October 30, 2009

TO: Holders of Traffic Engineering Manual

This is the third electronic update to the "Traffic Engineering Manual" (TEM).

The TEM now includes the 2007 versions of Chapters 1 thru 5 and 8 thru 13, the 2008 version of Chapter 6, Chapter 7, page 11-7 of Chapter 11, and an up to date Subject Index.

This update includes minor changes to several pages as stated in the Transmittal.

Printed versions of the TEM will no longer be available from the Map and Manual Sales Unit. The user may print as much or as little of the electronic version of the TEM as is needed.

Manual holders and users are reminded of the need to register on the OTSO Publication website in order for them to receive notification of future updates/revisions to the TEM. Those who wish to register must go to the following website location: http://www.dot.state.mn.us/traficeng/otepubl/updates.html, fill out the required boxes, and select “Traffic Engineering Manual” from the drop-down menu. Lastly, click on the “Submit Your Answers” button.

An electronic notification will be sent out to all registrants. Electronic notifications that are returned to the sender, will result in the subscribers name being removed from the notification list. In the event that a subscriber changes email address or internet service provider, it is the responsibility of the subscriber to submit a new request for notification.

Contact Kenneth Schroepfer, Office of Traffic, Safety, and Technology, MS 725, Minnesota Department of Transportation, 1500 West County Road B2, Roseville, Minnesota 55113, phone (651) 234-7379, with general questions concerning the TEM.

Your comments/suggestions are always appreciated.

Sincerely,

[Signature]
Susan M Groth, PE, PTOE
State Traffic Engineer
<table>
<thead>
<tr>
<th>TRANSMITTAL NUMBER</th>
<th>DATE</th>
<th>CHAPTER NUMBER</th>
<th>SUBJECT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metric (English) Conversion</td>
<td>7-1-00</td>
<td>Entire Manual</td>
<td>Complete conversion of the entire manual to Metric (English) units of measure. New covers are issued.</td>
</tr>
<tr>
<td>Revision 1</td>
<td>7-1-03</td>
<td>Chapter 5, Chapter 7, Chapter 8, Chapter 9</td>
<td>Replace the entire Chapter</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Selected pages</td>
<td>Replace Pages: 10-23 thru 10-27, 10-1-5, 11-9 thru 11-12, 12-5, 12-6, 13-7, 13-8, 13-13, 13-14, 13-17 thru 13-22.</td>
</tr>
<tr>
<td>Revision 2</td>
<td></td>
<td>Selected pages</td>
<td>Replace Pages: 6-1 thru 6-66h, 8-9, and 8-10.</td>
</tr>
<tr>
<td>Revision 3</td>
<td>8-1-07</td>
<td>Chapters 1, 2, 3, 4, 5, 8, 9, 10, 11, 12, 13</td>
<td>Replace the entire Chapter</td>
</tr>
<tr>
<td>Revision 4</td>
<td>3-3-08</td>
<td>Chapter 6, Subject Index</td>
<td>Replace the entire Chapter</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Selected pages</td>
<td>Replace Pages: 11-7</td>
</tr>
<tr>
<td>Revision 5</td>
<td>10-31-09</td>
<td>Selected pages</td>
<td>Replace Pages: 1-1, 1-3, 1-5, 1-6, 1-7, 1-9, 1-14 thru 1-17, 1-19, 1-20, 2-3, 2-12, 2-16, 4-9, 4-10, 4-11, 5-17, 6-5, 6-12, 6-15, 6-18 thru 6-21, 6-48, 6-50, 6-56, 6-67, 6-63, 6-64, 6-65, 6-77, 6-78, 6-85, 7-2, 7-3, 7-14, 7-13, 7-14, 7-20, 7-26, 7-29, 7-34, 7-39, 7-51, 7-62, 8-1, 8-10 thru 8-19, 10-7, 10-9, 10-16, 10-17, 10-19, 11-5 thru 11-9, 12-8, 12-9, 12-10, 13-4, 13-9, 13-14, 13-15, and 13-16.</td>
</tr>
</tbody>
</table>
# Summary of Contents

## Chapter 1
### GENERAL

<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-1.00</td>
<td>INTRODUCTION</td>
<td>1-3</td>
</tr>
<tr>
<td>1.01</td>
<td>Purpose</td>
<td></td>
</tr>
<tr>
<td>1.02</td>
<td>Scope</td>
<td></td>
</tr>
<tr>
<td>1.03</td>
<td>Organization of the Manual</td>
<td></td>
</tr>
<tr>
<td>1.04</td>
<td>Revisions</td>
<td></td>
</tr>
<tr>
<td>1-2.00</td>
<td>OFFICE OF TRAFFIC SAFETY, AND OPERATIONS FUNCTIONS</td>
<td>1-5</td>
</tr>
<tr>
<td>2.01</td>
<td>Mn/DOT Organization</td>
<td></td>
</tr>
<tr>
<td>2.02</td>
<td>OTSO’s Organization</td>
<td></td>
</tr>
<tr>
<td>2.03</td>
<td>Functions and Responsibilities</td>
<td></td>
</tr>
<tr>
<td>2.04</td>
<td>Delegation of Authority</td>
<td></td>
</tr>
<tr>
<td>1-3.00</td>
<td>DISTRICT TRAFFIC ENGINEER FUNCTION</td>
<td>1-9</td>
</tr>
<tr>
<td>3.01</td>
<td>General Function of the District Traffic Engineering Staff</td>
<td></td>
</tr>
<tr>
<td>3.02</td>
<td>Specific Functions Performed by the District/Division Traffic Engineering Staff</td>
<td></td>
</tr>
<tr>
<td>1-4.00</td>
<td>TRAFFIC ENGINEERING ORGANIZATION</td>
<td>1-13</td>
</tr>
<tr>
<td>4.01</td>
<td>Introduction</td>
<td></td>
</tr>
<tr>
<td>4.02</td>
<td>Purpose</td>
<td></td>
</tr>
<tr>
<td>4.03</td>
<td>Structures and Procedures</td>
<td></td>
</tr>
<tr>
<td>4.04</td>
<td>Documentation</td>
<td></td>
</tr>
</tbody>
</table>

## Chapter 2
### TRAFFIC LAWS

<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-1.00</td>
<td>INTRODUCTION</td>
<td>2-3</td>
</tr>
<tr>
<td>1.01</td>
<td>Purpose</td>
<td></td>
</tr>
<tr>
<td>1.02</td>
<td>Scope</td>
<td></td>
</tr>
<tr>
<td>1.03</td>
<td>Chapter Organization</td>
<td></td>
</tr>
<tr>
<td>2-2.00</td>
<td>GLOSSARY</td>
<td>2-4</td>
</tr>
<tr>
<td>2-3.00</td>
<td>LEGAL RESPONSIBILITIES</td>
<td>2-9</td>
</tr>
<tr>
<td>3.01</td>
<td>Legal Responsibilities of Mn/DOT</td>
<td></td>
</tr>
<tr>
<td>3.02</td>
<td>Legal Responsibilities of Local Authorities</td>
<td></td>
</tr>
<tr>
<td>3.03</td>
<td>Mn/DOT Approvals</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>August 1, 2007</th>
<th>TRAFFIC ENGINEERING MANUAL</th>
</tr>
</thead>
</table>
Chapter 3
FREEWAY CORRIDOR TRAFFIC MANAGEMENT

3-1.00 INTRODUCTION .................................................3-3
  1.01 Purpose
  1.02 Chapter Organization

3-2.00 GLOSSARY ..................................................3-3

3-3.00 REGIONAL TRAFFIC MANAGEMENT CENTER .................3-4

3-4.00 SURVEILLANCE SYSTEMS ....................................3-5
  4.01 Purpose
  4.02 Electronic Vehicle Detectors
  4.03 Closed-Circuit Television
  4.04 Radio Relay of Visual Observations

3-5.00 CONTROL SYSTEMS .........................................3-6
  5.01 Purpose
  5.03 Ramp Control Signal Systems
  5.02 Ramp Metering Algorithm
  5.04 Ramp Design
  5.05 Lane Control Signals

3-6.00 PREFERENTIAL TREATMENT SYSTEMS FOR HOVs ..........3-8
  6.01 Purpose
  6.02 Preferential Treatment Ramps
  6.03 Diamond Lanes
  6.04 Reversible Lanes
  6.05 Team Transit
Chapter 4
TRAFFIC ENGINEERING RESEARCH

4-1.00 INTRODUCTION ..................................................4-3
  1.01 Purpose
  1.02 Scope
  1.03 Chapter Organization

4-2.00 ROLE OF TRAFFIC RESEARCH .................................4-3

4-3.00 INDIVIDUAL ROLES IN TRAFFIC RESEARCH ..............4-4
  3.01 Technical Advisory Panel (TAP)
  3.02 Principal Investigator (PI)
  3.03 Technical Liaison (TL)
  3.04 Administrative Liaison (AL)
  3.05 Traffic Research Coordinator (TRC)

4-4.00 TRAFFIC RESEARCH PROGRAM ..............................4-5
  4.01 Purpose
  4.02 Research Monitoring
  4.03 Traffic Research Projects
  4.04 Support Services

4-5.00 TRAFFIC RESEARCH PROJECT DEVELOPMENT ............4-8
  5.01 Project Sources
  5.02 Project Subjects
  5.03 Task Sequence
Chapter 5
DATA COLLECTION

5-1.00 INTRODUCTION .................................................................5-5
  1.01 Purpose
  1.02 Scope
  1.03 Chapter Organization

5-2.00 GLOSSARY .................................................................5-5

5-3.00 VOLUME COUNTS ..........................................................5-9
  3.01 Types of Traffic Counts
  3.02 Regularly Conducted Counts
  3.03 Equipment
  3.04 Field Data Collection
  3.05 Data Recording Forms
  3.06 Sample Sizes
  3.07 Computations
  3.08 Uses of Volume Counts

5-4.00 SPOT SPEED .................................................................5-16
  4.01 Equipment
  4.02 Field Data Collection
  4.03 Data Recording Forms
  4.04 Sample Size
  4.05 Computations
  4.06 Uses of Spot Speed Data

5-5.00 TRAVEL TIME AND DELAY ..............................................5-17
  5.01 Types of Delay Studies
  5.02 Equipment
  5.03 Field Data Collection
  5.04 Data Recording Forms
  5.05 Sample Size
  5.06 Computations
  5.07 Uses of Travel/Delay Studies
<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>5-6.00</td>
<td>VEHICLE OCCUPANCY</td>
<td>5-21</td>
</tr>
<tr>
<td>6.01</td>
<td>Equipment</td>
<td></td>
</tr>
<tr>
<td>6.02</td>
<td>Field Data Collection</td>
<td></td>
</tr>
<tr>
<td>6.03</td>
<td>Data Recording Forms</td>
<td></td>
</tr>
<tr>
<td>6.04</td>
<td>Sample Size</td>
<td></td>
</tr>
<tr>
<td>6.05</td>
<td>Computations</td>
<td></td>
</tr>
<tr>
<td>6.06</td>
<td>Uses of Vehicle Occupancies</td>
<td></td>
</tr>
<tr>
<td>5-7.00</td>
<td>LANE OCCUPANCY</td>
<td>5-22</td>
</tr>
<tr>
<td>7.01</td>
<td>Equipment</td>
<td></td>
</tr>
<tr>
<td>7.02</td>
<td>Field Data Collection</td>
<td></td>
</tr>
<tr>
<td>7.03</td>
<td>Data Recording Forms</td>
<td></td>
</tr>
<tr>
<td>7.04</td>
<td>Sample Size</td>
<td></td>
</tr>
<tr>
<td>7.05</td>
<td>Computations</td>
<td></td>
</tr>
<tr>
<td>7.06</td>
<td>Uses of Lane Occupancies</td>
<td></td>
</tr>
<tr>
<td>5-8.00</td>
<td>VEHICLE DENSITY</td>
<td>5-23</td>
</tr>
<tr>
<td>8.01</td>
<td>Equipment</td>
<td></td>
</tr>
<tr>
<td>8.02</td>
<td>Field Data Collection</td>
<td></td>
</tr>
<tr>
<td>8.03</td>
<td>Data Recording Forms</td>
<td></td>
</tr>
<tr>
<td>8.04</td>
<td>Sample Size</td>
<td></td>
</tr>
<tr>
<td>8.05</td>
<td>Computations</td>
<td></td>
</tr>
<tr>
<td>8.06</td>
<td>Uses of Vehicle Densities</td>
<td></td>
</tr>
<tr>
<td>5-9.00</td>
<td>QUEUE STUDIES</td>
<td>5-24</td>
</tr>
<tr>
<td>9.01</td>
<td>Types of Queue Studies</td>
<td></td>
</tr>
<tr>
<td>9.02</td>
<td>Equipment</td>
<td></td>
</tr>
<tr>
<td>9.03</td>
<td>Field Data Collection</td>
<td></td>
</tr>
<tr>
<td>9.04</td>
<td>Data Recording Forms</td>
<td></td>
</tr>
<tr>
<td>9.05</td>
<td>Sample Size</td>
<td></td>
</tr>
<tr>
<td>9.06</td>
<td>Computations</td>
<td></td>
</tr>
<tr>
<td>9.07</td>
<td>Uses of Queue Data</td>
<td></td>
</tr>
<tr>
<td>5-10.00</td>
<td>VEHICLE CLASSIFICATION</td>
<td>5-26</td>
</tr>
<tr>
<td>10.01</td>
<td>Regularly Conducted Counts</td>
<td></td>
</tr>
<tr>
<td>10.02</td>
<td>Equipment Used</td>
<td></td>
</tr>
<tr>
<td>10.03</td>
<td>Field Data Collection</td>
<td></td>
</tr>
<tr>
<td>10.04</td>
<td>Data Recording Forms</td>
<td></td>
</tr>
<tr>
<td>10.05</td>
<td>Sample Size</td>
<td></td>
</tr>
<tr>
<td>10.06</td>
<td>Computations</td>
<td></td>
</tr>
<tr>
<td>10.07</td>
<td>Uses of Vehicle Classifications</td>
<td></td>
</tr>
<tr>
<td>5-11.00</td>
<td>LICENSE PLATE CHECKS</td>
<td>5-27</td>
</tr>
<tr>
<td>11.01</td>
<td>Equipment</td>
<td></td>
</tr>
<tr>
<td>11.02</td>
<td>Field Data Collection</td>
<td></td>
</tr>
<tr>
<td>11.03</td>
<td>Data Recording Forms</td>
<td></td>
</tr>
<tr>
<td>11.04</td>
<td>Sample Size</td>
<td></td>
</tr>
<tr>
<td>11.05</td>
<td>Computations</td>
<td></td>
</tr>
<tr>
<td>11.06</td>
<td>Uses of License Plate Checks</td>
<td></td>
</tr>
</tbody>
</table>
Chapter 6
TRAFFIC SIGNS

6-1.00 INTRODUCTION ..................................................6-5
1.01 Purpose
1.02 Scope
1.03 Organization of the Manual
6-2.00 GLOSSARY .................................................................6-6

6-3.00 LEGALITY - LEGAL AUTHORITY FOR PLACEMENT OF TRAFFIC SIGNS ..............6-8
   3.01 Traffic Signs Installed by Mn/DOT Maintenance Forces
   3.02 Traffic Signs Installed by Contract
   3.03 Traffic Signs Installed by Others by Maintenance Permit
   3.04 Temporary Traffic Control Signs Installed by Construction
       Contracts and Public Utility Companies at Work Sites

6-4.00 GENERAL PRINCIPLES OF TRAFFIC SIGNING .................................................6-8
   4.01 Principles of Traffic Control Devices
   4.02 Basic Considerations for Installation of Traffic Signs
   4.03 Functional Classifications of Traffic Signs
   4.04 Department Classification by Sign Design Type
   4.05 Elements of Traffic Sign Design
   4.06 Sign Design Type Classification
   4.07 Lateral Offset and Vertical Clearance Requirements
   4.08 Sign Installation and Maintenance Practices
   4.09 Implementation of Signing

6-5.00 APPLICATION GUIDELINES - REGULATORY SIGNS ...........................................6-21
   5.01 Purpose
   5.02 Typical Sign Placement
   5.03 Bridge Speed and Load Restrictions
   5.04 Bus Shoulder Sign (R4-X7)
   5.05 BYPASS LANE Sign (R4-X8)
       BYPASS & RIGHT TURN LANE Sign (R4-X8a)
   5.06 DO NOT PASS Sign (R4-1)
   5.07 Intersection Lane Control Signs (R3-8)
   5.08 ONE WAY Sign (R6-1)
   5.09 RIGHT LANE MUST TURN RIGHT Sign (R3-7)
       LEFT LANE MUST TURN LEFT Sign (R3-7)
   5.10 SLOWER TRAFFIC MOVE RIGHT Sign (R4-3a)
   5.11 Speed Zone Signing
   5.12 STOP Sign (R1-1)
   5.13 Two-Way Snowmobile Trail Signing
   5.14 VEHICLE NOISE LAWS ENFORCED Sign (R16-X13)

6-6.00 APPLICATION GUIDELINES - WARNING SIGNS .....................................................6-29
   6.01 Purpose
   6.02 Acceleration Lane Signing
   6.03 Advance Warning Signs on Local Road Approaches
   6.04 Advisory Exit Speed Sign (W13-2)
   6.05 BRIDGE ICES BEFORE ROAD Sign (W8-13)
   6.06 Channelized Intersections
   6.07 Chevron Alignment Sign (W1-8)
   6.08 Controlled Burning Signs
   6.09 Crossing Signs
   6.10 EVENT CONGESTION AHEAD Sign (W14-X11)
6.11 Low Clearance Sign (W12-2)
6.12 No Passing Zones
6.13 Passing Lane Sections
6.14 SCHOOL BUS STOP AHEAD Sign (S3-1)
6.15 SHOULDER NARROWS Sign (W5-X1)
   NO SHOULDER Sign (W21-X1)
6.16 Speed Reduction Sign (W3-5)
6.17 Truck Hauling Signs
6.18 Typical Signing for Transitions Between Divided
   Highway Sections and Two Lane Two-Way Sections

6-7.00 APPLICATION GUIDELINES - GUIDE SIGNING ..........................6-36
   7.01 Purpose
   7.02 Freeways
   7.03 Signing Destinations
   7.04 Typical Junction Signing Layouts
   7.05 Independent Route Marker Assemblies
   7.06 Named Road, Street, and 911 Road Name Signs
   7.07 Boundary Signs
   7.08 Designated Roadways
   7.09 Supplemental Guide Signing Programs
   7.10 External Sign Variance Committee

6-8.00 APPLICATION GUIDELINES - MISCELLANEOUS SIGNING .............6-79
   8.01 Adopt-A-Highway Signing Program
   8.02 Adopt-A-Rest Area Signing Program
   8.03 Community Destination Signing Program
   8.04 DNR PUBLIC WATER ACCESS Sign (DNR NRM 8.2.35)
   8.05 General Service Signs
   8.06 Geological Marker Sign (D5-X1C, D7-X1, and D7-X2)
   8.07 Reference Location Sign (D10-1, D10-2, and D10-3)
   8.08 Rest Area Signing
   8.09 Seat Belt Signs (R16-X11 and R16-X2)
   8.10 Sign Attachments
   8.11 Test Section Signing

Chapter 7
MARKINGS AND DELINEATION

7-1.00 INTRODUCTION .................................................................7-3
   1.01 Purpose
   1.02 Scope
   1.03 Chapter Organization

7-2.00 GLOSSARY .................................................................7-3
Chapter 8
WORK ZONE TRAFFIC CONTROLS

8-1.00 INTRODUCTION ................................................................. 8-3
  1.01 Purpose
  1.02 Scope
  1.03 Relation to Other Mn/DOT Standards and Guidelines
  1.04 Chapter Organization

8-2.00 GLOSSARY ................................................................. 8-4

8-3.00 RESPONSIBILITY ............................................................ 8-4
  3.01 General Responsibility
  3.02 Legal Responsibility
<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>8-4.00</td>
<td>GENERAL PRINCIPLES</td>
<td>8-5</td>
</tr>
<tr>
<td>4.01</td>
<td>Temporary Traffic Control Goals</td>
<td></td>
</tr>
<tr>
<td>4.02</td>
<td>Traffic Management and Temporary Traffic Control Plan</td>
<td></td>
</tr>
<tr>
<td>8-5.00</td>
<td>TEMPORARY TRAFFIC CONTROL DEVICES</td>
<td>8-8</td>
</tr>
<tr>
<td>5.01</td>
<td>General Requirements</td>
<td></td>
</tr>
<tr>
<td>5.02</td>
<td>Signing</td>
<td></td>
</tr>
<tr>
<td>5.03</td>
<td>Pavement Markings in Temporary Traffic Control Zones</td>
<td></td>
</tr>
<tr>
<td>5.04</td>
<td>Channelizing Devices</td>
<td></td>
</tr>
<tr>
<td>5.05</td>
<td>Ballast</td>
<td></td>
</tr>
<tr>
<td>5.06</td>
<td>Portable Precast Concrete Barrier (PPCB) Delineators</td>
<td></td>
</tr>
<tr>
<td>5.07</td>
<td>Surface Mounted (centerline) Delineators</td>
<td></td>
</tr>
<tr>
<td>5.08</td>
<td>Portable Changeable Message Signs (PCMS)</td>
<td></td>
</tr>
<tr>
<td>5.09</td>
<td>Flashing Arrow Panels</td>
<td></td>
</tr>
<tr>
<td>5.10</td>
<td>Crash Cushions and Attenuators</td>
<td></td>
</tr>
<tr>
<td>5.11</td>
<td>Flagging</td>
<td></td>
</tr>
<tr>
<td>5.12</td>
<td>Longitudinal Joints and Edge Drop-Offs</td>
<td></td>
</tr>
<tr>
<td>8-6.00</td>
<td>TEMPORARY TRAFFIC CONTROL PLANS</td>
<td>8-18</td>
</tr>
<tr>
<td>6.01</td>
<td>Placement of Temporary Traffic Control Devices</td>
<td></td>
</tr>
<tr>
<td>6.02</td>
<td>Traffic Control Devices Tabulation</td>
<td></td>
</tr>
<tr>
<td>6.03</td>
<td>Typical Traffic Control Pay Items</td>
<td></td>
</tr>
<tr>
<td>8-7.00</td>
<td>ESTABLISHING AND MAINTAINING DETOURS</td>
<td>8-19</td>
</tr>
<tr>
<td>7.01</td>
<td>Conditions Requiring or Permitting a Detour</td>
<td></td>
</tr>
<tr>
<td>7.02</td>
<td>Selection of a Route</td>
<td></td>
</tr>
<tr>
<td>7.03</td>
<td>Maintenance of a Detour</td>
<td></td>
</tr>
<tr>
<td>7.04</td>
<td>Maintenance Agreement</td>
<td></td>
</tr>
<tr>
<td>7.05</td>
<td>Emergency Detour</td>
<td></td>
</tr>
<tr>
<td>7.06</td>
<td>Special Maintenance Work on Detours</td>
<td></td>
</tr>
<tr>
<td>7.07</td>
<td>Discontinuance of a Detour</td>
<td></td>
</tr>
<tr>
<td>8-8.00</td>
<td>INSTALLATION AND INSPECTION OF TEMPORARY TRAFFIC CONTROL DEVICES</td>
<td>8-20</td>
</tr>
<tr>
<td>8.01</td>
<td>Installation</td>
<td></td>
</tr>
<tr>
<td>8.02</td>
<td>Responsibility</td>
<td></td>
</tr>
<tr>
<td>8.03</td>
<td>Inspection Program</td>
<td></td>
</tr>
<tr>
<td>8-9.00</td>
<td>REFERENCES</td>
<td>8-21</td>
</tr>
<tr>
<td>8-8.00</td>
<td>APPENDICES</td>
<td>8.1-1</td>
</tr>
<tr>
<td>8.01</td>
<td>Traffic Management Plan Checklist</td>
<td></td>
</tr>
<tr>
<td>8.05</td>
<td>Detours</td>
<td></td>
</tr>
</tbody>
</table>
Chapter 9
TRAFFIC SIGNALS

9-1.00 INTRODUCTION .................................................................9-3
  1.01 Purpose
  1.02 Scope
  1.03 Chapter Organization

9-2.00 LEGALITY .................................................................9-4
  2.01 Legal Authority
  2.02 Jurisdiction
  2.03 Meaning of Signal Indications
  2.04 Tort Claims

9-3.00 GENERAL DESCRIPTION OF TRAFFIC SIGNALS .................9-4
  3.01 Types of Traffic Signals
  3.02 Elements of Traffic Signals
  3.03 Timing and Coordination of Traffic Signals

9-4.00 TRAFFIC SIGNAL JUSTIFICATION PROCESS .......................9-10
  4.01 Engineering Studies for Traffic Signals
  4.02 Warrants and Justification for Signals and Flashing Beacons

9-5.00 TRAFFIC SIGNAL PROJECT PROCEDURES .........................9-17
  5.01 Traffic Signal Project Management Flowchart
  5.02 Notes on Traffic Signal Project Management Flowchart

9-6.00 TRAFFIC SIGNAL DESIGN ............................................9-24
  6.01 General Considerations
  6.02 Intersection Geometry
  6.03 Operational Characteristics
  6.04 System (Arterial) Considerations
  6.05 Signal Design Elements

9-7.00 TRAFFIC SIGNAL PLANS AND SPECIFICATIONS ...................9-27
  7.01 General
  7.02 Traffic Signal Plans
  7.03 Special Provisions
  7.04 Tabulation of Quantities
  7.05 Standard Plates Manual
  7.06 Mn/DOT Standard Specifications for Highway Construction
  7.07 Other Standards

9-8.00 TRAFFIC SIGNAL CONSTRUCTION ....................................9-28
  8.01 State Furnished Material
  8.02 Signal Turn-on Procedure
  8.03 Post Turn-On Procedures
Chapter 10
LIGHTING OF TRAFFIC FACILITIES

10-1.00 INTRODUCTION .........................................................10-3
  1.01 Purpose
  1.02 Scope
  1.03 Chapter Organization

10-2.00 GLOSSARY ...............................................................10-3

10-3.00 LIGHTING PROJECT PROCEDURES ................................10-5
  3.01 Warrants
  3.02 Programming
  3.03 Negotiations
  3.04 Work Authorities
  3.05 Preparation of Plans
  3.06 Preparation of Special Provisions
  3.07 Preparation of Agreements
  3.08 Project Letting

10-4.00 LIGHTING SYSTEM DESIGN .......................................10-11
  4.01 Typical Lighting Systems
  4.02 Lighting System Components
  4.04 Temporary Lighting
  4.05 Sign Lighting

10-5.00 CONSTRUCTION .......................................................10-19
  5.01 Field Placement of Light Poles
  5.02 Documentation
Chapter 11
TRAFFIC CRASH SURVEILLANCE

11-1.00 INTRODUCTION ..................................................11-3
  1.01 Purpose
  1.02 Scope
  1.03 Transportation Information System (TIS)
  1.04 Chapter Organization

11-2.00 ACCIDENT REPORT FORMS ..................................11-3
  2.01 Responsibilities
  2.02 Accident Report Forms

11-3.00 ACCIDENT REPORT PROCESSING ............................11-4
  3.01 Department of Public Safety
  3.02 Department of Transportation

11-4.00 CRASH DATA REPORTS .......................................11-5
  4.01 T.I.S. Reports
  4.02 Data Requests
  4.03 Other Reports
  4.04 General Procedures and Services

11-5.00 SAFETY IMPROVEMENT PROGRAM PROCESS .............11-11
  5.01 Hazard Elimination Study
  5.02 Safety Capacity

11-6.00 REFERENCES ....................................................11-11
## Chapter 12
### TORT CLAIMS

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>12-1.00</td>
<td>INTRODUCTION</td>
<td>12-3</td>
</tr>
<tr>
<td>1.01</td>
<td>Background</td>
<td></td>
</tr>
<tr>
<td>12-2.00</td>
<td>GLOSSARY</td>
<td>12-3</td>
</tr>
<tr>
<td>12-3.00</td>
<td>TORT LIABILITY</td>
<td>12-4</td>
</tr>
<tr>
<td>3.01</td>
<td>Basic Characteristics of a Tort</td>
<td></td>
</tr>
<tr>
<td>3.02</td>
<td>Legal Duty</td>
<td></td>
</tr>
<tr>
<td>3.03</td>
<td>Negligence</td>
<td></td>
</tr>
<tr>
<td>3.04</td>
<td>Causation</td>
<td></td>
</tr>
<tr>
<td>3.05</td>
<td>Liability</td>
<td></td>
</tr>
<tr>
<td>12-4.00</td>
<td>IMMUNITIES</td>
<td>12-6</td>
</tr>
<tr>
<td>4.01</td>
<td>Discretionary Immunity</td>
<td></td>
</tr>
<tr>
<td>4.02</td>
<td>Official Immunity</td>
<td></td>
</tr>
<tr>
<td>4.03</td>
<td>Other Immunities</td>
<td></td>
</tr>
<tr>
<td>12-5.00</td>
<td>RECORD KEEPING</td>
<td>12-7</td>
</tr>
<tr>
<td>12-6.00</td>
<td>REQUESTS FOR INFORMATION</td>
<td>12-7</td>
</tr>
<tr>
<td>6.01</td>
<td>Purpose</td>
<td></td>
</tr>
<tr>
<td>6.02</td>
<td>Procedure to Follow When Requests are Made</td>
<td></td>
</tr>
<tr>
<td>12-7.00</td>
<td>FILING A CLAIM</td>
<td>12-9</td>
</tr>
<tr>
<td>12-8.00</td>
<td>INVESTIGATIONS</td>
<td>12-9</td>
</tr>
<tr>
<td>8.01</td>
<td>Claim File</td>
<td></td>
</tr>
<tr>
<td>8.02</td>
<td>Claims Investigations</td>
<td></td>
</tr>
<tr>
<td>8.03</td>
<td>Interrogatories</td>
<td></td>
</tr>
<tr>
<td>8.04</td>
<td>Depositions</td>
<td></td>
</tr>
<tr>
<td>12-9.00</td>
<td>EFFECT OF LITIGATION ON MN/DOT</td>
<td>12-10</td>
</tr>
</tbody>
</table>
Chapter 13
MISCELLANEOUS TRAFFIC ITEMS

13-1.00 INTRODUCTION .................................................................13-3
  1.01 Purpose
  1.02 Scope
  1.03 Chapter Organization
  1.04 Glossary

13-2.00 SCHOOL CROSSING PROTECTION .......................................13-5
  2.01 Responsibility
  2.02 Guidelines
  2.03 School Safety Patrols
  2.04 Crossing Guards
  2.05 School Speed Limits
  2.06 School Site Plan Review
  2.07 Rural School Bus Stops
  2.08 School Zone and Crossing Signs

13-3.00 REVIEWS AND PERMITS ..................................................13-7
  3.01 Geometric Review
  3.02 Preliminary Layouts
  3.03 Evaluation of New Facilities
  3.04 Entrance Permits
  3.05 Transportation Permits
  3.06 Parade Permits

13-4.00 ROUTE NUMBERING AND REFERENCE POINT SYSTEM ............13-11
  4.01 General
  4.02 Constitutional Routes
  4.03 Legislative Routes
  4.04 Names and Designations of Certain Highways
  4.05 Interstate Routes
  4.06 U.S. Highways
  4.07 Trunk Highway Routes
  4.08 Turnbacks
  4.09 Reference Point System
  4.10 Exit Numbers

13-5.00 SPECIAL INVESTIGATIONS AND STUDIES ............................13-14
  5.01 Videologging
  5.02 Rumble Strips
  5.03 Experimental Traffic Control Devices
  5.04 Speed Trend Studies
  5.05 Plat Review
  5.06 Sight Distances at Crossroads
  5.07 Railroad Crossing Review
  5.08 Advisory Curve Study

13-6.00 ENGINEERING AND TRAFFIC INVESTIGATION REQUIREMENTS
   TO ESTABLISH OR CHANGE REGULATORY SPEED LIMITS ...............13-20

13-7.00 REFERENCES .................................................................13-27
ABBREVIATIONS

AADT  Annual Average Daily Traffic  Mn/DTED  Minnesota Department of Trade and Economic Development
AASHTO American Association of State Highway and Transportation Officials  MPH  Miles Per Hour
ACL Accident Cross Reference File  MS  Minnesota Statutes
ADT Average Daily Traffic  MSA  Minnesota Statutes Annotated
AME Area Maintenance Engineer  MSAS  Municipal State Aid Street
ANOVA Analysis of Variance  MTC  Metropolitan Transit Commission
ASCE American Society of Civil Engineers  MUTCD Manual on Uniform Traffic Control Devices
ATR Automatic Traffic Recorder  NCHRP National Cooperative Highway Research Program
B/C Benefit/Cost Ratio  NEMA National Electrical Manufacturers' Association
CAES Computer-Aided Engineering Services  NFPA National Fire Prevention Association
CCTV Closed Circuit Television  O-D Origin/Destination
CMS Changeable Message Sign  OTE Office of Traffic Engineering
CR County Road  OTSO Office of Traffic, Safety, and Operations
CRT Cathode Ray Tube  PC Personal Computer
CS Control Section  PD Property Damage
CSAH County State Aid Highway  PI Personal Injury
DE District Engineer  PPCB Portable Precast Concrete Barrier
DMI Distance Measuring Instrument  PSF Pounds Per Square Foot
DNR Department of Natural Resources  PW Present Worth
DPS Department of Public Safety  RP Reference Point
DTE District Traffic Engineer  RTMC Regional Traffic Management Center
DTWO District Traffic Work Order  RV Recreational Vehicle
EIS Environmental Impact Statement  SOP Source of Power
ESU Electrical Services Unit  SPAR Systems Planning & Analysis Report
EUAC Equivalent Uniform Annual Cost  STD-DEV Standard Deviation
FHWA Federal Highway Administration  STD-ERR Standard Error
HAR Highway Advisory Radio  TAM Traffic Analysis - Metro
HI High Intensity  TCO Traffic Control Order
HOV High Occupancy Vehicles  TCP Traffic Control Plan
HP&R Highway Planning and Research  TH Trunk Highway
I/I Intersection/Interchange  TIS Transportation Information System
IGDS Interactive Graphics Design Software  TMP Traffic Management Plan
INL Intersection Leg Information File  TRB Transportation Research Board
INT Intersection Detail File  TRPM Temporary Raised Pavement Markers
INX Intersection Cross-Reference File  TWP Township
IPCEA Insulated Power Cable Engineers' Association  UMTA Urban Mass Transit Administration
ITE Institute of Transportation Engineers  VAR Variance
K Fatality  VPLM Vehicles Per Lane Mile
LOS Level of Service  Mn/DOT Minnesota Department of Transportation
# Chapter 1
## GENERAL

<table>
<thead>
<tr>
<th>TABLE OF CONTENTS</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-1.00 INTRODUCTION</td>
<td>1-3</td>
</tr>
<tr>
<td>1.01 Purpose of the Traffic Engineering Manual</td>
<td></td>
</tr>
<tr>
<td>1.02 Scope of the Manual</td>
<td></td>
</tr>
<tr>
<td>1.03 Organization of the Manual</td>
<td></td>
</tr>
<tr>
<td>1.04 Revisions</td>
<td></td>
</tr>
<tr>
<td>1-2.00 OFFICE OF TRAFFIC, SAFETY, AND OPERATIONS FUNCTIONS</td>
<td>1-5</td>
</tr>
<tr>
<td>2.01 Mn/DOT Organization</td>
<td></td>
</tr>
<tr>
<td>2.02 OTST’s Organization</td>
<td></td>
</tr>
<tr>
<td>2.03 Functions and Responsibilities</td>
<td></td>
</tr>
<tr>
<td>2.04 Delegation of Authority</td>
<td></td>
</tr>
<tr>
<td>1-3.00 DISTRICT TRAFFIC ENGINEER FUNCTION</td>
<td>1-9</td>
</tr>
<tr>
<td>3.01 General Function of the District Traffic Engineering Staff</td>
<td></td>
</tr>
<tr>
<td>3.02 Specific Functions Performed by the District Traffic Engineering Staff</td>
<td></td>
</tr>
<tr>
<td>1-4.00 TRAFFIC ENGINEERING ORGANIZATION</td>
<td>1-13</td>
</tr>
<tr>
<td>4.01 Introduction</td>
<td></td>
</tr>
<tr>
<td>4.02 Purpose</td>
<td></td>
</tr>
<tr>
<td>4.03 Structures and Procedures</td>
<td></td>
</tr>
<tr>
<td>4.04 Documentation</td>
<td></td>
</tr>
<tr>
<td>Figures</td>
<td>1-19</td>
</tr>
<tr>
<td>Forms</td>
<td>1-23</td>
</tr>
</tbody>
</table>
### LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>Minnesota Department of Transportation Organization</td>
<td>1-19</td>
</tr>
<tr>
<td>1.2</td>
<td>Mn/DOT, Operations Division, Office of Traffic, Safety and Operations</td>
<td>1-20</td>
</tr>
<tr>
<td>1.3</td>
<td>Minnesota Department of Transportation Traffic Engineering Organization</td>
<td>1-21</td>
</tr>
</tbody>
</table>

### LIST OF FORMS

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.A</td>
<td>District Traffic Work Order</td>
<td>1-23</td>
</tr>
<tr>
<td>1.B</td>
<td>This Form is no longer used</td>
<td></td>
</tr>
<tr>
<td>1.C</td>
<td>Local Street or Highway Speed Limit Authorization Form</td>
<td>1-25</td>
</tr>
<tr>
<td>1.D</td>
<td>Trunk Highway Speed Limit Authorization Form</td>
<td>1-26</td>
</tr>
</tbody>
</table>
CHAPTER 1 - GENERAL

1-1.00 INTRODUCTION

1-1.01 Purpose of the Traffic Engineering Manual

The Traffic Engineering Manual (TEM) is issued and updated by the Minnesota Department of Transportation (Mn/DOT) Office of Traffic, Safety, and Technology (OTST). The purpose of the TEM is to establish uniform guidelines and procedures, primarily for use by personnel at Mn/DOT. Counties, cities, and local units of government will also find this manual useful when striving for uniformity in traffic engineering throughout the state of Minnesota. Uniform application of guidelines and procedures aids the road user in recognizing and understanding the various traffic control devices used throughout the United States. It aids road users, police officers, and traffic courts by giving everyone the same interpretation and guidance. It aids public highway and traffic officials through economy in manufacture, installation, maintenance, and administration. The TEM is to be used as a day-to-day operations guide and training tool for engineers and technicians associated with traffic engineering. It is the intent of this Manual to set forth accepted practices, procedures, and guidelines, chiefly for the sake of uniformity of application, but there is no legal requirement for their use.

1-1.02 Scope of the Manual

1-1.02.01 Relationship to the Minnesota Manual on Uniform Traffic Control Devices.

The Minnesota Manual on Uniform Traffic Control Devices (MN MUTCD) sets forth the basic principles, and presents the state and federal standards, which govern the design and usage of traffic control devices on all streets and highways in Minnesota. The TEM complements, but does not duplicate, the MN MUTCD. The MN MUTCD sets forth standards for traffic control devices in Minnesota. Where such standards exist, the TEM merely references the appropriate section of the MN MUTCD. Where the MN MUTCD does not specify warrants or applications, the TEM clarifies the accepted Mn/DOT practice. The TEM also details Mn/DOT traffic engineering guidelines and procedures not included in the MN MUTCD.

1-1.02.02 Relationship to Mn/DOT Policies

The TEM does not include Mn/DOT policies per se, although sections of the Manual reflect existing Mn/DOT policies related to traffic engineering. Formal Mn/DOT policies can be found at http://ihub.policies.

1-1.02.03 Relationship to Other Mn/DOT Manuals

The TEM is one of many manuals which describe guidelines, procedures, specifications, and references for activities of Mn/DOT. The TEM is intended primarily for Mn/DOT’s traffic engineers working in the Central Office and the District Offices. It is not a textbook or a design and construction manual, and it is not all-inclusive. Rather, it is a guide for traffic engineers to use in fulfilling their daily duties. Accordingly, where appropriate, references are made to other Mn/DOT manuals which may be useful to the traffic engineering function.
1-1.02.04 Complementary References

Traffic engineers at Mn/DOT should have ready access to the latest editions of the following documents to complement the material presented in the TEM. Additional references, which may also be useful, are listed in each of the individual chapters of this Manual.


2. Traffic Control Devices Handbook, - Institute of Transportation Engineers (ITE).

3. Minnesota Standard Signs Manual. This Manual has 3 parts and establishes details and specifications for signs, including dimensions, colors, and other requirements.


6. Roadside Design Guide - AASHTO.


8. Traffic Engineering Handbook - ITE. This Handbook provides a comprehensive description of all basic traffic and transportation engineering functions.

9. Manual of Transportation Engineering Studies - ITE. This Manual describes basic traffic engineering studies performed by traffic engineers.

1-1.03 Organization of the Manual

There are 13 chapters. These chapters are organized around the basic functions performed by traffic engineers within Mn/DOT.

- Chapter 1 General Information
- Chapter 2 Traffic Laws
- Chapter 3 Freeway Corridor Traffic Management
- Chapter 4 Traffic Research
- Chapter 5 Data Collection
- Chapter 6 Traffic Signs
- Chapter 7 Marking and Delineation
- Chapter 8 Work Zone Traffic Control
- Chapter 9 Traffic Signals
- Chapter 10 Lighting
- Chapter 11 Collision Analysis
- Chapter 12 Tort Claims and Lawsuits
- Chapter 13 Miscellaneous Traffic Items
1-1.04 Revisions
The material in the TEM will be continuously subject to revision as the guidelines, procedures, and other information evolve. Changes to the TEM may be preceded by Technical Memorandums which will describe the guideline or procedure that is to be modified, added, or deleted. Technical Memorandums are used for quick distribution of information.

An electronic notification of changes/revisions will be sent to those individuals who have subscribed to an electronic notification list for such updates, changes/revisions, or training planned specific to the Traffic Engineering Manual.

This subscription form can be found at http://www.dot.state.mn.us/trafficeng/otepubl/updates.html

1-2.00 OFFICE OF TRAFFIC, SAFETY, AND TECHNOLOGYS FUNCTIONS

1-2.01 Mn/DOT Organization
Mn/DOT is organized as shown in Figure 1.1. The Office of Traffic, Safety, and Technology (OTST) is part of the Policy, Safety, and Strategic Initiatives Division. OTST's primary emphasis is on setting standards, policies and guidelines, providing training, managing traffic operation activities, and providing technical support.

1-2.02 OTST’s Organization
The OTST is divided into three sections as shown in Figure 1.2.

1. Traffic Engineering
   a. Signing
   b. Work Zones, Pavement Markings, and Product Evaluation
   c. Traffic Safety
   d. Traffic Standards, Tort Claims, and Training

2. Intelligent Transportation Systems (ITS)
   a. ITS Project Management and Research
   b. Electrical Systems
   c. Administrative Support

3. Traffic Operations (Regional Transportation Management Center)
   a. Freeway Systems Operations
   b. Incident Management
   c. MnPass (I-394 electronic toll collection system)
1-2.03 Functions and Responsibilities

The OTST provides leadership, expertise, and education in the operations and safety programs, and the development, use, and maintenance of traffic control devices in order to create a safe and efficient highway system in Minnesota. All the Traffic Engineering units act as liaisons between the Districts and the Federal Highway Administration, and provide technical expertise to the Districts and the Office of State Aid concerning traffic operations. The sections and their functions are as follows:

1. Signing
   b. Develop and maintain standards, guidelines, concepts, and applications for signs.
   c. Evaluate materials, equipment, and methods to be incorporated into signing projects.
   d. Ensure that signing projects conform to Mn/DOT policy, the MN MUTCD, the TEM, and other applicable standards.
   e. Support statewide sign design and sign management software.
   f. Analyze the relationships between geometrics, driver expectancy, traffic flow, standardization, and operations.
   g. Develop and implement statewide signing training.
   h. Administer the TEO Signing/Pavement Marking Committee.

2. Work Zones, Pavement Markings, and Product Evaluation
   a. Provide technical expertise for temporary traffic controls, pavement marking needs, and provide quality assurances for plan preparation, specifications, and estimates.
   b. Develop and maintain standards, guidelines, concepts, and applications for pavement marking and temporary traffic controls.
   c. Ensure that pavement marking projects conform to Mn/DOT policy, The MN MUTCD, the TEM, and other applicable standards.
   d. Develop a statewide pavement marking plan and performance measures, and support the central striping business.
   e. Establish and maintain models for pavement marking life cycles.
   f. Develop and maintain pavement marking material and installation specifications and requirements.
   g. Evaluate materials, equipment, and methods to be incorporated into pavement marking projects.
   h. Perform temporary traffic control reviews.
   i. Coordinate all new traffic control and safety product evaluations, and establish a reporting system.
   j. Coordinate new products with traffic engineering research efforts, evaluation, and approvals.
   k. Provide data on active and closed new product evaluations and act as a liaison with Contract Administration and Maintenance Operations.
   l. Administer the statewide Work Zone Safety Committee and TEO Temporary Traffic Control Committee.
3. Traffic Safety
   a. Provide leadership and expertise on traffic safety issues.
   b. Administer the Highway Safety Improvement Program (HSIP).
   c. Coordinate and administer speed authorizations and the Speed Monitoring Program.
   d. Manage the Transportation Information System (TIS) crash data, and conduct training for the districts and local agencies.
   e. Conduct safety audits as required.
   f. Develop and implement Minnesota's Strategic Highway Safety Plan, working closely with the Department of Public Safety, Minnesota State Patrol, and other safety partners.
   g. Propose needed traffic safety research projects and act as the technical liaison to these projects.
   h. Interact with other states and research groups in order to exchange information and assist in practical safety research.
   i. Administer the TEO Safety Committee.

4. Traffic Standards, Tort Claims, and Training
   a. Direct and coordinate state and Mn/DOT traffic engineering policy.
   b. Coordinate and administer the Minnesota Committee on Uniform Traffic Control Devices.
   c. Prepare, coordinate, and administer standards, specifications, and technical memoranda.
   d. Arrange for publication and distribution of various traffic engineering manuals and provide expertise on their interpretation.
   e. Identify and prioritize statewide traffic engineering training needs, procure services as required, and assist with course development.
   f. Represent Mn/DOT interests in the defense against claims and lawsuit.
   g. Evaluate claims, negotiate and approve settlements, and develop Mn/DOT policies and practices regarding tort liability settlement decisions.
   h. Administer the TEO Education/Training Committee.

5. Intelligent Transportation Systems (ITS) Project Management and Research
   a. Support the research activities in the areas of traffic engineering, traffic safety, and operations.
   b. Plan and administer funding for ITS research, development, and operational testing.
   c. Manage ITS research, development, and operational test projects.
   d. Provide a full range of administrative services to all OTST staff as well as the Traffic Engineering Organization.
   e. Provide technical, funding, planning, and contractual expertise to the Districts, Office of State Aid, cities, counties, and contractors concerning ITS.
   f. Maintenance of greater Minnesota ITS field devices.
   g. Administer the TEO Intelligent Transportation Systems Committee.
6. Electrical Systems
   a. Provide technical expertise to the Districts, Office of State Aid, cities, counties, and consultants concerning traffic signal and roadway lighting design, operation, construction, and the contract process.
   b. Provide quality assurance for plan preparation and specifications.
   c. Evaluate materials, equipment, and methods to be incorporated into signal and lighting projects.
   d. Research new traffic equipment and software technology for lighting and signal systems and design.
   e. Develop concepts, standards, and applications for lights and signals.
   f. Ensure that signal and lighting projects conform to Mn/DOT policy, the TEM, and other applicable standards.
   g. Provide electrical maintenance for traffic signals and lighting.
   h. Provide dispatching for locating Mn/DOT underground facilities as part of the Gopher State One Call system.
   i. Perform locates of Mn/DOT underground facilities within the Metro District.
   j. Provide training in traffic signal and roadway lighting design and traffic signal operations.
   k. Administer the TEO Lighting and Signals Committees.

7. Freeway Systems Operations
   a. Plan completion, fill-in, and expansion of the freeway management system (FMS), in conjunction with FMS design and integration staff of the Office of Electronic Communication.
   b. Develop and support freeway management software that monitors and controls field equipment (e.g. ramp meters, changeable message signs, and lane control signals).
   c. Provide real-time traffic and incident information.
   d. Furnish traveler information to the general public and local information service providers.
   e. Provide motorists with a safer, more reliable, and less congested trip on Metro area roadways.
   f. Provide support and technical assistance to the Metro district construction forces and other Mn/DOT units regarding FMS issues.
   g. Integrate freeway operations with other road agencies operating arterial street traffic signal systems.
   h. In conjunction with the Office of Homeland Security and Emergency Management, develop and be prepared to administer evacuation of the Metro area in case of catastrophic disaster.

8. Incident Management
   a. Manage the Freeway Incident Response Safety Teams (FIRST).
   b. Lead Mn/DOT's incident management cooperative effort with the State Patrol, municipal law enforcement, municipal fire departments, Mn/DOT Maintenance, and private tow companies.
   c. Provide expertise in the area of incident response.
   d. Develop incident management plans for major construction projects on Metro freeways.
   e. Manage Mn/DOT's special freeway operations projects to supplement the current freeway management system.
9. MnPASS
   a. Maximize capacity in the I-394 corridor, and make better use of the capacity in the HOV lane.
   b. Develop, coordinate, and implement strategies and work plans for the Mn PASS program.
   c. Administer partnership agreements with law enforcement agencies providing additional enforcement in the corridor.
   d. Oversee the administration and execution of the I-394 MnPASS express lanes capital and operating contracts.

1-2.04 Delegation of Authority

In addition to the responsibilities of the State Traffic Engineer which are carried out by the various units of the OTST, the State Traffic Engineer is delegated very specific authority and responsibility from the Commissioner of Mn/DOT for providing traffic control devices on the trunk highway system. In addition, some authority is further delegated to the District Traffic Engineers. The general levels of authority and responsibility are described in the following sections:

1. Orders approved by the District Traffic Engineer
   a. For standard traffic signs and markings which are in accordance with the MN MUTCD, the District Traffic Engineer may issue a District Traffic Work Order, Form 29187 (Form 1.A).
   b. Files are kept in the District Traffic Office.

2. Speed limit authorization by the Office of Traffic, Safety, and Operations.
   a. The OTST authorizes speed limits for streets described in MS 169.14, Subd. 5 and 8.
   b. For speed zoning on local streets, roads, bridges, and temporary speed limits in construction zones, an engineering and traffic investigation with recommended speed limits shall be submitted to OTST on Form 1.B for approval.
   c. For trunk highways described in MS 169.14, Subd. 4, the OTST also authorizes all speed limits. Form 1.C should be prepared and submitted to OTST for approval.

1-3.00 DISTRICT TRAFFIC ENGINEERING FUNCTION

1-3.01 General Function of the District Traffic Engineering Staff

The function of the District is primarily to implement policies and preferred practices, contact and advise local governmental agencies, manage day-to-day operational problems in the field, provide feedback to Central Office on policies and practices, advise District staff, perform field investigations, collect data, supervise signing and striping operations as assigned within the District, and perform numerous studies.

Within the organization of Mn/DOT many important traffic engineering functions are carried out by the District Traffic Engineer (DTE) and staff. While each District has a slightly different organization, the functions performed by the DTE's and their staffs are essentially the same.
1-3.02 Specific Functions Performed by the District Traffic Engineering Staff

The specific functions performed by the District Traffic Engineering Staff are as follows:

1. Collect, analyze, and use data as part of various studies of traffic volumes, crashes, and special programs.
2. Lead the preparation of the Intersection Control Evaluation report.
3. Design coordination.
   a. Review preliminary and construction road plans from a traffic engineering perspective.
   b. Obtain and administer all work authorities needed by and/or assigned to the traffic office.
   c. Review all comprehensive plans, plats, and proposed developments.
   d. Obtain local approvals of traffic engineering projects where needed.
   e. Review proposed design standards and provide feedback.
4. Safety design.
   a. Develop District Safety Improvement Program, including contract and maintenance work.
   b. Investigate safety issues and develop safety project proposals.
   c. Review entrance permits.
   d. Make recommendations to designers.
   e. Prepare design study reports for safety projects, if requested.
   f. Prepare portions of large study reports relating to crashes, traffic volume, present operation, etc.
   g. Assist in the development of guardrail improvement programs.
   h. Review and assist local safety programs.
   i. Provide capacity analysis of present roadways, intersections, etc.
   j. Provide District support of traffic-oriented research programs.
   k. Provide a before and after evaluation of past projects.
   l. Manage the District Transportation Information System (TIS) and crash files.
   m. Facilitate District tort claim responses.
5. Signal design.
   a. Design and prepare traffic signal plans.
   b. Prepare traffic signal special provisions.
   c. Develop, administer, and process signal agreements with local governmental agencies in conjunction with the Office of Technical Support.
   d. Prepare and approve intersection control evaluations, which replaces the signal justification report.
   e. Assist in the determination and preparation of signal installation and operation programs.
   f. Investigate and recommend signal system concepts on trunk highways and local roads.
   a. Develop, administer, and process lighting agreements and exhibits with local agencies and utility companies in conjunction with the Office of Technical Support.
   b. Prepare and process exhibits for lighting systems.
   c. Design and prepare lighting plans.
   d. Prepare lighting special provisions.
   e. Prepare lighting study reports.
   f. Review lighting permits submitted by local municipalities and utility companies.
   g. Determine the source of power obtained from the utility company.

7. Signal and lighting construction.
   a. Supervise contracts and provide inspection for assigned signal and lighting projects as directed by the District Engineer.
   b. Assist in the inspection of signal and lighting contracts assigned to others.
   c. Assist local governments in the inspection of signal and lighting projects.
   d. Originate traffic engineering requests for state furnished equipment.
   e. Update the Automated Facilities Management System (AFMS).

8. Signal and lighting operations.
   a. Investigate and prepare replies to questions pertaining to signal and lighting operations.
   b. Supervise lighting procedures.
   c. Time all signals, and develop and maintain a systematic review of the operation of all signal systems, including railroad emergency preemption.
   d. Coordinate activities with the appropriate Electrical Services Unit (ESU).
   e. Provide inventory of signal and lighting equipment in the field for maintenance by the appropriate ESU.
   f. Assist in minor troubleshooting of signals as requested by the appropriate ESU.
   g. Provide liaison with power companies for repairs where Mn/DOT furnishes lane closures.
   h. Provide routine surveillance patrols to determine all lighting outages within the District. This includes all roadway lighting and sign lighting.
   i. Locate underground facilities in response to requests from Gopher State One Call.
   j. Write simple lighting and signal agreements.
   a. Investigate and reply to complaints relative to signing.
   b. Investigate and prepare District Traffic Work Orders for needed signs.
   c. Administer special signing projects such as signing for resorts, campgrounds, corporate limits, specific service signs, etc.
   d. Prepare layouts for routine sign maintenance programs.
   e. Assist in the formulation of signing standards and policies.
   f. Design and/or review designs of contract signing, layouts, and plans.

   a. Prepare Traffic Control Orders which cover traffic control devices used for construction operations.
   b. Coordinate sign crew activities in the field.
   c. Determine with the project engineer the construction staging required for designs, and prepare the Traffic Control Plan for the project.
   d. Assist in the preparation of time and traffic provisions.
   e. Assist in the layout and installation of contract signing.
   f. Assist in the preparation of public information for construction work.

11. Speed zoning and special studies.
   a. Prepare speed limit studies and manage the District speed limit authorization process.
   b. Investigate complaints and systematically review all speed zoning on the trunk highway system.
   c. Maintain the reference post system.
   d. Collect data for determining speed trends and influences.
   e. Conduct investigations and provide reports for school safety programs.
   f. Conduct investigations and provide reports for railroad crossing programs.

12. Pavement marking operations.
   a. Maintain appropriate pavement markings on all highways and interstates.
   b. Oversee construction and maintenance activities related to pavement marking.
   c. Make and report handheld retroreflectometer readings to the pavement marking unit to be added to the inventory data base.
   d. Provide daily work planning and supervision for latex pavement marking.

13. Oversee the design, construction, maintenance, and operation of District ITS systems which may include cameras, electronic signs, vehicle detection, and communications networks.

14. Assist in the issuance of permits for parades and events.

15. Respond to numerous public and legislative concerns and requests.
1-4.00 TRAFFIC ENGINEERING ORGANIZATION (TEO)

1-4.01 Introduction
To provide a forum for the sharing of new ideas, experiences, and the opportunity to discuss general traffic engineering topics of mutual interest, the TEO was established to better address the traffic engineering challenges of the present and the future. These challenges include the need to:

1. Remain innovative in an era in which standardization is increasingly emphasized.
2. Maintain flexibility while working under today's budget constraints.
3. Maximize the utilization of existing corridors for increasing traffic volumes.
4. Take the initiative on matters affecting traffic safety and engineering within Mn/DOT.

1-4.02 Purpose
Deliberate and active pursuit of the following purposes of the TEO will produce effective cooperation within Mn/DOT and other agencies and will provide better service to the motoring public.

1. Provide leadership and promote uniformity in traffic engineering practices and policies within Mn/DOT.
2. Play a cooperative role in addressing traffic engineering topics that affect the Districts.
3. Communicate, obtain information, and exchange ideas with other traffic engineers, Mn/DOT groups, other agencies, and outside groups and organizations; and become aware of and act on issues affecting Mn/DOT.
4. Make recommendations for the implementation of solutions to traffic problems of a department wide nature.
5. Stay abreast of new technology and methods and promote the implementation of new technology in daily practice.
6. Continue the relationships with the District staffs and assist them in solving problems affecting District operations.
7. Provide leadership to identify, design, and deliver continuing education courses for traffic engineering professionals.
1-4.03 Structure and Procedures

Mn/DOT has adopted a general organizational philosophy of decentralization. With regard to the Districts the role of the OTST in the Central Office is to provide leadership, education, standards and policies, technical expertise, and support. The District Traffic Engineering Offices are largely responsible for direct public and agency contact on specific issues as well as program delivery and traffic operations in the field.

In order to maintain efficiency in the working relationships between the Central and District Traffic Offices, Mn/DOT has adopted the formal TEO described below.

1. Organization
   
a. Membership consists of the Director, Assistant State Traffic Engineers, and Functional Area Supervisors from OTST, District Traffic Engineers (DTE's), Geometrics Engineer in the Office of Technical Support, and the FHWA Safety and Traffic Operations Engineers. Others may be invited by TEO members to attend and participate in the meetings.

b. Responsibilities are to:
   1) Provide overall direction and guidance to Mn/DOT on traffic policy, operation, and uniformity.
   2) Adopt formal positions of the Organization.
   3) Initiate action on items needing work.
   4) React to items in which input from the entire TEO is desired.
   5) Annually, at the last meeting of the year, elect by majority vote of the DTE's the new DTE representative to serve on the Executive Committee.

c. Meetings are to be held semi-annually or as determined by the Executive Committee or a majority of the TEO membership.

d. At any meeting there are two officers, the Chair and the Recorder. Chair duties are assumed by the DTE serving as the Executive Committee Vice-Chair. The Chair serves for the entire calendar year. Recorder duties will be assigned to the host office member by the Director of OTST.

e. Organization meeting Chair duties are to:
   1) Arrange TEO meeting times and facilities with the Executive Committee. Facilities are currently being arranged by the host office.
   2) Govern the activities at the Organization meeting.

f. TEO recorder duties are to:
   1) Request agenda items, prepare agenda in consultation with the Director of OTST, and distribute the agenda for the meeting. The person responsible for these duties is the Office and Administrative Specialist of OTST.
   2) Prepare a list of future TEO meeting dates, Standing Committee memberships, current bylaws, and any additional attachments members would like to add, and send them to all TEO members. The person responsible for these duties is the OTST Office and Administrative Specialist.
   3) Take appropriate notes and distribute them in final form to the mailing list as soon as possible after the meeting. Action items indicating who is responsible for follow-up are to be highlighted in the notes. These duties are the responsibility of the host office.

The agenda is to be organized by subject, rather than by person.
2. Executive Committee:
   a. Membership consists of the Director of OTST, the three DTEs elected by all the DTE representatives, and the traffic electrical systems engineer. If a member is unavailable, an alternate should attend in their place.
   b. Responsibilities are to:
      1) Be the contact body for the Organization.
      2) Coordinate and direct the working activities of the Organization.
      3) Assist the Director of OTST in recommending policy to Mn/DOT staff.
      4) Assist the Chair in arranging the meetings.
      5) Identify and present to the Committee those items in which input and direction are required.
      6) Make decisions on behalf of the TEO for matters not deemed controversial enough to warrant TEO consideration.
      7) Establish appropriate Ad Hoc committees.
      8) Periodically review the operating procedures of each Standing Committee, Ad Hoc committee, and Sub-committees to "fine tune" them as needed.
      9) Evaluate and approve scientific equipment requests for traffic engineering uses.
     10) Speak for the Committee.
     11) At the last meeting of each year seek the desires of the other TEO members regarding Standing Committee assignments, and then make all the appointments for the coming calendar year. The Executive Committee will resolve all assignment conflicts by majority vote.
   c. The Director of OTST will serve as the Chair of the Executive Committee. A DTE will serve as the Vice-chair. The responsibilities of the Chair are to:
      1) Call meetings of the Executive Committee as needed.
      2) Obtain progress reports from each of the committees prior to Executive Committee and TEO meetings, and report on the progress at those meetings.
      3) Organize the agenda at all Executive Committee meetings.
      4) Serve as the initial principal contact of the Organization for other people or groups.
   d. At the last meeting of each year the DTE's as a group elect one DTE to serve on the Executive Committee for a three year term. After the first year, the elected DTE will serve as the TEO meeting Vice-chair for a year, and then during the third year serve as the Chair for the TEO meetings and as the Executive Committee Vice-chair. Any vacancies that occur during the year will be filled on an interim basis by majority vote of the remaining Executive Committee members.
   e. A member of the Executive Committee, or one of the OTST Assistant State Traffic Engineers serves as the TEO contact with the Operation Managers Group (OMG), the Construction Managers Group (CMG), the Pre-Construction Managers Group (PCMG), the Office of Technical Support, and the District Operation Division's staff.
3. TEO Standing Committees
   a. The TEO has eight Standing Committees.
      1) Executive
      2) Education/Training
      3) ITS
      4) Lighting
      5) Safety
      6) Signals
      7) Signing/Pavement Marking
      8) Temporary Traffic Control
   b. Responsibilities of the Standing Committees are:
      1) Review, evaluate, and report to the Executive Committee on matters that had been referred to it.
      2) Identify issues and provide recommendations to the Executive Committee for consideration.
      3) Act as a resource group by serving on other Mn/DOT committees or task forces at the request of the Executive Committee.
      4) Assist other Standing Committees when issues overlap.
   c. Each Standing Committee shall consist of at least one member from OTST, two DTE's, and additional members as deemed appropriate.
   d. A member of TEO appointed by the Executive Committee will serve as Chair for each calendar year period. Normally, this person will be the OTST functional area engineer.
   e. The Standing Committee Chair will be responsible for:
      1) Organizing the work of the Committee.
      2) Keeping the Executive Committee informed on activities.
      3) Ensuring that Committee work is well documented.
   f. Appointments to the Standing Committees and Officer positions will be made by the Executive Committee elected to serve that year. Appointments will be made in January and individual desires will be accommodated as much as possible.
4. Ad Hoc Committees
   a. Ad Hoc committees will be established by the Executive Committee or Standing Committees as necessary.
   b. Membership will consist of a Chair and at least two other people with appropriate backgrounds (within or outside of Mn/DOT).
   c. Responsibilities for each Ad Hoc Committee will be determined by the requesting authority.
   d. The requesting authority will disband the Ad Hoc Committee when it's charge is completed.
5. Sub-Committees
   a. Any Standing Committee or Ad Hoc Committee may establish one or more Sub-committees to assist in carrying out its responsibilities.
   b. Sub-committees will serve at the discretion of the Committee Chair.
1-4.04 Documentation

It is imperative that work done and decisions made within the TEO are well documented. The Executive, Standing, Ad Hoc, and Sub-committee Chairs are responsible for keeping accurate written documentation of their activities.

The Director of OTST will maintain a journal documenting all TEO group activities each calendar year. This journal will serve as the official record of the TEO's activities. The Director will write, or cause to have written, an executive summary of the journal, and will distribute the executive summary to appropriate Mn/DOT staff.

The Director of OTST will incorporate all issues resolved by the TEO into the Minnesota Traffic Engineering Manual (TEM), or the Minnesota Manual on Uniform Traffic Control Devices (Mn MUTCD), as appropriate. The Director will also include the documentation of the TEO contained herein in Chapter 1 of the Minnesota TEM.
Office of Traffic, Safety and Operations (OTSO)
DISTRICT TRAFFIC WORK ORDER

<table>
<thead>
<tr>
<th>County</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>T.H. No.</td>
<td>Dist. No.</td>
</tr>
<tr>
<td>Control Section</td>
<td>Order No.</td>
</tr>
<tr>
<td>Location</td>
<td></td>
</tr>
</tbody>
</table>

To ________________________________

Make the (permanent/temporary) changes in traffic controls as follows:

Date work completed ________________________________

District/Division Traffic Engineer
Signed by: ________________________________

White and Pink -- Work Unit
(Return White to DTE upon completion or work)
Orange -- Project Engineer or Project Supervisor
Blue -- District Traffic Engineer

Text Ref.: 1-2.04
As authorized in Minnesota Statutes 169.14, it is hereby ordered that the following speed limits are approved and shall be put into effect on the described roadway or sections thereof.

(filled out by District staff)
As authorized in Minnesota Statutes 169.14, it is hereby ordered that the following speed limits are approved and shall be put into effect on the described roadway or sections thereof.

(filled out by District staff)

Date traffic control devices changed implementing this authorization

(1) White -- District Traffic Engineer
(1) Pink -- Central Office Traffic

NOTE: Reference Points (RP) shown are for state reference system only.

Text Ref.: 1-2.04
# Chapter 2
## TRAFFIC LAWS

<table>
<thead>
<tr>
<th>TABLE OF CONTENTS</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-1.00 INTRODUCTION</td>
<td>2-3</td>
</tr>
<tr>
<td>1.01 Purpose</td>
<td></td>
</tr>
<tr>
<td>1.02 Scope</td>
<td></td>
</tr>
<tr>
<td>1.03 Chapter Organization</td>
<td></td>
</tr>
<tr>
<td>2-2.00 GLOSSARY</td>
<td>2-4</td>
</tr>
<tr>
<td>2-3.00 LEGAL RESPONSIBILITIES</td>
<td>2-9</td>
</tr>
<tr>
<td>3.01 Legal Responsibilities of Mn/DOT</td>
<td></td>
</tr>
<tr>
<td>3.02 Legal Responsibilities of a Local Authority</td>
<td></td>
</tr>
<tr>
<td>3.03 Mn/DOT Approvals</td>
<td></td>
</tr>
<tr>
<td>2-4.00 SIGNS, SIGNALS, AND MARKINGS</td>
<td>2-10</td>
</tr>
<tr>
<td>4.01 Legal Background</td>
<td></td>
</tr>
<tr>
<td>4.02 Minnesota Manual on Uniform Traffic Control Devices</td>
<td></td>
</tr>
<tr>
<td>4.03 Placement and Maintenance on Trunk Highways</td>
<td></td>
</tr>
<tr>
<td>4.04 Placement and Maintenance on Local Streets and Roads</td>
<td></td>
</tr>
<tr>
<td>4.05 Unauthorized Traffic Control Devices</td>
<td></td>
</tr>
<tr>
<td>4.06 Railroad Stop Crossings</td>
<td></td>
</tr>
<tr>
<td>4.07 Vandalism</td>
<td></td>
</tr>
<tr>
<td>2-5.00 SPEED RESTRICTIONS</td>
<td>2-11</td>
</tr>
<tr>
<td>5.01 Basic Speed Rule</td>
<td></td>
</tr>
<tr>
<td>5.02 Authority to Establish Speed Limits</td>
<td></td>
</tr>
<tr>
<td>5.03 Speed Limits</td>
<td></td>
</tr>
<tr>
<td>2-6.00 NO PASSING ZONES AND LANE DESIGNATIONS</td>
<td>2-15</td>
</tr>
<tr>
<td>6.01 No Passing Zones</td>
<td></td>
</tr>
<tr>
<td>6.02 Lane Designations</td>
<td></td>
</tr>
<tr>
<td>2-7.00 THROUGH HIGHWAYS AND CONTROLLED ACCESS HIGHWAYS</td>
<td>2-15</td>
</tr>
<tr>
<td>7.01 Through Highways</td>
<td></td>
</tr>
<tr>
<td>7.02 Controlled Access Highways</td>
<td></td>
</tr>
<tr>
<td>2-8.00 PARKING REGULATIONS</td>
<td>2-15</td>
</tr>
<tr>
<td>8.01 General Regulations</td>
<td></td>
</tr>
<tr>
<td>8.02 Limited Time Parking</td>
<td></td>
</tr>
<tr>
<td>8.03 Parking Meter Zones</td>
<td></td>
</tr>
<tr>
<td>8.04 Disabled Parking</td>
<td></td>
</tr>
<tr>
<td>8.05 Angle Parking</td>
<td></td>
</tr>
<tr>
<td>8.06 Parking on One-Way Streets</td>
<td></td>
</tr>
<tr>
<td>2-9.00 LOAD RESTRICTIONS</td>
<td>2-17</td>
</tr>
<tr>
<td>9.01 General Load Restrictions</td>
<td></td>
</tr>
<tr>
<td>9.02 Seasonal Restrictions</td>
<td></td>
</tr>
</tbody>
</table>
CHAPTER 2 - TRAFFIC LAWS

2-1.00 INTRODUCTION

2-1.01 Purpose

The purpose of this chapter is to identify and describe the Minnesota State laws and Mn/DOT regulations which regulate traffic on Minnesota highways and therefore, govern the actions and responsibilities of traffic engineers in the State. Under Minnesota law, the regulation of traffic may be accomplished by: statute, Mn/DOT regulation, and local order, ordinance, or resolution approved by Mn/DOT. While this chapter identifies traffic laws and regulations and presents their application as related to the safe and expeditious movement of traffic, it does not purport to be a legal document, nor shall it be interpreted as such. Readers are referred to the latest official publication of the Minnesota Statutes for more complete legal information.

2-1.01.01 Laws

Both laws and regulations are principles governing actions or procedures. A law has been made obligatory and enforceable by a supreme authority or sanction. In Minnesota, "official" State laws are statutes passed by the State Legislature and approved by the Governor. They are commonly referred to as Minnesota Statutes (MS) or Minnesota Statutes Annotated (MSA).

2-1.01.02 Regulations

A regulation is a rule which may be enforced. Regulations can be established or approved only by the proper authority as provided in the law. In Minnesota, the Mn/DOT Commissioner may establish or approve regulations affecting traffic movement on Trunk Highways. Failure to conform to a regulation is a violation of law.

2-1.01.03 Common Traffic Laws and Regulations

The most common laws and regulations of concern to Mn/DOT are those regarding:

1. Signs, signals and markings.
2. Speed restrictions.
3. No passing restrictions.
4. Parking prohibitions.
5. Through highways.
7. Lane use restrictions and controls.
8. Advertising restrictions.
9. Restrictions of certain classes of traffic, along with pedestrians, bicycles, and animals.
10. Right-of-way and rules of the road.

2-1.02 Scope

Since the primary purpose of the Traffic Engineering Manual is to provide the information needed by Traffic Engineering personnel to carry out their daily duties, only those laws affecting these activities will be discussed in this chapter. Chapters 160-173 of the Minnesota Statutes include most of the State Laws affecting roads and highways in Minnesota. Chapter 169, Highway Traffic Regulation, is most important to traffic engineers and will be the primary focus of this chapter of the Traffic Engineering Manual. The KEY WORD INDEX at the end of this chapter references other laws which traffic engineers may need to refer to occasionally.
2-1.03 Chapter Organization

The following section includes a key word index of the Minnesota Statutes and a selected glossary of legal definitions. The remaining sections of the chapter will describe specific laws and regulations of concern to traffic engineers. In each of these sections the applicable law(s) and regulations will be identified, an interpretation of the law will be provided and the law's legal implications will be discussed. Where appropriate, references to other sections of the Manual will be provided. The applicable law(s) are not quoted verbatim in the interest of brevity. Readers should consult the latest official publication of the Minnesota Statutes for current and complete legal information where necessary.

2-2.00 GLOSSARY

Advertising device - any billboard, sign, notice, poster, display, or other device visible to and primarily intended to advertise and inform or to attract the attention of operators and occupants of motor vehicles and shall include any structure erected primarily for use in connection with the display of any such device and all lighting or other attachments used in connection therewith. MSA 173.02, Subd. 2.

Authorized Emergency Vehicle - Any of the following vehicles when equipped and identified according to law: (l) a vehicle of a fire department; (2) a publicly owned police vehicle or a privately owned vehicle used by a police officer for police work under agreement, express or implied, with the local authority to which he is responsible; (3) a vehicle of a licensed land emergency ambulance service, whether publicly or privately owned; (4) an emergency vehicle of a municipal department or a public service corporation approved by the Commissioner of Public Safety or the Chief of Police of a municipality; (5) any volunteer rescue squad operating pursuant to Laws 1959, Chapter 53; (6) a vehicle designated as an authorized emergency vehicle upon a finding by the Commissioner of Public Safety that designation of that vehicle is necessary to the preservation of life or property or to the execution of emergency governmental functions. MSA 169.01, Subd. 5.

Bicycle - Every device propelled solely by human power upon which any person may ride having two tandem wheels except scooters and similar devices and including any device generally recognized as a bicycle equipped with two front or rear wheels. MSA 169.01, Subd 51.

Bicycle Lane - That portion of a roadway or shoulder designed for exclusive use or preferential use by persons using bicycles. Bicycle lanes are to be distinguished from the portion of the roadway or shoulder used for motor vehicle traffic by physical barrier, striping, marking, or other similar device. MSA 169.01, Subd. 70.

Bicycle Path - That facility designed for exclusive or preferential use by persons using bicycles and constructed or developed separately from the roadway or shoulder. MSA 169.01, Subd. 69.

Bicycle Route - A system of bikeways designated by appropriate route markers, and by the jurisdiction having authority. MN MUTCD, Section 9A-3.

It is developed by the Commissioner of Natural Resources under section 85.016. MSA 169.01, Subd. 71.

Bicycle Trail - A separate trail or path from which motor vehicles are prohibited and which is for the exclusive use of bicycles or the shared use of bicycles and pedestrians. Where such trail or path forms a part of a highway, it is separated from the roadways for motor vehicle traffic by an open space or barrier. MN MUTCD, Section 9A-3.

It is developed by the Commissioner of Natural Resources under section 85.016. MSA 169.01, Subd. 71.

Bikeway - A bicycle lane, bicycle path, or bicycle route, regardless of whether it is designed for the exclusive use of bicycles or is to be shared with other transportation modes. MSA 169.01, Subd. 72.

Bus - Every motor vehicle designed for carrying more than 15 passengers including the driver and used for the transportation of persons. MSA 169.01, Subd. 50.

Business District - The territory contiguous to and including a highway when 50 percent or more of the frontage thereon for a distance of 300 feet or more is occupied by buildings in use for business. MSA 169.01, Subd. 39.
**Business Sign** - A separately attached sign mounted on the rectangular specific information sign panel to show the brand, symbol, logo, trademark, or name, or combination of these, for a motorist service available on a crossroad at or near an interchange or an intersection.

**Commissioner** - Unless stated otherwise, "Commissioner" means the Commissioner of Transportation of this State. Regardless of the Commissioner referred to, however, the Commissioner is to be considered as acting directly or through the Commissioner's duly authorized officers and agents. MSA 169.01, Subd 21.

**Controlled Access Highway** - Every highway, street, or roadway in respect to which the right of access of the owners or occupants of abutting lands and other persons has been acquired and to which the owners or occupants of abutting lands and other persons have no legal right of access to or from the same except at such points only and in such manner as may be determined by the public authority having jurisdiction over such highway, street, or roadway. MSA 169.01, Subd. 54.

Any highway, street, or road, including streets within cities, over, from, or to which owners or occupants of abutting land or other persons have or are to have no right of access, or only a controlled right of the easement of access, light, air, or view. MSA 160.02, Subd. 12.

**County Highways** - Those roads which have heretofore been or which hereafter may be established, constructed, or improved under authority of the several county boards, including all roads lying within the county or on the line between counties established by judicial proceedings, except those roads established, constructed, or improved by the counties that have been maintained by the towns for a period of at least one year prior to July 1, 1957. All roads heretofore designated prior to July 1, 1957, as county-aid highways shall be county highways until abandoned or changed in accordance with law. MSA 160.02, Subd 4.

**County State-Aid Highways** - All roads established in accordance with law as county state-aid highways. MSA 160.02, Subd 3.

**Crosswalk** - (1) That portion of a roadway ordinarily included with the prolongation or connection of the lateral lines of sidewalks at intersections; (2) Any portion of a roadway distinctly indicated for pedestrian crossing by lines or other markings on the surface. MSA 169.01, Subd. 37.

**Department** - Unless stated otherwise, "department" means the Department of Transportation of this State. Regardless of the department referred to, however, it is to be considered as acting directly or through its duly authorized officers and agents. MSA 169.01, Subd. 22.

**Designated Bicycle Lane** - A portion of a roadway which has been designated for use by bicyclists. It is distinguished from the portion of the roadway for motor vehicle traffic by a paint stripe, curb, or other similar device. MN MUTCD, Section 9A-3.

**Electric-Assisted Bicycle** - A motor vehicle with two or three wheels that:

1. has a saddle and fully operable pedals for human propulsion;
2. meets the requirements of federal motor vehicle safety standards in Code of Federal Regulations, title 49, sections 571.01 et seq.; and
3. has an electric motor that has a power output of not more than 1,000 watts, is incapable of propelling the vehicle at a speed of more than 20 miles per hour, is incapable of further increasing the speed of the device when human power alone is used to propel the vehicle at a speed of more than 20 miles per hour, and disengages or ceases to function when the vehicle's brakes are applied. MSA 169.01, Subd. 4b.

**Expressway** - A divided highway with partial control of access and generally with grade separations at major intersections.

**Freeway** - A divided highway with full control of access with grade-separated interchanges at all access points. A "freeway" may be designated "Interstate" or "non-Interstate."
Intersection - (a) The area embraced within the prolongation or connection of the lateral curb lines, or if none, then the lateral boundary lines of the roadways of two highways which join one another, at, or approximately at, right angles, or the area within which vehicles traveling upon different highways joining at any other angle may come in conflict. (b) Where a highway includes two roadways 30 feet or more apart, then every crossing of each roadway of such divided highway by an intersecting highway shall be regarded as a separate intersection. In the event such intersecting highway also includes two roadways 30 feet or more apart, then every crossing of two roadways of such highways shall be regarded as a separate intersection. MSA 169.01, Subd. 36.

Laned Highway - A highway the roadway of which is divided into two or more clearly marked lanes for vehicular traffic. MSA 169.01, Subd. 34.

Local Authority - Every county, municipal, and other local board or body having authority to adopt local police regulations under the constitution and laws of this State, and the Regents of the University of Minnesota, with reference to property owned, leased, or occupied, by the Regents of the University of Minnesota, or the University of Minnesota. MSA 169.01, Subd 28.

Logo - A single or multicolored symbolic design unique to a product, a business or a service facility; a national, regional or local commercially recognized pictorial reference to a specific product, service or business used as a means of identification of a business's products, services or of the business itself.

Maximum Speed Limit - The limit above which any speed is automatically unlawful. It is an absolute limit, which may not be legally exceeded under any circumstances.

Motorized Bicycle - A bicycle that is propelled by a motor of a piston displacement of 50 cubic centimeters or less, and a maximum of two brake horsepower, which is capable of a maximum speed of not more than 30 miles per hour on a flat surface with not more than one percent grade in any direction when the motor is engaged. "Motorized bicycle" includes an electric-assisted bicycle as defined in subdivision 4b. MSA 169.01, Subd. 4a.

Municipal State-Aid Street - Any street within a city having a population of 5,000 or more, established in accordance with law as municipal state-aid streets. MSA 160 02, Subd. 5.

Official Traffic Control Device - All sign, signal, marking, and device consistent with MSA 169 placed or erected by authority of a public body or official having jurisdiction, for the purpose of regulating, warning, or guiding traffic. MSA 169.01, Subd. 41.

Prima Facie Limit - A limit which, on the face of it, is reasonable and prudent under normal conditions. A driver may exceed any prima facie limit if it is safe to do so under prevailing conditions. However, when a police officer cites a driver for exceeding a prima facie speed limit, it is up to the driver to prove, if he can, that he was driving in a reasonable and prudent manner under the existing conditions. The opportunity given to the driver to exceed a prima facie speed limit when it is safe to do so recognizes the fact that any posted speed limit cannot adequately reflect the many different conditions of traffic, weather visibility, etc, that may be found on the same highway at different times.

Private Road or Driveway - Every way or place in private ownership and used for vehicular travel by the owner and those having express or implied permission from the owner, but not by other persons. MSA 169.01, Subd. 30.

Railroad Sign or Signal - Any sign, signal, or device erected by authority of a public body or official or by a railroad and intended to give notice of the presence of railroad tracks or the approach of a railroad train. MSA 169.01, Subd. 43.

Residence District - The territory contiguous to and including a highway not comprising a business district when the property on such highway for a distance of 300 feet or more is in the main improved with residences or residences and buildings in use for business. MSA 169.01, Subd. 40.
Residential Roadway - A street or portion of a street that is less than one-quarter mile in length and is functionally classified as a local street by the road authority having jurisdiction. MSA 169.01, Subd. 81.

Road Authority - The Commissioner, as to trunk highways; the county board, as to county state-aid highways and county highways; the town board, as to town roads and the governing bodies of cities, when the governing bodies or city streets are specifically mentioned. MSA 160.02, Subd. 9.

Roadway - That portion of a highway improved, designed, or ordinarily used for vehicular travel, exclusive of the sidewalk or shoulder. In the event a highway includes two or more separate roadways the term "roadway" as used herein shall refer to any such roadway separately but not to all such roadways collectively. MSA 169.01, Subd. 31.

Rural Residential District - The territory contiguous to and including any town road within a subdivision or plat of land that is built up with dwelling houses at intervals of less than 300 feet for a distance of one-quarter mile or more. MSA 169.14, Subd. 2

Safety Zone - The area or space officially set apart within a roadway for the exclusive use of pedestrians and which is protected or is so marked or indicated by adequate signs as to be plainly visible at all times set apart as a safety zone. MSA 169.01, Subd. 38.

School Bus - A motor vehicle used to transport pupils to or from a school defined in MS 120A.22 or to or from school-related activities, by the school or a school district, or by someone under an agreement with the school or a school district. A school bus does not include a motor vehicle transporting children to or from school for which parents or guardians receive direct compensation from a school district, a motor coach operating under charter carrier authority, a transit bus providing services as defined in section 174.22, subdivision 7, or a vehicle otherwise qualifying as a Type III vehicle under paragraph (5), when the vehicle is properly registered and insured and being driven by an employee or agent of a school district for nonscheduled transportation. A school bus may be type A, type B, type C, or type D or type III as follows:

1. A "type A school bus" is a conversion or body constructed upon a van-type or cutaway front section vehicle with a left-side driver's door, designed for carrying more than ten persons. This definition includes two classifications: type A-I, with a gross vehicle weight rating (GVWR) over 10,000 pounds; and a type A-II with a GVWR of 10,000 pounds or less.

2. A "type B school bus" is a conversion or body constructed and installed upon a van-type or cutaway front section vehicle chassis, or stripped chassis, with a gross vehicle weight rating of more than 10,000 pounds, designed for carrying more than ten persons. Part of the engine is beneath or behind the windshield and beside the driver's seat. The entrance door is behind the front wheels.

3. A "type C school bus" is a body installed upon a flat back cowl chassis with a gross vehicle weight rating of more than 10,000 pounds, designed for carrying more than ten persons. All of the engine is in front of the windshield and the entrance door is behind the front wheels.

4. A "type D school bus" is a body installed upon a chassis, with the engine mounted in the front, midship, or rear, with a gross vehicle weight rating of more than 10,000 pounds, designed for carrying more than ten persons. The engine may be behind the windshield and beside the driver's seat; it may be at the rear of the bus, behind the rear wheels, or midship between the front and rear axles. The entrance door is ahead of the front wheels.

5. Type III school buses and type III Head Start buses are restricted to passenger cars, station wagons, vans, and buses in service after January 1, 1999, having an original maximum manufacturer's rated seating capacity of ten or fewer people, including the driver, and a gross vehicle weight rating of 10,000 pounds or less. In this subdivision, "gross vehicle weight rating" means the value specified by the manufacturer as the loaded weight of a single vehicle. A "type III school bus" and "type III Head Start bus" must not be outwardly equipped and identified as a type A, B, C, or D school bus or type A, B, C, or D Head Start bus. MSA 169.01, Subd. 6.
School Zone - That section of a street or highway which abuts the grounds of a school where children have access to the street or highway from the school property or where an established school crossing is located provided the school advance sign prescribed by the Manual on Uniform Traffic Control Devices adopted by the Commissioner pursuant to MSA 169.06 is in place. All signs erected by local authorities to designate speed limits in school zones shall conform to the Manual on Uniform Traffic Control Devices. MSA 169.14, Subd. 5a.

Sidewalk - That portion of a street between the curb lines, or the lateral lines of a roadway, and the adjacent property lines intended for the use of pedestrians. MSA 169.01, Subd. 33.

Specific Information Sign Panel - A rectangular metal sign panel consisting of the words gas, food, lodging, or camping, and directional information on which a business sign(s) is mounted.

Specific Service - Restaurants; rural agricultural or tourist-oriented businesses; places of worship; gasoline service stations and other retail motor fuel; businesses; and motels, resorts, or recreational camping areas that provide sleeping accommodations for the traveling public. "Tourist-oriented business" means a business, service, or activity that receives the major portion of its income or visitors during the normal business season from motorists not residing in the immediate area of the business or activity. "Tourist-oriented business" includes, but is not limited to: a greenhouse or nursery, a bait and tackle shop, a marina, and a gift or antique shop. MSA 160.292, Subd. 10.

Specific Service Sign - A rectangular sign panel displaying the name or optional business panel, or both, of a rural agricultural or tourist-oriented business, place of worship, motel, restaurant, resort, recreational camping area or gasoline service station or other retail motor fuel business and, where appropriate, the direction to and distance to the rural agricultural or tourist-oriented business, place of worship, recreational camping area, motel, restaurant, resort or gasoline service station or other retail motor fuel business. MSA 160.292, Subd. 2.

Street or Highway - The entire width between boundary lines of any way or place when any part thereof is open to the use of the public, as a matter or right, for the purposes of vehicular traffic. MSA 169.01, Subd. 29.

Through Highway - Every highway or portion thereof at the entrances to which vehicular traffic from intersecting highways is required by law to stop before entering or crossing the same and when stop signs are erected as provided in this chapter. MSA 169.01, Subd. 35.

Town Road - That road and cartway which has heretofore been or which hereafter may be established, constructed, or improved under the authority of the several town boards, and roads established, constructed or improved by counties that have been maintained by the towns for a period of at least one year prior to July 1, 1957. MSA 160.02, Subd. 6.

Traffic - Pedestrians, ridden or herded animals, vehicles, street cars, and other conveyances, either singly or together, while using any highway for purposes of travel. MSA 169.01, Subd. 44.

Traffic Control Signal - Any device, whether manually, electrically or mechanically operated, by which traffic is alternately directed to stop and permitted to proceed. MSA 169.01, Subd. 42.

Transportation District Engineer - As used in this chapter, refers to the Transportation District Engineer or representative, which in terms of this Manual is usually the District Traffic Engineer.

Trunk Highway - Any road established or to be established under the provisions of Article 14, Section 2 of the Constitution of the State of Minnesota. MSA 160.02, Subd. 2.

Urban District - The territory contiguous to and including any street which is built up with structures devoted to business, industry, or dwelling houses situated at intervals of less than 100 feet for a distance of a quarter of a mile or more. MSA 169.01, Subd. 59.
2-3.00 LEGAL RESPONSIBILITIES

2-3.01 Legal Responsibilities of Mn/DOT

Minnesota Statutes Annotated (MSA) 161.20 places Mn/DOT under the supervision and control of a Commissioner "who shall have and exercise the rights and powers and perform the duties prescribed by law." These duties are generally described in MSA 161.20 and are more specifically defined in many other sections of the Statutes, primarily in Chapters 160-173. In general, the Commissioner must carry out the provisions of the State Constitution as it relates to the State highway system (i.e., Trunk Highways). To do so, he has the power to acquire property, construct and maintain highways, let contracts, make agreements with local communities, expend funds, and promulgate regulations.

2-3.02 Legal Responsibilities of a Local Authority

2-3.02.01 The Law - MSA 169.04

MSA 169.04, A Local Authority, has two important implications for Mn/DOT engineers. First, the local authority have virtually complete authority (with notable exceptions such as Speed Zoning and Experimental Devices) over all streets and highways under their jurisdiction (county state-aid highways, county highways municipal state-aid streets and town roads). Since the statutes permit it, the local authority may enact any ordinance or regulation authorized by the statutes affecting traffic operation on these facilities (for a legal definition of the various local roads, see MSA 160.02 - also see MSA 169.06, Subd. 2 and 3 on requirement to conform to the MN MUTCD). Second, local governments may undertake actions affecting Trunk Highways only with the consent of Mn/DOT. The Transportation District Engineer is responsible for the review of all ordinances, regulations, or proposed actions affecting Trunk Highways.

2-3.03 Mn/DOT Approvals

2-3.03.01 Approval by the District

Proposed ordinances, regulations, or restrictions affecting State Trunk Highways shall be investigated and approved by Mn/DOT before implementation. A formal resolution requesting an investigation shall be submitted to the District by the local authority along with a draft of the proposed ordinance, regulation, or restriction. Proposals which would inhibit capacity or movement of Trunk Highway traffic, such as improper parking procedures, turn restrictions, truck routing, or similar items, must be investigated by Mn/DOT. If the proposed change is covered by the Minnesota Manual on Uniform Traffic Control Devices (MN MUTCD), the Traffic Engineering Manual or Technical Memorandums, the District may approve the action without a review by the State Traffic Engineer, OTST. A District Traffic Work Order, may be used for this purpose.

2-3.03.02 Approval by the State Traffic Engineer, Office of Traffic, Safety and Operations

The need for statewide uniformity and the legally sensitive nature of some work orders requires a centralized review. In these cases, the District conducts an investigation of the proposed action and transmits the proposal to the State Traffic Engineer, OTST with recommendations for action. At all times the District should make an effort, through close contact with local officials, to ensure that the applicable legal requirements are fulfilled. The State Traffic Engineer, OTST shall review and sign any order affecting:

1. Speed restrictions (see Section V).
2. Designations of through highways (see Section VII).
3. Experimental traffic control devices.
2-4.00 SIGNS, SIGNALS, AND MARKINGS

2-4.01 Legal Background

This section will discuss the legal rights and responsibilities of Mn/DOT regarding the placement and maintenance of signs, signals, and markings on streets and highways in Minnesota. Chapters 6, 7, 8 and 9 of this Manual describe standards and procedures for their design and implementation. Areas that will be covered in this section include: (1) the Minnesota Manual on Uniform Traffic Control Devices, (2) the placement and maintenance of signs, signals, and markings, (3) unauthorized devices, (4) railroad stop crossings, and (5) vandalism.

2-4.02 Minnesota Manual on Uniform Traffic Control Devices

Under MSA 169.06, Subd. 1, a Minnesota Manual on Uniform Traffic Control Devices (MN MUTCD) has been prepared and adopted by the Commissioner. Unless a variation is approved by Mn/DOT all traffic control devices shall conform to the specifications in the MN MUTCD.

2-4.03 Placement and Maintenance on Trunk Highways - MSA 169.06, Subd. 2

2-4.03.01 Mn/DOT Responsibility

Under MSA 169.06, Subd. 2, it is the sole responsibility of Mn/DOT to place and maintain all necessary traffic control devices on Trunk Highways although permission to do so may be granted to other authorities by Mn/DOT. All such devices shall conform to the MN MUTCD and to Mn/DOT specifications unless a variance for experimental devices has been granted by Commissioners order.

2-4.04 Variations from the MN MUTCD

Mn/DOT may authorize variations from the MN MUTCD only for purposes of investigation and research. It is important to note that any authorized variation (experimental traffic control devices) in traffic regulations must be published in a "qualified newspaper of general circulation" in the area affected by the variance. A qualified newspaper is one which is recognized as a legal or official publication of the municipality (see MSA 331.02). Experimental devices are only authorized on Trunk Highways.

2-4.04 Placement and Maintenance on Local Streets and Roads - MSA 169.06, Subd. 3

2-4.04.01 Local Responsibility

Under MSA 169.06, Subd. 3 local authorities have both the right and the responsibility to place and maintain traffic control devices on streets and highways under their jurisdiction. All new traffic control devices shall conform to the MN MUTCD and to State specifications. Legal liability for the existence and condition of these facilities rests with the local authority, and not with Mn/DOT.

2-4.05 Unauthorized Traffic Control Devices

2-4.05.01 Unauthorized Devices - (MSA 169.07)

MSA 169.07 gives Mn/DOT and local road authorities the authority and responsibility to identify and remove any sign, signal, marking or other device on Trunk Highways or other roads which is a traffic hazard or deters the effectiveness of official traffic control devices. Such devices may be removed by Mn/DOT without notice to the owner. This authority does not extend to informational signs on private property which cannot be mistaken as official traffic control devices.
2-4.05.02 Red Lights, Signs, and Signals

While most unauthorized devices may simply be removed by Mn/DOT, the removal of red lights, signs, and signals must be preceded by official notice. MSA 169.073 prohibits private individuals and companies from placing red lights, signals, or signs within view of highways or active railroads in such a way that affects the effectiveness or efficiency of official traffic control devices. Mn/DOT may order the removal or replacement of such lights by giving official written notice to the owner that the light is a traffic hazard. Notices shall be issued officially as required in MSA 216.17. In addition, the aggrieved party has the rights of appeal as required in MSA 216.25.

2-4.06 Railroad Stop Crossings - MSA 219.20

2-4.06.01 Responsibility for Railroad Crossing Signs

With respect to the provisions of MSA 219.20 Mn/DOT does not have the authority to install, replace, or remove signs on railroad property, including at railroad crossings. These signs and signals are the responsibility of the railroad company. Mn/DOT may declare a crossing "dangerous" and order the installation of stop signs at the crossing. Procedures for determining the need for traffic control devices at railroad crossings are discussed in Chapter 13 of this Manual.

2-4.07 Vandalism - MSA 169.08

2-4.07.01 Prosecution

MSA 169.08 clearly provides a recourse against vandalism related to highways and traffic control devices. Vandalism is usually a misdemeanor. Prosecution is normally handled by the county or municipality in which the vandalism occurred.

2-5.00 SPEED RESTRICTIONS

2-5.01 Basic Speed Rule - MSA 169.14, Subd. 1

The basic rule states in part that "No person shall drive a vehicle on a highway at a speed greater than is reasonable and prudent under the conditions. This law governing motor vehicle speed provides that motorists are responsible for restricting their speed to that which is reasonable under the existing conditions. Regardless of the posted speed limit, this basic concept governs the enforcement of speed laws.

2-5.02 Authority to Establish Speed Limits

Mn/DOT has the authority and responsibility to establish speed limits on Trunk Highways and to authorize speed limits on any street or highway in the State. The purpose of this section is to discuss the laws and regulations permitting the restriction of speed on Minnesota streets and highways.
2-5.03 Speed Limits

2-5.03.01 MSA 169.14, Subd. 2 states in part that:

1. "Where no special hazard exists, the following speeds shall be lawful, but any speeds in excess of such limits shall be prima facie evidence that the speed is not reasonable or prudent and that it is unlawful; except that the speed limit within any municipality shall be a maximum limit and any speed in excess thereof shall be unlawful:

a. 30 miles per hour in an urban district or on a town road in a rural residential district;
b. 65 miles per hour on non-Interstate freeways and expressways, as defined in section 160.02, subd. 16;
c. 55 miles per hour in locations other than those specified in this section;
d. 70 miles per hour on Interstate highways outside the limits of any urbanized area with a population of greater than 50,000 as defined by order of the commissioner of transportation;
e. 65 miles per hour on Interstate highways inside the limits of any urbanized area with a population of greater than 50,000 as defined by order of the commissioner of transportation;
f. 10 miles per hour in alleys; and
g. 25 miles per hour in residential roadways if adopted by the road authority having jurisdiction over the residential roadway.

2. A speed limit adopted under paragraph (a), clause (7), is not effective unless the road authority has erected signs designating the speed limit and indicating the beginning and end of the residential roadway.

3. For the purposes of this subdivision, "rural residential district" means the territory contiguous to and including any town road within a subdivision or plat of land that is built up with dwelling houses at intervals of less than 300 feet for a distance of one-quarter mile or more."

Residential Roadway - Residential roadway means a street or a portion of a street that is less than one-quarter mile in length and is functionally classified as a local street by the road authority having jurisdiction.

This portion of the law establishes basic speed limits in Minnesota under normal conditions. Current modifications are as noted in the following section.

2-5.03.02 Establishment of Zones by Commissioner - MSA 169.14, Subd. 4

Guidelines - The determination and implementation of speed limits on Trunk Highways is solely the responsibility of Mn/DOT. Procedural elements of speed zone determination including the "engineering and traffic investigation" are discussed in Chapter 6. Information on Data Collection may be found in Chapter 5.

2-5.03.03 Speed Zoning within Local Areas - MSA 169.14, Subd. 5

Guidelines - On all streets and highways other than Trunk Highways, the local authority must request investigation and authorization by Mn/DOT. Following Mn/DOT authorization, the local authority is responsible for placing and maintaining the speed limit signs on roadways under its jurisdiction.

2-5.03.04 District Investigation

The District Traffic Engineer is responsible for the surveys and data collection needed to determine speed limits on all streets and highways. The results of the District Traffic Engineer's investigation and his recommendations shall be transmitted to and approved by OTST before any speed limit may be revised. The procedures on establishing appropriate speed limits are described in Chapter 6 of this Manual.
2-5.03.05 Sign Placement

Speed limit signs must be placed at the beginning of all speed zones and at appropriate intervals through each zone. On divided highways, supplemental speed limit signs may be placed in the median. More specific details on speed limit sign placement are provided in Chapter 6.

2-5.03.06 School Speed Limits - MSA 169.14, Subd. 5a

**Authority** - MSA 169.14, Subd. 5a, grants local authorities (City Councils and County Board but not School Districts) the power to establish reduced speed limits in "school zones" without Mn/DOT authorization. Mn/DOT consent is required only if a Trunk Highway would be affected by the proposed action. Except on Trunk Highways, the placement and maintenance of any such traffic control devices is the responsibility of the local authority. School speed zoning will not automatically reduce speeds or crashes, and therefore must be done carefully.

Furthermore, the school zone limit is "part time" (in effect only when children are present, going to or leaving school during normal school hours) and must be identified accordingly. It is therefore important to consider alternatives which can be effective 24 hours per day before school speed zones are implemented. Examples of these alternatives are sidewalk construction, parking restrictions, crossing guards, stop signs and signals, and pedestrian rerouting.

**Engineering and Traffic Investigation** - The required procedures for conducting the investigation are outlined in "A Guide to Establishing Speed Limits in School Zones." The local authority shall complete an engineering and traffic investigation as prescribed by Mn/DOT before a school speed zone can be established. This investigation shall include:

1. a school route plan and
2. a school zone hazard evaluation.

2-5.03.07 Segments in Urban Districts - MSA 169.14, Subd. 5b

**Authority** - MSA 169.14, Subd. 5b, grants local authorities the power to reduce a previously established speed limit greater than 30 mph on a segment of a city street, municipal state street or town road in an area that meets the "urban district" as defined in MSA 169.01, subd. 59. The speed established will be as specified in MSA 169.14, Subd. 2.

**Responsibility** - A copy of the resolution must be sent to the Commissioner at least 10 days prior to sign installation.

**Speed Zoning in Alleyways** - MSA 169.14, Subd. 5c. Under this law local authorities may regulate speed limits for alleyways as defined in MSA 169.01 based on their own engineering and traffic investigations. Alleyway speed limits established at other than 10 miles per hour are effective when proper signs are posted.

**Speed Zoning in Work Zones** - MSA 169.14, Subd. 5d. Under this law the Commissioner, on trunk highways and temporary trunk highways, and local authorities, on streets and highways under their jurisdiction, may authorize the use of reduced maximum speed limits in highway work zones. The Commissioner or local authority is not required to conduct an engineering and traffic investigation before authorizing a reduced speed limit in a highway work zone.

The minimum highway work zone speed limit is 20 miles per hour. The work zone speed limit must not reduce the established speed limit on the affected street or highway by more than 15 miles per hour, except that the highway work zone speed limit shall not exceed 40 miles per hour. Highway work zone speed limits are effective on erection of appropriate regulatory speed limit signs designating the beginning and end of the affected work zone. The signs must be removed or covered when they are not required. A speed greater than the posted highway work zone speed limit is unlawful. For purposes of this subdivision, "highway work zone" means a segment of highway
or street where a road authority or its agent is constructing, reconstructing, or maintaining the physical structure of the roadway, its shoulders, or features adjacent to the roadway, including underground and overhead utilities and highway appurtenances. Procedures on establishing speed limits in work zones are described in Chapter 8 of this manual.

2-5.03.08 Minimum Speed Limits - MSA 169.14, Subd. 8

Mn/DOT has the authority to establish minimum, as well as maximum, speed limits on Trunk Highways. The determination of minimum speed limits is usually based on engineering judgment, taking into consideration the fact that safety decreases as speed differences increase. As a general rule, speed differences greater than 15-20 miles per hour are not desirable. The application of minimum speed limits is generally limited to higher speed freeway sections. An engineering and traffic investigation must precede the determination of minimum speed limits. Such regulations become effective when minimum speed signs are erected on the affected Trunk Highway.

2-5.03.09 Speed Limits on Bridges - MSA 169.16

Mn/DOT has the authority to determine maximum safe speeds on any bridge or elevated structure which is part of a highway. Local communities may also request investigations of bridges. The Office of Bridge is responsible for all bridge investigations. Bridge speed limits are usually lowered when the condition of the bridge and general nature of vehicle loads could create unusually heavy load impact on the bridge deck. The District is responsible for erecting bridge speed limit signs on Trunk Highways. Mn/DOT may require local authorities to place and maintain bridge speed limit signs on roadways under their jurisdiction. Suitable signs shall be placed 100 feet from each end of the structure.

2-5.03.10 Speed Limits on Local Roads Having an Established Bicycle Lane - MSA 160.263, Subd. 4

This piece of legislation is contained within a broad statute covering many facets of bicycle activities, including policies, registration, licensing, safety studies and bicycle lanes, ways and trails. The law gives local authorities the power to designate "safe" speed limits without the normally required "engineering and traffic investigation," only on streets and highways under their jurisdiction (not Trunk Highways) and only on a road upon which it has established a bicycle lane. The law prohibits a speed limit lower than 25 miles per hour. The legislation defines a "bicycle lane" as that portion of a roadway set aside by the governing body of a political subdivision having jurisdiction over the roadway for the exclusive use of bicycles or other vehicles propelled by human power and so designated by appropriate signs and markings."

Section 9A-3 and the addendum to Section 9A-3, Chapter 9, MN MUTCD covers important definitions relating to bicycles.

2-5.03.11 Speed Limits in Manufactured Home Parks and Recreational Camping Areas - MSA 327.27, Subd. 2 and 2c

Subd. 2. State speed limit. Except as provided in subdivision 2a, it shall be unlawful for any type of vehicle to travel at a rate in excess of ten miles per hour while within the limits of a manufactured home park or recreational camping area. The ten miles per hour limit shall be clearly posted throughout the manufactured home park or recreational camping area, and may be enforced by the municipality in which the park or area is located.

Subd. 2a. Local speed limit. A municipality may, by ordinance, set and enforce in a manufactured home park a speed limit which is higher than ten miles per hour but which is not higher than 30 miles per hour. The local speed limit shall be clearly posted throughout the manufactured home park.
2-6.00 NO PASSING ZONES AND LANE DESIGNATIONS

2-6.01 No Passing Zones - MSA 169.18, Subd. 5(B)

MSA 169.18, Subd. 5(b) provides the legal basis for establishing "no passing zones." It is Mn/DOT practice to indicate such no passing zones on rural (two-and three-lane roadways) by "No Passing Zone" pennant signs and distinctive pavement markings. Since drivers have become very dependent upon these devices, proper maintenance of these signs and markings is very important. The Transportation District Engineer is responsible for the application and proper maintenance of no passing zone signs and markings in accordance with the procedures set forth in Chapters 6 and 7 of this Manual.

2-6.02 Lane Designations - MSA 169.18, Subd. 7(c)

Under MSA 168.18, Subd. 7(c), Mn/DOT may erect signs on Trunk Highways (or authorize the erection of such signs on local highways) directing traffic to use specific lanes. Special lanes may be designated when certain vehicles (for example, trucks) cannot maintain the speed required to keep the speed differential within 15-20 mph and there is adequate space available. In addition, special bus and car pool lanes, known as restricted lanes, are designated on certain freeway entrance ramps within the Minneapolis-St. Paul Metropolitan Area.

2-7.00 THROUGH HIGHWAYS AND CONTROLLED ACCESS HIGHWAYS

2-7.01 Through Highways - MSA 169.30

The general rule in determining through highways is that intersection controls should be designed to favor the predominant traffic flow. Normally, it is desirable to erect STOP signs at all public entrances to Trunk Highways except where another means of control is provided. However, where Trunk Highway traffic is minor in comparison to traffic on the intersecting road, the intersecting road could have priority. Mn/DOT places and maintains the necessary STOP signs on all public streets and roads intersecting a Trunk Highway. STOP signs are usually not placed at private or commercial entrances, except as determined by the District Traffic Engineer. See Chapter 6 for practice on installation and maintenance of advance warning signs on local road approaches to trunk highway intersections.

Local authorities may designate through highways and stop or yield intersections involving Trunk Highways only with Mn/DOT's prior consent.

2-7.02 Controlled Access Highways - MSA 169.305

Section 169.305 of the Statutes grants authority to Mn/DOT and local authorities to prohibit "incompatible" traffic on controlled access highways under their respective jurisdictions. The restriction of nonmotorized traffic, including pedestrians and bicyclists, and of motorized bicycles is specifically included within this authority. Such prohibitions and restrictions are effective only when appropriate signs are erected on the affected highway. It is important to note that Mn/DOT may restrict traffic classes but is not required to do so by law.

2-8.00 PARKING REGULATIONS

2-8.01 General Regulations

MSA 169.34 Prohibitions; Stopping, Parking contains general regulations on prohibiting stopping or parking on public streets and highways.
2-8.01.02 Restrictions on Trunk Highways

Beyond the parking regulations established by law in Section 169.34, Mn/DOT may restrict or prohibit parking on Trunk Highways whenever it is dangerous to highway users or would interfere with the free movement of traffic. Any parking restrictions on Trunk Highways within the municipalities should be established with the concurrence of the local authority.

2-8.01.02 Local Authority

Local authorities may also restrict parking by ordinance or resolution. Any proposed local restrictions on Trunk Highways shall normally be approved by the Transportation District Engineer.

2-8.02 Limited Time Parking

Limited time parking is a local concern which is controlled by local authorities. It is Mn/DOT’s policy to give considerable latitude to local communities in setting parking time limits.

2-8.03 Parking Meter Zones

Local authorities may establish parking meter zones as they deem necessary within local communities, and should use standard pavement markings to designate parking spaces. Standards for parking space dimensions and markings are described in Chapter 7 of this Manual and the MN MUTCD.

2-8.04 Disabled Parking

2-8.04.01 Applicable Laws

MSA 169.345, Parking Privileges for Physically Disabled, and MSA 169.346, Parking for Physically Disabled; Prohibitions, Penalties, establish necessary criteria and requirements to provide the handicapped with adequate parking facilities. In addition, Minnesota Rules Chapter 1340, with respect to automobile parking areas, state, in part:

Subd. 5 Automobile Parking Areas. Where automobile parking spaces are provided at least one space per 50 spaces or fraction thereof, shall be provided for the use of the handicapped, and shall be identified for such use. Such parking spaces shall be not less than 12 feet in width, and located as near as practicable to the building entrance specified in part 1340.0300, subpart 3.

Subd. 3 Floor of Building Access. At least one required entrance or exit of a building must be accessible for use by the handicapped, and must be identified for that use. The building entrance or exit must be at the main lobby or corridor and must provide access to all levels of the floor of access. Access to these levels must be by ramp or elevator.

2-8.04.02 Signing and Marking for Disabled Parking Spaces

The MN MUTCD and Minnesota Standard Signs Manual provide sign designs and details. Full size drawings for the "Disabled Parking" sign (R7-8a) and for the handicapped pavement marking symbol are available from the Office of Traffic, Safety, and Technology (OTST).

2-8.04.03 Source of Information

The Minnesota State Council for the Handicapped, phone (651) 296-6785, is a good source of information on legal issues concerning handicapped parking.
2-8.05 Angle Parking

2-8.05.01 Applicable Law MSA 169.35, Subd. 1 is as follows:

"Except where angle parking is permitted by local ordinance, each vehicle stopped or parked upon a two-way roadway where there is an adjacent curb shall be so stopped or parked with the right-hand wheels of the vehicle parallel with and within 12 inches of the right-hand curb, provided, that such exception shall only apply to a State trunk highway after approval by the Commissioner."

Note: In recent years, approval was granted for a small number of angle parking locations on the trunk highway system.

2-8.05.02 Mn/DOT Policy

It is the policy of Department not to approve angle parking on trunk highways. Exceptions to this policy shall be approved by the Commissioner or an authorized representative.

2-8.06 Parking on One-Way Streets

Under MSA 169.35, Subd. 3 local authorities may permit parking near the left curb of local one-way streets by ordinances. Prior consent of Mn/DOT is required to permit such parking on Trunk Highways.

2-9.00 LOAD RESTRICTIONS

2-9.01 General Load Restrictions

Load restriction laws in Minnesota restrict: (1) the width, (2) the height, (3) the length, and (4) the mass of loads which may be carried on streets and highways in Minnesota. These laws are included in MSA 169.80-169.88; they are very specific and include many exceptions and conditions, the user should refer directly to the Minnesota Statutes.

2-9.02 Seasonal Restrictions

According to Section 169.87, Subd. 1, Mn/DOT, with respect to Trunk Highways, and local authorities, with respect to highways under their jurisdiction, may prohibit or restrict the operation or mass of vehicles on any highway which would be seriously damaged or destroyed by such use. The basis for this determination should include deterioration, rain, snow, or other climactic conditions. Signs stating the prohibition or restrictions must be erected on the affected highways to promulgate these regulations.

2-9.03 Truck Routes

Based on MSA 169.87, Subd. 1, when a local authority petitions Mn/DOT to establish a truck route for travel into, through, or out of the territory under its jurisdiction, Mn/DOT shall investigate the matter. If the request is approved, Mn/DOT may designate certain highways under Mn/DOT's jurisdiction as "truck routes" and may restrict truck travel to those routes when signs are erected. However, except under conditions stated in MSA 169.87, Mn/DOT is not authorized to prohibit truck travel on Trunk Highways. The designation of a truck route is based on the design of the roadway, the type and mass of trucks using the facility, load carried, and the weather conditions.
2-9.04 Load Permits

Under the provisions of MSA 169.86, Special Permits, Mn/DOT may issue several types of permits related to load restrictions. "Single trip" permits are issued for a specific trip; "job" permits are issued for a specific activity and period, i.e., 2 month, etc; "annual" permit for a period not to exceed 365 days; and "special interest" permit for a certain project--again a limited time period, i.e. 1 or 2 months.

These special permits are issued, where the applicant shows good cause, for the vehicle to travel over a certain route where the vehicle and/or load exceed the normal legal operating size or mass limits. Mn/DOT may only issue permits for use on Trunk Highways. Load permits are issued by the District Offices, and through the Office of Freight and Commercial Vehicle Operations, Transportation Permit Section.

2-10.00 ADVERTISING DEVICES

2-10.01 Minnesota Outdoor Advertising Control Act - MSA 173.01

2-10.01.01 Advertising Restrictions

MSA 173.01 "Declaration of Policy" forms the basis for the control of advertising along interstate and primary highways in Minnesota. Chapter 173 of the Statutes provides for: (1) the designation, acquisition, and control of "scenic areas" along interstate and primary highways, and (2) the general control of outdoor advertising along interstate and primary highways. Special advertising controls are provided in Articles 173.01-173.11 may be exercised in scenic areas. In addition, the law specifically prohibits advertising devices:

1. In or within 500 feet of national parks, state parks, local parks, historic sites, and public picnic or rest areas.
2. Within 100 feet of a church or school.

2-10.01.02 Design of Advertising Devices

Advertising devices near highways must, in general, be structurally safe and of a design which does not resemble a traffic control device or create a traffic hazard. Specific rules and regulations affecting Outdoor Advertising are provided in Minnesota Rules 1987, 8810.0200 - 8810.1400 and in MSA 173.15.

2-10.01.03 Advertising Permits

All advertising devices adjacent to interstate or primary highways outside business districts require a permit from Mn/DOT. Advertising permits are issued by the District in each appropriate District office. Questions regarding advertising devices should be directed to the District Sign Technician. Local zoning authorities issue permits for advertising devices in business districts.

2-10.02 Resort Information Signs (County "Slat Sign" Program) - MSA 160.283

Intent of the County "Slat" Sign Program is to govern the installation of resort* information "slat" type signs on county state-aid highways, county highways, and town roads within one-half mile of areas that have advertising restrictions. The intent of these signs is to give motorists confirmatory guidance or reassurance that they are on the right road once they have turned off a Trunk Highway. Standard guide signs must guide them to this point.

* Note: Under the above mentioned statutes "resort" is defined as including resorts, golf courses, restaurants, motels, and recreational camping areas.

A complete description of the County "Slat" Sign Program as well as required procedures and specifications for implementing same is given in Chapter 6 of this Manual.
2-10.03 Specific Service Signs - MSA 160.292

Intent of the Specific Services Sign Program is to govern the installation, design, and criteria for specific service signs. The intent of these signs is to direct the traveling public on non-freeway trunk highways in rural areas to tourist oriented services; namely motels, restaurants, resorts, recreational camping areas, rural agricultural or tourist-oriented businesses, places of worship, gasoline service stations and other retail motor fuel businesses where outdoor advertising restrictions have prevented owners of these facilities from directing the public to their establishments.

A complete description, required procedures, and specifications for implementing the specific services sign program are given in Chapter 6 of this Manual.

2-10.04 LOGO Specific Services Sign Program (Sign Franchise Program) - MSA 160.80

The LOGO Specific Services Sign Franchise Program allows Mn/DOT to establish a sign franchise program. The intended purpose is to provide, on the right-of-way of interstate and certain specified controlled-access trunk highways, specific information on gas, food, camping, and lodging, for the benefit of the motoring public.

Pertinent information on this Program is given in Chapter 6 of this Manual.

2-10.05 Directional Signs (Advertising Devices) - MSA 173.081

This statute provides for the establishment of advertising "directional" signing standards for qualifying public or private attractions, which are nationally or regionally known and of outstanding interest to the traveling public MSA 173.02, Subd 6, (a) and (d) help define terminology.

"Directional" signing in this advertising context should not be confused with guide signing of a traffic control nature as developed in the Manual on Uniform Traffic Control Devices.

"Selection Methods and Criteria Outdoor Advertising Directional Signs" was developed by the Office of Environmental Services (in cooperation with FHWA) and is available therefrom. Signs are erected off Mn/DOT right-of-way.

Applicants for advertising directional signing should deal with District Office.

2-11.00 PERMITS

2-11.01 General

Beyond the load restriction permits described in Section 2-9.04 above, traffic engineers in Minnesota should be aware that under special circumstances, permits may be issued for studded tires, parades, and entrances.

2-11.02 Studded Tire Permits - MSA 169.72, Subd. 1

Under most circumstances, the use of studded tires is not permitted on streets or highways in Minnesota. Special permits may be issued to certain traction engines, tractors, and other farm machinery. These permits are issued by the District Offices and through the Office of Contract Administration and Maintenance, Emergency Operations Unit, Transportation Permits.

2-11.03 Parade Permits - MSA 169.04

Local authorities, with the consent of Mn/DOT, may regulate or prohibit all assemblages on the streets and highways under their jurisdiction. Mn/DOT procedures are described in the criteria listed in Chapter 13 of this Manual.
2-11.04 Entrance Permits - MSA 160.18, Subd. 3

"The owner or occupant of property abutting upon a public highway, having a right of direct private access thereto, may provide such other or additional means of ingress from and egress to the highway as will facilitate the efficient use of the property for a particular lawful purpose, subject to reasonable regulation by and permit from the road authority as is necessary to prevent interference with the construction, maintenance and safe use of the highway and its appurtenances and the public use thereof."

2-11.04.01 Driveway Permits and Design

No driveway shall be constructed to or from a Trunk Highway until permits have been obtained from the Transportation District Engineer and the local governing authority. Rules and regulations for the design of driveways along the Trunk Highway system are provided in 1987 Minnesota Rules 8810.4100-8810.5600.

2-11.05 Special Event Permits and Agreements

Mn/DOT, from time to time, receives requests from various organizations wishing to sponsor special events that require special traffic control measures and/or special use of the highway right-of-way. These special events include such activities as major snowmobile races, major golf tournaments, farm fests, and major music festivals. Where special events are found to be in the public interest, the sponsor may be granted a permit or a formal agreement may be executed wherein certain conditions must be met. Items to be concerned with include:

1. Insofar as applicable to the event, all Minnesota laws pertaining to the use of highway right-of-way shall be obeyed.
2. Additional traffic control devices and/or law enforcement officers shall be provided by the sponsor (Mn/DOT may furnish services and bill the sponsor) as deemed necessary by Mn/DOT to adequately control traffic generated by the event, or as related to the event itself.
3. The sponsor shall agree to assume the entire responsibility and liability for all damages or injury to all persons, whether employees or otherwise and to all property, arising out of, resulting from or in any manner connected with the operation of the special event. The sponsor shall agree to indemnify Mn/DOT, its agents and employees from all such claims including, without limiting the generality of the foregoing claims for which Mn/DOT may be claimed to be liable and legal fees and disbursements paid or incurred to enforce the provisions of this paragraph, and the sponsor shall further agree to obtain, maintain, and pay for such general liability coverage as will ensure the provisions of this paragraph.
4. The sponsor shall be responsible for any damage done to the highway property as a result of the special event, damages payable upon receipt of invoice.

Since many special events will be unique, Mn/DOT's Claims Engineer should be consulted as deemed necessary.

2-12.00 OTHER LEGAL CONSIDERATIONS

2-12.01 Particular Use of Right-of-Way - MSA 160.27

2-12.01.01 Permitted Devices

As stated in MSA 160.27, Subd. 1, 2, 3, and 4, the only items other than official traffic control devices which may be placed within street or highway right-of-way include: (1) public notices, (2) benches and bus shelters, (3) outdoor telephone booths, and (4) customs inspection facilities. These items shall be authorized by written permit by the appropriate road authority. In the case of Trunk Highways, it is the responsibility of the Transportation District Engineer to issue such permits. Before issuing such permits an investigation should be conducted to insure compliance with the appropriate safety criteria.
2-12.01.02 Prohibited Devices

MSA 160.27, Subd. 5 provided a detailed list of actions which are not permitted within highway rights-of-way. Most important to traffic engineers, this law states that it is unlawful to "improperly place or fail to place warning signs and detour signs as provided by law."

2-12.01.03 Violations

Violations of MSA 160.27 are misdemeanors.

2-12.02 Plat Review - MSA 505.03

Under the provisions of MSA 505.03, Subd. 2, any proposed plat which includes lands adjacent to an existing or proposed Trunk Highway shall be submitted to Mn/DOT for review. Districts/Division may be asked by Mn/DOT to review these plats. Procedures for reviewing proposed plats are outlined in Chapter 13 of this Manual. Mn/DOT has 30 days to complete the plat review and to submit written comments and recommendations to the local authority. The law does not require the local authority to receive these comments; it only requires that final action be delayed until comments are received or the 30-day waiting period has passed.

2-12.03 Technical Assistance - MSA 161.39

Under the provisions of MSA 161.39, Subd. 1, 2, 3, 4, 5a and 6, Mn/DOT, when staff and work load conditions permit, may provide technical assistance to both local communities and other state agencies upon request. This assistance may include: technical and engineering advice, assistance and supervision; surveys; plans; studies; investigations; and pavement markings. The local authority or State agency shall pay Mn/DOT for any technical services provided to them by Mn/DOT representatives.

2-12.04 Bridge Width and Clearance Requirements - MSA 165.04 and MSA 165.05

2-12.04.01 Bridge and Culverts

MSA 165.04 requires that all bridges and culverts on any trunk highway, county state-aid highway, or municipal state-aid street hereafter established, constructed, or improved shall be at least 24 feet wide between curbs, and approaches thereto shall be at least 28 feet wide, shoulder to shoulder.

On other roads, all bridges, culverts, and approaches hereafter established, constructed, or improved shall be at least 20 feet wide.

There are notable exceptions to these requirements and the Law should be reviewed carefully relative to bridge width requirements.

2-12.04.02 Railroad Bridge

MSA 165.05 requires that any railroad bridge hereafter constructed over a public highway, including city streets, shall be constructed so as to leave a clear opening for the highway at least 4 feet wider than the surfaced portion of the highway, but in no event less than 28 feet wide, except as may be modified and approved by Mn/DOT.

MSA 165.05 further requires that at least 16 feet vertical clearance shall be provided from the surface of the highway to the bottom of the bridge.

On non-trunk highways, the vertical clearance shall not be less than 14 feet.

Lesser clearances may be approved by Mn/DOT.
2.13.00 REFERENCES


<table>
<thead>
<tr>
<th>Key Word</th>
<th>Minnesota Statutes Annotated</th>
<th>Key Word</th>
<th>Minnesota Statutes Annotated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accident reports</td>
<td>169.09, 169.10, 171.12</td>
<td>Maximum speed limit</td>
<td>169.14, Subd. 2, 4, 5, 5a, 169.141, 169.16</td>
</tr>
<tr>
<td>Advertising</td>
<td></td>
<td>Memorial Highways</td>
<td>161.14</td>
</tr>
<tr>
<td>On right-of-way</td>
<td>160.27</td>
<td>Mn Manual on Uniform Traffic Control Devices</td>
<td>169.06</td>
</tr>
<tr>
<td>Highway beautification</td>
<td>173</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Auction</td>
<td>169.06</td>
<td>Motel</td>
<td>157.01</td>
</tr>
<tr>
<td>Bicycles</td>
<td>169.222, 169.67</td>
<td>Motorcycles</td>
<td>169.974</td>
</tr>
<tr>
<td>Bridge speed limits</td>
<td>169.16</td>
<td>Motorized bicycle</td>
<td>169.01, Subd. 4a</td>
</tr>
<tr>
<td>Constitutional Trunk Highways</td>
<td>161.114, 161.115</td>
<td>Municipal state aid streets</td>
<td>162.09 - 162.14</td>
</tr>
<tr>
<td>Controlled access</td>
<td>169.305</td>
<td>Named Highways (Memorial)</td>
<td>161.14</td>
</tr>
<tr>
<td>County highways</td>
<td>163</td>
<td>Noise limits</td>
<td>169.693</td>
</tr>
<tr>
<td>County state-aid highways</td>
<td>162.01 - 162.08</td>
<td>Notices</td>
<td>216</td>
</tr>
<tr>
<td>Crossovers in median</td>
<td>169.305</td>
<td>Parking</td>
<td>169.32, 169.34, 169.35, 169.345, 121.212, 169.346, 169.33</td>
</tr>
<tr>
<td>Definitions</td>
<td>169.01, 173.02</td>
<td>Particular Use of Right-of-way</td>
<td>160.27</td>
</tr>
<tr>
<td>Directional Signs</td>
<td>173.081</td>
<td>Passing prohibition</td>
<td>169.18, Subd. 5</td>
</tr>
<tr>
<td>(Advertising)</td>
<td></td>
<td>Pedestrians</td>
<td>169.21</td>
</tr>
<tr>
<td>Driving rules</td>
<td>169.18, 169.22</td>
<td>Penalties</td>
<td>169.02, 169.03, 169.89, 169.90</td>
</tr>
<tr>
<td>Electric-assisted bicycle</td>
<td>169.01, Subd. 4b</td>
<td>Permits</td>
<td></td>
</tr>
<tr>
<td>Experimental Devices</td>
<td>169.06, Subd. 2</td>
<td>Load</td>
<td>169.86, 169.861</td>
</tr>
<tr>
<td>Explosives</td>
<td>169.28, 169.75, 169.76</td>
<td>Studded tire</td>
<td>169.72</td>
</tr>
<tr>
<td>Federal-State Safety Account</td>
<td>161.51</td>
<td>Parade</td>
<td>169.04</td>
</tr>
<tr>
<td>Great River Road</td>
<td>161.142, 161.148</td>
<td>Entrance</td>
<td>160.18, Subd. 3</td>
</tr>
<tr>
<td>Height and length limitation</td>
<td>169.81</td>
<td>Plat review</td>
<td>160.085, 161.19, 505.02</td>
</tr>
<tr>
<td>Hitchhiking</td>
<td>169.22</td>
<td>Prima facie speed limit</td>
<td>169.14, Subd. 2, 4, 5, 8</td>
</tr>
<tr>
<td>Hotel</td>
<td>157.01</td>
<td>Private roadway</td>
<td>169.05</td>
</tr>
<tr>
<td>Impeding traffic</td>
<td>169.15, 169.18, Subd. 10</td>
<td>Railroads</td>
<td></td>
</tr>
<tr>
<td>Intersections</td>
<td>169.19</td>
<td>Stops</td>
<td>169.26, 169.28, 169.29</td>
</tr>
<tr>
<td>Turning and starting</td>
<td>169.19</td>
<td>Stop crossings</td>
<td>219.20</td>
</tr>
<tr>
<td>Right-of-way</td>
<td>169.06, 169.20</td>
<td>Recreational camping area</td>
<td>327.14, Subd. 8</td>
</tr>
<tr>
<td>Parking</td>
<td>169.34</td>
<td>Red lights forbidden</td>
<td>169.073</td>
</tr>
<tr>
<td>Kiosks</td>
<td>160.276</td>
<td>Residential roadway</td>
<td>169.01, Subd. 81</td>
</tr>
<tr>
<td>Left turn on red</td>
<td>169.06, Subd. 5</td>
<td>Resorts</td>
<td>157.01</td>
</tr>
<tr>
<td>Lighting and Marking</td>
<td>160.13</td>
<td>Resort signs</td>
<td>160.283</td>
</tr>
<tr>
<td>Littering</td>
<td>169.42</td>
<td>Right-of-way</td>
<td>169.20</td>
</tr>
<tr>
<td>Loads, seasonal restrictions</td>
<td>169.87</td>
<td>Right turn on red</td>
<td>169.06, Subd. 5</td>
</tr>
<tr>
<td>Local authorities</td>
<td>169.04</td>
<td>Rustic Residential District</td>
<td>169.14, Subd. 2</td>
</tr>
<tr>
<td>LOGO</td>
<td>160.80</td>
<td>Rustic Roads Program</td>
<td>160.83</td>
</tr>
<tr>
<td>(Sign Franchise Program)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Markings</td>
<td>169.06</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mass and loads</td>
<td>169.83 - 169.88</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### KEY WORD INDEX

<table>
<thead>
<tr>
<th>Key Word</th>
<th>Minnesota Statutes Annotated</th>
</tr>
</thead>
<tbody>
<tr>
<td>School buses</td>
<td>169.44, 169.45, 169.64</td>
</tr>
<tr>
<td>Seasonal Load Restrictions</td>
<td>169.87</td>
</tr>
<tr>
<td>Signals</td>
<td>169.06</td>
</tr>
<tr>
<td>Signs</td>
<td>169.06</td>
</tr>
<tr>
<td>Sign Franchise</td>
<td>160.80</td>
</tr>
<tr>
<td>Slow moving vehicles</td>
<td>169.15, 169.18, Subd. 10</td>
</tr>
<tr>
<td>Signs required</td>
<td>169.522</td>
</tr>
<tr>
<td>Snowmobiles</td>
<td>84.87</td>
</tr>
<tr>
<td>Specific Services Signing</td>
<td>160.292 - 160.297</td>
</tr>
<tr>
<td>Speed restrictions</td>
<td>169.14; 169.16; 160.263, Subd. 4; 327.27, Subd. 2 and 2a</td>
</tr>
<tr>
<td>Stops</td>
<td>169.31, 169.34</td>
</tr>
<tr>
<td>Studded tires</td>
<td>169.72</td>
</tr>
<tr>
<td>Technical Assistance</td>
<td>161.39</td>
</tr>
<tr>
<td>Tort Claims</td>
<td>3.736</td>
</tr>
<tr>
<td>Through highways</td>
<td>169.30</td>
</tr>
<tr>
<td>Town roads</td>
<td>164</td>
</tr>
<tr>
<td>Truck routes</td>
<td>169.87</td>
</tr>
<tr>
<td>Trucks prohibited</td>
<td>169.87</td>
</tr>
<tr>
<td>on city streets</td>
<td></td>
</tr>
<tr>
<td>Trunk Highways</td>
<td>161.114 - 161.124</td>
</tr>
<tr>
<td>Turning and Starting</td>
<td>169.19</td>
</tr>
<tr>
<td>Turnback law</td>
<td>161.082, 161.083</td>
</tr>
<tr>
<td>U turns</td>
<td>169.19, Subd. 2</td>
</tr>
<tr>
<td>U turns on freeway</td>
<td>169 305, Subd. 1(b)</td>
</tr>
<tr>
<td>Unauthorized signs</td>
<td>169.07</td>
</tr>
<tr>
<td>Use of right-of-way</td>
<td>160.27</td>
</tr>
<tr>
<td>Vandalism to signs</td>
<td>169.08</td>
</tr>
<tr>
<td>Yield signs</td>
<td>169.201</td>
</tr>
</tbody>
</table>
Chapter 3
FREEWAY CORRIDOR TRAFFIC MANAGEMENT

TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>TABLE OF</th>
<th>CONTENTS</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-1.00  INTRODUCTION</td>
<td>----------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>1.01 Purpose</td>
<td></td>
<td>3-3</td>
</tr>
<tr>
<td>1.02 Chapter Organization</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3-2.00  GLOSSARY</td>
<td></td>
<td>3-3</td>
</tr>
<tr>
<td>3-3.00  REGIONAL TRAFFIC MANAGEMENT CENTER</td>
<td></td>
<td>3-4</td>
</tr>
<tr>
<td>3-4.00  SURVEILLANCE SYSTEMS</td>
<td></td>
<td>3-5</td>
</tr>
<tr>
<td>4.01 Purpose</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.02 Electronic Vehicle Detectors</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.03 Closed-Circuit Television</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.04 Radio Relay of Visual Observations</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3-5.00  CONTROL SYSTEMS</td>
<td></td>
<td>3-6</td>
</tr>
<tr>
<td>5.01 Purpose</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.02 Ramp Control Signal Systems</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.03 Ramp Metering Algorithm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.04 Ramp Design</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.05 Lane Control Signals</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3-6.00  PREFERENTIAL TREATMENT SYSTEMS FOR HOVs</td>
<td></td>
<td>3-8</td>
</tr>
<tr>
<td>6.01 Purpose</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.02 Preferential Treatment Ramps</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.03 Diamond Lanes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.04 Reversible Lanes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.05 Team Transit</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3-7.00  INCIDENT MANAGEMENT</td>
<td></td>
<td>3-9</td>
</tr>
<tr>
<td>7.01 Purpose</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.02 Incident Detection and Response</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.03 Motorist Information and Route Guidance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.04 Emergency Response Vehicles</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3-8.00  COMPUTER SYSTEMS</td>
<td></td>
<td>3-11</td>
</tr>
<tr>
<td>8.01 Purpose</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.02 Field Microprocessor Activities</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.03 Central Computer Real-Time Activities</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.04 Communication with Field Microprocessors</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.05 Communication with Control Center Devices</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.06 Operational Reports</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.07 Data Retention</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.08 Research and Statistical Reporting</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
CHAPTER 3 - FREEWAY CORRIDOR TRAFFIC MANAGEMENT

3-1.00 INTRODUCTION

Mn/DOT is responsible for the planning, design, integration, operation, and maintenance of freeway corridor traffic management systems. These responsibilities, within the metropolitan area, are assigned to the Office of Traffic, Safety, and Technology - Freeway Operations Section. This section participates in research and development to evaluate freeway operations projects and promote the use of new technologies and concepts. The section also works with the Intelligent Transportation System (ITS) section in the development of projects that integrate with the current traffic management system.

