Application Guideline No.
6 - G2

Subject: Use of Pull-off Areas in Work Zones ***Page: 1 of 13***

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Brief Description:

Guidance for the use and placement of pull-off area in work zones.

Attachment(s):

Use of Pull-off Areas in Work Zones

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Maryland Department of Transportation
State Highway Administration

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USE OF PULL-OFF AREAS IN WORK ZONES

September 2009

A. INTRODUCTION

Work zone pull-off areas may be included in work zones along expressways and freeways where one or both shoulders are closed due to construction activities. The pull-off areas may serve one or more of three primary functions:

1. **Vehicle refuge.** Motorists who experience mechanical problems, flat tires, distractions from children or other passengers, etc. may not be able to travel completely through the work zone before their situation becomes a safety hazard. Appropriately designed pull-off areas can increase the likelihood of a driver reaching a safe area without potential involvement in an incident.
2. **Law enforcement.** Law enforcement near the upstream end of a work zone can have a significant effect toward promoting safer driver behavior. However, the effect may be diminished if aggressive drivers perceive that the law enforcement officer will not engage in pursuit. By providing pull-off areas, law enforcement officers can pursue aggressive drivers and have a safe area within the work zone in which to issue citations.
3. **Crash clearing and/or investigation.** When crashes occur within the work zone, vehicles need to be cleared to the shoulder quickly in order to minimize the amount of upstream traffic congestion. Pull-off areas can provide locations where a greater proportion of motorists may feel comfortable moving their vehicles after a minor incident. Additionally, a pull-off area may provide emergency response vehicles with adequate space to aid victims after a crash without taking up an additional traffic lane.

B. OBJECTIVES

- Improve safety for both motorists and workers by reducing the occurrence and severity of certain types of work zone crashes.
- Reduce the extent and duration of traffic congestion related to crashes that occur in work zones.

C. LITERATURE REVIEW SUMMARY

C.1. ADVANTAGES

- Short pull-off areas allow for some motorists experiencing problems to get off the roadway with minimal lane blockage.
- Longer pull-off areas may provide additional space for acceleration and deceleration for disabled and responder vehicles.
- Longer pull-off areas provide area within the work zone for law enforcement officers to apprehend non-compliant motorists.
- Longer pull-off areas provide space for both law enforcement officers and incident management personnel to respond to a minor crash that has been moved out of the travel lanes.
- Frequently-spaced pull-off areas increase the likelihood that they will be used for both vehicle refuge and crash investigation purposes. After a minor crash, motorists whose vehicles are still operable are less likely to move their vehicles out of the travel lanes to an obscure location. Many motorists are more secure exchanging information with a stranger when the incident occurs near the main road visible to passing traffic, rather than an isolated location.
- The presence of a law enforcement officer has been demonstrated to be one of the most effective means of lowering speeds in the vicinity of a work zone. Reduced speed differentials between vehicles correlate with reduced crash frequency and severity.

C.2. DISADVANTAGES

- Pull-off areas may have an impact to the project schedule, particularly where grading work is involved in the area where the pull-offs are to be located. The contractor may have to reserve space for the pull-off area that would otherwise be used for construction. To maintain a pull-off area for the entire duration of the project, an additional pull-off area must be provided in another location when the initial pull-off area is under construction.

- Providing a smooth transition between temporary traffic lanes on existing grade and a pull-off area on proposed grade (or vice versa) can be problematic for projects where the proposed profile of the roadway differs significantly from the existing profile for long segments. Temporary asphalt may need to be installed and later removed to facilitate transitions over such elevation differences.
- Where temporary concrete barrier separates the work area from traffic, there is an added cost associated with relocating barrier to provide pull-off areas in multiple locations along the work zone for different phases, as described above.
- Short pull-off areas will require motorists who use them to perform most of their acceleration and deceleration maneuvers in the adjacent travel lane. This increases the risk of rear-end and other crashes associated with lane changing to avoid the slowing vehicles.
- Longer pull-off areas can be restrictive because of the requirement to provide adequate sight distance along their entire length.
- To be effective for enforcement, additional time, planning, and cost are required for coordination between the contractor, engineer, and law enforcement personnel.
- It is more costly to realize the full benefit of law enforcement in conjunction with pull-off areas, since two law enforcement officers may be required – one to maintain presence upstream of the work zone for visibility and another to pursue non-compliant motorists and issue citations. For motorists' safety, law enforcement presence is primarily needed at the beginning of a work zone where a shoulder or lane closure first occurs, since that is where lane changing is more likely to occur and where the highest crash rates tend to be. However, for workers' safety it may be desirable to have law enforcement presence more often in the vicinity of the workers.

