Research Report
KTC-06-08/SPR287-05-1F

KENTUCKY TRANSPORTATION CENTER

EVALUATION OF WORK ZONE SAFETY OPERATIONS AND ISSUES

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EVALUATION OF WORK ZONE SAFETY OPERATIONS AND ISSUES

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EXECUTIVE SUMMARY

Work zone activities are one of the areas with a high potential for compromised safety for workers and road users. Various measures have been taken to increase the level of safety in work zones; including the use of double fines for speeding and the application of speed displays based on radar detection. There has been an effort to improve the effectiveness and safety of flaggers by requiring the use of a stop/slow paddle for most work zone conditions, using lights on the paddle, and increasing visibility by using more reflective clothing. It has been suggested that safety in work zones could also be improved with the application of more automated equipment which would control traffic in work zones without the use of flaggers. Other special operations in work zones require the use of elevated platforms or bucket trucks to perform work over or near traffic that create special safety problems. Another work zone safety issue of importance that would benefit from more specific guidance is routine short duration and mobile maintenance operations such as roadway surface patching.

The objectives of this research included the following: 1) evaluation of measures and procedures that will alter or control the speed of motorists in work zones, 2) investigate the feasibility of using automated equipment to replace flaggers in work zones, 3) develop policy and guidelines for use of elevated platforms near traffic, and 4) evaluate the safety issues associated with mobile and short-term work activities.

In an attempt to determine the effectiveness of various speed control measures in work zones, speed data were collected for several strategies including signs, radar displays, and police enforcement. It was determined that the largest reduction in speed can be achieved with the presence of police enforcement at the work site.

The use of automated flagger devices were investigated, and it was determined that these devices have potential for application in long-term lane closures at work zone locations such as bridge deck repairs. Flashing STOP/SLOW paddles were purchased and provided to maintenance personnel for evaluation. The paddles were used by employees with mixed results in terms of their practicality and durability.

Guidelines for use of aerial lifts/elevated platforms were developed, in conjunction with a typical application drawing for aerial work within an intersection. Application of the guidelines and drawing were reviewed and discussed with representatives of the Kentucky Transportation Cabinet, with one area of focus being work over an open lane of traffic.

A handbook was developed to provide guidelines for traffic control in short duration and mobile work zones. Areas of emphasis were the following: 1) Work Duration, 2) Major Traffic Control Considerations, 3) Fundamental Principles, 4) Guidance, Options, and Support for Short Duration or Mobile Operations, 5) Component Parts of a Temporary Traffic Control Zone, 6)Tapers, 7) Flaggers, and 8) Arrow Panels. Typical application diagrams were developed for various types of short duration and mobile work activities.

1.0 INTRODUCTION AND BACKGROUND

Work zone activities continue to be one of the areas with the highest potential for compromised safety for workers and road users. Various measures have been taken to increase the level of safety in work zones; including the use of double fines for speeding and the application of speed displays based on radar detection. There has been an effort to improve the effectiveness and safety of flaggers by requiring the use of a STOP/SLOW paddle for most work zone conditions, using lights on the paddle, and increasing visibility by using more reflective clothing. It has been suggested that safety in work zones could also be improved with the application of more automated equipment which would control traffic in work zones without the use of flaggers. However, there is a wide range of the types of work zone activities and roadway conditions and investigative work is required to determine those situations that may be conducive to the application of automated equipment for controlling traffic.

Special operations require the use of elevated platforms or bucket trucks to perform work over or near traffic that create special safety problems. Another work zone safety issue of importance that would benefit from more specific guidance is routine short duration and mobile maintenance operations such as roadway surface patching.

Recent statistics indicate that more than 1,000 fatalities occur annually in highway work zones in the United States. Kentucky crash statistics show there has been an average of about 642 collisions per year coded as occurring in construction and maintenance work zones in recent years, including an annual average of about four fatal collisions. With continued reconstruction and maintenance of many highways in Kentucky and elsewhere, the issues of safety and efficiency of travel in work zones are being addressed.

A Kentucky Transportation Center research study titled “Analysis of Accidents in Construction and Maintenance Work Zones” was completed in 1988 and addressed the overall trends in crashes and the types of crashes most frequently associated with work zones (1). Various methods have been tested that provide motorists with real-time information relating to the work activity in order for them to make decisions about their travel alternatives. A more recent Transportation Center report involved an evaluation of the Traffic Information Prediction System that was installed on I-64 between Frankfort and Shelbyville (2). Other reports have documented the results of evaluations of various types of real-time work zone information systems in Kentucky (3, 4, 5). Another report evaluated various innovative devices developed through the Strategic Highway Research Program (SHRP) (6). Various types of flashing STOP/SLOW paddles were included in that evaluation.

2.0 KENTUCKY WORK ZONE CRASH STATISTICS

Crash data in Kentucky have codes which indicate if a contributing environmental factor involved either a construction work zone (code 2 as an environmental factor) or a

maintenance or utility work zone (code 9 as a contributing factor). The following table summarizes the number of crashes which have been coded as occurring in these work zones. The data show the total number of crashes as well as the number of fatal and injury crashes from 2000 through 2005.

Construction/Maintenance Zone Crashes

	Construction Zone			Maintenance/Utility Zone			Total		
YEAR	Fatal	Injury	Total	Fatal	Injury	Total	Fatal	Injury	Total
2005	5	100	441	1	28	127	6	128	571
2004	4	104	490	0	19	104	4	123	594
2003	4	165	719	3	32	139	7	197	858
2002	4	133	544	0	23	107	4	156	651
2001	3	170	750	1	27	112	4	197	862
2000	6	156	738	0	38	149	6	194	887
Total	26	828	3,682	5	167	738	31	995	4,432

A code is given to describe the pedestrian factors if a pedestrian is involved in the crash. One code is "working in roadway" (pedestrian code 20). Following is a summary of the number of crashes where the codes indicated a pedestrian was working in the roadway in a work zone. The total number of crashes involving the pedestrian conducting any type of work in the roadway is also given.

Working in Roadway

	Construction Zone			Maintenance/Utility Zone			Total		
YEAR	Fatal	Injury	Total	Fatal	Injury	Total	Fatal	Injury	Total
2005	0	6	6	1	2	3	2	48	53
2004	0	1	2	0	0	0	0	31	41
2003	0	3	3	2	0	3	3	46	61
2002	0	5	5	0	0	0	1	31	37
2001	0	3	3	0	1	2	2	48	57
2000	0	8	8	0	2	3	2	43	53
Total	0	26	27	3	5	11	10	247	302

Only 38 of 302 crashes involving a pedestrian working in the road occurred in a work zone with only 3 of 10 fatal crashes and 31 of 247 injury crashes in a work zone. An example of other work in the roadway would be garbage collection.

There were 31 fatal crashes in the six years of 2000 through 2005 where the environmental code indicated the crash occurred in a work zone (environmental contributing factor either code 2 or 9). Following is a description of each crash along with the date and location of the crash (county, route, and milepoint (MP)).

Fatal Crashes in Work Zones

DATE	LOCATION	DESCRIPTION
12/16/05	Fleming Co.; KY 11; MP 4.4	Impact with road equipment; road closed
12/9/05	Floyd Co.; US 23; MP 8.1	Off road impact with road equipment
9/28/05	Whitley Co.; I 75; MP 0.5	Truck hit pedestrian pushing disabled vehicle
6/16/05	Clay Co.; KY 149; MP 2.1	Flagman; utility zone
4/18/05	Madison Co.; KY 52; MP 14.4	Head on; construction zone not factor
1/3/05	Jefferson Co.; I 265; MP 14.2	Sideswipe and then crossed median
11/30/04	Harlan Co.; US 421; MP 11.4	Head on; truck lost control on wet pavement
9/10/04	Madison Co.; KY 52; MP 13.5	Angle; first day new road opened
8/1/04	Clinton Co.; US 127; MP 6.1	Rear end; construction equipment; on road
5/9/04	Garrard Co.; KY 52; MP 11.3	Single vehicle; construction equipment; off road
10/18/03	Franklin Co.; I 64; MP 51.5	Rear end; stopped due to road construction
10/3/03	Pike Co.; US 119; MP 27.0	Left turn from parking lot
9/29/03	Clay Co.; HR Pkwy; MP 27.0	Slowing in traffic; hit vehicle and rock wall
8/18/03	Kenton Co.; KY 8; MP 0.6	Pedestrian; DOH worker; sight distance issue
7/7/03	Hart Co.; I 65; MP 65.5	Rear end; stopped due to road construction
4/16/03	Boone Co.; I 275; MP 10.5	Pedestrian; construction workers; dropoff
1/7/03	Clay Co.; HR Pkwy.; MP 23.7	DOH flagger; drove around stopped vehicles
11/8/02	Knox Co.; I 75; MP 24.4	Rear end: stopped due to road construction
11/6/02	Calloway Co.; KY 121; MP 13.7	Single vehicle; dip in road prior to new bridge
7/3/02	Pike Co.; US 23; MP 19.5	Head on; non-local confused by signs
6/14/02	Warren Co.; I 65; MP 26.3	Single vehicle; other vehicle improper merge
7/19/01	Madison Co.; I 75; MP 78	Rear end; stopped due to construction
5/7/01	Warren Co.; I 65; MP 32.7	Truck; pedestrian changing tire; no work activity

DATE	LOCATION	DESCRIPTION
1/27/01	Fayette Co.; US 27; MP 15.3	Offset head on; drifted across centerline
1/12/01	Pike Co.; US 119; MP 2.8	Rear end then head on in opposing lane
11/7/00	Franklin Co.; I 65; MP 0.3	Rear end; stopped due to road construction
10/3/00	Perry Co.; HR Pkwy.; MP 51.8	Rear end; stopped by flagger
8/27/00	Pike Co.; US 23; MP 23.8	Single vehicle; difference in elevation in lanes
7/6/00	Madison Co.; I 75; MP 86.7	Sideswipe; towing boat too large for vehicle
6/10/00	Knox Co.; KY 11; MP 6.3	Single vehicle; bump in road; asphalt to gravel
6/7/00	Warren Co.; I 65; MP 37.8	Rear end; stopped due to road construction

The following list gives the number of injury or fatal crashes involving a worker in a work zone. There were 34 crashes in the six-year period with 12 of the crashes involving a vehicle hitting a flagger. These crashes involve a pedestrian code of 20 which indicates the pedestrian was "working in roadway" and the environmental contributing factors code was either a 2 or 9.

Work Zone Injury or Fatal Crashes Involving "Working in the Road"

DATE	LOCATION	DESCRIPTION
10/19/05	Christian Co.; KY 115; MP 7.5	Truck flagged on; worker knocked into asphalt
9/30/05	Jefferson Co.; I 265	Hit flagger who was standing behind barrels
8/23/05	Hopkins Co.; Pen. Pkwy; MP 49	Hit flagger after hit other vehicle
8/9/05	Carter Co.; I 64; MP 172	Worker hit by van merging onto interstate
6/16/05	Clay Co.; KY 149; MP 2.1	Hit flagger for utility work
5/11/05	Letcher Co.; KY 931; MP 5.1	Hit worker due to dust limiting visibility
5/10/05	Jefferson Co.; Pendleton Rd.	Hit worker; construction truck backing
4/1/05	Jefferson Co.; I 65; MP 135.2	Hit worker after driving through cones
4/1/05	Boone Co.; US 42; MP 6.2	Flagger hit; truck could not stop

DATE	LOCATION	DESCRIPTION
9/14/04	Nelson Co.; BG Pkwy.; MP 32.5	Hit workers who he did not see in work zone
9/24/03	Shelby Co.; KY 148; MP 1.8	Worker jumped into path of vehicle
8/18/03	Kenton Co.; KY 8; MP 0.6	DOH worker; sight distance issue
8/1/03	McCracken Co.; I 24; MP 11.4	Picking up signs when worker hit
7/21/03	Pike Co.; US 119; MP 18.5	Confused and hit worker (behind barrels)
1/7/03	Clay Co.; HR Pkwy.; MP 23.7	DOH flagger; drove around stopped vehicles
11/1/02	Elliott Co.; KY 7; MP 12.3	Hit flagger who had traffic stopped
7/9/02	Hopkins Co.; US 41; MP 20.0	Hit flagger trying to stop traffic
6/3/02	Casey Co.; KY 70; MP 15.2	Hit flagger trying to stop traffic
2/25/02	Meade Co.; KY 941; MP 2.3	Hit worker in construction area
1/15/02	Jefferson Co.; Floyd St.	Drove thru barricades hitting worker
9/4/01	Daviess Co.; US 60B; MP 6.3	Work vehicle backed into worker
6/25/01	Bell Co.; US 119; MP 6.6	Went around stopped vehicles hitting flagger
6/19/01	Kenton Co.; Harris Pike	Hit flagger; driver said did not see flagger
1/9/01	Jefferson Co.; Dumesnil	Road worker hit by driver who was backing
11/20/00	Madison Co.; US 421; MP 12.5	Utility; driver said did not see signs; orange vest
9/14/00	Barren Co.; KY 90; MP 21.5	Flagger hit by vehicle which did not stop
8/10/00	Estill Co.; Winchester Rd.	Worker stepped in front of vehicle
6/23/00	Boone Co.; I 275; MP 1.6	Lost control and hit worker (behind barrels)
6/5/00	Floyd Co.; KY 979; MP 7.2	Foot slipped off brake and hit flagger
5/11/00	Marion Co.; KY 426; MP 3.0	DOH; hit worker in blacktopping project
4/15/00	Scott Co.; I 75; MP 137.2	Worker hit by work vehicle (blind spot)
2/21/00	Pulaski Co.; KY 837; MP 6.5	DOH; hit worker - not flagger
2/15/00	Laurel Co.; KY 192; MP 18.2	Taking survey reading
1/31/00	Lincoln Co; Hustonsville Rd.	Water department; sun in eyes of driver

The percentage of all crashes involving a work zone were summarized by type of roadway and compared to all crashes. As shown below, the largest differences between work zone crashes and all crashes was the higher percentage of work zone crashes occurring on interstates and smaller percentage on local streets compared to other types of roadways.