3-1.01 Purpose

The purpose of freeway traffic management systems is to optimize traffic flow in the metro area freeway corridors, with specific objectives including the following:

1. Minimize the magnitude and duration of congestion.
2. Maximize the traffic flow through freeway bottlenecks.
3. Reduce the crash rate and improve safety.
4. Minimize the impact of incidents.
5. Provide freeway operations support of special events, construction, and maintenance activities.
6. Promote travel demand management via High Occupancy Vehicle (HOV) facilities and other demand management initiatives.
7. Provide aid to stranded motorists.
8. Provide traveler information.

3-1.02 Chapter Organization

Chapter 3 is subdivided into six sections the Regional Transportation Management Center, Surveillance Systems, Control Systems, Preferential Treatment Systems for HOVs, Incident Management, and Computer Systems. Each subdivision describes the purpose and nature of the systems in that subdivision, and provides guidelines for design and operation. In addition, a list of important terms used in freeway traffic management is provided below.

3-2.00 GLOSSARY

Bottleneck - A section of freeway where the capacity is less than previous sections thereby creating a restriction in the normal flow of traffic in peak-demand periods.

Capacity - The maximum number of vehicles that can pass over a section of roadway during typical conditions (normally expressed as vehicles per hour per lane).

Delay - An interruption of normal travel involving a slowing or stopping. The difference between interrupted and uninterrupted travel times.

Demand - The number of vehicles desiring to use a section of road during a specified time period.

Density - The number of vehicles on a section of freeway per unit of length, usually expressed in vehicles per kilometer or vehicles per mile.

Headway - The time, in seconds between consecutive vehicles, measured from the front bumper of one vehicle to the front bumper of the next vehicle, as they move past a given point.
Incident - An event on or near the roadway which blocks or restricts the flow of traffic or has the potential to do so. Examples are crashes, stalled vehicles, and spilled loads.

Metering Rate - The rate at which vehicles are permitted to enter a freeway via a ramp control signal usually measured in seconds per vehicle.

Occupancy - The percentage of time that a detector in a lane on a roadway is covered or occupied by a vehicle or vehicles. The occupancy is computed for given lengths of time, i.e., 30 seconds, one minute, or five minutes, and expressed as a percentage. Occupancy, as computed using 6’ x 6’ loop detectors, may be used as a direct measure of traffic density, each 10 percent occupancy being equivalent to 25 vehicles per mile.

Platoon - A number of vehicles moving together at the same speed as a group. Traffic leaving a signalized intersection when the light turns green is a platoon.

Queue - A line of vehicles waiting at a traffic signal or ramp meter signal, or backed up at a bottleneck.

Recurrent or Recurring Congestion - Congestion occurring at predictable times daily or weekly due to demand exceeding capacity.

Shockwave - The phenomenon which describes the movement of the point in a traffic stream where stopping or slowing of successive vehicles occurs. If the upstream flow rate is about equal to the downstream flow rate, the shockwave will stay in one location on the freeway (standing shockwave). If the upstream flow rate is greater than the downstream flow rate, the shockwave will move upstream. This is a principal cause of rear-end collisions on a freeway.

Weaving - A situation in traffic flow which describes necessary lane changing both right to left and left to right by numerous vehicles, usually at freeway entrances, exits, or diverge areas.

3-3.00 REGIONAL TRAFFIC MANAGEMENT CENTER (RTMC)

The original Traffic Management Center opened in 1972 as part of the I-35W Urban Corridor Demonstration Project. The new RTMC has re-located from downtown Minneapolis to the Waters Edge campus at 1500 W County Road B2 in Roseville. As part of the relocation, Mn/DOT's Metro Maintenance Dispatch, the Office of Traffic, Safety and Operations' Traffic Operations Section and the Department of Public Safety's State Patrol Dispatch have integrated into a unified command center in the new RTMC.

Freeway corridor operations activities coordinated from the RTMC include traffic management system maintenance and operation, incident management, and integration of freeway operations with agencies operating arterial street traffic signal systems.

The RTMC currently operates 430 ramp meters, 285 closed circuit television (CCTV) cameras plus access to 40 other cameras deployed by others in the metro area, 70 changeable message signs (CMS), the Mn/DOT Traffic Radio program and provides traveler information for various media outlets including the internet and 511.

Fiber optic communications cables have been installed between the RTMC and a number of key agencies involved in arterial street traffic control, enforcement, transit operations, and incident response. These agencies include the State Patrol, Mn/DOT Maintenance Operations, Metro Transit, the cities of Minneapolis and St. Paul, and Hennepin and Ramsey counties. The fiber optic communications subsystem makes it possible to provide integrated corridor traffic management in the entire metro area. Fiber optic communications has also been extended to the Center for Transportation Studies (CTS) at the University of Minnesota providing video and data for a student traffic management lab and CTS traffic management research projects. CCTV signals have also been made available to many of the Twin Cities television stations.
3-4.00 SURVEILLANCE SYSTEMS

3-4.01 Purpose

Surveillance systems provide department personnel and computer systems with "real-time" information on traffic flow and incidents on the freeways so that appropriate control decisions and immediate action can be taken to maintain safe and efficient operation. Surveillance data is also used to provide information to motorists approaching an incident or congested area.

Continuous information is provided on the volume of traffic and level of congestion (lane occupancy) on each monitored freeway segment. This information is used to determine metering rates at ramp control signals, appropriate displays on CMSs and lane control signals and operation of a color graphics map display indicating volume or occupancy which allow department personnel to monitor overall operation of the freeway.

The principal surveillance systems used by the department are electronic vehicle detectors and CCTV. Additional surveillance is provided through visual observations via cellular 911 calls monitored by the State Patrol and local police radios, Freeway Incident Response Safety Team (FIRST) emergency response vehicles and aerial surveillance through a partnership with the State Patrol helicopter.

Detector data and CCTV pictures of incidents on the freeway provided to emergency service providers (police, fire, ambulance) allow them to accelerate dispatching.

3-4.02 Electronic Vehicle Detectors

Electronic vehicle detectors (inductive loop detectors) are devices used to indicate the presence of vehicles in a lane. These detectors are 6’ x 6’ loops of wire cut and sealed into the pavement of the freeway. The wire in the loops is connected to an amplifier in a nearby cabinet. The electrical current in the loop sets up a magnetic field which is disturbed when a vehicle moves above it. This disruption is reported to a controller and in turn to a central computer at the RTMC. Through these detectors, it is possible to determine traffic volume (e.g., vehicles per hour, vehicles per five minutes, vehicles per 30 seconds) and the general traffic density, level of congestion or lane occupancy.

To measure lane occupancy, the controller records the percent of time, over a 30-second time interval, that the space monitored by the loop is occupied. If the loop is occupied 40 percent of the time (12 seconds of a 30 second period), the traffic density on the freeway is about 100 vehicles per mile. If it is occupied 20 percent of the time (six of the 30 seconds) the density is about 50 vehicles per mile.

Vehicle detectors are the backbone of the freeway surveillance system because they provide continuous system-wide volume and lane occupancy data which can be monitored and analyzed by a computer. "Mainline" detectors at one half mile spacing measure volume and occupancy in each freeway traffic lane. “Queue” detectors are placed at the top of ramps upstream of ramp meters. These are used to measure queue lengths and ensure that vehicles do not wait more than the prescribed four minutes. "Exit" detectors count the number of vehicles leaving the freeway. "Entrance" detectors count the vehicles entering the freeway.

Data from mainline detectors are displayed in the RTMC which show the "real-time" status of traffic on the freeways. The display is a map of the freeways representing vehicle detectors in the roadway which show green, yellow or red, in response to occupancy (traffic density) on the freeway, as indicated by the computer analysis of the data received from the detectors.

RTMC staff continues to evaluate various new advances in detector technologies. Detectors are evaluated based upon the performance and life cycle costs. New detectors being evaluated include machine vision video image processing, microwave radar and magnetometer.
3-4.03 Closed-Circuit Television

CCTV systems consist of a series of cameras mounted on 50-foot poles at strategic vantage points to provide a comprehensive visual surveillance of roadways. Good viewing capability is limited to about one half mile in each direction. Therefore, a spacing of one mile or less between cameras is necessary for total coverage.

Remote control of the cameras originates from a CCTV control panel located within the RTMC. Currently two types of cameras are used. One type of camera has pan and tilt capability, zoom lenses, iris and focus adjustment, environmental housing with thermostatically controlled heaters and blowers. The other type of camera is the dome camera with zoom lenses, pan and tilt, and 360 degree rotation. Most of the CCTV signals are transmitted to the RTMC via fiber optic cable. The control of the camera and the camera environmental housing utilize fiber optic cable and a single pair of communication cables.

CCTV enables operators in the RTMC to view traffic conditions on the freeway. CCTV provides the operator the ability to respond quickly with the appropriate course of action to warn approaching vehicles. For example, a vehicle detector might alert the RTMC operator to a congestion problem. The operator would respond by aiming and focusing a camera in the area where the congestion was reported. If the problem were created by an incident, the dispatcher would contact FIRST or the State Patrol and relay all information as to type of incident, severity, and probable needed services. CCTV is also used to verify the validity and determine the severity of incidents detected by other means.

3-4.04 Radio Relay of Visual Observations

Surveillance information is also obtained in the RTMC by monitoring the State Patrol and local law enforcement agencies' radio frequencies. This information enables the operator at the RTMC to locate incidents on the freeway, monitor complications and proceed with incident management accordingly. Department personnel, who spend a considerable amount of time working or driving on the freeways, provide surveillance information by Department two-way radios and cellular phones.

3-5.00 CONTROL SYSTEMS

3-5.01 Purpose

Ramp metering has been used by Mn/DOT for more than twenty-five years to improve freeway traffic flow and to enhance motorist safety. One objective of ramp metering is to ease the merge of ramp traffic into the flow of traffic on the mainline. The main benefit at the merge area is to minimize the disruption of flow on the freeway caused by platoons of merging vehicles. Early in Minnesota's experience with freeway traffic management, another necessary objective of ramp metering became apparent. If not controlled, flow on the freeway will exceed the capacity at critical bottlenecks and the resultant congestion (shockwave activity) will cause crashes and reduce traffic flow. To accomplish the second objective, the Minnesota algorithm has evolved into a real-time volume based zone control equation.

3-5.02 Ramp Control Signal Systems

Ramp control signal systems are used for regulating or metering access to the freeway. Traffic signals are mounted on the freeway ramp 300 to 600 feet upstream from the point where the ramp and freeway merge.

Ramps with a two-lane, single vehicle release operation require a pedestal with dual signal heads mounted on each side of the entrance ramp. The signal heads are three-section, 8-inch circular red, yellow, and green indications mounted at 5 and 10 feet, respectively. One head is aimed at the stop line and one is aimed upstream at vehicles entering the ramp. Two lane ramps, with a pavement width of 18 to 24 feet, require similar pedestals with similar dual signal heads mounted on the left and right sides of the ramp.
The signing sequence for a two-lane, single-vehicle release operation consists of the "Signal Ahead" sign (W3-3) and a "ONE CAR PER GREEN" sign (R10-X2 or R10-X6) mounted on the pedestal shaft. Multi-lane, single vehicle release ramps also have appropriate lane signing mounted on the signal pedestal shaft.

Flashers are installed above standard "Signal Ahead" signs on high-speed ramps requiring advance warning of the metering operation. The flashers, 8-inch circular yellow indications mounted at a height of 10 feet, operate during the metering period.

Proper utilization of the ramp control signal system is achieved when a vehicle approaches the signal, stops for the red signal, waits for the green signal, and then proceeds onto the freeway. Subsequent vehicles utilize the same operation. Vehicles are released alternately from each lane. In periods of light traffic flow on the freeway, the signal flashes yellow and vehicles may proceed directly onto the freeway.

In traffic-responsive metering systems, the ramp control signals operations are based on commands from a controller in a field control cabinet. The control cabinet in turn responds to the central computer at the RTMC. The metering rate of a ramp control signal is based on the traffic flow as determined by the central computer using data from the surveillance system. The metering rate used on a ramp will be restrictive (fewer vehicles allowed on) if the mainline flow from upstream is heavy (high volume) or if congestion (high occupancy) occurs downstream. If the upstream traffic flow is light and no congestion is present downstream, the metering rate will be faster (more vehicles allowed on). If conditions warrant, the RTMC control room staff can override the computer selected metering rate. (See Section 3-5.03 for a detailed description of the metering rate algorithm.)

3-5.03 Ramp Meter Algorithm

3-5.03.01 Minnesota Experience

Freeway ramp metering has been used by Mn/DOT for over twenty-five years to improve freeway traffic flow and to enhance motorist safety. There are two main objectives of freeway ramp metering. The first objective is to ease the merge of traffic from an entrance ramp with traffic on the mainline. The benefit to the merge area is to minimize the disruption of flow on the freeway caused by platoons of merging vehicles. The second objective of freeway ramp metering is to minimize congestion. With little or no volume control of traffic on entrance ramps, flow rates on that freeway will exceed the capacity at critical bottleneck locations. The resultant shockwave activity (congestion) limits the flow rate on the freeway to below 1700 vehicles per lane per hour, and has the potential to cause increased crashes. The Minnesota algorithm allows sustained flow rates on a managed freeway of 2200 to 2400 vehicles per hour per lane. To accomplish the second objective the Minnesota algorithm has evolved into a real-time, volume based control equation, called stratified ramp metering.

Stratified metering considers traffic volumes on mainline and ramps and attempts to maximize mainline traffic volume while limiting queue waits to four minutes on local access ramps and two minutes on freeway to freeway ramps. If queue detectors sense ramps queues exceed the limits or are backing up onto local streets, the metering rates increase which clears the queue backups in the ramps.
3-5.04 Ramp Design

The following are general design guidelines for metered freeway entrance ramps:

1. Minimum of 300 feet between the ramp control signal and the nose (end of physical curb separation between ramp and freeway).
2. Minimum storage distance of 25 feet per vehicle for a six-minute metered volume between the cross street and the ramp control signal.
3. Two-lane ramps with single-lane entrance for all ramps with projected volumes of 500 vph or greater.
4. Adequate graded width on all ramps for future pavement widening to accommodate an HOV bypass ramp.
5. Maximum of plus one percent grade for the last 500 feet of the ramp.

3-5.05 Lane Control Signals

Lane control signal systems, such as the I-94 Lowry Hill Tunnel system, are used to warn or control traffic on the freeway. Lane control signals are 18-inch square indications which display either a red X, a downward yellow arrow, or a downward green arrow. Lane control signal systems are used on potentially hazardous sections of freeway to provide adequate advance warning of traffic conditions in each lane.

3-6.00 PREFERENTIAL TREATMENT SYSTEMS FOR HIGH OCCUPANCY VEHICLES (HOVS)

3-6.01 Purpose

Preferential treatment for High Occupancy Vehicles (buses, car pools, and van pools) is one approach to improve the operational efficiency of freeways (i.e. moving greater numbers of people without moving greater numbers of vehicles). Time savings and higher Level of Service (LOS) due to preferential treatments are meant to provide an incentive for Single Occupant Vehicle (SOV) drivers to change their mode of travel.

Preferential treatment systems for HOVs include ramps to permit HOVs to bypass meters, diamond lanes, reversible lanes, and a cooperative effort, with the Metro Transit, called Team Transit.

3-6.02 Preferential Treatment Ramps

HOV preferential access to the freeway is generally provided with an adjacent ramp lane (meter bypass lane) separated from other ramp lanes by a raised island. Given right-of-way and freeway operational constraints (e.g., access openings, right-of-way costs, number and proximity of freeway access points, etc.), HOVs and SOVs generally should share ramp entry and freeway merge locations. In this case, it is important that the length of freeway ramp is sufficient to accommodate the ramp meter queue without blocking HOV access to the ramp meter bypass. Exclusive HOV ramps, with separate ramp entry and freeway merge points, may be constructed when justified.

Ramp meter bypasses are not metered unless platoons on the bypass have potential to cause problems on the freeway.

Preferential treatment for HOVs entering a freeway is provided whenever vehicle occupancies are such that person-delay at the ramp control signals is sufficient to warrant the expense of constructing special meter bypass ramps and sufficient R/W exists.
3-6.03 Diamond Lanes

Freeway lanes may be designated for use only by HOVs. HOV lanes contiguous with mixed-use lanes are called diamond lanes (the diamond, ♦️, painted on the lane designates special use). Diamond lanes for HOVs on freeways offer time savings and higher LOS over travel in congested mixed-use traffic lanes (e.g., I-394 between TH 100 and I-494).

Diamond lanes are generally located to the left of mixed-use lanes. They are usually separated by a skip strip delineation which allows for continuous access from the mixed use lanes. These lanes may be open for use by mixed traffic during non-peak traffic periods.

User compliance with diamond lanes may be particularly difficult to enforce. To minimize problems with the user not understanding diamond lane requirements, HOV lane signing and diamond pavement markings (♦️) should be displayed at frequent intervals.

3-6.04 Reversible Lanes

On some freeway segments where peak period travel demand is directional by time of day, reversible lanes for HOVs may be constructed to provide added capacity in the peak direction. Mn/DOT is using reversible HOV lanes on I-394 between I-94 and TH 100. The development of reversible HOV facilities requires special traffic control systems. To ensure compliance to directional flow roadways, a physical control similar to a railroad crossing gate is used.

3-6.05 Team Transit

Team Transit is a cooperative effort by several transportation agencies including Mn/DOT, Metro Transit, and the Cities of Minneapolis and St. Paul. Together the team plans and implements innovative improvements to the transportation system to move buses and other HOVs efficiently through peak period traffic congestion.

Bus-only shoulders allow transit buses to use the shoulder to pass traffic congestion on freeways and queues at traffic signals (i.e., T.H. 36 from T.H. 61 to I-35W). We currently have over 217 miles of bus-only shoulders and add approximately 15-20 miles per year.

There are operating guidelines that bus drivers must follow when using the shoulders to ensure the safe use of the shoulder. Team Transit projects also include advantages for transit at ramp meters (i.e., ramp meter bypasses and bus-only gates) and other projects to encourage transit use (i.e., park and ride lots).

3-7.00 INCIDENT MANAGEMENT

3-7.01 Purpose

Incidents cause about 60 percent of the congestion and between 10 and 15 percent of the peak period crashes on metro area freeways. Incident management systems minimize the impact of incidents and reduce secondary crashes via the following:

1. Rapid detection, response, and removal.
2. Providing motorist information services.
3. Integrated corridor traffic management techniques.

The RTMC control room staff coordinates incident management activities with the State Patrol, Mn/DOT maintenance operations, Metro Transit, commercial radio stations, and other agencies responsible for traffic signal operations.
3-7.02 Incident Detection and Response

Most incidents are initially detected and reported by motorists who make 911 calls to the State Patrol dispatcher. Incident reporting in this manner is so fast that the RTMC currently does not employ an incident detection algorithm. Occasionally, the RTMC system operators observe an incident on CCTV that has not been dispatched on police scanners. In these cases, the system operators call the State Patrol dispatcher on the hotline.

Response to and removal of incidents is the responsibility of the State Patrol. The state trooper responding to an incident is in charge of on-site incident management and traffic control, including arranging for a tow truck and other emergency response vehicles as needed.

3-7.03 Motorist Information and Route Guidance

Traveler information systems provide real time traffic information to motorists at a variety of locations before they enter the highway system, as well as en route. Information is presented on lane closures, congestion, incidents, and the advisability of taking an alternate route. The route guidance and vehicle navigation systems of the future are in the planning stages as part of the ITS program.

Following is a brief overview of the traveler information techniques utilized by the department.

3-7.03.01 Changeable Message Signs

CMSs are used to provide real-time information to motorists on the freeway and on city streets prior to freeway entrances. CMSs mounted over the freeway provide advance warning of hazardous situations or incidents, including their location and the action the motorist should take to assure safety and minimize delay. CMSs mounted on entrance ramps or on city streets provide advance warning of conditions on the freeway in order to allow motorists to consider taking an alternate route.

In the past, the design standard for overhead CMSs was a three-line, six-sided drum sign. The current design standard is a three-line, LED sign. The two remaining drum style signs will be replaced within the next year.

3-7.03.02 Commercial Radio

Commercial radio relays traffic information to the motoring public and has the advantage of reaching a large listening audience. However, drivers often need detailed and specific information regarding freeway segments. Commercial radio broadcasters are generally reluctant to broadcast information targeted for a limited listener segment unless it is a newsworthy item also of general interest to other listeners. The Traffic Operations Section recognizes commercial radio as an important and widely used source of traffic information. Therefore, it places a high priority in providing information to these broadcasters. Commercial radio contracts with private traffic information sources and a few stations gather their own information. This information is available to the RTMC and can be particularly helpful on those freeway segments where surveillance is yet to be deployed.

3-7.03.03 Mn/DOT Traffic Radio

In 1989, Mn/DOT established a metro area traffic advisory radio service partnership with Minneapolis Public Schools (MPS). This service utilizes the MPS non-commercial student training station, KBEM 88.5 FM. The partnership provides for metro area traffic reports from the control room every ten minutes between 6:00 and 9:00 A.M., and 3:30 and 7:00 P.M. and half hour reports between 11:30 A.M. and 1:00 P.M. In the event of a major incident, KBEM broadcasts continuously at RTMC's discretion. CMSs can be used to alert drivers to the continuous broadcasts. In addition to incident management, Mn/DOT Traffic Radio has also been used for special event traffic management. The current Mn/DOT and MPS agreement expires in 2007.
3-7.03.04 511 Internet and Telephone Traffic Reports

Mn/DOT has made up-to-date traveler information available to travelers by both phone and Internet. Dialing 511 will give the traveler information about highway traffic, road, weather and construction conditions. Internet site: www.511mn.org gives information about current critical incidents, road and weather conditions, construction, commercial vehicle permit status and camera images as well as a traffic congestion map.

3-7.04 Emergency Response Vehicles

The department's Freeway Incident Response Safety Team (FIRST) primary purpose is to minimize congestion and prevent secondary crashes through the quick response and removal of incidents. The FIRST program, originally known as Highway Helper, was initiated in 1987. There are presently 8 heavy-duty pickup trucks that patrol 160 miles of the most congested freeway segments. An Automated Vehicle Location (AVL) system has been implemented to better manage the operation of the FIRST program. This program has provided an average of more than 15,000 assists per year for the last several years.

3-8.00 COMPUTER SYSTEMS

3-8.01 Purpose

Computers are an important part of freeway traffic management because rapid control decisions are needed and a large amount of data must be managed. Computers are used in freeway traffic management both to process data at interchange locations and to manage the overall system. They are used to provide continuous real-time response to freeway conditions and to provide off-line support for other freeway traffic management activities. At the system-wide level, the computer supports surveillance and control systems. It operates automatically with minimal human intervention on a seven day, 24-hour basis to gather information, calculate parameters, and make traffic control decisions. Computers operate in real-time and are programmed so that events which occur initiate processes and functions to handle freeway traffic situations. These functions are pre-established by traffic engineers. Computer systems also record system performance and perform related calculations and analyses.

3-8.02 Field Microprocessor Activities

Detector inputs are normally scanned at a high rate (30 times/second) by field microprocessors to accumulate lane volume and lane occupancy. Output commands are sent to field microprocessors which control many field devices, including ramp meter signals, lane control signals, and CMSs.

3-8.03 Central Computer System Real-Time Activities

The RTMC central system consists of a network server and workstations. Its most important function is to receive, process, and analyze the data from vehicle detectors. The system also updates a color graphics map of the freeway system with real-time data, so that operators in the control room can see at a glance where the worst traffic conditions are. The other main functions of the system are to:

1. Gather traffic-flow information from the field microprocessors.
2. Process the data and send control decisions to the field microprocessors.
3. Provide real-time displays for each field device to the system operators.
4. Allow the operator to make control overrides.
5. Provide numerical values such as volume, occupancy, and other status information needed on demand by the operators.
3-8.04 Communication with Field Microprocessors

Data communications between the central server and field microprocessors are achieved in a variety of ways. Traditionally, copper cables have been used with standard modems on each end, but newer devices use a network of fiber-optic communication lines. In a few locations, leased telephone lines and wireless cameras are used.

3-8.05 Communication with Control Center Devices

The server communicates with a number of peripheral devices via the network, including workstations, graphic displays, storage units, and printers. The server is also connected to the Metro local area network (LAN) and the Mn/DOT wide area network (WAN).

3-8.06 Operational Reports

The traffic management system requires reports both to evaluate the day-to-day activities and to maintain a record of the systems performance. The reported data includes lane and station volume and occupancy by various time periods, ramp vehicle counts, logs of activity for lane control signals and CMSs and logs of equipment malfunctions.

3-8.07 Data Retention

Data is retained to prepare long-term operational evaluations. Computer data is stored on the network, then recalled and processed. The retained data includes volume and occupancy for various time intervals.

3-8.08 Research and Statistical Reporting

Installations performing freeway traffic management have the capability for a wide variety of research and statistical reporting activities. The huge amounts of traffic data and related information available along with the hardware and software necessary to perform analysis, evaluation, and reporting tasks in traffic management systems make an attractive research environment. Examples of statistical reporting include:

1. Travel time study reports.
2. Car pooling studies.
4. Various speed analyses.
5. Plots, charts, and other graphic reports.
7. Violation studies.

In addition, the computer may be used for research activities not directly related to traffic management data, e.g., For example, crash studies or studies concerning roadway systems other than freeways.
# Chapter 4
## TRAFFIC ENGINEERING RESEARCH

### TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>4-1.00 INTRODUCTION</td>
<td>4-3</td>
</tr>
<tr>
<td>1.01 Purpose</td>
<td></td>
</tr>
<tr>
<td>1.02 Scope</td>
<td></td>
</tr>
<tr>
<td>1.03 Chapter Organization</td>
<td></td>
</tr>
<tr>
<td>4-2.00 ROLE OF TRAFFIC RESEARCH</td>
<td>4-3</td>
</tr>
<tr>
<td>4-3.00 INDIVIDUAL ROLES IN TRAFFIC RESEARCH</td>
<td>4-4</td>
</tr>
<tr>
<td>3.01 Technical Advisory Panel (TAP)</td>
<td></td>
</tr>
<tr>
<td>3.02 Principal Investigator (PI)</td>
<td></td>
</tr>
<tr>
<td>3.03 Technical Liaison (TL)</td>
<td></td>
</tr>
<tr>
<td>3.04 Administrative Liaison (AL)</td>
<td></td>
</tr>
<tr>
<td>3.05 Traffic Research Coordinator (TRC)</td>
<td></td>
</tr>
<tr>
<td>4-4.00 TRAFFIC RESEARCH PROGRAM</td>
<td>4-5</td>
</tr>
<tr>
<td>4.01 Purpose</td>
<td></td>
</tr>
<tr>
<td>4.02 Research Monitoring</td>
<td></td>
</tr>
<tr>
<td>4.03 Traffic Research Projects</td>
<td></td>
</tr>
<tr>
<td>4.04 Support Services</td>
<td></td>
</tr>
<tr>
<td>4-5.00 TRAFFIC RESEARCH PROJECT DEVELOPMENT</td>
<td>4-8</td>
</tr>
<tr>
<td>5.01 Project Sources</td>
<td></td>
</tr>
<tr>
<td>5.02 Project Subjects</td>
<td></td>
</tr>
<tr>
<td>5.03 Task Sequence</td>
<td></td>
</tr>
<tr>
<td>4-6.00 RESEARCH SERVICES SECTION</td>
<td>4-10</td>
</tr>
<tr>
<td>6.01 Scope</td>
<td></td>
</tr>
<tr>
<td>6.02 Intra-Office Cooperation.</td>
<td></td>
</tr>
<tr>
<td>6.03 Research Services</td>
<td></td>
</tr>
<tr>
<td>6.04 Technology Development</td>
<td></td>
</tr>
<tr>
<td>6.05 Financial Services</td>
<td></td>
</tr>
<tr>
<td>6.06 Library</td>
<td></td>
</tr>
<tr>
<td>6.07 Technical Specialists</td>
<td></td>
</tr>
</tbody>
</table>
## LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.1</td>
<td>Project Flow Diagram</td>
<td>4-13</td>
</tr>
</tbody>
</table>
CHAPTER 4 - TRAFFIC ENGINEERING RESEARCH

4-1.00 INTRODUCTION

Traffic Research is critical to fully utilizing existing transportation facilities and associated devices as well as to the development of new methods and devices. This chapter introduces the general concept of traffic engineering research.

4-1.01 Purpose

The purpose of this chapter is to: (1) familiarize the reader with the responsibilities and capabilities of the Traffic Research Coordinator, (2) describe the nature and use of traffic engineering research activities, (3) improve the effectiveness of the district traffic offices and the central office traffic sections by facilitating the use of special skills, services, and knowledge that are available from the Research Services Section, and (4) improve the quality of research done directly by Districts or other Sections.

4-1.02 Scope

This chapter will discuss: (1) the role of traffic engineering research, (2) research techniques, and (3) the use of research activities to benefit the traffic engineer's work. This chapter will not describe past, current, or future research projects. Information on current research is available through the Traffic Research Coordinator.

4-1.03 Chapter Organization

Certain terms commonly used in traffic engineering research are defined in the following section. Further sections include:

1. A definition of the role of traffic research.
2. A description of the individual roles in traffic research
3. A description of the traffic research program.
4. A discussion of project development, including project sources, typical task sequence, and implementation of recommendations.
5. An overview of research methods, including data collection, data processing, data analysis and equipment.

4-2.00 ROLE OF TRAFFIC RESEARCH

Traffic engineering research may be defined as the careful, systematic and patient study of traffic engineering concepts, methods, and products undertaken to discover or describe facts, techniques, or applications related to traffic engineering.

The concepts and methods of traffic engineering are similar to those used for typical traffic engineering or operation analysis studies. The primary differences being the degree of effort, the level of detail, and the use of the results. In the case of operational studies, just enough data is gathered to permit a decision-maker to answer a question by making assumptions and supplying judgment. This information is compared to known principles and standards and applied to real-time problems. The researcher, on the other hand, must gather sufficient data to satisfy statistical tests to prove that his conclusions are correct. The researcher gathers the same information as the operations analyst, but the researcher collects data in greater detail to search for new innovative facts, concepts, principles, and/or techniques for future use and to advance the "state-of-the-art."
4-3.00 INDIVIDUAL ROLES IN TRAFFIC RESEARCH

The following section describes roles and responsibilities of the individuals conducting and facilitating traffic research at any given time.

4-3.01 Technical Advisory Panel (TAP)

The research TAP may consist of a principal investigator (PI) performing the research, a technical liaison (TL) representing the agency's interest, an administrative liaison (AL) representing Mn/DOT's contractual obligations, a Traffic Research Coordinator (TRC) who monitors, evaluates and disseminates information from research projects to applicable parties and additional panel members (PM) representing agency practitioner's, beneficiaries', or stakeholders' interests in transportation research.

4-3.02 Principal Investigator (PI)

It is the responsibility of the PI to:
1. Design, perform, and document the research project with Technical Advisory Panel (TAP) guidance and input
2. Provide timely notification to the Technical Liaison (TL) and Administrative Liaison (AL) of any matters which may affect contractual obligations
3. Submit project progress reports on a quarterly (calendar year) basis
4. Develop and provide contract task deliverables for approval
5. Obtain current Electronic Publishing Guidelines and Software Deliverable Guidelines for final deliverable requirements
6. Contact CTS for technical and editorial review coordination of draft final deliverables

4-3.03 Technical Liaison (TL)

It is the responsibility of the TL to:
1. Assist with development of the project work plan and its final approval
2. Coordinate Mn/DOT assistance for the Principle Investigator (PI)
3. Assist with the recruiting and selection of TAP members
4. Provide technical expertise to the project
5. Review and recommend approval of any contractual changes to Research Services Section (RSS)
6. Schedule and conduct Technical Advisory Panel (TAP) meetings following the appropriate agenda outlines (initial, intermediate, final)
7. Record and distribute TAP meeting notes using the Panel Meeting Form
8. Review and approve or disapprove (provide comments) contract deliverables based on recommendations from the TAP using the electronic Deliverable Approval Form
9. Lead efforts in implementation planning using the Implementation Guide as a reference for completion of the Implementation Plan Outline
10. Provide draft final deliverable technical comments, including additional Panel Member (PM) comments, to the Center for Transportation Studies (CTS)
11. Provide Report Dissemination Categories
4-3.04 Administrative Liaison (AL)

It is the responsibility of the AL to:
1. Assist Technical Liaison (TL) in recruiting TAP members
2. Outline the research process and review the responsibilities of TAP members
3. Monitor projects for contract compliance
4. Ensure TAP meetings are scheduled
5. Maintain project status updates in Automated Research Tracking System (ARTS) database in a timely manner
6. Coordinate with the TL for Task Approvals using the Deliverable Approval Form. Deliverable Approval Forms should be submitted to the TL and returned by TL within the quarter after submittal of a deliverable
7. Document implementation activities
8. Ensure research funds are spent effectively
9. Provide TL with the necessary contract evaluation and reporting forms
10. Consult with Mn/DOT Research Manager and university/consultant representative with concerns or problems.

4-3.05 Traffic Research Coordinator (TRC)

It is the responsibility of the TRC to:
1. Monitor and evaluate ongoing research
2. Disseminate information to district and central office staff
3. Coordinate the validation of new traffic engineering concepts
4. Assist in research projects being done by others in the department
5. Coordinate with Research Services Section and university personnel.

Additional panel members (PMs) may be asked to provide user perspective and technical input on research projects as well as reviews of deliverables materials.

4-4.00 TRAFFIC RESEARCH PROGRAM

4-4.01 Purpose

There are literally thousands of people and organizations involved in transportation and traffic research programs on the national and international levels. The Transportation Research Board (TRB), the Federal Highway Administration (FHWA), the Urban Mass Transportation Administration (UMTA), the American Association of State Highway and Transportation Officials (AASHTO) and the Institute of Transportation Engineers (ITE) sponsor hundreds of projects each year. In addition, there are many ongoing projects being done in cooperation with the Regional Transportation Management Center, the Center for Transportation Studies at the University of Minnesota, other offices within Mn/DOT, and in partnership with various consulting firms.

The Traffic/ITS research program, which is administered by the Research Services Section and operates within this framework, has three primary responsibilities:
1. To monitor research conducted by others and disseminate the information as appropriate
2. To conduct in-house research in response to Department requirements, needs or concerns and to publish and disseminate results
3. To assist in the implementation of research derived from recommendations
4-4.02 Research Monitoring

One of the major responsibilities of the Traffic Research Coordinator is to monitor and evaluate ongoing research. By maintaining knowledge of the state-of-the-art in traffic research, costly duplication of effort can be avoided and results can be practically applied much earlier.

4-4.02.01 Information Sources

Some of the primary sources of information regarding traffic research include: (1) newsletters, (2) journals, (3) reports, (4) technical conferences, (5) technical society committees such as ITE and the American Society of Civil Engineers (ASCE), (6) TRB committees, (7) AASHTO committees, and (8) other research gatherings. All research project results must be analyzed for technical validity and for limitations to their usefulness in Minnesota.

Research results are often known many months before they are formally presented in generally available publications. For this reason, the Traffic Research Coordinator attempts to monitor ongoing programs by developing personal contacts with other researchers. Thus, any significant findings can be discovered, evaluated, and practically applied to local problems more quickly.

4-4.02.02 Dissemination of Information

The Traffic Research Coordinator attempts to relate monitoring activities to current traffic problems in Minnesota. Therefore, this individual maintains frequent contact with the district and central office staffs to identify existing or anticipated problems. Further coordination is required through the Traffic Engineer's Organization (TEO) to ensure relevant research information is fully disseminated throughout the Department. Appropriate ongoing research programs can then be identified and evaluated for immediate as well as future use in Minnesota. Information is disseminated via published reports, presentations, technical memos or other means as appropriate.

4-4.03 Traffic Research Projects

The Department also conducts research studies where there is:

1. An important gap in traffic engineering knowledge,
2. An immediate need for the data, or
3. A unique Minnesota concern.

The latter may be created by legislation, weather conditions, or population characteristics which are different from those conditions found in most other states. If a project can be conducted by the researcher, an analysis of Department priorities must be made. This requires input from the client, Department management, Research Services Section and ongoing program review. This process will be partly facilitated by the TRC. If the assigned priority is low, the project will be deferred (Task 6A) until the resources are available or priorities change and the client will be notified. The project will be reviewed periodically and scheduled when possible (Task 7A).

Traffic research may involve but is not limited to:

1. Original research,
2. New techniques,
3. New traffic control devices, or
4. New traffic engineering concepts.
4-4.03.01 Original Research

Original research projects may fall into a number of categories, depending on current Department priorities. The scope of effort may range from a few hours to several years, and may involve from one person to as many as 20 to 30 people.

4-4.03.02 New Techniques

Research in this category may involve the development and analysis of new traffic engineering techniques including but not limited to:
1. New systems such as automatic data recording and processing,
2. New statistical tests and
3. New analytical methods.

This individual is responsible for testing and evaluating new techniques as well as for developing any new forms or computer programs which may be necessary.

4-4.03.03 New Traffic Control Devices

Research in this category may involve the development and analysis of new traffic control devices and methods as well as modifications of existing tools and devices. Common tools used for traffic control include but are not limited to;
1. Signal systems
2. Signing and striping techniques
3. Ramp metering
4. ITS applications not listed above

4-4.03.04 New Traffic Engineering Concepts

The basic principles of driver performance and traffic flow dynamics are still not completely understood. Therefore, this category of research involves the development and validation of new traffic engineering concepts, particularly as they relate to human behavior in traffic situations.

4-4.04 Support Services

One of the functions of the Research Services Section (RSS) is to assist in research projects being done by others within the department. Many of the special study techniques used by the RSS staff can be used by other traffic engineering personnel as well. Examples are statistical analyses, computerized data processing and special data acquisition techniques. Staff from RSS will provide assistance in the use of these techniques as well as in conducting literature searches and reviews. RSS staff can arrange for contacts between internal and external researchers.

Questions on implementation of findings can also be answered by the RSS staff, either by using available documents or by contacting report authors.
4-5.00 TRAFFIC RESEARCH PROJECT DEVELOPMENT

4-5.01 Project Sources

Ideas and requests for research projects come from a variety of sources, both within the research unit and from other units and agencies. Internal projects usually develop because of staff interest or are an extension of research for others. External projects are developed to provide assistance to district or other central office personnel, or local or federal agencies.

4-5.02 Project Subjects

Research projects address many problems encountered by traffic engineers.

The general classes of projects are:
1. General traffic engineering, and
2. Freeway corridor traffic management.

Traffic research studies typically evaluate new or existing concepts or applications.

4-5.02.01 General Traffic Engineering

Examples of research subjects in general traffic engineering include the following:
1. Signals 7. Warrants
2. Signs 8. Safety improvements
4. Policies 10. Study methods

4-5.02.02 Freeway Corridor Traffic Management

The following are typical subjects of traffic research in the area of freeway traffic management:
1. Ramp metering
2. Priority treatments
3. Lane use signals
4. Changeable-message signs
5. Closed-circuit television
6. Motorist-aid systems
7. Driver information systems

4-5.03 Task Sequence

Each research project involves a series of tasks that address various aspects of the question. The sequence of these tasks is shown in Figure 4-1 and the tasks are defined as follows

4-5.03.01 Isolate the Research Question

Most traffic engineering problems involve several variables that are unknown to some degree. Before a study can be conducted, the researcher and the client must be in agreement about which problems are of most concern.
4-5.03.02 Determine Available Data

Once the problem is defined, the researcher, with assistance from RSS, can review current literature and ongoing programs to determine if someone else has already studied the problem and if so, are results are valid and applicable. If usable results are available, the researcher will report to the client and the project will be terminated, or assistance in implementing the results will be provided. If usable results are not available, further analysis will be needed.

4-5.03.03 Research Plan Development

After a set of potential research projects has been identified, the scope of the proposed study should be determined. Plan development also includes forming of the Technical Advisory Panel, and appointments of the Technical Liaisons, Administrative Liaisons and Principal Investigators that develop the research work plan.

4-5.03.04 Determine Level of Effort

If additional work is needed to obtain answers for the client, the researcher and RSS will analyze the methods and resources required. This analysis will include manpower, equipment, supplies, and budget.

4-5.03.05 Determine Staff Capability

Once the scope of effort is known, a decision is made regarding the researcher's ability to handle the technical or practical needs of the project. Special expertise or resource demands beyond those available may require that the problem be referred to others for consideration (Task 5A), and this fact will be reported to the client.

4-5.03.06 Adjust Work Schedule

High priority projects are started as soon as ongoing projects can be completed or delayed to release resources. Staff assignments and budget allocations are determined for the projects which will be undertaken.

4-5.03.07 Obtain Approval and Funds

Traffic engineering research projects can be funded by any of several means. RSS can provide administrative assistance and the TRC will facilitate searches for funding sources for research projects. If the funding is provided from the OTST budget, these projects must be approved by the Traffic Engineer and the TRC. If other Department funds (for example State Planning and Research-SP & R) are used, the appropriate staff (usually Research Services) must concur and approve the expenditure. If sources of funds outside the Department are used, agreements must be executed and approved by the Commissioner. Even if project expenses are to be reimbursed, the expenditures must be budgeted and encumbered before they are incurred. RSS can provide the guidance in searching for financial assistance, including new public/private partnerships authorized by the 1993 Legislature.

4-5.03.08 Prepare Study Design

When approvals have been given and funds are available, detailed plans will be prepared for the data collection and analysis. Quantities of data for statistical reliability, appropriate measures, study techniques and personnel, and material needs will be determined. Schedules will be set to minimize extraneous variables.
4-5.03.09 Gather Data

Appropriate quantities and types of data will be gathered as needed. Techniques must be carefully controlled to avoid interference with the measured objective.

4-5.03.10 Analyze Data

When data has been collected, it will be processed (by computer if possible) and calculations will be made. Statistical tests of before/after comparisons or other measures will be utilized to determine data accuracy.

4-5.03.11 Determine Results

After all the results have been analyzed and tested, they will be compared with known and suspected hypotheses, and conclusions (or answers) will be drawn.

4-5.03.12 Report to Client

The final results of the project will be reported to the client by memo, oral report, or formal written report, depending on the scope of the effort. In some cases, multiple reports for several different users will be needed. Users may also require follow up assistance in implementing research results.

4-6.00 RESEARCH SERVICES SECTION

4-6.01 Scope

The Mn/DOT Research Services Section (RSS) in the Office of Investment Management Division manages and coordinates the Department's research program. Departmental research is funded through a number of sources within and outside of Mn/DOT. RSS provides the Office of Traffic, Safety and Operations, as well as other Mn/DOT offices with administrative assistance in Research Management, Financial Services, Technology Development and Library/Informational Services. Research Services staff determine the research needs of the Department, and develop and manage a research program to meet those needs. Financial Services staff provide contract administration and manage budgets for the Cooperative Program for Transportation Research (COPTRS), the Local Road Research Board (LRRB) and others.

Technology Development staff provide technology transfer, research implementation, new technology development and evaluation services.

4-6.02 Intra-Office Cooperation

OTST collaborates with the RSS through participation in identifying Departmental research needs. Brainstorming sessions are used to identify issues and barriers being experienced by transportation practitioners that might be solved by research. One of the 13 Research Categories is "Traffic/ITS". Representatives from Mn/DOT, municipalities, counties, consultants, contractors and public interest groups brainstorm ideas and prioritize them as a group. RSS works through the process of eliminating duplicates, evaluating and prioritizing these ideas with staff from OTST. Contact: Research Program Development Engineer (651) 366-3779.
4-6.03 Research Services

The Research Services Section develops contracts and monitors the progress of a variety of research projects. Each research project includes a Technical Advisory Panel (TAP) made up of individuals with technical expertise from Mn/DOT and Minnesota's transportation community. The TAP works closely with the project Principal Investigator (PI) to provide input and practitioner perspective to the investigation. OTST provides personnel to serve on TAP's, in addition to the Traffic Research Coordinator as needed. Funding for research is provided by local and state government at the following levels:

- Local Government Funding: Local Road Research Board (LRRB); Research Implementation Committee (RIC).
- State Government Funding: State Transportation Improvement Program (STIP) and Cooperative Program for Transportation Research and Studies (COPTRS); Implementation Funding Program (IMP); Federal Funding (SPR); National Cooperative Highway Research Program (NCHRP)

Contact: Research Program Manager (651) 366-3757.

4-6.04 Technology Development

The Research Implementation, Outreach and Marketing Unit provides OTST a program of Technology Transfer (T2) which provides research and technology information from within and outside of Mn/DOT. The T2 effort is accomplished partially through the development and dissemination of information. An example is the publication of technical reports and summaries or training. Usable products are applied to traffic problems through product development or demonstration efforts. Organizational issues are addressed by establishing conduits for implementation and dealing with barriers to implementation. The focus of these efforts is to provide measurably effective technology to solve traffic engineering problems. The OTST's Traffic Research Coordinator is the liaison with the RSS in this exchange of information.

Contact: Marketing Program Coordinator (651) 366-3769 or Implementation Coordinator (651) 366-3772

4-6.05 Financial Services

This section handles contract development and the program budget. Tasks include drafting contractual documents, coordinating the approval process, allocating funding, processing payment requests and managing program budgets.

Contact: Financial Services Manager (651) 366-3759.

4-6.06 Library

Mn/DOT's Library serves a broad spectrum of customers - the general public, city and county engineers, university faculty and students. The library exists to serve, and is structured to meet the needs, primarily of Mn/DOT employees, especially its professional, technical and managerial staff.

4-6.07 Technical Specialists

Mn/DOT also has technical specialists in the following research specialty areas who are available as resources:

- Sandy McCully (651) 366-3768
  Location: Research Services Section
  Technology Transfer Specialist (Publications)

- Mn/DOT Library (651) 366-3743
  Location: 1st Floor, Transportation Bldg.
  Conducts literature searches on specific research topics
CLIENTS
Internal
Districts
C.O. Traffic
Other D.O.T.
Others

Problem

Isolate
Research
Question

TASK 1.0

Determine
if Answer
Exists

No

Determine
Effort
Needed

TASK 3.0

Yes

Report
to
Client

TASK 12

Request
Action by
Others

No

Determine
if Staff
is Capable

TASK 4.0

Yes

Determine
Results

TASK 11

Determine
Future
Policy

TASK 6A

High

Determine
Project
Priority

TASK 5.0

Low

Analyze
Data

TASK 10

Program
for
Future
Action

TASK 7A

Adjust
Work
Schedule

TASK 6.0

Gather
Data

TASK 9.0

Prepare
Study
Design

TASK 8.0

Obtain
Approvals
& Funds

TASK 7.0

Text Ref.: 4-5.03

FIGURE 4.1
# Chapter 5
## DATA COLLECTION

### TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>5-1.00 INTRODUCTION</td>
<td>5-5</td>
</tr>
<tr>
<td>1.01 Purpose</td>
<td>5-5</td>
</tr>
<tr>
<td>1.02 Scope</td>
<td>5-5</td>
</tr>
<tr>
<td>1.03 Chapter Organization</td>
<td>5-5</td>
</tr>
<tr>
<td>5-2.00 GLOSSARY</td>
<td>5-5</td>
</tr>
<tr>
<td>5-3.00 VOLUME COUNTS</td>
<td>5-9</td>
</tr>
<tr>
<td>3.01 Types of Traffic Counts</td>
<td>5-9</td>
</tr>
<tr>
<td>3.02 Regularly Conducted Counts</td>
<td>5-9</td>
</tr>
<tr>
<td>3.03 Equipment</td>
<td>5-9</td>
</tr>
<tr>
<td>3.04 Field Data Collection</td>
<td>5-9</td>
</tr>
<tr>
<td>3.05 Data Recording Forms</td>
<td>5-9</td>
</tr>
<tr>
<td>3.06 Sample Sizes</td>
<td>5-9</td>
</tr>
<tr>
<td>3.07 Computations</td>
<td>5-9</td>
</tr>
<tr>
<td>3.08 Uses of Volume Counts</td>
<td>5-9</td>
</tr>
<tr>
<td>5-4.00 SPOT SPEED</td>
<td>5-16</td>
</tr>
<tr>
<td>4.01 Equipment</td>
<td>5-16</td>
</tr>
<tr>
<td>4.02 Field Data Collection</td>
<td>5-16</td>
</tr>
<tr>
<td>4.03 Data Recording Forms</td>
<td>5-16</td>
</tr>
<tr>
<td>4.04 Sample Size</td>
<td>5-16</td>
</tr>
<tr>
<td>4.05 Computations</td>
<td>5-16</td>
</tr>
<tr>
<td>4.06 Uses of Sport Speed Data</td>
<td>5-16</td>
</tr>
<tr>
<td>5-5.00 TRAVEL TIME AND DELAY</td>
<td>5-17</td>
</tr>
<tr>
<td>5.01 Types of Delay Studies</td>
<td>5-17</td>
</tr>
<tr>
<td>5.02 Equipment</td>
<td>5-17</td>
</tr>
<tr>
<td>5.03 Field Data Collection</td>
<td>5-17</td>
</tr>
<tr>
<td>5.04 Data Recording Forms</td>
<td>5-17</td>
</tr>
<tr>
<td>5.05 Sample Size</td>
<td>5-17</td>
</tr>
<tr>
<td>5.06 Computations</td>
<td>5-17</td>
</tr>
<tr>
<td>5.07 Uses of Travel/Delay Studies</td>
<td>5-17</td>
</tr>
<tr>
<td>5-6.00 VEHICLE OCCUPANCY</td>
<td>5-21</td>
</tr>
<tr>
<td>6.01 Equipment</td>
<td>5-21</td>
</tr>
<tr>
<td>6.02 Field Data Collection</td>
<td>5-21</td>
</tr>
<tr>
<td>6.03 Data Recording Forms</td>
<td>5-21</td>
</tr>
<tr>
<td>6.04 Sample Size</td>
<td>5-21</td>
</tr>
<tr>
<td>6.05 Computations</td>
<td>5-21</td>
</tr>
<tr>
<td>6.06 Uses of Vehicle Occupancies</td>
<td>5-21</td>
</tr>
</tbody>
</table>
12.06 Uses of Wrong Way Information
<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>5-13.00</td>
<td>CONFLICT ANALYSIS</td>
<td>5-29</td>
</tr>
<tr>
<td>13.01</td>
<td>Equipment</td>
<td></td>
</tr>
<tr>
<td>13.02</td>
<td>Field Data Collection</td>
<td></td>
</tr>
<tr>
<td>13.03</td>
<td>Data Recording Forms</td>
<td></td>
</tr>
<tr>
<td>13.04</td>
<td>Sample Size</td>
<td></td>
</tr>
<tr>
<td>13.05</td>
<td>Computations</td>
<td></td>
</tr>
<tr>
<td>13.06</td>
<td>Uses of Conflict Information</td>
<td></td>
</tr>
<tr>
<td>5-14.00</td>
<td>QUESTIONNAIRES AND SURVEYS</td>
<td>5-31</td>
</tr>
<tr>
<td>14.01</td>
<td>Equipment</td>
<td></td>
</tr>
<tr>
<td>14.02</td>
<td>Field Data Collection</td>
<td></td>
</tr>
<tr>
<td>14.03</td>
<td>Data Recording Forms</td>
<td></td>
</tr>
<tr>
<td>14.04</td>
<td>Sample Size</td>
<td></td>
</tr>
<tr>
<td>14.05</td>
<td>Computations</td>
<td></td>
</tr>
<tr>
<td>14.06</td>
<td>Uses of Questionnaires</td>
<td></td>
</tr>
<tr>
<td>5-15.00</td>
<td>OTHER STUDIES</td>
<td>5-32</td>
</tr>
<tr>
<td>15.01</td>
<td>Origin-Destination Studies</td>
<td></td>
</tr>
<tr>
<td>15.02</td>
<td>Compliance (Violation) Studies</td>
<td></td>
</tr>
<tr>
<td>15.03</td>
<td>Mass Transit Studies</td>
<td></td>
</tr>
<tr>
<td>15.04</td>
<td>Wheel Path Studies</td>
<td></td>
</tr>
<tr>
<td>5-16.00</td>
<td>STUDY METHODS &amp; EQUIPMENT</td>
<td>5-33</td>
</tr>
<tr>
<td>16.01</td>
<td>Data Collection</td>
<td></td>
</tr>
<tr>
<td>16.02</td>
<td>Data Processing</td>
<td></td>
</tr>
<tr>
<td>16.03</td>
<td>Statistical Analysis</td>
<td></td>
</tr>
<tr>
<td>16.04</td>
<td>Special Equipment</td>
<td></td>
</tr>
<tr>
<td>5-17.00</td>
<td>BENEFIT/COST ANALYSIS</td>
<td>5-37</td>
</tr>
<tr>
<td>5-18.00</td>
<td>REFERENCES</td>
<td>5-38</td>
</tr>
</tbody>
</table>
CHAPTER 5 - DATA COLLECTION

LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.1</td>
<td>Portable Traffic Recorder Printer Tape</td>
<td>5-39</td>
</tr>
<tr>
<td>5.2</td>
<td>Fifteen Minute Intersection Counts</td>
<td>5-40</td>
</tr>
<tr>
<td>5.3A</td>
<td>Traffic Volume and Turning Movement Study (A.M.)</td>
<td>5-41</td>
</tr>
<tr>
<td>5.3B</td>
<td>Traffic Volume and Turning Movement Study (P.M.)</td>
<td>5-42</td>
</tr>
<tr>
<td>5.4</td>
<td>Portable Traffic Recorder Data</td>
<td>5-43</td>
</tr>
<tr>
<td>5.5A</td>
<td>Summary of Automatic Traffic Recorder Data</td>
<td>5-44</td>
</tr>
<tr>
<td>5.5B</td>
<td>Summary of Automatic Traffic Recorder Data</td>
<td>5-45</td>
</tr>
<tr>
<td>5.5C</td>
<td>Summary of Automatic Traffic Recorder Data</td>
<td>5-46</td>
</tr>
<tr>
<td>5.5D</td>
<td>Summary of Automatic Traffic Recorder Data</td>
<td>5-47</td>
</tr>
<tr>
<td>5.5E</td>
<td>Summary of Automatic Traffic Recorder Data</td>
<td>5-48</td>
</tr>
<tr>
<td>5.6</td>
<td>Field Speed Survey Data</td>
<td>5-49</td>
</tr>
<tr>
<td>5.7</td>
<td>Travel Time and Delay Study Data</td>
<td>5-50</td>
</tr>
<tr>
<td>5.8</td>
<td>Test Vehicle Method II (Freeways)</td>
<td>5-51</td>
</tr>
<tr>
<td>5.9</td>
<td>Travel Time Study License Plate Technique Data</td>
<td>5-52</td>
</tr>
<tr>
<td>5.10</td>
<td>Estimating Volume and Travel Time Data</td>
<td>5-53</td>
</tr>
<tr>
<td>5.11</td>
<td>Moving Vehicle Method (Computations)</td>
<td>5-54</td>
</tr>
<tr>
<td>5.12</td>
<td>Intersection Delay Study Data</td>
<td>5-55</td>
</tr>
<tr>
<td>5.13</td>
<td>Vehicle Occupancy Data Recording</td>
<td>5-56</td>
</tr>
<tr>
<td>5.14</td>
<td>Queue Length Data Recording</td>
<td>5-57</td>
</tr>
<tr>
<td>5.15</td>
<td>Vehicle Classification Data</td>
<td>5-58</td>
</tr>
</tbody>
</table>

LIST OF FORMS

<table>
<thead>
<tr>
<th>Form</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.A</td>
<td>Traffic Density Station Report</td>
<td>5-59</td>
</tr>
<tr>
<td>5.B</td>
<td>Portable Traffic Recorder Data Sheet</td>
<td>5-60</td>
</tr>
<tr>
<td>5.D</td>
<td>Traffic Volume and Turning Movement Study</td>
<td>5-62</td>
</tr>
<tr>
<td>5.E</td>
<td>Summary of Hourly Approach Volumes</td>
<td>5-63</td>
</tr>
<tr>
<td>5.F</td>
<td>Field Speed Survey</td>
<td>5-64</td>
</tr>
<tr>
<td>5.G</td>
<td>Travel Time and Delay Study</td>
<td>5-65</td>
</tr>
<tr>
<td>5.H</td>
<td>Test Vehicle Method II (Freeways)</td>
<td>5-66</td>
</tr>
<tr>
<td>5.I</td>
<td>Travel Time Study License Plate Technique</td>
<td>5-67</td>
</tr>
<tr>
<td>5.J</td>
<td>Estimating Volume and Travel Time</td>
<td>5-68</td>
</tr>
<tr>
<td>5.K</td>
<td>Intersection Delay Study</td>
<td>5-69</td>
</tr>
<tr>
<td>5.L</td>
<td>Vehicle Occupancy Data Recording</td>
<td>5-70</td>
</tr>
<tr>
<td>5.M</td>
<td>Queue Length Data Recording</td>
<td>5-71</td>
</tr>
<tr>
<td>5.N</td>
<td>Vehicle Classification Form</td>
<td>5-72</td>
</tr>
</tbody>
</table>

5-1.00 INTRODUCTION

Traffic data is collected both by offices directly involved in research, and by other offices which may not be directly connected with research or even with traffic engineering. Traffic data is demanded for design, operations, maintenance, programming, forecasting and other functions, as well as by politicians and political units for their information and use. Personnel involved in actual data collection require specific guidance in collection
methodology and basic data handling. This chapter provides such guidance.

5-1.01 Purpose
Traffic data collection provides the basis for identifying problems, confirming earlier hypotheses, quantifying the impact of changes, and determining the nature or magnitude of needed improvements. Data adequacy and reliability, which are absolutely essential to any traffic engineering study, require careful, standardized collection and analysis to ensure valid interpretation and comparability. The purpose of this chapter is to outline standards for traffic data collection.

5-1.02 Scope
This chapter describes the manner in which basic traffic engineering data are obtained and recorded, as well as basic calculations and analysis techniques. The following subjects are addressed for each type of traffic engineering data:

1. Equipment used
2. Field data collection
3. Forms used
4. Sample size required
5. Computations
6. Uses of data

In addition, other subjects are included for some types of data as required. None of the subjects are meant to be covered exhaustively. Special case uses may be made of data, new equipment may come out, forms may be modified to include additional desired information, sample sizes may be adjusted for greater or less precision etc. This chapter provides a foundation for both standard and ad hoc studies.

5-1.03 Chapter Organization
Data collection techniques for 16 basic data types are discussed in this chapter. These are listed in the Table of Contents. References given at the end of this chapter provide for a much more thorough, definitive review of the studies covered in this chapter, and one or more of them should be utilized as appropriate, especially in the case of a particularly extensive or critical study.

5-2.00 GLOSSARY
The definitions given below were selected either because, 1. The terms are used elsewhere in this chapter, or 2. The terms are key to a basic understanding of data acquisition and analysis. In the latter case, a grasp of such concepts as randomness, correlation, and normality will greatly aid even those who merely use research information provided by others. With the proliferation of statistical calculators and computer software, it has become increasingly common to find mathematically correct procedures inappropriately applied to data due to a lack of understanding of basic statistical concepts. This emphasizes the general need to have research studies overseen by personnel trained in research and associated statistical techniques. For those without appropriate training, it is intended that the definitions listed here, as well as the text throughout this chapter, will give them a foundation in the general concepts and execution of traffic research. With this goal in mind, the following definitions include not only simple descriptions, but additional comments and examples as required to provide a working understanding of each concept.
Analysis of Variance (ANOVA) - A statistical technique generally used to assess whether three or more sample means were based on samples drawn from the same population. For example, the researcher may obtain average speeds of motorcycle, automobile, and pickup drivers at a roadway location.

The average speed of each group is somewhat different from that of the others. Are the average speeds for these groups really different, or are these differences just due to chance? ANOVA answers this question by comparing how much the speeds vary in each group with how much the speeds vary from group to group.

Average - a general term used to describe the CENTRAL TENDENCY of the data i.e., what value describes the "middle" of the data. The most common measure of this is the MEAN, which is often just called the average, and consists of the sum of values divided by the number of values. The mean is usually denoted by drawing a bar over the variable letter e.g. \( \bar{x} \). This is not always the best measure to use. In many cases, the MEDIAN is a better measure. The median is the value which 50% of the data lies above, and 50% lies below, i.e. it is the middle value. The median often makes more intuitive sense, as in economic or speed data.

Bias - bias indicates that the sampling method, analysis procedure used, or other factor, yields results which "unfairly" tend toward certain values or conclusions. For example, common data collection errors--being more sensitive to record high speed, high occupancy, or larger vehicles--yield biased results. These errors may result in exaggerated average speeds, incorrect high average occupancies, or invalid vehicle classification counts, respectively. There are many such possible errors, most of which can be eliminated by proper study design and proper random data collection. Other sorts of bias can result from improper application of statistical techniques. For example, if data is simply gathered "shot gun" (i.e. collecting everything that might conceivably be used) style, without prior defining of the hypothesis being tested (i.e. what are we looking for?) then some otherwise valid statistical techniques can not be applied, since they would show differences to be significant which, in fact, were not. If in doubt about a study plan, have it reviewed by trained research personnel.

Categorical Data - categorical data is data regarding variables which belong in one of several categories or classes. For example people may be classified as Democrats, Republicans, Independents or Other. This constitutes categorical data. Categorical data commonly results from the use of questionnaires. A special case of categorical data is one in which only two responses are possible e.g. smoker or non-smoker. Coding the results in this case as either zero (smoker) or one (non-smoker) yields a BERNOUlli variable The number of "successes" i.e. 1's in n trials is a BINOMIALLY DISTRIBUTED random variable. In dealing with categorical data, somewhat different statistical techniques, for example binomial distributions and CHI-SQUARED test procedures, may be used.

Chi-square distribution - a nonsymmetrical distribution used in statistical analysis of categorical data, specifically, to test whether the number falling into each category is different from the number that was expected to fall into each category.

Confidence Interval - the range in which some true value is expected to lie, given some CONFIDENCE desired. For example, it may be stated that the average speed of traffic is 59 ± 4 mph at 95% confidence. Thus our sample average was 59 mph and, given the nature of our data, the true value i.e. the true population average will be within 4 mph of this value 95% of the time (when the data looks like ours). Confidence intervals or levels of significance should virtually always be given when reporting information. In addition to averages, confidence intervals can be found for slopes and y-intercepts in regression, variances, probabilities, changes in mean, and ratios of variances. A 95% confidence interval is generally obtained by taking two standard deviations to either side of the sample mean. Thus, if the sample average found were 59 mph and the sample standard deviation were 2 mph, the 95% confidence interval would be 59 mph ± (2)(2 mph) = 59 ± 4 mph, as above.

Continuous vs. discrete data - Continuous data is data which may be any of an infinite number of values within
an interval. Speed, for instance, is continuous in that we may give a value as 56 mph, 56.3 mph, 56.32854 mph and so on depending upon the accuracy of our measurement and our needs. Discrete data, by contrast, takes on only a countable number of values, for example the number of crashes in a given year on a segment of highway. Probabilities associated with particular values of discrete or continuous variables must be handled somewhat differently. This is due to the fact that exact values actually occur with discrete variables (e.g. exactly 20 crashes per year) but do not occur with continuous variables (e.g. 20 mph implying exactly 20.000000 will not occur as it is only one of an uncountable infinite set of possibilities).

Control Site - a site at which no treatment takes place. If new signing is installed at an intersection, a control site would be a similar site at which there were no change in signing. The use of control sites allows the researcher to account for extraneous changes unrelated to the treatment. Thus if speeds seem to be slower at the new signing, the control site can help determine whether this is really due to the signing or whether speeds for other unknown reasons are just generally lower. One of the greatest difficulties in using control sites is finding sites which are adequately similar to treatment sites in all respects except the treatment itself. Selected improperly, control sites can lead to bias and unjustified conclusions. Often it is preferable to utilize before/after studies of the same (treatment) site rather than using a control site, since time dependent biases inherent in before/after studies are generally smaller and easier to account for than biases due to control site selection.

Dispersion - the degree to which the data is "spread out." The numbers 20, 41, 10, 6 are more dispersed than 18, 15, 20, 24, even though the average of both sets is the same (19.25). Dispersion is usually given either in terms of VARIANCE, (s² for sample data) or of STANDARD DEVIATION (s for sample data). Variance is sometimes simpler to use. In calculations, but for final reporting standard deviation is usually preferred since it is in the same units as the data Standard deviations, s, for the above sets of numbers are 13.55 and 3.27 respectively. Population standard deviation and variance are usually represented by \( \sigma \) and \( \sigma^2 \) respectively.

Distributions - Normal and students t distributions are used in analysis of data to determine confidence intervals, Type I error, probabilities of particular values etc. The t distribution is specifically intended for small samples, but may be used for large samples as well. Since t distribution tables are not as thorough in presenting large sample values, usually the normal (or z) distribution is used for these cases.

Other distributions, for example chi-square or F, are used for certain analysis techniques. Chi-square can be used to assess confidence intervals, Type I errors etc. for sample variances, for example to test the equal variance assumption.

Error - Type I (\( \alpha \)) and Type II (\( \beta \)) - A type I error (or \( \alpha \) error) consists of mistakenly rejecting the NULL HYPOTHESIS when it is true e.g. saying the average speed of cars from before to after has changed when, in fact, it has not. This type of error is accounted for in giving the significance level of a test i.e. if we say the speed has increased with 95% confidence we imply that there is a 5% chance of our being wrong--or making a type I error. Confidence may be represented as 1 - \( \alpha \).

A type II error (or \( \beta \) error) consists of mistakenly accepting the null hypothesis when, in fact, it is false. This error is made if we say that average speed has not changed, when it actually has. Obviously this sort of error depends upon how large a change we are trying to detect. For example we may "miss" a small 1 mph change without concern since it is not of practical significance, whereas we would like to certainly "find" real changes of 5 mph or greater. In general, if the sample size n does not change, making the \( \beta \) error smaller results in a larger \( \alpha \) error 1. The only other alternative is to collect a larger sample. Clearly a reasonable \( \beta \) should be selected so that \( \alpha \) does not become unacceptably large or so that inordinate data collection is not required.

Hypothesis - a statement or proposition which is set up to describe a set of facts. Statistical testing is used to determine if the hypothesis should be accepted or rejected. The two types of hypotheses referred to are the NULL HYPOTHESIS \( Ho \) and the ALTERNATIVE HYPOTHESIS \( Ha \). The null hypothesis describes the condition of no change or difference, for example "the speeds did not change with the new signing," or "crashes did not increase this year." The alternative hypothesis simply gives the other possibility, "the speeds did change," or "crashes
increased." It is actually the null hypothesis that is tested.

**Mean Speed** - The mathematical average of all observed speeds.

**Median Speed** - The 50th percentile speed, or the speed at or below which 85 percent of the observed vehicles are traveling.

**Modal Speed** - The most frequently observed speed.

**Normal** - data that is normal is distributed as the normal ("bell shaped") curve and can be analyzed with ordinary statistical techniques. Data should always be checked for normality (visual checks, NORMAL PROBABILITY or RANKIT plots, knowledge about the nature of data, SKEW indices etc may be used).

**Pace** - The 10 mph speed range containing the greatest percentage of the observed vehicle speeds. The speed limit should be near the upper bound of the pace.

**Percent in Pace** - The percentage of the observed speeds that were within the 10 mph pace. The higher this percentage is, the more uniform the speeds are. If this is less than 67% of the speeds in the pace, it would indicate that the data may be skewed or that the sample size is too small.

**Percent Speeds** - The percentage of the sample vehicles traveling at a speed greater than the indicated speed. Thus, if a speed limit change is being considered, the percentage of violators at various speeds can be determined.

**Percentile Speeds** - Values of percentile speeds incremented to provide for construction of cumulative speed frequency curves. Each value is the percentage of vehicles at or below the indicated percentile speed. The 50th and 85th percentile speeds are located with the median and mode speeds.

**Population** - the set of all measurements of the characteristic in question, e.g. the set of all vehicle speeds past a certain point. A SAMPLE, by contrast, is a subset of the population from which population statistics (mean, Standard deviation etc ) are estimated e.g. the set of speeds of every third car past a certain point, or a five minute sample of speeds past a point etc. Often only SAMPLES (rather than entire populations) are gathered and are used to estimate population statistics.

**Power** - the probability of rejecting the null hypothesis when it is in fact wrong. This is equivalent to $1 - \beta$ (see "Error" above).

**Random** - Sampling techniques should be random so that they do not result in bias. Random number tables often can be used to randomize collection, as can careful selection of collection methodology.

**Range** - The spread from the highest to the lowest values observed.

**Regression** - the method of fitting the best line or curve to a set of data points. Often this consists of fitting the best straight line (using root mean squared, RMS, method) to two variable data points. For example the researcher may graph points representing fatalities by vehicle speed, and observe that higher speeds tend to increase fatalities. Regression may be used to fit the best straight line to this data which can then be used to assess how much fatalities increase with each 10 mph speed increase, or to predict fatalities with future speed changes etc. Statistical tests may be performed on the slope and Y intercept of this line, on the value it yields at specified locations, or on predictions made from it. In spite of the ease with which many hand calculators fit regression lines to data, the underlying statistics are relatively complex, conclusions can be totally misleading, and values should be statistically analyzed to yield confidence intervals etc. The facile use of regression has resulted in perhaps more bad information than any other basic statistical procedure.

**Sample Size** - The number of observations made. Sample size needed for statistical reliability depends on the variability of the population (as reflected by variance or standard deviation) and the level of confidence needed.
Sample sizes smaller than \( n = 30 \) are generally considered too small.

**Significance** - statistical significance implies that the differences found are likely to be real and not due merely to chance. The significance level for a test represents the weight of evidence for rejecting \( H_0 \), i.e. the probability of observing a sample outcome more contradictory to \( H_0 \) than the observed outcome. This level of significance is usually called \( P \). Thus if \( P = 25 \), there is a 25\% chance of having found a more extreme value even if \( H_0 \) were correct. It should be noted then that \( P \) is really an \( \alpha \) value which has been computed for our particular findings rather than being preset. Confidence may be reported as \( 1 - \alpha \) or \( 1 - P \) depending upon how results are reported.

**Skew Index** - A measure of symmetry of the distribution about the mean. A "normal" distribution, symbolized by a bell-shaped curve, would have a skew index between 0.90 and 1.10, and is indicative of randomness of observed values. A positive skewness (\( > 1.10 \)) is caused by a preponderance of higher values in the sample. A negative skewness (\( < 0.90 \)) is caused by a preponderance of lower values. The skew index is highly susceptible to minor changes in the distribution. If the value obtained indicates the presence of skewness, consider the possibility that the environment or even the presence of the observer was adversely affecting data.

**Skew Index Variance** - The variance of the skew index.

**Standard Deviation** - (Std-Dev), the square root of the variance, another measure of variability used for statistical tests.

**Standard Error of the Mean** - (STD-ERR), the standard error is the standard deviation divided by the square root of the sample size. The standard error is used to determine the accuracy with which the mean has been determined.

**Variance** - (VAR), a value calculated based on differences between individual observations and the average of all observations. High values of variance indicate greater variability between observations. The variance is used in statistical computations.

**85th Percentile Speed** - The speed at or below which 85 percent of the observed vehicles are traveling. This factor

<table>
<thead>
<tr>
<th>PROGRAM</th>
<th>WHERE CONDUCTED</th>
<th>FREQUENCY</th>
<th>NUMBER OF COUNTS MADE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. ATR Program</td>
<td>Outstate Municipal CSAH</td>
<td>Continuous</td>
<td>125</td>
</tr>
<tr>
<td></td>
<td>Outstate Rural CSAH</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Outstate Municipal TH</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Outstate Rural TH</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>7-County Metro Area</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Rural TH</td>
<td>Rural TH</td>
<td>Every other year (even numbers)</td>
<td>6,000</td>
</tr>
<tr>
<td></td>
<td>Municipal TH</td>
<td>48-hour counts</td>
<td></td>
</tr>
<tr>
<td>3. County and Municipal</td>
<td>County and Municipal CSAH</td>
<td>Over a four year period -- 48-hour</td>
<td>27,000</td>
</tr>
<tr>
<td></td>
<td>CSAH</td>
<td>counts</td>
<td></td>
</tr>
<tr>
<td>4. Municipal State Aid</td>
<td>State Aid streets within</td>
<td>State Aid streets within</td>
<td>4,000</td>
</tr>
<tr>
<td></td>
<td>municipalities</td>
<td>municipalities</td>
<td></td>
</tr>
<tr>
<td>5. Seven-County Metro</td>
<td>Sample of TH and other</td>
<td>Sample of TH and other</td>
<td>9,000</td>
</tr>
</tbody>
</table>

Text Ref.: 5-3.02

---

| July 1, 1991 | TABLE OF DEPARTMENT TRAFFIC COUNTING PROGRAMS | TABLE 5.1 |
is commonly used in establishing speed limits.

5-3.00 VOLUME COUNTS

5-3.01 Types of Traffic Counts

Traffic counts are the most basic type of data collected in the field of traffic engineering. Quite simply, traffic counts involve counting vehicles passing a point for varying intervals of time. They can range from 24 hours per day, 365 days per year, to five minutes of a peak period. Common types of traffic counts, count intervals and the regular traffic counting program of Mn/DOT, are described below. In addition to their use for purely traffic engineering purposes, traffic counts are used to determine vehicle miles of travel for the purpose of distributing gas tax revenues throughout various levels of state and local government.

5-3.01.01 Total Volume Counts

The principal use of traffic volume data is the determination of average daily traffic (24 hours) on a particular segment of roadway. The most common product of traffic volume data accumulation is a traffic map identifying the volume of traffic on major roadways. Traffic counts are also used to identify the highest volume of traffic occurring on a segment of roadway during a specific time period, such as the peak period (e.g., 6-9 A.M., 3-6 P.M.), the peak hour, or 5 and 15-minute peaks within the peak period.

5-3.01.02 Directional Counts

Directional counts are counts taken of traffic movements on a roadway by direction of travel. On a segment of highway, directional counts include counts of each movement past the point at which the count is being taken. At an intersection, directional counts are made of each possible movement-through movements by direction of travel, and left and right turns by direction of travel.

5-3.01.03 Lane Counts

Lane counts are directional traffic counts taken for each travel lane on a multi-lane roadway.

5-3.01.04 Pedestrian Counts

Pedestrian counts are counts of the number of people walking through the area being studied. Pedestrian counts are normally taken only between 8 A.M. and 6 P.M.

5-3.01.05 Metropolitan Freeway Counts

In addition to other counts, each metropolitan area freeway segment is being counted at least once every two years as part of a program monitoring peak period operating conditions. These counts (either 5, 15, or 60-minute increments) are used to determine if congestion is becoming, or has become, a problem; and if so, what corrective measures (such as ramp metering) can be used to alleviate the problem. The Metro District works in cooperation with the Transportation Data and Analysis Section (TDA), Office of Planning, Modal and Data Management Division to gather and analyze this data.

5-3.02 Regularly Conducted Counts

The Department conducts five regular traffic counting programs throughout the state. These programs are summarized in Table 5.1 and described below.

5-3.02.01 Automatic Traffic Recorder Program
1. **Location** - Automatic traffic recorders (ATRs) are permanently installed at approximately 125 selected locations throughout the state. These ATR locations were selected to best represent statewide travel and are usually located on trunk highways. Locations on other than trunk highways are determined by population, average daily traffic, and land use. ATR locations in the eight county metropolitan area are based on locale; they include urban, suburban, and outlying areas with road use characteristics that are commuter, mix, and recreational. Combining area classifications with road use classifications - urban commuter, suburban mix, etc., comprise the spectrum of ATR locations in the metropolitan area.

2. **Data Collection** - ATRs are permanently installed and continuously record traffic volumes by direction of travel. All data is accumulated by hour. Approximately one-fourth of the ATRs determine the speed and length of vehicles passing their locations. These are then sorted into one of 12 speed ranges and one of two length categories. Data is retrieved from all locations via telephone lines. A central controller polls each location and stores this data by location and date. This data is processed and edited. Monthly reports are prepared showing hourly volumes and appropriate totals and averages. An automatic Traffic Recorder Data Report is published each year showing monthly ADT for the current and previous year for all ATRs. A Traffic Recorder Data Summary is also published annually. This shows days of week, monthly relationships to average daily traffic and to average summer weekday traffic, peak hours of travel, and average hourly traffic. Graphs included show volume variations throughout the year. These reports may be obtained from the TDA Section.

**5-3.02.02 Portable Traffic Counting Program**

1. **Location** - Forty-eight hour machine counts are taken on designated outstate roadways, and on highways in the eight county metropolitan area. Portable traffic counting programs involve placing traffic counters at selected locations to obtain traffic estimates. The sample locations are determined by the TDA Section.

2. **Data Collection** - These counts are taken by personnel in the district offices, and are sent back to the TDA Section where they are coded by road use. ADT is estimated by applying an appropriate seasonal and weekly adjustment factor. ADT estimates are plotted on work maps where they are compared to historical traffic and land-use data to determine final estimates of average daily traffic. The total number of counts and the time period required to complete the portable traffic counter program are shown in Table 5.1.

**5-3.02.03 Computerized Data Collection**

1. **Special Counts** - Special Counts are conducted within the metropolitan area on I-35W, I-94, I-494, I-694, and associated ramps. There are approximately 800 permanent vehicle loop detectors currently being monitored by computers at the Regional Traffic Management Center (RTMC) in Roseville. Volume and occupancy data from these detectors are used to determine operational parameters and evaluate the effectiveness of the traffic management systems on these freeways.

Data is collected in either 30 second or five minute intervals depending on operational needs. This data is then retained for varying lengths of time. Five minute volume and occupancy counts from detectors are available from computer disk files dating back to January 1, 1994. However, data availability usually lags by one day. Counts may be printed from these files at any interval desired, from five minute to 24 hours. As other newly constructed or reconstructed segments of freeway are added to the metropolitan area network, loop detectors will be installed and added to the number of locations already monitored from the RTMC. In addition to detectors installed for traffic management operational needs, detectors are being installed to help reduce the use of portable tube-type counters with their attendant problems and hazards. This should benefit planners and
others needing traffic counts from Metropolitan freeway systems.

2. **Tape Processing** - Many portable traffic recorders are designed so that the recorded tape can be read either manually or by translating equipment. These translators convert the coded data into computer format to obtain the desired summaries.

---

**5-3.03 Equipment**

**5-3.03.01 Traffic Counters**

1. **Description** - Manually operated traffic counters are a commonly used piece of equipment for manual counts, especially for turning movement directional counts. Traffic counter boards are composed of a number of hand-operated counters arranged so that each approach lane to a conventional four-legged intersection is represented by a counter. Usually, a piece of tape is placed in front of each counter row, upon which the observer marks the direction of the movement being counted-through, right turn, left turn, etc.

2. **Operation** - Operation of the counter board is simple. At the start of the count, each of the dials is read and the reading is indicated on a recording form. As each vehicle passes the observer, the counter mechanism is depressed for that particular movement. At prescribed intervals as predetermined by the data requirements - 5-minute, 15-minute, or hourly - the counter is read and the number is recorded. There is no need to set back the counter to zero although most counters are designed to permit this. The actual traffic volumes are determined by subtraction of the initial reading from the final reading.

**5-3.03.02 Portable Traffic Recorders**

1. **General** - Portable traffic recorders are either accumulative or nonaccumulative. In either case, the machine which is usually used has a rubber hose (or road tube) over which the vehicles to be counted pass. At permanent locations, a fixed loop detector permanently imbedded into the roadway is utilized to detect vehicles for machine counting.

2. **Accumulative Counters** - An accumulative counter is termed "accumulative" because the counter bank continually advances. Therefore, the counter must be directly read at preselected times. The main parts of an accumulative counter are: (1) the road tube, (2) a dry cell battery to power the unit, (3) a diaphragm, and (4) a counter bank. A surge of air through the tube, caused by a vehicle depressing the tube, deforms the diaphragm and thereby completes an electrical circuit which transmits the electric impulse from the batteries to advance the counter. In most cases, one depression of the road tube advances the counter bank one-half number; two depressions result in one full advancement of the counters or an increase of one number in the counter reading.

3. **Nonaccumulative Counters** - A nonaccumulative counter operates on the same principle as the accumulative counter. However, the nonaccumulative counter records only at specific time intervals - usually 15 minutes - and the recording is made directly upon a paper tape. Only the count for that particular time interval is recorded. Figure 5.1 shows typical portable traffic recorder printed tapes with examples of the recorded data. Both the time and the traffic count are recorded on the tapes. Typical data increments are 15 minutes or one hour. The machines with electronic clocks can be set for intervals as short as one minute.
a. **Quarter Hour Counts** - The quarter hour record is most widely used because it permits the identification of traffic volumes by quarter-hour intervals, which is useful in the determination of peak-hour volumes. The quarter-hour counter also accumulates the traffic count for the hour clock interval. Both the first 15-minute count and the total counts for that hour can be read directly from the tape. Quarter-hour counts between the beginning and ending of the clock hour must be obtained by subtraction. The count during any quarter-hour period is, thus, the difference between any two counts printed opposite the quarter-hour intervals.

b. **Hourly Counts** - The hourly count merely totals the count during the hour interval, prints the hourly volume, resets the counter to zero, and advances the hour indicator.

5-3.03.03 *P.C. Compatible Counters*

1. **Manual** - Used primarily for intersection/turning movement studies, a manually operated 12-button panel can be used in conjunction with a counter that is preprogrammed with the necessary parameters such as date, starting time, site identification, and desired time intervals (generally 15 minute). Form 5.D (Mn/DOT 2944A Rev.) is used in the field with the counting operation so that each movement can be identified with a specific button on the panel. Upon completion of a study the counter can be returned to the office and the count data transferred to a P.C. compatible retriever. Once the retriever is connected to a computer, printouts can be made containing a variety of information such as 15 minute totals for each movement, hourly totals, total intersection volumes, and AM and/or PM peak volumes. An example of these printouts can be seen in Figures 5.2, 5.3A, and 5.3B.

A second type of manual counter is a microprocessor-based device designed specifically for manual counting. This device has 16 buttons of which 12 are keyed to intersection movements, the remaining four buttons can be used for counting pedestrians, trucks, or buses. Up to 12 hours of count data are automatically stored in the memory in five or 15 minute intervals. Data can be read directly from the counter or transferred to a computer for analysis and printout.

2. **Portable Recorders** - Portable recorders that are P.C. compatible generally consist of two pieces of equipment, a traffic counter and a retriever. The counter is a nonaccumulative portable recorder that is used in the field with associated tubes or loops to obtain volume counts over a prescribed length of time, usually 48 hours. The retriever is used to monitor, set parameters, and collect the stored data from the counter. Prior to beginning a study, the retriever is connected to the counter and various parameters such as time intervals, date, and start time are set. Once the parameters have been set the retriever is disconnected and the counter is left to accumulate the needed data. When the desired study time has elapsed the retriever is returned to the site and reconnected to the counter. The accumulated data is then "dumped" from the counter into the retriever. The retriever is returned to the office, connected to a P.C. and the desired printouts made.

5-3.03.04 *Counter Maintenance*

1. **ATR Stations** - All of the maintenance of the ATR stations is performed by the Office of Maintenance, Electrical Services Section (ESS). The cost of the power to operate each station is paid for by the District Office that each station is located in. Phone bills are processed by the Business Administration Unit of the Program Management Division.

2. **Portable Traffic Recorders** - The portable traffic counter cases, hoses, chains, and chain locks are maintained and budgeted for by ESS. All counters needing repairs should be transported to the ESS. It is best to spread out the maintenance of counters to avoid delay due to work overloads.
The goal at ESS is to provide repair service when defective counters are turned in. At times, vendors will be used to do some of the repair work. All portable counters are listed in the Office of Maintenance inventory.

Shortly after the first of July each year, each district must advise the Office of Maintenance of the number of counters required to maintain this counting program. This report goes directly to the ESS and is incorporated into an annual budget request for additional and replacement counters.

5-3.04 Field Data Collection

5-3.04.01 ATR Program

All automatic traffic recorders are in permanent locations. These locations are recorded in the "Minnesota Automatic Traffic Recorder Data Summary" prepared by the TDA Section.

5-3.04.02 Portable Counter Placement

Care should be taken in selecting the location for installing portable traffic-counting equipment. There are two crucial location considerations: (1) placement of the road tube and (2) security of the traffic counter. The selection of an appropriate time and day for counting should also be coordinated with street maintenance and cleaning schedules to avoid road tube damage by maintenance vehicles.

1. Road Tube Placement - The road tube should be located along a smooth portion of the roadway to be counted. The hose should not fall along a construction joint as the roadway depression at the joint could cause a misreading of the tube. Care should also be taken to locate the hose far enough away from intersections so that any vehicle crossing the hose would still be moving at right angles to the hose and not turning across the hose. The offsetting of wheels during vehicular traffic turning movements could cause a traffic counter to misread if the counter were located within the turning arc. In securing the roadway tube, PK concrete nails are commonly utilized. The far end of the roadway tube has a clamp through which the PK nail is inserted and driven into a crack in the roadway or, ideally, into the construction joint between the gutter section and the pavement edge. A clamp is also usually attached to the hose at the near side of the counter. This clamp is affixed to the roadway with a nail driven into the construction joint between the gutter section and the pavement edge. Tubes are especially vulnerable to damage by snow plows so they should not be used during inclement weather.

2. Security - Traffic counters should be securely chained to a sign post, utility pole, or light pole to prevent theft.

5-3.04.03 Other Considerations

Machine numbers should be recorded on the data tape so that corrections can be made if maintenance problems or bad data are encountered. The date, direction of travel, location, and other identifying information should also be included. A length of blank tape should be left on both ends to permit proper machine processing.

5-3.05 Data Recording Forms

This section describes the standard forms utilized for many of the traffic counts described above. Standardized forms are not available for the collection of all data described in this chapter.

5-3.05.01 Data Sheets
Examples of forms used to record data from the portable counters are shown in Form 5.A (Mn/DOT 2914 (5-77)) and Form 5.B (Mn/DOT 29176 (3-77)). Form 5.A is used for recording data from accumulative counters while Form 5.B is used for recording data from nonaccumulative counters.

Accumulative counters must be read directly and the number read should be placed on a form for the appropriate time period. These numbers are then translated to actual volumes by subtraction and the result entered below. Where hourly counters are used, the recording tapes are collected and the traffic volumes are transferred to Form 5.B in the office. Traffic volume data from counters that are P.C. compatible will be produced on computer printouts such as those shown in Figure 5.5A.

5-3.05.02 Directional Counts

Directional, or turning movement counts, are generally taken during AM and/or PM peak periods and are recorded on either a Motor Vehicle Traffic Volume and Turning Movement Field Report or a Traffic Volume and Turning Movement Study or a , Form 5.C and Form 5D (Mn/DOT 2944 Rev) respectively. For examples, see Figures 5.2, 5.3A and 5.3B.

5-3.06 Sample Sizes

Depending on the purpose of the study, sample sizes can vary from a fraction of an hour to 24 hours a day, 365 days a year. Generally, peak periods will be included in all samples. Traffic counts are normally not taken on a holiday nor on the day before or after a holiday. Monday mornings and Friday evenings will generally show high volumes.

Typical sample sizes are:

1. Type of Study  | Sample Size
    ADT | 24 or 48 hrs.
2. ATR | 24 hrs./day, 365 days/yr.
3. Signal Warrants | 8 to 12 hrs. including both peak periods
4. Vehicle Classification | 16 hrs.

5-3.07 Computations

5-3.07.01 Data Review

The first step in utilizing field data is to check its reasonableness by comparing the data with data obtained from similar locations. If the data is not comparable, the equipment and the field data sheets should be inspected for malfunction or error; and an additional count should be taken for verification.

5-3.07.02 Factoring

The TDA Section provides the necessary factors for adjusting weekday machine traffic counts to estimated average daily traffic. These factors are derived from individual counts or groups of counts produced by the automatic traffic recorders. Since all frequencies of data (hourly, daily, weekday, day of week, monthly and ADT) are available at each ATR, the relationships or factors that can be identified and developed are almost unlimited. All factors and factoring procedures are developed and applied by the TDA Section.

5-3.07.03 Average Daily Traffic from 48-Hour Portable Counts

Average Daily Traffic estimates can be obtained based upon the portable 48-hour traffic count by applying the appropriate weekday or weekly factor to the count data.
5-3.07.04 Data Summaries

Many types of data and related factors can be developed from the ATR data. Currently these data are summarized in the “Automatic Traffic Recorder Annual Report” available from the TDA Section. The types of data recorded within this report for each ATR station are shown in Figures 5.5A through 5.5E.

5-3.08 Uses of Volume Counts

Volume counts play a major roll in traffic engineering. Their uses include:

1. Determining the need for traffic control devices
2. Obtaining various factors (hourly, daily, weekly, etc.)
3. Developing traffic flow maps
4. Research studies
5. Operational studies
6. Determining ADTs
7. Determining peak periods and peak hours
8. Signal phasing and timing
9. Determining trends
10. Determining the need for channelization
11. Simulation studies
12. Vehicle classifications
13. Calculating crash rates

5-4.00 SPOT SPEED

Spot speeds are the vehicle speeds taken at a specified point along the roadway. The average of such speeds is sometimes referred to as time mean speed.

5-4.01 Equipment

Spot speeds are usually collected by the use of radar or laser equipment, although spot speeds may be gathered during travel time runs by reading the speedometer at specified points along each run. Another method involves the use of a short "speed trap." This trap may consist of a short marked area on the roadway over which vehicles are timed and speeds computed, or may consist of a very short section beginning and ending with vehicle sensors (tubes or electronic) over which an electronic data collection device computes and records vehicular speeds.

5-4.02 Field Data Collection

Regardless of data collection method, the location of collection vehicles, personnel and equipment is of primary importance. The obvious or obstructive presence of these may have a large impact on the speeds of passing vehicles. Because of this, all equipment and personnel should be employed in the most inconspicuous manner possible, and note should be made when reporting information in cases where it is believed vehicular speeds were significantly affected by collection activities. Regarding radar speed collection, the following should also be considered:

1. The angle between the radar and the vehicle path affects speed readings. The further the radar is from a straight roadway section, the slower the speed will read. Although trigonometric adjustment can be made to correct these readings, it is generally more advisable to keep collection in as direct a line with oncoming
traffic as possible, which usually means as close to the roadway as possible. Exception to this must be made when the collection vehicle and equipment would tend to affect vehicle speeds significantly.

2. Depending on the use of the data, the observer must consider whether to collect speeds of all vehicles, including platooned vehicles, or only the speeds of unimpeded vehicles. One may collect all speeds, for example, to assess traffic flow during peak periods; whereas only unimpeded vehicle speeds would be collected to assess the impact of speed zone signing.

3. Speed samples may be biased due to larger or faster vehicles being more easily picked up by radar, and vehicles screening vehicles directly behind them. These considerations must be kept in mind both while collecting and while analyzing data. Laser speed detection devices can collect discrete vehicles.

5-4.03 Data Recording Forms

Typical data recording forms, one filled out and one blank, are shown in Figure 5.6 and blank Form 5.F, respectively.

5-4.04 Sample Size

As a rule of thumb, at least 100 speeds should be collected within the time period under consideration. This will generally provide mean or 85th percentile speeds within ± one mph with 95% confidence. Samples must always be both random and representative. Use a sampling plan which does not distort (bias) values you are looking for. The largest sample size possible is often dictated by the volume at the location and/or the time period being studied. If the volume is very light or the time period very short, large sample sizes may not be possible. In these cases, a minimum sample size of 30 vehicles must be collected. For ordinary conditions this will provide an estimate of mean or 85 percentile speed. The limited data that is gathered should be analyzed by personnel familiar with small sample statistics. It should be noted that the information derived from very small samples may not be adequate for some uses.

5-4.05 Computations

Speed calculations can be done manually, but are usually done with an Excel spreadsheet which is available from OTST. The basic procedure is to tally the number of vehicles in any one speed category (see Figure 5.6 and Form 5F), accumulatively add the vehicles for each category, and translate the accumulative totals to percentages. A pace (the 10 mph band where most observations occur) is then indicated on the field survey sheet by a vertical arrow. A horizontal arrow is used to indicate the 85th percentile speed.

5-4.06 Uses of Spot Speed Data

Vehicle speed data are used for many purposes including:

1. Establishing speed zones
2. Crash analysis
3. Environmental impacts (noise and air analysis)
4. Designing safety appurtenances
5. Evaluating traffic signal locations
6. Assessing the need for advisory speed limits
7. Setting signal clearance intervals
8. Assessing enforcement needs
9. Assessing speed trends
10. Conducting before/after analysis of various geometric, traffic control, or legal changes

5-5.00 TRAVEL TIME AND DELAY

Travel time studies involve recording the time it takes vehicles to traverse a specified length of roadway. This stretch of roadway may include one or more intersections, or may be a relatively long stretch of freeway. In any case, a long "zone" is often broken into shorter, individually analyzed "links." Travel time data is often reported in terms of delay (travel time in excess of free-flow, unimpeded travel time) or of average speeds in links or zones.

5-5.01 Types of Delay Studies

Delay studies can be broken into two broad categories. The first category is delay caused by traffic flow conditions rather than by traffic control devices. The prime example of this would be delay occurring along a segment of freeway. In this case, most delay is due to slowing in response to congestion, although some stopped delay may also occur. Delay is considered to be excess time spent in the segment above what would be spent if travel were free-flow. The base free flow speed may be determined empirically, using the 50th percentile speed of low volume traffic (<1300 pc ph pl), or may be taken as either the posted limit or some reasonable lower figure. For freeways, use a base equal to 70 for urban and 75 for rural and adjustments for lane width, right shoulder lateral clearance, number of lanes, and interchange density.

The second category of delay studies is that encompassing traffic control devices, particularly traffic signals at intersections. In this case, delay may be considered as excess time over free-flow (green phase, unimpeded) similar to that above, or it may be further refined to establish percent of vehicles delayed, delay per delayed vehicle, delay per all vehicles, and stopped delay per stopped or all vehicles. This refinement of delay is useful in assessing the operation of a traffic control device.

5-5.02 Equipment

The equipment required for delay studies depends upon the type of delay study being conducted. For freeway or other congestion delay type studies at least one vehicle and driver is required. In this case, the driver will need an audio tape recorder with a microphone input so that various checkpoints can be noted during the run. If a second person is used, that person can record the data directly onto a form so that the tape recorder is unnecessary. Intersection travel time/delay studies may be conducted similarly or may be conducted by stationary observers at the intersection. In this case the observers will need forms, clipboards and stopwatches to record the various counts and events.

5-5.03 Field Data Collection

5-5.03.01 Test Vehicle Method

To obtain travel time data, a test vehicle is usually operated within the traffic stream between check points along the route for which travel time information is required. The test vehicle is either operated as a "floating car" or at the "average speed." In the floating-car technique, the driver attempts to estimate the median speed by passing and being passed by an equal number of vehicles. In the average-speed technique, the driver operates the test vehicle
at the speed perceived to be the average speed of other vehicles in the traffic stream. Tests have shown that some inaccuracies occur utilizing the floating-car technique, especially during periods of congested flow on multi-lane highways and on roads with very low traffic volumes. The average-speed technique has generally resulted in more representative test speeds.

The first task in obtaining travel time data is to identify check points along the route where travel time recordings will be entered on the worksheet.

Check points are located at intersections or railroad crossings or other easily-identified physical locations where speed changes are anticipated. Generally, check points in downtown areas should be about two or three blocks apart; in the downtown fringe, four to six blocks apart; and in other areas, eight to 12 blocks apart, depending upon the number of intersecting routes. The check points are indicated on a map and the distances between the check points are either obtained from true distance (TIS) files or from field measurements. Check points should also be referenced by reference post. The data are then transferred to the travel time data recording form.

Travel time test run is usually accomplished by an observer with two stopwatches. The observer starts one stopwatch at the beginning of the run and records the time at each check point along the route. The second stopwatch is utilized to determine the duration of any delays encountered along the route. The locations of delays are indicated on the recording form or noted on a voice recording.

5-5.03.02 Observed Vehicle Method

The observed vehicle method is used only to obtain total travel time information. Observers are stationed at check points where they record the time and the license number of each vehicle which passes an observation point. Later, the license plates are matched using the License Plate Match Computer Program and the total travel time between the check points is determined. Synchronized stopwatches and tape recorders are utilized in this procedure.

5-5.03.03 Moving Vehicle Method

The moving vehicle method presents an interesting way to compute volumes and average travel times in both directions by making only 6 runs (loops) in a test car. The features of interest of this method are:

1. It accurately estimates volume by direction for the entire route, in spite of intervening intersections, varying volume etc. This could be done by tubes, but only by setting counters in each section e.g. each block, and then weighting the average by section lengths.

2. It estimates average travel time not just of the test vehicle runs, but of all traffic.

3. The method applies best to city street type situations.

4. Because of the amount of data gathered during each run (total travel time, vehicles overtaken, vehicles which overtake, and opposing direction vehicles met), at least three persons will be required in the test vehicle. Data analysis is straight forward and given by example on Figures 5.10 and 5.11 and Form 5.J.

5-5.03.04 Intersection Study

The most common method of obtaining intersection delay, other than by a running vehicle method as above, is to station observers at the intersection. These observers collect:

1. The total number of vehicles stopped on the approach at regular, specified intervals - usually every 15 seconds
unless the pre-timed cycle length is an even multiple of 15 seconds, in which case 13 seconds is used.

2. The total number of vehicles stopping and the total number not stopping.

In addition, other data is often collected during the delay study, such as movement counts, road and lane numbers and widths, and phase lengths. These are not required to compute delay, but are useful in assessing intersection performance.

**5-5.04 Data Recording Forms**

Several forms, both completed and blank, are shown in Figures 5.7 through 5.12 and Forms 5.F through 5.K, respectively. Note that the forms are self explanatory, and include notes regarding their use.

Travel time forms shown include provision for recording spot speeds (speedometer readings). Intersection delay forms include a worksheet area for computations.

**5-5.05 Sample Size**

1. **Test vehicle method**: at least 6 runs.

This will provide a range for the computed mean speed shown on the graph below, where $\Delta$ is merely the average difference in speed from one run to the next for the six runs:

$$\Delta = \frac{[S_1 - S_2] + [S_2 - S_3] + [S_3 - S_4] + [S_4 - S_5] + [S_5 - S_6]}{5}$$

$$\Delta = \sum_{i=1}^{5} \frac{[S_i - S_{i+1}]}{5} \text{ where } S_1 = \text{speed for the 1st run, etc.}$$

The graph is as follows:

\[\text{Graph showing trend line with confidence interval.}\]
Example: If the average difference in run speeds is 15 mph, and the overall average speed has been computed as 41 mph, then (from the graph) the speed may be reported with an estimated precision of 41 mph ± 4 mph with 95% confidence.

2. **Observed Vehicle Method**: at least 30 matches. If only 6 matches were made, accuracy could be estimated as above. Since these are usually easier to collect in a short period of time than are actual travel time runs, it is wiser to collect a minimum of 30 samples to avoid small sample problems and to increase precision. A minimum of 30 samples will generally provide a precision of ± 2 mph with 95% confidence.

3. **Intersection Study**: Peak period or peak hour - gather data for 1 entire period.

   Notes: Samples should be gathered on typical days. In general, Monday AM and Friday PM peaks should be avoided. Days with inclement weather or on which significant crashes, stalls etc. occur should be avoided. If these occur during a study, the study must be partially or completely redone.

### 5-5.06 Computations

Computations are as outlined above, or as indicated on the data collection forms.

### 5-5.07 Uses of Travel Time/Delay Studies

This data has many uses, including:

1. Evaluation of level of service
2. Selection of traffic control devices
3. Before/after studies
4. Design of traffic control devices
5. Signal timing selection
6. Calculation of user costs
7. Identification of trends
8. Identification of sections needing geometric revision

### 5-6.00 VEHICLE OCCUPANCY

Vehicle occupancy refers to the number of persons in each vehicle, including the driver, and often excludes both buses and commercial trucks. This data is distinct from lane occupancy, described in section 5-106.00.

### 5-6.01 Equipment

The equipment required for data collection consists of pencil and paper, a watch, and a manual counter of at least six "banks." Usually a vehicle is needed to get to the site and to sit in during data collection. At very low volume sites, data can be collected using tally marks rather than counters, although even where volume is low counters are more convenient.

### 5-6.02 Field Data Collection

Data is collected manually by field observers with six bank counters. One "bank" (individual counter) is used for each of:

1. Vehicles with driver only
2. Vehicles with 2 persons
3. Vehicles with 3 persons
4. Vehicles with 4 persons
5. Trucks
6. Buses

The occupancy data collection form has columns for 5, 6 and 7 or more persons per vehicle as well. Since the number of vehicles with occupancies this high is usually small, these are collected by simple hand tally marks near these columns on the form. Cumulative totals are recorded on the form at 15 minute intervals for all data (counters are NOT rolled back to zero).

**5-6.03 Data Recording Forms**

Completed and blank data recording forms are shown in Figures 5.13 and Form 5.L, respectively.

**5-6.04 Sample Size**

For most locations data may be collected for one session during the time period under consideration e.g. peak hour. To find the differences shown in the table below with 95% confidence, the minimum sample size should be as follows:

<table>
<thead>
<tr>
<th>occupancy as small as</th>
<th>sample size of</th>
</tr>
</thead>
<tbody>
<tr>
<td>.01</td>
<td>19,208</td>
</tr>
<tr>
<td>.02</td>
<td>4,802</td>
</tr>
<tr>
<td>.03</td>
<td>2,134</td>
</tr>
<tr>
<td>.04</td>
<td>1,201</td>
</tr>
<tr>
<td>.05</td>
<td>768</td>
</tr>
<tr>
<td>.06</td>
<td>534</td>
</tr>
<tr>
<td>.07</td>
<td>392</td>
</tr>
<tr>
<td>.08</td>
<td>300</td>
</tr>
<tr>
<td>.09</td>
<td>237</td>
</tr>
<tr>
<td>.10</td>
<td>192</td>
</tr>
</tbody>
</table>

**5-6.05 Computations**

Computations are generally self-explanatory. The "bottom line" information usually includes the average number of persons per car, e.g. 1.21 persons/car, given to hundredths. Also often presented are percentages of persons in vehicles with one occupant, two occupants, three occupants etc. Note that this is different from the percentage of vehicles carrying one occupant, two occupants etc. Since occupancies tend to vary with time of day, the time period during which the study was conducted is also given.

**5-6.06 Use of Vehicle Occupancies**

Occupancy data are usually used to assess the impact of various geometric (e.g. the addition of a high occupancy vehicle, HOV, lane), control (e.g. the implementation of metering), or operational (e.g. the use of additional bus runs) changes. Occupancy data also reveals the total number of persons utilizing a facility, or a theoretical maximum people carrying capacity. Trends in vehicle occupancy are often caused by new HOV facilities, rideshare
promotion, changes in gasoline prices, and changes in bus service.

5-7.00 LANE OCCUPANCY

Lane occupancy is the percentage of time a point on a lane is occupied (covered) by a vehicle. This is directly related to the density of traffic flow, and thus also to speed, level of service (LOS) etc.

5-7.01 Equipment

Occupancy data are usually collected using six by six sawn in loop detectors. Although these are not strictly point sampling devices, the percentage of time such a detector is occupied yields an adequate occupancy value. Occupancies could be obtained less directly from speeds, headways, densities, aerial photography etc. but this is rarely, if ever done.

5-7.02 Field Data Collection

Data collection is usually done by automated equipment. Field collection of volumes and speeds may be used to estimate occupancies, but is not generally done.

5-7.03 Data Recording Forms

Data is usually recorded by automated, computer equipment.

5-7.04 Sample Size

Occupancies are collected for the time period of interest (usually in 30 second, one minute or five minute intervals) and used or reported. Since they are usually used only in evaluating flow during that same period, the sample size of one is the entire population, and any error is a result of equipment error etc. rather than sample size considerations.

5-7.05 Computations

A relationship between density and occupancy is approximated by:

Density = 2.5 veh/lane mile x % occupancy

where occupancy is given in percent and density in vehicles/lane mile.

5-7.06 Uses of Lane Occupancies

Occupancies are used primarily to assess traffic flow during real time traffic management. This data is used as input into computer algorithms which control changeable message signing, metering rates, and traffic flow information devices.

Occupancies are also used to evaluate whether flow is at capacity, to assess changes in flow conditions, and to evaluate the impact of crashes or stalls on traffic flow.

5-8.00 VEHICLE DENSITY

Vehicle density, mentioned above as being indirectly obtainable from lane occupancy information, is occasionally obtained directly. Information is usually presented in units of vehicles per mile or vehicles per lane mile (VPLM). According to the 2000 “Highway Capacity Manual”, density is the primary measure use to calculate the Level of Service for basic freeway segments. The Level of Service thresholds are summarized below:
LEVEL OF SERVICE | DENSITY RANGE  
---|---  
A | 0 - 11  
B | 11 - 18  
C | 18 - 26  
D | 26 - 35  
E | 35 - 45  
F | >45

5-8.01 Equipment
Density may be estimated from lane occupancy data, using the same collection equipment (5-6.01). Other methods of estimating the number of vehicles on a section include aerial photography, which requires the use of an airplane or helicopter as well as appropriate photographic equipment. Although this is a direct, accurate method of determining instantaneous vehicle density, it is also complex, costly and in most cases of more theoretical than practical.

5-8.02 Field Data Collection
See section 5-7.02

5-8.03 Data Recording Forms
No special forms are required. If density is estimated by counting volume into and out of a section of known initial state (i.e. the number of vehicles on the section at the start of the study is known or assumed), then volume counting forms may be used.

5-8.04 Sample Size
Usually the density is averaged for the time period in question, similar to occupancy data. Due to seasonal variation, trends, variation in the time of occurrence of peak density etc. precise long term densities are not normally given, or if given, are presented without confidence intervals. If densities are used for before/after studies (this is rare), sample sizes may be established based on appropriate variances.

5-8.05 Computations
See Section 5-7.05

5-8.06 Uses of Vehicle Densities
Vehicle densities are used to assess the quality of flow on a roadway section and are the primary measure of Level of Service for freeway segments. Most uses are theoretical rather than practical.

5-9.00 QUEUE STUDIES

5-9.01 Types of Queue Studies
Queue studies are of two primary types, related to two general ways of defining a queue:

1. A line of stopped (or nearly stopped) vehicles created by some traffic control device, notably a signal or a stop sign, or due to some movement restriction, for example a queue buildup behind a vehicle waiting for a gap in order to make a left turn.

2. A number of cars moving as a group or definable platoon moving at a speed less than free flow speed due to
congestion or some particular traffic stream and/or roadway anomaly (e.g. congestion induced shock waves, queues formed upstream of bumps, potholes, lane drops, stalled vehicles etc.).

This section is concerned only with the first type of queue, which may be simply called a waiting line of stopped vehicles. The second type of queue is used far less frequently and will not be considered. For a discussion of this second type, see references.

5-9.02 Equipment

Collection equipment for queues usually includes a stopwatch and a clipboard with appropriate forms. Special equipment such as delay meters, intersection counting boards or programmed hand held computers may be used, especially when delay, capacity or other characteristics are the end products desired rather than queue lengths themselves. In this case the use of electronic equipment may significantly reduce data reduction person-hours.

5-9.03 Field Data Collection

Data is usually collected by stationing an observer within view of the queue, and having this observer record queue lengths at set intervals, see Form 5.M. For intersection studies, an interval of 15 seconds is usually used, as long as the cycle is not an even multiple of this, in which case another interval, usually 13 seconds, would be used. Other studies often use 30 second intervals, which allows more accurate counting of long queues. For this reason, a longer interval may also be used for intersection studies if the queue is difficult to count at shorter intervals. Another method of counting very long queues is to count the number of vehicles back to a known point, and then count only the remainder or "tail" at each interval thereafter when vehicles are backed up beyond the known point. Later the length of the tail and the vehicles back to the known point are summed to find the actual queue length. This system is particularly useful where the queue is constant, such as at ramp meters.

5-9.04 Data Recording Forms

For delay studies at intersections, the forms presented in section 5-5.04 are used to record queue lengths. A more general queue length form is given in Figure 5.12. If all that is needed is maximum queue length, which is sometimes the case, no specialized form is needed.

5-9.05 Sample Size

For delay at intersection studies, see section 5-5.05. Other queue studies usually require collecting queues at 30 second intervals over the time period in question on three separate occasions. The primary reason for collecting data three times is to ensure that data has not been collected on an anomalous day. If it is certain that a day is "typical," queues may be collected only once.

5-9.06 Computations

Maximum queue length (Maximum queue): This is taken directly from data recording forms.

Average queue length: This is the mean of all measured queues (Sum of all lengths ÷ number of queues counted).

Median queue: From a driver's standpoint, this is more meaningful than the mean. The median queue is the queue with 50% of queues longer than it. Easily obtained by writing queue lengths in order by length then by observation. If the number of queue lengths is odd, take the middle length; if the number of queue lengths is even, take average of middle two lengths. Also called 50th percentile queue.

Queue delay: See section 5-5.03.04

Note that all of the above report queue lengths in terms of numbers of vehicles. For some special purposes queue lengths may be reported in terms of meters or delay, although these are usually derived rather than directly
collected.

5-9.07 Uses of Queue Data

In addition to use in delay studies assessing the performance of traffic signals, ramp meters or other traffic control devices, queues may be used directly to quickly evaluate timing plans, the quality of traffic flow, or the need for additional facilities and appurtenances.

5-10.00 VEHICLE CLASSIFICATION

Vehicle classification consists, in its most basic form, of determining the percentages of automobiles and trucks in the traffic stream at a particular location. Often an additional category of buses is used. Further, the category of trucks is sometimes subdivided into semi and unibody styles, or into subdivisions based on length or number of axles. Other categories sometimes considered separately include motorcycles, vans and pickups, taxis, and recreational vehicles (RVs). What categories are utilized depends upon the purpose of the study, the level of the category in the traffic stream, and the categories used in previous studies which will be used for comparison. Also, some categories are avoided due to the difficulty of collecting the data. Trucks by length in meters is an example of this, as are categories based on vehicle ownership.

5-10.01 Regularly Conducted Counts

Vehicle classification counts are conducted at numerous stations throughout the State by the TDA Section. Information regarding the classification categories used and sites available may be obtained from that office.

5-10.02 Equipment Used

Most special purpose classification counts are done manually with no more than a multiple bank mechanical counter and a data recording form. Occasionally the data is first recorded on film or video tape and then the data is extracted. This may allow filming during unusual hours or for long periods while confining data extraction to normal working hours. Also, simple data may be gathered from tapes or film played back at fast speed, reducing actual collection time. Some portable electronic equipment is also available to do classification counts, usually based on axle spacings. This equipment can greatly simplify collecting large samples, but may restrict the classification categories that may be used, e.g. the equipment will not distinguish between buses, RVs, and trucks, between private and commercial vehicles etc.

5-10.03 Field Data Collection

Simple classification data is sometimes a by-product of other studies. For instance, collection of vehicle occupancies generally includes a separate tally of trucks and buses (5-6.03). Field collection is usually done with tally marks on a form (5-10.04) or with counters sufficient to accumulate each of the classification categories desired.

One of the common difficulties involved with field data collection is defining categories clearly enough so that the field data collector can count each category confidently. Typical problems with categories include: In what category is a motorcycle, taxi, airport limousine or vanpool? Is a delivery van, a van or a truck? Are pickups with crew cabs and six tires pickups or trucks? What about recreational vehicles or cars pulling boats, trailers or campers? What is a semi cab without a trailer?

If the study has separate categories for each of these vehicles, the problem disappears. This is usually not the case. There may be only two to five categories, so that study planners must decide how to handle questionable cases.
Occupancy studies done by the RTMC often involve only three categories: automobiles, trucks, and buses. In this case motorcycles are classified as cars, taxis and limousines as buses, van pools as cars, delivery vans, six wheel pickups, RV's and cars towing trailers or boats as trucks etc.

The way the categories are defined depends upon which categories are used and the purpose of the study. Must the study differentiate between commercial and private vans? Is motorcycle usage being studied? Once the purpose of the study is clearly defined, the categories must be selected and defined so that appropriate data is collected. Both the study purpose and the definitions must be passed on to the field data collectors to allow them to make quick, appropriate real-time decisions. After the first session of data collection, field notes and comments should be reviewed to allow "fine tuning" of the categories and definitions.

5-10.04 Data Recording Forms

Typical forms are included as Figures 5.13 and Form 5.N. Note that often special purpose studies will require the creation of new forms for data collection.

5-10.05 Sample Size

In most cases extreme accuracy is not needed for classification studies. The usual procedure is to collect classification data for one session during the time period of interest e.g. peak hour.

5-10.06 Computations

Usually computations consist of simply figuring the percent of each category of vehicle for the time period studied. In low volume situations, the classification count may include all vehicles, in which case the number of vehicles in each category is also immediately available. In other cases, the percentages obtained may be applied to separately collected volumes in order to estimate the number of vehicles in each category.

5-10.07 Uses of Vehicle Classifications

Vehicle classifications are used in capacity computations, in assessing the impact of traffic regulations or controls not directed at all types of vehicles, in some economic analysis of travel or delay, and to evaluate the people moving effectiveness of HOV and other facilities.

5-11.00 LICENSE PLATE CHECKS

5-11.01 Equipment

In all but the lowest volume situations, it is simplest to read license numbers into a cassette recorder. Microphones with integral on/off switches are easiest to use and conserve tape. In the office the data is recorded onto a computer coding form. If the license numbers are being used for simple matching, as in an origin destination (O-D) study, the data can be evaluated by hand, by PC using an ad hoc program, or by programs available at IMB (License plate matching system, DTTC 6110 and DTTC 6210).

If the license plates are being recorded for the sake of obtaining address labels, as for mail-out questionnaires, the numbers, recorded on general purpose coding forms should be sent to the Department of Public Safety for processing.

5-11.02 Field Data Collection

The observer should be stationed as near the roadway as possible, at a point where the traffic is slow or stopping. Because of dirt and salt, the winter months are usually bad for collecting plate numbers, although an adequate
sample may be taken. The observer should face oncoming traffic to read plates. Plate numbers are read into the cassette recorder. When an O-D Study is being conducted, begin and end data collection times for various observers must be coordinated to account for the distance between observers, the traffic already in the system, and the desired time interval.

5-11.03 Data Recording Forms

No special forms are necessary.

5-11.04 Sample Size

Usually as close to a 100% sample as possible is gathered during the time period in question. This is especially important for O-D studies. For questionnaire use, sample size may be dictated by the relevant time period or may be arbitrarily limited to a minimum of about 250. Expect a return rate of about 25% on mail back questionnaires.

5-11.05 Computations

For O-D studies, information computed usually includes the percent of traffic entering at a specified location and exiting at one or more downstream locations.

Questionnaires usually require computing the percent of respondents giving each specified answer, the percent of respondents by category (e.g. heavy or light users of a facility) giving each specified answer, and a compilation of written remarks (See references).

5-11.06 Uses of License Plate Checks

License plate data is used for:

- Obtaining addresses for use in mailed questionnaire data acquisition.
- Obtaining vehicle fleet information (average age, size etc. of vehicles).
- Traffic pattern ("O-D" or in/out) studies.

5-12.00 WRONG WAY MOVEMENTS

5-12.01 Equipment

A wrong way movement counter is available at the RTMC. This counter provides both a count of wrong way vehicles and a picture of each wrong way vehicle. Equipment that merely counts is not adequate in many locations e.g. at the top of ramps or at intersections on grade, since rollbacks incorrectly count as wrong way.

5-12.02 Field Data Collection

RTMC Research personnel will instruct users on proper installation and use of equipment. Short term studies in the metro area may be conducted by RTMC staff, upon request.
5-12.03 Data Recording Forms
No special forms are required.

5-12.04 Sample Size
The counter is usually left at the site for one week.

5-12.05 Computations
The only computations usually performed are wrong way movements by time period (hour, day, year etc.) and the ratio between wrong way counts and volume:

\[
\frac{\text{# of wrong way movements}}{\text{total volume}}
\]

5-12.06 Uses of Wrong Way Information
Wrong way information is used to assess the need for, or impact of signing, marking and geometric conditions or changes.

5-13.00 CONFLICT ANALYSIS
In many cases traffic problems are very hard to assess by crash studies since:

1. Sufficient time must pass to accumulate a meaningful crash history.
2. Many conditions show up only weakly or not at all in crash statistics in spite of having a significant impact on traffic flow.

Often, the best way to assess these problems is by using conflict analysis techniques. These techniques involve observing traffic and noting instances of apparent conflict, such as lane changing, brake application, or other erratic driving practices.

5-13.01 Equipment
Usually manual tally sheets or count boards. For some studies video tape or film equipment is preferred for data collection.

5-13.02 Field Data Collection
Field data collection consists of collecting:

1. Volume information
2. Counts of conflicts by type of conflict.

Depending on site characteristics, one or more of the following conflict categories is used:

- Left turn, same direction
- Right turn, same direction
- Slow vehicle, same direction
- Opposing, left turn
- Right turn, cross traffic from right
• Left turn, cross traffic from right
• Through, cross traffic from right
• Left turn, cross traffic from left
• Through, cross traffic from left
• Others

These are all purely conflict, multiple vehicle categories. When a conflict occurs, it is recorded by category. If this conflict produces a secondary conflict e.g. one car has to brake for a left turning vehicle, which causes a second vehicle to brake for the braking vehicle, then a secondary conflict is recorded by primary conflict category (or sometimes by secondary conflict category). Further conflicts resulting from the primary conflict are not recorded.

In addition to actual conflicts, conflict studies often include data that may be considered erratic maneuvers:

• Backing up
• Driving Slowly
• Exiting from wrong lane
• Sudden lane changing
• Run off Road
• Stopping
• Braking or encroachments:
  • Center line
  • Edge line
  • Stop line
  • Shoulder

All of these are single vehicle measures.

5-13.03 Data Recording Forms

Forms should be produced for the specific study to be performed. Data to be logged must include the number of each category of conflict used, and the total volume of traffic exposed to the potential conflict.

5-13.04 Sample Size

As long as it is certain that the day of study is not anomalous, one data collection effort during the time period in question should be sufficient.

5-13.05 Computations

Computations include conflicts per total volume and conflicts per time period. To determine the significance of changes in conflicts from before to after, the following may be used:

\[
Z = \frac{P_1 - P_2}{\sqrt{\frac{N_1 P_1 + N_2 P_2}{N_1 + N_2}} \left(1 - \frac{N_1 P_1 + N_2 P_2}{N_1 + N_2}\right) \left(\frac{N_1 + N_2}{N_1 N_2}\right)}
\]

Where: \( P_1 = \text{before } \% \text{ of conflicts} \)

i.e. \( \frac{\text{no. of conflicts}}{\text{total potential conflicting vol.}} \)
\[ P_2 = \text{after } \% \text{ of conflicts} \]
\[ N_1 = \text{total potential conflicting volume before} \]
\[ N_2 = \text{total potential conflicting volume after} \]

This Z value can be used with standard tables to determine whether the null hypothesis, that is whether the true population proportions before to after are identical, should be rejected, and at what level of significance.

**5-13.06 Uses of Conflict Information**

Conflict information is used to estimate crash potential at a location or to evaluate the impact of various operational changes. Many researchers feel conflict analysis allows assessment of safety without actually waiting for a long term historical record of crashes to occur. In addition, safety or impact of short term measures may be studied, even though no crashes may occur during the abbreviated implementation period.

**5-14.00 QUESTIONNAIRES AND SURVEYS**

Questionnaires are often used to obtain driver or agency attitudes, knowledge and use regarding various traffic control or informational measures. Surveys usually involve either in person interviews, phone interviews, handed out/mailed back questionnaires, or mailed out/mailed back questionnaires. Sometimes these methods are combined, for example those not returning a questionnaire will be contacted and interviewed by phone.

**5-14.01 Equipment**

No special equipment is ordinarily required. If addresses are derived from license plate numbers, See section 5-11.01.

**5-14.02 Field Data Collection**

"Field" data collection consists of either in-person or phone interviews, or collecting license plate numbers (5-10.0). Interviews should be conducted in an organized manner using a set format (group of questions).

**5-14.03 Data Recording Forms**

Data recording forms consist of either survey forms filled out by an interviewer or of questionnaires. Questionnaires are virtually always study specific, and a variety of mail-back formats are available. The questions used must be very carefully thought out. Even with careful preparation, it often happens that when questionnaire data is actually evaluated it is discovered that key points were not addressed, or if addressed were not clarified and corroborated with related questions. Preparation of questions should be pursued only after it has become absolutely clear what the objectives of the study are. The "shotgun" (i.e. collect everything anyone can think of) method of questionnaire design does more harm than good, and the results often multiply the confusion rather than provide the answers.

Unnecessary questions should not be asked and all necessary questions must be included. Questions must be asked in a logically neutral (to avoid biasing answers) and an emotionally inoffensive (to avoid antagonizing the respondent) way. Some rules of thumb for questionnaire development:

1. Always use an introductory paragraph or page which states the subject of the questionnaire, the purpose of...
the questionnaire, and the name of the agency and/or section conducting the study.

2. Never ask personal questions such as age, sex or income unless they are clearly required for the study.

3. Order the questions in a logical way. Funnel or filter questions should allow the respondent to skip irrelevant questions.

4. Before using a questionnaire, have it reviewed and completed by various people (pilot test) to ensure that questions are asking what you think they are asking, and to detect ambiguities. Questionnaire development is not a one person job.

5. Response rate is a very important factor in evaluating questionnaire information. Unnecessarily long (one page or less is preferable) or poorly written questionnaires reduce response rate. A response rate of 40-60 percent may be expected for a single mailing, mail out, mail back form.

6. Phrase questions in such a way that the answer is not biased. Some questions bias the answer by leading, embarrassing, complementing etc. the respondent.

7. Word choice is critical. Words should be simple, unambiguous, and emotionally neutral.

8. There is a tremendous variety of question types (dichotomous, multiple choice, rating, ranking, open-ended etc.) and evaluation procedures. If you are not clear on what to use or how to use it, ask someone who experience with designing questionnaires.

5-14.04 Sample Size

The sample size required for statistical evaluation of responses depends on return rate and the specific question. Generally, at least 100 questionnaires should be distributed. This ensures a returned questionnaire number of at least 30, and avoids certain small sample considerations. When feasible, 300 or more questionnaires should be utilized to strengthen results. In depth small sample surveys, multiple mailings, and phone follow-up are sometimes used but generally require more time consuming collection, more experienced data collection personnel, and more expertise in evaluation.

5-14.05 Computations

Computations always include the percent of polled persons responding, and the percent of all respondents giving each possible question answer. Often various subsets of responses are picked out for evaluation, e.g. the percent of all commuters making various responses. Statistical techniques are not always applied and when they are, they depend upon the nature of the specific question. See references for a more thorough discussion of statistical evaluation of survey responses.

5-14.06 Uses of Questionnaires

Questionnaires and surveys are used for Origin-Destination studies, to determine driver attitudes regarding traffic control devices, to clarify the meaning of other data, such as travel times or occupancies, to verify driver understanding of signs, control devices etc., and to determine driver concerns.

5-15.00 OTHER STUDIES

Various other studies are occasionally performed by traffic personnel. Many of these are used in conjunction with the studies already covered.

5-15.01 Origin-Destination Studies

Full blown Origin-Destination (O-D) studies are virtually never conducted by traffic engineering personnel. Smaller, limited O-D studies are sometimes performed to evaluate a certain length of roadway or a limited number
of entrances, exits or intersections. These are not true O-D studies in that the actual origins and destinations of the vehicles are not known, only where they entered and exited a particular road. The usual method of collecting this data is by using a license match methodology (5-11.0).

Another sort of small O-D study is conducted to determine the origins and destinations of vehicles crossing a certain point, or using a certain facility (e.g. an entrance ramp). The usual method for conducting this is to collect license numbers (5-11.0) and mail questionnaires to users (5-14.0).

5-15.02 Compliance (Violation) Studies

Compliance with various traffic control devices is often studied. In general, such a study consists of counting the number of cars complying and the number violating. The ratio of violators to compliers or the percent of violators is then judged for acceptability, or compared between control and treatment sites or from before conditions to after. Statistical evaluation of changes in percent violating may be conducted using the formula given in Section 5-13.05.

5-15.03 Mass Transit Studies

Some metropolitan area studies, for example studies of HOV facilities, involve monitoring bus loadings. Bus loading and route information may be obtained from the Metro Transit.

5-15.04 Wheel Path Studies

Some evaluations, notably studies of roadway markings, involve describing the paths of vehicles (lane placement) under varying conditions.

Equipment used may include a series of road tubes ending at different points within the lane, video tape or film cameras, specialized lane placement counters, or simple counters used with field observers.

5-16.00 STUDY METHODS AND EQUIPMENT

5-16.01 Data Collection

5-16.01.01 Sample Data

Most data collected for traffic engineering studies is sample data. Sample data by definition are a subset of the universal set, and may or may not be an accurate representation of the universe. Whether or not an observation is a sample or just part of a sample depends on the eventual use of the data. For example, in a vehicle classification count identifying autos, trucks, and buses, each vehicle observed would be a sample. If that same data were totaled and considered a volume count for the duration of the time the count was conducted, it would be a volume count of sample size one.

5-16.01.02 Sampling Error

When the sample size is very small compared to the population, the probability that the sample will be a good representation of the population is low. The term "sampling error" refers to errors incurred when estimates based on sample data are used to make some judgment about the population parameters. Sampling error is normally high with small sample sizes and decreases as the sample size increases. Sampling error is controlled in the design of the study. Sampling error should not be confused with sampling bias or mistakes in gathering and analyzing data. Sampling bias refers to an error in study design that prevents each item or member of the population being studied.
from having an equal chance of being selected or sampled.

5-16.01.03 Sample Size

The types of data collected and the methods used to collect data for research purposes are generally the same as for operational studies except that the quantity and detail is greater in research studies. Exceptions may occur when sample size requirements dictate special data acquisition techniques or devices.

The larger sample sizes required for research purposes are due to the variability of traffic parameters. Because parameters vary naturally, small observed differences can be mistaken for differences resulting from controlled changes. Thus, true differences may be obscured and incorrect conclusions may be drawn by using small samples. Statistical methods can be used to determine required sample sizes. If questions arise relating to how many samples are needed or what typical values should be used, the research staff can be asked for help.

5-16.01.04 Study Design

A good study design must take into account the final objectives of the study, the level of accuracy required, the manpower and equipment available, and the cost. The research staff can help determine study methods, types of data to collect, when to collect data, etc.

5-16.02 Data Processing

Most of the data collected for research studies can be processed by computers. If a large amount of data is to be collected, it may be expedient to design survey forms for easy keypunching or entry at a terminal. In addition, various pieces of equipment have been developed which allow collected data to be dumped directly into a PC or compatible. This greatly reduces processing time although it requires a trained processing person to conduct the computer operations. Several software packages are available to do actual analysis, although the mistake is often committed of conducting certain types of data breakdown and analysis simply because it is available in the software, rather than because it is appropriate. Worthwhile analysis is thus often missed, and faulty conclusions drawn from the computer generated information.

5-16.03 Statistical Analysis

Statistical reliability is an extremely important consideration in research because collected data—for example, measures of speed and volume are only estimates of the true value. For instance, in a speed study the average speed is calculated from the values of the speed of individual vehicles sampled at a given site at a particular point in time. This average is assumed to represent the average speed of all vehicles on all days at all times. Stated another way, the mean or average obtained by sampling is assumed to be the true average for the entire population. The validity of this assumption depends on the quality and variability of the individual observations. If the variability is low and/or the sample size is high, we can be relatively confident that we are close to the true value. The variability parameter, known as the standard deviation(s); or its square, the variance (s²), can be used to measure these fluctuations "Statistics" or "statistical analysis" is the computation and use of variability parameters.

5-16.03.01 Average Value

One important application of statistics in traffic research is an analysis of the accuracy of the estimated average value.

The variance formula which is used is:
or the summation of the differences between individual observations and the average value, each difference having been squared (or multiplied by itself), and the total divided by the number of observations minus one. Several versions of this formula may be found (in standard statistics books) that make the computation for grouped data or other special applications much easier.

The value of the population mean can be estimated as being within the range of $X \pm t \cdot \frac{s}{\sqrt{n}}$ or the sample average plus or minus a confidence factor ("t") times a parameter known as the standard error of the mean, where $s = \frac{s}{\sqrt{n}}$ and $t$ is a table value. The most typical value of "t" is 1.96 which corresponds to a 95 percent confidence level (95 chances out of 100 that the decision is correct) when the sample size is large.

For example:

If $X = 50$ mph and $s = 10$ mph, and $n = 200$, we can say that at the 95 percent confidence level the true population average speed, $U$, is between $X \pm 1.96 \cdot \frac{10}{\sqrt{200}}$ or between 50 mph \pm 1.4 mph (48.6 to 51.4 mph). To illustrate the effect of sample size, for the same level of confidence but $n = 10$, $U = 50 \pm 1.96 \cdot \frac{10}{\sqrt{10}} = 50 \pm 6.2$ mph (44 to 56 mph). Thus, the smaller the sample size, the wider the range must be to have the same probability that the true mean is included.

5-16.03.02 Volume Variability

Another example of statistical analysis can be used to show a typical volume variability problem. For instance: If $X = 2,000$ vehicles per hour (VPH), $s = 80$ vph, and $n = 3$ days of sampling, the true average volume for that time at that location is $2,000 \pm 3.18 \cdot \frac{80}{\sqrt{3}}$ or $2,000 \pm 147$ (1,853 to 2,147 vph) a range of \pm 7.4 percent! (3.18 = "t" value for n=3) This possible error must be acknowledged when drawing inferences for research purposes.

5-16.03.03 "Before-After" Comparisons

Another example of statistical methods is the comparison of two different situations, for example, the average speed before and after new lanes are opened. In a typical case, it may be difficult to determine if an observed difference was due to variation within the population or due to a roadway change. The difference can be tested statistically by what is known as the "t" test: For example:
If \( x_i = 50.0 \) and \( s_i = 10 \text{ mph} \) and \( n_i = 100 \) while \( x_j = 53.0 \) and \( s_j = 10 \text{ mph} \) and \( n_j = 100 \)

The calculated "t" value = \[ \frac{x_j - x_i}{s_p} \]

where \( s_p = s_p \sqrt{\frac{n_i + n_j}{n_i \times n_j}} \)

and \( s_p = \sqrt{\frac{s_i^2 (n_i - 1) + s_j^2 (n_j - 1)}{(n_i - 1) + (n_j - 1)}} = 10 \) = pooled variance

\[ s_p = 10 \sqrt{\frac{100 + 100}{10000}} \]

\[ 10 \times 0.1414 = 1.414 \]

and \( t_c = \frac{53.0 - 50.0}{1.414} = 2.12 \)

From statistical tables it can be determined that, at a 95 percent confidence level, a value of 1.65 would be outside limits of chance and, since a greater value was calculated, that the differences are real and not due to chance. If the sample size were 200 instead of 100, the calculated "t" value would have been 3.0 and the difference would have been even more meaningful. At \( n=200 \), a difference of only 2.0 miles per hour would have been statistically significant. If more than two conditions are being compared such as 1970, 1971, 1972, and 1973 average speeds, the "t" test is not appropriate. An analysis of variance test as described in statistical text books will determine if any statistical significance differences are present.

5-16.04 Special Equipment

5-16.04.01 Time Lapse Movie Camera--16MM

Complicated traffic situations or other difficult conditions can be filmed and then observed repeatedly either in real-time or on a frame-by-frame basis. In this way, various measures of driver performance can be observed where
manual field observers could not record all measures. In addition, time between frames is known allowing for precise timing of events.

5-16.04.02 Video Tape

A portable TV camera with a tape recorder is often used for filming traffic situations. The tape can be recorded either in time-lapse or in real-time. Video tape has the advantage of being immediately available for review, and the tapes can be reused.

5-16.04.03 Twenty-Pen Recorder

The twenty-pen recorder is a moving graph recorder with 20 inked pens tracing lines and indicating the start or stop time of input signals. Typical uses include delay studies, headway studies and other cases where closely-spaced events preclude using stopwatches. By measuring the distance between marks on the paper, it is possible to determine the length of time between the marked events.