C.3 OTHER RELEVANT ISSUES

- In lieu of or to enhance the effectiveness of pull-off areas, it may be desirable to coordinate with the freeway service patrol, if available, and/or have the contractor provide or contract with a towing service to handle breakdowns and move crash investigation functions to an off-site location away from the work area. These off-site locations should be in well-lit, public spaces frequented by people during the hours when the service will be available. Such measures have the added benefit of reducing "rubbernecking" congestion by moving crashes completely away from the main highway.

- On some projects, it may be necessary after other options have been investigated to combine pull-off areas with construction vehicle access points. However, such combined pull-off access points can create conflicts between construction vehicles and regular traffic and should be avoided if possible.

D. DEPLOYMENT GUIDELINES

When to Use Pull-Off Areas:

Pull-off areas should be considered where any of the following conditions exist:

- Both the left and right shoulders will be closed simultaneously for a distance greater than 0.5 mile.
- On divided highways with three or more lanes in each direction, the left or right shoulder is to be open while the opposite shoulder is to be closed.
- Speeding is expected to be or has been shown to be a problem.
- The duration of construction will be significant.
- High crash locations have been identified within or near the work zone limits.
- Projects have been identified as "significant projects," as defined by the "Maryland State Highway Administration Guidance on Identifying Significant Projects".
- Traffic volumes are such that, during peak hours, a blockage of a through lane by a disabled vehicle due to the lack of a pull-off area would create an unacceptable level of congestion.
- Alternate places of refuge do not exist nearby.

Spacing of Pull-Off Areas

Pull-off area spacing of about 0.5 mile is desirable. Spacing of 1.0 mile is acceptable, and spacing of 2 miles should be considered the maximum acceptable.

