

Table of Contents

Executive Summary	ES-1
1.0 Project Background.....	1-1
2.0 Evaluation Team	2-1
3.0 Evaluation Objectives and Performance Measures.....	3-1
4.0 Evaluation Methodologies.....	4-1
4.1 Overview of Evaluation Methodologies	4-1
4.2 Corridor Selection.....	4-2
4.2.1 Corridor Selection Criteria.....	4-3
4.2.2 Identification of Candidate Corridors	4-4
4.2.3 Selection of Corridors To Be Studied	4-4
4.3 Field Data Collection.....	4-5
4.3.1 Traffic Flow Data.....	4-11
4.3.2 Travel Time Data	4-11
4.3.3 Ramp Impact Data	4-13
4.3.4 Safety Impact Data	4-13
4.3.5 Transit Impact Data	4-14
4.4 Focus Groups and Traveler Survey Methodology	4-15
4.4.1 Focus Group Methodology	4-16
4.4.2 Sampling Frame and Survey Logistics.....	4-17
4.4.3 Design of the “With Ramp Meters” Surveys	4-20
4.4.4 Design of the “Without Ramp Meters” Surveys	4-21
4.5 Benefit/Cost Analysis.....	4-21
4.6 Secondary Research.....	4-24
5.0 Field Evaluation Results	5-1
5.1 Travel Performance Data Analysis	5-1
5.1.1 Statistical Significance Tests.....	5-1
5.2 Travel Performance Results	5-4
5.2.1 Travel Time and Travel Speed	5-4
5.2.2 Freeway Traffic Volume and Throughput.....	5-9
5.2.3 Ramp Traffic Volume and Ramp Travel Time.....	5-14
5.2.4 Freeway Mainline Versus Ramp Travel Times	5-20
5.3 Safety Impacts	5-26
5.4 Transit and Park-and-Ride Impacts.....	5-28
5.5 Air Quality.....	5-

Table of Contents

(continued)

6.0	Traveler Surveys and Focus Groups	6-1
6.1	Analysis Objectives	6-1
6.2	Section Outline.....	6-2
6.3	Overview of the Analysis Approach	6-3
6.3.1	Focus Group Findings	6-3
6.3.2	Statistical Analysis Methods.....	6-10
6.3.3	Steps in the Survey Analysis	6-12
6.4	Socioeconomic Characteristics.....	6-13
6.5	Travel Patterns	6-16
6.5.1	Overall Travel Profile	6-16
6.5.2	Time-of-Day and Route Diversion Patterns	6-21
6.5.3	Retrospective Evaluation of Traffic Conditions.....	6-23
6.6	Ramp Wait Times	6-26
6.7	Attitudes Toward Ramp Metering.....	6-31
6.8	Differences in Attitudes Following the Shutdown	6-35
6.9	Travelers’ View of the Ramp Metering Future	6-42
7.0	Benefit/Cost Analysis	7-1
7.1	Analysis Approach.....	7-1
7.1.1	Estimation of Benefits	7-1
7.1.2	Estimation of Costs	7-2
7.2	Analysis Findings	7-5
7.2.1	Benefits of Ramp Metering	7-5
7.2.2	Ramp Metering Costs	7-7
7.2.3	Comparison of Ramp Metering Benefits and Costs	7-8
8.0	Secondary Research.....	8-1
8.1	Basics of Ramp Metering.....	8-1
8.2	Use of Ramp Metering Across the Country.....	8-2
8.3	Keys to a Successful Ramp Metering Program	8-3
8.4	Peer City Interviews.....	8-4
8.5.1	Seattle, Washington.....	8-4
8.5.2	Phoenix, Arizona	8-5
8.5	Comparison of Twin Cities Evaluation Findings to Other Ramp Meter Evaluation Studies.....	8-6
9.0	Summary of Findings, Conclusions, and Recommendations.....	9-1
9.1	Evaluation Conclusions	9-1
9.1.1	Traffic Volumes and Throughput	9-5
9.1.2	Travel Time	9-7
9.1.3	Travel Time Reliability	9-7

Table of Contents

(continued)

9.1.4	Safety	9-9
9.1.5	Annual Benefits of Ramp Metering	9-10
9.1.6	Annual Costs of Ramp Metering	9-12
9.1.7	Comparison of Ramp Metering Benefits and Costs	9-13
9.1.8	Results from the Traveler Surveys and Focus Groups.....	9-14
9.2	Secondary Research.....	9-16
9.3	Recommendations	9-17

Appendix A - Dates and Locations of License Plate Number Data Collection

Appendix B - Summary of Field Data: Freeway and Arterial Speeds

Appendix C - Summary of Field Data: Freeway and Arterial Traffic Volumes

Appendix D - Ramp Volumes

Appendix E - Socioeconomic Distribution of Market Research Samples

Appendix F - Geocoding of Respondents' Origin-Destination Trips

Appendix G - Evaluation Plan

Appendix H - Comparison Between “With” and “Without” Ratings for the Random Samples