5-16.04.04 Hand-held Computers

Laptop computers allow for collection and some or all processing by the same unit. For larger efforts, data can be dumped to PC or mainframe computers for full processing. Laptop units may be programmed for specific needs and situations.

5-16.04.05 Dedicated Collection Equipment

Several companies, e.g. Golden River, produce devices which collect certain types of data and output the data in useable form to PC's. Equipment for collecting counts, classifications, speeds and other data types is available.

5-16.04.06 Hand-held Counters

Simple counters are available for counting cars, automobile occupancies etc. These counters merely increment by 1 each time the button is pushed.

5-16.04.07 Audio Tape Recorders

Audio tape recorders greatly simplify some sorts of data collection, as well as reduce collection personnel needs. Recording license plates or taking travel times are two common uses of this equipment.

5-16.04.08 Computer Collection

Various types of data can be collected directly by computer where data is desired on a traffic managed segment of roadway. In addition, other equipment housed at or operated from TMC can be used for exceptional data collection efforts.

5-16.04.09 Wrong-way Movement Counter

A portable wrong-way movement recorder is available. This device records the number of wrong-way movements and takes a picture of each wrong-way vehicle for verification.

5-17.00 BENEFIT/COST ANALYSIS

The ratio of dollar value of benefits to dollar value of costs is often used in state or federal project planning and evaluation. It is not necessarily the best method of assessing the monetary merits of a project, but it is widely accepted and used in the field of transportation, and so is briefly reviewed here.
PORTABLE TRAFFIC RECORDER PRINTER TAPE

MR TAPE - Machine or Manual

Coded for Electric
Scan Reader

Hourly Total
7:15 A.M.
7:30 A.M.
7:45 A.M.

Binary Traffic Count on
24-hour Clock

Text Ref.: 5-3.03.02
### Fifteen Minute Intersection Counts

**Location:** TH36 & ENGLISH

<table>
<thead>
<tr>
<th>From: East</th>
<th>From: South</th>
<th>From: West</th>
<th>From: North</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Time</th>
<th>From: East</th>
<th>From: South</th>
<th>From: West</th>
<th>From: North</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td></td>
</tr>
<tr>
<td>0:00</td>
<td>6</td>
<td>212</td>
<td>2</td>
<td>2</td>
<td>136</td>
</tr>
<tr>
<td>0:15</td>
<td>3</td>
<td>396</td>
<td>5</td>
<td>0</td>
<td>196</td>
</tr>
<tr>
<td>0:30</td>
<td>6</td>
<td>544</td>
<td>6</td>
<td>3</td>
<td>135</td>
</tr>
<tr>
<td>0:45</td>
<td>14</td>
<td>537</td>
<td>9</td>
<td>3</td>
<td>236</td>
</tr>
<tr>
<td>0:00</td>
<td>10</td>
<td>626</td>
<td>5</td>
<td>6</td>
<td>107</td>
</tr>
<tr>
<td>0:15</td>
<td>22</td>
<td>624</td>
<td>4</td>
<td>2</td>
<td>197</td>
</tr>
<tr>
<td>0:30</td>
<td>8</td>
<td>612</td>
<td>10</td>
<td>11</td>
<td>39</td>
</tr>
<tr>
<td>0:45</td>
<td>22</td>
<td>530</td>
<td>11</td>
<td>7</td>
<td>51</td>
</tr>
<tr>
<td>0:00</td>
<td>9</td>
<td>417</td>
<td>7</td>
<td>8</td>
<td>281</td>
</tr>
<tr>
<td>0:15</td>
<td>6</td>
<td>369</td>
<td>10</td>
<td>9</td>
<td>29</td>
</tr>
<tr>
<td>0:30</td>
<td>5</td>
<td>314</td>
<td>8</td>
<td>9</td>
<td>220</td>
</tr>
<tr>
<td>0:45</td>
<td>2</td>
<td>262</td>
<td>11</td>
<td>11</td>
<td>35</td>
</tr>
<tr>
<td>AM Total</td>
<td>127</td>
<td>5427</td>
<td>82</td>
<td>88</td>
<td>523</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Time</th>
<th>From: East</th>
<th>From: South</th>
<th>From: West</th>
<th>From: North</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td></td>
</tr>
<tr>
<td>6:00</td>
<td>3</td>
<td>292</td>
<td>10</td>
<td>9</td>
<td>37</td>
</tr>
<tr>
<td>6:15</td>
<td>5</td>
<td>296</td>
<td>17</td>
<td>8</td>
<td>45</td>
</tr>
<tr>
<td>6:30</td>
<td>7</td>
<td>336</td>
<td>16</td>
<td>5</td>
<td>53</td>
</tr>
<tr>
<td>6:45</td>
<td>3</td>
<td>264</td>
<td>20</td>
<td>12</td>
<td>43</td>
</tr>
<tr>
<td>7:00</td>
<td>4</td>
<td>342</td>
<td>18</td>
<td>14</td>
<td>50</td>
</tr>
<tr>
<td>7:15</td>
<td>5</td>
<td>379</td>
<td>22</td>
<td>11</td>
<td>23</td>
</tr>
<tr>
<td>7:30</td>
<td>6</td>
<td>400</td>
<td>18</td>
<td>13</td>
<td>49</td>
</tr>
<tr>
<td>7:45</td>
<td>3</td>
<td>346</td>
<td>19</td>
<td>16</td>
<td>31</td>
</tr>
<tr>
<td>PM Total</td>
<td>81</td>
<td>3997</td>
<td>203</td>
<td>139</td>
<td>32</td>
</tr>
</tbody>
</table>

| Total | 188 | 9424 | 265 | 227 | 72 | 970 | 719 | 9265 | 165 | 236 | 58 | 133 | 21762 |

**Text Ref.: 5-3.03.03**
A.M.

DATE: SEPT. 24, 1986
S.P. - 6211
LOCATION: TH36 & ENGLISH ST.
PEAK HOUR: 7:00 - 8:00

MINNESOTA DEPARTMENT OF TRANSPORTATION
TRAFFIC ENGINEERING SECTION
TRAFFIC VOLUME AND TURNING MOVEMENT STUDY

NORTH

LANES OF APPROACH

<table>
<thead>
<tr>
<th></th>
<th>RIGHT TURN</th>
<th>LEFT TURN</th>
<th>THRUSH LINES</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>#2</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>#3</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>#4</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

Note:
Approaches 1 & 3 to be used for major roads, approaches 2 & 4 to be used for minor roads.

Text Ref.: 5-3.03.03

July 1, 1991

TRAFFIC VOLUME AND TURNING MOVEMENT STUDY (A.M.)

FIGURE 5.3A
P.M.

DATE: SEPT. 24, 1986
S.P.: 6211
LOCATION: TH36 & ENGLISH ST.
PEAK HOUR: 4:30 - 5:30

MINNESOTA DEPARTMENT OF TRANSPORTATION
TRAFFIC ENGINEERING SECTION
TRAFFIC VOLUME AND TURNING MOVEMENT STUDY

NORTH

LANES OF APPROACH

<table>
<thead>
<tr>
<th></th>
<th>RIGHT TURN</th>
<th>LEFT TURN</th>
<th>THRU LANES</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>#2</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>#3</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>#4</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

Note:
Approaches 1 & 3 to be used for major roads, approaches 2 & 4 to be used for minor roads.

Text Ref.: 5-3.03.03
<table>
<thead>
<tr>
<th>DATE</th>
<th>MON</th>
<th>TUE</th>
<th>WED</th>
<th>THUR</th>
<th>FRI</th>
<th>SAT</th>
<th>SUN</th>
<th>WEEKDAY</th>
<th>WEEKEND</th>
</tr>
</thead>
<tbody>
<tr>
<td>12-1AM</td>
<td>10</td>
<td>28</td>
<td>32</td>
<td>23</td>
<td>59</td>
<td>55</td>
<td>23</td>
<td>23</td>
<td>57</td>
</tr>
<tr>
<td>1-2</td>
<td>24</td>
<td>15</td>
<td>17</td>
<td>16</td>
<td>37</td>
<td>60</td>
<td>18</td>
<td>18</td>
<td>48</td>
</tr>
<tr>
<td>2-3</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>14</td>
<td>25</td>
<td>22</td>
<td>6</td>
<td>6</td>
<td>23</td>
</tr>
<tr>
<td>3-4</td>
<td>8</td>
<td>4</td>
<td>8</td>
<td>1</td>
<td>12</td>
<td>13</td>
<td>5</td>
<td>5</td>
<td>12</td>
</tr>
<tr>
<td>4-5</td>
<td>10</td>
<td>13</td>
<td>13</td>
<td>16</td>
<td>13</td>
<td>9</td>
<td>13</td>
<td>13</td>
<td>11</td>
</tr>
<tr>
<td>5-6</td>
<td>58</td>
<td>69</td>
<td>56</td>
<td>44</td>
<td>22</td>
<td>19</td>
<td>56</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>6-7</td>
<td>228</td>
<td>237</td>
<td>199</td>
<td>195</td>
<td>77</td>
<td>37</td>
<td>214</td>
<td>57</td>
<td></td>
</tr>
<tr>
<td>7-8</td>
<td>316</td>
<td>316</td>
<td>354</td>
<td>305</td>
<td>109</td>
<td>52</td>
<td>322</td>
<td>80</td>
<td></td>
</tr>
<tr>
<td>8-9</td>
<td>246</td>
<td>233</td>
<td>245</td>
<td>253</td>
<td>179</td>
<td>110</td>
<td>244</td>
<td>144</td>
<td></td>
</tr>
<tr>
<td>9-10</td>
<td>230</td>
<td>204</td>
<td>205</td>
<td>208</td>
<td>262</td>
<td>147</td>
<td>211</td>
<td>204</td>
<td></td>
</tr>
<tr>
<td>10-11</td>
<td>221</td>
<td>217</td>
<td>240</td>
<td>208</td>
<td>310</td>
<td>190</td>
<td>221</td>
<td>250</td>
<td></td>
</tr>
<tr>
<td>11-12N</td>
<td>227</td>
<td>222</td>
<td>232</td>
<td>244</td>
<td>303</td>
<td>304</td>
<td>231</td>
<td>303</td>
<td></td>
</tr>
<tr>
<td>12-1</td>
<td>259</td>
<td>211</td>
<td>235</td>
<td>246</td>
<td>242</td>
<td>254</td>
<td>238</td>
<td>254</td>
<td></td>
</tr>
<tr>
<td>1-2</td>
<td>235</td>
<td>236</td>
<td>257</td>
<td>261</td>
<td>252</td>
<td>267</td>
<td>247</td>
<td>259</td>
<td></td>
</tr>
<tr>
<td>2-3</td>
<td>226</td>
<td>252</td>
<td>286</td>
<td>283</td>
<td>270</td>
<td>272</td>
<td>261</td>
<td>271</td>
<td></td>
</tr>
<tr>
<td>3-4</td>
<td>242</td>
<td>297</td>
<td>235</td>
<td>246</td>
<td>242</td>
<td>261</td>
<td>255</td>
<td>251</td>
<td></td>
</tr>
<tr>
<td>4-5</td>
<td>302</td>
<td>314</td>
<td>254</td>
<td>285</td>
<td>225</td>
<td>251</td>
<td>288</td>
<td>238</td>
<td></td>
</tr>
<tr>
<td>5-6</td>
<td>320</td>
<td>339</td>
<td>312</td>
<td>267</td>
<td>222</td>
<td>234</td>
<td>309</td>
<td>228</td>
<td></td>
</tr>
<tr>
<td>6-7</td>
<td>263</td>
<td>320</td>
<td>265</td>
<td>347</td>
<td>246</td>
<td>254</td>
<td>298</td>
<td>250</td>
<td></td>
</tr>
<tr>
<td>7-8</td>
<td>251</td>
<td>223</td>
<td>250</td>
<td>236</td>
<td>211</td>
<td>259</td>
<td>240</td>
<td>235</td>
<td></td>
</tr>
<tr>
<td>8-9</td>
<td>167</td>
<td>247</td>
<td>192</td>
<td>218</td>
<td>224</td>
<td>190</td>
<td>206</td>
<td>207</td>
<td></td>
</tr>
<tr>
<td>9-10</td>
<td>140</td>
<td>157</td>
<td>142</td>
<td>161</td>
<td>131</td>
<td>220</td>
<td>150</td>
<td>175</td>
<td></td>
</tr>
<tr>
<td>10-11</td>
<td>109</td>
<td>136</td>
<td>114</td>
<td>137</td>
<td>117</td>
<td>137</td>
<td>124</td>
<td>127</td>
<td></td>
</tr>
<tr>
<td>11-12M</td>
<td>60</td>
<td>82</td>
<td>54</td>
<td>83</td>
<td>92</td>
<td>58</td>
<td>69</td>
<td>75</td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>4156</td>
<td>1773</td>
<td>2838</td>
<td>4212</td>
<td>4293</td>
<td>3894</td>
<td>3675</td>
<td>4258</td>
<td>3784</td>
</tr>
</tbody>
</table>

**SKETCH**

- **N**

**AVERAGE DAILY TRAFFIC**

- 24 hour factor: 0.897
- ADT: 3819
- Machine No. _______ Tape No. _______ File No. _______

**Remarks:**

- Recorder Type: HR □ MR □ AR □

Text Ref.: 5-3.05.01

---

**FIGURE 5.4**

Portion of the page with the text: **Portion of Portable Traffic Recorder Data**

**August 1, 2007 TRAFFIC ENGINEERING MANUAL 5-43**

**Text Ref.: 5-3.05.01**
### SUMMARY OF AUTOMATIC TRAFFIC RECORDER DATA

#### AVERAGE DAILY VOLUMES
FOR MONTH, WEEKDAY, SATURDAY AND SUNDAY

**A.T.R. STATION NO. 204**

**LOCATION**
T.H. 169, 0.3 Mi. S. of S.C.L. of Onamia - Mille Lacs County

<table>
<thead>
<tr>
<th>MONTH</th>
<th>ADJUSTED DAILY AVERAGE FOR THE MONTH</th>
<th>AVERAGE WEDNESDAY</th>
<th>AVERAGE SATURDAY</th>
<th>AVERAGE SUNDAY</th>
<th>PERCENTAGE ADJUSTED DAILY AVERAGE IS TO THE ANNUAL AVERAGE</th>
<th>PERCENTAGE THE AVERAGE WEEKDAY IS TO ADT</th>
</tr>
</thead>
<tbody>
<tr>
<td>JANUARY</td>
<td>2813</td>
<td>2440</td>
<td>3627</td>
<td>3865</td>
<td>65.2</td>
<td>114.8</td>
</tr>
<tr>
<td>FEBRUARY</td>
<td>2718</td>
<td>2414</td>
<td>3215</td>
<td>3740</td>
<td>63.0</td>
<td>114.8</td>
</tr>
<tr>
<td>MARCH</td>
<td>2644</td>
<td>2403</td>
<td>3308</td>
<td>3182</td>
<td>61.3</td>
<td>114.8</td>
</tr>
<tr>
<td>APRIL</td>
<td>3416</td>
<td>2952</td>
<td>4060</td>
<td>5097</td>
<td>79.2</td>
<td>114.8</td>
</tr>
<tr>
<td>MAY</td>
<td>5815</td>
<td>5059</td>
<td>7125</td>
<td>8287</td>
<td>134.9</td>
<td>114.8</td>
</tr>
<tr>
<td>JUNE</td>
<td>5986</td>
<td>4950</td>
<td>7728</td>
<td>9430</td>
<td>138.8</td>
<td>114.8</td>
</tr>
<tr>
<td>JULY</td>
<td>6726</td>
<td>7297</td>
<td>4976</td>
<td>5622</td>
<td>156.0</td>
<td>114.8</td>
</tr>
<tr>
<td>AUGUST</td>
<td>6302</td>
<td>5279</td>
<td>7744</td>
<td>9980</td>
<td>146.2</td>
<td>122.4</td>
</tr>
<tr>
<td>SEPTEMBER</td>
<td>5065</td>
<td>4388</td>
<td>5957</td>
<td>7564</td>
<td>117.5</td>
<td>114.8</td>
</tr>
<tr>
<td>OCTOBER</td>
<td>4429</td>
<td>3644</td>
<td>5529</td>
<td>7258</td>
<td>102.7</td>
<td>114.8</td>
</tr>
<tr>
<td>NOVEMBER</td>
<td>4064</td>
<td>3761</td>
<td>3786</td>
<td>5858</td>
<td>94.2</td>
<td>114.8</td>
</tr>
<tr>
<td>DECEMBER</td>
<td>1766</td>
<td>1442</td>
<td>1850</td>
<td>2007</td>
<td>41.0</td>
<td>114.8</td>
</tr>
</tbody>
</table>

**ANNUAL DAILY AVERAGE**

| 4312      | 3835                                  | 4908              | 5990             | 135.2                                                   |

Text Ref.: 5-3.07.04
1985 MONTHLY VOLUME VARIATION (PERCENT OF AVERAGE)

150%
140%
130%
120%
110%
100%
90%
80%
70%
60%
50%

JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC

1985 DAILY VOLUME VARIATION (PERCENT OF AVERAGE)

150%
140%
130%
120%
110%
100%
90%
80%
70%
60%
50%

MON TUE WED THU FRI SAT SUN

STATION 2040 TH-169, .3 MI. S OF ONAMIA, MILLE LACS CO.
SUMMARY OF AUTOMATIC TRAFFIC RECORDER DATA

1995 MONTHLY VOLUME VARIATION (PERCENT OF AVERAGE)

150%
140%
130%
120%
110%
100%
90%
80%
70%
60%
50%

JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC

1995 DAILY VOLUME VARIATION (PERCENT OF AVERAGE)

150%
140%
130%
120%
110%
100%
90%
80%
70%
60%
50%

MON TUE WED THU FRI SAT SUN

STATION 2040 TH-169, .3 MI. S OF ONAMIA.....MILLE LACS CO.

Text Ref.: 5-3.07.04

July 1, 1991  SUMMARY OF AUTOMATIC TRAFFIC RECORDER DATA  FIGURE 5.5C
### AUTOMATIC TRAFFIC RECORDER DATA
**SUMMARY OF HOURLY VOLUMES FOR HIGHEST HOURS**

<table>
<thead>
<tr>
<th>Highest Hour</th>
<th>Traffic Volume</th>
<th>Date</th>
<th>Day</th>
<th>Hour</th>
<th>Percent of Annual Daily Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>1740</td>
<td>07-07</td>
<td>SUN</td>
<td>11-12 AM</td>
<td>39.3</td>
</tr>
<tr>
<td>02</td>
<td>1320</td>
<td>05-27</td>
<td>MON</td>
<td>04-05 PM</td>
<td>29.8</td>
</tr>
<tr>
<td>03</td>
<td>1210</td>
<td>09-02</td>
<td>MON</td>
<td>02-03 PM</td>
<td>27.4</td>
</tr>
<tr>
<td>04</td>
<td>1200</td>
<td>05-27</td>
<td>MON</td>
<td>03-04 PM</td>
<td>27.1</td>
</tr>
<tr>
<td>05</td>
<td>1160</td>
<td>05-27</td>
<td>MON</td>
<td>05-06 PM</td>
<td>26.7</td>
</tr>
<tr>
<td>06</td>
<td>1160</td>
<td>09-02</td>
<td>MON</td>
<td>12-01 PM</td>
<td>25.3</td>
</tr>
<tr>
<td>07</td>
<td>1160</td>
<td>09-02</td>
<td>MON</td>
<td>01-02 PM</td>
<td>26.0</td>
</tr>
<tr>
<td>08</td>
<td>1120</td>
<td>07-07</td>
<td>SUN</td>
<td>12-01 PM</td>
<td>25.3</td>
</tr>
<tr>
<td>09</td>
<td>1120</td>
<td>08-11</td>
<td>SUN</td>
<td>05-06 PM</td>
<td>25.3</td>
</tr>
<tr>
<td>10</td>
<td>1110</td>
<td>07-28</td>
<td>SUN</td>
<td>06-07 PM</td>
<td>25.1</td>
</tr>
<tr>
<td>11</td>
<td>1100</td>
<td>07-07</td>
<td>SUN</td>
<td>03-04 PM</td>
<td>24.9</td>
</tr>
<tr>
<td>12</td>
<td>1090</td>
<td>07-07</td>
<td>SUN</td>
<td>04-05 PM</td>
<td>24.6</td>
</tr>
<tr>
<td>13</td>
<td>1090</td>
<td>09-02</td>
<td>MON</td>
<td>11-12 AM</td>
<td>24.6</td>
</tr>
<tr>
<td>14</td>
<td>1070</td>
<td>07-07</td>
<td>SUN</td>
<td>06-07 PM</td>
<td>24.2</td>
</tr>
<tr>
<td>15</td>
<td>1070</td>
<td>09-02</td>
<td>MON</td>
<td>03-04 PM</td>
<td>24.2</td>
</tr>
<tr>
<td>16</td>
<td>1060</td>
<td>07-07</td>
<td>SUN</td>
<td>02-03 PM</td>
<td>24.0</td>
</tr>
<tr>
<td>17</td>
<td>1050</td>
<td>07-21</td>
<td>SUN</td>
<td>06-07 PM</td>
<td>23.7</td>
</tr>
<tr>
<td>18</td>
<td>1050</td>
<td>07-28</td>
<td>SUN</td>
<td>05-06 PM</td>
<td>23.7</td>
</tr>
<tr>
<td>19</td>
<td>1040</td>
<td>05-27</td>
<td>MON</td>
<td>06-07 PM</td>
<td>23.5</td>
</tr>
<tr>
<td>20</td>
<td>1040</td>
<td>07-21</td>
<td>SUN</td>
<td>05-06 PM</td>
<td>23.5</td>
</tr>
<tr>
<td>21</td>
<td>1040</td>
<td>08-11</td>
<td>SUN</td>
<td>06-07 PM</td>
<td>23.5</td>
</tr>
<tr>
<td>22</td>
<td>1030</td>
<td>05-19</td>
<td>SUN</td>
<td>04-05 PM</td>
<td>23.3</td>
</tr>
<tr>
<td>23</td>
<td>1030</td>
<td>06-16</td>
<td>SUN</td>
<td>06-07 PM</td>
<td>23.3</td>
</tr>
<tr>
<td>24</td>
<td>1030</td>
<td>07-07</td>
<td>SUN</td>
<td>01-02 PM</td>
<td>23.3</td>
</tr>
<tr>
<td>25</td>
<td>1020</td>
<td>07-28</td>
<td>SUN</td>
<td>04-05 PM</td>
<td>23.1</td>
</tr>
<tr>
<td>26</td>
<td>1020</td>
<td>08-04</td>
<td>SUN</td>
<td>05-06 PM</td>
<td>23.1</td>
</tr>
<tr>
<td>27</td>
<td>1010</td>
<td>06-16</td>
<td>SUN</td>
<td>05-06 PM</td>
<td>22.8</td>
</tr>
<tr>
<td>28</td>
<td>1010</td>
<td>07-07</td>
<td>SUN</td>
<td>05-06 PM</td>
<td>22.8</td>
</tr>
<tr>
<td>29</td>
<td>1010</td>
<td>08-11</td>
<td>SUN</td>
<td>04-05 PM</td>
<td>22.8</td>
</tr>
<tr>
<td>30</td>
<td>1010</td>
<td>08-18</td>
<td>SUN</td>
<td>04-05 PM</td>
<td>22.8</td>
</tr>
<tr>
<td>40</td>
<td>970</td>
<td>07-07</td>
<td>SUN</td>
<td>07-08 PM</td>
<td>21.9</td>
</tr>
<tr>
<td>50</td>
<td>950</td>
<td>06-21</td>
<td>FRI</td>
<td>08-09 PM</td>
<td>21.5</td>
</tr>
<tr>
<td>60</td>
<td>940</td>
<td>08-31</td>
<td>SAT</td>
<td>11-12 AM</td>
<td>21.3</td>
</tr>
<tr>
<td>80</td>
<td>900</td>
<td>08-18</td>
<td>SUN</td>
<td>02-03 PM</td>
<td>20.3</td>
</tr>
<tr>
<td>100</td>
<td>860</td>
<td>09-29</td>
<td>SUN</td>
<td>05-06 PM</td>
<td>19.4</td>
</tr>
<tr>
<td>130</td>
<td>830</td>
<td>08-30</td>
<td>FRI</td>
<td>08-09 PM</td>
<td>18.8</td>
</tr>
<tr>
<td>500</td>
<td>550</td>
<td>07-07</td>
<td>SUN</td>
<td>09-10 PM</td>
<td>12.4</td>
</tr>
<tr>
<td>1000</td>
<td>380</td>
<td>08-08</td>
<td>THUR</td>
<td>01-02 PM</td>
<td>8.6</td>
</tr>
</tbody>
</table>

Text Ref.: 5-3.07.04

<table>
<thead>
<tr>
<th>July 1, 1991</th>
<th>SUMMARY OF AUTOMATIC TRAFFIC RECORDING DATA</th>
<th>FIGURE 5.5D</th>
</tr>
</thead>
</table>
### AUTOMATIC TRAFFIC RECORDER DATA
### SUMMARY OF YEARLY HOURLY AVERAGES

<table>
<thead>
<tr>
<th>Time</th>
<th>Volume %</th>
<th>Volume %</th>
<th>Volume %</th>
<th>Volume %</th>
<th>Volume %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Saturday</td>
<td>Sunday</td>
<td>Weekday</td>
<td>Jun-Aug</td>
<td>Day</td>
</tr>
<tr>
<td></td>
<td>By Hour</td>
<td>By Hour</td>
<td>By Hour</td>
<td>By Hour</td>
<td>By Hour</td>
</tr>
<tr>
<td>MID-01</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>01-02</td>
<td>75 1.4</td>
<td>50 0.8</td>
<td>24 0.6</td>
<td>40 0.8</td>
<td>35 0.8</td>
</tr>
<tr>
<td>02-03</td>
<td>56 1.0</td>
<td>36 0.6</td>
<td>14 0.4</td>
<td>23 0.4</td>
<td>23 0.5</td>
</tr>
<tr>
<td>03-04</td>
<td>34 0.6</td>
<td>21 0.3</td>
<td>9 0.2</td>
<td>13 0.2</td>
<td>15 0.3</td>
</tr>
<tr>
<td>04-05</td>
<td>27 0.5</td>
<td>13 0.2</td>
<td>10 0.3</td>
<td>14 0.3</td>
<td>13 0.3</td>
</tr>
<tr>
<td>05-06</td>
<td>33 0.6</td>
<td>13 0.2</td>
<td>23 0.6</td>
<td>26 0.5</td>
<td>23 0.5</td>
</tr>
<tr>
<td>06-07</td>
<td>52 1.0</td>
<td>22 0.3</td>
<td>45 1.2</td>
<td>52 1.0</td>
<td>43 1.0</td>
</tr>
<tr>
<td>07-08</td>
<td>97 1.8</td>
<td>41 0.6</td>
<td>74 1.9</td>
<td>95 1.8</td>
<td>72 1.6</td>
</tr>
<tr>
<td>08-09</td>
<td>166 3.1</td>
<td>90 1.4</td>
<td>133 3.5</td>
<td>150 2.8</td>
<td>131 3.0</td>
</tr>
<tr>
<td>09-10</td>
<td>282 5.2</td>
<td>145 2.2</td>
<td>166 4.3</td>
<td>208 3.9</td>
<td>180 4.1</td>
</tr>
<tr>
<td>10-11</td>
<td>400 7.4</td>
<td>251 3.9</td>
<td>207 5.4</td>
<td>264 5.0</td>
<td>240 5.4</td>
</tr>
<tr>
<td>11-Noon</td>
<td>472 8.8</td>
<td>350 5.4</td>
<td>245 6.4</td>
<td>331 6.2</td>
<td>292 6.6</td>
</tr>
<tr>
<td></td>
<td>484 9.0</td>
<td>439 6.8</td>
<td>263 6.9</td>
<td>369 6.9</td>
<td>320 7.2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Time</th>
<th>Volume %</th>
<th>Volume %</th>
<th>Volume %</th>
<th>Volume %</th>
<th>Volume %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Noon-01</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>01-02</td>
<td>441 8.2</td>
<td>455 7.0</td>
<td>263 6.9</td>
<td>369 6.9</td>
<td>316 7.1</td>
</tr>
<tr>
<td>02-03</td>
<td>402 7.5</td>
<td>477 7.4</td>
<td>270 7.1</td>
<td>372 7.0</td>
<td>316 7.2</td>
</tr>
<tr>
<td>03-04</td>
<td>380 7.1</td>
<td>537 8.3</td>
<td>282 7.4</td>
<td>376 7.1</td>
<td>332 7.5</td>
</tr>
<tr>
<td>04-05</td>
<td>349 6.5</td>
<td>578 8.9</td>
<td>287 7.5</td>
<td>383 7.2</td>
<td>337 7.6</td>
</tr>
<tr>
<td>05-06</td>
<td>320 6.0</td>
<td>626 9.6</td>
<td>298 7.8</td>
<td>392 7.4</td>
<td>348 7.9</td>
</tr>
<tr>
<td>06-07</td>
<td>303 5.6</td>
<td>624 9.6</td>
<td>285 7.4</td>
<td>384 7.2</td>
<td>336 7.6</td>
</tr>
<tr>
<td>07-08</td>
<td>257 4.8</td>
<td>563 8.7</td>
<td>246 6.4</td>
<td>346 6.5</td>
<td>293 6.6</td>
</tr>
<tr>
<td>08-09</td>
<td>238 4.4</td>
<td>468 7.2</td>
<td>227 5.9</td>
<td>339 6.4</td>
<td>263 5.9</td>
</tr>
<tr>
<td>09-10</td>
<td>193 3.6</td>
<td>327 5.0</td>
<td>188 4.9</td>
<td>308 5.8</td>
<td>208 4.7</td>
</tr>
<tr>
<td>10-11</td>
<td>144 2.7</td>
<td>198 3.1</td>
<td>131 3.4</td>
<td>226 4.3</td>
<td>142 3.2</td>
</tr>
<tr>
<td>11-Mid</td>
<td>100 1.9</td>
<td>109 1.7</td>
<td>87 2.3</td>
<td>146 2.7</td>
<td>92 2.1</td>
</tr>
<tr>
<td>Total (Day)</td>
<td>5372</td>
<td>6488</td>
<td>3837</td>
<td>5312</td>
<td>4426</td>
</tr>
</tbody>
</table>

Text Ref.: 5-3.07.04
**Field Speed Survey Sheet**

<table>
<thead>
<tr>
<th>EAST</th>
<th>Bound</th>
<th>VEHICLES</th>
<th>T. A.T.</th>
<th>%</th>
<th>WEST</th>
<th>Bound</th>
<th>VEHICLES</th>
<th>T. A.T.</th>
<th>%</th>
<th>TRUCKS &amp; BUSES</th>
<th>Bound</th>
<th>VEHICLES</th>
<th>T. A.T.</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>70</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>69</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>68</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>67</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>66</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>65</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>64</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>63</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>62</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>61</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>60</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>59</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>58</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>57</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>56</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>55</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>54</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>53</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>52</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>51</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>49</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>48</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>47</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>46</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>45</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>44</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>43</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>42</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>41</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>40</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>39</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>38</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>37</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>36</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>35</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>34</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>33</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>32</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>31</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>29</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>28</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>27</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>26</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>24</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>23</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Text Ref.: 5.4.03**

**Figure 5.6**
TRAVEL TIME AND DELAY STUDY
TEST CAR TECHNIQUE
FIELD SHEET
TEST VEHICLE METHOD 1

DATE 5-10-83    WEATHER CLEAR, 70°    TRIP NO. 1

ROUTE WASHINGTON - CEDAR TO 11TH    DIRECTION WB

TRIP STARTED AT 4/12:33    AT S JCT (LOCATION) (MILEAGE)

TRIP ENDED AT 4/14:40   AT 11TH (LOCATION) (MILEAGE)

<table>
<thead>
<tr>
<th>CONTROL POINTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOCATION</td>
</tr>
<tr>
<td>S. JCT 12 (WASH)</td>
</tr>
<tr>
<td>N. JCT 12</td>
</tr>
<tr>
<td>15TH</td>
</tr>
<tr>
<td>E. JCT 35</td>
</tr>
<tr>
<td>W. JCT 35</td>
</tr>
<tr>
<td>11TH</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>STOPS OR SLOWS</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOCATION</td>
</tr>
<tr>
<td>N. JCT 12</td>
</tr>
<tr>
<td>E. JCT 35</td>
</tr>
</tbody>
</table>

TRIP LENGTH _______ TRIP TIME 2.07 TRAVEL SPEED _______
RUNNING TIME 1.25 STOPPED TIME 0.82 RUNNING SPEED _______

SYMBOLS OF DELAY CAUSE: S - TRAFFIC SIGNALS SS - STOP SIGN LT - LEFT TURNS
PK - PARKED CARS DP - DOUBLE PARKING T - GENERAL
PED - PEDESTRIANS BP - BUS PASSENGERS LOADING OR UNLOADING

COMMENTS ________________________________

Text Ref.: 5-5.04   RECORDER __________________________
July 1, 1991   TRAVEL TIME AND DELAY STUDY FIGURE 5.7
TEST VEHICLE METHOD II (Freeways)

Data was collected by a single observer into a tape recorder (e.g. reading in start time of day, point name of next point, and "mark" when point is passed. Data written to log in office with running stopwatch. End stopwatch time checked to agree with field end time.
TRAVEL TIME STUDY
LICENSE PLATE TECHNIQUE
FIELD SHEET

LOCATION on 66TH ST. ENT. RAMP = I-35W
WEATHER = CLR/DYR

DATE = 7-11-91
ROUTE LENGTH = 1.27 MI
DIRECTION OF TRAFFIC = NR

TIME OF START = 8 AM
TIME OF END = 9 AM
TIME CORRECTION = 0

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>01:03</td>
<td>19:03</td>
<td>32:26</td>
<td>32:12</td>
<td>32:12</td>
<td>32:12</td>
<td>32:12</td>
<td>32:12</td>
<td>32:12</td>
<td>32:12</td>
</tr>
</tbody>
</table>

NOTE: ONLY RECORD LAST THREE DIGITS OF LICENSE PLATE NUMBER. UNDERLINE ANY BUS OR TRUCK WITH DUAL REAR WHEELS OR HEAVIER VEHICLES

Text Ref.: 5-5.04

OBSERVER ________________________ RECORDER ______________

July 1, 1991

TRAVEL TIME STUDY LICENSE PLATE TECHNIQUE

FIGURE 5.9
## Analysis of Data for Moving Vehicle Method of Estimating Volume and Travel Time

### Link I

#### S. JCT 12 - N. JCT 12

<table>
<thead>
<tr>
<th>Run Number</th>
<th>Travel Time (in minutes)</th>
<th>Vehicles Met By Test Car from Opposing Direction</th>
<th>Vehicles Overtaking Test Car</th>
<th>Vehicles Passed by Test Car</th>
</tr>
</thead>
<tbody>
<tr>
<td>bound Trips</td>
<td>$T_n$</td>
<td>$M_n$</td>
<td>$O_n$</td>
<td>$P_n$</td>
</tr>
<tr>
<td>1.</td>
<td>0.44</td>
<td></td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>2.</td>
<td>0.50</td>
<td></td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>3.</td>
<td>0.17</td>
<td></td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>4.</td>
<td>0.27</td>
<td></td>
<td>0</td>
<td>9</td>
</tr>
<tr>
<td>5.</td>
<td>0.31</td>
<td></td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>6.</td>
<td>0.53</td>
<td></td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>2.22</td>
<td></td>
<td>0</td>
<td>13</td>
</tr>
<tr>
<td>Average</td>
<td>0.37</td>
<td></td>
<td>0</td>
<td>2.17</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>bound Trips</th>
<th>$T_s$</th>
<th>$M_s$</th>
<th>$O_s$</th>
<th>$P_s$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>0.40</td>
<td></td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>0.15</td>
<td></td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>0.09</td>
<td></td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>0.13</td>
<td></td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>0.16</td>
<td></td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>0.15</td>
<td></td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>1.13</td>
<td></td>
<td>4.5</td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td>0.19</td>
<td></td>
<td>7.5</td>
<td></td>
</tr>
</tbody>
</table>
MOVING VEHICLE METHOD (Computations)

VOLUMES AND TRAVEL TIMES

<table>
<thead>
<tr>
<th>Link</th>
<th>$M_s$</th>
<th>$O_n$</th>
<th>$P_n$</th>
<th>$T_n$</th>
<th>$T_s$</th>
<th>$V_n$</th>
<th>$\bar{T}_n$</th>
</tr>
</thead>
<tbody>
<tr>
<td>S Jct 12 – N Jct 12</td>
<td>7.50</td>
<td>0</td>
<td>2.17</td>
<td>0.37</td>
<td>0.19</td>
<td>571</td>
<td>0.598</td>
</tr>
<tr>
<td>N Jct 12 – 15th Ave</td>
<td>12.67</td>
<td>1.67</td>
<td>2.17</td>
<td>0.51</td>
<td>0.24</td>
<td>983</td>
<td>0.539</td>
</tr>
<tr>
<td>15th Ave – E Jct 35</td>
<td>6.33</td>
<td>0.67</td>
<td>1.83</td>
<td>0.36</td>
<td>0.20</td>
<td>552</td>
<td>0.486</td>
</tr>
<tr>
<td>E Jct 35 – W Jct 35</td>
<td>3.15</td>
<td>0.83</td>
<td>1.00</td>
<td>0.54</td>
<td>0.23</td>
<td>232</td>
<td>0.583</td>
</tr>
<tr>
<td>W Jct 35 – 11th Ave</td>
<td>11.67</td>
<td>0.33</td>
<td>0.17</td>
<td>0.38</td>
<td>0.68</td>
<td>674</td>
<td>0.362</td>
</tr>
<tr>
<td>OVERALL:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S Jct 12 – 11th Ave</td>
<td>41.67</td>
<td>2.83</td>
<td>7.33</td>
<td>2.16</td>
<td>1.53</td>
<td>604</td>
<td>2.607</td>
</tr>
</tbody>
</table>

NOTE: $V_n = \frac{60(M_s + O_n - P_n)}{T_n + T_s}$ = Veh/Hr

$\bar{T}_n = T_n - \frac{60(O_n - P_n)}{V_n} = \text{min.}$

* Reverse subscripts for opposite direction
$V_n$ = Northbound hourly volume
$M_s$ = Count of vehicles met (opposing flow) while test vehicle was traveling south
$O_n$ = Number of vehicles passing the test car (overtaking) while the test car was traveling north
$P_n$ = Number of vehicles passed by the test car while it was traveling north
$T_n$ = Travel time in minutes while traveling north

Text Ref.: 5-5.04
# INTERSECTION DELAY STUDY

## FIELD SHEET

**Location:** W/S-35W on Washington

**Approach:** West

**Movement:** Straight R.T.

**Date:** May 19, 1991

**Weather:** Cloudy, W/ Slight Rain

**Study No.:** 1

**Observer:**

<table>
<thead>
<tr>
<th>Time (minute starting at)</th>
<th>Total Number of Vehicles Stopped in the Approach at Time:</th>
<th>Approach Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>+0 sec +15 sec +30 sec +45 sec</td>
<td>Number Stopped</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Number Not Stopping</td>
</tr>
<tr>
<td>1610</td>
<td>0 0 0 2</td>
<td>3 17</td>
</tr>
<tr>
<td>1611</td>
<td>2 0 0 0</td>
<td>2 18</td>
</tr>
<tr>
<td>1612</td>
<td>0 7 3 10</td>
<td>11 1</td>
</tr>
<tr>
<td>1613</td>
<td>11 20 0 10</td>
<td>5 7</td>
</tr>
<tr>
<td>1614</td>
<td>16 4 0 0</td>
<td>8 19</td>
</tr>
<tr>
<td>1615</td>
<td>0 1 2 2</td>
<td>4 0</td>
</tr>
<tr>
<td>1616</td>
<td>4 0 0 1</td>
<td>3 15</td>
</tr>
<tr>
<td>1617</td>
<td>2 5 5 13</td>
<td>12 0</td>
</tr>
<tr>
<td>1619</td>
<td>0 2 4 7</td>
<td>5 0</td>
</tr>
<tr>
<td>1620</td>
<td>7 15 3 6</td>
<td>13 5</td>
</tr>
<tr>
<td>1621</td>
<td>10 12 12 23</td>
<td>10 0</td>
</tr>
<tr>
<td>1622</td>
<td>8 5 9 10</td>
<td>10 0</td>
</tr>
<tr>
<td>1623</td>
<td>9 18 5 6</td>
<td>13 0</td>
</tr>
<tr>
<td>1624</td>
<td>7 8 10 17</td>
<td>9 0</td>
</tr>
<tr>
<td>1625</td>
<td>2 4 6 9</td>
<td>11 0</td>
</tr>
</tbody>
</table>

Subtotal: 360

Total: 216

**Total Delay** = Total Number Stopped x Sampling Interval

= \( \frac{360 \times 15}{5} \) = 5400 veh sec

**Average Delay per Stopped Vehicle** = \( \frac{\text{Total Delay}}{\text{Number of Stopped Vehicles}} \)

= \( \frac{5400}{121} \) = 44.6 sec

**Average Delay per Approach Vehicle** = \( \frac{\text{Total Delay}}{\text{Approach Volume}} \)

= \( \frac{5400}{216} \) = 25.0 sec

**Percent of Vehicles Stopped** = \( \frac{\text{Number of Stopped Vehicles}}{\text{Approach Volume}} \)

= \( \frac{121}{216} \) = 56.0 percent

---

Text Ref.: 5-5.04

---

5-55
**VEHICLE CLASSIFICATION FORM**

LOCATION NUMBER: 260  DIRECTION:  NORTH  DATE:  6-29-76  HOUR:  6-7 AM  RECORDER: J. Smith  


**SINGLE UNIT TRUCKS**

<table>
<thead>
<tr>
<th>OTHER THAN HEAVY COMMERCIAL TRAFFIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>1043</td>
</tr>
</tbody>
</table>

**2-AXLE 6-TIRE TRUCKS**

<table>
<thead>
<tr>
<th>TANK</th>
<th>STAKE</th>
<th>REFRIGERATOR</th>
<th>VAN</th>
<th>DUMP</th>
<th>PANEL</th>
<th>PICKUP</th>
<th>GRAIN BOX</th>
<th>CATTLE RACK</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 | 61 | 62 | 63 | 64 | 65 | 66 | 67 | 68 | 69 | 70 |

**3-AXLE TRUCKS**

<table>
<thead>
<tr>
<th>TANK</th>
<th>STAKE</th>
<th>REFRIGERATOR</th>
<th>VAN</th>
<th>DUMP</th>
<th>GRAIN BOX</th>
<th>CATTLE RACK</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 | 61 | 62 | 63 | 64 | 65 | 66 | 67 | 68 | 69 | 70 |

**4-AXLE & + TRUCKS**

<table>
<thead>
<tr>
<th>TANK</th>
<th>DUMP</th>
<th>OTHER</th>
<th>COMM.</th>
<th>SCHOOL</th>
<th>OTHER</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| 71 | 72 | 73 | 74 | 75 | 76 | 77 | 78 | 79 | 80 |

**BUSES**

<table>
<thead>
<tr>
<th>TANK</th>
<th>DUMP</th>
<th>OTHER</th>
<th>COMM.</th>
<th>SCHOOL</th>
<th>OTHER</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| 81 | 82 | 83 | 84 | 85 | 86 | 87 | 88 | 89 | 90 |

**TRACTOR-SEMIMTRAILER TRUCKS**

<table>
<thead>
<tr>
<th>TRACTOR-SEMI</th>
<th>4-AXLE SEMI</th>
<th>5-AXLE SEMI</th>
<th>6-AXLE SEMI</th>
</tr>
</thead>
<tbody>
<tr>
<td>STAKE</td>
<td>VAN</td>
<td>OTHER</td>
<td>T</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 | 61 | 62 | 63 | 64 | 65 | 66 | 67 | 68 | 69 | 70 |

**HEAVY TRUCK/MOTOR TRAILER**

| 53 | 54 | 55 | 56 | 57 | 58 |

**6-AXLE & + TRAILER**

| 59 | 60 | 61 | 62 | 63 | 64 | 65 | 66 | 67 | 68 | 69 | 70 |

**TWIN TRAILERS**

| 71 | 72 | 73 | 74 | 75 | 76 | 77 | 78 | 79 | 80 |

Text Ref.: 5-10.04
## TRAFFIC DENSITY STATION REPORT

<table>
<thead>
<tr>
<th>County</th>
<th>District</th>
<th>Cycle</th>
<th>Station</th>
<th>Recorder</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### I. Route

<table>
<thead>
<tr>
<th>Date Removed</th>
<th>Hour</th>
<th>a.m.</th>
<th>Reading</th>
<th>a.m.</th>
<th>P.m.</th>
<th>Reading</th>
<th>a.m.</th>
<th>P.m.</th>
<th>Reading</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Direction from Station</th>
<th>Date Set</th>
<th>Total Hours</th>
<th>Total Traffic</th>
<th>24 Hr. Traffic</th>
<th>Factor</th>
<th>A.D.T.</th>
<th>Previous Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Machine Number</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Machine Type</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Remarks:**

---

### II. Route

<table>
<thead>
<tr>
<th>Date Removed</th>
<th>Hour</th>
<th>a.m.</th>
<th>Reading</th>
<th>a.m.</th>
<th>P.m.</th>
<th>Reading</th>
<th>a.m.</th>
<th>P.m.</th>
<th>Reading</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Direction from Station</th>
<th>Date Set</th>
<th>Total Hours</th>
<th>Total Traffic</th>
<th>24 Hr. Traffic</th>
<th>Factor</th>
<th>A.D.T.</th>
<th>Previous Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Machine Number</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Machine Type</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Remarks:**

---

### III. Route

<table>
<thead>
<tr>
<th>Date Removed</th>
<th>Hour</th>
<th>a.m.</th>
<th>Reading</th>
<th>a.m.</th>
<th>P.m.</th>
<th>Reading</th>
<th>a.m.</th>
<th>P.m.</th>
<th>Reading</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Direction from Station</th>
<th>Date Set</th>
<th>Total Hours</th>
<th>Total Traffic</th>
<th>24 Hr. Traffic</th>
<th>Factor</th>
<th>A.D.T.</th>
<th>Previous Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Machine Number</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Machine Type</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Remarks:**

---

### IV. Route

<table>
<thead>
<tr>
<th>Date Removed</th>
<th>Hour</th>
<th>a.m.</th>
<th>Reading</th>
<th>a.m.</th>
<th>P.m.</th>
<th>Reading</th>
<th>a.m.</th>
<th>P.m.</th>
<th>Reading</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Direction from Station</th>
<th>Date Set</th>
<th>Total Hours</th>
<th>Total Traffic</th>
<th>24 Hr. Traffic</th>
<th>Factor</th>
<th>A.D.T.</th>
<th>Previous Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Machine Number</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Machine Type</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Remarks:**

---

### V. Route

<table>
<thead>
<tr>
<th>Date Removed</th>
<th>Hour</th>
<th>a.m.</th>
<th>Reading</th>
<th>a.m.</th>
<th>P.m.</th>
<th>Reading</th>
<th>a.m.</th>
<th>P.m.</th>
<th>Reading</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Direction from Station</th>
<th>Date Set</th>
<th>Total Hours</th>
<th>Total Traffic</th>
<th>24 Hr. Traffic</th>
<th>Factor</th>
<th>A.D.T.</th>
<th>Previous Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Machine Number</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Machine Type</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Remarks:**

---

Weather and Road Conditions:

---

Text Ref.: 5-3.05.01

---

July 1, 1991

---

FORM 5.A

---
<table>
<thead>
<tr>
<th>DATE</th>
<th>MON</th>
<th>TUE</th>
<th>WED</th>
<th>THUR</th>
<th>FRI</th>
<th>SAT</th>
<th>SUN</th>
<th>WEEKDAY</th>
<th>WEEKEND</th>
</tr>
</thead>
<tbody>
<tr>
<td>12-1AM</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2-3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3-4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4-5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5-6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6-7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7-8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8-9</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9-10</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10-11</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11-12</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12-1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2-3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3-4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4-5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5-6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6-7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7-8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8-9</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9-10</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10-11</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11-12</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11-12PM</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

AVERAGE DAILY TRAFFIC

Remarks:

Recorder Type:  HR  MR  AR

<table>
<thead>
<tr>
<th>HOUR</th>
<th>FROM</th>
<th>TO</th>
<th>Total</th>
<th>FROM</th>
<th>TO</th>
<th>Total</th>
<th>FROM</th>
<th>TO</th>
<th>Total</th>
<th>FROM</th>
<th>TO</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>6:00-6:15</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6:15-6:30</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6:30-6:45</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6:45-7:00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7:00-7:15</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7:15-7:30</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7:30-7:45</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7:45-8:00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8:00-8:15</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8:15-8:30</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8:30-8:45</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8:45-9:00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9:00-9:15</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9:15-9:30</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9:30-9:45</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9:45-10:00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10:00-10:15</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10:15-10:30</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10:30-10:45</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10:45-11:00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11:00-11:15</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11:15-11:30</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11:30-11:45</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11:45-12:00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12:00-12:15</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12:15-12:30</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12:30-12:45</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12:45-1:00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1:00-1:15</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1:15-1:30</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1:30-1:45</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1:45-2:00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2:00-2:15</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2:15-2:30</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2:30-2:45</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2:45-3:00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3:00-3:15</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3:15-3:30</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3:30-3:45</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3:45-4:00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4:00-4:15</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4:15-4:30</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4:30-4:45</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4:45-5:00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5:00-5:15</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5:15-5:30</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5:30-5:45</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5:45-6:00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6:00-6:15</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6:15-6:30</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6:30-6:45</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6:45-7:00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7:00-7:15</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7:15-7:30</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7:30-7:45</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7:45-8:00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8:00-8:15</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8:15-8:30</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8:30-8:45</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8:45-9:00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9:00-9:15</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9:15-9:30</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9:30-9:45</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9:45-10:00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

TOTAL

Text Ref.: 5-3.05.02

REduced SCALE

July 1, 1991

MOTOR VEHICLE TRAFFIC VOLUME AND TURNING FIELD REPORT

FORM 5.C
MINNESOTA DEPARTMENT OF TRANSPORTATION
TRAFFIC ENGINEERING SECTION
TRAFFIC VOLUME AND
TURNING MOVEMENT STUDY

NORTH

NOTE:
Approaches 1 & 3 to be used for major highway or street.
Indicate number of driving lanes of approach.

LANES OF APPROACH

<table>
<thead>
<tr>
<th></th>
<th>RIGHT TURN</th>
<th>LEFT TURN</th>
<th>THRU LINES</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>#2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>#3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>#4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Text Ref.: 5-3.05.02
C.S. __________________________________________
Location ________________________________________

Hourly Vol. App. #2
6 8 10 12 2 4 P.M. 6 8 10

Hourly Vol. App. #4
6 8 10 12 2 4 P.M. 6 8 10

Hourly Vol. of Ped., Crossing Major Street
(Plot each x-walk separately)

Hourly Vol. App. #1
6 8 10 12 2 4 P.M. 6 8 10

Hourly Vol. App. #3
6 8 10 12 2 4 P.M. 6 8 10

Hourly Vol. App. #1 & 3
6 8 10 12 2 4 P.M. 6 8 10

Volume

Volume

Volume

Volume

Text Ref.: 5-3.05.02

SUMMARY OF HOURLY APPROACH VOLUMES

FORM 5.E
<table>
<thead>
<tr>
<th>Road No.</th>
<th>Zone</th>
<th>M.P.H.</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ref. Pt.</td>
<td>Time</td>
<td>A.M.–P.M.</td>
<td></td>
</tr>
<tr>
<td>County</td>
<td>Weather</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Date</td>
<td>Machine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Day</td>
<td>Observer</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**PASSENGER CARS, PICKUPS, VANS**

<table>
<thead>
<tr>
<th>Bound</th>
<th>VEHICLES</th>
<th>T</th>
<th>A.T.</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>TRUCKS &amp; BUSES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bound</td>
</tr>
<tr>
<td>-------</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

Mn/DOT 21273 (9-73)

Text Ref.: 5-4.03

July 1,1991 | FIELD SPEED SURVEY SHEET | FORM 5.F
TRAVEL TIME AND DELAY STUDY
TEST CAR TECHNIQUE
FIELD SHEET
TEST VEHICLE METHOD 1

DATE ___________ WEATHER _______________ TRIP NO. ___________

ROUTE _______________ DIRECTION _______________

TRIP STARTED AT _______________ AT _______________ (LOCATION) _______________ (MILEAGE) _______________

TRIP ENDED AT _______________ AT _______________ (LOCATION) _______________ (MILEAGE) _______________

CONTROL POINTS

<table>
<thead>
<tr>
<th>LOCATION</th>
<th>TIME</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

STOPS OR SLOWS

<table>
<thead>
<tr>
<th>LOCATION</th>
<th>SEC DELAY</th>
<th>CAUSE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

TRIP LENGTH _______ TRIP TIME _______ TRAVEL SPEED _______
RUNNING TIME _______ STOPPED TIME _______ RUNNING SPEED _______

SYMBOLS OF DELAY CAUSE: S – TRAFFIC SIGNALS SS – STOP SIGN LT – LEFT TURNS
PK – PARKED CARS DP – DOUBLE PARKING T – GENERAL
PED – PEDESTRIANS BP – BUS PASSENGERS LOADING OR UNLOADING

COMMENTS __________________________________________________

Text Ref.: 5-5.04
RECORER _____________________________

July 1, 1991

TRAVEL TIME AND DELAY STUDY

FORM 5.G

5-65
TRAVEL TIME STUDY
LICENSE PLATE TECHNIQUE
FIELD SHEET

LOCATION on ___________________________ at ___________________________ WEATHER ___________________________

DATE ___________________________ ROUTE LENGTH ___________________________ DIRECTION OF TRAFFIC ___________________________

TIME OF START ___________________________ TIME OF END ___________________________ TIME CORRECTION ___________________________

<table>
<thead>
<tr>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
</table>

NOTE: ONLY RECORD LAST THREE DIGITS OF LICENSE PLATE NUMBER. UNDERLINE ANY BUS OR TRUCK WITH DUAL REAR WHEELS OR HEAVIER VEHICLES.

Text Ref.: 5-5.04

FORM 5.1
<table>
<thead>
<tr>
<th>Run Number</th>
<th>bound Trips</th>
<th>Total</th>
<th>Average</th>
<th>bound Trips</th>
<th>Total</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

ANALYSIS OF DATA FOR MOVING VEHICLE METHOD OF ESTIMATING VOLUME AND TRAVEL TIME

Text Ref.: 5-5.04
### INTERSECTION DELAY STUDY

**FIELD SHEET**

<table>
<thead>
<tr>
<th>Location</th>
<th>Approach</th>
<th>Movement</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Date</th>
<th>Weather</th>
<th>Study No.</th>
<th>Observer</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Time (minute starting at)</th>
<th>Total Number of Vehicles Stopped in the Approach at Time:</th>
<th>Approach Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>+0 sec</td>
<td>+15 sec</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Subtotal

Total

\[
\text{Total Delay} = \text{Total Number Stopped} \times \text{Sampling Interval} \\
= \underline{\hspace{1cm}} \times 15 = \underline{\hspace{1cm}} \text{veh sec} \\
\]

\[
\text{Average Delay per Stopped Vehicle} = \frac{\text{Total Delay}}{\text{Number of Stopped Vehicles}} \\
= \underline{\hspace{1cm}} = \underline{\hspace{1cm}} \text{sec} \\
\]

\[
\text{Average Delay per Approach Vehicle} = \frac{\text{Total Delay}}{\text{Approach Volume}} \\
= \underline{\hspace{1cm}} = \underline{\hspace{1cm}} \text{sec} \\
\]

\[
\text{Percent of Vehicles Stopped} = \frac{\text{Number of Stopped Vehicles}}{\text{Approach Volume}} \\
= \underline{\hspace{1cm}} = \underline{\hspace{1cm}} \text{percent} \\
\]

Text Ref.: 5-5.04

July 1, 1991

INTERSECTION DELAY STUDY

FORM

5.K
Text Ref.: 5-6.03

July 1, 1991

VEHICLE OCCUPANCY DATA RECORDING FORM

FORM 5.L
### Queue Length Data Recording Form

**Form 5.M**

<table>
<thead>
<tr>
<th>Location:</th>
<th>Observer:</th>
<th>Direction:</th>
</tr>
</thead>
</table>

**Queue Length Study**

<table>
<thead>
<tr>
<th>Time</th>
<th>15 18 20 24 28</th>
<th>15 18 20 24 28</th>
<th>15 18 20 24 28</th>
<th>15 18 20 24 28</th>
<th>15 18 20 24 28</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Text Ref.:** 5-9.03

July 1, 1991
August 1, 2007

TRAFFIC ENGINEERING MANUAL

Text Ref.: 5-10.04
July 1,1991

VEHICLE CLASSIFICATION FORM

5-72

FORM

5.N


# Chapter 6
## TRAFFIC SIGNS

### Table of Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>6-1.00 INTRODUCTION</strong></td>
<td>6-5</td>
</tr>
<tr>
<td>1.01 Purpose</td>
<td></td>
</tr>
<tr>
<td>1.02 Scope</td>
<td></td>
</tr>
<tr>
<td>1.03 Organization of the Manual</td>
<td></td>
</tr>
<tr>
<td><strong>6-2.00 GLOSSARY</strong></td>
<td>6-6</td>
</tr>
<tr>
<td><strong>6-3.00 LEGALITY - LEGAL AUTHORITY FOR PLACEMENT OF TRAFFIC SIGNS</strong></td>
<td>6-8</td>
</tr>
<tr>
<td>3.01 Traffic Signs Installed by Mn/DOT Maintenance Forces</td>
<td></td>
</tr>
<tr>
<td>3.02 Traffic Signs Installed by Contract</td>
<td></td>
</tr>
<tr>
<td>3.03 Traffic Signs Installed by Others by Maintenance Permit</td>
<td></td>
</tr>
<tr>
<td>3.04 Temporary Traffic Control Signs Installed by Construction Contracts and Public Utility Companies at Work Sites</td>
<td></td>
</tr>
<tr>
<td><strong>6-4.00 GENERAL PRINCIPLES OF TRAFFIC SIGNING</strong></td>
<td>6-8</td>
</tr>
<tr>
<td>4.01 Principles of Traffic Control Devices</td>
<td></td>
</tr>
<tr>
<td>4.02 Basic Considerations for Installation of Traffic Signs</td>
<td></td>
</tr>
<tr>
<td>4.03 Functional Classifications of Traffic Signs</td>
<td></td>
</tr>
<tr>
<td>4.04 Department Classification by Sign Design Type</td>
<td></td>
</tr>
<tr>
<td>4.05 Elements of Traffic Sign Design</td>
<td></td>
</tr>
<tr>
<td>4.06 Sign Design Type Classification</td>
<td></td>
</tr>
<tr>
<td>4.07 Lateral Offset and Vertical Clearance Requirements</td>
<td></td>
</tr>
<tr>
<td>4.08 Sign Installation and Maintenance Practices</td>
<td></td>
</tr>
<tr>
<td>4.09 Implementation of Signing</td>
<td></td>
</tr>
<tr>
<td><strong>6-5.00 APPLICATION GUIDELINES - REGULATORY SIGNS</strong></td>
<td>6-21</td>
</tr>
<tr>
<td>5.01 Purpose</td>
<td></td>
</tr>
<tr>
<td>5.02 Typical Sign Placement</td>
<td></td>
</tr>
<tr>
<td>5.03 Bridge Speed and Load Restrictions</td>
<td></td>
</tr>
<tr>
<td>5.04 Bus Shoulder Sign (R4-X7)</td>
<td></td>
</tr>
<tr>
<td>5.05 BYPASS LANE Sign (R4-X8)</td>
<td></td>
</tr>
<tr>
<td>BYPASS &amp; RIGHT TURN LANE Sign (R4-X8a)</td>
<td></td>
</tr>
<tr>
<td>5.06 DO NOT PASS Sign (R4-1)</td>
<td></td>
</tr>
<tr>
<td>5.07 Intersection Lane Control Signs (R3-8)</td>
<td></td>
</tr>
<tr>
<td>5.08 ONE WAY Sign (R6-1)</td>
<td></td>
</tr>
<tr>
<td>5.09 RIGHT LANE MUST TURN RIGHT Sign (R3-7)</td>
<td></td>
</tr>
<tr>
<td>LEFT LANE MUST TURN LEFT Sign (R3-7)</td>
<td></td>
</tr>
<tr>
<td>5.10 SLOWER TRAFFIC MOVE RIGHT Sign (R4-3a)</td>
<td></td>
</tr>
<tr>
<td>5.11 Speed Zone Signing</td>
<td></td>
</tr>
<tr>
<td>5.12 STOP Sign (R1-1)</td>
<td></td>
</tr>
<tr>
<td>5.13 Two-Way Snowmobile Trail Signing</td>
<td></td>
</tr>
<tr>
<td>5.14 VEHICLE NOISE LAWS ENFORCED Sign (R16-X13)</td>
<td></td>
</tr>
</tbody>
</table>
6-6.00 APPLICATION GUIDELINES - WARNING SIGNS

6.01 Purpose
6.02 Acceleration Lane Signing
6.03 Advance Warning Signs on Local Road Approaches
6.04 Advisory Exit Speed Sign (W13-2)
6.05 BRIDGE ICES BEFORE ROAD Sign (W8-13)
6.06 Channelized Intersections
6.07 Chevron Alignment Sign (W1-8)
6.08 Controlled Burning Signs
6.09 Crossing Signs
6.10 EVENT CONGESTION AHEAD Sign (W14-X11)
6.11 Low Clearance Sign (W12-2)
6.12 No Passing Zones
6.13 Passing Lane Sections
6.14 SCHOOL BUS STOP AHEAD Sign (S3-1)
6.15 SHOULDER NARROWS Sign (W5-X1)
       NO SHOULDER Sign (W21-X1)
6.16 Speed Reduction Sign (W3-5)
6.17 Truck Hauling Signs
6.18 Typical Signing for Transitions Between Divided Highway Sections and Two Lane Two-Way Sections

6-7.00 APPLICATION GUIDELINES - GUIDE SIGNING

7.01 Purpose
7.02 Freeways
7.03 Signing Destinations
7.04 Typical Junction Signing Layouts
7.05 Independent Route Marker Assemblies
7.06 Named Road, Street, and 911 Road Name Signs
7.07 Boundary Signs
7.08 Designated Roadways
7.09 Supplemental Guide Signing Programs
7.10 External Sign Variance Committee

6-8.00 APPLICATION GUIDELINES - MISCELLANEOUS SIGNING

8.01 Adopt-A-Highway Signing Program
8.02 Adopt-A-Rest Area Signing Program
8.03 Community Destination Signing Program
8.04 DNR PUBLIC WATER ACCESS Sign (DNR NRM 8.2.35)
8.05 General Service Signs
8.06 Geological Marker Sign (D5-X1C, D7-X1, and D7-X2)
8.07 Reference Location Sign (D10-1, D10-2, and D10-3)
8.08 Rest Area Signing
8.09 Seat Belt Signs (R16-X11 and R16-X2)
8.10 Sign Attachments
8.11 Test Section Signing
## List of Figures

<table>
<thead>
<tr>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.1   Sign Placement</td>
<td>.6-89</td>
</tr>
<tr>
<td>6.2   Sign Placement</td>
<td>.6-90</td>
</tr>
<tr>
<td>6.3A  Type C &amp; D Structure Details (sheet 1 of 3)</td>
<td>.6-91</td>
</tr>
<tr>
<td>6.3B  Type C &amp; D Structure Details (sheet 2 of 3)</td>
<td>.6-92</td>
</tr>
<tr>
<td>6.3C  Type C &amp; D Structure Details (sheet 3 of 3)</td>
<td>.6-93</td>
</tr>
<tr>
<td>6.3D  Type C Signs Mounted on O-Posts, OH Sign Posts or Signal Standards</td>
<td>.6-94</td>
</tr>
<tr>
<td>6.3E  Alternate Type C &amp; D Mounting System</td>
<td>.6-95</td>
</tr>
<tr>
<td>6.4   Regulatory Signs on Divided Highways at Entrances</td>
<td>.6-96</td>
</tr>
<tr>
<td>6.5   Regulatory Signs for Divided Highway Intersections - T-Intersections</td>
<td>.6-97</td>
</tr>
<tr>
<td>6.6   Regulatory Signs for Divided Highway Intersections - Medians &lt;30 feet Wide</td>
<td>.6-98</td>
</tr>
<tr>
<td>6.7A  Regulatory Signs for Divided Highway Intersections - Median 30 Feet or Greater</td>
<td>.6-99</td>
</tr>
<tr>
<td>6.7B  Regulatory Signs for Divided Highway Intersections - Median 30 Feet or Greater</td>
<td>.6-100</td>
</tr>
<tr>
<td>6.8   Regulatory Signs for Divided Highway Intersections with Frontage Roads</td>
<td>.6-101</td>
</tr>
<tr>
<td>6.9   Regulatory Signs for Divided Highway Intersections with a One-Way Street/Ramp</td>
<td>.6-102</td>
</tr>
<tr>
<td>6.10  3/4 Access Intersection Signing</td>
<td>.6-103</td>
</tr>
<tr>
<td>6.11  Regulatory &amp; Warning Signs for 3/4 Right-in - Right-out Intersections</td>
<td>.6-104</td>
</tr>
<tr>
<td>6.12  Highway Intersection with One-way Street/Ramp</td>
<td>.6-105</td>
</tr>
<tr>
<td>6.13  Extended Left Turn Lane</td>
<td>.6-106</td>
</tr>
<tr>
<td>6.14  Regulatory Signs on Diamond Interchange Ramps</td>
<td>.6-107</td>
</tr>
<tr>
<td>6.15  Regulatory Signs on Cloverleaf Interchange Ramps</td>
<td>.6-108</td>
</tr>
<tr>
<td>6.16  Authorized Bus Lane Signing on Shoulders</td>
<td>.6-109</td>
</tr>
<tr>
<td>6.17  Bypass Lanes</td>
<td>.6-110</td>
</tr>
<tr>
<td>6.18A Lane Designation on Ramps (1 of 2)</td>
<td>.6-111</td>
</tr>
<tr>
<td>6.18B Lane Designation on Ramps (2 of 2)</td>
<td>.6-112</td>
</tr>
<tr>
<td>6.19  Acceleration Lane Signing/Striping Options</td>
<td>.6-113</td>
</tr>
<tr>
<td>6.20A Channelized Intersection Signing (Raised Median)</td>
<td>.6-114</td>
</tr>
<tr>
<td>6.20B Channelized Intersection Signing (Painted Median)</td>
<td>.6-115</td>
</tr>
<tr>
<td>6.21  Pedestrian Crossing Signing at Unsignalized Intersections</td>
<td>.6-116</td>
</tr>
<tr>
<td>6.22A Passing Lane Section Signing</td>
<td>.6-117</td>
</tr>
<tr>
<td>6.22B Passing Lane Signing Near Low-Volume Cross Roads</td>
<td>.6-118</td>
</tr>
<tr>
<td>6.23  Transition Signing Divided and Undivided Roadways</td>
<td>.6-119</td>
</tr>
<tr>
<td>6.24  Signal Mast Arm Intersection Signing</td>
<td>.6-120</td>
</tr>
<tr>
<td>6.25  T-Intersection Signing (w/ Divided Highway)</td>
<td>.6-121</td>
</tr>
<tr>
<td>6.26  Diamond Interchange &amp; Crossroad Signing (Unsignalized)</td>
<td>.6-122</td>
</tr>
<tr>
<td>6.27  Diamond Interchange &amp; Crossroad Signing (Signalized)</td>
<td>.6-123</td>
</tr>
<tr>
<td>6.28  Folded-Diamond Interchange &amp; Crossroad Signing (Unsignalized)</td>
<td>.6-124</td>
</tr>
<tr>
<td>6.29  Cloverleaf Interchange &amp; Crossroad Signing</td>
<td>.6-125</td>
</tr>
<tr>
<td>6.30A Signing for Auxiliary Lanes on Freeways,</td>
<td></td>
</tr>
<tr>
<td>Lane Less than 1/2 Mile without Escape Lane</td>
<td>.6-126</td>
</tr>
<tr>
<td>6.30B Signing for Auxiliary Lanes on Freeways,</td>
<td></td>
</tr>
<tr>
<td>Lane Less than 1/2 Mile with Escape Lane</td>
<td>.6-127</td>
</tr>
<tr>
<td>6.30C Signing for Auxiliary Lanes on Freeways,</td>
<td></td>
</tr>
<tr>
<td>Lane 1/2 Mile or Greater without Escape Lane</td>
<td>.6-128</td>
</tr>
</tbody>
</table>
Description | Page
---|---
6.309D Signing for Auxiliary Lanes on Freeways Lane 1/2 Mile or Greater with Escape Lane | 6-129
6.31 T-Intersection Signing (Two-Lane, Two-Way) | 6-130
6.32 Four-Leg Intersection Signing | 6-131
6.33 Local Road/Street Intersection Signing | 6-132
6.34 Single Lane Roundabout | 6-133
6.35 Named County Road Signing on an Expressway | 6-134
6.36 Community Recognition Signing | 6-135
6.37A Specific Service Signing - Typical Clarification Diagrams | 6-136
6.37B Specific Service Signing - Typical Clarification Diagrams | 6-137
6.38 Wayside Rest Signing | 6-138

List of Forms

Description | Page
---|---
6.1A Specific Services Application (front side) | 6-139
6.1B (back side) | 6-140
6.1C Specific Services Application, Page 2 (front side) | 6-141
6.1D (back side) | 6-142
6.2A Guide and Information Signs Application (front side) | 6-143
6.2B (back side) | 6-144
6.3A Adopt-A-Highway Application (front side) | 6-145
6.3B (back side) | 6-146
6.4A Adopt-A-Rest Area Application (front side) | 6-147
6.4B (back side) | 6-148
6.5 Community Destination Signing - Sample Resolution | 6-149

List of Charts & Tables

Description | Page
---|---
6-1A Guidelines for Type D Guide Signs | 6-151
6-1B Guidelines for Type D Guide Signs (cont.) | 6-152
6-1C Guidelines for Type D Guide Signs (cont.) | 6-153
6-1D Guidelines for Type D Guide Signs (cont.) | 6-154
6-1E Guidelines for Type D Guide Signs (cont.) | 6-155
6-2 U Post Structure Chart (3# Post) | 6-156
6-3 U Post Structure Chart (2.5# Post) | 6-157
6-4 Sign Post Spacing Chart | 6-158
6-5 Warning Sign Placement Chart | 6-159
6-6 Chevron Sign Spacing | 6-160
6-7 Ball Bank Angles for Safe Curve Speeds | 6-161
6-8A Requester Pays Signing Costs - Tables 1, 2 & 3 | 6-162
6-8B Requester Pays Signing Costs - Tables 4, 5 & 6 | 6-163
CHAPTER 6 - TRAFFIC SIGNS

6-1.00 INTRODUCTION

6-1.01 Purpose

Traffic signs regulate, warn, and guide motorists, pedestrians, and other traffic on all public roads. The traffic sign is the most commonly used traffic control device, and it is the oldest device for controlling, safe guarding, and expediting traffic. Signs are not ordinarily needed to confirm the basic rules of the road, but they are essential to inform highway users of specific regulations, to warn users where hazards are not self evident, and to furnish information and guidance.

The Minnesota Manual on Uniform Traffic Control Devices (MN MUTCD) provides legal standards, allowable limits, and alternatives for the design, use, and application of traffic signs. The purpose of this chapter is to describe typical applications and procedures related to placement of traffic signs on Mn/DOT streets and highways.

Since the basic principles of signing are set forth in the MN MUTCD and must be adhered to, the engineers, technicians, and maintenance personnel responsible for the design, selection, and placement of these devices should have ready access to and be familiar with the MN MUTCD.

6-1.02 Scope

This chapter covers general procedures for selecting proper traffic signs and implementing the correct installation of these devices. General principles of traffic signing and practical application guidelines are strongly emphasized.

The layouts show applications (selection and placement) of recommended traffic signs for typical situations which occur frequently. All distances shown on the layouts are approximate. Not all situations can be addressed; therefore, the applications shown must be considered and applied as directed by engineering judgment.

Although it is usually desirable to provide all traffic signs as shown in the layouts, situations arise where this becomes impractical. Engineering judgment may dictate modifications to the typical layouts. When modifications are made, factors such as traffic volume, speed, sign distance, right of way, etc. must be considered.

The major source documents for this chapter are the MN MUTCD, the Standard Signs Manual, and the Mn/DOT Standard Specifications for Construction. Individuals responsible for designing and fabricating signs should have access to and be familiar with these reference materials. Technical support on the design of guide signs is available from the Mn/DOT Office of Traffic, Safety, and Technology (OTST).

6-1.03 Chapter Organization

This chapter is organized into six major sections. These sections cover (6-3) legal authority for placing traffic signs, (6-4) general principles of traffic signing, (6-5) application guidelines for regulatory signs, (6-6) application guidelines for warning signs, (6-7) application guidelines for guide signs, and (6-8) application guidelines for miscellaneous signs. Preferred signing practice for construction and maintenance work zone traffic control is found in Chapter 8.
6-2.00 GLOSSARY

A-Frame - The combination of vertical flanged channel sign posts with knee braces and lateral framing to form an assembly to which a sign panel is mounted.

Attrition - The process of evaluating existing traffic control devices and removing and/or replacing devices that no longer meet standards through scheduled construction or routine maintenance activities.

Breakaway Supports - Supports designed to yield when struck by an errant vehicle, thereby minimizing injury to occupants of the vehicle and damage to the vehicle itself. Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals, published by the American Association of State Highway and Transportation Officials, indicates acceptable performance standards and dynamic test conditions.

Business Panel - A separately attached sign panel that shows, either individually or in combination, the brand, symbol, trademark, or logo of the business service.

Cone of Vision - A fan-shaped field of view extending in front of a vehicle operator.

Conventional Highway - A two-lane, two-way trunk highway.

Direct Applied - Adhesive-backed pressure sensitive retroreflective sheeting.

Expressway - A high speed, multi-lane highway which is generally an arterial road with the design speed 45 mph and greater. Two types of expressways exist, divided and undivided for both urban and rural sections. Most intersections are at grade, although grade separation and interchanges may be needed in some areas where high volume road or rail crossings exist, or terrain conditions favor grade separation.

Extruded Section - An aluminum channel substrate 6 inches or 12 inches in height.

Freeway - A divided highway with full control of access.

Iso-tacs - Lines of equal wind velocity given in various mean recurrence intervals.

Knee Brace - A flanged channel sign post attached diagonally to a riser post or a lateral brace to increase stability of the sign structure.

Legend - The message on the face of a sign panel. It includes all alpha-numeric text, arrows, route markers, and special symbols. Legends are made of retroreflective materials except where opaque black paints are prescribed for text on certain signs.

Local Road - Any road that is not a trunk highway.

Logo - A single or multicolored symbolic design unique to a product, a business, or a service facility used as a means of identification of a company's products, services, or business.

Metro District - The Mn/DOT Metropolitan District encompassing the eight-county Minneapolis-St. Paul Metropolitan Area.

Overlay - A thin, flat aluminum sheet with sign face material applied, which is bolted or pop riveted to a sign panel.

Primary Guide Signs (freeways only) - These signs consist of advance junction signing, exit directional signs, exit gore signs, destination, and distance signs. Exit numbers are included on interstate freeways.
**Screening Process** - Method of sign fabricating by screen printing with colored inks (pastes) over a given retroreflective sheeting.

**Sheeting, Encapsulated Lens Retroreflective** - A material utilizing retroreflective spherical lens elements adhered to a synthetic resin and covered by a smooth plastic surface (commonly referred to as High Intensity). See Mn/DOT Standard Specification 3352.2A2b.2

**Sheeting, Pressure Sensitive** - Retroreflective or non-retroreflective sheeting which has an adhesive backing that permits application of the sheeting to the substrate by pressure, and requires no heat, solvent, or other preparation for adhesion to smooth, clean surfaces.

**Sheeting, Prismatic Retroreflective (DG3)** - A material utilizing full cube corner lenses formed in a transparent, synthetic resin, sealed and backed with a pressure sensitive adhesive and blue poly liner.

**Sheeting, Wide Angle Prismatic Retroreflective for Visual Impact Performance (VIP)** - A material utilizing prismatic lenses formed in a transparent, synthetic resin, sealed and backed with a pressure sensitive adhesive and blue poly liner. This sheeting material has optimum performance over a broad range of observation angles.

**Shop Drawing** - Detail drawings of sign structures indicating materials used, dimensions, and fabricating processes.

**Sign Base Material or Sign Blank (Substrate)** - Sheet aluminum joined by backup splice plates, or extruded sections bolted together to form a flat surface.

**Sign Face Material** - Retroreflective or non-retroreflective sheeting material applied to the sign substrate.

**Spliced U-Post** - The combination of two flanged channel sign posts nested together and bolted to obtain the desired post length.

**Square Tube** - A square steel tube formed of 10 or 12 gauge steel rolled to size and welded in the corners. Tubes have holes spaced at one inch intervals on all four sides along entire length of tube.

**Stringer** - A lateral structural member forming a frame to which the sign panel is attached. They also may provide additional strength to the assembly. Type D signs generally utilize flanged channel sign posts as stringers.

**Supplemental Guide Signs** - Guide signs which further orient the driver to geographical identification and secondary destinations. Destinations include cities, motorist services, and state parks. Exit numbers are included on interstate freeway signs.

**Trunk Highway** - Any highway or segment of highway, including the interstates, under the jurisdiction of the State of Minnesota.

**U-Post (Flanged Channel Sign Post)** - A steel post of a channel or modified channel design, with flanges against which a sign panel will be placed. Holes are punched at a uniform spacing along the centerline of the back of the post.

**Windloading** - The pressure of the wind on the horizontal and vertical supports of a structure are given in Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals, published by the American Association of State Highway and Transportation Officials.
6-3.0 LEGALITY - LEGAL AUTHORITY FOR PLACEMENT OF TRAFFIC SIGNS

6-3.01 Traffic Signs Installed by Mn/DOT Maintenance Forces

Minnesota Statute (MS) 169.06, subd.2, provides that the Commissioner of Transportation (Commissioner) shall place and maintain traffic signs conforming to the MN MUTCD and the Mn/DOT Standard Specifications for Construction as deemed necessary to regulate, warn, or guide traffic on the Minnesota trunk highway system. Mn/DOT district traffic offices and maintenance forces act as agents of the Commissioner in this duty. Additional Statutes may also be applicable.

6-3.02 Traffic Signs Installed by Contract

Under the provisions of MS 161.32, subd.1, the Commissioner may elect to conduct sign installation work by construction contract rather than by maintenance forces. Additional statutes may also be applicable.

6-3.03 Traffic Signs Installed by Others by Maintenance Permit

Under the provision of MS 169.06 subd. 2, the Commissioner may authorize others to install approved traffic signs by maintenance permit (Mn/DOT Form 1723). All signs shall conform to the MN MUTCD, Minnesota Standard Specifications for Construction, this Manual, and any specific conditions outlined in the permit. District traffic engineers should approve all sign installations to ensure that all applicable standards and practices are followed. Additional statutes may also be applicable.

6-3.04 Temporary Traffic Control Signs Installed by Construction Contracts and Public Utility Companies at Work Sites

The MN MUTCD, Part 6, Temporary Traffic Control provides standards and guidelines for placing traffic control signs at work sites to protect the public, workers, and equipment. Section 6A covers the legal responsibility of authorities having jurisdiction to comply with the requirements of Part 6.

6-4.0 GENERAL PRINCIPLES OF TRAFFIC SIGNING

6-4.01 Principles of Traffic Control Devices

As stated in the MN MUTCD Section 1A.2, in order for traffic signs to be effective, they should meet the following basic requirements:

1. Fulfill a need.
2. Command attention.
3. Convey a clear, simple meaning.
4. Command respect from road users.
5. Give adequate time for proper response.
6.4.02 Basic Considerations for Installation of Traffic Signs

As stated in the MN MUTCD, and summarized in the Transportation and Traffic Engineering Handbook (published by the Institute of Transportation Engineers) five basic considerations are employed to ensure that the above basic requirements are met. These considerations are:

1. Design: the combination of physical features such as size, colors, and shape needed to command attention and convey a clear message.

2. Placement: the installation of devices should be within the viewer's cone of vision, so they will command attention and allow time for response.

   A 20 degree cone of vision should be used for placement of signs. Signs must remain within this cone of vision to be read. Care should be taken when placing signs near intersections so that they do not restrict intersection sight distance.

3. Operation: the application of devices so that they meet traffic requirements in a uniform and consistent manner. Devices should fulfill a need, command respect, and allow time for proper response.

4. Maintenance: the upkeep of devices to retain legibility and visibility, the removal of devices if not needed, and to aid in commanding respect and attention while fulfilling the needs of users.

5. Uniformity: the uniform application of similar devices for similar situations so that they fulfill the needs of users and command their respect. **The importance of uniformity in signing cannot be overemphasized.**

6.4.03 Functional Classifications of Traffic Signs

The MN MUTCD classifies signs by their functional usage as follows:

1. Regulatory signs inform highway users of traffic laws or regulations and indicate the applicability of legal requirements that would not otherwise be apparent.

2. Warning signs are used to call attention to hazardous conditions, actual or potential, on or adjacent to a highway or street that would not be readily apparent to the motorist.

3. Guide signs are used to provide directions to motorists, informing them of intersecting routes, directing them to cities and other important destinations, and guiding them to available services, points of interest, and other geographical, recreational, or cultural sites.

Further, guide signs for expressways and freeways have two sub classifications:

1. Primary guide signs consist of advance junction signing, exit directional signs, exit gore signs, destination, and distance signs. Exit numbers are included on interstate freeway signs.

2. Supplemental guide signs further provide the driver geographic orientation and secondary destinations at certain interchanges. Destinations include cities, motorist services, or state parks. Exit numbers are included on interstate freeway signs.
6-4.04 Department Classification by Sign Design Type

While the previous sign classifications describe general functions, Mn/DOT has further classified signs by design type.

Type A signs are large breakaway guide, directional, or informational signs normally installed on mainline freeways, expressways, and occasionally on conventional highways. They are supported on wide-flange steel posts.

Type C signs are primarily regulatory, warning, route marker assemblies, and auxiliaries, as found in the Standard Signs Manual. They are the most common sign type and are typically installed by Mn/DOT sign crews.

Type D signs are the smaller guide, destination, or informational signs. They are supported on driven U posts or mounted on overhead structures with punching and stringer spacing as indicated in the Standard Signs Manual.

Type OH signs are large overhead guide, directional, or informational signs, either spanning a roadway, cantilevered over the roadway/shoulder, or bridge-mounted. The requirements of the structural support system generally require installation or maintenance by contract. There are three kinds of Type OH signs: 1) sign support (no walkway or sign lighting), 2) truss (may or may not include walkway and sign lighting) and 3) bridge-mounted (may or may not include walkway and sign lighting).
Type OH signs are necessary where ground-mounted signs are not deemed effective. Typical applications include, but are not limited to, the following:

1. Freeway signing where space is not available for ground mounted signs or where there are three or more lanes of travel.

2. Guide and/or lane use control signing approaching intersections in urban areas.

3. Approach warning sign/flashing for mid-block pedestrian crosswalks.

4. Locations with restricted sight distance (may be coupled with other factors cited).

Type EA signs are exit number panels attached with U-posts to Type A sign panels.

Type EO signs are exit number panels attached with U-posts to Type OH sign panels.

Changeable Message Signs (CMS) may be used to inform the road user of special conditions about advisory situations, traffic congestion, or safety messages as determined by the district traffic engineer.

6-4.05 Elements of Traffic Sign Design

Elements of sign design include shape, color, size, legend, border, retroreflective properties, illumination, and uniformity. These elements are discussed in the MN MUTCD; however, some permitted alternatives are as follows.

If there is more than one sign panel on an overhead sign structure and the sheeting is being replaced on one sign panel, the sheeting shall be replaced on all of the sign panels.

6-4.05.01 Shape

Sign shapes should be designed as stated in the MN MUTCD, except that it is the policy in Minnesota to use the rectangular shape (rather than trapezoidal) for recreation area signs.
6-4.05.02 Color

The color of signs, legends, and borders are specified in the MN MUTCD.

Mn/DOT policy is that all warning signs shall be fluorescent yellow, except for the following which shall be fluorescent yellow-green:

1. BICYCLE CROSSING (W11-1) sign.
2. PEDESTRIAN (W11-2) sign.
3. SCHOOL (S1-1) sign.
4. ADVISORY SPEED (W13-1) plaque, AHEAD (W16-9P) plaque, DISTANCE (W20-100P) plaque, and the DOWN ARROW (W16-7p) plaque when used with the BICYCLE CROSSING, PEDESTRIAN, and SCHOOL signs.
5. SCHOOL (S4-3) plaque.
6. SCHOOL SPEED LIMIT (S5-1) sign.

6-4.05.03 Size

The sign dimensions are specified in the MN MUTCD and Standard Signs Manual. Increases above these standard sizes are desirable where greater legibility or emphasis is needed. Special designs or large signs are prescribed for use on freeways and expressways. Standard shapes and colors shall be used and standard proportions shall be retained for enlarging signs insofar as practicable. The overall dimensions of sign panels should be in 6-inch increments. The use of smaller than standard size signs may sometimes be justified under the guidelines specified in the MN MUTCD.

6-4.05.04 Legend

Mn/DOT's preferred practice is to use symbol messages when the MN MUTCD allows the use of word messages as alternatives to symbols.

New warning or regulatory symbol signs not readily recognizable by road users should be accompanied by an educational plaque which is to remain in place for at least three years after initial installation.

It is Mn/DOT policy to use upper/lower case lettering on all guide signs with proper name destinations.

The SignCAD program is currently used by Mn/DOT staff in designing guide signs. Contact OTST for technical assistance in the design of guide signs and usage of this program.

See Charts 6-1A, 6-1B, 6-1C, 6-1D and 6-1E for guidelines to determine Type D Guide Sign panel riser and format. These charts give the current recommended letter sizes based on roadway type and posted speed.

6-4.05.05 Retroreflective Sheeting Policy

Retroreflective sheeting requirements for object markers and delineators can be found in Chapter 7. Retroreflective sheeting requirements for construction, maintenance, utility, and incident management operations can be found in Chapter 8.

All Mn/DOT signs shall use DG3 prismatic sheeting except for signs installed under contract. Contract specifications shall allow the use of either ASTM Type IX or DG3 prismatic sheeting.
6-4.05.06 Sign Lighting

Driving on freeways and expressways is a complex and demanding task. Communication with the driver by signing is in constant competition for the driver's attention, particularly in the urban environment. As a countermeasure, overhead signs are typically utilized on urban area freeways.

The following guidelines were developed as a result of studies and field trips. Generally, overhead sign lighting is not needed. Each district shall conduct a field review to determine if it is necessary to light overhead signs. During the field review of each site, viewing of the signs should be made only with low beam vehicle headlights. Also, it is recommended that personnel unfamiliar with the sign message be part of the review team to ensure the most objective decision possible.

By turning off or not installing overhead sign lighting, Mn/DOT benefits by reducing energy and maintenance costs while maintaining adequate sign legibility.

Any one of the following guidelines may make it necessary to light overhead sign panels:

1. Advertising devices and/or lighting sources competing for drivers' attention.

2. Engineering judgment based on various factors including, but not limited to:
   a. At least 650 foot legibility distance.
   b. At least 1000 foot detection distance.
   c. Roadway and interchange geometrics.
   d. High weaving traffic volumes.
   e. Three or more overhead mounted sign panels on the same sign structure facing one direction of traffic (sign message overload).
   f. Number of lanes (horizontal and vertical alignment).
   g. Major forks.
   h. Skewed bridge crossings.
   i. Horizontal curves.

3. High density fog areas.

4. Roadway lighting located in close proximity to overhead signs causing glare from the sign panels.

5. Regulatory and diagrammatic signs.

Sign lighting shall be provided for all sign panels if one sign panel on a sign structure requires lighting.

The details of sign lighting are discussed in Chapter 10, Lighting.
6-4.06 Sign Design Type Classification

6-4.06.01 Type A signs
1. Support system - poured concrete footings or driven structural steel H-piles to support breakaway wide-flange steel posts.
2. Sign panels - bolted extruded aluminum sections covered with sheet aluminum and direct applied retroreflective legend. The sign panel is attached with post clips to wide flange steel posts.

6-4.06.02 Type C signs
1. Support system - ground-mounted signs are spliced or single U-posts driven into subsoil, attached to a bridge railing utilizing O-posts, or banded to traffic signal pedestals or mast arm poles. Unsupported length and sign panel area determines number of U-posts and need for stringers and/or knee bracing.
2. Sign panel - sheet aluminum with direct applied retroreflectorized or screen processed legend. Punching is specified in the Standard Signs Manual.

6-4.06.03 Type D signs
1. Support system - same as Type C signs but generally supporting greater sign panel area. They may be affixed to a bridge railing, traffic signal mast arm, etc.
2. Sign panel - same as for Type C signs but splice plates may be required as specified in the Standard Signs Manual.

6-4.06.04 Type OH signs
1. Support systems
   a. Sign support - Poured concrete shaft footing(s) supporting a sign bridge or cantilever structure with a single horizontal support for attaching sign panels.
   b. Truss type - Poured concrete spread, shaft or median barrier footings supporting a sign bridge or cantilever structure. The horizontal truss supports panel mounting posts for attaching sign panels. The horizontal truss may incorporate a walkway and sign lighting system.
   c. Bridge Mounted - Truss system attached to a bridge which includes sign panel supports for attaching sign panels. The truss may incorporate a walkway and sign lighting system.
2. Sign panels
   a. Sign support - sheet aluminum with direct applied retroreflective legend. The sign panel is bolted to a sign bracket assembly.
   b. Truss Type and Bridge Mounted - bolted extruded aluminum sections covered with sheet aluminum and direct applied retroreflective legend. The sign panel is attached with post clips to the panel mounting posts.
6-4.06.05 Traffic Signal Mast Arm Signs

1. General

These signs are designed specifically to be mounted on traffic signal mast arms. Signs are limited in size due to wind loading factors considered in the design of these structures.

Figure 6.24 shows typical mast arm signing.

2. Internally lit street name signs

Mn/DOT's practice is to install sheet aluminum sign panels on traffic signal mast arms. Internally lit street name signs may be installed by a road authority. The local road authority shall be responsible for all costs of fabrication, installation, power, and maintenance. Mn/DOT may require that internally lit signs be removed and replaced with standard sheet aluminum if a major problem develops, e.g. driver distraction that causes accidents.

a. General criteria

An internally lit street name sign may be displayed on the same mast arm with sheet aluminum signs (regulatory, warning, and guide signs).

Shop drawings of internally lit street name signs shall be submitted to OTST for review and approval.

b. Sign housing

The sign housing should be either aluminum or stainless steel. All exterior hardware on the housing (hinges, hinge plates, bolts, nuts, and washers) shall be stainless steel.

There shall be a minimum of two rows of fluorescent lamps installed in each internally lit street name sign. One row of lamps will be wired for standby operation. In the event the main row of lamps fails, the second row of lamps can be activated either automatically or manually by a switching device. Ground access to manual switches should be provided.

The fluorescent lamps should be sized to provide no more than 1.5 to 2 watts per square foot of sign face.

c. Sign face

The sign face shall use translucent diamond grade retroreflective sheeting for the sign background. If the road authority has an established community-wide color scheme (green, blue, or brown) for the background color of street name signs, the background color of the internally lit street name sign may use this color. No other colors will be approved.

The sign legend may be screened or cut from translucent diamond grade retroreflective sheeting. In the event of a complete lamp outage, the retroreflectivity of this material provides a fail-safe operation.

The legend (letters and arrows) on internally lit street name signs shall be white. No border is required since the sign face is framed by the sign housing.

Standard letter sizes, series, and spacing shall be used. In the event a route marker is to be displayed, it shall be of the standard size, 24" x 24" unless mast arm loading becomes critical. In this case, an 18" x 18" route marker shall be installed.
6-4.07 Lateral Offset and Vertical Clearance Requirements

6-4.07.01 Type A Signs
See Figure 6.1 for normal lateral offsets and vertical clearances.

The typical placement for Exit signs (E5-1 and E5-1a), Merge signs (W4-1) and Added Lane sign (W4-3) is also shown on Figure 6.1.

6-4.07.02 Type C and Type D Signs
See Figure 6.2 for normal lateral offsets and vertical clearances.

6-4.07.03 Type OH Signs
1. The lateral placement of sign panels is the relationship of the sign panel to the lane. This is to ensure that the sign message will be correctly interpreted by motorists and proper lane assignment is achieved. Even a small error in placement can have a detrimental effect on traffic operation and sign message clarity.

The lateral offset of sign posts is normally 7.5 feet from the edge of shoulder or the face of curb to the center of the post. Post locations and guardrail requirements will be in accordance with the current edition of the Road Design Manual.

2. The minimum vertical clearance over the high point of the roadway or mountable curb shall be 17.33 feet.

6-4.08 Sign Installation and Maintenance Practices

6-4.08.01 Sign Installation Practice
1. Utilities and underground traffic control components

Care should be exercised in the installation of signs with respect to underground and overhead in place public service utilities. In addition, care should be taken when working around traffic control devices and communication installations such as signal system cables, signal interconnection conduit systems, surveillance cables, roadway lighting electric cables, and traffic counting cables. The Regional Traffic Management Center (RTMC) should be contacted whenever installation is planned on a freeway within the Metro Area.

Minnesota Statute 216D requires anyone who engages in any type of excavation to provide advance notice of at least 48 hours to underground facility operators who may be affected by the excavation. Excavation means an activity that moves, removes, or otherwise disturbs the soil by use of a motor, engine, hydraulic or pneumatically-powered tool, or machine-powered equipment of any kind, or by explosives.

Gopher State One-Call is a statewide one-call notification system which was established as a result of Minnesota law to inform all Minnesota underground facility operators of intended excavation. Gopher State One-Call is open 24 hours a day, seven days a week. Calls after 5:00 p.m., before 7:00 a.m., on weekends, and on holidays are accepted for emergencies only. An emergency is defined by state law as "A condition that poses a clear and immediate danger to life or health or a significant loss of property."

PHONE NUMBERS
Twin Cities Metro (651) 454-0002
In or Out State-Toll Free (800) 252-1166

WEBSITE
http://www.gopherstateonecall.org/
A free brochure is available and should be obtained by personnel responsible for installing sign structures in the ground.

2. Sign groupings

Traffic signs of different functional classification should not be mixed in a given sign installation.

It is not always feasible to erect signs separately in urban areas where mounting space is limited and visibility problems occur. In such cases, a sign of major importance may be placed above a relatively small sign of routine or secondary significance. However, if the design of the individual panels could mislead or confuse the motorist, this practice should be avoided.

3. Spacing of signs

General - Signs in a series must be uniformly spaced so that a driver traveling at normal speed has adequate time for the proper response (MN MUTCD, Section 1A.2). Since one of the primary objectives of traffic signing is to convey a needed message to motorists, care should be taken to provide compatible and effective sign spacing and avoid reliance strictly on minimum distances unless absolutely necessary. As a rule of thumb for guide signs, every one inch of capital letter text height is equivalent to 40 feet of legibility distance.

Rural Areas - Sign spacing in rural areas should not be less than the distance required to read each sign at the upper range of anticipated vehicle approach speeds. For minimum recommended distances between signs of different purposes on rural thru two-lane, two-way highways see Figures 6.31, 6.32, and 6.33.

Urban Areas - In urban areas with speed limits of 30 mph or less, the minimum desirable distance between signs is approximately 100 feet.

Freeways - Although conditions may exist where lesser sign spacings will be found necessary, freeway guide signs should be spaced at least 800 feet apart. A spacing of at least 400 feet should be provided between guide signs and all other types of signs on freeways.

Double Signing - If sign spacing approaches the minimum desirable distance, double signing (right and left shoulder) may be utilized. Double signing should be used if the number of traffic conflicts is high.

4. Specular glare

Care should be exercised in the placement of ground-mounted and overhead signs to reduce the problem of mirror reflection. This reflection is known as specular glare and is caused by motor vehicle headlights at night. Specular glare renders the sign useless by making the message impossible to read.

Normally signs should be mounted approximately at right angles to the direction of, and facing, the traffic that they are intended to serve.

Where mirror reflection from the sign face is encountered in such degree as to reduce legibility, the sign should be turned slightly away from the road. At curve alignments, the angle of placement should be determined by the course of approaching traffic rather than by the roadway edge at the point where the sign is located. Sign faces normally are vertical, but on grades it may be desirable to tilt the sign forward or back from the vertical to improve the viewing angle.
5. Windloading

AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals (current edition), governs the design of all permanent signing installations prepared for construction contract letting. Briefly, AASHTO specifies iso-tacs and corresponding wind pressures on sign panels as follows:

All ground-mounted and overhead signs shall be designed for a 50 year mean occurrence interval, which results in 90 mph wind speeds for Minnesota.

6. A-Frame and U-Post mountings

Assuming an average distance of ten feet from the bottom of the sign panel to the ground line, the correct sign structure design and post spacing shall be determined by using Charts 6-2, 6-3, and 6-4.

To use these charts, first determine the total length of the sign panel. Then, determine the height of the sign panel or add the heights of all of the individual sign panels to be mounted on the same sign structure. Based upon these dimensions (in inches), select either Chart 6-2 or Chart 6-3, depending upon the weight of the U-posts to be used for the sign structure. After determining the correct number of riser posts to be used for the sign structure, refer to the punch codes in the Standard Signs Manual for the spacing from center to center of posts. If there is no punch code or the sign structure is unique, then refer to Chart 6-4 to determine riser post (center to center) spacing.

In lieu of using two riser posts (in accordance with Chart 6-2 or Chart 6-3) for a sign panel, one riser post may be used for any of the following conditions:

a. Rocky soils where holes are drilled for sign posts.
b. Concrete sidewalk or median.
c. Protected area experiencing low wind speeds.
d. Urban location
e. Other locations where the placement of two riser posts is impractical.

On a sign assembly with three or more riser posts, the posts and knee braces shall be spaced at least 45 inches on centers.

Sign structures using U-posts shall be assembled according to the details shown in Figures 6.3A, 6.3B, and 6.3C. These details were designed based on crash tests conducted at Texas Transportation Institute in 1988 and 1989.

Sign bracket and details are shown in Figures 6.3D and 6.3E.

6-4.08.02 Sign Maintenance Practice

1. Recurring maintenance schedule

Each maintenance area is charged with implementing recurring sign maintenance. A recurring maintenance schedule should be developed using a maximum 12 year cycle for encapsulated lens sheeting and a 15 year cycle for VIP and DG3 sheeting (unless field performance studies coordinated by OTST staff determine otherwise). In order to monitor the performance of the retroreflective qualities of in place signs, each district should conduct periodic nighttime retroreflectivity observations. This review shall include all signs on Mn/DOT right-of-way facing traffic entering from local roads. See the Mn/DOT Maintenance Manual for those procedures.
2. Traffic sign management system

Each district is charged with developing and maintaining a field inventory in accordance with the statewide sign management system. The development of a comprehensive field record of all signs is vital to sound maintenance management practice and budgets.

3. Missing or damaged signs

Mn/DOT is responsible for replacing all damaged or missing signs, except Logo signs, on the trunk highway system. Generally, STOP, YIELD, and DO NOT ENTER signs have the highest priority for replacement. These signs warrant weekend or overtime work for repair or replacement. Other signs should be evaluated on a case by case basis to determine relative priority. However, each district should develop a procedure for dealing with reports of damaged or missing signs to assure the prompt replacement of critical signs.

6-4.09 Implementation of Signing

Each district shall decide whether signs should be installed by maintenance personnel or by contract. The following reasons usually justify the installation of signs by contract:

1. Need for breakaway supports.
2. Overhead or Type A guide sign installations.
3. Scope of work beyond capability of district forces.
4. Safety reasons.
5. Extensive need for refurbishment.

Installation of signs by maintenance personnel is generally authorized by a District Traffic Work Order (DTWO).

6-4.09.01 Work Programming

Each district shall program any work to be done by contract.

6-4.09.02 Preliminary Design

1. Work authorization

   The district shall request a charge identifier.

2. Preliminary plan

   The district shall prepare a preliminary signing plan for new roadway construction. The preliminary plan shall be transmitted to the OTST Signing Unit for review and comment. The district shall also transmit a copy of the plan to any involved municipalities.
6-4.09.03 Detailed Design

Standard detail sheets for signing plans can be found on the OTST website:

http://www.dot.state.mn.us/trafficeng/

The plan format and sequence of details shall, generally, be as follows:

1. Title sheet.
2. Estimate of quantities.
3. Sign data sheets giving pertinent information for each sign.
4. Sign lighting, delineation, and traffic barrier data sheets.
5. Roadway plan sheets showing signing for mainline and interchanges.
6. Sign panel drawings for all non-standard signs.
7. Standard details.
8. Structural details.
10. Cross sections for Type A and Type OH signs

6-4.09.04 Special Provisions

Disposition of salvaged material and specialty items shall be specified in the Special Provisions of a contract. Each district should determine if sign structures should be salvaged and re-installed.

1. The district or OTST, if requested, shall be responsible for writing the special provisions for items which are not fully covered in the Standard Specifications, including description of work, material requirements, construction requirements, method of measurement, and basis of payment. OTST may provide technical assistance.

2. Other items which shall be included in the Special Provisions are traffic provisions, time schedule, and information regarding concurrent contracts.

6-4.09.05 Cost Estimating

If requested, OTST will provide cost estimates.

6-4.09.06 Construction Activities

1. Inspection

Generally, all materials designated for use on state projects are subject to requirements covered by the Mn/DOT Standard Specifications for Construction, the plan, and the special provisions included in the contract proposal. Sampling, testing, and inspection of all materials shall be done in accordance with the provisions of Mn/DOT 1603.

2. Technical assistance

OTST shall provide technical assistance to district project personnel, as requested. Also, OTST shall inform the Project Engineer of any contacts initiated by suppliers, etc., concerning project matters.
3. Placement of signs

Type OH and Type A signs shall be located at plan stationing unless field conditions require relocation. Dimensioned elevation drawings of each sign and roadway cross section shall be included in the plan.

The importance of the positioning of overhead sign panels cannot be overemphasized. Project personnel shall notify the State Signing Engineer if panel placement is not as intended, or if the overhead sign location is to be changed.

Type A signs, excluding the exit direction sign (placed at the beginning of the deceleration taper) may be moved longitudinally up to 100 feet without generally affecting the sign system requirements.

4. Project critique

Prior to job acceptance, the district traffic engineer, project engineer, and designer should critique the project. This critique should include construction problems and improving methods or procedures, condition of materials incorporated in the project, and workmanship.

6-4.09.07 Post-Contract Activities

OTST is a source of certain information as follows:

1. District personnel often have the opportunity to observe in place signing. Apparent failures in materials should be reported to the State Signing Engineer so that field observations may be made.

2. A report of the district's recurring structural inspection procedure findings, Form 17267, shall be forwarded to OTST.

3. OTST is a source of annual quantities, unit prices, and other tabulations concerning contract signing items.

6-5.0 APPLICATION GUIDELINES-REGULATORY SIGNS

6-5.01 Purpose

Generally, the only regulatory sign applications that are discussed in this Section are those which:

1. Are not specifically addressed in the MN MUTCD.

2. Provide additional guidance to that given in the MN MUTCD on application, location, and usage of certain types of regulatory signs.

3. Establish procedures relating to engineering and traffic investigation requirements for certain regulatory signs.

6-5.02 Typical Sign Placement

The MN MUTCD, Section 2B illustrates typical positions for a number of regulatory signs.

Figures 6.4 through 6.10 show typical signing arrangements for the various intersection geometric elements encountered at divided highway intersections.

Figure 6.11 shows typical regulatory and warning signing for right-in and right-out intersection.

Figure 6.12 shows typical regulatory signing for highway intersection with a one-way street or ramp.

Appropriate signing for private and low volume entrances is the responsibility of each district. Therefore, each location needs to be reviewed on a case by case basis. This allows the flexibility to deny or install signing depending on the entrance specifics.
In order to clarify and ensure uniform application for installation and maintenance of signing at entrances with trunk highways, the following guidelines are provided:

1. Private house or farm entrance

   Stop signs and/or other signing should not normally be installed. If any extraordinary condition exists, the signing shall be installed by the district in accordance with State standards. Maintenance will be performed by Mn/DOT.

2. Low volume entrance

   a. If the entrance serves a single business, stop signs and/or other signing should not be installed unless a field investigation reveals that an extraordinary condition exists. If warranted, the signing shall be installed, either by the business (by permit) or by the district, in accordance with State standards. Maintenance will be performed by Mn/DOT.

   b. If the entrance serves several small businesses (e.g., a small strip mall), a field investigation should be conducted to determine if a stop sign or other signing is warranted based upon high traffic volumes, restricted sight distance, crash experience, intersection geometrics, pedestrian activity, etc.

      1) Signing at an entrance for existing businesses, if warranted, shall be installed, either by the business (by permit) or by the district, in accordance with State standards. Maintenance will be performed by Mn/DOT.

      2) Signing at an entrance to a proposed new development, if warranted, shall be installed by the developer in accordance with State standards. Maintenance will be performed by Mn/DOT.

3. High volume entrance

   Stop signs are required at each entrance. Other regulatory signs may be required depending on the highway type. A field investigation may be necessary to determine if any additional signing is warranted.

   a. Signing at an entrance for an existing high volume business shall be installed either by the business (by permit) or by the district, in accordance with State standards. Maintenance will be performed by Mn/DOT.

   b. Signing at an entrance to a proposed new high volume business shall be installed by the developer in accordance with State standards. Maintenance will be performed by Mn/DOT.
6-5.03 Bridge Speed and Load Restrictions

Posting requirements for bridges on trunk highways are determined by the Bridge Office.

1. BRIDGE SPEED LIMIT Sign (R2-X5)

Use and application of this sign is stated in the MN MUTCD, Section 2B.13.1. The Bridge Office shall inform the district traffic engineer when a reduced speed zone is needed on a bridge or other elevated structure based on an engineering investigation. The district traffic office shall process the Speed Limit Authorization following Mn/DOT’s standard procedure and install the appropriate BRIDGE SPEED LIMIT signs.

2. Bridge Weight Limit Sign (R12-5)

Use and application of this sign is stated in the MN MUTCD, Section 2B.49.1. This sign shall be installed either on or immediately in advance of the bridge or structure that is restricted. The Bridge Office shall determine the proper weights to display on the sign and inform the district traffic engineer.

3. BRIDGE WEIGHT LIMIT Supplement Sign (R12-5 Supplement)

The BRIDGE WEIGHT LIMIT Supplement sign shall be installed well in advance of bridges or structures that are restricted. Signs should be placed at the nearest intersecting road or wide point in the road at which a vehicle can detour or turn around. The BRIDGE plaque shall be installed above and MILE plaque shall be installed below the BRIDGE WEIGHT LIMIT (R12-5) sign. Both plaques shall have a black legend and border on yellow retroreflectorized background.

4. WEIGHT RESTRICTION AHEAD Sign (W14-X3)

The WEIGHT RESTRICTION AHEAD sign shall be installed where it is necessary to inform drivers of vehicles that there is a weight restriction ahead.
6-5.04 Bus Shoulder Sign (R4-X7)

Authorized buses are allowed to drive on designated shoulders on freeways and expressways in the Metro District. Typical signs and locations are shown in Figure 6.16.

The SHOULDER AUTHORIZED BUSES ONLY (R4-X7) sign shall be used to designate shoulders for bus use. The BEGIN/END (R4-X7p) plaque shall be used at the beginning and end of each section.

Where the shoulder width is less than ten feet (11.5 feet on bridges) for a distance less than 1000 feet, the merge sign for buses (W14-X10) shall be installed at the beginning of this restricted width. In locations where there is insufficient shoulder width for 1000 feet or greater, the END and BEGIN plaques shall be used with the SHOULDER AUTHORIZED BUSES ONLY sign.

The WATCH FOR BUSES ON SHOULDER (W14-X9) sign shall be placed on all freeway ramps, intersecting city, township, and county roads, and high volume entrances. These signs should not be installed for low volume entrances and private drives.

6-5.05 BYPASS LANE Sign (R4-X8)
BYPASS & TURN LANE Sign (R4-X8a)

See Chapter 7 for striping of bypass lanes.

See Figure 6.17 for the typical signing of bypass lanes.

Bypass lanes shall be signed in accordance with the following guidelines:

1. T-intersections - the 30" x 30" BYPASS LANE sign shall be installed at the beginning of the taper of the bypass lane.

2. Four-legged intersections - the 30" x 30" BYPASS & TURN LANE sign shall be installed at the beginning of the taper of the combined bypass/turn lane.

6-5.06 DO NOT PASS Sign (R4-1)

Mn/DOT policy is to use the NO PASSING ZONE (W14-3) pennant sign (48" x 60" x 60"). This does not preclude use of the DO NOT PASS sign where it is deemed necessary based on engineering judgment.

6-5.07 Intersection Lane Control Sign (R3-8)

The Intersection Lane Control sign (R3-30AD) may be used at a four-legged intersection with a through two-lane, two-way highway, a public street, and a private driveway if the following conditions are met:

1. The left turn lane from the through trunk highway to the public street is striped, and
2. The adjacent through lane of the trunk highway also functions as a right turn lane to a private entrance. The private entrance is required to have a STOP sign for controlling traffic entering the trunk highway. The private entrance serves a private residence, commercial business, or development.
6-5.08 ONE WAY Sign (R6-1)

This section clarifies the recommended use and minimum size of ONE WAY signs (R6-1) on Mn/DOT trunk highways.

1. 36” x 12”
   This is the standard size for conventional highways. The sign should be installed above 30” x 30” and 36” x 36” STOP signs and either independently or on traffic signal poles or pedestals at signalized intersections.

2. 48” x 18”
   The sign should be installed:
   a. Above 36” x 36” STOP signs on all city, township, or county roads and conventional highways intersecting expressways.
   b. Above all 36” x 36” YIELD signs in medians on expressways
   c. On independent sign structures viewed by motorists crossing expressways
   d. Other locations as directed by the district traffic engineer.

6-5.09 RIGHT LANE MUST TURN RIGHT Sign (R3-7) LEFT LANE MUST TURN LEFT Sign (R3-7)

RIGHT/LEFT TURN LANE signs shall be removed through attrition unless otherwise noted.

The RIGHT/LEFT LANE MUST TURN RIGHT/LEFT sign shall be installed in accordance with the following guidelines:

1. Conventional highways
   a. If the ADT is less than 2500 or the posted speed limit is 40 mph or less, the use of a RIGHT/LEFT LANE MUST TURN RIGHT/LEFT and/or lane-use pavement arrow to identify turn lanes on highways is optional.
   b. If the ADT is 2500 or greater or the posted speed limit is 45 mph or greater, all turn lanes shall be signed. If any one existing RIGHT/LEFT TURN LANE sign requires replacement, replace all turn lane signs at the intersection with the appropriate RIGHT/LEFT LANE MUST TURN RIGHT/LEFT sign.

2. Interchange exit ramps
   a. All turn lanes shall be signed unless the turn lane(s) is(are) included on an EXCLUSIVE LANE USE (R3-8) sign(s).
   b. If an exit ramp has a right turn lane signed with a RIGHT TURN LANE sign and a left turn lane signed with a LEFT TURN LANE sign, and either sign requires replacement before the end of its useful life, replace all turn lane signs on the exit ramp with RIGHT/LEFT LANE MUST TURN RIGHT/LEFT signs or EXCLUSIVE LANE USE signs.
   c. See Figures 6.18A and 6.18B for typical EXCLUSIVE LANE USE signs on ramps.

3. Expressways
   a. If the posted speed limit is 40 mph or less, the use of a RIGHT/LEFT LANE MUST TURN RIGHT/LEFT sign to identify turn lanes on highways is optional.
   b. If the posted speed limit is 45 mph or greater, sign all turn lanes based on the district sign replacement cycle. Adjoining districts should coordinate installing RIGHT/LEFT TURN LANE MUST TURN RIGHT/LEFT signs within the same time frame on those highways that cross district boundaries. If any one RIGHT/LEFT TURN LANE sign requires replacement before the end of its useful life, replace all turn lane signs at the intersection.
6-5.10 SLOWER TRAFFIC MOVE RIGHT Sign (R4-3a)

The SLOWER TRAFFIC MOVE RIGHT signs advise slower motorists to move into the right or slower lane on Interstate roadways throughout the state.

These signs were installed to educate motorists of Minnesota Statute 169.18, subd. 1 which states that vehicles should be driven on the right unless:

1. Passing another vehicle
2. The right lane is closed to traffic during road construction or repair
3. On three-lane or one-way roads.

6-5.11 Speed Zone Signing

Speed zone signs should be installed in the most advantageous locations to promote driver compliance. Speed zone signs should be installed according to the following criteria.

6-5.11.01 Speed Limit Sign (R2-1)

A Speed Limit sign shall be installed at the terminal points of each speed zone.

The first Speed Limit sign in a lower speed zone shall be one size larger than the supplemental lower speed zone signs. Supplemental Speed Limit signs may be installed at intervals approximately equal to 60 seconds of travel time at the posted speed.

Signs should be posted near junctions that are major traffic generators. Closer spacing may be used in urban areas due to numerous access points. Signs may be spaced further apart in rural areas where the character of the roadway remains constant.

6-5.11.02 Minimum Speed Limit Sign (R2-4b)

1. General

The Minimum Speed Limit sign shall be used on all freeways designated as interstates. The minimum speed limit should be 40 mph unless a traffic investigation identifies a unique traffic pattern justifying a different value. The minimum speed shall be omitted whenever there are warning signs with advisory speeds advising motorists of a value lower than the minimum. The minimum speed limit should resume after the hazard is passed.

Signs should be installed downstream of all entrance ramps. If sign spacing criteria cannot be met due to high sign density in urban areas, the Minimum Speed Limit sign should be placed at the first available location. The next smaller sign size may be used where proper lateral clearances cannot be achieved.

2. Rural interstates

On rural interstates located outside the limits of urbanized areas (population greater than 50,000 as defined by the Commissioner) the 48" x 96" Minimum Speed Limit sign shall be used. The speed limit shall be 70 mph. The spacing between signs should not exceed ten miles. Signs should be installed downstream of all entrance ramps.

3. Urban interstates

On urban interstates the 48" x 96" Minimum Speed Limit sign shall be used. The speed limit shall not exceed 70 mph. A 48" x 60" Speed Limit (R2-1) sign may be used if a traffic investigation determines that a minimum speed limit is not required.
6-5.12 STOP Sign (R1-1)

This section clarifies the recommended use and minimum size of STOP signs on Mn/DOT trunk highways.

1. Primary location
   a. 30” x 30”
      Install on all two-lane, two-way city, township, or county roads intersecting a conventional highway.
   b. 36” x 36”
      Install at the following locations:
      1) Freeway/expressway ramps.
      2) Conventional highways.
      3) City, township, or county road with more than one through lane of approach to an intersection.
      4) All two-lane, two-way county, city or township roads and conventional highways intersecting expressways

2. Additional location (left side)
   Install on any road with more than one through lane of approach to an intersection based on a traffic engineering study. Justification may be based on unusual roadway geometrics, sight restrictions, or crash problems. Sign size shall not exceed the size of the STOP sign mounted on the right side of the road.

6-5.13 Two-Way Snowmobile Trail Signing

Signing of Mn/DOT permitted two-way snowmobile trails within trunk highway right-of-way, which will be the responsibility of the Department of Natural Resources, shall be in accordance with the following:

1. The 18” x 24” sign panel shall be black legend and border on white background.
2. The sign panel shall display BEGIN and END plaques (18” x 6”) in black legend and border on white background above the two-way sign panel, designating the beginning and end of the two-way trail.
3. A 3” x 3” piece of yellow retroreflective sheeting shall be attached in the lower left corner on the back of the sign panel.
4. The sign post shall be on the FHWA approved listing of breakaway posts to support the sign panel at a mounting height of five feet.
5. The sign shall be installed on the right side of the trail.
6. All sheeting material shall be a minimum of ASTM Type III retroreflective sheeting.
6-5.14 VEHICLE NOISE LAWS ENFORCED Sign (R16-X13)

Large trucks use a method of braking which utilizes engine exhaust manipulation to slow the vehicle. This method, referred to as engine braking, may produce a very loud distinctive sound on a truck with a poorly muffled or un-muffled exhaust. Excessive exhaust noise may also be produced by other types of vehicles, including motorcycles.

Mn/DOT has developed the following guidelines for use of the VEHICLE NOISE LAWS ENFORCED sign to assist local law enforcement agencies in enforcing MS 169.69 MUFFLERS and MS 169.693 MOTOR VEHICLE NOISE LIMITS.

6-5.14.01 General Criteria

1. Signing may be permitted on conventional highways and on segments of expressways without interchanges. Signing will not be permitted on freeways.

2. Only one sign shall be allowed per approach to an urban or suburban area. Signs shall not be installed for isolated driveways in rural areas.

3. The sign shall be installed on an independent structure and should be one of the following sizes:
   a. Low speed areas - 24" x 24" size
   b. High speed areas - 36" x 42" size

   NOTE:
   There shall be adequate space for each sign as determined by the district traffic engineer.

4. The request for installation of a sign(s) shall be made through the community.

5. It is the responsibility of the local law enforcement agency to enforce the sign(s).

6. The district traffic engineer may require that the community pass a resolution stating that it will enforce Minnesota Statute 169.69 (MUFFLER) and Minnesota Statute 169.693 (MOTOR VEHICLE NOISE LIMITS) prior to installing the sign(s).

6-5.14.02 Fabrication and Installation Guidelines

The district traffic engineer shall determine which of the following installation methods shall be used:

1. The requesting community may fabricate and install the sign(s) with their own forces or under contract. A permit from Mn/DOT shall be required for placement of signs on trunk highway right-of-way. The location of the sign shall be determined by the district traffic engineer.

   The sign panel shall be fabricated with sheet aluminum and retroreflective sheeting in accordance with Mn/DOT standards.

   If a sign structure is to be located within the clear zone, it shall meet FHWA breakaway requirements.

   All future maintenance of signs (knockdown, replacement, etc.) shall be the responsibility of the community.

2. Mn/DOT forces may fabricate and install the sign(s). The requesting community shall pay all fabrication and installation costs prior to the start of the work.

   All future maintenance of signs will be performed by Mn/DOT forces at the expense of the community.
6-6.0 APPLICATION GUIDELINES - WARNING SIGNS

6-6.01 Purpose
The warning sign applications that are discussed in this section are those which:

1. Are not specifically addressed in the MN MUTCD.
2. Provide additional guidance to that given in the MN MUTCD on application, location, and usage of certain types of warning signs.
3. Establish practices relating to engineering and traffic investigation requirements for certain warning signs.

6-6.02 Acceleration Lane Signing (W6-X1, W6-X2, and W20-X3)
Acceleration lanes at rural unsignalized intersections shall be signed in accordance with the following (see Figure 6.19):

1. Advance warning sign shall be a LEFT/RIGHT ACCELERATION LANE sign (W6-X1) with a 1000 FEET plaque mounted below the sign.
2. The first warning sign in the acceleration lane shall be an ACCELERATION LANE ENDS sign (W6-X2) with a XX FEET plaque mounted below the sign.
3. The second sign in the acceleration lane shall be the MERGE w/Arrow sign (W20-X3) displaying the word MERGE with the appropriate left or right arrow at proper warning sign spacing distance (see MN MUTCD Table 2C-4) in advance of the beginning of the taper at the end of the lane.

6-6.03 Advance Warning Signs on Local Road Approaches (W3-1, W3-2, and W3-3)
This section details the installation and maintenance of advance warning signs on local road approaches to trunk highway intersections.

The advance warning signs are:
Stop Ahead (W3-1), Yield Ahead (W3-2), and Signal Ahead (W3-3).

1. Maintenance of these advance warning signs on all local road approaches to trunk highway intersections is the responsibility of the road authority.

2. At new intersections, or at intersections where traffic control is revised by Mn/DOT, Mn/DOT will investigate the need for advance warning signs on the local road approaches and furnish and install the appropriate sign. The road authority(s) should be notified in writing of the sign installations. Maintenance of the advance warning signs become the responsibility of the road authority.

6-6.04 Advisory Exit Speed Sign (W13-2)
The Advisory Exit Speed sign advises motorists of the maximum recommended speed on a ramp.

This sign shall be installed if the maximum recommended speed on a ramp, as it exits the mainline roadway is 70 percent or less of the design speed of the mainline roadway. The exit ramp shall be signed with an Advisory Exit Speed sign located along the mainline in accordance with the MN MUTCD, see Section 2C.36.
6-6.05 BRIDGE ICES BEFORE ROAD Sign (W8-13)
On State maintained roadways, the State is not liable for losses caused by
snow or ice on roadways unless the State affirmatively creates the condition
on the roadways.
Minnesota Statute 3.736, subd 3(d) provides immunity for “a(any) loss caused
by snow or ice on any highway or other public place, except when the
condition is affirmatively caused by the negligent acts of a state employee.”
An exception can be made if recent crash reports clearly define an unusual crash problem related to icing on a
bridge. This situation is expected to occur only when a bridge is in an area of unique or unusual geometrics. If there
are bridge locations which have a serious crash history related to icing, consideration should be given to correcting
the situation rather than merely warning of it.
Application of these guidelines will best serve motorists by providing only those signs that are necessary to warn
of an unusual situation.
Any existing warning sign for icy or frosty bridge conditions should not be replaced at the end of its useful life
unless a crash problem exists, as stated above, and correction of the problem contributing to the crashes cannot be
accomplished.

6-6.06 Channelized Intersections
Figures 6.20A and 6.20B indicate the signing required for channelized intersections.

6-6.07 Chevron Alignment Sign (W1-8)
The Chevron Alignment sign is a warning sign and, as with all
warning signs, should be used sparingly, as excessive use will reduce its
effectiveness. Generally, this sign should be used only on curves of six
degrees or greater. Curves of less than six degrees are to be marked by
standard delineation as covered in Chapter 7.
Variables such as approach speed, grade, super elevation, visibility, and vertical alignment affect the spacing of the
signs. Chart 6-6 shows spacing of signs on various curves. Generally, the sign size is governed by the road
classification (refer to Appendix C of the MN MUTCD or the Standard Signs Summary). Although the standard
size for trunk highways is 18” x 24”, the 24” x 30” sign may be used based on engineering judgment.

6-6.08 Controlled Burning Signs
When controlled burning on trunk highway right-of-way occurs, a
CONTROLLED BURNING AHEAD sign (W14-X12) should be
installed prior to the burn area at a distance in conformance with
the MN MUTCD, Table 2C.4.
The SMOKE OVER ROAD sign (W14-X13) shall be installed
beyond the CONTROLLED BURNING AHEAD sign to warn
motorists.
Installation of a SMOKE OVER ROAD sign may require relocating the CONTROLLED BURNING AHEAD sign to allow adequate distance between the two signs.
These signs shall be made of 48” x 48” fluorescent orange retroreflective sheeting with a black legend and border.
The signs should be installed on temporary stands.
In the event that a portable changeable message sign (PCMS) is to be used in conjunction with the above signing
to alert motorists, the PCMS should be located at least 1000 feet ahead of the advance sign(s).
6-6.09 Crossing Signs

Non-Vehicular and Vehicular Crossing signs should only be used at locations where the condition, crossing activity, or shared use of the roadway is unexpected or where a sight restriction or other geometric constraint exists.

Advance Non-Vehicular or Vehicular Crossing signs shall be placed in accordance with the MN MUTCD, Table 2C-4.

If a crossing is to be signed, whether or not there are crosswalk markings, advance NON-VEHICULAR or VEHICULAR CROSSING signs shall be installed.

6-6.09.01 Non-Vehicular Signs

Guidance for evaluating the installation of pedestrian crosswalks can be found in Chapter 7.

Specific information for the installation of the STOP FOR PEDESTRIAN IN CROSSWALK sign (R1-X1) is in the MN MUTCD.

1. Pedestrian Crossing Signs

Specific information for the installation of disabled or senior citizen signing is in the MN MUTCD, Appendix B.

Typical examples where special treatment should be considered include isolated intersections where there are heavy pedestrian volumes, pedestrian crossings where approach visibility is poor, and at mid-block crossings.

Special treatment is not usually required at normal intersections within municipalities, or at rural intersections.

See Figure 6.21 for typical placement of a Pedestrian Crossing sign (W11-2) at an intersection. In urban areas, the distance for the advance crossing sign may be less where lateral clearance is limited or where inadequate sign spacing exists.

The In-Street Pedestrian Crossing Sign (R1-6b) may be used to remind road users of the state law that requires the driver of a vehicle to stop and yield the right of way to a pedestrian crossing the roadway within a marked or unmarked crosswalk.

Guidelines for installation of In-Street Pedestrian Crossing signs on state highways are as follows:

a. The sign shall be installed only by permit through Mn/DOT district offices.

b. The sign shall only be used in 35 mph or lower speed zones.

c. Only one sign structure shall be used per approach near marked crosswalks.

d. The sign shall not be used at intersections controlled by traffic control signals or on approaches controlled by STOP signs.

e. The sign should only be used at key locations, such as high volume pedestrian crosswalks, to avoid overuse.

f. The sign shall only be used as an in-street sign, not on the outside shoulder or parking lane. When installed, the sign shall not impede or obstruct any traffic movement including through or turning movements.

g. When the sign is used at, or in advance of, a school crossing to supplement ground mounted school warning signs, the sign shall include the SCHOOL plaque.

h. The STOP FOR legend shall be used as Minnesota state law specifically requires that a driver must stop for a pedestrian in a crosswalk.

i. The sign shall have a black legend and border on white and fluorescent yellow-green background and shall have the same dimensions shown on Standard Sign Number R1-6b.

j. The sign shall have the same sign message on both sides or a retroreflective strip mounted on the backside the same color as the centerline or lane line. To avoid driver confusion, back-to-back signs should only be used on two-lane two-way roadways. See the MN MUTCD, Figure 2B-2.
k. The device shall meet the crashworthiness requirements of NCHRP Report 350.

l. The maximum mounting height shall be two feet to the bottom of the sign panel.

m. The sign may be used seasonally to prevent damage in winter due to plowing operations, and may be removed at night if pedestrian activity is minimal.

2. TRAIL CROSSING Sign (W11-X7)

A TRAIL CROSSING sign should only be installed for officially designated trails which cross the highway and are not continuously visible for a distance of 850 feet from the crossing. To determine if the visibility distance is adequate, use the sight restriction determination procedure under 6-6.05.02 Vehicle Crossing Signs.

3. Deer Crossing Sign (W11-3)

Mn/DOT policy is to not install Deer Crossing signs. In place signs shall be removed through attrition.

6-6.09.02 Vehicle Crossing Signs

1. Sight restriction determination

To determine whether or not a sight restriction exists for a crossing that can not be relocated, the following procedure may be used.

Temporarily place a traffic cone (28 inches tall) at the crossing. Using a vehicle or measuring device move to a point 850 feet in advance of the cone. If the cone is not continuously visible for the observer (at eye height of 3.5 feet above the pavement) then a sign shall be installed in accordance with MN MUTCD Table 2C-4.

If the crossing is located on a long, continuous downgrade, consult the Mn/DOT Road Design Manual, Table 2-5.09B. Based on engineering judgment, the distance obtained from Table 2-5.09B may be added to the standard 850 foot distance. The observation shall then be made from this distance to determine if a sign needs to be installed.

2. Snowmobile Crossing Sign (W11-6)

In addition to the criteria for installing Vehicle Crossing signs, engineering judgment may be used to install signs for crossings based on unique trail geometric conditions, such as deep ditches, steep inslopes, narrow shoulders, or at locations where MS 84.87, subd 1 b (6) permits snowmobiles to be operated on highway bridges (other than part of the main traveled lanes of interstate highways) when no other method of avoidance is possible.

If an established crossing meeting the guidelines for signing remains in the same location for several years, the district may consider installing warning signs with diagonal down arrows at the crossing.

Snowmobile Crossing signs should NOT be removed in the spring and reinstalled in the fall due to variations in the length of the snowmobiling season from year to year.

Do not sign all crossings since many Grant in Aid trail crossings move annually (some by as little as 100 feet).

If a snowmobile trail crossing is a multi-use trail and the criteria for sign installation are met, TRAIL CROSSING signs shall be used instead of Snowmobile Crossing signs.
6-6.09.03 Down Arrow Plaque (W16-7mp)

If a NON-VEHICULAR or VEHICULAR CROSSING sign is placed at a crossing, the supplemental DOWN ARROW plaque shall be installed below the crossing sign whether or not there are crosswalk markings at the crossing.

6-6.10 EVENT CONGESTION AHEAD Sign (W14-X11)

The EVENT CONGESTION AHEAD sign is a temporary sign that should be installed one hour before the event begins and removed each day after the event has ended. The 36" x 36" sign panel shall be used in urban, low speed areas. The 48" x 48" sign panel shall be used in rural, high speed areas. The sign shall have a black legend and border on an orange background.

Fabrication and installation shall be done by local authorities.

In addition, NO PARKING signs may be considered. If local road authorities decide to use them, the NO PARKING signs may be non-retroreflective since they are temporary, less expensive than retroreflective aluminum signs, and accomplish the same purpose.

6-6.11 Low Clearance Sign (W12-2)

According to MS 169.81, subd. 1, no vehicle loaded or unloaded shall exceed 13 feet 6 inches in height except double-deck buses with written authority from the Commissioner of Transportation. The LOW CLEARANCE sign shall be installed to warn drivers that the clearance is less than the maximum clearance allowed plus one foot or 14 feet, 6 inches.

All structures with a clearance less than 14 feet 6 inches shall be signed. An additional 3-inch allowance for frost action should be reflected in the signing.

Periodic checking of clearances needs to be done on bridges and other structures, especially when the roadway has been resurfaced.

6-6.12 No Passing Zones

6-6.12.01 NO PASSING ZONE Sign (W14-3)

NO PASSING ZONE signs used on conventional highways shall be 48" x 60" x 60".

The purpose of this larger size on conventional highways is to provide added visibility of the sign for motorists.

6-6.12.02 Terminal Marker Posts

A yellow post may be used to mark each terminal end of a No Passing Zone. A yellow 360 degree visibility enhancer (or equivalent) shall be mounted on the top of each marker post.

A 3-1/2" x 2" sticker stating "Mn/DOT NO PASSING ZONE TERMINAL MARKER" shall be installed near the top of each visibility enhancer so that the sticker is visible from the roadway. The stickers are available from the state sign shop in Oakdale.
6-6.13 Passing Lane Sections

6-6.13.01 Advance Passing Lane Sign (R4-X6)
The Advance Passing Lane sign should be used to notify and prepare drivers of the upcoming passing opportunity so that they can make effective use of the passing lane. One sign should be placed 1/2 mile upstream and additional advance signs are desirable 2-5 miles in advance of a passing section.

6-6.13.02 SLOWER TRAFFIC KEEP RIGHT Sign (R4-3)
The SLOWER TRAFFIC KEEP RIGHT sign should be placed at the beginning of the lane addition.

6-6.13.03 LEFT/RIGHT LANE ENDS Sign (W9-1) and LANE ENDS MERGE RIGHT/LEFT Sign (W9-2)
Signs should be placed in advance of the lane drop transition area as shown on Figure 6.22A.

Figure 6.22A shows signing for typical passing lane sections. Figure 6.22B shows signing for a passing lane section ending near a low volume crossroad.

6-6.14 SCHOOL BUS STOP AHEAD Sign (S3-1)
Criteria for the use of the SCHOOL BUS STOP AHEAD sign are specified in the MN MUTCD, Part 7 - Traffic Controls for School Areas, Section 7B.10.

The district traffic offices should maintain an inventory of existing signs. The district traffic offices should regularly contact each school district to determine whether students are still picked up by a bus at locations presently signed, to determine if any new locations need signs, and if any locations may present unusual safety problems for students. This contact will result in a more consistent application of SCHOOL BUS STOP AHEAD signs and ensure that the signs provide the intended level of safety.

6-6.15 SHOULDER NARROWS Sign (W5-X1) NO SHOULDER Sign (W21-X1)
The SHOULDER NARROWS sign (W5-X1) and the NO SHOULDER sign (W21-X1) are suitable for certain rural high-speed locations (posted at 45 mph or greater) that have an abrupt change in the right side shoulder width.

At high-speed locations where the right side shoulder width abruptly reduces by at least three feet and results in a useable width of less than six feet, a SHOULDER NARROWS sign may be installed.

