# 5.0 Test Plan for Field Data Collection

# 5.0 Test Plan for Field Data Collection

Ramp meters throughout the entire system will be deactivated during the test. Collecting field data on the entire transportation system would require an extraordinary amount of resources. However, in order to make better use of evaluation resources and meet the demanding schedule requirements of the project, the evaluation team will instead focus field data collection on several select corridors that are representative of other corridors throughout the entire system. This data will then be extrapolated to the entire system.

The objective of the field data collection portion of this study is to measure the impacts of ramp metering on a host of transportation variables over different types of freeway corridors. The results of the information from this data collection will then be analyzed and applied to the entire metropolitan transportation system to derive the systemwide impacts of ramp metering. The results of the corridor-specific data collection and analysis will also be used to directly report the statistically valid effects of ramp metering on each corridor studied.

## ■ 5.1 Corridor Selection Process

The key to the approach of the evaluation is to select study corridors that are representative of most of the freeway corridors in the Twin Cities Metropolitan Area so that the results can be extrapolated to the entire freeway system. The first task in the corridor selection is to classify the Twin Cities Metropolitan Area freeways into four corridor types. Each freeway corridor type represents a number of freeway sections within Twin Cities Metropolitan Area. This "categorization" of freeway sections allows the CS team to extrapolate the measured impacts of the four study corridors to the rest of the Twin Cities Metropolitan Area freeway system to provide systemwide evaluation results.

The four basic types of freeway corridors are defined as follows:

- **Type A –** Freeway section representing the I-494/I-694 beltline, which has a high percentage of heavy commercial and recreational traffic. The commuter traffic on the corridor type is generally suburb-to-suburb commuters.

- **Type B –** Radial freeway outside the I-494/I-694 beltline with a major geographic constraint that does not allow for alternate routes (i.e., major freeway river crossing).

- **Type C –** Intercity connector freeway corridor that carries traffic moving between major business and commercial zones. This type of freeway has a fairly even directional split of traffic throughout the a.m. and p.m. peak periods.

- **Type D –** Radial freeway inside the I-494/I-694 beltline that carries traffic to/from a downtown or suburban work center.

Next, a three-step process is used to select the four study corridors. Process steps are listed below and defined in greater detail in the following pages:

1. Identify the corridor selection criteria;
2. Identify candidate corridors; and
3. Apply corridor selection criteria and select corridors to be studied.

### 5.1.1 Identify the Corridor Selection Criteria

In coordination with the Technical and Advisory Committees the CS team developed the criteria for corridor selection. The criteria account for the types of freeway corridors, philosophy for metering the different types of freeway corridors, variations in traffic demand on the corridors, lane drops, interchange or geometric constraints, ease of data collection, HOV facilities and transit services in the corridor, unmetered ramps along corridor, etc. The corridor selection criteria were ranked as shown in the following list, with the first four criteria being the primary criteria used for the initial corridor screening:

- Availability and type of alternate routes,
- Level of congestion,
- Geographic representation,
- Construction activity on freeway and alternate routes,
- HOV lanes and bypass ramps,
- Transit service on corridor,
- Geographic balance within the Twin Cities Metropolitan Area,
- Geometric constraints,
- Market segments,
- Geometric constraints, and
- Representative corridor length.

### 5.1.2 Identify Candidate Corridors

Mn/DOT had identified four sample test corridors in the project Request for Proposals (RFP). These corridors represented a good variation of traffic characteristics and ramp meter locations. The CS team applied the corridor selection criteria to freeway sections throughout the Twin Cities Metropolitan Area and identified an initial list of 11 freeway corridors that adequately met the primary selection criteria. These initial corridors are shown in Table 5.1.

Next, the CS team gathered detailed information on the 11 candidate corridors and applied the remaining corridor selection criteria to these corridors, resulting in the presentation of nine candidate freeway corridors for review by the Technical and Advisory Committees. The nine candidate corridors are shown in the map on Figure 5.1, and the attributes of the corridors are shown in Table 5.2.

### 5.1.3 Apply Corridor Selection Criteria and Select Corridors To Be Studied

The CS team presented the candidate corridors to the Technical and Advisory Committees and facilitated the discussion and final selection of the four corridors to be studied in detail. The four corridors selected for the study provide geographic balance with the Twin Cities Metropolitan Area. The four corridors selected for the study are shown in Figure 2 and described as follows:

1. **I-494 Corridor –** This corridor serves traffic from outside the Twin Cities Metropolitan Area and commuter traffic between the residential area north of the corridor and employment destinations to the south.

2. **I-35W Corridor –** This corridor serves commuter traffic between the residential communities south of the Minnesota River (e.g., Burnsville and Lakeville) and employment destinations north of the river.

3. **I-94 Corridor –** This corridor serves traffic demand between downtown Minneapolis and downtown St. Paul.

4. **I-35E Corridor –** This corridor serves commuter traffic between the northern residential communities and various employment destinations further south.

## 5.2 Field Data Collection Plan

The premise of the field data collection test plan is to measure the transportation system impacts of the ramp metering system in the Twin Cities Metropolitan Area. This task involves an extensive "with ramp metering" and "without ramp metering" traffic data collection program to address the impacts on traffic operations and safety by means of on-the-ground collection of empirical data about the metered and non-metered systems. To accomplish this, field data will be collected and evaluated with and without the ramp metering system in operation.

Traffic data will be collected at specific ramps and along selected corridors within the region over several weeks for both the "with" and "without" ramp metering evaluation scenario. Data collection will occur during a.m. and p.m. peak periods from Monday

## Table 5.1 Candidate Corridors for Ramp Meter Evaluation

| # | Type | Corridor | From | To | Length (miles) | Alternate Routes | Level of Congestion | Geographic Area |
|---|---|---|---|---|---|---|---|---|
| 1 | A | I-494 (NB) | Carlson Parkway | Weaver Lake Road | 8 | Vicksburg CR 61 | H - L | N.W. |
| | | I-494 (SB) | Weaver Lake Road | Carlson Parkway | 8 | Vicksburg CR 61 | M - L | |
| 2 | A | I-694 (WB) | I-35W | TH 252 | 4.5 | | M - L | North Central |
| | | I-694 (EB) | TH 252 | I-35W | 4.5 | | M - L | |
| 3 | B | TH 77 (NB) (a.m. only) | 140th St. | Old Shakopee Road | 6.8 | I-35W | H - L | South |
| 4 | B | I-35W (NB) (a.m. only) | Cty. Road 42 | 98th St. | 5 | TH 77 | High | South |
| 5 | C | I-94 (WB) | I-35E | I-394 | 10.9 | Univ. Ave. TH 36<br>Franklin Ave.<br>Lake St. – Marshall Ave. | H - L | Central |
| | | I-94 (EB) | I-394 | I-35E | 10.9 | Univ. Ave. TH 36<br>Franklin Ave.<br>Lake St. - Marshall Ave. | H - L | |
| 6 | D | I-394 (WB) | TAD | TH 101 | 11 | TH 55 | H - L | West Central |
| | | I-394 (EB) | TH 101 | TAD | 11 | TH 55 | H - L | |
| 7 | D | I-35E (NB) | I-694 | I-94 | 5.4 | Rice St. (TH 49)<br>Edgerton Ave. | M - L | East Central |
| | | I-35E (SB) | I-94 | I-694 | 5.4 | Rice St. (TH 49)<br>Edgerton Ave, | H - L | |
| 8 | D | I-35W (NB) | TH 36 | TH 10 | 7.4 | CR 77 | H - L | North Central |
| | | I-35W (SB) | TH 10 | TH 36 | 7.4 | CR 77 | H - L | |