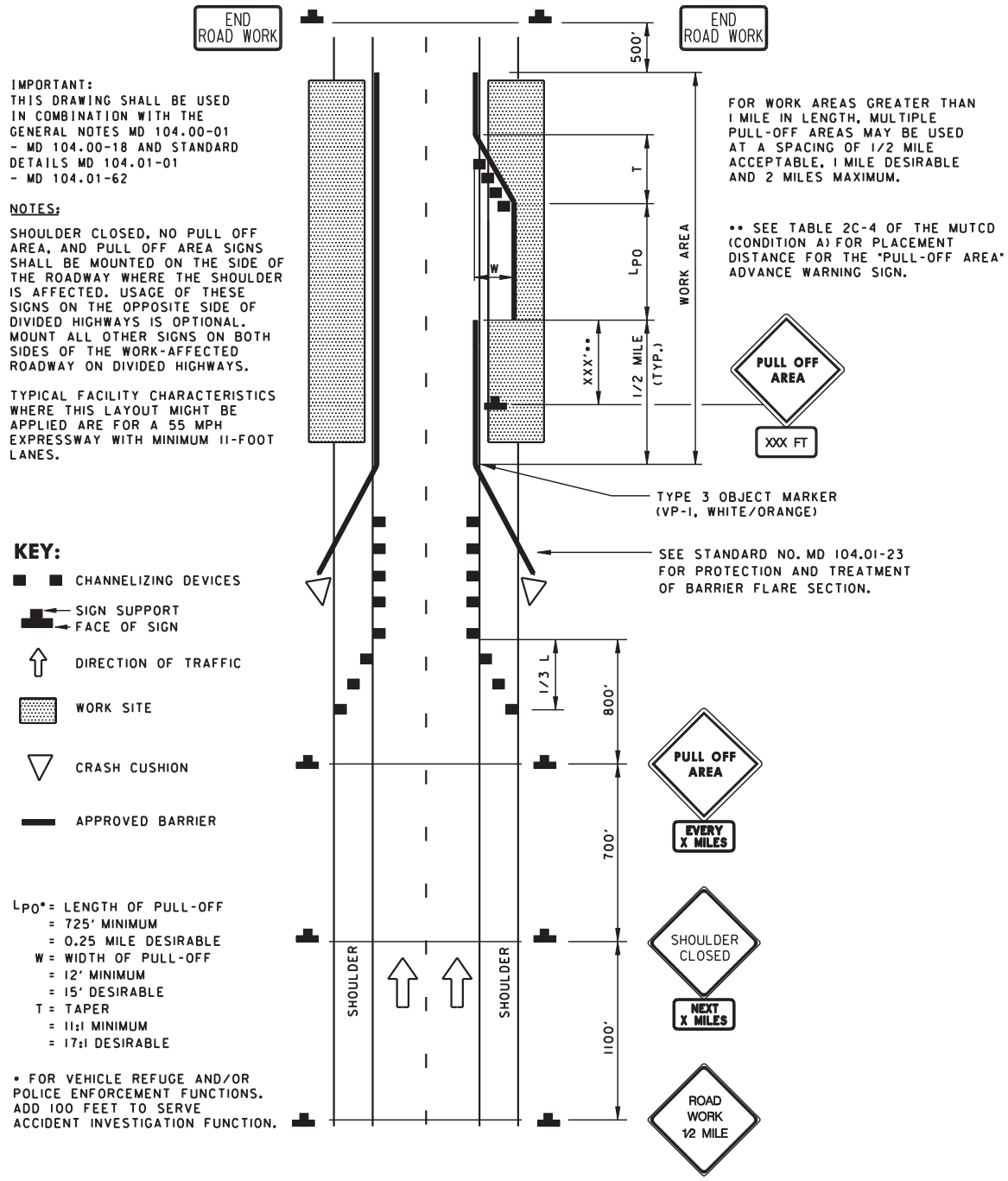
Dimensions of Pull-Off Areas

- As illustrated in Figure 1, pull-off areas should be a minimum of 725 feet long, with 0.25 mile length desirable. An additional 100 ft. should be added to these lengths when the pull-off area is intended to serve a crash investigation function. The width of pull-off areas should be at least 12-15 feet.

Implementation Notes:

- Buffer and shoulder taper distances should be included in the length of the shoulder closure when making measurements for the purposes of applying pull-off areas. Likewise, any other area where the shoulder is not completely open for vehicles should be included in the measured length of shoulder closure.
- Where pull-off areas are intended to enhance the role of law enforcement, coordination with law enforcement personnel should begin early in the project implementation schedule.
  To assess capacity concerns, consider performing lane closure analysis with a slightly modified procedure from that typically used for many work zones. Allowable lane closure schedules may be designed using lane closure analysis in the Lane Closure Analysis Program (LCAP or LCAP Pro) software packages, (see http://attap.umd.edu/lcap/). To determine whether pull-off areas would be warranted for reducing congestion in the event of an incident when the shoulder is closed:

    1. An incident where a vehicle blocks an open lane because no pull-off area is provided should be analyzed as a short-term lane closure.
    2. LCAP limits the duration of lane closures to one hour intervals. Perform an LCAP lane closure analysis with a one-hour duration of lane closure during the peak hour traffic.
    3. Divide the resulting queue length by two to obtain an estimate of the resulting queue length for a 30-minute incident or by four to obtain an estimate for a 15-minute incident, etc.



IMPORTANT:
THIS DRAWING SHALL BE USED IN COMBINATION WITH THE GENERAL NOTES MD 104.00-01 - MD 104.00-18 AND STANDARD DETAILS MD 104.01-01 - MD 104.01-62

NOTES:

SHOULDER CLOSED, NO PULL OFF AREA, AND PULL OFF AREA SIGNS SHALL BE MOUNTED ON THE SIDE OF THE ROADWAY WHERE THE SHOULDER IS AFFECTED. USAGE OF THESE SIGNS ON THE OPPOSITE SIDE OF DIVIDED HIGHWAYS IS OPTIONAL. MOUNT ALL OTHER SIGNS ON BOTH SIDES OF THE WORK-AFFECTED ROADWAY ON DIVIDED HIGHWAYS.

TYPICAL FACILITY CHARACTERISTICS WHERE THIS LAYOUT MIGHT BE APPLIED ARE FOR A 55 MPH EXPRESSWAY WITH MINIMUM 11-FOOT LANES.

FOR WORK AREAS GREATER THAN 1 MILE IN LENGTH, MULTIPLE PULL-OFF AREAS MAY BE USED AT A SPACING OF 1/2 MILE ACCEPTABLE, 1 MILE DESIRABLE AND 2 MILES MAXIMUM.

•• SEE TABLE 2C-4 OF THE MUTCD (CONDITION A) FOR PLACEMENT DISTANCE FOR THE "PULL-OFF AREA" ADVANCE WARNING SIGN.