A NO SHOULDER sign may be installed at rural, high speed locations where the right side shoulder width abruptly reduces from a width of three feet or greater to a width of less than one foot.
Examples of how to apply this guideline:

1. If a vehicle on a through roadway is not required to stop at an intersection and the right side shoulder width is narrower (as described above) on the downstream side of the intersecting road, a SHOULDER NARROWS or NO SHOULDER sign may be installed.

2. If a vehicle is required to stop at an intersection and the right side shoulder width is narrower (as described above) on the downstream side of the intersecting road, a SHOULDER NARROWS or NO SHOULDER sign should not be installed.

3. If a shoulder width is narrower on the downstream side of a bridge than on the approach side, and that reduction meets the criteria set forth in the above guidelines, a SHOULDER NARROWS sign may be installed.

These guidelines do not apply where auxiliary lanes are present.

6-6.16 Speed Reduction Sign (W3-5)

The Speed Reduction sign shall be used if the reduction in speed limits between two zones is 15 mph or greater. This sign may be used if the difference between two zones is 10 mph or less, based on engineering judgment.

The Speed Reduction sign shall be 48" X 48".

The Speed Reduction sign shall be installed at least 1000 feet in advance of the first speed limit sign.

The sign may be installed up to 1700 feet in advance of the speed zone if geometrics, grade, or sign clutter may impact the motorist's ability to reduce speed.

A two-line Distance (W20-100p) plaque may be installed on the left post directly below the speed reduction sign at the option of the district traffic engineer.

In place speed reduction signs (R2-5a, R2-5b, and R2-X1) shall be replaced through attrition.

6-6.17 Truck Hauling Signs

6-6.17.01 Sugar Beet Piling Station Signs

When a site is open to commercial trucks, the TRUCKS ENTERING sign (W11-X3) and the Slippery When Wet sign (W8-5) should be used on each approach to the access.

Both signs shall be: 48" x 48", provided by the requester and delivered to Mn/DOT for installation and maintenance.

If requested, a flasher may be installed above the TRUCKS ENTERING sign under Mn/DOT's permit process.

When the site is in operation, the signs shall be opened and closed by the requester.

Changeable message signs shall not be used.
6-6.17.02 Corn and Other Harvest, Gravel Pits, and Logging Operations

The MN MUTCD Section 2C.40 provides guidance on the use of permanent and seasonal VEHICULAR TRAFFIC signs.

6-6.18 Typical Signing for Transitions Between Divided Highway Section and Two-Lane, Two-Way Sections

Figure 6.23 indicates signing for transitions between divided highways and two-lane, two-way highways.

6-7.0 APPLICATION GUIDELINES - GUIDE SIGNING

6-7.01 Purpose

Generally, the only guide sign applications that are discussed in this section are those which:

1. Are not specifically addressed in the MN MUTCD.
2. Provide additional guidance to that given in the MN MUTCD on application, location, and usage of certain types of guide signs.
3. Must be addressed because Mn/DOT is charged with developing and implementing design, use, and application of certain guide signs in accordance with Minnesota Statutes.

Typical signing for expressway intersections is found in Figure 6.25.

The following typical layouts show the signing for freeway/expressway interchanges:

1. Diamond interchange on crossroad (Figures 6.26 and 6.27).
2. Folded diamond interchange on crossroad (Figure 6.28).
3. Cloverleaf interchange on crossroad (Figure 6.29).

6-7.02 Freeways

6-7.02.01 Primary Guide Signing

Rural exits shall be identified by the route number of the U.S., State, or County highway intersected as well as the exit number on interstate highways. Criteria for selecting destinations may be found in Section 6-7.03 (destination signs).

Urban and suburban exits intersecting with local street and road systems, shown on available area maps, shall be identified by route number, street name, and exit number if the interchange is on an interstate highway.

Cardinal directions should be displayed on freeway guide signs, in particular at cloverleaf interchanges (where the intersected highway either begins or ends at the interchange) and at interchanges with collector distributor roads (e.g. I-94 at I-494/I-694) or with a single exit splitting to serve both movements to the crossroad (e.g. I-494 at I-35E).

6 7.02.02 Supplemental Guide Signing

The installation of supplemental guide signing should be strictly controlled in areas with closely spaced interchanges due to the many demands on the motorist to make major decisions and the large number of requests from generators of high traffic volumes. Supplemental guide signs shall not interfere with primary guide signing and sign spacing criteria shall be met. In no case shall signs directing motorists to secondary or supplemental destinations be installed at interchanges of two or more freeways.
If qualified, supplemental guide signs may be provided for the following:

1. Geographical features, such as county lines, incorporated city limits, major river and stream crossings, highways and streets crossed by the freeway, and similar features which provide orientation for the driver.
2. A city in each direction along the intersected route (see Section 6-7.03 for city criteria).
3. National parks.
5. Major state parks which are no more than 15 miles from the freeway and have water, toilets, campsites, picnic areas, and accommodations for 35 overnight camp sites.
6. Airports (see Section 6-7.09.06).
7. Educational Institutions (see Section 6-7.09.08).
8. Major traffic generators (see Section 6.7.07.07).
9. General motorist services (see Section 6-7.09.03).
10. LOGO sign franchise program (see Section 6-7.09.09).

6-7.02.03 Auxiliary Lane Signing

This section outlines uniform signing standards for auxiliary lanes on freeways, with and without escape lanes.

The following layouts should be used in the appropriate situation.

1. Auxiliary lane less than 1/2 mile in length, without escape lane (See Figure 6.30A).
2. Auxiliary lane less than 1/2 mile in length, with escape lane (See Figure 6.30B).
3. Auxiliary lane 1/2 mile in length or greater, without escape lane (See Figure 6.30C).
4. Auxiliary lane 1/2 mile in length or greater, with escape lane (See Figure 6.30D).

6-7.03 Signing Destinations

Mn/DOT shall fabricate, install, and maintain destination and distance signs on trunk highways.

In general, Mn/DOT shall pay for the maintenance of signs. However, if a city, meeting the criteria in this section, requests to be added to an existing sign displaying less than three cities/destinations, the city shall pay for design, fabrication, and installation of the signs unless the existing sign is due for replacement. If the existing sign is due for replacement, the city name may be added at Mn/DOT’s expense.

1. Signing Destinations - At-grade intersections

   MN MUTCD Sections 2D.34 and 2D.35 establish guidelines for destination signs at at-grade intersections.

   The following criteria also apply:
   a. Only one destination sign is permitted from the closest state highway on each approach to an intersection.
   b. The destination shown for each direction should ordinarily be the next county seat or the next principal city, rather than a more distant destination.
   c. Destination cities should be used which will be most meaningful to the motorist unfamiliar with the area. Lakes and rivers shall not be used as destinations.
   d. Normally only one destination per route or direction should be identified. Not more than three city names should be on a sign. A few exceptions have been made where multiple routes intersect at junctions. Arrangement of arrows on a sign panel shall be consistent with the MN MUTCD.
e. Destinations shall be located on the intersected numbered highway. The destination selected for each route, in order of preference, should be:

1) The county seat, if it is not too distant.
2) The first city located at an important junction.
3) The first large city, taking into account the size of cities in the general area.
4) The next important junction.
5) In rare instances, a major state or national park or other significant geographical site or traffic generator may be considered.

f. The following guidelines shall be met for a city to be added to an existing destination sign:

1) The existing sign displays less than three cities/destinations.
2) The city shall meet the selection criteria in a-e.

2. Signing Destinations - Freeways and interchanges on expressways.

MN MUTCD, Section 2E.12 provides guidance for destination signs on freeways. The following criteria also apply:

a. Rural

One or two destinations identifying the interchange may be included on primary guide signing for rural interchanges, based on the following criteria:

1) Where the intersecting road is a U.S. or State highway, the destinations shown shall usually be the first city in each direction which is a county seat or is located at a junction with another major highway, unless another city better identifies the interchange to the majority of travelers.

2) At interchanges with county or secondary roads, the destination shown shall usually be the nearest city in each direction. Cities identified on guide signs shall appear on the official Minnesota Highway Map. In the absence of such a city, a geographical area or other significant public land use may be shown.

In rural areas, one supplemental guide sign naming cities that did not qualify for display on the primary guide signing may be placed in each direction.

A city in each direction along the intersected route may be signed in accordance with the following:

1) The city(ies) shall be required to pay all of the signing costs (if new signs are installed or existing signs are modified or replaced) if the request is approved prior to the normal replacement of the existing signing.

2) The city(ies) shall not be required to pay for signing if the approved signing can be included in conjunction with the replacement of existing signing through attrition.

In both of the above cases, the maintenance of requested signing shall be performed by Mn/DOT at no cost to the city(ies).

b. Urban-Suburban

At interchanges having more than one exit to the intersecting highway, names of cities may be included only if they clearly aid in orienting the majority of the drivers.

Supplemental guide signs shall not be provided for suburban cities served by roads and streets within the metropolitan grid system in urban-suburban areas.

c. Adjacent Land Uses

The names of adjacent land uses such as airports may be shown if the exit has been provided specifically to serve that land use. These destinations may be signed only when they cannot be related to the street or road identified at the exit.
3. Distance signing

A distance sign indicates how far it is from the sign location to the center of the next city, geographical site, or important junction.

MN MUTCD Sections 2D.36 and 2D.37 establish guidelines to follow in selecting city names or other traffic generators, and in locating distance signs on conventional highways. Only one distance sign is permitted on each conventional highway leaving an intersection, municipality, or interchange.

MN MUTCD Section 2E.36 provides guidelines for distance signs on freeways.

City name selection shall be in accordance with the following guidelines:

a. The first city along the route.

b. The first county seat, route number of an intersecting conventional highway, or a significant geographical site or generator.

c. The next major destination or control city.

The following guidelines must be met for a city to be added to an existing destination sign:

a. The existing sign displays less than three cities/destinations.

b. The city shall pay for all sign replacement costs if the request is made prior to the sign requiring replacement.

c. The city shall meet the selection criteria as previously listed.

The city name may be added to a sign, at Mn/DOT’s expense, at the time the existing sign is due for replacement.

6-7.04 Typical Junction Signing Layouts

The following typical sign installations should be used as guidelines in establishing sign locations and distances between signs at junctions. The final decision shall be made by the district traffic engineer based on individual intersection geometrics and sound engineering judgment.

1. T-intersection (two-lane, two-way) (See Figure 6.31).

2. T-intersection (two-lane, two-way with four-lane divided) (See Figure 6.25).

3. Typical four-leg intersection (See Figure 6.32).

4. Typical intersection with county road (See Figure 6.33).

5. Typical rural single lane roundabout intersection (See Figure 6.34).

6-7.05 Independent Route Marker Assemblies

Independent route markers used on junction and directional sign assemblies shall follow the MN MUTCD Section 2D.27 and shall be 24" x 24", except for 3-digits on M1-1 signs which shall be 30" x 24" for both urban and rural applications on conventional highways.

MN MUTCD Section 2E provides guidance for expressways and freeways. Independent route markers shall be 36" x 36" except for 3-digits on M1-1 signs which shall be 45" x 36".

In general, the color of the route marker auxiliaries shall match the color of the route marker it supplements (see MN MUTCD, Section 2D.12). For example, white on blue auxiliaries shall be used to supplement the Interstate and Minnesota route markers and black on white auxiliaries shall be used to supplement U.S. route markers.
It sometimes becomes necessary to include two different color route markers on the same structure. When this happens the auxiliaries may not always match the color combinations of both route markers. To avoid this, route markers should be installed on separate structures whenever possible. When this is not possible the following guideline should be used to determine the color of the route marker auxiliaries:

1. When two or more route markers must be mounted vertically on a single structure, the auxiliaries shall match the color of the route marker which takes precedence.

2. The order of precedence is Interstate, U.S., State, county, township, and then other routes.

This guideline applies to all route marker assemblies installed on trunk highways and to mark any detours of trunk highways.

6-7.05.01 County Pentagon Route Markers

The pentagon shaped Uniform County Route Marker (M1-6) is an alternate to the standard County Route Marker (M1-X4) in Minnesota.

Upon request by a county, each Mn/DOT district may elect to upgrade its county junction assemblies on state highways to include pentagon route markers at those county roads where they are being used. If the district decides to do this, pentagon route markers may be installed as a part of the normal sign replacement cycle.

Mn/DOT shall fabricate pentagon route markers using the same retroreflective materials used for all route markers on the conventional highway system and meeting the colors as stated in the MN MUTCD, Section 2D.11.

6-7.06 Named Road, Street, and 911 Road Name Signs

This section is based on Chapter 2D, Guide Signs Conventional Roads (see Sections 2D.2 and 2D.38) of the MN MUTCD.

Road name or street signs shall be white legend on green background and fully retroreflectorized in accordance with current Mn/DOT requirements.

Street name signs are typically installed on a sign structure which must conform to FHWA breakaway requirements based on the current edition of the AASHTO Standard Specifications for Highway Signs, Luminaires and Traffic Signals.

6-7.06.01 General Criteria

Signing for named roads will be provided, at the request of the road authority, on the basis of all of the following conditions:

1. The appropriate local government having jurisdiction over the road shall officially designate a name for the road.

2. An official road name may include the word lake, beach, or some other geographic point if the road serves only one such item. Otherwise, such word usage should be discouraged.

3. Combination names which attempt to incorporate multiple identifications are confusing and shall not be used.

4. Signing for names which identify a specific business or establishment, in order to identify roads which lead to specific establishments or special commercial or private interest facilities, should be discouraged. Generic names are permissible.

5. If the official road name is changed by the road authority prior to the sign requiring replacement, the requester will be responsible for all sign replacement costs. However, the road name may be changed at Mn/DOT's expense at the time the original sign would normally be replaced.

6. The use of first and last names of individuals shall be discouraged.
6-7.06.02 Urban Areas

Urban street name signs, such as the small slat versions mounted at intersection corners, are to be furnished and installed by the appropriate city.

Advance arterial and major street name signs (including mast arm mounted signs) on conventional highways in urban areas will be provided by Mn/DOT, as needed, to fulfill basic guide signing responsibilities.

If street name signs are to be installed in an urban area (business, commercial, or residential district) where parking or pedestrian movement is likely to occur or where there are other obstructions to view, the clearance to the bottom of the sign panel shall be at least 7 feet in accordance with MN MUTCD Section 2A.18.

Lateral offset should be at least two feet from the face of curb in accordance with MN MUTCD Section 2A.19.

6-7.06.03 Rural Areas

When the trunk highway intersects a public road, appropriate identification of that public road will be provided on conventional roads and expressways with at grade intersections by Mn/DOT (see Figures 6.33 and 6.35), based on all of the following conditions:

1. When so requested by the local governing body, Mn/DOT will furnish and install route marker assemblies on the trunk highway, provided that the intersecting local road is numbered and marked with route markers. Route marker assemblies shall be in accordance with the MN MUTCD. Identification by number only should be encouraged whenever possible.

2. When a numbered public road is also known by an officially designated name, both types of identification may be used on a sign.

3. For road name signs, all initial signing costs, including overhead factors and installation by Mn/DOT, shall be paid by the road authority requesting the signing, at the current rate per square foot of sign, as established by Mn/DOT. Mn/DOT will maintain road name signs at its own expense.

6-7.06.04 Street Name Signs Above Stop Signs

Small street name signs may be installed above Mn/DOT maintained STOP signs at the discretion of the district traffic office:

Criteria for installation shall be based on all of the following conditions:

1. No street name signs are allowed if there are any other signs, such as a ONE WAY sign, in place on the STOP sign structure.

2. The street name sign assembly shall be mounted six inches above the STOP sign.

3. Street name signs shall be double faced and fabricated with retroreflective sheeting on extruded or flat aluminum blades.

4. The signs shall be fully retroreflectorized and have white legend and border on green background.

5. The sign panel size should be 9 inches by a variable length (maximum 36 inches) with 6-inch upper case and 4-1/2 inch lower case letters Series B, C, D, or E.

6. The street name sign assemblies shall be constructed so that the name plate cannot be turned.

7. Not more than three slats (six-way installation) shall be permitted above any one STOP sign.
6-7.06.05 911 Emergency Telephone System Street Name Signs

All of the following criteria should be used for fabricating and installing road name signing for the 911 Emergency Telephone System:

1. The local governing body is responsible for naming the road.

2. Once named, the local governing body shall have street name signs fabricated. Lettering should be a minimum of six inches high (in accordance with the MN MUTCD, Section 2D.38). The sign shall be fully retroreflectorized and should have white legend and border on green background to provide the best target value both day and night.

3. The local governing body shall install the street name signs, under the Mn/DOT permit process, if the street name signs are to be installed on Mn/DOT right of way. Installation of signs shall not obstruct or interfere with existing traffic control devices. The physical location of the signs should be in accordance with the MN MUTCD, Section 2D.38. This would provide placement of the signs, on their own sign structure, "...at least on diagonally opposite corners of the intersection. Signs naming both streets should be installed at each intersection. They should be mounted with their faces parallel to the streets they name."

4. The signs shall be mounted at a height of five feet measured vertically from the near edge of the pavement to the bottom of the sign panel(s) in accordance with MN MUTCD Section 2A.18. In addition the sign panel(s) shall meet the following mounting heights (measured perpendicular from the ground line) to satisfy FHWA breakaway requirements:
   a. 7 feet minimum from the ground line to the bottom of the sign panel(s).
   b. 9 feet minimum from the ground line to the nearest top corner of the top sign panel.

The preferred lateral offset to the street name signs is 30 feet or greater from the roadway (near the right-of-way line if practical). The minimum lateral offset should be at least 12 feet from the edge of the shoulder. Unique locations should be reviewed with the district traffic office.

The street name signs are typically installed on a single post sign structure which shall conform to FHWA breakaway requirements based on the current edition of the AASHTO Standard Specifications for Highway Signs, Luminaires, and Traffic Signals.

5. Guidelines for handling conflicts between names of existing road names and 911 Emergency Telephone System Street Name signs:
   a. Remove any existing advance road name signs that conflict with 911 Emergency Telephone System Street Name signs.
   b. Replace the removed advance road name signs with new signs on the following basis:
      1) Upon the request of the road authority, Mn/DOT shall fabricate and install new advance road name signs containing the correct name displayed on the new 911 sign at Mn/DOT’s expense if the removed advance road name signs are near the end of their useful life.
      2) If the road authority requests new advance road name signs and can pay for their fabrication and installation, Mn/DOT will install the new signs if the existing road name signs are removed before the end of their useful life.
      3) If the road authority requests new advance road name signs and can not pay for their fabrication and installation, Mn/DOT will schedule the replacement based on road authority priority and the availability of Mn/DOT funds if the existing road name signs are removed before the end of their useful life.
      4) If the road authority does not request new advance road name signs, new signs shall not be installed.
6-7.07 Boundary Signs

There is a need to provide certain boundary signs to give orientation and guidance to the motorist. Details on sign design for common boundary signs used on the trunk highway system are found in the Mn/DOT Standard Signs Manual.

6-7.07.01 City Name Sign (I2-3)

City Name signs should be installed only for communities identified on the official Minnesota Highway Map and/or official county highway maps. Signs should normally be installed at the actual corporate boundary, subject to the following guidelines:

1. Urban areas
   Signs should be installed at or near the corporate limits on all trunk highways.

2. Rural areas
   Signs should be installed at or near the corporate limits on all trunk highways, excluding interstate highways.

On interstate highways, the following criteria apply:

a. If the corporate limits of a community are crossed by the interstate highway, and there is no interchange serving the community, install the sign on the interstate highway at the corporate limit crossings.

b. If the corporate limits of a community are crossed by the interstate highway, and an interchange directly serves the community and the community is not identified on either the major interchange guide signs or on a supplemental guide sign, install the sign on the interstate highway at the corporate limit crossings.

c. If the corporate limits of a community are crossed by the interstate highway, and an interchange directly serves the community and the community is identified on either the major interchange guide signs or on a supplemental guide sign, do not install the sign on the interstate highway.

Where proper city names have two words, it may be desirable to arrange the name on two lines rather than one, especially when the words are long. City names shall not be abbreviated.

All city name signs shall include the population figure. The figure used shall be that of the last official Federal or State census. Population figures are changed only after an official census. If a community decides that it does not want the population included on this sign, Mn/DOT will cover this legend.

An exception to the above applies to unincorporated communities which warrant city name signs, but for which population counts are not available. The sign installed at these locations shall carry only the community name.

Occasionally municipalities attach certain unauthorized sign panels, (e.g. Green River Ordinance Enforced, Radar Patrolled, etc.) beneath the CITY NAME sign on approaches to the municipality. These attachments, dealing with regulatory and enforcement issues, are not appropriate. The only attachments to signs on the trunk highway system are those allowed under Community Recognition Signs. Extraneous and unauthorized sign panels should be removed and no such attachments permitted on any signs on the trunk highway system.

6-7.07.02 Community Identification Sign

Criteria for these signs, which are allowed outside the trunk highway right-of-way, are specified in MS 173.08 subd. 1 (10).

This signing program is administered by the district offices under the direction of the Office of Technical Support.
6-7.07.03 Community Recognition Signing Program

The Community Recognition Sign Program allows communities to express their own identity. Permitting the displaying of sign panels allows the community to pick what is locally important to their community for installation on trunk highway rights-of-way.

Community Recognition Sign panels shall not be installed on Interstate freeways statewide, or on freeways and expressways in the Metro District.

The Community Recognition sign panels shall be initiated and coordinated by the community.

Political or commercial advertising will not be allowed on sign panels.

The sign panel designs shall be approved by the district traffic engineer.

1. Examples of permitted sign panels:
   a. Non-profit service organizations.
   b. Special programs, either permanent or temporary; e.g. DARE, Tree City, Storm Ready City, Fit City, and Sister City.
   c. City logo.
   d. City recognition slogans; e.g. State Baseball Champions.
   e. Drinking Water Protection Area sign panel.

2. Costs
   a. Community Recognition Sign panels shall be fabricated, installed, and maintained by the community under the Mn/DOT permit process.
   b. If more than two Community Recognition Sign panels are to be installed by the community on an existing sign structure, the community shall pay an up-front charge of $200 to Mn/DOT for reimbursement of costs incurred by state forces to:
      1) Raise the existing CITY NAME sign panel or the STAR CITY sign panel as required to meet the nine foot clearance from the ground.
      2) Modify the U-channel sign structure to include knee braces if necessary in order to meet breakaway and wind loading requirements.
      3) Furnish and install a horizontal stringer for the mounting of Community Recognition Signs.

3. Sign Format
   The sign panel background, or the predominant color, may be any color except red or orange.
   The message on a sign panel shall not simulate a traffic control device or contain directional sign messages or advertising for a commercial product or service.
   The sign panels may be made of either retroreflective or non-retroreflective sheeting. If made of retroreflective sheeting, they shall be no more retroreflective than High Intensity Sheeting. Fluorescent materials shall not be used on sign panels.
   The sign base material shall be sheet aluminum or other material approved by Mn/DOT. See Minnesota Standard Specifications for Construction, 3352.2A1b.
   Any combination of sign panels may be allowed up to a total of 72” in length by 24” in height having a total square footage not to exceed 12 square feet. These panels shall be installed horizontally either below the CITY NAME sign panel or below an existing STAR CITY sign panel if it is mounted on its own structure.
4. Installation Guidelines

The attachment of Community Recognition Sign panels to horizontal stringers or sign posts shall be as shown in Figure 6.36, Sign Panel Attachment Detail and as follows:

a. More than two Community Recognition Sign panels shall be installed on horizontal stringers (installed by Mn/DOT forces) by the community as shown in Figure 6.36, Sign Panel Attachment Detail.

b. If less than three Community Recognition Sign panels are to be installed on an existing sign structure, they shall be installed by the community in accordance with the following:

1) If only one Community Recognition Sign panel is to be installed, it should be attached to the sign post farthest from the roadway.

2) If two Community Recognition Sign panels of the same size (24" x 24") are to be installed, they shall be centered horizontally on each existing sign post.

3) If two Community Recognition Sign panels of different heights are to be attached to the sign posts, and the existing sign structure is located on the inslope, the sign panels should be mounted as shown in Figure 6.36. The shortest sign panel shall be attached to the sign post nearest the roadway and the tallest sign panel attached to the other sign post. This will provide the maximum clearance from the ground line to each sign panel.

4) If two Community Recognition Sign Panels of different heights are to be attached to the sign posts, and the existing sign structure is located on the back slope, the shortest sign panel should be attached to the sign post farthest from the roadway.

5) If a sign panel is greater than 24 inches and less than or equal to 30 inches in height, it shall be attached to the sign post furthest from the roadway. When the existing sign structure is located on the backslope, this sign panel shall be attached to the sign post nearest to the roadway. In place sign panels less than 24 inches in height shall be relocated to another sign post to make room for the new, larger sign panel.

6) Only one sign panel greater than 24 inches and less than or equal to 30 inches is allowed for each sign structure. If there is a desire to install a new sign panel of this size and there is a sign panel of this size in place on the sign structure, the city shall decide which of the two sign panels shall be attached to the sign structure.

Mn/DOT Traffic Services employees should check any Community Recognition Sign panel(s) for proper attachment hardware (see Figure 6.36). If an improper mounting procedure or hardware has been used, Mn/DOT will reinstall the sign panels with the correct hardware.

The replacement cycle (end of useful life) of the sign panels will be determined by each Mn/DOT district office.

6-7.07.04 County Name Sign (I2-5)

COUNTY NAME sign shall be installed at all county line boundaries on the trunk highway system. When the county line is also at a river or municipal boundary, the sign should include both entities.

County Land Use Zoning signs shall not be installed or retained on trunk highways, either individually or as part of a sign assembly.

Extraneous sign panels shall not be installed on this structure.
6-7.07.05 Drainage Divide Sign

The Minnesota map displays drainage area divides. It shows the four major drainage divides for Hudson Bay, the Mississippi River, Lake Superior and the Missouri River crossing approximately fifty state highways. Nine highways are crossed at least twice by a drainage divide.

Drainage divides in Minnesota are not obvious to motorists and are not geographically distinct features, nor is their identification of interest, significance, or benefit to the majority of motorists.

Drainage divides shall not be signed on any trunk highways.

Drainage divide identification signs may be installed within a rest area or wayside parking area established at the site to accommodate vehicles off the roadway.

Site viewing, explanatory signs, and trails as needed shall be located completely off the roadway and shoulder areas.

Existing drainage divide identification signs without roadside parking facilities shall be removed at the end of their sign life.

Signing for drainage divides shall be paid for by the requester.

6-7.07.06 Municipal Identification Entrance Sign

These signs shall be located outside of the clear zone, and shall be installed only through the Mn/DOT permit process.

Refer to the latest Mn/DOT Maintenance Bulletin for all applicable guidelines and provisions. This bulletin may be obtained from district maintenance and permit offices, or from the Office of Maintenance and Security in Central Office.

6-7.07.07 Reservation Boundary Sign

Signs may be installed for federally recognized reservation boundaries which cross trunk highways, except for freeways. The sign panel may include the name of the reservation, the tribal logo and either the year of treaty or the reservation population. The sign panel design shall be approved by the district traffic engineer.

6-7.07.08 Soil and Water Conservation District Sign

The Soil and Water Conservation District shall complete and submit an Application for Permit (Mn/DOT Form 1723) to the appropriate area maintenance engineer for approval to install a sign in accordance with all of the following criteria:

1. Sign shall be located on the top of the back slope just inside the right-of-way line. The sign cannot be placed on the shoulder slope or in the ditch bottom. The sign should be placed to obtain a minimum hazard location.

2. Signs shall be permitted only on non-freeway types of roadways.

3. Where the approved location is within the clear zone (Road Design Manual), the sign support shall be a breakaway type.

4. The sign panel shall be the same design or equal to that available from the National Association of Conservation Districts.
5. The sign installation shall be maintained in good repair. If this requirement is not met, the applicant will be notified to remove the sign.

6. The sign cannot be placed at a location where it will interfere with the effectiveness of any traffic control device, or interfere in any way with the safe operation of motor vehicle traffic or the safety of pedestrians and non-motorized vehicles.

7. The Soil and Water Conservation Districts will be responsible for furnishing the signs and posts, and for installation at the designated locations.

6-7.07.09 Township Boundary Sign

Township boundary signs shall not be installed or retained on trunk highways, either individually or as part of a sign assembly. Township boundary signs do not have sufficient orientation value to warrant installation on the trunk highway system.

6-7.07.10 Watershed District Sign

Watershed districts are local units of government which exist to protect water resources. There are over 40 watershed districts throughout the state authorized by the Legislature in 1995.

They are established at the request of citizens, counties, or cities when water management problems escalate. The boundaries are widely variable and do not follow political boundaries.

In Minnesota, watershed districts are not obvious to motorists, nor is their identification of interest, significance, or benefit to the majority of motorists.

Watershed districts shall not be signed on any freeway or at interchanges on expressways. Signs may be installed on conventional highways and on portions of expressways with at-grade intersections.

Watershed district identification signs may be installed within a rest area or wayside parking area established at the site to accommodate vehicles off the roadway.

Site viewing, explanatory signs, and trails as needed shall all be located completely off the roadway and shoulder areas.

Existing signs at watershed district boundaries without roadside parking facilities shall be removed at the end of their sign life.

Signing for watershed districts is to be paid for by the requester.

6-7.07.11 WELCOME TO MINNESOTA Sign (I2-10) and VISIT AGAIN Sign (I2-12)

At major entrances to Minnesota, Mn/DOT has installed large concrete signs on stone/concrete bases. Wooden signs, mounted on stone/wood marker assemblies are in place at several other state entrances.

The WELCOME TO MINNESOTA sign and VISIT AGAIN sign have been installed at all other trunk highway entrances.

The colors on the WELCOME TO MINNESOTA sign panel were revised in 2006. In place sign panels should be replaced through attrition.
6-7.08 Designated Roadways

The practice of designating routes or roadways is becoming more common as a means of commemorating a person, place, or event, or for the purposes of tourism promotion.

Mn/DOT is required by Minnesota Statute 161.14 to mark trunk highways as memorial routes. A complete and current list of these routes is available from OTST. OTST shall design or approve all memorial signs. The design standards for memorial route signs are available from OTST.

Auxiliary arrow plates shall be used to mark points where the route turns. Auxiliary arrow plates shall match the color of the memorial route sign.

The following signing programs are administered by the Mn/DOT Office of Environmental Services:

1. Corridor-Based Promotions

   Examples include Heritage Trails, and Birding and Wildlife Trails. These trails involve a collection of specific interest sites located in a generalized area or in a general corridor. Sites are not all located on a specific roadway. The term trail is used metaphorically and connotes the trek from site to site along the trail. Heritage, birding or wildlife trails are supported with mapping and supplementary information to help people locate and understand the significance of sites.

   Fabrication, installation, and maintenance of signs shall be funded by the sponsoring organization.

   Corridor-based promotions shall meet all of the following guidelines:
   a. The corridor shall include at least two cities.
   b. The corridor shall be part of a statewide marketing campaign.
   c. The corridor shall be approved by Mn/DOT and the Office of Tourism.
   d. Signing on the trunk highway shall be at the entrance to the site. If the site is located on a local road system, the road authority will sign on the local road at the entrance to the site.
   e. If the site is located within an existing signed facility (state park, historic site, etc.), a logo or icon may be attached to the right sign post on the in place signing (state park, historic site, etc.) on the trunk highway.
   f. The design of the logo or icon sign panels shall be approved by OTST prior to fabrication.
   g. Sheeting on sign panels shall be made using Mn/DOT's current sign sheeting standard.
   h. Signs are to be installed by Mn/DOT forces.

2. Eisenhower Interstate System

   These signs have been installed on standard U-posts on the rest area entrance ramp in each of the rest areas on the Interstate highways in Minnesota. These signs are not installed along the Interstate highways in conformance with the MN MUTCD.
3. Great River Road

The federal Great River Road program was established to provide a parkway-like road paralleling the Mississippi River, from its source at Lake Itasca to the Gulf of Mexico.

There is a national and a state route in Minnesota. The Great River Road is identified in Minnesota Statutes.

The Mississippi River Parkway Commission (MRPC) is the organization that provides governance for the route. Membership, funding, and responsibilities of the MRPC is established in State Statutes.

Road authorities are responsible for signing route segments within their jurisdiction.

4. Memorial Routes and Bridges

Memorial routes and bridges are established on trunk highways by statute to commemorate an individual or organization, or for tourism promotions.

The organization sponsoring the route or bridge designation shall reimburse Mn/DOT for the cost of fabricating, installing, and maintaining signs on trunk highways. (see Minnesota Statute 161.139)

Memorial highway signs installed in rest areas shall be fabricated in accordance with MN MUTCD standards. A new sign panel should be installed on its own structure or may be installed on an existing memorial highway sign structure if there is no room for a new structure along the entrance ramp. Not more than two panels shall be installed on one sign structure. The structure shall be installed on the right side on the entrance ramp, between the entrance gore and the parking area, with 150 to 200 foot spacing between signs.

5. Minnesota Scenic Byways

The Scenic Byway program was established in 1992 by a memorandum of understanding between Mn/DOT, the Department of Natural Resources, the DTED, Office of Tourism, and the Minnesota Historical Society. The Commission designates Scenic Byways with an application process that requires local support and approval by the road authority. Some Minnesota Scenic Byways have been designated as National Scenic Byways or All-American Roads. The designations are conditional and require local byway organizations to actively pursue their objectives along the route. Since there are only twenty designations in the state, inactive byways run the risk of being de-designated so that other byways may be designated.

The memorandum of understanding includes a commitment by the Commissioner of Transportation to fund the fabrication, installation, and maintenance of signing on trunk highways. Byway organizations must negotiate signing on local road segments with the appropriate road authority. No additional signing is required for national Scenic Byways or All-American Roads.

Confirmatory signs on designated trunk highways may be installed at 20 to 25 mile intervals along the route.
6. Nationally Coordinated Trails

Examples include Prairie Passage and King of Trails.

Some designated roadways in Minnesota are part of a larger, national initiative. One example is Prairie Passage, which is a single route through the western part of Minnesota. It is part of a national Prairie Passage route that extends from Canada to Mexico through the central part of the nation. It was identified and signed in 2002. Its purpose is similar to the wildflower routes but involves a greater degree of local involvement in the identification of the route and the projects along the route.

Signing for Nationally Coordinated Trails will be negotiated with Mn/DOT OTST on a case by case basis. In the case of Prairie Passage, initial signing was funded through a Federal Highway Administration project.

7. National Forest Scenic Byways

The National Forest Service began designating Scenic Byways in National Forests in the 1980's, prior to the state and national Scenic Byways programs. In Minnesota, all of these byways have also been designated as State Scenic Byways.

While these byways are designated State Scenic Byways, the signing policy for Scenic Byways will be followed. Should they lose their designation by the Minnesota Scenic Byway Commission, sign maintenance and replacement will be funded by the National Forest Service in accordance with signing policy for memorial routes.

8. Wildflower Routes

Wildflower routes were established in 1990. They were designated to identify and protect existing native vegetation along Minnesota roadides, restore native wildflowers and grasses, and increase public awareness of the value of native plants. There have been no new designations since 1990.

Signs were fabricated and installed by Mn/DOT when the routes were designated.

6-7.09 Supplemental Guide Signing Programs

The MN MUTCD, Minnesota statutes, and Mn/DOT policy allow supplemental guide signs to be installed on trunk highways for a variety of public and private facilities.

6-7.09.01 Signing Programs

Mn/DOT provides signs at no cost to the requester for qualified facilities under the following signing programs:

1. General Motorist Service
2. Hospital
3. Resort and Camping

Qualified facilities shall pay for signs under the following signing programs:

1. Airports
2. Casinos
3. Educational Institutions (post-secondary)
4. LOGO Signing Program
5. Major Traffic Generators
6. Minor Traffic Generators
7. National Monuments
8. National Parks
9. Regional Shopping Centers
10. Specific Services
11. State Parks
12. Tourist Information
13. Trail Access
See the Mn/DOT Standard Signs Manual for sign designs for some of the previous sign programs. For all other signing programs, design guidance can be found in the MN MUTCD and Charts 6.1A, 6.1B, and 6.1C in the Traffic Engineering Manual.

See Mn/DOT's Signing Programs Summary for a complete list of eligible and ineligible facilities.

6-7.09.02 General Criteria

Unless specifically noted under a particular signing program, the following GENERAL CRITERIA apply to all of Mn/DOT's signing programs:

1. Mn/DOT shall fabricate, install, and maintain signs on trunk highways unless otherwise specified by the district traffic engineer.

2. The cost of fabrication, installation, and maintenance shall be paid by the requester.

3. Appropriate trailblazing signs shall be the responsibility of the facility and approved by the road authority. If appropriate trailblazing cannot be installed, signing on trunk highways shall not be installed. The color and design of trailblazing signs shall match that of the signing installed on the trunk highway.

4. Signs shall not be allowed from intersections or interchanges that do not provide the closest or most direct route from a trunk highway to a facility.

5. Mn/DOT retains the authority to specify message content (including abbreviations), size of sign, sign location, and combination of messages, in accordance with standards for acceptable signing practice. The sign design, including message and logos if applicable, shall be identical on ramp and mainline signs at an interchange.

6. Location and placement of signs is dependent upon space availability as determined by the district traffic engineer. Sign installations shall meet sign spacing guidelines for the type of roadway on which they are allowed. No sign installations shall be placed at a location that will interfere with other necessary signing as determined by the district traffic engineer. If space is unavailable, requests shall be denied.

7. Mainline signs shall not be installed for a facility if there is no space available to install signs on the ramp and vice versa.

8. All sign installations on trunk highways shall conform to Mn/DOT's current sign design and sign sheeting standards.

9. Signs not meeting Mn/DOT's current criteria shall be removed through attrition. If mainline signing is removed, ramp signing and any trailblazing on trunk highways shall also be removed.

10. Only one sign per facility may be installed in each direction along a trunk highway.

11. The criteria for installing logos (business panels) on Specific Service and Logo signs are specified in sections 6-7.09.13 and 6-7.09.09 respectively.

   a. Logos are allowed on guide signs for the following Supplemental Guide Signing Programs:

   1) Airports
   2) Casinos
   3) Educational Institutions (Post-Secondary Schools)
   4) Major Traffic Generators
   5) Minor Traffic Generators
   6) National Parks
   7) Regional Shopping Centers
   8) State Parks
   9) Trail Access
b. Logos shall meet all of the following guidelines:
   1) Logos shall not resemble a traffic control device.
   2) Inappropriate logos or logo panels shall not be permitted.
   3) There shall be only one logo or logo panel per sign.
   4) The logo or logo panel shall supplement the text message.
   5) The logo or logo panel shall not exceed 25 percent of the size of the sign panel.
   6) The logo or logo panel shall fit within the border of the sign panel. Logos or logo panels shall not be a separate attachment outside the limits of the sign panel.
   7) The logo and sign panel designs shall be reviewed and approved by the district traffic office prior to fabrication.
   8) The logo or logo panel shall be fabricated on sheet aluminum conforming with Mn/DOT specification 3352.

12. Signs may be considered on trunk highways that intersect with local roads which serve as logical, primary routes for motorists approaching from other directions.

13. Signs shall not be provided if the facility is readily visible or if effective off right-of-way directional signing is present or can be provided.

14. Mn/DOT retains the authority to deny requests for signing where acceptable standards cannot be met, including locations where other supplemental guide signs are already in place. At the discretion of the district traffic engineer, signing requests denied based on Mn/DOT policy may be appealed to the External Sign Variance Committee. Requests denied based on Minnesota statutes or engineering standards (i.e. insufficient space and design standards found in the MN MUTCD) may not be appealed.

15. If a district traffic office decides that a contract for signing a facility is required, the following process shall be used:
   a. The requester should obtain proposals from at least three consulting engineering firms to prepare the signing contract.
   b. The requester evaluates the proposals and enters into a contract with one of the consulting engineering firms to provide all of the following:
      1) A complete design of a signing plan (including field cross sections if necessary), assembly of special provisions, and proposal. Technical assistance is available from the State Signing Engineer.
      2) Submit the plan and proposal to the signing contractors. Typically allow ten days for the contractors to review and submit bids.
      3) Review the bids and award the contract to the signing contractor.
      4) Inspect the signing contractor’s work with technical assistance provided by Mn/DOT’s district staff.
6-7.09.03 General Motorist Services Signing Program (E10-1)

General Motorist Services signs may be provided for all of the following:
1. Gas, Diesel, and/or alternative fuels (LP Gas, E85) - The business shall meet all of the following criteria:
   a. Provide vehicle services including fuel and oil.
   b. Provide restroom facilities and drinking water.
   c. Provide continuous staffed operation for at least 12 hours a day, seven days a week.
   d. Provide public access to a telephone.
   e. Be located within two miles of the interchange.
2. Food - The business shall meet all of the following criteria:
   a. Serve three meals each day, seven days a week.
   b. Be licensed by the State and/or the appropriate political subdivision.
   c. Be located within two miles of the interchange.
3. Lodging - The business shall meet all of the following criteria:
   a. Provide lodging 24 hours a day throughout the year.
   b. Be licensed by the State and/or the appropriate political subdivision.
   c. Be located within ten miles of the interchange.
4. Camping - The business shall meet all of the following criteria:
   a. Have a State Department of Health license as required by Minnesota Statute (Chapter 327.15),
   b. Provide at least 20 spaces available for camping and parking.
   c. Provide modern sanitary facilities (flush, chemical, or incinerator toilets).
   d. Provide services 24 hours a day, seven days a week.
   e. Be located within ten miles of the interchange via an all-weather road, with adequate trailblazing signing provided by the operator to enable the traveler to reach the site.
5. Hospitals (See Section 6-7.09.04)

In addition to the general criteria for all signing programs, the following criteria apply for the General Motorist Services Signing Program:
1. General Motorist Services signs may be installed at rural freeway and expressway interchanges.
2. The costs of fabrication, installation, and maintenance of these signs shall be paid by Mn/DOT.

6-7.09.04 Hospital Signing Program (D9-2a, D9-2b, E10-1, E10-3, E10-4, and E10-8)

In addition to general criteria for all signing programs, all of the following criteria apply for the HOSPITAL signing program:
1. HOSPITAL signs may be installed on all trunk highways. The hospital requesting signing shall meet all of the following criteria:
   a. Accept all emergency cases, without discrimination for any reason (including ability to pay).
   b. Be readily accessible from the nearest intersection or interchange (normally within a ten mile radius).
   c. Provide 24-hour emergency medical care with a physician on the premises (metropolitan area) or on-call (rural areas).
2. The costs of fabrication, installation, and maintenance of signs shall be paid by Mn/DOT.

3. Signing directing motorists from one trunk highway onto another may be allowed if the facility is within ten miles of the intersection of the two trunk highways. Signs directing motorists from one freeway to another freeway shall not be allowed.

4. In place EMERGENCY HOSPITAL signs shall be removed through attrition and replaced with HOSPITAL signs. Mainline signing and ramp signing at an interchange shall be replaced at the same time.

5. HOSPITAL signs should be installed in accordance with the following:
   a. Interchange signs (E10-1, E10-3, E10-4 and E10-8)
      1) At rural interchanges where General Motorist Service signs (E10-1) are in place, the word HOSPITAL (E10-1 Supplement) may be included on the General Motorist Service sign if the word CAMPING is not displayed.
      2) At urban or rural interchanges where General Motor Services are not signed, the E10-3 sign shall be installed at the interchange nearest the hospital. The appropriate signing, E10-4 or E10-8, shall be installed on the ramp(s).
      3) If the hospital is located less than two miles from an interchange, the E10-8 sign shall be installed on the ramp(s). If the hospital is located two miles or more from an interchange, the E10-4 sign shall be installed on the ramp(s).
      4) Trailblazing signs on trunk highways shall display the number of miles in one mile increments (E10-8 or E10-4 if mileage is required).
      5) Trailblazing signs (D9-2a) on local roads shall display the number of blocks from the trunk highway to the facility.
   b. At-grade intersection signs (D9-2a and D9-2b)
      1) The D9-2b sign shall be ground-mounted in advance of, or on a traffic signal mast arm at, the intersection with the road leading to the hospital.
      2) Trailblazing signing (D9-2a) on trunk highways and/or local roads shall display either the number of blocks or miles (in one mile increments) to the facility. Trailblazing signs on local roads directing motorists to the facility shall display the appropriate distance and arrow.

6-7.09.05 Resort and Camping Signing Program

RESORT signs (D9-X3) and CAMPING signs (D9-X4) direct the motorist to campgrounds or resorts in rural areas where the Advertising Regulation Law has restricted the installation of private advertising signs off the highway right-of-way. (See Figures 6.33) These signs may only be installed where resort information signs (or County Slat Sign program) are in place on local roads in accordance with MS 160.283-160.285.

In addition to the general criteria for all signing programs, the following criteria apply to the Resort and Camping Signing Program.

1. Signs may be installed in rural areas on conventional highways and at at-grade intersections on expressways.

2. Signs shall only be allowed from the nearest trunk highway intersection. Signs directing motorists from one trunk highway to another trunk highway shall not be allowed.
3. The cost of fabrication, installation, and maintenance of the signs shall be paid by Mn/DOT.

4. One guide sign from each direction in advance of a private road or entrance is allowed when the following conditions exist:
   
   a. The main access from the trunk highway is via a private road or entrance.
   
   b. The resort or campground is located near, but not visible from, the trunk highway.
   
   c. The sign located on private property cannot be effectively seen by approaching drivers because of the width of the highway right of way and/or growth of vegetation.

5. Where the access to resorts or private campgrounds is via county, township, or other public road and the road is identified with a road name or destination sign, the sign panel or panels may be combined with the in place sign. Minimum height to the bottom of the lowest sign panel shall be seven feet.

6. Businesses signed under this signing program shall not be signed under the Specific Service signing program. Normally, these signs are installed where SPECIFIC SERVICE signs are not erected at intersections.

7. Resorts shall have a State Department of Health license as required by MS 157.16. A resort is defined in MS 157.15, subd. 11.

8. Private campgrounds shall have a State Department of Health license as required by MS 327.15, modern sanitary facilities (flush, chemical, or incinerator toilets), and no restrictions on type of camping (Tent, RV, Trailer, etc.).

6-7.09.06 Airport Signing Program (D1-X4, I-5)

In addition to the general criteria for all signing programs, all of the following criteria apply to the Airport Signing Program.

1. Airport signs may be installed on all trunk highways. Private airports requiring owner's permission to use shall not be eligible for signing.

2. The airport shall be located within 15 miles of the trunk highway intersection or interchange.

3. Signing from one trunk highway onto a second trunk highway may be allowed if the airport is located within:
   
   ten miles for an Air Carrier/Commercial Service airport and 7.5 miles for a General Aviation airport.

4. These guidelines may also be applied to heliports.

Airport signs should be installed in accordance with the following:

1. Individual airport names may be used on signing, as necessary, to ensure adequate identification for motorists.

2. The AIRPORT (D1-X4) sign with arrow will be adequate for most intersections at which airport signing is permitted.

3. At interchanges, the E10-3 sign design (with the word AIRPORT or proper name replacing the word HOSPITAL) shall be installed on the mainline. The D1-X4 sign, or a custom guide sign if proper name is used, shall be installed on ramp(s). The message on the ramp sign shall match the message on the mainline sign.

4. Trailblazing signing on local roads, when needed, shall utilize the Airplane Symbol sign (I-5) with appropriate arrow.
6-7.09.07 Casino Signing Program

In addition to the general criteria for all signing programs, all of the following criteria apply to the Casino Signing Program:

1. CASINO signs may be installed on all trunk highways.
   In order to be considered for signing, all of the following criteria shall be met by the casino requesting signing:
   a. Events or activities shall be held continuously throughout the year.
   b. Events or activities shall be non-local in scope and draw visitors from outside the local area.
   c. The facility shall provide adequate on-site parking or parking in the immediate area of the facility.
   d. The facility shall provide seating for at least 200 people.

2. The facility shall be located within ten miles of the trunk highway intersection or interchange where signs are requested.

CASINO signs should be installed in accordance with all of the following:

1. Signing shall have a white legend and border on a brown background.

2. Distances to casinos located two miles or more from the trunk highway intersection or interchange shall be shown on the sign.

3. Signs shall only be allowed from the nearest trunk highway and signs shall not be provided if the facility is readily visible or if effective off right-of-way directional signing is present or can be provided.

4. Additional proposed signing locations on other trunk highways are to be processed with Mn/DOT in accordance with the following procedure (developed and concurred in with the Indian Affairs Council in 2003):
   a. The Tribe assembles the proposed signing package (road system map, locations of proposed signing, and casino business logo panel design).
   b. The Tribe forwards the proposed signing package to the Mn/DOT district engineer for evaluation (including field review of roadway network and existing signing). This may include coordination with local road authorities (county, city) if any proposed signing is to be installed on local roads.
   c. In order to assist in the decision making process, the Mn/DOT district office will contact the State Traffic Engineer and State Signing Engineer in Mn/DOT OTST, to field review the proposed signing locations.
   d. After completion of the field review and evaluation, Mn/DOT staff shall assemble a response package (sign panel designs, private sign company contacts, sign fabrication specifications) and meet with the Tribe to present Mn/DOT's proposed sign locations.
   e. Upon concurrence of acceptable sign locations by the Tribe, the Tribe shall submit completed application form(s) and business logo panel design to the District Traffic Engineer for review and approval.
   f. After approval by Mn/DOT, the Tribe shall submit sign panel designs, business logo panel design, and fabrication specifications to a private sign company(ies) for bid(s).
   g. The private sign vendor invoices the Tribe and fabricates and delivers sign panel(s) to the Tribe.
   h. The Tribe coordinates with the Mn/DOT district office to arrange for installation of signs. Sign installation costs are to be paid for by the Tribe.

5. In place casino signs shall be replaced through attrition in accordance with the general criteria (section 6-7.09.02) and the above criteria. Existing casino signs should remain eligible for signing.
6-7.09.08 Educational Institution Signing Program (Post-Secondary Schools)

In addition to the general criteria for all signing programs, all of the following criteria apply to the Educational Institution Signing Program.

1. Educational Institution signs may be installed on all trunk highways. In order to be considered for signing, all of the following criteria must be met by the educational institution requesting signing:
   a. School grants two or four year degrees and is accredited by the North Central Association of Colleges and Schools. Examples are the University of Minnesota, State Universities, State Community Colleges, private four-year colleges, private two-year colleges, private professional schools, private vocational schools and technical colleges.
   b. Minimum on-campus average daily student enrollment for credit shall be 400 students, except in the Metro District where the minimum enrollment shall be 1500 students.
   c. Schools shall be located within five miles (urban area) or ten miles (rural area) of the intersection or interchange.

2. In rural districts, schools which front directly on trunk highways may be allowed signs to assist the motorist in making proper entrance turns.

3. In the Metro District, signs shall only be allowed from the nearest trunk highway intersection. Signs directing motorists from one trunk highway to another trunk highway shall not be allowed.

Educational Institution signs should be installed in accordance with the following:

1. The sign shall have a white legend and border on a green background.
2. Signs on freeways shall have the institution name on the top line and EXIT XXX. on the bottom line if the exit is numbered, otherwise the bottom line shall read NEXT (or SECOND) RIGHT.
3. Signs on freeway ramps shall display the institution name and appropriate arrow, without extraneous legend.
4. Distances to schools located two miles or more from the trunk highway intersection or interchange shall be shown on the ramp or intersection sign.

6-7.09.09 LOGO Sign Franchise Program

Logo signs are permitted on interstate highways and urban controlled access trunk highways (freeways) as specified in the Logo Sign Franchise Program Agreement 90212-P.

The MN MUTCD, Part 2F covers standards and guidelines on the use of logo signing. Minnesota Statute 160.80, the Logo Sign Franchise Program, authorizes Mn/DOT to establish this program for the purpose of providing specific information on gas, food, lodging, and camping for the benefit of the motoring public on the right-of-way of interstate and certain other controlled-access trunk highways.

This program is currently operated by Minnesota Logos, Inc. under an agreement with Mn/DOT. Businesses interested in this program shall contact Minnesota Logos, Inc.

Existing Mn/DOT installed GENERAL MOTORIST SERVICE signs should remain in place at each interchange if all businesses are not accommodated in the Logo Sign Franchise Program. The State Signing Engineer, OTST, in conjunction with district traffic offices shall review and approve all proposed logo installation locations to verify that Logo signs will not have a negative impact on other required signing and that proper sign spacing is maintained.
6-7.09.10 Major Traffic Generator Signing Program

Supplemental guide signs may be provided to direct motorists to major traffic generators. These traffic generators are major regional attractions, events, or facilities which attract persons or groups from beyond a local community, city, or metropolitan area. They are significant because of their unique educational, cultural, historical, or recreational experience and public appeal. Predominantly retail, business, or manufacturing centers are not normally eligible for guide signing.

In addition to the general criteria for all signing programs, the following criteria apply for the Major Traffic Generator Signing Program.

1. Major Traffic Generator signs may be installed on all trunk highways.

   In order to be considered for signing, all of the following criteria shall be met by the major traffic generator requesting signing:

   a. Parking for at least 1,000 vehicles.
   b. A minimum of ten events per year.
   c. Average event attendance of at least 5,000 persons.
   d. Located within ten miles of the trunk highway interchange/intersection where signs are requested.

2. Major Traffic Generator signs should be installed in accordance with all of the following:

   a. The sign shall have a white legend and border on a green or brown background in accordance with the MN MUTCD.
   b. Distances to major generators located two miles or more from the trunk highway intersection or interchange shall be shown on the sign approaching the intersection or on the ramp at an interchange.

3. Signs directing motorists from one trunk highway to another trunk highway may be allowed except when they direct a motorist from one freeway to a second freeway.

4. In the Metro District, the names of major traffic generators may be displayed on Mn/DOT permanent changeable message signs (CMS) located on freeways approaching the downtown areas in accordance with all of the following criteria:

   a. The facility shall have public/private parking for at least 1000 vehicles within 2000 feet of the facility.
   b. Event frequency and attendance shall be:
      1) A minimum of ten events per year with an attendance of at least 5000 persons within a two hour period/event.
      2) One day event per year with an attendance of at least 20,000 persons per event.
      3) One recurring event, two to seven days in length, per year with a total minimum attendance of 50,000 persons.
   c. Located not more than two miles from the interchange on the freeway where the permanent CMS is located.
   d. Only the facility name(s) shall be displayed on a permanent CMS which is located on a freeway.
   e. The display of a unique event by name (e.g. Winter Carnival, Aquatennial) may be approved on a case by case basis by the district traffic engineer and the RTMC.
   f. If a facility is having an event either concurrent with or overlapping an event with another facility, the duration of the display of each facility name and action message on a permanent CMS will be two seconds. This is based on the total reading time, including the change time between message displays, at vehicle operating speeds on metro area freeways.
g. Not more than two facilities (each with an action message) may be alternately displayed on a permanent CMS with the entire message for each facility displayed at one time.

h. The facility name and action message for an event may be displayed from:

1) One hour before the gate opens until 30 minutes after the event begins when normal attendance is for the entire event (i.e. a sporting event).

2) One hour before the event begins and continuously throughout the duration of the event when normal attendance is part time (i.e. an automobile show).

i. The duration of the display shall be continuous if only one facility is having an event to be displayed on a permanent CMS.

j. Messages on a permanent CMS directing motorists to a facility at more than one exit on the same freeway or to an exit(s) on another freeway shall only be allowed for traffic management at the discretion of the district traffic engineer and the RTMC.

k. Mn/DOT shall install, maintain, and operate permanent CMS installations. Their operation is under the direction of the district traffic engineer and the RTMC.

l. Mn/DOT retains the authority to use the permanent CMS(s) for traffic management purposes, in lieu of displaying the facility name(s) having the event, if a traffic incident occurs. If the permanent CMS(s) is (are) used for traffic management purposes, neither prepaid fees nor any portion thereof will not be refunded.

m. The facility shall pay $10,000 annually or $500 per event per day on all appropriate permanent CMS's.

6-7.09.11 Minor Traffic Generator Signing Program

Minor traffic generators are facilities which generally attract non-local persons or groups unfamiliar with the location of the generator but which do not qualify as major traffic generators. The use and installation of highway signing shall be limited to only those generators which have broad motorist appeal, serve non-familiar motorists, or are the kind of facility for which a motorist normally expects highway signing.

In addition to the general criteria for all signing programs, all of the following criteria apply for the Minor Traffic Generator Signing Program.

1. Minor Traffic Generator signs may be installed on conventional highways, at at-grade intersections on expressways, and rural bypasses that have interchanges at non-trunk highways. In order to be considered for signing, the following criteria must be met by the minor traffic generator requesting signing:

   a. Unless specified otherwise, facilities shall be open at least eight hours per day five days per week.

   b. For seasonal generators, Mn/DOT may incorporate signing indicating periods of closure where appropriate.

   c. Signing shall not be permitted within the corporate limits of one city directing motorists to a facility located in another city.

   d. Generators shall be located within specified distances from the trunk highway intersection or interchange at which signing is permitted. These distances vary depending on the type of generator and whether the signed intersection is located within an urban or rural environment.

      1) Urban environment - typical characteristics are highly developed areas having slower speeds, higher proportion of local traffic, increased difficulty in finding acceptable locations for traffic signs, and more stressful and complicated driving environment.
2) Rural environment - typical characteristics are relatively undeveloped or agricultural land, higher speeds, higher proportion of non-local traffic, easy ability to find acceptable locations for traffic signs, and relatively uncomplicated driving environment. Small cities in otherwise rural areas are included in this definition.

e. When Mn/DOT determines that the number of qualifying generators that a community is requesting signing for cannot all be accommodated on signing at the same intersection due to driver information overload and sign spacing guidelines, the local governing body(ies) shall prioritize which facilities may be signed.

2. Signs shall only be allowed from the nearest trunk highway intersection. Signs directing motorists from one trunk highway to another trunk highway shall not be allowed.

3. Signing shall not be provided if the facility is readily visible or if effective off-right-of-way directional signing is present or can be provided. Visibility from the approach to an intersection may be determined by adding 175 feet to Condition B (deceleration to ten mph from the posted speed) in MN MUTCD Table 2C-4. Signing is not allowed if the facility can be readily identified or if effective off highway right-of-way directional signing is legible at or beyond this distance.

Minor Traffic Generator signs should be designed in accordance with the following:

1. Distances to generators are to be shown in one mile increments.

2. When designing sign panels to be installed on rural expressways for private minor generators:
   a. Use the appropriate chart (Charts 6.1A, 6.1B, or 6.1C) to determine the required font size for guide signs on expressways.
   b. The next smaller font size may be used to design the sign panels for private generators if existing guide signing to other private generators on the highway section were designed with one font size smaller than that specified in the charts.

Signing may be provided for the following minor traffic generator facilities:

1. **Amtrak Station**
   This facility is a National Railroad Passenger Corporation (Amtrak) station. In addition to the general criteria for the Minor Traffic Generator Signing Program, all of the following criteria apply for an Amtrak station:
   a. The facility shall be located within one mile of the intersection or interchange.
   b. The sign shall have a white legend and border on a green background.

2. **Arboretum**
   This facility has trees, shrubs and plants which are cultivated and displayed for scientific and educational purposes.
   In addition to the general criteria for the Minor Traffic Generator Signing Program, all of the following criteria apply for an arboretum:
   a. The facility should provide:
      1) Parking for at least 50 vehicles.
      2) Walking or driving trails along with viewing facilities.
      3) An interpretive program, and/or audio/visual self-guiding presentations.
   b. The facility shall be located within three miles of the intersection or interchange.
   c. The sign shall have a white legend and border on a brown background.
3. **Bus Depot**

   This facility is a bus terminal with staffed ticket counters and public waiting rooms, providing inter-city and inter-state motorcoach bus services. In addition to the general criteria for the Minor Traffic Generator Signing Program, all of the following criteria apply for a bus depot:
   
a. The facility shall be located within one mile of the intersection or interchange.
   
b. The sign shall have a white legend and border on a green background.

4. **Camp (Private-rural environment)**

   This facility is generally a specialized rural summer camp. It is operated or sponsored by church, fraternal, scouting, or similar organizations and is not open to the general public for overnight camping. The facility generally accommodates pre-arranged sessions of several days duration and is oriented toward recreation, education, training, or combinations thereof. Visitors are usually not familiar with the camp location.

   In addition to the general criteria for the Minor Traffic Generator Signing Program, all of the following criteria apply for a private camp:
   
a. The facility shall:
      
      1) Provide full-time staff on site to accommodate clientele.
      
      2) Be a private operation.
      
      3) Accept pre-arranged accommodations only.
      
      4) Not allow public overnight camping.
   
b. For a seasonal camp, Mn/DOT may incorporate signing indicating periods of closure where appropriate.
   
c. The facility shall be located in a rural area within ten miles of the intersection or interchange.
   
d. The sign shall have a white legend and border on a brown background.

5. **Civic Center and Convention Center**

   This facility accommodates various types of activities and is primarily oriented toward conventions, meetings, expositions, and performances.

   In addition to the general criteria for the Minor Traffic Generator Signing Program, all of the following criteria apply for a civic center or convention center:
   
a. The facility shall:
      
      1) Hold events or activities that are non-local in scope and draw visitors from outside the local area.
      
      2) Hold events or activities continuously throughout the year on an average of at least once a month (rural environment) and three times a month (urban environment).
      
      3) Provide adequate on-site parking or parking in the immediate area of the facility.
      
      4) Provide seating for at least 1000 people (urban environment).
   
b. The facility shall be located within one mile of the intersection or interchange.
   
c. The sign shall have a white legend and border on a green background.
6. Correctional Institution
This facility may be a state or federal penal institution that generates a significant number of non-local visitors. In addition to the general criteria for the Minor Traffic Generator Signing Program, all of the following criteria apply for a correctional institution:
   a. The facility shall be located within three miles of the intersection or interchange.
   b. The sign shall have a white legend and border on a green background.

7. County Fairground
This is typically a multi-use facility. In addition to the general criteria for the Minor Traffic Generator Signing Program, all of the following criteria apply for a county fairground:
   a. The facility shall be located within one mile (urban environment) or five miles (rural environment) of the intersection or interchange.
   b. The sign shall have a white legend and border on a green background.

8. Disc Golf Course (rural environment)
In addition to the general criteria for the Minor Traffic Generator Signing Program, all of the following criteria apply for a disc golf course:
   a. The facility shall:
      1) Be its own entity located on its own property (not located on or in another facility that can be signed as a minor traffic generator).
      2) Have at least 18 holes.
      3) Be a member of the Professional Disc Golf Association (PDGA).
   b. The facility shall be located within ten miles (rural environment) of the intersection or interchange.
   c. The sign shall have a white legend and border on a brown background.

9. Downtown or Business District (rural environment)
Signing may be provided to direct motorists to the primary business district of a rural city when a conventional highway does not pass through it. In addition to the general criteria for the Minor Traffic Generator Signing Program, all of the following criteria apply for a downtown or business district:
   a. Signing is allowed to designate the primary business center, NOT to designate any other business or shopping area.
   b. The signs shall use either the legend "DOWNTOWN" or "BUSINESS DISTRICT", based on the preference of the city administration.
   c. The facility shall be located within three miles (rural environment) of the intersection or interchange.
   d. The sign shall have a white legend and border on a green background.
10. Drivers License/Road Test Exam Station

This facility shall be a permanent site. In addition to the general criteria for the Minor Traffic Generator Signing Program, all of the following criteria apply for a drivers license or road test exam station:

a. The facility shall:
   1) Provide a complete staff, including road testing of drivers.
   2) Be an official facility operated or designated by the Department of Public Safety.

b. The facility shall be located within one mile (urban environment) or three miles (rural environment) of the intersection or interchange.

c. The sign shall have a white legend and border on a green background.

11. Golf Course (public)

In addition to the general criteria for the Minor Traffic Generator Signing Program, all of the following criteria apply for a golf course:

a. The facility shall:
   1) Have at least nine holes.
   2) Be open to the public.

b. The facility shall be located within three miles (urban environment) or ten miles (rural environment) of the intersection or interchange.

c. The sign shall have a white legend and border on a brown background.

For driving ranges and miniature golf courses see the Specific Service Signing Program.

12. Great River Road (GRR) Amenity Site

This facility includes parks, boat/canoe access sites, picnic areas, campsites, historic sites, and other points of interest that are directly related to the officially designated national GRR route. In addition to the general criteria for the Minor Traffic Generator Signing Program, all of the following criteria apply for a GRR amenity site:

a. Only those sites directly tied to the national GRR system and identified on GRR maps or brochures may be signed.

b. The sign format and size shall be determined by OTST.

c. The facility shall be located within one mile (urban environment) or three miles (rural environment) of the intersection or interchange.

d. The sign shall have a white legend and border on a brown background.

The district traffic office should coordinate sign requests with the Office of Environmental Services.
13. **High School**

This is a multi-purpose facility which hosts a variety of activities throughout the year. Some of these facilities may have a remote stadium or athletic complex which generates traffic and also qualifies for signing. In addition to the general criteria for the Minor Traffic Generator Signing Program, all of the following criteria apply for a high school:

a. The facility shall:
   1) Hold events or activities that are non-local in scope and draw visitors from outside the local area.
   2) Provide adequate on-site parking.

b. The facility shall be located within one mile (urban environment) or three miles (rural environment) of the intersection or interchange.

c. The sign shall have a white legend and border on a green background.

14. **Historical Marker** (Minnesota Historical Society [MHS] site)

In addition to the general criteria for the Minor Traffic Generator Signing Program, all of the following criteria apply for a historical marker:

a. Requests for signing to historical markers maintained by the MHS shall be submitted to the State Signing Engineer, OTST.

b. All costs for MHS historical marker signs shall be paid by Mn/DOT.

c. The facility shall be located within one mile (urban environment) or ten miles (rural environment) of the intersection or interchange.

d. The sign shall have a white legend and border on a brown background.

15. **Historical Marker** (non-Minnesota Historical Society [MHS] site)

In addition to the general criteria for the Minor Traffic Generator Signing Program, all of the following criteria apply for a historical marker:

a. Requests for signing to historical markers maintained by a non-MHS organization shall be submitted to the State Signing Engineer, OTST. These requests shall be forwarded to the MHS for recommendations. The MHS recommendations shall govern Mn/DOT’s approval or denial of the request.

b. A historical marker shall:
   1) Document a topic with historical significance.
      Fifty years is a general rule of thumb of the time needed to develop a historical perspective and to evaluate significance. Topics that explain the recent past shall be exceptionally significant to be considered for approval. To establish significance, requesters should explain why a topic played a role or why it made a difference in the context of local, regional, or state history. Requesters shall provide a copy of the text and a photograph of the historical marker.

      As a general rule, signing shall not be approved for historical markers that explain ubiquitous historical phenomena or places that were common everywhere. Examples of these places include: the sites of towns, communities, or settlements that no longer exist; the birthplaces or gravesites of significant individuals; and cemeteries.

      2) Be located on public land and accessible to the public.

      3) Be legible using letters at least 5/8 inch high.

   c. The requester shall be responsible for maintaining and ensuring access to the historical marker.
d. There shall be at least three year-round parking places located off the road or street maintained by the requester.

e. All costs shall be paid by the requester.

f. The facility shall be located within one mile (urban environment) or ten miles (rural environment) of the intersection or interchange.

g. The sign shall have a white legend and border on a brown background.

16. **Historic Site**

   In addition to the general criteria for the Minor Traffic Generator Signing Program, all of the following criteria apply for a historic site:
   
a. Requests for signing to historic sites shall be submitted to the State Signing Engineer, OTST. These requests shall be forwarded to the Minnesota Historical Society (MHS) for recommendations. The MHS recommendations shall govern Mn/DOT's approval or denial of the request.

b. The facility shall be located within one mile (urban environment) or ten miles (rural environment) of the intersection or interchange.

c. The sign shall have a white legend and border on a brown background.

17. **Indoor Ice Arena**

   This is a high usage facility built primarily to accommodate ice skating activities, both competitive and recreational in nature.

   In addition to the general criteria for the Minor Traffic Generator Signing Program, all of the following criteria apply for an indoor ice arena:
   
a. The facility shall be located within one mile (urban environment) or three miles (rural environment) of the intersection or interchange.

b. The sign shall have a white legend and border on a brown background.

18. **Industrial Park** (rural environment)

   In addition to the general criteria for the Minor Traffic Generator Signing Program, all of the following criteria apply for an industrial park:
   
a. The facility shall:
      1) Be in a rural environment.
      2) Be serviced mainly by non-local delivery vehicles.
      3) Be open to both local and non-local customers.

b. The facility shall be located within three miles (rural environment) of the intersection or interchange.

c. The sign shall have a white legend and border on a green background.

19. **Interpretive Center**

   This facility provides explanations and interpretations of historical, cultural, and educational subject matter. In addition to the general criteria for the Minor Traffic Generator Signing Program, all of the following criteria apply for an interpretive center:
   
a. The facility shall have on premise staff and/or guides to present continuing service to visitors.

b. The facility shall be located within one mile (urban environment) or three miles (rural environment) of the intersection or interchange.

c. The sign shall have a white legend and border on a brown background.
20. **Library**
   In addition to the general criteria for the Minor Traffic Generator Signing Program, all of the following criteria apply for a library:
   a. The facility shall be located within one mile of the intersection or interchange.
   b. The sign shall have a white legend and border on a green background.

21. **Lock and Dam Site**
   This facility is operated and maintained by the US Army Corps of Engineers. The visitors to this facility are interested in viewing boating operations through the locks, and/or utilizing other available recreational facilities. In addition to the general criteria for the Minor Traffic Generator Signing Program, all of the following criteria apply for a lock and dam site:
   a. The facility shall provide viewing provisions for the public.
   b. The facility should:
      1) Provide parking for at least 15 vehicles.
      2) Provide restroom facilities.
      3) Have a telephone available.
   c. The facility shall be located within one mile (urban environment) or five miles (rural environment) of the intersection or interchange.
   d. The sign shall have a white legend and border on a brown background.

22. **Multi-Purpose Facility** (rural environment)
   This facility includes but is not limited to public community centers and National Guard Armories. A public community center is a public building designed for a community's social, cultural, educational, and recreational activities.
   A National Guard Armory is a facility where arms and military equipment are stored, and/or which is used for training military reserve personnel. It is frequently used for other public purposes.
   In addition to the general criteria for the Minor Traffic Generator Signing Program, all of the following criteria apply for a multi-purpose facility:
   a. The facility shall be located in a rural environment.
   b. The facility shall be located within three miles of the intersection or interchange.
   c. The sign shall have a white legend and border on a green background.

23. **Museum**
   In addition to the general criteria for the Minor Traffic Generator Signing Program, all of the following criteria apply to profit and non-profit museums:
   a. Requests for signing shall be submitted to the State Signing Engineer. These requests shall be forwarded to the Minnesota Historical Society (MHS) for recommendations. The MHS recommendations shall govern Mn/DOT's approval or denial of the requests.
   b. The facility shall be located within one mile (urban environment) or five miles (rural environment) of the intersection or interchange.
   c. The sign shall have a white legend and border on a brown background.
   A non-profit museum is required to be a Federal tax exempt organization Internal Revenue Code [IRC] 501(c)(3).
24. **Park**

This is a recreational facility, open to the public, of varying size, type, and purpose. It can be operated by various agencies or jurisdictions. For signing purposes, they are classified as a city park, county park, regional park, state park, state park, or national park.

The facility typically provides picnic tables, playground equipment, drinking water, trash barrels, and rest room facilities. In addition to the general criteria for the Minor Traffic Generator Signing Program, all of the following criteria apply for a park:

a. The facility shall meet Minnesota Department of Health standards regarding water supply and rest room facilities.

b. The facility shall be maintained in a sanitary and park-like condition.

c. The facility shall be located within three miles (urban environment) or ten miles (rural environment) of the intersection or interchange.

d. The sign shall have a white legend and border on a brown background.

25. **Public Access to Lake and River**

In addition to the general criteria for the Minor Traffic Generator Signing Program, all of the following criteria apply for a public access to a lake or river:

a. All requests for signing to State-provided public access sites shall be approved by the Department of Natural Resources (DNR). Requests for signing to all other access sites shall be approved by Mn/DOT.

b. The facility shall have:
   1) An access road that is maintained in passable condition.
   2) A parking area at the access site whose surface is gravel, bituminous, or concrete.
   3) A concrete boat-launching ramp or equivalent for trailered boats.
   4) A cleared access to water for canoes or carry-in boats.
   5) Free admission.

c. The facility should provide parking for at least 20 vehicles at the access site. A smaller parking area is acceptable at remote access sites.

d. The message on the public access sign shall be one of the following:
   1) Trunk highway signing: "Public Access" symbol with lake name, appropriate directional arrow, and mileage as shown on Standard Sign Drawing D7-X7 or D7-X7A.
   2) Local road trailblazing signing: "Public Access" symbol, with appropriate arrow as shown on Standard Sign Drawing D7-X8 or D7-X8A.

e. The facility shall be located within one mile (urban environment) or ten miles (rural environment) of the intersection or interchange.

f. The sign shall have a white legend and border on a brown background.
26. **Public Office Building**

This facility includes public administrative offices (federal, state and local) where the general public visits on a regular basis to conduct business. In addition to the general criteria for the Minor Traffic Generator Signing Program, all of the following criteria apply for a public office building:

a. This facility shall have adequate on-premise signing visible to the motorist.

b. The facility shall be located within one mile (urban environment) and three miles (rural environment) of the intersection or interchange.

c. The sign shall have a white legend and border on a green background.

27. **Recreational Complex**

In addition to the general criteria for the Minor Traffic Generator Signing Program, all of the following criteria apply for a recreational complex:

a. The facility shall provide:
   1) A site for events or activities that are non-local in scope and draw visitors from outside of the local area.
   2) Adequate on-site parking.

b. The facility shall be located within one mile (urban environment) or three miles (rural environment) of the intersection or interchange.

c. The sign shall have a white legend and border on a brown background.

28. **Recycling Center**

This facility shall comply with the permit rules of, and be officially designated by, the Minnesota Pollution Control Agency (MPCA). (Reference: MS 173.086 and 115A.555.) In addition to the general criteria for the Minor Traffic Generator Signing Program, all of the following criteria apply for a recycling center:

a. The facility shall:
   1) Be open to receive materials at least 12 hours per week, 12 months a year.
   2) Accept at least four different types of recyclable materials.
   3) Comply with Minnesota Rule 7035.2845 regarding the permitting of recycling facilities.

b. The facility shall be located within one mile (urban environment) and five miles (rural environment) of the intersection or interchange.

c. The sign shall have a white legend and border on a green background.

29. **Regional Human Services Center, Regional Treatment Center**

This is a public treatment facility operated by the Minnesota Department of Human Services. (Reference: MS 252, 253 and 254.) In addition to the general criteria for the Minor Traffic Generator Signing Program, all of the following criteria apply for a regional human services center and a regional treatment center:

a. The facility shall be located within one mile (urban environment) and three miles (rural environment) of the intersection or interchange.

b. The sign shall have a white legend and border on a green background.
30. **Sanitary Landfill, Demolition Landfill, Solid Waste Transfer Station, and Household Hazardous Waste sites**

These facilities shall be approved by the Minnesota Pollution Control Agency (MPCA). MPCA literature refers to a household hazardous waste site as an HHW Center. In addition to the general criteria for the Minor Traffic Generator Signing Program, all of the following criteria apply for a sanitary landfill, demolition landfill, solid waste transfer station, and household hazardous waste site:

a. The facility shall be open to the public as well as commercial and governmental users.
b. Compost sites shall not be signed.
c. The facility shall be located within three miles (urban environment) and five miles (rural environment) of the intersection or interchange.
d. The sign shall have a white legend and border on a green background.

31. **Scientific and Natural Area**

This facility is developed by the Department of Natural Resources (DNR) and offers various types of displays in a natural setting. In addition to the general criteria for the Minor Traffic Generator Signing Program, all of the following criteria apply for a scientific and natural area:

a. The facility shall provide viewing areas.
b. The facility should provide:
   1) Parking for at least 20 vehicles.
   2) An on-site explanation (audio, visual, or staff person) of the subject matter.
   3) Restroom facilities.
c. The facility shall be located within one mile (urban environment) or ten miles (rural environment) of the intersection or interchange.
d. The sign shall have a white legend and border on a brown background.

32. **Ski Area**

This is a public or private winter recreational site which provides downhill and/or cross country skiing. In addition to the general criteria for the Minor Traffic Generator Signing Program, all of the following criteria apply for a ski area:

a. The facility shall be open to the public.
b. The facility should provide parking for at least 100 vehicles at downhill sites and at least 30 vehicles at cross-country sites.
c. Downhill skiing facilities shall provide adequate staff in case of an emergency.
d. Cross-country facilities shall have trails which are maintained with trail guide signs or maps placed at key locations indicating location and distances.
e. The message on the ski area signs shall be as follows:
   1) Trunk highway signing: SKI AREA or Name of Ski Area with left (right) arrow at an intersection or NEXT RIGHT at an interchange.
   2) Local road trailblazing signing: Downhill symbol sign (D7-X13) or cross country symbol sign (D7- X14) with appropriate arrow.
f. The facility shall be located within five miles (urban environment) or ten miles (rural environment) of the intersection or interchange.
g. The signs shall have a white legend and border on a brown background.
33. **Veteran Memorial or War Memorial**

This is an independently located outdoor site built to commemorate veterans of U.S. military actions and/or the actions themselves. In addition to the general criteria for the Minor Traffic Generator Signing Program, all of the following criteria apply for a veteran memorial and/or memorial site:

a. The facility shall provide adequate on-site parking or parking in the immediate area of the memorial.

b. The facility should:
   1) Be of a unique size and presence.
   2) Be easily available for public viewing.
   3) Not be part of any other building or facility.

c. The facility shall be located within one mile (urban environment) or three miles (rural environment) of the intersection or interchange.

d. The sign shall have a white legend and border on a brown background.

34. **Wildlife Refuge or Wildlife Management Area**

This is a facility which is open to the public and offers viewing of a variety of wildlife. In addition to the general criteria for the Minor Traffic Generator Signing Program, all of the following criteria apply for a wildlife refuge or wildlife management area:

a. The facility shall provide interpretive facilities or programs, or provide viewing areas or nature trails.

b. The facility should provide:
   1) Parking for at least 20 vehicles in rural areas and at least 50 vehicles in urban areas.
   2) Restroom and telephone facilities.

c. The facility shall be located within one mile (urban environment) or ten miles (rural environment) of the intersection or interchange.

d. The sign shall have a white legend and border on a brown background.

35. **Workforce Center**

This facility is formed through a partnership between locally based community, county, and state agencies that the general public visits on a regular basis to obtain employment and training services. In addition to the general criteria for the Minor Traffic Generator Signing Program, all of the following criteria apply for a workforce center:

a. The facility shall have adequate on-premise signing visible to the motorist.

b. The facility shall be located within one mile (urban environment) and three miles (rural environment) of the intersection or interchange.

c. The sign shall have a white legend and border on a green background.
36. **Zoo**

This is a zoological garden or park where a wide variety of living wild animals are kept and safely displayed for public exhibition. In addition to the general criteria for the Minor Traffic Generator Signing Program, all of the following criteria apply for a zoo:

a. The facility shall be registered and approved by the American Association of Zoological Parks and Aquariums.

b. The facility shall provide identification and explanation of displays and wildlife.

c. The facility shall be located within five miles (urban environment) or ten miles (rural environment) of the intersection or interchange.

d. The sign shall have a white legend and border on a brown background.

37. **Facilities Not Eligible for Signing**

The following is a list of specific facilities that frequently request signing and are not eligible for signing under the Minor Traffic Generator Signing Program. This list is not all inclusive.

- American Legion/VFW & other "fraternal" organizations
- Athletic Field
- Cemetery (except national cemetery)
- Compost Site
- Correctional Facility (local and regional)
- Dance Hall
- Drive-In Theater
- Driving Range (Golf)
- Fish Hatchery
- Forest Preserve (county, state or federal)
- Game Farm and Preserve
- Half-way House/Shelter House
- Health Club
- Nursing/Senior Citizens Home or Center
- Office Building or Facility (Private)
- Office Park
- Performing Arts Theater
- Post Office
- Rehabilitation Center
- Road Maintenance Facility
- School (Elementary, Junior High)
- Sportsman Club
- Swimming Beach and Swimming Pool
- Tennis Court
- Veterans Home
- Wildlife Treatment Facility

To obtain signing under the Minor Traffic Generator Signing Program, the application form shall be completed and submitted to the district traffic engineer. For a copy of the Application Form for Guide and Information Signs see Forms 6.2A and 6.2B.
6-7.09.12 Regional Shopping Center Signing Program

In addition to the general criteria for all signing programs, the following criteria apply for the Regional Shopping Center Signing Program. Regional Shopping Center signs may be installed on all trunk trunk highways. In order to be considered for signing, all of the following criteria shall be met by the regional shopping center requesting signing:

1. At least 600,000 square feet of retail floor space, all under one roof, available for lease.
2. At least two major department stores owned by a national or regional chain organization.
3. Located within two miles of the trunk highway intersection or interchange.
4. Located outside of the downtown or central business district, except in the Metro District.

6-7.09.13 Specific Service Signing Program (D9-X6)

The Specific Service Signing Program was mandated by the 1980 Legislature under Minnesota Statutes 160.292 to 160.297. See these statutes for complete legislative intent.

1981 - permitted the inclusion of motels
1984 - permitted the inclusion of restaurants
1988 - added rural agricultural businesses and places of worship
1989 - added tourist-oriented businesses
1996 - added gasoline service station or other retail motor fuel business and optional business panel (logo)

Only Specific Service signs shall be installed on Specific Service sign assemblies.

To obtain signing under the Specific Service Signing Program, the application form shall be completed and submitted to the district traffic engineer. For a copy of the Application for Installation of Specific Service Signs see Forms 6.1A through 6.1E.

Definitions:

1. Specific Service - restaurants, rural agricultural or tourist-oriented businesses, places of worship, gasoline service stations or other retail motor fuel businesses, motels, resorts, and recreational camping areas.
2. Specific Service Sign - a rectangular sign panel no greater than 72” x 18” displaying the name or optional business panel, or both, of the specific service, the direction to, and where appropriate the distance to the facility.
3. Specific Service Sign Assembly - a combination of specific service sign panels on a single sign structure. The assembly shall be placed within the right-of-way on appropriate approaches to an intersection or interchange. Mn/DOT allows a maximum of four sign panels on a sign structure.
4. Specific Service Sign Cluster - a grouping of specific service sign assemblies on appropriate approaches to an intersection or interchange.
Specific Service signs may be provided for the following:

1. Gasoline service station or other retail motor fuel business - a business that provides vehicle services including fuel and oil; restroom facilities and drinking water; staff for continuous operation at least 12 hours per day, seven days per week; and public access to a telephone.

2. Motel - defined in M S 157.15, sub. 7. It shall be licensed by the State Department of Health. Bed and breakfast facilities previously allowed signing as a tourist-oriented business that meet the motel criteria are eligible for signing as a motel.

3. Place of worship - (no legislative definition provided) Mn/DOT defines a place of worship as any church, chapel, temple, synagogue, mosque, building, area, space, plaza, or dwelling wherein or whereat respect, reverence, or devotion is paid to a Divine Being. There is no restriction on time or frequency of devotional activities. However, the place or structure should be primarily intended for such purpose, and may not be a private home or school or any other site which is not primarily a place of worship.

MS 173 allows religious notices signs to be permitted in areas adjacent to trunk highway right-of-way. If this type of signing is permissible and effective, specific service signs shall not be installed.

4. Recreational camping area - defined in MS 327.14, subd. 8.

   The recreational camping area shall meet the following criteria:
   a. Be licensed by the State Department of Health.
   b. Provide at least 15 camping spaces.
   c. Provide modern sanitary facilities (flush, chemical, or incinerator toilets) and drinking water.
   d. Services available 24 hours a day.
   e. Accept all forms of campers (tent, trailer, motor home, etc). unless restriction is included in the official name, i.e. "Smith's Tent Camping" or "Joe's RV Camping".

5. Resort - defined in MS 157.15, subd. 11 as “a building, structure, enclosure, or any part thereof located on, or on property neighboring, any lake, stream, skiing or hunting area, or any recreational area for purposes of providing convenient access thereto, kept, used, maintained, or advertised as, or held out to the public to be a place where sleeping accommodations are furnished to the public, and primarily to those seeking recreation for periods of one day, one week, or longer and having for rent five or more cottages, rooms, or enclosures.”

6. Restaurant - defined in MS 157.15, subd. 12.

   The restaurant shall meet the following criteria:
   a. Provide a continuously staffed food service operation open at least four hours a day, five days a week except holidays as defined in MS 645.44, subd. 5, and except as provided for seasonal restaurants,
   b. Provide seating for at least 20 people,
   c. Serve meals prepared on the premises (reheated, prepackaged, ready-to-eat food is not food prepared on the premises), and
   d. Possess any required state or local licensing or approval.

Seasonal restaurants shall provide a continuous, staffed food service operation at least four hours a day, five days a week, during their months of operation.
7. Rural agricultural business - defined in MS 160.292, subd. 20. Mn/DOT further defines a rural agricultural business as any commercial activity engaged in as a means of livelihood or profit, located completely outside any urban district or suburban area or residence district or business district, which receives the major portion of its income from providing goods, services, commerce trade, or industry directly related to agriculture or providing for the care and well-being of animals. Year-round businesses shall be open a minimum of eight hours per day, six days per week, and twelve months per year. Seasonal businesses shall be open eight hours per day, six days per week, during the normal seasonal period.

Agriculture is the science or art of cultivating the soil, producing crops, or raising livestock of any kind, and in varying degrees preparing these products for marketing and consumer use.

Rural agricultural businesses shall be located in rural areas in order to be eligible.

The following is a list of eligible rural agricultural businesses:

- Agricultural equipment
- Commodity storage/elevator
- Farm implement dealer
- Food, seed, fertilizer store
- Greenhouse
- Humane society
- Kennel
- Orchard/produce sales
- Tree farm, nursery
- Veterinary clinic
- Welding & machine shop for agricultural equipment

8. Tourist-oriented business - Mn/DOT defines a tourist-oriented business as a generally interactive recreational based business that receives a majority of its income or visitors from tourism. A business shall have a majority of its retail floor space dedicated to the specific type of business for which signing is being requested. Year-round businesses shall be open a minimum of eight hours per day, six days per week, and 12 months per year. Seasonal businesses shall be open eight hours per day, six days per week, during the normal seasonal period.

a. Antique shop - a business where at least 50 percent of the total inventory is at least 50 years old.

b. Bookstore - a business where at least 25 percent of the total inventory is over 50 years old.

The following is a list of businesses that are eligible for signs:

- Amusement park
- Antiques, antique shop
- Archery range
- Bait and tackle
- Bookstore
- Gift, craft, art sales
- Miniature golf, driving range
- Marina, boat launch, guide service
- Recreational rentals (bicycle, boat, canoe, jet ski, snowmobile)
- Riding stable
- Trap & skeet shooting range
- Wildlife park, animal park

The following is a list of businesses (not all inclusive) that are not eligible for signs:

- Barber shop
- Bowling alley
- Butcher shop
- Car sales/service/rental
- Car wash
- Carpet sales
- Convenience store
- Day care center
- Flea market
- Grocery store
- Gun shop
- Hardware store
- Ice cream shop
- Laundromat
- Live theater (orchestra, band concert)
- Lumber yard
- Movie theater
- Performing arts theater
- Pet shop
- Recreational equipment sales/service
- Recreational vehicle sales/service/rental
- Repair business
- Second hand store
- Softball, baseball, soccer field
- Storage facility
- Any other predominately retail, business, or manufacturing center
In addition to the general criteria for all signing programs, all of the following criteria apply for the Specific Service Signing Program.

1. Specific Service signs may be installed in rural areas at at-grade intersections on conventional highways and expressways, and on rural bypasses of outstate municipalities that have interchanges at intersections of trunk highways with local roads or with other trunk highways.

2. A Specific Service sign is allowed on an approach to an intersection if either one or both sides of the approach meets less than four of the following factors:
   a. Within corporate limits
   b. Curb and gutter
   c. Sidewalk
   d. Street lighting
   e. Posted speed limit of 45 mph or less
   f. Zoning (commercial, industrial, retail, residential)
   g. Platted development
   h. Multi-lane divided highway
   i. Established local road system
   j. Frontage road

3. The Minnesota Statutes are not perfectly clear on urban qualifying businesses to be signed at rural intersections. The general authorization for each of the four basic combinations of specific service/intersection locations is summarized as follows:
   a. Service rural, intersection rural - Authorized
   b. Service rural, intersection urban - Not Qualified
   c. Service urban, intersection urban - Not Qualified
   d. Service urban, intersection rural - the following criteria need to be considered:
      1) The environment of the rural intersection as well as municipal boundaries.
      2) Straight ahead signing if overlapping routes are involved and one route does not serve the municipality.
   See Figures 6.37A & 6.37B to clarify questionable situations.

4. In order to be considered for signing on trunk highways, the following criteria shall be met by the specific service requesting signing:
   a. The business shall conform with all applicable laws and rules concerning the provisions for public accommodation without regard to race, religion, color, sex, or national origin.
   b. The business shall be located within 15 miles of the signed intersection or interchange.

5. Signing shall not be provided if the facility is readily visible or if effective off right-of-way directional signing is present or can be provided. Visibility from the approach to an intersection may be determined by adding 175 feet to Condition B (deceleration to ten mph from the posted speed) in MN MUTCD Table 2C-4. If the facility can be readily identified or effective off right-of-way directional signing is legible at this distance, or beyond, then signing is not allowed.

6. A facility is limited to signing at one intersection or interchange on the trunk highway system. Additional signing may be considered when the facility is located between, or approximately equal distance from, two or more trunk highways.

7. When a place of business is located off a conventional highway and can be served by two intersections with a local road (e.g., a bypass), one sign may be installed at each of the two intersections, so as to provide the shortest route for motorists on the conventional highway.

8. A facility that meets eligibility criteria from only one approach to an intersection or interchange shall only be signed from that approach.
Specific Service signs should be installed in accordance with all of the following:

1. Priority of installation
   a. A business shall not be allowed to “bump” another business from a specific service sign.
   b. If two or more eligible businesses apply at the same time, year-round businesses shall have priority over seasonal businesses.
   c. Left - or right-oriented businesses have priority over straight-ahead oriented businesses. If a business is eligible for a left or right directional sign panel on one approach, then it is eligible for a straight-ahead directional sign panel on the other approach. Although straight ahead signing is to be discouraged, it may be permitted at certain intersections.

2. Sign placement
   a. No specific service sign or assembly shall be placed at a location that will interfere with other necessary signing as determined by the Commissioner of Transportation. If space is unavailable, requests shall be denied.
   b. A specific service sign on a ramp shall not be allowed if the business is readily visible from the ramp terminal or effective directional signing is visible.
   c. A specific service sign should be installed on the right side of the roadway.
   d. A sign assembly shall be limited to four panels. Assemblies on mainline approaches to interchanges are limited to three panels and one action message panel, e.g. NEXT RIGHT.
   e. Specific service signs shall be installed at least 300 feet from any in place signs on a conventional road. In place signs are not to be removed to accommodate specific service signs. The maximum number of specific service sign assemblies per intersection approach shall be the number of structures that can be placed within a half mile of the intersection.
   f. Specific service signs shall be installed at least 400 feet from any in place signs on an expressway. The maximum number of specific service sign assemblies per interchange approach shall be the number that can be placed either within one half mile of the exit ramp gore or past the previous interchange entrance ramp, whichever distance is the shortest.

3. Order of installation
   The following sequence of signs shall be used at intersections on conventional highways to integrate specific service signs with other traffic signs in a uniform manner. The signs are listed in the order that a motorist would encounter them as they approach an intersection. The spacing of the signs shall be as shown in Figure 6.33.
   a. Junction assembly (if applicable).
   b. Road name advance sign (if applicable).
   c. Directional sign to cities (if applicable).
   d. Other guide signing (hospital, landfill, etc. if applicable).
   e. In place RESORT/CAMPING motorist service signs (D9-X3 and D9-X4).
   f. Specific Service Sign (D9-X6) or assembly(ies).
   g. Road name with arrow sign at or near intersection (if applicable).
   h. Route marker directional assembly at intersection (if applicable).
   i. Turn lane sign, where a turn lane is in place.
4. Sign panel details
   a. All distances shall be shown in one mile increments. Those distances less than one mile shall be omitted.
   b. Left directional panels shall be mounted above right directional panels.
   c. Only one business shall be displayed on a sign panel.
   d. Businesses which have combinations of approved services may combine these names in their sign legend, if possible, e.g. “RESORT CAMPING”, “MOTEL CAFE”. The legend size shall not be reduced. Abbreviations may be required, but only standard abbreviations may be used.
   e. Proper name abbreviations may be used as determined by the district traffic engineer.
   f. Inappropriate business names shall not be allowed to be displayed on sign panels.
   g. Business Panels or Logos
      1) Size of the logo may be up to 48 inches long by 12 inches high.
      2) The logo shall be left-justified.
      3) A short business name may be displayed to the right of the logo.
      4) Logos shall not resemble traffic control devices.
      5) Inappropriate logos shall not be permitted.
      6) Businesses shall deliver the business panel (logo) to the Mn/DOT district office for installation.
      7) Sheeting should not exceed Mn/DOT's current sign sheeting standard.
     8) If a business panel (logo) is stolen or damaged beyond repair, the business shall supply a new business panel paid for by the business.
   h. Both the ramp sign and the mainline sign shall be identical in format. Ramp signs shall have left or right directional arrows (if needed) and mileage (for distances of one mile or greater). Mainline signs shall have the business panel and/or the name centered on the sign panel.
   i. All sign panels for seasonal services shall be covered or removed when the service is not available. A CLOSED plaque may be bolted over the arrow/distance portion of the sign panel, for seasonal businesses. CLOSED plaques shall only be required on the mainline sign and not on the ramp sign at an interchange.
   j. Specific service sign panel (D9-X6) details are shown in the Standard Signs Manual.
   k. One or two lines of legend may be used as needed on a panel, and directions and distance are to be shown as indicated in the drawing. Left directional arrows shall be on the left end of the panel, and right arrows on the right end.
   l. Legend size should be 5-inch, Series C upper case for specific service names, and 4-inch, Series D modified numerals for distance figures.

6-7.09.14 Tourist Information Signing Program (D9-10a)
Contact OTST for assistance with signing for Mn/DOT Travel Information Centers
In addition to the general criteria for all signing programs, Tourist Information signs may be installed on conventional highways, at at-grade intersections on expressways, and rural bypasses that have interchanges at non-trunk highways. In order to be considered for signing, all of the following criteria must be met by the tourist information facility requesting signing:
   1. Located within one mile of the intersection or interchange in an urban environment and three miles in a rural environment as defined in the Minor Traffic Generator Signing Program criteria.
2. Requests shall only be accepted from a community group (e.g. chamber of commerce), business association, or governmental unit.

3. Only one site in a city or area may be approved for signing. Only Office of Tourism sites may be signed.

4. A sign shall be in place on the outside of the facility, clearly stating the operator and means of contact.

5. If the facility is operated seasonally, the signs shall be removed or covered; or closure clearly indicated.

6-7.09.15 Trail Access Signing Program

Signing may be permitted for access points to major recreational trails having improved and well maintained surfaces for hiking, biking, etc. All trails shall provide complete marking or trail maps for user guidance.

In addition to the general criteria for all signing programs, the following criteria apply for the Trail Access Signing Program.

1. Trail Access signs may be installed on all trunk highways, except in the Metro District where signs shall not be installed on freeways. In order to be considered for signing on trunk highways, the following criteria shall be met:

   a. Parking shall be provided at the site or within the immediate vicinity. The parking facility shall be surfaced and maintained year-round. Parking shall be provided for at least 40 vehicles at freeway signed sites and at least 20 vehicles at other sites. Smaller lots are acceptable at remote areas with the approval of the district traffic engineer.

   b. The minimum trail length shall be five miles.

   c. All requests for signing to DNR provided public trails shall be approved by the DNR and Mn/DOT. Signing for other trails is at the discretion of Mn/DOT.

   d. Access sites shall be located within ten miles of the interchange or intersection.

2. Signing shall only be allowed from the nearest trunk highway intersection or interchange. Signs directing motorists from one trunk highway to another trunk highway shall not be allowed.

Trail Access signs shall have a white legend and border on a brown background. The format of the Trail Access signs should be as follows:

1. Freeway - the official trail name and the freeway exit number.
2. Expressway interchanges - the official trail name and the message NEXT RIGHT.
3. At-grade intersections - the word ACCESS plus the official trail name and a directional arrow.

6-7.10 External Sign Variance Committee

Signing requests denied may be appealed to the External Sign Variance Committee (ESVC).

The group serves as a variance committee making recommendations to the Commissioner's Office on signing requests that have been denied by the district office. Those denials can be substantiated to have negative effects on the requester and/or motorists. The ESVC also reviews policies and criteria on informational signing matters.

The focal point for all sign requests shall remain with the district traffic engineer. If the district traffic engineer is uncertain as to whether or not a specific signing request should be approved, the request should be discussed with the district engineer. They will determine if the district will approve or deny the signing request. If Mn/DOT policies or guidelines do not address a specific signing request, the district should confer with OTST staff and other districts' staff since all signing requests have statewide implications. Once the district has made a ruling, the district traffic engineer will respond to the requester. If the request is denied, the requester can appeal to the ESVC for a variance. If the variance is granted, it does not change the guidelines covering that specific sign issue, but only that specific situation.
The ESVC is composed of persons outside of Mn/DOT who meet periodically to consider various requests for signing. The chair is a Mn/DOT employee who serves in a non-voting capacity to organize and schedule all functions of the ESVC. This individual serves as secretary and records decisions on sign variance requests. The chair represents the ESVC, not Mn/DOT, on all matters pertaining to the ESVC.

The procedures for this Committee are as follows:

1. A requester who has been denied signing by the district office and is interested in appealing the decision must request a hearing by the ESVC. The requester should contact the chair of the ESVC directly, and will then be advised of procedures and meeting date. The ESVC hears the requester's appeal and Mn/DOT's presentation separately.

   The recommendations of the ESVC will be based on pertinent factors, and will always consider the degree of financial hardship to the requester and safety implications.

2. For each signing request, the recommendations made by the ESVC and the state traffic engineer are forwarded to the Commissioner's Office for review. Presentations on each request are made to a special committee (Internal Sign Variance Committee) appointed by the Commissioner for final concurrence or denial. The requester and the district involved will be notified by the chair of the ESVC of the decision made by the Commissioner.

6-8.00 APPLICATION GUIDELINES - MISCELLANEOUS SIGNS

6-8.01 Adopt-A-Highway Sign Program (I-X1)

This signing program is administered by the district offices under the direction of the Office of Maintenance and Security. Mn/DOT shall fabricate and install signs. One sign shall be installed in each direction at the beginning of the adopted highway segment. Volunteer group names shall be limited to a maximum of eighteen (18) characters per line to maximize legibility. Each space between words and each type of punctuation takes up a character on a line.

Adopt-A-Highway signs are not allowed on Metro District freeways. If a section of freeway is approved for litter removal, a 42” x 24” sign shall be installed on the freeway entrance ramp.

A 60” x 18” plate with the words THIS SECTION AVAILABLE should be attached to the bottom half of the 60” x 36” sign panel if a group ceases to participate in the Adopt-A-Highway program and no other group adopts that section of highway for a period of time. This plate is to be attached to the sign panel with bolts utilizing spacers to minimize damage to the retroreflective sheeting on the overlaid sign panel. The colors on the bottom 60” x 18” portion of the sign panel were reversed (white legend and border on blue background) in 2006. A 60” x 18” panel may be attached to the bottom half of the 60” x 36” sign panel for new volunteer groups until the 60” x 36” sign panel reaches the end of its useful life. At that time, the complete sign panel shall be replaced with the new sign panel design.

A Reference Location sign panel may be combined with an Adopt-A-Highway sign panel on the same structure. For ease of reference and termini location for litter pickup, many districts have installed the Adopt-A-Highway signs either adjacent to, or in close proximity to reference post markers on rural sections of freeways and expressways.
Rather than two separate sign structures close together, both sign panels may be combined on one sign structure in accordance with all of the following criteria:

1. The Adopt-A-Highway sign panel is the primary sign panel on the sign structure.

2. At the correct Engineering station for the Reference Location sign, install a 2-1/2 pound or 3 pound per foot U-post structure to provide an offset of 12 feet from the edge of the shoulder to the left edge of the Adopt-A-Highway sign panel. Install the sign structure in accordance with Figures 6.3A, 6.3B, and 6.3C and Charts 6.2 or 6.3, and 6.4.

3. Attach the Adopt-A-Highway sign panel to the sign structure as shown in Figure 6.3A and meet the following minimum clearances (or see Figure 6.2):
   a. A minimum clearance of six feet from the surface of the nearest traffic lane to the bottom of the sign panel.
   b. A minimum clearance of seven feet measured perpendicular from the ground line to the bottom of the sign panel.

4. Attach the reference post marker to the left vertical post, directly below the Adopt-A-Highway sign panel with mounting hardware shown in Figure 6.3B.

See Forms 6.3A and 6.3B for a copy of the Adopt-A-Highway agreement form.

6-8.02 Adopt-A-Rest Area Sign Program

Rest areas/wayside rests (Class II and Class III Rest Areas) may be adopted by groups for the purpose of litter pickup, similar to adopting a portion of highway. These rest areas typically are located off the interstate highway system. Rest areas which are maintained by the Green View organization may not be adopted under the Adopt-A-Rest Area guidelines.

One ADOPT-A-REST AREA sign (I-X1), 42" x 24" may be installed along the exit ramp or road into the rest area or in the rest area at a site determined by the Site Development staff.

All other pertinent guidelines of the Adopt-A-Highway program shall apply to the Adopt-A-Rest Area program.

See Forms 6.4A and 6.4B for a copy of the Adopt-A-Rest Area agreement form.

6-8.03 Community Destination Sign Program

1. Introduction

   The community must develop a master plan for Community Destination signing which contains a map of the community, including the city street/local road system and a concept design of a typical community destination sign, which may include the city logo or name and up to a total of three destinations/attractions.

2. Community Map

   The map of the community shall include:

   a. Exact locations of private and publicly owned destinations and attractions to be included in this signing program. Destinations or attractions must be of general interest to the traveling public and shall not be a retail, business, or manufacturing center. In addition, this type of signing shall not display advertising for a commercial product or service.

   Only those destinations/attractions which qualify under Mn/DOT's Minor Traffic Generator Signing program guidelines are eligible for signing (contact the Mn/DOT district traffic engineer to obtain the listing of destinations/attractions eligible for signing). Community requests for other types of destinations/attractions may utilize Mn/DOT's sign variance process.
b. Conventional highway and expressway approaches to city street/local road intersections where signing is proposed.

c. Which destination(s) and attraction(s) are to be signed on each conventional highway and expressway approach at each city street/local road intersection.

d. City street/local road intersections where trailblazing signing is required to direct motorists to each facility. If signing is approved on the conventional highway or expressway to a facility, trailblazing signing shall be installed on the city streets/local roads by the community before signing is installed on the conventional highway/expressway.

3. General Requirements

The master plan shall be submitted to the Mn/DOT district traffic engineer for review. A resolution (see Form 6.5) shall be included with the submission of the master plan. This submission shall be initiated and coordinated by the community, and identify one contact (lead) person in the community through which all Mn/DOT correspondence and contact will be made.

If a community obtains Mn/DOT approval for Community Destination Signing, Mn/DOT will remove any existing minor traffic generator signs within the community. No requests for minor traffic generator signing will be approved within the community while the Community Destination Signing program is in effect.

For those facilities that Mn/DOT considers eligible for signing on state trunk highways, the eligible community is responsible for the construction, installation, and maintenance of the community destination sign structures and sign panels at its own expense.

If community destination signs are not properly maintained, Mn/DOT shall request that the community remove the signs at its own expense. If the signs are not removed within 30 days of notification, Mn/DOT will remove the community destination signs at the expense of the community.

4. Criteria for Community Destination Signing

a. Signing may be permitted on conventional highways and on expressways with at-grade intersections located within a community.

b. Sign locations on conventional highways and expressways shall be approved by the Mn/DOT district traffic engineer. Installation of signs shall be through the Mn/DOT permit process.

c. Only one sign structure is allowed in each direction approaching an intersection and shall be located on the right side of the roadway.

d. Sign locations shall be approved by the district traffic engineer. The MN MUTCD, Section 2A-16 states "Signs requiring different decisions by the road user shall be spaced sufficiently far apart for the required decisions to be made safely. One of the factors considered when determining the appropriate spacing shall be the posted or 85th-percentile speed limit."

e. A sign shall not obscure or detract from any existing traffic control devices.

f. If a sign structure is located in the clear zone, it shall meet Federal Highway Administration breakaway requirements or be protected as approved by the Mn/DOT district office.

g. Sign panel offset and mounting heights shall be in accordance with the MN MUTCD.

h. Signing is allowed for left and right turning movements; straight ahead confirmatory signing may be permitted in unique circumstances.

i. A specific destination may only be displayed on one sign structure in each direction on a conventional highway or expressway unless straight ahead confirmatory signing is also approved by the Mn/DOT district traffic engineer.
j. Sign lighting shall not obscure or detract from any existing traffic control devices and shall be in conformance with MS 173.16, subd. 3.

k. Roadway reconstruction and/or installation of new regulatory, warning, or guide signs may necessitate relocation or removal of community destination signs by the community at its own expense.

5. Sign Design Criteria

a. The sign panel background, or the predominant color, may be any color except Federal Highway red, yellow, or orange.

b. The sign panels shall be made of retroreflective sheeting no more retroreflective than High Intensity Sheet. See Mn/DOT Standard Specifications for Construction (Mn/DOT Spec.), Section 3352.2A2b). Fluorescent sheeting shall not be used on sign panels.

c. The sign base material shall be sheet aluminum. See Mn/DOT Spec., Section 3352.2A1a.

d. If separate sign panels are to be used, each sign panel should not exceed six feet in length and two feet in height.

e. A city logo or symbol, if displayed, shall be placed at the top of the sign structure (independently or on the top of a sign panel). It shall be simple and easily recognizable.

f. A city name, if displayed, shall be placed near the top of the sign panel. The lettering shall be of a font style and high color contrast for motorists to read at normal highway speeds.

g. Logos for destinations and attractions are not permitted (since the traveling public will not recognize logos of local destinations).

h. Up to three destinations/attractions may be displayed on a sign structure (three separate sign panels or one sign panel with three destinations).

i. Destinations/attractions shall be displayed (from top to bottom of sign) in the following sequence: left-oriented destination/attraction (closest to furthest) followed by straight ahead and then right-oriented destinations/attractions (closest to furthest).

j. Lettering shall be 5-inch high Series C Federal Highway Gothic font (or a similar font style that does not detract noticeably from legibility) with a maximum number of 14 characters per line (including spaces between words). Abbreviations, if used, shall be standard abbreviations.

k. Lettering and arrows shall be the same color.

l. Arrows shall be Mn/DOT standard arrows or similar so as to be legible and not a distraction.

m. Arrows shall not have encircling accents or contrasting mini-backgrounds.

n. Left arrows and upward pointing arrows shall be displayed on the left side, and a right arrow on the right side of a sign panel. If a border is used, it shall be plain, not decorative.

o. All sign panel designs should be reviewed by the Mn/DOT district traffic office before fabrication.

p. The sign shall not contain any animated or moving parts or flashing disks.

q. Distracting flashing or moving lights are not allowed. Lighting which presents a new message, pictorial image, or changes illumination at a rate less than once every six seconds is determined to be a flashing or moving light and is in violation of MS 173.15, subd. 7.
6-8.04 **DNR PUBLIC WATER ACCESS Sign (DNR NRM 8.2.35)**
The DNR may continue its current sign replacement program (replacing existing 12" x 18" signs with new 18" x 24" signs) in accordance with all of the following:

1. DNR staff will remove any PUBLIC WATER ACCESS sign panel attached to a Mn/DOT sign structure and install it on its own sign structure, which shall be an FHWA accepted breakaway sign support.
2. The location of the DNR sign structure shall be authorized by the Mn/DOT district traffic office.
3. The sign installation shall not hide from view nor interfere with the effectiveness of any official traffic control device.

6-8.05 **General Service Signs**
The MN MUTCD, Section 2D.45, addresses General Service Signs.

6-8.05.01. **Emergency 911 sign**
This sign informs motorists entering Minnesota that emergency services may be reached by dialing 911. It shall be installed within five miles of the state border on major entry points into the state. Additional signs may be placed at locations such as airports, weigh stations, and rest areas.

6-8.05.02. **Road/Weather Information System (R/WIS) sign**
Mn/DOT has approved signing for the R/WIS program, which provides road and weather information to the motorist. These signs have been installed statewide to promote this program.

6-8.06 **Geological Marker Sign (D5-X1C, D7-X1, and D7-X2)**
The Geological Society of Minnesota (GSM), a non-profit corporation, has constructed and maintained geological markers throughout the state for many years. The markers consist of descriptive bronze plaques, approximately 24" x 36" mounted on stone work pedestals or walls.

Many exist in Mn/DOT Rest Areas, Wayside Rests, Scenic Overlooks, and/or Wayside Historical Marker Sites. The markers detail the geological significance of the area near their location.

Mn/DOT-GSM cooperation occurred in the development of many sites located along conventional highways. Signing to these sites began in 1997, and will continue in accordance with the following guidelines.

6-8.06.01 **Criteria**

1. Sites shall be approved by the GSM.
2. Sites shall be located along conventional highways and expressways and easily accessible as part of a wayside development such as a wayside rest, scenic overlook, historical marker site, adjacent city parks, or similar sites.
3. Sites within state parks shall not be signed.
4. Sites shall not be signed along freeways.
6-8.06.02. Signing Method

1. Sites having only geological markers:
   a. Install advance sign D7-X1, GEOLOGICAL MARKER ½ MILE on RIGHT/LEFT.
   b. Install sign D7-X2, GEOLOGICAL MARKER with arrow at the entrance road or turnoff.

2. Sites located in other facilities (as listed above):
   a. Install sign D5-X1C beneath the in place advance sign.
   b. If there is no advance sign in place for the facility, install sign D5-X1C beneath the directional sign.

3. Signs shall have a white legend and border on brown background.

4. Sign fabrication, installation, and maintenance costs will be paid by Mn/DOT.

6-8.07 Reference Location Sign (D10-1, D10-2, and D10-3)

Reference Location signs, formally referred to as Reference Post markers, shall be erected along trunk highways to assist drivers in estimating their progress, provide a means for identifying the location of emergency incidents, and aid in highway maintenance. The zero mile point should begin at the south or west state line, and at the south or west junctions where routes begin. When a Reference location sign cannot be erected in its correct location, it may be moved up to 50 feet in either direction. If it cannot be placed within 50 feet of its correct location, it should not be installed.

Further information about Reference Location signs can be found in the MN MUTCD, Section 2D.45 and in Chapter 13 of the Traffic Engineering Manual, Chapter 13.

For the design and size of Reference Location signs refer to the MN MUTCD.

Mn/DOT installed One Tenth Mile markers on the interstate highway system to further enhance the usefulness of the Reference Location Sign System. Fabrication details are specified in Chapter 7.

6-8.08 Rest Area signing

Signing for Rest Areas may be found in the MN MUTCD.

6-8.08.01 Bus Parking in Rest Areas

Signing within rest areas provides guidance to separate parking locations for autos and for trucks and trailers.

When the need arises to sign for bus parking in a particular rest area, the following signing and pavement message guidelines are recommended:

1. Fabricate and install a plaque reading Buses above the "Trucks/Trailers", "Autos" or "Trailers/Autos" sign located at the roadway split to the parking areas until such time that the existing sign panels are to be replaced. When the existing sign panels are due to be replaced, add the word "Buses" to the legend of the sign panel.

   NOTE: The buses should be directed to that parking area which not only has the availability and storage capacity for parking, but also provides adequate year round access to the rest area facilities.

2. To designate the specific bus parking locations, either install pavement markings in the designated parking stalls or fabricate and install a sign reading BUS PARKING ONLY sign along side the designated parking stall(s).
6-8.08.02 Teletypewriter (TTY) Facility Signing in Rest Areas

This symbol sign provides travelers that have hearing impairments or speech difficulties advance notice of TTY equipped public pay telephones located in several Mn/DOT Class I rest areas.

Guidelines for fabrication and installation of TTY sign panels are as follows:

1. The sign panel shall display the white TTY symbol on a blue background.

2. The TTY symbol sign panel may be installed on an existing advance rest area sign structure for each of the rest areas equipped with TTY equipment. If there is more than one rest area sign, OTST and district traffic office staff will determine which advance sign structure will display the TTY symbol sign panel.

3. If the advance rest area sign panel is on a ground mounted sign structure, the TTY symbol sign panel shall be attached in accordance with the following size guidelines:
   a. U-channel sign structures - the TTY symbol sign panel shall be 24" x 24". The sign panel shall be mounted directly below the rest area sign panel on the right U-channel post with standard sign panel mounting hardware.
   b. I-beam sign structure - the TTY symbol sign panel shall be 30" x 30". The mounting will be determined by OTST and district traffic office staff.

4. If the advance rest area sign panel is mounted overhead, the TTY symbol sign panel shall be 30" x 30" and shall be mounted overhead. The mounting location will be determined by OTST and district traffic office staff. If there is more than one overhead mounted advance rest area sign panel, OTST and district traffic office staff will determine which advance sign structure will display the TTY symbol sign panel.

5. All costs for the TTY symbol sign panels (fabrication, installation, and removal) will be borne by Mn/DOT, since Mn/DOT is providing this equipment and let the statewide contract for the installation and maintenance of the TTY equipment in all Class I rest areas.

6-8.08.03 WAYSIDE REST Sign (D5-X1)

Wayside rests (State owned and maintained facilities only) are rest stop facilities with limited services located on conventional highways in rural areas. (See Figure 6.38) If the wayside rest is closed for the season, a CLOSED plaque may be installed as shown in Figure 6.38.

1. A WAYSIDE REST advance sign shall be installed approximately 1/2 mile in advance of the point of turn. When appropriate supplemental signs are used they shall be placed below the D5-X1 or the D5-X2 sign. If the wayside rest has only picnic tables, no supplemental signs shall be used.

2. A WAYSIDE REST with arrow sign (D5-X2) shall be installed approximately 200 feet in advance of the point of turn.
6-8.09 Seat Belt Sign (R16-X11 and R16-X12)

Seat Belt signs shall be installed on all trunk highways near the state entrance point. They are used to alert motorists entering Minnesota to the state law regarding seat belt usage and promote safety for the traveling public. The R16-X11 sign shall be used at all state border entrances on the trunk highway system and at entrances from airports.

The R16-X12 (36" x 36") sign may be installed at an entrance from a weigh station, or a rest area.

The R16-X12 (18" x 18") sign may be installed at an entrance from a parking lot, or a park and ride lot.

6-8.10 Sign Attachments

The purpose of attention getting devices, in the form of flags and/or orange horizontal panels, is to advise motorists of a new sign, an altered traffic control condition or similar situation where an eye-catching device is desirable to alert the repeat driver of the change. The flags are normally mounted above a new or altered traffic sign. Horizontal panels are always mounted above a new or altered traffic sign.

6-8.10.01 Horizontal Panels (Batten Boards)

1. General

   Horizontal panels as attention getting devices on signs are recommended only for usage on a limited basis, based on a site by site evaluation. Overuse of this type of attention getting device could easily lead to proliferation statewide which may decrease the effectiveness of this device.

2. Design

   All horizontal panels shall be fabricated using fluorescent orange prismatic sheeting.

   The size of horizontal panels shall be based on a height to width ratio of 1 to 3. The width shall not exceed that of the sign it is being placed above. For diamond shaped warning signs, the height to width ratio is based upon the dimension measured along one side of the sign.

3. Permanent Use

   Horizontal panels may be installed above any regulatory sign, except not above STOP or YIELD signs. Horizontal panels should only be considered if other methods (such as sign enlargement, additional median mounted signs, etc.) have been attempted without positive results. Any one of the following criteria may justify their use:

   a. The location has an unusually high rate of violations when compared with other similar types of locations within the district.

   b. The location has an extreme sight distance limitation where the sign is not visible or legible for a sufficient distance.

   c. Geometric or engineering factors which may indicate that some specific existing sign(s) needs additional motorist' attention.

   Any horizontal panel may be retained until the end of its useful life or when it is no longer needed.
4. Temporary Use

Horizontal panels may be installed above any warning or regulatory sign, but not above STOP or YIELD signs. It is recommended they be installed for a period of approximately three months. However, at those locations where they need to be retained longer, they should be removed within one year of original installation.

Any one of the following criteria may justify the use of horizontal batten boards:

a. The location has a change in traffic control.

b. The location has a change in permanent signing.

c. It is determined that additional attention to a situation is required for a period of time, not to exceed one year.

6-8.10.02. Flags

The temporary use of non-metal flags is permitted as stated in the MN MUTCD. Non-metal flags may be used for up to three months and should then be removed.

Other types of attention getting devices, such as flags (cloth, metal or plastic), may be used on a temporary or permanent basis. Metal or plastic flags shall be fabricated using fluorescent orange diamond grade retroreflective sheeting.

6-8.10.03. Un-authorized Sign Attachments

Extraneous and unauthorized sign panels should be removed and no such attachments are permitted on any signs on the trunk highway system.

6-8.11. Test Section Signing

Test sections are developed and monitored by the Office of Materials and Road Research and by district maintenance forces. Test sections should be signed in accordance with all of the following guidelines.

1. Each test section shall have an identifying number.

2. The Office of Materials and Road Research should track these sections and work with the district traffic and materials engineers to determine which test sections should be signed.

3. Test sections shall be identified by one of the following methods:

a. The preferred method is paint, retroreflective tape, or some other device embedded in the pavement at the outside edge of the shoulder (if paved) or the edge of the roadway.

b. Signs or markers located at the edge of the right of way line. If this method is used, a sign panel should identify the number of the test section. The sign panel shall have black, 2-inch high numbers and border on a white non-retroreflectorized background. It shall be attached to a lightweight two pound per foot U-post or plastic delineator post and positioned so the sign panel faces the roadway.

4. All test section signing installations should be coordinated by the district traffic offices.

5. All in place test section signs should be removed at the end of their useful life, with the exception of SHRP signing which should be retained as long as the program is still operating.

If a test section is to be retained when signs are due to be removed, the test section, with the exception of SHRP signing, should be identified by one of the methods specified in Item 3.
SIGN PLACEMENT

GORE PLACEMENT

ROADSIDE PLACEMENT

ROUTE MARKER, REGULATORY & WARNING SIGNS - TYPE C

MAJOR GUIDE SIGN - TYPE A

MAJOR GUIDE SIGN - TYPE D

NOTES:

1. IF A SECONDARY SIGN IS MOUNTED BELOW A MAJOR SIGN, THE MAJOR SIGN SHALL BE AT LEAST 8 FEET ABOVE THE PAVEMENT EDGE AND THE SECONDARY SIGN AT LEAST 5 FEET.

2. ALL ROUTE MARKERS, REGULATORY, AND WARNING SIGNS SHALL BE AT LEAST 5 FEET ON CONVENTIONAL ROADS AND 7 FEET ON EXPRESSWAYS OR FREEWAYS ABOVE THE PAVEMENT EDGE.

3. SIGN FACES SHALL BE VERTICAL.

4. OVERHEAD SIGNS SHALL BE POSITIONED AT RIGHT ANGLES TO THE THRU ROADWAY UNLESS OTHERWISE NOTED.

5. TO AVOID SPECULAR GLARE, \( \alpha \) SHALL BE APPROXIMATELY 93° FOR SIGNS LOCATED LESS THAN 30 FEET FROM THE EDGE OF THE PAVEMENT AND APPROXIMATELY 92° FOR SIGNS LOCATED 30 FEET OR MORE FROM THE EDGE OF THE PAVEMENT. THIS APPLIES TO TYPE A, C, AND D SIGNS AND INCLUDES SIGNS IN THE GORE.

6. \( \gamma \) IS THE PERPENDICULAR DISTANCE FROM THE GROUND LINE TO THE FRICTION FUSE ON THE POST. THIS DISTANCE SHALL BE AT LEAST 7 FEET.

7. WHERE \( X \) IS LESS THAN 30 FEET, \( H \) SHALL BE 7 FEET 6 INCHES.

8. LATERAL CLEARANCES GIVEN APPLY TO RIGHT AND OR LEFT SIDE INSTALLATION.


SPECIFIC NOTES:

1. EXIT SIGNS
   IF THESE OFFSETS CANNOT BE ATTAINED WITHIN 100 FEET OF THE PAVED CONE, A 4 FOOT OFFSET IS ACCEPTABLE. IF THE 4 FOOT OFFSETS CANNOT BE ATTAINED WITHIN 100 FEET OF THE PAVED GORE, CONTACT THE OTST SIGNING UNIT.

2. MERGE SIGNS
   IF THESE OFFSETS CANNOT BE ATTAINED WITHIN 200 FEET OF THE PAVED GORE, A 4 FOOT OFFSET IS ACCEPTABLE. IF THE 4 FOOT OFFSETS CANNOT BE ATTAINED WITHIN 200 FEET OF THE PAVED GORE, CONTACT THE OTST SIGNING UNIT.

Text Ref.: 6-4.07.01
**FIGURE 6.2**

**SIGN PLACEMENT**

Text Ref.: 6-4.07.02

**NOTE:** All dimensions are minimums.

- A secondary sign (e.g., advisory speed) mounted on a single post of a multi-post structure does not affect the mounting height of the primary sign.
- 5 feet for conventional road, 7 feet for expressway or freeway.

**URBAN**

Typical speeds below 45 MPH:
- Elevation of traveled roadway
- Shoulder edge of shoulder or face of curb
- 2 ft.
- 7 ft.

**RURAL**

Typical speeds 45 MPH and above:
- Elevation of traveled roadway
- Shoulder edge of shoulder or face of curb
- 12 ft.
- 9 ft.
- 7 ft.

**Text Ref.: 6-4.07.02**
NOTES:

1. USE 3LB/FT. STUB POSTS, RISER POSTS, STRINGERS, KNEE BRACES, LATERAL BRACES AND KNEE BRACE STUB POSTS. ALL SHALL CONFORM TO MN/DOT 3401.

2. FOR TYPE D SIGN POSTS, LENGTH, AND SPACINGS, SEE SIGNS DATA SHEET.

3. TYPE D SIGN PANELS SHALL BE BOLTED TO STRINGERS AT 24" MAXIMUM INTERVALS IN ACCORDANCE WITH TYPE D STRINGER AND PANEL JOINT DETAIL. (SEE MN/DOT STANDARD SIGNS MANUAL).

4. MOUNTING (PUNCH CODE) FOR TYPE C SIGN PANELS SHALL BE AS INDICATED IN THE MN/DOT STANDARD SIGNS MANUAL UNLESS OTHERWISE SPECIFIED.

5. ALL RISER (VERTICAL) U POSTS SHALL BE SPICED. DRIVEN STUB POSTS SHALL BE AT LEAST 7' LONG.

6. USE STAINLESS STEEL 5/16" BOLTS, WASHERS, AND NYLON INSERT LOCK NUTS AS SHOWN FOR ALL GROUND MOUNTED AND OVERHEAD SIGNS.

7. STAINLESS STEEL WASHER WITH SAME DIMENSIONS SHALL BE PROVIDED BETWEEN ALL NYLON WASHERS AND BOLT HEADS.

8. BRACING STUBS SHALL BE NO MORE THAN 4" ABOVE GROUND AND IMBEDDED AT LEAST 3-1/2'.

9. A-FRAME BRACKET SHALL BE STEEL CONFORMING TO MN/DOT 3306 AND GALVANIZED IN ACCORDANCE WITH MN/DOT 3394.

10. COLLARS SHALL BE USED TO SHIM OVERLAYS AND DEMOUNTABLE LEGEND AWAY FROM PANEL WHERE INTERFERENCE WITH BOLT HEADS IS ENCOUNTERED. MN/DOT 3352.2A5.

11. 2 POST TYPE C SIGNS SHALL BE REINFORCED WITH AT LEAST ONE LATERAL BRACE. INSTALLATIONS WHERE THE TOTAL PANEL HEIGHT IS 60" OR MORE SHALL HAVE TWO LATERAL BRACES LOCATED APPROXIMATELY AT THE QUARTER POINTS.

12. WHERE 2 SINGLE POST TYPE C SIGNS ARE INSTALLED SIDE BY SIDE, THEY SHALL BE REINFORCED LATERALLY BY AT LEAST 2 BRACES, BOLTED AT EACH POST AND LOCATED APPROXIMATELY AT THE QUARTER POINTS.

13. WHERE 3 OR MORE TYPE C SIGNS ARE INSTALLED SIDE BY SIDE, THEY SHALL BE REINFORCED LATERALLY BY AT LEAST 2 BRACES, BOLTED AT EACH POST AND POST SECTION AND LOCATED APPROXIMATELY AT THE QUARTER POINTS AS SHOWN IN MODIFIED TYPE C INSTALLATION.
**FIGURE 6.3B**

**Lateral Brace or Stringer Splice Detail (Exploded View)**

- **SECTION A-A**
  - 5/16" Stainless steel bolts with nylon insert lock nuts closest to splice & outside holes.
  - Stainless steel washer and nylon washer (T=1/32" min., I.D.=3/8" max., O.D.=7/8" max.)
  - 5/16" Stainless steel bolts with nylon insert lock nuts placed near top and bottom holes

- **SECTION B-B**
  - Vertical post
  - Stringer
  - Sign panel
  - 3-1/2" x 3-1/2" shim plate

- **Typical A-Frame Installation**
  - Type D signs
  - Mounting height
    - Edge of pavement
    - 9’ min.
    - 7’ min.

- **Typical "A-Frame" Installation**
  - Type C signs
  - Height
    - 1’ max.
    - 4’ max.
  - 3.5’

- **Knee Brace Splice**
  - One splice required

- **Text Ref.: 6-4.08.01**
6.3C

FIGURE 6.3C

TYPE C & D SIGN
STRUCTURE DETAILS (SHEET 3 OF 3)

Text Ref.: 6-4.08.01

October 28, 2008

<table>
<thead>
<tr>
<th>TRAFFIC ENGINEERING MANUAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>March 1, 2008</td>
</tr>
</tbody>
</table>

Revision 10-28-08
FIGURE 6.3D

TYPE C SIGNS MOUNTED ON O-POSTS, OH SIGN POSTS OR SIGNAL STANDARDS

1. FOR DETAILS AND NOTES NOT SHOWN, SEE TYPE C & D SIGN DETAILS.
2. FOR ONE PANEL ONLY, ROTATE STRINGERS SUCH THAT PANELS CAN BE MOUNTED AT THE SAME ELEVATION.
3. DETAIL A STRINGER MAY BE ONE OF THE THREE DESIGNS SHOWN, OR AN APPROVED EQUAL.

NOTES:

1. STRUCTURAL STEEL SHALL BE IN ACCORDANCE WITH MN/DOT 3306 AND GALVANIZED IN ACCORDANCE WITH MN/DOT 3394.
2. FASTENERS SHALL BE IN ACCORDANCE WITH MN/DOT 3391.2B AND SHALL BE GALVANIZED EITHER BY THE HOT-DIP PROCESS IN ACCORDANCE WITH ASTM A153, OR BY THE MECHANICAL PROCESS IN ACCORDANCE WITH ASTM A876, CLASS 50 OR GREATER.

Text Ref.: 6-4.08.01
ALTERNATE STRUCTURE FOR TYPE C & D SIGNS MOUNTED ON O-POSTS, OH SIGN POSTS OR SIGNAL STANDARDS

NOTES:
1. For details and notes not shown, see Type C and D Sign Details.
2. For back-to-back installation, rotate stiffeners for one panel 180 degrees such that panels can be mounted at the same elevation.
3. The approved stiffener is the SignFix Large Extrusion SX0130, made of 6061-T6 aluminum alloy or approved equal.
4. Horizontal spacing of stiffeners shall be according to the punch codes as shown in the Standard Signs Manual.
5. Mounting holes are not required on signs smaller than 6.3 square feet, except on single post punched signs.
6. On signs smaller than 6.3 square feet, stiffeners are to be attached to signs with 3M VHB (Very High Bond) or approved equal double-faced tape.
7. On signs larger than 6.3 square feet, stiffeners shall be attached to signs using 3M VHB (Very High Bond) or approved equal double-faced tape and supplemented with mechanical fasteners, either 3/16" diameter pop rivets or 5/16" bolts.
8. The approved pole mounting product is the ULTRA-LOK System of Bandit-IDEX, Inc. using 0.75" x 0.030" banding straps of type 201 1/4" hard stainless steel, double-wrapped around the pole, or approved equal.
9. Band pretension shall not exceed 1300 pounds.
10. All hardware shall be compatible with the approved stiffener and mounting systems.

Text Ref.: 6-4.08.01
TEXT REF.: 6-5.02

REGULATORY SIGNS ON
DIVIDED HIGHWAYS AT ENTRANCES

FIGURE
6.4
FIGURE 6.5

REGULATORY SIGNS FOR DIVIDED HIGHWAY - T INTERSECTIONS

Notes:
1. If "ONE WAY" signs are to be used, both shall be installed.
2. See Chapter 7 for application of markings.

Legend
- Hazard Marker (X4-2)
- Alignment Delineator (X4-7)
- Cylinder Style Delineator (X4-13)
* Optional

Text Ref.: 6-5.02

March 1, 2008

MEDIAN 30 FT. OR GREATER

MEDIAN LESS THAN 30 FT.
FIGURE 6.6
REGULATORY SIGNS FOR DIVIDED HIGHWAY INTERSECTIONS - MEDIANS LESS THAN 30 FT. WIDE

Note:
1. See Chapter 7 for application of markings.

Legend

- Hazard Marker (X4-2)
- Alignment Delineator (X4-7)
- Cylinder Style Delineator (X4-13)
- Optional

Text Ref.: 6-5.02
NOTES:
See Figure 6.8 for DO NOT ENTER and WRONG WAY signs.

* Optional

Text Ref.: 6-5.02
NOTES:

1. These ONE WAY signs are mounted in the far right quadrant rather than above the STOP or YIELD sign in the median to avoid confusion.
2. Mount the ONE WAY signs above the STOP or YIELD sign.
3. See Figure 6.8 for DO NOT ENTER and WRONG Way signs.

* Optional

Text Ref.: 6-5.02
FIGURE 6.8

REGULATORY SIGNS FOR DIVIDED HIGHWAY INTERSECTIONS WITH FRONTAGE ROADS

Median Less Than 30 ft.

Median 30 ft. or Greater

NOTES:
1. The signing is the same for both approaches to the intersection.
2. See Chapter 7 for application of markings.

Text Ref.: 6-5.02
Median Less Than 30 ft.

NOTES:
1. See Figures 6.11 and 6.12 for regulatory signs on ramps.
2. See Figure 6.7B for optional location of ONE WAY signs above YIELD signs.
3. The DIVIDED HIGHWAY sign should not be used when the roadway is divided only at the junction.

Legend
- Hazard Marker (X4-2)
- Alignment Delineator (X4-7)
- Cylinder Style Delineator (X4-13)
- Optional

Median 30 ft. or Greater

NOTES:
1. See Figures 6.11 and 6.12 for regulatory signs on ramps.
2. See Figure 6.7B for optional location of ONE WAY signs above YIELD signs.
3. The DIVIDED HIGHWAY sign should not be used when the roadway is divided only at the junction.

Legend
- Hazard Marker (X4-2)
- Alignment Delineator (X4-7)
- Cylinder Style Delineator (X4-13)
- Optional

Text Ref.: 6-5.02
NOTE:
1. See Chapter 7 for application of markings.

Text Ref.: 6-5.02
March 1, 2008
REGULATORY & WARNING SIGNS FOR ¾ AND RIGHT IN - RIGHT OUT INTERSECTIONS

6.11

NOTE:
1. See Chapter 7 for application of markings

Text Ref.: 6-5.02
NOTE:
Install "ONE-WAY" signs on or as near to the signal pole as possible.

* Optional
** If used, the near right "ONE-WAY" sign is not required.

Text Ref.: 6-5.02
NOTE:
1. See Chapter 7 for application of markings
NOTE:
① Additional sign required on left when ramp is 3 lanes or wider.
FIGURE 6.15
REGULATORY SIGNS ON CLOVERLEAF INTERCHANGE RAMPS
NOTE:
① The WATCH FOR BUSES ON SHOULDER signs shall be located beyond the ramp meter signals.

Text Ref.: 6-5.04
Note:
See Chapter 7 for application of markings.