Type of Roadway

Type of Roadway	Percent of Crashes (2000-2005) Construction Zone	Maintenance/Utility Zone	(2004) All
County	2.4	5.2	7
Federal	24.9	24.7	22
Interstate	34.8	15.1	7
Local Street	10.3	18.1	26
Parkway	2.6	1.8	1
State	22.1	30.3	28
Other	2.9	4.8	9

3.0 LITERATURE REVIEW AND SURVEY OF STATES

3.1 Speed Control Measures in Work Zones

Speed control in work zones continues to be a concern with an increasing shift of resources toward the reconstruction and rehabilitation of roadway sections as opposed to new construction where the interaction of vehicles and workers is less likely. Excessive speed is a frequently documented contributing factor for crashes on all public roads, including those categorized as work zones. Travel speed that is incompatible and inconsistent with roadway conditions has been shown to be a significant contributor to roadway crashes. Excessive speed reduces a driver's ability to respond to roadway conditions by extending the perception-reaction distance, braking distance and stopping distance. Furthermore, the severity of a crash will increase with increasing speed, due to the kinetic energy being dissipated in the collision. This kinetic energy is a function of mass and velocity, with the velocity squared, resulting in an exponential increase in the forces at impact as speed increases.

A study by Solomon in 1964 found a relationship between vehicle speed and crash incidence that could be represented by a u-shaped curve (7). Crash rates were found to be lowest for vehicle travel speeds near the mean speed of traffic and increased with greater deviations above and below the mean. Estimated travel speeds from crash records were compared to speeds measurements at representative sites to show that crash-involved drivers were over-represented in both high and low-speed ranges of the speed distribution. Crash involvement rates decreased with increasing speeds up to 65 mph and then increased at higher speeds. Changing speed limits has had limited success in changing vehicle travel speed on low to moderate speed roadways, and therefore resulted in little or no effect on crashes. This suggests that drivers typically travel at speeds they feel are reasonable and safe for the road and traffic conditions regardless of the posted speed limit.

Work zone speed control has been the subject of numerous research efforts in the past. Various techniques and procedures have been tested and evaluated; including

variations of traditional fixed signing, changeable message displays, radar units with speed display messages, and a range of electronic devices to sense and display information related to speeds and/or intrusions. Possibly the most effective method to control speeds in work zones is active police enforcement. Information obtained from the National Work Zone Safety Information Clearinghouse indicates that the use of police in work zones by the California DOT (Caltrans) has been very successful with the result of no work zone fatalities during a five-year period (8).

Traffic control and management strategies as a means to control speeds in freeway work zones were evaluated by the Iowa DOT (9). Electronic devices evaluated were the Wizard CB Alert System, the Safety Warning System, and the Speed Display Monitor. The Wizard CB Alert System broadcasts a CB message warning motorists of an upcoming work zone. The Safety Warning System transmits a message to vehicles with compatible receivers, informing them of the upcoming work zone. This system also serves as a drone radar system, actuating radar detectors and creating the impression that radar-equipped enforcement officers may be present. The Speed Display Monitor uses radar to detect and display speeds of passing vehicles, as well as to actuate radar-equipped vehicles and create the impression that enforcement officers may be present. Of the three devices tested, the Wizard CB Alert System provided the most promising results. Neither the Safety Warning System nor the Speed Monitor Display resulted in a statistically significant reduction in the average speed of vehicles approaching the work zone.

A study performed by the Virginia Transportation Research Council in 1994 addressed the use of changeable message signs equipped with a radar unit as a means of reducing speeds in work zones (10). The radar unit was attached directly to the message sign to measure the speed of individual vehicles, creating a capability of displaying a personalized warning message. It was concluded that a changeable message sign with a radar unit was a dynamic speed control measure that was more effective than static Manual on Uniform Traffic Control Devices (MUTCD) signs in altering driver behavior in work zones. Using the personalized messages for high-speed drivers was found to improve safety by increasing the likelihood of those drivers reducing their speeds and the overall speed variance in work zones.

Another study to evaluate supplementary traffic control measures for work zones was conducted in Missouri and reported in 2001 (11). The measures evaluated were white lane drop arrows, the CB Wizard Alert System, and orange rumble strips. All devices or measures were found to promote some increases in early merging at lane drops and some decreases in mean speeds of vehicles approaching an interstate work zone with a lane drop. The effects all three devices on speed variance were inclusive.

3.2 Automated Flagger Devices

Several new devices have been developed in an attempt to reduce the exposure of flaggers in work zones, with the resultant effect of increasing the overall safety of

workers responsible for flagging. Among the devices determined to be available and that were investigated to varying degrees as part of this study were the following:

- R.C. Flagman
- AutoFlagger
- Synergy Automated Flagger Device
- IntelliStrobe Automated Flagger Assistance Device

Each of these devices is being marketed as an alternative to placing flaggers within work zones. All systems are intended to remove the flagger from the traditional position of controlling traffic by using automatic flagging devices that can be operated remotely. In addition to the safety benefit of removing the flagger from exposure to traffic, work zone personnel requirements can be reduced by using one person to control and operate two automatic flagger devices. There appears to have been limited application of the devices by other transportation agencies, possibly related to cost and the time/convenience factors of placing the devices in the work zone. It appears that the devices may have considerable potential for application in long-term lane closures at work zone locations such as bridge deck repairs.

3.3 Aerial Lift/Elevated Platforms

The use of aerial lift or elevated platforms serve a useful purpose for work on traffic signals and other hardware positioned at a height inaccessible for normal work operations. General safety requirements are provided for "vehicle-mounted elevating and rotating work platforms" and "aerial lifts" by the U.S. Department of Labor as part of the regulations of the Occupational Safety and Health Administration (12). However, these regulations are directed to the overall safe operation of the devices and not specific to the application in a highway maintenance/work zone. Typical Application 26 in the MUTCD provides guidance for "Closure in the Center of Intersection"; however, information on the use of an aerial lift is not provided (13). A draft typical application drawing for consideration and possible inclusion in the MUTCD has been developed to provide guidance when aerial work is being undertaken in the center of an intersection (14). Specific guidance is proposed in the draft that would include the following mandatory requirement, "no portion of an aerial lift platform, or the supporting structure, shall extend over an open lane of traffic, regardless of working height".

3.4 Traffic Incident Management Techniques to Reduce Crashes in Work Zones

Additional information relative to traffic management techniques was tabulated through the National Work Zone Safety Information Clearinghouse based on a survey conducted by the Virginia Transportation Research Council (15). The techniques used by states responding to the survey included the use of enforcement officers, various applications of advance warning signs, double fine laws, alternate routes, and providing work zone condition information through the use of changeable message signs.

3.5 Flashing STOP/SLOW Paddles

STOP/SLOW paddles are the primary and preferred hand-signaling device included in the MUTCD and approved for use to control traffic through temporary traffic zones (16). The standard for a STOP/SLOW paddle is an octagonal shape on a rigid handle, 18 inches in width, 6-inch high letters, and fabricated from light semi-rigid materials. An option for use of STOP/SLOW paddles is to improve conspicuity by incorporating either white or red flashing lights on the STOP face, and either white or yellow lights on the SLOW face. In addition, several options are provided for arrangements of the lights on the STOP and SLOW faces.

The evaluation conducted as part of the SHRP study found that the experience with the flashing STOP/SLOW paddles was very positive indicating the potential for expanded use in the future (6). Six different models of flashing paddles were evaluated with some having better results than others. Contacts with numerous states and manufacturers found that only a couple of flashing paddle models were currently in use.

Several states have used flashing STOP/SLOW paddles with varying degrees of success and satisfaction based on survey information obtained from the National Work Zone Safety Information Clearinghouse and direct correspondence with states (17). There seems to be a general consensus that the flashing STOP/SLOW paddles are more effective than standard paddles in attracting the attention of road users; however, discussions with states which have experience with the use of flashing paddles found there have been problems with durability, battery life, and the overall size/weight of the devices. These problems have resulted in decreased use of the flashing paddles.

3.6 Structured Interview – Traffic Enforcement Strategies for Work Zones

As part of a NCHRP Project 3-80 titled “Traffic Enforcement Strategies for Work Zones”, a structured interview was conducted in Kentucky in conjunction with the Study Advisory Committee by researchers from the Texas Transportation Institute (18). The structured interview was arranged to involve representatives of the Study Advisory Committee, as well as representatives of the construction industry in Kentucky with experience and knowledge related to the various enforcement strategies used in work zones. Some of the primary findings from the interview process are listed below:

- In general, work zone enforcement is conducted in an informal manner in Kentucky
- Participants emphasized that police officer enforcement activities were used to supplement and not replace the traffic control plan
- Enforcement in work zones is primarily performed by the Department of Vehicle Enforcement
- Within the Kentucky Transportation Cabinet, it was suggested that one state-level work zone safety coordinator should be assigned to schedule and interact with enforcement personnel and contractors

- Several examples were cited where coordination between enforcement officers and highway contractors, as well as state construction personnel, was fluid and effective
- Enforcement strategies used in combination with officers on site included signs indicating double fines and speed-display trailers
- Contractors noted that enforcement officers were best used as added deterrence for speed control and not as a replacement for other forms of traffic control
- Contractors recommended that work zone enforcement be included as a separate bid item in order to ensure consistency in the level of enforcement provided through competitive bidding
- It was noted that supplemental enforcement should address the safety of the traveling public, in addition to the focus on worker safety

A complete summary of the results of the structured interview is included as Appendix A.

4.0 EVALUATION AND TESTING OF WORK ZONE CONTROL DEVICES

4.1 Speed Control Measures in Work Zones

In an attempt to determine the effectiveness of various speed control measures in work zones, speed data were collected for the following strategies:

- Double fine signs within an active work zone
- Double fine signs and police enforcement within an active work zone
- Double fine signs and radar display unit within an active work zone
- Standard signs within an active work zone
- Work zone with no activity
- Road section adjacent to the work zone

4.2 Automated Flagger Devices

Automated flagger devices evaluated and investigated as part of this study were the following:

- R.C. Flagman
- AutoFlagger
- Synergy Automated Flagger Device
- IntelliStrobe Automated Flagger Assistance Device

Each of these devices is being marketed as an alternative to human flaggers within work zones. These systems are intended to remove the flagger from the traditional position of controlling traffic by using automatic flagging devices that can be operated remotely. In addition to the safety benefit of removing the flagger from exposure to traffic, another benefit may be to reduce work zone personnel requirements by using one person to control and operate two automatic flagger devices.

4.3 Aerial Lift/Elevated Platforms

The use of aerial lift/elevated platforms were not evaluated or tested; however, the MUTCD draft typical application drawing for aerial work within an intersection was reviewed and discussed with representatives of the Kentucky Transportation Cabinet. An area of focus was the hazard associated with working over an open lane of traffic.

4.4 Flashing STOP/SLOW Paddles

The following two types of flashing STOP/SLOW paddles were evaluated as part of this research.