Appendix I - Qualitative Research with Travelers

Appendix J - Summary of Benefit Cost/Calculations

Appendix K - Technical Memorandum: Secondary Research

List of Tables

ES.1	Annual Benefits of the Ramp Metering System (Year 2000 Dollars).....	ES-11
ES.2	Annual Congestion Management and Ramp Metering System Costs (Year 2000 Dollars).....	ES-13
ES.3	Comparison of Annual Costs and Benefits	ES-14
3.1	Evaluation Goals and Objectives	3-2
3.2	Evaluation Measures	3-3
4.1	Distribution of Survey Returns for “With Ramp Meters” and “Without Ramp Meters” Surveys.....	4-18
4.2	Categorization of Metered Corridors in the Twin Cities.....	4-23
5.1	Summary of Freeway and Ramp Evaluation Results	5-2
5.2	Field Conditions T-Test Results Across All Corridors	5-3
5.3	“With” Versus “Without” T-Test Results.....	5-4
5.4	Summary of Arterial Evaluation Results.....	5-11
5.5	Calculation of Net Travel Time for Selected Corridors During a 3.5-Hour Period.....	5-25
5.6	Comparison of Crash Occurrences by Crash Type (for Peak Period Metered Freeways)	5-27
5.7	Transit Ridership Summary	5-28
5.8	Park-and-Ride Usage.....	5-29
5.9	Impacts of Ramp Metering Shutdown Reported by Transit Providers	5-29
6.1	Overview of Socioeconomic Characteristics in the “With Ramp Meters” Survey	6-14
6.2	Total and Freeway Travel Times Reported in the Surveys.....	6-21
6.3	Diversion Patterns in the “With Ramp Meters” Surveys	6-22

List of Tables (continued)

6.4	Diversion by Frequent Freeway Users in the “Without Ramp Meters” Surveys	6-22
6.5	Reported Changes in Total Travel Time: “Without Ramp Meters” Surveys	6-24
6.6	Reported Changes in Freeway Travel Time: “Without Ramp Meters” Surveys	6-24
6.7	Reported Changes in Traffic Conditions: “Without Ramp Meters” Surveys	6-24
6.8	Attitudinal Statements for Freeway and Ramp Meter Performance	6-32
6.9	Statistically Significant Differences in Travelers’ Attitudes N=250 in Each Corridor and N=500 in the Random Sample.....	6-36
6.10	Statistically Significant Differences in I-494 Corridor N=250 in Each Corridor and N=500 in the Random Sample.....	6-39
6.11	Ramp Metering Modifications – All “With Ramp Meters” and “ Without Ramp Meters” Surveys	6-46
6.12	Ramp Metering Modifications – “Without Ramp Meters” Surveys by Corridor.....	6-46
7.1	Impact Value Assumptions	7-3
7.2	Congestion Management Subsystems Proportional Support of Ramp Metering.....	7-4
7.3	Annual Ramp Metering Benefits	7-7
7.4	Annual Congestion Management and Ramp Metering System Costs	7-8
7.5	Comparison of Annual Costs and Benefits	7-9
8.1	Changes to Performance Measures Resulting from the Implementation of Ramp Metering	8-6
8.2	Comparison of Twin Cities Evaluation Findings to Other Ramp Meter Evaluation Studies	8-8

List of Tables

(continued)

9.1 Summary of Evaluation Findings..... 9-2

9.2 Annual Benefits of the Ramp Metering System (Year 2000 Dollars)..... 9-11

9.3 Annual Congestion Management and Ramp Metering System Costs
(Year 2000 Dollars)..... 9-12

9.4 Comparison of Annual Costs and Benefits 9-13

List of Figures

ES.1	Twin Cities Corridors Selected for Detailed Evaluation	ES-3
ES.2	I-94 Eastbound Afternoon – Example of Freeway Traffic Volume Reduction and Earlier Departures	ES-6
ES.3	I-35E Southbound Morning – Example of Traffic Volume Reduction	ES-7
ES.4	I-494 Southbound Morning Speed – Example of Reduced Freeway Speed and Increased Speed Variability	ES-8
ES.5	Example of Increased Speed Variability (I-94 Corridor Location)	ES-9
ES.6	Crash Occurrence in the “With Meters” and “Without Meters” Study Periods (for Metered Freeways in the Morning and Afternoon Peak Period).....	ES-10
ES.7	Reported Changes in Traffic Conditions After the Shutdown	ES-15
ES.8	Travelers’ View of the Future of Ramp Metering	ES-16
1.1	Project Schedule	1-2
2.1	Evaluation Team	2-3
4.1	Twin Cities Corridors Selected for Detailed Evaluation	4-5
4.2	I-494 Corridor	4-6
4.3	I-35W Corridor	4-7
4.4	I-94 Corridor	4-8
4.5	I-35E Corridor	4-9
5.1	I-494 NB Afternoon Speed and Speed Variability	5-5
5.2	I-494 SB Morning Speed and Speed Variability	5-5
5.3	I-35W NB Morning Speed and Speed Variability	5-6
5.4	I-94 EB Afternoon Speed and Speed Variability	5-6
5.5	I-94 WB Morning Speed and Speed Variability	5-7

List of Figures (continued)