Text Ref.: 6-5.05
NOTE:
1. Arrows are not pavement marking arrows.

Text Ref.: 6-5.09
* Required if turn lane is longer than 300 feet.

NOTE:
1. Arrows are not pavement marking arrows.

Text Ref.: 6-5.09
NOTE:
1. See Chapter 7 for application of markings.

Text Ref.: 6-6.02
NOTES:
1. The signing is the same for both approaches to the intersection.
2. See Chapter 7 for application of markings.

* - Optional

Text Ref.: 6-6.06
NOTE:

1. The signing is the same for both approaches to the intersection.
2. See Chapter 7 for application of markings.

* - Optional

Text Ref.: 6-6.06
NOTES:
1. Intended for use where a definite need exists:
   -- Heavy pedestrian volumes
   -- Mid-block crossings, etc.
2. See Chapter 7 for application of markings.

* Optional

Text Ref.: 6-6.09.01
NOTES:
1. The signing is the same for both approaches to the intersection.
2. Desirable location 2 - 5 miles in advance of passing lane.
3. Lane skip striping shall end approximately 50 feet beyond the Lane Reduction Transition sign.
4. See Chapter 7 for application of markings.

Text Ref.: 6-6.13.03
Crossroad (Low Volume)

NOTE:
See Chapter 7 for application of markings.

Text Ref.: 6-6.13.03
NOTES:
1. All sign location distances are approximate.
2. Distances between advance signs in the two-lane, two-way section to the painted gore are 500-1200 feet.
3. See Chapter 7 for application of markings.
4. On high speed roadways (45 mph and greater), the spacing should be 400-500 feet. On low speed roadways (40 mph and less), the spacing should be 200-400 feet.
5. Do not use Divided Highway Begins and Divided Highway Ends signs when the highway is divided only at intersections or junctions.

* - Optional

Text Ref.: 6-6.18
FIGURE 6.24

SIGNAL MAST ARM INTERSECTION SIGNING

Text Ref.: 6-4.06.05
FIGURE 6.25

“T” INTERSECTION SIGNING (w/ DIVIDED HIGHWAY)

Text Ref.: 6-7.01 & 6-7.04

NOTES:
- See Figures 6.4 thru 6.9 for other regulatory signs.
- If Stop Ahead sign is not required, install signs 300 ft. apart.
- If there is no turn lane, install these signs 500 ft. from the intersection.

March 1, 2008

6-121
DIAMOND INTERCHANGE AND CROSSROAD SIGNING (UN SIGNALIZED)

NOTES:
1. Place regulatory signs as shown in Figures 6.12, 6.14, 6.18A, and 6.18B.
2. The signing is the same for both approaches and both exit ramps.
3. This sign shall be installed prior to a right turn lane.
NOTES:

1. Place regulatory signs as shown in Figures 6.12, 6.14, 6.18A, and 6.18C.

2. The signing is the same for both approaches and both exit ramps.

3. This sign shall be installed prior to a right turn lane.

4. This sign may be used if Sign C is installed, but shall be used if Sign B is installed.

Text Ref.: 6-7.01

March 1, 2008

DIAMOND INTERCHANGE AND CROSSROAD SIGNING (SIGNALIZED)

FIGURE 6.27
NOTES:
1. Place regulatory signs as shown in Figures 6.12, 6.14, 6.18A, and 6.18B.
2. The signing is the same for both approaches and both exit ramps.
3. This sign shall be installed prior to a turn lane.

Text Ref.: 6-7.01

March 1, 2008

FOLDED-DIAMOND INTERCHANGE AND CROSSROAD SIGNING

FIGURE

6.28
NOTES:
1. Place regulatory signs as shown in Figures 6.15.
2. The signing is the same for both approaches and both exit ramps.
3. This sign shall be installed prior to a right turn lane.
4. Install 200 feet past the end of the taper.
NOTES:
1. This type of auxiliary lane is located either between loops at a cloverleaf interchange or between two closely spaced interchanges.
2. Install a MERGE sign (W4-1) in the gore of the entrance ramp located at the beginning of the auxiliary lane.
3. Install a standard Exit Direction sign (overhead mounted) at the location where the exiting lane begins to diverge from the through roadway.
4. See Figure 7.8A for striping details.
NOTES:
1. This type of auxiliary lane is located either between loops at a cloverleaf interchange or between two closely spaced interchanges.
2. Install a MERGE sign (W4-1) in the gore of the entrance ramp located at the beginning of the auxiliary lane.
3. Install a standard Exit Direction sign (overhead mounted) at the location where the exiting lane begins to diverge from the through roadway.
4. If the full width escape lane extends at least 800 feet past the Exit Gore sign:
   a. Install a ground mounted RIGHT LANE ENDS sign (W9-1) 600 feet before the end of the full width escape lane, and
   b. Install a LANE ENDS MERGE LEFT sign (W9-2) 400 feet past the W9-1 sign. This sign will provide 200 feet between the W9-2 sign and the end of the full width escape lane.
5. See Figure 7.8A for striping details.

Text Ref.: 6-7.02.03
NOTES:
1. Install an Added Lane sign (W4-3) in the gore located at the beginning of the auxiliary lane.
2. Install an EXIT ONLY Advance Guide sign (overhead mounted) 1000 feet preferred, 800 feet minimum, ahead of the EXIT ONLY Exit Direction sign.
3. Install a RIGHT LANE MUST EXIT sign (R16-X7) 500 feet ahead of the EXIT ONLY Exit Direction sign.
4. Install an EXIT ONLY Exit Direction sign (overhead mounted) at the location where the exiting lane begins to diverge from the through roadway.
5. See Figure 7.8A for striping details.

Text Ref.: 6-7.02.03
NOTES:
1. Install an Added Lane sign (W4-3) in the gore located at the beginning of the auxiliary lane.
2. Install an EXIT ONLY Advance Guide sign (overhead mounted) 1000 feet preferred, 800 feet minimum, ahead of the EXIT ONLY Exit Direction sign.
3. Install an EXIT ONLY Exit Direction sign (overhead mounted) at the location where the exiting lane begins to diverge from the through roadway.
4. If the full width escape lane extends at least 800 feet past the Exit Gore sign:
a. Install a ground mounted RIGHT LANE ENDS sign (W9-1) 600 feet before the end of the full width escape lane, and
b. Install a LANE ENDS MERGE LEFT sign (W9-2) 400 feet past the W9-1 sign. This sign will provide 200 feet between the W9-2 sign and the end of the full width escape lane.
5. See Figure 7.8A for striping details.

Text Ref.: 6-7.02.03

FIGURE 6.30D
Text Ref.: 6-7.04
NOTES:
1. The signing is the same for both approaches to the intersection.
2. Install this sign 500 ft. from the intersection if there is no turn lane.
3. This sign shall be installed prior to a right turn lane.

* Optional

Text Ref.: 6-7.04
NOTES:

1. The signing is the same for both approaches to the intersection.
2. The Resort & Camping signs may be combined with the road name sign location.
3. Install sign 500 ft. from the intersection if there is no turn lane.

Text Ref.: 6-7.04, 6-7.06.03, 6-7.09.05, and 6-7.09.13, item 3, pg. 6-76
NOTES:

1. Consider these factors for placement: visibility, skew, and geometrics.
2. Placement of the sign shall not block the view of the YIELD sign.
3. Minor Traffic Generator sign is not allowed if the intersected road is a trunk highway.
4. See Figure 6.32 for post intersection signing.
5. Optional where posted speed limit is \( \leq 40 \) mph.  
   See Chart 6.5 for sign placement distance.

* Optional

Text Ref.: 6-7.04
NOTES:
1. The signing is the same for both approaches to the intersection.

Text Ref.: 6-7.06.03
TYPICAL MOUNTING

9 ft. Min.

7 ft. Min.

SIGN PANEL ATTACHMENT DETAIL

Sign panel

Oversize stainless steel washer with nylon washer (next to sign face).

Post

5/16 inch stainless steel bolt with nylon insert lock nut.

U-POST MOUNTING

Text Ref.: 6-7.07.03, section 4
**DIAGRAM A**

Trunk Highway Intersection
QB is adjacent to the Trunk Highway

Diagram A is addressed in sections
6-7.04.04 item 2, 6-7.04.04 items 5a and 5b.

---

**DIAGRAM VARIATION A**

Trunk Highway Intersection
QB on a Grid System

If the QB is located on the city street system
OFF the Trunk Highway, signs are permitted
on Trunk Highway Y if the QB has effective
off R/W directional advertising signs inplace on
Trunk Highway X, as "trailblazing".

---

**DIAGRAM B**

Interstate

Diagram B is addressed in section
6-7.04.04 item 2.

---

**DIAGRAM C**

Diagram C signing is considered "straight ahead"
on both Trunk Highways, no signing is permitted.

---

**LEGEND:**

- OK - Permissible Sign Location
- QB - Qualifying Business
- - City
- - Specific Service Sign(s)

Text Ref.: 6-7.09.13, item 3, pg. 6-75
March 1, 2008

TRAFFIC ENGINEERING MANUAL

FIGURE 6.37B

SPECIFIC SERVICE SIGNING
TYPICAL CLARIFICATION DIAGRAMS

Text Ref.: 6-7.09.13, item 3, pg. 6-75

One Sign for each QB qualifies. Second sign may be purchased.

DIAGRAM D

Trunk Highway X southbound qualifies for signs for QB-1 and QB-2 since it intersects Trunk Highway Y. Section 6-7.04.04 item 6b applies for straight ahead signing.

DIAGRAM E

Trunk Highway X southbound qualifies for a sign for QB-2 and Trunk Highway Y qualifies for a sign for QB-1. Section 6-7.04.04 item 6b applies for straight ahead signing.

Diagram F is addressed in section 6-7.09.13 item 7.

Diagram G is addressed in sections 6-7.04.04 item 2 and 6-7.04.04 item 5a.

LEGEND:
- OK - Permissible Sign Location
- QB - Qualifying Business
- City
- Specific Service Sign(s)

Text Ref.: 6-7.09.13, item 3, pg. 6-75
NOTES:
1. The signing is the same for both approaches to the intersection.
2. The sign shall be installed prior to a turn lane.

Required if closed
May be mounted below D5-X1 or D5-X2 as required.
**MINNESOTA DEPARTMENT OF TRANSPORTATION (MN/DOT)**

Installation of Specific Service Signing on Trunk Highways (T.H.)

(PLEASE PRINT)  
(revised 01-05-07)  

(Please Print)

<table>
<thead>
<tr>
<th>Business Name</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

Is signing requested at a rural interchange?  
Yes ___ No ___

Is signing requested on the interchange ramp?  
Yes ___ No ___  
(If the business or business signing is visible from the end of a ramp, a sign is not required on the ramp.)

Number of signs requested: (circle) 1 2 3 4  
[all signs must contain the same legend]

Circle the direction of travel to be signed:  
Eastbound  Westbound  Northbound  Southbound

Distance from the signed Intersection/Interchange to the business: ___________ miles.  
Businesses must be within 15 miles of the intersection/interchange.

Direction to the business from the signed intersection/interchange (circle one):  
East  West  North  South

---

**OPTION OF 3 SIGN STYLES (check one)**

See Sample A

<table>
<thead>
<tr>
<th>Exact business name to be shown on sign</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

See Sample B  
(name optional)

<table>
<thead>
<tr>
<th>18” long x 12” high</th>
</tr>
</thead>
</table>

See Sample C

<table>
<thead>
<tr>
<th>30” to 48” long x 12” high</th>
</tr>
</thead>
</table>

Normal Hours of Operations:

|------|-------|------|--------|-----|------|------|

Seasonal Businesses:

<table>
<thead>
<tr>
<th>Months of Operation:</th>
</tr>
</thead>
</table>

Applicant must read, complete, and sign the reverse side (Certification of Compliance) prior to the fabrication and installation of the sign(s).  

Individual sign fee: $ _____ x _____ signs = __________ (includes fabrication, installation, and overhead)

Payment for sign installation must be included with the completed application.

Make check or money order payable to: COMMISSIONER OF TRANSPORTATION

Return this form to: Minnesota Department of Transportation  
NAME - TITLE  
ADDRESS  
CITY, MN ZIP CODE

Questions call (xxx)xxx-xxxx

Text Ref.: 6-7.09.13

February, 2008  

SPECIFIC SERVICES APPLICATION  

FORM 6.1A
CERTIFICATION OF COMPLIANCE
(page 1)

☐ RESORT: I, the undersigned, do hereby certify that this business is licensed by the State Department of Health as required by Minnesota Statute 157.16.

☐ MOTEL: I, the undersigned, do hereby certify that this business is licensed by the State Department of Health as required by Minnesota Statute 157.16.

☐ RESTAURANT: I, the undersigned, do hereby certify that this business is licensed by the State Department of Health as required by Minnesota Statute 157.16 and that the restaurant provides continuous staffed food service at least 4 hours a day, 5 days a week except holidays as defined in MS 645.44, subd. 5, and except as provided for seasonal businesses; seating capacity for at least 20 people, serve meals prepared on the premises, and possess any required state or local licensing or approval.

☐ CAMPGROUND: I, the undersigned, do hereby certify that this camping area does possess a State Department of Health license, as required by Minnesota Statute 327.15, and that the following criteria will be met:
   (1) a minimum of 15 spaces available;
   (2) modern sanitary facilities (flush, chemical, or incinerator toilet) and drinking water available;
   (3) services available 24 hours per day

☐ GASOLINE SERVICE STATION/RETAIL MOTOR FUEL BUSINESS: I, the undersigned, do hereby certify that the "gasoline service station" or "retail motor fuel business" provides services including fuel and oil, restroom facilities and drinking water, public access to a telephone, and provides continuous operation at least 12 hours per day, 7 days per week.

☐ PLACE OF WORSHIP

☐ RURAL AGRICULTURAL BUSINESS: Type of business: ____________________________
   I, the undersigned, do hereby certify that the "rural agricultural business" is open a minimum of 8 hours per day, 6 days per week, 12 months per year or for a seasonal business 8 hours per day, 6 days per week during the normal seasonal period.

☐ TOURIST ORIENTED BUSINESS: Type of business: ____________________________
   I, the undersigned, do hereby certify that the "tourist oriented business" is open a minimum of 8 hours per day, 6 days per week, 12 months per year or for a seasonal business 8 hours per day, 6 days per week during the normal seasonal period.

Further, I do hereby certify that this business conforms with all applicable laws and regulations concerning the provisions for public accommodations without regard to race, color, creed, religion, national origin, sex, disability, age, and sexual orientation.

I also certify, that to be in compliance with Minnesota Statutes, that (1) my business is not readily visible from the trunk highway intersection to be signed; (2) effective directional advertising is not possible; and (3) no business advertising signs can be legally and effectively located near the intersection.

I agree to accept the sign format, design, and location determined by Mn/DOT, in compliance with all pertinent state signing standards, and to make payment in advance in the amount of $__________ per sign installation.
CERTIFICATION OF COMPLIANCE

I do also agree to participate in any additional maintenance and/or sign replacement costs for my specific service sign(s) resulting from damage, vandalism and other such occurrences beyond the control of Mn/DOT. I agree to pay Mn/DOT for all current costs required to repair the sign panel and/or sign structure. If total replacement is required, I agree to provide at my cost a new sign(s) and pay Mn/DOT, in advance, the current cost for installing the sign(s) and/or replacing the sign structure. In addition, I understand that when signs must be refurbished due to natural deterioration, (based on manufactures warranties, an approximate 12 year replacement cycle at Mn/DOT’s discretion), I will be required to reapply for signing and pay current replacement costs. I understand that the replacement costs of the background panel and/or the business panels (logos) are entirely my responsibility. I also agree to notify Mn/DOT 30 days in advance if my business name changes, if there is a change in business ownership, or when my business ceases to exist. I understand that Mn/DOT reserves the right to permanently remove or relocate specific service signs due to roadway construction or maintenance, when new or additional regulatory, warning or guide signs are required to be installed or as required by changes in State Statute applying to specific service signs.

Additional guidance (trailblazing) signing from the trunk highway intersection/interchange to the business will be the responsibility of the applicant and the local road authority, as mandated by Minnesota Statute 160.293, and must be in place prior to installation of trunk highway signing.

All signing is installed on a first come, first served basis. If two businesses apply at the same time, year-round businesses have priority over seasonal businesses.

Inappropriate business names and/or business logos are not permitted to be displayed on sign panels.

Applicant may obtain the salvaged sign panel within 30 days of removal, on condition that the sign shall not be reinstalled on any public right of way nor shall it be reinstalled in any location readily visible to any motor vehicle on the Mn/DOT trunk highway system.

I, the undersigned, herewith accept the terms and conditions of the regulations of the Commissioner of Transportation and agree to fully comply herewith to the satisfaction of the Mn/DOT. Mn/DOT may remove the sign(s) for failure to comply with these terms and/or non-payment of any repair or replacement costs.

Date ________________ Applicant’s signature ___________________________________________________

Business Name _____________________________________________________________________________

(PLEASE PRINT)

MN/DOT Use Only

Dated ________________ Authorized ________________

Minnesota Department of Transportation

Permit No. _______ Area _______ T.H. _______ R.P. _______ C.S. _______
Examples of Specific Service Signs

If the business intends to display a business panel on each Specific Service sign, the business panel design should be submitted to the District for review. A logo on a business panel shall not resemble a traffic control device.

A business, at its expense, shall have the business panel(s) fabricated by a commercial sign manufacturer. Business panels shall be made of aluminum sheeting (min. 0.063 inch thickness) covered with a minimum of DG3 prismatic reflective sheeting. It is acceptable for a sign fabricator to incorporate the logo onto the sign without using a separate business panel.

Sample “A”
Name only
Blue panel (72” x 18”)

Sample “B”
Small business panel (18” x 12”) and short name
Blue panel (72” x 18”)

Sample “C”
Large business panel (maximum 48” x 12”) and no name
Blue panel (72” x 18”)

March 1, 2008 TRAFFIC ENGINEERING MANUAL

February, 2008 SPECIFIC SERVICES APPLICATION 6.1D
MINNESOTA DEPARTMENT OF TRANSPORTATION (MN/DOT)
Installation of Guide and Informational Signing on Trunk Highways (T.H.)
(PLEASE PRINT) (revised 01-05-07)

Applicant Name ____________________________________________

Street Address ____________________________________________

City, State, Zip__________________________________________ County_________ Phone (_____ ) ________

Facility Name (as requested to appear on the sign)__________________________________________

____________________________________________________________________________________

Exact location of facility __________________________________________________________________

____________________________________________________________________________________

Signing location(s): Intersection of T.H. __________________________ and __________________________

____________________________________________________________________________________

Number of signs requested: (circle) 1 2 3 4 (all the signs must contain the same legend)

Circle the direction of travel to be signed.

Eastbound Westbound Northbound Southbound

Distance from signed intersection/interchange to business: _____________ miles.

Direction to the facility from the signed intersection/interchange: (circle one) East West North South

Applicant must read, complete, and sign the reverse side (Certification of Compliance) prior to the fabrication and installation of the sign(s).

Total current costs = ___________________ (includes installation, fabrication, and overhead)

Payment for sign installation must be included with the completed application.

Make check or money order payable to: COMMISSIONER OF TRANSPORTATION

Return this form to: Minnesota Department of Transportation

Questions:

NAME-TITLE call (XXX) XXX-XXXX
ADDRESS
CITY, MN ZIP CODE

Mn/DOT Use Only

□ Bill (State Agencies only) □ Payment Received

Dated ______________________ Authorized __________________

Minnesota Department of Transportation

Permit No. _______ Area ________ T.H. _______ R.P. _________ C.S. _______

6-143
CERTIFICATION OF COMPLIANCE

I, the undersigned, do hereby certify that this facility conforms to all applicable laws and regulations concerning the provisions for public accommodations without regard to race, color, creed, religion, national origin, sex, disability, age, and sexual orientation.

I agree to accept the sign(s) format, design, structure, and location(s) determined by Mn/DOT, in compliance with all pertinent state signing standards, and to make payment in advance for all current costs for the installation of signs by Mn/DOT. I agree to provide at my cost the sign(s) to be installed. If signing needs to be fabricated and installed under contract, I agree to pay the amount determined by contract bid prices.

I do also agree to pay any costs incurred in relocating signs, if feasible, to achieve proper spacing distances.

I do also agree to participate in any additional maintenance and/or sign replacement costs for the guide and information signs(s) resulting from damage, vandalism, and other such occurrences beyond the control of Mn/DOT. I agree to pay Mn/DOT for all current costs required to repair the sign panel and/or sign structure. If total replacement is required, I agree to provide at my cost a new sign(s) and to pay Mn/DOT, in advance, the current cost for installing the sign(s) and/or replacing the sign structure. In addition, I understand that when signs must be refurbished due to natural deterioration, (based on manufacturer’s warranties, an approximate 12 year replacement cycle at Mn/DOT’s discretion), I will be required to reapply for signing and pay current replacement costs. I also agree to notify Mn/DOT 30 days in advance if the facility name changes, if there is a change in facility ownership, or when the facility ceases to exist. I understand that Mn/DOT reserves the right to permanently remove or relocate guide and information signs due to roadway construction or maintenance, when new or additional regulatory, warning, or guide signs are required to be installed, or as required by changes in State Statutes applying to guide and information signs.

Additional guidance (trailblazing) signing from the trunk highway intersection/interchange to the facility will be the responsibility of the applicant and the local road authority, and must be in place prior to the installation of trunk highway signing.

The applicant may obtain the salvaged sign panel within 30 days of removal, on condition that the sign shall not be reinstalled on any public right of way nor shall it be reinstalled in any location readily visible to any motor vehicle on the Mn/DOT trunk highway system.

I, the undersigned, herewith accept the terms and conditions of the regulations of the Commissioner of Transportation and agree to fully comply herewith to the satisfaction of Mn/DOT. Mn/DOT may remove the sign(s) for any failure to comply with these terms and/or non-payment of any repair or replacement costs.

Date _______________ Applicant’s signature ________________________________________

Facility Name ________________________________

(PLEASE PRINT)
Adopt-A-Highway Agreement

(check one)

☐ Adopt-A-Highway. The group agrees to pick up litter at least three times a year for a minimum of two years.

☐ Pick-A-Highway. The group agrees to pick up litter one time only. Proposed date: _______________________

The requested highway segment is located on __________________ between __________________ and ____________________________ for a total of __________ miles.

The Minnesota Department of Transportation (Mn/DOT) reserves the right to refuse, cancel, or revise this agreement if in its sole judgement the nature of the group or its sign is political, controversial or in questionable taste, or if the group is not meeting the terms and conditions of this agreement. By signing this agreement, the group acknowledges the hazardous nature of the work and agrees to comply with the terms and conditions herewith to the satisfaction of the Minnesota Department of Transportation.

Except for the negligent acts of the State, its agents and employees, the volunteers or their agents shall assume all liability for, and save the State, its agents and employees, harmless from any and all claims for damages, actions or causes of action arising out of the work to be done herein.

Any and all volunteers of the group or other persons while engaged in the performance of any work or service performed under this agreement shall not be considered employees of the State, and any and all claims that may or might arise under all claims made by any third party of the group’s volunteers or other persons while so engaged in any of the work or services to be rendered shall in no way be the obligation or responsibility of the State.

Name of group ____________________________ (please print)

Name of group representative ____________________________

Signature ____________________________ Date __________

Address ____________________________ City __________ Zip __________

Phone (day) ____________________________ (evening) ____________________________

Name to appear on sign ____________________________ (block letters)

(Maximum 18 characters including spaces and punctuation. M and W may count as more than one character.)

Agreement Confirmation

Special Provisions ____________________________

Your Adopt-A-Highway Contact: ____________________________ Phone ____________________________

Mn/DOT Authorized Representative ____________________________ Date __________

July 1, 1998 ADOPT - A - HIGHWAY APPLICATION FORM 6.3A
Adopt-A-Highway Terms and Conditions

The Adopting Group agrees to:

1. Pick up litter on a segment of state highway selected in consultation with the Minnesota Department of Transportation’s (Mn/DOT) local office. Recommended length is two miles. At Mn/DOT’s discretion, certain highways may not be eligible.
2. Review the safety training materials before each pick up to alert participants to the hazards and precautions of working on a highway right-of-way.
3. Pick up litter during daylight hours only. Pickups may not be allowed at certain times such as on or near holidays.
4. Provide adequate supervision to participants eighteen years of age or younger. Unless specifically permitted, children age eleven or younger shall not participate.
5. Limit work to the area between the outer shoulders and the right-of-way boundary. Participants shall not pick up litter in the median unless specifically permitted by Mn/DOT. Work may not be done on the roadway itself.
6. Coordinate litter pick up date(s) with the Adopt-A-Highways contact in the appropriate Mn/DOT office. The group will be instructed how and where to obtain its supplies.
7. Place filled trash bags on the shoulder grass line. Arrange with Mn/DOT to pick up the bags. Groups are encouraged to recycle appropriate materials for their own benefit.
8. Return borrowed or unused supplies to Mn/DOT when discontinuing participation.

The Minnesota Department of Transportation agrees to:

1. Provide high visibility vests, trash bags, safety training materials and temporary traffic warning signs when necessary and as determined by Mn/DOT.
2. Remove filled trash bags from the adopted highway.
3. Remove large, heavy, or hazardous materials from the adopted highway.
4. Erect a highway sign or otherwise recognize the group’s cleanup efforts. Highway signs shall be erected only for groups that agree to adopt a highway for a minimum of two years. The name on the sign shall be limited to two lines of eighteen characters (including punctuation and spaces). Mn/DOT reserves the right to approve and/or edit names or acronyms.
The below named group agrees to pick up litter once a month from May 1 thru October 31 for a minimum of two years at the Rest Area.

The Minnesota Department of Transportation (Mn/DOT) reserves the right to refuse, cancel, or revise this agreement if in its sole judgement the nature of the group or its sign is political, controversial or in questionable taste, or if the group is not meeting the terms and conditions of this agreement. By signing this agreement, the group acknowledges the hazardous nature of the work and agrees to comply with the terms and conditions herewith to the satisfaction of the Minnesota Department of Transportation.

Except for the negligent acts of the State, its agents and employees, the volunteers or their agents shall assume all liability for, and save the State, its agents and employees, harmless from any and all claims for damages, actions or causes of action arising out of the work to be done herein.

Any and all volunteers of the group or other persons while engaged in the performance of any work or service performed under this agreement shall not be considered employees of the State, and any and all claims that may or might arise under all claims made by any third party of the group’s volunteers or other persons while so engaged in any of the work or services to be rendered shall in no way be the obligation or responsibility of the State.

Name of group __________________________ (please print)

Name of group representative __________________________

Signature __________________________ Date ____________

Address __________________________ City ____________ Zip ____________

Phone (day) __________________________ (evening) __________________________

Name to appear on sign

(Maximum 20 characters including spaces and punctuation. M and F may count as more than one character.)

Special Provisions __________________________

________________________________________

Area Maintenance Engineer Date
The Adopting Group agrees to:

1. Pick up litter at a rest area selected in consultation with the Minnesota Department of Transportation’s (Mn/DOT) local office.
2. Review the safety training materials before each pick up to alert participants to the hazards and precautions of working on or near a highway right-of-way.
3. Pick up litter during daylight hours only. Pickups may not be allowed at certain times such as on or near holidays.
4. Provide adequate supervision to participants eighteen years of age or younger. Unless specifically permitted, children age eleven or younger shall not participate.
5. Limit work to rest areas. Work may not be done on the roadway itself.
6. Arrange litter pick up date(s) in advance with the maintenance engineer or his/her designee in the appropriate Mn/DOT office. The group shall obtain their supplies during regular business hours.
7. Return borrowed or unused supplies to the Mn/DOT office within one week.

The Minnesota Department of Transportation agrees to:

1. Provide high visibility vests, trash bags, safety training materials and temporary traffic warning signs when necessary and as determined by Mn/DOT.
2. Remove filled trash bags from the adopted rest area.
3. Remove large, heavy, or hazardous materials from the adopted rest area.
4. Erect a sign or otherwise recognize the group’s cleanup efforts. Signs shall be erected only for groups that agree to adopt a rest area for a minimum of two years. The name on the sign shall be limited to two lines of eighteen to twenty characters (including punctuation and spaces). Mn/DOT reserves the right to approve and/or edit names or acronyms.
Community Destination Signing

SAMPLE RESOLUTION

BE IT RESOLVED that the City of ____________ agrees to comply with the guidelines adopted by the Minnesota Department of Transportation (Mn/DOT) for Community Destination Signing to be located within the rights of way of state (trunk) highways and city streets/local roads. The city agrees that it is solely responsible for the construction, installation and maintenance of all sign structures and sign panels at its own expense and that if the community destination signs are not properly maintained, the city will remove the signs, at its sole expense, upon request by Mn/DOT. The city also agrees that if the signs are not removed within 30 days of notification by Mn/DOT, Mn/DOT forces will remove the signs at the sole cost and expense of the city.

CERTIFICATION

State of Minnesota
County of __________
City of __________

I hereby certify that the foregoing Resolution is a true and correct copy of a resolution presented to and adopted by the Council of the City of __________ at a duly authorized meeting thereon held on the ____ day of _______, as shown by the minutes of said meeting in my possession.

________________________
City Administrator-Clerk

Text Ref.: SPECIFIC SERVICES APPLICATION FORM 6.1A
### GUIDELINE FOR NON-FREEWAY GUIDE SIGNS

<table>
<thead>
<tr>
<th>Sign Type</th>
<th>Speeds &lt; 45 mph</th>
<th>2 lane (inches)</th>
<th>2 way (inches)</th>
<th>4 or more lanes (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>GROUND MOUNTED:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Destination</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>City</td>
<td>6-4.5</td>
<td>8-6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distance</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cardinal Direction</td>
<td>6</td>
<td>6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Route Marker</td>
<td>18 OL</td>
<td>18 OL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>City</td>
<td>6-4.5</td>
<td>6-4.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Junction</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cardinal Direction</td>
<td>8</td>
<td>8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Route Marker</td>
<td>24 OL</td>
<td>24 OL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Action Message</td>
<td>8</td>
<td>8</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Directional</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cardinal Direction</td>
<td>6</td>
<td>8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Route Marker</td>
<td>18 OL</td>
<td>24 OL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>City/Street Name</td>
<td>6-4.5</td>
<td>8-6</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Supplemental</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Generic</td>
<td>6</td>
<td>6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Proper Name</td>
<td>6-4.5</td>
<td>6-4.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Route Marker</td>
<td>18 OL</td>
<td>18 OL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cardinal Direction</td>
<td>6</td>
<td>6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Action Message</td>
<td>5</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>SIGNAL MAST ARM MOUNTED:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cardinal Direction</td>
<td>8</td>
<td>8</td>
<td>DM or EM</td>
<td>DM or EM</td>
</tr>
<tr>
<td>Route Marker</td>
<td>24 OL</td>
<td>24 OL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>City/Street Name</td>
<td>8-6</td>
<td>8-6</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>OTHER OVERHEADS:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cardinal Direction</td>
<td>8</td>
<td>8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Route Marker</td>
<td>24 OL</td>
<td>24 OL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>City/Street Name</td>
<td>8-6</td>
<td>8-6</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

OL = Overlay       DM = D Modified letters
EM = E Modified letters

**NOTES:**
1. Letter fonts are E Modified unless otherwise noted.
2. In urban areas, limited horizontal space in which to place a sign can occur. It is then permissible to reduce the size of the letters of a sign by one step.
3. Due to the wide range of roadway designs, see the MN MUTCD, Section 2E.13 and Tables 2E-1 through 2E-4, and/or call the OTSO Signing Unit for additional information.
4. These are the minimum numeral and letter sizes for Type D Guide signs.

Text Ref.: 6-7.09, and 6-7.09.11, page 6-60
GUIDELINE FOR NON-FREEWAY GUIDE SIGNS

<table>
<thead>
<tr>
<th>Sign Type</th>
<th>Speeds 45 &amp; 50 mph</th>
<th>2 lane</th>
<th>4 or more lanes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>inches</td>
<td>inches</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 lane</td>
<td>4 or more lanes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>inches</td>
<td>inches</td>
</tr>
<tr>
<td>GROUND MOUNTED:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Destination</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>City</td>
<td>8-6</td>
<td>10.7-8</td>
<td></td>
</tr>
<tr>
<td>Distance</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cardinal Direction</td>
<td>6</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Route Marker</td>
<td>18 OL</td>
<td>24 OL</td>
<td></td>
</tr>
<tr>
<td>City</td>
<td>6-4.5</td>
<td>8-6</td>
<td></td>
</tr>
<tr>
<td>Junction</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cardinal Direction</td>
<td>8</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Route Marker</td>
<td>24 OL</td>
<td>24 OL</td>
<td></td>
</tr>
<tr>
<td>Action Message</td>
<td>8</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Directional</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cardinal Direction</td>
<td>8</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Route Marker</td>
<td>24 OL</td>
<td>24 OL</td>
<td></td>
</tr>
<tr>
<td>City/Street Name</td>
<td>8-6</td>
<td>10.7-8</td>
<td></td>
</tr>
<tr>
<td>Supplemental</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Generic</td>
<td>6</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Proper Name</td>
<td>6-4.5</td>
<td>8-6</td>
<td></td>
</tr>
<tr>
<td>Action Message</td>
<td>5</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>SIGNAL MAST ARM MOUNTED:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cardinal Direction</td>
<td>8</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Route Marker</td>
<td>24 OL</td>
<td>24 OL</td>
<td></td>
</tr>
<tr>
<td>City/Street Name</td>
<td>8-6</td>
<td>8-6</td>
<td></td>
</tr>
<tr>
<td>OTHER OVERHEADS:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cardinal Direction</td>
<td>8</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Route Marker</td>
<td>24 OL</td>
<td>24 OL</td>
<td></td>
</tr>
<tr>
<td>City/Street Name</td>
<td>8-6</td>
<td>10.7-8</td>
<td></td>
</tr>
<tr>
<td>OL = Overlay</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DM or EM</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DM = D Modified letters</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EM = E Modified letters</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

NOTES: 1. Letter fonts are E Modified unless otherwise noted.
2. In urban areas, limited horizontal space in which to place a sign can occur. It is then permissible to reduce the size of the letters of a sign by one step.
3. Due to the wide range of roadway designs, see the MN MUTCD, Section 2E.13 and Tables 2E-1 through 2E-4, and/or call the OTSO Signing Unit for additional information.
4. These are the minimum numeral and letter sizes for Type D Guide signs.

Text Ref.: 6-7.09, and 6-7.09.11, page 6-60
GUIDELINE FOR NON-FREEWAY
GUIDE SIGNS

<table>
<thead>
<tr>
<th>Sign Type</th>
<th>Speed &gt;50 mph</th>
<th>55 mph</th>
<th>&gt;55 mph</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2 lane, 2 way</td>
<td>4 or more lanes</td>
<td>4 or more lanes</td>
</tr>
<tr>
<td></td>
<td>(inches)</td>
<td>(inches)</td>
<td>(inches)</td>
</tr>
<tr>
<td>GROUND MOUNTED:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Destination</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>City</td>
<td>8-6</td>
<td>10.7-8</td>
<td>13.3-10</td>
</tr>
<tr>
<td>Distance</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cardinal Direction</td>
<td>6</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>Route Marker</td>
<td>18OL</td>
<td>24 OL</td>
<td>24 OL</td>
</tr>
<tr>
<td>City</td>
<td>6-4.5</td>
<td>8-6</td>
<td>10.7-8</td>
</tr>
<tr>
<td>Junction</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cardinal Direction</td>
<td>8</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Route Marker</td>
<td>24 OL</td>
<td>24 OL</td>
<td>24 OL</td>
</tr>
<tr>
<td>Action Message</td>
<td>8</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Directional</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cardinal Direction</td>
<td>8</td>
<td>8</td>
<td>10</td>
</tr>
<tr>
<td>Route Marker</td>
<td>24 OL</td>
<td>24 OL</td>
<td>24 OL</td>
</tr>
<tr>
<td>City/Street Name</td>
<td>8-6</td>
<td>10.7-8</td>
<td>13.3-10</td>
</tr>
<tr>
<td>Supplemental</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Generic</td>
<td>8</td>
<td>8</td>
<td>* 8</td>
</tr>
<tr>
<td>Proper Name</td>
<td>8-6</td>
<td>8-6</td>
<td>* 8-6</td>
</tr>
<tr>
<td>Action Message</td>
<td>6</td>
<td>6</td>
<td>* 8</td>
</tr>
<tr>
<td>SIGNAL MAST ARM MOUNTED:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cardinal Direction</td>
<td>8</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>Route Marker</td>
<td>24 OL</td>
<td>24 OL</td>
<td>24 OL</td>
</tr>
<tr>
<td>City/Street Name</td>
<td>8-6</td>
<td>8-6</td>
<td>8-6</td>
</tr>
<tr>
<td>OTHER OVERHEADS:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cardinal Direction</td>
<td>8</td>
<td>8</td>
<td>10</td>
</tr>
<tr>
<td>Route Marker</td>
<td>24 OL</td>
<td>24 OL</td>
<td>24 OL</td>
</tr>
<tr>
<td>City/Street Name</td>
<td>8-6</td>
<td>10.7-8</td>
<td>13.3-10</td>
</tr>
</tbody>
</table>

OL = Overlay      DM = D Modified letters   EM = E Modified letters

NOTES: 1. Letter fonts are E Modified unless otherwise noted.
2. In urban areas, limited horizontal space in which to place a sign can occur. It is then
   permissible to reduce the size of the letters of a sign by one step.
3. Due to the wide range of roadway designs, consult the MN MUTCD tables, sections 2E-11
   (expressway) and 2F-11 (freeway), and/or call the O.T.E. Signing Unit for additional
   information.
4. These are the minimum numeral and letter sizes for Type D Guide signs.

* These letters may be reduced from 8 to 6 and 8-6 to 6-4.5.

Text Ref.: 6-7.09, and 6-7.09.11, page 6-60

July 1, 1998
**Destination Signs**

- ← Roscoe  
  Cold Spring →
- ↑ Alexandria  
  St Cloud →
- ↑ Remer  
  Aitkin  
  Grand Rapids →
- ↑ Tracy
- ← Marshall  
  Alda
- ← Albany 15

**Directional Signs**

- ← Interstate 94  
  West  
  Alexandria
- ↑ Interstate 94  
  North  
  St Cloud
- ↑ Interstate 94  
  East
- NORTH 23  
  SOUTH 23
- ← Century Avenue

**Distance Signs**

- Askov 8  
  Duluth 65
- Hastings 13  
  West 41  
  Winona 104
Junction Signs

Signal Mast Arm Mounted Signs

Supplemental Signs

Junction Signs

Supplemental Signs
U-POST STRUCTURE CHART FOR GROUND-MOUNTED SIGNS using 3 lb/ft Posts

LEGEND
90 mph Wind with gusts = 23.7 psf
2.5 lb/ft posts
SM = 0.341 cu. in.
FY = 60,000 psi
Typical 10 ft distance below sign to ground
U = Vertical U-post
A = Knee Brace

Text Ref.: 6-4.08.01, page 6-18
LEGEND
90 mph Wind with gusts = 23.7 psf
2.5 lb/ft posts
SM = 0.341 cu. in.
FY = 60,000 psi
Typical 10 ft distance below sign to ground
U = Vertical U-post
A = Knee Brace

Text Ref.: 6-4.08.01, page 6-18
<table>
<thead>
<tr>
<th>PANEL WIDTH (inches)</th>
<th>POST SPACING</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2 POSTS (inches)</td>
</tr>
<tr>
<td>36</td>
<td>24</td>
</tr>
<tr>
<td>42</td>
<td>30</td>
</tr>
<tr>
<td>48</td>
<td>30</td>
</tr>
<tr>
<td>54</td>
<td>30</td>
</tr>
<tr>
<td>60</td>
<td>36</td>
</tr>
<tr>
<td>66</td>
<td>42</td>
</tr>
<tr>
<td>72</td>
<td>42</td>
</tr>
<tr>
<td>78</td>
<td>54</td>
</tr>
<tr>
<td>84</td>
<td>54</td>
</tr>
<tr>
<td>90</td>
<td>54</td>
</tr>
<tr>
<td>96</td>
<td>54</td>
</tr>
<tr>
<td>102</td>
<td>60</td>
</tr>
<tr>
<td>108</td>
<td>66</td>
</tr>
<tr>
<td>114</td>
<td>66</td>
</tr>
<tr>
<td>120</td>
<td>72</td>
</tr>
<tr>
<td>126</td>
<td>78</td>
</tr>
<tr>
<td>132</td>
<td>78</td>
</tr>
<tr>
<td>138</td>
<td>78</td>
</tr>
<tr>
<td>144</td>
<td>90</td>
</tr>
<tr>
<td>150</td>
<td>90</td>
</tr>
<tr>
<td>156</td>
<td>90</td>
</tr>
<tr>
<td>162</td>
<td>96</td>
</tr>
<tr>
<td>168</td>
<td>96</td>
</tr>
<tr>
<td>174</td>
<td>102</td>
</tr>
<tr>
<td>180</td>
<td>108</td>
</tr>
</tbody>
</table>

Use this chart if punch codes cannot be found in the Standard Signs Manual.
### NOTES:

1. The distances are adjusted for a sign legibility distance of 175 ft, which is the appropriate legibility distance for a 5 inch Series D word legend. The distances may be adjusted by deducting another 100 feet if alignment symbol signs are used. Adjustments may also be made for grades, limited sight distance, or pavement condition.

2. Typical conditions are locations where the road user might use extra time to adjust speed and change lanes in heavy traffic because of a complex driving situation. A typical sign is Right Lane Ends. The distances are based on the 2001 AASHTO Policy, Exhibit 3-3, Decision Sight Distance, Avoidance Maneuver E, providing the driver a PIEV/Maneuver time of 14.0 to 14.5 seconds minus the sign legibility distance of 175 feet.

3. Typical condition is the warning of a potential Stop situation. Typical signs are Stop Ahead, Yield Ahead, Signal Ahead, and Intersection Warning signs. The distances are based on the 2001 AASHTO Policy, Equation 3-2, providing the driver a PIEV time of 2.5 seconds, a deceleration rate of 8.1 ft/second, minus the sign legibility distance of 175 ft.

4. Typical conditions are where the road user must decelerate to the advised speed to maneuver through the warned condition. Typical signs are Turn, Curve, Reverse Turn, or Reverse Curve, combined with an Advisory Speed sign. The distances are based on the 2001 AASHTO Policy, Equation 3-2, providing the driver a PIEV time of 2.5 seconds, a deceleration rate of 8.1 ft/second, minus the sign legibility distance of 175 ft.

5. No suggested minimum distances are provided for these speeds, as placement location is dependent on site conditions and other signing to provide an adequate advance warning for the driver.
Formula for finding the degree of curvature from the radius:

\[
D = \frac{5729.578}{\text{Radius}}
\]

<table>
<thead>
<tr>
<th>Radius of Curve (feet)</th>
<th>Degree of Curvature</th>
<th>Chevron Spacing (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>150</td>
<td>38°15'</td>
<td>45 - 60</td>
</tr>
<tr>
<td>200</td>
<td>28°45'</td>
<td>53 - 70</td>
</tr>
<tr>
<td>250</td>
<td>23°00'</td>
<td>60 - 80</td>
</tr>
<tr>
<td>300</td>
<td>19°00'</td>
<td>75 - 100</td>
</tr>
<tr>
<td>400</td>
<td>14°15'</td>
<td>83 - 110</td>
</tr>
<tr>
<td>500</td>
<td>11°30'</td>
<td>98 - 130</td>
</tr>
<tr>
<td>600</td>
<td>9°30'</td>
<td>105 - 140</td>
</tr>
<tr>
<td>700</td>
<td>8°15'</td>
<td>112 - 150</td>
</tr>
<tr>
<td>800</td>
<td>7°15'</td>
<td>120 - 160</td>
</tr>
<tr>
<td>900</td>
<td>6°15'</td>
<td>127 - 170</td>
</tr>
<tr>
<td>Ball Bank Indicator Limiting Values in Degrees</td>
<td>Recommended Speed of Curve in MPH</td>
<td>Sign Drawing</td>
</tr>
<tr>
<td>---------------------------------------------</td>
<td>---------------------------------</td>
<td>-------------</td>
</tr>
<tr>
<td>14 Degrees</td>
<td>Below 20 MPH</td>
<td>W1-1(R)</td>
</tr>
<tr>
<td>12 Degrees</td>
<td>20 - 30 MPH</td>
<td>W1-1(R)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>W1-3(R)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>W1-2(R)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>W1-4(R)</td>
</tr>
</tbody>
</table>

Use this sign when two turns are connected by a tangent of less than 600 feet. The lesser of the recommended speeds for the two turns will prevail.

Use this sign when two curves are connected by a tangent of less than 600 feet. The lesser of the recommended speeds for the two curves will prevail.
# Requester Pay Sign Costs

## Table 1: Initial Sign Structure and Sign Panel

<table>
<thead>
<tr>
<th>Sign size</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Base Cost</td>
</tr>
<tr>
<td></td>
<td>(1)</td>
</tr>
<tr>
<td>up to 20 sq ft</td>
<td>$715.00</td>
</tr>
<tr>
<td>20 - 50 sq ft</td>
<td>$805.00</td>
</tr>
<tr>
<td>50 - 90 sq ft</td>
<td>$921.00</td>
</tr>
</tbody>
</table>

Notes:
(1) Includes structural materials, equipment, and installation labor costs.
(2) Includes aluminum, sheeting materials, and panel fabrication costs.

## Table 2: Replace Sign Panel Only

<table>
<thead>
<tr>
<th>Sign size</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Base Cost</td>
</tr>
<tr>
<td></td>
<td>(1)</td>
</tr>
<tr>
<td>up to 20 sq ft</td>
<td>$278.00</td>
</tr>
<tr>
<td>20 - 50 sq ft</td>
<td>$317.00</td>
</tr>
<tr>
<td>50 - 90 sq ft</td>
<td>$357.00</td>
</tr>
</tbody>
</table>

Notes:
(1) Includes structural materials, equipment, and installation labor costs.
(2) Includes aluminum, sheeting materials, and panel fabrication costs.

## Table 3: Sign Relocation Costs

<table>
<thead>
<tr>
<th>Sign size</th>
<th>Cost to move in place sign</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 to 20 sq ft</td>
<td>$398.00</td>
</tr>
<tr>
<td>20.1 - 50 sq ft</td>
<td>$437.00</td>
</tr>
<tr>
<td>50.1 - 90 sq ft</td>
<td>$477.00</td>
</tr>
</tbody>
</table>
## REQUESTER PAY SIGN COSTS

### Table 4: Specific Service Sign Costs

<table>
<thead>
<tr>
<th>Work Type</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Sign Structure and Panel Installation</td>
<td>$926.00</td>
</tr>
<tr>
<td>Replace Sign Structure and Sign Panel</td>
<td>$712.00</td>
</tr>
<tr>
<td>Replace Sign Structure or Relocate</td>
<td>$500.00</td>
</tr>
<tr>
<td>Replace Sign Panel</td>
<td>$490.00</td>
</tr>
</tbody>
</table>
# Chapter 7
## PAVEMENT MARKING

<table>
<thead>
<tr>
<th>TABLE OF CONTENTS</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>7-1.00 INTRODUCTION</td>
<td>7-3</td>
</tr>
<tr>
<td>1.01 Purpose</td>
<td></td>
</tr>
<tr>
<td>1.02 Scope</td>
<td></td>
</tr>
<tr>
<td>1.03 Chapter Organization</td>
<td></td>
</tr>
<tr>
<td>7-2.00 GLOSSARY</td>
<td>7-3</td>
</tr>
<tr>
<td>7-3.00 LEGALITY</td>
<td>7-4</td>
</tr>
<tr>
<td>3.01 Legal Authority</td>
<td></td>
</tr>
<tr>
<td>3.02 Responsibility for Placement and Removal</td>
<td></td>
</tr>
<tr>
<td>3.03 Legal Effect</td>
<td></td>
</tr>
<tr>
<td>7-4.00 PAVEMENT MARKINGS</td>
<td>7-5</td>
</tr>
<tr>
<td>4.01 Materials</td>
<td></td>
</tr>
<tr>
<td>4.02 Standards and Specifications</td>
<td></td>
</tr>
<tr>
<td>4.03 Application Guidelines</td>
<td></td>
</tr>
<tr>
<td>4.04 No-Passing Zone Surveys</td>
<td></td>
</tr>
<tr>
<td>4.05 Standard Spotting Procedure</td>
<td></td>
</tr>
<tr>
<td>4.06 Special Markings</td>
<td></td>
</tr>
<tr>
<td>7-5.00 OBJECT MARKINGS</td>
<td>7-18</td>
</tr>
<tr>
<td>5.01 Purpose</td>
<td></td>
</tr>
<tr>
<td>5.02 Types of Object Markers</td>
<td></td>
</tr>
<tr>
<td>5.03 Applications and Guidelines</td>
<td></td>
</tr>
<tr>
<td>7-6.00 DELINEATION</td>
<td>7-21</td>
</tr>
<tr>
<td>6.01 Types and Materials</td>
<td></td>
</tr>
<tr>
<td>6.02 Delineator Location</td>
<td></td>
</tr>
<tr>
<td>6.03 Deer Reflectors</td>
<td></td>
</tr>
<tr>
<td>7-7.00 REFERENCES</td>
<td>7-22</td>
</tr>
</tbody>
</table>


List of Figures

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.1</td>
<td>Two-Lane, Two-Way Roadway Pavement Marking Details</td>
<td>7-23</td>
</tr>
<tr>
<td>7.2</td>
<td>Multi-lane Undivided Roadway Pavement Marking Details</td>
<td>7-24</td>
</tr>
<tr>
<td>7.3</td>
<td>Two-Way Left Turn Lane Pavement Marking Details</td>
<td>7-25</td>
</tr>
<tr>
<td>7.4</td>
<td>Passing Lane Section Pavement Markings</td>
<td>7-26</td>
</tr>
<tr>
<td>7.5A</td>
<td>Major Intersection Pavement Markings</td>
<td>7-27</td>
</tr>
<tr>
<td>7.5B</td>
<td>Major Intersection Pavement Markings</td>
<td>7-28</td>
</tr>
<tr>
<td>7.6</td>
<td>Ramp and Through Lane Pavement Markings</td>
<td>7-29</td>
</tr>
<tr>
<td>7.7</td>
<td>Exit Ramp on Curved Roadway Pavement Markings</td>
<td>7-30</td>
</tr>
<tr>
<td>7.8</td>
<td>Removed</td>
<td></td>
</tr>
<tr>
<td>7.8A</td>
<td>Auxiliary Lane Pavement Markings</td>
<td>7-31</td>
</tr>
<tr>
<td>7.8B</td>
<td>Auxiliary Lane Pavement Markings</td>
<td>7-32</td>
</tr>
<tr>
<td>7.9</td>
<td>Turn Lane &amp; Left Turn Island Pavement Markings</td>
<td>7-33</td>
</tr>
<tr>
<td>7.10</td>
<td>Bypass Lane Pavement Markings</td>
<td>7-34</td>
</tr>
<tr>
<td>7.11</td>
<td>Divided Roadway Transition Pavement Markings</td>
<td>7-35</td>
</tr>
<tr>
<td>7.12</td>
<td>Undivided Roadway Transition Pavement Markings</td>
<td>7-36</td>
</tr>
<tr>
<td>7.13</td>
<td>Truck Climbing Lane Pavement Markings</td>
<td>7-37</td>
</tr>
<tr>
<td>7.14</td>
<td>Railroad Crossing with Truck Stopping Lane Pavement Markings</td>
<td>7-38</td>
</tr>
<tr>
<td>7.15</td>
<td>Free Right Turn Lane Pavement Markings</td>
<td>7-39</td>
</tr>
<tr>
<td>7.16</td>
<td>No Passing Zone - Survey Procedure for a Vertical Curve</td>
<td>7-40</td>
</tr>
<tr>
<td>7.17</td>
<td>Removed</td>
<td></td>
</tr>
<tr>
<td>7.18</td>
<td>Spotting Symbols for Pavement Striping</td>
<td>7-41</td>
</tr>
<tr>
<td>7.19</td>
<td>Pedestrian Crosswalk Markings</td>
<td>7-42</td>
</tr>
<tr>
<td>7.20</td>
<td>Pedestrian Crosswalk Markings - Zebra Design</td>
<td>7-43</td>
</tr>
<tr>
<td>7.21</td>
<td>School Zone Markings - Unsignalized Intersection</td>
<td>7-44</td>
</tr>
<tr>
<td>7.22</td>
<td>Stop Ahead &amp; Stop Line Pavement Markings</td>
<td>7-45</td>
</tr>
<tr>
<td>7.23A</td>
<td>Parking Area Pavement Markings - Disabled Parking Details</td>
<td>7-46</td>
</tr>
<tr>
<td>7.23B</td>
<td>Parking Area Pavement Markings - Disabled Parking Details</td>
<td>7-47</td>
</tr>
<tr>
<td>7.23C</td>
<td>Parking Area Pavement Markings - Parking Stall Details</td>
<td>7-48</td>
</tr>
<tr>
<td>7.23D</td>
<td>Parking Area Pavement Markings - Truck Parking Stall Details</td>
<td>7-49</td>
</tr>
<tr>
<td>7.24</td>
<td>Airplane Pavement Markings</td>
<td>7-50</td>
</tr>
<tr>
<td>7.25</td>
<td>High Occupancy Vehicle (HOV) Pavement Markings</td>
<td>7-51</td>
</tr>
<tr>
<td>7.26</td>
<td>Commonly Used Object Markers</td>
<td>7-52</td>
</tr>
<tr>
<td>7.27</td>
<td>Narrow Bridge Signing &amp; Delineation</td>
<td>7-53</td>
</tr>
<tr>
<td>7.28</td>
<td>One-Lane Bridge Signing &amp; Delineation</td>
<td>7-54</td>
</tr>
<tr>
<td>7.29</td>
<td>Unprotected Large Culvert &amp; Cattle Pass Delineation</td>
<td>7-55</td>
</tr>
<tr>
<td>7.30</td>
<td>Delineator Types &amp; Installation</td>
<td>7-56</td>
</tr>
<tr>
<td>7.31</td>
<td>Delineator Types &amp; Installation</td>
<td>7-57</td>
</tr>
<tr>
<td>7.32</td>
<td>Divided-Highway Intersection Delineation</td>
<td>7-58</td>
</tr>
<tr>
<td>7.33</td>
<td>Diamond Interchange Delineation - Partial and Full Lighting</td>
<td>7-59</td>
</tr>
<tr>
<td>7.34</td>
<td>Diamond Interchange Delineation - Unlit</td>
<td>7-60</td>
</tr>
<tr>
<td>7.35</td>
<td>Cloverleaf Interchange Delineation - Full Lighting</td>
<td>7-61</td>
</tr>
<tr>
<td>7.36</td>
<td>Roundabout Intersection Pavement Markings</td>
<td>7-62</td>
</tr>
</tbody>
</table>

List of Charts

<table>
<thead>
<tr>
<th>Chart</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>7-1</td>
<td>Removed</td>
<td></td>
</tr>
<tr>
<td>7-2</td>
<td>Minimum Length of a No Passing Zone in Advance of a Stop Condition</td>
<td>7-63</td>
</tr>
<tr>
<td>7-3</td>
<td>Minimum Passing Sight Distance</td>
<td>7-63</td>
</tr>
<tr>
<td>7-4</td>
<td>Minimum Distance or Gap Between No-Passing Zones</td>
<td>7-63</td>
</tr>
<tr>
<td>7-5</td>
<td>Object Markers</td>
<td>7-64</td>
</tr>
<tr>
<td>7-6</td>
<td>Delineator Fabrication Details</td>
<td>7-65</td>
</tr>
<tr>
<td>7-7</td>
<td>Finding the Degree of Curve for a Horizontal Curve</td>
<td>7-66</td>
</tr>
<tr>
<td>7-8</td>
<td>Crosswalk Warrants</td>
<td>7-67</td>
</tr>
</tbody>
</table>
CHAPTER 7 - PAVEMENT MARKINGS

7-1.00 INTRODUCTION

7-1.01 Purpose

It is MN/DOT’s mission to provide appropriate pavement markings on all highways 365 days per year.

This chapter gives specific guidelines for the use of pavement markings. The Minnesota Manual on Uniform Traffic Control Devices (MN MUTCD), sets forth general standards, while this manual outlines preferred practices within the MN MUTCD standards.

7-1.02 Scope

Standards for the application of markings and delineation are set forth in the MN MUTCD, and those basic principles must be followed by the engineers, technicians, and maintenance personnel responsible for the design, selection, placement, and documentation of these devices. The Traffic Engineering Manual (TEM) does not duplicate or violate the standards established in the MN MUTCD. The TEM presents the preferred practice in the application of pavement markings, object markers, and delineators. Information presented in this chapter includes: (1) types and use of materials, (2) general principles to be followed, (3) design details, including standards and specifications, and (4) the specific use of markings and delineation. Users of the TEM should be completely familiar with the current MN MUTCD requirements before attempting to apply the guidelines established in this chapter.

7-1.03 Chapter Organization

Important terms used in this chapter are defined in the Glossary of the TEM. The remaining sections of the chapter discuss: (1) legality, (2) pavement markings, (3) special markings, (4) object markings, (5) delineation.

7-2.00 GLOSSARY

Appropriate Pavement Marking - One that meets or exceeds the standards defined in the MN MUTCD including any minimum levels of retroreflectivity, when weather permits. During winter operations, pavement markings should provide presence after bare pavements are attained.

Centerline - A line indicating the division of the roadway between traffic traveling in opposite directions.

Channelizing Line - A line which directs traffic and indicates that traffic should not cross the line.

Continental Block - White longitudinal lines placed at crosswalks that are parallel to the flow of traffic.

Contrast Marking - A marking placed alongside and/or on the ends of a light colored marking and/or within the whole groove for the light marking. Black may be used in combination with the light markings on concrete to enhance the visibility of the marking. The light marking is typically placed in the middle of the black contrast marking.

Delineator - A light-reflecting device mounted at the side of the roadway, in a series with others, to indicate the alignment of the roadway.

Durable Markings - Marking materials designed to provide year round presence and retroreflectivity for at least two years.

Edge Line - A line which indicates the edge of the roadway.

Hazardous Waste - With respect to removal of pavement markings, waste debris created may be toxic (see Toxicity in Specified Products) and/or flammable and require handling and disposal procedures prescribed by waste management laws, rules, and regulations.
Lane Line - A line separating two lanes of traffic traveling in the same direction.

Non-Hazardous Waste - With respect to the removal of pavement markings, waste debris may be disposed of using less stringent criteria. This would make it acceptable at some in-state waste facilities as designated by the Office of Environmental Services.

Object Markers - Markings intended for use on obstructions within or adjacent to the roadway.

Pavement Markings - All lines, symbols, words, colors, or other devices, except signs and power-operated traffic control devices, set into the surface of, applied upon, or attached to the roadway.

Roadway - That portion of a highway used for vehicular travel, exclusive of the berm or shoulder. A divided highway includes two or more separate roadways.

Sharks Teeth - Triangular shaped markings placed at roundabout intersection as a yield line.

Stop Line - A line which indicates where vehicles should stop when directed to stop.

Toxics in Specified Products - Minnesota Statute 115A.9651 prohibits the use of toxic heavy metals in any ink, dye, pigment, paint, or fungicide after September 1, 1994. The prohibited toxic heavy metals are lead, cadmium, mercury, and hexavalent chromium. They may be found in older pavement markings, particularly lead and chromium in yellow markings. Consequently, non-toxic pavement markings must be specified in contracts and purchases.

Waste Debris - With respect to pavement marking materials, white or yellow-colored paint/bituminous or concrete mixtures generated by the removal of pavement markings.

7-3.0 LEGALITY

7-3.01 Legal Authority

Minnesota Statutes 169.06 (Subdivisions 1-4) and 169.07 establishes the legal authority for the Department and local units of government to: (1) place and maintain markings, (2) require obedience to official markings, (3) prohibit the display of unauthorized markings, and (4) prohibit interference with official markings. Markings shall be placed only by the authority of the public body having jurisdiction over the highway, road, or street for the purpose of regulating, warning, or guiding traffic. Pavement and curb markings, object markers, and delineators are all normally within highway, road, or street rights-of-way and, therefore, should never be installed except under public authority.

Two 1990 Session Laws, Chapters 482 and 497, modified handicapped parking requirements for the disabled.

7-3.02 Responsibility for Placement and Removal

Permanent pavement markings are the responsibility of the governing road authority. These markings may be placed or removed by maintenance personnel or contractor.

7-3.03 Legal Effect

Minnesota Statutes, Section 169.18, refers to specific distinctive pavement markings which prohibit the driver from making specified maneuvers or guide the driver in certain paths.

It is important that correct markings are used since markings have specific meanings defined in the law. The use of inappropriate markings and delineators could lead to legal claims of negligence.
7-4.0 PAVEMENT MARKINGS

7-4.01 Materials

The basic requirements for pavement markings are: (1) specified colors are identifiable day and night and (2) minimum visibility standards are maintained throughout the material's lifetime. Factors considered in selecting markings are durability, workability, drying and non-track time, accommodation of heavy traffic volumes, replacement of material, safety, and environmental concerns.

7-4.01.01 Durable Markings

Experience has shown that traffic volumes and resulting snow and ice operations have the greatest impact on the performance of pavement markings. The following chart outlines the life expectancy of various materials based on traffic volumes.

<table>
<thead>
<tr>
<th>Material</th>
<th>Average Daily Traffic</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt; 1500</td>
</tr>
<tr>
<td>Latex Paint</td>
<td>&gt; 1 year</td>
</tr>
<tr>
<td>Epoxy (Plural component Liquid)</td>
<td>&gt; 5 years</td>
</tr>
<tr>
<td>Preformed Polymer Tape</td>
<td>&gt; 5 years</td>
</tr>
</tbody>
</table>

Statewide Policy

To meet the goal of providing an appropriate marking 365 days per year, the following Policy for the application of pavement marking materials has been developed.

Multi-Lane Divided or Undivided Roadways

<table>
<thead>
<tr>
<th>Remaining Pavement Surface Life 1</th>
<th>Edgeline</th>
<th>Centerline, Lane Line, and Special Markings 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>(years)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 - 2</td>
<td>Paint</td>
<td>Paint</td>
</tr>
<tr>
<td>2 - 6</td>
<td>Epoxy</td>
<td>Epoxy</td>
</tr>
<tr>
<td>6 +</td>
<td>Epoxy</td>
<td>Tapé 3</td>
</tr>
</tbody>
</table>

1 Anticipated life of existing pavement is based on planned projects and anticipated life of surface is based on preventive maintenance plans.
2 Special markings include transverse markings (i.e. stop bars and crosswalks), gore markings, and word and symbol markings.
3 Preformed Polymer Tape shall utilize the inlayed method on both bituminous and concrete pavements (including bridge decks).
All marking materials shall be on Mn/DOT's Qualified Products List and shall be installed according to the manufacturer's specifications. This may include removal of existing pavement markings and other surface treatments as recommended by the manufacturer.

Part VI of the MN MUTCD should be consulted for interim pavement marking requirements.

7-4.01.02 Temporary Markings

Temporary markings are used in construction areas and at locations where a temporary hazard must be properly marked until the necessary repairs or improvements can be made.

The types of temporary pavement markings which are used in Minnesota and their respective characteristics are described in Chapter 8 of this Manual.

7-4.01.03 Retroreflectivity

Pavement markings which must be visible at night shall be reflectorized unless ambient illumination assures adequate visibility. Most pavement markings are reflectorized with the exceptions of curb and parking lines.

Retroreflectorization, defined as the return of light from a vehicle head lamp to the driver's eye, is accomplished by retroreflective elements (glass, ceramic, etc) imbedded into the marking material. Road grime, salt, dirt, damp or wet conditions, and snow plow damage reduce the retroreflectivity of a marking. Snow plowing, particularly by the under-body plow blade type, can destroy retroreflectivity by shaving or removing the glass beads. Retroreflectivity of in place pavement markings by handheld or mobile retroreflectometers. The handheld is more accurate while the mobile can collect large quantities of data at highway speeds.

A mobile retroreflectometer has three major components:

1. laser and feedback sensor,
2. distance measuring device, and
3. data acquisition computer.

The data collected from retroreflectometers will be used in the development of a pavement marking management system.

<table>
<thead>
<tr>
<th>Remaining Pavement</th>
<th>Edgeline</th>
<th>Centerline</th>
<th>Edgeline</th>
<th>Centerline</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 2</td>
<td>Paint</td>
<td>Paint</td>
<td>Paint</td>
<td>Paint</td>
</tr>
<tr>
<td>2 +</td>
<td>Paint</td>
<td>Paint</td>
<td>Epoxy</td>
<td>Epoxy</td>
</tr>
</tbody>
</table>

1 Anticipated life of existing pavement is based on planned projects and anticipated life of surface is based on preventive maintenance plans.
7-4.01.04 Removal of Markings

Markings that are no longer applicable for roadway conditions or restrictions and that might cause confusion for the road user shall be removed or obliterated to be unidentifiable as a marking as soon as practical.

Overly aggressive removal techniques leave scars that can confuse drivers during night and wet conditions.

Do not allow excessive scarring. Any excessive scarring should be repaired to avoid wet weather confusion.

Typically, sandblasting, grinding, and high pressure water jet have been used to remove markings, but the results at times have been less than desirable. For larger projects, truck-mounted, hydraulically controlled, dual scarifying drums with a built-in vacuum system could be considered. A trailing sweeper/vacuum unit recovers the coarser paint/surface waste mixture.

Markings may be temporarily masked with tape (not paint) until they can be removed or obliterated.

Lines and scars from line removal may look different at night. Nighttime inspections are desirable to determine that the pavement markings are visible and understandable under day and night conditions.

7-4.02 Standards and Specifications

The Minnesota cycle length for pavement marking is 50 feet. The cycle consists of a 10 foot stripe and a 40 foot gap.

Implementation

These guidelines shall be followed on all MN/DOT striping operations:

1. All new surfaces/overlays shall be striped with the 50 foot cycle.
2. All striping done on existing surfaces shall match the cycle currently in place. If the cycle is to be changed from a 40 foot to a 50 foot cycle, the existing pavement markings shall be removed.

7-4.03 Application Guidelines

Where used, pavement striping shall conform to the Highway Striping Plan, Standard Plan Nos. 5-297.341, 5-297.342 and Figure 7.1 as follows:

7-4.03.01 Two-Lane, Two-Way Roadways and Passing Lane Sections

1. Two-lane, Two-way roadways (see Figure 7.1) shall have:
   - Broken yellow centerlines
   - Pavement edge lines wherever there is poor color contrast between pavement and shoulders (especially at night), where fog conditions or the unusual hazards may exist, or on approaches to piers, abutments, and retaining walls. Edge lines are used extensively by MN/DOT.
   - Solid yellow lines to restrict passing where required, in accordance with the warrants and criteria for such markings. (See Section 7-4.04 of this chapter).
2. Passing Lane Sections

   Pavement markings are needed as follows:
   a. Lane Addition (see Figure 7.4)

      Both the pavement edge marking and the diagonal gore marking should be installed immediately prior to the beginning of the left lane line.
b. Passing Lane

A solid double yellow centerline pavement marking should be used to separate the lanes that carry opposing traffic. A broken white skip pavement marking is used to separate traffic moving in the same direction. Pavement edge markings are recommended for both directions of opposing traffic in the passing lane sections.

c. At the Lane Drop

Pavement markings in the lane drop transition area should be provided in accordance with the MN MUTCD, Section 3B-9 and Figure 3B-12. Pavement edge markings are important in the lane drop transition area.

7-4.03.02 Undivided Multi-lane Roadways

Pavement Markings shall conform to Figure 7.2.

Use the following for all Multi-lane, two-way roadways (four or more lanes):

- Double yellow solid line as centerline markings
- Lane lines
- Pavement edge lines. They are not required in urban areas with curbs.

7-4.03.03 Roadways with Two-Way Left Turn Lanes

Pavement markings shall conform to Figure 7.3.

7-4.03.04 One-Way Roadways

One-way roadways shall have the following:

- Lane lines to provide for better use of each lane
- Pavement edge lines on right side or both sides where needed for night visibility or where fog conditions or other unusual hazards may be encountered.

7-4.03.05 Narrow Bridges

Bridge decks on two-lane, two-way bridges may have double yellow barrier lines depending on bridge width and length. No-passing zones shall begin 1000 feet in advance of a narrow bridge. (see Figure 7.27)

7-4.03.06 Intersections

Supplementary pavement markings at intersections, where used, shall conform to the standards shown in Figures 7.5a and 7.5b, and Figure 7.22.

7-4.03.07 Interchange Exit and Entrance Ramps

Pavement markings for interchange ramps, where applied, shall conform to the standards shown in the Highway Striping Plan (see Figure 7.7 and Mn/DOT Standard Plan Sheet 5-297.341).
7-4.03.08 Auxiliary Lanes and Lane Drops

The purpose of this section is to clarify the use of these markings. Mn/DOT Standard Plan Sheet 5-297.342 displays the size, spacing of these markings and typical applications for lane drops and auxiliary lanes.

7-4.03.09 Turn Lanes

Use of a turn lane message is not required. If the district traffic engineer determines a need, use Figure 7.9 for placement guidance. Messages are required to supplement appropriate signing where a normal through lane is designated for turn option—through and/or turn only operation.

7-4.03.10 Bypass Lanes at Intersections

Bypass lanes at intersections should be marked as illustrated in Figure 7.10.

7-4.03.11 Obstructions in Traveled Way

See the MN MUTCD, Section 3B-10 and Figure 3B.13.

7-4.03.12 Transitions

Approaches to median islands in roadways shall be marked as illustrated in Figure 7.11. Markings for two-lane to four-lane undivided pavements shall be as shown in Figure 7.12.

7-4.03.13 Special Climbing Lanes

Pavement markings for special climbing lanes shall conform to the standards shown in Figure 7.13.

7-4.03.14 Truck Stopping Lane

Pavement markings for truck stopping lanes at railroad crossings shall be as shown in Figure 7.14.

7-4.03.15 Free Right Conditions

Pavement Markings for free right conditions shall conform to the standards shown in Figure 7.15.

7-4.03.16 Bicycle Lanes

See the MN MUTCD, Chapter 9 - Traffic Control for Bicycle Facilities.

7-4.04 No-Passing Zone Surveys

7-4.04.01 Warrants

A no-passing zone is warranted when the minimum sight distance is less than the distances shown in Chart 7-3. No-passing zone surveys shall be run at an eye height of 3.5 feet to an object height of 3.5 feet at the sight distance required in Chart 7-3 based upon the 85th percentile speed. The beginning of a no-passing zone shall be the point at which the sight distance first becomes less than that specified in Chart 7-3. The end of the marking shall be that point at which the sight distance becomes greater than the minimum specified in Chart 7-3. A no-passing line should not be less than 500 feet in length unless in advance of a stop sign as specified in Chart 7-2 or as specified in a specific figure. If the end of a no-passing line is less than that specified in Chart 7-4 from the beginning of the line for the next no-passing zone, the two no-passing lines should be connected to provide a continuous restriction through both zones.

If a re-survey of an existing no-passing zone is done and it changes in length, the NO PASSING ZONE pennant does not have to be relocated if the new termini is within 100 feet of the sign.
7-4.04.02 Survey Procedures

The first step in any surveying operation is work zone traffic control. Typically, the work zone traffic control for executing a no passing zone survey is considered a mobile operation. For the methods described below, this implies that workers are not typically stopped on the road for more than 15 minutes and the traffic control devices are vehicle mounted. MN MUTCD, Section 6K, (the Field Manual) Layout 5 would be a typical minimum treatment. Layout 2 would be a higher level of treatment if the road has challenging geometry. Ideally, surveys can be scheduled for the lowest volume periods. Higher ADT volumes, narrow shoulders or intense geometric changes may require additional measures all the way from advance road signs, shadow vehicles or all the way up to lane closures to protect survey workers and the motoring public. These impacts should be assessed and appropriate work zone treatments scheduled to coincide with the no passing zone survey.

There are several methods for surveying no-passing zones and a complete discussion of all those methods is found in the ITE Traffic Control Handbook (2001). An efficient and accurate method is the two vehicle method with both vehicles being equipped with electronic distance measuring instruments and handheld two way radios. In addition, the operators should have optical range finders and height-of-eye sight paddles. This will allow the survey operators the ability to accurately layout no passing zone surveys for both directions with one drive thru on roadways with simple geometry. Range finders will facilitate minimum time on the road determining distances. Ideally, no passing zones are established to an accuracy of 50 feet (approximately one painted skip stripe).

This method requires two vehicles equipped with two-way radios, calibrated distance measuring instruments (DMI), flashing amber lights, and a target for eye height on the lead vehicle. Operators should also have height-of-eye paddles to assist them in unusual geometry. Intermediate sedan size vehicles will work the best but at least the trailing vehicle should be an intermediate sedan with a drivers eye height near the 3.5 foot mark. Verify tire pressure since the DMI's are calibrated at correct tire pressure. Handheld radios will permit the drivers to communicate if they get out of the car to verify distances with the rangefinder. The target should be mounted so the top of the target is at 3.5 feet and should be a bright color different than the vehicle so that a sharp cut off can be observed from 1000 feet. Typically the target should be mounted on the driver's side of the rear of the vehicle. A 4-inch 12 volt LED light from an arrow board can also be a good target but do not use white lights since law prohibits bright white lights projecting from the rear of a vehicle while traveling.

To set the minimum sight distance interval, both cars should park abreast on the roadway or shoulder and the DMI's set at 0.000. The lead vehicle will then move forward the minimum passing sight distance for the speed indicated. When the lead vehicle has gone the required distance, it should stop and the DMI should be reset to 0.000. Not all DMI's have the capability to work in reverse so verify the operation of the particular DMI used. Newer DMI's have GPS capability and can have read outs for the distance between them. The vehicles with drivers are deployed with the appropriate minimum sight distance between them. From then on, radio contact should be maintained between the vehicles to coordinate their movement. Upon a signal from the trailing vehicle, both vehicles can move forward. The vehicles are to be kept at the correct distance and speed by the lead vehicle observer calling off feet often enough to keep identical readings on the DMI's. To practice this procedure, readings should be called off every 100 feet with the vehicles traveling approximately at 5 mph. Later with added experience, this speed may be increased. If identical readings cannot be maintained, the trailing vehicle should have a lower reading. This will result in the vehicles being farther apart than required. One note of caution, the vehicles should not be backed up to adjust the spacing, unless the DMI's being used are capable of operating backwards.

Most vertical curves can be done from the shoulder. Horizontal curves should be sighted from near the centerline. Given the slow vehicle pace necessary to conduct this study, care must be taken when locating no-passing zones to see that traffic does not become confused or congested. Both vehicles should pull over on the shoulder when the rear driver notices cars being held back.
While making measurements, the driver of the trailing vehicle should stop both vehicles just before the lead vehicle goes out of sight. At this time, the trailing vehicle can move up to obtain identical DMI readings. From this point each vehicle will move forward 50 feet, stop, then move another 50 feet until the target on the lead vehicle goes out of sight over the crest of a hill or is obscured by obstructions along the roadside on horizontal curves. With practice, a team may be able to move continuously and stop only when the lead vehicle goes out of sight. When the lead vehicle's target disappears, the pavement should be marked with spray paint or by some other method.

The trailing vehicle operator should mark to the right of the centerline and the leading vehicle to the left. The trailing vehicle marks will represent the beginning and end of the no-passing zone for vehicles traveling in the direction of the study.

The lead vehicle marks will represent the no-passing zone for the opposite direction of travel. See Figure 7.18 for spotting symbols.

The two vehicles should then proceed forward with identical DMI readings until the driver of the trailing vehicle sees the top of the lead vehicle. Both vehicles are stopped and the trailing vehicle is moved forward to obtain identical DMI readings. Then both vehicles should move forward 50 feet, and stop to determine if the target has re-appeared. This "stepping" is repeated until the target re-appears. Both drivers should then stop and mark the roadway. The lead driver marks on the left of the centerline and the trailing driver marks on the right of the centerline. See Sketch 1 below and Figure 7-16.
It is possible for vehicles positioned in-between the study vehicles to become lost in depressions although the vehicles are spaced the minimum sight distance apart and the drivers may see each other. Reverse horizontal curves can create similar situations. See Sketch 2 below.

The following procedure is suggested for handling these lost vehicle situations. The driver of the lead vehicle estimates where the low point of a depression is and stops there, after notifying the trailing vehicle of what process is being performed. The trailing vehicle then moves forward until the target on the lead vehicle is in sight. If it is noted by the trailing driver that other on-coming vehicles continue to become lost, the trailing vehicle must move forward to a point where the driver does not lose an on-coming car in the depressions. At this point, a spot should be marked to the right of the centerline by the trailing vehicle's driver. With the trailing vehicle stopped, the lead vehicle then moves forward so it has a DMI reading identical to the trailing vehicle and marks a spot to the left of the centerline. The two vehicles are now synchronized and may proceed with the study. If traffic volumes are high enough, the trailing vehicle can use oncoming cars to spot depressions and sight in on both headlights instead of the target on the lead vehicle. The trailing driver would then radio this reading to the lead driver to re-synchronize the vehicles.

Horizontal curves can be more challenging. Ideally, sight lines should be made from the wheel path nearest the centerline or on the centerline. Drivers may have to exit their vehicles and use the height-of-eye paddles (See Sketch 3). Multiple horizontal curves in a row or compound curves will probably have to be driven in both directions to verify accurate placement.

The minimum passing sight distance used during the study should be changed to accommodate changes in the speed limit. This may require changing passing sight distances while in a no passing zone. If there is any doubt, the longer of the two distances should be used. It is advisable to drive these situations in both directions to confirm placement.
Range finders will help in determining if zones should be connected. If at the end of a potential zone, the trailing operator sees a stop sign ahead, the operator can target the stop sign and get a reading. If that reading is less than the distance in Chart 7-2 plus the gap distance shown in Chart 7-4, then a mark should not be made at the end of the zone until reaching the intersection. Similar range finding techniques can be used to assist in placement of zones in advance of bridges, RR crossings, and medians. The use of temporary pavement tape for spotting marks can also be a time saver in challenging alignment where many gaps need to be connected. The tape can be easily pulled off the pavement without scarring or causing black paint erasure marks.

Before final no passing zones are marked on the pavement, minor adjustments may be made to survey data so that the marking of sight restrictions of short duration are either extended to 500 feet (0.095 mile) or disregarded altogether. If extended, the addition shall be made to the beginning of the zone. Before a sight restriction of less than 500 feet is either installed or disregarded, close field examination shall be made, checking to see if the target is completely out of sight for approximately 2 seconds at the prevailing speed. If the target vehicle does not go completely out of sight, the no-passing zone may be disregarded.

**Sound judgment must be exercised by the No-Passing Zone crew leader, taking into consideration distance traveled and time elapsed during the sight restriction and weighing these factors against the time which both drivers have to observe each other prior to reaching the sight obstruction. If doubt exists, the no-passing zone should be marked to a minimum of 500 feet.**

Chart 7-1 shows a typical form that may be used to log the placement and type of no passing zones. This form is available in an excel spreadsheet from the OTST Pavement Marking Engineer.

**7-4.04.03 Removal of Sight Obstructions**

When minor maintenance activity can be performed to remove sight obstructions, a request explaining the obstruction shall be sent to the appropriate Maintenance Area for action. Requests for removal(s) of sight obstructions shall normally be limited to work needed to avoid extending a no passing zone.
7-4.05 Standard Spotting Procedure

A standard practice of the department is to "spot" or mark guidelines for pavement markings and striping. Traffic technician, survey crew or contractor does the spotting with a spray paint. Use the spotting system, shown in Figure 7.18 and described below, for all striping.

Match color of spot to the color of the stripe to be painted.

Generally spot as necessary to ensure proper placement of markings. Edgelines and no passing zone lines should not be carried thru public access intersections. They should be carried thru driveways.

7-4.06 Special Markings

7-4.06.01 Pedestrian Crossings

An engineering study should be completed to determine the necessity of a pedestrian crosswalk. The study should include the following detailed information:

- Geometrics
- Motorist sight distance
- Traffic volume data including truck traffic and turning movements
- Daily pedestrian volume estimates
- Observation of site characteristics that could divert driver attention from the crosswalk
- Posted speed limit
- Crash history
- Sidewalks and pedestrian pathways

Performing engineering analysis on potential crosswalk locations should result in a more uniform application of the use of pedestrian crosswalks.

Not all sites warrant a pedestrian crosswalk or a crosswalk with additional treatments. The following are possible outcomes that may result from non-uniform application, misuse, or overuse of crosswalk safety treatments.

1. Noncompliance with traffic control devices.
   In general, a motorist's decision on whether to comply with a traffic control device message is related to how reasonable the driver perceives the intended message conveyed by the device. If the message is not regarded as reasonable, the likelihood of noncompliance with the device increases.

2. Decrease in safety.
   Studies have demonstrated that in some circumstances installing pedestrian crosswalks without some other type of treatment such as signing, warning lights, etc. may not only be ineffective but could actually decrease the safety of crossing the roadway.

3. Disregard of traffic control device.
   Overuse of traffic control devices such as signs or striping can lead to a general disregard of the device. Drivers may start to ignore them creating a more hazardous situation.
Crosswalk Installation Guidelines

Mn/DOT has developed a flowchart (see Chart 7-8) to help decision makers determine whether or not a crosswalk is warranted. The following conditions must be met at all potential crosswalk locations:

- Adequate stopping sight distance for motorists
- Minimal truck traffic
- Minimal vehicle turning movements
- Minimal driver distractions

The following sections support the criteria contained in the flowchart.

**Condition Red**

The following design options may be considered at locations that present a relatively high risk to pedestrians:

- Pedestrian bridge or underpass
- Pedestrian signal

**Condition Yellow**

The following design options may be considered at locations that present a relatively medium risk to pedestrians:

- Modify existing lane configurations
- Raised median (minimum width of four feet and length of eight feet)
- Curb extensions
- Pedestrian crossing island
- Advanced stop lines and associated signing
- Parking restrictions
- Increased law enforcement
- Modify and/or add lighting

Some Condition Yellow crossings may be determined sufficient without additional crosswalk enhancements.

**Condition Green**

Crossings that are identified as having a relatively low risk for pedestrians are those that typically require only pavement markings. Signing may be included based on engineering analysis.

Crosswalk treatments should be selected to address a specific problem, such as crossings at multi-lane locations where multiple conflicts may be expected.

See also "School Crossings" section below.

Place pedestrian crosswalk lines as shown in Figure 7.19 and 7.20. If used, the words PED XING in white may be placed on the approaching pavement lane or lanes for the benefit of approaching traffic. This pavement message should be placed near the PEDESTRIAN CROSSING (W11 2) sign.

In municipalities, crosswalks and pavement markings for school and pedestrian crossings are usually provided by local authorities. The district traffic engineer may provide expertise in the initial efforts by the municipality. The department usually does not provide crosswalks or pedestrian markings in unincorporated areas. However, if a definite need exists, the department may install crosswalk and pavement markings.
7-4.06.02 School Crossings

The following guidelines govern the provision of school markings:

1. School Adjacent to Highway

When a school building or its grounds are adjacent to a trunk highway, the School Advance Warning assembly (S1-1 with appropriate supplemental distance plaque) should be erected. If no crosswalk is provided, the word "SCHOOL" may be applied in white on the approaching traffic lane or lanes near the School Advance Warning assembly. The School Advance Warning assembly and "SCHOOL" pavement message should not be used if the highway right-of-way is fenced and no access is provided directly to the highway.

2. Crosswalk

When a crosswalk is designated within a school zone, install the School Crosswalk Warning Assembly (S1-1 with diagonal down arrow) as specified in the MN MUTCD, section 7B.9. The crosswalks may also be painted and the words SCHOOL XING may be applied in white near the School Advance Warning assembly. Sidewalks or hard-surface pedestrian paths with ADA compliant pedestrian ramps shall be present before the crosswalks will be installed. It is also recommended to advise the school district to furnish crossing guard protection at these locations to ensure safety.

3. Roadway Message

If a sight restriction exists, the advance warning message SCHOOL XING shall be applied along with appropriate advance warning signs required by the MN MUTCD, Section 4D-15.

In municipalities, crosswalks and pavement markings for school and pedestrian crossings are usually provided by local authorities. The district traffic engineer may provide expertise in the initial efforts by the municipality. The department usually does not provide crosswalks or pedestrian markings in unincorporated areas. However, if a definite need exists, the department may install crosswalk and pavement markings.

7-4.06.03 Railroad Crossing with Stopping Lane

All approaches to railroad grade crossings with a stopping lane in rural areas, except minor spurs, shall be marked as shown in Figure 7.14. The local road authority is responsible for marking all railroad crossings on their roadways.

7-4.06.04 Stop Lines

Use stop lines to emphasize stopping location. Stop lines shall extend across all approach lanes. See Figure 7.22 and guidelines below:

1. Stop Sign

It is preferable to place Stop Line in line with the STOP sign. However, if the STOP sign cannot be located exactly where vehicles are expected to stop, the stop line should be placed at the desired stopping point.

2. Rural Areas

Stop lines in rural locations shall be placed only where the district traffic engineer has determined a need for such control. A traffic control order shall be used.

3. Urban Areas

Stop lines in urban areas should be placed 4 feet in advance of and parallel to the nearest crosswalk line. In the absence of a marked crosswalk, the stop line should be placed at the desired stopping point. In no case shall a stop line be placed more than 30 feet or less than 4 feet from the nearest edge of the intersecting curb line or edge of the thru traveled lane.
7-4.06.05  Stop Ahead or Signal Ahead

The STOP AHEAD or SIGNAL AHEAD messages shall be placed where a study by the district traffic engineer has determined a need for this type of warning. A pavement message is usually placed at or shortly beyond the sign giving the same message and may be repeated wherever approach speeds are high or unusual alignment exists. A solid yellow no-passing line shall be used with the STOP AHEAD or SIGNAL AHEAD pavement message (see Figure 7.22).

7-4.06.06  Parking Space Markings

Parallel parking spaces, where used, are to be marked with white lines with desirable dimensions of 8 feet by 22 to 26 feet (see MN MUTCD, Section 3B.18 and Figure 3B-8). Parking spaces in state rest areas should be striped as shown in Figure 7.23. Municipal parking spaces are marked by local authorities.

7-4.06.07  Curb Markings

Use curb markings only to indicate parking is prohibited at all times. Other restrictions should be shown by standard parking signs. Local authorities may paint curbs yellow under the conditions described in Minnesota Statutes Section 169.34. Local authorities may also prohibit parking at other locations. Permission to restrict parking on trunk highways must be obtained from the appropriate district traffic engineer.

7-4.06.08  Markings for Speed Enforcement (Airplane Markings)

See Figure 7.24.

To determine appropriate pavement markings for State Patrol airplanes, each district traffic engineer should confer annually with the patrol captain and chief pilot to review existing zones. This review should identify any zones which can be eliminated because they are not being used.

Use white stripes, with dimensions of 4 feet by 2 feet if in the traffic lane or on the centerline. Use white stripes 6 feet by 2 feet for markings on the shoulder. The marking should extend 2 feet into the driving lane.

A zone should consist of a set of 5 markers and be placed on a straight roadway if possible. Zones should be separated by 1/2 to 1 mile.

7-4.06.09  Preferential Lane Markings

1. Bus and Car Pool

See Figure 7.25 for an example of the application of "restricted lane" markers at a freeway on-ramp. The use of "restricted lane" markings shall be documented by a Traffic Control Order and approved by the State Traffic Engineer.

7-4.06.10  Roundabout Intersections

The overall concept for roundabout marking is similar to general intersection marking. Typical pavement marking for Roundabout Intersections consists of delineating the entries and marking the circulatory roadway on multi-lane Roundabout Intersections. This task is not easy and must be reviewed by an experienced roundabout designer and the District traffic engineer.

1. Specifying Materials and Installation

Dotted extension lines and crosswalks near roundabout will deteriorate at an accelerated rate. It is recommended that a durable pavement marking be used. This should be clearly spelled out in the specifications and mentioned at the preconstruction conference.
2. Single Lane Roundabout Intersections

In general, single lane Roundabout Intersections need no lane arrows or circulatory roadway pavement marking. Bike lane marking within the circulatory roadway is not permitted on any Roundabout Intersections. (See Figure 7.36)

3. Multi-Lane Roundabout Intersections

Contact the Office of Traffic, Safety and Operations for assistance in development of pavement marking plans for a multi-lane roundabout.

4. Relationship with the MN MUTCD

The Minnesota Manual on Uniform Traffic Control Devices (MN MUTCD) governs the design and placement of signs and markings. The MN MUTCD follows the guidelines in the Federal MUTCD.

5. Other Standards

Applicable local standards may also govern the design and placement of pavement markings as long as they do not conflict with the MN MUTCD and Mn/DOT policies. Roundabout Intersections present a number of new pavement marking issues that are not addressed in the MN MUTCD or the FHWA Roundabout: “An Informational Guide.” On connecting highways coordinate pavement marking with the district traffic office and the local agency to maintain consistency on the facility. Contact the Office of Traffic, Safety and Operations for additional guidance.

6. Approach and Entry Pavement Markings

Approach and entry pavement markings consist of dotted edge line extension marking and optional yield line and optional symbol markings. Consult the District Traffic Engineer for optional marking recommendations.

7. Approach Marking

Splitter islands will be marked in accordance with standard Mn/DOT guidelines for "Approach Markings for Obstructions" MN MUTCD, Section 3B.19. Where pedestrian traffic is expected and signing is provided, the designer may provide crosswalk pavement markings.

The dotted edge line extension used to demarcate the entry approach from the circulatory roadway is 8-inches wide for single lane entries to the roundabout with a 3 ft line, 3 ft gap and located along the inscribed circle. Set the dotted edge line extension slightly back from the circulating roadway to prevent circulating traffic from scuffing the markings. Do not place pavement marking to demarcate the exit from the circulatory roadway.

Pavement word or symbol markings to supplement the signing and yield point marking may be desirable, consult with the District Traffic Engineer for further guidance. These markings should conform to the standards given in MN MUTCD, Section 3B.19.

7-5.0 OBJECT MARKINGS

7-5.01 Purpose

Object markers are used to identify physical features located within or adjacent to the roadway such as traffic islands, road or street termination and freeway gore areas. Obstacles such as bridge piers and abutments that are close to a traveled lane generally require additional warning techniques.
7-5.02 Types of Object Markers

For object marker types, color, and uses, consult the Mn/DOT Standard Signs Manual and the MN MUTCD. Additionally, Mn/DOT uses a Snowplow Marker (X4-5) which is not referenced in the MN MUTCD.

Information pertaining to materials, sheeting, and sign substrates can be found in the Minnesota Standard Specifications for Construction, sections 2564 and 3352.

7-5.02.01 Snowplow Marker (X4-5)

This marker indicates to a snowplow operator the beginning and end of a guardrail installation. The snowplow marker is shown in Chart 7-5 and Figure 7.26.

7-5.03 Applications and Guidelines

7-5.03.01 Bridges Abutments, Piers, and Rails

Bridge abutments, piers, and rails within the width of the approaching shoulders shall be marked with Type 3 Object Markers (Clearance Marker X4-4). A typical application can be found in Figure 7.26.

7-5.03.02 Narrow Bridges/One Lane Bridges

A narrow bridge shall be defined as any of the following:

1. A bridge with a minimum driving surface width greater than 18 feet and less than the roadway approach width (not including shoulders).
2. A bridge where engineering judgment of approach grades, curvatures, number of trucks or other considerations justifies a narrow bridge classification.

Narrow bridges should be marked and delineated as shown in Figure 7.27.

A one-lane bridge is defined as any bridge having a clear opening width of 18 feet or less. One-lane bridges shall be marked and delineated as shown in Figure 7.28.

7-5.03.03 Cattle Passes/Large Culverts

Cattle passes and larger culverts that meet one of the following descriptions are subject to the provisions of this subsection:

1. Headwalls are present and are not protected by guardrail, subject to engineering judgement
2. Minimum width of 42 inches and a maximum width of 20 feet. Large culverts 20 feet or wider may be treated as a bridge, subject to engineering judgement.
3. Any culvert with an end or opening that is within 8 feet of the outside edge of the shoulder. This 8 foot distance was selected because it may allow a motorist to pull off of a narrow shouldered roadway if other conditions permit.
4. Other structures as determined by the district traffic engineer.
All cattle passes and larger culverts meeting the above criteria should be marked with Type 2 object markers as described in Section 3C.3 of the MN MUTCD and the following:

1. The Type 2 Marker used shall be a 6” x 12” marker constructed of 0.062-inch aluminum or other lightweight material such as fiberglass or flexible urethane sheeting. The marker shall use fluorescent yellow prismatic retroreflective sheeting of a type compatible with the base material.

2. On special flexible post designs that cannot accommodate the 6” x 12” marker, a 3” x 12” marker may be used.

3. Two markers shall be mounted back-to-back on a flexible post or 2-pound steel post. A flexible post is preferred due to its resistance to being knocked down by snowplows and farm equipment. Additionally, it provides better daytime visibility.

4. The two-way marker assembly shall be installed on the near right side immediately in front of the structure as shown in Figure 7.29.

The typical marking of cattle passes and large culverts not protected by guardrail are shown in Figure 7.29.

7-5.03.04 Guardrail

The approach end of plate beam guardrail installations should be marked with a striped object marker sized to fit the end terminal of the guardrail. The alternating black and reflective yellow stripes shall slope downward at a 45 degree angle toward the side on which traffic is to pass. The marker shall be made of fluorescent yellow prismatic retroreflective sheeting.

On guardrail installations with flat end treatments, the object marker shall fit within the recessed area. On installations with round end treatments, the object marker shall wrap around the circular end treatment and shall be mounted so that the top of the marker is even with the top of the circular end treatment.

Both ends of all guardrails shall be marked with the Snowplow Marker (X4-5) as shown in Figure 7.26.

7-5.03.05 Islands and Interchange Gores

A typical application of the placement of object markers on island or interchange gores can be found in Chart 7-5 and Figures 7.26 and 7.30.

7-5.03.06 End of Roadway

A typical placement of markings for a roadway that ends with no alternative vehicular path is shown in Figure 7.26.

7-5.03.07 Driveway Reflectors

A property owner may mark each side of a driveway entrance with reflectors. Blue colored reflectors are preferred although white (colorless) may be used. Place each reflector on its own structure (not to exceed a 1.0 pound post), not more than 5 feet above the ground, and at least 12 feet from the outside edge of the shoulder to prevent snowplow damage.

Red or yellow reflectors should not be used since they can be easily confused with motor vehicle tail lights. Mn/DOT forces may remove existing reflectors if they obstruct or interfere with the effectiveness of any traffic control device (Reference: MS169.07).

7-5.03.08 Other Objects

Objects located within the clear zone should be marked with the proper object marker. The clear zone should be determined as stated in Chapter 4 of the Road Design Manual.
7-6.0 DELINEATION

7-6.01 Types and Materials
For delineator types and colors, consult the Mn/DOT Standard Signs Manual, the MN MUTCD, and Figure 7.30 and Chart 7-6 of this manual.

Information pertaining to materials, sheeting, and sign substrates can be found in the Minnesota Standard Specifications for Construction, sections 2564 and 3352.

7-6.02 Delineator Location
The details of height and location of delineators are shown in Figure 7.30 and stated below.

7-6.02.01 Delineator Height and Lateral Placement
When used, install delineators so that the bottom of the delineator is 4 feet above the surface of the nearest traffic lane. Install delineators between 2 feet and 8 feet outside the roadway or pavement edge. On roadways with shoulders, delineators should be installed 6 feet outside the shoulder break. Along curbed sections of roadways, delineators shall be placed not less than 2 feet, nor more than 5 feet, from the curb face.

7-6.02.02 Delineator Spacing
Delineators should be placed at a constant distance from the edge of the roadway except where a guardrail or other obstruction intrudes into the space between the pavement edge and the extension of the line of delineators. The delineators should then be in line with or inside the innermost edge of the obstruction. A typical delineator installation is shown in the MN MUTCD, Section 3D.4, and Figure 7-30 of this manual.

A simple method for field personnel to determine the degree of curve or the radius of a curve is shown in Chart 7-7.

1. Along Horizontal Curves
   When applied on the approaches to and throughout horizontal curves, spacing should permit several delineators to always be visible along the curve ahead of the driver. Figure 3D-1 and Table 3D-1 of the MN MUTCD show the recommended spacing for delineators along horizontal curves. A typical layout for delineator spacing on horizontal curves is shown in Chart 7-7.

2. Along Vertical Curves
   When applied on crest vertical curves, the spacing should permit a minimum of three delineators to be visible from all points along the centerline of the curve at an eye level of 4 feet above the pavement.

3. Along Tangent
   When used, delineators should be spaced 0.1 mile apart along the through roadway, except along acceleration and deceleration lanes where the spacing should be as indicated in Section 3D.4 of the MN MUTCD.

7-6.02.03 Divided-Highway Crossovers
Delineation of divided-highway crossovers is shown in Figure 7.32.

7-6.02.04 Interchanges
Delineation of cloverleaf and diamond interchanges is shown in Figures 7.33 through 7.35.
7-6.02.05 Guardrail

Three cable guardrail shall be delineated as shown in the current version of Mn/DOT Standard Plate Nos. 8330 and 8331. The color of the reflective sheeting shall match the color of the adjacent edge line.

Plate-beam guardrail delineation is under investigation.

7-6.03 Deer Reflectors

Each district may make the decision to remove existing deer reflectors based on any of the following conditions:

1. The existing installations are more than six years old and there is no intent of maintaining them due to replacement costs (lack of maintenance funds), complicated installation procedures, and a lack of staff.

2. The existing installations are a problem for maintenance activities (their lateral placement causes mowing and snow removal problems).

3. Written documentation indicates that either the number of deer kills has not been significantly reduced or the number of deer kills has actually increased.

7-7.0 REFERENCES


www.dot.state.mn.us/bike/bikewaysdesignmanual.html
SECTION B-B
(24 ft. roadway)

NOTE: Do not place longitudinal pavement marking lines on the roadway joints.

1 Contact traffic engineer for No Passing Survey

Text Ref.: 7-4.03.01
NOTE: Do not place longitudinal Pavement Marking Lines on the roadway joints.
**SECTION C-C**

4 in. Solid Line Yellow  
4 in. Broken Line Yellow  
4 in. Solid Line Yellow

4 in. 4 in. Broken Line Yellow

**SECTION C-C**

4 in. Solid Line Yellow  
4 in. Broken Line Yellow  
4 in. Solid Line Yellow  
4 in. Broken Line Yellow  
4 in. Solid Line Yellow

4 in. Broken Line White  
4 in. Broken Line Yellow

4 in. Solid Line White

**These distances should be equal. The Pavement Arrows are placed to show the operation and do not have to line up with any of the driveways.**  

**See “TYPICAL MESSAGE PLACEMENT FOR TURN LANES” for the number and placement of turn arrows and how to introduce this lane — Figure 7.9**

Text Ref.: 7-4.03.03

May 15, 2008  |  TWO-WAY LEFT TURN LANE PAVEMENT MARKING DETAILS  |  FIGURE 7.3
NOTE:

1. The same treatment is used for both approaches.
2. The lane skip striping shall end approximately 50 feet beyond the Lane Reduction sign.
3. More details on signing can be found in Chapter 6.

Text Ref.: 7-4.03.01 (2a)
FIGURE 7.5A

** Optional

** see Charts 7-2 and 7-4

*** from Curb Line or near edge of the thru traveled lane.

Text Ref.: 7-4.03.06

May 15, 2008

MAJOR INTERSECTION PAVEMENT MARKINGS

FIGURE 7.5A
**FIGURE 7.5B**

Major Intersection Pavement Markings

- **4 in. Solid Line Yellow**
- **4 in. Broken Line Yellow**

Solid White Stop Line should be placed at the stopping point.

4 ft. Minimum, Maximum from edge of shoulder.

50 ft. Maximum from edge of shoulder.

NOTE: Pavement Messages are 8 ft. White Letters

Optional see Charts 7-2 and 7-4

*** from Curb Line or near edge of the thru traveled lane.

Text Ref.: 7-4.03.06

May 15, 2008

MAJOR INTERSECTION PAVEMENT MARKINGS

7-28
SEE DESIGN C
8 in. Solid Line White (Channelizing)

PARALLEL ACCELERATION LANE

SEE DESIGN C
8 in. Solid Line White (Channelizing)

EXIT RAMP MARKINGS

SEE DESIGN C
8 in. Solid Line White (Channelizing)

RAMP MARKINGS

SEE DESIGN C
8 in. Solid Line Yellow from edge of pavement to edge of stripe

4 in. Broken Line White for one-half the length of full width acceleration lane.

Through lane Markings

SEE DESIGN A
4 in. Solid Line White

SEE DESIGN A
4 in. Solid Line White

SEE DESIGN C
8 in. Solid Line White (Channelizing)

SEE DESIGN D
8 in. Solid Line White

SEE DESIGN C
8 in. Solid Line Yellow from edge of pavement to edge of stripe

4 in. Broken Line White from edge of pavement to edge of stripe

TAPERED ACCELERATION LANE

SEE DESIGN E
4 in. Solid Line White

SEE DESIGN F
4 in. Solid Line Yellow from edge of pavement to edge of stripe

2 in. 1 in. from edge of pavement to edge of stripe

Shoulder Area

Bituminous Shoulder

SECTION A-A

(THEE LANES)

End of chapter
4 in. Solid Line White
4 in. Solid Line Yellow

8 in. Solid Line White

4 in. Solid Line White

Dotted white extension of edge line
Length: 3 feet
Spacing: 12 feet
Width: 8 inches

4 in. Solid Line White

4 in. Broken Line White

4 in. Solid Line Yellow

Exit Ramp
Exit Ramp
NOTES:

1. Extend 8 in. solid line white 50 ft. minimum beyond gore area to compensate for sharp curvature.

2. On pavements over 24 ft. wide (i.e., 27 ft.) edge lines will be placed so lanes are a maximum of 12 ft. wide.

3. Omit broken line white when auxiliary lane is less than 1000 ft. long. Extend 8 in. solid line white up to 200 ft., if deemed necessary for better delineation, at the discretion of the district traffic engineer.

4. Extend 8 in. solid line white for 200 to 300 ft., on curvature or for other situations where needed for better delineation, at the discretion of the district traffic engineer.

5. When the distance between Design A Details exceeds 1000 ft., start 8 in. solid line white 100 ft. before right side Design A Detail and place standard 4 in. broken line white (10-40) between the solid lines.

6. 8 in. dotted line white, 3 ft. long with a 12 ft. gap, as detailed in Figure 3-11a of the MN MUTCD. This type of stripping should be used whenever a lane is dropped.

7. Extend 8 in. solid line white the entire length of the escape lane and to the end of the taper. Pick up the normal 4 in. solid line white beyond the taper. The taper must be at least 50:1.

DENOTES SHOULDER AREA
Typical markings for
Left Turn Islands

At speeds over 40 mph the
crosshatch spacing may be
increased to 30 ft. between
crosshatch lines.

At speeds less than 40 mph
the width of the crosshatch
line may be reduced to 12 in.

Text Ref.: 7-4.03.09

FIGURE 7.9
Note:
1. No Passing Zones at intersections shall be striped for 500 feet on both sides of the intersection if it is located within the city limits. No Passing Zones at intersections shall be striped if located within any established No Passing Zone. No Passing Zone striping is optional at the discretion of the district traffic engineer for rural intersections. See Chart 7-4.
2. See Figure 6.17 for signing.

★ See Figure 7.9 for the typical message placement of turn arrows.
★★ 3 foot long line with a 12 foot gap.
DIVIDED ROADWAY TRANSITION

Text Ref.: 7-4.03.12

FIGURE 7.11

Text Ref.: 7-4.03.12

May 15, 2008

DIVIDED ROADWAY TRANSITION
PAVEMENT MARKINGS

FIGURE 7.11

* See Chart 7-4.

May 15, 2008

DIVIDED ROADWAY TRANSITION
PAVEMENT MARKINGS

FIGURE 7.11

* See Chart 7-4.
* See Chart 7-4.

Text Ref.: 7-4.03.12
FOR TAPER DESIGN, SEE MN/DOT ROAD DESIGN MANUAL

4 in. Solid Line Yellow
700 ft. Minimum*

200 ft.
End 4 in. Broken Line White

4 in. Solid Line Yellow *

4 in. Broken Line Yellow

Begin 4 in. Broken Line White

50 ft.

4 In. Solid Line White

4 In. Solid Line White

1:15 TAPER

* See Chart 7-4.

Text Ref.: 7-4.03.13
Use the same signing and marking for the opposite direction.

Text Ref.: 7-4.03.14 and 7-4.06.03

FIGURE 7.14

RAILROAD CROSSINGS WITH TRUCK STOPPING LANE PAVEMENT MARKINGS

May 15, 2008

TRAFFIC ENGINEERING MANUAL

August 15, 2008
STOP CONDITION

YIELD CONDITION

ACCELERATION LANE CONDITION

Text Ref.: 7-4.03.15

FREE RIGHT TURN LANE
PAVEMENT MARKINGS

FIGURE 7.15
a - No-passing zone at VERTICAL CURVE

Sight distance becomes less than minimum measured between points 1.07 m (3.5 ft) above pavement

No-passing zone, a to b (in direction indicated)

Minimum passing sight distance for 85th percentile, posted, or statutory speed

Profile View

NOTE: No-passing zones in opposite directions may or may not overlap, depending on alignment.

Plan View

Minimum passing sight distance for 85th percentile, posted, or statutory speed

NOTE: No-passing zones in opposite directions may or may not overlap, depending on alignment.

b - No-passing zone at HORIZONTAL CURVE

Sight distance again exceeds minimum

No-passing zone, a to b (in direction indicated)

Text Ref.: 7-4.04.02

May 15, 2008

NO PASSING ZONE PROFILES

FIGURE 7.16
End of Solid Line White

End of Broken Line White

End of Broken Line Yellow

End of double Solid Line Yellow

End of double Solid Line White

No Passing Zone Markings

Text Ref.: 7-4.05
NOTES:

1. Pavement messages are optional.
2. Engineering judgement should be used to determine whether they are necessary.
3. 6’ letters may be used if approach speeds are low.
4. See Figure 6.21 in Chapter 6 for appropriate signing.

Text Ref.: 7-4.06.01
### PEDESTRIAN CROSSWALK MARKINGS - CONTINENTAL BLOCK DESIGN

#### FIGURE 7.20

<table>
<thead>
<tr>
<th>(L) WIDTH OF INSIDE LANE</th>
<th>(W) WIDTH OF PAINTED AREA</th>
<th>(S) WIDTH OF SPACE</th>
</tr>
</thead>
<tbody>
<tr>
<td>9 feet</td>
<td>2.0 feet</td>
<td>2.5 feet</td>
</tr>
<tr>
<td>10 feet</td>
<td>2.5 feet</td>
<td>2.5 feet</td>
</tr>
<tr>
<td>11 feet</td>
<td>2.5 feet</td>
<td>3.0 feet</td>
</tr>
<tr>
<td>12 feet</td>
<td>3.0 feet</td>
<td>3.0 feet</td>
</tr>
<tr>
<td>13 feet</td>
<td>3.0 feet</td>
<td>3.5 feet</td>
</tr>
</tbody>
</table>

NOTES:

1. Painted areas to be centered on centerline and lane lines.
2. A minimum of 1.5 feet clear distance shall be left adjacent to the curb. If the last painted area falls into this distance, it must be omitted.
3. On two-lane, two-way streets, use the spacing shown for a 11 foot inside lane.
4. For divided roadways, adjustments in spacing of the blocks should be made in the median so that the blocks are maintained in their proper location across the traveled portion of the roadway.
5. At skewed crosswalks, the blocks are to remain parallel to the lane lines as shown.
6. The blocks shall be placed so that they are not located in the wheel path of the vehicles.

Text Ref.: 7-4.06.01
For optional crosswalk design see Figure 7.20

4 in. Solid ** Line Yellow

S1-1
W16-9p

S1-1
W16-9p

S2-P2

White Blocks

NOTE:
Pavement messages are optional

* 6 ft. Letters may be used if the approach speeds are low.

** See Charts 7-2 and 7-4 for length of No Passing Zone line

Text Ref.: 7-4.06.02
NOTES:

1. Do not install a STOP AHEAD pavement message if the intersection has adequate lighting.

2. Install only one set of STOP AHEAD pavement messages. If a Stop Ahead sign needs to be installed more than 1000 feet from the STOP sign, contact the district traffic engineer to determine if, and where, a second set of STOP AHEAD pavement messages should be installed.

3. The stop line should ordinarily be placed 4 feet in advance of and parallel to the nearest crosswalk line. In the absence of a marked crosswalk, the stop line should be placed at the desired stopping point, and in no case no more than 30 feet or less than four feet from the nearest edge of the intersecting curb line or the near edge of the thru lane.

   If a stop line is used in conjunction with a stop sign, it should ordinarily be placed in line with the stop sign. However, if the sign cannot be located exactly where vehicles are expected to stop, the stop line should be placed at the stopping point.

Text Ref.: 7-4.06.04
FIGURE

PARKING AREA PAVEMENT MARKINGS
DISABLED PARKING DETAILS

7.23A

SINGLE PARKING STALL

DOUBLE PARKING STALL

Text Ref.: 7-4.06.06

May 15, 2008
PARKING AREA PAVEMENT MARKINGS
DISABLED PARKING DETAILS

FIGURE 7.23A
**Figure P**

**Parking Area Pavement Markings**

### Disabled Parking Details

- **4 in. Solid Line White**
- **International Symbol of Accessibility (optional)** (see Detail A)
- **4 in. Solid Line White Border**
- **4 in. Solid Line White Diagonals**
- **3 ft. Center-to-Center**
- **12 in. Solid White Lettering (optional)**

**Diagonal Double Parking Stalls**

**Detail A**

- **International Symbol of Accessibility Marking**

<table>
<thead>
<tr>
<th>Total number of parking spaces or stalls</th>
<th>Minimum number of disabled accessible parking spaces or stalls</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 - 25</td>
<td>1</td>
</tr>
<tr>
<td>26 - 50</td>
<td>2</td>
</tr>
<tr>
<td>51 - 75</td>
<td>3</td>
</tr>
<tr>
<td>76 - 100</td>
<td>4</td>
</tr>
<tr>
<td>101 - 150</td>
<td>5</td>
</tr>
<tr>
<td>151 - 200</td>
<td>6</td>
</tr>
<tr>
<td>201 - 300</td>
<td>7</td>
</tr>
<tr>
<td>301 - 400</td>
<td>8</td>
</tr>
<tr>
<td>401 - 500</td>
<td>9</td>
</tr>
<tr>
<td>501 - 1000</td>
<td>2 percent of total</td>
</tr>
<tr>
<td>Greater than 1000</td>
<td>20 plus 1 for each 100 or fraction thereof over 1000</td>
</tr>
</tbody>
</table>

Text Ref.: 7-4.06.06

May 15, 2008

PARKING AREA PAVEMENT MARKINGS
DISABLED PARKING DETAILS

FIGURE 7.23B
NOTES: When the parking area is located on a curve, the dimensions for the parking spaces should be adjusted (fanned) to compensate for curvature. The location of the pedestrian curb ramp for the disabled will depend on the site development and landing location.

### Parking Space data (based on 18 ft. minimum stall length)

<table>
<thead>
<tr>
<th>Angle</th>
<th>All stalls</th>
<th>10 ft wide stalls</th>
<th>12 ft wide stalls</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>B</td>
<td>C</td>
</tr>
<tr>
<td>45°</td>
<td>22.00</td>
<td>22.00</td>
<td>31.11</td>
</tr>
<tr>
<td></td>
<td>20.00</td>
<td>20.00</td>
<td>28.28</td>
</tr>
<tr>
<td>50°</td>
<td>22.00</td>
<td>18.46</td>
<td>28.72</td>
</tr>
<tr>
<td></td>
<td>21.00</td>
<td>17.62</td>
<td>28.41</td>
</tr>
<tr>
<td>55°</td>
<td>22.00</td>
<td>15.40</td>
<td>26.86</td>
</tr>
<tr>
<td></td>
<td>21.00</td>
<td>14.70</td>
<td>25.64</td>
</tr>
<tr>
<td>60°</td>
<td>22.00</td>
<td>12.70</td>
<td>25.40</td>
</tr>
<tr>
<td></td>
<td>21.00</td>
<td>12.12</td>
<td>24.25</td>
</tr>
</tbody>
</table>

Text Ref.: 7-4.06.06
NOTES: When the parking area is located on a curve, the dimensions for the parking spaces should be adjusted (fanned) to compensate for curvature.
An island up to 14 ft. wide may be included between every ten stalls in the parking area.
The location of the pedestrian curb ramp for the disabled will depend on the site development and landing location.
The need for 150 ft. parking stalls should be studied on a case by case basis and additional parking provided for as may be required.

Parking Space data (based on 14 ft. x 75 ft. minimum stall length)
(All dimensions are in feet or fractions of feet)

<table>
<thead>
<tr>
<th>Δ</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>δ - δ</th>
</tr>
</thead>
<tbody>
<tr>
<td>30°</td>
<td>50.00</td>
<td>86.60</td>
<td>100.00</td>
<td>28.00</td>
<td>24.25</td>
<td>75.75</td>
<td>14.00</td>
<td>15.00</td>
<td>79.00</td>
</tr>
<tr>
<td>35°</td>
<td>55.00</td>
<td>78.55</td>
<td>95.89</td>
<td>24.41</td>
<td>20.00</td>
<td>75.90</td>
<td>19.00</td>
<td>18.00</td>
<td>92.00</td>
</tr>
<tr>
<td>40°</td>
<td>59.00</td>
<td>70.31</td>
<td>91.79</td>
<td>21.78</td>
<td>16.69</td>
<td>75.10</td>
<td>26.00</td>
<td>21.00</td>
<td>106.00</td>
</tr>
<tr>
<td>45°</td>
<td>63.00</td>
<td>63.00</td>
<td>89.10</td>
<td>19.80</td>
<td>14.00</td>
<td>75.10</td>
<td>32.00</td>
<td>25.00</td>
<td>120.00</td>
</tr>
<tr>
<td>50°</td>
<td>67.00</td>
<td>56.22</td>
<td>87.46</td>
<td>18.28</td>
<td>11.75</td>
<td>75.72</td>
<td>40.00</td>
<td>28.00</td>
<td>135.00</td>
</tr>
<tr>
<td>55°</td>
<td>70.00</td>
<td>49.01</td>
<td>85.45</td>
<td>17.09</td>
<td>9.80</td>
<td>75.65</td>
<td>46.00</td>
<td>31.00</td>
<td>147.00</td>
</tr>
<tr>
<td>60°</td>
<td>72.00</td>
<td>41.57</td>
<td>83.14</td>
<td>16.17</td>
<td>8.08</td>
<td>75.06</td>
<td>54.00</td>
<td>34.00</td>
<td>160.00</td>
</tr>
</tbody>
</table>

Text Ref.: 7-4.06.06
Airplane Pavement Markings

Zone 1:
- 2-Lane Roadway with Gravel Shoulders
  - Center Airplane Pavement Markings on centerline

Zone 2:
- 2-Lane Roadway with Paved Shoulders

Zone 3:
- 4-Lane Undivided Roadway with Gravel Shoulders

Zone 4:
- 4-Lane Undivided Roadway with Paved Shoulders

Zone 5:
- 4 or more lane Divided Roadway with Gravel Shoulders

Zone 6:
- 4 or more lane Divided Roadway with Paved Shoulders
FIGURE 7.25

HIGH OCCUPANCY VEHICLE (HOV) PAVEMENT MARKINGS

1. Metered Ramp
2. White HOV Pavement Marker
3. R3-X3

- 30 in.
- 12 ft.
- 6 in.

2 PERSON CAR POOLS, BUSES & MOTORCYCLES ONLY
Use clearance marker to mark hazards adjacent to the roadway.

Use clearance marker to mark hazards within the roadway. See Figures 7.33 through 7.35 for typical application in gore areas of interchanges.

Use end of roadway marker to mark the end of the roadway.

Use snowplow marker to mark guardrail for snowplowing operations.
GUARDRAIL

Structural plate beam type guardrail:
Where inplace, mount delineators on steel or plastic post sections fastened to wood posts 4 ft. above the edge of pavement.

3 cable type guardrail:
1. Where inplace on tangent approaches, mount delineators same as above at spacing indicated.
2. Where approach is on a curve, mount same as above but at reduced spacing based on MN MUTCD, Table 3D-1.

NOTE: Treatment is based on ideal conditions with a tangent approach, good sight distance, etc.
GUARDRAIL
Structural plate beam type guardrail:
where in place, mount delineators on steel or plastic post sections fastened to wood posts 4 ft. above the edge of pavement.

3 cable type guardrail:
1. Where in place on tangent approaches, mount delineators same as above at spacing indicated.
2. Where approach is on a curve, mount same as above but at reduced spacing based on MN MUTCD, Table 3D-1.

4 in. x 8 in. Yellow Alignment Delineator
● Single White Alignment Delineator

NOTE: Treatment is based on ideal conditions with a tangent approach, good sight distance, etc.

Text Ref.: 7-5.03.02

May 15, 2008

FIGURE

7.28

ONE LANE BRIDGE SIGNING, MARKING & DELINEATION
Back-to-Back Type 2 Object Markers (Yellow)

Flexible Post or 2 lb./ft. Steel Post

End of Culvert

Shoulder P.I.

Shoulder

Roadway

Shoulder

42 in. - 20 ft.

4 ft

0 - 8 ft.

Text Ref.: 7-5.03.03
TYPES OF DELINEATORS

ONE-TENTH MILE X4-8
4 in. x 4 in.

GUIDE X4-6
8 in. x 24 in.

CYLINDER STYLE X4-13
6 in. x 9.5 in. or 8 in. x 9.5 in.

TYPICAL DELINEATOR PLACEMENT

HAZARD MARKER AT EXIT GORE

Text Ref.: 7-5.03.05, 7.06.01, and 7-6.02.02
OPTIONAL LAYOUT

Text Ref.: 7-5.03.05, 7.06.01, and 7-6.02.02
Delineation of Median
under 30 ft. width between
dege of roadway

Cylinder Style Delineator
mounted independently
or to Yield sign post
(if present)

Cylinder Style Delineator

Cylinder Style Delineator mounted on Yield sign post

Delineation of Median
over 30 ft. width between
dege of roadway

Cylinder Style Delineator

Cylinder Style Delineator

NOTE: Corners to be handled
as shown in Figure 7.31.

Text Ref.: 7-6.02.03
The District Traffic Engineer will determine if guide delineators are required on the outside of any subsequent curves.

Plan A

* = Location of Guide Delineators

NOTE: Where there is guardrail, the guide delineators are mounted either above or immediately behind the guardrail.

NOTE: For cross sections of guide delineator placement A-A and B-B, see Figure 7.30.

* Optional if no hazard exists

Minimum of 3 white guide delineators
Spacing: 100 ft.

Opposite first yellow guide delineator

Minimum of 4 yellow guide delineators
Spacing: 90 ft.

Begin at EXIT sign or closer (100 ft. maximum)

X4-2 Hazard Marker at nose

Hazard Marker at nose

Minimum of 4

Plan A

NOTE: Where there is guardrail, the guide delineators are mounted either above or immediately behind the guardrail.

Text Ref.: 7-6.02.04
The District Traffic Engineer will determine if guide delineators are required on the outside of any subsequent curves. If installed, use white Guide Marker (X4-5). Begin at the point of taper and carry past the gore nose. Spacing: 100 ft. on center. Lateral placement: see Figure 7.30, Section A-A.

Plan A

* = Location of Delineators

The District Traffic Engineer will determine if guide delineators are required on the outside of any subsequent curves.
At unlit interchanges, the District Traffic Engineer will determine if guide delineators are required on a Deceleration Lane or Taper at ramp exits. If installed, use white Guide Delineator (X4-5). Begin at the point of taper and carry past the gore nose.

Spacing: 100 ft. on center.

Lateral placement: see Figure 7.30, Section A-A

**NOTE:** Where there is guardrail, the guide delineators are mounted either above or immediately behind the guardrail.
Standard Crosswalk (optional)

Splitter Island

Island Nose Painted Yellow

4 in. Solid Line Yellow

24 in. Solid Line Yellow 45-degrees at 20 ft. spacing

Bike Lanes (optional)

4 in. Solid Line White (Bicycle Marking)

Pavement Message (Bike Symbol) (optional)

500 ft. Solid Line Yellow (see Chart 7-4)

Text Ref.: 7-4.06.10

10 ft. Shared-use Pedestrian and Bicycle Path
### Minimum Passing Sight Distance

<table>
<thead>
<tr>
<th>Speed Limit (or 85th Percentile)</th>
<th>Minimum Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>MPH</td>
<td>Feet</td>
</tr>
<tr>
<td>0 - 30</td>
<td>300</td>
</tr>
<tr>
<td>40 - 50</td>
<td>400</td>
</tr>
<tr>
<td>55 or greater</td>
<td>500</td>
</tr>
</tbody>
</table>

Text Ref.: 7-4.04.01

### Minimum Length of a No Passing Zone in Advance of a Stop Condition

<table>
<thead>
<tr>
<th>Speed Limit (or 85th Percentile)</th>
<th>Minimum Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>MPH</td>
<td>Feet</td>
</tr>
<tr>
<td>0-3</td>
<td>300</td>
</tr>
<tr>
<td>4-5</td>
<td>400</td>
</tr>
<tr>
<td>55 or greater</td>
<td>500</td>
</tr>
</tbody>
</table>

### Minimum Passing Sight Distance

<table>
<thead>
<tr>
<th>85th Percentile Speed MPH</th>
<th>Minimum Sight Distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>30 or less</td>
<td>500</td>
</tr>
<tr>
<td>31-40</td>
<td>600</td>
</tr>
<tr>
<td>41-50</td>
<td>800</td>
</tr>
<tr>
<td>51-60</td>
<td>1,000</td>
</tr>
<tr>
<td>61 or greater</td>
<td>1,100</td>
</tr>
</tbody>
</table>

Text Ref.: 7-4.04.01

### Minimum Distance or Gap Between No Passing Zones

<table>
<thead>
<tr>
<th>85th Percentile Speed MPH</th>
<th>Distance Between Zones</th>
</tr>
</thead>
<tbody>
<tr>
<td>20-39</td>
<td>500</td>
</tr>
<tr>
<td>40-54</td>
<td>650</td>
</tr>
<tr>
<td>55 and above</td>
<td>800</td>
</tr>
</tbody>
</table>

If the distance between zones is less than specified, the zones should be connected.

Text Ref.: 7-4.04.01
<table>
<thead>
<tr>
<th>OBJECT MARKER</th>
<th>SIZE</th>
<th>COLOR</th>
<th>INFORMATION SEE MN MUTCD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hazard Marker Type 1 (X4-2)</td>
<td>12&quot; x 12&quot;</td>
<td>All Yellow</td>
<td>Section 3C-3</td>
</tr>
<tr>
<td>Culvert Marker Type 2 (X4-3)</td>
<td>18&quot; x 18&quot;</td>
<td>Yellow on Black</td>
<td>Section 3C-3</td>
</tr>
<tr>
<td>Clearance Marker Type 3 (X4-4)</td>
<td>12&quot; x 36&quot;</td>
<td>Yellow on White</td>
<td>Section 3C-3</td>
</tr>
<tr>
<td>End of Roadway Marker (X4-1)</td>
<td>18&quot; x 18&quot;</td>
<td>All Yellow</td>
<td>Section 3C-4</td>
</tr>
</tbody>
</table>

**Wide Angle VIP Retroreflective Sheeting (TYPE IX)**

<table>
<thead>
<tr>
<th>NAME</th>
<th>SIZE</th>
<th>COLOR</th>
<th>INFORMATION SEE MN MUTCD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Snowplow Marker (X4-5)</td>
<td>6&quot; x 12&quot;</td>
<td>Black on Yellow</td>
<td>None</td>
</tr>
</tbody>
</table>

**Encapsulated Retroreflective Sheeting - (Type III)**

Text Ref.: 7-5.02.01
**Wide Angle VIP Retroreflective Sheeting (TYPE IX)**

<table>
<thead>
<tr>
<th>NAME</th>
<th>SIZE</th>
<th>COLOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>One Tenth Mile Delineator (X4-8)</td>
<td>4” x 4”</td>
<td>White</td>
</tr>
<tr>
<td>Guide Delineator (X4-6)</td>
<td>8” x 24”</td>
<td>Black on White or Yellow</td>
</tr>
<tr>
<td>Chevron Alignment Sign (W1-8)</td>
<td>18” x 24”</td>
<td>Black on Yellow</td>
</tr>
<tr>
<td>Alignment Delineator (X4-7)</td>
<td>4” x 8”</td>
<td>White or Yellow</td>
</tr>
</tbody>
</table>

**Type VII MD Retroreflective Sheeting**

<table>
<thead>
<tr>
<th>NAME</th>
<th>SIZE</th>
<th>COLOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cylinder Style Delineator (X4-13)</td>
<td>6” or 8” Diameter</td>
<td>White or Yellow</td>
</tr>
<tr>
<td></td>
<td>9.5” Height</td>
<td></td>
</tr>
</tbody>
</table>

Text Ref.: 7-5.04
Take 200 foot tape, chain, or rope and stretch it between two points on a curve. At the center (100 foot mark), measure the distance in feet and inches between the chord and the arc.

**DEGREE OF CURVE RELATED TO "M" FOR A 200 FOOT CHORD**

<table>
<thead>
<tr>
<th>Degree of Curve</th>
<th>Distance &quot;M&quot; feet</th>
<th>Distance &quot;M&quot; inches</th>
<th>Radius feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>0'30&quot;</td>
<td>0.44</td>
<td>5-1/2</td>
<td></td>
</tr>
<tr>
<td>1'00&quot;</td>
<td>0.87</td>
<td>10-1/2</td>
<td></td>
</tr>
<tr>
<td>1'30&quot;</td>
<td>1.31</td>
<td>15-3/4</td>
<td>5,730</td>
</tr>
<tr>
<td>2'00&quot;</td>
<td>1.75</td>
<td>21</td>
<td></td>
</tr>
<tr>
<td>2'30&quot;</td>
<td>2.18</td>
<td>26</td>
<td></td>
</tr>
<tr>
<td>3'00&quot;</td>
<td>2.62</td>
<td>31-1/2</td>
<td></td>
</tr>
<tr>
<td>3'30&quot;</td>
<td>3.06</td>
<td>36-3/4</td>
<td></td>
</tr>
<tr>
<td>4'00&quot;</td>
<td>3.96</td>
<td>42</td>
<td></td>
</tr>
<tr>
<td>4'30&quot;</td>
<td>3.49</td>
<td>47-1/2</td>
<td></td>
</tr>
<tr>
<td>5'00&quot;</td>
<td>3.93</td>
<td>52-1/2</td>
<td></td>
</tr>
<tr>
<td>5'30&quot;</td>
<td>4.37</td>
<td>57-3/4</td>
<td></td>
</tr>
<tr>
<td>6'00&quot;</td>
<td>4.81</td>
<td>63</td>
<td></td>
</tr>
<tr>
<td>6'30&quot;</td>
<td>5.25</td>
<td>68-3/8</td>
<td>955</td>
</tr>
<tr>
<td>7'00&quot;</td>
<td>5.69</td>
<td>73-5/8</td>
<td>881</td>
</tr>
<tr>
<td>7'30&quot;</td>
<td>6.13</td>
<td>78-7/8</td>
<td>819</td>
</tr>
<tr>
<td>8'00&quot;</td>
<td>6.57</td>
<td>84-1/4</td>
<td>764</td>
</tr>
<tr>
<td>8'30&quot;</td>
<td>7.02</td>
<td>89-1/2</td>
<td>716</td>
</tr>
<tr>
<td>9'00&quot;</td>
<td>7.46</td>
<td>94-3/4</td>
<td>674</td>
</tr>
<tr>
<td>9'30&quot;</td>
<td>7.90</td>
<td>100-1/4</td>
<td>637</td>
</tr>
<tr>
<td>10'00&quot;</td>
<td>8.35</td>
<td>105-1/5</td>
<td>603</td>
</tr>
</tbody>
</table>

Text Ref.: 7-6.02.02
Chapter 8
WORK ZONE TRAFFIC CONTROLS

TABLE OF CONTENTS

8-1.00 INTRODUCTION ............................................................ 8-3
1.01 Purpose ........................................................................ 8-3
1.02 Scope .......................................................................... 8-3
1.03 Relation to Other Mn/DOT Standards and Guidelines  8-3
1.04 Chapter Organization .................................................... 8-3

8-2.00 GLOSSARY ................................................................. 8-4

8-3.00 RESPONSIBILITY ......................................................... 8-4
3.01 General Responsibility .................................................. 8-4
3.02 Legal Responsibility ...................................................... 8-4

8-4.00 PLANNING FOR TRAFFIC CONTROLS ....................... 8-5
4.01 Temporary Traffic Control Goals .................................. 8-5
4.02 Traffic Management and Temporary Traffic Control Plan 8-5

8-5.00 TEMPORARY TRAFFIC CONTROL DEVICES ............. 8-8
5.01 General Requirements .................................................. 8-8
5.02 Signing ....................................................................... 8-8
5.03 Pavement Markings in Temporary Traffic Control Zones 8-8
5.04 Channelizing Devices .................................................... 8-8
5.05 Ballast ....................................................................... 8-8
5.06 Portable Precast Concrete Barrier (PPCB) Delineators  8-8
5.07 Surface Mounted (centerline) Delineators ...................... 8-8
5.08 Portable Changeable Message Signs (PCMS) ................. 8-8
5.09 Flashing Arrow Panels .................................................. 8-8
5.10 Crash Cushions and Attenuators .................................. 8-8
5.11 Flagging ..................................................................... 8-8
5.12 Longitudinal Joints and Edge Drop-Offs ......................... 8-8

8-6.00 TEMPORARY TRAFFIC CONTROL PLANS .................. 8-18
6.01 Placement of Temporary Traffic Control Devices .......... 8-18
6.02 Traffic Control Devices Tabulation ................................. 8-18
6.03 Typical Traffic Control Pay Items ................................. 8-18

8-7.00 ESTABLISHING AND MAINTAINING DETOURS .......... 8-19
7.01 Conditions Requiring or Permitting a Detour .................. 8-19
7.02 Selection of a Route ..................................................... 8-19
7.03 Maintenance of a Detour .............................................. 8-19
7.04 Maintenance Agreement .............................................. 8-19
7.05 Emergency Detour ...................................................... 8-19
7.06 Special Maintenance Work on Detours ......................... 8-19
7.07 Discontinuance of a Detour .......................................... 8-19

8-1
8-8.00 INSTALLATION AND INSPECTION OF TEMPORARY TRAFFIC CONTROL DEVICES ............... 8-20
8.01 Installation
8.02 Responsibility
8.03 Inspection Program

8-9.00 REFERENCES ......................................................... 8-21

8-10.00 APPENDICES ...................................................... 8.1-1
8.10.01 Traffic Management Plan Checklist
8.10.02 Detours

List of Figures

8.1 Type A, B, and C Channelizers ........................................ 8a-1
8.2A Temporary Construction Sign Panel Overlay Covering
   a Complete Extruded Sign Panel ................................ 8a-2
8.2B Temporary Construction Sign Panel Overlay Covering
   a Portion of an Extruded Sign Panel ............................. 8a-3
8.2C Temporary Construction Sign Panel Overlay Covering
   Type C or D Sign Panels ............................................. 8a-4

List of Forms

8.A Establishment of Detour Form ...................................... 8.2-5
8.B Release of Detour Form ............................................. 8.2-6
CHAPTER 8 - WORK ZONE TRAFFIC CONTROLS

8-1.00 INTRODUCTION

8-1.01 Purpose

This chapter is intended to show applications of basic principles of work zone traffic control and assist in developing traffic control plans.

8-1.02 Scope

This chapter has been written to supplement, not to replace, the MN MUTCD. This chapter includes guidelines varying from planning traffic control to fit the needs of a particular activity to the reasons for keeping accurate records. These guidelines should be useful to any qualified individual involved with planning, designing, installing, maintaining, and inspecting traffic control in work zones. Individuals are qualified by means of adequate training in traffic control practices, having a basic understanding of the principles of traffic control in work zones, or having experience in applying traffic control in work zones.

Other road authorities are encouraged to evaluate the MN MUTCD and establish guidelines to meet their needs.