- BlinkerStop LED Enhanced STOP/SLOW Paddle
- Detronics Flashing STOP/SLOW Paddle

Each of these STOP/SLOW paddles were purchased and provided to maintenance personnel with the Kentucky Transportation Cabinet for evaluation. The paddles were used by employees as they conducted various types of activities with input received concerning their effectiveness, any problems encountered, and suggestions for future use.

5.0 MOBILE, SHORT DURATION, AND SHORT-TERM STATIONARY WORK ZONE OPERATIONS

A review of the literature and contacts with various state agencies identified very few guidelines specifically for short duration or mobile work zones. However, there are some consistent practices. These include the use of high-intensity lights on work vehicles and using shadow vehicles and/or truck mounted crash attenuators with routine short duration or mobile maintenance operations.

Definitions of a work zone based on work duration are given in the MUTCD in Section 6G.02 (19). Short duration is work that occupies a location up to one hour. Mobile is work that moves intermittently or continuously. Guidance is given for the use of appropriate traffic control devices in short duration or mobile work zones. The traffic control includes signs, lights, flashing arrows, shadow vehicles, and truck mounted attenuators. The following three typical application diagrams for mobile or short duration operations are given in the MUTCD: work on shoulders (TA-4), two lane roads (TA-17), and multilane facilities (TA-35).

The review of literature and contacts with several states found the following specific information relating to traffic control during short duration and mobile operations.

MUTCD: gives general guidance and few typical applications
New York: set of typical application diagrams for mobile work zones
North Carolina: two diagrams for pavement markings caravans

California:	application diagrams include moving lane closures
Oregon:	handbook for short term traffic control
Texas:	applications based on MUTCD with video for mobile work zones
Wisconsin:	handbook with section for mobile operations

6.0 SUMMARY OF RESULTS

6.1 Speed Control Measures in Work Zones

Data were collected at 23 locations across the state with speed data collected for approximately 100 vehicles at each location. Sites were selected to provide data for each of the speed control variations listed in Section 4.1. All sites were located on interstates or parkways. The 50th and 85th percentile speeds were calculated for each site. The results were grouped by type of speed control as shown below.

	Average Speed (MPH)		Speed Limit
Description	**50th**	**85th**	**(MPH)**
Not In Work Zone	67.8	71.6	65
Work Zone: No Activity	62.7	67.7	55
Work Zone: Active, Typical Signs	57.5	62.8	55
Work Zone: Active, Double Fine Signs only	57.8	62.2	55
Work Zone: Active, Double Fine Signs, Police	53.8	57.3	55
Work Zone: Active, Double Fine Signs, Radar Box, Police	54.8	56.2	55

It can be seen that the largest reduction in speed is achieved when there is police presence at the work site. The speed data and description for each site is shown in Appendix B.

6.2 Automatic Flagger Devices

Literature was reviewed to determine the automatic flagger devices which are either currently available or under development. Information was obtained for the following devices.

- R.C. Flagman
- AutoFlagger
- Synergy Automated Flagger Device
- IntelliStrobe Automated Flagger Assistance Device

The AutoFlagger and IntelliStrobe devices were brought to Kentucky with their use demonstrated. Currently, there appears to have been limited application of the devices by other transportation agencies. The lack of widespread use is possibly related to cost and the time/convenience factors of placing the devices in the work zone. It appears that the devices may have considerable potential for application in long-term lane closures at work zone locations such as bridge deck repairs.

6.3 Aerial Lift/Elevated Platforms

The MUTCD draft typical application diagram was used as a basis for one of the diagrams provided in the handbook for traffic control in short duration or mobile work zones. Based on the potential safety issues related to aerial work within an intersection, the following guidelines were recommended for consideration:

- All work vehicles shall be equipped with rotating lights or strobe lights
- A warning sign should be placed on each intersection approach affected by the work activity and additional signing should be placed at high-speed, high volume locations
- Cones should be placed adjacent to the work vehicle
- No portion of the aerial lift platform shall extend over an open lane of traffic
- A minimum of two workers shall be used at the work site with one worker controlling traffic (additional workers may be required at high speed, high volume locations)
- If conditions warrant, the traffic signals should be placed on all-red flash (alternate is to use police officers to regulate traffic)
- On multilane roads, an arrow panel may be used
- A shadow vehicle (with optional use of a TMA) may be used at high speed, high volume locations.

6.4 Flashing STOP/SLOW Paddles

A review of current practice found two manufacturers. One BlinkerStop LED enhanced paddle and one Detronics flashing paddle were purchased. The cost was $355 for the BlinkerStop paddle and $545 for the Detronics paddle. Maintenance personnel from the Kentucky Transportation Cabinet used and evaluated the paddles and made the following comments concerning the use of the paddles.

- The paddle poles are too short
- The BlickerStop paddle was very lightweight and could be easily damaged
- The Detronics paddle was very heavy and was less preferred to the BlickerStop paddle
- A four-legged stand would be helpful in supporting the weight of either paddle
- The LED lights are not very visible in the daytime

The suggestion was made that flashing LEDs could be added to the portable “flagger ahead” sign. This type of sign would provide more advance warning than the standard warning sign which would increase the flagger’s safety. However, discussion with the manufacturer found that the cost quoted for such a device was extremely high.

6.5 Mobile, Short Duration, and Short-Term Stationary Work Zone Operations

6.5.1 Development of Handbook

An objective of the study was to develop a handbook giving guidelines for traffic control in short duration and mobile work zones. A handbook was developed with the following information included (as given in the table of contents).

- Introduction
- Work Duration
- Major Traffic Control Considerations
- Fundamental Principles
- Guidance, Options, and Support for Short Duration or Mobile Operations
- Component Parts of a Temporary Traffic Control Zone
- Tapers
- Flaggers
- Arrow Panels
- Warning Lights
- Nighttime Operations
- Signs
- Typical Application Diagrams

After reviewing the various typical application diagrams in the literature for short duration and mobile operations, the following diagrams were prepared to represent typical situations.

- Aerial Work at Signalized Intersection
- Shoulder Closure
- Single Lane Closure on Multi-Lane Road with Full Shoulder
- Single Lane Closure on Multi-Lane Road (Narrow Shoulder)
- Closure of Two Lanes on Multi-Lane Road
- Mobile Operation on Two-Lane Road
- Slow Moving Operation (Mowing off Shoulder)
- Slow Moving Placement of Rapid-Dry Pavement Marking on Multi-Lane Road
- Slowly Moving Placement of Rapid-Dry Pavement Marking on Two-Lane Road
- Mobile Worksite with Flaggers

The two following basic diagrams were prepared for short term maintenance operations.

- Short Term Maintenance (Two-Lane Road)
- Short-Term Maintenance (Multi-Lane Road)

The handbook is designed so that it is a size that can be taken to the field by maintenance personnel. A copy of the handbook is shown in Appendix C.

6.5.2 Survey of Workshop Participants

A survey was given to participants of a one-day work zone workshop taught periodically by the Kentucky Transportation Center (with 216 surveys completed). The survey asked participants to give examples of work activities, traffic control devices used, and problems or concerns for short duration and mobile activities. Participants were also asked to rate the effectiveness of various methods of controlling speeds in work zones.

Following are lists of the most common activities given as examples of short duration and mobile activities.

Short Duration Activity	Number Listed
pot hole repair	99
signs/traffic signals	92
cutting trees/bushes	60
dead animal removal	22
ditching	20
trash pickup	20
mowing	17
reading meter	17

Mobile Activity	Number Listed
pot hole repair	68
mowing	52
trash pickup	30
spraying	29
ditching	26
cutting trees	24
maintaining traffic signs	24
shouldering	20

Following is a list of the types of traffic control devices used for short duration and mobile activities.

Short Duration Traffic Control	Number Listed
stop/slow signs	112
flaggers	102
cones	102
truck lights/strobe	77
lights	43
flashing arrow	36
signs	23
barrels	16

Mobile Activity Traffic Control	Number Listed
signs	81
trucks lights/strobe	64
flags	59
lights	57
flashing arrow	45
trucks	32
cones	28
impact attenuator	18

Following is a list of the most common problems or concerns encountered while conducting short duration or mobile activities.

	Type of Activity		
Comment	Short Duration	Mobile	Total
Driver inattention	41	34	75
Speed too fast	32	34	66
Congestion; traffic volume	20	13	33
Drivers inconsiderate/impatient	15	13	28
Sight distance limited	6	8	14
Inadequate traffic control devices	9	2	11
Weather	5	4	9
Communication between flaggers	4	3	7
Work lasted longer than expected	4	2	6
Need more workers	3	2	5
Moving traffic control with work area	1	3	4

The effectiveness of various methods of controlling speeds in work zones were rated using a scale from 1 to 5 with a rating of 5 for very effective and 1 for not effective. Following is a weighted rating for the various speed control methods.

	Weighted Rating
Radar signs which display the speed of motorists in the work zone	3.22
Presence of police enforcement officers at the work zone (with blue lights flashing)	4.61
Advisory speed signs supplementing work zone warning signs	2.96
Reduction in the regulatory speed limit	3.10
Signs doubling the fines in work zones	3.58
Variable message signs	3.07

Respondents felt the most effective method of speed control was the use of police at the work zone with this method rated substantially higher than the second most effective method of doubling fines. The least effective method was advisory speed signs. The range of difference in shown in that 80 percent of the respondents rated the use of police at the work site as very effective compared to only 12 percent for advisory speed signs.

7.0 RECOMMENDATIONS

1. Distribute the handbook providing guidelines for traffic control in work zones to maintenance and utility workers.
2. Use the diagram included in the handbook as guidance for state personnel and contractors performing aerial work at intersections.
3. Provide flashing STOP/SLOW paddles (using the LED type flasher) to workers who routinely perform work during nighttime hours.
4. Implement a test of automated flagger devices at a sample of high volume, high speed locations to determine if this type of device is feasible for future wide spread use.
5. Include work zone enforcement as a separate bid item in major construction projects.
6. Expand the use of radar signs which display the speed of motorists in the work zone to include major maintenance activities.
7. Encourage the use of police enforcement officers for maintenance activities.
8. Expand the use of signs doubling fines in work zones to major maintenance work zones (as specified in Kentucky Administrative Regulations).
9. Assign a statewide work zone safety coordinator to interact with enforcement personnel and contractors.
10. Develop a certification process for all flaggers (including contractors, utilities companies, and state personnel).
11. Require high-intensity lights on all equipment used in construction and maintenance work zones.

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APPENDIX A

NCHRP 3-80
Traffic Enforcement Strategies for Work Zones

Structured Group Interview

Sponsored and Organized by the Kentucky Transportation Cabinet

Lexington, KY
December 9, 2005

NCHRP 3-80 Work Zone Enforcement Effectiveness

Pilot Group Interview

Kentucky Transportation Cabinet (KYTC)

December 9, 2005

Workshop Attendance Profile

Majority Kentucky Transportation Cabinet (KYTC), several contractors, and two enforcement officers

Overall

- KYTC did a presentation in Florida last week (week of November 28, 2005). This workshop/meeting was attended by most of the southern States. Work zone enforcement was a major issue.
- In general, work zone enforcement is conducted in an informal manner in Kentucky.
- Respondents emphasized and recognized that the police officer enforcement is not intended to replace the traffic control plan but to supplement it.
- Most of the enforcement on State highways in Kentucky is performed by Kentucky Vehicle Enforcement (KVE). Their primary mandate was the enforcement and administration of commercial vehicles but now their duties have expanded to include passenger vehicles as well.
- The KYTC does not have a state level work zone safety coordinator. They do have a lead safety person in the central office but no designated work zone safety coordinator.

We can't use police enforcement in every work zone. So how are decisions made on resource allocation – how do you decide which work zones to enforce and not?

- Generally, the locations where there are exposures to worker in the work zone is the high priority. Sometimes it is as simple as whether there is positive separation or not. The decision-making on which work zones are enforced is done at the district level. There is no statewide scheme for such resource allocation. There are 12 districts in Kentucky.
- There is a problem with long work zones. For example, in a four mile work zone drivers will slow down initially and then they just speed up. On a major project where safety is a big issue, they have two police enforce the work zone.
- The state (KVE and Kentucky State Police) does not have enough police to be at all work zones. The commissioner noted that the KVE needs to use local police officers for work zone enforcement even on state highways and interstates. There is enough law enforcement to go around. There is a need for one law enforcement coordinator for the state who coordinates everything. This will help maximize all available police officers from the state as well as local agencies. This discussion brought up the issue of potential liabilities associated with using local officers on interstate highways.

