11. TRAFFIC CONTROL

Introduction

This chapter gives a basic overview of signs, signals, markings and traffic controls including those used in construction zones. Basic references are provided.

Responsibility

The control of vehicular or pedestrian traffic along a county roadway is the vested responsibility of the local authorities; that is, the county, municipal and other local board or agency exercising jurisdiction over the roadway under the construction and laws of the state. This is clearly spelled out in A.R.S.§28-643, Local Traffic Control Devices.

Local authorities in their respective jurisdictions shall place and maintain the traffic control devices on highways under their jurisdiction as they deem necessary to indicate and to carry out this chapter or local traffic ordinances or to regulate, warn or guide traffic. All traffic control devices erected shall conform to the manual and specifications prescribed in § 28-641.

In the case State vs. Watson (1967), it was noted that the state manual is accepted as evidence of standard custom or usage in this country. Devices used to control traffic include all signs, signals, markings placed on, over or adjacent to the roadway and used to regulate, warn or guide the traffic. Other powers of local authorities with respect to traffic control are summarized in A.R.S.§28-627. This statute authorizes local authorities to regulate traffic in a number of ways such as speed limits, restricting turns, etc. Per A.R.S §28-6901, local authorities are defined as every county, municipal, and other local board or body exercising jurisdiction over highways under the constitution and laws of the state. Therefore, all regulatory traffic control devices are approved by the County Board of Supervisors (usually by resolution).

Uniformity

Uniformity in the use of traffic control devices is a critical consideration and a nationwide objective. To achieve this objective, the United States' Uniform Vehicle Code (UVC) has the following provision in U.V.C.§15-104 for the adoption of a uniform manual:

The (State Highway Agency) shall adopt a manual and specifications for a uniform system of traffic-control devices consistent with the provisions of this act for use upon highways within this State. Such uniform system shall correlate with and so far as possible conform to the system set forth in the most recent edition of the Manual on Uniform Traffic Control Devices for Streets and Highways, and other standards issued or endorsed by the Federal Highway Administrator. Under authority granted by Congress in 1966, the Secretary of Transportation has decreed that traffic control devices on all streets and highways in each State
shall be in substantial conformance with standards issued or endorsed by the Federal Highway Administrator.

Accordingly, the State of Arizona has adopted the Manual of Uniform Traffic Control Devices (MUTCD) developed by the National Joint Committee on Uniform Traffic Control Devices and published by the Federal Highway Administration, with some exceptions, as the official standard for use on all streets and highways open to public travel. This is described in A.R.S.§28-641: *The director shall adopt a manual and specifications for a uniform system of traffic control devices for use upon highways within this state. As of 2004, ADOT has adopted the 2003 edition of the MUTCD as its state manual.*

A.R.S.§28-643 describes requirements for local traffic control devices:

*Local authorities in their respective jurisdictions shall place and maintain the traffic control devices on highways under their jurisdiction as they deem necessary to indicate and to carry out this chapter or local traffic ordinances or to regulate, warn or guide traffic. All traffic control devices erected shall conform to the manual and specifications.*

The concern with uniformity and conformance may be viewed from two perspectives: From the drivers perspective, uniformity promotes recognition, comprehension and predictable behavior which, in turn, promotes driver safety and convenience. From the perspective of the county agency, the proper uniform application of traffic control devices can help protect the agency from adverse judgments in tort liability cases. It is important to understand that while the "shall" stipulation indicates a mandatory situation, there are many instances where the courts have ruled that a "should" stipulation in some specific situations is, in effect, mandatory to provide "reasonable care." A full discussion of the legal implications under current liability law involving traffic control devices is presented in the Traffic Control Devices Handbook (TCDH), (Ref. 5).

**Signs**

Signs, in the context of this manual, convey a message to the driver that should result in the orderly and predictable movement of traffic. There are three basic types of signs: *Regulatory, Warning, and Guide*. Table 11-1 indicates the purpose and typical uses of each of these.