KEY:

- CHANNELIZING DEVICES
- SIGN SUPPORT / FACE OF SIGN
- DIRECTION OF TRAFFIC
- WORK SITE
- CRASH CUSHION
- APPROVED BARRIER

L_{PO}* = LENGTH OF PULL-OFF
= 725' MINIMUM
= 0.25 MILE DESIRABLE
W = WIDTH OF PULL-OFF
= 12' MINIMUM
= 15' DESIRABLE
T = TAPER
= 11:1 MINIMUM
= 17:1 DESIRABLE

* FOR VEHICLE REFUGE AND/OR POLICE ENFORCEMENT FUNCTIONS, ADD 100 FEET TO SERVE ACCIDENT INVESTIGATION FUNCTION.

SPECIFICATION	CATEGORY CODE ITEMS

APPROVED _____
DIRECTOR – OFFICE OF TRAFFIC AND SAFETY

Maryland Department of Transportation
STATE HIGHWAY ADMINISTRATION
OFFICE OF TRAFFIC & SAFETY

Typical Application of A Pull-Off Area: Dimensions, Spacing and Signing

4. If the resulting queue length is unacceptable, consider the traffic volumes to be significant enough to warrant consideration of pull-off areas. (Other factors like the duration of construction should still affect the ultimate decision on whether to provide pull-off areas).
5. Alternatively, consider using microscopic traffic simulation to model a simple case of an incident without pull-off areas to determine the congestion that would occur.

- An example of a situation with alternate places of refuge would be on highways where maintained driveways for businesses or other public spaces with adequate parking exist. In such locations, pull-off areas may not be necessary.
- On divided highways with three or more lanes in each direction, it may be difficult for motorists to make multiple lane changes to reach an open shoulder in the event of an incident. Relevant factors include:
  - the number of lanes on the highway or freeway in question
  - the length of the work zone
  - availability of shoulders
  - Average Daily Traffic (ADT)
  - the level of congestion expected on the roadway during construction

  For instance, on a four-lane divided highway with two lanes in each direction and low traffic volumes where the right shoulder is to be closed, it may be acceptable to assume traffic will use the open full-width left shoulder instead of providing pull-off areas. However, on a six-lane facility with an available left shoulder, it may be desirable to provide pull-off areas on the right because of the increased distance it would take for a driver to change lanes from the right lane to the left shoulder.
- Pull-off areas should not be located where adequate sight distance for acceleration and deceleration maneuvers would not exist, such as in proximity to horizontal or vertical crest curves. The location of temporary traffic barrier and construction activities occurring on the inside of horizontal curves just behind that barrier should be considered when determining whether motorists will have adequate sight distance through a horizontal curve.
- Any pull-off areas provided, regardless of frequency, will provide a greater benefit than no pull-off areas at all.

- The dimensions in Figure 1 show minimum and desirable dimensions for typical pull-off areas. The pull-off area lengths in these figures are based on the assumptions found in Appendix A. Different assumptions could be used based on project-specific information, if available, to accommodate their intended functions of vehicle refuge, law enforcement, and/or crash investigation. Relevant factors include:
    - the percentage of heavy vehicles using the highway;
    - roadway grades and alignment; and
    - acceleration and deceleration characteristics of the vehicles that are expected to use the pull-off areas
- To minimize conflicts with adjacent construction work, pull-off areas should be avoided on grades steeper than 2% if possible. Where level areas are not available in locations that meet all other criteria, adjust the minimum and desirable lengths of Figure 1 as per the instructions in Appendix A.

Signing for Pull-Off Areas

Figure 1, which combines elements of MD 104.00.07, MD 104.06-14, and the guidelines presented herein, also provides details on signing that should be considered in conjunction with pull-off areas. Some relevant notes about pull-off area signing include:

- From MD 104.00.07, "For shoulder closures greater than a half (1/2) mile in length, advance warning signs should be placed as follows:
    a. A NEXT XX MILES supplemental plate should be provided with the first SHOULDER CLOSED sign in the sequence
    b. The second SHOULDER CLOSED sign in the sequence should be replaced with either:
        - A NO PULL OFF AREA warning sign with NEXT XX MILES supplemental plate, if there are no pull off areas throughout the work area, or
        - A PULL OFF AREA warning sign with EVERY XX MILES supplemental plate, if pull off areas are provided (see MD 104.06-14)."

    (The NO PULL OFF AREA warning sign is not included in Figure 1 as it would be inconsistent with the pull-off area shown).