- When asked if there was any work zone specific training provided to police officers (both local and State), the KVE noted that there is no work zone specific training for police. Whatever they learn is at the police academy and through on-the-job training.
- To some contractors, it seems like a waste of a police officer's expertise and time for them to be present at a work zone, rather than dealing with something where they have an active duty to perform. However, as other contractors noted, this seems to be the only way to slow people down through work zones. Traffic signs asking people to slow down or drive carefully do not work.
- There was mutual agreement in the audience that during the design phase of a project, the need for work zone enforcement is best addressed up front. During traffic control planning, the issue of whether enforcement is needed and if so, how it will be provided needs to be addressed.
- A question was asked by a contractor concerning what type of work zone we are talking about; that is, are we talking about just interstate work zones? The response is that we are talking about any work on the state highway system (maintenance or construction). Note that sometimes, the state is also responsible for construction on city and county roads. The KYTC has a specific definition of a work zone.

Work zone enforcement support strategies

- KYTC uses alternative strategies, such as double fines and speed trailers, which can be treated as enforcement support strategies.
- In some cases, designated pullouts have been incorporated into the work zone design so that officers may pull over offending vehicles.
- In some projects, methods have been incorporated for police officers to get from point A to point B along the work zone without necessarily hindering traffic or workers.

What are the differences between maintenance and construction Work Zones from an enforcement perspective?

- Very few maintenance work zones are provided law enforcement support (less than 10 percent). In Louisville, most work that is conducted at night (including maintenance) is provided enforcement support, ranging from sweeping to cleaning to guard rail work. Enforcement is also used for emergency work that is performed at night. It is important to note that, from a maintenance perspective, the purpose of using police officers is mainly for traffic control, visibility, and deterrence. Very rarely is actual enforcement performed in maintenance work zones.
- In the case of construction projects, there is an opportunity to plan for traffic control and enforcement as part of the pre-construction coordination process. However, for maintenance jobs, there is not this opportunity because there is not much pre-planning for enforcement.
- Decision-making on the need for enforcement is made during review of traffic control notes (after the Cabinet's maintenance staff puts a project together). They make

enforcement a bid item by the hour – then the contractor figures out how to get the officers.

- In the Louisville District of the KYTC (District 5) it is standard policy to use enforcement officers for night maintenance work. Total traffic volume on the facility is one of the criteria for determining whether or not enforcement is needed. A 160,000 ADT facility was cited as an example. It also depends on the type of activity they are doing. Job engineers make the decision. The Cabinet has a very good informal working relationship with the Kentucky Vehicle Enforcement (KVE) department – so when they need someone – they just pick up the phone and ask for someone – generally KVE will be there within an hour or so. They also use local police and State police. It was noted that a contractor or cabinet work crew might actually adjust their work schedule if the law enforcement were not able to provide support on a given day or night and wait until an officer was available.

- Sometimes, contractors work together with KYTC maintenance crew in maintenance work zones.

How do police departments (in this case, KVE because they were the ones present at the workshop) make a decision on which work zones get enforced?

- The KVE has a great relationship with the Cabinet. Local captains have a blanket "do whatever you can do" directive to help out the Cabinet with work zone enforcement needs.
- KVE makes the call on how much one person can do in one day – the KVE commissioner, Mr. Greg Howard controls that pretty tightly. KVE takes guidance from the Cabinet on decision-making on which work zones to cover when they don't have enough troopers to cover all ongoing projects.

Enforcement funding and paying for the use of police officers in work zones

- <u>Double Fine Law</u>.
  - In Kentucky, they have been attempting to use the fines generated from double fines in work zones law to fund the use of enforcement officers in work zones. However, this has turned out to be a very expensive process and has not been serving the purpose.
  - The money from the double-fines was not coming into the funding pool for work zone enforcement – only 50% would come into the pool – the rest of it was being diverted to traffic school or other programs.
  - Then, there are also situations where no tickets are written.
  - The KVE and the Cabinet do not know what happens in the courts. Often times, violators appeal their citations and get them rescinded in courts. This takes away the teeth from the enforcement program. This issue is not endemic to work zone enforcement alone – it applies to general enforcement on Kentucky's highways. A comment was made that for the double-fine law, the legislation should say that

the judge should not reduce the double fine citation, if a person were to challenge in court.

- The double-fine zone is applicable only to very specific situations and is enforceable only when the work zone is active (i.e., workers must be present, actual work must be taking place, there needs to be positive separation in the work zone, etc.). This is very different from a maintenance situation where the work zone setup is temporary.

- Administratively, the Cabinet is trying to do something regarding funding sources for work zone enforcement – nothing has quite taken shape yet. The Cabinet has agreed to take construction money and allocate it directly to the KVE for work zone enforcement. This is separate from any bid item on a project. Before (in the old days), the police would directly deal with the contractors for the billing – the contractors would reimburse the police. But now, the Cabinet is working to establish a program where they reimburse the police directly and manage the enforcement levels across projects and regions.

- Participants noted that one of the reasons that paying for enforcement became more complicated is that KVE was moved over to the Dept. of Justice within state government (previously they were housed under the DOT). This now requires transfer of funds across branches of government, rather than between divisions in the same branch (as it had been).

- <u>Bid Items for Work Zone Enforcement</u>.

  - There is inconsistency in the use of bid items for work zone enforcement. Both the Cabinet staff and contractors noted that contractors should be given a chance to provide input on work zone enforcement decision-making. Contractors want consistency in the use of bid items for enforcement – to set it up as part of the pay back – so that the contractors can make sure that there is adequate enforcement when they need it. There is not enough consistency in how the enforcement officers can be used either. Contractors are rarely involved in maintenance – so this primarily applies to construction projects.

  - In the Louisville District (District 5) of the Cabinet, they routinely use bid items in the contract for work zone enforcement. They have a process (during project development and design) to determine the need for work zone enforcement. Enforcement is generally used for projects in urban areas and for night work. Once the enforcement is identified as a bid item, the contractor is responsible for procuring the enforcement officers.

  - However, the practice of using bid items for work zone enforcement is unique to the Louisville District (District 5). Other districts don't use bid items for enforcement – it is treaded as an incidental item.

  - One Northern-Kentucky contractor mentioned that he has never seen a bid item for use of enforcement officers in Northern-Kentucky projects. However, he stated that they don't ever do a job "without blue lights," period. Police officer presence with flashing blue lights appears to slow drivers down – increasing both

traffic and worker safety. So, they would prefer that work zone enforcement be included in all projects as a bid item.

- In response to the above statement, another contractor stated that not all contractors have the luxury of having a police officer in the work zone all the time.
- Contractors feel that in order to ensure a level-playing-field, work zone enforcement should be included in the contract as a separate bid item. They noted that when the contract does not specify enforcement as a bid item, the Cabinet needs to distinguish between those bids that include work zone enforcement costs and those that don't. Once work zone enforcement is included as a bid item, the contractor can choose where the enforcement officer comes from. Contractors would be able to deal directly with the overtime officers.
- In response to the above, the following question was asked: "If work zone enforcement were included as a bid item, would the contractor have the option to direct what the officer does?" The response was that the contractor would not have any authority over the police officer – but it was also mentioned that if the purpose of the officer is to be at the job site, then that's what the officer needs to do. This was raised as one of the issues that need to be resolved if work zone enforcement were to be included as bid items in contracts.
- Some participants suggested that standard specifications can be revised to incorporate work zone enforcement as a bid item. It would be the responsibility of the contractor to procure the police officers – and the dollar value in the bid item would only be charged back if enforcement is actually used during the project. Some participants noted that if enforcement were to be made a bid item, there is no guarantee that the police officers may be available – police man power would still be an issue. Participants also noted that in order to successfully include work zone enforcement in bid items, they should be able to quantify it and ensure the use of police officers during the project.
- With respect to including work zone enforcement as a bid item, participants observed that the intent is not to replace traffic control with police officers.

When a police officer is assigned to a work zone what happens when there is a crash or something else – will the officer be pulled away?

- It depends on what the officer was doing in the work zone – say if the officer is a point cover for a paver he would try to get a different officer – it is very situation specific. There is no written guidance on this issue, but officers are allowed to make their own decisions based upon specific circumstances.
- There is general recognition that if something major were to happen, creating a major emergency, then the police officers would have to leave their work zone posts.

Active enforcement verses passive or stationary deterrence

- There is a problem with presence versus. active enforcement. Contractors would prefer that enforcement officers assigned to the work zone remain at their posts with

their lights flashing, rather than leave their posts to write speeding tickets. In that regard, they perceived that sometimes the agenda of the police is to make money by writing tickets, rather than staying at their posts for visibility and deterrence. If an officer is issuing a citation on the side of the road, instead of the assigned spot, their perception of the officer's effectiveness decreases.

- There is no fear of law enforcement anymore. Every situation might not deserve a ticket (police do get money on overtime) but no money is obtained from the tickets for funding the police. The public has become numb to work zones and to police. Most times, the public is aware that an officer is present just for deterrence and not for active enforcement. However, if the police do not write tickets people are not going to slow. Drivers are not necessarily afraid of the double-fine law either. Its provisions are very specific (i.e., workers have to be present, positive separation is a must, etc.).
- Further, work zone designs do not lend themselves to active enforcement. There are no pullouts and it is not wise to stop people on the traveled lanes or on narrow shoulders. Also, the KVE does not have enough resources to use chaser cars downstream of the work zone to chase and stop offenders.

Automated enforcement and other advanced techniques

- Drive Smart (radar speed trailers and display boards) is used for speed detection and display "within the work zone." This is applicable especially in long work zones where police officers cannot be stationed throughout the work zone. It was not clear as to exactly how the Drive Smart system worked (whether it is used only for speed detection/display or for active enforcement).
- Someone mentioned that Arizona and New Mexico use a similar automated work zone enforcement system. Participants also mentioned the Illinois Variable Speed Limit (VSL) and automated work zone enforcement system. A participant noted that in Illinois, special legislation had to be passed for implementing the automated work zone enforcement system. In Kentucky, automated enforcement issues have been proposed for legislation (e.g., red light running cameras) but no action was taken.
- It was mentioned that positive driver identification is required for automated enforcement and mail-in citations.
- KYTC is trying to develop a plan for advanced enforcement technologies and participants mentioned that advanced work zone enforcement technologies can also be addressed in that plan.

Public communication

- It was noted that in order to communicate better with the public, more "active" electronic message signs are needed not only in the advance area but also throughout the work zone.
- Kentucky conducts the annual work zone safety awareness week. This includes press conferences and media releases on work zone safety, information on the double fine law, etc. In 2005 there had been a large number of public service announcements

including cooperation with neighboring cities and local jurisdictions into the work zone safety campaign.

- National poster campaigns regarding work zone safety education and information dissemination are included in any safety campaign.
- An attempt is made to communicate to the public about the "Get in – Get out – and Stay out" approach for road construction and maintenance.
- Public information campaigns for specific projects/work zones are used very rarely. In Louisville in2002 a full-road-closure approach was used for a major interstate reconstruction project. Since then the full-closure approach was used for another major project. On both closures, there was a large police presence (for example, a police officer was placed at each ramp for enforcement/deterrence and also to provide general information on alternate routes to destinations that are served by the closed route). A formal evaluation of the 2002 full-closure was performed, including a user-cost evaluation and public surveys and interviews.
- The KYTC and KVE use a Citizens Band (CB) "override" radio system to communicate with truckers on specific projects. The system is set up in advance of work zones to ask truckers to slow down.
- Effectiveness of these communication efforts is generally measured in terms of a lack of complaints by the public. If no one complains, the effort must have worked.

Communications between the KYTC, Police, and Contractors

- Quite often on major construction projects, there is a lot of coordination and communication that takes place between the KYTC, the contractor and the enforcement agency during pre-construction meetings.
- In one of the KYTC districts, both the KYTC district chief and the KVE police post commander are co-located in the same office. This helps smooth and sustain communications.
- In the Louisville district (District 5) of the KYTC, there is regular communication on a daily basis between the KYTC and the local KVE post. They talk every morning on the phone to discuss the activities and ongoing work zones for the day.
- KVE does not get dispatch calls for other general law enforcement problems. Police officers who serve at work zones on an overtime basis are normally not dispatched through police dispatch. They are also generally not dispatched away from their work zone duties.
- Contractors and others noted that work changes on a daily basis so it is important for enforcement officers to know what kind of construction activity is taking place during their shift. So, when the enforcement officer reports to the job site, they should first contact the construction supervisor, and then ask him/her what their specific responsibilities are, and what they need to do for that session.
- Some contractors provide a radio to the police officer for communication and coordination during the officer's shift at the job site.