Several design elements work together to provide visibility, and a clear meaning to the driver. These include color, shape, legend or symbol, lettering size, size of sign, and reflection or illumination. To assure uniformity across the nation as well as within the state, these are four basic reference sources that should be available in every county engineering office within Arizona:

- **The MUTCD, Part II**: This is a national standard describing the dimensions and appearance of the various types of signs, warrants for usage and other application guidelines, location, design, and size to be used (Ref. 7).
**The Traffic Control Devices Handbook:** This is a companion document to the MUTCD and provides guidelines for implementing the standards called for in the MUTCD (Ref. 5).

**ADOT Manual of Approved Signs:** Published by ADOT, this document (Ref. 2) presents the dimension, lettering size, and precise color detail for each individual sign used in the state (see Figure 11-1).

**ADOT Signing and Marking Standard Drawings:** This document provides typical plans for signing requirements for numerous locations and applications (Ref. 3).

<table>
<thead>
<tr>
<th>Table 11-1 - SIGN TYPES</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sign Type</strong></td>
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<td>----------------</td>
</tr>
</tbody>
</table>
| Regulatory      | To inform users of traffic laws and regulations which apply at definite locations and at specific times. | • Intersection Control  
• Definition of Right-of-way  
• Speed limits  
• Turning movement control  
• Pedestrian Control  
• Exclusions and Prohibitions  
• Parking control and limits  
• Regulations for maintenance and construction |
| Warning         | To warn traffic of unusual or potentially hazardous condition(s) on or adjacent to a street or highway. | • Horizontal and vertical alignment  
• School areas  
• Crossings and entrances to streets, highways, and freeways  
• Intersection areas  
• Road construction and maintenance |
| Guide           | To provide simple and specific information to aid motorists in reaching their destination. | • Route markings  
• Destination signing  
• Information signing  
• General services  
• Parks and recreation signing |

Source: Traffic Control Devices Handbook

An additional source of signing data is the **Uniform Standard Details for Public Works Construction**, sponsored and distributed by the Maricopa Association of Governments (2003) (Ref. 8). This document includes a Standard Detail for Street Sign Base (Detail No. 131) and for barricades (Detail No. 130). Also published by MAG is the Uniform Standard Specifications for Public Works Construction, which includes standard specifications for bidding on Public Works Projects.

A relatively new development in sign technology is the adaptation of the new fluorescent yellow-green sign color. This color is used exclusively for pedestrian, school, and bicycle signs primarily because of its high visibility during both day and night. Additional information of fluorescent yellow-green signs can be found in the Traffic Control Devices Handbook.
Some symbol signs have been found to be less effective in conveying its message that the equivalent text signs. As a result, the symbol signs are being phased out in favor of the text sign. Our example is the NARROW BRIDGE sign. The W5-2 a symbol sign is being replaced by the W5-2 text sign. Another example is the MERGE sign. The W5-2 (R o L) symbol sign is being replaced by the W9-d (R or L) text sign.

Many new pedestrians, bicycle, and construction zone signs have been added in the 2000 and 2003 editions of MUTCD. County engineering staff are encouraged to familiarize themselves with these signs described in Parts 2, 5, 6, and 9 of the 2003 MUTCD.

Markings

Roadway markings are used to provide visual information to the driver so that the vehicle may be driven along a safe and appropriate path of travel. They may also be used to supplement the regulations and warnings of other traffic control devices. In effect, markings constitute a traffic-regulation system and, consequently, must be readily seen, recognized, and understood in daylight and darkness, and in periods of adverse weather such as rain and fog.

Roadway markings are generally either longitudinal lines (such as, center lines, lane lines, edge lines) or transverse markings (such as, crosswalks, stop bars, and islands). Words and symbols are also considered markings when used to communicate information; such as, speed limit, directional arrows, and approach warnings (e.g., STOP AHEAD, PED XING). Another form of markings are those used to define parking stalls on the roadway. Painted curbs are used to supplement signs. Table 11-2 describes the various types of pavement stripes.

In addition to the roadway markings defined above, post-mounted delineators and object markers are generally considered a part of the "markings" system. These devices are retro reflective and should be visible under normal night conditions for 1,000 feet. The post-delineators consist of reflective devices or materials usually mounted on a three- to four-foot post and are specifically used to outline the edge of the road and guide the driver through critical locations, such as curves or turns.