8-1.03 Relation to other Mn/DOT Standards and Guidelines

As stated, this chapter is to supplement, not to replace, Part 6 Temporary Traffic Controls of of the latest edition of the MN MUTCD. The MN MUTCD includes the Field Manual for Temporary Traffic Control Zone layouts and the Standard Signs Manual.

The guidelines contained in this chapter and in traffic control plans should conform to, or be of higher standards than, the MN MUTCD and other Mn/DOT technical standards and guidelines. Adequate protection of the workers, traveling public, and pedestrians is the primary goal of any traffic control. These measures must be consistent with the MN MUTCD and other Mn/DOT technical standards and guidelines.

8-1.04 Chapter Organization

This chapter is divided into nine major sections:

1. 8-1.00 Introduction
2. 8-2.00 Glossary
3. 8-3.00 Responsibility
4. 8-4.00 Application of Traffic Controls
5. 8-5.00 Temporary Traffic Control Devices
6. 8-6.00 Temporary Traffic Control Plans
7. 8-7.00 Detours
8. 8-8.00 Installation, Maintenance, and Inspection of Temporary Traffic Control Devices
9. 8-9.00 Reference
10. 8-10.00 Appendix, Figures, and Forms

Each section contains information important to providing proper work zone traffic controls for Mn/DOT operations.

The footnote on appropriate pages contains hyperlinks to the primary documents referred to within this chapter. These links are generally mentioned in the text along with the document's description. Additional hyperlinks are included within the chapter for other documents as needed.
8-2.00 GLOSSARY

Refer to the MN MUTCD for definitions of common Work Zone Traffic Control terminology. Definition of terms found within this manual that are not included within the MN MUTCD are listed below.

Barricade Mounted Signs - traffic control signs that are mounted on TYPE III barricades.

Ground Mounted Signs - traffic control signs that are mounted on permanent supports.

Portable Support Mounted Signs - traffic control signs that are mounted on portable sign supports.

Sign Overlay - typically a route marker or other symbol placed directly on a sign face. If not otherwise specified, it will be of the same color as the legend on the sign face.

Supplemental Sign Plaque - a sign mounted above or below a primary sign and providing additional information concerning this primary sign.

Supplemental Sign Plate - legend made demountable by mounting it to a plate which is then bolted to the sign face.

Traffic Management Plan (TMP) - a plan of action which, when put into effect, details the procedures that Mn/DOT utilizes to assure that adequate provisions are made for the safety of motorists, pedestrians, and workers.

8-3.00 RESPONSIBILITY

8-3.01 General Responsibility

It is essential that various sections of the district be involved in providing proper work zone traffic controls. Exact details on the involvement of these sections is contained in Section 8-4.00 Application of Traffic Controls.

8-3.02 Legal Responsibility

Minnesota Statutes 169.06 and 169.07 provide that: (1) traffic signs shall be placed only by the authority of a public body or official having jurisdiction, for the purpose of regulating, warning, or guiding traffic; and that (2) no traffic sign or its support shall bear any message that is not essential to traffic control. Any unauthorized sign placed on the highway right-of-way by a private organization or individual without authority constitutes a public nuisance, and all such unofficial and nonessential signs should be removed.

Minnesota Statutes 169.06 (Subdivisions 1-4) and 169.07 establishes the legal authority for Mn/DOT and local units of government to: (1) place and maintain markings, (2) require obedience to official markings, (3) prohibit the display of unauthorized markings, and (4) prohibit interference with official markings. Markings shall be placed only by the authority of the public body having jurisdiction over the highway, road, or street for the purpose of regulating, warning, or guiding traffic. Pavement and curb markings, object markers, and delineators are all normally within highway, road, or street rights-of-way and, therefore, should never be installed except under public authority.

Construction contractors and public utility companies are permitted to erect temporary construction and maintenance signs and place temporary pavement markings at work sites to protect the public, equipment and workers, provided that such signs and markings conform to the standards of the MN MUTCD and the proper authority has been given by Mn/DOT.

Minnesota Statutes 169.14 (Subdivision 5d) allows the establishment of a work zone speed limit. Refer to the "Work Zone Speed Limits Guidelines". The document can be found online at: http://www.dot.state.mn.us/speed/pdf/WZSpeedLimitGuideline.pdf
8-4.00 PLANNING FOR TEMPORARY TRAFFIC CONTROLS

8-4.01 Temporary Traffic Control Goals

During planning for work zones, one should strive for the greatest payoff in terms of safety and convenience at a cost commensurate with the hazards and problems involved. A properly installed temporary traffic control zone will allow traffic to pass through or around a work zone safely. It requires time and effort for planning, installation, and maintenance.

All work zone traffic control planning centers around an analysis of the work activity and relating it to the provision of adequate safety and capacity. What is the likelihood of motorists failing to negotiate the work zone safely? What are the consequences of such action on pedestrians, workers, or other motorists?

Planning for traffic control through a work zone may be more involved than for maintenance or utility zones because of the differences in traffic disruption and duration of the work. The exposure of traffic to potential hazards is a function of the traffic volume and the length of time that the closure will be in effect. The goals common to all traffic control zones are:

1. to minimize crashes and crash severity; and
2. to minimize inconvenience and conflicts as a result of the work.

It should be recognized that these goals may at times be in conflict with one another.

8-4.02 Traffic Management and Temporary Traffic Control Plan

The Traffic Management Plan (TMP) is a plan of action which, when put into effect, details the procedures that Mn/DOT utilizes to assure that adequate provisions are made for the safety of motorists, pedestrians and workers.

Purpose of the TMP

The purpose of the TMP is to emphasize the need for thorough planning, to provide a detailed set of guidelines and a checklist for the district to consider when developing a traffic control plan for each construction/maintenance project performed in their district. For all construction projects attention must be given to traffic control from the early stages of development of the project, through the completion of the actual construction, including the preliminary layout studies, detailed design, and the drafting of the special provisions. It is considered essential that various sections of the district be involved in order to provide their specialty input so that a traffic control plan can be developed. Careful consideration of the TMP should result in minimizing confusion and delays to motorists and pedestrians as well as reduce crashes, provide greater safety to the various parties involved in the project, and improve the image of Mn/DOT and the construction industry.

Scope of the TMP

These procedures should be implemented on all federal and non-federal aid construction and contract maintenance projects. They should also be implemented on maintenance and utility operations to the extent practical and feasible. Generally, for maintenance and utility operations, the provisions of the MN MUTCD, Field Manual will be sufficient; however, there may be times when the principles and philosophy described below will be appropriate to include during the development of these projects. The standard specifications, sample special provisions and checklist should be used as tools in developing a traffic control plan and assessing its effectiveness during construction.

The checklist will help you think through the traffic requirements. Depending on the complexity of the individual project, certain items on the list may not be applicable. It is recommended that the work sheets be a permanent part of the project file. It will be very helpful to be able to produce the checklist together with documentation explaining why certain traffic controls were needed and used, while others were considered, but not used.
Temporary Traffic Control Plan

The Temporary Traffic Control (TTC) Plan is a plan for handling traffic through a specific highway or street, work zone or project. A TTC Plan may range in scope from a very detailed TTC Plan designed solely for a specific project, to a reference to standard specifications, a section of the MN MUTCD, or a standard highway agency manual. The degree of detail in the TTC Plan will depend on the project complexity and traffic interference with construction activity.

On most projects, the procedures for developing time and traffic provisions will produce a satisfactory TTC Plan. See Section 8-6.00 for more information on TTC Plans.

Responsibility

Mn/DOT needs a total commitment by all persons involved to insure that adequate consideration is given to proper traffic control for all operations. In order to assure that this commitment is met, it will require early involvement by all parties involved, such as pre design, design, traffic, maintenance, and construction. Typical guidelines have been developed for the various stages.

Preliminary Design

During the preliminary plan development, the Project Manager should review the scope of the project with the District Traffic Engineer, Assistant District Engineer Construction, and the District Detail Design Engineer to determine traffic control concepts for the proposed construction. Construction staging should be determined by the traffic carrying capacities of the roadway under construction, bypasses or detours. Consideration should be given for other construction work in the proposed highway corridor or general vicinity by other than Mn/DOT forces such as cities and counties. Refer to checklist for items to consider. The FHWA also requires that traffic control considerations and effects be mentioned in the Environmental Impact Statement (EIS).

Detail Design

The District Detail Design Engineer should involve the District Traffic Engineer, the Assistant District Engineer Construction, the assigned Resident/Project Engineer, and appropriate FHWA personnel as the final detail plans are being developed so the necessary details for traffic control are worked into the construction plan and proposal. This may range in scope from a very detailed plan (or proposal) designed solely for a specific project, to a reference to a standard specification, a section of the MN MUTCD, or a standard agency manual. This TTC Plan shall be incorporated into the plans, specifications, and estimate (P.S. & E). If the complexity of a project warrants, a traffic control layout may be prepared by the District Traffic Engineer and be included in the P.S. & E.

On some projects it may be appropriate to provide broad TTC Plan parameters in the P.S. & E., and then permit the successful bidder to develop a detailed TTC Plan and use it if Mn/DOT and FHWA find it acceptable.

The District Detail Design Engineer should involve the District Traffic Engineer, the Resident/Construction Engineer and the District Work Zone Safety Coordinator personnel to develop detailed time and traffic provisions.

The pay items to be included in the plans must be determined by the districts during design. Individual projects may have varying pay items depending on size, complexity and location. Districts are encouraged to use appropriate pay items to the fullest practical extent.

Construction

During the construction stage, the resident/project engineer will generally be the Mn/DOT person responsible for traffic control. The resident/project engineer may delegate this authority. This should be done at or before the pre-construction conference.
The responsible person should have the following duties:

1. Develop a familiarity with the MN MUTCD, the contract plans and special provisions, the current Minnesota Standard Specifications for Highway Construction and its supplements.

2. Coordinate Mn/DOT personnel assigned to the project relative to proper techniques of traffic safety and traffic operations prior to beginning construction and specifically how they relate to the TTC Plan. The District Traffic Engineer and others shall be available to assist in this task.

3. Ensure that all affected agencies such as State Patrol, local Police, fire departments, sheriff's office, hospital, ambulance services, local government, post office, school districts, etc., are informed of the scope of the project and how it may affect their individual needs and services. This public relations work is extremely critical in the case of a total detouring of traffic. The District Public Affairs Coordinator and/or the Office of Communications may be of help in this responsibility.

4. Notify the major local news media (TV, radio stations, newspapers, etc.), local tourism associations, AAA, local legislators, etc. of the scope of the project prior to beginning operations. Cooperation with the Contractor and any involved local government agencies is advised. All items of interest should be included.

These include:

   a. Type of work to be performed.
   b. Hours the highway will be fully opened to traffic.
   c. Hours of restricted usage.
   d. Type and place delays can be expected.
   e. Suggested alternate routes.
   f. Duration of the project.
   g. Location of the detour, if applicable.
   h. Anticipated completion date of project.
   i. A name and phone number the public can contact for information or to make comments about the project.

At appropriate times during the life of the project the responsible person should update the information mentioned above so that the public is kept current on the status of the project. The Public Affairs Coordinator may be of help in this responsibility.

1. Ensure that the Road Information Unit is notified at the start of construction, listing details on how traffic details on how traffic is affected. This is needed for the Weekly Road Condition Bulletin.

2. Monitor the Contractor's operations with regard to traffic and safety operations and enforce the requirements of the contract. On some projects, it may be necessary to change the TTC Plan during construction, depending on the contractor's schedule, progress of utility work, etc.

3. Review traffic operations through the project limits, including the condition of all traffic control devices on a regular basis.

During the construction stage the District Work Zone Safety Coordinator should make periodic reviews of projects to determine the adequacy of the TTC Plan and compliance with the TTC Plan by the Contractor. The frequency of these reviews should vary with the complexity of the projects.

1. Ensure that current documentation is maintained as to when deficiencies were noted in the implementation of the traffic control plan and how and when they were corrected.

2. Document any traffic crashes within the construction work zones and submit this information to the District Work Zone Safety Coordinator. This is in addition to the regular crash reporting done by citizens and law enforcement personnel.
The District Work Zone Safety Coordinator should compile a record of all known crashes within a work zone. This record should include all available information, such as: time of day, probable cause, location, pictures, sketches, weather conditions, interferences to traffic, etc. The District Work Zone Safety Coordinator should study this data to determine what, if any, changes should be made in the TTC Plan.

8-5.00 Temporary Traffic Control Devices

8-5.01 General Requirements

All traffic control devices used on Mn/DOT street and highway construction or maintenance work shall conform to the specifications of the latest edition of the MN MUTCD, the Mn/DOT Standard Specifications for Construction; and all other appropriate Mn/DOT technical manuals.

All devices shall be placed where they will convey their messages most effectively so the driver will have adequate time to react. All traffic control devices must be kept clean to insure proper effectiveness and retroreflectivity. All devices shall conform to the quality standards of the MN MUTCD Field Manual.

8-5.02 Signing

8-5.02.01 Guide Signs

The placement and revision of guide signs is important to providing traffic control through work zones. However, placement of these signs should not interfere with necessary regulatory and warning signs. One commonly used guide sign is the advance notice guide sign. It is used to provide notice of when and where construction or maintenance will occur. There are two types of advance notice guide signs:

1. those signs that inform motorists of a date when construction and/or closures will begin, and
2. those signs that inform motorists of exact location(s) of construction that is underway.

Beside addition of special guide signs to highway work zones it is important that in-place guide signs be covered or modified to reflect actual conditions. For example if a ramp is closed, all advance guide signs should be properly modified to inform the motorist of the closure. For short term closures this signing is impractical and warning signs may be used to provide this information.

8-5.02.02 Regulatory and Warning Signs

Refer to the MN MUTCD Parts 2 and 6 for standards on regulatory and warning signs in work zones.

8-5.02.03 Business Signing in Work Zones

Mn/DOT construction projects have frequently caused disruption of traffic patterns in business areas and have sometimes caused difficulty and confusion for motorists attempting to reach specific businesses or groups of businesses. This has resulted in the development of business signs for use in construction areas.

These signs are used to improve driver guidance, create safer operations, and minimize the impact on businesses created by construction activities and detours.
The following guidelines apply to business signing in construction areas.

**General Business Signing Guidelines:**

1. The district should contact the affected traffic oriented businesses during the project development process for a construction project to explain the project, the detours (if required), the project schedule, and to obtain for lessening the project's impact on a business.

2. Businesses should be encouraged to use special advertisements via the media and directional information to inform customers.

3. Businesses that receive signing must be "vehicular traffic sensitive" and significantly affected by the construction project.

4. All business signs should conform to the MN MUTCD to the extent practical and possible.

5. Business signs which would interfere with permanent or construction signing shall not be allowed.

6. All business sign panels shall be 72” x 18” in size with black legend on orange reflectorized background. See Standard Sign G20-X4.

7. Up to four business sign panels may be installed on a structure.

8. All business sign panels shall be installed on a separate structure within the highway right-of-way by Mn/DOT or contract forces.

9. Business signs shall be removed when the impact to traffic ends, or at such time that permanent changes in the affected area are completed.

10. All business signing that is proposed by Mn/DOT to guide traffic shall be funded by Mn/DOT. Any additional business signing proposed by the businesses and allowed by Mn/DOT shall be funded by the businesses.

**Specific Business Signing Guidelines:**

When there is a detour required, whether the roadway is open to local traffic only or completely closed, the following guidelines apply:

1. When the construction zone is open to a local street, a sign may be installed indicating that the road is open to that street.

2. In areas where there are four or fewer traffic oriented businesses, sign panels for each specific business may be installed.

3. In areas where there are more than four traffic oriented businesses along the closed section, one of the following options may be used:
   a. When the businesses are scattered, a sign with the message "LOCAL BUSINESSES" may be installed.
   b. When the businesses are grouped in an area, a sign with the message "BUSINESS DISTRICT" may be installed.

4. Major attractions such as shopping centers, cities, and geographic areas may be approved for signing.

5. Trailblazing signs may be required.

When there is no detour required or the roadway is being reconstructed under traffic and motorists are having difficulty locating the access to the businesses, "BUSINESS ACCESS" signs may be used. In areas where there are four or fewer traffic oriented businesses, sign panels for each specific business may be installed.
8-5.02.04 Supplemental Sign Plates

Separate demountable plates were introduced to allow greater flexibility in some cases of work zone signing. However, demountable legend plates should meet all of the following standards:

1. Legend plates shall have proper legend.
2. The legends shall be of proper letter size and series.
3. They shall be properly fastened to the sign face and shall have plastic spacers behind them to provide a minimum clearance of 1/4 inch from the existing legend.
4. The plates shall be made from the same type of retroreflective material as the sign face.
5. The sign sheeting shall be oriented the same as the sign face material.

The following signs are allowed to utilize demountable legend plates as detailed in the Standard Signs Manual:

1. Lane Reduction Transition (Right or Left) Sign (W4-2)
2. MERGE w/Arrow Sign (W20-X3)
3. RIGHT/LEFT TWO LANES CLOSED Sign (W20-X13)
4. Vehicle Mounted Signs for Mobile Operations Sign (W21-X4)
4. RIGHT/LEFT LANE CLOSED Sign (W21-X5)

Signing for moving operations also allows the use of demountable legend plates.

All work zone signs not listed above shall have the legend directly applied to the sign face as detailed in Mn/DOT specifications 3352.2A5c and 3352.2A5d. The methods detailed in these specifications are:

1. Painting the legend on the sign face using a direct or reverse screening process as detailed in Mn/DOT specification 3352.2A5c and as recommended by the sign sheeting manufacturer.
2. Properly applying a legend cut from pigmented plastic film as detailed in Mn/DOT specification 3352.2A5d. This non-retroreflective cast vinyl material shall have a life expectancy equal to the life of the sign sheeting.

The sign face shall maintain a uniform color and brilliance when viewed during both daytime and nighttime hours. To achieve this, the sheeting shall be applied as described in Mn/DOT specification 3352.2B4.

8-5.02.05 Sign Mounting


Temporary signs that will remain in place for 30 days or less may be mounted on portable crashworthy support structures as defined in the MN MUTCD, Part 1. Refer to the Approved Products web page listed below for examples of NCHRP Report 350 tested and approved temporary sign support structures.

Links to Primary Documents:
Approved Products Lists & Product Specifications: [http://www.dot.state.mn.us/products/](http://www.dot.state.mn.us/products/)
MN MUTCD: [http://www.dot.state.mn.us/trafficeng/publ/mutcd/index.html](http://www.dot.state.mn.us/trafficeng/publ/mutcd/index.html)
Unless designed and crash tested with other ballasting systems, the ballast system for use on portable support mounted signs is sandbags. See section 8-5.05 Ballast for more information.

8-5.02.06 Temporary Sign Covering

When it is necessary to cover an in place sign, care must be taken to preserve the in place sign since some coverings may cause permanent damage to the sign face sheeting. Avoid the use of ropes, wire fasteners or strapping that may abrade the sign sheeting surface. Do not apply tape to the sign sheeting surface because sunlight will cause it to bond permanently. Pre-mask or application tape must be removed prior to exposure to sunlight. Do not use paper or plastic covers as heat and moisture entrapment can cause permanent damage to the reflective sheeting on the sign face.

On smaller signs such as Type C or D, porous cloth covers (such as burlap) that are folded over the sign edges and secured to the back of the sign have been used successfully for limited periods. The cloth shall be opaque and nighttime viewing is recommended to assess if the cover adequately blocks light from headlights. See Figure 8.2C in the appendix for more details on these sign covers.

Sign panel overlays for covering larger signs and/or overhead signs should be rigid panel (such as sheet aluminum or plywood). The installation shall allow adequate air flow between the overlay panel and the sign, by providing a minimum spacing of 1/8" inch (1" maximum). The spacers shall be a material that will not harm the sign sheeting face (such as plastic or rubber). Refer to Figure 8.2A & 8.2B in the appendix for more details on the recommended sign panel overlay method for overhead or ground mounted extruded signs.

8-5.02.07 Sign Panel Overlays

When it is necessary to cover an in place sign, care must be taken to preserve the in place sign. Coverings for overhead sign should be sheet aluminum and installed according to the sheeting manufacturer’s instructions.

8-5.02.08 Sign Sheeting Specifications

There are many varieties of retroreflective sign sheeting available. Different types of sheeting are best suited for various applications, signs versus devices. See the Sign Sheeting Chart.

**Sign Sheeting Chart**

<table>
<thead>
<tr>
<th>Mn/DOT Name</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sign Sheeting for Rigid Signs</td>
<td>Existing Rigid Orange Temporary Signs</td>
</tr>
<tr>
<td>ASTM Type VII or ASTM Type VII FL</td>
<td></td>
</tr>
<tr>
<td>High Performance Sign Sheeting for Rigid Signs Type HP FLO</td>
<td>Upgraded Rigid Orange Temporary Signs</td>
</tr>
<tr>
<td>Sign Sheeting for Rigid Signs Type IX FLO</td>
<td>Upgraded Rigid Orange Temporary Signs</td>
</tr>
<tr>
<td>Sign Sheeting for Rigid Permanent Signs, Delineators and Markers Type HP</td>
<td>Upgraded Rigid Non-orange Temporary Signs</td>
</tr>
<tr>
<td>Sign Sheeting for Rigid Permanent Signs, Delineators and Markers Type IX</td>
<td>Upgraded and Existing Rigid Non-orange Temporary Signs</td>
</tr>
<tr>
<td>Sign Sheeting for Drums and Weighted Channelizers Type VII MD</td>
<td>Drums and Weighted Channelizers</td>
</tr>
<tr>
<td>Sign Sheeting for Tube Delineators</td>
<td>Tubular Markers and Surface Mount Delineators</td>
</tr>
<tr>
<td>Sign Sheeting for Traffic Cones</td>
<td>Cones</td>
</tr>
</tbody>
</table>

*Qualified Products shown on [http://www.dot.state.mn.us/products/signing/sheeting.html](http://www.dot.state.mn.us/products/signing/sheeting.html)*

Refer to Technical Memorandum No. 06-04-7-02 for implementation and compliance requirements.
See the Approved Products web page listed below for the Signing Approved Products List of the various retroreflective sign sheeting and their applications. Additional information found on that page includes the Specifications for Sign Sheeting, and the Sheeting Size and Specifications for various types of devices.

8-5.03 Pavement Markings in Temporary Traffic Control Zones

These guidelines apply to all Mn/DOT construction and maintenance activities. They will apply to any temporary traffic control zone of at least 350 feet in length on tangent sections and of 50 feet in length or longer on curves of 6 degrees or greater.

8-5.03.01 Pavement Marking Definitions

Final Pavement Marking - the pavement marking that will be installed until the next time the pavement marking is scheduled to be renewed (typically one or more years). Final markings would include full length centerline markings, edgelines and messages.

Temporary Pavement Marking - the pavement marking that will be installed in staged long-term temporary traffic control zones. The temporary markings will either be removed or covered with another pavement surface prior to the application of the final markings. The temporary markings would include full length centerline markings, edgelines and messages. All temporary pavement markings shall be in conformance Part 6 Sections 6F-71 to 6F-73 and Part 3 of the MN MUTCD.

Interim Pavement Marking - any pavement markings that are not the final marking or is temporarily placed for staging purposes.

Temporary Raised Pavement Marker (TRPM) - retroreflective pavement markers applied to the roadway surface which maintain retroreflective properties during wet weather conditions. TRPMs are used alone to substitute for pavement marking segments or to provide wet weather capabilities to other pavement markings.

8-5.03.02 Interim Pavement Marking Guidelines

For all projects greater than 2 km (1.25 miles) in length, interim broken line stripe pavement markings shall use the same cycle length as final pavement markings, 50 feet, and shall be a minimum of 2 feet in length. See Figures 6F-8a and 8b of Part 6 of the MN MUTCD.

On projects greater than 350 feet in length, but less than 1-1/4 miles in length, the interim marking shall match the cycle length at either end of the project. On roadways marked with a 50 foot cycle, the interim stripe shall be 2 feet in length. See Figures 6F-8a and 8b of Part 6 of the MN MUTCD.

Material specifications and tolerances for interim pavement markings will be the same as for final pavement markings.

Temporary raised pavement markers, when used as interim pavement markings, shall be installed in accordance with Section 8-5.03.05.

Links to Primary Documents:
Approved Products Lists & Product Specifications: http://www.dot.state.mn.us/products/
MN MUTCD: http://www.dot.state.mn.us/trafficeng/publ/mutcd/index.html
In areas where paint or tape will not adhere to the surface (i.e. chip or sand seal operations), temporary raised pavement markers may be used to simulate a centerline as details in Section 8-5.03.05.

The minimum required interim pavement markings shall be installed prior to opening the roadway to traffic and should not be left in place for more than 14 calendar days unless they meet the requirements of temporary or final markings. Minimum required interim pavement markings include:

1. On Multi-lane Undivided Roadways, all double yellow centerlines, interim lane lines and interim broken line stripe pavement markings.
2. On Multi-lane Divided Roadways, all interim lane lines.
3. On Three and Five Lane Roadways with Two Way Left Turn Lanes, all solid yellow lines with yellow interim broken line stripe pavement markings and interim lane lines (for five lane sections).
4. On Two Lane Undivided Roadways, all broken line stripes.

In the event that it is not possible or practical to install interim marking before opening the road to traffic, plastic drums may be used to delineate the centerline if there is a minimum roadway width of 30 feet. Reflectorized cones, tubular markers, or weighted channelizers may be used on narrower roadways, but constant surveillance (24 hours per day) of the cones shall be maintained. Spacing of the channelizing devices shall be 100 feet in areas with a speed limit of 45 mph or higher and 50 feet in areas where the speed limit is 40 mph or lower.

In areas where passing is prohibited, no passing zone markings shall be installed prior to opening the road to traffic. A 2 foot broken line segment may be used in conjunction with the solid line for interim markings. See Figures 6F-8a and 8b of Part 6 of the MN MUTCD. The use of signs alone or signs with broken line pavement markings shall not be used to mark no passing zones on Mn/DOT projects.

8-5.03.03 Temporary Pavement Marking Guidelines

Through many work zones, traffic is moved from one lane to another. Traffic must be given clear direction as to which pathway to follow. Pavement markings such as center lines and edge lines provide direction for the motorist. Typically the markings placed for staging purposes on long term projects are temporary, meaning they will eventually be covered by surfacing materials or removed completely. The type of temporary pavement marking should be selected upon whether the marking is placed on the final surface (such as a lane shift crossing the final surface) or not.

For temporary pavement markings placed upon pavement surfaces that are to be overlaid or reconstructed, temporary tape or marking paint, or epoxy, on edge lines and/or centerline can be used.

1. For approved Temporary Tape products, see the Temporary Traffic Control Approved Product List on the Approved Products web page listed below.
2. For approved Pavement Marking products, see the Pavement Markings Approved Product List on the Approved Products web page listed below.

For temporary pavement markings placed upon a final pavement surface that is only being used on a temporary basis and will remain in place after the project is completed, removable lane tape (Mn/DOT's specification 3355) should be used.

1. For approved Removable Tape products, see the Temporary Traffic Control Approved Product List on the Approved Products web page listed below.

Links to Primary Documents:
Approved Products Lists & Product Specifications: http://www.dot.state.mn.us/products/
MN MUTCD: http://www.dot.state.mn.us/traficeng/publ/mutcd/index.html
Temporary or final markings and all other pavement markings including edgelines, channelizing lines, lane reduction transitions, gore markings and other longitudinal markings and the various non-longitudinal markings (stop lines, railroad crossings, crosswalks, words, symbols, etc) should be installed within 14 calendar days.

The time limitations for installing temporary or final markings begin when construction operations first remove the in place marking from the roadway. These time limitations restart any time temporary or final markings are restored.

Lane lines and edge lines through transition and alignment change areas that remain in place for more than 14 days, shall be marked with temporary pavement markings with Wet Retroreflective Properties. Transition and alignment change areas include: lane closure tapers, sharp curves, exits, shifts onto temporary roadways or detours, etc.

**Wet Retroreflective Properties**

A temporary pavement marking that has wet retroreflective properties (commonly called Wet Retroreflective Pavement Markings) retains retroreflectivity, presence, and color when wet or submerged in water. The following wet retroreflective pavement markings consist of a combination of one or more products to achieve the required properties:

1. Solid temporary pavement marking tape lines supplemented with TRPMs (temporary raised pavement markings) or
2. Solid temporary wet retroreflective pavement marking tape lines or
3. Solid pavement marking paint or epoxy lines supplemented with TRPMs (temporary raised pavement markings) or
4. Solid wet retroreflective pavement marking paint or epoxy lines.

For approved Removable Tape, TRPM, and Wet Retroreflective Removable Tape products, see the Temporary Traffic Control Approved Product List on the Qualified Products web page listed below.

For approved Wet Retroreflective Marking Paint or Epoxy products, see the Pavement Markings Approved Product List on the Approved Products web page listed below.

There is a high risk of damage or removal of wet retroreflective products by snow plowing operations. Therefore pavements markings which are applied for winter carry-over in transition and alignment change areas should be applied as double width markings and additional wet retroreflective properties may be omitted.

5.03.04 Final Pavement Markings

Standard final striping plan sheets shall be included in each Project Construction Plan. Refer to Chapter 7 on Pavement Markings, for more information on final pavement markings.

---

**Links to Primary Documents:**

Approved Products Lists & Product Specifications: [http://www.dot.state.mn.us/products/](http://www.dot.state.mn.us/products/)

MN MUTCD: [http://www.dot.state.mn.us/trafficeng/publ/mutcd/index.html](http://www.dot.state.mn.us/trafficeng/publ/mutcd/index.html)

8 5.03.05 Temporary Raised Pavement Markers (TRPMs)

TRPMs may be used to simulate solid lines without the use of any other pavement marking material, or they may be used to supplement other types of pavement markings. See the Standards for TRPMs as posted on the Approved Products web page for guidelines on how to use TRPMs to simulate and supplement pavement markings.

For approved TRPM products, see the Temporary Traffic Control Approved Product List on the Approved Products web page listed below.

8-5.04 Channelizing Devices

Channelizing devices are classified into 3 types. Type A channelizing devices include cones, surface mounted delineators, tubular delineators, weighted channelizers, and opposing traffic lane dividers. Type B channelizers include drums, Type I & II barricades and direction indicator barricades. Type C channelizers include Type III barricades. See Figure 8.1 for the 3 types. Refer to the MN MUTCD Part 6 for proper spacing, applications, sizes, color, and retroreflective sheeting requirements. See the Approved Products web page listed below for examples of NCHRP Report 350 tested and approved Type III barricades.

8-5.05 Ballast

Sandbags are the most common ballast for temporary traffic control devices. When sandbags are used, they should be constructed so they will not readily rot or allow the sand to leach when exposed to the highway environment. Also, the sandbag should be constructed of a material which will allow the bag to break and disperse its contents when struck by an errant vehicle. Sandbags should not be filled to the extent that they become too heavy to be readily moved when a traffic control device is relocated. The number and size of sandbags used as traffic control device ballast should be kept to the minimum needed to provide stability for the device. Sandbags shall not be suspended from the traffic control device.

Other ballasting systems, such as the manufacturer provided weighted bases, may be used on some temporary traffic control devices provided they are crashworthy.

8-5.06 Portable Precast Concrete Barrier (PPCB) Delineators

See the MN MUTCD Part 6 for application information and spacing requirements.

For approved PPCB Delineator products, see the Temporary Traffic Control Approved Product List on the Approved Products web page listed below.

8-5.07 Surface Mounted (Centerline) Delineators

See the MN MUTCD Part 6 for application information and spacing requirements.

For approved Surface Mounted Delineator products, see the Temporary Traffic Control Approved Product List on the Approved Products web page listed below.

Links to Primary Documents:
Approved Products Lists & Product Specifications: http://www.dot.state.mn.us/products/
MN MUTCD: http://www.dot.state.mn.us/trafficeng/publ/mutcd/index.html
8-5.08 Portable Changeable Message Signs (PCMS)

8-5.08.01 Definitions

**Change Interval** - The time interval which occurs between display of each panel (during this time no message is displayed).

**Character** - It is composed of 35 pixels. The pixels are arranged in a seven high by five wide matrix.

**Font** - The pixel description of the alphanumeric character. The format used for highways for all alpha-numeric characters (with the exception of the letter "I" and the number "1" is seven units high by five units wide.

**Message sign panel** - It presents or delivers the message to the motoring public. The message is displayed by forming various alpha-numeric characters.

**Panel** - A message (of up to three lines) displayed on a message sign panel.

**Pixel** - A pixel is one element of a total of 35 elements per character. A pixel changes its color electronically, which in turn will show the desired alpha-numeric character.

**PCMS (Portable Changeable Message Sign)** - A traffic control device with the flexibility to display a variety of messages to fit the needs of highway and street authorities. The components of a PCMS include: message sign panel, control system, power source and mounting and transporting equipment.

8-5.08.02 Message Sign Panel

The message sign panel shall meet the following requirements under both day and night conditions:

- **Field Setup** -- The sign shall be placed to be visible from a minimum of 800 feet. When locked in place, the front panel shall be tilted forward 3 to 5 degrees to reduce daylight and headlight glare on the sign face.

- **Minimum Performance Standard** -- The message shall become legible a minimum of 800 feet for traffic on all lanes of the roadway. The message shall remain legible for at least 750 feet from the nearest travel lane from the message sign panel.

  For approved PCMS products, see the Temporary Traffic Control Approved Product List on the Approved Products web page listed below.

The 750 feet distance is based on the ability of a driver to read two complete messages of two 2-second panels, which includes the change interval (0.5 seconds maximum) between panels, for a total of 8.0 seconds.

8 5.09 Flashing Arrow Panels

Any flashing arrow board used for purposes of traffic control shall meet criteria as defined in Part 6 of the MN MUTCD.

For approved Flashing Arrow Board products, see the Temporary Traffic Control Approved Product List on the Approved Products web page listed below.

---

**Links to Primary Documents:**

Approved Products Lists & Product Specifications: [http://www.dot.state.mn.us/products/](http://www.dot.state.mn.us/products/)

MN MUTCD: [http://www.dot.state.mn.us/trafficeng/publ/mutcd/index.html](http://www.dot.state.mn.us/trafficeng/publ/mutcd/index.html)

8 5.10 Crash Cushions and Attenuators

This specification details the general requirements for crash cushions used to protect the end(s) of PPCB in highway work zones. The crash cushions shall be one of two types.

1. Non-Redirective (Gating)

   The non-redirective impact attenuator shall consist of barrel-type modules complete with cores and discs for proper retention of predetermined sand content and have tight fitting covers. Depending upon manufacturer, the modules are approximately 1m (36 inches) in diameter and height. The number of barrels, layout pattern, and installation shall be as recommended by the manufacturer. Sand for filling the modules shall be reasonably dry and mixed with a minimum of 5% by mass of sodium chloride.

2. Redirective (Non-Gating)

   The redirective impact attenuator shall be a six bay unit provided with a deflector vane anchored to the concrete median barrier. Installation shall be as recommended by the manufacturer.

   For approved Crash Cushion and Attenuator products, see the Temporary Traffic Control Approved Product List on the Approved Products web page listed below.

8-5.11 Flagging

Flagging procedures, when used, can provide positive guidance to the motorist traversing the work area. Part 6 of the MN MUTCD contains methods, procedures, and specifications for flagging. Refer to the 2007 Flagging Handbook at: http://www.dot.state.mn.us/trafficeng/publ/fieldmanual2007/fm_2007_flagginghandbook.pdf

8-5.12 Longitudinal and Edge Drop-offs

For uneven lanes, milled edges, and edge drop offs that occur in highway work zones, the best way to increase traffic safety is to make every attempt to minimize exposure to uneven lanes, milled edges, and edge drop offs; however it is realized that this is often not possible or feasible.

The Longitudinal Drop-off Guidelines for utilizing traffic control devices to mitigate the hazards of drop-offs are included in Figures 6K-4, 5, and 6 of the Field Manual which can be viewed at the web page listed below.

8-5.12.01 Drop-off Definitions

For the purpose of the longitudinal drop-off guideline, the following definitions have been established:

**Edge Drop-Off** - The change in elevation when a shoulder is lower than the adjacent traveled lane at the edge of the lane, on the shoulder, or at the edge of the shoulder.

**Excavation** - A vertical change in elevation in the roadway, in the shoulder, or in the adjacent roadside that exceeds 300 mm (12 inches) in depth.

**Milled Edge** - The raised longitudinal edge of a lane or shoulder caused by a milling operation.

**Safety Treatment** - The treatments contained herein for increasing traffic safety using traffic control devices, safety related appurtenances, and construction techniques for uneven lanes, milled edges, and edge drop-offs that occur in street and highway work zones.

Links to Primary Documents:
Approved Products Lists & Product Specifications: http://www.dot.state.mn.us/products/
MN MUTCD: http://www.dot.state.mn.us/trafficeng/publ/mutcd/index.html
Traffic Carrying Lanes - The travelled lanes including turn lanes and their tapers, acceleration and deceleration lanes, and the travelled area to and from freeway ramps and loops.

Uneven Lanes - A drop-off condition between adjacent traffic carrying lanes when one lane is higher than the other.

8-5.12.02 Special Provisions for Drop-offs

The project's special provisions shall specifically state that every attempt should be made to minimize uneven lanes, milled edges, and edge drop offs before the safety treatments are applied.

Consideration should be given to including conditions for the contractor to have the necessary traffic control and safety devices available on the project site within a reasonable time when directed by the Project Engineer.

8-6.00 Temporary Traffic Control Plans

The provisions of this chapter of the Traffic Engineering Manual should be useful to any qualified individual involved with planning, designing, installing, maintaining, and inspecting work zone traffic control.

When preparing specific traffic control plans:

1. the spacing of all traffic control devices should be shown,
2. the traffic control device tabulation should be completed, and
3. the proper pay items for all traffic control devices should be used.

8-6.01 Placement of Temporary Traffic Control Devices

A set of standard temporary traffic control plan sheet templates for use on traffic control plans have been developed. These templates are listed on the Work Zone website: [http://www.dot.state.mn.us/trafficeng/workzone/ttp-templates.html](http://www.dot.state.mn.us/trafficeng/workzone/ttp-templates.html).

The template sheets show typical plan sheets for title sheets, tabulation sheets, and various temporary traffic control operations (such as various types of lane closures, flagging operations, Intelligent Work Zone applications, etc.). These templates do not cover all situations encountered. Because all situations differ (geometrics, traffic volume, speed, etc.) engineering judgment is required to insure proper traffic control application.

8-6.02 Traffic Control Devices Tabulation

For many traffic control plan layouts it is often advantageous to tabulate all traffic control devices used for the project. The templates contain a suggested plan sheet showing how to provide this tabulation. This tabulation is useful during preparation of the plan, for estimated traffic control costs, for bidding the project, and for determining what devices to have available on the project.

It is not always possible to provide a listing of estimated quantities of all traffic devices due to the dynamic and unpredictable nature of the construction staging. However, it is still recommended to provide this tabulation as a quick reference and field guide for necessary devices.

8-6.03 Typical Traffic Control Pay Items

The list of "Typical Pay Items" is the recommended method to use on all contracts and special provisions. Use of a standard set of pay items on all contracts will aid in providing the proper work zone traffic controls at the lowest possible cost. This list of "Typical Pay Items" can be found at: [http://www.dot.state.mn.us/bidlet/misfiles/pdf/AVGPR052010.pdf](http://www.dot.state.mn.us/bidlet/misfiles/pdf/AVGPR052010.pdf)
A set of standard special provisions can be obtained from MN/DOT's Special Provisions Unit on their website: http://www.dot.state.mn.us/pre-letting/prov/index.html.

8-7.00 ESTABLISHING AND MAINTAINING DETOURS

Specification pertaining to traffic provisions, public convenience and safety provide for continued use of the highway under construction by traffic or the diversion of all except local traffic. Under certain conditions it may be necessary to provide a detour.

8-7.01 Conditions Requiring or Permitting a Detour

When a construction contract requires by special provisions and specifications that through traffic be diverted, a detour must be provided. When a construction contract requires by special provisions and specifications that traffic is to be permitted to use the route under construction, no detour need be established around the work, unless, during the course of construction, unusual conditions beyond the control of the contractor make the carrying of through traffic impossible or inadvisable. In such case, a detour may be established for the length of time it is required, but only after it has been requested by the contractor and approved by the Commissioner of Transportation.

8-7.02 Selection of a Route

When a route is to be selected for a detour, the appropriate personnel should be consulted as soon as possible for review of the proposed route. The District should designate a person to coordinate this review. The review team may include the District Traffic Engineer, District State Aid Engineer, District Design Engineer, Project Engineer, Area Maintenance Engineer, as well as the supervisory authorities in charge of the road(s) which will be affected. The information obtained in this review should include a detailed surface condition report, recommendations for reinforcement or modification of the proposed route, and recommendations for traffic control and signing on the proposed route. The form for Establishment of Detour, Form 8.A, must be filled out and submitted, along with a map of the proposed route, to the Central Office, Office of Land Management. The Commissioner's Order establishing the proposed route as a detour (temporary trunk highway) will be prepared by this office. Once the order is signed, copies will be distributed to the appropriate parties.

When a detour is found to be necessary after actual construction has begun and is requested by the contractor, the above procedure is followed except that generally the Project Engineer coordinates the route review. In addition, a Supplemental Agreement will have to be written documenting the change from the original contract.

Once the detour route has been established the Traffic Engineer and the Area Maintenance Engineer should work together to develop the signing layout and have the necessary signs prepared. The Project Engineer should consult with the Traffic and Area Maintenance Engineers to determine the advance notice they would need before the detour is to go into effect. This advance notice should allow enough time to have all signing and other traffic control devices properly installed and reviewed before traffic is diverted onto the detour.

8-7.03 Maintenance of a Detour

Unless other arrangements are made in the contract, it will be assumed that the detour is to be maintained by state forces. However, if conditions make it advisable to have local authorities maintain their own roads, such arrangements can be made by agreement.

8-7.04 Maintenance Agreement

When local authorities prefer to maintain their roads which are used for detours, and agreement will have to be reached. See the Maintenance Manual for specific instructions on maintenance agreements.
8-7.05 Emergency Detour

Whenever it is necessary to establish an emergency detour around a section of road, the Road Information Office, Area Maintenance Offices, and Office of Land Management should be notified immediately by telephone or facsimile giving details as to location. This message should then be immediately confirmed by submitting the Establishment of Detour form.

This action will then be followed by the same procedure, both in the Office of Right of Way and the District, as is required in establishment of any detour.

8-7.06 Special Maintenance Work on Detours

Refer to the Maintenance Manual.

8-7.07 Discontinuance of a Detour

Prior to discontinuing the detour and rerouting traffic onto the construction project, the Project Engineer, accompanied by the Traffic and Maintenance Engineers, should inspect the project to determine that the required signs and traffic control devices are in place. The project must be generally in a safe condition.

A final review of the detour must be made as well. This should include the same individuals who made the initial review. The detour roadway must be acceptable to the governmental subdivision before it can be released as a temporary trunk highway. Reference should also be made to the Maintenance Manual. See Release of Detour form, Form 8.B.

8-8.00 INSTALLATION AND INSPECTION OF TTC DEVICES

8-8.01 Installation

Motorists do not expect to encounter workers in the roadway setting up a traffic control zone. Since the goal is to make the entire operation safe, high-level warning devices, flaggers, or flashing vehicle lights should be used to warn the drivers of the presence of workers. Flashing arrow boards are valuable to assist the workers during placement or removal of channelizing devices for lane closures.

8-8.02 Responsibility

For each project, an individual shall be assigned the responsibility for traffic control. On construction projects, the Contractor should designate a specific person by name and telephone number. In addition, on large projects the traffic control responsibility should be assigned to an employee in the agency's organization.

Routine inspections of the traffic control installations should be carried out by these individuals.

8-8.03 Inspection Program

8-8.03.01 Frequency of TTC Inspections

Prior to the daily work beginning, the supervisor and/or inspector should complete a comprehensive TTC inspection including all signs, pavement marking material, and channelizing devices that are being used.

During the work shift, TTC devices should be routinely monitored and misaligned devices should be readjusted on an hourly basis.

When the devices in a short term stationary TTC zone will not be able to be monitored and repaired on an hourly basis, then the requirements for an intermediate term stationary/night time TTC layout shall be utilized.

Less frequent but periodic inspections should be performed by senior staff of the Contractor (typically the superintendent) and the agency (the resident engineer and/or the traffic engineer).
8-8.03.02 TTC Inspection Programs

A comprehensive TTC inspection program should follow a formalized inspection plan including:

1. Defined inspection procedures
   a. A review to insure that the travel path is clearly marked through the entire work zone, both day and night

2. Established repair/correction procedures
   a. Assurance of an adequate inventory of devices for emergency replacements or repairs
   b. Follow-up procedures to assure that specified repairs/corrections are made

3. Documentation of the TTC
   a. Prepare a form on which the findings of the field inspection are recorded. See Section 8-8.03.03 Record Keeping for more information,
   b. Several methods of recording traffic controls are available. These include photolog, photographs, plans, and video tape.
   c. Identify possible causes of crashes or skid marks.
   d. When the inspection process reveals a condition that requires repair/correction, the documentation should include:
      1) Description of the repair/correction needed, when it was noted, and by whom;
      2) Repairs/corrections or replacements made or deferred and why;
      3) Any other needed actions
   e. Change orders or work orders also serve as a documentation, and should be keyed to the diary when used.

The inspector will be faced with the need to make decisions during the inspection and must exercise judgment in establishing appropriate practices.

8-8.03.03 Record Keeping

Good record keeping procedures suggest that the time and location of the installation and removal of traffic control devices be noted. Although this can be time consuming for a moving maintenance operation, it is important to record significant traffic control actions taken by the field crew. It is desirable that this include:

1. Starting and ending time of work;
2. Location of work;
3. Type, condition and position of traffic control devices;
4. Names of personnel;
5. Type of equipment used; and
6. Any change in temporary or permanent regulatory devices.

Major projects will require more detailed record keeping since they may involve greater amounts of funds, outside (Federal or State Aid) funding sources, and longer distances and times of physical exposure to the workers, motorists, or pedestrians.

8-9.00 REFERENCES

1. Minnesota Department of Transportation, Minnesota Manual of Uniform Traffic Control Devices, current edition, including Part VI.
TYPE A CHANNELIZERS

- Surface Mounted Delineator
- Tubular Markers
- Opposing Traffic Lane Divider
- Cones
- Weighted Channelizer

TYPE B CHANNELIZERS

- Vertical Panel
- Type I Barricade
- Type II Barricade
- Direction Indicator Barricade
- Drum

TYPE C CHANNELIZER

- Type III Barricade

Text Ref.: 8-5.04
OVERLAY ASSEMBLY STEPS:

1) DRILL 1/4" HOLES ON THE SHEET ALUMINUM OVERLAYS IN ACCORDANCE WITH THE HOLE SPACING ON THE DIAGRAM. OUTSIDE HOLES SHALL NOT BE SPACED MORE THAN 24" APART.

2) ATTACH PLASTIC SPAVER(S) (1/8" MIN. THICKNESS, 3/8" I.D., AND 7/8" O.D.) WITH DOUBLE-FACED TAPE, CENTERED BEHIND EACH DRILLED HOLE.

3) POSITION THE FIRST OVERLAY PANEL'S BOTTOM EDGE FLUSH WITH THE BOTTOM OF THE INPLACE EXTRUDED SIGN PANEL AND THE OVERLAY PANEL'S LOWER LEFT EDGE FLUSH WITH THE LOWER LEFT EDGE OF THE BOTTOM INPLACE EXTRUDED PANEL SECTION.

4) DRILL ALL OF THE OUTSIDE HOLES THROUGH THE INPLACE EXTRUDED SIGN PANEL AND ATTACH THE OVERLAY PANEL WITH 1/2" POP RIVETS (SPACERS THICKER THAN 1/8" WILL REQUIRE LONGER POP RIVETS) MEETING THE REQUIREMENTS ON Mn/DOT 3352.A7a.

5) DRILL THE INNER HOLES THROUGH THE INPLACE EXTRUDED SIGN PANEL AND ATTACH WITH RIVETS AS SPECIFIED IN STEP 4 ABOVE.

6) ABUT THE NEXT OVERLAY PANEL TO THE FIRST ATTACHED OVERLAY PANEL AND PERFORM THE SAME WORK AS SPECIFIED IN STEPS 4 AND 5 ABOVE.

7) INSTALL EACH ADDITIONAL OVERLAY PANEL AS SPECIFIED IN STEP 6 ABOVE.

NOTES:

1) IF THE TOP EXTRUDED PANEL IS 6" HIGH, THIS VERTICAL SPACE IS 6".
   IF THE TOP EXTRUDED PANEL IS 12" HIGH, THIS VERTICAL SPACE IS 12".

2) THE CENTER RIVETS SHALL BE SPACED AT 1/2 OF THE PANEL'S WIDTH.

3) IF THE SHEET ALUMINUM PANEL IS GREATER THAN 48" WIDE, THE RIVET SPACING SHALL BE NO GREATER THAN 24". IF THE SHEET ALUMINUM PANEL IS LESS THAN 24" WIDE THERE SHALL BE NO INNER HOLES.

Text Ref.: 8-5.02.06
OVERLAY ASSEMBLY STEPS:

1) DRILL 1/4" HOLES ON THE SHEET ALUMINUM OVERLAYS IN ACCORDANCE WITH THE HOLE SPACING ON THE DIAGRAM. THE HOLES SHALL NOT BE SPACED MORE THAN 24" APART.

2) ATTACH PLASTIC SPACER(S) (1/8" MIN. THICKNESS, 3/8" I.D., AND 7/8" O.D.) WITH DOUBLE-FACED TAPE, CENTERED BEHIND EACH DRILLED HOLE.

3) POSITION THE OVERLAY PANEL ON THE INPLACE EXTRUDED SIGN PANEL MAKING SURE THAT THE MOUNTING HOLES IN THE OVERLAY PANEL DO NOT LINE UP WITH ANY HORIZONTAL EXTRUDED ALUMINUM PANEL JOINTS.

4) DRILL ALL OF THE OUTSIDE HOLES THROUGH THE INPLACE EXTRUDED SIGN PANEL AND ATTACH THE OVERLAY PANEL WITH 1/2" POP RIVETS (SPACERS THICKER THAN 1/8" WILL REQUIRE LONGER POP RIVETS) MEETING THE REQUIREMENTS ON Mn/DOT 3352.A7a.

5) DRILL THE INNER HOLES THROUGH THE INPLACE EXTRUDED SIGN PANEL AND ATTACH WITH RIVETS AS SPECIFIED IN STEP 4 ABOVE.

NOTES:

1) VERTICAL SPACING FOR THE MOUNTING HOLES IS 50% OF THE PANEL HEIGHT. IF THE PANEL IS LESS THAN 24" HIGH, THERE SHALL BE NO INNER HOLES.

2) HORIZONTAL SPACING FOR THE MOUNTING HOLES SHALL NOT BE LESS THAN 15" NOR MORE THAN 24".

Text Ref.: 8-5.02.06
A rigid opaque panel overlay such as sheet aluminum or plywood panel

The overlay panel should be approximately the same size as the sign panel such that the sign message is completely covered.

Hooks or preformed straps extend over top edge(s) of sign panel.

A spacer is required to provide air flow gap between the sign face and the overlay panel.

Spacers should allow between 1/8" to 1" gap and be a material that will not harm the sign sheeting face (such as plastic or rubber).

All fasteners (such as bolts, rivets, hooks or screws) shall not touch the sign sheeting face.

The overlay panel shall be attached to the sign structure such that it will not move due to wind.

A flexible porous opaque cover such as a cloth sheet or bag (as shown). Air must be able to flow through the cloth material.

All flexible covers shall be anchored to the structure such that it will not be effected by wind and not harm the sign sheeting face.

Sheet type covers should be wrapped around the edges of the sign panel and tied together on the back side (not shown on this figure).

The open end of bag type covers should be closed (such as shown) to prevent removal by wind.

Nighttime viewing is required to assess whether the cover adequately blocks light from headlights.

In-place sign panel

In-place sign panel

A flexible porous opaque cover such as a cloth sheet or bag (as shown). Air must be able to flow through the cloth material.

All flexible covers shall be anchored to the structure such that it will not be effected by wind and not harm the sign sheeting face.

Sheet type covers should be wrapped around the edges of the sign panel and tied together on the back side (not shown on this figure).

The open end of bag type covers should be closed (such as shown) to prevent removal by wind.

Nighttime viewing is required to assess whether the cover adequately blocks light from headlights.

In-place sign panel

In-place sign panel

Not drawn to scale.

**Figure 8.2C**

**Opaque Rigid Overlay**

**Opaque Porous Cover**

Text Ref.: 8-5.02.06
Chapter 8
WORK ZONE TRAFFIC CONTROLS

APPENDIX 8-10.01
TRAFFIC MANAGEMENT PLAN CHECKLIST
CHECKLIST FOR TRAFFIC CONTROL

DATE ________________________________
S.P. ________________________________
LOCATION ________________________________
LETTING DATE ________________________________

DETOUR (Preliminary Design Stage)

1. Will traffic be detoured? If no, go to #7.

2. Are various detours adequate in terms of:
   A. Weight - Spring restrictions, height, width?
   B. Wide loads and oversized?
   C. Capacity and adequate traffic control devices?
   D. Railroad crossings and controls?
   E. Geometrics (turning radii, etc.)?
   F. Bridge restrictions and other structures?
   G. Conflict with other detour in the area?
   H. Other local motorist routes available?
   I. Can the detour be carried over winter (snow removal)?

3. If the detour is to be established on other than trunk highways, has the preliminary contact been made with:
   A. County, City, or Townships?
   B. Who will stripe the detour?
   C. Does the signing require upgrading?
   D. Who will be responsible for routine maintenance (i.e. patching)?

4. Will all fronting businesses have acceptable ingress and egress and will other municipalities be served?
   A. Are TOD’S necessary for businesses?

ACTION TAKEN:
### 5. Should the following be contacted?

<table>
<thead>
<tr>
<th></th>
<th>A. School Bus</th>
<th>B. Public Transit</th>
<th>C. Police</th>
<th>D. Fire</th>
<th>E. Ambulance</th>
<th>F. Postal Route</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes</td>
<td>No</td>
<td>N/A</td>
<td>Spec</td>
<td>Prov</td>
<td>Plan</td>
</tr>
</tbody>
</table>

### 6. Is a public information meeting required?

- [ ] Yes
- [ ] No
- [ ] N/A

### TRAFFIC CARRIED THROUGH THE PROJECT

7. Will capacity be restricted during the peak hours (Lane Closure)?

<table>
<thead>
<tr>
<th></th>
<th>A. Will alternate routes handle the diverted traffic?</th>
<th>B. Have local governments been contacted?</th>
<th>C. Number of lanes or reversible lanes needed?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes</td>
<td>No</td>
<td>N/A</td>
</tr>
</tbody>
</table>

8. Consider staging (i.e. lengths of permitted construction)

<table>
<thead>
<tr>
<th></th>
<th>A. Include in plans or let the contractor plan?</th>
<th>B. Can contractor stage work differently than planned?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>

9. Bypasses or temporary widening needed?

<table>
<thead>
<tr>
<th></th>
<th>A. What standards are used?</th>
<th>B. What locations?</th>
<th>C. Design speed?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes</td>
<td>No</td>
<td>N/A</td>
</tr>
</tbody>
</table>

10. Minimum width?

- [ ] Yes
- [ ] No
- [ ] N/A

11. Will oversized load permits be affected?

   If yes, will it be signed?

   - [ ] Yes
   - [ ] No
   - [ ] N/A

12. Will the project be inplace over the winter months? If yes,

   A. Are traffic control devices adequate for winter?

   B. Are there provisions for the TCD's to be maintained over winter suspension?

   If yes, who will maintain them?

   - [ ] Yes
   - [ ] No
   - [ ] N/A

   Spec | Prov | Plan | Det.
### GENERAL CHECKLIST (Detailed Design Stage)

<table>
<thead>
<tr>
<th>Question</th>
<th>Yes</th>
<th>No</th>
<th>N/A</th>
<th>Spec</th>
<th>Prov</th>
<th>Plan</th>
<th>Det.</th>
</tr>
</thead>
<tbody>
<tr>
<td>13. Signing (State or Contractor)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A. Who maintains or inspects?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B. How often</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C. TCP provided by State or Contractor?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D. Are any special signs needed</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>If yes, where?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E. Is cross road signing needed?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>If yes, by whom (State or Contractor)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14. Are temporary signals needed?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A. If yes, what type?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manual</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fixed time</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Actuated</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15. Can inplace signals be shutdown?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>If yes, during what hours?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Does a local municipality need to be contacted?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16. Is temporary street lighting needed?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>If yes,</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A. Who will install?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(State or Contractor)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>If State, is request letter needed?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B. Are breakaway or non-breakaway poles needed?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C. How will power be furnished?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D. Is an agreement needed with the power company?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E. Does inplace lighting need to be kept operational?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17. Is temporary barrier needed?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>If yes,</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A. Who will furnish, install, and maintain?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B. Barrier justification</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High ADT</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Excessive drop-off</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C. Will it be incorporated into existing permanent barrier?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D. How will the barrier be delineated?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Warning lights (type)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Delineators (type)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E. How will the barrier ends be protected?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Taper buried out to the clear zone</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GREAT attenuator</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Barrel attenuator</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F. Is a spare attenuator needed?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

8.1-5
18. Are equipment traffic controls going to be used?  
   If yes, has the proper permission been obtained?  

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
<th>N/A</th>
<th>Spec</th>
<th>Prov</th>
<th>Plan</th>
<th>Det.</th>
</tr>
</thead>
</table>

19. Is the Contractor’s equipment permitted to use crossovers?  
   If yes, what type?  
   A. Which ones?  
   B. Do the Contractor’s vehicles need to be marked?  

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
<th>N/A</th>
<th>Spec</th>
<th>Prov</th>
<th>Plan</th>
<th>Det.</th>
</tr>
</thead>
</table>

20. Can the Contractor store equipment, material, and waste material on the construction site?  
   If yes, must they follow AASHTO guidelines?  
   If no, where?  

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
<th>N/A</th>
<th>Spec</th>
<th>Prov</th>
<th>Plan</th>
<th>Det.</th>
</tr>
</thead>
</table>

21. Can the Contractor’s workers park their vehicles on the construction site?  
   If yes, where?  
   If no, where?  

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
<th>N/A</th>
<th>Spec</th>
<th>Prov</th>
<th>Plan</th>
<th>Det.</th>
</tr>
</thead>
</table>

22. Are temporary pavement markings required?  
   A. Who will furnish, install, and maintain?  
   B. What type?  
      Paint  
      Tape  
      TRPM  

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
<th>N/A</th>
<th>Spec</th>
<th>Prov</th>
<th>Plan</th>
<th>Det.</th>
</tr>
</thead>
</table>

23. Do inplace stripes need to be replaced?  
   A. If yes, where?  
      Centerline  
      Edgeline  
   B. How will they be removed?  
   C. Who will accomplish this?  

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
<th>N/A</th>
<th>Spec</th>
<th>Prov</th>
<th>Plan</th>
<th>Det.</th>
</tr>
</thead>
</table>

24. Is temporary post-mounted delineation needed?  
   If yes, who will furnish, install, and maintain?  

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
<th>N/A</th>
<th>Spec</th>
<th>Prov</th>
<th>Plan</th>
<th>Det.</th>
</tr>
</thead>
</table>

25. Will drop-offs and excavations exist?  
   If yes,  
   A. Will the drop-off exceed 50 mm (2 inches)?  
   B. Will the drop-off exceed 100 mm (4 inches)?  
   C. Will the drop-off exceed 150 mm (6 inches)?  

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
<th>N/A</th>
<th>Spec</th>
<th>Prov</th>
<th>Plan</th>
<th>Det.</th>
</tr>
</thead>
</table>
26. Do inplace signs have to be removed or relocated?  
   If yes, by whom?  

27. Are flagging operations required?  
   If yes,  
   A. What type of operation is being considered?  
      Radio communication  
      Pilot car  
      Flag carrying  
   B. Will the flagging operation be continued during daylight hours?  
      If yes, is supplemental lighting needed?  

28. Is a construction or work zone speed limit needed?  
   If yes, will they use advisories or regulatories?  

29. Will the project require any special devices  
   Changeable Message Signs, how many?  

30. Will extra protection be required for other road users?  
   pedestrians  
   bicyclists  
   snowmobiles  
   trail users  
   schools  
   parks  

31. Do utility operations affect traffic control?  

32. Will the project require dust control?  

33. Are there any restrictions for traffic control which can not be inplace concurrently?  
   (i.e. fire, police, and traffic routing)  
   If yes, by where?  

ACTION TAKEN
<table>
<thead>
<tr>
<th>Question</th>
<th>Yes</th>
<th>No</th>
<th>N/A</th>
<th>Spec</th>
<th>Plan</th>
<th>Det.</th>
</tr>
</thead>
<tbody>
<tr>
<td>34. Will the source of material on or off the project interfere with</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>traffic or a certain type of traffic?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>35. Does the Contractor have to give advance notice</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>of traffic control changes?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>36. Is the starting or completion date controlled by a</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>school, special events, or holidays?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>If yes, (event and date)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>37. Is a working day other than as specified,</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>such as an 18 hour day?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>What is the work week?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>38. Is there as conflict between working hours and</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>local ordinances due to noise, air, or water restrictions?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>39. Is there an incentive clause needed in the contract?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>40. Will working days be charged between</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>November 15 and April 15 or</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>suspended by a work order?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(See 1806)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>41. Should there be other than ordinary liquidated</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>damages such as additional penalties? (See 1807)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>42. Is there a possibility that another contract</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>will delay the work of this project?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**ACTION TAKEN**
# Chapter 8
## WORK ZONE TRAFFIC CONTROLS

### APPENDIX 8-10.02
#### Detours

<table>
<thead>
<tr>
<th>TABLE OF CONTENTS</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>8-10.02.01 Establishing and Maintaining Detours</td>
<td>8.2-1</td>
</tr>
</tbody>
</table>

**List of Forms**

<table>
<thead>
<tr>
<th>Form</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.A</td>
<td>Establishment of Detour Form</td>
<td>8.2-5</td>
</tr>
<tr>
<td>8.B</td>
<td>Release of Detour Form</td>
<td>8.2-6</td>
</tr>
</tbody>
</table>
8-10.02.01 ESTABLISHING AND MAINTAINING DETOURS

Specification pertaining to traffic provisions, public convenience and safety provide for continued use of the highway under construction by traffic or the diversion of all except local traffic. Under certain conditions it may be necessary to provide a detour.

Conditions Requiring or Permitting a Detour

When a construction contract requires by special provisions and specifications that through traffic be diverted, a detour must be provided. When a construction contract requires by special provisions and specifications that traffic is to be permitted to use the route under construction, no detour need be established around the work, unless, during the course of construction, unusual conditions beyond the control of the contractor make the carrying of through traffic impossible or inadvisable. In such case, a detour may be established for the length of time it is required, but only after it has been requested by the contractor and approved by the Commissioner of Transportation.

Selection of a Route

When a route is to be selected for a detour, the appropriate personnel should be consulted as soon as possible for review of the proposed route. The District should designate a person to coordinate this review. The review team may include the District Traffic Engineer, District State Aid Engineer, District Design Engineer, Project Engineer, Area Maintenance Engineer, as well as the supervisory authorities in charge of the road(s) which will be affected. The information obtained in this review should include a detailed surface condition report, recommendations for reinforcement or modification of the proposed route, and recommendations for traffic control and signing on the proposed route. The form for Establishment of Detour, Form 8.A, must be filled out and submitted, along with a map of the proposed route, to the Central Office, Office of Land Management. The Commissioner’s Order establishing the proposed route as a detour (temporary trunk highway) will be prepared by this office. Once the order is signed, copies will be distributed to the appropriate parties.

When a detour is found to be necessary after actual construction has begun and is requested by the contractor, the above procedure is followed except that generally the Project Engineer coordinates the route review. In addition, a Supplemental Agreement will have to be written documenting the change from the original contract.

Once the detour route has been established the Traffic Engineer and the Area Maintenance Engineer should work together to develop the signing layout and have the necessary signs prepared. The Project Engineer should consult with the Traffic and Area Maintenance Engineers to determine the advance notice they would need before the detour is to go into effect. This advance notice should allow enough time to have all signing and other traffic control devices properly installed and reviewed before traffic is diverted onto the detour.

Maintenance of a Detour

Unless other arrangements are made in the contract, it will be assumed that the detour is to be maintained by state forces. However, if conditions make it advisable to have local authorities maintain their own roads, such arrangements can be made by agreement.

Maintenance Agreement

When local authorities prefer to maintain their roads which are used for detours, and agreement will have to be reached. See section 5-791.664 in the Maintenance Manual for specific instructions on maintenance agreements.
Emergency Detour
Whenever it is necessary to establish an emergency detour around a section of road, the Road Information Office, Area Maintenance Offices, and Office of Land Management should be notified immediately by telephone or facsimile giving details as to location. This message should then be immediately confirmed by submitting the Establishment of Detour form.

This action will then be followed by the same procedure, both in the Office of Right of Way and the District, as is required in establishment of any detour.

Special Maintenance Work on Detours
Refer to section 5-791.666 of the Maintenance Manual.

Discontinuance of a Detour
Prior to discontinuing the detour and rerouting traffic onto the construction project, the Project Engineer, accompanied by the Traffic and Maintenance Engineers, should inspect the project to determine that the required signs and traffic control devices are in place. The project must be generally in a safe condition.

A final review of the detour must be made as well. This should include the same individuals who made the initial review. The detour roadway must be acceptable to the governmental subdivision before it can be released as a temporary trunk highway. Reference should also be made to section 5-791.667 of the Maintenance Manual. See Release of Detour form, Form 8.B.

Maintenance of Construction Projects
When the contractor is required to take care of through traffic on a construction project, it is expected that satisfactory travelways will be provided by the contractor over or around those portions of the trunk highway that are disturbed by construction operations. The contractor's responsibility in this respect is continuous throughout day, night, Sundays and holidays. However, if satisfactory traffic service is not being provided by the contractor, and once the Project Engineer becomes knowledgeable of the situation, it is his/her duty to advise the contractor accordingly and to insist that such satisfactory service be provided at once.

During the course and development of the construction project, the contractors will be required to extend and expand their traffic service operations until their project is completed and they are released from their obligation as previously specified and indicated.

In the case the contractor refuses to, or neglects to provide a passable and safe travelway for traffic after being instructed to do so by the Project Engineer, appropriate action will be taken in accordance with Spec. 1514.

Prior to the suspension of any construction project which is carrying traffic, the Project Engineer will review the project with regards to traffic safety. This review may include the Area Maintenance Engineer and the District Traffic Engineer.
RE: ESTABLISHMENT OF DETOUR FOR T.H. ____

1. S.P. No. ___________________________ City of ___________________________
   County of ___________________________

2. Reason for Detour ___________________________

3. Total length of Detour (including portions of other T.H. if used) ___________________________

4. Mileage of T.H. No. ___________ closed ___________________________

5. Designation and mileage of each road, and mileage of each surface type of road used as Detour ___________________________

6. General and minimum width of surface ___________________________

7. Will adverse weather affect detour? ___________________________
   If so, additional sheet for alternate road should be prepared.

8. List all structures on detour indicating those limited to less than 20 tons, also list limited clearances. ___________________________

9. Will additional Detour be needed for this Project? ___________________________

10. Who will maintain Detour? ___________________________

11. Approximate date Detour will become effective ___________________________

12. If Detour is in City or Village, give names of streets used, type and mileage: ___________________________

13. Proposed Detour, including questionable structures should be inspected by District Maintenance Engineer with County Engineer or Township Official. Comments ___________________________

14. Give detailed description of detour and submit sketches as required. (Use Village or City plats if in municipality.) Include township and range. ___________________________

   Project Engineer ___________________________

   Date ___________________________

   District Maintenance Engineer ___________________________

   NOTE: Complete this form and return to Office of Land Management, Central Office.

Text Ref.: 8-8.05.01
RELEASE OF DETOUR

ORDER NO. ____________

It is hereby ordered that the route designated as a detour for Trunk Highway No. ______ in the ________________________________
County of ________________________________ by Order No. _________________, was released ____________________
and therefore, said route will revert to its original status.

Dated: ____________________

AREA MAINTENANCE ENGINEER

__________________________

PROJECT ENGINEER

APPROVED BY

DISTRICT ENGINEER

Note: Complete this form and return it to the Office of Land Management, Central Office.

Text Ref.: 8-8.05.01
Chapter 9
TRAFFIC SIGNALS

TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>TABLE OF CONTENTS</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>9-1.00 INTRODUCTION</td>
<td>9-3</td>
</tr>
<tr>
<td>1.01 Purpose</td>
<td></td>
</tr>
<tr>
<td>1.02 Scope</td>
<td></td>
</tr>
<tr>
<td>1.03 Chapter Organization</td>
<td></td>
</tr>
<tr>
<td>9-2.00 LEGALITY</td>
<td>9-4</td>
</tr>
<tr>
<td>2.01 Legal Authority</td>
<td></td>
</tr>
<tr>
<td>2.02 Jurisdiction</td>
<td></td>
</tr>
<tr>
<td>2.03 Meaning of Signal Indications</td>
<td></td>
</tr>
<tr>
<td>2.04 Tort Claims</td>
<td></td>
</tr>
<tr>
<td>9-3.00 GENERAL DESCRIPTION OF TRAFFIC SIGNALS</td>
<td>9-4</td>
</tr>
<tr>
<td>3.01 Types of Traffic Signals</td>
<td></td>
</tr>
<tr>
<td>3.02 Elements of Traffic Signals</td>
<td></td>
</tr>
<tr>
<td>3.03 Timing and Coordination of Traffic Signals</td>
<td></td>
</tr>
<tr>
<td>9-4.00 TRAFFIC SIGNAL JUSTIFICATION PROCESS</td>
<td>9-10</td>
</tr>
<tr>
<td>4.01 Engineering Studies for Traffic Signals</td>
<td></td>
</tr>
<tr>
<td>4.02 Warrants and Justification for Signals and Flashing Beacons</td>
<td></td>
</tr>
<tr>
<td>9-5.00 TRAFFIC SIGNAL PROJECT PROCEDURES</td>
<td>9-17</td>
</tr>
<tr>
<td>5.01 Traffic Signal Project Management Flowchart</td>
<td></td>
</tr>
<tr>
<td>5.02 Notes on Traffic Signal Project Management Flowchart</td>
<td></td>
</tr>
<tr>
<td>9-6.00 TRAFFIC SIGNAL DESIGN</td>
<td>9-24</td>
</tr>
<tr>
<td>6.01 General Considerations</td>
<td></td>
</tr>
<tr>
<td>6.02 Intersection Geometry</td>
<td></td>
</tr>
<tr>
<td>6.03 Operational Characteristics</td>
<td></td>
</tr>
<tr>
<td>6.04 System (Arterial) Considerations</td>
<td></td>
</tr>
<tr>
<td>6.05 Signal Design Elements</td>
<td></td>
</tr>
<tr>
<td>9-7.00 TRAFFIC SIGNAL PLANS AND SPECIFICATIONS</td>
<td>9-27</td>
</tr>
<tr>
<td>7.01 General</td>
<td></td>
</tr>
<tr>
<td>7.02 Traffic Signal Plans</td>
<td></td>
</tr>
<tr>
<td>7.03 Special Provisions</td>
<td></td>
</tr>
<tr>
<td>7.04 Tabulation of Quantities</td>
<td></td>
</tr>
<tr>
<td>7.05 Standard Plates Manual</td>
<td></td>
</tr>
<tr>
<td>7.06 Mn/DOT Standard Specifications for Construction</td>
<td></td>
</tr>
<tr>
<td>7.07 Other Standards</td>
<td></td>
</tr>
</tbody>
</table>
CHAPTER 9 - TRAFFIC SIGNALS

9-1.00 INTRODUCTION

9-1.01 Purpose

The purpose of this chapter is to present uniform guidelines, procedures, and preferred practice used in the planning, construction, revisions and maintenance of traffic signals on Trunk Highways in Minnesota.

9-1.02 Scope

This chapter applies to all traffic signals that are on State Trunk Highways. Traffic signals that are installed by agencies other than the State of Minnesota and that are not on State Trunk Highways may utilize the guidelines in this chapter, as appropriate. There is no legal requirement, for using these guidelines by local agencies.

Traffic signals include all power-operated (manually, electrically or mechanically operated) traffic control devices (except signs) by which traffic is warned of conflicting movements or directed to take some specific action. Traffic signals assign right-of-way where conflicts exist or where passive devices, such as signs and markings, do not provide the necessary flexibility to properly move traffic safely and efficiently.

Traffic control signals, flashing beacons, movable bridge signals, and temporary signals are covered in this chapter. The planning, design, and operation of traffic signals in Minnesota must conform to the standards, limits, and alternatives provided in the "Minnesota Manual on Uniform Traffic Control Devices" (MN MUTCD). Where the standards in the MN MUTCD are broad, the Traffic Engineering Manual describes preferred practice of design and operation of signals. The standards and guidelines of the MN MUTCD and the Traffic Engineering Manual are to be a basis for engineering judgment, not a substitute for it.

This chapter is intended as an overview of guidelines and procedures for the process of traffic signal design and operation in Minnesota. Please refer to "Mn/DOT Signal Design Manual" (Signal Design Manual) and "Mn/DOT Traffic Signal Timing and Coordination Manual" (Signal Timing Manual) when signal design and operations training and/or detailed description is needed. This chapter may reference to appropriate chapters in Signal Design Manual and Signal Timing Manual when appropriate.

This chapter should be used together with other documents to design and operate traffic signals on trunk highways in Minnesota. The MN MUTCD details minimum standards for the planning, design, and operation of traffic signals. The National Electrical Manufacturers Association (NEMA) Standards Publication No. TS 1-1989 or TS 2-1993, "Traffic Control Systems", latest revision, gives specifications for traffic signal control equipment. Detail drawings for traffic signal construction are in the Mn/DOT "Standard Plates Manual". Symbols for use in drafting traffic signal plans are found in the Mn/DOT "Technical Manual." The Mn/DOT "Standard Specifications for Construction" book, latest revision, governs the construction of traffic signals. Other applicable documents include the latest version of the "National Electrical Code" by the National Fire Protection Association (NFPA), Technical Memoranda from the Office of Traffic, Safety, and Operations, the "Traffic Control Devices Handbook" by the Federal Highway Administration (FHWA), Minnesota Statutes, and the "Transportation and Traffic Engineering Handbook" by the Institute of Transportation Engineers (ITE).

9-1.03 Chapter Organization

Sections 2 through 3 of this chapter present a general overview of traffic signals, including legal considerations, and a general description of traffic signal systems. Sections 4 through 7 address the justification, procedures, design, and plan preparation for a traffic signal installation. Traffic signal construction is the topic of Section 8. Traffic signal timing, operation, and revisions appear in Section 9. Section 10 covers traffic signal maintenance. Section 11 gives an overview of available traffic signal computer software. References and abbreviations/acronyms appear at the end of the chapter.
9-2.00 LEGALITY

For traffic control signals to serve any useful purpose, their indications must be clearly understood and strictly observed. To achieve these objectives, traffic signals should be uniform, the authority for the installation unimpeachable, and compliance with them legally enforceable. Thus, national standards have been developed for the installation and operation of traffic control signals, and the actions required of motorists and pedestrians are specified by statute or by local ordinance or resolution consistent with national standards. Legislation establishing the authority for installation, the meanings of the signal indications, and the required compliance to these indications by the road user, are outlined in such documents as the Uniform Vehicle Code and Minnesota Statutes.

9-2.01 Legal Authority

Legal authority is established in Minnesota Statutes 169.06 (Subdivisions 1-4) for the Department and local units of government to place and maintain traffic signals, require obedience to traffic signals, prohibit the use of unauthorized traffic signals, and prohibit interference with official traffic signals.

Minnesota Statutes 169.06 refers to specific types of signals as follows: Subdivision 5 - Traffic Control Signals, Subdivision 6 - Pedestrian Control Signals, Subdivision 7 - Flashing Signals and Subdivision 8 - Lane-Direction Control Signals.

9-2.02 Jurisdiction

All traffic signals to be installed on Minnesota Trunk Highways shall have previous approval by the Mn/DOT District Engineer.

When a traffic signal is to be installed for which agencies in addition to the State of Minnesota have responsibility, an agreement shall detail the responsibility of each participating agency.

9-2.03 Meaning of Signal Indications

The legal meaning of traffic control signal indications in Minnesota is found in the MN MUTCD, 4D-4 and in Minnesota Statutes 169.06, Subdivision 5.

9-2.04 Tort Claims

Chapter 12 of this manual discusses tort claims and shall be considered to apply to tort claims related to traffic signals.

9-3.00 GENERAL DESCRIPTION OF TRAFFIC SIGNALS

A traffic signal is a device which contains one or more lights to warn of an impending hazard or right-of-way change. Traffic signals, are commonly called stoplights, stop-and-go lights, semaphores, or flashers. The largest percentage of traffic signals are intersection traffic control signals.

Most signals are installed to respond to high vehicle and/or pedestrian volumes, or a high number of correctable crashes. A justified signal, properly designed, installed, operated and maintained, is an asset to the traveling public. A traffic signal that is unjustified, poorly designed, installed, operated, or maintained may decrease the safety or the efficiency of an intersection.

The decision to install a traffic signal should be made after an engineering study is performed for the intersection. The engineering study provides data for warrant analysis. If a signal for the intersection is warranted and justified, a design using the latest standards will result in a safe operation. The signal is installed according to the plans and special provisions. After a signal is installed, it must be maintained to ensure safe operation.
9-3.01 Types of Traffic Signals

The general category of traffic signals includes traffic control signals, flashing beacons, railroad crossing signals, freeway ramp control signals (ramp meters), lane-use control signals, movable bridge signals, and temporary signals. See MN MUTCD for detail descriptions.

9-3.01.01 Traffic Control Signals

**Intersection traffic control signal** (commonly called traffic control signal) - It is the most common type of traffic signal. The primary function of an intersection traffic control signal is to assign the right-of-way to different movements at intersecting streets or highways. It does this by giving to each movement, in turn, a green indication, which allows drivers to proceed through the intersection. Intersection traffic control signals allow traffic and pedestrians to cross heavily traveled roadways safely, provide for the efficient operation of intersections, and reduce right angle crashes.

Traffic control signals can operate under two types of control, pretimed or traffic actuated (see Signal Timing Manual).

- **PRETIMED** - Under pretimed control the intersection is operated using predetermined, fixed cycle lengths, splits and offsets.
- **TRAFFIC ACTUATED** - Under traffic actuated control the intersection is operated according to traffic demands. Cycle lengths, splits and offsets change according to traffic demands.

Two or more traffic control signals that are operated as a system are said to be coordinated. These coordinated traffic control signals are operated to permit continuous movement or minimize delay along an arterial highway or throughout a network of major streets.

**Pedestrian or Mid-block Signal** - A pedestrian signal is a traffic control signal installed, usually at a mid-block, to allow pedestrians to cross a road. Pedestrians can push a button to give them the right-of-way to cross the road. These signals are installed to benefit a nearby school or other pedestrian generator.

**Emergency Traffic Signal** - An emergency traffic signal is a traffic control signal in front of or near a building housing emergency equipment where a signal is not otherwise warranted, but is needed to allow emergency vehicles, to safely enter the roadway.

At mid-block locations, the traffic signal stays green for the mainline traffic until preempted in the station. This permits the emergency vehicle to receive the right-of-way and enter the roadway immediately.

**One-lane, Two-way Signal** - A one-lane, two-way signal is a traffic control signal used at a location, which is not wide enough to allow traffic to flow in both directions simultaneously (one lane bridge or other construction areas). These signals essentially operate as a two-directional control.

9-3.01.02 Flashing Beacons

Flashing beacons are signals that are used to draw attention to signs, pedestrian crossings, and intersections. A flashing beacon is either a red or yellow circular indication.

**Warning Beacon** - This type of yellow flashing beacon is used to identify obstructions in or immediately adjacent to the roadway, to supplement warning and regulatory signs, except the "STOP", "YIELD" and "DO NOT ENTER" signs and to identify pedestrian crosswalks.

**Speed Limit Sign Beacon** - This type of yellow flashing beacon is used with fixed or variable speed limit signs. Where applicable, a flashing speed limit beacon (with an appropriate accompanying sign) may be used to indicate that the speed limit is in effect. The use with a "SCHOOL SPEED LIMIT" sign is an example.
Intersection Control Beacon - Intersection Control Beacons are used at intersections where traffic or physical conditions exist that do not justify the installation of a traffic signal, but where high crash rates indicate a special hazard. The installation of intersection control beacons overhead above the intersection is limited to Red on all approaches (where an all-way stop is warranted).

Stop Beacon - This type of red flashing beacon is located above a stop sign to emphasize and draw attention to the stop sign.

9-3.01.03 Railroad Crossing Signals
Railroad approach signals are used at highway-railroad grade crossings to give warning of the approach or presence of a train. When indicating the approach or presence of a train, the signal displays to the approaching highway traffic two red lights in a horizontal line flashing alternately. The signals may be supplemented by gates which extend across the roadway lanes and keep vehicles off the tracks while trains are present or approaching. A detailed explanation of railroad signals can be found in Chapter 8 of the MN MUTCD.

Railroad approach signals are designed and installed by the railroad companies, and reviewed and approved by Mn/DOT's Office of Freight and Commercial Vehicle Operations (OFCVO).

If a signalized intersection is near a railroad crossing, the traffic signals may have a preemption system connected with the railway approach signal system which allows vehicles to safely clear the railroad tracks, and modifies the operation of the signal to allow traffic movements which do not conflict with the train while it is present.

9-3.01.04 Freeway Ramp Control Signals (Ramp Meters)
Freeway ramp control signals (ramp meters) are described in this Traffic Engineering Manual, Chapter 3, Freeway Corridor Traffic Management.

9-3.01.05 Lane-Use Control Signals
Lane-Use Control Signals are special overhead indications which permit or prohibit the use of specific lanes of a street or highway. They are placed directly over the lane they control and have distinctive shapes and symbols. Lane-Use Control Signals are described in this Traffic Engineering Manual, Chapter 3, Freeway Corridor Traffic Management, and in MN MUTCD, Part Four, Highway Traffic Signals.

Lane-use control signals are most often used for reversible lane control. They may also be used to:

1. To keep mainline traffic out of certain lanes at certain hours, so that traffic from a ramp or other freeway can merge more easily.
2. To indicate that a freeway lane ends.
3. To indicate that a lane is blocked by a crash or breakdown, or closed for maintenance work.

9-3.01.06 Movable Bridge Signals
On roadway approaches to a movable (draw, swing or lift) bridge, traffic control signals are generally used to stop vehicular traffic when the bridge is opened. Signal heads are installed at both approaches to the bridge, often in conjunction with warning gates or other forms of protection. The traffic signal is coordinated with the bridge control and arranged so that adequate warning time is provided in advance of the bridge opening to ensure that the bridge will be clear of all traffic.
9-3.01.07 Temporary Traffic Control Signals

A temporary traffic signal differs from a permanent signal in that it uses wood poles and span wires to place the signal indications in the driver's line of sight. A temporary signal may also use a more portable means of vehicle detection, such as microwave or video detection. In all other ways, a temporary signal is just like a permanent signal.

Temporary signals are meant to be in place for only a short time, from a few months up to a few years. Most are used as intersection traffic control signals or as one-lane, two-way bridge signals, during construction projects.

9-3.01.08 Portable Traffic Control Signals

Another type of temporary traffic signal is the portable traffic control signal. Portable traffic control signals have limited use in conjunction with construction and maintenance projects and should normally not operate longer than 30 days. A portable traffic control signal must meet the physical display and operation requirements of conventional traffic control signals.

9-3.02 Elements of Traffic Signals

9-3.02.01 Signal Indications

A traffic signal must be seen in order for the driver to react and make the required action. The most basic part of a traffic signal is the signal indication. This is how the traffic signal transmits information to the driver. This information or message is portrayed by selective illumination of one or more colored indications.

A signal indication is made up of a lamp, socket and reflector, or Light-Emitting Diode (LED) array, and housing with a lens and visor. Signal indications, normally 12 inches in diameter, are red, yellow, or green, and can be circular or arrows. When three to five signal indications are mounted together vertically, they form a signal face or signal head. Each signal face is outlined with a black background shield. Traffic signal indications and heads are covered in more detail in the MN MUTCD, in sections 4D-5 through 4D-12.

These signal heads for vehicular traffic are often accompanied by signal heads for pedestrian control. Pedestrian signal indication symbols are normally 9 inches or 12 inches in size, are white for WALKING PERSON (WALK) and orange for HAND (DON'T WALK). Section 4E of the MN MUTCD deals with the design and application of pedestrian signal indications.

Vehicle and pedestrian signal heads are attached to poles and pedestals by bracketing, which supports the signal heads and serves as a conduit for the electrical wiring. There are many different possible bracketing arrangements; the standard arrangements are shown on Standard Plates 8110 and 8111.

9-3.02.02 Poles, Mast Arms and Pedestals

Poles, mast arms and pedestals are the structures which support signal heads. They are made of metal for structural strength and for the purpose of protecting the wiring to the signal heads.

A mast arm is a structure that is extended over the roadway. The typical pole and mast arm, shown on Standard Plate 8123, consists of a tapered octagonal shaft positioned on a cubical transformer base. A mast arm is attached near the top of the shaft, which is actually two arms braced together to form a truss. The mast arm can extend horizontally from the top of the pole shaft. Extending vertically from the top of the pole shaft is the luminaire arm extension, at the top of which the street light (luminaire) is placed.
Traffic control signals on arterial highways usually use two or four mast arm poles per intersection. Signal pedestals are mostly used in dense urban areas, they are shorter, do not have mast arms, and are not used for overheads. They are designed to break away from the foundation on impact, in order to minimize damage to a striking vehicle. A typical signal pedestal and its base are shown on Standard Plate 8122.

Sometimes signal heads are mounted on street light poles or wood poles, or are suspended from span wire which is stretched over the roadway.

**9-3.02.03 Cabinet and Control Equipment**

The control equipment for the traffic signal at an intersection is kept in a metal cabinet at the side of the intersection. The cabinets are placed close enough so that the maintenance or operation technicians can see the intersection while they are working on the cabinet; but far enough away so that the cabinet is not too likely to be hit by a vehicle out of control.

The typical signal cabinet is about 6 feet high, 3 feet wide, and 2 feet deep; it sits on a concrete foundation. It may have a vent fan for summer.

The wiring between the signal cabinet and the poles or pedestals usually travels in underground conduit.

The controller is a specialized solid-state microcomputer which is programmed to control the signal indications, and give the right-of-way to various approaches, according to a definite plan.

There are two basic types of controllers. The pretimed (fixed time) controller will repeat the signal indications, cycle after cycle, according to one or more preset timing plans, without regard to actual vehicle or pedestrian demand on the street. A traffic actuated controller varies the timing for some or all controlled conflicting movements depending upon vehicular or pedestrian demand as determined by detectors placed in the roadway or near the pedestrian crossing.

The typical controller is an 8-phase traffic actuated NEMA controller. This means it can control up to eight separate traffic movements, including protected left turn movements, for all four approaches to an intersection. A NEMA controller is built to the specifications of the National Electrical Manufacturers' Association. The controller may include a time-clock to control events by time of day and a coordinator to synchronize the operation of the intersection controller with that of other controllers in a coordinated system of controllers.

Other equipment to be found in the cabinet includes load switches, a conflict monitor, detector units, flasher, miscellaneous equipment and wiring.

Load switches are devices which, activated by the controllers low voltage output, actually turn on and off the 120-volt electric power that goes to the signal heads and powers the indications.

The conflict monitor, also called a failsafe, is a device which monitors cabinet output and internal cabinet voltages. If the conflict monitor senses an improper signal output or internal voltage, the conflict monitor puts the intersection into the flashing mode of operation.

Detector units sense very small frequency changes as vehicles pass over coils of wire, also known as loops, imbedded in the roadway. This change is converted to an on/off signal connected to a controller input so that the controller can take appropriate action.

The flasher is the device which controls the signal indications when the intersection goes out of the mode of normal operation into the flashing mode. It provides a backup flashing operation. In the flashing mode the signal indications should be flashed red for all approaches.

Preemption devices override the normal sequencing of the controller and channel it into special sequence routines to allow for the presence of trains or emergency vehicles approaching or present at an intersection.
9-3.02.04 Detection

Most traffic signal systems on trunk highways today are traffic-actuated, which means that the intersection approaches are given right-of-way in response to actual traffic demand, rather than according to a fixed time pattern.

Detectors enable the controller to "know" which approaches to an intersection have traffic demand which must be served.

The most common type of vehicle detection device in use today is the inductive loop. This is a coil of wire imbedded in the pavement that carries a very low level, high frequency signal. When a conductive mass passes over the loop it creates an inductance change causing this frequency to change. The frequency change is sensed by the detector and it signals the controller that a vehicle is present.

Other types of vehicle detectors include magnetic coil, microwave, radar, sonic, and video; descriptions of which can be found in technical literature.

Vehicle detectors perform a variety of functions. They can place a call to the controller to change the right-of-way at the intersection, extend the amount of time the phase is given and can be used to count traffic.

Detector placement for most efficient operation of a traffic-actuated intersection is a complex subject and is discussed in Signal Design Manual.

A pedestrian detector, usually called a pedestrian pushbutton, is a push button switch mounted near a crosswalk. When the button is pushed, it indicates to the controller that a pedestrian is present and wishes to cross the street.

The installation of saw cut loop detectors is shown on Standard Plate 8130; the installation of the NMC saw cut loop detectors is indicated in the contract documents; the installation of a pedestrian push button is shown on Standard Plate 8115.

9-3.02.05 Source of Power and Service Equipment

Signal controller cabinets are powered by 120-volt electricity from the local utility company. The cabinet is wired to a signal service cabinet or circuit breaker box and meter. The power company brings power to the meter; on the load side of the meter, the wiring and circuit breakers or fuses belong to the agency that owns the signal. The combination of meter and circuit breakers is called service equipment; the location of the service equipment is called the source of power.

Service equipment can be mounted on a wood pole near the controller cabinet, or it can be mounted on the equipment pad. It can be a simple meter and circuit breaker load center, or a signal service cabinet designed for the specific purpose, depending on the electrical and aesthetic requirements of the signal system.

A typical simple set of service equipment is shown on Standard Plate 8118; more complex types of service equipment are detailed in the plans.

9-3.02.06 Conduit and Handholes

The electrical wiring between the signal cabinet and the poles or pedestals usually travels in underground conduit. Conduit is usually rigid steel conduit or non-metallic conduit whose size is determined by the application and the number of cables that it must accommodate. For the non-metallic conduit, a grounding wire is needed if there are power conductors in the conduit.

Handholes can be made of concrete or PVC, and have a metal cover. They are placed in conduit runs to provide junctions for conduit, to facilitate the pulling of cables, and to provide water drainage for the conduits.
9-3.03 Timing and Coordination of Traffic Signals

Details for timing and coordination of traffic control signals are shown in the Signal Timing Manual.

It is often necessary to consider the movement of traffic through a system of consecutive intersections or through an entire network, rather than through a single intersection. In this case, each signal is considered a dependent part of a system; the goal is to maximize the efficiency of the whole system rather than any one intersection in the system.

A system of traffic signals can be made up of a number of fixed-time controllers, a number of actuated controllers, or a combination of both kinds. A group of intersection controllers is usually interconnected by wire or telephone circuits, though sometimes time-based coordination or wireless interconnect is used.

In coordinated master or central controller systems, the entire system and all individual controllers can be controlled by a computer which receives information from detectors and adjusts the signal system according to traffic demand.

In general, two or more signalized intersections can be coordinated if they are less than one-half mile apart, or if the travel time between them is less than a cycle length. A timing mismatch of even a few seconds between two intersections can result in considerable delay to traffic.

A time-space diagram can be constructed to show and to help coordinate signal timing at adjacent intersections.

The selection and use of specific coordination equipment should take into account the nature of the area, the traffic characteristics of the roadway, and the available capital and operating budget.

9-4.00 TRAFFIC SIGNAL JUSTIFICATION PROCESS

9-4.01 Engineering Studies for Traffic Signals

If signals are proposed for an intersection, enough study should be done and documented to demonstrate the need for a signal.

Studies which will be helpful in assessing and demonstrating the need for a signal are the following:

- Volume studies, including approach volumes, turning movements, and peak hour detail counts;
- Pedestrian counts, including any unusual numbers of children, handicapped, and elderly;
- Traffic gap studies;
- Speed studies;
- Crash studies;
- Intersection delay studies.

Procedures for doing various traffic studies are found in the Institute of Transportation Engineers' Manual of Traffic Engineering Studies and a discussion of data collection for traffic studies can be found in Chapter 5 of the Traffic Engineering Manual.

The studies which are required to be included in a signal justification report are discussed below, and in section 4C of the MN MUTCD.

Examples of many of these studies can be found on the Office of Traffic, Safety, and Operations website.
9-4.02 Warrants and Justification for Signals and Flashing Beacons

9-4.01.01 Traffic Signal Warrants (New warrants in 2001 MN MUTCD)

Warrants have been developed to determine if an intersection needs some type of traffic control. Justification for a signalized intersection should be based meeting one or more of the established warrants as stated in the Minnesota Manual on Uniform Traffic Control devices (MN MUTCD). Traffic signals should not be installed unless one or more of the signal warrants in the MN MUTCD are met, but the meeting of a warrant or warrants does not alone justify the installation of a signal.

The data that was collected as part of the engineering studies should be used in combination with the warrants to justify the need to install the traffic control device. The engineering study should show that the intersection will benefit in improved safety and/or operation.

The traffic signal warrants are stated in section 4C of the MN MUTCD. There were major changes to the structure of the warrants in the revision of 2001 MN MUTCD. Comparing to the previous version, the following are the equivalent warrants for the 1991 and 2001 MN MUTCD versions:

<table>
<thead>
<tr>
<th>2001 MN MUTCD</th>
<th>1991 MN MUTCD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Warrant 1</td>
<td>Warrants 1, 2, and 8</td>
</tr>
<tr>
<td>Warrant 2</td>
<td>Warrant 9</td>
</tr>
<tr>
<td>Warrant 3</td>
<td>Warrants 10 and 11</td>
</tr>
<tr>
<td>Warrant 4</td>
<td>Warrant 3</td>
</tr>
<tr>
<td>Warrant 5</td>
<td>Warrant 4</td>
</tr>
<tr>
<td>Warrant 6</td>
<td>Warrant 5</td>
</tr>
<tr>
<td>Warrant 7</td>
<td>Warrant 6</td>
</tr>
<tr>
<td>Warrant 8</td>
<td>Warrant 7</td>
</tr>
</tbody>
</table>

The statements that follow give intents and interpretations of the warrants. Only the warrants which need clarifications are listed here.

WARRANT 1

Warrant 1 is the warrant that pertains to volume, and is the most common warrant for justifying intersection control.

The same eight hour period must be used for both the Major and the Minor Streets. The first standard in Warrant 1 combine the former warrants 1 (volume warrant) and 2 (interruption of continuous traffic). Either Condition A must be met for 8 hours or Condition B must be met for 8 hours. The second standard in Warrant 1 is the former Warrant 8 (combination of warrants). Condition A must be met for 8 hours and Condition B must be met for 8 hours. It does not need to be the same 8 hours for Condition A and Condition B.

Mn/DOT policy on the use of the speed reduction factor is that if a mainline has a posted speed limit of 45 mph or above, that is sufficient evidence that the 85th percentile speed is above 40 mph, and a speed study is not required.

The population reduction factor mentioned in warrants 1-3 states that an intersection lying "within the built-up area of an isolated community having a population of less than 10,000...". In the seven-county metropolitan area, it is often a judgment call whether a community is isolated or not. There are no strict criteria on this.

Geometrics play an important part in determining the volume requirements.
WARRANTS 2 and 3

These warrants may not be addressed by projected or hypothetical volumes, or for currently nonexistent intersections. Actual on-site studies are required.

WARRANT 4

This warrant allows the installation of a traffic signal if there is a considerable number of pedestrians. If a signal is warranted, the signal should be traffic actuated with pedestrian indications.

WARRANT 6

A signal justification report addressing Warrant 6 should contain a time-space diagram of the proposed intersection and nearby signals, helping to demonstrate that a progressive system will help maintain platooning and group speed.

Signals are installed under Warrant 6 on the basis of the 85th percentile speed, so a speed study is necessary for this warrant. It is expected that any signal installed under Warrant 6 would include interconnect.

WARRANT 7

For Warrant 7, the requirement is the 80% columns of Warrant 1 Condition A or Condition B or 80% of the pedestrian volumes of Warrant 4.

Signal justification reports which address Warrant 7 are to include a collision diagram. A time-space diagram showing that the proposed signal system will not seriously disrupt progressive traffic flow should be included. Discussion of the failure of less restrictive remedies is also required by the MN MUTCD.

Current Mn/DOT policy is that in general, Warrant 7 is not applicable to an intersection which is already signalized.

WARRANT 8

Current Mn/DOT interpretation of Warrant 8 is that its intent is the use of a signal to pull traffic away from other intersections, "to encourage concentration and organization of traffic flow networks." Therefore, policy is that Warrant 8 does not apply to isolated intersections, but rather to intersections in urban grid systems.

9-4.02.02 Warrants for Flashing Beacons at Intersections

Flashing beacons at intersections include intersection control beacons mounted on span wire directly over an intersection (all-way stop only), stop beacons mounted on a pedestal above stop signs (red), and warning beacons mounted on a pedestal above intersection ahead symbols signs (yellow). Both overhead and pedestal mounted beacons have advantages and disadvantages. Overhead beacons may distract the motorist from roadway signing, but they aid the motorist in locating the intersection. Pedestal mounted beacons help draw attention to stop and intersection ahead signing, but do not help locate the intersection for the mainline driver who sees only flashing yellow mounted on an intersection ahead sign, somewhere in advance of the intersection itself. In any case, any flashing beacon must be justified under one or more of the following warrants.
**WARRANT 1: Limited Visibility**

Where sight distance is limited, a flashing beacon may be installed if the sight distance is less than that shown in the table below for any approach to the intersection. Locations qualifying under limited visibility must have previously had adequate warning signs and pavement markings installed.

<table>
<thead>
<tr>
<th>SPEED (mph)</th>
<th>SIGHT DISTANCE LESS THAN (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>105</td>
</tr>
<tr>
<td>25</td>
<td>145</td>
</tr>
<tr>
<td>30</td>
<td>195</td>
</tr>
<tr>
<td>35</td>
<td>250</td>
</tr>
<tr>
<td>40</td>
<td>320</td>
</tr>
<tr>
<td>45</td>
<td>390</td>
</tr>
<tr>
<td>50</td>
<td>460</td>
</tr>
<tr>
<td>55</td>
<td>540</td>
</tr>
<tr>
<td>60</td>
<td>635</td>
</tr>
<tr>
<td>65</td>
<td>745</td>
</tr>
<tr>
<td>70</td>
<td>840</td>
</tr>
</tbody>
</table>

*NOTE: The distances here are to ensure the driver (3.5 ft. height of eye) who can not see an oncoming vehicle (3.5 ft. height of object), has enough time TO react and make a stop. They are based on the 1994 AASHTO Policy for stopping sight distance (page 120) providing a PIEV time of 2.5 seconds, friction factor of 0.28 to 0.40 based on speed.*

**WARRANT 2: Crash Rate**

A flashing beacon may be installed where high-hazard safety improvement criteria are met, as described elsewhere in this manual or, in one year where there have been four or more crashes of the right-angle or left-turn type, or of the type deemed preventable by a flashing beacon.

**WARRANT 3: School Crossing**

A flashing beacon may be installed at an established school crossing where, during the heavy crosswalk usage periods, there are more than 500 vehicles per hour (actual or effective rate) crossing the crosswalk, AND, insufficient usable gaps for pedestrians using the crosswalk.

**WARRANT 4: Rural Trunk Highway Junctions**

At or near some rural junctions of two or more high speed trunk highways, a flashing beacon may be installed to warn drivers of an unexpected crossing of another highway.

**9-4.02.03 Advance Warning Flashers Consideration**

An Advance Warning Flasher (AWF) is a device which Mn/DOT uses to convey to the motorist information about the operation of a traffic signal. An AWF is typically found at certain high speed locations where it may be necessary to get the motorists attention through a visual indication about a pending change in the indication of a traffic signal. The AWF assists the motorists in making safer and more efficient driving decisions by informing them that they must prepare to stop. The AWF configuration, placement, and timing details can be found the Chapter 4M of the MN MUTCD.
The following guidelines indicate when the installation of advance warning flashers (AWF) for signal change interval should be considered. Due to the complex nature of traffic flow characteristics, these guidelines should be applied along with engineering judgment. Guidelines should be reviewed for each prospective installation.

An AWF should only be installed in response to a specifically correctable problem, not in anticipation of a future problem. Generally, AWF implementation is appropriate only at high speed locations. Before an AWF is installed, other remedial action should be considered.

The following guidelines generally apply only where posted speed is 55 mph or higher:

1. An isolated or an unexpected signalized intersection
   
   This situation can occur where there is a long distance from the last intersection at which the mainline is controlled, or the intersection is otherwise unexpected. This guideline may be applicable where the distance from the last intersection is greater than 10 miles, a freeway terminus, or at other locations where the intersection is unexpected.

2. A Limited sight distance
   
   This can occur where the distance to the stop bar, D, with two signal heads visible is insufficient. See Graphs of Limited Sight Distance, Table 9.1A & Table 9-1B. A sight distance falling below the lines for the given speed and grade indicates the possible need for an AWF.

   \[
   D \leq 1.467vt + \frac{v^2}{0.93(a + 32.2s)}
   \]

   Where:
   
   D = distance to stop bar in feet
   v = posted speed limit in mph
   t = reaction time, 2.5 seconds
   a = deceleration rate
   
   for trucks use \( 8 \text{ ft/s}^2 \)
   for all traffic use \( 10 \text{ ft/s}^2 \)
   s = positive or negative decimal gradient

3. Dilemma zone
   
   This situation exists when a dilemma zone exists for all traffic or for heavy vehicles. A dilemma zone exists if the yellow interval time cannot practically be set to at least the yellow interval time indicated in Signal Timing Manual. An AWF may be considered but longer yellow should be considered first.

4. Crashes
   
   If an approach has a crash problem, the intersection should be examined for existence of dilemma zone or sight distance restriction. If no sight distance or dilemma zone problems exist, an AWF may not be an appropriate countermeasure for accident problems.

5. Heavy Truck Volume
   
   Where the roadway has a grade of 3% or greater and truck volume exceeds 15%.

6. Engineering Judgment
   
   Combinations of the above guidelines or other considerations may justify the installation of an AWF.
Engineering judgment should be based on additional data such as complaints, violations, conformity of practice, and traffic conflicts. Prior to installing an AWF, consideration should be given to other countermeasures including but not limited to: adjustment of timing parameters which may include increasing yellow and/or all red intervals, improving detection, modification of the signal system as by adding signal heads, adjusting speed limits, and installing continuously operating flashers with standard "signal ahead" warning signs.

9-4.02.04 Signal Justification

Signal Justification Report (SJR)

A signal justification report (SJR) must be prepared for all new construction of signalized intersections, when a signal is completely rebuilt, when major work is done on a signal, or when a signal is upgraded preceding turnback to the local jurisdiction. The signal justification report may incorporate the project memo when the project is only to install or revise an existing signal. When the signal is part of a larger project, the signal justification report is a separate document from the project memorandum, and only its cover sheet is included with the project memorandum. The signal justification report should not be included in the project memo when the signal is only part of the project.

A signal justification report need not be prepared for minor work done on a signal if each district still considers the signal a justified installation. In general, work that changes the displays seen by drivers or changes the operation drivers are accustomed to requires a signal justification report. When in doubt, a signal justification report should be prepared.

The purpose of a signal justification report is to document that an engineering study has been done and that engineering judgment has been used to demonstrate that a traffic signal installation is justified, to show that an analysis of the factors contained in the warrants of the MN MUTCD has been done, and to demonstrate that the installation or improvement of a signal will improve the overall safety and/or operation of an intersection and be in the public's best interest.

This purpose can best be met when the report includes the following information:

1. Intersection location: trunk highway cross-street name and county road numbers, municipality, county. A map should be included which identifies the site.
2. Type of work: type of signal or beacon proposed, whether temporary or permanent.
3. Character of site: function and importance of roads, number of lanes, existing and proposed geometrics, channelization, grades, presence or absence of parking, bus stops and routes, posted speed limit, 85th percentile speed if markedly different, sight distance restrictions.
4. Land use: present land use at the intersection, presence of any special traffic generators, proposed or likely future development.
5. Traffic control: existing traffic control, present and planned adjacent signals, proposed or existing coordinated systems.
6. Actual traffic volumes at an in place intersection. Volumes must include at least 16 hours of counts on all approaches, turning movement counts for at least a.m. and p.m. peak hours. Unusual numbers of heavy vehicles and unusual percentages of turning movements must be noted. Volumes shall have been counted within two years of the date of submission of the report.
7. Mn/DOT-generated or-approved volume estimates for a proposed intersection, such as found in an official TAM or SPAR report, and for which warrant estimation methods are acceptable.
8. Pedestrian counts, particularly if the intersection is a school crossing or is used by large numbers of elderly
9. Crash data: number and general types of crashes which have occurred for a minimum of 12 months before the date of the report. If Warrant 7 for crash experience is addressed, a collision diagram must be included, showing crashes by type, location in the intersection, directions of movement, severity, date, time of day, weather, light, and roadway conditions.

10. Any special site conditions: which add to the engineer's judgment that signals are necessary.

The information can be presented in either checklist or narrative form, so long as it is clearly and logically presented. Volumes can be presented in graph or tabular form.

A sample SJR can be found on the Office of Traffic, Safety, and Operations website.

**Signal Removal Justification Criteria**

Signalized intersections that meet 80 percent of the volume requirements of MN MUTCD Warrant 1 should be considered justified and should not be removed. Signalized intersections that do not meet 80 percent of the volume requirements of MN MUTCD Warrant 1, but meet 60 percent of the volume requirements of Warrant 1 are in the gray area and should be considered for signal removal. Additional studies, findings, engineering judgment and documentation beyond the volume requirements will be needed to justify retaining the signal.

Signalized intersections that do not meet 60 percent of the volume requirements of MN MUTCD Warrant 1 and meet no other Warrant should be considered unjustified traffic control signals and should be removed. The traffic signal removal decision process shall be followed as set forth in the "User Guide for Removal of Not Needed Traffic Signals", FHWA-IP-80-12, November 1980.

In the traffic signal removal process, the District Traffic Engineer considers all the findings and the decision is made whether or not to remove the traffic signal. The final decision concerning signal removal is a blend of analytical procedures and political considerations coupled with professional judgment. However, the technical findings from the analysis should provide a strong factual basis for reaching, supporting and defending the final decision or recommendation.

All findings of the decision process shall be summarized by the District Traffic Engineer in a signal justification report or a signal removal justification report, if so determined.

All traffic signals that are determined to be retained should be revised to meet current standards. These traffic signals should be prioritized along with other traffic signal projects and scheduled for revision as permitted.

**9-5.00 TRAFFIC SIGNAL PROJECT PROCEDURES**

**9-5.01 Traffic Signal Project Management Flowchart**
The accompanying chart illustrates a typical state let traffic signal project management flowchart based on the deliverables and important milestones.

9-5.02 Notes on Traffic Signal Project Management Flowchart

A. START PROJECT

The Statewide Transportation Improvement Plan (STIP) and the Program and Project Management System (PPMS) identify the project and project manager. This is the beginning of tracking of the project.

Signal design projects can be characterized based upon the following parameters:

1. Contracting agency - Mn/DOT let versus local agency let, or force account.
2. Funding source - State Federal funds, Local Federal funds, state funds, state funds through a cooperative agreement, state aid funds, local funds.
3. Designer - Mn/DOT, consultant, design build contractor, and city.
4. Scope - Stand alone signal project or part of larger construction project.

B. PROJECT NOTIFICATION LETTER

Early project coordination is the key to a successful review process. For Mn/DOT designed projects, the Project Notification Letter from the Mn/DOT district to the affected local agencies alerts the local agencies that a project is upcoming. The letter describes the project need and justification, scope, proposed letting date, expected construction duration, contact personnel (name, title, mailing address, phone, e-mail), funding source(s), and any need for in place plans and mapping.

For externally designed projects, the designer should send the Project Notification Letter to the Mn/DOT District Traffic Engineering office with similar information.

C. PROJECT KICKOFF MEETING

The designer should schedule a Project Kickoff Meeting to discuss the project scope, data collection findings and goals, and Mn/DOT and local agency issues and goals. The meeting's purpose is to make all project participants fully aware of all issues so that the project management, scope, funding, and technical issues are resolved prior to the beginning of signal design activities. This meeting should include the signal designer, local agency project manager (city, county, etc.), agencies affected by the project (cost, operation, maintenance) and Mn/DOT District Traffic Engineering office personnel.

In preparation for the Project Kickoff Meeting, the designer will begin data collection. The data to be collected (as needed) shall include: obtaining in place signal plans (or CADD files if available), obtaining mapping if available, identifying any current problems with signal operations and/or maintenance, identifying signal design standard or geometric deficiencies, checking for other proposed projects in the vicinity including project time lines, checking crash rates, checking existing cabinet/controller condition and compatibility, and obtaining a preliminary cost estimate for state furnished materials and labor.
Start - See Note A

Notification Letter - See Note B

Project Kickoff Meeting - See Note C

Preliminary Estimate - See Note D

Pre-Agreement Letter - See Note E

SJR - See Note F

Pencil Sketch - See Note G

Preliminary Plans & Special Provisions - See Note H

TE Request - See Note I

Agreement Request - See Note J

Plan Turn-In - See Note K

Engineer’s Estimate - See Note L

Agreement Executed by Local Agency - See Note J

Advertisement and Letting

Agreement Fully Executed - See Note J

Contract Award

TE Finalized - See Note I

Pre-Construction Meeting - See Note M

Start of Work

State Furnished Materials Pick-up - See Note I

Construction Complete

As-Built Plans - See Note N

Typical State Let Traffic Signal
Project Management Flowchart
The following is the project Kick-off Meeting check List for each intersection affected by a project:

**Project Management**
- Mn/DOT Traffic Engineering project manager
- Project sponsor/lead (Mn/DOT, city, county)
- Designer (Mn/DOT, city, county, consultant)
- Project location (TH/Intersection)
- Project process (Permit, S.A., local initiative/AM funding, Mn/DOT Programmed)
- Proposed project time line

**Project Scope**
- Work proposed (new signal, major/minor revision, EVP, phasing change, standard)
- Project proposer's specific goals (lanes, phasing, heads, EVP, etc.)
- Mn/DOT's specific goals (lanes, phasing, heads, EVP, etc.)
- Affect/coordination with TMC systems
- Affect/coordination with lighting systems
- SJR/project memo required
- Operation issues
- Operation issues not addressed by proposed project
- Maintenance issues
- Safety/accident issues
- Traffic engineering construction liaison scope of responsibilities

**System Operation/Management**
- Use Cost Participation, Operations, and Maintenance Responsibilities Worksheet

**Funding / Costs**
- State, City or County furnished materials and labor estimate for proposed work
- Need for an agreement (signals/lighting) for this proposed work (Pre-agreement letter to follow, if necessary.)
- Need for a permit for this work
- Funding sources and Cost participation of proposed work
Technical Issues (Use Field Walk Checklist to Identify all Issues)
Field walk
Affect on in place SOP
SOP meeting and notification letter needed
Equipment pad revisions needed
EVP sight lines adequate (vertical and horizontal)
Affect on in place interconnect - need for interconnect
Affect on in place HH's - need to be moved or receive replacement covers
Standards upgrades proposed / needed (LED, EVP, pedestrian indication, etc.)
Phasing review needed
Detection needs/changes
Striping/signing affected
Approach signing affected (review conflicts)/needed (coordinate)
Utility information and process/needs - notification letter and time line
Specification requirements (design, operations, CESU for EVP card delivery, etc.)
Pedestrian amenities status (ramps, sidewalk, indications, PB placement, markings)

Further Contacts
Since the project scope can change as result of data review and this meeting, define what actions will be taken to inform all attendees and cc:s of project scope changes.

References
Refer to www.dot.state.mn.us\trafficeng site for checklists, details, standards, sample special provisions, and other significant information.

Refer to signal and lighting design manuals for processes and technical information.

D. PRELIMINARY ESTIMATE

A Preliminary Estimate will be the basis for the costs in the Pre-Agreement Letter. The Preliminary Estimate will include the preliminary construction contract cost and will additionally identify costs for state furnished materials and labor, and costs for design and construction engineering. As the project costs become better defined, the designer should update the Preliminary Estimate.
E. PRE-AGREEMENT LETTER

The District Traffic Engineering project manager will send a Pre-Agreement letter to affected local agencies and Mn/DOT offices identifying the following:

1. Preliminary Estimate with breakdown
2. Project scope
3. Funding and cost participation
4. Time line
5. Major/minor maintenance responsibilities
6. Power supply costs and responsibilities
7. Signal and coordination operation responsibilities
8. State, County or City furnished material / labor
9. Construction engineering costs

See details of cost sharing in the Signal Design Manual and Mn/DOT Policy and Procedures for Cooperative Construction Projects with Local Units of Government.

F. SIGNAL JUSTIFICATION REPORT

A Signal Justification Report shall be approved by the Mn/DOT District Traffic Engineer. This report should be completed prior to or near commencement of signal plan development, but only after the project scope is clearly defined. See Section 9-4.02.04 of this chapter for details of the SJR.

G. PENCIL SKETCH

A "pencil sketch" or preliminary CADD drawing (usually graphics and charts - no pole or construction notes) of the new signal should be provided to the Mn/DOT District Traffic Engineering office for review. This will allow Mn/DOT to comment on important design elements (head placement, detection, phasing) prior to signal plan development. This will eliminate significant design changes once the signal design has begun, and is strongly recommended.

Signal designers should meet and confer to agree on preliminary signal design. The design topics to be discussed should include but not be limited to the following:

1. General nature of the signal project: new installation, minor or major revisions.
2. Phasing of the intersection, relation of proposed phasing to the traffic volumes and turning movements; use of protected-permissive left-turn phasing rather than protected-only; use of overlaps.
3. Determine design standards based on who will operate the system.
4. Use of 4- and 5-section heads and non standard bracketing.
5. Head type (LED, Optically programmed, etc.).
6. Appropriateness of poles and pedestals for the site.
7. Placement of signal standards to ensure legal placement of all vehicle and pedestrian signal indications. See the Signal Design Manual, for signal head placement diagrams.
8. Placement of pedestrian pushbuttons relative to signal standards and in place sidewalks and crosswalks.
10. Detector placement and functions. See the Signal Design Manual for loop detector placement diagrams.
11. Placement and type of handholes.
12. Design of equipment pad.
13. Type of service equipment.
14 Discuss needs for combined pad with lighting and/or TMC.
15 Need for intersection geometric improvements.
16. For revised systems, the wording of the signal pole notes for the revision.
17. Need for AWF's, supplemental heads, etc.
19. Painting of signal.
20. Luminaires metered or unmetered.
21. Source of power (to determine cabinet location).
22. Interconnect (determine need and type, location of master).

H. PRELIMINARY PLANS AND SPECIAL PROVISIONS

The Mn/DOT District Traffic Engineering office project manager distributes the preliminary signal design package (as distinct from a roadway design package) for review to the Mn/DOT District Traffic Engineering office, District State Aid office, Cooperative Agreements, Consultant Agreements, Permits, Metro or Regional Electrical Service Unit, and other district functional offices as appropriate. The preliminary signal design package shall consist of the appropriate number of copies of signal plans (hard copies), signal special provisions, Microstation CADD file, Preliminary Estimate, source of power letter, and power application form (if applicable). The preliminary signal design package is required for all projects. The District Traffic Engineering office project manager works directly with the designer on format and technical comments, keeping other project managers informed.

The plan should identify the TE number, the system ID number, and the master ID number (if applicable).

NOTE: To expedite the signal plan review process, the signal plan should be checked by the signal designer prior to submittal. A checklist for plan reviews is available in the Signal Design Manual.

I. TE REQUEST

A Traffic Engineering (TE) Request is a work order requesting state furnished materials and/or labor from the Central Electrical Services Unit. Most signal projects let by Mn/DOT will utilize a state furnished traffic signal controller and cabinet. Other state furnished materials, especially for temporary traffic signal systems, may include microwave or video detection systems. In addition to the state furnished materials, a TE Request may also include a request for labor, such as modifying wiring within an existing signal controller cabinet in the field. The District Traffic Engineering office prepares and submits the TE Request in the AFMS system and the Central Electrical Services Unit approves it.

The project special provisions should require the Contractor to contact the Central Electrical Services Unit to request the state furnished materials at least 30 days before the materials are needed. The Central Electrical Services Unit will final the TE Request, which ensures that the materials are correctly charged to the signal construction project.

The project special provisions should require the Contractor to again contact the Central Electrical Services Unit 3 days before picking up the state furnished materials.
J. SIGNAL AGREEMENT

Mn/DOT shall prepare a signal agreement as needed. Items typically covered within the agreement are:

1. Construction cost participation
2. Responsibility for power cost
3. Responsibility for major maintenance
4. Responsibility for minor maintenance
5. Responsibility for maintenance costs
6. Responsibility for signal timing and operation
7. Costs and responsibility for Emergency Vehicle Preemption (EVP) systems
8. Reimbursement for State, County or City furnished materials / labor
9. Construction engineering costs

The signal Agreement Request is often combined with the final Plan Turn-In.

Projects requiring signal agreements should not be let without the agreement signed by the local unit of government. The construction project should not be awarded without a fully executed agreement (signed by all parties).

K. PLAN TURN-IN

The Mn/DOT District Traffic Engineering office project manager ensures that all of the comments to the preliminary submittal have been appropriately addressed. Upon completion of the final review, Mn/DOT (either the District Traffic Engineering office project manager or the larger roadway project manager) will begin final processing of the project package. Once all the district and local signatures are obtained, the project will be submitted to the Pre-Letting Section of the Office of Technical Support for final processing.

Traffic signal plan approvals handled by Mn/DOT for other agencies, with or without the state aid process, are handled differently depending on whether the project has federal funding participation, and whether or not the intersection involved is on or off the trunk highway system.

If a signal at a trunk highway intersection is being built or revised by any other agency, the District Traffic Engineer shall approve the final plans before bids are opened on the project. If a proposed signal is not at a trunk highway location, the District Traffic Engineer will indicate concurrence with the design by means of a memorandum to the State Aid office.

The project submittal package shall include:

1. Hard copy and Microstation CADD files of the signal plans
2. Hard copy and Microsoft Word files of the signal special provisions
3. Tabulation of Quantities for the signal project

L. ENGINEER'S ESTIMATE

The Office of Technical Support prepares the final Engineer's Estimate based upon the tabulation of quantities provided by the signal designer.

M. PRECONSTRUCTION MEETING

For the Pre-construction Meeting the District Traffic Engineering office project manager should invite the Mn/DOT District Traffic Engineering office operations personnel as appropriate.
N. AS-BUILT PLANS

As-built signal plans should be forwarded to the Mn/DOT District Traffic Engineering office upon completion of projects administered by local agencies.

9-6.00 TRAFFIC SIGNAL DESIGN

9-6.01 General Considerations

The design of a traffic signal system is a process of balancing, among other things, the requirements of MN MUTCD, intersection geometrics, operational characteristics of the intersection vehicle and pedestrian traffic; the nature and volume of arterial traffic; and the constraints of the construction process. Please see the traffic signal project management flowchart.

See the Signal Design Manual for more detailed information.

9-6.02 Intersection Geometry

Intersection geometry is an important element of traffic signal design. The design of traffic signal system hardware and operation of the traffic signal system should be preceded by a thorough evaluation and, if necessary, geometric improvement of the existing intersection.

The following geometric elements should be considered:

1. Pavement width should be adequate for anticipated traffic movements and future capacity requirements. Highway capacity analysis should be performed to get a better understanding of the capacity of the intersection.

2. If appropriate islands should be designed and constructed so that the driver has adequate reaction distance to them and they are large enough to install a standard signal foundation. Existing shoulders should always be carried through the intersection; this will usually provide enough reaction distance to the island. However, turning radii should be checked to ensure enough setback for comfortable turns.

3. Turn lanes must provide adequate storage in order to prevent turning traffic from interfering with other traffic movements and thus causing capacity breakdown.

4. When a median width is more than 30 feet between opposing through lanes, special signal design considerations are necessary (See MN MUTCD, Section 4H). Extremely wide medians confuse drivers on the crossing street, prevent them from being comfortable with opposing traffic, and cause them to lose track of their path. Wide medians also cause capacity restrictions because more time is needed for vehicle movements and clearances through the intersection.

5. Sidewalks should be constructed as close to the center of the corner as possible. Pedestrian crosswalks should be inline with sidewalk and as close to the intersection as practical.

6. Alignment changes within the intersection should be avoided. Vehicles approaching the intersection should be directed through the intersection. Vertical alignments approaching signals must allow for proper signal visibility.

7. Driveways within an intersection should be signalized and accommodated by the intersection geometrics. Whenever feasible, the driveways should be located or relocated outside the limits of the intersection.
8. The size of corner radii is an important consideration. Excessively large corner radii may obscure intersection limits and create a hazard for bicycles and pedestrians, while very small radii may create a hazard for motorists. Corner radii at signalized intersections should not be less than 20 feet nor more than 60 feet. A turning radius guide for 58-foot vehicles should be used to determine proper corner radii. At intersections where bus routes are located, corner radii should be analyzed giving due consideration to bus maneuvers.

9. It may be necessary to relocate utilities such as manholes, catch basins, fire hydrants, overhead power and telephone lines and power poles, to obtain adequate geometrics for signalization. The existence of these utilities must not get in the way of adequate geometrics.

10. Pedestrian curb ramps are required at all corners.

9-6.03 Operational Characteristics

The behavior of the traffic at an intersection is another highly important element of signal design. The following elements should be considered:

1. Existing 15-minute vehicle volumes, by vehicle class, and pedestrian volumes, are the most basic operational consideration. Data used should represent intersection operation in peak periods.

2. Intersection capacity should be determined based on the Highway Capacity Manual and other sources.

3. The vehicle approach posted speeds should be determined for the location of advance detection.

4. Adjacent land uses should be evaluated to identify activities which may conflict with intersection operation. Items which should be considered include entrances, advertising devices, and areas of high pedestrian activity (schools, manufacturing plants, shopping centers, etc.).

5. Crashes within the intersection should be studied to determine causes and possible design solutions.

6. Pedestrian volumes and school-crossing activities should be studied to determine pedestrian routes and necessary design treatments. Pedestrian movements in and around signals should be routed into the intersection crosswalks in front of vehicles stopped for the signal.

9-6.04 System (Arterial) Considerations

In many cases, an individual traffic control signal must be considered as part of a system, either as one of a series of signals along a linear route, or as one signal in a grid network. System considerations in signal design should include but are not limited to the following:

1. Adjacent signals should be interconnected whenever they are less than one-half mile apart, when the travel time between adjacent signals is less than the cycle length at each signal, or when platoons leaving one intersection remain intact to the next signal.

2. Properly spaced signalized intersections greatly simplify coordination in planning new signals. Minimum spacing of one-quarter mile is recommended. Irregular signal spacing reduces the overall operational efficiency of the mainline movements and greatly complicates signal coordination.

3. Whenever possible, platoons should be kept intact to allow easier mainline coordination and minimize cross-street delay.

4. New street or roadway construction should anticipate the need for future signals and the need for handholes and conduit, particularly under the roadway.
5. Pretimed controllers are used in built-up urban environments, particularly central business districts. The streets are not excessively wide and the traffic patterns are quite predictable. In this environment, a signal cycle should contain pedestrian movements. Actuated controllers are used in suburban and rural environments. In the rural environment, the actuated controller tends to reduce the number of stops and does not cut off platoons of vehicles. In the suburban environment, the arterial streets tend to be very wide, and the volumes are usually quite high on these arterials. There are not usually many pedestrians crossing such an arterial, so an actuated controller tends to operate much more efficiently, as it is not necessary to time pedestrian intervals except when an actual demand exists.

6. Splits and offsets should be carefully estimated to determine their impact on arterial flow. A split is the relative percentage of green time allocated to each of the various phases at a single intersection. An offset is the travel time between signals, usually expressed in percent of cycle length.

7. Minimum pedestrian walk and clearance timings should be anticipated when designing coordinated signal systems.

9-6.05 Signal Design Elements

1. The most efficient operation of a signal system is attained with the fewest phases that are enough to move traffic without hazardous conflicts. Procedures exist to determine the optimum number of phases for an intersection. See the Signal Design Manual for a discussion of phasing considerations.

2. The primary consideration in signal head placement is clear visibility. Drivers approaching an intersection shall be given a clear and unmistakable indication of their right-of-way assignment. The number and placement of signal faces shall conform to the requirements of Sections 4D-15, 4D-16, and 4D-17 of the MN MUTCD. Overheads should be located as near as practicable to the line of the driver's normal view. When an overhead is to control two lanes, it should be installed over the lane line dividing the two lanes. An overhead should be used over each lane when speeds are above 40 mph. The size of lenses shall be as stated in section 4D-15 of the MN MUTCD. See the signal head placement charts in the Signal Design Manual. In general, vehicle signal faces should be placed and aimed to have maximum effectiveness for an approaching driver located a distance from the stop line equal to the distance traveled while reacting to the signal and bringing the vehicle to a stop at an average approach speed. Visors, shields, or visual delimiting should be used to help in directing the signal indication to the approaching traffic, and to reduce sun phantom resulting from external light entering a signal lens. The Horizontal Location of Signal Faces shown in MN MUTCD Figure 4D-6 should be used as an aid in placing vehicle signal faces.

3. Vehicle detectors should be placed according to the detector spacing chart and the loop placement diagrams shown in Signal Design Manual.

4. At locations where pedestrians are expected, provisions must be made to control pedestrian activity in and around the signalized intersection. At locations where pedestrians are expected, pedestrian indications shall be provided if minimum pedestrian crossing time exceeds minimum vehicular green time, or if any of the conditions set out in section 4E.3 of the MN MUTCD are met. Pedestrian push buttons should be installed at locations with pedestrian activity where it is not operationally efficient to provide pedestrian timing on every cycle. Pedestrian signal indications shall be mounted, positioned, and aimed so as to be in the line of pedestrians' vision, and to provide maximum visibility at the beginning of the controlled crossing.

5. If it is determined to prohibit pedestrian movement across any approach, that prohibition must be clearly visible to pedestrians by use of Standard Sign R9-3a on each side of the prohibited crosswalk. See part 4 of the MN MUTCD for further information.

6. Street lighting should normally be installed with traffic signals and flashing beacons. The luminaires are generally 250-watt high-pressure sodium vapor luminaires, mounted in the far-right quadrants of the major street. Larger intersections may require additional luminaires. Forty foot mounting heights provide even light distribution. Street lights installed on type A signal mast-arm poles should be mounted at approximately 350 degrees clockwise from the mast arm in order to provide frontal illumination of any signs mounted on the mast arm.
Signal design must take into account the existing adjacent lighting systems and the equipment available to provide access to the luminaires for relamping and maintenance. The presence of overhead power lines must also be taken into account. These must be designed around or moved.

A document called the Signal Design Review Check List is in the Signal Design Manual.

**9-7.00 TRAFFIC SIGNAL PLANS AND SPECIFICATIONS**

**9-7.01 General**

The end products of the pre-construction activities in signal design are the Plan, Special Provisions, and Engineer's Estimate. Supporting the Plans and Special Provisions are the standard design practices, Standard Plates Manual, the Mn/DOT Standard Specifications for Construction, other applicable national and local standards, and any necessary agreements. Detailed information is shown in the Signal Design Manual.

**9-7.02 Traffic Signal Plans**

The districts develop plans. If the districts desire they may request the review of plans by the Office of Traffic, Safety, and Operations.

**9-7.03 Special Provisions**

The Special Provisions for signal projects include complete detailed specifications of the signal system(s) and Maintenance of Traffic section which details the contract time schedule and provisions for traffic during construction. The Special Provisions are project specific specifications that supplement the Mn/DOT Standard Specifications for Construction book.

Responsibilities related to the Special Provisions are as follows:

1. District Traffic Engineer
   - Submits to the Special Provisions Engineer of the Office of Technical Support the Special Provisions for Mn/DOT designed signal system projects. The Special Provisions shall be submitted in accordance with the pre-determined "Project Pre-Letting Date" deadlines.
   - Submits to the Special Provisions Engineer in the Office of Technical Support a completed copy of Form 21184, Contract Time Schedule Recommendations and Misc. Data and Form 21185, Provisions for traffic During Construction. This information shall be submitted in accordance with the pre-determined “Project Pre-Letting Date” deadlines.

2. Office of Traffic, Safety, and Operations, Signal Unit
   - Upon request of the District, reviews Special Provisions for signal system projects let by the State or other agencies involving the trunk highway system. The Office of Traffic, Safety, and Operations website will maintain sample Special Provisions for District, Consultant, and other Agencies to access.

**9-7.04 Tabulation of Quantities**

The Detailed Construction Estimate (Engineer's Estimate) for all signal system projects let by the State is prepared by the Office of Technical Support. The District is responsible for providing a detailed tabulation of quantities to the Office of Technical Support as a basis for the Engineer's estimate. The Signal Design Manual provides a sample tabulation of quantities.
9-7.05 Standard Plates Manual


9-7.06 Mn/DOT Standard Specifications for Construction

The "Spec Book" contains standard provisions to be used and referred to in signal plans and special provisions.

9-7.07 Other Standards

Other national and local standards which are applicable to traffic signal plans and specifications are as follows:

1. National Electrical Code
3. ICEA-NEMA Standards for Electrical Wire and Cable
4. ITE Standards
5. State and Local Statutes and Ordinances
7. Mn/DOT Signal Design Manual

9-8.00 TRAFFIC SIGNAL CONSTRUCTION

9-8.01 State Furnished Material

It is in the public interest for Mn/DOT to supply both new and refurbished traffic signal equipment and to assemble and modify this equipment for federal-aid projects because of the cost savings. The purchase of large quantities of materials occurs using the low bid process and then the material is supplied to the contractor for each contract. The state purchasing of material shall conform with FHWA PPM 21-6.3, Para. 14 and a Public Interest Finding will be completed.

When it is determined that there will be State furnished materials to be provided by the Central Electrical Services Unit (CESU):

2. The AFMS System ID and TE Request number should be on the Traffic Signal plan.
3. One or two weeks prior to the letting of the contract, the District Traffic Office approves the TE Request on the AFMS.
4. The CESU reviews the TE Request and enters the Electronic Concurrence in the AFMS.
5. The work is then assigned and completed by CESU personnel.

9-8.02 Signal Turn-On Procedure

Advance notice should be given to the public when a signal is to be activated. Those who should be present when the signal is activated include: (1) Project Engineer, (2) Contractor, (3) District Traffic Engineer (4) Regional Electrical Services Unit (RESU) / Metro Electrical Services Unit (MESU), and (5) City Police, if appropriate. The MN MUTCD describes the considerations for bringing the new signal out of flashing operation into normal stop and go operation.
9-8.03 Post Turn-On Procedures

After a signal has been activated, a copy of a memorandum of notification should be sent to:

(1) the city, (2) the county, (3) the affected power company, (4) the State Patrol, (5) CESU & RESU/ MESU, and (6) the Office of Traffic, Safety, and Operations (Central Office). This notice should include the location, date and time of turn-on; maintenance responsibilities (including dates of warranties affecting the project); and the vertical clearances of any objects suspended over the roadways.

A sample signal turn on letter can be found on the Office of Traffic, Safety, and Operations website.

9-9.00 TRAFFIC SIGNAL OPERATIONS

9-9.01 General

It is the responsibility of the District Traffic Engineer to observe the operation of all traffic signals in his or her district. Any timing or operation that is not correct should be corrected. The determination of the timing can be assisted by personnel in the Central Office Signal Unit. Unusual hardware implementations may require the assistance of personnel from the Central Electrical Services Unit. The District Traffic Engineer shall maintain a complete timing record, including all preemption timing, in the controller cabinet and in the District office. In the event the District Traffic Engineer determines a traffic signal is to be revised by state maintenance forces, a TE request is to be written. The TE Request should outline the work that is to be done. Normally, the District Traffic Office will be contacted by the Central, Metro, or Regional Electrical Services Unit, as appropriate, after concurrence and before the work is done.