- In general, communication between police officers and contractors is pretty fluid and informal. It was noted that a contractor or cabinet work crew might actually adjust their work schedule if law enforcement were not able to provide support on a given day or night and wait until an officer was available.

Other discussion items

- Contractors made it clear that they don't want to use police officers instead of traffic control (cones, barrels, etc.); rather, they want police officers as added deterrence so that drivers actually slow down.
- One of the law enforcement consultants on the project team mentioned that in work zones there are other enforcement issues in addition to speed enforcement; for example, drivers passing on shoulders. Such issues may be addressed with aerial enforcement.
- KYTC and all others present at the meeting recognize that the old work zone culture needs to change. The industry must develop some creative means to obtain the public's attention so that they actually take heed of work zone signs and reduce speeds through work zones.
    - We need to have work zone enforcement.
    - We need to be creative in managing and enforcing speed and safety in advance of and through the work zone.
    - We need to find better ways to actively communicate with the public in advance of and through the work zone.
- One of the specific locations in work zones which is very prone to crashes is the interface between the work area and the travel lanes where construction and other vehicles enter and exit the work area. This highlights the need for police officer protection of such interface areas.
- Use of police enforcement should not focus just on worker safety. It should also address safety of the traveling public.
- Kentucky has a move over law, which requires people to move over to the next lane, if there is any public service vehicle on the shoulder (including police vehicles, ambulances, fire-trucks, contractor vehicles, etc).
- The Kentucky Transportation Center (KTC), under the sponsorship of the KYTC has conducted research on Driving Under the Influence (DUI) conviction rates for different counties in the state. This was done due to ongoing differences with district judges regarding conviction rates. The KTC has information and statistics from that study. No such studies or other types of studies have been done with regards to work zone enforcement.

APPENDIX B

SPEED DATA

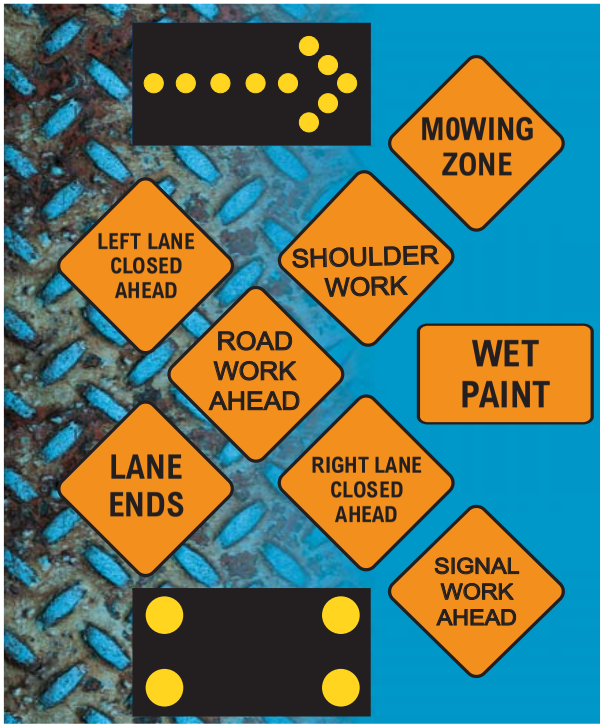
APPENDIX B. SPEED DATA BY SITE LOCATION

					TRUCK				Treatments				
County	Route	Speed Limit	50th	85th	50th	85th	Dir	Location	WZ Signs	Double Fine	Police	VMS	Radar Box
Clark	I-64	55	64.5	69	62	66.5	WB	MP 92.8	YES	NO	NO	NO	NO
Clark	I-64	65	67	69	68	70.5	EB	Just past Fayette Co. Line	NO	NO	NO	NO	NO
Clark	I-64	55	59	64	60	68.5	EB	Just past lane closure (flashing arrow)	YES	YES	NO	NO	NO
Clark	I-64	65	68	74	64.5	67	WB	US 60 bridge past Mt. Pkwy 101.7	NO	NO	NO	NO	NO
Clark	I-64	55	57.5	62	58.5	62.5	WB	MP 96.8	YES	YES	NO	NO	NO
Clark	I-64	55	60	64	58	62.5	EB	Just before exit 94	YES	YES	NO	NO	NO
Jefferson	I-265	55	57.5	62	56	58.5	WB	Just past exit 17	YES	YES	NO	YES	NO
Hardin	WK	55	53.5	57	53	56.5	WB	126	YES	YES	YES	NO	NO
Grayson	WK	65	67	71	65.5	68.5	WB	117	NO	YES	NO	NO	NO
	WK	55	55	59	54.5	57	EW	129	YES	YES	NO	NO	NO
Hardin	WK	55	54	57.5	53.5	56	EB	125.7	YES	YES	YES	NO	NO
Grayson	WK	65	67.5	71.5	67	69.5	EB	MP 143	NO	YES	NO	NO	NO
Rowan	I-64	55	60	54.5	53.5	55.5	EB	MP 143	YES	YES	YES	NO	YES
Rowan	I-64	55	52.5	56.5	52	55	EB	MP 131	YES	YES	YES	NO	YES
Clark	I-64	55	54.5	60	53	56.5	WB	Mp 94	YES	YES	YES	NO	NO
Jefferson	I-265	55	58.5	64.5	57	59.5	WB	Gene Snyder near exit 17	YES	NO	NO	NO	NO
Rowan	I-64	55	52	57.5	52	55	WB	I 64 before exit 133	YES	YES	YES	NO	YES
Grant	I-75	55	63.5	69	61	68	SB	just past exit 159	YES	NO	NO	NO	NO
Grant	I-75	55	61.5	66.5	57.5	62.5	NB	Just before exit 156	YES	NO	NO	NO	NO
Fayette	I-64	65	69.3	72.5	64.1	68.1	EB	prior to work zone MP 87.6	NO	NO	NO	NO	NO
Clark	I-64	55	61	66.4	57.5	62.6	EB	MP 92.2	YES	NO	NO	NO	NO
Clark	I-64	55	56.4	61	54.2	57.8	EB	east of exit 94	YES	NO	NO	NO	NO
Boyd	I-64	55	63.1	67.7	62.2	65.3	WB	MP 180	YES	NO	NO	NO	NO

Appendix C

Handbook

Guidelines for Traffic Control in Short Duration/Mobile Work Zones



KENTUCKY TRANSPORTATION CABINET

UK
UNIVERSITY OF KENTUCKY
College of Engineering
Kentucky Transportation Center

Guidelines for Traffic Control In Short Duration / Mobile Work Zones

Guidelines for Traffic Control in Short Duration / Mobile Work Zones

Table of Contents

Introduction

A temporary traffic control (TTC) zone is an area of highway where road user conditions are changed because of a work zone or an incident through the use of TTC devices, uniformed law enforcement officers, or other authorized personnel.

The primary function in such locations is to provide for the reasonably safe and efficient movement of road users through or around the work zone while reasonably protecting workers, responders to traffic incidents, and equipment. Part 6 of the Manual on Uniform Traffic Control Devices (MUTCD) is the national standard for all traffic control devices used during construction, maintenance, and utility activities plus incident management.

This handbook summarizes guidelines listed in the MUTCD with specific focus on short duration and mobile activities. It contains basic principles, a description of standard traffic control devices used in work areas, guidelines for the application of the devices, and typical application diagrams.

The application diagrams shown represent minimum requirements for typical situations. They are not intended as substitutes for engineering judgment and should be altered to fit the conditions of a particular site. The design, selection, and placement of the TTC devices for a TTC plan should be based on engineering judgement. All traffic control devices used. The Kentucky General Assembly has adopted the MUTCD as the standard for traffic control devices on public highways in Kentucky (KRS 189.337 and 603 KAR 5.050).

Work Duration

Work duration is a major factor in determining the number and types of devices used in TTC zones. The duration of a TTC zone is defined relative to the length of time a work operation occupies a spot location. The five categories of work duration and time at a location (as defined in the MUTCD) shall be:

- Long-term stationary - Work that occupies a location more than three days.
- Intermediate-term stationary - Work that occupies a location more than one daylight period up to 3 days, or nighttime work lasting more than 1 hour.
- Short-term stationary - Daytime work that occupies a location for more than one hour and within a single daylight period.
- Short duration - Work that occupies a location up to one hour.
- Mobile - Work that moves intermittently or continuously.

This handbook focuses on short duration and mobile activities with additional examples given for short-term maintenance on two-lane and multi-lane roads.

Major Traffic Control Considerations

The TTC needed at a specific location varies relative to the characteristics of that location and the work being conducted. Following is a list of some questions that should be considered when determining the TTC needed.

1. Where is the work zone located (on the roadway, on the shoulder, or off the roadway)?
2. What type of road is involved?
3. What is the speed of the traffic?
4. What is the traffic volume on the roadway? Should the work be rescheduled to avoid heavy volume conditions?
5. Will the nature of traffic change while work is underway?
6. Do the local law enforcement agencies need to be notified?
7. What kind of signing will be required?
8. Are cones, drums, barricades, or an arrow panel needed for traffic channelization?
9. Will a flagger be required?
10. What will be the duration of the work?
11. What type of work is being performed?
12. What are the weather conditions?

Fundamental Principles

The control of road users through a TTC zone shall be an essential part of highway construction, utility work, maintenance operations, and incident management. The following principles provide guidance to assist road users and help protect workers in the vicinity of temporary traffic control zones.

1. Road user and worker safety in temporary traffic control zones should be an integral and high priority element of every project from planning through design and construction.
2. General plans or guidelines should be developed to provide safety for drivers, bicyclists, pedestrians, workers, enforcement/emergency officials, and equipment.
3. Road user movement should be inhibited as little as practical.
4. Drivers, bicyclists, and pedestrians should be guided in a clear and positive manner while approaching and traversing temporary traffic control zones and incident sites.
5. Routine day and night inspections of temporary traffic control elements should be performed.
6. Attention should be given to the maintenance of roadside safety during the life of the temporary traffic control zone.
7. Each person whose actions affect temporary traffic control zone safety should receive training appropriate to the job decisions each individual is required to make.
8. Good public relations should be maintained.
9. All temporary traffic control devices shall be removed as soon as practical when they are no longer needed.

Guidance, Options, and Support for Short Duration or Mobile Operations in Work Zones

The following standard, support, guidance, and option information is given in Part 6 of the MUTCD relative to short duration or mobile operations.

STANDARD

Mobile operations that move at speeds greater than 20 mph (such as pavement marking operations) shall have appropriate devices on the equipment (high-intensity lights, signs) or shall use a separate vehicle with appropriate warning devices.

All traffic control devices shall be retroreflective or illuminated if work is performed during nighttime hours.

A mobile operation involving a lane closure on a multi-lane road does not require a transition area containing a merging taper.

Vehicle mounted signs shall be mounted in a manner such that they are not obscured by equipment or supplies. Sign legends on vehicle-mounted signs shall be covered or turned from view when work is not in progress.

SUPPORT

Mobile operations include work activities where workers and equipment move along the road (usually at slow speeds) without stopping and with the advance warning area moving with the work area.

Devices having greater mobility than for stationary operations (such as signs mounted on trucks) might be necessary.

In mobile operations, the transition area moves with the work space.

Maintaining reasonably safe work and road user conditons is a paramount goal.

During short duration work, it often takes longer to set up and remove traffic control devices than to perform the work.

Work in an intersection usually involves a small work force with only a few vehicles and a minimal number of traffic control devices.

Except for short duration and mobile operations, when a highway shoulder is occupied, a shoulder work sign should be placed in advance of the activity area.

Type B arrow panels, (minimum size 60 x 30 inches) are appropriate for mobile operations on high-speed, multi-lane roadways.

GUIDANCE

Fewer devices should not be used just because the operation will frequently change its location.

In mobile operations a shadow vehicle (equipped with an arrow panel or sign) should follow the work vehicle.

Where feasible, in mobile operations, warning signs should be placed along the roadway and moved periodically as work progresses. The distance between warning signs and the work should not exceed two miles.

Under high-volume conditions, consideration should be given to scheduling mobile operations work during off-peak hours.

If there are mobile operations on a high-speed travel lane of a multi-lane divided highway, arrow panels should be used.

When practical and when needed, the work and shadow vehicles should pull over periodically to allow vehicular traffic to pass.