Object markers consist of various arrangements of reflectorized devices or materials on or next to obstructions within or near the roadway; such as, the approach end of medians, bridge piers, guardrails, culvert walls, etc. These markers serve to alert and warn drivers that such objects exist.

The ideal form of roadway markings and the best material to be used are those that provide the most guidance and warning, particularly in periods of darkness and adverse weather. The materials most generally used are:

- Paint
- Thermoplastic
• Pre-formed tape (“cold plastic”)
• Raised retroreflective markers

A number of factors must be considered in determining the most cost-effective materials for a given location. In addition to visibility, pavement surface, and durability considerations, climate exerts a vital influence on the type of material to be selected. Painted markings are the least expensive, but do not provide the high degree of visibility during rain that is available with raised markers or even thermoplastic. Blowing sand can not only reduce visibility and obscure the markings, it can damage paint, thermoplastic, and reflective lenses through an abrasive sandpaper effect. In summer heat, thermoplastic tends to crawl or distort when surface temperatures reach 120 degrees F. However, some paint and thermoplastics have been specially formulated to withstand these extreme temperatures.

Raised markers are the most expensive in their original application, but in some cases cost less to maintain over time. Their value lies in the increased visibility at night during adverse weather combined with the rumble effect created when a vehicle passes over them.

There are three basic reference sources on markings that should be available in each county traffic engineering office:

• The Manual on Uniform Traffic Control Devices. Part III of the MUTCD provides usage standards for the application of pavement markings, object markers, and post-mounted delineators (Ref. 7).
• The Traffic Control Devices Handbook. Part III provides comprehensive guidelines on applications, materials, installation, and operations and maintenance (Ref. 5).
• ADOT Signing and Marking Standard Drawings. This state document provides typical layout plans for markings and striping implementation (Ref. 3).

The standard reference sources are listed in Chapters 12 and 15. Price estimates for marking materials and reflectors are available from ADOT’s contract and specification services.

Signals

The MUTCD describes a highway traffic signal as "any power-operated traffic control device, other than a barricade warning light or steady burning electric lamp, by which traffic is warned or directed to take some specific action." There are various classifications of signals according to their purpose as characterized below:

• Traffic Control Signals are used to control the assignment of right-of-way at locations where possible conflicts exist or where passive devices, such as signs and markings, do not provide the necessary flexibility of control to properly move
traffic in a safe and efficient manner. The definition of traffic control signal legends are detailed in A.R.S.§28-645.

- **Hazard Identification Beacons** warn motorists of unexpected conditions in or immediately adjacent to the roadway (such as a bridge pier in the center of the road), or which supplement passive control devices (such as flashing beacons at stop sign controlled intersections).
- **Lane-Use Control Signals** are used to indicate and control the direction of travel on reversible lanes or adjacent lanes; for example, one or more lanes where traffic can proceed in one direction during a certain time of day and in the reverse direction during another.
- **Freeway Ramp Control Signals** are a special application of traffic control signals installed on freeway entrance ramps to limit, or "meter," the amount of traffic entering the freeway.
- **Movable Bridge Signals** are used to stop traffic on approaches to drawbridge sections when the bridge is not available for use by highway traffic.
- **Railroad Crossing Signals** are used to warn traffic of an approaching train at railroad grade crossings.

The key issue in the use of signals is to determine whether or not they are needed (warranted). The primary references for the application of traffic control signals include:

- **Manual on Uniform Traffic Control Devices, Part IV** addresses the accepted standards on signal indications: number, size, design, and arrangement of signal faces; vehicle change interval and installation requirements (Ref. 7).
- **Traffic Control Devices Handbook**. Signal warrants and the required engineering studies are explained in Part IV. It also provides guidelines on operational requirements, signal equipment and hardware, signal timing, and operations and maintenance (Ref. 5).
- The Arizona Department of Transportation's **General Specifications for Traffic Signals and Overhead Lighting**. Detailed specifications are provided for signal implementation (Ref. 1).
- The Arizona Department of Transportation's **Standard Drawings for Traffic Signals and Lighting**. Detailed specifications are provided for signal implementation (Ref. 4).

