NOTICE OF APPLICABLE USE:

This document contains *Indiana Design Manual* Chapters 81, 82, and 83 prior to the publication of IDM Chapter 503 (Design Memo 19-12). The chapters in this document should be used for projects with a Stage 1 submittal before October 11, 2019, except as follows.

Design guidance for work zone design elements for pedestrian accessibility, positive protection, and temporary traffic control devices should be used for projects with a Stage 2 design submittal on or after November 1, 2019. Chapter references are below.

Subject	Existing Chapter Stage 2 before Nov. 1	New Chapter Stage 2 after Nov. 1
Work zone design elements for pedestrian accessibility	82-2.04(05)	503-3.04(13)
Positive Protection	82-4.0 - Roadside Safety	503-3.05
Temporary Traffic Control Devices	Chapter 83 - Traffic Control Devices in a Work Zone	503-7.0

INDIANA DEPARTMENT OF TRANSPORTATION

Driving Indiana's Economic Growth

Design Memorandum No. 19-12
Technical Advisory

October 10, 2019

TO:	**All Design, Operations, and District Personnel, and Consultants**
FROM:	***/s/ David H. Boruff*** **David H. Boruff** **Office of Traffic Administration Manager** **Traffic Engineering Division**
SUBJECT:	***Indiana Design Manual*** **Rewrite, Chapter 503**
REVISES:	***Indiana Design Manual*** **Chapters 81, 82, and 83**
SUPERSEDES:	**Design Memos 16-06 and 18-10**
EFFECTIVE:	**Stage 2 submittal on or after November 1, 2019 for the following sections** • **503-3.04(13) Pedestrian Accessibility** • **503-3.05 Positive Protection** • **503-7.0 Temporary Traffic Control Devices** **Stage 1 submittal on or after October 11, 2019 for all other sections**

Indiana Design Manual Chapter 81, Transportation Management Plans, Chapter 82, Traffic Control Plan Design, and Chapter 83, Traffic Control Devices in a Construction Zone, have been updated. These chapters are now combined into a single chapter, Chapter 503, Maintenance of Traffic and are available for download at

http://www.in.gov/indot/design_manual/design_manual_2013.htm

Where a project is beyond the plan develop stage effective date, designers are encouraged to use the revised guidance where practical.

A brief summary of the significant changes in the new chapter is included below.

- 503-2.02 Work Zone for Significant and Non-Significant Projects. Criteria for determining whether a project is defined as having significant impacts during construction to motorists has been added. New content has been created regarding requirements for the traffic management plans for projects with significant work zone impacts.

- 503-2.05 Traffic Control Strategies. A hierarchy of traffic control strategies has been established that prioritizes separating workers from traffic. Emphasis is placed on closing the road and detouring traffic where a viable detour route is available. If not then the MOT plan should be based on a crossover or runaround. If a crossover or runaround is not viable then traffic will be maintained adjacent to the work area.

- 503-3.04(13) Pedestrian Accessibility. New design guidance has been added for maintaining pedestrian access during construction.

- 503-3.05(02) Positive Protection Devices. The construction clear zone distances have been increased based on the AASHTO *Roadside Design Guide*. Guidance has been added on when positive protection should be considered for worker and motorist's safety.

- 503-7.01(02) Regulatory Signing. New guidance has been added on selecting the proper pay item for continuous use worksite speed limit sign assemblies. These are to be paid for as construction signs per the *Standard Specifications*.

- 503-7.04 Temporary Traffic Control Signals. The default method of vehicle detection for portable signals will now be microwave or Doppler vehicle detection, as this is the most common method of vehicle detection used with portable signals in work zones. The microwave or Doppler vehicle detection units are mounted to the portable signals so there is no need to show the vehicle detection area on the temporary traffic control plans.

Questions regarding project-specific maintenance of traffic design issues should be discussed with the appropriate district Traffic Engineer. General questions should be directed to Dave Boruff, Office of Traffic Administration Manager at dboruff@indot.in.gov.

DHB/jeb

CHAPTER 503

Maintenance of Traffic (Previous Version)

Design Memorandum	Revision Date	Sections Affected
13-01	Jan. 2013	Figure 82-6B, Figure 82-6C
13-03	Feb. 2013	82-6.03
16-06	Mar. 2016	Section 83-5.0, Figure 83-5A
18-10	May 2018	83-4.01(03), 83-4.02
19-12	Oct. 2019	Ch. 81-83 superseded by Ch. 503. See Notice on page 1.

CHAPTER 81

Transportation Management Plans

NOTE: This chapter is currently being re-written and its content will be included in Chapter 503 in the future.

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CHAPTER 81

TRANSPORTATION MANAGEMENT PLANS

81-1.0 GENERAL

81-1.01 Purpose

A transportation management plan (TMP) is an overall strategy for accommodating traffic during construction. The TMP not only must address the alternatives confined to the project site, but it must also evaluate the impact traffic will have on the entire corridor. The TMP will address the proposed traffic-control plan, alternative traffic control applications, the effect traffic will have on other facilities, local concerns, cost effectiveness of various alternatives, etc. For a large project, a TMP team may be organized during the preliminary-engineering stage to study the traffic-control alternatives and their effect on the corridor.

The TMP includes the traffic-control plan (TCP). The major difference between a TMP and a TCP is that the TCP focuses on the maintenance and protection of traffic within the construction zone, and the TMP addresses project-related impacts throughout the project corridor and sometimes beyond. The designer will be responsible for incorporating the TMP objectives into the TCP. Changes made during the preparation of the TCP will affect the overall TMP. For example, a lane closure which causes a large queue on a freeway may cause traffic to divert to a nearby urban arterial. This may require signal coordination, lane widening, turn restrictions, etc., on the arterial to improve its capacity. Chapter 82 discusses INDOT criteria for a TCP. If the TMP was not developed during the preliminary-engineering stage, it will be the designer's responsibility to ensure that a reasonable transportation-management strategy has been incorporated into the TCP.

81-1.02 Application

A formal transportation-management plan will most often not be required. However, the concepts discussed in this Chapter should be considered for each project. A formal TMP, including a TMP team, may be considered for a project that has one or more of the characteristics as follows:

1. the project scope of work consists of major reconstruction or new construction (e.g., 4R Interstate-route);
2. high traffic volume;

3. is in an urban or suburban area;

4. there may be significant detrimental impacts on mobility for either through or local trips in the corridor;

5. the facility's capacity will be significantly reduced (e.g., lane, ramp, or interchange closure);

6. alternate routing will be necessary (e.g., detour routing for hazardous materials);

7. there will be significant impacts on local communities and businesses (e.g., emergency vehicles, school buses);

8. timing and seasonal impacts may be significant; or

9. there will be significant grade changes.

Where a series of proposed projects are along the same corridor or along corridors of close proximity, a single TMP covering all such projects should be used. If circumstances prohibit a single TMP, the individual TMPs should be coordinated.

81-1.03 TMP Development

81-1.03(01) Procedure

Where a TMP is used, the following procedure applies.

1. TMP Determination. The Environmental Policy Team, with input from the district, the Office of Urban and Corridor Planning, and the Office of Pavement Engineering, will determine if there is a need for a TMP during the scoping process. The Environmental Policy Team will collect the initial data and conduct the initial analyses to determine whether or not a TMP will be required.

2. TMP-Team Selection. Once it has been determined that a TMP is required, the Environmental Policy Team will initially recommend who the TMP team representatives will be, based on the purpose, goals, and constraints of the TMP. Section 81-1.03(02) lists the members for a TMP-team project.

3. TMP-Team Responsibilities. Section 81-1.03(03) discusses the TMP-team responsibilities during the scoping process, project design, and construction. The expected level of traffic impact will dictate the extent and nature of the TMP team's responsibilities.

4. Preliminary Engineering Studies Report. The Office of Environmental Services' Environmental Policy Team will incorporate the TMP recommendations into the Engineer's Report. If improvements are required to other facilities (e.g., widening of detour route), it is important that these improvements be implemented as soon as practical prior to construction of the mainline facility. Local agencies should be provided sufficient opportunity to complete their improvements before construction begins. Agreements may be necessary between the State and local agencies to determine cost sharing arrangements or approval of a local road as an alternate route.

5. Design. During the design phase, it will be the designer's responsibility to implement the recommendations of the TMP team. The designer may be required to collect additional data and conduct additional analyses, as necessary. The TMP team should be consulted if design or TCP decisions dictate a revision to the proposed TMP. During this project stage, representatives from local agencies, businesses, homeowner associations, etc., may be added to the TMP team.

6. Construction. The TMP will be implemented during construction. All significant proposed changes to the TMP by the district or the contractor must be reviewed with the TMP team prior to implementation. For a larger project, the district will appoint a TMP coordinator. A public-relations campaign may be required prior to construction. During construction, the district will be responsible for collecting data on the TMP so that the TMP team can prepare a report on the successes and failures of the TMP. See Item 7 below to determine the applicable data to be collected.

7. Final Report. Upon project completion, the TMP team will prepare a report identifying the successes and failures of the TMP. This report should discuss the following:

    a. an overall statement reflecting the usefulness of the TMP;
    b. where changes were necessary to correct oversights in the TMP;
    c. what changes were made to the original plan and if they were successful;
    d. public reaction to the TMP;
    e. the average delay time encountered (e.g., average queue length, slowdown extent);
    f. identification of the peak loading times;
    g. frequency of legitimate complaints and the nature of the complaints;
    h. types of accidents that occurred during construction;
    i. suggested improvements or changes for similar future projects; and

j. what areas of the TMP were successfully implemented.

81-1.03(02) TMP Team

A well-balanced TMP team is an important ingredient for a successful project. The variety of disciplines represented presents an effective liaison group to meet the various needs of a TMP. Depending on the project logistics, the team composition may vary from project to project. The Office of Environmental Services' Environmental Policy Team will determine the team's composition. The TMP team may include representatives from the entities as follows:

1. Office of Traffic Engineering;
2. Office of Environmental Services, Environment Assessment Team;
3. Production Management Division;
4. district Office of Traffic;
5. district Office of Design;
6. District Construction Team;
7. Traffic Control Review Committee;
8. FHWA;
9. Local government agency;
10. Planning Division;
11. Office of Communications; and
12. others as deemed necessary (e.g., State Police, hospitals, etc.).

81-1.03(03) TMP-Team Responsibilities

The anticipated traffic impacts will dictate the extent and nature of the TMP team's responsibilities. These may include all or part of the functions as follows:

1. collecting data (e.g., traffic counts, accident history, roadway geometrics, proposed developments, operating speeds);

2. conducting analyses (e.g., capacity analyses, traffic impact studies, safety studies, queuing analysis);

3. reviewing design alternates;

4. reviewing traffic-control alternates;

5. reviewing the adequacy of alternate routes (e.g., geometrics, capacity, safety, structural);

6. reviewing on-site and off-site traffic operational improvements (e.g., signal improvements, parking restrictions);

7. reviewing construction phasing and scheduling alternates;

8. determining the cost of various options and improvements;

9. determining which options are the most cost effective;

10. coordinating with local officials and businesses;

11. coordinating funding and timing with other projects within the corridor;

12. coordinating the design with other TMP plans in the region;

13. planning for emergency responses (incident management);

14. planning rideshare and transit strategies;

15. providing recommendations for the Engineer's Report;

16. reviewing design and TMP changes made by the designer to ensure that they satisfy the TMP objectives;

17. reviewing proposed changes made by the contractor or project engineer during construction; and

18. evaluating and preparing a report on the successes and failures of the TMP after construction.

81-1.04 Public-Relations Information

For a TMP to be successful, it often requires public involvement and revision of its traveling habits. The following discusses how the public can become informed and involved in the TMP.

1. Public-Relations Campaign. It is important that the public be informed initially and be kept informed in a timely manner to ensure that the TMP will work. The elements of a public-

relations campaign to be considered where significant impacts to traffic are expected are as follows:

a. information provided to news media;
b. television advertisements;
c. radio advertisements;
d. brochures to be passed out to motorists at key locations;
e. information given to motorists at rest area or welcome centers; or
f. contacting local businesses with large numbers of affected employees or customers.

2. Car and Van Pooling. Car and van pooling campaigns may be considered where it may be expected to reduce the number of vehicles through a work zone and where it appears practical to expect a successful campaign.

3. Charter Bus. A charter bus may be considered where it could be expected to draw a large number of users along a corridor and where it can be shown to be more cost effective than other alternatives.

4. Transit Incentives. Transit incentives provided to transit customers and companies may be considered where it can be shown to be more cost effective than other alternatives.

81-2.0 TRAFFIC-CONTROL MANAGEMENT

81-2.01 Terminology

The following definitions are used to define the time required for construction, maintenance, or utility work.

1. Mobile Work Zone. A work site that is continuously being moved during the period while work is actively in progress.

2. Short-Duration Work Zone. A work site that occupies a location for up to 1 hour.

3. Short-Term Stationary Work Zone. A work site that requires traffic control in the same location and where the activity lasts from 1 to 12 hours.

4. Intermediate-Term Stationary Work Zone. A work site that requires traffic control in the same location and occupies a location from overnight to 3 days.

5. Long-Term Stationary Work Zone. A work site that requires traffic control in the same location and where the activity lasts longer than 3 days.

81-2.02 Work-Zone Type

The work zone types that may be considered in a TMP are described below. A work site which is completely off the roadway and does not disrupt traffic is not addressed, as it will not have a major effect on traffic.

1. Lane Constriction. This work-zone type is configured by reducing the width of one or more lanes to retain the number of lanes normally available to traffic. An example of lane constriction is shown in Figure 81-2A. This application is the least disruptive work-zone type, but it is only appropriate if the work area is mostly outside the normal traffic lanes. Narrow lane widths may reduce the facility's capacity, especially where there is significant truck traffic. The use of a shoulder as part of the lane width will help reduce the amount of lane-width reduction that may be required. Where this application is applied for a long-term work zone, the current lane markings must be obliterated to avoid motorist confusion. Section 82-3.02 discusses the minimum lane width that must be provided.

2. Lane Closure. This work-zone type closes one or more normal traffic lanes. A lane-closure example is shown in Figure 81-2B. Capacity and delay analyses may be required to determine whether serious congestion will result from a lane closure. Use of the shoulder or median area as a temporary lane will help mitigate the problems arising from the loss in capacity. Upgrading or replacement of existing pavement or placement of temporary pavement may be necessary.

3. One-Lane, Two-Way Operation. This work-zone type involves utilizing one lane for both directions of traffic. Figure 81-2C illustrates a one-lane, two-way operation work zone. Flaggers or signals are used to coordinate the two directions of traffic. Signing alone may be sufficient for a short-term work zone on a very low-volume, 2-lane road. This work-zone type is applicable only for a low-volume road or for a short-term. INDOT has developed a computer program, WORK, which determines the expected delays and queue lengths for this work-zone type.

4. Runaround. This work-zone type involves the total closure of the roadway (one or both directions) where work is being performed and the traffic is rerouted to a temporary roadway constructed within the highway right-of-way. A runaround example is shown in Figure 81-2D. This application may require the purchase of temporary right of way and requires extensive preparation of the temporary roadway.

5. Intermittent Closure. This work-zone type involves stopping all traffic in one or both directions for a relatively short period of time to allow the work to proceed. This application is illustrated in Figure 81-2E. After a specific time, depending on traffic volume, the roadway is re-opened and all vehicles can travel through the area. This application is appropriate only on a low-volume roadway or at times of very low volume (e.g., Sunday morning).

6. Use of Shoulder or Median. This work-zone type involves using the shoulder or the median as a temporary traffic lane. Figure 81-2F illustrates an example. To use this technique, it may be necessary to upgrade the shoulder to adequately support the anticipated traffic loads. This technique may be used in combination with other work-zone types or as a separate technique.

7. Crossover. This work-zone type involves routing all or a portion of one direction of the traffic stream across the median to the opposite traffic lanes. This application can also incorporate the use of the shoulder or a lane constriction to maintain the same number of lanes. Examples of crossovers are shown in Figure 81-2G. Section 82-3.0 discusses the geometric design criteria that should be used to develop a crossover. Item 8 below addresses two-way traffic on a divided facility.

8. Two-Way Traffic on Divided Facility. This work-zone type involves transferring traffic from a divided facility to two-way operations on one roadway. This application requires consideration in the planning, design, and construction phases. This application should be used only if one or more conditions can be applied as follows:

   a. an alternate suitable detour is unavailable or is not cost-effective;
   b. the use of temporary lanes or shoulders are impractical;
   c. construction cannot reasonably occur with one lane open;
   d. construction time will be significantly reduced using this option;
   e. all safety issues can be reasonably addressed; or
   f. pavement and shoulder structures can be reasonably upgraded.

   A crossover as discussed in Item 7 above will be required for this application. Section 82-6.02 discusses the design issues relative to designing a two-way application (e.g., maximum length). If this application is used, opposing traffic must be separated with positive barriers, drums, cones, or vertical panels throughout the length of the two-way operation. Section 83-3.0 discusses the channelization devices that may be used with this layout. One construction technique involves the reconstruction of the shoulder to allow it to be used as a travel lane. Once traffic is shifted to a two-way operation, the availability of the shoulder as a third lane provides for an improved buffer between the bidirectional traffic and may facilitate emergency access.

9. Detour. This work-zone type involves total closure of the roadway (one or both directions) where work is being performed and rerouting the traffic to existing alternate facilities. This application is desirable where there is unused capacity on a road running parallel to the closed roadway. In addition to maintaining an official detour, INDOT may be required to repair a county highway being used as an unofficial detour, per current detour policy.

81-2.03 Work-Zone Traffic-Control Strategy

Selection of the appropriate work-zone type represents one of the most significant elements of a control strategy. Other elements of a control strategy that should be considered include length of the work zone, time of work, number of lanes, widths of lanes, traffic speeds, or right of way. Considering these and other factors, reasonable alternatives can be narrowed to a select few for further review. Only a small number of feasible work-zone alternatives will emerge for a particular project and only one may be practical. Identification of these alternates at an early stage in the planning process can significantly reduce the analysis effort necessary.

Figure 81-2H provides guidelines for identifying feasible work-zone alternates based on roadway type, lane closure requirements, shoulder width, traffic volume, availability of right of way, and detour routes. However, every work-zone location will have a wide variation of conditions and an all-inclusive selection matrix is not practical.

In using Figure 81-2H, local policy and regulations should be recognized. Many jurisdictions have adopted safety regulations and public convenience policies as safeguards against the unacceptable impacts of work-zones. These regulations and policies may impose additional constraints regarding the types of control strategies that can be implemented. Knowing these constraints can help eliminate infeasible alternates from consideration. The public convenience policies or local regulations may specify peak hour restrictions, access requirements, noise level limitations, material storage and handling, excavation procedures, work-zone lengths, and number of traffic lanes that must remain open.

81-3.0 TRANSPORTATION-MANAGEMENT-PLAN STRATEGIES

In addition to the traffic-control strategies discussed in Section 81-2.0, the following provides brief summaries of the strategies that may be considered during the development of a TMP. These strategies must be reviewed and adjusted to meet each project location and situation. The strategies discussed below are not all-inclusive, and that other options may be applicable for the location under consideration.

81-3.01 Construction Phasing

How a project is constructed can greatly impact the traffic flow through the work area. The following discusses the basic construction phases for freeway reconstruction.

81-3.01(01) Reconstruction by Halves or Sides

This approach involves the reconstruction of all lanes in one direction while the opposing lanes share the same roadway with traffic in the other direction. This basic concept is illustrated in Figure 81-3A, Reconstruction by Halves or Sides. For a 6-lane facility, traffic is restricted to two lanes in each direction. This may require using the shoulders, reducing the lane widths, or providing minor widening. Under certain circumstances, depending on the median width and shoulder configuration, the inner lane of the two-way operation may not be readily accessible during an emergency. Providing for emergency turnouts or emergency-vehicle access at appropriate intervals on the segment under construction may be considered. Some advantages and disadvantages of this strategy include the following.

1. Advantages.

    a. It provides an effective work area.
    b. Workers are well-separated from the traffic stream.
    c. Work-site access can be arranged with minimal interference from the general traffic flow.

2. Disadvantages.

    a. Crossovers are required.
    b. There is a need for positive separation of the traffic streams.
    c. There are potential emergency access problems in the inner lane.
    d. There may be problems at interchanges with traffic crossing the work zone.

81-3.01(02) Parallel or Adjacent Reconstruction

This approach involves a variety of lane-closure sequences. A typical sequence of this approach is as follows, which is also illustrated in Figure 81-3B, Parallel or Adjacent Reconstruction.

1. The existing shoulders are widened and strengthened.

2. Traffic is shifted to the shoulders to allow construction of the inner lanes and median reconstruction.

3. Traffic is then shifted to the newly-constructed inner lanes to allow reconstruction of the outer lanes.

4. After construction is completed, traffic is returned to the normal travel lanes.

An advantage of this strategy is that traffic need not cross over the median and does not operate in a two-way operation. Some of the disadvantages include the following:

1. it provides a more constrained work area for the contractor;
2. work crews are closer to moving traffic; and
3. access to the construction zone involves entry and exit from the travel lanes.

A 6-lane facility is reduced to 2 lanes in each direction and the above sequence is used. If closing the middle lane, it is preferable to keep the two through lanes on the same side of the construction zone (e.g., by using the shoulder) versus splitting the two lanes on either side of the construction zone.

81-3.01(03) Serial or Segmental Reconstruction

This strategy consists of permitting only short segments of the facility to be under construction at one time. This also requires one or more of the other concepts for traffic accommodation. An example of this application may include a bridge-deck replacement where each segment can be completed within a 12-hour time period. This concept is illustrated in Figure 81-3C, Serial or Segmental Reconstruction.