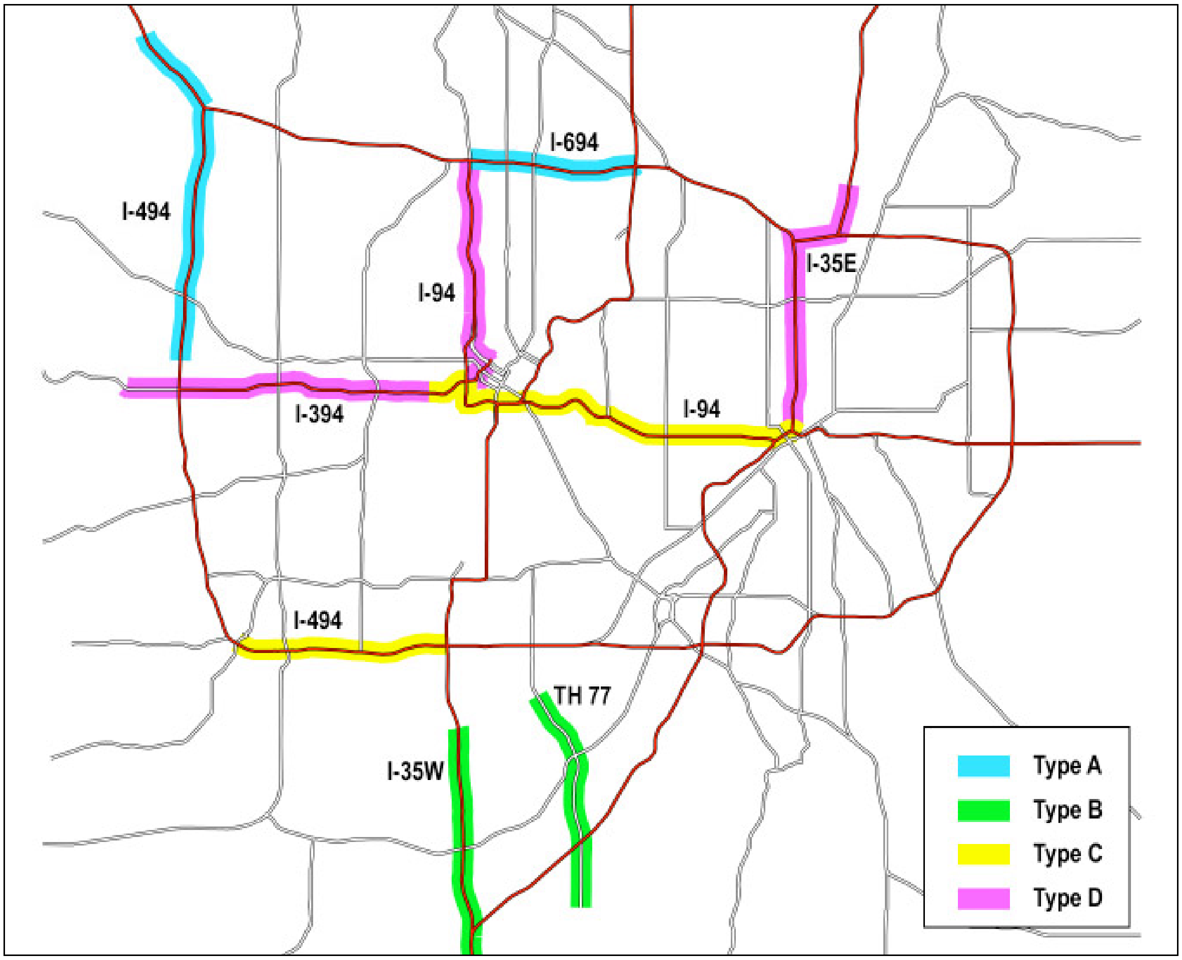
## Table 5.1 Candidate Corridors for Ramp Meter Evaluation (continued)

| # | Type | Corridor | From | To | Length (Miles) | Alternate Routes | Level of Congestion | Geographic Area |
|---|---|---|---|---|---|---|---|---|
| 9 | C | TH 100 (NB) | I-494 | I-394 (Glenwood) | 8 | France Ave.<br>TH 169 | H - L | S.W. |
| | | TH 100 (SB) | I-394 (Glenwood) | I-494 | 8 | France Ave.<br>TH 169 | H - L | |
| 10 | D | I-94 (WB) | I-394 | I-694 | 6.4 | Lyndale Central | Low | North Central |
| | | I-94 (EB) | I-694 | I-394 | 6.4 | Lyndale Central | Low | |
| 11 | C | I-494 (EB) | TH 212 | I-35W | 7 | TH 62 | High | S.W. |
| | | I-494 (WB) | I-35W | TH 212 | 7 | | High | |

**Key:**

| Freeway Type | Attributes |
|---|---|
| A | Freeway section representing the I-494/I-694 beltline, commuter, heavy commercial and recreational traffic (suburb-to-suburb). |
| B | Radial freeway outside the beltline, major geometric constraint (e.g., river bridge) presenting limited alternate routes. |
| C | Intercity connector. |
| D | Radial freeway. |

## Figure 5.1 Candidate Corridors for Ramp Meter Evaluation



## Table 5.2 Candidate Corridors for Ramp Meter Evaluation Versus Selection Criteria

| No. | Type | Corridor | From | To | Length (Miles) | Alternate Routes | Level of Congestion | Geographic Area |
|---|---|---|---|---|---|---|---|---|
| 1 | A | I-494 (NB) | Carlson Parkway | I-94/C.R. 30 | 9 | Vicksburg CR 61 | H - L | N.W. |
| | | I-494 (SB) | I-94/C.R. 30 | Carlson Parkway | 9 | Vicksburg CR 61 | M - L | |
| 2 | A | I-694 (WB) | I-35W | TH 252 | 4.5 | | M - L | North Central |
| | | I-694 (EB) | TH 252 | I-35W | 4.5 | | M - L | |
| 3 | B | TH 77 (NB) (a.m. only) | C.R. 38 – 140th St. | Old Shakopee Road | 6.8 | I-35W | H - L | South |
| 4 | B | I-35W (NB) (a.m. only) | C.R. 46 | 98th St. | 6 | TH 77 | High | South |
| 5 | C | I-94 (WB) | I-35E & Mounds | I-394/Penn. | 12 | Univ. Ave. Lake-Marshall | H - L | Central |
| | | I-94 (EB) | I-394/Penn. | I-35E & Mounds | 12 | Univ. Ave. Lake-Marshall | H - L | |
| 6 | C | I-494 (EB) | TH 212 | I-35W | 7 | TH 62 | High | S.W. |
| | | I-494 (WB) | I-35W | TH 212 | 7 | | High | |
| 7 | D | I-394 (WB) | TAD | C.R. 101 | 11 | TH 55 TH 7 | H - L | West Central |
| | | I-394 (EB) | C.R. 101 | TAD | 11 | TH 55 TH 7 | H - L | |
| 8 | D | I-94 (WB) | I-394 | I-694 | 6.4 | Lyndale Central | Low | North Central |
| | | I-94 (EB) | I-694 | I-394 | 6.4 | Lyndale Central | Low | |
| 9 | D | I-35E (NB) | C.R. 96 | I-94 | 6.5 | Rice St. (TH 49) Edgerton Ave. | M - L | East Central |
| | | I-35E (SB) | I-94 | I-694 | 6.5 | Rice St. (TH 49) Edgerton Ave, | H - L | |

## Table 5.2 Candidate Corridors for Ramp Meter Evaluation Versus Selection Criteria (continued)

| No. | Type | Corridor | ADT | Traffic Type | No. of Lanes | HOV Lanes/ Ramps | Geometric Constraints | Transit Route | No. of Metered Ramps |
|---|---|---|---|---|---|---|---|---|---|
| 1 | A | I-494 (NB) | 48,500 | Commuter Recreational HC (7%) | 2 | 2 Bypass ramps | Steep Grades Auxiliary Lanes | Minor | 5 |
| | | I-494 (SB) | 48,500 | Commuter Recreational HC (7%) | 2 | 3 Bypass ramps | Steep Grades Auxiliary Lanes | Minor | 5 |
| 2 | A | I-694 (WB) | 80,000 | Commuter Recreational HC (7%) | 3 | Bypass ramps | Auxiliary Lanes | Minor | 9 |
| | | I-694 (EB) | 80,000 | Commuter Recreational HC (7%) | 3 | Bypass ramps | Auxiliary Lanes | Minor | 10 |
| 3 | B | TH 77 (NB) (a.m. only) | 48,500 | Commuter HC (2.5%) | 3 | Bypass at every ramp | River Crossing | MVTA Major No AVL Buses | 6 |
| 4 | B | I-35W (NB) (a.m. only) | 51,500 | Commuter HC (6.7%) | 2 + HOV | HOV Lanes + 3 bypasses | River Crossing | Major No AVL Buses | 5 |
| 5 | C | I-94 (WB) | 128,500 | Commuter HC(5.7%) | 3 | Bypass ramps | Tunnel River Bridge | Major | 13 |
| | | I-94 (EB) | 128,500 | Commuter HC(5.7%) | 3 | Bypass ramps | Tunnel River Bridge | Major | 12 |
| 6 | C | I-494 (EB) | | | 2 - 3 | 3 Bypass ramps | | | 10 |
| | | I-494 (WB) | | | 2 - 3 | 2 Bypass ramps | | | 8 |
| 7 | D | I-394 (WB) | 74,000 | Commuter HC (3.2%) | 2 3 | HOV lanes + 5 Ramps | Bottleneck | Major | 16 |
| | | I-394 (EB) | 74,000 | Commuter HC (3.2%) | 2 3 | HOV Lanes + 10 ramps | Bottleneck | Major | 13 |
| 8 | D | I-94 (WB) | 63,000 | Commuter HC (3.8%) | 4 | 2 Bypass ramps | Auxiliary Lanes | Major | 3 |
| | | I-94 (EB) | 63,000 | Commuter HC (3.8%) | 4 | 2 Bypass ramps | Auxiliary Lanes | Major | 5 |