The MUTCD lists specific “warrants” that must be met before a traffic signal is warranted. However, existing traffic conditions above these threshold values do not automatically justify the installation of a new traffic signal. In these cases, engineering judgment must be used to determine if the overall operation and safety will be improved with a new traffic signal. Traffic signals installed of intersections where the existing traffic conditions do not warrant them can result in more traffic delay and congestion, and even less safe conditions.
Source: Arizona Department of Transportation
Manual of Approved Signs

Figure 11-1

SAMPLE ILLUSTRATION FROM THE MANUAL OF APPROVED SIGNS
## Table 11-2

### TYPES OF PAVEMENT STRIPES

<table>
<thead>
<tr>
<th>Description</th>
<th>Color</th>
<th>Min. Width</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single broken</td>
<td>White</td>
<td>4 in.</td>
<td>Separation of lanes on which travel is in the same direction, with crossing from one to the other permitted, e.g., lane lines on multilane roadways.</td>
</tr>
<tr>
<td>Single broken</td>
<td>Yellow</td>
<td>4 in.</td>
<td>Separation of lanes on which travel is in opposing directions and where overtaking (passing) is permitted, e.g., centerline on two-lane, two-way roadways.</td>
</tr>
<tr>
<td>Single solid</td>
<td>White</td>
<td>4 in. / 6 in.</td>
<td>Separation of same-direction lanes where lane changing is discouraged, or separation of a lane and shoulder; e.g., lane lines at intersection approaches or right edge lines.</td>
</tr>
<tr>
<td>Single solid</td>
<td>White</td>
<td>4 in. / 6 in.</td>
<td>Separation of a motor vehicle lane from a bike lane.</td>
</tr>
<tr>
<td>Single solid</td>
<td>White</td>
<td>8 in.</td>
<td>Separation of same-direction lanes where crossing is strongly discouraged, e.g., separation of special turn lanes from through lanes, gore areas at ramp terminals, paved turnouts.</td>
</tr>
<tr>
<td>Single solid</td>
<td>Yellow</td>
<td>4 in.</td>
<td>Delineation of left edge lines on divided highways, one-way roads and ramps.</td>
</tr>
<tr>
<td>Double solid</td>
<td>White</td>
<td>4-4-4 in.*</td>
<td>Separation of same-direction lanes where crossing from one side to the other is prohibited, e.g., channelization in advance of an obstruction that may be passed on either side.</td>
</tr>
<tr>
<td>Double solid</td>
<td>Yellow</td>
<td>4-4-4 in.*</td>
<td>Separation of opposing-direction lanes where passing is prohibited in both directions; left turn maneuvers across these markings permitted; also used in advance of obstructions that may be passed only on the right side.</td>
</tr>
<tr>
<td>Solid plus broken</td>
<td>Yellow</td>
<td>4-4-4 in.*</td>
<td>Separation of opposing-direction lanes where passing is permitted with care for traffic adjacent to the broken line, but prohibited for traffic adjacent to solid line; used on two-way roadways with two to three lanes; also used to delineate edges of a two-way left-turn lane: solid lines on the outside, broken lines on the inside.</td>
</tr>
<tr>
<td>Double broken</td>
<td>Yellow</td>
<td>4-4-4 in.*</td>
<td>Delineates the edge of reversible lanes.</td>
</tr>
<tr>
<td>Single dotted</td>
<td>Either</td>
<td>4 in.</td>
<td>Extension of lane lines through intersections; color same as the line being extended; also used to extend right edge of freeway shoulder lanes through off-ramp diverging areas in problem locations.</td>
</tr>
<tr>
<td>Wide dotted</td>
<td>White</td>
<td>8 in.</td>
<td>Separation of through lane and auxiliary lane or dropped lane.</td>
</tr>
<tr>
<td>Transverse</td>
<td>White</td>
<td>12 in.</td>
<td>Limit lines or STOP bars (to 24 in.); also crosswalk edge lines (minimum 6 ft. apart).</td>
</tr>
<tr>
<td>Diagonal</td>
<td>White</td>
<td>12 in.</td>
<td>Cross hatch markings, placed at an angle of 45 degrees, at varying distances apart, on shoulders, gore areas, or channelization islands to add emphasis to these roadway features (optional chevron design in gores).</td>
</tr>
</tbody>
</table>