The advantages of this strategy include relatively short work zones, and few if any interchanges are impacted at one time. A disadvantage of this strategy is that the overall time period that the facility is under construction may be lengthened considerably because the construction for each segment will proceed independently. Therefore, the exposure to the potentially hazardous conditions of a work zone for both the traveling public and the work force may be substantially greater than with one of the other strategies.

81-3.01(04) Complete Closure

Complete closure of the facility or closure of one direction of travel may be an effective strategy. This strategy may also be effective for only certain hours of the day (e.g., 8 p.m. to 6 a.m. on weekdays and from 8 p.m. to 8 a.m. on weekends). Some of the advantages and disadvantages of this strategy include the following.

1. Advantages.

    a. Increases the safety for construction workers.
    b. Provides cost and time savings.
    c. Reduces the overall travel impacts to the public due to reduced construction time.

2. Disadvantages.

    a. Potentially significant short-term travel impacts to the public.
    b. Potential increase in traffic congestion on other routes.
    c. May need to construct a detour or runaround.
    d. Potential adverse impact on businesses due to trip suppression (not enough traffic).
    e. Potential adverse impact to businesses on alternate routes (too much traffic).

81-3.01(05) Combinations

A combination of construction sequences may be the best strategy. An example is reconstructing existing shoulders prior to the initiation of parallel construction activities. The sequence of construction can be as follows.

1. Phase A. Reconstruct shoulders as appropriate to allow one side of the roadway to accommodate four lanes.

2. Phase B. Shift traffic to the four available lanes on one side of the roadway.

3. Phase C. Shift traffic to the newly constructed side of the roadway using the additional reconstructed shoulder lane.

Other combination-type construction sequences involve the reconstruction of interchanges where both sequential and parallel activities may occur simultaneously. Ramps are reconstructed in a sequential arrangement, involving closure during construction with temporary detours to adjacent or alternate freeway-access points.

81-3.02 On-Site Strategies

81-3.02(01) Traffic-Control Devices

The following traffic-control devices applications may be considered when developing a TMP.

1. Changeable-Message Sign. This device may be used where a static sign message is not sufficient to handle the changing conditions of a work zone (e.g., lane closure, ramp closure, advise motorists of conditions for which they must possibly react).

2. Additional-Information Panel Sign. This may be used to give the motorist additional information about a work zone. The message should be pertinent to the likely conditions the motorist will encounter.

3. Traffic-Signals Interconnection. Consider interconnecting traffic signals where the benefit of moving traffic through a work zone more efficiently will be enhanced by adding interconnection between the traffic signals on the system.

4. Traffic-Signal Timing. Traffic-signal timing changes should be considered for all traffic signals within a work zone for which capacity improvements can be gained. Adding or deleting signal phases may be required for changes in travel patterns.

5. Highway-Advisory Radio. Consider using highway-advisory radio where changing work-zone conditions make it important to give the motorist a longer, more accurate message than can be obtained through the use of signs or other means. This option requires additional information and signing to alert motorists.

6. Temporary Work-Site Speed-Limit Sign. A reduced regulatory speed limit may be warranted where work activity may constitute a hazard to traffic, especially for a lane closure. The *Indiana Statutes* permit INDOT to establish a reduced work-site speed limit without an Official Action. Section 83-2.03 provides the criteria for establishing speed-limit signing in a construction zone.

7. Flashing-Arrow Sign. A flashing-arrow sign is used to supplement conventional traffic control devices. It is warranted where additional warning or directional information is required to assist in merging and controlling traffic through and around the work activity. Section 83-2.07 provides additional guidance for the use of a flashing-arrow sign.

81-3.02(02) Capacity

Each construction site will affect the capacity of the existing facility. The extent that the roadway is occupied for work and safety purposes will determine the number of strategies required to compensate for the loss of capacity. Some of the following capacity strategies may be considered when developing a TMP.

1. Temporary Parking Restriction. One option to increase capacity is to eliminate on-street parking to create an additional lane or to reduce traffic conflicts. However, the concerns of on-street parking for local businesses must be addressed. The elimination can be for only during a peak traffic-volume period or for the entire 24-h day.

2. Restriction of Trucks. Restriction of trucks may increase the facility's capacity. However consideration must be given to State or local ordinances, and the availability and suitability of alternate routes that the restricted trucks would be required to take.

3. Turn Restrictions. Turn restrictions should be considered where it may be necessary for capacity or safety reasons. The turn restrictions may be at intersections or drives. Turn restrictions can be for only during a peak traffic-volume period or for the entire 24-h day.

4. Reversible or Contra-Flow Lane. Consider the use of a reversible or contra-flow lane where the peak-traffic flow distribution is in one direction for a specified period of time. The use of such a lane may be limited in use due to the cost of providing and maintaining the daily changes required. There also may be safety considerations which will need to be evaluated if such a lane is contemplated.

5. High-Occupancy Vehicle (HOV) Lane. An HOV lane may be considered where a dedicated lane for high-occupancy vehicles is available and it is desired to discourage use of single-occupancy vehicles. The use of an HOV lane can be during a peak traffic-volume period or for the entire 24-h day. Due to the lack of driver familiarity with this type of lane, it is unlikely that its use will be appropriate.

6. Ramp Metering. Ramp metering may be considered where it is necessary to restrict the amount of traffic entering a freeway for capacity and safety reasons. Ramp metering may be

used during peak traffic-volume period or for the entire 24-h day. The impact of ramp metering on an intersecting road will also need to be considered (e.g., traffic backup).

7. Six-Lane Facility. Where three lanes cannot be maintained in both directions, determine if three lanes can be provided in one direction with two lanes in the other direction.

81-3.02(03) Other On-Site Considerations

In addition to the above strategies, the following other on-site strategies may be considered in developing a TMP.

1. Ramp Closure (Short or Intermediate Term). This may be necessary for construction purposes. If a closure is required, additional signage will be necessary to forewarn the motorist. Signs should be posted on the affected ramp two weeks in advance to advise the motorist of the closure date or portion of the day during which the ramp will be closed.

2. Ramp Closure (Long Term). This may be necessary to construct or to improve traffic flow on the mainline. Local access and business impacts should be considered before deciding on a long-term ramp closure. Also consider the user costs for a detour route and the capacity and safety impact of the detour route. Two adjacent ramps should not be closed at the same time unless necessary for safety reasons.

3. Incident Management. Consider the use of on-site tow trucks for a freeway work zone with limited to unavailable shoulder width. They should also be considered where an accident or breakdown would seriously impact traffic flow and cause significant backups and delays.

4. Special Materials. Examine the use of fast-setting or precast concrete, or other special materials where traffic restrictions must be minimized (e.g., ramp, intersection).

5. Lane Rental by Contractor. In this application, a contractor formulates its bid around the number of hours that it expects to keep a number of lane-miles closed, and then can earn or lose money if the actual number is higher or lower than that bid. This concept has not yet had widespread use.

6. Police Patrol for Speed Control. A police patrol may be required to ensure that vehicular speeds are at or below the posted speed limit, or for other safety reasons. Because this requires a special funding mechanism and special provisions, the designer will need to coordinate this with the Highway Operations Division.

7. Incentive/Disincentive. Consider adding an incentive/disincentive provision to minimize the time that a facility may be affected by construction. Section 81-3.05 discusses the types of work for which an incentive/disincentive provision should be considered.

8. A + B Bidding. If the impact of the construction on traffic is significant, the designer should consider the A + B bidding incentive. Section 81-3.06 provides information on A + B bidding.

81-3.03 Off-Site Strategies

Where construction will significantly impact the traffic flow away from the work zone, the following off-site strategies may be considered in the TMP.

1. Capacity Improvement. Additional improvements on the alternate route may be necessary for capacity reasons to handle the expected diversion of traffic. Examples of capacity improvement include prohibiting or restricting parking, turn restrictions, and truck restrictions, all as described in.81-3.02(01), additional pavement width, or adding a turn lane.

2. Trailblazing to Attraction or Point of Interest. Trailblazing may be necessary to guide the motorist to an attraction or point of interest where the normal route is closed or seriously restricted, or where an alternate route to the attraction or point of interest would assist traffic which would otherwise travel through the work zone.

81-3.04 Scheduling

Project scheduling can affect the overall success of the TMP. For example, restrictive scheduling may be required to facilitate the opening of a highway prior to a special event. In determining a construction schedule, the following should be considered.

1. Short Schedule. A schedule to minimize construction activities and disruption to traffic may be required if motorist user costs are expected to be excessive. However, a short schedule may increase the cost of the project.

2. Longer Schedule. A longer schedule of construction activities may be cost effective if it does not significantly increase the adverse impact to the motorist. The contractor may offer to provide a lower price for a longer schedule.

3. Time-of-Day or Day-of-Week Restriction. This type of restriction may be necessary if the work-zone capacity cannot accommodate the expected demand during a peak traffic period and other measures are not as cost effective. For example, night work may be required to allow longer work hours than can be provided between morning and afternoon peaks and to decrease the excessive traffic delays or congestion associated with lane closures during the daytime.

4. Project Staging. Project staging or completing smaller portions of a project one portion at a time may be necessary to limit disruption to traffic. However, construction activity in the same area over several seasons should be discouraged.

5. Combining with Other Work. Projects within a corridor may be combined or scheduled at the same time where practical, pending available funding, to minimize impacts to the motoring public.

81-3.05 Incentive/Disincentive Justification

Incentive/disincentive is used to minimize the time that a facility may be affected by construction. The contractor is provided additional funds if the project is completed early, or is assessed damages if the project is not completed on time. Due to administrative concerns of implementing this concept, limit incentive/disincentive to a project that has one or more of the characteristics as follows:

1. high traffic volume occurs in an urban area;
2. it completes a gap in the highway facility;
3. it severely disrupts traffic or highway services;
4. it significantly increases road user’s costs;
5. it significantly impacts adjacent neighborhoods or businesses;
6. it replaces a major bridge that is out of service; or
7. it includes lengthy detours.

Figure 81-3D consists of the Department’s worksheet for determining the appropriate incentive/disincentive amount. An editable version of this form may also be found on the Department’s website at www.in.gov/dot/div/contracts/design/dmforms/. An incentive/disincentive justification request should be forwarded to the Contract Administration Division’s Office of Contracting as soon as practical due to the time required for the Central Office to process the request.

81-3.06 A + B Bidding

Where the impact of the work site is significant, an A + B bidding incentive may be used to encourage the contractor to minimize these impacts by reducing the exposure time. A + B bidding consists of two parts as follows.

1. Part A. The total dollar amount required to complete the work.

2. Part B. The total dollar amount based on peak- and non-peak-traffic-volume lane-closure periods, and the total contract days proposed by the contractor to complete the work.

Part A is determined using the contractor's unit prices and the estimate of quantities determined by the Department. Part B is established by adding together the costs for each of the following:

1. peak-traffic-volume lane-closure periods = (no. of periods) x (cost / lane / period);
2. non-peak-traffic-volume lane = (no. of periods) x (cost / lane / period); plus
3. Contract days = (no. of days) x (cost / day)

The contractor is required to estimate the number of periods that the facility will be closed during peak- and non-peak-traffic-volume hours and the overall number of calendar days required to complete the contract. The cost for each of the above items is determined by the Department and is the same for each bidder.

A + B bidding is used only for comparison purposes to determine a successful bidder. It is not used to determine payments to the contractor. A + B bidding is used in conjunction with incentive/disincentive as discussed in Section 81-3.05. Before adding an A + B bidding special provision to a contract, the designer should coordinate its use with the Highway Operations Division and the district construction engineer.

81-4.0 COST-EFFECTIVE ANALYSES

81-4.01 General

There may be more than one option that will address the problem of traffic congestion during construction. To determine the most appropriate option, the user will need to compare the benefits and costs of each to determine the most appropriate option. Chapter 50 provides information on economic analyses relative to benefit/cost analysis and safety-cost analysis. The user should review Chapter 50 in conjunction with the following to determine which option will be the most cost-effective.

A project may not have alternate methods of maintaining traffic. The user-cost calculations will not be required. However, for a project with incentive/disincentive, the user costs must still be determined.

There are computer programs available which the designer may use to determine the cost effectiveness of the various options and alternates. For a freeway, INDOT uses the QUEWZ program. The Department's application of this program is further described in Section 81-4.03.

81-4.02 Cost Evaluation

81-4.02(01) On-Site

If determining the costs of on-site options (e.g., runaround, lane closure, shoulder use), the designer should consider the following:

1. right-of-way cost (temporary and permanent);
2. additional construction costs;
3. effect on wetlands;
4. vehicular delay;
5. user costs (including detour user costs);
6. accident potential; and
7. driving time.

If determining the effect of each on-site option, the designer should also consider the effect the selected option will have on an unofficial detour (i.e., a detour which a motorist selects on his or her own to avoid the construction area). The designer should see the *INDOT Detour Policy* regarding an unofficial local detour.

81-4.02(02) Detour

For an official detour or unofficial detour, the designer must determine the total cost of the detour. To determine the daily detour user costs, use the following equations.

1. Detour User Cost = (Cost in Lost Time) + (Cost in Extra Distance Traveled).

2. Cost of Lost Time = (No. of vehicles detoured) x (increase in travel time per vehicle, h) x (value of motorist's time)

3. Increase in travel time = (length of detour, mi / average detour travel speed, mph) – (length of construction zone, mi / average travel speed through construction zone, mph)

4. Cost in Extra Travel Distance = (net increase in length of travel, mi) x (vehicle operating expense),

   Where:

   The net increase in length of travel distance is the difference between the detour and non-detour distances.

   The value of motorist time not only considers lost wages but also lost free time. A value from $10 to $15 per hour is used.

   The vehicular operating expense includes fuel, maintenance, and depreciation costs, and is set at $0.25 per mile.

In addition to the above detour user costs, the designer must add the cost for improvements needed to the detour route (e.g., repaving, pavement widening, signal improvements). The designer should also consider the effect the detour will have on the community and local businesses.

81-4.03 QUEWZ Program

The Department uses the computer program QUEWZ for a freeway project to determine the queue length and user costs that are associated with work-zone lane closures. Based on the type of lane closure, traffic volume, time schedules, etc., the program will provide the user with the expected queue length and estimated user costs. The Office of Environmental Services' Environment Assessment Team may use this program during the preliminary-engineering stage to compare the various options. The designer may use this program to ensure that the proposed traffic-control plan is still cost effective. The program user should review the user's manual to determine how to use the program.

81-4.03(01) Inputs

The user must provide inputs into the program as follows:

1. lane-closure configurations;

2. the schedule of work activities (e.g., work activity hours, lane-constriction hours); and
3. the traffic volume approaching the freeway segment.

The program provides default values for the following:

1. cost update factor;
2. percentage of trucks;
3. speeds and volumes at various points on a speed-volume curve;
4. capacity of a lane in the work zone;
5. maximum acceptable delay to the motorist; and
6. critical length of queue.

To obtain meaningful results, the designer should consider revising the default values to satisfy the site location. For example, the program assumes that if a queue lasts longer than 20 min some motorists will divert. To account for actual queues and the corresponding user costs, the designer may need to adjust the 20-min time frame to satisfy the project situation. The designer should review the user's manual to determine if the default values are applicable to the location under consideration.

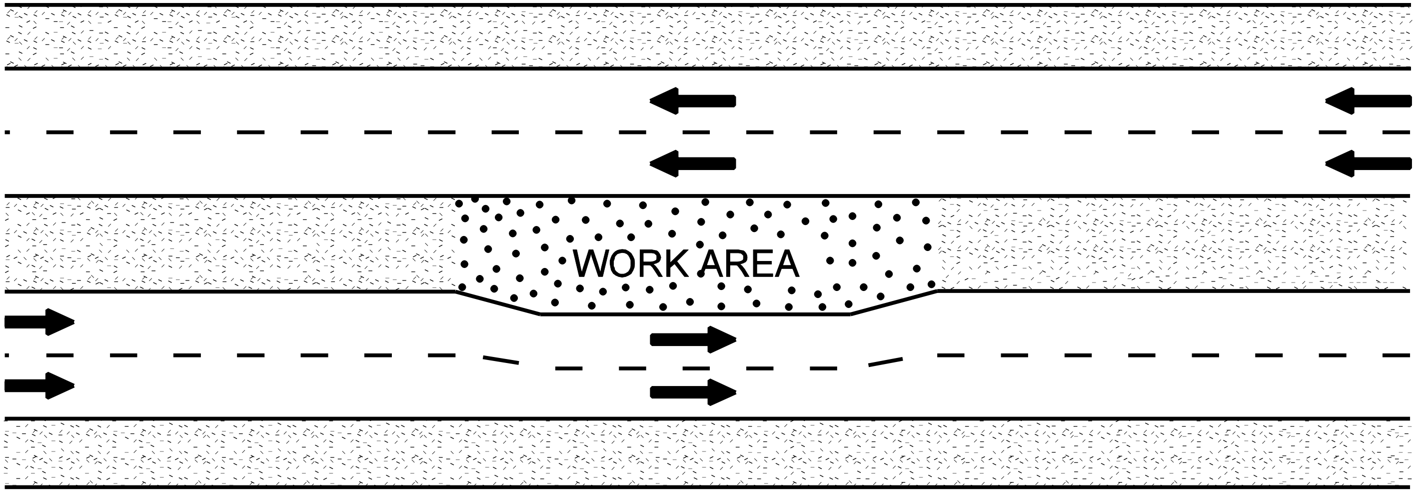
81-4.03(02) Outputs

QUEWZ has two output options: road-user cost and lane-closure schedule. The road-user-cost output option analyzes a specified lane-closure configuration and schedule of work activities, and provides estimates of traffic volume, capacity, speed, queue length, diverted traffic, and additional road user costs for each hour affected by the lane closure. The lane-closure-schedule option summarizes the hours of the day during which a given number of lanes can be closed without causing excessive queuing.

In addition to the values obtained from the program, supplemental user-cost calculations may be required where changes are expected based on existing traffic patterns and volume. Supplemental calculations for a detour are required where an exit or entrance ramp within the construction zone (including that using crossovers) will be closed and where the designer judges that the QUEWZ program is not properly estimating the full amount of diverting mainline traffic.

Additional detour user-cost calculations should be conducted if an exit ramp is to be closed. Experience has shown that most or all of the traffic that would have used a ramp if it was open will divert from the mainline before the construction zone. Therefore, the exit-ramp volume should be deleted from the input mainline volume before using QUEWZ.

A closed entrance ramp may or may not lead to changes in the input values for QUEWZ.