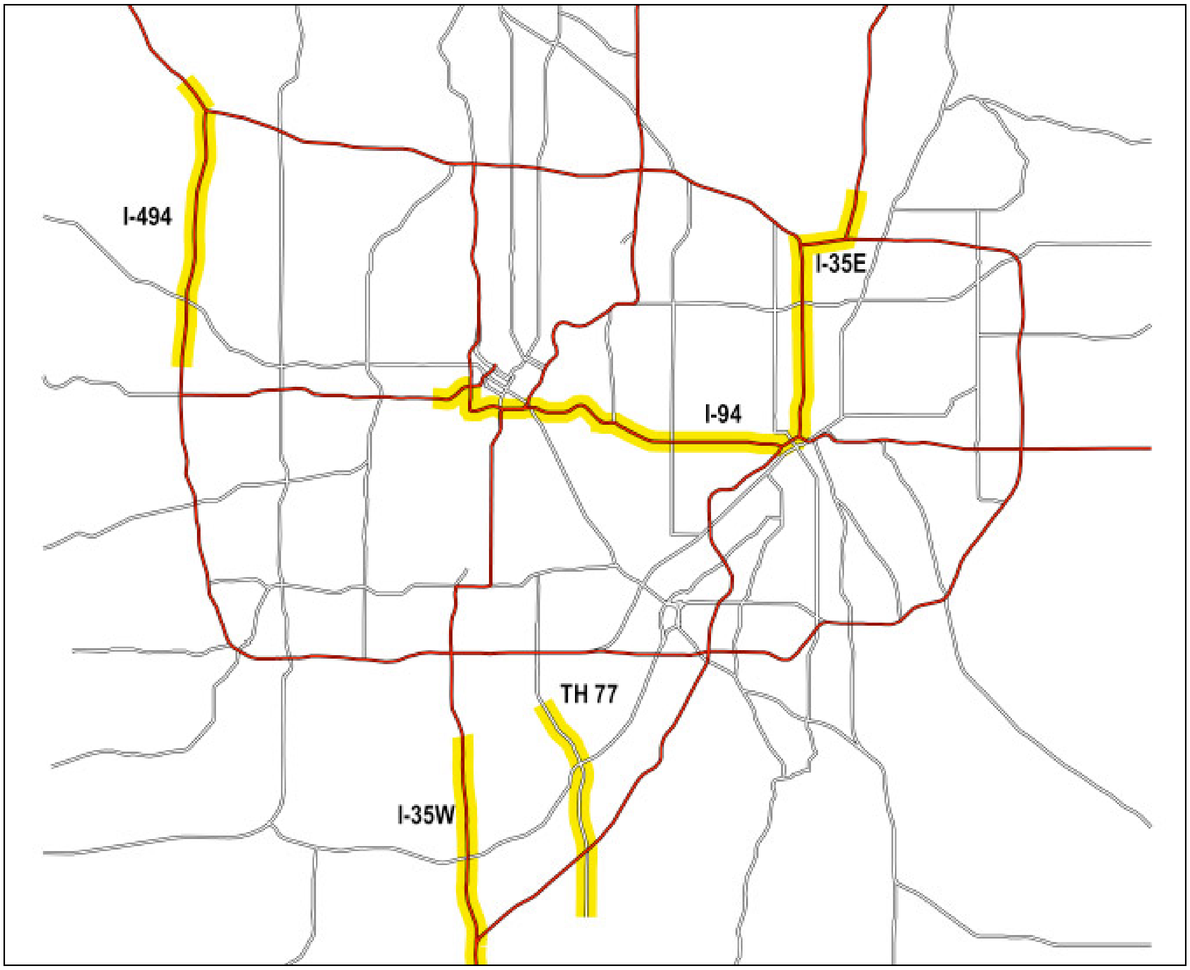
## Table 5.2 Candidate Corridors for Ramp Meter Evaluation Versus Selection Criteria (continued)

| No. | Type | Corridor | ADT | Traffic Type | No. of Lanes | HOV Lanes/ Ramps | Geometric Constraints | Transit Route | No. of Metered Ramps |
|---|---|---|---|---|---|---|---|---|---|
| 9 | D | I-35E (NB) | 62,500 | Commuter HC (4.3%) | 3 | 1 Bypass ramp & shoulder lanes | | Minor | 9 |
| | | I-35E (SB) | 62,500 | Commuter HC (4.3%) | 3 | No bypass ramps – shoulder lanes | | Minor | 6 |

**Key:**

| Freeway Type | Attributes |
|---|---|
| A | Freeway section representing the I-494/I-694 beltline, commuter, heavy commercial and recreational traffic (suburb-to-suburb). |
| B | Radial freeway outside the beltline, major geometric constraint (e.g., river bridge) presenting limited alternate routes. |
| C | Intercity connector with even directional split. |
| D | Radial freeway inside the beltline. |

## Figure 5.2 Twin Cities Corridors Selected for Detailed Evaluation



through Friday of the evaluation period. Subsets will be created for Monday and Friday data and for Tuesday through Thursday data. The Tuesday through Thursday data are the primary data collection days, and will be used to provide statistically valid data. Travel time data will be collected during the morning and afternoon peak periods for approximately 3.5 hours per peak period. Ramp operational studies will be conducted during hours the ramps are metered; this varies depending on the particular ramp.

### 5.2.1 Field Data Collection Schedule

A preliminary field data collection schedule is shown in Table 5.3. The schedule applies to those elements of the data collection which will be implemented by the consultant team during the course of the evaluation period, including ramp observations in which specific ramps will be monitored, floating car studies in which travel times across specific corridors are measured, and traffic flow data will be collected along alternate routes by means of tube counts. This schedule applies to both the "with" and "without" ramp metering conditions. Other data will be supplied by the routine automated data collection systems used by Mn/DOT to monitor traffic flow, such as freeway loop detectors. These systems are always in operation and Mn/DOT will provide the data from these systems to the consultant team for analysis.

**Table 5.3 Field Data Collection Schedule**

| | Travel Time Data Collection | | | | | Volume and Ramp Study |
|---|---|---|---|---|---|---|
| **Week of:** | **Monday** | **Tuesday** | **Wednesday** | **Thursday** | **Friday** | |
| Sept. 11 | I-494 | I-35W | I-494 | I-35W | I-494 | I-494 |
| Sept. 18 | I-35E | I-94 | I-35E | I-94 | I-35E | I-35E |
| Sept. 25 | I-35W | I-494 | I-35W | I-494 | I-35W | I-35W |
| Oct. 2 | I-94 | I-35E | I-94 | I-35E | I-94 | I-94 |
| Oct. 9 (1) | | | | | | |
| Oct. 16 (2) | I-94 | I-94 | I-94 | I-94 | I-94 | I-94 |
| Oct. 23 | I-494 | I-35W | I-494 | I-35W | I-494 | I-494 |
| Oct. 30 | I-35E | I-94 | I-35E | I-94 | I-35E | I-35E |
| Nov. 6 | I-35W | I-494 | I-35W | I-494 | I-35W | I-35W |
| Nov. 13 | I-94 | I-35E | I-94 | I-35E | I-94 | I-94 |

**Notes:**

1. On October 9 the public will be notified that the ramp meters will be shutoff beginning October 16. No data will be collected this week.
2. On October 16 the ramp meters will be shutoff. Data collection will be concentrated on I-94 during this week, and repeated along this corridor during the last week of the evaluation so that traveler behavioral change over the course of the ramp meter deactivation period can be assessed.