Whenever adequate stopping sight distance exists to the rear, the shadow vehicle should maintain the minimum distance from the work vehicle and proceed at the same speed. The shadow vehicle should slow down in advance of vertical or horizontal curves that restrict sight distance.

OPTION

Appropriately marked vehicles with high intensity lights may be used in place of signs and channelizing devices.The high intensity lights may be rotating, flashing, oscillating, or strobe lights (typically LED).

Simplified control procedures may be warranted with a reduction in the number of devices offset by use of more dominant devices such as high-intensity lights on work vehicles.

For mobile operations that move at speeds less than 3 mph, mobile signs or stationary signing that is periodically retrieved and repositioned in the advance warning area may be used.

At higher speeds, vehicles may be used as components of the traffic control zone for mobile operations. Appropriately marked vehicles may follow a train of moving work vehicles.

For some continuously moving operations a single work vehicle with appropriate warning devices may be used to provide warning.

For mobile operations, a sign may be mounted on a work vehicle, a shadow vehicle, or a trailer stationed in advance of the TTC zone or moving along with it. The work vehicle, the shadow vehicle, or the trailer may or may not have an impact attenuator.

For mobile and constantly moving operations, such as pothole patching and striping operations, a shadow vehicle, equipped with appropriate lights and warning signs, may be used to protect the workers from impacts by errant vehicles. The shadow vehicle may be equipped with a rear-mounted impact attenuator.

Flaggers may be used for mobile operations that often involve frequent short stops.

The distance between the work and shadow vehicles may vary according to terrain, paint drying time, and other factors.

Component Parts of a Temporary Traffic Control Zone

Following is a description of the general sections of a work zone (specifically related to short duration/mobile work zones).

Advance Warning Area: In this section of highway road users are informed about the upcoming work zone or incident area. In short duration or mobile operations advance warning signs could be placed along the roadway and moved periodically as work progresses or placed on work vehicles which move with the work area.

Transition Area: Road users are redirected out of their normal path. Stationary areas usually involve use of tapers while the transition area moves with the work space in mobile operations.

Activity Area: This is the section of highway where the work activity takes place and includes the work space, traffic space, and buffer space. In short duration and mobile operations the work space moves as work progresses.

- **Work Space:** Area for workers, equipment, and materials storage.
- **Buffer Space:** Lateral and longitudinal area providing protection for traffic and workers.

Termination Area: This area returns road users to their normal path. It is not typically used in short duration and mobile operations.

TAPERS

Tapers are used as the transition area in stationary operations. Taper lengths are given in the following table. Typical channelizing devices include cones (28" minimum), vertical panels, and barricades. In short duration and mobile operations other methods are used to provide advance warning and transition around and past the work area. This may typically include a shadow vehicle (equipped with an arrow panel or sign) following the work vehicle.

Taper Length (L)*

Speed Limit (MPH)	Lane Width (feet)			Spacing Between Devices (Feet)
	10	11	12	
25	105	115	125	25
35	205	225	245	35
45	450	495	540	45
55	550	605	660	55
65	650	715	780	65

*Following are the formulas used to calculate taper length:

Posted Speed	**Formula**
40 mph or under	$L = WS^2/60$
45 mph or over	$L = WS$

where: L = taper length; W = width of lane or offset, and S = posted speed, or off-peak 85th percentile speed
Note that the spacing for a one-lane, two-way taper shall be 20 feet for all conditions.

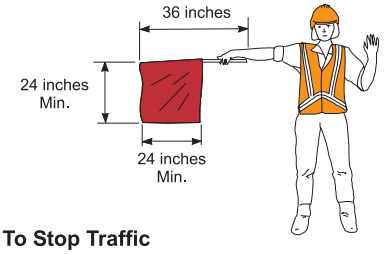
Flaggers

Flaggers are typically used in stationary operations, and may be used for mobile operations that often involve frequent short stops. Guidelines for the minimum qualifications, devices to use, flagger stations, flagging procedures, and communications are given in the MUTCD (Chapter 6E). The following guidelines for high visibility clothing apply to all workers in a work area.

The use of the flag and sign paddle are displayed in the following illustration.

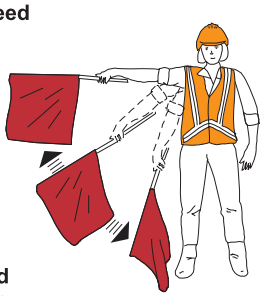
PREFERRED METHOD
STOP/SLOW PADDLE

EMERGENCY SITUATIONS ONLY
RED FLAG



To Stop Traffic

To Let Traffic Proceed



To Alert and Slow Traffic

High Visibility Clothing

High visibility retroreflective safety apparel shall be worn at all times. The retroreflective material shall be either orange, yellow, white, silver, yellow-green, or a fluorescent version of these colors, and shall be visible at a minimum distance of 1,000 feet. The retroreflective clothing shall be designed to clearly identify the wearer as a person. All clothing shall meet ANSI 107-2004 standards.

Arrow Panels

Arrow panels are effective day and night, for moving traffic out of a lane to the left or right, and may be used for tapered lane closures and mobile operations. The minimum size (for any roadway) must be 48" x 24" with at least 12 panel lamps to provide a minimum legibility distance of 1/2 mile. The minumum size on high-speed, multi-lane highways is 60" x 30". Arrow panels should be equipped with a dimming device capable of 50 percent dimming for use at night along with circular hoods. The only permissible use of an arrow board on a two-lane, two-way street or road is the flashing caution mode.

An arrow panel shall be a sign with a matrix of elements capable of either flashing or sequential displays. This sign shall provide additional warning and directional information to assist in merging and controlling road users through or around a temporary traffic control zone. The arrow panel shall be mounted on a vehicle, a trailer, or other suitable support.

An arrow panel should be used in combination with appropriate signs and other temporary traffic control devices. A vehicle displaying an arrow panel shall be equipped with high-intensity rotating, flashing, oscillating, or strobe light. When arrow panels are used to close multiple lanes, a separate arrow panel shall be used for each closed lane.

Warning Lights

If used, warning lights shall be mounted on signs or channelizing devices in a manner that, if hit by an errant vehicle, they will not be likely to penetrate the windshield. Flashing warning lights shall not be used for delineation, as a series of flashers fails to identify the desired vehicle path. Warning lights shall have a minimum mounting height of 30 inches to the bottom of the lens.

Type A Low-Intensity flashing warning lights are used to warn road users during nighttime hours that they are approaching or proceeding in a potentially hazardous area. Type A warning lights may be mounted on channelizing devices.

Type B High-Intensity flashing warning lights are used to warn road users during both daylight and nighttime hours that they are approaching a potentially hazardous area. Type B warning lights may be mounted on advance warning signs or on independent supports.

Type C Steady-Burn warning lights may be used during nighttime hours to delineate the edge of the traveled way. When used to delineate a curve, Type C warning lights should only be used on devices on the outside of the curve, and not on the inside of the curve.

Nighttime Operations

All traffic control devices shall be retroreflectorized when used at night. Workers shall wear ANSI approved retroreflective apparel. Cones shall be equipped with a reflective collar when used at night. When barricades are used, it is desirable to add flashing lights when the barricades are used singly and steady burn lights when they are used in a series for channelization. If a flagger is used, the flagger stations should be adequately illuminated.

Signs

Types

1. **Regulatory signs** inform road users of traffic laws or regulations and indicate the applicability of legal requirements that would not otherwise be apparent. Regulatory signs shall be authorized by the public agency or official having jurisdiction. They are generally rectangular with a black legend and border on a white background.
2. **Warning signs** in temporary traffic control zones notify road users of specific situations or conditions on or adjacent to a roadway that might not otherwise be apparent. Temporary traffic control warning signs shall be diamond-shaped with a black symbol or message and border on an orange background.
3. **Guide signs** provide road users with information to help them along their way through the temporary traffic control zone. The design of guide signs is presented in Part 2 of the MUTCD.

Size

Advance warning signs for higher-speed locations shall have a size of 48 x 48 inches. Where speeds and volumes are moderately low or, where there is a lack of shoulder width, a minimum size of 36 x 36 inches, may be used for advance warning signs. Deviations from standard sizes shall be in 6-inch increments. The bottom of the sign shall be a minimum of 12 inches from the ground.

Sign Placement

Signs should normally be located on the right side of the roadway. Where special emphasis is needed, signs may be placed on both the left and right sides of the roadway. Signs mounted on barricades and barricade/sign combinations shall be crashworthy. For mobile operations, a sign may be mounted on a work vehicle, a shadow vehicle, or a trailer stationed in advance of the TTC zone or moving along with the work.

Advance Warning Area

The distance from the first sign to the start of the transition area should be long enough to give motorists adequate time to respond to the conditions. The first warning sign may have a flag or cone. Guidelines are presented in the summary of layout dimensions as referenced in Table A (with A, B, and C distances indicated in the typical application diagrams.)

Table A
Summary of Layout Dimensions Sign Spacing

	Distance Between Signs (feet)		
Road Type	A	B	C
Urban (<40 mph)	100	100	100
Urban (Eq. or >45 mph)	350	350	250
Rural	500	500	500
Expressway/Freeway	1,000	1,500	2,640

Buffer Space

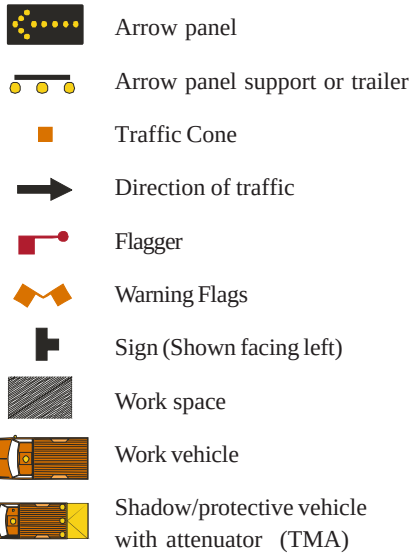
When a longitudinal buffer space is used, the values shown in the following table may be used.

Table B
Longitudinal Buffer Space Dimension

Speed (mph)	Distance (ft)
25	155
35	250
45	360
55	495
65	645

Typical Application Diagrams

The diagrams on the following pages represent examples of the application of principles and procedures for safe and efficient temporary traffic control in work zones. The layouts represent minimum requirements. It is not possible to include illustrations to cover every situation which will require work area protection. They are not intended as a substitute for engineering judgment and should be altered to fit the conditions of a particular site. All traffic control devices used must be in compliance with the MUTCD. The diagrams represent short duration and mobile operations except for two diagrams describing short-term maintenance operations. For further information, refer to Part 6 of the MUTCD.



Arrow panel

Arrow panel support or trailer

Traffic Cone

Direction of traffic

Flagger

Warning Flags

Sign (Shown facing left)

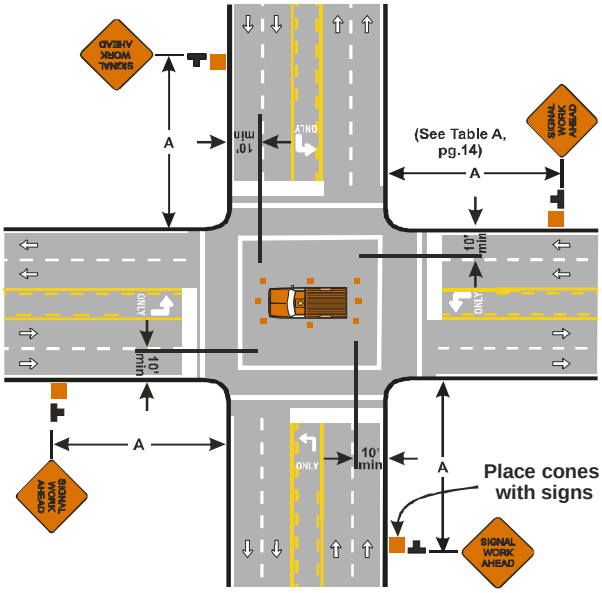
Work space

Work vehicle

Shadow/protective vehicle with attenuator (TMA)

Note: The application diagrams are not to scale.