LANE CONSTRUCTION WORK ZONE

Figure 81-2A

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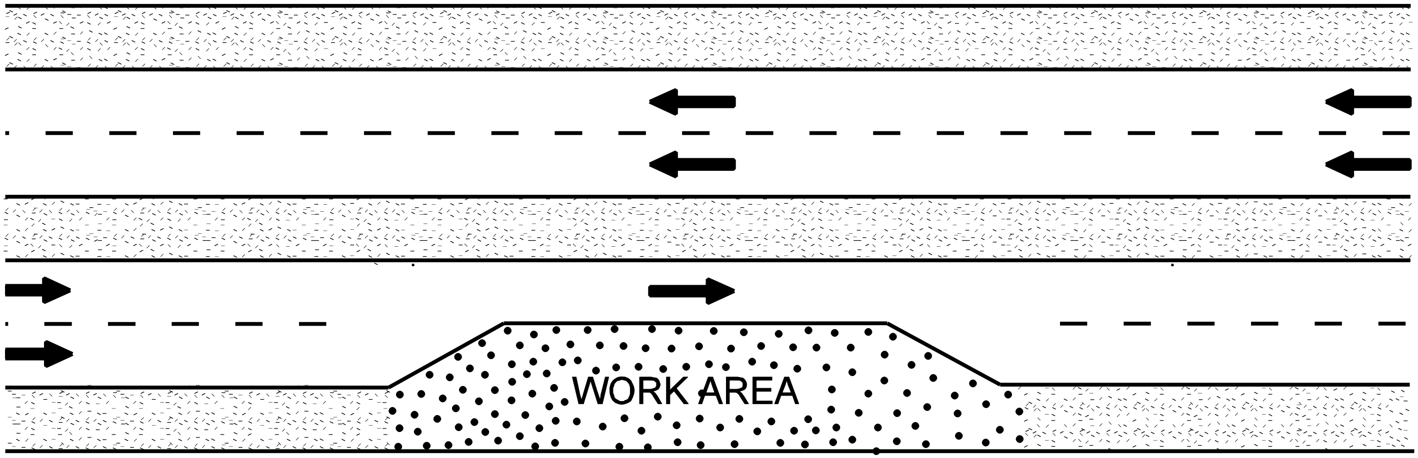

LANE CLOSURE WORK ZONE

Figure 81-2B

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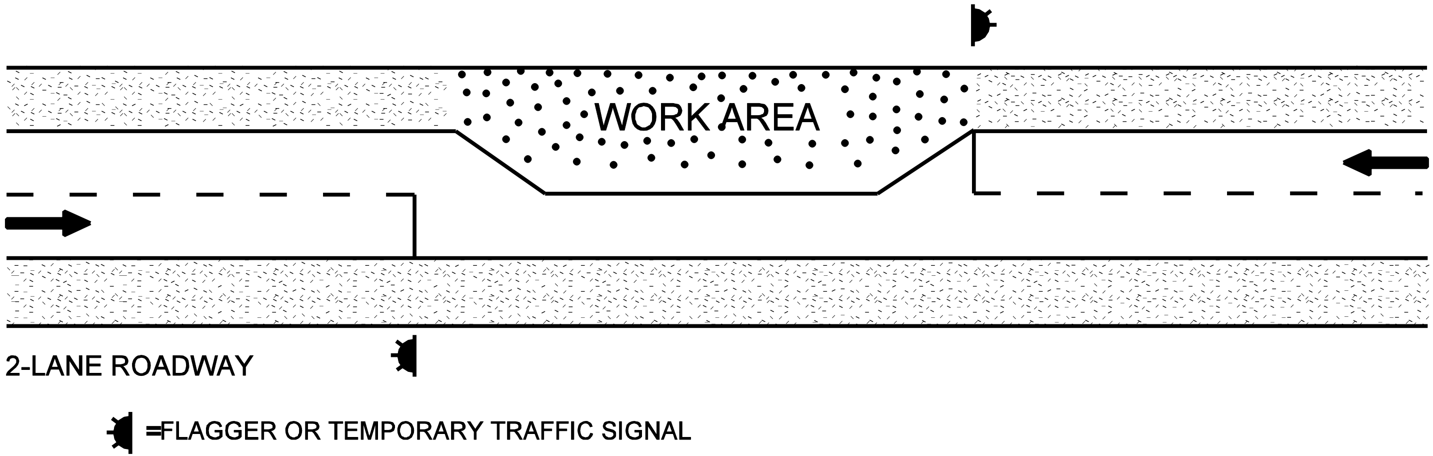

ONE-LANE, TWO-WAY WORK ZONE

Figure 81-2C

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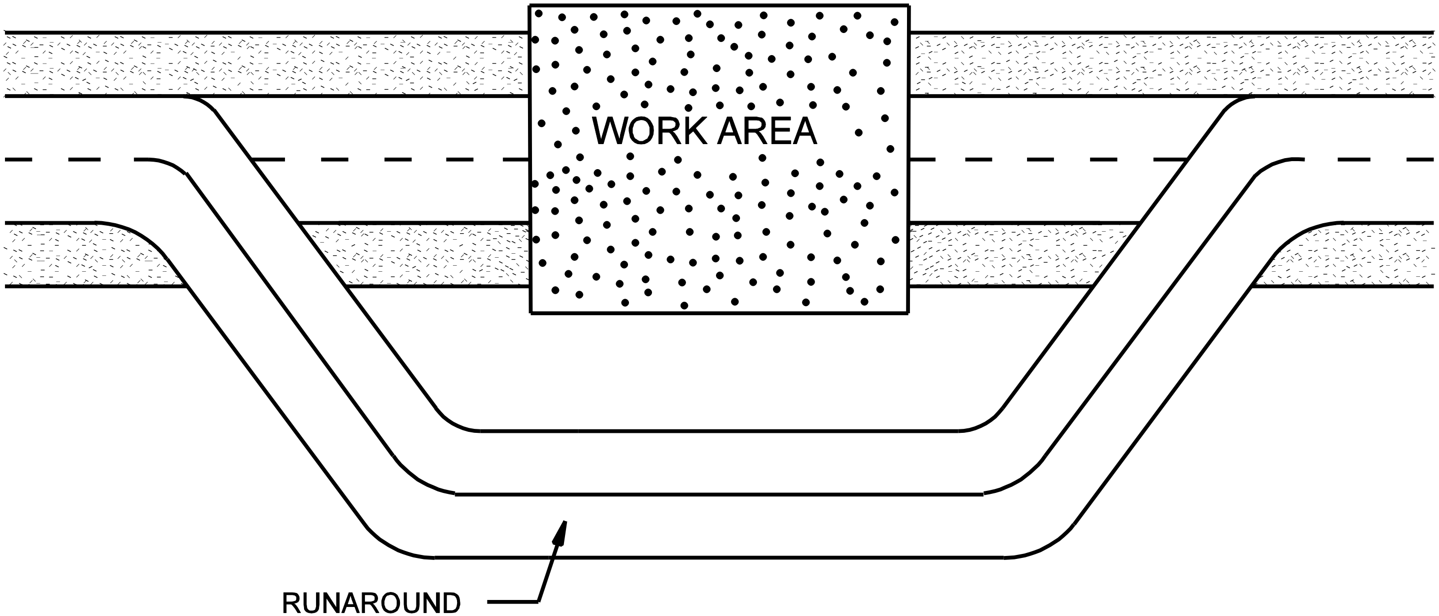

RUNAROUND WORK ZONE

Figure 81-2D

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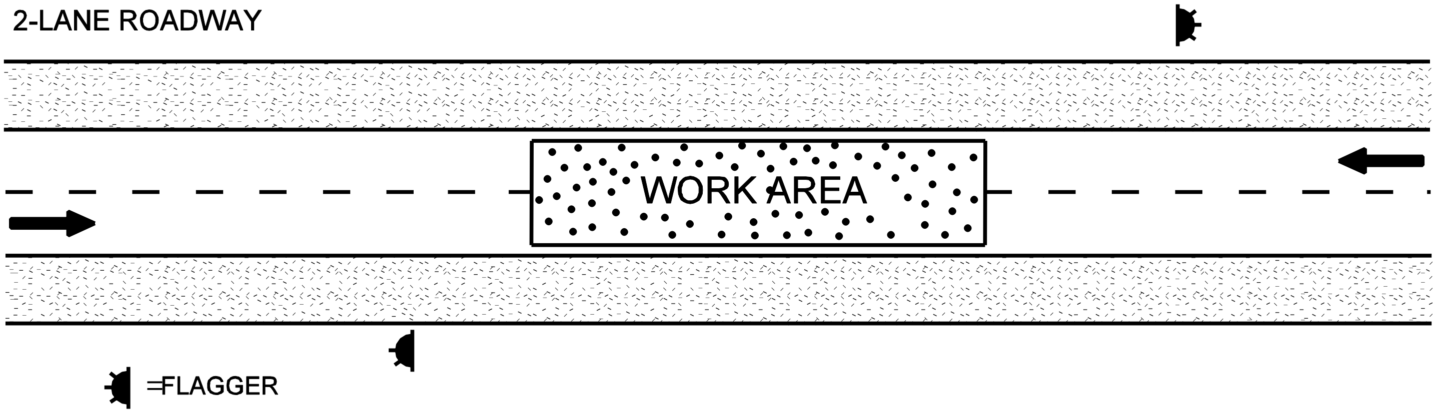

INTERMITTENT CLOSURE

Figure 81-2E

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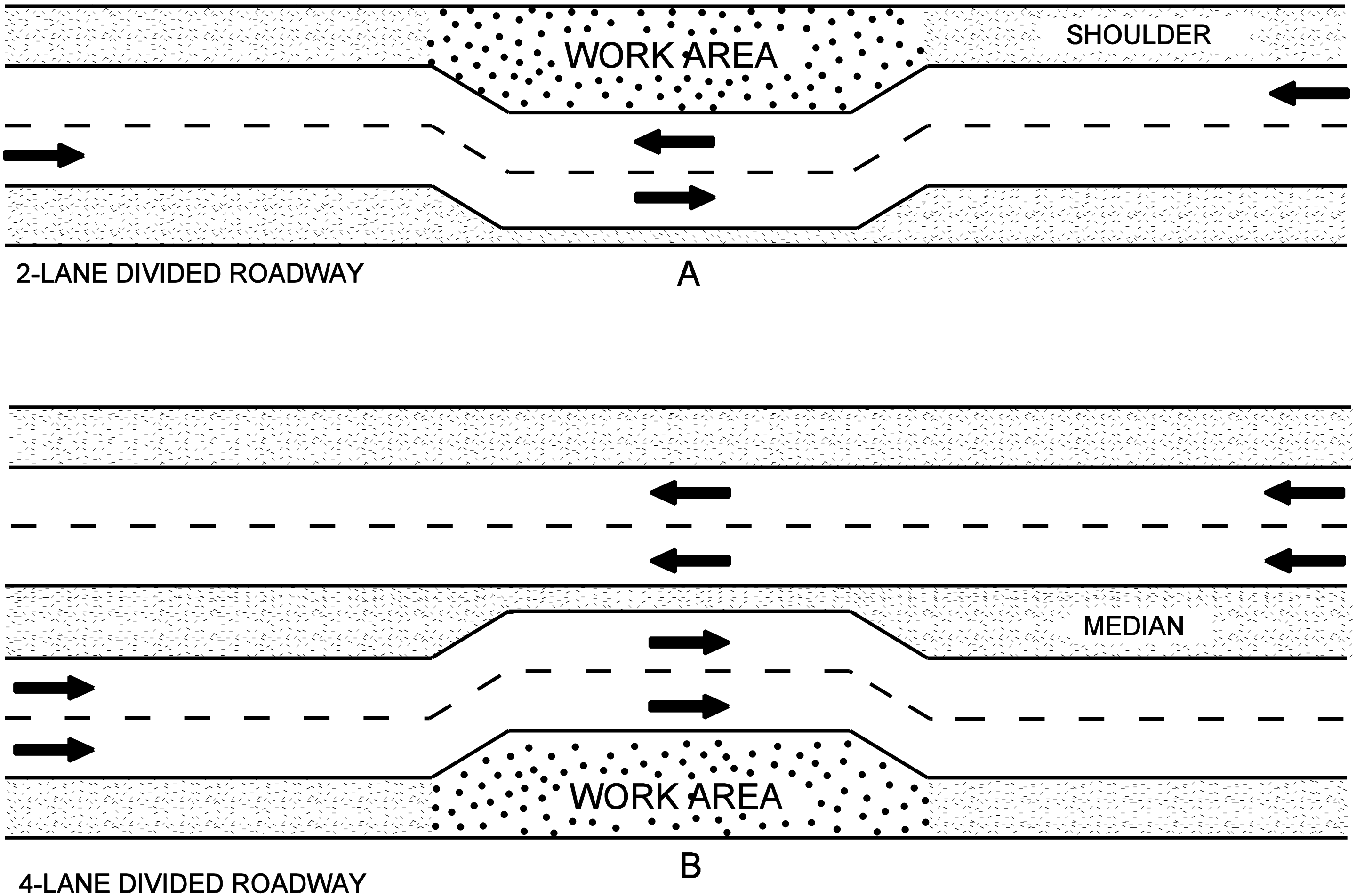

SHOULDER OR MEDIAN USE WORK ZONES

Figure 81-2F

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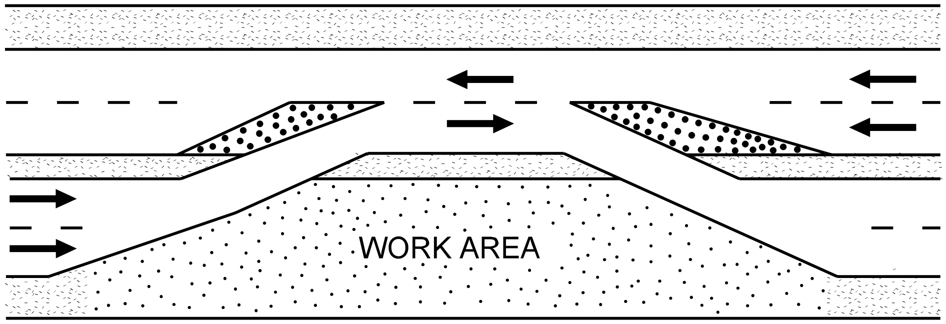
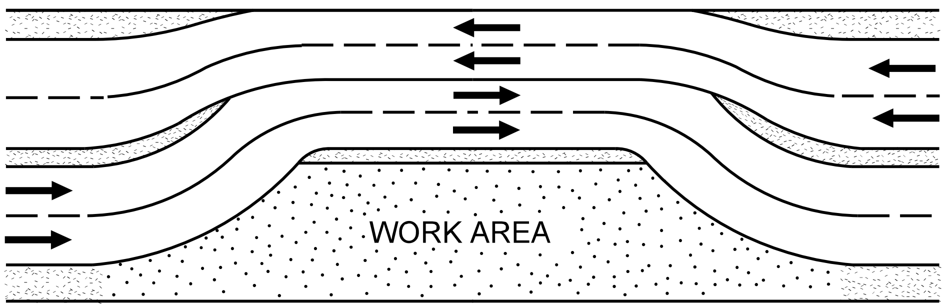
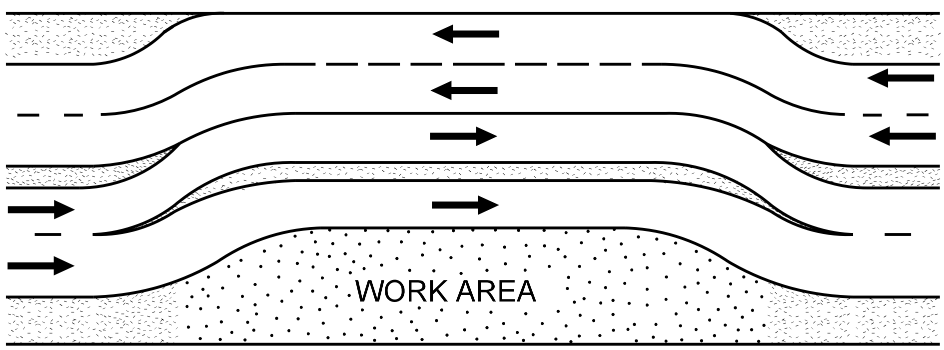


A



4-LANE DIVIDED ROADWAY

B

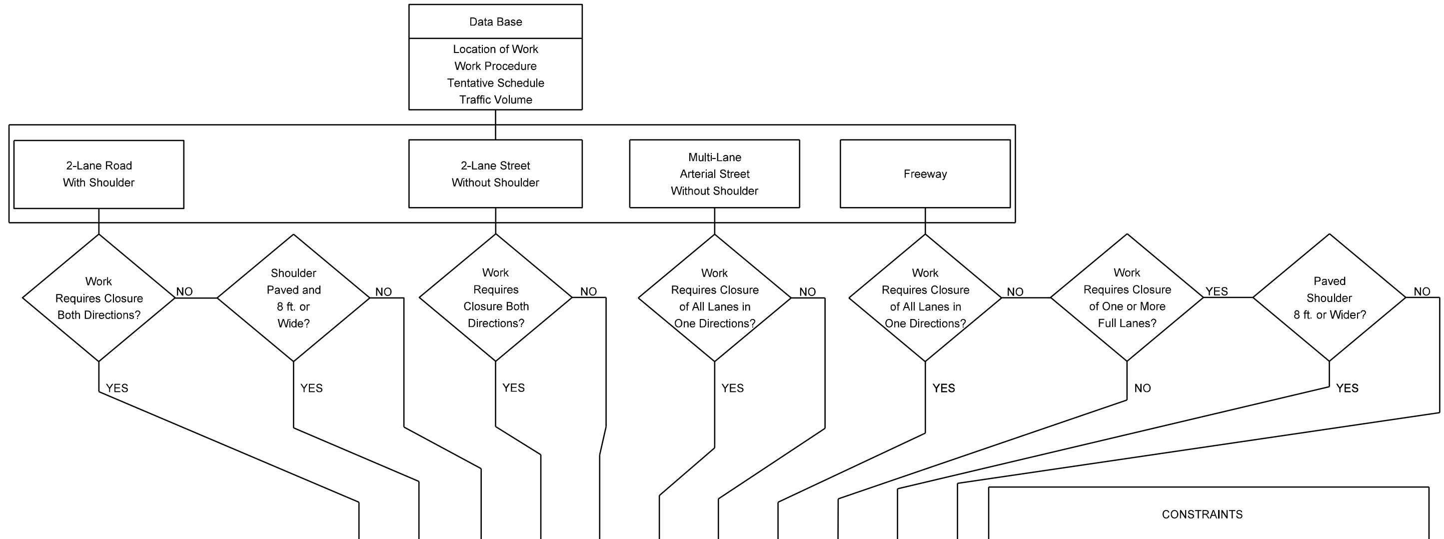


4-LANE DIVIDED ROADWAY

C

CROSSOVER WORK ZONES

Figure 81-2G



ALTERNATIVE WORK ZONE TYPES												CONSTRAINTS
LANE CONSTRICTION (Use part of the shoulder if necessary)		√	√						√			Restripe lanes lines; keep lanes 10 ft. or wider. For freeways and other divided highways, the minimum lane width is 11 ft.
LANE CLOSURE							√		√	√	√	
ONE-LANE, TWO-WAY OPERATION		√	√		√							Traffic volume less than 1000 vehicles per hour both directions. (See INDOT computer program "WORK")
RUNAROUND	√		√					√				Sufficient right-of-way available.
INTERMITTENT TOTAL CLOSURE	√			√				√				Off-peak hours only.
USE OF SHOULDER (As a full lane)		√								√		May need to ugrade shoulder structure.
CROSSOVER						√		√				
TWO-WAY TRAFFIIC ON DIVIDED FACILITIES						√		√				
DETOUR TO EXISTING ROAD	√		√	√	√	√	√	√		√	√	Resonable detour route (s) available. Maintain local access.

√ Fessible Alternatives

CHART FOR IDENTIFICATION OF FEASIBLE WORK ZONE TYPES

Figure 81-2H

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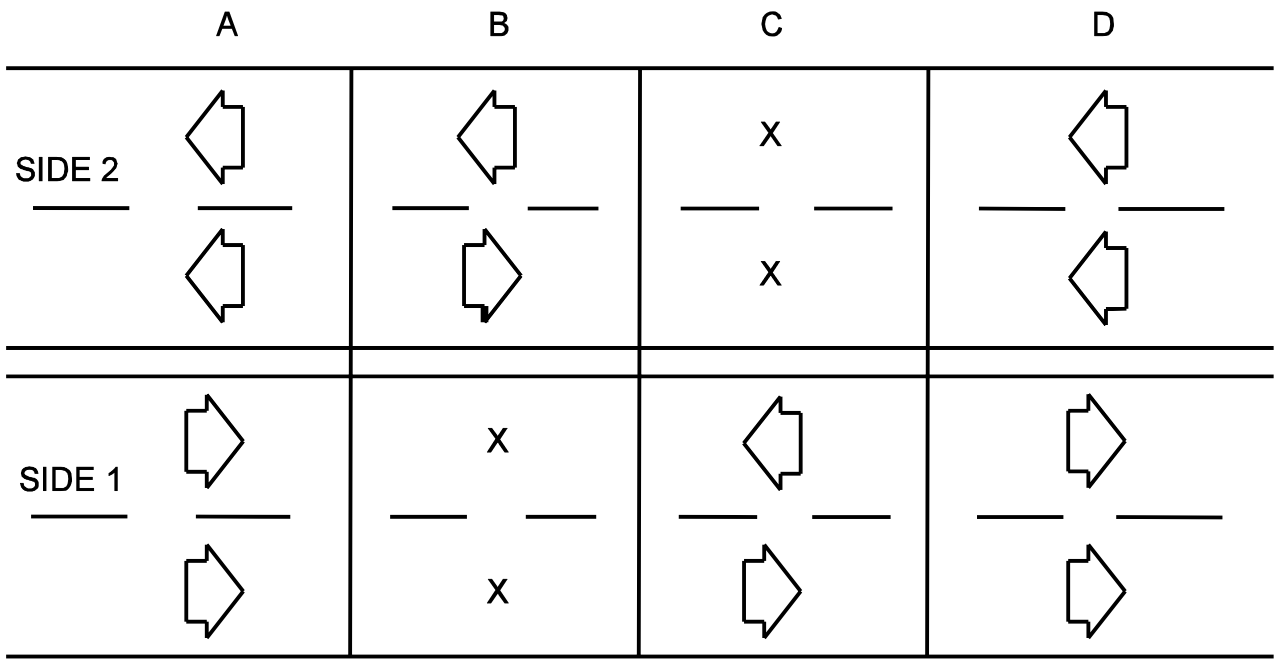

A = Prior Construction
B = During Construction of Side 1
C = During construction of Side 2
D = Following Compleation
X = Construction Activity
⇦ = Traffic Flow

RECONSTRUCTION BY HALVES (SIDES)

Figure 81-3A

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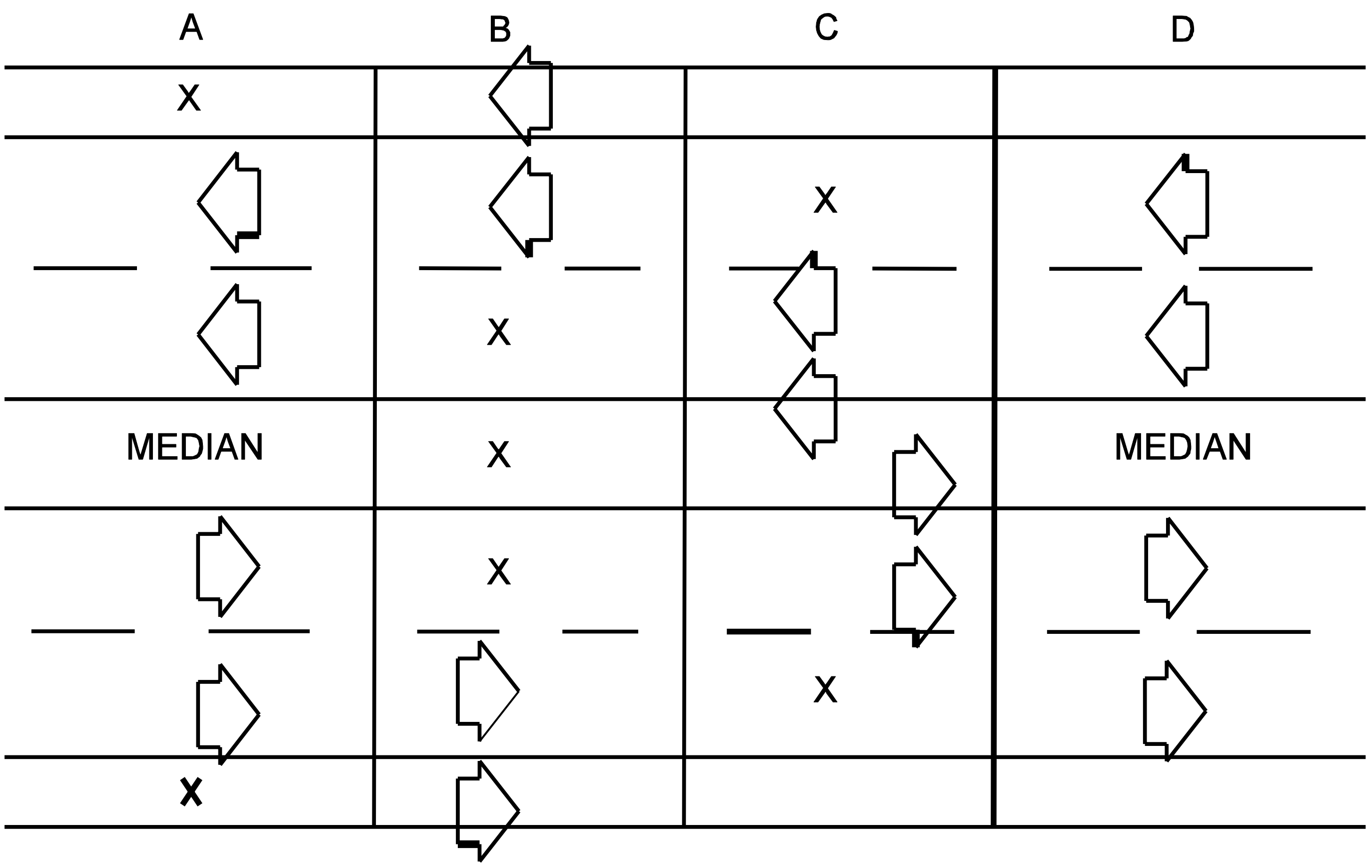