### 5.2.2 Evaluation Objectives

The following five objectives will be used to evaluate and quantify the transportation system impacts with and without the ramp metering system:

- Assess traffic flow impacts;
- Assess travel time impacts;
- Assess ramp impacts;
- Assess safety impacts; and
- Assess transit impacts.

Specific measures of effectiveness and their corresponding data sources are presented for each of the five evaluation objectives supporting this test plan in the sections that follow.

#### *5.2.2.1 Objective 1: Assess Traffic Flow Impacts*

This evaluation objective will examine the traffic flow impacts of the ramp metering system. Traffic volume and occupancy data from freeway mainline detector stations and volume data from alternate routes will be collected. Two different data collection methods will be used including existing freeway loop detectors and portable counting devices (road tubes). Further detail on each type of data and data source is provided below.

##### 5.2.2.1.1 Freeway Mainline Traffic Volume and Occupancy

Data from the Mn/DOT Traffic Management Center (TMC) freeway loop detector stations will be collected along each of the corridors under evaluation. The following information pertains to freeway data:

1. Sample size:
   - Thirty-second traffic volume data per lane, 24-hours per day;
   - Data aggregated to 15-minute periods during the four-hour a.m. and four-hour p.m. peak periods;
   - Four-hour peak periods selected to allow analysis of any peak-period spreading;
   - Data aggregated to daily totals;
   - Five days of data per week (Monday through Friday):
     - Monday and Friday (subset); and
     - Tuesday through Thursday (primary data subset).
   - Data will be collected from the detector stations within the corridor study limits.

2. Assumptions:
   - Mn/DOT TMC detector count data will be available;
   - Mn/DOT Maintenance will have the majority of detectors on study corridors operational at the beginning of the test, and will maintain them in operation throughout the test period;
   - Not all mainline detector counts are needed for the study;
   - Detector data can be downloaded remotely/electronically; and
   - Evaluator will run a daily automated check of the data.
3. Data collection methods and tools:
   - Mn/DOT TMC will download detector data files to SRF FTP site; and
   - Spreadsheet and/or database will be used to process data.

**5.2.2.1.2 Alternate Route Traffic Volume –** Road tubes will be used to collect traffic volume data along each of the arterial corridors under evaluation. The following information pertains to alternate route data:

1. Sample size:
   - Fifteen-minute volumes per lane during the four-hour a.m. and four-hour p.m. peak periods;
   - Daily volume totals; and
   - Five days of data per week (Monday through Friday):
     - Monday and Friday (subset); and
     - Tuesday through Thursday (subset).
2. Assumptions:
   - Collect data on arterial routes during the same period as the corresponding freeway route; and
   - Backup data collection will be done via spare portable counters and/or manual counts.
3. Data collection methods and tools:
   - Road tubes; and
   - Spreadsheet and/or database will be used to process data.

### *5.2.2.2 Objective 2: Assess Travel Time Impacts*

This evaluation objective will examine the travel time impacts of the ramp metering system. A statistically significant sample of actual running speeds over the four freeway corridors and corresponding alternate routes will be collected. Travel times and distances will be recorded from probe vehicles driven along the corridor by members of the evaluation team. The floating car method will be used, whereby the probe vehicle driver estimates the median speed of the traffic flow by passing and being passed by an equal number of vehicles.

Four Geographic Positioning System (GPS)-equipped vehicles will be used to capture the travel time profiles at discrete intervals. One GPS-equipped vehicle will be used on each freeway (and alternate route) corridor. Three additional vehicles will be equipped with traditional distance measuring instruments (Jamar) to gain enough travel time data to produce results meeting a 95 percent confidence interval. The specified error will be +/-two mph for freeways, and +/-one mph on the alternate routes. Data will be collected in both directions of travel along the corridor.

The travel time runs for two corridors, I-494 and I-35E, will have a start and end point that represents a "virtual" home to work trip. This will allow the CS team to plot the sample travel time data on a map, providing a useful tool for conveying the travel time data to the public.

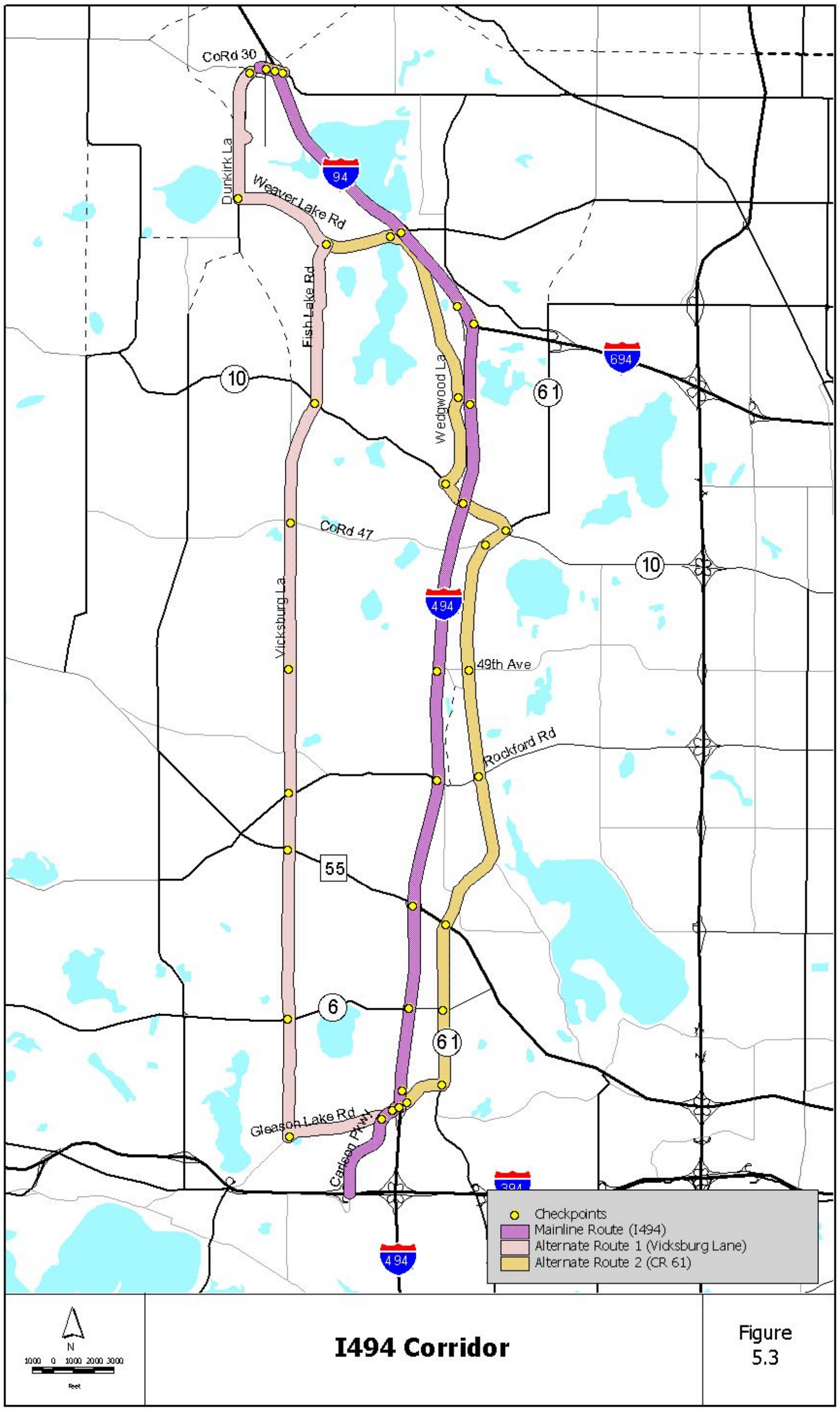
In selecting the alternate route travel time, traffic flow patterns were examined to identify routes that would be used during periods of congestion on the freeway. An overview of the travel time routes along each of the corridors is provided below:

- **I-494 Corridor –** This corridor serves traffic coming from outside the Twin Cities Metropolitan Area, as well as commuter traffic between the residential area on the north end of the corridor and employment destinations on the southern end. Travel time runs will be conducted between I-94/County Road 30 in Maple Grove and the Carlson Towers in Minnetonka. Traffic flow has a directional split with southbound congestion occurring in the a.m. peak period and northbound congestion occurring in the p.m. peak period. There are two alternate routes for this corridor. To the west of I-494 Vicksburg Lane, Weaver Lake Road and Dunkirk Lane are used between I-94/County Road 30 and Carlson Parkway. Various roadways (mainly County Road 61) are used for the route primarily to the east of I-494 between I-94/County Road 30 and Carlson Parkway. This corridor is shown in Figure 5.3.