* 4-4-4 in. indicates typical width of stripes and gaps between them. This spacing may vary among states and localities. (Some agencies increase this spacing to allow for raised pavement markers used as guidance devices.) Often, agencies will use a 3 in. separation between the dual stripes.
85th Percentile Speed Determination

As stated in the Traffic Control Devices Handbook, "in the context of sign application, the '85th percentile speed' is the critical factor. This speed factor is defined as 'that speed at or below which 85 percent of all vehicles travel.' The 85th percentile speed is nationally recognized and accepted as the basis of posting speed limits unless there is a combination of unusual geometrics, high accident conditions, limited sight distance or other extenuating circumstances."

The procedure for determining the 85th percentile speed is described in many engineering texts. This is one of many traffic engineering studies included in the "Manual of Transportation Engineering Studies", available from ITE. This is an excellent source manual which should be available to all county engineers. Some of the major aspects involved in this procedure include:

- The speed sample should be taken in good weather during off-peak hours to measure relatively free moving vehicles.
- The desired sample size is at least 100 vehicles traveling in each direction. In rural areas and low volume roadways this may be difficult to achieve in a reasonable time period. The sample size may be lowered accordingly in these cases. Should this present a problem, the prevailing traffic speeds can be estimated by driving the route.
- Methods for measuring speeds are varied and have inherent advantages and disadvantages. Commonly used methods include hand-held radar and road tube volume/speed counters.

A sample study procedure to calculate the 85th percentile and average speeds is illustrated in Figure 11-2. The requirement of obedience to signs is detailed in A.R.S.§28-644. This statute reads as follows:

A. Unless otherwise directed by a traffic or police officer and subject to the exemptions granted the driver of an authorized emergency vehicle in this chapter, the driver of a vehicle shall:

1. Obey the instructions of an official traffic control device applicable to the driver that is placed in accordance with this chapter.

2. Not drive over or across or park in any part of a gore area. This paragraph does not apply to the driver of a vehicle that is disabled while on the paved or main traveled portion of a highway in a manner and to an extent that it is impossible to avoid stopping and temporarily leaving the disabled vehicle in that position. For the purposes of this paragraph, " gore area" means the area that is between a through roadway and an entrance ramp or exit ramp and that is defined by two wide solid white lines that guide traffic entering or exiting a roadway. Gore area does not include a safety zone.

B. Any provision of this chapter that requires signs shall not be enforced against an alleged violator if at the time and place of the alleged violation an official sign is not in proper position and sufficiently legible to be seen by an ordinarily observant person. If a particular section of law does not state that signs are required, that section is effective even though no signs are erected or in place.

Traffic Control Through Construction Zones
When construction, maintenance, or similar activities are conducted on or near the roadway, traffic control is needed to safely guide and protect motorists, pedestrians, and construction workers. A significant majority of the liability cases brought against state and local traffic agencies involve accidents occurring in or around construction zones. The proper application of traffic control devices in work areas is, therefore, of vital concern. The Arizona Revised Statutes mandate traffic control to be in compliance with the MUTCD, as per A.R.S.§28-650, Warning Devices at Construction Sites:

A person, contractor or political subdivision performing work on roads, streets or highways shall post and maintain warning signs, signals, markers and barricades that are in compliance with the manual and specifications prescribed in §28-641. These warning signs, signals, markers or barricades shall be maintained at the work site to warn those using the street, road or highway until the work is completed or until such time as the governing body authorizes removal.

The construction or work site is termed a traffic control zone and is divided into the various parts shown in Figure 11-3. Various forms of traffic control devices are combined and applied as a function of the work location. Table 11-3 summarizes the type of devices for typical work locations for each area of a traffic control zone.

The principal reference sources that should be used in designing and implementing traffic control though construction are:

**Manual on Uniform Traffic Control Devices.** Part VI provides the standard specifications for signs, barricades and channeling devices, markings, and lighting devices (Ref. 7). It also provides typical plans such as those shown in Figures 11-4 and 11-5.