5.6	I-94 WB Afternoon Speed and Speed Variability	5-7
5.7	I-35E NB Afternoon Speed and Speed Variability	5-8
5.8	I-35E SB Morning Speed and Speed Variability	5-8
5.9	Detector Reading – Example of Changes to Speed and Speed Variability	5-10
5.10	CR-61 NB Afternoon Speed and Speed Variability	5-12
5.11	Vicksburg Avenue NB Afternoon Speed and Speed Variability	5-12
5.12	I-494 NB P.M. Traffic Volume Differences	5-13
5.13	I-494 SB A.M. Traffic Volume Differences	5-13
5.14	I-35W NB A.M. Traffic Volume Differences	5-14
5.15	I-94 EB P.M. Traffic Volume Differences	5-15
5.16	I-94 WB A.M. Traffic Volume Differences	5-16
5.17	I-94 WB P.M. Traffic Volume Differences	5-17
5.18	I-35E NB P.M. Traffic Volume Differences	5-18
5.19	I-35E SB A.M. Traffic Volume Differences	5-18
5.20	I-94 EB Afternoon Volume Spread	5-19
5.21	I-35W NB Morning Ramp Travel Time	5-20
5.22	I-494 NB Afternoon Ramp Travel Time	5-21
5.23	I-494 SB Morning Ramp Travel Time	5-21
5.24	I-35W NB Morning Ramp Travel Time	5-22
5.25	I-94 EB Afternoon Ramp Travel Time	5-22
5.26	I-94 WB Morning Ramp Travel Time	5-23
5.27	I-94 WB Afternoon Ramp Travel Time	5-23

List of Figures (continued)

5.28	I-35E NB Afternoon Ramp Travel Time	5-24
5.29	I-35E SB Morning Ramp Travel Time	5-24
5.30	I-94 EB Morning Ramp Travel Time	5-25
5.31	Comparison of Crash Occurrences in the “With” and “Without” Study Periods (for Metered Freeways in the Morning and Afternoon Peak Periods)	5-27
6.1	Educational Profile of Respondents	6-15
6.2	Age Profile of Respondents	6-15
6.3	Origins of Travelers – “With Ramp Meters” Surveys	6-17
6.4	Origins of Travelers – “Without Ramp Meters” Surveys	6-18
6.5	Origin-Destination Patterns – “Without Ramp Meters” Surveys.....	6-19
6.6	Origin-Destination Total Travel Times – “With Ramp Meters” Surveys.....	6-20
6.7	Freeway Travel Times – “With Ramp Meters” Surveys	6-20
6.8	Reported Changes in Travel Time After the Shutdown “Without Ramp Meters” Surveys	6-25
6.9	Reported Changes in Traffic Conditions After the Shutdown “Without Ramp Meters” Surveys.....	6-26
6.10	Distribution of Ramp Wait Times Among Metered Users “With Ramp Meters” Corridor and Random Sample Surveys.....	6-28
6.11	Average Ramp Wait Times Among Metered Users “With Ramp Meters” Corridor Surveys.....	6-29
6.12	Experience of Longer Ramp Wait Times	6-30
6.13	Maximum Willingness to Wait at a Ramp “With Ramp Meters” Corridor Surveys (N=507).....	6-31
6.14	General Attitudes Toward Travel “With Ramp Meters” Corridor Surveys (N=500).....	6-33

List of Figures (continued)

6.15	Attitudes Toward Ramp Metering “With Ramp Meters” Corridor Surveys (N=507).....	6-33
6.16	“With Ramp Meters/Without Ramp Meters” Wait Time Attributes and Need for Meters – N=906 for Corridor Surveys	6-37
6.17	Differences in “Some Meters May Not Be Necessary” for Corridor N=250 in Each Corridor and N=500 in the Random Sample.....	6-38
6.18	Differences in “Meters Shorten My Travel Time” for Corridor N=250 in Each Corridor and N=500 in the Random Sample.....	6-40
6.19	“Overall Satisfied With Meters” by Travel Time Market Segments N=903 in the Corridor Sample	6-41
6.20	“Meters Shorten My Time” by Travel Time Market Segments N=903 in the Corridor Sample	6-41
6.21	Future of Ramp Metering – Random Sample	6-43
6.22	Future of Ramp Metering – Corridor Sample.....	6-44
6.23	Future of Ramp Metering – Random Sample	6-44
6.24	Differences in Future of Ramp Metering by Total Travel Time “Without Ramp Meters” Corridor Surveys (N=508)	6-45
9.1	I-94 Eastbound Afternoon – Example of Freeway Traffic Volume Reduction and Earlier Departures	9-6
9.2	I-35E Southbound Morning – Example of Traffic Volume Reduction	9-6
9.3	I-494 Southbound Morning Speed – Example of Reduced Freeway Speed and Increased Speed Variability	9-8
9.4	Example of Increased Speed Variability (I-94 Corridor Location).....	9-9
9.5	Crash Occurrence in the “With Meters” and “Without Meters” Study Periods (for Metered Freeways in the Morning and Afternoon Peak Period.....	9-10
9.6	Reported Changes in Traffic Conditions After the Shutdown.....	9-15
9.7	Travelers’ View of the Future of Ramp Metering	9-16