 14 percent in the meters-off condition.
- **Travel time:** With meters on, improved travel speeds on freeway facilities more than offset ramp delays. This resulted in annual systemwide savings of 25,121 hours of delay.
- **Travel time reliability:** Without ramp metering freeway travel time was found to be almost twice as unpredictable as with ramp metering. This produced annual savings of 2.6 million hours of unexpected delay.
- **Safety:** Ramp metering resulted in annual savings of over 1,000 crashes or approximately four crashes per day. In the absence of metering and after accounting for seasonal variations, peak period crashes on metered freeways and ramps increased by 24 percent.
- **Emissions:** Ramp metering resulted in annual savings of 1,160 tons of emissions.
- **Fuel consumption:** Ramp metering resulted in an annual disbenefit of 22,246 gallons of fuel.
- **Benefit/cost analysis:** Ramp metering resulted in annual savings of approximately \$40 million to the Twin Cities traveling public. The benefits of ramp metering

outweighed the costs by a significant margin and resulted in a net benefit of approximately \$32 million per year. The benefit/cost ratio indicated that benefits are approximately five times greater than the cost of the system.

In parallel to the field evaluation, the Phase I evaluation included traveler surveys and focus groups to identify traveler’s perceptions of ramp metering. The results of these market research efforts are summarized as follows:

- Respondents reported experiencing average wait times at ramps “with meters” of four to nine minutes depending on the corridor, but mainly between five to six minutes.
- Respondents in the “without meters” survey tended to believe that traffic conditions overall had become worse with the meters off. These findings were generally consistent with the traffic data, which indicated that travel conditions had on the whole deteriorated.
- Respondents in the “without meters” survey had an increased appreciation of the role of ramp meters, but also were more inclined to believe that there was too much metering in free flow conditions; that ramp meter wait times were too long; and that there were too many meters in general.
- Findings varied considerably with trip length, consistent with the traffic data. Respondents with origins furthest from the urban core, and with the longest trips, were most likely to believe that traffic conditions got worse during the shutdown. These travelers also had a greater appreciation for the role of metering and were least supportive of a continued shutdown.
- The most commonly supported modifications to the Twin Cities metering system were to shorten the wait times, to increase green time when freeway flow at the ramp was light, to shorten hours of meter operation, and to reduce the number of meters and limit them to areas of high traffic congestion.

The Phase I evaluation suggested that ramp metering is an overall cost-effective investment of public funds for the Twin Cities area. This finding notwithstanding, the Twin Cities users of the highway system supported the need for modifications toward an efficient but more publicly acceptable operation of ramp meters. The combination of these two factors pointed towards the adoption of an overriding principle regarding the operation of ramp meters in the Twin Cities: This principle would seek to *“balance the efficiency of moving as much traffic during the rush hours as possible, consistent with safety concerns and public consensus.”*

In light of this “new balance” and pending the development of a general policy for optimizing ramp meter operation, several steps were taken soon after the Phase I evaluation data collection was completed, including reduced operating timeframe of ramp meters, allowing meters to change more quickly from red to green, and keeping several meters at flashing yellow. When the ramp meter shutdown study ended on December 8, 2000, several interim changes to the ramp metering system occurred, including:

- A number of meters were left turned off;
- Ramp meter operations were limited to four hours each day; and
- Faster metering rates were used.

Until a policy for optimizing ramp meter operation was developed, Mn/DOT continued to voluntarily monitor ramp wait times, freeway travel time and its reliability and crashes, and conducted market research to identify changing traveler perceptions. The Phase II evaluation's objectives were to:

- Enable the development of a policy for optimizing ramp meter operations based on lessons-learned from Phase I of the ramp meter evaluation study; and
- Capture and evaluate the public and system impacts of short- and long-term ramp meter strategies.

The "Phase II" evaluation's methodology and results are presented in this report. The Phase II evaluation concluded that traffic operations and safety continued to experience the degraded performance which was documented during the ramp meter shutdown. The Phase II evaluation's findings include:

- Crash rates increased by 15 percent when comparing the first seven months of years 1998 to 2000 (fully metered) and year 2001 (interim metering operation).
- Freeway speeds in 2001 varied from corridor to corridor, but were consistently five to 10 percent slower than in 2000.
- Freeway travel times also varied from corridor to corridor, with results showing them to be consistently five to 10 percent longer in 2001 than in 2000.
- Freeway traffic volume throughput declined by five percent since the Fall of 2000.
- University Avenue speed was about 11 to 17 percent slower compared to the Fall 2000 speed.
- Phase II market research showed strong support for modification of the system. A major market research finding shows that 60 percent of commuters polled support modification of the ramp metering system. About one-quarter (26 percent) believe that the system should continue to operate as is, while 14 percent believe that the meters should be shutdown completely. These percentages are similar to those expressed during the pre-shutdown condition, except support for a complete shutdown has declined significantly from 21 percent previously.

Based on the Phases I and II evaluations and in coordination with key stakeholders, Mn/DOT defined a new set of objectives, constraints, and criteria for ramp meter application and operation. This policy was based on a thorough investigation of efficiency, equity, and other criteria for the evaluation of ramp metering strategies. Criteria involve variables, such as ramp wait times and ramp storage capacities, target freeway peak-

period speeds, and maximum metering rates in the Twin Cities metropolitan area. The goals of the new ramp metering system are:

- To reduce delays caused by congestion and crashes;
- To reduce the number of crashes caused by congestion;
- To provide travelers with more reliable travel times; and
- To manage ramp meter wait times.

A key aspect of the new responsive ramp metering system is the addition of an automated system that will monitor wait times at meters so they can be adjusted as needed by Mn/DOT's traffic management center computers. The new system will provide real-time information about ramp delays and will limit wait times based on ramp conditions, as well as freeway conditions. Specific system features include:

- Ramp meter waits will be no more than four minutes on local ramps and no more than two minutes on freeway-to-freeway ramps;
- Vehicles waiting at meters will not back up onto adjacent roadways;
- Meter operation will respond to congestion and only operate when needed; and
- A number of current ramp meters will be removed; these meters are not currently used and, based upon traffic projections, will not be needed in those areas for at least five years.

An additional objective of this report is to identify, evaluate, and recommend methods for developing and testing long-range ramp meter strategies. To this end, Sections 4.0 and 5.0 contain descriptions of the use of various spreadsheet tools developed for the Phase I evaluation. Section 7.0 presents detailed instructions on how to conduct benefit-cost analysis using a spreadsheet tool developed for the Phase I evaluation; this tool can readily be used in future evaluations of ramp metering or other traffic management strategies. Section 8.0 presents an evaluation of other planning and micro-simulation tools that can be used in the context of a ramp metering deployment plan.

This document is organized as follows:

- Phase II Evaluation Objectives (Section 2.0);
- Phase II Performance Measures and Evaluation Overview (Section 3.0);
- Phase II Field Data Collection Plan (Section 4.0);
- Results of the Phase II Field Evaluation (Section 5.0);
- Phase II Traveler Surveys (Section 6.0);
- Benefit/Cost Analysis Methodology (Section 7.0); and
- Planning for Future Ramp Meter Deployments (Section 8.0).