Each district shall budget for payment of electrical power usage where the State has that responsibility.

The district shall keep a current maintenance log in each controller cabinet and any timing change performed to that signal shall be duly recorded on that log.

A sample signal maintenance log sheet can be found on the Office of Traffic, Safety, and Operations website.

9-9.02 Operational Timing Practices

Detailed information is shown in Signal Timing Manual. It should be noted that those guidelines, procedures and practices are general and should only be used as a guide. Many other factors at each individual intersection must be considered along with engineering judgment when applying the guidelines.

9-10.00 TRAFFIC SIGNAL MAINTENANCE

9-10.01 General

Maintenance work on traffic signal systems that is the responsibility of the State is performed by the Metro or Regional Electrical Services Unit. Metro or Regional Electrical Services Unit personnel perform electrical and hardware field repairs and minor installation projects. The Central Electrical Service Unit (CESU) performs shop repairs of traffic signal control equipment, receives Gopher State One Call location requests, prepares State-furnished equipment for installation by contractors on traffic signal projects, and provides technical field assistance.

A municipality or county may, by resolution, request that the State with its own forces perform certain maintenance work assigned to the municipality or county by a Cooperative Signal Agreement, for which work the State will be reimbursed. The District and the Metro or Regional Electrical Services Unit should evaluate such request for feasibility for the State to do this additional work. The signal agreement will define responsibilities for maintenance and power cost.
9-10.02 Malfunction Repair

In the event of an equipment malfunction, the District Traffic Engineer, State Patrol, or other authorities call the Metro or Regional Electrical Services Unit to dispatch a repair crew. The District Traffic Engineer assigns each intersection a Signal Maintenance Priority which indicates the order in which traffic signal malfunctions should be serviced when malfunctions are known to exist at more than one intersection. In general, any signals outside of the metropolitan area have priorities no higher than C. The Signal Maintenance Priorities are as follows:

A. Repair as soon as possible
B. Repair before next peak hour
C. Repair next scheduled workday
D. Repair as schedule permits
N. No State maintenance responsibility

After hours, the District traffic personnel shall call the District Maintenance Dispatcher. The dispatcher will contact the appropriate Metro or Regional Electrical Services Unit "on call" person. After the dispatcher makes contact with the Metro or Regional Electrical Services Unit, it is the responsibility of this person to follow-up on the problem. If needed, appropriate District traffic personnel may be contacted after hours.

When a traffic signal malfunction has been reported to the District, and the local authority is responsible for the maintenance of that traffic signal, the responsible jurisdiction should be contacted immediately to arrange for prompt repair.

9-10.03 Lamp-outs

All lamp-outages that are the responsibility of Mn/DOT shall be reported to the Metro or Regional Electrical Services Unit personnel. Lamp-outages that are the responsibility of other agencies shall be reported to them for correction. Any lamp-outage report received by the Metro or Regional Electrical Services Unit that is not the responsibility of Mn/DOT will be referred to the responsible agency for correction. All such reports shall be documented by the Metro or Regional Electrical Services Unit.

9-10.04 Signal Maintenance Log

Anyone who does any repair work or modifications in the cabinet or at the intersection shall record the action in the signal maintenance log. The signal maintenance log provides a historical record of work done in the cabinet to assist personnel in diagnosing problems in the cabinet and in making operational adjustments.

9-10.05 Automated Facilities Management System

In addition to the signal maintenance log contained in the intersection controller cabinets, the Automated Facilities Management System (AFMS) maintains a record of signal maintenance for each intersection for which the State has maintenance responsibility. Whenever a maintenance call is made to an intersection, the work that is done is recorded and entered into the AFMS. The AFMS provides data for analysis of such factors as maintenance time apportionment and equipment reliability.

The Automated Facilities Management System contains computer records for all traffic signals and flashing beacon systems on trunk highways in Minnesota and for any additional traffic signals or other devices for which the State has any responsibility.
9-11.00 TRAFFIC SIGNAL COMPUTER AIDS

9-11.01 General

The computer is an important and powerful tool in traffic engineering. District traffic offices, traffic engineers and technicians in the State of Minnesota have access to a number of computer programs which assist in the intersection or network geometry setup and/or modification; traffic signal warrant analysis and justification, design, timing and coordination plan development, operations, and management of traffic signal systems. Computer programs can also help with signal inventory and maintenance management. More information can be found in the Signal Timing Manual.

9-11.02 Desktop Computer (PC) Software

There are many PC software programs available to the traffic signal designer or operations analyst.

The Highway Capacity Manual software was developed for the Federal Highway Administration and follows the capacity analysis procedures found in the latest edition of the Highway Capacity Manual.

The signal warrant analysis software, given volume, speed and geometric data for an intersection, will produce a table and graphs, and will analyze the volume counts against traffic signal warrants defined in the Minnesota Manual of Uniform Traffic Control Devices (MN MUTCD).

There are many computer tools that users can choose from for signal timing and coordination analysis applications. A detailed introduction of the Mn/DOT most used software, Synchro, and a brief description of three other widely utilized programs, including, TRANSYT-7F, PASSER-II, and CORSIM are provided in Mn/DOT Traffic Signal Timing Manual. It is important to know that one can not (or should not) simply implement the computer-generated timing and offset settings. The engineers must carefully fine-tune the settings in the field based on observations of actual traffic flows.

9-11.03 Computer-Aided Drafting

Microstation is an extremely powerful computer-aided drafting software. Training is available through the Office of Computer-Aided Engineering Services (CAES) in Central Office.

9-12.00 REFERENCES


5. Minnesota Department of Transportation, Standard Specifications for Construction.


7. Minnesota Manual on Uniform Traffic Control Devices (MN MUTCD)


ABBREVIATIONS / ACRONYMS

AFMS - Automated Facilities Management System
AWF - Advance Warning Flasher
CAES - Office of Computer-Aided Engineering Services
CESU - Central Electrical Service Unit
FHWA - Federal Highway Administration
ITE - Institute of Transportation Engineers
ITS - Intelligent Transportation Systems
LED - Light-Emitting Diode
MESU - Metro Electrical Service Unit
Mn/DOT - Minnesota Department of Transportation
MN MUTCD - Minnesota Manual on Uniform Traffic Control Devices
MUTCD - Manual of Uniform Traffic Control Devices
NEMA - The National Electrical Manufacturers Association
NFPA - National fire Protection association
RESU - Regional Electrical Service Unit
SJR - Signal Justification Report
TE request - Traffic Engineering Request
Limited Sight Distance

\[ a = 2.4 \text{ meters} \times \text{speed}^2 \]

\[ \text{Sight Distance to Stop Bar, meters (feet)} \]

A sight distance falling below the lines for the given speed and grade indicates the possible need for an AWF.

Text Ref.: 9-4.02.03
A sight distance falling below the lines for the given speed and grade indicates the possible need for an AWF.

Limited Sight Distance

\[ a = 3.0 \text{ meters (10 feet)} \text{ per second squared (} \leq 15\% \text{ trucks)} \]

Sight Distance to Stop Bar, meters (feet)

<table>
<thead>
<tr>
<th>Posted Speed, mph</th>
<th>70</th>
<th>65</th>
<th>60</th>
<th>55</th>
<th>50</th>
<th>45</th>
</tr>
</thead>
<tbody>
<tr>
<td>300 (880)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>250 (760)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>200 (650)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>150 (490)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>100 (330)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 9.1B

Text Ref.: 9-4.02.03
Chapter 10
LIGHTING OF TRAFFIC FACILITIES

TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>10-1.00</td>
<td>INTRODUCTION</td>
<td>10-3</td>
</tr>
<tr>
<td>1.01</td>
<td>Purpose</td>
<td></td>
</tr>
<tr>
<td>1.02</td>
<td>Scope</td>
<td></td>
</tr>
<tr>
<td>1.03</td>
<td>Chapter Organization</td>
<td></td>
</tr>
<tr>
<td>10-2.00</td>
<td>GLOSSARY</td>
<td>10-3</td>
</tr>
<tr>
<td>10-3.00</td>
<td>LIGHTING PROJECT PROCEDURES</td>
<td>10-5</td>
</tr>
<tr>
<td>3.01</td>
<td>Warrants</td>
<td></td>
</tr>
<tr>
<td>3.02</td>
<td>Programming</td>
<td></td>
</tr>
<tr>
<td>3.03</td>
<td>Negotiations</td>
<td></td>
</tr>
<tr>
<td>3.04</td>
<td>Work Authorities</td>
<td></td>
</tr>
<tr>
<td>3.05</td>
<td>Preparation of Plans</td>
<td></td>
</tr>
<tr>
<td>3.06</td>
<td>Preparation of Special Provisions</td>
<td></td>
</tr>
<tr>
<td>3.07</td>
<td>Preparation of Agreements</td>
<td></td>
</tr>
<tr>
<td>3.08</td>
<td>Project Letting</td>
<td></td>
</tr>
<tr>
<td>10-4.00</td>
<td>LIGHTING SYSTEM DESIGN</td>
<td>10-11</td>
</tr>
<tr>
<td>4.01</td>
<td>Typical Lighting Systems</td>
<td></td>
</tr>
<tr>
<td>4.02</td>
<td>Lighting System Components</td>
<td></td>
</tr>
<tr>
<td>4.03</td>
<td>Temporary Lighting</td>
<td></td>
</tr>
<tr>
<td>4.04</td>
<td>Sign Lighting</td>
<td></td>
</tr>
<tr>
<td>10-5.00</td>
<td>CONSTRUCTION</td>
<td>10-19</td>
</tr>
<tr>
<td>5.01</td>
<td>Field Placement of Light Poles</td>
<td></td>
</tr>
<tr>
<td>5.02</td>
<td>Documentation</td>
<td></td>
</tr>
<tr>
<td>10-6.00</td>
<td>OPERATION AND MAINTENANCE</td>
<td>10-20</td>
</tr>
<tr>
<td>6.01</td>
<td>General</td>
<td></td>
</tr>
<tr>
<td>6.02</td>
<td>Budgeting</td>
<td></td>
</tr>
<tr>
<td>6.03</td>
<td>Maintenance</td>
<td></td>
</tr>
<tr>
<td>6.04</td>
<td>Obtaining Electrical Power from Mn/DOT Lighting or Signal Systems</td>
<td></td>
</tr>
<tr>
<td>10-7.00</td>
<td>REFERENCES</td>
<td>10-23</td>
</tr>
<tr>
<td>10-8.00</td>
<td>APPENDIX</td>
<td>10-1.1</td>
</tr>
</tbody>
</table>
# LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.1</td>
<td>Typical Luminaire Locations-Partial Interchange Lighting, Davit Arm Poles</td>
<td>10-25</td>
</tr>
<tr>
<td>10.2</td>
<td>Typical Luminaire Locations-Partial Interchange Lighting, Vertical Mount Poles</td>
<td>10-26</td>
</tr>
<tr>
<td>10.3</td>
<td>Standard Illumination Plan for Intersections</td>
<td>10-27</td>
</tr>
<tr>
<td>10.4</td>
<td>Pole Type Designations</td>
<td>10-28</td>
</tr>
<tr>
<td>10.5</td>
<td>Typical Conduit Placement (Cloverleaf Interchange)</td>
<td>10-29</td>
</tr>
<tr>
<td>10.6</td>
<td>Typical Conduit Placement (Diamond Interchange)</td>
<td>10-30</td>
</tr>
<tr>
<td>10.7</td>
<td>Removed</td>
<td></td>
</tr>
<tr>
<td>10.8</td>
<td>Voltage Drop Calculation Values</td>
<td>10.1-4</td>
</tr>
<tr>
<td>10.9</td>
<td>Voltage Drop Calculation Examples</td>
<td>10.1-5</td>
</tr>
</tbody>
</table>
CHAPTER 10 - LIGHTING OF TRAFFIC FACILITIES

10-1.00 INTRODUCTION

10-1.01 Purpose

The purpose of this chapter is to present the preferred practice in Minnesota for the lighting of traffic facilities. The chapter also presents the step by step procedure for initiating, designing, and letting a contract for the construction of an electric lighting system.

10-1.02 Scope

This chapter is to be a guideline rather than a standard. Together with other documents, this chapter gives guidelines for lighting installations on roadways, underpasses, tunnels, rest areas, weigh stations, parking lots, lighted signs, and bridges.

The principal reference for lighting design is the "Roadway Lighting Design Guide" published by the American Association of State Highway and Transportation Officials (AASHTO), hereafter referred to as the AASHTO Guide.

The AASHTO Guide is an essential document to accompany this chapter and is a frequent reference within the chapter.

Other important documents include the "American National Standard Practice for Roadway Lighting" published by the Illuminating Engineering Society and the National Electrical Code" published by the National Fire Prevention Association. Other references are listed at the end of the chapter.

10-1.03 Chapter Organization

Following this introduction is a glossary. Following the glossary are step by step procedures for producing a lighting project. Next follows detailed information about the design of lighting systems. A section discussing the construction of lighting systems is included followed by operation and maintenance considerations. A listing of references follows. The appendix details the method for calculating voltage drops in lighting system wires. Figures are included throughout the text.

10-2.00 GLOSSARY

Ambient Light - Illumination at, near, or around a traffic facility but outside of the right-of-way.

Average Initial Illumination - The average level of horizontal illumination on the pavement area of a traveled roadway at the time the lighting system is installed, when lamps are new and luminaires are clean; expressed in footcandles (lux).

Average Maintained Illumination - The average level of horizontal illumination on the pavement area of a traveled roadway when the illuminating source is at its lowest output and when the luminaire is in its dirtiest condition; expressed in footcandles (lux).

Ballast - An auxiliary device used with high intensity discharge (HID) lamps to provide proper starting and operating characteristics. It limits the current through the lamp and may also regulate the voltage.

Candela - The unit of luminous intensity (the force generating the luminous flux). Formerly the term "candle" was used.

Complete Interchange Lighting - The lighting of the roadway through the interchange, the traffic lanes of all ramps, the acceleration and deceleration lanes, all ramp terminals, and the crossroad between the outermost ramp terminals.
Davit Mast Arm - One-piece shaft which curves from vertical to horizontal.

Footcandles (lux) - The unit of illumination when the foot is taken as the unit of length. It is the illumination on a surface one square foot in area on which there is a uniformly distributed flux of one lumen, or the illumination produced on a surface, all points of which are at a distance of one foot from a directionally uniform point source of one candela.

Glare - The brightness of a light source which causes eye annoyance, discomfort, or loss in visual performance and visibility.

Gore - On a freeway or expressway, the area where the mainline of the roadway and the ramp diverge or converge.

High Base - Transformer base which tapers from a base plate to a smaller shaft.

Horizontal Lux - Lux measured in a horizontal plane.

Illuminance - The density of luminous flux incident on a surface; it is the quotient of the luminous flux by the area of the surface when the latter is uniformly illuminated, expressed in lumens per square meter.

Lamp - A source of light. The device within a luminaire which converts the electrical energy to light.

Light-Loss Factor - A depreciation factor which is applied to the calculated initial average footcandle (lux) to determine the value of depreciated average illumination at a predetermined time in the operating cycle, usually just prior to relamping, and which reflects the decrease in effective light output of a lamp and luminaire during its life.

Lumen - The unit of luminous flux (time rate of flow of light). A lumen is defined as the luminous flux emitted by a point source having a uniform luminous intensity of one candela.

Luminaire - A complete lighting fixture consisting of a lamp or lamps together with the ballast, reflector, refractor, photocell when required, and the housing.

Luminance - The luminous intensity of any surface in a given direction per unit of projected area of the surface as viewed from that direction, expressed in candela per square meter.

Lux - The International System (SI) unit of illuminance. One lux is defined as the illuminance incident on a surface of one square meter, all points of which are one meter from a uniform source of one candela.

Partial Interchange Lighting - Lighting which consists of a few luminaires located in the vicinity of some or all ramp terminals. The usual practice is to light those general areas where the exit and entrance ramps connect with the through traffic lanes and those areas where the ramps intersect the crossroad.

Pavement Reflection Factor (or Reflectance) - The ratio of the light reflected by a pavement surface to the light incident upon it.

Post Top Lighting Unit - A light pole with a short vertical shaft for mounting the luminaire.

Progressive-Shear Base - A high base that is riveted or spot-welded to a base plate designed to shear progressively on impact.

Shoe Base - A low profile casting that connects the shaft to the pole base plate.

Slip Base - A pole base plate designed to slide off a lower plate on impact.

Specular Glare - Glare resulting from light being reflected from polished or glossy surfaces.

Transformer Base - A box-like structure between the foundation and pole base plate which can be used to accommodate the ballast and the underground wiring connections.

Truss Mast Arm - A horizontal bracket used to support the luminaire.
Uniformity Ratio - Average to minimum uniformity ratio is the ratio of average footcandle (lux) of illumination on the design area to the footcandle (lux) at the point of minimum illumination on the area. Maximum to minimum uniformity ratio is the ratio of the maximum footcandle (lux) value at any point on the design area to the point of lowest footcandle (lux) value.

Vertical Lux - Lux measured in a vertical plane.

10-3.00 LIGHTING PROJECT PROCEDURES

This section describes the process involved in bringing a state administered lighting project from its inception to its completion. The section lists the steps involved and then describes each step separately.

For projects that utilize state funds but are not administered by the state, the Office of State Aid will request the District Traffic Engineer for any assistance it needs to handle the project. Local jurisdictions may also, with proper permission, administer lighting projects on state trunk highways at their sole expense, as when the local jurisdiction desires lighting that is determined by the state to be unwarranted. Form 2525, the utility permit application, is obtainable from the district office for this purpose. Any lighting on state trunk highways must be approved by the Mn/DOT regardless of the agency installing.

The district initiates state administered lighting projects.

The following steps are necessary for completing a lighting project:

1. Programming the project
2. Negotiating with local authorities and utilities
3. Implementing a work authority
4. Preparing plans
5. Preparing special provisions
6. Preparing agreements
7. Letting the project

10-3.01 Warrants

The primary purpose of warrants is to assist administrators and designers in evaluating locations for lighting needs and selecting locations for installing lighting. Warrants give conditions which should be satisfied to justify the installation of lighting. Meeting these warrants does not obligate the state to provide lighting. Conversely, local information in addition to that reflected by the warrants, such as roadway geometry, ambient lighting, sight distance, signing, crash rates, or frequent occurrences of fog, ice, or snow, may influence the decision to install lighting. The warrants are applicable to all lighting projects for which the state participates in the cost, whether the contract is administered by the state or by a local governmental agency.

Warrants for freeway lighting are contained in the AASHTO Guide, with the modifications and additions indicated below:

Continuous Freeway Lighting

Case CFL-1 - Continuous freeway lighting is considered to be warranted on those sections in and near cities where the current ADT is 40,000 or more.

Case CFL-2 - Continuous freeway lighting is considered to be warranted on those sections where three or more successive interchanges are located with an average spacing of 1-1/2 miles or less, and adjacent areas outside the right-of-way are substantially urban in character.
Case CFL-3 - Continuous freeway lighting is considered to be warranted where for a length of 2 miles or more, the freeway passes through a substantially developed suburban or urban area in which one or more of the following conditions exist:

a. local traffic operates on a complete street grid having some form of street lighting, parts of which are visible from the freeway;

b. the freeway passes through a series of developments such as residential, commercial, industrial and civic areas, colleges, parks, terminals, etc., which includes roads, streets and parking areas, yards, etc., that are lighted;

c. separate cross streets, both with and without connecting ramps, occur with an average spacing of one-half mile or less, some of which are lighted as part of the local street system; and

d. the freeway cross section elements, such as median and borders, are substantially reduced in width below desirable sections used in relatively open country.

Case CFL-4 - Continuous freeway lighting is considered to be warranted on those sections where the ratio of night to day crash rate is at least 2.0 or higher than the state wide average for all unlighted similar sections, and a study indicates that lighting may be expected to result in a significant reduction in the night crash rate.

Continuous lighting should be considered for all median barriers on roadway facilities in urban areas. In rural areas each location must be individually evaluated as to its need for illumination.

Complete Interchange Lighting

Complete interchange lighting generally is warranted only if the mainline freeway has continuous lighting.

Partial Interchange Lighting

Case PIL-1 - Partial interchange lighting is considered to be warranted where the total current ADT ramp traffic entering and leaving the freeway within the interchange areas exceeds 5000 for urban conditions, 5000 for suburban conditions, or 2500 for rural conditions.

Case PIL-2 - Partial interchange lighting is considered to be warranted where the current ADT on the freeway through traffic lanes exceeds 25,000 for urban conditions, 20,000 for suburban conditions, or 10,000 for rural conditions.

Case PIL-3 - Partial interchange lighting is considered to be warranted where the ratio of night to day crash rate within the interchange area is at least 1.25 or higher than the state wide average for all unlighted similar sections, and a study indicates that lighting may be expected to result in a significant reduction in the night crash rate.

The AASHTO Guide also contains guidelines on special considerations for roadway lighting.

The AASHTO Guide gives no specific warrants for continuous lighting of roadways other than freeways (roads with fully controlled access, no at-grade intersections), but does suggest some general criteria that may apply when considering the installation of lighting.

Lighting of at-grade intersections is warranted if the geometric conditions mentioned in the AASHTO Guide exist or if one or more of the following conditions exists:

1. **Volume** - The traffic signal warrant volumes for the minimum vehicular volume warrant, the interruption of continuous traffic warrant, or the minimum pedestrian volume warrant are satisfied for any single hour during conditions other than daylight, excluding the time period between 6:00 a.m. and 6:00 p.m. See the "Traffic Signals" chapter of this manual and the "Signals" chapter of the "Minnesota Manual on Uniform Traffic Control Devices" (MN MUTCD) for further information about traffic signal warrants.
2. **Crashes** - There are three or more crashes per year occurring during conditions other than daylight.
3. **Intersecting Roadway** - The intersecting roadway is lighted.
4. **Ambient Light** - Illumination in areas adjacent to the intersection adversely affects the drivers' vision.
5. **Channelization** - The intersection is channelized and the 85th percentile approach speed exceeds 40 miles per hour. A continuous median is not considered as channelization for the purpose of this warrant.
6. **School Crossing** - Scheduled events occurring at least once per week during the school year make it necessary for 100 or more pedestrians to cross at the school crossing during any single hour in conditions other than daylight, or a traffic engineering study indicates a need for lighting.
7. **Signalization** - The intersection is signalized.
8. **Flashing Beacons** - The intersection has a flashing beacon.

Warrants covering lighting for roundabout intersections, tunnels, underpasses, rest areas, and signs are contained in the AASHTO Guide.

10-3.02 Programming

The Transportation District Engineer is responsible for requesting Planning and Programming to encumber funds for lighting installations.

10-3.03 Negotiations

In most instances, lighting installations involve negotiations and agreements with local authorities and power companies. The responsibility for negotiating with municipalities, counties, railroads, and power companies rests with the district. The Utility Agreements Unit of the Office of Technical Support, the Office of Freight and Commercial Vehicle Operations (OFCVO), and the Lighting Unit may all be available to assist the district in such negotiations.

10-3.04 Work Authorities

Work authorities are required before design or construction is started. A function 1 work authority is for preliminary design, function 2 is for detail design, and function 3 is for construction. Where the lighting design is part of the road plans, the engineer in charge of the road design should implement the work authority, including the lighting design work, and a separate work authority for the lighting portion of the plan is unnecessary.

10-3.05 Preparation of Plans

The district traffic office or the Lighting Unit in the Office of Traffic, Safety, and Technology (OTST) designs the lighting system and drafts the plans for lighting systems that will be installed under a state contract.

The lighting plans should include a title sheet showing the project location and description, the state and federal project number(s), the area and job number(s), appropriate signature lines, roadway design values, legends and symbols, a list of scales, and a plan index. Appropriate symbols are contained in the Mn/DOT road design "Technical Manual."

When a municipality is participating in the cost for installing or maintaining the lighting system, the title sheet should include a signature line for the appropriate authority from the municipality. The district traffic engineer should submit a final copy of the plan to the municipality for review and approval before the project is let.
Also included in the lighting plans should be a statement of estimated quantities. Normally, the lighting system pay items are itemized showing items for conduit, cable, light standards, etc. Any notes pertaining to any of the items in the estimated quantities should be included on the estimated quantities sheet. Paying for the lighting system as a lump sum item may be more convenient than itemizing in certain situations. To simplify estimating and bidding when a lump sum pay item is used, the plans should include a tabulation of the individual items that are part of the lump sum.

Detail sheets should show pole details for each type of pole used in the project, details for mounting the service cabinets and photoelectric controls, any special anchorage details, conduit attachment to bridges for underpass lighting, and any other necessary details.

Each layout sheet should include a layout of the roadway and locations of light standards, cable, service cabinets, conduit, junction boxes, and handholes. All of these items should be properly labeled and identified. A tabulation should list stations, locations, and types of lighting units.

All luminaires and sign lights indicated in the plans should be labeled with a unique number. Numbers for roadway, tunnel, and underpass luminaires should consist of the feedpoint number above a number indicating the luminaire on that feedpoint. The luminaires should be numbered consecutively. Sign light numbers should consist of the feedpoint number above a letter indicating the sign light on that feedpoint and should be numbered from left to right separately for signs facing each direction of travel on the roadway.

The plans should include wiring diagrams to detail the wiring of the lighting circuits and to show wire sizes. Information sheets should be included when appropriate.

The designer must contact the appropriate power company to establish source of power(s). The power company may require extra equipment and have an electrical service charge. All communications with the power company shall be confirmed in writing.

10-3.06 Preparation of Special Provisions

The special provisions for a lighting project should give any necessary information that is not given in the plans or in the Mn/DOT Standard Specifications for Construction, as well as information that is to be specially brought to the bidders' attention. This information may include an explanation of the electrical distribution system, materials specifications for materials that are not in the standard specifications book, construction requirements that are not included in the standard specifications book, a statement of items that are to be furnished by the state, and an explanation of what is included in each pay item.

The district lighting designer normally prepares the special provisions for lighting systems. The Lighting Unit may help if requested.

10-3.07 Preparation of Agreements

An agreement is a legal document detailing the cost responsibility of the various parties involved in installing, maintaining, and providing power to a lighting system. The district prepares agreements for lighting that is not a part of a road construction project.

Agreements for lighting that is a part of a road construction project are normally prepared by the Municipal Agreements Unit of the Office of Technical Support.

An agreement may be between the state and one or more power company, railroad, or municipality (city or county). An agreement with a railroad is described below, followed by a description of an agreement with a power company and then with a municipality. The terms of the agreements will be unique to each lighting project, and so only the general considerations are presented.
10-3.07.01 Agreement with a Railroad

Agreements and permits may be necessary for power cables over or under railroad tracks. Highway maintenance funds should be used for any costs incurred.

10-3.07.02 Agreement with a Power Company

Mn/DOT typically meters all roadway lighting and an agreement with the local power company is not needed. In rural locations, it may make sense to have an agreement with the local power company.

An agreement with a power company details the method of paying for power for the lights, certain maintenance of the lights, and possibly for providing power company owned lights. Rates for highway lighting may include maintenance such as luminaire and glassware maintenance and cleaning, lamp replacement, ballast maintenance, and photo-cell maintenance in addition to supplying electrical energy. The service cabinet, wiring system, and pole knockdowns are almost always maintained by the state and are not part of an agreement with the power company. Agreements with power companies should be open ended agreements such that additions or changes to the number and types of lights covered may be made by properly processing an exhibit showing the addition or change. A flat rate is then charged for each light fixture of each particular type.

The rates charged by power companies, except municipal utilities, are regulated by the Minnesota Public Service Commission. The power company must set forth these conditions in a letter to the Commission when filing a new proposed rate schedule or when filing a change of the rate schedule. The rates set forth in the schedule may be put into effect by the utility 30 days after the letter is filed with the Commission. Municipal utilities are regulated by the residents of the municipalities which own and operate them rather than by the Minnesota Public Service Commission.

When power company owned lights are to be provided, the district traffic office should prepare a preliminary exhibit containing the name of the power company, location, type, and number of lights, and send it to the Lighting Unit of the OTST for processing. If the state does not have an open ended agreement with the power company to provide power company owned lights, the district may request the Lighting Unit to write one. Agreements for power company owned lights should include maintenance by the power company.

Agreements with the power company may be required for extending power lines to the electrical service point of the lighting system. Costs for extending power lines should not be included in the open ended agreements with the utility for providing power and maintenance for lights.

Exhibits are necessary for additions and changes to existing open ended agreements. An exhibit is a reduced copy of a lighting plan layout sheet and shows the exhibit number, the highway, the city if applicable, the power company, the feedpoint number, and the total number of lights of each type after the addition or change. Attached to the layout is a Signature sheet indicating the exhibit number, the number and date of the open ended agreement which is being altered by the exhibit, and a summary of the changes. The district notifies the power company of the date of effect of the change once the lights have been turned on.

Two copies of all exhibits are sent to the Electrical Services Section to update their location files.

10-3.07.03 Agreement with a Local Road Authority - Cost Participation Policy

An agreement with a local road authority details the cost responsibility for the design, installation, maintenance, and power cost of a roadway lighting system.

- Cooperative Agreement - An agreement that includes participation by the local road authority in the installation cost as well as detailing the maintenance responsibility.

- Maintenance Agreement - An agreement that only involves the maintenance responsibility, with no participation by the local road authority for installation.
The roadway lighting system may be installed as a state contract or a local government contract. The local road authority or the state may pay the entire cost or part of the cost of any of these items. The negotiations between the district and the local road authority shall be in accordance with the state lighting cost participation policy found at www.dot.state.mn.us/stateaid/forms/dsll_1.pdf. Such factors as the location of the lights, the agency administering the contract, the types of light poles and luminaires used, the jurisdiction of the intersection roadways, warrants met, and past practice all may influence the negotiated cost splits.

The recommended cost splits are as described below:

1. **Trunk Highways - Freeway (Limited Access Including Interstate)**
   a. The state will determine what portions of freeway type highways will be lighted and the lighting intensities to be provided in accordance with the requirements in the Traffic Engineering Manual - Chapter 10. The state will install, maintain and pay the power cost for those lighting units it deems to be needed. Roadways which will be considered and may be lighted are the main travelled roadways, ramps, and the intersections of ramps with cross streets.

   The lighting of frontage roads not concurrent with ramps should be the sole responsibility of the local road authority.

   b. The lighting of every interchange is not deemed to be necessary. The state will install lighting units and pay for them where engineering and economic studies indicate the existence of appropriate justification in accordance with the requirements in the Traffic Engineering Manual - Chapter 10. If a local road authority requests that unjustified lighting at an interchange be installed and the requester is willing to pay the plan preparation, construction, maintenance and power costs and the installation is approved by the District/Division Engineer, the system will be installed in accordance with Mn/DOT's standards as indicated in the Traffic Engineering Manual - Chapter 10. The state will maintain the system and be reimbursed by the requesting agency.

2. **Trunk Highways (Arterial and Expressway)**
   a. The state will determine what portions of trunk highways will be lighted and the lighting intensities to be provided in accordance with the requirements in the Traffic Engineering Manual - Chapter 10. The state will install, maintain and pay the power cost for those lighting units it deems to be needed.

   b. If a local authority desires to install a lighting system on a trunk highway within its jurisdiction, the local authority is normally responsible for all costs. The state may pay up to 50% of the construction cost for continuous or intersection lighting at Mn/DOT's standards as indicated in the Traffic Engineering Manual. The local road authority will pay the remaining construction cost and be solely responsible for all maintenance and power costs. Any lighting systems installed on the right-of-way by Mn/DOT, or a local road authority with less than 100% Mn/DOT participation, requires the local road authority to apply for a Utility Permit, Form 2525.

   c. If a local road authority is operating a lighting system on a street at its own expense, and the reconstruction of the street by the state requires relocation of all or part of the system, the local road authority will pay the cost of relocation.

   d. The lighting of every rural intersection is not deemed to be necessary. If a local road authority requests that lighting be installed and lighting is justified, the state may pay 50% of the construction cost at trunk highway/local road authority intersections or may pay 100% of the construction cost at trunk highway/trunk highway intersections and the local road authority will be solely responsible for all maintenance and power costs. If a local road authority is willing to pay the plan preparation, construction and maintenance costs, including power, of an unjustified roadway lighting system, the District Engineer may approve the installation.
Preparing of an agreement involves several steps. The district and the municipality should agree on the percentage of the total cost that each agency will pay and the method of payment, and the district or Municipal Agreement Unit of Technical Support will prepare an agreement. The agreement should be processed in a similar fashion as the traffic signal agreements, detailed in the "Traffic Signals" chapter of this manual.

For lighting systems that are being installed by a municipal contract, the district should request funding from the Office of Investment Management with money from the special agreements fund.

3. Aesthetic Bridge Designs


10-3.08 Project Letting

Upon the completion of the plans, special provisions, cost estimate, and agreement, the project will be advertised, bids accepted, and the project awarded to the lowest qualified bidder.

10-4.00 LIGHTING SYSTEM DESIGN

Once the decision is made to install lighting, the design stage can begin. This section describes typical Mn/DOT designs. The design must be appropriate for the site and must provide the level and uniformity of light suggested in the AASHTO guide. The lighting described in this section is a product of the illuminance method of lighting design. Lighting may also be designed using the luminance method described in the AASHTO Guide. Both methods produce satisfactory results.

Several manufacturers of lighting fixtures and some consultants offer computer programs to analyze light levels for a user-defined roadway with user-defined lighting installed. These programs are excellent tools for determining luminaire mounting heights, wattages, and spacings necessary to provide the proper light levels and uniformity of light on a roadway.

10-4.01 Typical Lighting Systems

10-4.01.01 Continuous Freeway Lighting

In order to obtain the 0.6 - 1.1 footcandles light levels and the 3:1 to 4:1 average to minimum uniformity ratio as indicated for freeways in the AASHTO Guide, the lights may be median barrier mounted lighting units, roadside mounted lighting units, or both Median barrier mounted lighting units with double mast arms provide the same number of luminaires with fewer poles than roadside mounting requires. Back side spill light from the luminaires is utilized by the opposite roadway with median barrier mounted lighting units but is wasted with roadside mounted lighting units. Barrier mounted lighting units are less likely to be knocked down than are roadside mounted lighting units, however they can be very difficult to maintain.

Lighting units mounted on a median barrier typically use double 6-foot davit-type mast arms. Roadside mounted lighting units typically use either a single 12-foot davit-type mast arm and placed 19 - 26 feet behind the edge of the traveled roadway; or a tenon-type mounting assembly and placed 23 - 36 feet from the edge of the travelled roadway.

The lights for a roadway with two lanes in each direction are typically 40-foot poles with 250 watt high pressure sodium luminaires, and 240 feet between poles. For a roadway with four or more lanes in each direction, the lights are typically 49-foot poles with 250 watt high pressure sodium luminaires, and 280 feet or more between poles.
When adequate clearance and slopes are available, vertical mount lighting units may be utilized. The vertical mount lights are typically 45-foot poles with single or double tenon mounted with 250 watt high pressure sodium luminaires. They can also be mounted on a median barrier or bridge.

Roadways with three lanes in each direction may use either of the above configurations depending on the surrounding lighting. Roadways with more than 4 lanes in each direction may require both median barrier mounted lights and roadside mounted lights to achieve the desired light level and uniformity.

Median barrier mounted lights should not be used in high volume areas or in areas without a 10-foot inside shoulder.

10-4.01.02 Partial Interchange Lighting

Figure 10.1, "Typical Luminaire Locations, Partial Interchange Lighting" and Figure 10.2, “Typical Luminaire Locations, Partial Interchange Lighting, Vertical Mount Poles”, elsewhere in this chapter, shows typical luminaire locations for partial interchange lighting. This figure is a modification of a similar figure in the AASHTO Guide. The lights are typically the same as those described above for continuous freeway lighting with 2 lane roadways.

10-4.01.03 Complete Interchange Lighting

Complete interchange lighting places lights in the merging traffic and gore areas in the same locations as partial interchange lighting. In addition, it places lights along the ramps, on the through roadway through the interchange, and on the crossroad between the ramp terminals.

10-4.01.04 Tunnel Lighting

The AASHTO Guide contains lighting levels and uniformity values for tunnel lighting. A typical tunnel lighting system uses ceiling mounted counter beam or high pressure sodium underpass lighting fixtures. The fixtures are typically mounted to junction boxes embedded in the tunnel as part of the tunnel construction plan.

A short tunnel may only need lighting at night. A very long tunnel may require separate lighting controls for nighttime, clear days, and cloudy days. These requirements are discussed in the AASHTO Guide.

10-4.01.05 Underpass Lighting

Where the AASHTO Guide indicates that underpass lighting is desirable, the lights are typically high pressure sodium underpass fixtures for each direction of travel on the roadway, mounted on the abutment of the bridge or on a pier. If such mounting would place a fixture more than about 10 feet from the edge of the travelled roadway, the fixture is typically mounted on the bottom of the diaphragm.

10-4.01.06 Rest Area Lighting

The AASHTO Guide gives light levels and uniformity values for use in rest areas. The lights for the entrance and exit ramps of a rest area are typically the same as those described above for continuous freeway lighting with 2 lane roadways. Lights in the parking area of the rest area are typically 30 foot and 40 foot in the truck parking area, non-breakaway, single or double mast arm poles with metal halide luminaires. On walkways around rest area building, the lights are typically 12-foot poles utilizing a white light source. The spacing of poles for these areas varies with the geometrics. All poles except those on the entrance and exit ramps are typically painted steel decorative poles.
10-4.01.07 Lighting for Other Streets and Highways

Lighting levels and uniformity ratios for streets and highways other than freeways are contained in the AASHTO Guide. The design for these roadways is often matched to existing lighting in a city rather than to freeway design standards.

10-4.01.08 Bridge Lighting

The roadway on a bridge is normally treated the same as other parts of the roadway. If there is no lighting on the adjacent roadway, there is normally no need for lighting on the bridge. An exception is a very long bridge, which may be lit even though the roadway is not lit at other locations.

Where lights are to be installed on a bridge, the desirable locations for the lighting units are at abutments and at pier locations, or at distance from an abutment or pier not to exceed 25 percent of the length of the span. This placement of the lighting units reduces the effects of vibration. The light poles should utilize davit type mast arms so that there are no joints to be weakened by vibration.

If a local governmental agency requests ornamental lighting on a new Mn/DOT bridge or bridge replacement project, Mn/DOT will participate in funding in accordance with Highways (including Bikeways) 6.1G-1 Policy and Procedures for Cooperative Construction Projects with Local Units of Government.

The installation of navigation and air obstruction lights are an integral part of the bridge design. The Office of Bridges and Structures may ask the Lighting Unit to coordinate electrical service points for the roadway lighting and navigational/air obstruction lighting.

10-4.01.09 Airport Lighting

Where an airport or heliport is close enough to a highway lighting project that clearances are at or near minimum requirements, a sketch showing airport runways with all pertinent vertical and horizontal measurements should be done. A "Notice of Proposed Construction or Alteration" (FAA Form 7460-1) must be filed with the Federal Aviation Administration in such instances. The location near the airport may limit the height allowable for the poles or may mandate the use of cutoff type fixtures or obstruction lights. The distance within which an airport needs to be considered varies with the type of installation. For example, a high mast tower lighting system would affect an airport at a greater distance than would continuous freeway lighting utilizing 40-foot poles.

10-4.01.10 Weigh Station Lighting

Weigh station lighting level and uniformity values are the same as those for the lighting of rest areas. Because of the variety of weigh station designs, there is no typical weigh station lighting. Weigh station lighting should provide a manual means to turn off all lights except for necessary security lights when the weigh station is not in use.

10-4.01.11 Lighting of Roadways with Median Barriers

Median barrier lighting is described with continuous freeway lighting.

10-4.01.12 Intersection Lighting

Street lighting for at-grade intersections is shown in Figure 10.3, "Standard illumination Plan for Intersections." The poles and luminaires may be selected according to the guidelines given previously, or may be selected to match existing street lighting in the city where the intersection is located, or may be a part of a traffic signal system. The local agency may be required to maintain anything other than Mn/DOT standard fixtures.
Lighting should be provided at all signalized and flashing beacon intersections. A signal pole shaft extension with a luminaire mast arm should be utilized whenever possible to avoid adding more poles at the intersection. Street lights on traffic signal poles should be fed from the traffic signal service point. Additional light poles may be necessary when the intersection has channelization or complex turning lanes. The level of illumination of a signalized intersection is dictated by the area classification of the roadway. Suggested levels of illumination and average horizontal footcandles for roadway lighting are given in the IES RP 8.

The level of illumination at an intersection should be greater than that between intersections where there is continuous lighting.

Where the level of illumination is low between intersections, such as 0.6 foot candles, the light intensity at the intersection should be doubled as a rule.

10-4.01.13 Roundabout Intersection Lighting

Roundabout intersections are lit to a level similar to that of an intersection. Warrants and guidelines are given in the AASHTO Guide and the Mn/DOT Design Manual.

10-4.02 Lighting System Components

10-4.02.01 Poles

The latest version of the "Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals", published by AASHTO, specifies structural requirements for light poles. The Federal Highway Administration may have requirements differing from those found in this AASHTO standard, particularly with regard to breakaway devices, and the lighting system designer should check on such requirements before specifying types of poles for a lighting project.

The designer must determine the pole height, type and length of mast arm(s), material and finish, and method of mounting. Whenever possible, these choices should conform to standard products offered by manufacturers.

Pole height affects the illumination intensity, uniformity, area covered, and relative glare of the unit. Higher mounted units provide greater coverage, more uniformity, and a reduction of glare, but a lower footcandle level. By using higher poles, fewer poles are required and they can be set back farther from the traveled roadway. Typical pole heights are 30 feet, 40 feet, and 49 feet, and the applications of the different heights are indicated in section 10-4.01, Typical Lighting Systems. Power lines, nearby airports, and nearby residential neighborhoods may limit the height of poles used for lighting.

Where pole height is not restricted, high mast tower lighting may replace conventional lighting units at locations with complex roadways, such as at freeway interchanges. High mast tower lighting is a lighting system that places several high wattage luminaires atop high towers to illuminate a large area. It uses fewer poles, places poles farther from the traveled roadway, and provides a more uniform and pleasing lighting pattern than conventional lighting. High mast tower lighting may be objectionable near residential neighborhoods because the high luminaire mounting heights, sometimes exceeding 100 feet, can cause glare to those areas.

Conventional lighting units should have davit type mast arms or tenon-type mounting assembly unless a desire for decorative lighting dictates another type of arm, or the lights must match existing light poles with a different type of arm.

Non-breakaway poles should be galvanized steel. Breakaway poles should be unfinished aluminum or stainless steel. Decorative poles should usually be painted steel. A municipality may want painted poles or poles of a specific material to match its existing lighting.
Where traffic speeds exceed 40 mph, any poles located within the "clear zone" (See the Mn/DOT Road Design Manual for the definition of "clear zone") must either be breakaway devices, or must be protected by a suitable traffic barrier (guardrail). A breakaway pole has a special base and has been tested as a complete unit to show that it will "break away" when hit and will not impede a vehicle's movement more than a maximum set amount. In urban areas with speeds less than 30 mph and pedestrians present, a knocked down pole may present a greater hazard to traffic and pedestrians than would a non-breakaway device, and in such locations non-breakaway poles should be used. In urban areas with speeds between 30 mph and 40 mph, the designer may choose either breakaway poles or non-breakaway poles. These criteria for the use of breakaway poles apply regardless of the state's participation in the project.

Types of pole bases include the tapered high base, the anchor base, the shoe base, and the standard transformer base. Types of breakaway poles include the stainless steel progressive sheer base with a stainless steel shaft, the frangible cast aluminum transformer base with an aluminum pole shaft and arm, a slip base pole, and an aluminum shoe base pole.

Roadside light poles up to and including 40 feet in height should mount on the Design E light base. Light poles higher than 40 feet and up to 49 feet in height should mount on the Design H light base. These light bases and the anchorage for light standards mounted on a bridge or median barrier are detailed in the Mn/DOT Standard Plates Manual. Pole anchors in a median barrier require a specially widened section of the barrier, called an AL section, to be itemized in the road plans.

The designations for the various pole types are given in Figure 10.4, "Pole Type Designations."

Pole placement is an engineering decision which should be based upon geometry, character of the roadway, physical features, environment, available maintenance, economics, aesthetics, and overall lighting objectives.

Physical roadside conditions may require adjustment of the spacing determined from the base levels of illumination, indicated in the AASHTO Guide. Higher levels of illumination are justified when overhead structures, safety, and object clearances restrict the placement of poles. It is advisable to provide the higher illumination levels at diverging and merging areas.

Site considerations affecting pole placement include the presence at the site of noise walls, existing guard rail, rock, narrow roadside clearances, ditches, standing water, power lines, nearby airports, traffic signals and nearby residential neighborhoods. Poles should be placed behind noise walls if the site permits. Poles should be placed at least 2 feet behind any existing guard rail, or at a distance that will allow the guard rail to properly deflect upon impact. When street lights are installed in conjunction with traffic signals, the lights should be installed on the same poles as the traffic signals, if possible.

Long radius curves may be lighted as a straight roadway. Luminaires mounted on the inside of a short radius curve require closer spacing in order to produce adequate pavement brightness on the curved section. Light poles on the inside of a banked curve should be placed such that they will not be hit by trucks.

Light pole placement should consider maintenance. Bucket trucks must be nearly level to operate and are limited in the height and distance from the roadway that the bucket can reach. Different types of trucks may have different working ranges. Poles should also be placed to minimize knockdowns.
10-4.02.02 Luminaires

A luminaire consists of a lamp, reflector, refractor, ballast if required, photocell if required, and housing. Several factors have influenced the choice of the type of luminaire that the state currently uses. The efficiency of a lamp in converting electrical energy to light, the ability of the lamp to maintain its light output over the course of the lamp life, the length of the lamp life, the color of the light, and the distribution of the light are all factors which affect the cost and effectiveness of installing, operating, and maintaining the lights, and, hence, affect the choice of light source. The luminaires should be a standard type that is maintainable by and approved by OTST’s Electrical Services Section.

Most luminaires used for roadway lighting utilize high intensity discharge (HID) lamps. These lamps produce light by the discharge of an electric arc through an appropriate gas. These lamps require a ballast to provide proper starting and operating voltages to the lamp. A regulating ballast compensates for variations in the incoming voltage and certain types produce a constant wattage power load on the power lines.

The optical unit of the luminaire, consisting of the lamp, the reflector, and the refractor, determines the pattern of light that the luminaire emits. The Illuminating Engineering Society publication ANSI/IES RP8, "American National Standard Practice for Roadway Lighting", latest revision, defines light output patterns for luminaires based on isocandela traces for the light output in relation to the mounting height. The typical luminaire used by the state utilizes a Type II medium cutoff distribution. When the roadway is very wide, a Type III medium cutoff distribution is acceptable, but not required. A cutoff distribution does not allow more than 2.5% of the lumen output at an angle of 90 degrees above nadir, therefore reducing light pollution.

In determining the light output for a luminaire, the lighting system designer must consider the luminaire light loss factor. This is a factor that is applied to the light output of a new luminaire (initial light output) to determine the light output of the luminaire after a fixed period of time (maintained light output). The AASHTO Guide discusses the different aspects of the light loss factor. With these considerations, the actual factor to apply to arrive at a maintained light output value for the luminaire is an educated guess. A factor of 0.9 (10 percent light loss) may be used for normal roadway lighting, while a factor as low as 0.4 (60 percent light loss) may be used in a tunnel where the fixtures become very dirty very quickly.

Different types of lamps and luminaires have different advantages and disadvantages which make them more suitable or less suitable for a particular use.

The high pressure sodium (HPS) luminaire is most commonly used by the state. The lamp emits light across the spectrum with a predominance in the orange-yellow region. The HPS lamp is very efficient and is the best for most roadway lighting. HPS is not good for use on signs because the light it produces does not render the proper colors on standard signs. The lamp requires a ballast and special device to produce a very high voltage surge for starting. The HPS lamp usually cycles on and off at the end of normal life.

The metal halide (MH) luminaire is being used more often in the State because of the elimination of the mercury vapor (MV) luminaire. Some MH luminaires are in operation as part of high mast tower lighting. The color value of the metal halide lamp is good and phosphor is not required. There are two versions of the lamp, one designed for basedown operation and the other for baseup operation. The lamp must operate in the proper position.

The fluorescent lamp is no longer installed on new systems, but is still in operation on some existing sign lighting systems. The fluorescent lamp has shown a poor maintenance history and is adversely affected by cold weather.

The low pressure sodium (LPS) lamp is a very efficient light source in that it provides the most light for the same amount of electricity of any of the light sources described. LPS lighting has proven to have maintenance problems requiring frequent lamp replacement. The LPS lamp provides very poor color rendition. The lamps are very long, altering the light distribution pattern from the luminaire. For these reasons the State does not use LPS light sources.
Luminaires for roadway lighting should normally be the "cobra head" style. However, in certain circumstances "shoebox" style and "vertical mount" style luminaires are being used more often. Shoebox style luminaires are often appropriate for the interior (parking lot and walkway) lights in rest areas. Where a municipality is maintaining the lights, other decorative luminaires may be desirable.

Luminaires should only have photo electric cell when the electrical service point (feedpoint) does not provide photoelectric control.

**10-4.02.03 Electrical Service Point**

The electrical service point (feedpoint) consists of a lighting service cabinet complete with circuit breakers and photoelectric control where applicable, a concrete foundation or wood pole for mounting, electrical connections to the power company service conductors, provisions for grounding, and a meter and meter socket when necessary. The designer locates feedpoints for projects in the metropolitan area from the power company serving the area. The districts locate feedpoints in other areas of the state. The OTST Lighting Unit should then be contacted to assign a feed point number.

The local power company should be contacted early in the planning stage to determine the various locations where power is available for the project. The power company should be given the voltage, lighting load (sum of the wattages of all the luminaires connected to the system), and any other pertinent information in the form of a letter to a power company representative. The transformers necessary to provide the correct voltage and current are usually furnished and installed by the power company.

It is always desirable to have the source of power located at a point nearest the center of the load. Service cabinets should be located where they can be easily accessible for maintenance, will not obstruct the view of motorists, will not be prone to flooding, will not be prone to being hit, and located where highway electrical equipment currently exists or will probably be installed in the future. Gates should be provided through the right-of-way fence where necessary. If the service cabinet is located at ramp terminals or at intersections on a one-way street, the best locations are in the far left quadrant or far right quadrant of the intersection.

The power company may bring power of the proper voltage to a wood pole, or it may bring its primary voltage underground to a transformer on the concrete foundation with the service cabinet. When the power company brings power to its wood pole, service to the cabinet comes through a weatherhead on the wood pole, through a conduit with drainage provisions, and into the cabinet. When the power company comes to its transformer on the service cabinet foundation, service conductors come through conduit directly from the transformer to the cabinet.

The service cabinet should be a pad mounted type cabinet except for temporary lighting systems or where there is not space for a pad mounted cabinet, in which case a pole mounted cabinet would be appropriate.

A meter should be installed on the wood pole for wood pole service points, or mounted directly on the lighting service cabinet for cabinet foundation mounted transformer service points. The meter should be installed in an accessible location where the safety of the meter reader is not jeopardized, such as at the side of the road or on a frontage road, rather than in the median of a divided roadway. For some temporary systems, typically in rural areas, the district may request an agreement with the county or utility to pay a fixed monthly rate.

Where available, the electrical service should be three-wire, 240/480 volts, 60 cycle alternating current. By using 240/480 volt service rather than 120/240 volt service, smaller wires can be used on the lighting branch circuits for the same lighting load.

For installations consisting of only 3 or 4 lights, a circuit breaker load center can replace the service cabinet, with the luminaires operating at 120 volts and each luminaire having its own separate photoelectric control.
The branch circuit breakers in the standard Type L1, Type L2, Type T1, Type T2, Type A or type B lighting service cabinets are 20 ampere, single pole. The National Electrical Code allows circuit breakers to be loaded to only 80 percent of their ampere rating for loads that will be on for more than 3 hours. This means that the circuits should be designed so that there is no more than 16 ampere current on each phase wire. If it is not possible to limit the current to this value, the branch circuit breakers must have a higher current rating.

10-4.02.04 Lighting Branch Circuits

The lighting branch circuits normally consist of three-wire single phase circuits, with two phase wires, one shared neutral wire, and a ground conductor. Each luminaire should be wired between a phase conductor and the neutral conductor, not between the two phase conductors. This means that on a 240/480 volt system, the luminaires should operate at 240 volts. On 120/240 volt systems, the luminaires should operate at 120 volts. By wiring the luminaires as described and wiring adjacent luminaires on opposite phase wires, the system will operate with alternate lights still lit if one of the circuit breakers on the branch circuit opens.

Where lighting is installed along the side of a roadway in a grassy area, the lighting branch circuits should utilize direct buried armored cable. Direct buried cable has a lower installation cost than individual conductors in conduit. Where the direct buried cable passes under roadways, it should pass through a conduit for protection and to avoid the need to break up the pavement to trench the cable in. See Figure 10.5, "Typical Conduit Placement (Cloverleaf Interchange)" and Figure 10 5, Typical Conduit Placement (Diamond Interchange)." Conduit under roadways should be a minimum of 3 inches to allow space for future conductors to be run under the roadway and should have insulating bushings on each end to prevent damage to the cable jacket. The conduit should be installed as part of the roadway paving plan.

Where the lighting is installed on a median barrier, a bridge, a tunnel wall, or an underpass, the lighting branch circuits should be individual conductors run through conduit and junction boxes. The conduit and junction boxes will normally be installed as part of the median barrier, bridge, tunnel, or underpass. Conduit installed in a median barrier will usually be non-metallic conduit, and conduit installed as part of a bridge or tunnel will usually be rigid steel conduit. When individual conductors are run through a non-metallic conduit system, a separate equipment grounding conductor must be indicated in the plans along with the phase and neutral wires in the conduit. Separate equipment grounding conductor should also be run with the phase and neutral conductors inside rigid steel conduit also if the conduit passes through handholes, since the insulated grounding bushings on the conduit ends inside the handholes can corrode quickly, leaving the system ungrounded.

Continuous lighting systems should include a standby cable and, if appropriate, conduit between the adjacent end lights on branch circuits from adjacent sources of power for flexibility in the wiring of the lighting units, for temporary wiring during future construction, or for maintenance purposes.

For the main lighting branch circuits, the conductors should be number 4 wires as defined by the American Wire Gage (AWG). The bronze armor direct buried cable that the state uses is normally manufactured in the number 4 AWG wire size. Because of its availability, the number 4 AWG should be used when direct buried armored cable is used, even if a smaller wire size would be sufficient. If number 4 AWG wires result in a voltage drop in the wiring system, measured at the farthest light on the lighting branch circuit, of more than 3 percent of the system voltage, a larger wire size is necessary. The procedure for calculating voltage drop in a system is given in the Appendix to this chapter.

Lighting circuits that serve an underpass light may be single conductors no smaller than number 10 AWG run in conduit.

Lighting branch circuits are frequently spliced to provide the necessary circuits to operate all of the lights in the system. Splices should be avoided where possible. When splices are necessary because of the layout of the system, they should be made only in light pole bases. Splices in pull boxes are acceptable if there is no good way to make
the splice in a light pole base. Underground splices should not be utilized in a permanent lighting system installation. Every splice in a wiring system is a potential point for wiring system failure. Splicing lighting branch circuit wires in the light pole bases does not add extra splices since a splice is already required at each light pole base to connect the light to the system.

A ground rod should be indicated in the plans at every alternate light base, and at the first and last light base on each lighting branch circuit.

10-4.03 Temporary Lighting

The providing of temporary lighting may be desirable in construction areas or near at-grade intersections on highways where the warrants listed previously are met. The Transportation District/Division Engineer may request the installation of temporary lights from a power company, or the temporary lights may be installed by the contractor or state.

Lighting installed by the power company is maintained by the power company, and, while it may be a power company's standard design, it must meet all the state's safety requirements. Temporary lighting installed by the state or the contractor may be maintained by the power company, the state, or the contractor and is the state's or the contractor's design. Temporary lights in a construction zone are subject to being frequently moved, and so maintenance by the contractor is often the simplest to implement in that the state and the power company do not have to keep track of which lights are where at any given time. When the contractor maintains the system, the contract documents should indicate that the contractor also is responsible for paying for the power. If temporary lighting is to be left in place at the end of a project, to be removed as part of a later project, it may be better for the state to maintain the system and pay for the power. Temporary lighting which is not part of an agreement with the power company should be metered.

Power distribution to temporary lighting units is typically by means of self-supporting ACSR messenger quadplex aluminum cable. Quadplex cable should be used to provide the two phase wires, the neutral wire, and the ACSR messenger equipment ground wire. Aluminum wire should not be used if the lighting will be in place for a long period of time.

10-4.04 Sign Lighting

In general, Mn/DOT no longer uses sign lighting. When required, plans and specifications for illuminating overhead signs are done by the OTST Signing Unit.

10-5.00 CONSTRUCTION

10-5.01 Field Placement of Light Poles

The exact locations of light poles may be adjusted to avoid obstructions encountered in the field. Such items as solid rock, power lines, slopes, existing guard rail, ditches, standing water, etc., may make it necessary or desirable to locate the pole differently than is indicated in the plans. The project engineer may stake the poles up to 10 feet along the direction of the roadway from the locations indicated in the plans. If a farther change is required, the project engineer should consult with the lighting system designer to determine if such a change requires changing the placement of other light poles in the system. The plans typically place the poles 19 - 26 feet behind the edge of the travelled roadway for davit-type mast arms and 23 - 36 feet from the edge of the travelled roadway for tenon-type mount assemblies. If this distance can not be achieved, contact the District Traffic Office. If a guardrail or noise wall exists at the location and is not indicated in the plans, light poles should be placed behind it if possible. Clearance between the back of the guardrail and the front of the light pole should be at least 2 feet. Poles should not be closer than 20 feet in any direction from power lines. If 20 feet cannot be maintained, contact the power company.
10-5.02 Documentation

The project engineer should notify the district traffic engineer of the date the lights are energized. The district should then notify the power company of this date, in writing, for billing purposes, with a copy to the Lighting Unit.

The project engineer should document any field changes to the lighting system on final "as-built" plan sheets. These "as-built" plans should be kept by the district with a copy being sent to the Lighting Unit.

The Mn/DOT Standard Specifications for Construction requires the electrical distribution system to be tested for insulation resistance and short circuits to ground. The contractor should document the results of these tests and deliver the documentation to the project engineer.

When a municipality is participating in the cost of installing or maintaining the lighting system, the city utility engineer should attend the final inspection of the lighting system.

10-6.00 OPERATION AND MAINTENANCE

10-6.01 General

Operation of the lights involves supplying power to the light and paying all power costs. Maintenance of the lights includes cleaning glassware, replacing lamps, replacing ballasts, replacing broken glassware, replacing knocked down poles, painting poles when applicable, and repairing the electrical distribution system. Operation and maintenance are often lumped together under the term maintenance, with the supplying of electrical power being considered a type of maintenance.

Responsibility for operating and maintaining lighting systems is detailed in the agreement and may fall upon the power company, the local governing body, and/or the state. Responsibility may include performing maintenance, paying for maintenance, and/or paying for power. If a different party performs maintenance work than is responsible for its cost, the cost should be reimbursed.

Maintenance of an electrical lighting system includes maintaining everything within the system from the point of attachment to the power source or utility out to the last light on the feedpoint. The following are some definitions for lighting maintenance including power cost:

**Power Cost** - All energy costs associated with the lighting system after the system has been turned on.

**Luminaire Maintenance** - This includes relamping lighting units, replacing all damaged luminaire glassware and repairing loose connections, replacing luminaires when damaged or when the ballast fails, replacing photoelectric controls on luminaires when applicable, replacing defective starter boards and cleaning glassware.

**Pole or Knockdown Maintenance** - This includes replacing damaged fuse holders and blown fuses, repairing or replacing the pole when knocked down (including the wiring within the pole), replacing damaged poles, and painting poles when applicable.

**Underground Maintenance** (including all wiring from the line side of the fuse kit to the source of power) - This includes repairing or replacing handholes when needed, locating underground wire, installing approved splices or replacing wires, and repairing or extending conduit.

**Light Base Maintenance** - This includes repairing damaged bases, repairing or replacing bolts, repairing concrete, and repairing conduits.

**Cabinet and Pad Maintenance** - This includes a complete lighting cabinet, maintenance including photoelectric cell, repairing anything located on the pad, and repairing the electrical distribution system.
10-6.02 Budgeting (Mn/DOT)

Payment for Energy - The district should budget for the energy bills for roadway lighting for which the state has responsibility, as per the exhibits in effect.

Payment for Painting of Poles - Where the department has the responsibility of pole maintenance, the painting of light poles and bases should be arranged for, budgeted, and paid for by the district.

10-6.03 Maintenance (Mn/DOT)

10-6.03.01 Maintenance Procedures

The District Traffic Engineer is responsible for the surveillance of all lighting owned by Mn/DOT within their district. The district and the Electrical Services Section are responsible for entering all lights that are either inoperable or knocked down into the Facilities Management System (FMS).

1. Utility Repair - If the utility is responsible for the repair, the district traffic office sends a copy of the FMS form to the utility. When the utility completes its work, it should complete the form, return the original to the district/division traffic office which should file it. The district traffic office then closes out the report on the FMS.

2. Electrical Services Repair- If the Electrical Services Section is responsible for the repair, the Electrical Services Section will keep the FMS form. When the Electrical Services Section completes its work, it should complete the form and close out the report on the FMS.

10-6.04 Obtaining Electrical Power from Mn/DOT Lighting or Signal Systems

Other Mn/DOT offices as well as non-Mn/DOT agencies, have tapped into Mn/DOT signal and lighting equipment maintained by the Metro or Central Office Electrical Services Section (ESS). On occasion this has occurred without prior authorization or notification.

After a request for power (feedpoint) has been made with the local power utility, and no other source of power is available or deemed to be too expensive, the requester may request power from a Mn/DOT signal or lighting system. A signal system refers to any cabinet containing traffic signal, traffic management, or traffic recording equipment. Sharing an electrical power source with Mn/DOT benefits other offices and agencies, and can be accomplished without adverse effects on the efficiency or safety of the electrical system. In many cases, this type of installation will result in a substantial savings in tax payer cost when compared to establishing a separate source of electrical power. All costs incurred by the new installation shall be paid by the requester.

In order to assure safe and efficient operation of all equipment, however, and to monitor electrical power sharing and billing, prior approval must be obtained and certain procedures must be followed.

The following procedures vary depending on what agency requests the power and the type of equipment involved.

10-6.04.01 Lighting Cabinet or Unit

1. The requester seeking electrical power shall submit a scaled drawing, signed by a professional engineer or certified electrician, of the proposed installation to the district. The drawing shall include the reason for the request as well as the intended electrical loading.

2. The District Traffic Engineer will review the information with ESS, and will work with the requester to develop an acceptable proposal.

3. The requester shall contact the local utility company to notify them of the installation and set up a billing procedure. Documentation of this agreement shall be sent to the district prior to the start of construction.
4. If the request is approved, the applicable requirements from the following list and the general requirements must then be fulfilled.

Requirements

- If a Mn/DOT lighting unit is the power source, a 3 to 5 amp in-line fuse must be provided in the base of the lighting unit. This fuse must be a breakaway fuse and be labeled as to its use. If the Mn/DOT lighting unit is photoelectrically controlled, the circuit is only energized at night.

- If a Mn/DOT lighting cabinet is the power source, a separate circuit breaker shall be provided and labeled as to its use. Power to the circuit breaker must be obtained ahead of any photoelectrically controlled circuit unless the new installation is to be photoelectrically controlled.

- If the lighting system providing power is metered, only the lighting cabinet may be used as a power source, not a lighting unit, and a separate meter will be required. The conductors that supply the service shall be sized to supply both meters. This will be done by the requester at no cost to Mn/DOT.

- The installation must be inspected by ESS and the required electrical permits be obtained from the local electrical inspector to insure code compliance and safety to maintenance personnel and the public. ESS shall be notified as soon as a construction date is determined.

- All additional conductors and cables shall be labeled within the Mn/DOT lighting system.

10-6.04.02 Signal System

A signal system is defined as any cabinet containing traffic signal, traffic management, or traffic recording equipment.

The signal system refers to any cables that lead into or out of the signal cabinet. Power shall not be obtained from inside the signal cabinet. Power can be obtained from the service equipment/service cabinet or from the unmetered lighting conductors in the signal bases. If the lighting conductors are to be used as the power source, follow the requirements for obtaining power from a lighting unit as previously stated.

1. The requester seeking electrical power shall submit a scaled drawing, signed by a professional engineer or certified electrician, of the proposed installation to the district. The drawing shall include the reason for the request as well as the intended electrical loading.

2. The appropriate district will review the information with ESS, and will work with the requester to develop an acceptable proposal.

3. The requester shall contact the local utility company to notify them of the installation and set up a billing procedure. Documentation of this agreement shall be forwarded to the district prior to the start of construction.

4. If the request is approved, the applicable requirements from the following list and the general requirements must then be fulfilled.

Requirements

- A separate circuit breaker shall be provided and labeled as to its use. Power to the circuit breaker must be obtained from the un-metered side of the load center or ahead of the meter. A separate meter may be required by the power utility.

- All additional conductors and cables shall be labeled within the Mn/DOT signal system.

- The installation must be inspected by ESS and the required electrical permits be obtained from the local electrical inspector to insure code compliance and safety to maintenance personnel and the public. ESS should be notified as soon as a construction date is determined.
General

- Mn/DOT may disconnect the system without prior notice if the installation interferes with the operation of the Mn/DOT system.

- If Mn/DOT relocates or moves the system providing power, it is the requesting office's responsibility to reconnect to Mn/DOT's system or to find an alternate source of power.

- The requester shall submit as-built plan sheets, signed by a professional engineer or certified electrician, to the district within 48 hours of connection into a Mn/DOT system.

- Only a certified electrician will be allowed access to the systems used as the power source. Prior notification must be given to ESS.

- The requesting office will be responsible for maintaining all equipment after the power source.

- The requesting office shall provide the appropriate district and Electrical Services Section with contact information for the party who will be performing maintenance on the system.

- The requesting office shall identify a contact person within the office.

- The requesting office must be, or become, a registered owner with Gopher State One Call and be responsible for locating the cable from the Mn/DOT power source to the location being served.

10-6.04.03 Special Additional Requirements for a non-Mn/DOT Agency

A Mn/DOT permit will be required for any installation request.

10-7.00 REFERENCES

The AASHTO Guide and the IES American National Standard Practice for Roadway Lighting contain many additional references, including references for high mast tower lighting and tunnel lighting.


NOTE:
Luminaires shall be Type II or Type III, depending on the roadway width.

Luminaires may be oriented to tie in with existing or proposed city or county lighting systems.

Text Ref.: 10-4.01.12
Generally, the pole type designation contains the mast arm length, the type of pole, and the nominal pole height.

The first character before the dash is the mast arm length, usually 6 feet, 9 feet, or 12 feet.

The character(s) just preceding the dash indicate the type of pole used. See the list below. If no characters are in this position, the pole has a transformer base or high base, is intended for mounting on a light base, and has no finish for an aluminum or stainless steel pole or is galvanized for a steel pole.

The characters after the dash give the nominal pole height.

The pole type characters are as follows:

A - Anchor bolt pole (no transformer base)
B - Barrier or bridge mounting (6 bolt cluster)
C - Corten steel (no finish applied)
D - Double mast arms
M - Ornamental style pole
P - Painted pole
S - Combination traffic signal and street light pole
W - Wood pole lighting unit (for temporary lighting)
X - Decorative pole (usually square arms)
VM - Vertical mount

9-40: 9 foot mast arm with 40 foot mounting height, transformer base or high base, and aluminum or stainless steel, as indicated in the plans.

6BD-40: 6 foot double mast arms with 40 foot mounting height, provisions for barrier mounting.

VMD-45: Tenon mount double vertical luminaire with 45 foot mounting height.
Text Ref.: 10-4.02.04

January 1, 1996

TYPICAL CONDUIT PLACEMENT
(CLOVERLEAF INTERCHANGE)

FIGURE 10.5

78 mm (3") Rigid steel conduit placed 610 mm (24") below the finished grade.
Text Ref.: 10-4.02.04

- 78mm (3") Non-Metallic Conduit placed 610mm (24") below finished grade

January 1, 1996

TYPICAL CONDUIT PLACEMENT
(DIAMOND INTERCHANGE)

FIGURE 10.6
Chapter 10
LIGHTING OF TRAFFIC FACILITIES

APPENDIX 10-10.01
VOLTAGE DROP CALCULATIONS
APPENDIX 10-10.01:

VOLTAGE DROP CALCULATIONS

A voltage drop calculation shows the amount of voltage that will be present at the farthest luminaire on a lighting branch circuit. The voltage drop is of concern in order to assure that the voltage at all luminaires will be sufficient for the luminaires to operate properly, and also to avoid inefficient operation of the lighting system due to a large amount of power being dissipated in the electrical distribution system (wires).

The wires carrying current to the luminaires in the lighting system have a small amount of resistance. The resistance of the wire depends on the size (gauge) of the wire, the material of the wire, and the length of the wire. When current flows through the wires on its way to the luminaires, a voltage proportional to the resistance and to the current is developed along the length of the wire. This voltage subtracts from the voltage at the source of power and results in a lower voltage at the luminaire. If the resistance of the wire is too high for the amount of current flowing through it, the voltage dropped along the wire will be too high to allow sufficient voltage at the luminaire. The National Electrical Code suggests a value of 3 percent of the system voltage to be a reasonable limit to the amount of voltage drop to allow in the lighting branch circuit. The voltage along the wire multiplied by the current flowing through the wire yields the power dissipated in the wire. The higher the resistance of the wire, the higher the voltage dropped along the wire, and the more power is used up by the wiring system. The voltage drop calculation determines the size (gage) of wire of a specified material that is necessary to carry the required current the required distance without creating too large of a loss in the wire.

The basic equation that is used to determine the voltage drop in a lighting branch circuit is Ohm's Law

\[ E = I \times R \]

where \( E \) is the voltage drop along a segment of wire, \( I \) is the current through the same length of wire, and \( R \) is the resistance of the length of wire.

This equation is only completely accurate for direct current systems. With the current in the branch circuits limited to 20 ampere by the circuit breakers, and the frequency of the power at 60 hz, the equation is fairly accurate for the lighting branch circuits also.

\( E \) is the unknown value that is sought. \( I \) for any segment of wire is calculated by adding the currents for each luminaire the particular segment of wire feeds (i.e. all the luminaires downstream on that wire). \( R \) for a particular segment of wire is calculated by multiplying the length of the wire (in thousands of feet) in that segment by the resistance per 1000 feet of wire for that particular size and material of wire. The total voltage drop to the farthest luminaire is calculated by adding the voltage drops for each segment of wire from the service cabinet to that luminaire. The current for a single luminaire of various types and the resistance values for several types of wire is given in Figure 10.7, "Voltage Drop Calculation Values"

The voltage drop must be calculated for the phase wire (hot wire, ungrounded wire) and for the neutral wire (grounded wire), and these voltages must be added together to arrive at the total voltage drop. In a two-wire circuit, the current that travels out in the phase wire must return in the neutral, and so the current in the neutral wire is the same as the current in the phase wire. The total voltage drop in the two-wire circuit, then, can be calculated by figuring the voltage drop in just the phase wire and multiplying that number by 2.

Most of the lighting branch circuits in lighting systems designed by the state are three-wire single phase circuits. A three-wire circuit consists of two phase wires and a neutral wire instead of one phase wire and one neutral wire as in the two-wire circuit. In a three-wire circuit, the neutral is at approximately zero volts with respect to the ground. The two phase wires share the same neutral and are at opposite voltages with respect to the neutral wire. For example, if at some given time the voltage in one phase wire was 240 volts with respect to the neutral wire, then the voltage in the other phase wire at that same time would be -240 volts with respect to the neutral wire. The significance of this voltage arrangement is that the current returning in the neutral wire from one of the phase wires
will cancel out the current returning in the neutral wire from the other phase wire. Thus, if the loads on the two phase wires are exactly balanced, there will be no current in the neutral wire, and, therefore, no voltage drop in the neutral wire. In this case, the total voltage drop to the farthest luminaire is simply the total voltage drop in the phase wire, and the neutral wire can be disregarded.

Two examples of a voltage drop calculation are shown below. One example is for single luminaires wired to alternate phase wires as is typically done. The second example is for double luminaire poles such as might be found on a median barrier. Two different voltages are used in the examples to illustrate the application of the voltage drop at different voltages.

**EXAMPLE ONE: SINGLE LUMINAIRES**

The system in this example consists of 250 watt high pressure sodium luminaires on poles 130 feet apart. The wires are number 4 gage single conductor wires in a conduit system. This is a 120/240 volt lighting system. There are 9 lights total on the lighting branch circuit, with the lights wired to alternate phase wires. A circuit such as this might be found in a downtown city street light system.

A wiring diagram for the lighting branch circuit is shown in Figure 10.9 "Voltage Drop Calculation Examples." The wire segment labels and the distances between the lights are also shown on the diagram.

From Figure 10.8, "Voltage Drop Calculation Values," the current for a 250 watt high pressure sodium luminaire at 120 volts is 2.9 ampere. The resistance for number 4 gage copper wire is 0.259 ohms per 1000 feet. The following table calculates the voltage drop in the phase wire for each wire segment and gives the total voltage drop. The distance is a given from the layout of the system. The resistance is calculated by multiplying the distance in thousands of feet by the resistance per thousand feet. The current is calculated by multiplying the number of luminaires downstream of each wire segment by 2.9 ampere per luminaire. The voltage drop in each segment of wire is calculated by multiplying the current in each wire segment by the resistance of each wire segment. The total voltage drop is calculated by adding the voltage drops of all the wire segments. The current in the neutral wire is disregarded for this calculation. Depending on the system layout, the voltage drop in the neutral may add to the total voltage drop or subtract from the total voltage drop as calculated. The contribution of the voltage drop in the neutral wire is negligible compared to the voltage drop in the phase wire if the system is reasonably balanced.

<table>
<thead>
<tr>
<th>Wire Segment</th>
<th>Distance</th>
<th>Resistance</th>
<th>Current</th>
<th>Voltage Drop</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0.06</td>
<td>0.051</td>
<td>14.5</td>
<td>0.7395</td>
</tr>
<tr>
<td>B</td>
<td>0.09</td>
<td>0.0765</td>
<td>11.6</td>
<td>0.8874</td>
</tr>
<tr>
<td>C</td>
<td>0.09</td>
<td>0.0765</td>
<td>8.7</td>
<td>0.6656</td>
</tr>
<tr>
<td>D</td>
<td>0.09</td>
<td>0.0765</td>
<td>5.8</td>
<td>0.4437</td>
</tr>
<tr>
<td>E</td>
<td>0.09</td>
<td>0.0765</td>
<td>2.9</td>
<td>0.2219</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>2.958</strong></td>
</tr>
</tbody>
</table>

Since 3 percent of 120 volts is 3.6 volts, this value is acceptable, and the number 4 wires can be used. The calculation would be identical if three conductor number 4 armored cable were used instead of the single conductor number 4 gauge wires. Had number 6 gage wires been used, the resistance would be 0.410 ohms per 1000 feet and the voltage drop would have been 4.2805 volts. This is more than 3 percent of 120 volts, and so number 6 gauge wires are too small.
EXAMPLE TWO: DOUBLE LUMINAIRE

The system in this example consists of 250 watt high pressure sodium luminaires on poles 75 m apart with two luminaires on each pole. The wires are number 4 gage single conductor wires in a conduit system. This is a 240/480 volt lighting system. There are 16 lights total on the lighting branch circuit, with one light wired to each phase wire at each pole. A circuit such as this might be found in the median of a freeway.

A wiring diagram for the lighting branch circuit is shown in Figure 10.9. "Voltage Drop Calculation Examples." The wire segment labels and the distances between the lights are also shown on the diagram.

From Figure 10.8, "Voltage Drop Calculation Values," the current for a 250 watt high pressure sodium luminaire at 240 volts is 1.4 amperes. The resistance for number 4 gage copper wire is 0.259 ohms per 1000 feet. The following table calculates the voltage drop in the phase wire for each wire segment and gives the total voltage drop. The voltage drop in each segment of wire is calculated in the same manner as in example one. The current in the neutral wire is disregarded for this calculation. If only double luminaire poles are on the branch circuit, the load is exactly balanced at all points on the circuit, there is no current anywhere in the neutral, and the voltage drop is correct as calculated.

<table>
<thead>
<tr>
<th>Wire Segment</th>
<th>Distance</th>
<th>Resistance</th>
<th>Current</th>
<th>Voltage Drop</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0.06</td>
<td>0.05100</td>
<td>11.2</td>
<td>0.5712</td>
</tr>
<tr>
<td>B</td>
<td>0.075</td>
<td>0.06375</td>
<td>9.8</td>
<td>0.62475</td>
</tr>
<tr>
<td>C</td>
<td>0.075</td>
<td>0.06375</td>
<td>8.4</td>
<td>0.5355</td>
</tr>
<tr>
<td>D</td>
<td>0.075</td>
<td>0.06375</td>
<td>7</td>
<td>0.44625</td>
</tr>
<tr>
<td>E</td>
<td>0.075</td>
<td>0.06375</td>
<td>5.6</td>
<td>0.357</td>
</tr>
<tr>
<td>F</td>
<td>0.075</td>
<td>0.06375</td>
<td>4.2</td>
<td>0.26755</td>
</tr>
<tr>
<td>G</td>
<td>0.075</td>
<td>0.06375</td>
<td>2.8</td>
<td>0.1785</td>
</tr>
<tr>
<td>H</td>
<td>0.075</td>
<td>0.06375</td>
<td>1.4</td>
<td>0.08925</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>3.0702</strong></td>
</tr>
</tbody>
</table>

Since 3 percent of 240 volts is 7.2 volts, this value is acceptable, and the number 4 wires can be used. Had number 6 gauge wires been used, the resistance would be 0.410 ohms per 1000 feet and the voltage drop would have been 4.7757 volts. This value is still less than 3 percent, and so number 6 gauge wire could have been used. Had number 8 gauge wire been used, the resistance would be 0.6404 ohms per 1000 feet and the voltage drop would have been 7.4594 volts. Therefore, number 8 gauge wire should not be used.
### Current in AMPS for High Pressure Sodium Luminaires

<table>
<thead>
<tr>
<th>Luminaire Voltage</th>
<th>Lamp Wattage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>150</td>
</tr>
<tr>
<td>120</td>
<td>1.7</td>
</tr>
<tr>
<td>240</td>
<td>0.9</td>
</tr>
</tbody>
</table>

### Current in AMPS for Mercury Vapor Luminaires

<table>
<thead>
<tr>
<th>Luminaire Voltage</th>
<th>Lamp Wattage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>175</td>
</tr>
<tr>
<td>120</td>
<td>2.0</td>
</tr>
<tr>
<td>240</td>
<td>1.0</td>
</tr>
</tbody>
</table>

### Resistance of Conductors in Ohms Per 1000 Feet

<table>
<thead>
<tr>
<th>Conductor Material</th>
<th>Conductor Size (AWG)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>12</td>
</tr>
<tr>
<td>Copper</td>
<td>5.31 (1.62)</td>
</tr>
<tr>
<td>Aluminum</td>
<td>8.73 (2.66)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Conductor Material</th>
<th>Conductor Size (AWG)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4</td>
</tr>
<tr>
<td>Copper</td>
<td>0.85 (0.259)</td>
</tr>
<tr>
<td>Aluminum</td>
<td>1.39 (0.424)</td>
</tr>
</tbody>
</table>
Text Ref.: Chapter 10 Appendix

Example One

Example Two

B & R denote carrying conductors
W denotes neutral conductor

250 Watt HPS luminaires

C & R denote carrying conductors
W denotes neutral conductor

250 Watt HPS luminaires

Wire segment

Wire segment

120/240 Volts

240/400 Volts

10.1-5
Chapter 11
TRAFFIC CRASH SURVEILLANCE

TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>11-1.00</td>
<td>INTRODUCTION</td>
<td>11-3</td>
</tr>
<tr>
<td>1.01</td>
<td>Purpose</td>
<td></td>
</tr>
<tr>
<td>1.02</td>
<td>Scope</td>
<td></td>
</tr>
<tr>
<td>1.03</td>
<td>Transportation Information System (TIS)</td>
<td></td>
</tr>
<tr>
<td>1.04</td>
<td>Chapter Organization</td>
<td></td>
</tr>
<tr>
<td>11-2.00</td>
<td>ACCIDENT REPORT FORMS</td>
<td>11-3</td>
</tr>
<tr>
<td>2.01</td>
<td>Responsibilities</td>
<td></td>
</tr>
<tr>
<td>2.02</td>
<td>Accident Report Forms</td>
<td></td>
</tr>
<tr>
<td>11-3.00</td>
<td>ACCIDENT REPORT PROCESSING</td>
<td>11-4</td>
</tr>
<tr>
<td>3.01</td>
<td>Department of Public Safety</td>
<td></td>
</tr>
<tr>
<td>3.02</td>
<td>Department of Transportation</td>
<td></td>
</tr>
<tr>
<td>11-4.00</td>
<td>CRASH DATA REPORTS</td>
<td>11-5</td>
</tr>
<tr>
<td>4.01</td>
<td>T.I.S. Reports</td>
<td></td>
</tr>
<tr>
<td>4.02</td>
<td>Data Requests</td>
<td></td>
</tr>
<tr>
<td>4.03</td>
<td>Other Reports</td>
<td></td>
</tr>
<tr>
<td>4.04</td>
<td>General Procedures and Services</td>
<td></td>
</tr>
<tr>
<td>11-5.00</td>
<td>HIGHWAY SAFETY IMPROVEMENT PROGRAM PROCESS</td>
<td>11-11</td>
</tr>
<tr>
<td>5.01</td>
<td>Hazard Elimination Safety</td>
<td></td>
</tr>
<tr>
<td>5.02</td>
<td>Safety Capacity</td>
<td></td>
</tr>
<tr>
<td>11-6.00</td>
<td>REFERENCES</td>
<td>11-11</td>
</tr>
</tbody>
</table>

LIST OF FIGURES
<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>11.1</td>
<td>Traffic Accident Report (Police)</td>
<td>11-13</td>
</tr>
<tr>
<td>11.1A</td>
<td>Traffic Accident Report (Police)</td>
<td>11-15</td>
</tr>
<tr>
<td>11.1B</td>
<td>Traffic Accident Report (Police)</td>
<td>11-16</td>
</tr>
<tr>
<td>11.2</td>
<td>Minnesota Motor Vehicle Accident Report (Citizen)</td>
<td>11-17</td>
</tr>
<tr>
<td>11.2A</td>
<td>Minnesota Motor Vehicle Accident Report (Citizen)</td>
<td>11-18</td>
</tr>
<tr>
<td>11.3</td>
<td>Typical Interchange Element Sketch</td>
<td>11-19</td>
</tr>
<tr>
<td>11.4</td>
<td>Typical Collision Diagram</td>
<td>11-20</td>
</tr>
</tbody>
</table>
CHAPTER 11 - TRAFFIC CRASH SURVEILLANCE

11-1.00 INTRODUCTION

11-1.01 Purpose
Crash records and their analysis are an essential element in any traffic safety program for several reasons. First, crash studies aid in locating high crash locations on the existing highway system. Second, crash experience provides an evaluation of design features. Third, effective planning is based, in part, on traffic volumes and crash rates. Last, an analysis of crash records may have a direct influence on the budgeting of improvements. The District Offices are responsible for most crash analyses. The purpose of this chapter is to describe the existing data available to the crash analyst, how it may be obtained, how it may be used, and how it may affect the Highway Safety Improvement Program (H.S.I.P.).

11-1.02 Scope
This chapter describes the types of crash reports that are available to the crash analyst, presents guidelines concerning crash rate calculations, and discusses the crash analysis services available from the use of the Transportation Information System (T.I.S.). The use of crash analysis as it applies to the H.S.I.P. will be discussed later in the chapter.

11-1.03 Transportation Information System
The T.I.S. is a computer system that is used to relate several types of transportation data. The Accident Analysis Subsystem allows roadway files and crash files to be tied together. The Accident Subsystem details information on crash type, time, date, injuries, and vehicles involved. The Intersection Subsystem includes data on traffic control devices and intersection types. The Section Subsystem is used for analyzing crashes along portions of the roadways.

11-1.04 Chapter Organization
In this chapter the crash analysis process will be described. Crash reporting forms and processing procedures are described; crash data reports are discussed; and crash analysis procedures using T.I.S. are outlined; and the H.S.I.P. procedures are discussed.

11-2.00 CRASH REPORT FORMS

11-2.01 Responsibilities
Subdivision 7 of Minnesota Statutes (M.S.) Section 169.09 requires the driver of a vehicle involved in an crash (resulting in injury, death, or property damage in excess of $1000) to file a written report of the crash (Citizen Report) with the Department of Public Safety (DPS) within 10 days of the crash occurrence. Subdivision 8 requires the law enforcement officer investigating an crash resulting in injury, death, or total property damage in excess of $1000 to submit a report (Police Report) to the DPS. This report is also due within 10 days of the crash occurrence.

11-2.02 Crash Report Forms
Figures 11.1, 11.1A and 11.1B are copies of the Police Traffic Accident Report form and its overlay sheets. This form is used by all law enforcement agencies when reporting a crash to DPS. These forms as well as the Citizen Accident Report form, shown in Figures 11.2 and 11.2A, are used for entering data.
11-3.00 CRASH REPORT PROCESSING

11-3.01 Department of Public Safety (DPS)

1. Receipt of Accident/Crash Reports

Crash reports received by the DPS are channeled through the Drivers Compliance Section of the Drivers & Vehicles Services Division. Many law enforcement agencies also retain a copy of the police report form. The stubs of the citizen reports containing insurance information are sent to the insurance companies for verification.

2. Receiving Line

All reports (Citizen and Police) received by the DPS are passed through the receiving line. It is at this stage where they are combined into files and numbered. Crashes are numbered using an eight-digit format based on the Julian date. T.I.S. adds a decade number creating a nine-digit Crash number. These are the crash numbers by which each crash is filed and stored by the DPS. All major participants of a crash that are not Minnesota licensed drivers (pedestrians, bicyclists, owners of damaged property, out-of-state drivers, etc.) are cataloged on an application of an Alpha mini-computer housed at the Bureau of Criminal Apprehension.

3. Code-Locating Units

Only qualified traffic crashes (death, injury, or $1000 total damage occurring on trafficways by motorized vehicles) are entered on the Accident Records database. Individual crashes are coded and geographically located in this process. Locations of crashes are pinpointed using the reference point system. Crashes occurring at or near an interchange are additionally coded using interchange element numbers. A typical interchange element sketch is shown in Figure 11.3. Coders enter drivers license numbers and other pertinent crash information, using the police report as their primary data source. All data is entered on the Accident Records database (an Alpha 6410 system) located at the Bureau of Criminal Apprehension. Every night, all records entered for the day are passed on to the Driver’s License, Motor Vehicle, and T.I.S. databases on the Intertech mainframe to verify driver licenses, motor vehicle plates and reference point coordinates for correctness. The driver records in the Driver License database are updated with the eight-digit crash reference number, crash date, crash severity codes, and alcohol use codes. After the data is verified, appropriate information is brought back and placed on the Accident Records database. An error edit of incorrect data is run each morning. Department of Transportation personnel ensure that all crashes are included in the T.I.S. database by performing updates as needed.

4. Insurance Inspection

Insurance inspection is the means by which the DPS verifies a driver's insurance coverage. Data on owners who have not submitted a report with insurance information are entered on a tickler record of the Driver License database. Computer generated letters, that ask for a report and insurance information, are mailed to owners of motor vehicles. The owner has fifteen working days to respond. If no response is received, the computer then generates a notice of proposed motor vehicle license plate revocation. After ten working days, if still no response, the computer generates the revocation notice. The tickler record is deleted upon proof of insurance coverage given by the auto owner.

5. Electronic Imaging of Reports

All crash files, once processed, are sent to the Operations Support Unit of Driver & Vehicle Services (DVS) to be scanned and electronically imaged. Access to the imaged crash files is made available to government agencies for accident analysis.
11-3.02 Department of Transportation

The Department of Transportation (Mn/DOT) keeps a history of motor vehicle crash reports from 1984 to the present in the Office of Traffic, Safety, and Technology (OTST). In 1998, DPS switched crash report storage from microfilm to scanned computer files. Copies of crash reports are available to the Districts or local road authorities upon request. Caution must be exercised to maintain the confidential status of individual crash reports. Subdivision 13 of M.S. 169.09 should be consulted concerning this requirement.

11-4.00 CRASH DATA REPORTS

There are a number of general crash summation reports produced for Department use. The T.I.S. database offers a variety of these to traffic engineering personnel. The crash files used by the T.I.S. allow access to the system through a series of files. The user can gain access by date, location, or by individual crash number. Information requested and received may consist of crash details, vehicle characteristics, injury summaries or a combination of these. While it is not possible to explain all of the crash reports available, a brief summary of these crash reports follows

For more information please refer to the T.I.S. User's Manual.

11-4.01 Transportation Information System Reports

Crash listings are formatted in columns and rows of data. Code lists summarizing information on the listings can be provided in the printout. The lists contain a start-date and end-date specifying the time period under study. A list of elements printed for each crash on the listing is available in the T.I.S. User’s Manual.

1. List-Accident-By-Reference-Point
   
   Prints a list of crashes for the roadway and time period specified. The crashes are subjected to selection criteria if only crashes of a like nature are desired.

2. Find-Accident-Clusters

   Locates a "cluster" of crashes along a roadway. A cluster is a grouping of crashes that occurred within a given distance of each other. The number of crashes, the time period, and the length of roadway are user-defined parameters.

3. Accident-Matrix-Summary

   Produces general purpose summaries of crashes. Summaries can be broken down by one, two or three data elements. The summary provides system, vehicle type, or driver type studies.

4. Compute-Accident-Rates

   This command reports crash statistics for user-specified sections of roadway and user-specified time. It combines crash data and traffic volume to provide information on crash rates.

5. Intersection-Accident-Analysis Capabilities

   The Intersection/Interchange (I/I) files contain records for various intersections and interchanges for which crash analysis information is available. The I/I file is a highly flexible tool in T.I.S. A great deal of flexibility is provided in the software for performing many different types of analysis. As a result, a large number of user-specified parameters are available in the CREATE file and before the PRINT file function.

   Three types of reports can be obtained from the I/I crash analysis software: showing data for a single intersection, for a group of intersections, or for several groups of intersections.
6. Section-Accident-Analysis Capabilities

The section file contains information required to define sections of roadway for crash analysis reports. It is maintained by individual construction districts for analysis purposes, and is currently available for Trunk Highways only. Its data elements include codes describing general geometric design and environment, speed limit, route system, route number and reference points, construction district and categorization codes as well as a verbal description.

7. List-Accidents-By-Accident-Number

It lists crash records specified by crash number. It allows a user to print every data element in individual crash records.

8. Bridge-Accident-Analysis Capabilities

This aids user in analyzing crashes that occurred at various types of bridges. A great deal of flexibility is provided for performing many different types of analyses.

11-4.02 Data Requests

Requests for crash information are received frequently by traffic personnel. Data requested may involve specific areas of study, from annual reports prepared by the traffic office for distribution, to site-specific information on crash rates and numbers. Requests are received from individuals as well as various types of businesses that require crash data.

Any request, regardless of the source, for information concerning a specific location on the trunk highway system should be directed to the District Traffic Engineer in the appropriate District. General requests for statewide or system wide data should be referred to OTST.

Any request, regardless of source, seeking information NOT relating to the trunk highway system, should be directed to the local road authority for processing. This guarantees the local government agency will have full knowledge of all information being provided to the requester. If requested by the local agency, the district or OTST may assist them in completing the request.

When information is being requested as the result of a crash, personal injury, or property damage incident, the procedure outlined in Section 12-6.02 shall be followed.

Crash information requests can be reported in tabular form or illustrated with Geographical Information Systems (G.I.S.) Maps.

11-4.03 Other Reports

1. Minnesota Motor Vehicle Crash Facts

This report is published annually by the Office of Traffic Safety within the DPS. It is a detailed examination of motor vehicle crashes occurring on Minnesota roadways based on crash reports submitted by drivers and investigating police officers to the DPS. The report contains a discussion of apparent crash trends, and graphical and tabular displays of crash data. Its purpose is to provide summary information about crashes occurring in Minnesota.

2. Freeway Volume Accident Study

This report is prepared annually by DOT personnel located at the Regional Traffic Management Center (RTMC). It is a summary of data on the operating characteristics of freeways within the Twin Cities Metropolitan Area. Comparisons are made each year to determine crash rate trends for specific freeway sections. These areas are also ranked in order of the highest crash rates to determine where problem areas exist. It is useful for the monitoring of existing systems, establishing traffic management priorities, and identifying problem sections in the Twin Cities area.
11-4.04 General Procedures and Services

The Traffic Safety section of OTST serves as a direct contact with DPS regarding all available crash record data. Through this section, information is available upon request to the Districts and other agencies.

1. General Procedures

   Considerable effort is maintained at all times to provide the traveling public a safe roadway system. Efforts to reduce crashes generally involve several steps: location selection, study of possible improvements to that location, estimate of the benefit/cost of the improvement, selection and programming of locations to be improved, and finally, a determination of the improvement upon completion of the project. District personnel perform the foot work, in addition to making funding decisions and designation.

   The first step, location selection, is determined by crash experience. The number of crashes, severity of crashes, crash rate, crash cost, crash details, or a combination of these can be used to weight crash experience. The cost of the improvement project is then compared to the benefit to be derived from the improvement. A benefit/cost ratio greater than one indicates that the proposed improvement does not cost more than the cost of the crashes that may be eliminated by the improvement.

2. Crash Rates and Crash Severities

   The crash rate can be determined using the T.I.S. database by roadway sections, at specific locations, or by using the "clusters" command to determine areas with high crash counts. COMPUTE-ACCIDENT-RATES reports crash statistics for sections of roadway within a specified time period. Both the roadway section and time period are user-specified. The program retrieves traffic volume and crash data, combining them to provide crash rate information. Crash rates, severity rates and fatality rates are also provided. The user must specify the sections to be analyzed, using the ROUTES subcommand.

   The crash rate (CR): 

   \[
   CR_{\text{section}} = \frac{1,000,000 \times \text{CRASH}}{\text{ADT} \times \text{Length} \times \text{Days}} \\
   CR_{\text{intersection}} = \frac{1,000,000 \times \text{CRASH}}{\text{ADT} \times \text{Days}} 
   \]

   \text{CRASH} = \text{Number of crashes for the section} \\
   \text{Days} = \text{Number of days for the study} \\
   \text{ADT} = \text{Average Daily Traffic} \\
   \text{Length} = \text{Length of Section}

   The severity rate (SR) applies a weight value to the severity of the crash:

   \[
   SR_{\text{section}} = \frac{1,000,000 \times [5(K) + 4(A) + 3(B) + 2(C) + 1(PD)]}{\text{ADT} \times \text{Length} \times \text{Days}} 
   \]

   \text{K} = \text{Number of fatal crashes} \\
   \text{A} = \text{Number of incapacitating injury crashes} \\
   \text{B} = \text{Number of non-incapacitating injury crashes} \\
   \text{C} = \text{Number of possible injury crashes} \\
   \text{P} = \text{Number of property damage only crashes} \\
   \text{VM} = \text{Vehicle Miles}
The inclusion of crash and severity rate calculations in T.I.S. provides the user with numerous ways to apply these rates: significance limits, ordering of sections within groups, and best/worst section searches, to name just a few. More applications can be found in the T.I.S. User’s Manual. There are also several types of manual calculations performed as described below.

3. Analytical Tools

There are several tools available to the crash analyst which aid in the evaluation of crash locations and the determination of appropriate improvements. These tools, described below, include: a) intersection collision diagrams, b) individual crash reports, c) crash reduction estimates, d) crash costs, e) before-after studies, f) crash differentials, and g) family of measures.

a. Intersection Collision Diagrams

One of the most basic tools in analyzing intersection crashes is the intersection collision diagram. Figure 11.4 illustrates a typical collision diagram form. Crash data from summation reports and/or individual crash reports can be utilized in preparing a collision diagram. Preparation of a collision diagram will assist in identifying the crash "pattern" in a graphic sense, thus providing an aid to locating the most common crashes and determining appropriate corrective measures. The same results can be obtained for interchanges by preparing interchange collision diagrams. The study of collision diagrams consists of looking for crashes with common circumstances. This is often aided by visiting the crash location to view its physical characteristics or by analyzing a condition diagram of the site. A typical condition diagram is drawn to scale and illustrates all physical characteristics of the location under study.

b. Individual Traffic Accident Reports

It is often valuable to analyze individual crash reports to obtain the best available "picture" of a crash or series of crashes. As previously noted, copies of individual traffic crash reports are available from OTST. All information identifying persons and vehicles involved in crashes is obliterated prior to distribution as explained in Section 11-3.02.

c. Estimating Crash Reduction

After analyzing the crash experience, the crash reduction from a proposed improvement can be estimated. These estimated reductions can be translated into a benefit-cost relationship for establishing priorities for safety improvement projects.

d. Crash Costs

**Comprehensive costs**, as defined by the National Safety Council (NCS), include cost factors and a measure of the value of lost quality of life that society is willing to pay to prevent deaths and injuries associated with motor vehicle crashes. For calculation simplicity, the DOT converted the comprehensive costs as outlined in the Federal Highway Administration (FHWA) Technical Advisory T 7570.2 from cost per injury into a cost per crash. For documentation of the procedure, contact the Traffic Safety Unit at 651-634-5100.

The following comprehensive costs per crash are only to be used when computing a benefit/cost analysis:

- $560,000 per Fatal Crash (= 2 x Severity A Crash)
- $280,000 per Severity A Crash
- $61,000 per Severity B Crash
- $30,000 per Severity C Crash
- $4,400 per Property Damage Only Crash
Economic cost is a measure of the loss of productivity and expenses incurred because of the crash. If a district wants to approximate the economic impacts of motor vehicle crashes that occurred within its jurisdiction, it is suggested that NSC’s economic costs (2004) be used. The breakdown is as follows:

- $1,120,000 per Fatality
- $55,500 per Severity A Injury
- $18,200 per Severity B Injury
- $10,300 per Severity C Injury
- $8,200 per Property Damage Only Crash

It is important to note the units used in calculations. The comprehensive costs are per crash, whereas the economic costs are per injury except for property damage only.

e. Before-After Studies

While the previous three subsections were concerned with crash analysis in order to determine remedial measures, before-after studies are utilized to determine the actual effect of safety improvements that have been implemented. A comparison is not normally made until at least one year of "after" crash data has been accumulated. Three years of “after” crash data is preferred. Results are judged by comparing the "before" and "after" crash data.

f. Statistical Significance of Crash Differentials

There are several statistical procedures for determining the significance of crash differentials. If the analysis of one project does not contain a sufficient percent change to judge the improvement, the analysis of a number of similar projects may provide more reliable data.

The percent crash rate reduction must first be calculated. The following formula may be used:

\[
\text{Percent Crash Rate Reduction} = \frac{(CR_B - CR_A)(100)}{CR_B}
\]

\( CR_B \) = the "before" crash rate
\( CR_A \) = the "after" crash rate

Crash rate reduction by type can also be calculated using the following formula:

"Before" Crash Rate for a particular type crash equals \( \frac{1}{100} \cdot \text{(percent crash type)} \cdot CR_B \)

"After" Crash Rate for a particular type crash equals \( \frac{1}{100} \cdot \text{(percent crash type)} \cdot CR_A \)

The percent reduction is then calculated as shown previously.

g. Family of Measures

In October of 1998, OTST met with District Traffic Engineers to discuss DOT safety measures. A preferred organization of crash data was requested to assist the districts/division in their decision making.
Crash Rates by Trunk Highway Section as follows:
1) 2-Lane by Rural and Urban categories by ADT (Average Daily Traffic) in 4 categories:
   - Less than 1,500 ADT
   - 1,500 - 5,000 ADT
   - 5,000 - 8,000 ADT
   - Greater than 8,000 ADT
   (A total of 8 numbers for this measure)
2) Freeways (includes Interstates and Trunk Highways) by Rural and Urban categories in 2 categories:
   - 4 Lane
   - 6 Lane
   (A total of 4 numbers for this measure)
3) 4 Lane Expressways by Rural and Urban categories
   (A total of 2 numbers for this measure)
   Rural will be defined as roadways with speed limits of 55 mph or greater.
   Urban as roadways with speed limits of less than 55 mph.

Crash Rates by Roadway Intersection as follows:
1) Signalized Trunk Highway Intersections by High or Low Speed Limit (where High Speed is when any leg has an approach speed limit of 45 mph or greater; and Low Speed is when no legs have an approach speed limit of 45 mph or greater) in 2 categories:
   - Low Volume (ADT < 15,000)
   - High Volume (ADT > 15,000)
2) Non-Signalized Trunk Highway Intersections in 2 categories:
   - All-Way Stop
   - Thru/Stop

ADT = Total intersection Average Annual Daily Traffic (entering vehicles)
It was agreed to continue to use a 3-year roll-up of all data for these measures.
11-5.00 HIGHWAY SAFETY IMPROVEMENT PROGRAM

The purpose of the Highway Safety Improvement Program (H.S.I.P.) is to eliminate hazardous conditions and/or to increase intersection capacity. The projects consist of mainly intersection improvements (channelization, signals), widening turn lanes, guardrail, improving curves, and skid resistant surface treatments. This category has two sub-categories determined by funding eligibility.

11-5.01 Hazard Elimination Safety

Based on requirements of the Transportation Efficiency Act for the 21st Century (TEA 21) of 1991, Federal Funds are available to all local agencies within the state of Minnesota. To participate in the Hazard Elimination Safety (HES) program, all interested local agencies within the Area Transportation Partnership (ATP) regions must complete the necessary studies, computations and forms according to the established eligibility criteria. The ATPs would solicit these types of projects and prioritize them. These projects would then be included in the State Transportation Investment Program (STIP). For a copy of the forms and instructions, contact your District/Division Traffic Engineer or visit the website http://www.dot.state.mn.us/trafficeng/safety/hes/.

11-5.02 Safety Capacity

Safety Capacity (SC) projects are typically state funded. The project's potential to reduce crashes is reviewed but does not have a specific requirement for the Benefit/Cost Ratio.

11-6.00 REFERENCES


ABBREVIATIONS

AADT -- Annual average daily traffic
ADT -- Average daily traffic
Co. Rd. -- County Road
CS -- Control station
CSAH -- County State Aid Highway
DOT -- Department of Transportation
DPS -- Department of Public Safety
I/I -- Intersection/Interchange
K -- Fatality
MSAS -- Municipal State Aid Street
N -- Property damage
PI -- Personal injury
RP -- Reference point
TH -- Trunk highway
TIS -- Transportation information system
twp -- Township
This page is intentionally left blank
Text Ref.: 11-2.02

July 1, 1992

TRAFFIC ACCIDENT REPORT (POLICE) (OVERLAY - FRONT)

FIGURE 11.1A
As required by Minnesota Data Privacy Act you are hereby informed that the information requested on this form is collected pursuant to Minnesota Statute 169.09 Subdivision 13 to provide statistical data on traffic crashes. The time and place of the crash, names of parties involved and insurance information may be disclosed to any person involved in the crash or to others persons as specified by law. This written report cannot be used against you as evidence in any civil or criminal matter and your version of how the crash happened is confidential.

**SEAT OCCUPANT SEAT POSITION CODES**
1. DRIVER (INCLUDE MOTORCYCLE DRIVER)
2. FRONT CENTER
3. FRONT RIGHT
4. SECOND ROW SEAT LEFT
5. SECOND ROW SEAT RIGHT
6. THIRD ROW SEAT LEFT
7. THIRD ROW SEAT RIGHT
8. OUTSIDE OF VEHICLE
9. THIRD ROW SEAT CENTER
10. OUTSIDE OF VEHICLE
11. TRAILING UNIT
12. PICKUP TRUCK BED
13. TRUCK CAGE SLEEPER SECTION
14. PASSENGER IN OTHER POSITION (INCLUDE MOTORCYCLE PASSENGER)
15. PASSENGER IN UNKNOWN POSITION
16. FRONT LEFT (NON-DRIVER)

**TYPE SAFETY EQUIPMENT TYPE CODES**
1. NO SAFETY EQUIP IN PLACE
2. LAP BELT
3. SHOULDER BELT
4. LAP & SHOULDER BELT
5. CHILD SAFETY SEAT
6. CHILD BOOSTER SEAT
7. NOT APPLICABLE (MOTORCYCLE, SNOWMOBILE, ETC.)

**USE RESTRAINT DEVICE USED CODES**
1. BELTS NOT USED
2. LAP BELT ONLY USED
3. SHOULDER BELT ONLY USED
4. LAP AND SHOULDER BELT USED
5. CHILD SEAT NOT USED
6. CHILD SEAT USED IMPROPERLY
7. CHILD SEAT USED PROPERLY
8. BOOSTER SEAT NOT USED
9. BOOSTER SEAT USED IMPROPERLY
10. BOOSTER SEAT USED PROPERLY
11. HELMET NOT USED
12. HELMET USED

**AIR BAG SAFETY EQUIPMENT USED CODES**
1. DEPLOYED FRONT
2. DEPLOYED SIDE
3. DEPLOYED FRONT AND SIDE
4. NOT DEPLOYED-SWITCH ON
5. NOT DEPLOYED-SWITCH OFF
6. NOT DEPLOYED-UNKNOWN
7. NOT DEPLOYED-SWITCH OFF
8. NOT DEPLOYED-SWITCH OFF
9. OTHER DEPLOYMENTS
10. NOT APPLICABLE (MOTORCYCLE, SNOWMOBILE, ETC.)

**INJURY CODES**
K. KILLED
A. INCURRING INJURY
B. NON-INCURRING INJURY
C. POSSIBLE INJURY
N. NO APPARENT INJURY

**EJECT EJECTION CODES**
1. TRAPPED, EXTRICATED (BY MECHANICAL MEANS)
2. TRAPPED, FREED BY NON-MECHANICAL MEANS
3. PARTIALLY EJECTED
4. EJECTED
5. NOT EJECTED OR TRAPPED

**DESCRIPTION OF ACCIDENT IN SUFFICIENT DETAIL BELOW TO DISCLOSE CAUSES.**

**SIGN HERE**

SIGNATURE OF PERSON SUBMITTING REPORT IS REQUIRED

ADDRESS

DATE OF REPORT

MAIL THIS REPORT TO:

DVS / CRASH RECORDS
445 MINNESOTA STREET, SUITE 181
ST. PAUL, MN 55101-5181

**FIGURE 11.2B**

Text Ref.: 11-2.02

July 1, 1992

MINNESOTA MOTOR VEHICLE CRASH REPORT (CITIZEN - BACK)
USTH 10 JCT WITH CSAH 9
(ROUND LAKE BLVD.)

100's
USTH 10 200's USE RP = 226 + 0.362
A&B's
CSAH 9 300's
400's USE RP = 000 + 0.470

CSAH 9
(ROUND LAKE BLVD.)

USTH 10

Other Diamond
Revised 063098
02-2-10-226.3

Text Ref.: 11-3.01

July 1, 2000
TYPICAL INTERCHANGE ELEMENT SKETCH

FIGURE

11.3
Collision Diagram
Minnesota Department of Transportation

Location: C.S. 0208 TH 65 McKay Dr./153rd Ave m.p. 18.948

Time Period: 1-1-96 - 12-31-98 Date: 4-2-99

Prepared By: M. Kent

North

11-4

TYPICAL COLLISION DIAGRAM

FIGURE 11.4

Text Ref.: 11-5.02

July 1, 2000

11-20
# Chapter 12
## TORT CLAIMS

<table>
<thead>
<tr>
<th>TABLE OF CONTENTS</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>12-1.00 INTRODUCTION</td>
<td>12-3</td>
</tr>
<tr>
<td>1.01 Background</td>
<td></td>
</tr>
<tr>
<td>12-2.00 GLOSSARY</td>
<td>12-3</td>
</tr>
<tr>
<td>12-3.00 TORT LIABILITY</td>
<td>12-4</td>
</tr>
<tr>
<td>3.01 Basic Characteristics of a Tort</td>
<td></td>
</tr>
<tr>
<td>3.02 Legal Duty</td>
<td></td>
</tr>
<tr>
<td>3.03 Negligence</td>
<td></td>
</tr>
<tr>
<td>3.04 Causation</td>
<td></td>
</tr>
<tr>
<td>3.05 Liability</td>
<td></td>
</tr>
<tr>
<td>12-4.00 IMMUNITIES</td>
<td>12-6</td>
</tr>
<tr>
<td>4.01 Discretionary Immunity</td>
<td></td>
</tr>
<tr>
<td>4.02 Official Immunity</td>
<td></td>
</tr>
<tr>
<td>4.03 Other Immunities</td>
<td></td>
</tr>
<tr>
<td>12-5.00 RECORD KEEPING</td>
<td>12-7</td>
</tr>
<tr>
<td>12-6.00 REQUESTS FOR INFORMATION</td>
<td>12-7</td>
</tr>
<tr>
<td>6.01 Purpose</td>
<td></td>
</tr>
<tr>
<td>6.02 Procedure to Follow When Requests are Made</td>
<td></td>
</tr>
<tr>
<td>12-7.00 FILING A CLAIM</td>
<td>12-9</td>
</tr>
<tr>
<td>12-8.00 INVESTIGATIONS</td>
<td>12-9</td>
</tr>
<tr>
<td>8.01 Claim File</td>
<td></td>
</tr>
<tr>
<td>8.02 Claims Investigations</td>
<td></td>
</tr>
<tr>
<td>8.03 Interrogatories</td>
<td></td>
</tr>
<tr>
<td>8.04 Depositions</td>
<td></td>
</tr>
<tr>
<td>12-9.00 EFFECT OF LITIGATION ON MN/DOT</td>
<td>12-10</td>
</tr>
</tbody>
</table>
CHAPTER 12 - TORT CLAIMS

12-1.00 INTRODUCTION

Mn/DOT personnel, particularly those involved with maintenance and traffic control are becoming increasingly involved in a field of litigation that was recently of concern only to attorneys. Today, it is essential that state and local transportation agency staffs become aware and keep abreast of highway law in general and the legal elements of functional operational practices in particular.

This Chapter is a basic discussion of a complex subject. It is intended to alert Mn/DOT personnel of the need to recognize and respond to the possible consequences of failure to maintain and safeguard the highway system. It also provides guidance on responding to outside requests for information and for responding to a lawsuit.

12-1.01 Background

At one time, government entities were generally immune from lawsuits on the theory of "sovereign immunity" derived from English common law. Under the sovereign immunity doctrine, a government entity can be sued only if it consents to the suit in advance.

Over the past few decades this situation has changed dramatically. Sovereign immunity has been eroded through the actions of courts and/or legislatures and now survives in less than five States.

The State of Minnesota lost its Sovereign Immunity in 1976. At that time the State Legislature passed the Tort Claims Act which defines the conditions under which the State, their agencies, and their employees may be held accountable for damages resulting from the State's negligence.

12-2.00 Glossary

Claim - A request for compensation for damages caused by the negligence of Mn/DOT or a Mn/DOT employee, authorized by Minnesota Statutes Section 3.736.

Claimant - The person filing a claim.

Defendant - The person or persons in a lawsuit against whom the plaintiff has initiated a claim seeking some kind of relief.

Lawsuit - A legal action filed in a court-of-law alleging negligence by Mn/DOT or a Mn/DOT employee and requesting compensation for damages.

Plaintiff - The person or persons in a party who initiates a lawsuit for some kind of relief, typically monetary damages.

Tort - A tort, in legal terminology, is a civil wrong other than breach of contract, for which a court of law will provide a remedy in the form of an action for monetary damages. Torts can be either intentional (e.g., assault and battery, false imprisonment, trespass, and theft) or unintentional (e.g., negligence). The primary concern to highway agencies are allegations of negligence.

Tort Liability - Liability for a tort (or tort liability) is the legal obligation to pay money for damages to the person injured or damaged. More than one person or organization may be liable for damages arising out of the same incident. In the case of a traffic crash, there may be several negligent parties, including the driver(s), contractor(s) working in the area or the Department of Transportation.
12-3.00 TORT LIABILITY

12-3.01 Basic Characteristics of a Tort

In order for Mn/DOT to be liable for a tort claim, three elements must be present:

1. Mn/DOT must have a legal duty to the plaintiff to perform a particular task;
2. Mn/DOT must have been negligent in its duty to perform that task; and
3. The damages incurred by the plaintiff were caused by the negligent performance of that duty.

12-3.02 Legal Duty

In tort law, duty is an obligation requiring persons to conform to a certain standard of conduct for the protection of others against unreasonable risks. Mn/DOT owes certain duties, specifically or generally imposed by law, to all travelers on the Trunk Highway system to avoid creating unreasonable risks for those travelers, and to meet the standard of care imposed upon the Department.

Each Mn/DOT employee concerned with highway construction, operations, and maintenance shares that obligation to the traveling public to maintain the roadway in a reasonably safe condition. This involves inspection, anticipation of defects, and conformity with generally accepted standards and practices. Significantly, this requirement does not call for a perfect condition or for actions "beyond the limits of human ingenuity."

12-3.03 Negligence

Negligence is defined as the failure to do something which a "reasonable person" would ordinarily do, or the doing of something which a reasonably prudent person would not do. The reasonable person is a criteria used to set the standard of care in judging conduct. In effect, this test of negligence represents the "failure to use ordinary care," and is most often used in determining liability.

In the context of this Manual, the State may be found to be negligent if the conduct of its employees does not measure up to that of a hypothetical reasonable, prudent, and careful employee under similar circumstances.

12-3.03.01 Notice of Defect

Mn/DOT has a duty to correct a dangerous condition when it has received "actual" or "constructive" notice of the hazard. The courts have held that Mn/DOT must have had notice of the defect or hazard for a sufficient or reasonable time to afford them a reasonable opportunity to repair the condition or take precautions against the danger.

Actual notice occurs when an employee, law enforcement official, or any other party reports the existence of a hazard to Mn/DOT. Receipt of actual notice should be recorded in a dispatcher's log, diary, or other type of recording system.

Constructive notice occurs when the hazardous condition has existed for such a time and is of such a nature that the State should have discovered the condition by reasonable diligence. In this instance, the State's knowledge of the condition is said to be implied (i.e., the State should have known).

In deciding whether the State had notice, the courts may consider whether the defect was latent and difficult to discover. That is, the court will consider the nature of the defect, its location and duration, the extent and use of the highway, and whether the defect could be readily and instantly perceived.

Routine inspection and correction procedures are important in light of the trend by courts to permit less and less time before finding "constructive notice".
This notice requirement does not apply when the dangerous condition is the result of the Mn/DOT's own negligence. For example, it is not required for the State to have notice of faulty construction or poorly performed maintenance of its highways, because the State is expected to know of its own actions.

12-3.03.02 Standard of Care

The standard of care may be established by a multitude of factors. As a minimum, all persons are required to avoid the creation of unreasonable risks, where feasible. In addition, statutes and regulations governing conduct are also components of the standard of care by which conduct is judged. (For example, Rules of the Road for Operating Vehicles.) In general, a violation of a uniform law or regulation may be evidence of negligence or may constitute negligence per se.

The accepted standards and practices of a profession, trade, or industry may also define the standard of care by which conduct is judged. Included in the definition of "accepted standards and practices" is the MN MUTCD, this manual, and other similar manuals.

The MN MUTCD is unique in that it has been adopted by the State of Minnesota through a Commissioner's Order, and applies to all public roads in Minnesota. As regulated, this requirement has the full force and effect of the law. A failure by government personnel in Minnesota to conform with the requirements of the MN MUTCD may be sufficient to establish negligence (and therefore liability) should a crash result from failure to conform. On the other hand, as the MN MUTCD only sets forth minimum requirements, compliance may not in itself be sufficient to establish reasonable care. If more than a "minimum" is required by a specific situation, it should be done.

12-3.04 Causation

The third element in tort liability is causation. Causation is defined as an action or inaction which leads to or contributes to a particular event. To collect in claims against Mn/DOT, a claimant must demonstrate that a negligent action by Mn/DOT was a greater cause of the damages than any negligence on the part of the claimant, or in other words, Mn/DOT must be comparatively more negligent.

Comparative negligence is a rule of law adopted by this State whereby the negligence of both parties is compared, and recovery is permitted despite the negligence of the plaintiff. However, plaintiff's damages are decreased proportionately to his own negligence. If the plaintiff is found to have a higher percentage of negligence than a defendant, then the plaintiff is not entitled to collect from that defendant.

12-3.05 Liability

In order for Mn/DOT to have liability for damages, a claimant must prove:

1. that Mn/DOT had a legal duty to use reasonable care towards the plaintiff,
2. that Mn/DOT breached that duty by falling below the standard of care thus committing an act of negligence,
3. that the damages (injuries, property damage, pain and suffering, loss of income, etc.) incurred by the plaintiff were caused by Mn/DOT's negligence, and,
4. for the claimant to recover the damages suffered, the claimant must have had a percentage of fault that was less than or equal to the fault of the defendant.
12-4.00 IMMUNITIES

12-4.01 Discretionary Immunity

When the Torts Claim Act was passed in 1976, and the State lost its sovereign immunity, the legislature created other limited immunities for state agencies from liability for negligence. The first of the immunities which commonly apply to Mn/DOT is called discretionary immunity (Minnesota Statutes Section 3.736, Subdivision 3(b)).

The term "discretionary" refers to the power and duty of Mn/DOT to make informed choices among alternatives. Discretionary actions are planning level decisions involving questions of public policy, and are usually made at a high level in the organization. Discretionary actions require the evaluation and weighing of factors such as the financial, political, economic, and social effects of a given plan or policy.

Discretionary immunity is based upon the principle of separation of powers. This immunity prevents the judiciary branch of government from using tort suits as a medium to second guess, or otherwise to engage in, policy-making activities reserved to the legislative and administrative branches. Because discretionary immunity is based on this constitutional principle, claims of negligence are irrelevant since the immunity applies "whether or not the discretion is abused".

Examples of Mn/DOT activities which would likely be protected by discretionary immunity include; project selection, design standards, and snow removal priorities.

12-4.02 Official Immunity

Official immunity, in contrast to discretionary immunity, is a common law doctrine which survives the abolition of sovereign immunity. Official immunity serves a different purpose than statutory discretionary immunity. While statutory discretionary immunity exists to preserve the separation of powers by preventing juries and courts (the judicial branch) from second-guessing the policy decisions of Mn/DOT (i.e., the executive branch), the official immunity doctrine exists to encourage the exercise of the discretionary judgement by governmental officers. Therefore, official immunity extends to non-policy-type discretionary judgments such as professional engineering decisions. Official immunity prohibits plaintiffs from suing the government for difficult discretionary judgments when the threat of litigation will chill the exercise of this independent judgment.

Official immunity distinguishes between discretionary and ministerial actions. Discretionary acts are immune; ministerial acts which do not require the use of discretionary judgment, are not immune. Ministerial acts are defined as those which are "absolute, certain and imperative, involving merely the execution of a specific duty arising from fixed and designated facts." An example of a ministerial act may be the installation of a sign where the engineering decision has already been made that a sign is necessary.

In contrast, discretionary decisions are those which involve the exercise of judgment, including scientific or engineering judgment. For example, an engineering decision that a sign should not be used in a particular location may be an immune decision under official immunity.

Official immunity applies to individual public officials, and insure that the threat of personal liability does not unduly inhibit the exercise of judgment required of public officials in discharging their duties. In order to avoid defeating this purpose in cases where a claimant brings suit against the governmental employer claiming negligence by a public official, the Minnesota Supreme Court has recognized the concept of vicarious official immunity. Vicarious official immunity may be granted to an agency if it can be shown that the exercise of independent judgment by the public official would be chilled if immunity were not granted to the agency.

Together official immunity and vicarious official immunity apply to many situations in Mn/DOT.
12-4.03 Other Immunities

Minnesota Statutes Section 3.736, Subdivision 3 contains several other immunities relevant to various departments of state government. Following are two that are used by Mn/DOT:

1. **Snow and Ice Immunity.** The State and its employees are not liable for losses caused by snow or ice conditions on a highway or public sidewalk that does not abut a publicly owned building or a publicly owned parking lot, except when the condition is affirmatively caused by negligent acts of a state employee.

2. **Outdoor Recreation Immunity.** The State and its employees are not liable for losses incurred by a user arising from the construction, operation, or maintenance of the outdoor recreation systems, as defined in section 86A.04. This immunity is most commonly used by Mn/DOT at rest areas.

12-5.00 RECORD KEEPING

Good records are crucial in reducing Mn/DOT's exposure to liability. Complete written or photographic records often provide the grounds for denying a claim, being granted immunity from a lawsuit, or in proving that Mn/DOT was not negligent.

Some suggestions for helpful records to keep are:

1. Logs of complaints or reports of defects. This is used for establishing when Mn/DOT had notice of a defect. It is most helpful if the log includes when the reported defect was repaired.

2. Diaries or other daily work record sheets that indicate when and where routine work is performed. This has proven particularly useful in defending against pothole and traffic control claims by documenting Mn/DOT's use of due care.

3. Written records of decisions involving the use of engineering judgement or which involve policy considerations, such as those made in design of traffic signals, are valuable in establishing discretionary or official immunity.

4. Contact or incident reports are frequently helpful for preserving facts surrounding a particular incident. Since many claims and lawsuits are filed months or years after the incident, these are often the best or only way to reconstruct past events.

5. Photographs can be used for inventories or to document conditions before or after an incident, and are always helpful to reconstruct previously existing conditions.

In general with respect to tort liability, the more documentation that is kept, the better the chances for Mn/DOT to demonstrate that it was not negligent. While it is not practical to record and maintain documents on every activity, Mn/DOT employees should be alert to situations that are particularly prone to claims and document those situations accordingly.

12-6.00 REQUESTS FOR INFORMATION

12-6.01 Purpose

As previously stated, tort claims against the State continue to be filed in large numbers. As these cases are litigated or settled, the public and plaintiff's attorneys are getting a broad data base to draw from in looking for types of claims to submit against the State. As these claims become more sophisticated, it is important that we have uniform procedures within the Department for handling the release of information.
The reason for these procedures is that the investigation to prepare a case is a privileged activity, protected by law. Opposing litigants must abide by the rules for discovery which ensure that all parties to a lawsuit are treated equally and receive only the information that they are legally entitled to receive.

Documents assembled in response to a claim or lawsuit and kept in a claims file are considered confidential discussions between the client (Mn/DOT) and the Department of Administration (DOA) Risk Management Officer (claims), and/or the Attorney General's Office (lawsuits). This protection is only provided to the claims file. It is important to keep an exclusive claim file since discovery of investigated related documents could jeopardize the State's efforts to present the best defense possible.

All other files are considered public record and are subject to review at any time, with the exception of any information retrieved from the Transportation Information System (TIS) crash files or any information generated from data from the TIS crash files. TIS crash data may be privileged and not producible under both the Minnesota Government Date Practices Act (Minnesota Statutes, Chapter 13) and under 23 U.S.C. 409. In each case a decision regarding the release of TIS crash data must be made in light of those statutory provisions.

12-6.02 Procedure to Follow When Requests are Made

Frequently, requests for Department documentation are made directly to Mn/DOT employees by people outside the Department. These requests may or may not involve current claims against the Department.

When a request is received, determine the reason for the request. If the requester is not seeking information to investigate a crash, personal injury, or property damage incident, and it appears unlikely that the information will lead to a claim, the information may be provided without involving the Tort Claims Unit.

If the information is being requested as the result of a crash, personal injury, or property damage, the following procedures need to be followed.

1. All such requests for information must be made in writing. If a crash or incident is involved ask the requester to reference the location and date of the crash or incident in their letter of request.

2. Upon receiving the written request, contact the District Traffic Engineer, the Metro District Tort Claims Coordinator, your Office Tort Claims Coordinator (if one is so designated) or the Tort Claims Unit in the Office of Traffic, Safety, and Technology (OTST) to determine if a claim or lawsuit is pending. At that time, the content of the request can also be reviewed.

3. If no claim or lawsuit has been filed, a response can be provided through the District Traffic Engineer or the Office's tort claims coordinator. If the response is considered sensitive and should be reviewed, contact the OTST Tort Claims Unit, who will ask the Attorney General's Office for a legal opinion prior to the information being sent out.

4. If the request involves a pending claim or lawsuit, the request and the requested information should be sent to the OTST Tort Claims Unit. It will then be forwarded to either the Attorney General's Office or the ROA Risk Management Officer for response. It is not proper for plaintiffs or their attorneys to bypass the Attorney General's Office or the DOA Risk Management Officer when requesting information.

In some cases, responses to requests will result in a claim or lawsuit being filed. When this occurs it will be helpful to be able to retrieve all information that has been provided. Copies of all correspondence should be retained so that it can be easily retrieved for review by the Attorney General's Office or the DOA Risk Management Officer.
12-7.00 FILING A CLAIM

When a person reports damages that they believe to be caused by Mn/DOT's negligence, the following steps should be taken:

1. Determine if the incident occurred at a location that is under Mn/DOT jurisdiction. If not, refer the person to the appropriate agency.

2. Determine if the incident directly involved a Mn/DOT vehicle (such as a collision). If so, refer the person to the District Safety Officer who will handle the claim with Mn/DOT's insurance carrier.

3. If the incident is at a location under Mn/DOT jurisdiction and did not directly involve a Mn/DOT vehicle, send a Claim Report and Demand form to the person or refer them to the Tort Claims Unit. The claim forms are produced by the DOA Risk Management Officer and are available from the OTST Tort Claims Unit. Inform the person that their claim will be investigated and they will be notified of the results by the DOA Risk Management Officer.

If a claimant has any questions, they may be referred to the Tort Claims Unit.

12-8.00 INVESTIGATIONS

12-8.01 Claim File

When a District or office has been notified that a claim or lawsuit has been initiated against the State, only one file should be kept in the District regarding the case. This file should include any and all correspondence that has occurred as a result of the claim.

When an office provides responses for lawsuits or major claims the correspondence should be addressed to the Tort Claims Engineer and the assistant attorney general working on the case. Once a claim has been filed, the only copy of claim related correspondence kept by your office should be in the District claim file. The claim file should be kept by the tort claims coordinator or District Traffic Engineer. This file is not public information. It is considered Attorney Work Product and, by law, is confidential.

Any questions regarding this procedure may be directed to the OTST Tort Claims Unit.

12-8.02 Investigating Claims

After a claim has been filed, the DOA Risk Management Officer will send a copy of the claim and a request for information to the Tort Claims Unit. The Tort Claims Unit will in turn forward the claim and more detailed instructions on information that should be gathered during the investigation to the appropriate District Traffic Engineer or tort claims contact person to conduct an investigation.

The investigation will usually entail gathering documents from various District files, copying entries in logs or diaries, interviewing involved employee., and possibly a site visit. The State endeavors to respond to claims within 3-4 week period, and so the investigation needs to be completed and returned promptly within 2-3 weeks of receipt of the notice.

Upon completion of the investigation, the OTST Tort Claims Unit will respond to the DOA Risk Management Officer with the requested information and a recommendation on payment or denial of the claim. The DOA Risk Management Officer will then respond to the claimant.
12-8.03 The Discovery Process

When a lawsuit is filed, a more formal investigation process called discovery will begin. If the lawsuit was not preceded by a claims investigation, then the Tort Claims Unit will likely request that all information relevant to the lawsuit be gathered and made available to the assistant attorney general assigned to the case.

If the lawsuit proceeds, then at some point, plaintiffs' attorneys are likely to make a formal request for information through the court.

The request for information will include one or more of the following:

*Interrogatories*, which are simply a series of questions requesting information about a particular incident, location, or activity.

*Demand for Production of Documents*, which may include any documents in Mn/DOT's possession which are not privileged or otherwise protected by law. Generally this includes the contents of the construction and/or design files and any supporting manuals or documents.

*Production of Statements*, which is typically defined as a written reproduction of statements made by an individual concerning a particular incident, activity, or location.

Discovery documents are prepared jointly by the District tort claims coordinator and key personnel, the OTST Tort Claims Unit, and the Attorney General's office. It is extremely important that the requested information be provided by the deadline in the request to avoid legal sanctions against the Department. If the deadline cannot be met, then an extension must be requested by contacting the Tort Claims Unit.

If a lawsuit continues to proceed, the next phase of discovery is depositions. Depositions which involve Mn/DOT employees are requested by the plaintiff's attorney. The purpose of a deposition is for the plaintiff's attorney to gather additional information by directly questioning specified Mn/DOT employees. Employees requested to appear at a deposition will be briefed on procedures and the nature of the questioning prior to their appearance by the Department's legal counsel. The same legal counsel will also be present at the deposition.

12-9.00 EFFECT OF LITIGATION ON MN/DOT

The incident of civil litigation, primarily in the area of torts, has increased by many orders of magnitude in the last 30 years. This strong tendency toward legal action is closely followed by the trend towards large awards to plaintiffs.

It should be highly obvious that it is more logical to expend public funds in sound management practices and in the proper highway maintenance than in the settlement of claims or in payment of adverse judgments. Consequently, it would seem appropriate to review maintenance activities and reporting procedures to limit exposure to tort liability. It would also seem helpful to assure that all agency employees involved in such activities are well informed of the legal implications of their functions.
Chapter 13
MISCELLANEOUS TRAFFIC ITEMS

TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section Number</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>13-1.00</td>
<td>INTRODUCTION</td>
<td>13-3</td>
</tr>
<tr>
<td>1.01</td>
<td>Purpose</td>
<td></td>
</tr>
<tr>
<td>1.02</td>
<td>Scope</td>
<td></td>
</tr>
<tr>
<td>1.03</td>
<td>Chapter Organization</td>
<td></td>
</tr>
<tr>
<td>1.04</td>
<td>Glossary</td>
<td></td>
</tr>
<tr>
<td>13-2.00</td>
<td>SCHOOL CROSSING PROTECTION</td>
<td>13-5</td>
</tr>
<tr>
<td>2.01</td>
<td>Responsibility</td>
<td></td>
</tr>
<tr>
<td>2.02</td>
<td>Guidelines</td>
<td></td>
</tr>
<tr>
<td>2.03</td>
<td>School Safety Patrols</td>
<td></td>
</tr>
<tr>
<td>2.04</td>
<td>Crossing Guards</td>
<td></td>
</tr>
<tr>
<td>2.05</td>
<td>School Speed Limits</td>
<td></td>
</tr>
<tr>
<td>2.06</td>
<td>School Site Plan Review</td>
<td></td>
</tr>
<tr>
<td>2.07</td>
<td>Rural School Bus Stops</td>
<td></td>
</tr>
<tr>
<td>2.08</td>
<td>School Zone and Crossing Signs</td>
<td></td>
</tr>
<tr>
<td>13-3.00</td>
<td>REVIEWS AND PERMITS</td>
<td>13-7</td>
</tr>
<tr>
<td>3.01</td>
<td>Geometric Review</td>
<td></td>
</tr>
<tr>
<td>3.02</td>
<td>Preliminary Layouts</td>
<td></td>
</tr>
<tr>
<td>3.03</td>
<td>Evaluation of New Facilities</td>
<td></td>
</tr>
<tr>
<td>3.04</td>
<td>Entrance Permits</td>
<td></td>
</tr>
<tr>
<td>3.05</td>
<td>Transportation Permits</td>
<td></td>
</tr>
<tr>
<td>3.06</td>
<td>Parade Permits</td>
<td></td>
</tr>
<tr>
<td>13-4.00</td>
<td>ROUTE NUMBERING AND REFERENCE POINT SYSTEM</td>
<td>13-11</td>
</tr>
<tr>
<td>4.01</td>
<td>General</td>
<td></td>
</tr>
<tr>
<td>4.02</td>
<td>Constitutional Routes</td>
<td></td>
</tr>
<tr>
<td>4.03</td>
<td>Legislative Routes</td>
<td></td>
</tr>
<tr>
<td>4.04</td>
<td>Names and Designations of Certain Highways</td>
<td></td>
</tr>
<tr>
<td>4.05</td>
<td>Interstate Routes</td>
<td></td>
</tr>
<tr>
<td>4.06</td>
<td>U.S. Highways</td>
<td></td>
</tr>
<tr>
<td>4.07</td>
<td>Trunk Highway Routes</td>
<td></td>
</tr>
<tr>
<td>4.08</td>
<td>Turnbacks</td>
<td></td>
</tr>
<tr>
<td>4.09</td>
<td>Reference Point System</td>
<td></td>
</tr>
<tr>
<td>4.10</td>
<td>Exit Numbers</td>
<td></td>
</tr>
<tr>
<td>13-5.00</td>
<td>SPECIAL INVESTIGATIONS AND STUDIES</td>
<td>13-14</td>
</tr>
<tr>
<td>5.01</td>
<td>Videologging</td>
<td></td>
</tr>
<tr>
<td>5.02</td>
<td>Rumble Strips</td>
<td></td>
</tr>
<tr>
<td>5.03</td>
<td>Experimental Traffic Control Devices</td>
<td></td>
</tr>
<tr>
<td>5.04</td>
<td>Speed Trend Studies</td>
<td></td>
</tr>
<tr>
<td>5.05</td>
<td>Plat Review</td>
<td></td>
</tr>
<tr>
<td>5.06</td>
<td>Sight Distances at Crossroads</td>
<td></td>
</tr>
<tr>
<td>5.07</td>
<td>Railroad Crossing Review</td>
<td></td>
</tr>
<tr>
<td>5.08</td>
<td>Advisory Curve Study</td>
<td></td>
</tr>
</tbody>
</table>
13-6.00 ENGINEERING AND TRAFFIC INVESTIGATION REQUIREMENTS ........... 13-20
TO ESTABLISH OR CHANGE REGULATORY SPEED LIMITS

13-7.00 REFERENCES ................................................................. 13-27

LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>13.1</td>
<td>Railroad-Highway Grade Crossing Data Sheet</td>
<td>13-23</td>
</tr>
<tr>
<td>13.2a</td>
<td>Railroad-Highway Grade Crossing Data Sheet</td>
<td>13-24</td>
</tr>
<tr>
<td>13.3b</td>
<td>Railroad-Highway Grade Crossing Data Sheet (cont.)</td>
<td>13-25</td>
</tr>
</tbody>
</table>

LIST OF CHARTS AND TABLES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>13.1</td>
<td>Required Design Sight Distances for Combinations of Train and Highway Vehicle Speeds (English)</td>
<td>13-29</td>
</tr>
<tr>
<td>13.2</td>
<td>Sight Triangles for Moving Vehicle to Safely Cross at Railroad Crossings</td>
<td>13-30</td>
</tr>
<tr>
<td>13.3</td>
<td>Sight Triangles for Departure of Vehicle from Stopped Position</td>
<td>13-31</td>
</tr>
</tbody>
</table>

13-1.00 INTRODUCTION
13-1.01 Purpose

The purpose of this chapter is to present those traffic engineering functions which do not fall within material covered in other chapters.