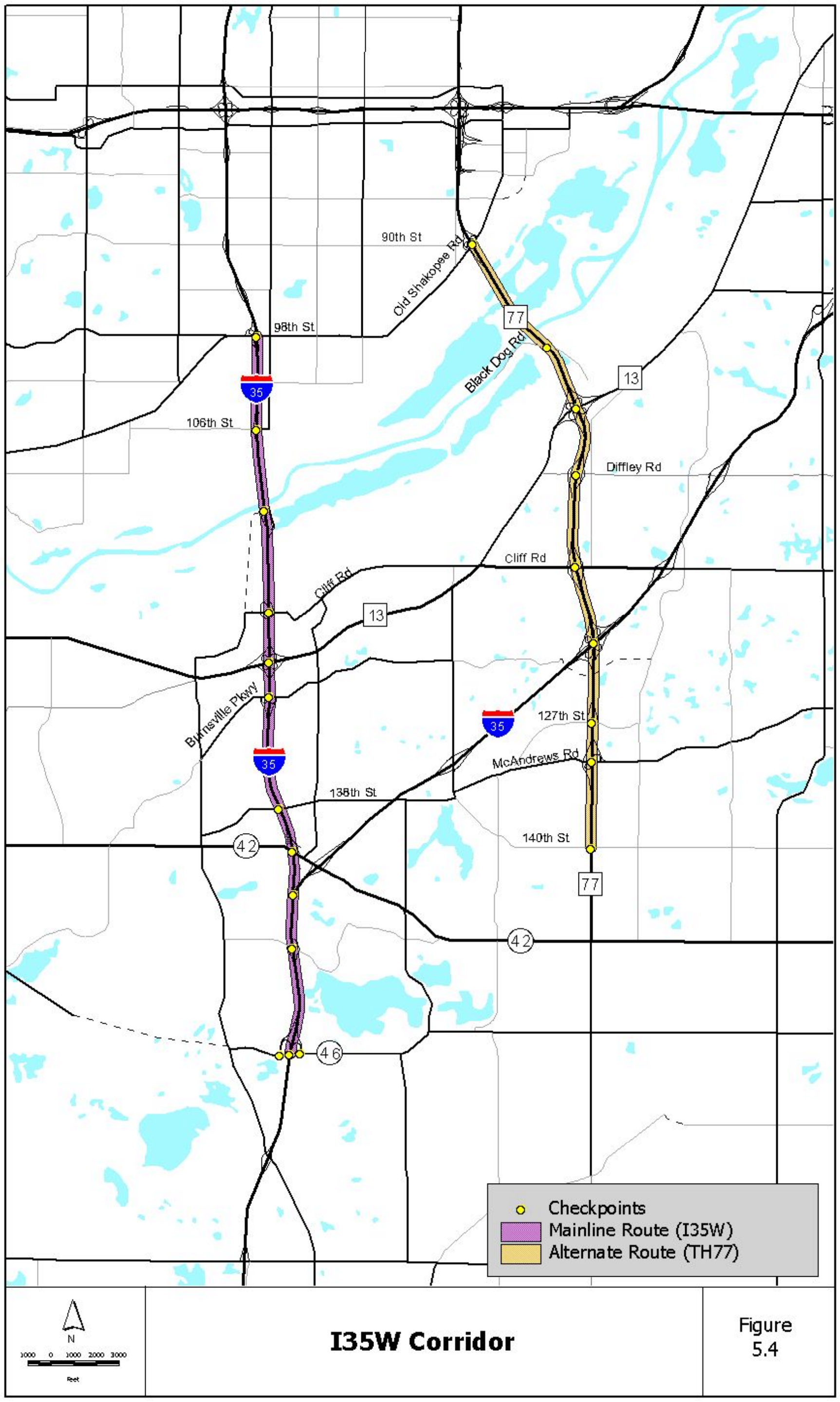
- **I-35W Corridor –** This corridor serves commuter traffic between the residential communities south of the Minnesota River (e.g., Burnsville and Lakeville) and employment destinations north of the river. Travel time runs will be conducted between Old Shakopee Road in Bloomington and County Road 46 (162nd Street West) in Lakeville. Traffic flow has a heavy directional split with northbound congestion occurring in the a.m. peak period. Data will only be collected in the northbound (a.m. period) along this route. The Minnesota River crossing creates a bottleneck in this corridor. The alternate route for this corridor is Trunk Highway (TH) 77 between Old Shakopee Road in Bloomington and County Road 38/140th Street in Apple Valley. This corridor is shown in Figure 5.4.

- **I-94 Corridor –** This corridor serves traffic demand between downtown Minneapolis and downtown St. Paul. The western end of the travel time runs will pass through the Lowry Hill Tunnel with a turn-around made via I-394 and Penn Avenue in Minneapolis. The eastern turn-around will be at Mounds Boulevard in St. Paul. Traffic flow is primarily bi-directional with congestion experienced in both directions during both the

## Figure 5.3 I-494 Corridor



## Figure 5.4 I-35W Corridor



morning and afternoon peak periods. There are two alternate routes for this corridor. To the north of I-94, University and Washington Avenue are used between Cedar Avenue in Minneapolis and Mounds Boulevard in St. Paul. To the south of I-94, Franklin, West River Parkway and Marshall Avenue are used between Cedar Avenue in Minneapolis and Rice Street/University Avenue in St. Paul. This corridor is shown in Figure 5.5.

- **I-35E Corridor –** This corridor serves commuter traffic between the northern residential communities and various employment destinations further south. Travel time runs will be conducted between County Road 96 in White Bear Lake and Wacouta Street in downtown St. Paul. Traffic flow has a directional split with southbound congestion occurring in the a.m. peak period and northbound congestion occurring in the p.m. peak period. There are two alternate routes for this corridor. To the west of I-35E, Rice Street (TH 49) is used between County Road 96 and University Avenue. Primarily to the east of I-35E, Edgerton Street and Centerville Road are used between County Road 96 and 7th Street West in downtown St. Paul. This corridor is shown on Figure 5.6.

Further detail on the travel time data collection approach is provided below.

1. Sample size:
   - The first step in determining the sample size is to identify the desired level of accuracy. The bounds of statistical error vary depending on the application; examples are listed below based on the Institute of Transportation Engineers (ITE) Traffic Engineering Manual – Page 95:
     - Transportation planning applications typically allow for speed data accuracy of +/-three mph to +/-five mph;
     - Traffic operations applications typically allow for speed data accuracy of +/-two mph to +/-four mph; and
     - Before and after evaluation studies typically allow for speed data accuracy of +/-one mph to +/-three mph.
   - A Confidence Interval of 95 percent is typically used for traffic studies (source ITE Traffic Engineering Manual – Page 96); and
   - Based on the information presented above and in the list of assumptions below, a sample size of 21 travel time runs in the a.m. period and 21 runs in the p.m. will be required in order to obtain a statistically significant sample size.
2. Assumptions:
   - Corridors range from approximately six to 12 miles in length;
   - Four-hour morning period is 5:00 to 9:00 a.m.;
   - Four-hour afternoon period is 3:00 to 7:00 p.m.;
   - Data will be collected Monday through Friday:
     - Monday and Friday (subset); and
     - Tuesday through Thursday (subset).