A = Construction of Shoulder
B = Construction of Inner Lanes
C = Construction of Outer Lanes
D = Following Construction
X = Construction Activity
⇦ = Trafic Flow

PARALLEL/ ADJACENT RECONSTRUCTION

Figure 81-3B

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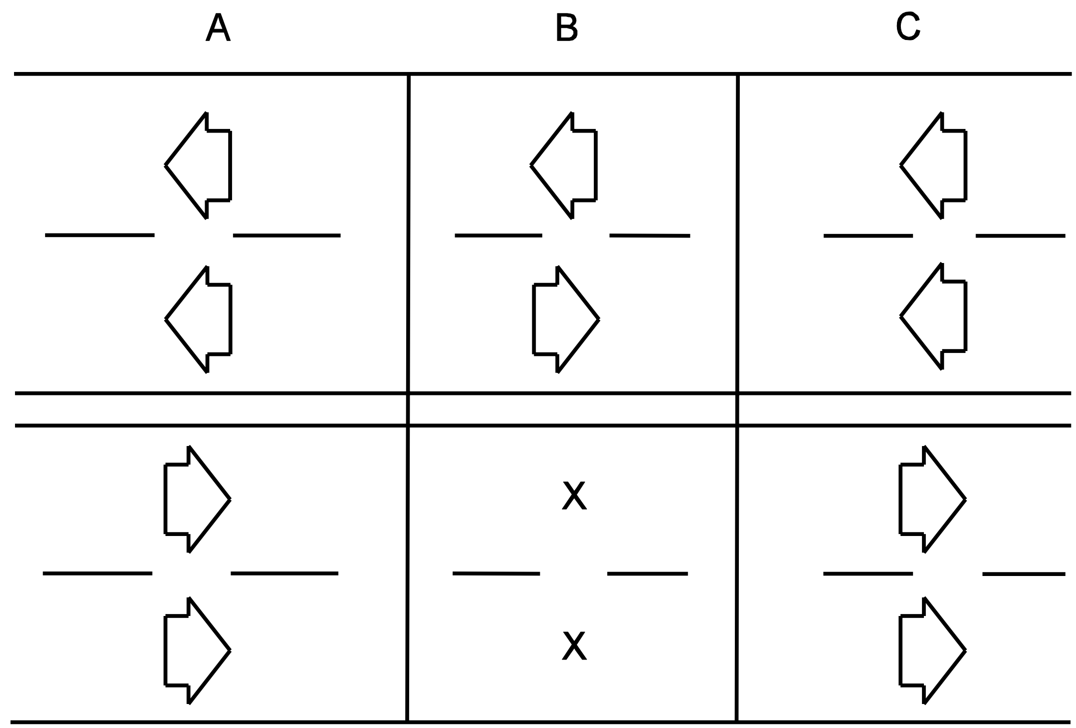

A = Prior to Construction
B = During Construction of a Segment While Maintaining Two-Way Traffic Operation
C = Completion of Construction
X = Construction Activity
⇦ = Trafic Flow

SERIAL/SEGMENTAL RECONSTRUCTION

Figure 81-3C

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INCENTIVE / DISINCENTIVE (I/D) AMOUNT DETERMINATION
English-Units Project

I. PROJECT CHARACTERISTICS

Route Contract No. Project No.
Des. No. District:
National Highway System (NHS) Route? ☐ Yes ☐ No
Location:
Estimated Start Date of Work:
Estimated Completion Date Without I/D:
Estimated Contract Amount: $
* Estimated Local-Traffic AADT: Trucks %
* Estimated Through-Traffic AADT: Trucks %
** Length of Local-Traffic Detour: mi
** Length of Through-Traffic Detour: mi

* Use best judgment for breakdown of traffic.
** Use official detour for through traffic.

II. I/D CONSIDERATIONS

Contract restrictions (e.g., utility adjustments, R/W acquisitions, permits, environmental constraints, closure times, special fabrication requirements):

Reasons for proposing I/D:

Critical construction elements:

Estimated Completion Date With I/D:
Estimated I/D Amount: $ per day
Proposed I/D Time: Calendar Days

Maximum I/D Adjustments = (I/D Amount) x (I/D Time):

$ x days = $

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User Vehicle Costs (UVC): $0.25 / mi / veh (Autos & Trucks)
User Time Value (UTV): $5.00 / h / veh
Local Design Speed: mph
Through Design Speed: mph
Traffic Adjustment Factor (TAF): Suggested Value 0.35
(TAF normal range is 0.30 to 0.45)

NOTE: Use either of the following analyses depending on the type of project (road closure-detoured or through-traffic project). Various computer programs are available such as QUEWZ for estimating queue lengths and user costs that can be used in lieu of the following for freeway work-zone lane closures. Contact the Highway Operations Division's Traffic Control Team for details.

A. User Costs for Closure-Detoured Project

Local Traffic:

Vehicle Costs = (UVC) (AADT) (Local-Detour Length)
($0.25) ( ) (mi) = $

User Costs = (UTV) (AADT) (Local-Detour Length) (1/Design Speed)
($5.00) ( ) (mi) (1/) = $

Local-Road User Costs (LRUC) = (Vehicle Costs + User Costs)
$ + $ = $

Through Traffic:

Vehicle Costs = (UVC) (AADT) (Through-Detour Length)
($0.25) ( ) (mi) = $

User Costs = (UTV) (AADT) (Through-Detour Length) (1/Design Speed)
($5.00) ( ) (mi) (1/) = $
Through-Road User Costs (TRUC) = (Vehicle Costs + User Costs)
$ + $ = $

Site RUC = LRUC + TRUC
$ + $ = $

B. Disruption Costs for Through-Traffic Project

NOTE: The following analysis provides delay cost for through traffic only. If the project includes ramp or intersection closures, the analysis from Part A above can be added to the through-traffic disruption costs or other factors commensurate upon the scope of the particular project.

Vehicle Costs = (UVC) (AADT) (TAF)
($0.25) ( ) ( ) = $

User Costs = (UTV) (AADT) (TAF)
($5.00) ( ) ( ) = $

Traffic Disruption Costs = (Vehicle Costs + User Costs)
$ + $ = $

C. General Comments

D. Other Factors to Consider. Is the route on or near one or more of the following?

School: ☐ Yes ☐ No
Hospital: ☐ Yes ☐ No
Emergency Route: ☐ Yes ☐ No
Hazardous-Materials Route: ☐ Yes ☐ No
Special or Seasonal Event: ☐ Yes ☐ No
Local Business: ☐ Yes ☐ No

III. SUMMARY

Recommended Maximum I/D Time: Calendar Days
Recommended I/D Date:
Recommended Maximum I/D Amount: $ per Day
Is I/D amount > 5% of contract amount? ☐ Yes ☐ No

NOTE: If the I/D amount per day is greater than the Site RUC or Traffic User Costs, I/D is not justified.

IV. APPROVALS

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A. Non-NHS Project

Prepared By: Date

Recommended By: ______________________________ Date __________
Field Construction Engineer, Construction Mgmt.. Div.

If I/D ≤ 5% of contract amount,

Approved By: ______________________________ Date __________
Director, Construction Management Division

If I/D > 5% of contract amount,

Approved By: ______________________________ Date __________
Chief Highway Engineer

Received By: ______________________________ Date __________
Contracting Office Manager, Contract Administration Division

B. NHS Project

Prepared By: Date

Recommended By: ______________________________ Date __________
Field Construction Engineer, Construction Mgmt.. Div.

Approved By: ______________________________ Date __________
Chief Highway Engineer

Received By: ______________________________ Date __________
Contracting Office Manager, Contract Administration Division

NHS Exemption: ☐ Yes ☐ No
If No, this document must be submitted to FHWA for approval.

Approved By: ______________________________ Date __________
Federal Highway Administration

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CHAPTER 82

Traffic Control Plan Design

NOTE: This chapter is currently being re-written and its content will be included in Chapter 503 in the future.

Design Memorandum	Revision Date	Sections Affected
13-01	Jan. 2013	Figure 82-6B, Figure 82-6C
13-03	Feb. 2013	82-6.03

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LIST OF FIGURES

CHAPTER 82

TRAFFIC-CONTROL-PLAN DESIGN

To some extent, highway construction disrupts the normal flow of traffic and poses safety hazards to motorists, bicyclists, pedestrians and workers. Therefore, to alleviate potential operational and safety problems, INDOT requires that work-zone traffic control be considered on each highway construction project. The work-zone traffic-control plan may range in scope from very detailed plans, incorporation of unique or recurring special provisions, or to merely referencing the INDOT *Standard Drawings*, *Standard Specifications*, or *Manual on Uniform Traffic Control Devices (MUTCD)*. This Chapter provides the necessary information to develop a well-conceived work-zone traffic-control plan that minimizes the adverse effects of traffic disruption and hazards.

82-1.0 PRELIMINARY ENGINEERING

82-1.01 Responsibilities

The Office of Environmental Services' Environmental Policy Team is responsible for initially addressing work-zone traffic control. This information is to be included in the Engineer's Report. In determining the initial work-zone traffic control, the Environmental Policy Team will perform the following:

1. collect all necessary data (e.g. traffic counts, accident history, roadway geometrics, proposed development, operating speeds);

2. coordinate planning and scoping meetings with the applicable participants (e.g., designer, Office of Traffic Engineering, district Office of Design, Highway Operations Division, local officials);

3. conduct analyses (e.g., capacity analyses, traffic impact studies, safety studies, queuing analysis);

4. review design alternates;

5. review traffic-control alternates (e.g., detour, crossovers, runaround, lane closure). The preferred plan will be incorporated into the Report;

6. estimate the construction cost and economic impact of various options and improvements;

7. coordinate funding and timing with other projects within the corridor; and

8. if required, form a transportation-management-plan team and include the team's recommendations in the Report. Chapter 81 provides information on the development of a TMP.

82-1.02 District Input

During the development of the Engineer's Report, the Environmental Policy Team will obtain the following information from the district.

1. The district's concurrence in the selected traffic-control alternate;
2. detour-route location and additional travel distance;
3. traffic projections anticipated to use detour;
4. anticipated delays to fire, police, emergency-medical, or postal service;
5. number of school buses using facility (additional delay and distance); and
6. local roads which may be used for official or unofficial detour.

82-1.03 Engineer's Report

The Environmental Policy Team will be responsible for incorporating the proposed work-zone traffic control plan in the Engineer's Report and ensuring that the following have been considered.

1. Traffic-Control Alternates. The Report will address the work-zone traffic-control information as follows:

   a. Applicability of INDOT *Standard Drawings*;
   b. alternate traffic-control strategies;
   c. alternate detour types and locations;
   d. construction scheduling and phasing requirements;
   e. alternate geometric design features;
   f. estimated costs for alternate traffic-control strategies; and
   g. special requirements of the work-zone traffic control.

2. Construction Operation Selection. The construction applications which may be considered are as follows:

   a. work beyond the shoulder;
   b. shoulder work and partial lane closure;
   c. lane closure for a 2-lane highway;
   d. single-lane closure for a 4-lane highway;
   e. two-way traffic on a divided highway;
   f. work within or near an intersection;
   g. offset alignments; and
   h. official or local detour (e.g., runaround, crossovers).

   Chapter 81 provides additional guidance for determining which of these construction applications may be appropriate.

3. Detour Location. The use of a detour (e.g., runaround, crossovers, alternate route) should be determined on a project-by-project basis. The detour location should be in accordance with the following:

   a. minimize impacts to adjacent developments (e.g., site access);
   b. minimize the magnitude and cost of utility relocations;
   c. minimize environmental impacts; and
   d. be offset a sufficient distance so that it will not interfere with construction.

   The Department may be required to repair local highways that may be damaged while being used as unofficial detour routes. See the *INDOT Detour Policy* for additional information. Investigations, details, and agreements with local officials may be required in subsequent phases.

4. Community Impact. The Report should address the impacts on neighborhoods, parks, schools, businesses, etc. A detour can significantly increase traffic through a community such that local traffic can no longer use the detour route. The Report should also address how the work-zone traffic control will affect fire, ambulance, police, and school-bus routes.

5. Interest Groups. The Report should address the concerns of local governments, agencies, public officials, or special interest groups (e.g., homeowner associations). If reasonable, changes should be made to the work-zone traffic control to address their concerns. Working with local officials and organizations early in project development can significantly reduce opposition to, or create support for, a project by addressing local concerns.

6. Transportation-Management Plan. Where a project does not warrant the development of a Transportation Management Plan (TMP), the Environmental Policy Team should still review Chapter 81 for applicable guidelines and criteria that should be discussed during this phase. The conclusion of this phase should result in a reasonable traffic-control strategy for the project.

82-2.0 TRAFFIC-CONTROL-PLAN DEVELOPMENT

82-2.01 Responsibilities

It is the designer's responsibility to ensure that an adequate traffic-control plan (TCP) is developed. If the traffic-control requirements are not entirely included in the INDOT *Standard Drawings* or *Standard Specifications*, the designer should prepare a TCP that will adequately address all required non-standard traffic-control work for the project. The designer will be responsible for the following.

1. reviewing the information in the Engineer's Report or, if not available, contacting the appropriate entity or agency (e.g., traffic-design, FHWA) to obtain the necessary information;

2. evaluating the proposed design alternates (e.g., detour, crossovers, runaround, lane closure); see Chapter 81;

3. developing the geometric design for a specially-constructed detour (e.g., crossovers, runaround, offset alignment); see Section 82-3.0;

4. addressing the roadside-safety concerns within the construction zone (e.g., construction clear zone, temporary concrete barrier); see Section 82-4.0;

5. selecting and locating the required traffic control devices (e.g., pavement markings, barricades, signs); see Chapter 83;

6. developing and evaluating alternate construction sequences;

7. performing the necessary capacity and queuing analyses, if not already provided;

8. making a written request to the Office of Pavement Engineering regarding use of a shoulder or a portion of it for traffic maintenance. A copy of the request should be sent to the project manager. The request should include the construction-year AADT, percent trucks of AADT, and the approximate duration of traffic's shoulder use;

9. ensuring that the proposed traffic-control plan is discussed and reviewed during the Preliminary Field Check; and

10. coordinating with public-information officials to inform the public of proposed road closure, detour route, etc.

82-2.02 Plan Development

The TCP should be developed through the phases described below before it can be incorporated into the contract and approved for letting. The following describes the development of the TCP at each project phase.

1. Engineer's Report. The Environmental Policy Team will be responsible for determining the initial work-zone traffic control strategies to be used on the project. These should be shown in the Engineer's Report. If changes are made to the recommendations in the Report, the designer should notify the Environmental Policy Team of these changes.

2. Structure Type and Size (Bridge-Replacement Project) or Grade Review (Sight-Distance Improvement or Small Structure Replacement. At this plan development stage, the designer is responsible for contacting the appropriate district to obtain its input regarding traffic maintenance. Figure 82-2B is a blank memorandum copy which the designer should download, fill in the project information blanks, then transmit to the district. An editable version of this form may also be found on the Department's website at www.in.gov/dot/div/contracts/design/dmforms/. District input should be solicited if a TCP is specified in the Engineer's Report. The district should provide the requested information to the designer.

3. Preliminary Field Check. During the Preliminary Field Check, review the proposed traffic-control strategy against actual and anticipated field conditions and be prepared to perform the following tasks.

   a. drive the local detour;

   b. determine the environmental effects of a crossover or runaround;

   c. estimate the extent and cost of property damage caused by a crossover or runaround, including additional right-of-way requirements and costs;

d. determine the feasibility of maintaining traffic on the facility (e.g., roadway, bridge) while work is in progress;

e. evaluate the need for scheduling work activities to avoid traffic delays during peak commute hours or local events;

f. determine the effects on project constructability; and

g. review the physical and operational elements of the TCP with other projects in the area to ensure that there are no conflicts with the proposed TCP.

At the conclusion of this phase, the preliminary geometric design, safety, and capacity analyses should be completed, and suggested plan modifications evaluated and reviewed. The designer should determine the proposed location of all traffic-control elements and special design elements (e.g., runaround, crossovers) and should establish the proposed construction phasing. The designer should contact the district for its input, even if the proposed TCP is recommended in the Engineer's Report.

4. <u>Hearing</u>. The plan and profile, cross-sections, construction schedule and phasing, and impact reports should be completed at this stage. Begin preparation of the required special provisions and the permit process. Prepare an estimate of the time required to re-open the facility (e.g., roadway, bridge) to traffic after construction starts.

5. <u>Final Field Check</u>. Review all issues emerging from the hearing stage and complete subsequent plan modifications. Review the project's physical and operational elements of the TCP with other projects in the area to ensure that there are no conflicts with the proposed TCP. Examples include detouring traffic onto a local road which is scheduled for reconstruction during the same time period, or closing a highly-traveled highway during special events or seasons. Coordinate with the Office of Communications so that they can begin to inform the public of road closures or alternate detour routes.

6. <u>District Construction Engineer Review</u>. After design approval, the designer should submit the proposed TCP to the district construction engineer. The district construction engineer will provide written comments or concurrence regarding the proposed TCP to the designer, with a copy to the appropriate Production Management Division office manager. The office manager will provide written comments or concurrence regarding the proposed TCP to the designer. If necessary, the designer will revise the proposed TCP until both district construction engineer and office manager concur.

7. Final Plans Review. Determine and check all quantity estimates. Complete the detail drawings and include all relevant special provisions in the contract documents. Do not show unofficial detour routes in the plans or special provisions.

The Department requires a coordinated team effort to develop and successfully implement a TCP. Figure 82-2A lists the participants involved in each phase of its development.

82-2.03 Traffic-Control Plan Content

The type and size of a project greatly impacts the amount of information required in the TCP. For example, for a traffic-signs project, the TCP may only be a listing of the appropriate INDOT *Standard Drawings*. However, for a freeway reconstruction project, the TCP may include full-size drawings, special details, special provisions, special task forces, etc. The TCP content will be determined on a project-by-project basis. The TCP may include the following.

1. Construction Plan Sheets. A reconstruction project will require detailed plans for accommodating traffic at each construction stage (e.g., specially-built detour, crossovers, staged construction). These plans may include geometric layout details, positive-protection strategies, the traffic-control devices, etc. A smaller project (i.e., partial 3R, traffic signs, signals, or a spot improvement) will rarely require this level of detail. Chapters 14 and 15 provide the Department's plans-preparation criteria (e.g., sheet sizes, scales, line weights, CADD symbols) which are also applicable to a TCP. The INDOT *Typical Plan Sheets* document provides traffic-maintenance detail sheet examples.

   A traffic-maintenance plan that requires at least one shoulder to carry traffic on a temporary basis during construction should include information regarding shoulder-corrugation installation requirements. A note should be included that reads, ―Corrugations shall not be milled into the _____ shoulder between Sta. _____ and Sta. _____ until after traffic is no longer temporarily using the shoulder."

2. Special Provisions. Special provisions are used to explain special procedures, materials, or equipment used in the TCP that are not addressed in the INDOT *Standard Specifications*. The TCP may only consist of special provisions. Prior to developing a new special provision, the designer should first ensure that its requirements do not already appear in the INDOT *Standard Specifications* or recurring special provisions. Chapter 19 provides information on the requirements for preparing a special provision.

3. Traffic-Control Devices. Include a complete listing of the traffic-control devices required to direct traffic through the work zone in the TCP. This may include the number of drums,

barricades, cones, signs, temporary pavement markings, warning lights, flashing-arrow signs or other devices required to implement the construction. Chapter 17 provides the Department's criteria for determining plan quantities.

4. Construction Sequence and Time. The TCP should include a proposed construction sequence.

5. Work Schedule. A special provision should identify restricted work schedules which the contractor will be required to follow (e.g., no construction work during specified hours or days).

6. Telephone Numbers. A special provision should require the contractor to provide names and telephone numbers of the contractor's superintendent and one other responsible employee.

7. Permits. For restricted-lane width, the district Office of Construction will be responsible for coordinating with the Planning Division's Office of Roadway Safety and Mobility after the contract is let to obtain the necessary permits to allow oversize vehicles through the work zone.