**Traffic Control Devices Handbook.** Part VI of the Traffic Control Devices Handbook provides extensive guidelines for the application, installation, maintenance, and inspection of traffic control devices (Ref. 5).

**Traffic Control for Other Situations**

Light-Rail Transit Grade Crossings – As of 2004, there are currently no light-rail transit systems operating in the state of Arizona. A light-rail system is being planned for the Phoenix Metropolitan Area in Maricopa County and is scheduled to begin construction in 2004. Part X of the Manual of Uniform Traffic Control (Ref. 7) provides information about light-rail transit crossing control systems as well as appropriate signs, illumination, and pavement marking associated with a light-rail system.

Low-Volume Roadways – As stated in the Manual of Uniform Traffic Control Devices, “a low volume road shall be a facility lying outside of built-up areas of cities, towns, and communities,
and it shall have a traffic volume of less than 400 AADT.” Part V of the MUTCD (Ref. 7) gives information about the appropriate signing for low-volume roads as well as pavement markings, and traffic control for rail crossings, and signing for temporary traffic control on this type of roadway.

Highway-Rail Grade Crossings – The Manual of Uniform Traffic Control Devices states, “For the purpose of installation, operation, and maintenance of traffic control devices at highway-rail grade crossings, it is recognized that the crossing of the highway and the railway is situated on a right-of-way available for the joint use of both highway traffic and railway traffic.” As such, a highway-rail grade crossing should be designed and operated to accommodate both kinds of traffic to the highest degree possible. This can be achieved by utilizing proper crossing control systems. Information on these systems, which include signing, pavement markings, illumination, and crossing control gates, can be found in Part VIII of the MUTCD (Ref. 7).

Bicycle Facilities- Bicycle facilities on roadways can consist of a variety of things from a dedicated bicycle lane, to a shared multi-use lane, to bicycle facilities for ordinary roadways. As mentioned in the signing section of this chapter, it has become increasingly common to use the new fluorescent yellow-green color for bicycle signs because they are highly noticeable during both day and night. However, yellow bicycle facility signs are still very common. Part IX of the Manual of Uniform Traffic Control Devices (Ref. 7) gives guidelines for proper signing for bicycle facilities. Figure 11-6 shows an example of a diagram for proper pavement marking for bicycle facilities, which are also available from the MUTCD.
Figure 11-2

SAMPLE SPEED STUDY

Procedures

1. Add up the number of vehicles for each individual speed and place it at the extreme right end of the line for that speed.

2. Add up the total number of vehicles for all speeds.

3. Multiply total number by 0.85

4. The total determined in #3 is the number of vehicles traveling at the 85 percentile speed or less.

Beginning at the lowest recorded speed, begin adding up the individual number of vehicles until the total in #4 is reached. The speed to the left of this number is the speed at which 85 percent of the total numbers of vehicles are traveling or less.
Source: Manual on Uniform Traffic Control Devices

Figure 11-3

AREAS IN A TRAFFIC CONTROL ZONE
Table 11-3

TRAFFIC CONTROL DEVICES FOR VARIOUS WORK LOCATIONS

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*A consistent pattern of messages is shown in this figure. Refer to MUTCD for other acceptable messages or symbol signs.

**Old pavement markings should be removed and new markings placed in transition area for longer-term activities.

***The use of barriers is determined by an engineering analysis of the need for positive protection.
Source: Manual on Uniform Traffic Control Devices

Figure 11-4

TYPICAL APPLICATION OF TRAFFIC CONTROL DEVICES ON A TWO LANE HIGHWAY WHERE ONE LANE IS CLOSED AND FLAGGING IS PROVIDED
TYPICAL APPLICATION OF TRAFFIC CONTROL DEVICES
ON A TWO-LANE HIGHWAY

Note: See Tables 6H-2 and 6H-3 for the meaning of the symbols and/or letter codes used in this figure.
Source: Manual of Uniform Traffic Control Devices

Figure 11-6

EXAMPLE OF TRAFFIC CONTROL SIGNING AND PAVEMENT MARKING FOR BICYCLE FACILITIES

REFERENCES
Arizona Counties Highway Manual 11 - 17 Rev. 5/04