## Figure 5.5 I-94 Corridor

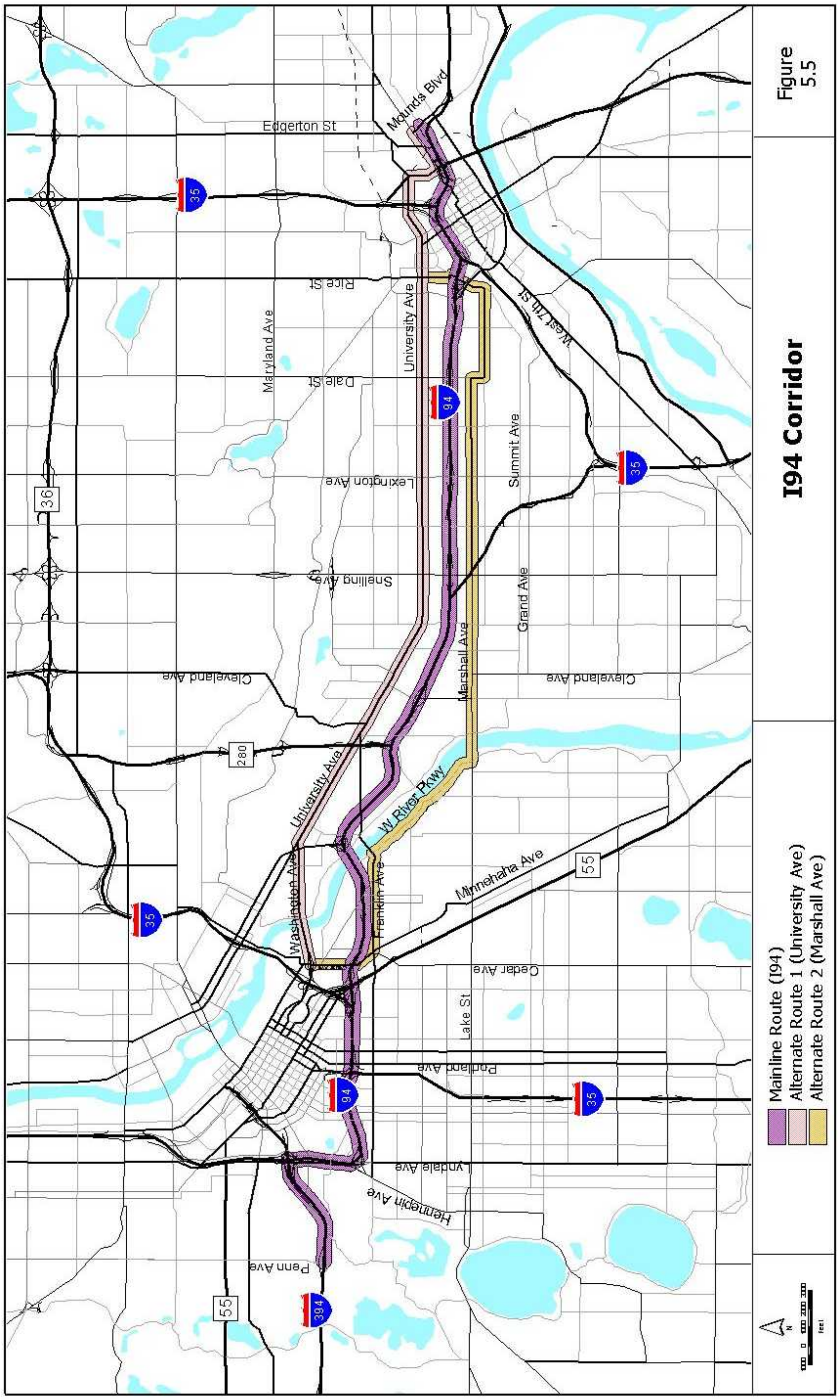
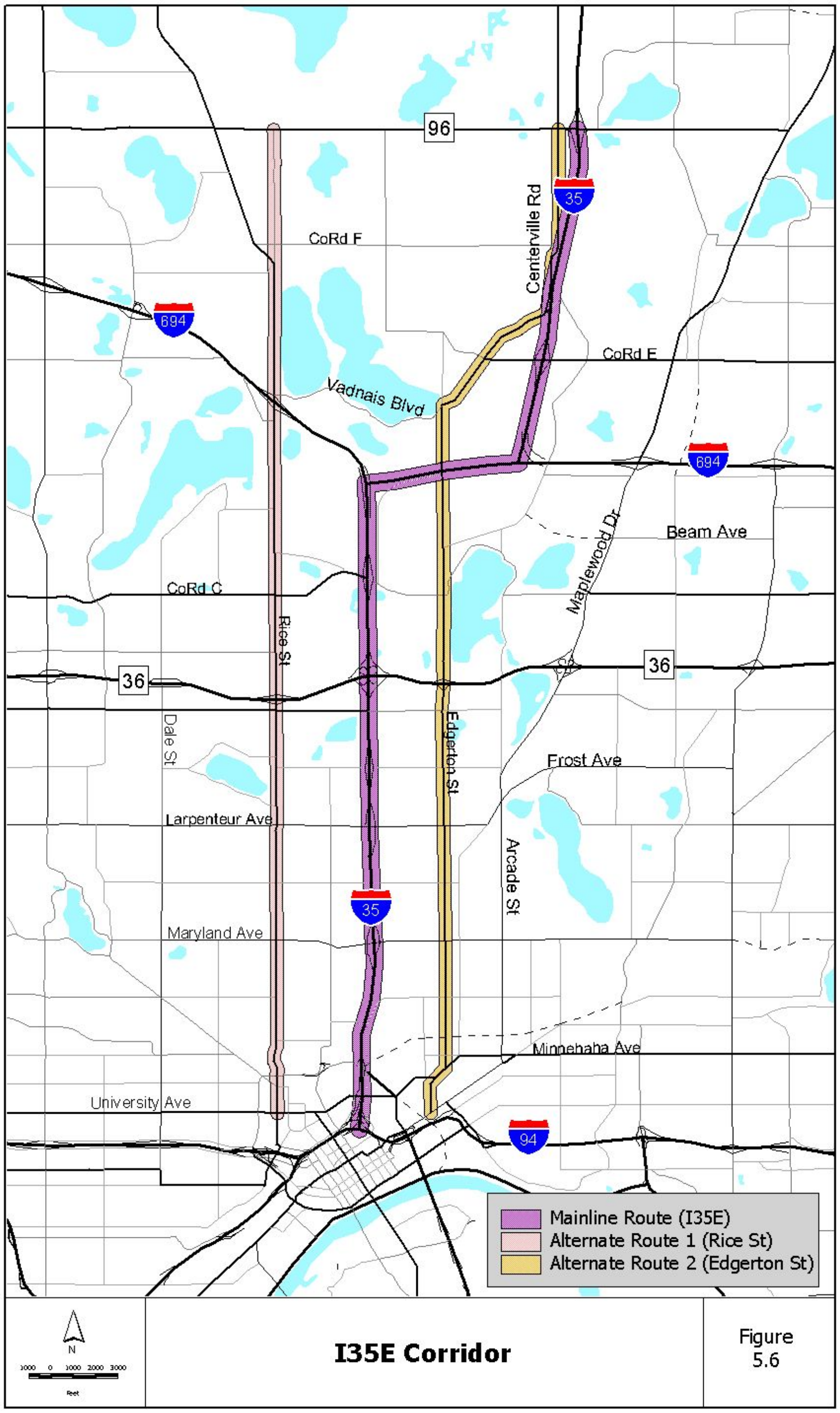


**Figure 5.6 I-35E Corridor**



- Four weeks with ramp metering and four weeks without;
- Average one run per hour;
- Average freeway speed will vary more than 20 mph between runs;
- Average alternate route speed will vary 10 mph between runs;
- Bound on error of +/-two mph for average freeway speed; and
- Bound on error of +/-one mph for average alternate route speed.

3. Data collection methods and tools:
   - Floating Car Method will be used to collect travel time data. With this method the probe vehicle driver estimates the median speed by passing and being passed by an equal number of vehicles.
   - GPS data collection will be used to collect travel time data in four of the probe vehicles
   - Jamar™ equipment data collection will be used to collect travel time data in three of the probe vehicles. Note that one of the vehicles will be equipped with both GPS and Jamar™ equipment in order to compare the two data collection methods. Therefore a total of six probe vehicles are available.
   - Travel time data will be collected in both the peak and non-peak direction.
   - Probe vehicle drivers will record weather, pavement conditions, light conditions, construction activity, and incidents; this will enable the isolation of anomalous data which might result from a day of severe weather, or the short-term effects of the start of standard time at the end of October which falls in the middle of the "without meters" evaluation period.

#### *5.2.2.3 Objective 3: Assess Ramp Impacts*

A variety of techniques will be used to assess the operational impact of ramp metering at freeway on-ramps. Ramp volume data (ramp merge detector data) and ramp meter turn-on times are readily available from the TMC system. Data will be collected from the ramps listed in Table 5.4.

1. Sample size:
   - Collect data for every ramp within the defined test corridors;
   - Five days of peak-period counts per site; and
   - All data will be collected in 15-minute intervals.
2. Assumptions:
   - Visual observation of ramp from persons in-field; and
   - Field observer will record ramp meter start-up/shut-off time.