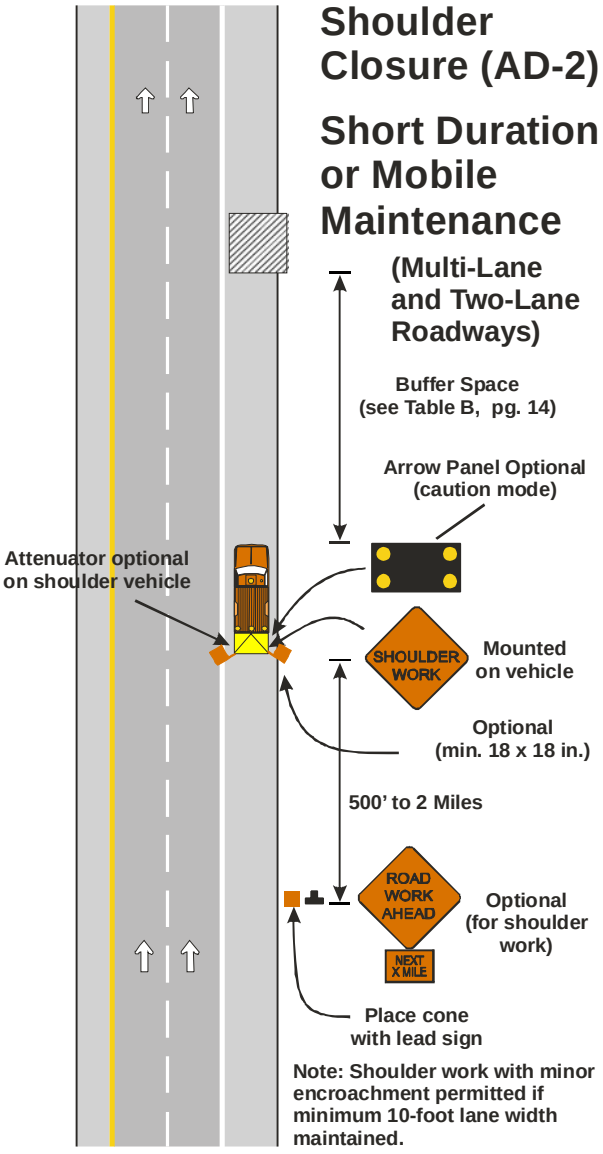
Aerial Work at Signalized Intersection (AD-1)



1. This diagram is not intended to represent all applications using aerial lifts at intersections. Engineering judgment should be used to determine appropriate traffic control applications for a specific site.
2. The use of police officers is suggested where signals are mounted diagonally across the intersection. If police officers are not an option and conditions warrant, place the traffic signal on all-red flash and/or place stop signs on all approaches.
3. No portion of an aerial lift platform, or the supporting structure, shall extend over an open lane of traffic, regardless of working height.
4. A TMA and arrow panel may be used in affected lanes on five or more lane roads with posted speeds of 45 MPH or greater.
5. The aerial lift vehicle shall be appropriately illuminated at night.

Shoulder Closure (AD-2)

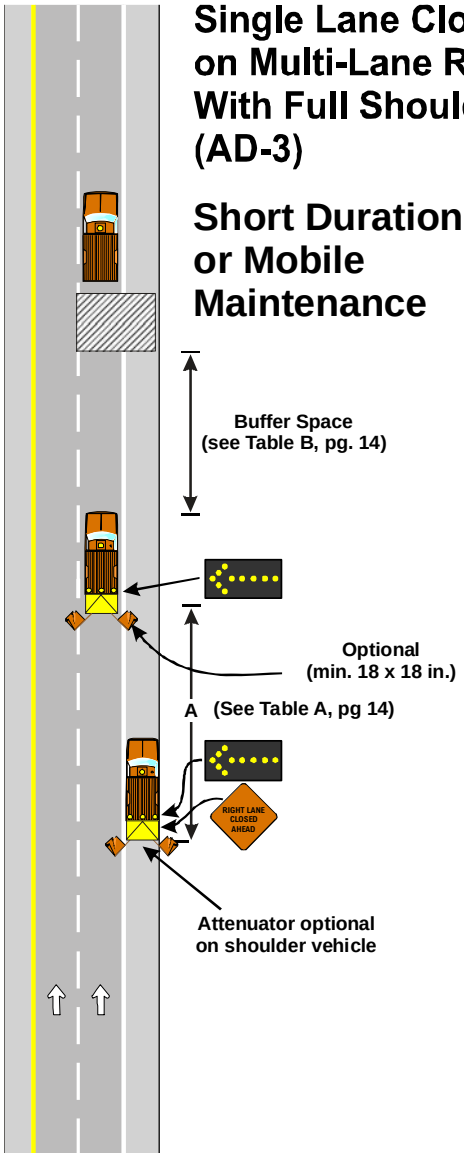
Short Duration or Mobile Maintenance



Note: Shoulder work with minor encroachment permitted if minimum 10-foot lane width maintained.

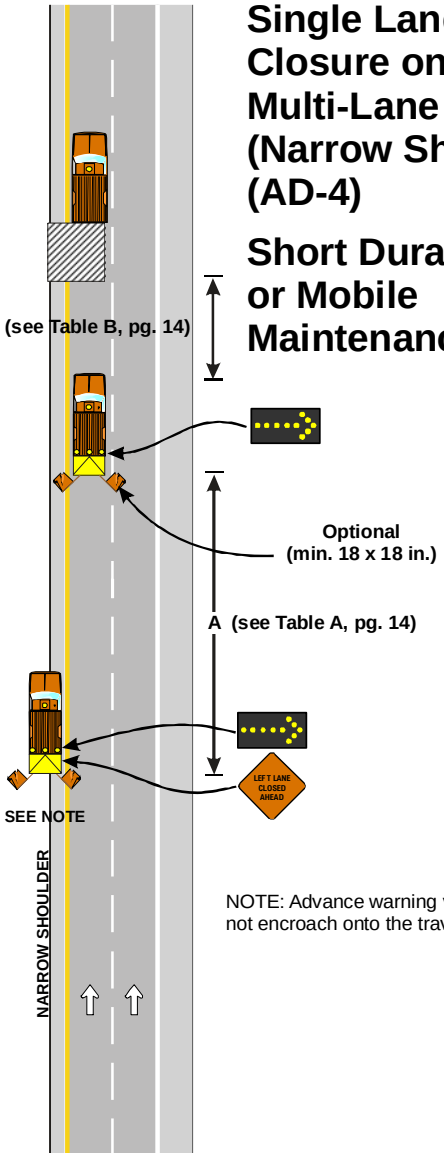
Single Lane Closure on Multi-Lane Road With Full Shoulder (AD-3)

Short Duration or Mobile Maintenance



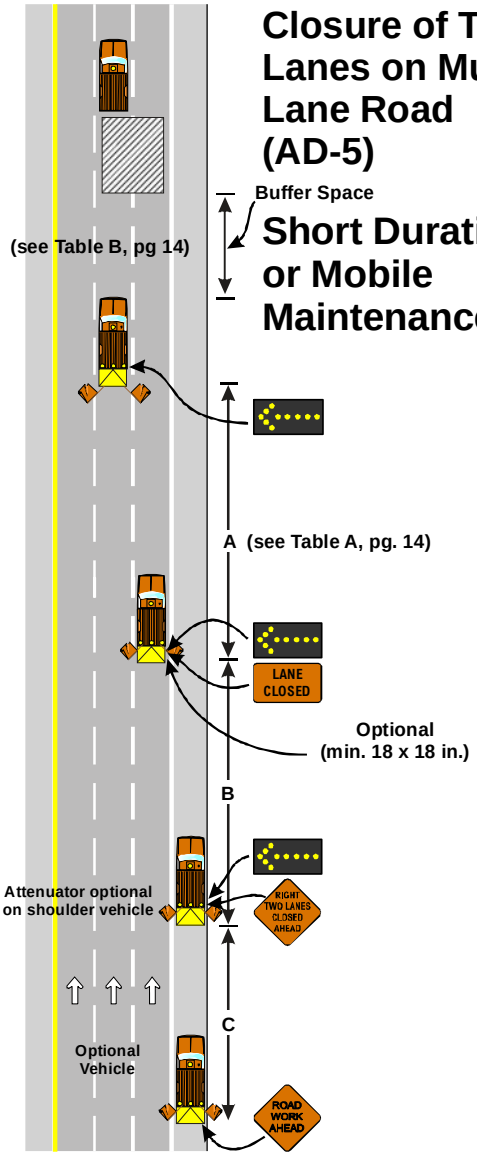
Single Lane Closure on Multi-Lane Road (Narrow Shoulder) (AD-4)

Short Duration or Mobile Maintenance

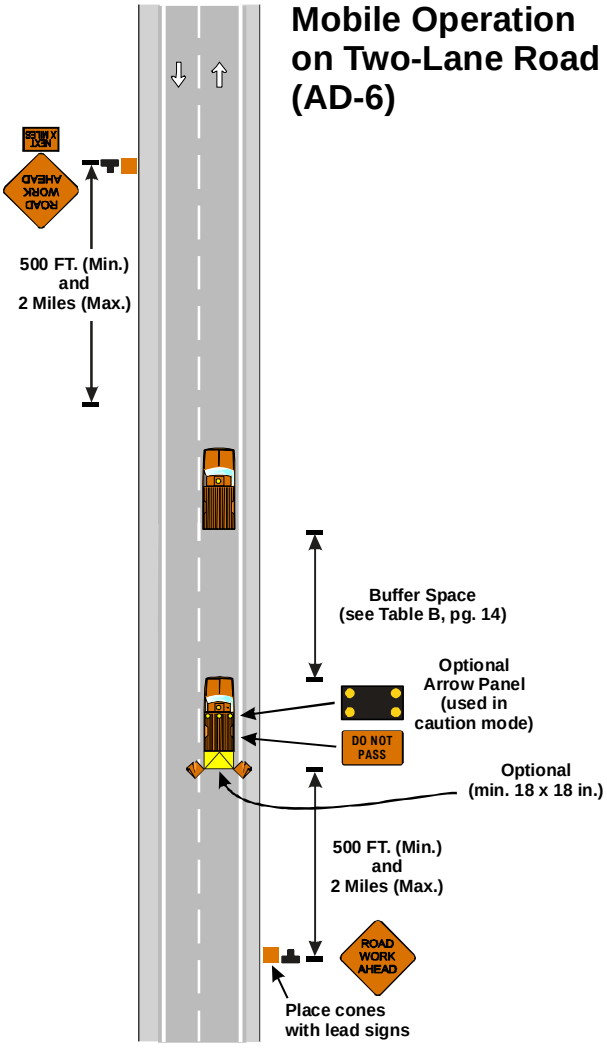


NOTE: Advance warning vehicle shall not encroach onto the travel lane.

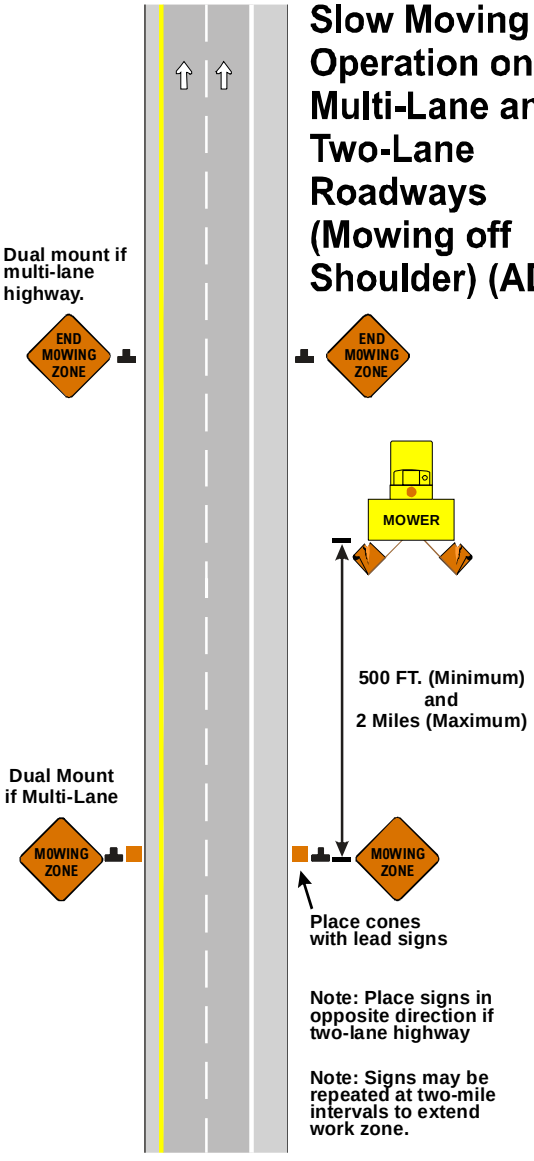
Closure of Two Lanes on Multi-Lane Road (AD-5)



Mobile Operation on Two-Lane Road (AD-6)