8. Agreement or Legal Release. An agreement or legal release may be required before INDOT can use a local facility as a detour route. The designer should initiate this process early in the design of the work-zone traffic control.

9. Media. The designer should inform the Office of Communications as to when and where there will be a major road or ramp closure or detour.

10. Pedestrians and Bicyclists. The TCP should address the safe accommodation of pedestrians and bicyclists through the work area. Construction phasing may need to be scheduled around non-peak pedestrian-traffic times.

11. Local Businesses and Residents. Maintain at least one reasonable access to each site of business establishment or residency. The designer should also ensure that these entities are kept informed of planned street, ramp or driveway closures.

12. Emergency Vehicles. The TCP should address the safe and efficient accommodation of emergency vehicles through the construction area.

13. Checklist. Section 82-7.0 provides a checklist which should be reviewed to ensure that all applicable work-zone traffic-control elements have been addressed in the TCP.

82-2.04 Design Considerations

The objective of the TCP is to provide an implementation strategy that will minimize the adverse effects of traffic disruption on motorists, pedestrians, bicyclists, or workers. Therefore, the designer should consider the following design considerations when developing the TCP. For a more in-depth analysis of these elements, the designer should review Chapter 81.

82-2.04(01) Engineering

The designer should consider the following engineering elements in developing the TCP.

1. Geometrics. The TCP should provide adequate facilities for a motorist to safely maneuver through the construction area, day or night. The design should avoid frequent and abrupt changes in roadway geometrics, such as lane narrowing, a lane drop, or a transition which requires a rapid maneuver. Section 82-3.0 provides geometric design criteria for a construction zone.

2. Roadside Safety. Motorist, pedestrian, bicyclist, and worker safety is a priority element of a TCP and should be an integral part of each phase of the construction project (i.e., planning, design, and construction). Section 82-4.0 addresses the roadside-safety issues which are encountered during construction.

3. Highway Capacity. The TCP should, where practical, provide the capacity necessary to maintain an acceptable level-of-service for the traveling public. This may require converting a shoulder to a travel lane, eliminating on-street parking, constructing a temporary lane, opening additional lanes during peak traffic-volume periods, or expanding public transportation. Section 82-5.0 provides further information on highway-capacity issues.

4. Traffic-Control Devices. Traffic-control devices should be included in the TCP to safely direct vehicles through or around the construction zone. Chapter 83 provides guidance on the selection and location of traffic-control devices.

5. Overhead Lighting. The design should maintain existing overhead lighting and consider the need for supplemental roadway lighting at a potentially hazardous site within the work area. Chapter 83 discusses the use of construction-zone lighting.

82-2.04(02) Constructability

The designer should evaluate the construction sequence to identify safety, operational, or logistical problems and to facilitate the timely completion of the project. Some of the elements which should be evaluated include the following:

1. the maneuverability of traffic through horizontal or vertical alignments during all construction phases;
2. the separation of opposing traffic, workers, equipment, or other hazards;
3. the work area which will be used for equipment maneuverability; and
4. the access points to work sites or material-storage sites.

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Adequate working space between the traffic and the work area should be provided. This applies especially where construction is phased or if the project includes a temporary runaround.

82-2.04(03) Construction Design

Available construction options that may improve the TCP include the following:

1. the use of special materials (e.g., quick-curing concrete that can support vehicular loads within hours after pouring);
2. the use of special designs (e.g., using a precast box structure instead of a bridge or cast-in-place box structure);
3. scheduling requirements which will reduce traffic disruptions (e.g., working at night and during off-peak traffic-volume hours);
4. project phasing which will allow traffic to use the facility prior to project completion; or

5. contractor cost incentives/disincentive for early or late completion of construction for a facility with a high AADT. For a project with FHWA oversight, a contractor incentive is subject to approval by the FHWA.

Chapter 81 provides additional information on construction alternates.

82-2.04(04) Economic or Business Impact

The designer should consider the economic impacts a TCP may have on road users, adjacent businesses, or residential developments. The designer should consider the following:

1. vehicular travel time;
2. fuel consumption;
3. vehicular wear;
4. air pollution;
5. access to residential developments;
6. patron access to businesses (e.g., restaurants, gas stations, stores);
7. employee or delivery access to commercial developments; and
8. shipments to manufacturing companies.

The designer should also review the TCP to ensure that it does not restrict access to businesses during peak retail shopping periods. For example, a road closure should not be made in the vicinity of a regional retail mall during the period from Thanksgiving to Christmas. Coordination with local businesses, developers, or other land owners should be made early in the development of the TCP. At least one access should be maintained to each development throughout the contract time.

82-2.04(05) Pedestrians and Bicyclists

Address the safe accommodation of pedestrians or bicyclists through the construction zone early in project development. Locations that would warrant pedestrian or bicyclist considerations include the following:

1. where a sidewalk traverses the work zone;

2. where a designated school route traverses the work zone;

3. where significant pedestrian or bicyclist activity or evidence of such activity exists; or

4. where existing land use generates such activity (e.g., park, school, shop).

The considerations to be made in addressing pedestrian or bicyclist accommodation through a construction zone are as follows:

1. physical separation of pedestrians and vehicles where practical;

2. providing temporary lighting for each walkway that is currently lighted;

3. directing pedestrians or bicyclists to a safe location (e.g., the other side of a street) where a pedestrian walkway or bicycle path cannot be provided;

4. staging construction operations such that if there are two walkways they are both not out of service at the same time;

5. planning the construction such that temporary removal of a sidewalk will occur in the shortest practical time or is scheduled around non-peak pedestrian traffic-volume times; or

6. for information on handicapped-accessibility criteria, see Section 51-1.0.

82-3.0 GEOMETRIC DESIGN

The following provides design criteria which apply to temporary crossovers on a divided highway, an existing roadway through a construction zone, or a detour specifically designed for construction project (e.g., crossovers, runaround). These criteria do not apply to a detour over existing routes.

82-3.01 Construction-Zone Design Speed

The construction-zone design speed applies to the design of the geometric elements through the work zone. It does not apply to the regulations that are used for posting the speed limit through the work zone. Regulatory speed limit is discussed in Section 83-2.03. In selecting the construction-zone design speed, the designer should consider the following.

1. Posted Speed Limit. The construction zone design speed should take into account the following:

    a. the posted speed limit of the facility immediately prior to the work zone;

b. the anticipated posted work-zone speed limit through the work zone (see Section 83-2.03); and

c. the posted speed limit of the facility before construction begins. The construction-zone design speed should not be more than 10 mph lower than the posted speed limit prior to construction.

2. Urban or Rural Area. The construction-zone design speed in a rural area should be higher than that in an urban area. This is consistent with the fewer constraints in a rural area (e.g., less development).

3. Terrain. A lower construction-zone design speed may be applicable to a rolling terrain. This is consistent with the higher construction costs as the terrain becomes more rugged.

4. Traffic Volume. The construction-zone design speed may vary according to the traffic volume. Therefore, consider a higher design speed as traffic volume increases.

The designer should work with the appropriate district traffic engineer to establish the construction-zone design speed for an INDOT route, or a local public agency's representative for a local-agency route. The designer should show the construction-zone design speed on the first sheet of the TCP.

If crossovers are used to maintain one lane of traffic in each direction on a rural Interstate route, the following will apply.

1. Use temporary concrete median barrier.

2. Unless the median shoulder is full depth, it is to be removed and replaced with a 6-ft width section with its pavement design to be requested by the designer.

3. The traffic maintenance should be as shown in Figure 81-3A(0).

4. Shoulder corrugations are to be milled into the new shoulder after traffic is crossed over to the other side.

82-3.02 Lane or Shoulder Width

There should not be a reduction in the roadway-cross-section width through the construction zone. However, this may not be practical. Section 83-3.02 provides the minimum taper rate that should be used on an approach to a lane-width reduction. The following lane and shoulder widths should be used in a construction zone.

1. Divided Highway. For a freeway or other divided highway, maintain a minimum 11-ft lane width with shoulders of 2 ft or wider. Under restrictive conditions, however, the designer may consider a 10-ft lane width if an alternate route is provided for wide vehicles.

2. Undivided Highway. Maintain a minimum 10-ft lane width and 1-ft shoulder width.

3. Runaround. Design a runaround with 12-ft lane width and 6-ft shoulder width.

4. Temporary Crossover. For 1-lane, one-way operations, the lane width should be 16 ft with 5-ft shoulder widths. For a multi-lane or multi-directional operation, each lane width should be 12 ft with 5-ft shoulder widths.

82-3.03 Transition Taper Rate

A lane closure, lane-width reduction, or lane shift requires the use of a transition taper to safely maneuver traffic around the encroaching restriction. Section 83-3.02 provides the minimum taper length for each taper application in a construction zone (e.g., lane closure, lane shift). Use the construction-zone design speed in selecting the appropriate taper rate from Section 83-3.02.

82-3.04 Sight Distance

For the approach to the first physical indication of the construction zone, the sight distance available to the motorist should be based on the decision-sight-distance criteria provided in Section 42-2.0 and, at a minimum, based on the stopping-sight-distance criteria provided in Section 42-1.0. Through the construction zone itself, the designer should ensure that at least the minimum stopping sight distance is available to the motorist. Unfortunately, the locations of many design features are often dictated by construction operations. However, an element may have an optional location. For example, a lane closure or transition should be located where the approaching motorist has decision sight distance available to the lane closure on transition. Throughout a horizontal curve in the construction area, the designer should check the horizontal clearance (i.e., the middle ordinate) of the horizontal curve using its radius and the minimum stopping sight distance for the construction-zone design speed (see Section 43-4.0). Figure 43-4B provides the horizontal-clearance criteria for each combination of minimum stopping sight distance and curve radius. The designer should also consider the percentage of trucks and other heavy vehicles in determining the controlling sight distance.

Computations must be submitted for horizontal stopping sight distance at the Grade Review or Structure Type and Size stage, or the next plan submission if the project is already beyond the Grade Review or Structure Type and Size stage, for a temporary runaround or other traffic-maintenance means. A statement that a temporary runaround is in accordance with the INDOT *Standard Drawings* is not sufficient to verify that adequate horizontal-alignment stopping sight distance is provided.

Computations must be submitted for intersection sight distance for each traffic-maintenance phase.

82-3.05 Horizontal Curvature

Design the horizontal curvature using the selected construction-zone design speed. Use AASHTO Method 2 for distributing superelevation and side friction to determine the radius and superelevation rate of the horizontal curve. In this method, superelevation is introduced only after the maximum allowable side friction has been reached. If compared to AASHTO Method 5, this approach results in no superelevation on a flatter curve (i.e., maintaining the normal crown through the curve) and a reduced rate of superelevation on a sharper curve. Figure 82-3A, Minimum Radius for Horizontal Curve in Construction Zones, provides the minimum radius (including the radius for retention of the normal crown section) for a horizontal curve through a construction zone based on AASHTO Method 2. For other horizontal-curvature elements (e.g., superelevation transition length), the criteria described in Chapter 43 is also applicable to a construction zone.

Where it is necessary to use the shoulder as a travel lane, the shoulder cross slope may be a concern on a horizontal curve (i.e., the slope may be in opposite direction than the superelevated section). One or more of the following options may be considered to alleviate this problem.

1. Rebuild the shoulder so that it has the proper superelevation rate based on the selected construction-zone design speed.

2. Install an advisory-speed plate for the horizontal curve,

3. Install buzz strips in conjunction with Item 2 above in advance of the temporary travel lane (see Figure 82-4A, Flare Rate for Temporary Concrete Median Barrier.

4. Prohibit trucks or other large vehicles from using the temporary travel lane.

5. Detour such large vehicles to other facilities.

82-3.06 Vertical Curvature

Design a sag vertical curve using the selected construction-zone design speed and the comfort criterion provided in Figure 82-3B. The comfort criterion is based on the comfort effect of change in vertical direction through a sag vertical curve because of the combined gravitational and centrifugal forces. The ride through a sag vertical curve is considered comfortable if the centripetal acceleration does not exceed 1 ft^2.

82-3.07 Cut or Fill Slope

Design a temporary cut or fill slope to satisfy the design criteria shown in Chapter 53 and Section 45-3.0. However, a 3:1 fill slope may be used where there is sufficient clear-zone width available at the bottom of the slope (see Section 82-4.04). The use of a steeper fill slope may be considered, but it may require the installation of a roadside barrier.

Although a detour rarely involves excavation, a 3:1 cut slope is acceptable in place of the flatter slope required in Chapter 53. The use of a slope steeper than 3:1 for a cut depth of less than 10 ft may be acceptable under restrictive conditions.

The anticipated traffic volume and the length of time that the detour will be in place should be considered in determining the final cut or fill slope. Stable embankment material must be used and placed in accordance with the INDOT *Standard Specifications*.

Drainage should be considered between the work zone and the traffic in establishing the phases of construction.

82-3.08 Maximum Grade

The vertical grade should be designed using the 3R criteria for the appropriate functional classification, rural or urban environment, and construction-zone design speed.

82-3.09 Through-Lane Cross Slope

The 3R criteria should be used for the appropriate functional classification and rural or urban environment. If the existing shoulder is used for through traffic, a 4% cross slope will be acceptable.

82-3.10 Vertical Clearances

The 3R criteria should be used for the appropriate functional classification and rural or urban environment.

If the design for a temporary runaround or other traffic-maintenance consideration excluding a detour over existing roads is not in accordance with the criteria for Level One elements, a design exception will be required.

82-4.0 ROADSIDE SAFETY

Through a construction zone, a motorist is often exposed to numerous hazards (e.g., restrictive geometrics, construction equipment, opposing traffic). A complete elimination of construction-zone hazards is impractical. A motorist's exposure to potential hazards should be reduced. The following lists roadside-safety criteria which apply only to the roadside elements within the construction zone. These criteria do not apply to a detour over existing routes.

82-4.01 Positive Protection

The designer should consider a traffic-control method which does not require the use of positive protection, minimizes the hazard exposure, or maximizes the separation of workers and traffic. However, positive protection is often required.

Positive-protection devices should be considered in each work-zone situation that places workers at increased risk from motorized traffic, and where positive-protection devices offer the highest potential for increased safety for workers and road users. The decision regarding the use of positive protection is to be documented and placed in the project file. Locations where positive protection should be considered include the following:

1. exposed end of temporary concrete barrier;
2. untreated guardrail end in a 2-way, 2-lane operation;
3. bridge pier;
4. bridge-railing end;
5. structure foundation (e.g., bridge falsework, sign foundation);
6. excavation or rock cut;
7. gap in median between dual bridges;
8. pavement edge or shoulder dropoff in excess of 12 in.; or

9. other location where construction will increase the potential hazards of existing conditions.

Each location listed above should be addressed separately in the documentation. Because each TCP is project-specific, the Department has not developed criteria for positive protection within a construction zone. However, considerations for assessing the need for positive protection are as follows:

1. duration of construction activity (14 days or less);
2. traffic volume (including seasonal and special-event fluctuations);
3. nature of hazard;
4. length and depth of dropoff;
5. construction-zone design speed;
6. highway functional classification;
7. length of hazard;
8. proximity between traffic and construction workers;
9. proximity between traffic and construction equipment;
10. adverse geometrics which may increase the likelihood of a run-off-the-road vehicle;
11. two-way traffic on one roadway of a divided highway;
12. transition area at crossover;
13. lane closure or lane transition;
14. work zone that provides workers no means of escape from motorists; or
15. construction-zone design speed is 45 mph or higher.

Other considerations may apply, as the above list is not considered to be all-inclusive. The decision regarding the use of positive protection should be documented and placed in the project file.

82-4.02 Appurtenance Type

In addition to Chapter 49 and the INDOT *Standard Drawings*, the following provides additional information on roadside-safety appurtenances.

Positive guidance for crossed-over two-lane two-way traffic should be provided as follows.

1. Temporary concrete barrier and temporary solid yellow lines are to be used on a freeway.

2. Temporary tubular markers and temporary double solid yellow lines are to be used on a multi-lane divided roadway that is not a freeway.

3. Temporary double solid yellow lines are to be used on an urban or rural multi-lane undivided roadway.

Temporary asphalt divider is not to be used for separating traffic.

82-4.02(01) Guardrail

A temporary guardrail installation for an Interstate-route project should be in accordance with the permanent installation criteria described in Chapter 49 and the INDOT *Standard Drawings*, except as shown in Figure 82-4B, Work-Zone Clear-Zone Width (ft). For short-term construction, the installation of new temporary guardrail is not practical.

The following should be used to determine the temporary guardrail length at each corner of a temporary bridge in a two-lane runaround. For a construction-zone design speed of 45 mph or lower, the minimum guardrail length is 50 ft. For a construction-zone design speed of 50 mph or higher, the minimum guardrail length is 100 ft.

A temporary guardrail run should continue until the guardrail warrant for an embankment as shown in Section 49-4.02 is satisfied. The design speed, and not the construction-zone design speed, should be used to determine the guardrail warrant for an embankment.

82-4.02(02) Temporary Traffic Barrier (TTB)

A TTB is used to provide protection to the motorist and the workers in the work zone. The primary functions of TTB are as follows:

1. to separate two-way traffic;
2. to protect workers and pedestrians;
3. to keep traffic from entering a work area (e.g., excavation, storage site); and
4. to protect construction elements (e.g., bridge falsework, exposed objects).

1. Types of TTB.

    a. Type 1. This type is used only to separate two-way traffic.

    b. Type 2. This type is used to separate traffic from the work zone. It should be used to protect traffic from an obstruction, including an elevation differential of greater than 6 in., which is inside the construction clear zone. It should also be used to shield traffic from an extreme hazard during construction that may necessitate consideration of a barrier between the construction clear zone and the permanent clear zone. For this situation, the designer should consider the construction-zone design speed, the extent of the obstruction, and the potential for an elevation differential, and use engineering judgment in determining whether a TTB is necessary.

c. Type 3. This is type 1 TTB which is to be left in place upon completion of the contract and becomes the property of the Department.

d. Type 4. This type is used as a readily-movable device to accommodate the shifting of traffic lanes possibly on a daily basis to better facilitate the directional distribution or other changing traffic volume during a day's peak traffic-volume hours. The barrier layout and signage for each phase, a staging-area diagram, and the location of the barrier-moving apparatus when it is not in use should be shown on the TCP. The size of the barrier-moving apparatus should be taken as 50 ft long by 16 ft wide.

2. Construction Clear Zone and Flaring Considerations. The terminal end of a TTB type 1, 2, or 4 should be flared away from the traveled way to a point outside the construction clear zone. Construction clear-zone width is shown in Figure 82-4B. The potentially hazardous conditions found within a construction zone warrant the use of considerable judgment when applying one of these widths. It is not necessary to adjust such width for horizontal curvature.

   Figure 82-4A, Flare Rate for Temporary Traffic Barrier, should be used to determine the desirable flare rate for the TTB based on the construction-zone design speed, and not a lower worksite speed limit.

   If a flared portion of TTB type 1 cannot be designed to end outside the construction clear zone, an acceptable construction-zone energy absorbing terminal as described in Section 82-4.02(03), Item 1, is required. A unit which has been successfully crash tested in accordance with NCHRP 350 Test Level 2 should be specified if the construction-zone design speed is 45 mph or lower. A unit which has been successfully crash tested in accordance with NCHRP 350 Test Level 3 should be specified if the construction zone design speed is 50 mph or higher.

   For a TTB type 2 or 4, if a field condition such as a public-road approach or drive renders the desirable flare rate impractical, the flare rate may range between 10:1 and 6:1. For a TTB type 2, the flare may be eliminated if the sharper flare rate cannot be attained. Such location and flare treatment should be shown on the TCP.

3. Glare Screen. A glare screen may be used in combination with TTB type 1 or type 3 to eliminate headlight glare from opposing traffic. The application is at a crossover transition or in a 2-way, 2-lane operation. Guidance regarding consideration of a glare screen is described in Section 49-4.05(03), though INDOT has not adopted specific warrants for the use of a glare screen.

4. Anchoring. TTB type 1, 2, or 3 should be anchored where indicated on the INDOT *Standard Drawings*. The locations of anchored TTB should be shown on the plans.

5. Traffic-Control-Plan Information. Types, locations, and quantities of TTB, including locations and quantities of glare screens and energy absorbing terminals, along with flare rates should be shown on the TCP for each traffic-maintenance phase.

See Section 17-3.13 for information regarding determination of pay quantities.

82-4.02(03) End Treatment or Impact Attenuator

The following discusses the end treatments or impact attenuators that may be used.

1. Energy-Absorbing Terminal. The use of a construction-zone energy-absorbing terminal should be based on National Cooperative Highway Research Program *Report 350* Test Levels. The Test Level 3 (TL-3) terminal should be specified for an Interstate or other route with a construction-zone speed limit of 50 mph or higher. The TL-2 terminal should be specified for a non-interstate route with a construction-zone speed limit of 45 mph or lower. If a lower temporary worksite speed limit is to occasionally apply, each terminal's Test Level should still correspond to that for the construction-zone speed limit. The location of each terminal with its Test Level should be shown on the TCP.

2. Guardrail. The treatment for an exposed end of guardrail includes the following:

   a. connection to existing barrier;
   b. using an acceptable end treatment. Use the construction year AADT, and see Section 49-5.04(01);
   c. flaring the end to a point outside the construction clear zone; or
   d. burying the end in the backslope.

3. Gravel-Barrel Array. Due to the size of the array, a gravel-barrel array has limited application in a work zone.

4. Other. Other INDOT-approved end treatments may be applicable. Chapter 49 provides information on some of the end treatments used by the Department. Provide the most applicable end treatment consistent with cost and geometric considerations.