## Table 5.4. Ramps Selected for Manual Field Data Collection

| Corridor | Ramp Description | A.M. Period | P.M. Period | Both Periods |
|---|---|---|---|---|
| **I-494 Corridor** | Weaver Lake Road to eastbound I-94 | X | | |
| | Bass Lake Road to northbound I-494 | | X | |
| | Bass Lake Road to southbound I-494 | X | | |
| | Rockford Road to northbound I-494 | | X | |
| | Rockford Road to southbound I-494 | X | | |
| | TH 55 to northbound I-494 | | X | |
| | TH 55 to southbound I-494 | X | | |
| | County Road 6 to northbound I-494 | | X | |
| | County Road 6 to southbound I-494 | X | | |
| | Carlson Parkway to northbound I-494 | | X | |
| **I-35W Corridor** | County Road 42 to northbound 35W | X | | |
| | Burnsville Parkway to northbound 35W | X | | |
| | Eastbound TH 13 to northbound 35W | X | | |
| | Westbound TH 13 to northbound 35W | X | | |
| | Cliff Road to northbound 35W | X | | |
| | 106th Street to northbound 35W | X | | |
| **I-94 Corridor** | Hennepin Avenue to eastbound 94 | | | X |
| | Lyndale Avenue to eastbound 94 | | | X |
| | 5th Avenue to eastbound 94 | | X | |
| | 6th Street to eastbound 94 | | X | |
| | Cedar Avenue to eastbound 94 | | X | |
| | Riverside Avenue to eastbound 94 | | X | |
| | Huron Street to eastbound 94 | | X | |
| | Cretin Avenue to eastbound 94 | | X | |
| | Snelling Avenue to eastbound 94 | | X | |
| | Lexington Parkway to eastbound 94 | | X | |
| | Dale Street to eastbound 94 | | X | |
| | Marion Street to eastbound 94 | | X | |
| | Jackson Street to eastbound 94 | | X | |
| | Broadway Street to eastbound 94 | | X | |
| | Mounds Boulevard to westbound 94 | | | X |
| | University Avenue to westbound 94 | | | X |
| | 12th Street/Wabasha to westbound 94 | | | X |
| | Marion Street to westbound 94 | | | X |
| | Dale Street to westbound 94 | | | X |
| | Lexington Parkway to westbound 94 | | | X |
| | Snelling Avenue to westbound 94 | | | X |
| | Vandalia Street to westbound 94 | | | X |
| | Highway 280 to westbound 94 | | | X |

**Table 5.4. Ramps Selected for Manual Field Data Collection (continued)**

| Corridor | Ramp Description | A.M. Period | P.M. Period | Both Periods |
|---|---|---|---|---|
| | Huron Street to westbound 94 | | | X |
| | 25th Avenue to westbound 94 | | | X |
| | Hiawatha Avenue to westbound 94 | | | X |
| | 35W to westbound 94 | | | X |
| | 4th Avenue to westbound 94 | | | X |
| **I-35E Corridor** | Broadway Street to northbound 35E | | X | |
| | Pennsylvania Avenue to northbound 35E | | X | |
| | Maryland Avenue to northbound 35E | | X | |
| | Larpenteur Avenue to northbound 35E | | X | |
| | Roselawn Avenue to northbound 35E | | X | |
| | Eastbound Highway 36 to northbound 35E | | X | |
| | Westbound Highway 36 to northbound 35E | | X | |
| | Little Canada Road to northbound 35E | | X | |
| | Little Canada Road to southbound 35E | X | | |
| | Westbound highway 36 to southbound 35E | X | | |
| | Eastbound highway 36 to southbound 35E | X | | |
| | Roselawn Avenue to southbound 35E | X | | |
| | Wheelock Parkway to southbound 35E | X | | |
| | Maryland Avenue to southbound 35E | X | | |

### 5.2.2.3.1 Ramp Queue Length and Delay

Manual field observations will be used to collect ramp queue length and delay data. The following information pertains to this data collection effort:

Data collection methods and tools:

- Jamar equipment to record when vehicles enter and when vehicles exit the ramp queue. Two observers will be required per ramp:
  - First observer will record vehicles entering ramp queue. (This observer will also note the time that the ramp queue backs into the intersection, see Section 5.2.2.3.4.)
  - Second observer will record vehicles exiting the ramp queue. (This observer will also record the number of ramp meter violators, see Section 5.2.2.3.2.)
- Jamar software will be used to calculate queue length and vehicle delay at the ramp.

#### 5.2.2.3.2 HOV Lane Usage and Ramp Meter Violations

Manual field observations will be used to collect ramp meter violations. The same observer that is recording the number of vehicles exiting the ramp queue will count the number of violators.

TMC loop detector station data will be used to obtain the number of vehicles using the ramp's HOV bypass (it should be noted that even after the meters are shut off, there may still be some travel advantage in using the HOV bypasses at certain locations).

#### 5.2.2.3.3 Frequency of the Ramp Queue Backing into Intersection

Manual field observations will be made to measure the length of time that a ramp queue backs into the adjacent intersection. The following information pertains to this data collection effort:

Data collection methods and tools:

- The same observer that is counting the number of vehicles entering the ramp queue will note the occurrences of ramp queues backing into the intersection.

#### 5.2.2.3.4 Quality of Merge

Traffic volumes and average traffic speeds will be analyzed to determine the quality of traffic merging onto the freeway. Approximate traffic speeds will be calculated from the freeway occupancy data. As a reasonableness check, the occupancy-derived speeds will be compared to the speeds captured during the travel time runs. The volume and speed data will be used to assess the "quality of merge" at each of the on-ramps along the corridor. In addition, the freeway volumes can be analyzed on a lane-by-lane basis; an even distribution of volumes across all lanes suggests a higher quality of merge. The following information pertains to this data collection effort:

Data collection methods and tools:

- TMC entrance ramp volumes and occupancy (15-minute intervals);
- TMC mainline detector volumes and occupancy (upstream and downstream of ramp, lane-by-lane in 15-minute intervals)
- Collect data during same periods and locations as the ramp queue delay study.

### *5.2.2.4 Objective 4: Assess Safety Impacts*

This evaluation objective will examine the safety impacts of the ramp metering system. The TMC incident logs will be reviewed to collect the number and duration of incidents on those freeway corridors selected for evaluation. In addition, the automated Mn/DOT crash log system will be reviewed to collect the number of crashes within the Twin Cities Metropolitan Area. This data will be used to directly measure the number of crashes in the "with ramp metering" and "without ramp metering" condition on a systemwide basis. In addition, historical crash data will be collected and analyzed as described below.

1. Sample size:
   - Collect TMC incident log data along corridors within study area;
   - TMC documents number and duration of incidents on freeways that are monitored by the traffic management system;
   - One-month lag time before incident logs are recorded in the database;
   - Collect metro-wide crash data from Mn/DOT's automated crash log system;
   - Four to six-week lag time before crash records are in the database;
   - "With ramp metering" four-week period data available early December;
   - "Without ramp metering" four-week period data available early January;
   - Collect crash data for entire freeway system;
   - Collect historical crash data;
   - Previous two years; and
   - Do not include data from ramps if metering was implemented within the two-year period.
2. Tools:
   - TMC incident log for four study corridors; and
   - Mn/DOT crash log system for full Twin Cities Metropolitan Area.
3. Analysis:
   - Separate data by freeway and parallel arterial segment;
   - Separate data for metered vs. unmetered freeways;
   - Identify crashes by type (rear-end, side-swipe, etc.);
   - Separate data by crash severity (PDO, injury, fatality);
   - Separate data by time of day: Crash data while meters are in operation versus data in the off-peak, while meters are off-line;
   - If possible separate data by speed range and level of congestion (allows correlation between congestion and number of crashes);
   - Ramps – examine data for ramp segments before and after meter; and
   - Arterials – examine data for cities that have freeway segments with ramp metering or diversion routes.

#### *5.2.2.5 Objective 5: Assess Transit Impacts*

This objective examines the impacts to transit caused by the ramp metering system. Numerous data sources will be used and performance measures will be collected. No transit data will be collected on the I-494 Corridor due to a lack of suburb-to-suburb transit service.

#### 5.2.2.5.1 Transit Vehicle Travel Times

Transit vehicle travel times will be collected on a sample of transit routes running on the mainline and alternate travel routes on two to three of the four selected corridors. Travel time data collection has been confirmed for I-94 and I-35E. Discussions are underway with Metro Transit and Minnesota Valley Transit Authority as to their resource availability and willingness to provide travel times on I-35W.