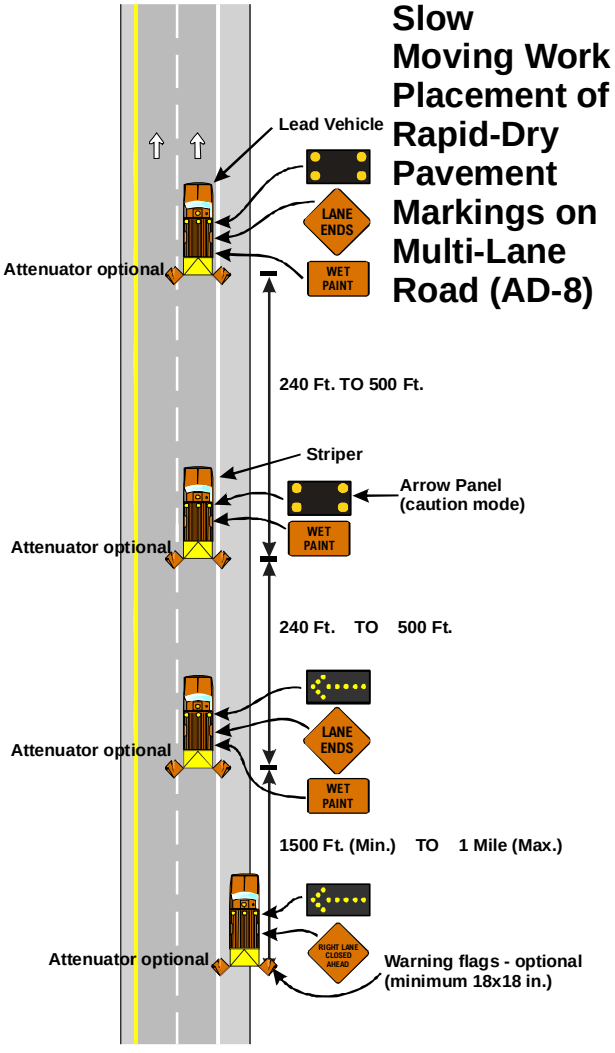
Slow Moving Operation on Multi-Lane and Two-Lane Roadways (Mowing off Shoulder) (AD-7)



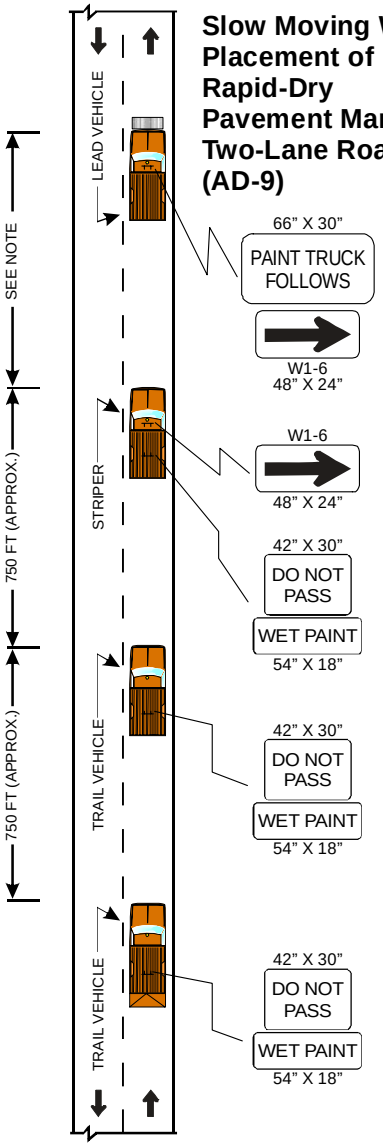
Note: Place signs in opposite direction if two-lane highway

Note: Signs may be repeated at two-mile intervals to extend work zone.

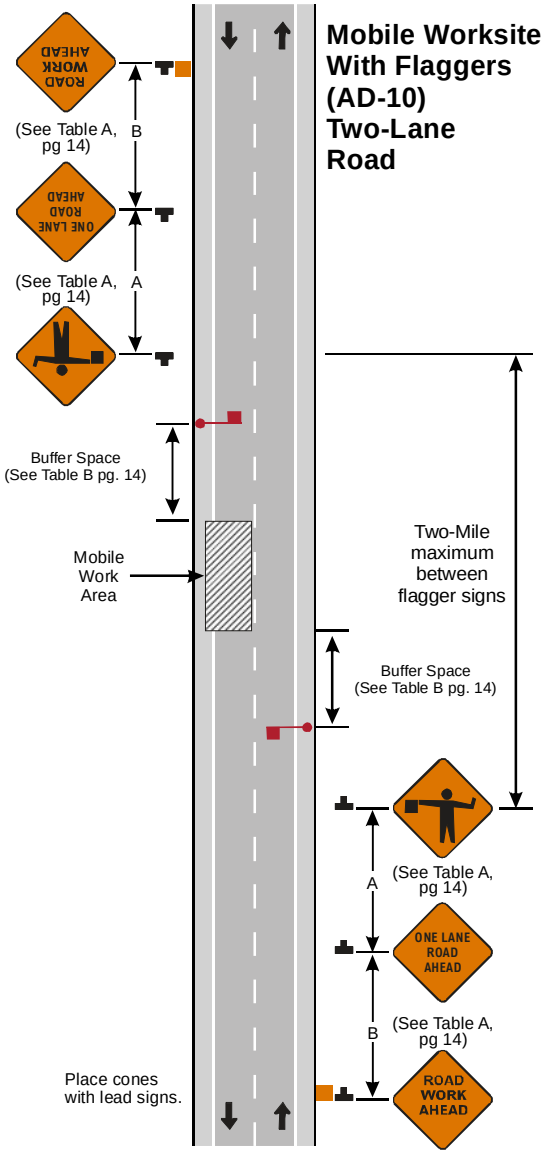
Slow Moving Work Placement of Rapid-Dry Pavement Markings on Multi-Lane Road (AD-8)



Slow Moving Work Placement of Rapid-Dry Pavement Markings Two-Lane Road (AD-9)



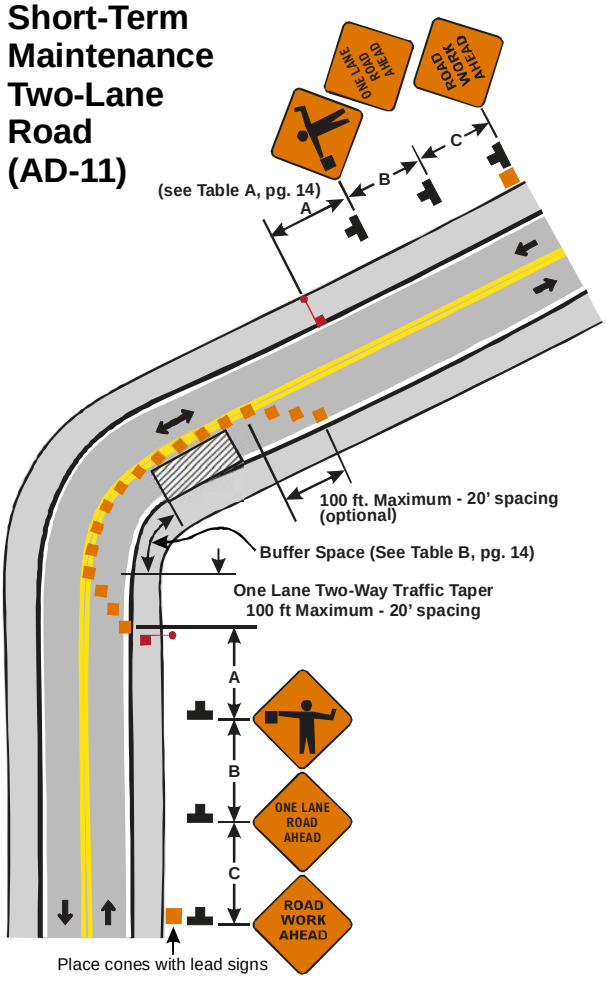
Note: The lead vehicle shall maintain visual contact with the striper whenever possible. The striping train shall be required to pull off the roadway periodically to alleviate traffic congestion.



Mobile Worksite With Flaggers (AD-10) Two-Lane Road

SUPPLEMENTAL DIAGRAM

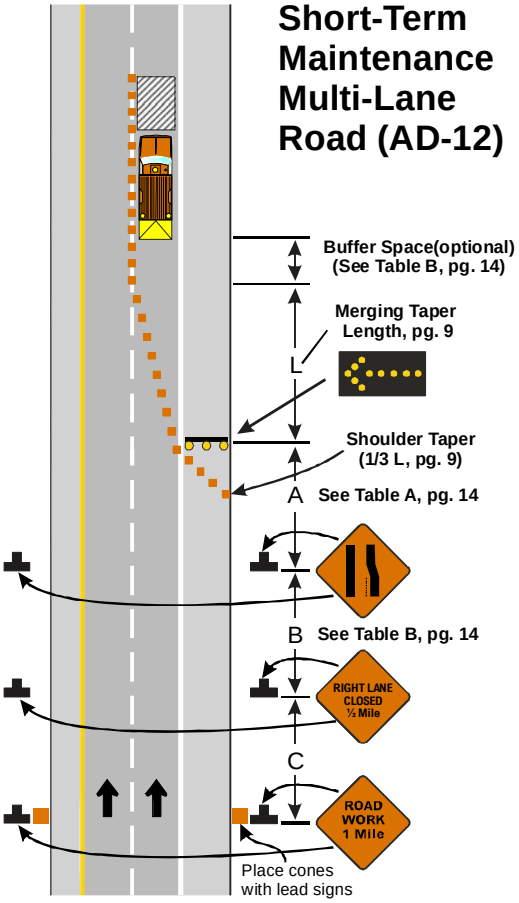
Short-Term Maintenance Two-Lane Road (AD-11)



Note: Cones in activity area should be spaced at 40' intervals.

SUPPLEMENTAL DIAGRAM

Short-Term Maintenance Multi-Lane Road (AD-12)



If a backup is anticipated to exceed 1 Mile advance signs up to 5 miles shall be used. (Variable Message Sign optional in place of signs or in addition).

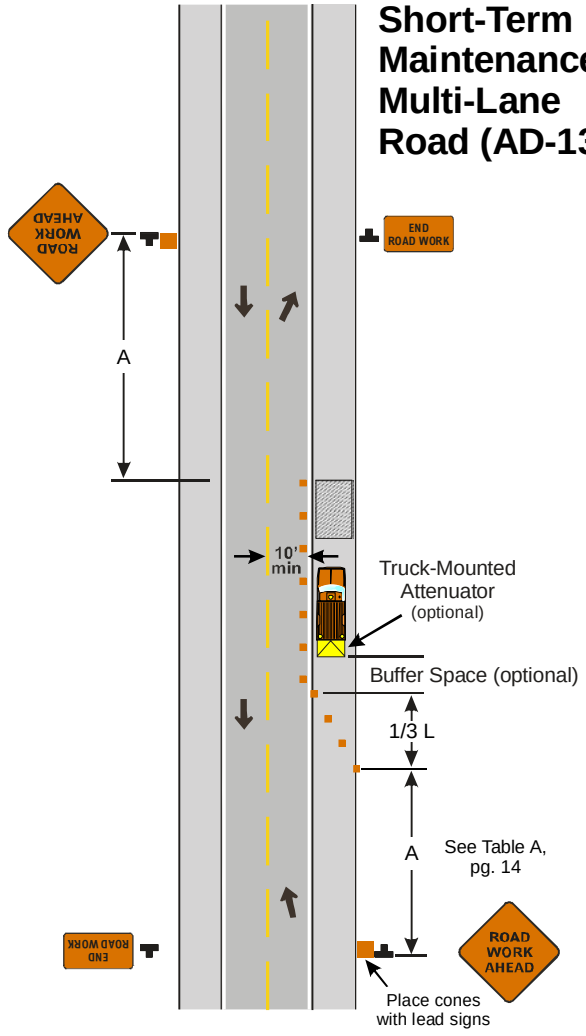
All vehicles, equipment, workers, and their activities should be restricted to one side of the pavement.

Cones spaced (in feet) equal to speed limit for shoulder and merging taper and two times speed limit for activity area.

Note: Cones in activity area should be spaced at 40' intervals.

SUPPLEMENTAL DIAGRAM

Short-Term Maintenance Multi-Lane Road (AD-13)



Note: Cones in activity area should be spaced at 40' intervals.

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