- Consideration should be given to whether there is adequate guide signing already in place for nearby intersections or interchanges to facilities that would provide adequate places for refuge. For instance, a pull-off area may not be needed within 0.5 mile of a freeway interchange exit if the exit is clearly signed and "PULL OFF AREA/NEXT EXIT" signing is provided. Depending on the interchange configuration, it may be desirable to sign a pull-off location on the cross street or highway and provide temporary guide signing on that facility to help a motorist return to the original roadway.
- Additional advance warning signs should be placed immediately prior to the pull-off area to give information to help a driver navigate to it safely. Additional options for the supplemental sign panel below "PULL OFF AREA" that could be considered for these locations include a distance message appropriate for the design speed of the roadway (for example "500 FT" or "1000 FT"), "NEXT EXIT", "EXIT XX", "NEXT LEFT" or "NEXT RIGHT".
- Table 2C-4 of the MdMUTCD 2006 Edition (Condition A) should be used for placement of the "PULL OFF AREA" advance warning signs with distance messages.

Disclaimer

The information provided in this section of the Maryland State Highway Administration's Work Zone Safety Tool Box is only to provide guidance. The Work Zone Safety Tool Box supplements current practices and standards provided in the current edition of the following documents:

1) The Manual on Uniform Traffic Control Devices (MUTCD)
2) The Maryland Manual on Uniform Traffic Control Devices (MdMUTCD)
3) Maryland State Highway Administration Standard Sign Book
4) Maryland State Highway Administration Book of Standards for Highway and Incidental Structures
5) Maryland Department of Transportation State Highway Administration Standard Specifications for Construction and Materials

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Appendix A: Assumptions for Calculating Pull-Off Area Lengths

- For Vehicle Refuge Only, minimum design assumptions include:
  - Storage for a single passenger car
  - Assume 50 MPH entry speed into pull-off area
  - No need for perception-reaction time – a driver about to use a pull-off area is looking out for it and does not need the perception-reaction distance incorporated into normal stopping sight distance.
  - Fast deceleration –Assume deceleration rate of 14.8 ft/s^2 as per AASHTO's "A Policy on Geometric Design of Highways and Streets", 2004 Edition (AASHTO), page 111.
  - Braking distance = 1.075 (V^2 / a) = 1.075 (50^2 / 14.8) = 182 feet
  - Assume length of vehicle = 19 feet (as per AASHTO Exhibit 2-3, page 21)
  - For acceleration, assume that the motorist will wait for larger gaps so that speed of only 40 MPH is needed before entering the travel lane. Also, assume acceleration length = 425 feet (for 0 to 40 MPH for passenger cars on level grade from AASHTO Exhibit 2-24, page 44)
  - Assume additional 100 feet for lane change maneuver / margin of safety
  - Length of pull-off area = 182 + 19 + 425 + 100 = 726 ft (Use 725 ft for design purposes)
- For Vehicle Refuge Only, desirable design assumptions include:
  - Storage for a single WB-50 Intermediate Semitrailer truck
  - Assume 60 MPH entry speed into pull-off area
  - No need for perception-reaction time, as above
  - Normal deceleration – Assume deceleration rate of 90th percentile (passenger car) deceleration rate of 11.2 ft/s^2 as per AASHTO's "A Policy on Geometric Design of Highways and Streets", 2004 Edition (AASHTO), page 111.
  - Braking distance = 1.075 (V^2 / a) = 1.075 (60^2 / 11.2) =346 feet
  - Assume length of vehicle = 55 feet (as per AASHTO Exhibit 2-14, page 32)

- For acceleration, assume driver desires a speed of 50 MPH before entering the travel lane - assume acceleration length = 720 feet (for 0 to 50 MPH for design of freeway entrance terminals on grades of 2% or less from AASHTO Exhibit 10-70)
- Assume additional 200 feet for lane change maneuver / margin of safety
- Length of pull-off area = 346 + 55 + 720 + 200 = 1,321 ft (Use 1,320 feet = 0.25 mile for design purposes)

- For law enforcement activities, assume that reduced speeds associated with law enforcement vehicle sirens and flashers on would compensate for the slightly longer storage length required such that 725 ft minimum length and 1,320 ft desirable length would still apply.
- For the Crash Investigation function, assume that two disabled vehicles at 20 ft each, a tow truck at 30 ft, and a law enforcement vehicle at 20 ft would need to be stored in the pull-off area, with 10 ft gaps between vehicles. Add (10 + 20 + 10 + 30 + 10 + 20 = 100 ft) to the above minimum and desirable values. Use 825 ft for the minimum and 1420 ft for the desirable lengths.
- To minimize conflicts with adjacent construction work, pull-off areas should be avoided on grades steeper than 2% if possible. Where level areas are not available in locations that meet all other criteria, adjust the minimum and desirable lengths of Figure 1 as per AASHTO Equation 3-3 and Exhibit 10-71.