Travel times on the following sample of routes will be collected over a one-week period.

| I-94 Corridor | I-35E Corridor | I-35W Corridor |
|---|---|---|
| 94BCD | 35ABC | 35MNRTV |
| 16 | 270 | 37W |
| 21 | 271 | 431 |
| 50 | 860 | 77PSV |
| | 210 | 77AST |
| | 212 | 442 |
| | 213 | |

Metro Transit will use AVL-equipped buses to collect this data on I-94. Metropolitan Council will use radio checks and field observations to collect this data on I-35E. Minnesota Valley Transit Authority will use radio checks to collect this data on I-35W.

1. Sample size:
   - A sampling of transit routes on the mainline and/or alternate travel routes within three of the four selected corridors;
   - Sample selection is dependent upon the availability of AVL-equipped transit vehicles or transit provider provided data collection personnel;
   - Selected routes are subject to change based upon data availability;
   - Transit vehicle travel times while within the corridor;
   - The a.m. and p.m. peak periods; and
   - Travel time data will be collected for one week within each of the three selected corridors.
2. Assumptions:
   - Request that Metro Transit use selected transit routes, to the extent possible, with AVL-equipped transit vehicles; and

- Request that Metro Transit and the Metropolitan Council provide personnel to conduct manual collection of travel time data on corridors lacking sufficient coverage of AVL-equipped transit vehicles.

3. Data collection methods and tools:
   - AVL-equipped transit vehicles;
   - Manual data collection; and
   - Extent of data collection to be determined by Metro Transit and other metro area transit providers.

#### 5.2.2.5.2 Transit Ridership

Transit ridership data will be collected on a sample of transit routes running on the mainline and alternate travel routes on three of the four selected corridors. Ridership data collection has been confirmed for I-94, I-35E, and I-35W.

Ridership on the following sample of routes will be collected over a four-week period during the before period and a five-week period during the during period.

| I-94 Corridor | I-35E Corridor | I-35W Corridor |
|---|---|---|
| 94BCDJL | 35ABC | 35MNRTV |
| 353 | 270 | 37W |
| 355 | 271 | 431 |
| 95MU | 860 | 77PSV |
| 16 | 210 | 77AST |
| 21 | 212 | 442 |
| 50 | 213 | |

Metro Transit, Metropolitan Council and Minnesota Valley Transit Authority will collect this data using both electronic farebox data and manual driver tally sheets.

1. Sample Size:
   - A sampling of transit routes on the mainline and/or alternate travel routes within the four selected corridors;
   - Sample selection is dependent on the availability of data;
   - Selected routes are subject to change based upon data availability;
   - The a.m. and p.m. peak periods; and
   - Entire study duration.

2. Assumptions:
   - Request that Metro Transit, the opt-out service providers and the contracted transit service providers provide ridership information on select routes with each corridor.
3. Data collection methods and tools:
   - Farebox data.

#### 5.2.2.5.3 Park-and-Ride Facility Usage

Park-and-ride utilization data will be collected at a sample of facilities serving transit routes on three of the four selected corridors. Park-and-ride utilization data collection has been confirmed for I-94, I-35E, and I-35W. Discussions are still ongoing with Minnesota Valley Transit Authority on the possible expanding the I-35W sample to include additional facilities.

Utilization at the following facilities will be collected on three days over a one-week period during both the before and during periods.

| I-94 Corridor | I-35E Corridor | I-35W Corridor |
|---|---|---|
| Woodbury Lutheran Church | Gustavus Adolphus Lutheran | Burnsville Transit Station |
| Christ Episcopal Church | Municipal Lot | Apple Valley Transit Station |
| Wooddale Recreation Center | TH61 & CRC | Palomino Hills |
| Faith United Methodist Church | Lake Owasso Beach | |
| West St. Paul Sports Complex | Rice & I-694 | |
| | Maplewood Mall | |
| | Cub Foods | |

The a.m. peak period auto travel time data collection personnel will manually collect this data through field observations directly after completion of the am peak travel runs.

1. Sample size and assumptions:
   - A sampling of facilities that serve transit routes traveling along three of the four selected corridors; and
   - Estimated number of facilities is 12.
2. Data collection methods and tools:
   - Park-and-ride lot occupancy count (after the a.m. peak period); and
   - Conducted by travel time personnel.

### *5.2.2.6 Summary of Performance Measures and Data Sources*

Table 5.5 summarizes the performance measures and data sources used in the field data collection.

**Table 5.5 Summary of Performance Measures and Data Sources**

| Objective | | Performance Measures | | Data Source |
|---|---|---|---|---|
| 1 | Assess traffic flow impacts | 1.1 | Freeway Volume | TMC Station Detectors |
| | | 1.2 | Freeway Occupancy | TMC Station Detectors |
| | | 1.3 | Alternate Route Volume | Road Tubes<br>Traffic Signal System Detectors |
| 2 | Assess travel time impacts | 2.1 | Freeway travel time | GPS- and Jamar-equipped vehicles |
| | | 2.2 | Alternate route travel time | GPS- and Jamar-equipped vehicles |
| 3 | Assess ramp impacts | 3.1 | Ramp queue length | Jamar counter |
| | | 3.2 | Ramp queue delay | Jamar counter |
| | | 3.3 | HOV lane usage | Observation |
| | | 3.4 | HOV lane violation | Observation |
| | | 3.5 | Ramp meter violation | Observation |
| | | 3.6 | Frequency of ramp queue backing into intersection | Observation |
| 4 | Assess crash impacts | 4.1 | Incidents on freeway corridors within study area | TMC Incident Logs |
| | | 4.2 | Systemwide crashes | Mn/DOT Crash Database |
| 5 | Assess transit impacts | 5.1 | Mainline route travel time | AVL-equipped vehicles; field observations |
| | | 5.2 | Alternate route travel time | AVL-equipped vehicles; field observations |
| | | 5.3 | Ridership | Farebox |
| | | 5.4 | Facility usage | Observation |

## 5.3 Field Data Analysis Plan

During both the "with" and the "without" study periods all data collected on bad weather days (rain/snow), bad incident days, and dark vs. light conditions will be flagged. The data will then be grouped and analyzed in separate categories. If there is a statistically significant difference between groups, the data will be analyzed separately and comparisons will be made for data under similar weather/light/incident conditions. Also, the data will be analyzed across groups to identify differences in the effectiveness of ramp metering under the varying conditions. Finally, all data will be analyzed to measure the effects of peak-period spreading. The following subsets will be created with the data:

- Pavement Condition:
  - Dry,
  - Wet, and
  - Snow covered.
- Presence of Incidents along Corridor:
  - Yes, and
  - No.
- Light Condition:
  - Light (sunrise to sunset), and
  - Dark (sunset to sunrise).
- Day of Week:
  - Monday and Friday; and
  - Tuesday through Thursday.

## 5.4 Field Data Management Plan

### 5.4.1 Field Data Collection, Transfer, and Storage

The specific form of data collection, transfer, and storage will be finalized when detailed information regarding the data formats is available. An archive copy and one or more working copies of the data will be made. The original data will be stored at the SRF offices. A second archive copy will be given to Cambridge Systematics and/or Mn/DOT for storage at their offices.

The TMC detector station volume data will be electronically transmitted to SRF via the Internet File Transfer Protocol (FTP) method. Data from the previous 24-hours will be sent on a daily basis.

### 5.4.2 Field Data Security

There are no security issues related to the transfer of the field data that will be used in the evaluation process. The data will consist of traffic data, various log data entries, and public information. There will not be any data collected that will involve privacy considerations.

### 5.4.3 Configuration Control

Mn/DOT shall provide the detector station data in a binary format.

### 5.4.4 Documentation of External Influences

The main external influences on the system's performance will be weather, changes in the transportation system (lane closures, repairs, etc.), incidents causing traffic delays (crashes, stalled vehicles, etc.), and major events. Each of these will be continually monitored as a part of the project and will be used when possible to schedule the individual tests of the system.

### 5.4.5 Quality Control and Quality Assurance

A very large amount of data will be collected over the course of this evaluation. The following steps will be taken to ensure that the data is reliable and secure:

- Data collection personnel will be trained by data collection supervisors;
- Data collection supervisors will make periodic spot checks on personnel in the field;
- Data will be inspected on a daily basis to insure that the data is reasonable;
- In the event that equipment problems are encountered, backup data collection equipment will be available whenever possible;
- Make-up data collection activities will take place during week five of the before study in the event that additional data collection is required.