82-4.03 Design/Layout

Where practical, a temporary roadside-safety appurtenance should be designed and located as determined in Chapter 49 (e.g., deflection distance, length of need). However, it is not cost effective to satisfy the permanent-installation criteria due to the limited time a motorist is exposed to a construction hazard. The designer will need to evaluate the exposure time of the hazard in determining the need for installing a roadside-safety appurtenance. The following provides alternatives the designer may consider in designing and locating a temporary roadside-safety appurtenance within a construction zone.

1. Construction Clear Zone. Applying the clear-zone width as described in Chapter 49 to a work zone is often impractical. Therefore, construction clear-zone width is shown in Figure 82-4B. However, the potentially hazardous conditions found within a construction zone warrant the use of engineering judgment in applying the construction clear-zone distance. It is not necessary to adjust the clear-zone-width value shown in Figure 82-4B for horizontal curvature.

2. Shoulder Widening. Where a temporary barrier is placed adjacent to a shoulder, it is not necessary to provide extra shoulder widening.

3. Flare Rate. A TCB terminal should be flared beyond the traveled way to a point outside the construction clear zone. Figure 82-4A provides the desirable flare rate for the TCB based on the selected construction-zone design speed. The designer should provide the flare rate unless extenuating circumstances render it impractical (e.g., stop condition, drive, intersection). See Section 82-4.03.

4. Opening. An opening in the barrier should be avoided. Where an opening is necessary, the barrier end should be shielded with acceptable end treatment as discussed in Section 83-4.03(03).

82-4.04 Pavement Edge Dropoff on Multilane Divided Highway

A pavement edge dropoff should be avoided immediately adjacent to a lane open to traffic during a construction activity such as shoulder rehabilitation or crossover construction.

In developing a traffic-maintenance plan, the desirable option is to close the lane adjacent to an edge dropoff. This will ensure that the edge dropoff is located outside the construction clear zone.

If the traffic lane adjacent to the edge dropoff cannot be closed for an extended period of time, a full-depth rehabilitated shoulder section should be provided that can be placed to within 3 in. of the top of pavement elevation before the end of a day's work. This should be done, for example, where the shoulder work is to be done at night so that all of the existing traffic lanes can be kept open during daylight hours. The pavement section required to fill a shoulder dropoff to within 3 in. of the top before exposure to adjacent traffic should be obtained from the Office of Pavement Engineering. A unique special provision will be required to address the time frame imposed on the contractor for bringing the shoulder paving up to the required grade. Also, drums should be placed on the shoulder dropoff, spaced as shown in Figure 83-3D, Suggested Maximum Spacing of Channelization Devices.

Where it is not feasible to limit exposure to the edge dropoff by the means described above, and the edge dropoff is greater than 3 in., one of the mitigating measures should be considered as follows:

1. Placing a temporary wedge of material along the face of the dropoff. The wedge should consist of asphalt material placed at a 45-deg angle or flatter. Warning signs should be placed in advance of and throughout the treatment. A 6-in. width solid edge line should be used to delineate the edge of the travel lane.

2. Placing drums along the traffic side of the dropoff and maintaining, if practical, a 3-ft width buffer between the edge of the travel lane and the dropoff. Warning signs should be placed in advance of and throughout the treatment.

3. Installing a temporary concrete barrier or other acceptable positive protection device with a buffer between the barrier face and the traveled way. An acceptable crashworthy terminal or flared barrier should be installed at the upstream end of the section. For nighttime use, standard delineation devices must supplement the barrier. Specifying the use of a temporary movable concrete barrier system will involve the use of proprietary materials.

If the work is to include deep milling or asphalt-pavement replacement, and the dropoff between adjacent lanes is greater than 1.5 in., mitigating measure No. 1 or No. 2 should be considered.

82-5.0 HIGHWAY CAPACITY

82-5.01 Traffic-Capacity Analysis

The need for a traffic-capacity analysis during the development of the TCP will be determined on a project-by-project basis. A freeway reconstruction project is a candidate for analysis, as is another project type under similar conditions. Maintaining an acceptable level-of-service during construction is especially important on a freeway or other high-speed rural highway.

The operational elements of a facility under construction (e.g., lane segments, ramp, intersection) should maintain a level-of-service which is not less than that provided by the facility prior to construction, although this is not always attainable. Achieving this may require the following:

1. converting a shoulder to a travel lane;
2. eliminating on-street parking (during peak traffic-volume hours or at all times);
3. constructing a temporary lane;
4. opening additional lanes during peak traffic-volume periods;
5. providing public transportation;
6. constructing a jug-handle type configuration for an indirect left-turn at an intersection;
7. closing or metering ramps at an interchange;
8. providing a turnout along long, restrictive stretch of highway construction;
9. constructing a passing blister at a T intersection;
10. providing a two-way, left-turn lane on an urban facility;
11. adjusting signal phasing and timing at an intersection;
12. providing an additional turn lane at an intersection;
13. lengthening a turn-lane storage bay;
14. adjusting acceleration or deceleration length at an interchange ramp;
15. closing an intersection;
16. restricting turns at an intersection;
17. providing extra pavement width;
18. providing signal or flagger control in a 1-lane, two-way operation;
19. public information; or
20. providing a temporary ramp connection.

82-5.02 Queuing Analysis

A TCP developed for a freeway reconstruction project should include, at a minimum, a queuing analysis to determine the anticipated traffic backups at particular times of the day. The results of the queuing analysis should be included with the proposed TCP and should be used to determine whether or not to consider the following:

1. restricting construction operations to off-peak traffic-volume hours or nighttime;
2. closing a ramp;
3. using alternate routes;
4. developing public relations strategies; or
5. temporary widening for an extra lane or for roadway capacity.

If a queuing analysis is required, the designer should use the FHWA computer program QUEWZ or other approved program to accomplish the task. QUEWZ is designed to evaluate a freeway work zone, but the designer may find it useful for another type of highway with 4 or more lanes. Section 81-4.0 provides additional information on the program. The program can provide the following:

1. estimation of vehicular capacity through a work zone;
2. calculation of average speed;
3. calculation of delay through a lane-closure section;
4. calculation of queue length;
5. estimate of percentage of diverted traffic; and
6. total user cost.

82-6.0 APPLICATIONS

Section 81-2.0 discusses the factors to consider in determining which construction application to use. The following provides the design considerations for such applications.

82-6.01 Lane or Shoulder Closure

In addition to the INDOT *Standard Drawings*, the designer should consider the following for a lane or shoulder closure.

1. Taper. A lane closure, lane-width reduction, or lane shift requires the use of a transition taper to safely shift traffic around the encroaching restriction. The designer should review Sections 82-3.03 and 83-3.02 regarding a transition taper.

2. Sight Distance. Provide decision sight distance to the beginning of the lane closure or transition. Section 82-3.04 provides additional information on sight distance within a construction zone.

3. Lane Width. Section 82-3.02 provides the Department's criteria for reduced lane width.

4. Shoulder Usage as Travel Lane. If the TMP involves placement of traffic on the shoulder or a portion of the shoulder, the designer should make a written request to the Office of Pavement Engineering, regarding the shoulder's use. The construction year AADT, percent trucks of AADT, and the approximate length of time during which traffic is expected to use the shoulder should be provided.

   The median shoulder should be replaced with a 6-ft width section. See the INDOT *Standard Drawings.* The proposed median shoulder for the new pavement section constructed in the first phase should also be 6 ft wide. Its pavement design should be provided by the Office of Pavement Engineering. Such shoulder will carry traffic during subsequent phases. The entire 6-ft width should remain in place. Shoulder corrugations are to be milled into the new shoulder after traffic is crossed over to the other roadway.

5. Lane Closure. The length of a lane closure should be held to a minimum so that the motorist is not passing a long section of a closed lane where no work activity is occurring.

6. Roadside Safety. A roadside barrier should not be used as a transition device. A transition should be provided with the appropriate traffic-control devices (see Chapter 83). Provide sufficient distance between the transition devices and roadside barrier to allow an errant motorist to safely return to the traveled way. A roadside barrier (e.g., temporary traffic barrier) may be used as a channelization device beyond the taper. When shifting traffic to be next to a roadside barrier, the shy distance, as discussed in Section 49-5.0, should be provided.

7. Traffic-Control Devices. Chapter 83 and the INDOT *Standard Drawings* provide the Department's criteria for the placement of traffic-control devices.

8. Bridge. Figure 82-6A, Lane Closure on a Bridge, illustrates a TCP for closing a lane on a bridge-reconstruction or -rehabilitation project. Figure 82-6A is applicable to a 30-ft wide structure on a 4-lane divided facility. The designer will need to adjust the design for another situation. Figure 82-6A provides the detail for a left-lane closure. This detail may also be used for a right-lane closure.

9. Roadway Under Overpass Structure. Work may include full-depth bridge-deck patching, structure removal or placement not protected by a bridge railing, or other work activity that affects under passing lanes that are open to traffic. Such work may not take place directly above such lanes. Appropriate warning signs and traffic-control devices should be provided

on the under passing roadway to warn motorists of lane closures for such work. Such signs and devices are required if no work is being done on the under passing roadway.

82-6.02 Two-Way Traffic on a Divided Highway

The following provides the considerations for where two-way traffic is to be placed onto a single roadway of a divided highway.

1. Length. The optimum segment length is less than 4 mi. Where the segment length exceeds 4 to 5 mi, operational efficiency may be severely reduced as traffic backs up behind slower vehicles.

2. Positive Protection.

   a. Freeway. Temporary traffic barrier along with temporary solid yellow lines as shown on the INDOT *Standard Drawings* should be used within each crossover and between the crossovers to separate opposing traffic.

   b. Other Multilane Roadway. Tubular markers should be used to enhance the delineation and separation of the opposing traffic flows on each side of a temporary double solid yellow line. The tubular markers are placed onto the pavement between the solid yellow lines as shown on the INDOT *Standard Drawings*.

      Where construction activities require temporary revision of traffic patterns within the construction zone to two-lane two-way operation at or near an intersection, the end of the temporary double solid yellow line should match the end of the existing broken white lane line.

      For a roadway with lanes which are narrower than 12 ft without paved or aggregate shoulders, compacted aggregate size No. 73 is required where slope and ditch conditions permit, as shown on the INDOT *Standard Drawings*. Such conditions must be assessed when developing the traffic-control plan. The cross slope of each temporary compacted aggregate shoulder is to be as shown on the INDOT *Standard Drawings*. Quantities for the compacted aggregate must be determined.

3. Roadside Safety. Where traffic is directed onto the opposing roadway, the designer should consider the effect this will have on the operational characteristics of roadside appurtenances. For example, an existing trailing end of an unprotected bridge railing may require an

approach-guardrail transition or impact attenuator. A blunt guardrail terminal may need to be protected with an acceptable end treatment.

4. Crossover. The following should be considered in the design of a crossover.

   a. The taper for a lane drop should not be contiguous with the crossover. See Section 82-3.03 for the acceptable taper rate and length.

   b. The crossover should have a construction-zone design speed that is not more than 10 mph below the posted speed limit before the construction zone; see Section 82-3.01.

   c. The crossover design should accommodate the anticipated truck traffic of the roadway (e.g., surfacing width, loads).

   d. A clear recovery area should be provided adjacent to the crossover; see Section 82-4.04.

   e. Temporary traffic barrier and the excessive use of traffic-control devices cannot compensate for a poor geometric design of a crossover.

   f. Provide signing prior to the crossover to indicate the length of the 2-way, 2-lane section. In addition, signing may be provided within the 2-lane section indicating the remaining distance of the 2-lane section.

5. Interchange. Maintain access to a freeway interchange ramp if the work space is in the lane adjacent to the ramps. An additional crossover for the purpose of maintaining full interchange access may be required. If interchange access is not feasible or presents a capacity problem, a ramp should be closed using proper detour signing for alternative routes. Where a ramp closure is deemed necessary, early coordination should be conducted with local officials having jurisdiction over the affected crossroad or street. The designer should also check that sufficient deceleration or acceleration distance is maintained where there is work in the vicinity of an interchange ramp. If this is not practical, additional traffic control devices or closing the ramp may be required. The designer should review the safety aspects and conduct a capacity analysis to determine the appropriate action.

7. Capacity. Conduct a capacity analysis to ensure that traffic can be reasonably handled in the one lane. If not, an alternate construction application should be considered (e.g., lane shift to the shoulder).

The needs of a left-turning motorist should be considered in developing a phased-construction scheme that reduces a 4-lane road to one lane in each direction.

82-6.03 Interstate Highways Congestion Policy [Rev. Feb. 2012]

It is Department policy to prohibit operations which restrict lanes or otherwise cause congestion to occur on an Interstate Route. Such operations may not be conducted except as described in the Interstate Highways Congestion Policy (IHCP). Policy exceptions and waivers are processed through the Office of Traffic Support, Work Zone Safety Section. Waivers to a prior Interstate Lane Closure Policy remain valid.

The IHCP is available for download at http://www.in.gov/indot/2731.htm.

82-6.04 Runaround or Detour

In addition to the criteria shown on the INDOT *Standard Drawings*, a temporary runaround or specially-built detour should satisfy the geometric and roadside-safety criteria provided in Sections 82-3.0 and 82-4.0.

The embankment for a temporary runaround should be shown on the mainline cross sections.

If the AADT is 5,000 or greater, or if the percent trucks is 10% or greater, a project-specific pavement design is required for a temporary runaround. See the INDOT *Standard Drawings* for the pavement section to be used if the AADT is less than 5000, or if the percentage of trucks is less than 10%.

** *PRACTICE POINTER* **

Unofficial detour routes should not be shown
on the plans or described in the special provisions.

A temporary runaround should be in accordance with the design criteria included herein. The following Level One elements should satisfy the criteria as follows.

	Element	Design Criterion
1.	Design speed	Section 82-3.01
2.	Lane width	Section 82-3.02
3.	Shoulder width	Section 82-3.02
4.	Bridge width	Standard Specifications Section 713.04
5.	Structural capacity	Standard Specifications Section 713.04
6.	Horizontal curvature	Figure 82-3A
7.	Superelevation transition length	Section 82-3.05 and Chapter 43
8a.	Stopping sight distance at horizontal curve	Section 82-3.04. Design speed should be used in the construction zone. Section 43-4.0
8b.	Stopping sight distance at vertical curve	Sag: Section 82-3.06; Crest: Section 82-3.04 and Chapter 44.
9.	Maximum grade	3R criteria for the design speed for the construction zone, appropriate functional classification, and rural or urban environment.
10.	Through lane cross slope	3R criteria for the appropriate functional classification and rural or urban environment. If the existing shoulder is used for through traffic, 4% cross slope will be acceptable.
11.	Superelevation rate	Section 82-3.05
12.	Vertical clearance	3R criteria for the appropriate functional classification.
13.	Americans with Disabilities Act requirements	Section 51-1.08, where sidewalk exists prior to construction.
14.	Bridge-railing safety performance	Standard Specifications Section 713.04

If the design for a temporary runaround or other traffic-maintenance means does not satisfy the above criteria, a design exception must be requested. The procedure established in Section 40-8.0 should be followed.

The INDOT reviewer should verify that the above criteria are satisfied as part of the limited review of a consultant-designed project.

A TCP checklist is shown as Figure 82-7A. An editable version of this form may also be found on the Department's website at www.in.gov/dot/div/contracts/design/dmforms/.

Participant	Project Stage				
	Scoping of Project	Prelim. Field Check	Hearing	Final Field Check	Final Plan Review
Designer	X	X	X	X	X
Office of Environmental Services	X	X	X	X	X
Consultant (if applicable)		X	X	X	X
District	X	X		X	X
Federal Highway Administration (if applicable)	X	X		X	
Communications Division (if applicable)	X		X	X	
Local Public Agency (City or Town, County, School, Fire Department)	X	X	X		X
Highway Operations Division (TMP)	X	X		X	

PARTICIPANTS DURING TRAFFIC-CONTROL-PLAN DEVELOPMENT

Figure 82-2A

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TRAFFIC-MAINTENANCE QUESTIONNAIRE
English-Units Project

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MEMORANDUM

TO:
District Deputy Director

ATTENTION:
District Traffic Office Manager

ATTENTION:
District Design Office Manager

FROM:
Project Manager

SUBJECT: Traffic Maintenance for English-Units Project

Route:
Des.:
Project No.:
Bridge File:
Location:
County:
Description:

We are preparing plans for the project identified above and are in the process of evaluating the relative merits of a temporary bridge and runaround, maintaining traffic through the project limits, or a detour during the construction period. In order that district input may be considered in this decision, we ask that you complete the blanks in this memorandum and return it to:

Project Manager
Indiana Department of Transportation
100 North Senate Ave., Room N642
Indianapolis, IN 46204-2216

If a detour is recommended, please submit the official detour map and signage with this memorandum with the blanks filled in. If the official detour route is totally over local roads, please initiate early coordination with the affected local public agency or agencies regarding the unofficial detour route.

The Engineer's Report recommended the following:
a temporary runaround should be used;

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traffic should be maintained through the project limits;
an official detour should be used.

The AADT during the construction year is

A. TRAFFIC-MAINTENANCE OPTIONS ANALYSIS

1. OPTION 1: TEMPORARY RUNAROUND

RUNAROUND COMPUTATIONS FURNISHED BY DESIGNER

Length of Runaround, ft* x Cost per Foot**	ft x $ = $
Length of Temporary Bridge x $1,000/ft or Cost of Pipe	ft x $1,000 = $ $
Total Runaround Cost (Total Cost Option 1)	$

* Length of Runaround = Distance from tie-in point to tie-in point minus Length of Temporary Bridge.

** For average fill height ≤ 6 ft, use $120/ft
For average fill height > 6 ft, increase as necessary

2. OPTION 2: TRAFFIC MAINTAINED THROUGH PROJECT LIMITS

Length of Roadway Treatment, ft* x Cost per Foot*	ft x $ = $
Length of Temporary Concrete Barrier x Cost per Foot	ft x $ = $
Cost of Crossovers	$
Total Maintained-Traffic Cost (Total Cost Option 2)	$

3. OPTION 3: INDOT-ROUTES OFFICIAL DETOUR

a. Best available official detour route over INDOT routes:

b. Extra distance to be traveled by through traffic using this route: mi

c. Percent of the traffic which would use this detour route: %

d. Road(s) that would be used as an unofficial detour route:

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(1) Existing condition and type of pavement for each road, (i.e., good, very good, rutted, gravel, asphalt, etc.)

(2) Distance over the above unofficial detour route: mi

INDOT-ROUTES OFFICIAL-DETOUR COMPUTATIONS

Detour	Through	Local
Detour Duration (days)		
Extra Distance (mi)		
Vehicles per Day		
User Cost per Mile	$0.30	$0.30
Total User Cost	$	$

User Cost = Detour Duration x Extra Distance x Vehicles per Day x $0.30/mi

e. Total User Cost = Through User Cost + Local User Cost. Therefore, Total User Cost = $.

f. Estimated payment to local public agencies due to use of unofficial detour route = $.

Total Cost Option 3 (e + f) $

4. OPTION 4: LOCAL-ROADS OFFICIAL DETOUR

a. Best available official detour route over local roads. It is feasible for this route to include one or more INDOT routes.

b. Extra distance to be traveled by through traffic using this route: mi

c. Percent of the traffic which would use this detour route: %

d. Cost to upgrade the local roads to accommodate INDOT traffic:
$

e. Existing condition and type of pavement for each road. (i.e., good, very good, rutted, gravel, asphalt, etc.)

LOCAL-ROADS OFFICIAL DETOUR COMPUTATIONS

Detour	Through	Local
Detour Duration (days)		

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Extra Distance (mi)		
Vehicles per Day		
User Cost per Mile	$0.30	$0.30
User Cost	$	$
Cost to Improve Local Roads (See Item 3b)	$	n/a

User cost = Detour Duration x Extra Distance x Vehicles per Day x $0.30/mi

Total User cost = Through User Cost + Local User Cost + Cost to Improve Local Roads. Therefore, Total Cost Option 4 = $

B. AFFECTS OF PROJECT WORK ON PUBLIC SERVICES

1. TIME DELAYS
   Fire and police protection: min
   Emergency medical service: min
   Postal service: min

2. SCHOOL BUSES
   Number of school buses using the facility per day:
   Additional travel distance required per bus: mi
   Total additional school-bus travel distance required mi

3. BUSINESSES AND PUBLIC FACILITIES
   Businesses or public facilities which are sensitive to the presence of this road work, and the degree of impact the work would have:

C. DISTRICT RECOMMENDATION

1. RECOMMENDATION:
   Rationale for this recommendation if it is different than what is included in the Engineer's Report:

2. DETOUR ROUTE MARKER ASSEMBLIES:
   If an official detour is recommended, detour route marker assemblies will be required.

3. MAP OF OFFICIAL DETOUR:
   If an official detour is recommended, a map of the detour with sign locations is shown on an accompanying sheet.

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Construction Zone Design Speed, V (mph)	f_{max} for Open-Roadway Conditions	Normal Crown Section Minimum Radius, R_{min} (ft), e = -0.02	Superelevated Section Minimum Radius, R_{min} (ft), e= +0.08
20	0.17	180	110
25	0.17	280	170
30	0.16	430	250
35	0.15	630	360
40	0.15	820	470
45	0.14	1130	620
50	0.14	1390	760
55	0.13	1840	960

Notes:

1. *Curve Radius. The radius is calculated from the equation as follows:*

$$R_{\min} = \frac{V^2}{15(e + f_{\max})};$$

Value shown in the table for design has been rounded up to the next higher 10-ft increment.