13-1.02 SCOPE

This chapter includes review procedures, permits and guidelines for conducting specific studies and investigations. Other specialized subjects are also discussed.

13-1.03 CHAPTER ORGANIZATION

This chapter has four major sections; School Crossing Protection, Review and Permits, Route Numbering and Reference Point System and Special Investigations and Studies.

13-1.04 GLOSSARY

Ball Bank Indicator - An instrument used to determine the safe speed that a passenger vehicle can comfortably travel around a curved section of roadway. This instrument typically consists of a steel ball in a sealed curved glass tube filled with an alcohol solution.

Commissioner - "Commissioner" means the Commissioner of the Minnesota Department of Transportation.

County Highway Engineer - "County Highway Engineer" means a registered professional engineer employed as the County Highway Engineer or the Director of Public Works-County Highway Engineer of each county.

County State-Aid Highway - A county state-aid highway which:

1. is projected to carry a relatively heavy traffic volume or is functionally classified as collector or arterial as identified on the county's functional plans as approved by the county board;

2. connects towns, communities, shipping points, and markets within a county or in adjacent counties; or provides access to rural churches, schools, community meeting halls, industrial areas, state institutions, and recreational areas; or serves as a principal rural mail route and school bus route;

3. occurs at reasonable intervals consistent with the density of population;

4. provides an integrated and coordinated highway system affording within practical limits, a state-aid highway network consistent with projected traffic demands.

Department - "Department" means the Minnesota Department of Transportation.

District State-Aid Engineer - "District State-Aid Engineer" means a registered professional engineer employed as the District State-Aid Engineer.

Eighty-Fifth Percentile Speed - The speed at or below which 85 percent of the traffic is moving and normally used as a rule of thumb for establishing numerical speed limits. This can be determined directly from field sheets by counting from the top speed the number of vehicles equaling 15 percent of the total number of vehicles observed. The 85th percentile speed is usually within 2 mph of the upper limit of the pace.

Experimental Traffic Control Device - Any device which varies from the specifications set forth in the MN MUTCD.
Municipal State-Aid Street - A municipal state-aid street which:

1. is projected to carry a relatively heavier traffic volume or is functionally classified as collector or arterial as identified on the urban municipality's functional plan as approved by the urban municipality's governing body;

2. connects the points of major traffic interest within an urban municipality;

3. provides an integrated street system affording, within practical limits, a state-aid street network consistent with projected traffic demands.

Pace - The 10 mph range of speeds containing the largest number of observations. The pace can usually be determined by visual inspection of the vehicle speed data sheet. A normal speed distribution will contain approximately 70 percent of the sample within the pace with 15 percent above and 15 percent below the pace.

Railroad - "Railroad" means a common carrier by railroad as defined in United States Code, title 49, section 1, clause (3) of the Interstate Commerce Act.

Roadway - "Roadway" means that portion of a highway improved, designed, or ordinarily used for vehicular travel, exclusive of the sidewalk or shoulder. In the event a highway includes two or more separate roadways, the term "roadway" as used herein shall refer to any such roadway separately but not to all such roadways collectively.

Rumble Strips - A device used to alert the driver that there is a change of conditions ahead. It may consist of raised strips or sawed grooves in the pavement or some other means of creating a "rumble" effect.

Rural Section - "Rural section" is a highway design that has wide rights-of-way, open ditches for drainage, and a clearway of usually 30 feet from the edge of the outside lane.

Shoulder - "Shoulder" means that part of the roadway which is contiguous to the regularly traveled portion of the roadway and is on the same level as the roadway. The shoulder may be pavement, gravel, or earth.

Sidewalk - "Sidewalk" means that portion of a street between the curb lines, or the lateral lines of a roadway, and the adjacent property lines intended for the use of pedestrians.

State-Aid Engineer - "State-Aid Engineer" means a registered engineer employed as the State-Aid Engineer of the Minnesota Department of Transportation.

State Traffic Engineer - A registered professional engineer employed as the Director, of the Office of Traffic, Safety, and Technology (OTST) in the Policy Safety & Strategic Initiatives Division of the Minnesota Department of Transportation.

Street or Highway - "Street or highway" means the entire width between the boundary lines of any way or place when any part thereof is open to the use of the public, as a matter of right, for the purposes of vehicular traffic.

Through Highway - "Through highway" means every highway or portion thereof at the entrances to which vehicular traffic from intersecting highways is required by law to stop before entering or crossing the same and when stop signs are erected.

Transportation District Engineer - "Transportation District Engineer" means a Transportation District Engineer of the Minnesota Department of Transportation.

Trunk Highway Turnback - "Trunk highway turnback" means a former trunk highway or portion of it that has reverted to a county or municipality in accordance with law.

Urban District - "Urban district" means the territory contiguous to and including any street which is built up with structures devoted to business, industry, or dwelling houses situated at intervals of less than 100 feet for a distance of one quarter mile or more. M.S. 169.01, Subd. 59.
Urban Section - "Urban section" means a roadway design used in urban districts where the right-of-way width is restricted. Because of the restricted right-of-way, there is not enough room for ditches, thus necessitating curbs and gutters.

Videologging - A permanent pictorial inventory providing instantaneous photographic references for the inspection of highways and roadside features.

13-2.00 SCHOOL CROSSING PROTECTION

13-2.01 Responsibility

The safety of school crossings is the joint responsibility of parents, school administrators, other public officials, and the general public. On Trunk Highways, the Department will install appropriate signs and markings at designated school crossings and may authorize local authorities to install additional devices conforming to approved standards in situations that meet reasonable warrants.

13-2.02 Guidelines

Information on school speed control is available in "A Guide to Establishing Speed Limits in School Zones," issued by the Department.

13-2.03 School Safety Patrols

School Safety Patrols are strongly recommended at all crossings used by grade school students. No other means of protection has been as effective as the School Patrol at crossings used by the younger pupils of the grade schools. However, these patrols have not proven effective for high school or junior high school students. Where a School Safety Patrol is functioning as recommended, normally the only necessary controls are the standard school crossing warning signs and markings.

13-2.04 Crossing Guards

Crossing Guards are effectively used at crossings where the use of a School Safety Patrol is considered impractical. Crossing guards are adults who operate in much the same manner as the school patrol in assisting school children to cross arterial streets safely.

13-2.05 School Speed Limits

School speed zoning will not automatically reduce crash frequency or severity. Improper zoning may actually create a situation favorable to crashes, by increasing the speed differential between vehicles and by causing pedestrians to rely on a posted limit which does not accurately reflect vehicular speeds. Thus, speed zoning must be done with great care. The legislation, MSA 169.14, Subd. 5a, granting local officials the authority to establish school zone speed limits was not intended as an endorsement of blanket zoning or maximum reductions. Mn/DOT practice is to use fluorescent yellow-green as the background color on the "SCHOOL" plaque (S4-3) and on the top portion of the "SCHOOL SPEED LIMIT" sign (S5-1).

Alternatives such as sidewalk construction, fencing, parking restrictions, crossing guard utilization, stop sign or signal placement, and pedestrian rerouting are virtually always more effective in reducing a pedestrian hazard. A traffic and engineering investigation must be undertaken before a speed zone is implemented and consists of two parts: (1) preparing a school route plan and (2) conducting a school zone hazard evaluation. See "A Guide to Establishing Speed Limits in School Zones".
1. **School Route Plan** - The main objective of a route plan is to minimize the number of streets crossed and to maximize the safety of crossings and routes used by school children. A school route plan for each school serving elementary and kindergarten students is useful in developing uniformity in the use of school area traffic controls. The plan, developed jointly by the school and traffic officials responsible for school pedestrian safety, consists of a map showing the street system, the school, existing traffic controls, established school routes and established school crossings.

2. **School Hazard Evaluation** - The hazard evaluation process determines those routes which can be made the most safe with the least cost and are most likely to be used by school children. The school route plan should be re-evaluated whenever changes in traffic or pedestrian patterns occur, when control devices change, or when the route's environment changes.

**13-2.06 School Site Plan Review**

It is the responsibility of the School District, when planning to build a new school facility or make major changes to an in place facility, to obtain all the necessary permits and approvals. The Minnesota Department of Education Planning Guide requires that the School District contact the District Traffic Engineer for guidance in planning for pedestrian and vehicle movements when Trunk Highways are involved. Other road authorities are to be contacted when their roadway is involved.

**13-2.07 Rural School Bus Stops**

When requested, the District Traffic Engineer shall review rural school bus stops in accordance with Section 7B-11 of the Minnesota Manual on Uniform Traffic Control Devices. This section establishes the warrants for placement of the "School Bus Stop Ahead" signs. A record should be kept in the District Traffic Office of the rural school bus stops which are so signed. As part of the record, the District Traffic Engineer should, at approximately two year intervals, check back with residents and/or bus operator that each stop is still being made.

When determining the need for the "School Bus Stop Ahead" (S3-1) warning sign where the school bus stop is located on or near a vertical curve with restricted sight distance, the height of eye of the driver is 350 feet and the height of object is 6 inches. Given this criteria, the sign is intended to be used where a school bus, when stopped to pick up or discharge passengers, on the roadway is not visible for a distance of 500 feet in advance of the stop. Where the driver can see the full outline of the bus at least 500 feet in advance of the stop, a sign is not required. At vertical curves, the flashing lights mounted at a height of 8 feet will appear sooner to give the driver an added safety factor. However, advance warning distance may not be available where the school bus stop is located on or near a horizontal curve with a visibility restriction. The location of the sign should give the driver 9-10 seconds reaction/decision time from the sign to the bus stop location. On those highways, a distance of 850 feet to 1000 feet is advised, with the distance of 1000 feet recommended in the horizontal curve case due to greater difficulty for the driver to track the bus. The advance posting distance for lower speeds may be lower, but should not be less than 500 feet in any case. The 9-10 second reaction/decision time times the 85% speed in feet per second is recommended.

When requested, the District Traffic Engineer shall review rural school bus stops to determine if a stop qualifies to be signed "School Bus Loading Area". The following criteria must be satisfied prior to the establishment of a school bus loading area:

- Children will not cross the roadway, either to be picked up or after disembarking from the bus.
- Shoulders must be wide enough to accommodate full bus width, plus sufficient space for the passengers to safely stand during loading and unloading.
- No loading area should be established adjacent to an obstruction; such as guardrail, culvert, mail boxes, etc.
- No loading area shall be permitted in a turn lane.
Districts, at their discretion, may also require that the loading area be hard-surfaced, in order to prevent shoulder breakup and/or bus traction problems during periods when the ground is soft.

The sign "School Bus Stop Ahead" shall not be used in advance of a "School Bus Loading Area" stop.

Reference: Minnesota Statute 169.44, Subdivision 2(b)(1).

13-2.08 School Zone and Crossing Signs

The "School" sign (S1-1) may be used in advance of locations where school buildings or grounds are adjacent to the trunk highway. If there is a signed school crossing, the "School" sign shall be used in advance of each approach. The sign shall be a fluorescent yellow-green background color with black legend.

The School Crossing sign assembly shall consist of the "School" sign (S1-1) and a supplemental down arrow plaque (S2-P2) mounted directly below the "School" sign. The sign and plaque shall be fluorescent yellow-green background with black legend. The School Crossing sign assemblies shall be mounted as near as possible to the crosswalk.

See Figure 7.21 for pavement marking details. The assembly may be used at a signalized intersection with crosswalks but should not be used at "Stop" sign controlled intersections.

The mixing of standard yellow and fluorescent yellow-green signs of the same type, within a selected site area, shall be avoided. The preferred practice is not to use the speed advisory plaque with school signs. If a black/yellow speed advisory plaque is determined necessary for use with the "School" sign, then the sign and plaque shall be the yellow background color utilizing the wide angle prismatic retroreflective sheeting (commonly referred to as VIP-see Chapter 6 for specifications).

13-3.00 REVIEWS AND PERMITS

13-3.01 Geometric Reviews

Geometric design is concerned with the visible features of a highway such as pavement width, horizontal and vertical alignment, slopes, channelization, interchanges, etc. The design of these features can significantly affect traffic operation, safety and capacity. In fact, some of the traffic problems existing today are the result of geometric design features which could have been corrected during the design stages if the design had been reviewed from a Traffic Engineering point of view. It is essential to maintain regular and cooperative communication between Traffic and Design personnel. Each group needs and benefits from the knowledge and experience of the other.

13-3.02 Preliminary Layouts

The District Traffic Engineers should review all preliminary layouts to provide early input into the design process.

13-3.03 Evaluation of New Facilities

All newly constructed facilities should be evaluated on a systematic operation basis by District Traffic Engineers to assess their effectiveness in moving traffic safely and efficiently. If the improvement is not working as expected, it is imperative that an evaluation of the reasons for failure be made. Positive and negative feedback based on Traffic Engineering evaluations can be an important contribution toward upgrading design standards and criteria to meet changing conditions. A copy of comments should be sent to the State Traffic Engineer.
13-3.04 Entrance Permits (Minnesota Rules, Chapter 8110)

No entrance or driveway from a Trunk Highway to private property may be constructed without permission of the Department. Under normal conditions any necessary entrance facilities are provided by the Department when the highway is constructed or reconstructed. However, property and the type of land use are subject to change. Thus, existing access often must be revised. After a highway has been constructed, no additional entrances shall be constructed, nor shall an existing entrance be changed without the approval of the Transportation District Engineer. It is the responsibility of the Area Maintenance Engineer to investigate all requests for such permits and to recommend proper action to the Transportation District Engineer. Entrance permit application forms are discussed in the Maintenance Manual. Traffic Engineering principles should be applied in the investigation, and the District Traffic Engineer should have direct input.

A variance from the standards set forth in Chapter 8110 may be allowed by the Department when the variance will facilitate the safe, efficient use of the property for a lawful purpose and will not interfere with the construction, maintenance or safe and efficient use of the highway and its appurtenances by the public.

13-3.05 Transportation Permits

Permits for the movement of over-size or over-weight loads are issued on the authority of the Transportation District Engineer. This is primarily a maintenance function, but the District Traffic Engineer may assist as necessary. Transportation permit guidelines and forms are contained in the Maintenance Manual.

13-3.06 Use of Highway Right-of-Way for Special Events

Use of the trunk highway right-of-way for activities will not be allowed unless a legitimate public interest is to be served. Use of highway right-of-way not related to construction or maintenance requires that the requester contact the Mn/DOT District Office. Mn/DOT authorization will be granted, through the district permit process, if all pertinent criteria covered in these guidelines are satisfied.

The permit shall identify that the sponsor agrees to assume the entire responsibility and liability for all damages or injury to all persons, whether employees or otherwise and to all property, arising out of, resulting from or in any manner connected with the operation of the special event. The sponsor shall agree to defend and indemnify Mn/DOT, its agents and employees from all such claims including, without limiting the generality of the foregoing, claims for which Mn/DOT may be claimed to be liable and legal fees and disbursements paid or incurred to enforce the provisions of this paragraph, and the sponsor shall further agree and pay for such general liability coverage which protects the state as an additional named insured.

The permit shall also identify that the sponsor shall be responsible for any damage done to the highway property as a result of the special event, damages payable upon receipt of invoice.

If Mn/DOT provides assistance in the form of traffic control devices, signs and/or labor, the requester should be billed for the actual costs incurred by Mn/DOT.

For purposes of these guidelines, the use of highway right-of-way is split into four categories:

1. Use of Right-of-Way Involving Road Closure
2. Use of Right-of-Way Involving Traffic Restrictions
3. Use of Right-of-Way Not Involving Traffic Restrictions
4. Signs, Banners, and Decorations
Within each of these categories, the categories are subdivided as follows:

**Freeways** - Includes interchange areas on expressways

**Expressways** - Does not include interchange areas

**High Speed, Two Lane, Two-Way Highways** - Speed limit 45 miles per hour or greater: includes segments that may have additional lanes for passing, turning or bypassing and/or short segments of four or more lanes.

**Low Speed Roads** - Speed limit 40 miles per hour or less; generally includes those segments of trunk highways that pass through a city and/or serve a city street-type function and all frontage roads.

### 13-3.06.01 Use of Right-of-Way Involving Road Closure

Examples of road closures include parades, races, filming, etc.

**Freeways, Expressways and High Speed Two Lane Two-Way Highways** - Closures should not be allowed.

**Low Speed Roads** - Closures may be allowed at the discretion of the District Office subject to the following criteria:

1. Closures shall not be allowed during peak traffic periods unless authorized by the District Traffic Engineer.
2. If the right-of-way is located within a city, requests shall be made through the offices of or by the city.
3. A plan for traffic control and documentation of the means to implement it should be submitted. An adequate detour route shall be provided. Motorists shall be guided through the detour by signs, traffic control personnel, law enforcement personnel or a combination of the three.
4. Signs, if used, shall be in accordance with the Minnesota Manual on Uniform Traffic Control Devices (MN MUTCD).
5. Adequate traffic control and law enforcement personnel shall be arranged by the requester.
6. Festivals with a long history of occurrence and no traffic mobility or safety problems in the past should be allowed to continue. If a new traffic mobility or safety problem arises, it should immediately be brought to the attention of the event sponsor, local municipality, and enforcement agencies to be addressed. If no solution can be found, the organizations shall jointly agree to revise the location of the festival.
7. Denials of permits for road closures may be appealed to the Commissioner of Transportation by the requester.

### 13-3.06.02 Use of Right-of-Way Involving Traffic Restrictions

Examples of this category include races, filming, etc.

**Freeways** - Use of the freeway mainline and the adjacent right-of-way should not be allowed. However, use of a local road overpass or underpass area may be allowed in those cases where there is no significant impact on freeway traffic, subject to the criteria covered under "High Speed Two Lane Two-Way Highways and Low Speed Roads," below.

**Expressways** - Use of right-of-way should not be allowed. However, use may be allowed in those cases where there is a limited impact on traffic, subject to the criteria covered under "High Speed Two Lane Two-Way Highways and Low Speed Roads," below.
High Speed Two Lane Two-Way Highways and Low Speed Roads - Use of right-of-way should not be allowed during peak traffic periods. Limited use is allowed subject to the following criteria:

1. The period of time for which a road is restricted for partial use should not exceed four hours.
2. If the right-of-way is located within a city, requests shall be made through the offices of or by the city.
3. The use of the right-of-way shall not interfere with motorists' safe operation of their vehicles.
4. The use of the right-of-way shall not obstruct sight distance and shall not detract from motorists' view of traffic control devices.
5. A plan for traffic control and documentation of the means to implement it should be submitted.
6. Adequate traffic control and law enforcement personnel shall be arranged by the requester.
7. All traffic restrictions should be coordinated with the State Patrol and the local law enforcement agency.

13-3.06.03 Use of Right-of-way Not Involving Traffic Restrictions

Examples in this category are parking, booths, sales, etc.

Freeways - Use of the freeway mainline and the adjacent right-of-way should not be allowed. However, use of a local road overpass or underpass area may be allowed in those cases where there is no significant impact on freeway traffic, subject to the criteria covered under "Low Speed Roads" below.

Expressways and High Speed Two Lane Two-Way Highways - Use of right-of-way should not be allowed. However, use may be allowed in those cases where there is a limited impact on traffic, subject to the criteria covered under "Low Speed Roads" below.

Low Speed Roads - Use of right-of-way may be allowed subject to the following criteria:

1. If the right-of-way is located within a city, requests should be made through the offices of or by the city.
2. No advertisements should be permitted on the right-of-way.
3. The use of the right-of-way shall not interfere with motorists' safe operation of their vehicles.
4. The use of the right-of-way shall not obstruct sight distance and shall not detract from motorists' view of traffic control devices.
5. Adequate law enforcement personnel protection shall be arranged by the requester, as necessary.
6. Use of the right-of-way shall not exceed 30 days and similar use should not recur within ten months.

13-3.06.04 Signs, Banners, and Decorations

Freeways - Signs, banners and decorations should not be allowed on the right-of-way.

Expressways, High Speed Two Lane, Two-Way Highways and Low Speed Roads - Directional signs may be allowed at the intersection of the local road leading to the event. Non-directional signs, banners and overhead decorations will be allowed only on low speed roads subject to the following criteria:

1. If the signs, banners or decorations are to be located within a city, the requests should be made through the offices of or by the city.
2. Signs, banners or decorations shall not be attached to any Mn/DOT structure (sign, signal, bridge, etc.).
3. Directional and non-directional signing are the responsibility of the requester. If, upon request, Mn/DOT provides assistance in the form of signs and labor, the requester should be billed for the actual costs to the Department.
4. The requester for directional signing will be advised that signing must conform to the MN MUTCD or as directed by the District Office.

5. Directional signing shall contain only directional information for the event.

6. Non-directional signs or banners shall not appear to represent or conflict with an official traffic control device in shape, form, color or legend. They should be of a neutral color.

7. Non-directional signs or banners should display only the name of the event and the scheduled time.

8. Signs, banners and decorations shall not obstruct sight distance or detract from motorists' view of traffic control devices.

9. No changeable message signs of the type used for temporary or permanent traffic control shall be permitted for event advertising purposes.

10. The minimum clearance for all signs, banners and decorations spanning a highway should be 22 feet above the roadway and shoulder.

11. Adequate traffic control shall be provided when overhead signs, banners, and decorations are being installed and removed.

12. Non-directional signs, banners, and decorations pertaining to an event shall not be in place longer than two weeks prior to the event and shall be removed within three days after the last day of the event.

13-4.00 ROUTE NUMBERING AND REFERENCE POINT SYSTEM

13-4.01 General

Each highway in Minnesota is part of a dual system of numbering. The first part of the system is a Constitutional or Legislative route number and the second part is a route signing number (i.e., U.S. route number, Interstate route number or a Minnesota Trunk Highway number). The total numbering system must be kept in logical order and great care must be exercised in changing or revising any portion of the system. There are certain rules which must be followed and certain committees, both locally and nationally, that must be involved to make the system workable.

13-4.02 Constitutional Routes

The Constitutional amendment adopted in 1920 establishing the Minnesota highway system listed 70 routes that by their very description connected various cities and areas in the state into a highway system. These first 70 routes are known as Constitutional Routes and are numbered 1-70. These routes are described in Minnesota Statutes 161.114 and, because of the constitutional nature of their establishment, should be considered unchangeable.

13-4.03 Legislative Routes

Since the original 70 routes were established, many additional routes have been added to the Trunk Highway system through action of the Legislature. These routes, currently numbering over three hundred, are known as Legislative Routes. These routes are modified, revised, changed and added to from time to time by the Legislature, usually on the recommendation of the Department. These routes are described in Minnesota Statutes 161.115. Any changes proposed by the district in these routes should be coordinated through the Department's Control Section and Route Numbering Committees as established by Department Directives 2-015A and 2-02A, respectively.

13-4.04 Names and Designation of Certain Highways

At various times the Legislature has named and designated portions of certain constitutional and legislative routes. Typical names are the "Capitol Highway," "Floyd B. Olson Memorial Highway," "Yellowstone Trail," etc. Named routes are listed in Minnesota Statutes 161.14 where the route itself is described and the special conditions for signing each route are set forth.
13-4.05 Interstate Routes

The National System of Interstate Highways was established in 1957 with a numbering system and distinctive markers designed by the American Association of State Highway and Transportation Officials (AASHTO). East-west routes have even numbers and north-south routes have odd numbers with the lowest number routes in the west and south. Major routes have one or two digit numbers, and the most important routes have numbers ending with 0 or 5. Special, related three-digit numbers are used to designate spurs and circumferential routes in urban areas. Any proposed revisions to this numbering system must be coordinated through the Route Numbering Committee since approval by a National Committee is required prior to any change in the system.

13-4.06 U.S. Highways

The system of United States Numbered Highways was adopted in 1926 in order to provide a uniform system of numbered highways extending across the nation for the benefit of the interstate traveler. The numbering system and the distinctive markers were developed by AASHTO at the request of the Federal Highway Administration and with the advice of several states. This system is kept current through the coordination of AASHTO and the cooperation of the states. From about 40 routes when the system was established there are now close to 200 U.S. routes in the continental United States. Even numbered routes generally follow an east-west alignment, while odd numbered routes are generally north-south. Any proposed changes to this system must be coordinated through the Route Numbering Committee since the approval of the Executive Board of AASHTO is necessary. The U.S. route system is only a route numbering signing system and is not related to Federal funding.

13-4.07 Trunk Highway Routes

All routes not designated as part of the Interstate or U.S. Route number systems are given a "Minnesota" route number. These numbers are assigned by the Route Numbering committee and all requests for new numbers or changes must be coordinated through that committee.

13-4.08 Turnbacks

As roads are rebuilt or new roads are constructed, certain old routes are turned back to the counties and municipalities. The route is deleted from the Trunk Highway system and is normally assigned a route number by the involved jurisdiction. Funds are available for restoration of the roads that have reverted to county and municipal jurisdiction (see Minnesota Statutes 161.082 and 161083). Rules and regulations for implementing a "turnback" are set forth in the current Right-of-Way Manual (5-491.128). Upon completion of a "turnback" all responsibility for providing traffic control devices rests totally with the local jurisdiction.

13-4.09 Reference Point System

Reference posting is a continuous distance reference system which indicates the distance from a known starting point. The purpose of a reference point system on freeways and highways is to provide uniform and accurate reference points for all highway-oriented activities. The actual physical reference points consist of reference post marker plates, installed approximately at either one mile intervals along the roadside, which show the continuous distance along the route.

Distance numbering is continuous for each route within the State, except where overlaps occur. Distances are computed from the west State line or the westerly terminus for highways running in a general west-east direction, and from the south State line or the southerly terminus for highways running in a general south-north direction.
The Trunk Highway Logpoint Listing specified the locations of side roads, bridges, crossroads, culverts and other identifiable physical features to the nearest mile. The Logpoint Listing was developed for the purpose of providing more precise and specific reference to locations between the reference posts. Logpoint systems will be developed for both county and municipal road systems.

The Reference Point System and Trunk Highway Logpoint Listing are used to aid the several offices and organizations directly associated with highway maintenance and control. Included in the practical uses of the system are the following:

1. Precise identification of crash locations.
2. Reference for the location of emergency incidents.
3. Reference points for roadway maintenance servicing.
4. Reference points for use in road inventory records.
5. Aid to motorists in estimating their progress.

13-4.09.01 Overlapping Routes

Mileage numbering should be continuous for each route within the state. On overlapping routes, continuity should be established for only one of the routes in accordance with the Control Section Record. On the route without Reference post continuity, the first Reference post beyond the overlap should indicate the approximate distance traveled from the beginning of the route.

13-4.09.02 Divided Highways

For divided highways, mileage measurements shall be made on northbound and eastbound roadways. The Reference posts for southbound and westbound roadways shall be set at directly opposite locations.

13-4.09.03 Transportation Information System (TIS)

Reference posts play a critical role in the TIS, as all road features, inventory items, or crash locations are directly or indirectly referenced to the field Reference post. It is imperative that the post be in place. If replacement is required, it must be done in accordance with location instructions from the Program Management Division, if its previous position cannot be precisely determined.

When construction projects or turnbacks affect reference posting on any Trunk Highway, the Transportation Research and Investment Management Division should be contacted as to placement of the required posts. Do not invent a new method, as the True Mileage System of the TIS established adjustment rules and procedures to follow.

13-4.10 Exit Numbering

Exits from Interstate highways in Minnesota are numbered in accordance with Federal Highway Administration requirements which specify a reference post format. Exit numbers are displayed at the top of major guide signs located in advance of an interchange at the exit. The exit number normally utilizes the last reference post number in a decreasing reference post direction from the interchange. When there are multiple exits at an interchange (cloverleaf, for example), or more than one interchange for a given reference post, the first exit number in the increasing reference post direction is given the letter "A" and the second the letter "B". Occasionally, a third exit may occur within the same reference post number assigned to an interchange. In that case, the exit would carry the reference post number followed by the letter "C".
13-5.00 SPECIAL INVESTIGATIONS AND STUDIES

13-5.01 Videologging

Mn/DOT has been recording images of Minnesota's trunk highway system since the summer of 1973. The initial system was a photographic system using a 35mm camera, mounted on a van, triggered to take photographs of the roadway every one-hundredth of a mile. In 1987 the system was improved by capturing images on video disc, and transferring them to an optical disc for viewing on dedicated view stations. Today, the video system is state of the art technology with two Video Image Capturing Systems in digital format. These digital images can be conveniently viewed on personal computers that have access to Mn/DOT's internal network system.

Since the photos are taken in both directions, 24,000 miles are being photographed and cataloged in the Department's video library. Video pictures are readily available for road condition studies, sign inventories, right-of-way development surveys, and traffic control device evaluation.

They also serve as an accurate record for estimating damages resulting from crashes and natural disasters. Viewing equipment is available in the Central Office as well as all District Offices. Copies of photographs can be obtained for Department use at no charge through the Office of Traffic, Safety and Operations.

Construction projects, maintenance or utility work and similar activities frequently offer the opportunity to make a photographic record of good or bad applications of traffic control devices. Therefore, when such situations are encountered and are deemed appropriate for photographic study and use in future analysis or training, the District Traffic Engineer is encouraged to request that the site be videologged. In all cases involving the videologging process, the Pavement Management Engineer, Office of Materials and Road Research should be notified so that duplication of requests is avoided.

Public access to the photographs will be balanced with Mn/DOT job requirements. Members of the public may view 35mm photographs, optical discs, or digital imagery with the assistance of Department personnel only. Print copies of the photographs may be purchased. This is the only form of duplication currently available. Uniform access to the videolog/photolog viewing equipment for the general public will be based on equipment and personnel availability through the following methods, which are flexible in unusual circumstances.

A member of the general public may come to the Office Traffic, Safety, and Technology (OTST), videolog/photolog viewing room or District Office to view the photographs by appointment with the conditions below.

1. Prior to the review, the OTST Tort Claims Office must be contacted so that a determination can be made as to whether or not the State of Minnesota is involved in any litigation relative to this request. If, as a result of this review, it is judges that the State is involved in the litigation, the interested party must make their request for information to the Attorney General's Office and follow the rules of discovery.

2. One week advance notice to arrange an appointment may be required depending on resources.

3. Appointments should be limited to approximately one hour. To accommodate work flow and public access, individuals will be allowed one appointment per week.

4. Prints of videolog/photolog photographs are available to the public from the OTST for a fee.
Viewing equipment and photographs may be used in court cases. Uniform guidelines for all personnel who must present photos of Minnesota's Trunk Highway System in court are as follows:

1. If the photographs are requested to be shown in court, a subpoena must be issued for the film or disc, viewing equipment and operator. (Print copies of the photographs may be obtained without a subpoena being issued if the State is not involved in the litigation. However, if copies of photographs pertaining to litigation against the State of Minnesota are requested, the request must follow the Rules of Discovery. The request MUST be made to the Attorney General's Office.)

2. The user will be charged for all costs incurred. These costs will include: labor costs (to include travel time) for the personnel, transportation costs, all applicable overhead costs, and $150.00 per day for the equipment usage.

3. If it is requested that the disc or film be shown at a speed equivalent to a highway travel speed, make it clear that it will be an approximation only.

4. The requester should be reminded that the photographs represent the date of filming or recording only.

**13-5.02 Rumble Strips**

Rumble strips may be used when unusual alertness is required of drivers, and standard traffic control devices such as signs and/or flashers have apparently not proven to give adequate warning. Several strips are placed laterally across the pavement to cause a rumble or bumpy motion that, when traversed by a vehicle, will alert the driver. Typical locations for use of rumble strips are approaches to toll gates and to stop signs hidden by horizontal or vertical curves. Proximity of the rumble strip to the hazard is important. If the rumble strip is located too close to the hazard, sufficient driver reaction time is not given; and if they are located too far away, the driver may not relate the rumble strip to the hazard. Mn/DOT has developed a formal rumble strip layout. See the Mn/DOT Road Design Manual, section 4-4.02.02.

**13-5.03 Experimental Traffic Control Devices**

**13-5.03.01 Legal Authority**

Minnesota Statutes 169.06, Subdivision 2, states, "The Commissioner may authorize variations from the manual and specifications for the purpose of investigation and research into the use and development of traffic control devices. When such authorized variation pertains to the regulations of traffic, notice of the intended regulatory purpose shall be published in a qualified newspaper of general circulation in the area where the research is being conducted."

**13-5.03.02 Procedures**

The following procedures shall be followed to obtain approval to use experimental traffic control devices:

1. The District Traffic Engineer or Traffic Research Engineer shall originate the procedure by making a thorough investigation relative to the needs for the experimental device, reasons for choosing it, description of devices and expected results.

2. The originator shall submit the above information to the State Traffic Engineer, Office of Traffic, Safety and Technology (OTST) for review with a request for approval.

3. Upon approval, the State Traffic Engineer, OTST shall draft a Commissioner's Order and shall send a copy to the Transportation District Engineer.

4. The Transportation District Engineer shall arrange for the required legal notice to be published in local newspapers.
5. The District Traffic Engineer shall prepare the appropriate Traffic Control Order covering the experimental devices for the State Traffic Engineer’s, OTST signature.

6. The District Traffic Engineer and/or Traffic Research Engineer shall review the site upon installation of the device and shall monitor it periodically to assure safe and efficient operation of the device and to recommend any necessary alterations to the State Traffic Engineer, OTST.

7. Upon termination of the operation or experiment, the originator shall submit a report to the State Traffic Engineer, OTST outlining all aspects of the experiment and evaluating the device, recounting both positive and negative aspects, and including comments and suggestions.

13-5.04 Speed Trend Studies

A speed trend study is a method of determining long or short range changes in motorist's travel speed. The study is a compilation of data collected from individual speed monitoring sessions (sometimes called speed surveys) which are analyzed and evaluated. The results from a speed trend study may identify changes in speeds within a certain area which may be attributable to reconstruction, improved lighting, or other roadway changes. Districts can perform speed trend studies to collect information about road segments where speed may be a concern.

Historically, speed trend studies were also performed for the Federal Speed Monitoring Program. This program was developed to establish a valid statistical method of measuring a sample of vehicle speeds on a sample of highways posted at 55 mph and 65 mph with sufficient accuracy to support a determination of compliance by a State's motoring public with the National Maximum Speed Limits.

In late 1995, the National Maximum Speed Limit was repealed and the submittance of speed monitoring data to the FHWA was performed on a voluntary basis as determined by each state. In order to provide continuity in Minnesota's speed data, it was decided that the monitoring program would continue. Since there are no longer FHWA guidelines to be followed, the program has been modified to best fit Minnesota's needs.

13-5.04.01 Minnesota Speed Monitoring Program

Every Federal Fiscal Year (October through September), quarterly and annual speed monitoring reports are prepared by the OTST and submitted to the Federal Highway Administration (FHWA) Division Administrator. The results of this program are used to determine speed trends throughout the United States. Additional reports are sent to the Commissioner, all Mn/DOT districts, the Mn/DOT Library, Department of Public Safety, and the Legislative Reference Library.

State roadways are divided into 5 categories. Within each of these categories, the total number of roadway miles determines the number of monitoring sites, which are shown below.

<table>
<thead>
<tr>
<th>Category</th>
<th>Number of Monitoring Sites</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urban Freeway (60 - 70 mph)</td>
<td>2</td>
</tr>
<tr>
<td>Rural Freeway (70 mph)</td>
<td>7</td>
</tr>
<tr>
<td>Rural 2-lane, 2-way Highway (55 mph)</td>
<td>14</td>
</tr>
<tr>
<td>Rural Divided Highway (65 mph)</td>
<td>6</td>
</tr>
<tr>
<td>Urban Divided Highway (55 mph)</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>31 Total</td>
</tr>
</tbody>
</table>
The 31 sites are located throughout the State and each site will be monitored four times a year, once each quarter. A quarterly monitoring schedule is prepared each year.

1. Speed Monitoring Sessions

   Speed monitoring sessions are performed to collect vehicle speed data which will be incorporated into the speed monitoring program. Various methods are currently being used for the collection of data. Radar transmission devices, although useful in certain situations, are not used in the speed monitoring program due to manpower requirements. Below is a list of speed data collection devices.

   a. Weigh-In-Motion (WIM) Stations

      These devices are located throughout the State and collect a variety of data including the weight and speed of vehicles. The information is collected automatically.

   b. Automatic Traffic Recorders (ATR) Sites

      ATRs automatically collect information by means of in-pavement loop detectors. ATRs are located throughout the State and are typically used to determine vehicle counts. A small number of them have been installed to allow the collection of speed data.

   c. Portable data collection machines with road tubes, in-pavement loop detectors, or portable magnetic sensing devices. This method of data collection requires the placement of a sensing device on the road surface which connects to the data collection machine located off the road. This method is undesirable due to manpower requirements.

   Data for all WIM and ATR sites is obtained from the Traffic Forecasts and Analysis Section. The districts are not directly responsible for obtaining WIM and ATR data.

   Each speed monitoring session will place vehicle speeds into speed ranges as follows:

   - Number of vehicles from 00 to 40 mph
   - Number of vehicles from 41 to 45 mph
   - Number of vehicles from 46 to 50 mph
   - Number of vehicles from 51 to 55 mph
   - Number of vehicles from 56 to 60 mph
   - Number of vehicles from 61 to 65 mph
   - Number of vehicles from 66 to 70 mph
   - Number of vehicles from 71 to 75 mph
   - Number of vehicles from 76 to 80 mph
   - Number of vehicles from 81 to 85 mph
   - Number of vehicles from 86 to 100 mph

   This data is then used for the computation of speed trends for the 5 roadway categories. Errors in vehicle speeds are put into a 110 mph range and should not be used in calculations.

2. Speed Monitoring Session Procedures

   The following procedures shall be followed in analyzing speed data:

   a. All sessions will be 24 hours in length to account for varying hourly traffic conditions and to facilitate the scheduling of data collection.

   b. No monitoring should be performed on holidays or weekends on recreational routes.

   c. The monitoring schedule for the program shows the month and day of week that each monitoring session is to take place. Due to inclement weather and other factors it is not always possible to meet the requirements of the schedule. In the event that the schedule has to be adjusted and a session performed on a different day, keep in mind that all sessions should be evenly distributed by day of week. Data should not be collected on any monitoring station more than once on any day of the week in any one year.
3. Speed Monitoring Session Location Requirements

When performing temporary speed monitoring sessions or placing permanent speed monitoring equipment, the following situations must be avoided:

a. near or at a sharp horizontal curve with a speed advisory plate less than the posted speed limit.
b. Steep grades (i.e. greater than 4%).
c. Within 100 feet of a significant at-grade intersection.
d. Within 1000 feet of an exit ramp or entrance ramp of an interchange.
e. Anywhere within the interchange (defined as the distance from the beginning of a deceleration lane through the end of an acceleration lane).
f. Where other unusual features exist that might influence vehicle speeds (e.g. a narrow bridge or railroad crossing).

13-5.05 Plat Review (MSA 160.085, 161.19, 505.02)

13-5.05.01 General Requirements

Any proposed plat which includes lands abutting upon an existing or proposed Trunk Highway which has been designated by a Centerline Order filed in the Office of the Register of Deeds shall first be presented to the Department for written comments and recommendations.

Where the plat includes land abutting upon an existing or established county or County State-Aid Highway, it shall first be submitted to the County Engineer for his written comments and recommendations. Plats involving both a Trunk Highway and a highway under County jurisdiction shall be submitted to both the Department and the County Highway Engineer.

13-5.05.02 Preliminary Drawing

A legible preliminary drawing or print of a proposed plat shall be acceptable for purposes of review by the Department or the County Highway Engineer. A written statement shall be attached describing the outlet for, and means of disposal of, surface waters from the proposed platted area.

13-5.05.03 Review Period

Written comments and recommendations shall be submitted to the city, town or county within 15 days after receipt of the plat for review. Final action on the plat by the city, town or county shall not be taken until after these required comments and recommendations have been received or until the 15-day period has elapsed.

Failure to obtain the written comments and recommendations of the Department or the County Highway Engineer shall in no manner affect the title to the lands included in the plat or the platting of said lands. No certificate or other evidence of written comments and recommendations is required to file the plat in the Office of the Registrar of Deeds or Registrar of Titles.

13-5.06 Sight Distance at Crossroads

A major safety aspect is the sight obstruction caused by noise barriers, plantings, poles, signs, fences, bridge rails, etc., at or near the intersections of ramps, frontage roads, and crossroads.

When evaluating sight distance at intersections, two different procedures must be followed in order to determine if it is adequate--perceptual and driver acceptance of a minimum 10 second vehicle interval. It is very desirable that both of these be met at all intersections.
13-5.06.01 Perceptual

When approaching an intersection at grade, the operator of a vehicle should have an unobstructed view of the whole intersection and enough of the intersecting highway such that the driver can perceive a hazard in sufficient time to alter the speed of his vehicle as necessary before reaching the intersection. Minimum distances along the intersection road (setback distance) which should be unobstructed are determined by the approach speed and the distance traveled by the vehicle in three seconds. This does not provide enough distance to stop the vehicle; however, the three seconds gives the driver two seconds for perception and reaction plus one additional second to actuate braking or accelerating his vehicle to avoid a collision. For additional information see Chapter 5 of the Road Design Manual.

13-5.06.02 Driver Acceptance of a 10-Second Vehicle Interval

Once a vehicle has stopped at the intersection, the driver must be provided adequate sight distance to safely enter the intersection. This distance is based on the acceptance of a 10 second vehicle interval. This may or may not be provided using the perceptual sight triangle method. Telephone and power poles, fences, and bridge rails do not obstruct vision when approaching an intersection (i.e., perceptual sight) but can block the entire view when stopped at the intersection. Figure 5-2.01A of the Road Design Manual provides the necessary information to determine the lengths needed for this sight distance.

13-5.07 Railroad Crossing Review

13-5.07.01 Background

See Part VIII of the Manual on Uniform Traffic Control Devices as well as Chapter 8830 of Minnesota Rules.

13-5.07.02 Federal and State Requirements

FHWA regulations require that Federally funded projects which cross any of Minnesota's 4,500 public railroad crossings at grade include a determination of adequate protective devices. Responsibility for advance warning signs and pavement markings at grade crossings belongs to the local road authority. The District Traffic Office must insure adequate traffic control devices at all Trunk Highway grade crossing approaches. This will entail an engineering review at unsignalized and authorized stop or yield crossings. It will entail verification of basic advance signs and pavement markings, at proper distances.

1. Signal Recommendations - When there are high speeds and high volumes on either the railroad or highway approaches to the crossing, and/or restricted sight corners, an engineering review, with participation from the Railroad Administration section of the Office of Freight and Commercial Vehicle operations, should be done to determine adequate protective devices. The District Office should communicate with the Rail Administration section of the Office of Freight and Commercial Vehicle Operations relative to all signal questions, considerations, minimum warrants, etc.

2. Study Reports - A grade crossing review and recommendations, with participation from the Rail Administration section of the Office of Freight and Commercial Vehicle Operations, should be included with all study reports on projects which involve Federal aid and which include at-grade railroad crossings.

3. Local Requests - Occasionally, the District Office may be requested to conduct a railroad crossing review at a county or municipal crossing, in order to assist the local agency. These requests should be directed to the Rail Administration section of the Office of Freight and Commercial Vehicle Operations or the Office of State Aid. The primary goal of all railroad crossing reviews is to improve traffic safety by applying standard traffic control devices where needed and as appropriate for each unique situation.
13-5.07.03 **Principles of Grade-Crossing Protection**

The adequate protection of grade crossings is based on basic traffic engineering principles and professional judgment. Prerequisites for protection at non-signalized crossings are outlined below. Signalization may be warranted where sight distances are inadequate and cannot be corrected with signing, speed zoning or other measures.

1. Standard advance warning signs should be properly placed and fully reflectorized. Pavement markings should be applied on hard surfaced roads.

2. The crossing should be visible to the motorist at a safe stopping distance based on the posted or 85th percentile speed.

3. Based on the posted or 85th percentile speed, the type of roadway surface, and the maximum train speed, motorists should be provided with sufficiently clear sight quadrants in either direction so that they can observe an oncoming train as they approach the crossing in time to either stop at the crossing or proceed through ahead of the train.

4. Adequate sight distance along the tracks must be provided for a stopped motorist to accelerate through the crossing in advance of an oncoming train, based on maximum train speeds. Examples of vehicles which must be considered are petroleum trucks, school buses, and vehicles with limited acceleration capabilities.

13-5.07.04 **Review Procedures**

A thorough review of a grade crossing with participation from the Rail Administration section of the Office of Freight and Commercial Vehicle Operations.

13-5.07.05 **Evaluation Criteria**

Table 13.1a, taken from the 2001 AASHTO Green Book, Exhibit 9-104, presents data on sight distances as a function of highway and train vehicle speeds, and includes factors obtained from AASHTO showing the effect of grade on stopping site distance. Tables 13.2 and 13.3 illustrate sight triangles for stopped and moving vehicles.

13-5.08 **Advisory Curve Study**

Curve and turn signs should be used to inform the driver of a change in geometrics that is not readily apparent or occurs in an unexpected location compared to the typical character of the roadway. These warning signs require caution on the part of the vehicle operator and may call for reduction of speed or a maneuver in the interest of comfort and safety. The need for curve and turn signs may be determined in the field by making several trial runs through the curves in a test vehicle equipped with a slope meter or an electronic meter, such as Model E45 manufactured by Rieker Instrument Company. The ball-bank reading is a measure of the amount of centrifugal force on the vehicle.
1. Slope Meter

The slope meter is an instrument used to determine the comfortable speed that a passenger vehicle can travel around a curved roadway section. This instrument consists of a steel ball in a sealed, curved glass tube filled with an alcohol solution. The tube, bent on the arc of a circle, is graduated from 0 to 20 degrees, both to the left and right of the zero point. The tube is enclosed in a metal case. When mounting the ball-bank indicator, the vehicle should be in a stationary level position. The speedometer of the test vehicle must be accurately calibrated and the tires uniformly inflated. The indicator should be mounted vertically, with the steel ball at the zero point. All occupants who are to be in the vehicle when the observations are made should be in the same position when mounting or checking the instrument as when making the test drive. This is necessary because changing the position of a passenger or the load in the test vehicle may cause the vehicle body to tilt to the right or left. This tilting action or body roll will cause a change in the slope meter readings.

2. Procedures for Testing A Curve

The use of the slope meter or electronic meter to measure the comfortable speed on curves involves the efforts of two people--one to drive and the other to observe the meter. The following procedures should be followed in each test:

a. The curve under observation should first be appraised by the driver to determine the approximate safe speed which can be maintained.

b. The driver should then conduct the first test at a speed 10 mph below the appraised speed.

c. Each succeeding test should be made at a speed 5 mph greater than the preceding test, until the meter has reached 10 degrees, except as indicated on Chart 13-1.

d. On each test, the driver should attain the trial run speed at a distance of at least 1/4 mile from the beginning of the curve.

e. The course throughout the curve should be maintained precisely in the center of the lane and at uniform speed. Using a vehicle with cruise control aids in this process.

f. The observer shall note carefully the position of the ball on the slope meter or the display on an electronic meter at the approximate center of the curve and shall record the reading.

g. The reading shall be recorded as right or left of zero. The turn sign showing an arrow bent at a right angle (W1-1 left or right) should be used to mark curves on which a meter indicates 10 degrees or more at a speed of 30 mph or less. Additional protection may be provided by use of the Advisory Speed plate.

h. The curve sign showing a curved arrow (W1-2 left or right) should be used to mark a curve where a test with a meter gives readings of 10 degrees or more at speeds equal to or greater than 35 mph and equal to or less than the legal speed limit established on that section of highway. Additional protection may be provided by the use of the Advisory Speed plate.

i. The reverse curve sign (W1-4 Left or Right) and reverse turn sign (W1-3 Left or Right) shall be installed to mark two curves or two turns as defined above and connected by a tangent of less than 600 feet. When an advisory speed plate is used, the lower of the two recommended speeds will prevail.

3. Curve Study Sheet

It is important that all information be recorded as indicated on a curve study sheet. As provided on the curve study sheet, trial runs should be made in each direction. The ball bank angles in Chart 13-1 shall be used to establish the safe speed on curves. As an example, for the speed range 35 mph and above, the comfortable speed for the curve is the exact speed which swings the ball 10 degrees off center on a slope meter or displays 10 degrees on an electronic meter. Any speed which causes the ball to move more than 10 degrees away from the zero position is considered uncomfortable to the driver and possibly unsafe at higher speeds.
13-6.00 ENGINEERING AND TRAFFIC INVESTIGATION REQUIREMENTS TO ESTABLISH OR CHANGE REGULATORY SPEED LIMITS

13-6.01 Authority

Minnesota Statute (MS) 169.14 sets forth speed limits to govern all highways and alleys in the state. Any posted speed limit greater or less than the statutory limits must be authorized by the Commissioner of Transportation. Any alteration of statutory speed limits on any public road or street shall be based upon the results of an engineering and traffic investigation. It is Mn/DOT policy that the entire Trunk Highway system shall have regulatory speed limits and they shall be determined by an engineering and traffic investigation. The regulatory speed limit shall be effective when such signs are erected.

There are exceptions to the Commissioner's authority to establish regulatory speed limits.

1. School zone speed limits greater than 15 mph, but no more than 20 mph below the established limit, may be set by local authorities according to MS 169.14 Subd. 5a. See Chapter 13 in this manual.
2. Work zone speed limits between 20 and 40 mph and up to 55 mph on divided highways may be set by local authorities according to MS 169.14 Subd. 5d. See Chapter 8 in this manual.
3. A municipality may establish a speed limit from 10 to 30 mph in a mobile home park according to MS 327.27.
4. Local authorities may establish speed limits not lower than 25 mph on a roadway that has a designated bike lane according to MS 160.263.
5. A political subdivision may establish a speed limit on a road within a park. The speed limit shall not be lower than 20 mph and shall be established in accordance with guidelines prescribed by the commissioner. The guidelines are the same as those outlined in this section.
6. A road authority may establish a 25 mph zone on a residential roadway. MS 169.01, subd. 81 defines a residential roadway as a local street less than one-half mile in length.

13-6.02 Administrative Procedures

The Commissioner has delegated authority to the Assistant State Traffic Engineer, OTE-ITS, to authorize the establishment of speed limits. The District Traffic Engineer is responsible for performing the engineering and traffic investigation necessary for speed limit determination.

1. Trunk Highways

A complete investigation report, along with a completed Trunk Highway Speed Limit Authorization Form Mn/DOT 29212, covering the entire Control Section, shall be submitted to the Assistant State Traffic Engineer, OTE-ITS, for signature. After this review and approval, the authorization will be returned to the district for implementation.

2. Local Streets and Highways

When a local authority deems an existing speed limit is not reasonable or safe on a road under its jurisdiction, the local road authority may request Mn/DOT to make an engineering and traffic investigation to determine if a change in the speed limit is necessary.

The procedure is for the local road authority to draw up a formal resolution requesting an investigation. The resolution should describe the road or street fully and should indicate the exact termini of each section where an investigation is desired. Normally the termini should describe a sufficiently long section (at least 1/4 mile or more) to provide for a meaningful study. The resolution should be forwarded to the District Traffic Engineer to initiate the investigation.
The District Traffic Engineer shall then make the field investigation and prepare speed limit recommendations. These recommendations should be discussed with the local authority after completion of the investigation. The local authority may be furnished with a copy of the investigation results, if they desire.

The District Traffic Engineer shall submit a speed limit recommendation report to the Assistant State Traffic Engineer, OTE-ITS, for review and approval. A formal authorization is then prepared by OTE-ITS for the approved speed limits. This authorization shall be limited to speed zoning only, and shall be signed by the Assistant State Traffic Engineer, OTE-ITS.

Following receipt of Mn/DOT authorization, the local authority shall install the speed limit signs implementing the authorization. Installation shall conform to the current MN MUTCD.

When roadways are turned back, exchanged with other roadways or renumbered, technically the speed limit authorization is still in effect. However, to prevent confusion and provide for unquestionable documentation in prosecuting speeding offenses, it is highly advised that the new road authority request a study of the road in question. Subsequently, the new authorization will list all information correctly.

13-6.03 Principles of Speed Zoning

The statutory speed limits are intended to provide uniformity for typical highways, under ideal conditions and no apparent hazards. Alteration of the statutory speed limits to fit existing traffic and physical conditions of the highway constitutes the basic principle of speed zoning. The objective of correct speed zoning is to influence as many drivers as possible to operate at or near the same speed, thus reducing conflicts created by wide differentials in speed. It is widely recognized by traffic engineers and is a proven fact that wide differences in speed frequently contribute to crashes. The speed zone study is conducted to determine the maximum safe speed that should be posted for that location to provide continuity of traffic flow.

Correct and realistic speed zoning will serve to protect the public and regulate the unreasonable behavior of an individual. Having recognized that normally careful and competent actions of a reasonable driver should be considered legal, Mn/DOT has a responsibility to assure this protection. If a speed zone is determined by the actions of the majority of drivers on a highway, then it is hoped that speed zoning will facilitate the most efficient and orderly movement of traffic by increasing driver awareness of a reasonable and prudent speed. The speed limit should aid the motorist in adjusting speed to the conditions and furnish police officers with an indication of what is excessive and unreasonable speed.

13-6.04 Determination of Speed Limits

The posted regulatory speed limits should be for off-peak hour traffic on an average weekday. The speed limit on a hard-surfaced road must reflect clear, dry and ideal conditions, so that the road may be driven at the highest safe speed. When the weather, or road surface, deteriorates or traffic congestion occurs, it is then the driver's responsibility to reduce speed and drive accordingly. When physical features at spot locations (such as limited sight distance, narrow bridges, blind intersections, etc.) or potential hazards (such as pedestrians, children in unfenced playgrounds, etc.) occur, the use of warning signs and advisory speeds should be considered.

Prevailing speeds, physical features, crash experience and traffic characteristics are the primary factors in determining the appropriate speed limit. The most important factor is the 85th percentile speed from a spot speed study. The 85th percentile speed reflects a safe speed for existing conditions as perceived by the majority of motorists. Using the 85th percentile speed tends to group the other factors since they are reflected in the driver's choice of speed, which is altered to adjust for those conditions. It also recognizes the need for considering the majority of drivers to be involved in the decision-making process which is necessary to establish an enforceable limit. The 85th percentile speed is usually at or near the upper limits of the 10 mile per hour incremental "pace speed". Posting a speed limit near the 85th percentile speed will result in the highest percentage of drivers being grouped in the pace speed.
Speed limits less than the midpoint of the pace should generally be avoided because they tend to increase the relative speed differentials among vehicles and, therefore, the potential for vehicle conflicts.

Physical features may dictate the regulatory speed limit. Where a continuous curvilinear section of roadway with short connecting tangents exists, a regulatory speed limit should be posted to aid the motorist in determining an appropriate speed to travel. On a section of road with only infrequent horizontal curves, "curve" or "turn" warning signs with correct advisory speed plates should be erected, with speed zoning determined by the essentially tangent alignment of the road and other factors. Safe speeds on the curves should be determined using a ball-bank indicator.

Other physical features which affect speed are roadway surface condition, shoulder width, lane width, and obstacles near the road. The effects of these factors are not easily measured but are reflected by checking the prevailing speed.

Traffic characteristics such as turning vehicles, traffic volumes, parking, traffic signals, and pedestrians all affect speed. Intersections by themselves do not necessitate a reduction in speed, but the traffic characteristics that occur near intersections do affect speed. It is difficult to measure the impact of any one of these factors or the collective affect. The varying speeds necessary for each reaction emphasizes why the study should be done in an off-peak period, so as to minimize this wide variation in speed. Again, the 85th percentile speed will reflect the maximum safe speed for the roadway without measuring the impact of each factor.

Crash experience should be reviewed for the preceding 3-year period. Contrary to popular belief, speed in itself is not a major cause of crashes. There is a consensus of professional opinions that many speed-related crashes result from both excessively low and high speeds. Many requests for a speed study will be initiated by an emotionally aroused public after a specific crash. It is important to review the crashes for the study area and determine if there is a problem that should be resolved rather than changing the speed limit. Typically, speed reductions may decrease the severity of crashes but not necessarily the frequency.

13-6.05 Investigation Procedures

When an engineering and traffic investigation is requested by local authorities, the exact length, as requested, must be investigated. If that length is too short to provide for a meaningful study, then the requesting authority should be notified and an amended resolution passed. On the Trunk Highway system, the area in question should be studied and the entire control section should be test driven to determine and verify the impact of any recommended speed change.

The location of the speed check is singularly important because it determines whether or not a complete picture of the speeds in the area is being obtained. The speed check locations must be strategically located to show all the important changes in prevailing speeds. In urban districts and on approaches to cities they should generally be located at intervals not to exceed 1/2 mile, depending upon the locality and the uniformity of physical and traffic conditions. Trial runs through the area may be of help in determining the speed check locations. Care should be taken to select locations sufficiently removed from any stop signs, traffic signals, or other traffic flow interruptions that significantly affect operating speeds. Mid-block locations generally represent typical flow conditions for accurate sampling. In rural areas, the spacing of speed check locations may be at much greater intervals so long as they reflect the general speed pattern. One speed check located at each end and the middle point of the selected zone should be sufficient.

Speed checks on new or reconstructed highway sections should not be performed until it is apparent that the traffic speeds have stabilized. Where speed limits are immediately necessary for the correct operation of the new roadway, then design speed and test run data will be acceptable for a temporary speed limit authorization. Local authorities should be made aware of this procedure when the initial study is done. A minimum of 100 cars should be checked. On highways carrying low traffic volumes, (up to 1000 ADT) the minimum of 30 samples may be used and, in any event, the study should be discontinued after two hours.
The cars checked should be the ones in which drivers are choosing his/her own speed and which have at least 6 to 9 second headways. When a line of vehicles moving closely behind each other passes the speed check station, only the speed of the first vehicle should be checked since the other drivers may not be selecting their own speeds. Cars involved in passing maneuvers should not be checked because they are probably traveling at an abnormal rate of speed. Speeds of trucks and buses may be recorded separately, and are not normally used in the calculations to determine the posted speed. Trucks and buses are usually a minor percentage of the traffic population and their speeds may not be representative of the rest of the traffic being studied. The truck and bus data is useful, however, in the evaluations of the speed profile, especially if the volume of trucks and buses is significant.

For both rural and urban areas, a map should be prepared showing the length of study area, north arrow, scale, in place speed limit zones, proposed speed limits, and the speed limits adjoining the study area. In urban or suburban areas, an accurate log should be made of all traffic signs, traffic signals, intersections, curves over 2 degrees, grades over 3 percent, and location of businesses and residences. Rural zones should have a log only if a speed limit, other than a statutory value, is being recommended. Normally in rural areas the Transportation Information System (T.I.S.) log point listing is adequate to show intersection spacing, along with some general comments about land use adjacent to the roadway.

All reports should contain physical characteristics such as surface type and width, shoulder type and width, condition of both, number of lanes, location of turn lanes, and ADT. The location, type and numerical limit of all advisory speed signs should be logged.

On trunk highways, the crash rates should be submitted for the study area. A comparison should be made with the district annual average crash rate by highway type. If the study area is significantly above the average rate, an crash summary report should be printed out and analyzed. Average rates are not published for local roads, but summary printouts can be obtained. Anytime the request for an investigation is the result of crash experience, the summary printout should be included in the study. Adequate consideration may then be given to corrective measures, the degree of enforcement emphasis needed and the impact of any speed changes.

13-6.06 Conditions Justifying Variations from the 85th Percentile Speed

The approved posted speed should normally be the nearest value below the 85th percentile speed which ends in 5 or 0. Conditions which justify varying the zone speed from the 85th percentile speed are:

1. If the 85th percentile speeds for adjacent speed check stations are approximately the same, they may be averaged to determine the zone speed. This method may also be used when differences occur in opposing directions. If directional speed differences are greater than 10 mph, different zones may be established for opposing directions. Enforcement officials should be notified of this decision and their reaction submitted with the investigation results.

2. Speed limits may be established 5 mph under the 85th percentile speed when there is a high crash record involving crashes of a type that would be reduced by enforcement of a lower speed limit. Crash severity rates should be calculated for each of the preceding 3-5 years and demonstrate an increasing progression of severity. These rates and the computer printouts used to determine them should be submitted with the report. A lower speed limit should be established only after the commitment of reasonable enforcement is assured.

3. At locations where traffic volumes are very light and a sufficient number of cars cannot be checked in the two hours that the speed check station is operated, the 85th percentile speed may not be reliable. In these cases, test runs should be done by experienced traffic engineering personnel. Test run speeds should be selected in 5 mph increments. Ideally, two test runs at each speed should be conducted out in each direction by two different drivers. The vehicle should have a calibrated speedometer. Test runs should provide a basis from which to select a reasonable and safe speed. This data and the recommended speed with a short justification statement should be marked on the report.
4. School zone speed limits are not based on the 85th percentile speed. Speed checks do provide an accurate reflection of the prevailing speed for average conditions and may be used as the base point from which speed limits can be adjusted downward for special conditions such as children crossing. The booklet "A Guide to Establishing Speed Limits in School Zones" outlines the methods to conduct the engineering and traffic investigation at these sites. This booklet is available from OTE-ITS and has been adopted by Commissioner's Order No. 63700 as the official method described in MS 169.14 Subd.5a.

5. If the study area is of a continuous curvilinear design, the area should be test driven and a ball bank survey done. Radar checks should be made at midpoints of tangents and used as a guideline for determining reasonable values, but the controlling factor of the speed limit will be the average of the safe speeds as determined by the ball bank survey. Establishing a speed limit by this method will prevent unnecessary accelerations by the driver, conserve fuel and provide safe traveling with minimum frustration encountered on winding roadways. Individual curves will still have to be checked and advisory speeds posted where necessary.

13-6.07 Speed Zone Locations

The length of any section of zone set for a particular speed should be as long as possible and still be consistent with the 85th percentile speeds. Transition zones may be used on approaches to a city to accomplish a gradual reduction from highway speeds to the speed posted in the city. In case the transition zones on the approach to the city are at locations where speeds fluctuate, the sections of such a zone may be as short as 1/4 mile. The change in speed between two transition zones should be greater than 5 mph, but should not normally be greater than 15 mph, because the change in speed would be too abrupt for driver observance.

Minnesota law states that the maximum speed limit in an urban district is 30 mph. It is possible that the engineering and traffic investigation will show that the 85th percentile speed reaches a value considerably higher than 30 mph in an urban district of an incorporated area, thus indicating that a speed limit of 30 mph is too low to be reasonable and prudent. Therefore, a reasonable and prudent speed limit should be determined and set by the Commissioner. On a city street, municipal state-aid street or town road, the governing body may elect to decrease the speed limit to 30 mph by the procedures defined in Minnesota Statute 169.14, Subd. 5b.

At locations where the study is extended into or through city limits, the exact point where the definition of urban district is met should be recorded. This is necessary because the speed limits inside the limits of the urban district may be established by the city government as described above, while the speed limits outside the urban district shall be established by the Commissioner. It is also necessary to show on the strip map, the exact location of the city limit either by station and project number, by reference post numbers, or by some other geographical physical feature to prevent misinterpretation if the city limits are changed.

Other important factors in speed zone locations include the speed limit and conditions presented in front of the driver as he leaves a zone. If an in place zone is being changed or a new zone established, the roadway on each adjoining side of the study area should be driven to determine if it is impacted by the recommended speed limit. The adjoining segments should be test driven for a length equal to 10 seconds of travel time at the posted or statutory speed limit. If adjoining speed limits are affected or there are potential hazards present that would affect the driver's choice of speed, then the road authority (or the adjacent road authority) should be notified that the study area should be expanded. If the road authority (or the adjacent road authority) refuses expansion of the study, this should be documented and included with the study report when it is submitted to OTE-ITS.
13-6.08 Checklist of Items Submitted with Speed Report

1. Administration Items
   - Resolution or reason for initiating study from road authority.
   - Exact road name and termini of study.
   - Entire control section reviewed and listed on Form 29212.
   - Reaction of local officials to proposed zoning.
   - Reaction of enforcement officials to proposed zoning.
   - Relative correspondence from citizens or political factions.
   - In place road, reconstructed or new construction.
   - Other

2. Roadway Features
   - North arrow, scale and copy of map with designated road shown.
   - Roadway width, shoulder width, surface type and condition.
   - Urban district limits and incorporated city limits.
   - Locations of buildings and entrances along road.
   - Crossroads with names or numbers.
   - Locations of traffic signals, signs and/or markings.
   - Limits of proposed zones, limits of existing zones and the limits of the zones entering and exiting the study area.
   - Horizontal and vertical curve locations.
   - School zones, playgrounds or other special zones.
   - Crash rates for the roadway.

3. Speed Data
   - Location of radar checks shown on map.
   - Speed data sheet with 10 mph pace, percent in pace, 50th percentile and 85th percentile shown.
   - Range of speeds at which test runs were executed if radar checks not feasible.
   - Corresponding advisory speeds listed for in place warning signs.
   - Show values of any other in place speed zones such as school zone speed limit or bridge speed limit.

13-6.09 Speed Zones on Gravel Roads

Gravel roads have considerable differences from paved roads. Typically, gravel roads are designed with minimal design criteria, are subject to fluctuating surface conditions, have low enforcement priority, and serve low ADT’s usually comprised of local repeat traffic. The principles of speed zoning are described in the ITE Traffic Engineering Handbook (4th Edition). In summary they address reduced stopping distance, traffic flow, capacity, safety and crash severity reduction. It is very difficult to equate these principles with the conditions that usually exist on a gravel road. Due to these principles and operational characteristics of gravel roads, Mn/DOT has generally not set speed limits on gravel roads and has relied on the "Basic Rule" described in MN Statute 169.14.

It is Mn/DOT’s policy to evaluate gravel roads based on the merits of the principles described above and if these principles are not met or there will be no improvement in the operation or safety of the road, then a reduced speed limit will not be authorized. Mn/DOT will honor all requests to investigate any type of road and perform the traffic investigation. Due to workload and economic factors, it will be necessary to quickly and accurately determine the type of road and whether speed limits would benefit the road based on the above principles.

To aid the study teams, the following list of typical qualifications should be used in the first phase of the investigation to facilitate their prompt judgement of whether or not a speed limit should be established on a gravel road.
1. Typical gravel roads where speed limits are not necessary:
   a. A gravel road that would not be zoned even if it was paved. (Many requests originate from dust control problems. Paving, not a speed limit, is the correct solution.)
   b. A DEAD END road without continuous traffic flow.
   c. Gravel roads that do not provide a connection (at both ends) between arterial roads or major traffic generators.
   d. Rural or urban non-collector type roads that serve scattered local residents only.
   e. Gravel roads that have no practical enforcement potential. Origin of the request should be determined so that unique problems can be isolated and solved by enforcement rather than a regulatory speed limit being used as a net to catch one violator.

2. Typical gravel roads where speed limits may be beneficial are:
   a. When there is a connecting section of gravel road that is between two paved roads, that serves to provide a continuous roadway. If the paved sections have speed limits, then a safe speed limit should be considered for the gravel section.
   b. When the gravel roadway meets or substantially meets urban district criteria (MS 169.01 subd.59), and the housing and roadway are predominantly used by seasonal tourists unfamiliar with the road, the posting of a safe speed will aid the motorist in his selection of speed to navigate the road and the potential hazards of pedestrians.

All gravel road speed limit authorizations will have a contingency typed on each authorization. The contingency will void the speed limit authorization in the event that the gravel road is paved or reconstructed with new alignment or grade.

It should be stressed and communicated to local authorities, that it is the local authorities' judgement and decision making power as to whether a resolution should be pursued. Two sections of statute that reference this decision making ability of the local authority are MS 160.13, which in part states, ". . . may install other safety devices as they deem necessary"; and MS 169.14, subd. 5, which in part states, "When local authorities believe . . ." This language allows the local authority to decide if a speed limit investigation is really necessary and if not, then they are not bound by statute to pass a resolution requesting one. Mn/DOT guidelines should be freely conveyed to them so that they are better able to make the right decision in requesting investigations.

13-7.00 REFERENCES

1. 1987 Minnesota Rules
2. Manual on Uniform Traffic Control Devices
4. Transportation and Traffic Engineering Handbook
<table>
<thead>
<tr>
<th>Train Speed (mph)</th>
<th>Case B Departure from stop</th>
<th>Design Sight for Highway Speed of:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Vehicle Speed (mph)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>10</td>
<td></td>
<td>240</td>
</tr>
<tr>
<td>20</td>
<td></td>
<td>480</td>
</tr>
<tr>
<td>30</td>
<td></td>
<td>721</td>
</tr>
<tr>
<td>40</td>
<td></td>
<td>961</td>
</tr>
<tr>
<td>50</td>
<td></td>
<td>1201</td>
</tr>
<tr>
<td>60</td>
<td></td>
<td>1441</td>
</tr>
<tr>
<td>70</td>
<td></td>
<td>1681</td>
</tr>
<tr>
<td>80</td>
<td></td>
<td>1921</td>
</tr>
<tr>
<td>90</td>
<td></td>
<td>2162</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Distance Along Railroad from Crossing, (d_T) (ft.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>69</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Distance on Highway from Crossing, (d_H) (ft.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
</tr>
<tr>
<td>10</td>
<td>240</td>
</tr>
<tr>
<td>20</td>
<td>480</td>
</tr>
<tr>
<td>30</td>
<td>721</td>
</tr>
<tr>
<td>40</td>
<td>961</td>
</tr>
<tr>
<td>50</td>
<td>1201</td>
</tr>
<tr>
<td>60</td>
<td>1441</td>
</tr>
<tr>
<td>70</td>
<td>1681</td>
</tr>
<tr>
<td>80</td>
<td>1921</td>
</tr>
<tr>
<td>90</td>
<td>2162</td>
</tr>
</tbody>
</table>

NOTE: This is for a 65-foot truck crossing a single set of tracks at 90 degrees.

Source Ref.: AASHTO -- Geometric Design of Highways and Streets, 2004

Text Ref.: 13-5.07
\[ d_H = 0.28 \frac{V_V}{254f} + V_V^2 + D + d_e \]

\[ d_T = \frac{V_T}{V_V} \left( 0.28 V_V t + \frac{V_V^2}{254f} + 2D + L + W \right) \]

- \( d_H \) = sight distance along the highway
- \( d_T \) = sight distance along the railroad tracks
- \( V_V \) = velocity of the vehicle
- \( V_T \) = velocity of the train
- \( t \) = perception/reaction time (assumed to be 2.5 seconds)
- \( f \) = coefficient of friction (see Table III-1)
- \( D \) = distance from stopline to the nearest rail (assumed to be 15 feet)
- \( W \) = distance between outer rails (single track \( W = 5 \) feet)
- \( L \) = length of vehicle (assumed to be 65 feet)
- \( d_e \) = distance from driver to front of vehicle (assumed to be 10 feet)

Source Ref.: AASHTO -- Geometric Design of Highways and Streets, 1994

Text Ref.: 13-5.07
\[
d_T = 0.28 V_T \left( \frac{V_G}{a_1} + \frac{L + 2D + W - d_a}{V_G} + J \right)
\]

- \(d_T\) = sight distance along the railroad tracks
- \(V_T\) = velocity of the train
- \(V_G\) = maximum speed of the vehicle in first gear (assumed to be \(9 \text{ ft/s}\))
- \(a_1\) = acceleration of the vehicle in first gear (assumed to be \(1.5 \text{ ft/s}^2\))
- \(D\) = distance from stop line to the nearest rail (assumed to be \(15 \text{ feet}\))
- \(J\) = sum of the perception time and the time to activate the clutch or the automatic shift (assumed to be \(2.0 \text{ seconds}\))
- \(W\) = distance between outer rails (single track \(W = 5 \text{ feet}\))
- \(L\) = length of vehicle (assumed to be \(65 \text{ feet}\))

\[
d_a = \frac{V_G^2}{2a_1}
\]

or the distance that the vehicle travels while accelerating to maximum speed in first gear.

Source Ref.: AASHTO -- Geometric Design of Highways and Streets, 1994
INDEX

A

911 Emergency sign ..... 6-83
Acceleration Lane Signing ..... 6-29
Administrative Liaison ..... 4-5
Adopt-A-Highway Sign Program ..... 6-79
Adopt-A-Rest Area Sign Program ..... 6-80
Advance Passing Lane sign (R4-X6) ..... 6-34
Advance Warning Signs on Local Road Approaches ..... 6-29
Advertising device
 defined ..... 2-4
Advertising Devices
design of advertising devices ..... 2-18
Minnesota Outdoor Advertising Control Act
 permits ..... 2-18
 statute ..... 2-19
Advertising Permits ..... 2-18
Advisory Curve Study ..... 13-20
Advisory Exit Speed Sign (W13-2) ..... 6-29
Advisory Speed plaque
color ..... 6-12
A-Frame
defined ..... 6-6
 sign mounting ..... 6-18
Agriculture Fertilizer Facility ..... 6-74
Ahead plaque
color ..... 6-12
Airplane Markings ..... 7-14
Airport Lighting ..... 10-13
Airport Signing Program ..... 6-55
Ambient Light
defined ..... 10-3
American Legion ..... 6-71
Amtrak Station ..... 6-60
Analysis of Variance
defined ..... 5-6
Angle Parking ..... 2-17
Animal Park ..... 6-74
Antique Shop
defined ..... 6-74
Appropriate Pavement Marking
defined ..... 7-3
Arboretum ..... 6-60
Art Sale ..... 6-74
Athletic Field ..... 6-71
Attenuator ..... 8-17
 non-redirective ..... 8-17
 redirective ..... 8-17
Attrition
defined ..... 6-6
Audio Tape Recorders ..... 5-36
Authorized Emergency Vehicle ..... 2-4
defined ..... 2-4
Automatic Traffic Recorder Program ..... 5-11, 5-14
Auxiliary Lane Signing ..... 6-37
Average
defined ..... 5-6
Average Maintained Illumination
defined ..... 10-3

B

Ball Bank Indicator
defined ..... 13-3
Ballast
defined ..... 10-3
Barricade mounted signs
defined ..... 8-4
Batten Board ..... 6-86
Before-After Studies ..... 11-9
Benefit/Cost Analysis ..... 5-37
Bias
defined ..... 5-6
Bicycle
defined ..... 2-4
Bicycle Crossing plaque
color ..... 6-12
Bicycle crossing sign
color ..... 6-12
## INDEX

<table>
<thead>
<tr>
<th>Term</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bicycle Lane</td>
<td>2-4</td>
</tr>
<tr>
<td>Bicycle Path</td>
<td>2-4</td>
</tr>
<tr>
<td>Bicycle Route</td>
<td>2-4</td>
</tr>
<tr>
<td>Bicycle Trail</td>
<td>2-4</td>
</tr>
<tr>
<td>Bikeway</td>
<td>2-4</td>
</tr>
<tr>
<td>Birthing and Wildlife Trail sign</td>
<td>6-48</td>
</tr>
<tr>
<td>Boat Launch Facility</td>
<td>6-74</td>
</tr>
<tr>
<td>Bookstore</td>
<td>6-74</td>
</tr>
<tr>
<td>Bottleneck</td>
<td>3-3</td>
</tr>
<tr>
<td>Boundary Signs</td>
<td>6-43</td>
</tr>
<tr>
<td>City Name sign (I2-3)</td>
<td>6-43</td>
</tr>
<tr>
<td>Community Identification sign</td>
<td>6-43</td>
</tr>
<tr>
<td>Community Recognition Signing Program</td>
<td>6-44</td>
</tr>
<tr>
<td>County Name sign (I2-5)</td>
<td>6-45</td>
</tr>
<tr>
<td>Drainage Divide sign</td>
<td>6-46</td>
</tr>
<tr>
<td>Municipal Identification Entrance sign</td>
<td>6-46</td>
</tr>
<tr>
<td>Reservation Boundary Sign</td>
<td>6-46</td>
</tr>
<tr>
<td>Soil and Water Conservation District Sign</td>
<td>6-46</td>
</tr>
<tr>
<td>Township Boundary Sign</td>
<td>6-47</td>
</tr>
<tr>
<td>Watershed District Sign</td>
<td>6-47</td>
</tr>
<tr>
<td>WELCOME TO MINNESOTA sign (I2-10)</td>
<td>6-47</td>
</tr>
<tr>
<td>Breakaway Support</td>
<td>6-6</td>
</tr>
<tr>
<td>Bridge</td>
<td>2-21</td>
</tr>
<tr>
<td>culvert</td>
<td>2-21</td>
</tr>
<tr>
<td>railroad Bridge</td>
<td>2-21</td>
</tr>
<tr>
<td>statute</td>
<td>2-21</td>
</tr>
<tr>
<td>width and clearance requirements</td>
<td>2-21</td>
</tr>
<tr>
<td>BRIDGE ICES BEFORE ROAD Sign (W8-13)</td>
<td>6-30</td>
</tr>
<tr>
<td>Bridge Lighting</td>
<td>10-13</td>
</tr>
<tr>
<td>Bus</td>
<td>2-4</td>
</tr>
<tr>
<td>defined</td>
<td>2-4</td>
</tr>
<tr>
<td>Bus Depot</td>
<td>6-61</td>
</tr>
<tr>
<td>Bus Parking in rest Areas</td>
<td>6-84</td>
</tr>
<tr>
<td>Business Center</td>
<td>6-74</td>
</tr>
<tr>
<td>Business District</td>
<td>6-62</td>
</tr>
<tr>
<td>defined</td>
<td>2-4</td>
</tr>
<tr>
<td>Business Panel</td>
<td>6-6</td>
</tr>
<tr>
<td>defined</td>
<td>6-6</td>
</tr>
<tr>
<td>Business Sign</td>
<td>2-5</td>
</tr>
</tbody>
</table>

### C

<table>
<thead>
<tr>
<th>Term</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>C.O. Traffic Engineering</td>
<td>1-5</td>
</tr>
<tr>
<td>delegation of authority</td>
<td>1-9</td>
</tr>
<tr>
<td>organization</td>
<td>1-5</td>
</tr>
<tr>
<td>Camp</td>
<td>6-61</td>
</tr>
<tr>
<td>Candela</td>
<td>10-3</td>
</tr>
<tr>
<td>defined</td>
<td>10-3</td>
</tr>
<tr>
<td>Capacity</td>
<td>3-3</td>
</tr>
<tr>
<td>defined</td>
<td>3-3</td>
</tr>
<tr>
<td>Casino Signing Program</td>
<td>6-56</td>
</tr>
<tr>
<td>Categorical Data</td>
<td>5-6</td>
</tr>
<tr>
<td>defined</td>
<td>5-6</td>
</tr>
<tr>
<td>Cattle Pass Marker</td>
<td>7-16</td>
</tr>
<tr>
<td>Causation</td>
<td>12-5</td>
</tr>
<tr>
<td>defined</td>
<td>12-5</td>
</tr>
<tr>
<td>Cemetery</td>
<td>6-71</td>
</tr>
<tr>
<td>Centerline</td>
<td>7-3</td>
</tr>
<tr>
<td>defined</td>
<td>7-3</td>
</tr>
<tr>
<td>Change interval</td>
<td>8-16</td>
</tr>
<tr>
<td>defined</td>
<td>8-16</td>
</tr>
<tr>
<td>Changeable Message Signs</td>
<td>3-10</td>
</tr>
<tr>
<td>Channelizing Devices</td>
<td>8-15</td>
</tr>
<tr>
<td>defined</td>
<td>8-15</td>
</tr>
<tr>
<td>Channelizing Line</td>
<td>7-3</td>
</tr>
<tr>
<td>defined</td>
<td>7-3</td>
</tr>
<tr>
<td>Character</td>
<td>8-16</td>
</tr>
<tr>
<td>defined</td>
<td>8-16</td>
</tr>
<tr>
<td>Chevron Alignment Sign (W1-8)</td>
<td>6-30</td>
</tr>
<tr>
<td>Chi-square distribution</td>
<td>5-6</td>
</tr>
<tr>
<td>defined</td>
<td>5-6</td>
</tr>
<tr>
<td>City Name Sign (I2-3)</td>
<td>6-43</td>
</tr>
<tr>
<td>Civic Center</td>
<td>6-61</td>
</tr>
</tbody>
</table>

Index - 2
Claim defined ..... 12-3
Claimant defined ..... 12-3
Closed Circuit Television ..... 3-6
Commercial Radio ..... 3-10
Commissioner defined ..... 2-5, 13-3
Community Destination Sign program ..... 6-80
criteria for signing ..... 6-81
general requirements ..... 6-81
sign design criteria ..... 6-82
Community Identification Sign ..... 6-43
Community Recognition Signing Program ..... 6-44
Complete Interchange Lighting ..... 10-6, 10-12
defined ..... 10-3
Compliance Studies ..... 5-33
Compost Site ..... 6-71
Computer Collection ..... 5-36
Computerized Data Collection ..... 5-11
Concert (band, orchestra) ..... 6-74
Conditions requiring a detour ..... 8-19
Cone of Vision defined ..... 6-6
Confidence Interval defined ..... 5-6
Conflict Analysis ..... 5-29
Constitutional Route Numbering ..... 13-11
Continental Block defined ..... 7-3
Continuous data defined ..... 5-7
Continuous Freeway Lighting ..... 10-5, 10-11
Control Site defined ..... 5-7
Control Systems ..... 3-6
lane control signals ..... 3-8
purpose ..... 3-6
ramp control signal systems ..... 3-6
ramp design ..... 3-8
ramp meter algorithm ..... 3-7
Controlled Access Highway defined ..... 2-5
sign placement authority ..... 2-15
Controlled Burning Signs ..... 6-30
Convention Center ..... 6-61
Conventional Highway defined ..... 6-6
Correctional Facility (local/regional) ..... 6-71
Correctional Institution ..... 6-62
County "Slat Sign" Program statute ..... 2-18
County Fairground ..... 6-62
County Highway Engineer defined ..... 13-3
County Highways defined ..... 2-5
County Name Sign (I2-5) ..... 6-45
County Pentagon Route Markers ..... 6-40
County State-Aid Highway defined ..... 2-5, 13-3
Craft Shop ..... 6-74
Crash Costs ..... 11-8
Crash Cushion ..... 8-17
Crash Data Reports ..... 11-5
Crash Rates ..... 11-7
Crash Report Forms ..... 11-3
Crash Report Processing ..... 11-4
Crash Severities ..... 11-7
Crash Surveillance
  crash data reports ..... 11-5
  crash report forms ..... 11-3
  crash report processing ..... 11-4
  highway safety improvement program ..... 11-11
Crossing Signs ..... 6-31
Down arrow plaque (W16-7mp) ..... 6-33
non-vehicle signs ..... 6-31
  Deer Crossing sign (W11-3) ..... 6-32
  pedestrian crossing signs ..... 6-31
  TRAIL CROSSING sign (W11-X7) ..... 6-32
  vehicle crossing signs ..... 6-32
  sight restriction determination ..... 6-32
  Snowmobile Crossing sign (W11-6) ..... 6-32
INDEX

Crosswalk
  defined ..... 2-5
Curb Markings ..... 7-13

D

Dance Hall ..... 6-71
Data Collection
  benefit/cost analysis ..... 5-37
  conflict analysis ..... 5-29
  equipment ..... 5-33
    audio tape recorders ..... 5-36
    computer collection ..... 5-36
    dedicated collection equipment ..... 5-36
    hand-held computers ..... 5-36
    hand-held counters ..... 5-36
    time lapse movie camera ..... 5-36
    twenty-pen recorder ..... 5-36
    video tape ..... 5-36
    wrong-way movement counter ..... 5-36
  glossary ..... 5-5
  lane occupancy ..... 5-22
  license plate checks ..... 5-27
  other studies ..... 5-32
  questionnaires and surveys ..... 5-31
  queue studies ..... 5-24
  spot speed ..... 5-16
  study methods ..... 5-33
  travel time and delay ..... 5-17
  vehicle classification ..... 5-26
  vehicle density ..... 5-23
  vehicle occupancy ..... 5-21
  volume counts ..... 5-9
  wrong way movements ..... 5-28

Davit Mast Arm
  defined ..... 10-4

Day Care Center ..... 6-74
Dedicated Collection Equipment ..... 5-36
Deer Crossing sign (W11-3) ..... 6-32
Deer Reflectors ..... 7-18
Defendant
  defined ..... 12-3
Delay
  defined ..... 3-3

Delineation
  divided highway crossover ..... 7-17
  guardrail ..... 7-18
  height ..... 7-17
  interchange ..... 7-17
  lateral placement ..... 7-17
  location ..... 7-17
  materials ..... 7-17
  spacing ..... 7-17
  types ..... 7-17
Delineator
  defined ..... 7-3
Demand
  defined ..... 3-3
Demand for Production of Documents ..... 12-10
Demolition Landfill ..... 6-69
Density
  defined ..... 3-3
Department
  defined ..... 2-5, 13-3
Designated Bicycle Lane
  defined ..... 2-5
Designated Roadways ..... 6-48
  birding & wildlife trail ..... 6-48
  Eisenhower Interstate System ..... 6-48
  Great River Road ..... 6-49
  heritage trail ..... 6-48
  memorial routes & bridges ..... 6-49
  Minnesota scenic byway ..... 6-49
  national coordinated trails ..... 6-50
  national forest scenic byways ..... 6-50
  Wildflower Routes ..... 6-50
Detours
  conditions requiring ..... 8-19
  discontinuing ..... 8-20
  emergency detour ..... 8-20
  establishing & maintaining ..... 8-19
  maintenance agreement ..... 8-19
  maintenance of ..... 8-19
  selecting a route ..... 8-19

DG3 Sheeting
  defined ..... 6-7
Diamond Lanes ..... 3-9
Direct Applied
  defined ..... 6-6
Disabled Parking ..... 2-16
Disc Golf Course ..... 6-62
Discontinuing a detour ..... 8-20
Discovery Process ..... 12-10
Discretionary Immunity ..... 12-6
Dispersion
Discrete data
Discretionary Immunity
Dispersion
Distance plaque
discreted marked
District State-Aid Engineer
district traffic staff
general function
specific function
Divided-Highway Crossover Delineation
Down Arrow plaque
defined
Down Arrow Plaque (W16=7mp)
Downtown
Drainage Divide
Drive-In Theater
Drivers License Station
Driveway Reflectors
Driving Range (golf)
Durable Markings
Edge Line
defined
Continuous Line
Disposing of documents
Discovery Process
interrogatories
production of statements
Discrete data
defined
Dispersion
defined
Distance plaque
color
distributions
defined
District State-Aid Engineer
defined
District Traffic Staff
genral function
specific function
Divided-Highway Crossover Delineation
defined
Down Arrow plaque
color
Down Arrow Plaque (W16=7mp)
Downtown
Drainage Divide
Drive-In Theater
Drivers License Station
Driveway Reflectors
Driving Range (golf)
Durable Markings
defined

E
85th Percentile Speed
defined
Edge Drop-Off
defined

F
511 Internet
Facilities Not Eligible for Signing
Filing a Tort Claim
Final Pavement Marking
defined
Fish Hatchery
INDEX

Flagging ..... 8-17
Flags ..... 6-87
Flanged Channel Sign Post
  defined ..... 6-7
Flashing Arrow Boards ..... 8-16
Font
  defined ..... 8-16
Footcandles
  defined ..... 10-4
Forest Preserve ..... 6-71
Fraternal Organization ..... 6-71
Freeway
  defined ..... 2-5, 6-6
Freeway Corridor Management ..... 3-3
  computer systems ..... 3-11
  control systems ..... 3-6
  incident management ..... 3-9
  preferential treatment systems ..... 3-8
  Regional Traffic Mgmt. Center ..... 3-4
  surveillance systems ..... 3-5
Freeway Exit Numbering ..... 13-13
Freeway Volume Accident Study ..... 11-6
Glare
  defined ..... 10-4
Golf Course ..... 6-63
Golf Driving Range ..... 6-74
Gore
  defined ..... 10-4
Grain Elevator ..... 6-74
Great River Road Amenity Site sign ..... 6-63
Great River Road sign ..... 6-49
Ground mounted signs
  defined ..... 8-4
Guardrail
  delineator ..... 7-18
  marker ..... 7-16
Guide Service (fishing) ..... 6-74

H

Half-way House ..... 6-71
Hand-held Computer ..... 5-36
Hand-held Counters ..... 5-36
Hazardous Waste
  defined ..... 7-3
Headway
  defined ..... 3-3
Health Club ..... 6-71
Heritage Trail ..... 6-48
High Base
  defined ..... 10-4
High School ..... 6-64
Highway
  defined ..... 2-8
Highway Designations ..... 13-11
Highway Names ..... 13-11
Highway Safety Improvement Program ..... 11-11
  hazard elimination safety ..... 11-11
  safety capacity ..... 11-11
Highway Turnbacks ..... 13-12
Historic Site ..... 6-65
Historical Marker (MHS site) sign ..... 6-64
Historical Marker (non-MHS site) signs ..... 6-64

Index - 6
INDEX

Horizontal Lux  defined ..... 10-4
Horizontal Panel  .....  6-86
Hospital Signing Program  .....  6-53
Household Hazardous Waste site  .....  6-69
Hypothesis  defined .....  5-8

Illuminance  defined ..... 10-4
Immunities  .....  12-6
discretionary immunity  .....  12-6
official immunity  .....  12-6
outdoor recreation immunity  .....  12-7
snow and ice immunity  .....  12-7
Incident  defined .....  3-4
Incident Detection and Response  .....  3-10
Incident Management  .....  3-9
511 Internet  .....  3-11
changeable message sign  .....  3-10
commercial radio  .....  3-10
emergency response vehicle  .....  3-11
incident detection and response  .....  3-10
Mn/DOT traffic radio  .....  3-10
motorist information and route guidance  .....  3-10
purpose  .....  3-9
telephone traffic report  .....  3-11
Independent Route Marker Assemblies  .....  6-39
Individual Traffic Accident Report  .....  11-8
Indoor Ice Arena  .....  6-65
Industrial Park  .....  6-65
Interchange Delineator  .....  7-17
Interchange Gore marker  .....  7-16
Interim Pavement Marking  defined .....  8-12
guidelines  .....  8-12
Internally Lit Street Name sign  .....  6-15
Interpretive Center  .....  6-65
Interrogatories  .....  12-10
Intersection  defined .....  2-6
Intersection Collision Diagrams  .....  11-8
Intersection Lighting  .....  10-13
Interstate Exit Numbering  .....  13-13
Interstate Route Numbering  .....  13-11
Investigations  .....  12-9
claim file  .....  12-9
discovery process  .....  12-10
investigating claims  .....  12-9
Investigations & Reviews  .....  13-14
advisory curve study  .....  13-20
experimental traffic control devices  .....  13-15
plat review  .....  13-18
railroad crossing review  .....  13-19
rumble strips  .....  13-15
sight distance at crossroads  .....  13-18
speed trend studies  .....  13-16
videologging  .....  13-14
Island Marker  .....  7-16
Iso-tac  defined .....  6-6

K
Knee Brace  defined .....  6-6

L
Lamp  defined .....  10-4
Lane Control Signals  .....  3-8
Lane Designations  .....  2-15
LANE ENDS MERGE RIGHT/LEFT Sign (W9-2)  .....  6-34
Lane Line  defined .....  7-3
Lane Occupancy  .....  5-22
Laned Highway  defined .....  2-6

Index - 7
INDEX

Large Culvert Marker ..... 7-16
Lawsuit
     defined ..... 12-3
LEFT/RIGHT LANE ENDS Sign (W9-1) ..... 6-34
Legal Duty
     defined ..... 12-4
Legend
     defined ..... 12-4
Legislative Route Numbering ..... 13-11
Library ..... 6-66
License Plate Check ..... 5-27
Lighting Branch Circuits ..... 10-18
Lighting for Other Streets and Highways ..... 10-13
Lighting of Traffic Facilities
     agreements ..... 10-8
     construction ..... 10-19
     cost splits ..... 10-10
     field placement of light poles ..... 10-19
     glossary ..... 10-3
     lighting system components
         branch circuits ..... 10-18
         luminaires ..... 10-16
         poles ..... 10-14
         service point ..... 10-17
     lighting system design ..... 10-11
     negotiations ..... 10-7
     operation & maintenance ..... 10-20
         cabinet & pad maintenance ..... 10-20
         knockdown maintenance ..... 10-20
         light base maintenance ..... 10-20
         luminaire maintenance ..... 10-20
         maintenance procedures ..... 10-21
         pole maintenance ..... 10-20
         power cost ..... 10-20
         underground maintenance ..... 10-20
     project procedures ..... 10-5
     sign lighting ..... 10-19
     special provisions ..... 10-8
     temporary lighting ..... 10-19
     typical lighting systems ..... 10-11
         airports ..... 10-13
         bridges ..... 10-13
         complete interchange ..... 10-12
         continuous freeway ..... 10-11
         intersections ..... 10-13
     other streets & highways ..... 10-13
     partial interchange ..... 10-12
     rest area ..... 10-12
     roadways with median barriers ..... 10-13
     roundabout intersections ..... 10-14
     tunnel ..... 10-12
     underpass ..... 10-12
     weigh station ..... 10-13
     warrants ..... 10-5
         complete interchange lighting ..... 10-6
         continuous freeway lighting ..... 10-5
         partial interchange lighting ..... 10-6
     work authorities ..... 10-7
     Lighting Pole ..... 10-14
     Light-Loss Factor
         defined ..... 10-4
     Load Permit ..... 2-18
     Load Restrictions
         general ..... 2-17
         load permit ..... 2-18
         seasonal ..... 2-17
         on truck routes ..... 2-17
     Local Authority
         defined ..... 2-6
         legal responsibilities ..... 2-9
     Local Road
         defined ..... 6-6
     Lock and Dam Site ..... 6-66
     Logo
         defined ..... 2-6, 6-6
     LOGO Sign Franchise Program ..... 6-57
     LOGO Sign Program
         statute ..... 2-19
     Longitudinal and Edge Drop-offs ..... 8-17
     Low Clearance Sign (W12-2) ..... 6-33
     Lumen
         defined ..... 10-4
     Luminaire
         defined ..... 10-4
     Luminaires ..... 10-16
     Luminance
         defined ..... 10-4
     Lux
         defined ..... 10-4
M

Machine Shop (agriculture) ..... 6-74
Maintenance Agreement for detours ..... 8-19
Maintenance of a Detour ..... 8-19
Major Traffic Generator Signing Program ..... 6-58
Manufacturing Center ..... 6-74
Mass Transit Studies ..... 5-33
Maximum Speed Limit defined ..... 2-6
Mean Speed defined ..... 5-8
Median Speed defined ..... 5-8
Memorial Route and Bridge ..... 6-49
Message sign panel ..... 8-16 defined ..... 8-16
Metering Rate defined ..... 3-4
Metro District defined ..... 6-6
Milled edge defined ..... 8-17
Minnesota Manual on Uniform Traffic Control Devices ..... 2-10
Minnesota Motor Vehicle Crash Facts ..... 11-6
Minnesota Outdoor Advertising Control Act ..... 2-18
Minnesota Scenic Byway ..... 6-49
Minnesota Speed Monitoring Program ..... 13-16
Minor Traffic Generator Signing Program ..... 6-59
Amtrak Station ..... 6-60
arboretum ..... 6-60
bus depot ..... 6-61
camp ..... 6-61
civic center ..... 6-61
convention center ..... 6-61
correctional institution ..... 6-62
county fairgrounds ..... 6-62
demolition landfill ..... 6-69
disc golf course ..... 6-62
downtown ..... 6-62
drivers license exam station ..... 6-63
facilities not eligible for signs ..... 6-71
golf course ..... 6-63
Great River Road amenity site ..... 6-63
high school ..... 6-64
historic site ..... 6-65
historical marker (MHS site) ..... 6-64
historical marker (non-MHS site) ..... 6-64
household hazardous waste site ..... 6-69
indoor ice arena ..... 6-65
industrial park ..... 6-65
interpretive center ..... 6-65
library ..... 6-66
lock & dam site ..... 6-66
multi-purpose facility ..... 6-66
museum ..... 6-66
natural area ..... 6-69
park ..... 6-67
public access to lake & river ..... 6-67
public office building ..... 6-68
recreational complex ..... 6-68
recycling center ..... 6-68
regional human services center ..... 6-68
regional human treatment center ..... 6-68
road test exam station ..... 6-63
sanitary landfill ..... 6-69
scientific & natural area ..... 6-69
ski area ..... 6-69
solid waste transfer station ..... 6-69
veterans' memorial ..... 6-70
war memorial ..... 6-70
wildlife management area ..... 6-70
wildlife refuge ..... 6-70
workforce center ..... 6-70
zoo ..... 6-71
Missing signs ..... 6-19
Mn/DOT legal responsibilities ..... 2-9
Mn/DOT Traffic Radio ..... 3-10
Modal Speed defined ..... 5-8
Motel
Motorist Information and Route Guidance ..... 3-10
Motorized Bicycle defined ..... 2-6
Multi-Purpose Facility sign ..... 6-66
Municipal Identification Entrance Sign ..... 6-46
Municipal State-Aid Street
defined ..... 2-6, 13-3
Museum ..... 6-66

911 Road Name sign ..... 6-40
above STOP sign ..... 6-41
Narrow Bridge Marker ..... 7-15
National Forest Scenic Byway ..... 6-50
Nationally Coordinated Trail ..... 6-50
Nature Area ..... 6-69
Negligence
defined ..... 12-4
notice of defect ..... 12-4
standard of care ..... 12-5
No Passing Zone ..... 6-33
NO PASSING ZONE sign (W14-3) ..... 6-33
signing & marking ..... 2-15
terminal marker post ..... 6-33
NO PASSING ZONE Sign (W14-3) ..... 6-33
NO SHOULDER Sign (W21-X1) ..... 6-34
Non-Hazardous Waste
defined ..... 7-3
No-Passing Zone Survey
distance-measurement instrument method ..... 7-10
hand signal method ..... 7-9
survey procedures ..... 7-8
two-way radio method ..... 7-10
warrants ..... 7-8
Normal
defined ..... 5-8
Notice of Defect ..... 12-4
Nursery ..... 6-74
Nursing Home ..... 6-71
Object Markings
bridge abutment ..... 7-15
bridge pier ..... 7-15
bridge rail ..... 7-15
cattle pass ..... 7-16
driveway reflector ..... 7-16
end of roadway ..... 7-16
guardrail ..... 7-16
interchange gore ..... 7-16
islands ..... 7-16
large culvert ..... 7-16
narrow bridge ..... 7-15
one-lane bridge ..... 7-15
purpose ..... 7-15
snowplow marker ..... 7-15
types ..... 7-15
Obtaining Electrical Power from Mn/DOT
Lighting or Signal Systems ..... 10-21
Occupancy
defined ..... 3-4
Office Building (private) ..... 6-71
Office of Traffic, Safety, and Operations ..... 1-5
delagation of authority ..... 1-9
electrical systems ..... 1-8
freeway systems operations ..... 1-8
functions and responsibilities ..... 1-6
incident management ..... 1-8
intelligent transportation systems ..... 1-7
MnPASS ..... 1-9
new product evaluation ..... 1-6
organization ..... 1-5
pavement markings ..... 1-6
signing unit ..... 1-6
tort claims ..... 1-7
traffic safety ..... 1-7
traffic standards ..... 1-7
training ..... 1-7
work zones ..... 1-6
Office Park ..... 6-71
Official Immunity ..... 12-6
Official Traffic Control Device
defined ..... 2-6
One Lane Bridge Marker ..... 7-15
Origin-Destination Studies ..... 5-32
Outdoor Recreation Immunity ..... 12-7
Overlay
defined ..... 6-6
P

Pace
 defined ..... 5-8, 13-4

Panel
 defined ..... 8-16

Park ..... 6-67

Parking
 angle parking ..... 2-17
disabled ..... 2-16
general regulations ..... 2-15
limited time parking ..... 2-16
on one-way streets ..... 2-17
parking meter zones ..... 2-16
restrictions on trunk highways ..... 2-16

Parking Meter Zones ..... 2-16

Parking on One-Way Streets ..... 2-17

Parking Space Markings ..... 7-13

Partial Interchange Lighting ..... 10-6, 10-12
defined ..... 10-4

Particular Use of Right-of-Way
 permitted devices ..... 2-20
prohibited devices ..... 2-21
statute ..... 2-20

Passing Lane Section
 Advance Passing Lane sign (R4-X6) ..... 6-34
LANE ENDS MERGE RIGHT/LEFT sign ..... 6-34
(W9-2) ..... 6-34
LEFT/RIGHT LANE ENDS sign (W9-1) ..... 6-34
SLOWER TRAFFIC KEEP RIGHT sign (R4-3)
 ..... 6-34

Pavement Marking
 final
 defined ..... 8-12
interim
 defined ..... 8-12
guidelines ..... 8-12
temporary
 defined ..... 8-12
guidelines ..... 8-13

Pavement Markings
 airplane markings ..... 7-14
application guidelines
auxiliary lanes ..... 7-7
bicycle lanes ..... 7-8
bypass lanes ..... 7-8
climbing lanes ..... 7-8
curb markings ..... 7-13
defined ..... 7-3
durable markings ..... 7-4
free right conditions ..... 7-8
interchange ramps ..... 7-7
intersections ..... 7-7
lane drops ..... 7-7
legal authority ..... 7-4
life expectancy of various materials ..... 7-4
narrow bridges ..... 7-7
obstructions in traveled way ..... 7-8
one-way roadways ..... 7-7
parking space markings ..... 7-13
passing lane sections ..... 7-6
pedestrian markings ..... 7-11
preferential lane markings ..... 7-14
Qualified Products List ..... 7-5
railroad crossings ..... 7-13
removal of markings ..... 7-6
responsibility for placement and removal ..... 7-4
retroreflectivity ..... 7-5
roadway transitions ..... 7-8
roundabout intersection markings ..... 7-14
school crossings ..... 7-12
signal ahead markings ..... 7-13
speed enforcement markings ..... 7-14
standard spotting procedure ..... 7-10
standards and specifications ..... 7-6
statewide policy ..... 7-5
stop ahead ..... 7-13
stop lines ..... 7-13
temporary markings ..... 7-5
turn lanes ..... 7-8
two-lane, two-way roadways ..... 7-6
two-way left turn lanes ..... 7-7
undivided multi-lane roadways ..... 7-7

Pavement Reflection Factor
 defined ..... 10-4

PCMS
 defined ..... 8-16

Pedestrian Crossing Markings ..... 7-11

Pedestrian plaque
color ..... 6-12

Pedestrian sign
color ..... 6-12
INDEX

Percent in Pace
  defined ..... 5-8

Percent Speeds
  defined ..... 5-8

Percentile Speeds
  defined ..... 5-8

Performing Arts Theater ..... 6-71

Permit for Signs, Banners, and Decorations . . .
  ..... 13-10

Permit for Use of Right-of-Way Involving Road Closure ..... 13-9

Permit for Use of Right-of-Way Involving Traffic Restrictions ..... 13-9

Permit for Use of Right-of-way Not Involving Traffic Restrictions ..... 13-10

Permits
  driveway permits ..... 2-20
  entrance permits ..... 2-20
  parade permits ..... 2-19
  special event permits ..... 2-20
  studded tire permits ..... 2-19

Pixel
  defined ..... 8-16

Place of Worship
  defined ..... 6-73

Plaintiff
  defined ..... 12-3

Plat Review ..... 13-18
  preliminary drawing ..... 13-18
  requirements ..... 13-18
  review period ..... 13-18
  statute ..... 2-21

Platoon
  defined ..... 3-4

Population
  defined ..... 5-8

Portable Changeable Message Signs (PCMS)
  defined ..... 8-16
  message sign panel ..... 8-16

Portable Precast Concrete Barrier (PPCB) Delineators
  ..... 8-15

Portable Support Mounted Signs
  defined ..... 8-4

Portable Traffic Counting Program . . . . . . . . . . . . . .
  ..... 5-11, 5-14

Post Office ..... 6-71

Post Top Lighting Unit
  defined ..... 10-4

Power
  defined ..... 5-8

Preferential Lane Markings ..... 7-14

Preferential Treatment Ramps ..... 3-8

Preferential Treatment Systems ..... 3-8
  diamond lanes ..... 3-9
  preferential treatment ramps ..... 3-8
  purpose ..... 3-8
  reversible lanes ..... 3-9
  Team Transit ..... 3-9

Preliminary Layouts ..... 13-7

Pressure Sensitive Sheeting
  defined ..... 6-7

Prima Facie Limit
  defined ..... 2-6

Primary Guide Sign
  defined ..... 6-6

Primary Guide Signing ..... 6-36

Principal Investigator ..... 4-4

Prismatic Retroreflective (DG3) Sheeting
  defined ..... 6-7

Private Road or Driveway
  defined ..... 2-6

Produce Sales ..... 6-74

Production of Statements ..... 12-10

Progressive-Shear Base
  defined ..... 10-4

Public Access to Lake and River signs ..... 6-67

Public Office Building ..... 6-68

Public Water Access ..... 6-83

Q

Qualified Products List ..... 7-5

Questionnaires and Surveys ..... 5-31

Queue
  defined ..... 3-4

Queue studies ..... 5-24
Radio Relay of Visual Observations ..... 3-6
Railroad
  defined ..... 13-4
Railroad Crossing Markings ..... 7-13
Railroad Sign or Signal
  defined ..... 2-6
Railroad Stop Crossings ..... 2-11
Ramp Control Signal Systems ..... 3-6
Ramp Design ..... 3-8
Ramp Meter Algorithm ..... 3-7
Random
  defined ..... 5-8
Range
  defined ..... 5-8
Record Keeping ..... 12-7
Recreational Camping Area
  defined ..... 6-73
Recreational Complex ..... 6-68
Recreational Equipment
  rental ..... 6-74
Recurrent Congestion
  defined ..... 3-4
Recurring Congestion
  defined ..... 3-4
Recycling Center ..... 6-68
Reference Location sign (D10-1, D10-2, D10-3)
  ..... 6-84
Reflectorized Sheeting Policy ..... 6-12
Regional Human Services Center ..... 6-68
Regional Shopping Center Signing Program 
  ..... 6-72
Regional Traffic Mgmt Center ..... 3-4
Regional Treatment Center ..... 6-68
Regression
  defined ..... 5-8
Regulatory Sign
  application guidelines ..... 6-21
  typical placement ..... 6-21
Rehabilitation Center ..... 6-71
Removal of Markings ..... 7-6
Requests for Information ..... 12-7
Research Services Section
  financial services ..... 4-11
  intra-office cooperation ..... 4-10
  library ..... 4-11
  research services ..... 4-11
  technical specialists ..... 4-11
  technology development ..... 4-11
Reservation Boundary Sign ..... 6-46
Residence District
  defined ..... 2-6
Residential Roadway
  defined ..... 2-7, 2-12
Resort
  defined ..... 6-73
Resort and Camping Signing Program ..... 6-54
Resort Information Signs
  statute ..... 2-18
Rest Area Lighting ..... 10-12
Rest Area Signing ..... 6-84
  bus parking in rest areas ..... 6-84
  teletypewriter (TTY) signing in rest areas 
  ..... 6-85
  WAYSIDE REST sign (D5-X1) ..... 6-85
Restaurant
  defined ..... 6-73
Retail Center ..... 6-74
Retail Motor Fuel Business
  defined ..... 6-73
Retroreflective Sheeting
  encapsulated lens ..... 6-7
  pressure sensitive ..... 6-7
  prismatic (DG3) ..... 6-7
  wide-angle prismatic (VIP) ..... 6-7
Reversible Lanes ..... 3-9
Reviews and Permits ..... 13-7
  entrance permits ..... 13-7
  evaluation of new facilities ..... 13-7
  geometric reviews ..... 13-7
  preliminary layouts ..... 13-7
  special events permits ..... 13-8
  transportation permits ..... 13-8
Road and Street sign ..... 6-40
Road Authority
  defined ..... 2-7
INDEX

Road Maintenance Facility ..... 6-71
Road Test Exam Station ..... 6-63
ROAD/WEATHER INFORMATION 511 sign ..... 6-83
Roadway defined ..... 2-7, 7-3, 13-4
Roundabout Intersection Lighting ..... 10-14
Roundabout Intersection Markings ..... 7-14
Route Numbering ..... 13-11
  constitutional routes ..... 13-11
  freeway exits ..... 13-13
  highway turnbacks ..... 13-12
  interstate routes ..... 13-11
  legislative routes ..... 13-11
  naming of certain highways ..... 13-11
  trunk highways ..... 13-12
  U.S. highways ..... 13-12
Rumble Strips ..... 13-15
  defined ..... 13-4
Rural Agricultural Business defined ..... 6-74
  eligible business ..... 6-74
Rural Residential District defined ..... 2-7
Rural School Bus Stops ..... 13-6
Rural Section defined ..... 13-4

S

Safety treatment defined ..... 8-17
Safety Zone defined ..... 2-7
Sample Data ..... 5-33
Sample Size ..... 5-33
  defined ..... 5-9
Sampling Error ..... 5-33
Sandbags ..... 8-15
Sanitary Landfill ..... 6-69
School (elementary/junior high school) ..... 6-71

School Bus defined ..... 2-7
  type A school bus ..... 2-7
  type B school bus ..... 2-7
  type C school bus ..... 2-7
  type D school bus ..... 2-7
  type III school bus ..... 2-7
School Bus Loading Area sign ..... 13-6
School Bus Stop Ahead sign ..... 13-6
SCHOOL BUS STOP AHEAD Sign (S3-1) ..... 6-34
School Crossing Guards ..... 13-5
School Crossing Markings ..... 7-12
School Crossing Protection ..... 13-5
  guidelines ..... 13-5
  responsibility ..... 13-5
  rural school bus stops ..... 13-6
  school crossing guards ..... 13-5
  school crossing signs ..... 13-7
  school hazard evaluation ..... 13-6
  school route plan ..... 13-5
  school safety patrols ..... 13-5
  school site plan review ..... 13-6
  school speed limits ..... 13-5
  school zone signs ..... 13-7
School Hazard Evaluation ..... 13-6
School plaque ..... 6-12
  color ..... 6-12
School Route Plan ..... 13-5
School Safety Patrols ..... 13-5
School sign color ..... 6-12
School Site Plan Review ..... 13-6
School Speed Limit sign ..... 13-5
  color ..... 6-12
School Speed Limits ..... 13-5
School Zone defined ..... 2-8
Scientific and Natural Area ..... 6-69
Screening Process defined ..... 6-7
Seasonal Load Restrictions ..... 2-17
Seed Store ..... 6-74
Selection of a detour route ..... 8-19
Senior Citizen Center ..... 6-71
Senior Citizen Home ..... 6-71
Service Station
defined ..... 6-73
Sharks Teeth
defined ..... 7-3
Shockwave
defined ..... 3-4
Shoe Base
defined ..... 10-4
Shooting Range (gun) ..... 6-74
Shop Drawing
defined ..... 6-7
Shoulder
defined ..... 13-4
SHOULDER NARROWS Sign (W5-X1) ...... 6-34
Sidewalk
defined ..... 2-8, 13-4
Sign Attachments ..... 6-86
batten board ..... 6-86
flag ..... 6-87
horizontal panel ..... 6-86
unauthorized attachments ..... 6-87
Sign Base Material
defined ..... 6-7
Sign Blank (Substrate)
defined ..... 6-7
Sign Face Material
defined ..... 6-7
Sign Franchise Program
statute ..... 2-19
Sign Lighting ..... 10-19
Sign Maintenance Schedule ..... 6-18
Sign overlay
defined ..... 8-4
Signal Ahead Markings ..... 7-13
Signal Mast Arm Sign ..... 6-15
internally lit signs ..... 6-15
Significance
defined ..... 5-9
Signing Destinations ..... 6-37
Signing Plan
construction activities ..... 6-20
cost estimating ..... 6-20
detailed design ..... 6-20
post-contract activities ..... 6-21
preliminary design ..... 6-19
special provisions ..... 6-20
work programming ..... 6-19
Signs, banners & Decorations ..... 13-10
Skew Index
defined ..... 5-9
Skew Index Variance
defined ..... 5-9
Ski Area ..... 6-69
Slip Base
defined ..... 10-4
SLOWER TRAFFIC KEEP RIGHT sign (R4-3) ..... 6-34
Snow and Ice Immunity ..... 12-7
Snowmobile Crossing sign (W11-6) ..... 6-32
Snowplow Marker ..... 7-15
Soil and Water Conservation District ..... 6-46
Solid Waste Transfer Station ..... 6-69
Special Events Permits ..... 13-8
no traffic restrictions ..... 13-10
road closure ..... 13-9
signs, banners & decorations ..... 13-10
traffic restrictions ..... 13-9
Specific Information Sign Panel
defined ..... 2-8
Specific Service
defined ..... 2-8, 6-72
Specific Service Sign
defined ..... 2-8
Specific Service Sign Assembly
defined ..... 6-72
Specific Service Sign Cluster
defined ..... 6-72
Specific Service Sign Program
Business Panels ..... 6-77
general criteria ..... 6-75
Logos ..... 6-77
priority of installation ..... 6-76
sign panel details ..... 6-77
sign placement ..... 6-76
Specific Service Signing Program ..... 6-72
specific service ..... 6-72
specific service sign ..... 6-72
specific service sign assembly ..... 6-72
specific service sign cluster ..... 6-72
Specific Service Signs
statute ..... 2-19
Specular Glare
defined ..... 10-4
Speed Enforcement Markings ..... 7-14
Speed Limits ..... 13-22
authority ..... 13-22
determining ..... 13-23
establish or change ..... 13-22
investigation procedures ..... 13-24
on gravel roads ..... 13-27
principles of speed zoning ..... 13-23
speed zone locations ..... 13-26
Speed Reduction Sign (W3-5) ..... 6-35
Speed Restrictions
authority to establish ..... 2-11
basic speed rule ..... 2-11
minimum speed limits ..... 2-14
school speed limits
authority ..... 2-13
engineering and traffic investigation ..... 2-13
segments in urban districts ..... 2-13
speed limits ..... 2-12
on bridges ..... 2-14
district investigation ..... 2-12
establishment of zones ..... 2-12
on local roads with established bicycle lane ..... 2-14
in manufactured home parks ..... 2-14
in recreational camping areas ..... 2-14
sign placement ..... 2-13
within Local Areas ..... 2-12
Speed Trend Studies ..... 13-16
Minnesota Speed Monitoring Program ..... 13-16
Speed Zones ..... 13-23
locations ..... 13-26
on gravel roads ..... 13-27
principles ..... 13-23
Spliced U-Post
defined ..... 6-7
Sportsman Club ..... 6-71
Spot Speed Studies ..... 5-16
Square Tube
defined ..... 6-7
Standard Deviation
defined ..... 5-9
Standard Error of the Mean
defined ..... 5-9
Standard of Care ..... 12-5
Standard Spotting Procedure ..... 7-10
State Traffic Engineer
defined ..... 13-4
State-Aid Engineer
defined ..... 13-4
Statistical Significance of Crash Differentials ..... 11-9
Stop Ahead Markings ..... 7-13
Stop Line
defined ..... 7-4
Stop Line Markings ..... 7-13
STOP Sign (R1-1) ..... 6-27
street name signs above ..... 6-41
Street
defined ..... 2-8
Street or Highway
defined ..... 13-4
Stringer
defined ..... 6-7
Study Design ..... 5-34
Sugar Beet Piling Station ..... 6-35
Supplemental Guide Sign
defined ..... 6-7
Supplemental Guide Signing ..... 6-36
Supplemental Guide Signing Programs ..... 6-50
Airport Signing Program ..... 6-55
Casino Signing Program ..... 6-56
Educational Institution Signing Program ..... 6-57
General Criteria ..... 6-51
General Motorist Services Signing Program ..... 6-53
Hospital Signing Program ..... 6-53
LOGO Sign Franchise Program ..... 6-57
Major Traffic Generator Signing Program ..... 6-58
Minor Traffic Generator Signing Program ..... 6-59
Regional Shopping Center Signing Program ..... 6-72
Resort & Camping Signing Program ..... 6-54
Specific Services Signing Program ..... 6-72
Tourist Information Signing Program ..... 6-77
Trail Access Signing Program ..... 6-78
Supplemental sign plaque defined ..... 8-4
Supplemental sign plate defined ..... 8-4
Surface mounted (centerline) delineators ..... 8-15
Surveillance Systems ..... 3-5
closed-circuit television ..... 3-6
electronic vehicle detectors ..... 3-5
Swimming Beach ..... 6-71
Swimming Pool ..... 6-71

T
Team Transit ..... 3-9
Technical Advisory Panel ..... 4-4
Technical Assistance statute ..... 2-21
Technical Liaison ..... 4-4
Telephone Traffic Reports ..... 3-11
Teletypewriter (TTY) signing in Rest Areas ..... 6-85
Temporary Lighting ..... 10-19
Temporary Markings ..... 7-5
Temporary Pavement Marking ..... 8-12
defined ..... 8-12
guidelines ..... 8-13
Temporary Raised Pavement Marker defined ..... 8-12
guidelines ..... 8-15
Temporary Traffic Control Devices business signs ..... 8-8
general requirements ..... 8-8
guide signs ..... 8-8
inspection program ..... 8-20
installation ..... 8-20
pay items ..... 8-18
placement ..... 8-18
regulatory signs ..... 8-8
responsibility ..... 8-20
sign mounting ..... 8-10
sign panel overlays ..... 8-11
sign sheeting specifications ..... 8-11
supplemental sign plates ..... 8-10
tabulation of devices ..... 8-18
temporary sign covering ..... 8-11
warning signs ..... 8-8
Temporary traffic control plans ..... 8-18
Tennis Court ..... 6-71
Terminal Marker Post ..... 6-33
Test Section signing ..... 6-87
Through Highway defined ..... 2-8, 13-4
sign placement authority ..... 2-15
Time Lapse Movie Camera ..... 5-36
Tort characteristics of ..... 12-4
defined ..... 12-3
Tort Claims ..... 12-3
immunities ..... 12-6
record keeping ..... 12-7
requests for information ..... 12-7
tort liability ..... 12-4
Tort Liability causation ..... 12-5
characteristics of a tort ..... 12-4
defined ..... 12-3
filing a claim ..... 12-9
investigations ..... 12-9
legal duty ..... 12-4
liability ..... 12-5
negligence ..... 12-4
Tourist Information Signing Program ..... 6-77
Tourist-Oriented Business defined ..... 6-74
eligible businesses ..... 6-74
ineligible business ..... 6-74
Town Road defined ..... 2-8
Township Boundary Sign ..... 6-47
Toxics in Specified Products defined ..... 7-4
INDEX

Traffic
defined ..... 2-8
Traffic carrying lanes
defined ..... 8-18
Traffic Control Devices
placement and maintenance on local streets
and roads ..... 2-10
placement and maintenance on trunk
highways ..... 2-10
unauthorized traffic control devices ..... 2-10
Traffic Control Signal
defined ..... 2-8
Traffic Counting Equipment
counter maintenance ..... 5-13
pc compatible counters ..... 5-13
portable traffic recorders ..... 5-12
accumulative counters ..... 5-12
non-accumulative counters ..... 5-12
traffic counters ..... 5-12
Traffic Counts, Types of
directional counts ..... 5-10
lane counts ..... 5-10
metropolitan freeway counts ..... 5-10
pedestrian counts ..... 5-10
total volume counts ..... 5-9
Traffic Data Recording Forms
data sheets ..... 5-14
directional counts ..... 5-15
Traffic Engineering Organization
purpose ..... 1-13
structure and procedures ..... 1-14
Traffic Engineering Research ..... 4-3
administrative liaison ..... 4-5
principal investigator ..... 4-4
research services section ..... 4-10
role of ..... 4-3
technical advisory panel ..... 4-4
technical liaison ..... 4-4
traffic research coordinator ..... 4-5
traffic research program ..... 4-5
Traffic management plan
defined ..... 8-4
Traffic Research Coordinator ..... 4-5
Traffic Research Program
purpose ..... 4-5
research monitoring ..... 4-6
support services ..... 4-7
traffic research projects ..... 4-6
Traffic Research Project Development
project sources ..... 4-8
project subjects ..... 4-8
task sequence ..... 4-8
Traffic Signs
911 road name signs ..... 6-40
acceleration lane signing ..... 6-29
Adopt-A-Highway sign (I-X1) ..... 6-79
Advance Passing Lane sign (R4-X6) ..... 6-34
advance warning signs on local road
approaches ..... 6-29
Advisory Exit Speed sign (W13-2) ..... 6-29
Airport Signing Program ..... 6-55
application guidelines ..... 6-21, 6-29, 6-36
batten board ..... 6-86
birding & wildlife trails ..... 6-48
BRIDGE ICES BEFORE ROAD sign (W8-13)
 ..... 6-30
Casino Signing Program ..... 6-56
Chevron Alignment sign (W1-8) ..... 6-30
City Name sign (I2-3) ..... 6-43
classification by sign type ..... 6-10
Changeable Message Signs (CMS) ..... 6-11
signal mast arm signs ..... 6-15
Type A signs ..... 6-10
Type C signs ..... 6-10
Type D signs ..... 6-10
Type EG signs ..... 6-11
Type EO signs ..... 6-11
Type OH signs ..... 6-10
clearance requirements ..... 6-16
Community Identification sign ..... 6-43
Community Recognition Signing Program ..... 6-44
controlled burning signs ..... 6-30
County Name sign ..... 6-45
county pentagon route markers ..... 6-40
crossing sign ..... 6-31
Deer Crossing sign (W11-3) ..... 6-32
demolition landfill ..... 6-69
destination ..... 6-37
Down Arrow plaque ..... 6-33
Drainage Divide ..... 6-46
Educational Institution Signing Program ..... 6-57
Eisenhower Interstate System ..... 6-48
elements of traffic sign design ..... 6-11
EMERGENCY DIAL 911 sign ..... 6-11
EVENT CONGESTION AHEAD sign ..... 6-83
(W14-X11) ..... 6-33

Index - 18
INDEX

flags ..... 6-87
freeways
  auxiliary guide signing ..... 6-37
  primary guide signing ..... 6-36
  supplemental guide signing ..... 6-36
functional class ..... 6-9
General Motorist Services Signing Program ..... 6-53
general principles ..... 6-8
glossary ..... 6-6
Great River Road ..... 6-49
heritage trail ..... 6-48
historic site ..... 6-65
horizontal panel ..... 6-86
Hospital Signing Program ..... 6-53
household hazardous waste site ..... 6-69
independent route marker assemblies ..... 6-39
indoor ice arena ..... 6-65
industrial park ..... 6-65
installation practice ..... 6-16
interpretive center ..... 6-65
introduction ..... 6-5
LANE ENDS MERGE RIGHT/LEFT sign (W9-2) ..... 6-34
LEFT/RIGHT LANE ENDS sign (W9-1) ..... 6-34
legal authority for placement ..... 6-8
  installed by construction contract ..... 6-8
  installed by contract ..... 6-8
  installed by Mn/DOT maintenance forces ..... 6-8
  installed by others ..... 6-8
  installed by public utility company ..... 6-8
library ..... 6-66
lock & dam site ..... 6-66
LOGO Sign Franchise Program ..... 6-57
Low Clearance sign (W12-2) ..... 6-33
maintenance practice ..... 6-18
  management system ..... 6-19
  missing signs ..... 6-19
Major Traffic Generator Signing Program ..... 6-58
memorial routes & bridges ..... 6-49
Minnesota scenic byway ..... 6-49
Minor Traffic Generator Signing Program ..... 6-59
multi-purpose facility ..... 6-66
Municipal Identification Entrance sign ..... 6-46
museum ..... 6-66
named road and street signs ..... 6-40
national forest scenic byway ..... 6-50
nationally coordinated trail ..... 6-50
nature area ..... 6-69
NO PASSING ZONE sign (W14-3) ..... 6-33
NO SHOULDER sign (W21-X1) ..... 6-34
non-vehicle crossing signs ..... 6-31
park ..... 6-67
Pedestrian Crossing signs ..... 6-31
public access to lake & river ..... 6-67
public office building ..... 6-68
PUBLIC WATER ACCESS sign ..... 6-83
purpose ..... 6-5
recreational complex ..... 6-68
recycling center ..... 6-68
regional human services center ..... 6-68
regional human treatment center ..... 6-68
Regional Shopping Center Signing Program ..... 6-72
Reservation Boundary sign ..... 6-46
Resort & Camping Signing Program ..... 6-54
ROAD/WEATHER INFORMATION 511 sign ..... 6-83
sanitary landfill ..... 6-69
SCHOOL BUS STOP AHEAD sign (S3-1) ..... 6-34
scientific & natural area ..... 6-69
Seat Belt sign (R16-X11 and R6-X12) ..... 6-86
Seat Belt signs (R16-X11 and R16-X12) ..... 6-86
SHOULDER NARROWS sign (W5-X1) ..... 6-34
sign grouping ..... 6-17
sign lighting ..... 6-13
sign spacing ..... 6-17
ski area ..... 6-69
SLOWER TRAFFIC MOVE RIGHT sign (R4-3) ..... 6-34
Snowmobile Crossing sign (W11-6) ..... 6-32
Soil and Water Conservation District sign ..... 6-46
solid waste transfer station ..... 6-69
Specific Services Signing Program ..... 6-72
specular glare ..... 6-17
Speed Reduction sign (W3-5) ..... 6-35
STOP sign (R1-1) ..... 6-27
Sugar Beet Piling signs ..... 6-35
terminal marker post ..... 6-33
test section sign ..... 6-87
Tourist Information Signing Program ..... 6-77

Index - 19
Township Boundary sign ..... 6-47
Trail Access Signing Program ..... 6-78
TRAIL CROSSING sign (W11-X7) ..... 6-32
TTY signs ..... 6-85
typical junction signing layouts ..... 6-39
un-authorized sign attachments ..... 6-87
vehicle crossing signs ..... 6-32
VEHICLE NOISE LAWS ENFORCED sign (R16-X13) ..... 6-28
veterans' memorial ..... 6-70
VISIT AGAIN Sign (I2-12) ..... 6-47
war memorial ..... 6-70
Watershed District sign ..... 6-47
WAYSIDE REST sign (D5-X1) ..... 6-85
WELCOME TO MINNESOTA Sign (I2-10) ..... 6-47
Wildflower Routes ..... 6-50
wildlife management area ..... 6-70
wildlife refuge ..... 6-70
workforce center ..... 6-70
zoo ..... 6-71
Traffic Studies
compliance studies ..... 5-33
mass transit studies ..... 5-33
origin-destination studies ..... 5-32
violation studies ..... 5-33
wheel path studies ..... 5-33
Traffic Volume Counts
regularly conducted counts ..... 5-10
automatic traffic recorder program ..... 5-11, 5-14
computerized data collection ..... 5-11
portable traffic counting program ..... 5-11, 5-14
types of traffic counts ..... 5-9
hourly counts ..... 5-12
quarter hour counts ..... 5-12
Trail Access Signing Program ..... 6-78
TRAIL CROSSING sign (W11-X7) ..... 6-32
Transformer Base
defined ..... 10-4
Transportation District Engineer
defined ..... 2-8, 13-4
Transportation Information System ..... 11-3
Transportation Permits ..... 13-8
Travel Time and Delay Studies ..... 5-17

Truck Hauling
Corn and other crop harvests ..... 6-36
sugar beet piling ..... 6-35
Trunk Highway
defined ..... 2-8, 6-7
Trunk Highway Route Numbering ..... 13-12
Trunk Highway Turnback
defined ..... 13-4
Truss Mast Arm
TTY Signing in Rest Area ..... 6-85
Tunnel Lighting ..... 10-12
Twenty-Pen Recorder ..... 5-36
Type A sign
clearance requirement ..... 6-16
defined ..... 6-10
sign construction ..... 6-14
support system ..... 6-14
Type C sign
clearance requirement ..... 6-16
defined ..... 6-10
sign construction ..... 6-14
support system ..... 6-14
Type D sign
clearance requirement ..... 6-16
defined ..... 6-10
sign construction ..... 6-14
support system ..... 6-14
Type EG sign
defined ..... 6-11
Type EO sign
defined ..... 6-11
Type I Error
defined ..... 5-7
Type II Error
defined ..... 5-7
Type OH sign
clearance requirement ..... 6-16
defined ..... 6-10
sign construction ..... 6-14
support system ..... 6-14
Typical Junction Signing Layouts ..... 6-39
U

U.S. Highway Numbering ..... 13-12
Un-authorized Sign Attachment ..... 6-87
Underpass Lighting ..... 10-12
Uneven lanes defined ..... 8-18
Uniformity Ratio defined ..... 10-5
U-Post defined ..... 6-7
sign mounting ..... 6-18
Urban District defined ..... 2-8, 13-4
Urban Section defined ..... 13-4

V

Vandalism ..... 2-11
Variance defined ..... 5-9
Vehicle Classification ..... 5-26
Vehicle Density Studies ..... 5-23
VEHICLE NOISE LAWS ENFORCED Sign ..... (R16-X13) ..... 6-28
Vehicle Occupancy Studies ..... 5-21
Vertical Lux defined ..... 10-5
Veteran Memorial ..... 6-70
Veterans Home ..... 6-71
VFW sign ..... 6-71
Video Tape ..... 5-36
Videologging ..... 13-14
defined ..... 13-5
Violation Studies ..... 5-33
VIP Sheeting defined ..... 6-7
VISIT AGAIN Sign (I2-12) ..... 6-47

W

War Memorial ..... 6-70
Waste Debris defined ..... 7-4
Watershed District ..... 6-47
WAYSIDE REST sign (D5-X1) ..... 6-85
Weather Information 511 ..... 6-83
Weaving defined ..... 3-4
Weigh Station Lighting ..... 10-13
WELCOME TO MINNESOTA Sign (I2-10) ..... 6-47
Wheel Path Studies ..... 5-33
Wide Angle Prismatic Sheeting (VIP) defined ..... 6-7
Wildflower Route ..... 6-50
Wildlife Management Area ..... 6-70
Wildlife Refuge ..... 6-70
Wildlife Treatment Facility ..... 6-71
Windloading ..... 6-18
defined ..... 6-7
Work zone traffic controls ..... 8-3
establishing & maintaining detours ..... 8-19
installation & inspection of TTC devices ..... 8-20
planning for temporary traffic controls ..... 8-5
responsibility ..... 8-4
temporary traffic control devices ..... 8-8
temporary traffic control plans ..... 8-18
Workforce Center ..... 6-70
Wrong Way Movements ..... 5-28
Wrong-way Movement Counter ..... 5-36

Z

Zoo ..... 6-71