2. *Normal-Crown Section. If the normal-crown section is maintained through the horizontal curve, the superelevation rate is -0.02 assuming a typical cross slope of 2%. Therefore, the R_{min} column with e = -0.02 lists the minimum radius which can be used if retaining the normal section through the horizontal curve.*

3. *Other Radius. For a proposed radius or superelevation rate intermediate between the table values, the equation in Note 1 may be used to determine the proper curvature layout. For example, if the construction-zone design speed is 55 mph and the proposed curve radius is 1000 ft, the superelevation rate is determined as follows:*

$$e = \frac{V^2}{15R} - f$$

$$e = \frac{(55)^2}{(15)(1000)} - 0.12$$

$$e = +0.07$$

MINIMUM RADIUS FOR HORIZONTAL CURVE IN CONSTRUCTION ZONE

Figure 82-3A

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Construction-Zone Design Speed (mph)	Calculated *K* Value ($K = V^2/46.5$)	*K* Value Rounded For Design
20	8.6	9
25	13.4	14
30	19.4	20
35	26.3	27
40	34.4	35
45	43.5	44
50	53.8	54
55	65.1	66

$$L = \frac{AV^2}{46.5} = KA$$

Where:

L = *Length of vertical curve, ft*
A = *Algebraic difference between grades, %*
K = *Horizontal distance required to effect a 1% change in gradient*
V = *Design speed, mph*

_K_ VALUE FOR SAG VERTICAL CURVE
(Comfort Criteria in a Construction Zone)

Figure 82-3B

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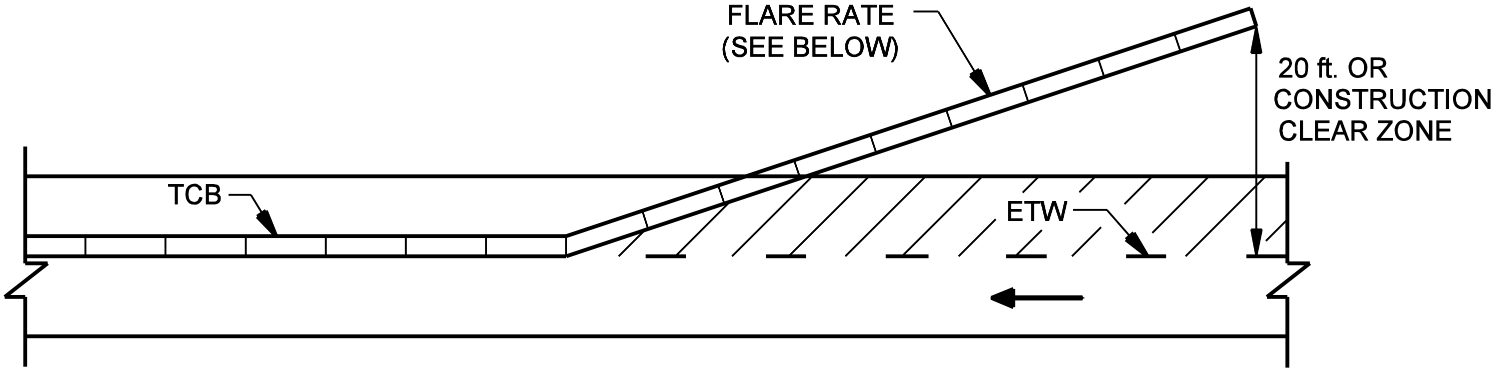

Construction Zone Design Speed (mph)	Flare Rates
≤ 40	10:1
45	12:1
50	14:1
55	16:1

FLARE RATES FOR TEMPORARY CONCRETE MEDIAN BARRIER
(Construction Zones)

Figure 82-4A

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Construction-Zone Design Speed	Cut Slope					Fill Slope			
	3:1	4:1	5:1	6:1	Flatter Than 6:1	6:1	5:1	4:1	3:1
40 mph or lower	8	8	8	8	8	8	8	10	See Note 2
45 mph	8	8	8	8	8	10	10	12	
50 mph	8	10	10	10	10	12	13	15	
55 mph	8	12	12	12	12	13	15	18	

Notes:

1. *Width is measured from the edge of traveled way.*

2. *For a facility with 3:1 fill slopes, the clear-zone width shown above should be used in conjunction with the procedures described in Section 49-2.03(01).*

CLEAR-ZONE WIDTH (ft)
FOR CONSTRUCTION ZONE

Figure 82-4B

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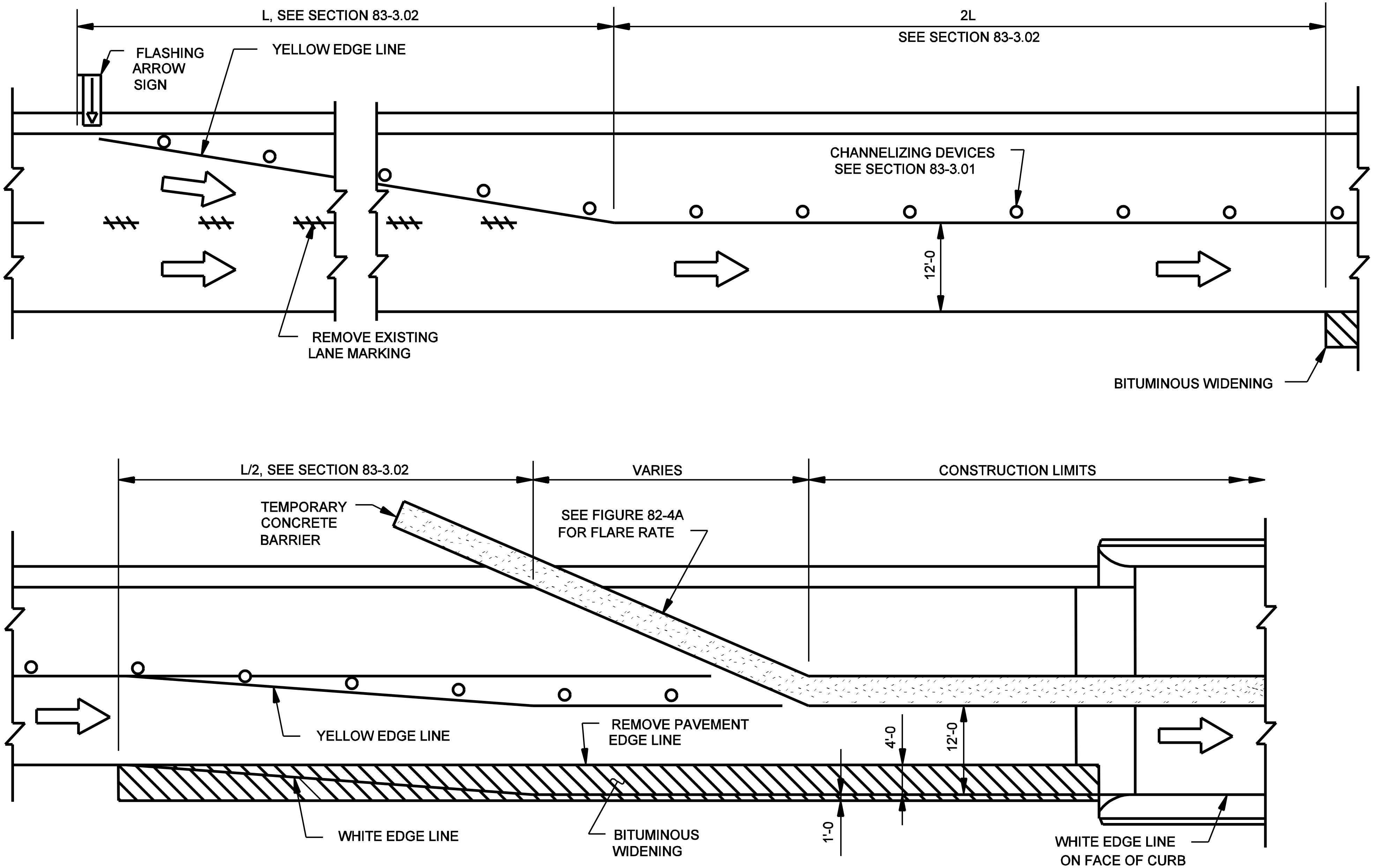

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LANE CLOSURES ON BRIDGES

Figure 82-6A

This figure deleted.

For related information, see the Interstate Highways Congestion Policy (IHCP), available for download at http://www.in.gov/indot/2731.htm.

INTERSTATE LANE CLOSURE POLICY – STATEWIDE
Figure 82-6B

This figure deleted.

For related information, see the Interstate Highways Congestion Policy (IHCP), available for download at http://www.in.gov/indot/2731.htm.

INTERSTATE LANE CLOSURE POLICY – SELECTED URBAN AREAS
Figure 82-6C

TRAFFIC-CONTROL-PLAN CHECKLIST Route Des GENERAL INFORMATION	YES	NO	n/a	On Plans
1. Has a transportation management plan been developed?	☐	☐	☐	☐
a. Have all recommendations been implemented?	☐	☐	☐	☐
b. Has Environmental Policy Team been notified of major changes?	☐	☐	☐	☐
2. Have all applicable work-zone types listed below been adequately considered?				
a. Work outside of roadway	☐	☐	☐	☐
b. Lane constriction	☐	☐	☐	☐
c. Lane closure	☐	☐	☐	☐
d. One-lane, two-way operation	☐	☐	☐	☐
e. Runaround	☐	☐	☐	☐
f. Intermittent closure	☐	☐	☐	☐
g. Use of shoulder or median as travelway	☐	☐	☐	☐
h. Crossovers	☐	☐	☐	☐
i. Two-way traffic on one roadway of divided facility	☐	☐	☐	☐
j. Detour	☐	☐	☐	☐
3. Has all information listed below been incorporated into the contract plans?				
a. INDOT *Standard Drawings*	☐	☐	☐	☐
b. INDOT *Standard Specifications*	☐	☐	☐	☐
c. Recurring special provisions	☐	☐	☐	☐
d. Unique special provisions	☐	☐	☐	☐
e. Detail plans	☐	☐	☐	☐
4. Will extra publicity be required prior to letting (e.g., radio, T.V., newspaper, clubs)?	☐	☐	☐	☐
5. The contractor can restrict the roadway during:				
a. Morning or evening rush hour				
i. One direction	☐	☐	☐	☐
ii. Both directions	☐	☐	☐	☐
b. Local celebration	☐	☐	☐	☐
c. Holidays or weekends	☐	☐	☐	☐
d. Other special event:	☐	☐	☐	☐
e. Overnight	☐	☐	☐	☐
6. Nighttime hours of operation required? If Yes, When?	☐	☐	☐	☐
a. Between p.m. and a.m.				
b. Are special precautions needed (e.g., lighting, clearance lights on equipment)?	☐	☐	☐	☐

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GENERAL INFORMATION (Cont'd.)		YES	NO	n/a	On Plans
7.	Are there changes that cannot be made concurrently for traffic routing, fire, police, etc.? If Yes, What?	☐	☐	☐	☐
8.	Can two adjacent street or road crossings be closed at the same time? If Yes, where or which ones?	☐	☐	☐	☐
9.	Will the source of material from off the project site interfere with traffic?	☐	☐	☐	☐
	a. On and off project limits	☐	☐	☐	☐
	b. Certain roads may not be used (e.g., environmental, recreational). If Yes, which ones?	☐	☐	☐	☐
10.	Is the contractor required to provide advance notice for a change in traffic pattern?	☐	☐	☐	☐
11.	The starting or completion date is controlled by:				
	a. School closings or openings	☐	☐	☐	☐
	b. Holiday:	☐	☐	☐	☐
	c. Other projects	☐	☐	☐	☐
	d. Sporting event:	☐	☐	☐	☐
	e. Other:	☐	☐	☐	☐
12.	Are there present or future contracts in the immediate area that may affect traffic or the Contractor's operations?	☐	☐	☐	☐
DETOUR		YES	NO	n/a	On Plans
1.	Will traffic be detoured? If Yes, is the detour adequate in terms of:	☐	☐	☐	☐
	a. Weight restriction	☐	☐	☐	☐
	b. Height – width	☐	☐	☐	☐
	c. Wide load	☐	☐	☐	☐
	d. Capacity	☐	☐	☐	☐
	e. Adequate traffic-control devices	☐	☐	☐	☐
	f. Railroad crossing and controls	☐	☐	☐	☐
	g. Geometrics (turning radius, etc.)	☐	☐	☐	☐
	h. Restriction on bridge or other structure	☐	☐	☐	☐
	If No for a. through h., what correctives can be taken?				
2.	Will trucks using the detour conflict with other traffic using the detour?	☐	☐	☐	☐

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DETOUR (Cont'd.)	YES	NO	n/a	On Plans
3. Will there be other construction along the detour that can influence traffic flow?	☐	☐	☐	☐
4. Have other affected Districts or States been notified?	☐	☐	☐	☐
5. If the detour is to be established on other than a State highway, has contact been made with:				
a. County?	☐	☐	☐	☐
b. City?	☐	☐	☐	☐
c. Town?	☐	☐	☐	☐
6. Will there be an unofficial detour?	☐	☐	☐	☐
If Yes, has a Letter of Understanding been sent to the local officials?	☐	☐	☐	☐
7. Will all fronting businesses have acceptable ingress and egress?	☐	☐	☐	☐
8. Can the detour be continued over winter (snow removal)?	☐	☐	☐	☐
9. Are alternate routes available to local motorists?	☐	☐	☐	☐
10. Should the following be contacted?				
a. Public-school system	☐	☐	☐	☐
b. Public-transit system	☐	☐	☐	☐
c. Police, fire, or ambulance services	☐	☐	☐	☐
d. Postal mail-route service	☐	☐	☐	☐
e. Others:	☐	☐	☐	☐
If any Yes, list who and when, with telephone numbers.				
11. Has the District established a detour route?	☐	☐	☐	☐
WORK ZONE	**YES**	**NO**	**n/a**	**On Plans**
1. Will capacity be restricted? If Yes, what is extent of restriction?	☐	☐	☐	☐
a. Where will excess traffic be diverted?				
b. Can an alternate route handle the traffic?	☐	☐	☐	☐

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WORK ZONE (Cont'd.)		YES	NO	n/a	On Plans
2. How will staging be addressed (e.g., lengths of times of permitted construction)?					
	a. As shown on plans	☐	☐	☐	☐
	b. Have the contractor provide a plan	☐	☐	☐	☐
	c. The contractor may stage work differently than shown on plans	☐	☐	☐	☐
3. Where runaround or temporary widening is required:					
	a. What criteria should be applied regarding:				
	i. Design speed? mph ii. Lane widths? ft iii. Alignment? iv. Pavement thickness? in. v. Pedestrian traffic?				
	b. Has the location been determined?	☐	☐	☐	☐
4. Number of lanes maintained in each direction:					
	a. At all times, ☐ One ☐ Two				
	b. During rush hours, ☐ One ☐ Two ☐ Three				
	c. Reversible lanes required, ☐ One ☐ Two				
5. What is the facility's traffic-carrying capability considering the effect of winter:					
	a. Adequate	☐	☐	☐	☐
	b. Special traffic-control devices are required	☐	☐	☐	☐
	c. Procedure modifications are necessary for snow removal and maintenance	☐	☐	☐	☐
	d. Modifications are required to the pavement structure:				
	i. HMA Base	☐	☐	☐	☐
	ii. HMA Base and Surface	☐	☐	☐	☐
TRAFFIC-CONTROL DEVICES		YES	NO	n/a	On Plans
1. Traffic-control signing layout will be:					
	a. Shown on the plans	☐	☐	☐	☐
	b. Available prior to contract letting	☐	☐	☐	☐
	c. Consisting of special traffic delay or advance signs	☐	☐	☐	☐
	d. That for temporary crossover, designed to match INDOT *Standard Drawings*	☐	☐	☐	☐
2. Will the effects of construction operation require sign message modifications to permanent signage?		☐	☐	☐	☐

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TRAFFIC-CONTROL DEVICES (Cont'd.)	YES	NO	n/a	On Plans
3. Are temporary traffic signals required?	☐	☐	☐	☐
a. Equipment type:				
i. Manual	☐	☐	☐	☐
ii. Fixed timed	☐	☐	☐	☐
iii. Actuated	☐	☐	☐	☐
b. Will existing signals need to be kept operational?	☐	☐	☐	☐
c. Has an agreement been reached with the local municipality?	☐	☐	☐	☐
4. Will temporary street lighting be needed? If Yes, what type of equipment?	☐	☐	☐	☐
a. Wood poles	☐	☐	☐	☐
b. Breakaway poles	☐	☐	☐	☐
c. Agreement with power company required?	☐	☐	☐	☐
5. Which temporary pavement markings are required?				
a. Paint	☐	☐	☐	☐
b. Tape	☐	☐	☐	☐
c. Raised pavement markers	☐	☐	☐	☐
6. Striping removal required of:				
a. Center line / Lane lines	☐	☐	☐	☐
b. Right edge line	☐	☐	☐	☐
c. Left edge line	☐	☐	☐	☐
d. Both edge lines	☐	☐	☐	☐
7. Flashing warning lights required for:				
a. Equipment kept overnight within 30 ft of traveled way	☐	☐	☐	☐
b. All barricades and warning signs	☐	☐	☐	☐
c. Construction roadside hazards	☐	☐	☐	☐
8. Steady-burn warning lights required for:				
a. Edge of travelway, dropoff of in.	☐	☐	☐	☐
b. Channelizing traffic	☐	☐	☐	☐
9. Have speed limits been considered? If Yes, what limits?	☐	☐	☐	☐
a. Work zone, mph				
b. Worksite, mph				
c. Minimum, mph				
d. Advisory, mph				

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ROADSIDE SAFETY	YES	NO	n/a	On Plans
1. Temporary barriers				
a. Required for traffic protection	☐	☐	☐	☐
b. Required for workers' protection	☐	☐	☐	☐
c. Delineation of barriers provided by:				
i. Electrical devices	☐	☐	☐	☐
ii. Reflectorization	☐	☐	☐	☐
d. Upon completion of project, retained by:				
i. Department	☐	☐	☐	☐
ii. Contractor	☐	☐	☐	☐
2. Will temporary impact attenuators be required? If Yes, Type	☐	☐	☐	☐
3. Extra protection will be required for:				
a. Pedestrians	☐	☐	☐	☐
b. School area and crossings	☐	☐	☐	☐
c. Playground or park	☐	☐	☐	☐
d. Type of protection:				
4. Where may the contractor store equipment, construction material, or waste material?				
a. On site with flashers or other protection	☐	☐	☐	☐
b. 30 ft or more from edge of traveled way	☐	☐	☐	☐
c. Designated storage site	☐	☐	☐	☐
5. Where may contractor's employees park personal vehicles?				
a. On-site	☐	☐	☐	☐
b. Off-site	☐	☐	☐	☐

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NOTE: This chapter is currently being re-written and its content will be included in Chapter 503 in the future.

CHAPTER 83

Traffic Control Devices in a Construction Zone

Design Memorandum	Revision Date	Sections Affected
16-06	Mar. 2016	Section 83-5.0, Figure 83-5A
18-10	May 2018	83-4.01(03), 83-4.02

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CHAPTER 83

TRAFFIC CONTROL DEVICES IN A CONSTRUCTION ZONE

83-1.0 GENERAL

The proper use of traffic control devices is critical to both public and worker safety and has been proven to significantly reduce accidents in a construction zone. This Chapter provides supplemental information on these devices and provides specific Department policies and procedures. For additional information, the designer is encouraged to review the references listed in Section 83-1.01.

83-1.01 References

For additional information on the design, application, and placement of traffic control devices in a work area, the designer is referred to the latest editions of the publications as follows:

1. *Manual on Uniform Traffic Control Devices* (*MUTCD*), FHWA;
2. INDOT *Standard Drawings*;
3. INDOT *Standard Specifications*;
4. *Indiana Design Manual,* Section 502-1.0 – Roadway Signing;
5. *Indiana Design Manual,* Section 502-2.0 – Pavement Markings;
6. *Indiana Design Manual,* Section 502-3.0 – Traffic Signals;
7. *Indiana Design Manual,* Section 502-4.0 – Highway Lighting.

The INDOT publications can be obtained by contacting the Contract Administration Division. For other publications, the indicated source should be contacted.

83-1.02 MUTCD Context

Throughout the *MUTCD*, the words shall, should, and may are used to describe the appropriate application each traffic-control device. The *MUTCD* defines the terms as follows:

1. Shall. A mandatory condition. Where certain requirements in the design or application of a device are described with the "shall" stipulation, it is mandatory that if an installation is made that these requirements be met.

2. Should. An advisory condition. Where the word should is used, it is considered to be advisable usage, recommended but not mandatory.

3. May. A permissive condition. No requirement for design or application is intended.

83-1.03 Official Action

An Official Action is required before installing a regulatory temporary traffic control device, if a proposed change is made to a facility's regulatory control. For example, an Official Action is required where a proposed change is made regarding a parking restriction, intersection control, no-passing zone, traffic signal, or work-zone speed limit. However, Indiana Statutes provide for the establishment of an enforceable reduced speed limit in a work site without an Official Action (see Section 83-2.03). For a State-controlled facility, the designer must contact the appropriate INDOT district Traffic Engineer and obtain a copy of the approved Official Action, and include it in the contract documents. For a locally-controlled facility, approval (i.e., local ordinance) must be obtained from the appropriate jurisdiction.

83-2.0 HIGHWAY SIGNS

In a construction zone, a regulatory sign is used to temporarily override an existing mandate or prohibition (e.g., reduced speed limit). A warning sign is used in advance of the construction area to indicate a potentially-hazardous condition. A guide sign is used to inform the motorist of a detour route, destination, or point of interest.

The INDOT *Standard Drawings*, the INDOT *Standard Specifications*, and *MUTCD* Part VI provide the Department's criteria for the design, application, and placement of signs in a construction zone. This Section provides the designer with supplemental information on the application of a highway sign. The designer should review Section 502-1.0 and the *MUTCD* regarding permanent signs.

83-2.01 Sign-Legend Measurement Units

Regulatory or advisory speed limit, distance message, or other sign legend displayed in a construction zone will remain in English units until notified otherwise. Figure 83-2A provides guidelines for converting English units to metric.

83-2.02 Placement

The uniform placement of construction signing, although desirable, is not always practical. Road geometrics or other factors often dictate a more advantageous placement. The designer should consider the following guidelines together with established criteria in determining the placement of construction signing.

1. Permanent Sign. A construction sign in close proximity to a permanent sign should be reviewed after the theoretical temporary sign location has been determined. For example, the permanent sign should not block the view of the temporary sign nor convey conflicting information. The designer should also avoid creating an information overload by placing too many signs near each other.

2. Intersection. If construction signing is warranted near an intersection, the designer should consider placing the temporary sign beyond the intersection. On the intersection approach, a permanent sign provides control and directional information to the motorist. Locating a construction sign beyond the intersection will usually enhance a motorist's comprehension of the sign.

3. Roadside Barrier. The designer should consider placing a temporary construction sign behind an existing roadside barrier if practical. This will reduce the probability that it will be impacted.

83-2.03 Regulatory Signing

83-2.03(01) Work-Zone and Work-Site Speed Limit Signing [Rev. June 2012]

Different speed limits may apply based on whether the speed limit is within the work zone or if it is within a work site. The work-zone speed limit applies throughout the project as does a work-site speed limit authorized for continuous use to protect motorists. A work-site speed limit authorized for intermittent use to protect workers applies to a specific location within the work zone where work is actually occurring. The following provides guidance in the selection and implementation of a work-zone or work-site speed limit.

1. Work-Zone Speed Limit. The work-zone speed limit will be determined based on the construction-zone design speed, traffic volume, work type, geometrics, project length, etc. The work-zone speed limit should not exceed the construction-zone design speed through the construction area. Section 82-3.01 provides guidance on the selection of a construction-zone design speed. If the work-zone speed limit is different than the existing posted speed limit

prior to the start of construction, an Official Action as discussed in Section 83-1.03 will be required.

2. Work-Site Speed Limit. Indiana Statutes permit INDOT to establish a work-site speed limit without an Official Action. They also stipulate that the work-site speed limit will be at least 10 mph below the original posted speed limit. An intermittent-work-site speed limit will be applicable only where and while work is actually in progress and workers are present, and is authorized by the district Traffic Engineer. The district Technical Services Director will authorize a work-site speed limit for continuous use. Additional signs for the normal speed limit should be specified to aid enforcement by properly defining the speed zones as follows:

   a. For a rural Interstate-route application, R2-1-B and R2-Y2-B signs for the normal speed limits should be placed approximately 500 ft downstream from the end of the work site.

   b. For another application, an R2-1 or R2-1-B sign for the normal speed limit should be placed 500 ft downstream from the end of the work site.

   The additional signs for the normal speed limit may be omitted if such existing signs are located within sight distance. As an option, the R2-Y12 or R2-Y12-B "End Work Site Speed Limit" sign may also be provided alongside the sign for the normal speed limit at the end of the work site. The statutes also stipulate that the work-site speed limit will either be 45 mph, or 10 mph below the original posted speed limit, whichever is lower.

3. Sign Size and Assembly. A work-zone or work-site speed-limit-sign assembly should be placed according to the *MUTCD* and should be of a size specified for the facility. Each work-site assembly should include a "Worksite" plaque mounted above the regulatory sign.

4. Flashing Beacon. Each work-site speed-limit-sign assembly for intermittent use must incorporate strobe-type flashing beacons with one mounted at each upper corner of the regulatory sign. A "When Flashing" plaque must be placed below the sign. The beacons should be activated only while work is in progress and workers are present. The device provides for both workers' and public safety without imposing unnecessary travel delays during non-working periods. Flashing beacons and the "When Flashing" plaque will not be incorporated with a continuous-use work-site speed limit.

5. Selection. Figure 83-2B provides suggested work-zone and work-site speed limits for a freeway based on the type of facility and the proposed construction application.

6. <u>Location and Spacing</u>. In determining the location and spacing of signs, the following will apply.

   a. Work-Zone Sign. The designer should coordinate with the district traffic engineer to determine the appropriate beginning and ending locations for the work-zone speed limit. A work-zone speed limit sign should be placed prior to the construction zone and after each interchange entrance ramp within the construction zone. The reduced-speed zone should begin prior to an expected queue backup due to a lane closure, lane restriction, etc.

   b. Work-Site Sign. The INDOT *Standard Specifications* provide the guidelines for determining the appropriate location for a work-site speed-limit-sign assembly.

7. <u>Speed Limit Reduction Greater than 10 mph</u>. The regulatory sign, R2-15b, “Reduced Speed XX Ahead” should not be specified. Instead, reduced-speed-limit warning sign W3-5 or W3-5a should be specified. The details are shown on the INDOT *Standard Drawings*. Only one of the sign designations should be specified for the entire project.

8. <u>Divided Facility</u>. An assembly should be placed on each side of each roadway.

83-2.03(02) “Stop” or “Yield” Sign

Each specific site may warrant the use of other regulatory-sign changes. For example, the installation of a “Stop” or “Yield” sign may be considered at a previously uncontrolled merge and acceleration area if the taper length is reduced during construction operations. An Official Action, as described in Section 83-1.03, must be coordinated through the district traffic engineer. Based on *MUTCD* guidelines, the implementation of a “Stop Ahead” or “Yield Ahead” sign may also be considered.

83-2.03(03) Selective-Exclusion Sign

Where a lane shift occurs through a construction zone and the lane shift requires the use of the shoulder as a travel lane, the designer may consider the use of a selective-exclusion sign to assign heavy-truck traffic to lanes on the pavement proper (i.e., a heavy truck is not be permitted to use the shoulder as a travel lane). An Official Action, as described in Section 83-1.03, must be coordinated through the district traffic engineer.

83-2.04 Advance-Warning Sign

A warning sign is used to alert the motorist of a potentially hazardous condition on or adjacent to the roadway. The unnecessary use of this type of sign may breed motorist disrespect for signing in general. The designer should therefore only use the minimum number of warning signs necessary to adequately warn the motorist. The following provides additional information on the sequence and placement of advance warning signs.

A warning sign is used in an advance warning, transition, or activity areas of a construction zone. The advance-warning area is the first opportunity to inform a motorist regarding the safe negotiation of the upcoming construction activity. The designer should consider the following in determining the sequence and placement of advance-warning signs.

1. road facility type and location;
2. traffic volume and mix;
3. posted speed limit;
4. construction activity type and location; and
5. actual or anticipated field conditions.

Based on these factors, the advance-warning area may warrant either a single warning sign or a multiple sign sequence. An advance-warning sign sequence may be classified as A, A-B, or A-B-C. Figure 83-2C, Advance-Warning Signs, and the *MUTCD* provide applications for each sequence classification. The following describes each sign sequence category and its application.

1. A Sequence. This consists of a single sign placed upstream from the nearest point of transition or restriction. The designer should consider the sequence for work outside a shoulder.

2. A-B Sequence. This is a two-sign configuration within the advance-warning area. The B sign is placed upstream from the A sign. The sequence should be considered for a construction activity as follows:

    a. work on a shoulder;
    b. interior-lane closure on a roadway with 3 or more lanes; or
    c. lane closure on a minor street.

3. A-B-C Sequence. This consists of three or more signs within the advance-warning area. The C sign is placed upstream from the B sign. The sequence should be considered for a construction activity as follows.

a. road closure with traffic diversion;
b. lane closure for one-lane, two-way traffic control; or
c. lane closure for a highway with 4 or more lanes or a freeway.

The use of a multiple advance-warning sign sequence is required on a limited access facility with a higher speed or a facility with construction activities which present the motorist with major decision points (e.g., lane closure, multiple-lane shift, queue backup). Advance warning signs tend to be spread out over a greater distance on such a facility to provide the motorist with adequate time and distance to safely negotiate the downstream construction activity.

Figure 83-2C provides the suggested sign-placement distance for each facility type. The columns headed A, B, and C represent the distances between signs and should be used to mark the theoretical sign location. The designer should use these distances as a starting point and adjust each sign location as necessary based on actual and anticipated field conditions (e.g., sign location relative to a crest vertical curve, line of sight obstruction). Figure 83-2C should be used in conjunction with each construction activity discussed above and with the diagrams shown in the *MUTCD*. The warning-sign placement distances previously shown in Figure 75-4A are not directly applicable to a work-zone application.

83-2.05 Guide Sign [Rev. Jul. 2015]

The references in Section 83-1.01 provide the Department's criteria for the placement, design, and application of a guide sign. The designer should also review applicable criteria for permanent guide signs in Section 502-1.04 and in the *MUTCD*. The following provides supplemental information on the use of a guide sign in a construction zone.

1. Panel Sign. A guide sign is warranted in a construction zone or alternate route where a temporary route change is necessary. For example, the designer may consider using a large panel sign for a ramp or lane closure, e.g., "Ramp ___ Closed Use Ramp ___," "Ramp ___ Closed (date)". See the INDOT *Standard Drawings* for information for determining the size of a panel-sign support.

2. Other. Route markers, street-name signs, special-information signs, directional, or detour signs may also be warranted based on the particular work on the facility.

3. Worksite Increased-Penalty Signs. Signs are required which inform the motorist of increased penalties for moving violations.

   Sign messages and details are shown on the INDOT *Standard Drawings* Series 801-TCSN.

Use of a Single Worksite Added Penalty (WAP) Sign

The XW2-6-A Worksite Added Penalty sign, 78 in. x 42 in., should be specified for a rural area with sufficient right of way to accommodate the sign. It should be specified for an urban area with a posted speed limit of 40 mph or higher, and sufficient right of way to accommodate the sign.

The XW2-6 Worksite Added Penalty sign, 60 in. x 36 in., should be specified for an urban area with a posted speed limit of 35 mph or lower, under one of the conditions as follows:

a. the existing conditions outside the edge of pavement make installation of driven posts impractical, or

b. the width of the right of way outside of the edge of pavement is not sufficient to accommodate the XW2-6-A sign.

Use of Speeding and Reckless Driving Signs In Place of a Single WAP Sign

Rural Project. The XW2-6a-B Speeding and XW2-6b-B Reckless Driving signs, both 48 in. x 48 in., should be specified to be used in series with each other, and should be used in a rural area under one of the conditions as follows:

a. the project is in an area where the right-of-way width outside of the edge of pavement is not sufficient to accommodate the XW2-6-A sign; or

b. the project is a moving operation where construction signs are set and removed each day to accommodate the changing location of the work.

Urban project. The XW2-6a-A Speeding and XW2-6b-A Reckless Driving signs, both 36 in. x 36 in., should be specified to be used in series with each other, and should be used in urban areas where the right-of-way width outside of the edge of pavement is not sufficient to accommodate the XW2-6 or if the project is a moving operation where construction signs are set and removed each day to accommodate changing location of work.

Sign Location

The following guidelines should also be used to determine the location and quantity of the signs.

a. Signs are required for each project in which traffic will travel through an active construction zone marked by “Road Construction Ahead” and “End Construction” signs.

b. An XW2-6-A or XW2-6 sign, where warranted, should be placed in advance of the first “Road Construction Ahead” sign for each direction of travel on the project mainline. The advance distance should be 500 ft in a rural areas, or 100 ft in an urban area.

c. Rural project. XW2-6b-B Reckless Driving and XW2-6a-B Speeding signs, where warranted, should be placed in advance of the first “Road Construction Ahead” sign for each direction of travel on the project mainline. The advance distance for the XW2-6b-B Reckless Driving sign should be 1000 ft. The advance distance for the XW2-6a-B Speeding sign should be 500 ft.

   Urban project. XW2-6b-A Reckless Driving and XW2-6a-A Speeding signs, where warranted, should be placed in advance of the first “Road Construction Ahead” sign for each direction of travel on the project mainline. The advance distance for the XW2-6b-A Reckless Driving sign should be 200 ft. The advance distance for the XW2-6a-A Speeding sign should be 100ft.

d. Signs should not be placed on side roads or ramps leading into a construction zone.

e. Signs are not required if the active construction zone is completely isolated from live traffic, i.e., a full road closure with a detour, or construction along a new alignment.

The location of each sign should be indicated as for other construction signs shown on the traffic-maintenance plan.

83-2.06 Portable Changeable Message Sign [Rev. May 2012]

A portable changeable message sign (PCMS) is effective in communicating construction-zone information to the general public. Its use in a project shall be as outlined in the *INDOT Guidelines for Portable Changeable Message Signs*. The *Guidelines* appear on the Department website, at http://www.in.gov/dot/div/contracts/design/PCMS.pdf.

83-2.06(01) Need [Rev. May 2012]

A PCMS should be considered for each project which includes the following:

1. intermittent or short term, road, lane, or ramp closure;
2. frequent changes in traffic patterns;
3. at least one road with traffic volume that will be at or over capacity during construction; or
4. other project as deemed necessary by the following:
   a. the district office;
   b. the Construction Management Division; or
   c. the Traffic Management and District Support Business Unit.

A PCMS should not be used to convey a message that can be effectively conveyed with static signing.

The need for a PCMS and the selection of messages should be considered during the course of Maintenance of Traffic (MOT) Plan development.

In developing the MOT Plan, the designer should determine the answers to the questions as follows.

1. What type of closures or restrictions does the MOT Plan generate?
2. How long will the closures or restrictions be in effect?
3. Will potentially hazardous conditions exist, such as narrow lane widths, or workers, equipment, or materials encroaching onto the travel lanes? If so, for how long?
4. Is queuing or delay likely to occur as a result of the MOT Plan?
5. Will a work zone speed limit that is at least 15 mph lower than the permanent posted speed be enacted?
6. What is the crash history of the project location?

Conferring with the district Construction and Traffic offices will provide insights to these issues. With this information, the *Guidelines* can be applied to determine whether a PCMS should be included, and, if so, what messages should be displayed.

83-2.06(02) Design Considerations [Rev. May 2012]

The *MUTCD* provides the design and application criteria relative to a PCMS. The designer should also consider the following in specifying a PCMS.

1. Display. The display should provide not more than the maximum amount of information that can be read and comprehended by the motorist at a quick glance, i.e., no rolling messages. A

PCMS is capable of displaying three lines of eight characters each. There should be not more than two messages phased in order to provide readability and comprehension. Each message should be able to stand alone. For more than two messages, two signs should be used.

2. Location. The sign should be visible from 2500 ft under ideal day and night conditions. The first message should be legible at a minimum distance of 650 ft from each lane. A PCMS is typically placed in advance of other advance warning signs. For more information on location see the *Guidelines*, Placement section**.**

3. Traffic-Control Devices. A PCMS may be used as a supplement, but it should not be used as a substitute to the proper use of other traffic control devices.

4. Flashing-Arrow Sign. A PCMS should not be used as an alternative to a flashing-arrow sign. However, a PCMS may be used to simulate an arrow display in the message.

83-2.06(03) Plans Requirements [Added May 2012]

If a PCMS is required, the following information will be shown on the plans.

1. Approximate Location. Unless there are specific reasons otherwise, each PCMS is to be located as shown in the *Guidelines*, Tables 1 and 2.

2. Message Content. Each message shall be selected from the standard messages shown in the *Guidelines*, Table 7, or developed as non-standard, as described in the *Guidelines*, Section V. The district Traffic Office or the Traffic Management Center can be consulted for assistance with message development.

   Figure 83-2E, Programming Information for Portable Changeable Message Sign, on the editable-documents website, http://www.in.gov/dot/div/contracts/design/dmforms/index.html, shall be completed and included in the Contract Information book for each non-standard message on each PCMS.

83-2.06(04) TMC Control of PCMS Operation [Added May 2012]

As part of the Traffic Management Plan for a project in an Advanced Traffic Management System (ATMS) area, the designer shall consult with the district Construction Office and the appropriate Traffic Management Center (TMC) to determine whether TMC control of the PCMS is desired. The ATMS areas are as follows.

1. <u>Indianapolis and Southern Indiana, Indianapolis TMC</u>
   I-64, mile 118 to 124
   I-65, mile 0 to 9
   I-65, mile 86 to 149
   I-69, mile 0 to 29
   I-70, mile 55 to 106
   I-74, mile 66 to 73
   I-74, mile 94 to 101
   I-265, mile 0 to 9
   I-465, mile 0 to mile 53
   I-865, mile 0 to mile 5

2. <u>Northwest Indiana, Gary TMC</u>
   I-65, mile 236 to 262
   I-80/94, mile 0 to 16
   I-94, mile 16 to 46
   SR 912, mile 6 to 10

If the PCMS will be TMC controlled, a unique provision for the Aries Field Processor should be included in the contract. This unique provision should be obtained from the ITS Technology Deployment Office upon agreement that the TMC will control messaging.

83-2.07 Flashing-Arrow Sign

A flashing-arrow sign is used to supplement other traffic-control devices. It is used where additional warning and directional information is required to assist in merging and controlling traffic through or around the work activity. A flashing-arrow sign should be used on each freeway construction project requiring a lane closure. For another site, the designer will determine the need for a flashing-arrow sign on a project-by-project basis. The applications where a flashing-arrow sign may be considered are as follows:

1. work in vicinity of an entrance or exit ramp;
2. median crossover on a freeway;
3. interior or double-lane closure on a freeway or other roadway of 4 or more lanes;
4. right-lane closure on the far side of an intersection; or
5. mobile operation on a shoulder or roadway of 4 or more lanes.

The INDOT *Standard Drawings*, the INDOT *Standard Specifications*, and the *MUTCD* provide the Department's criteria for the placement, design, and application of a flashing arrow sign. The

MUTCD also includes application diagrams. The following provides the designer with supplemental information on the use of a flashing-arrow sign.

1. Display. The applicable display modes are as follows.

   a. Flashing Arrow or Sequential Arrow. This is used for a left- or right-lane shift or diversion.

   b. Flashing Double Arrow. This is used for an interior-lane closure where traffic is permitted to either travel left or right around the work activity.

2. Use and Location. The flashing-arrow sign should be located at the beginning of a lane-merge taper. For a stationary activity, locate the sign on the shoulder or in the closed lane behind a channeling or barricade device. For a mobile operation, locate a mounted sign at the rear of the activity upstream of the maintenance vehicles. Where used in the vicinity of a ramp, median crossover, or side-road intersection, the flashing-arrows sign placement should not confuse the motorist. Figure 83-2D provides the recommended usages and the minimum legibility distances under ideal day or night conditions.

3. Two-Lane, Two-Way Operation (TLTWO). A flashing-arrow sign should not be used to shift traffic in a TLTWO.

4. Shoulder or Roadside Activity. A flashing-arrow sign should only be used in the flashing caution mode for a shoulder or roadside work activity.

5. Flagger. A flashing-arrow sign should not be used if a flagger is used for traffic control at the work site.

6. Multiple-Lane Closure. The designer should consider using multiple flashing-arrow signs for a multiple-lane closure. In this situation, a flashing-arrow sign should be located at the beginning of each lane-merge taper. The designer should not use a flashing-arrow sign to laterally shift multiple lanes of traffic.

7. Traffic-Control Devices. The flashing-arrow sign may be used as a supplemental traffic-control device, but it should not be used as a substitute to the proper use of signs, pavement markings, or lighting in a construction zone. The flashing-arrow sign should not replace other required signing.

83-3.0 CHANNELIZATION DEVICES

The INDOT *Standard Drawings*, the INDOT *Standard Specifications*, and the *MUTCD* provide the Department's criteria for the selection, application, and placement of channelization devices. The *MUTCD* also includes application diagrams for the use of these devices.

83-3.01 Types

There are a number of channelization devices available, each having its specific application in a construction operation (e.g., crossover, runaround, lane closure, road closure, or 2-lane, two-way operation). The following channelization devices are used in a construction zone.

1. Barricade.

    a. Type I or Type II Barricade. INDOT does not use this type of barricade.

    b. Type III Barricade. This is used to close a roadway. Section 83-3.04 provides the guidelines for its application and placement.

2. Drums. Drums are used in a linear series to channelize and delineate the desired travel path. They may also be used individually or a group to mark a specific location. They are used for channelization and can be easily shifted to accommodate changing conditions within the construction zone. However, for a temporary lane closure during daylight hours, cones, tubular markers, or vertical panels may be used in lieu of drums.

3. Cones. Traffic cones are channelization devices used to delineate a travel path, divide opposing traffic lanes, divide traffic lanes in the same direction, or delineate a short-duration construction, maintenance, or utility activity.

4. Tubular Markers or Vertical Panels. These devices are used to channel traffic, divide opposing lanes of traffic, or divide travel lanes in place of drums where space is limited. Tubular markers and vertical panels have less visible area than other devices and should be used only where space restrictions do not allow for use of more-visible devices. These devices are to be used a divided non-freeway.

5. Temporary Asphalt Divider. This device should not be used for separating traffic.

6. Temporary Concrete Barrier (TCB). TCB should only be used where positive protection is desired, and not based on channelization needs. This device should be used on a freeway.

The TCB should be located behind and in conjunction with supporting channelization devices, delineators, or pavement markings. Section 82-4.03 provides information on the application and placement of the TCB. Delineators and steady-burning lamps should also be attached to the TCB. However, where used between lanes in a 2-lane, two-way operation, experience has shown that opposing vehicular headlights wash out the lamp and cannot be safely maintained. Therefore, lamps should not be used in this situation.

7. Delineators. Delineators provide retro-reflection from headlights and are supplemental devices used to indicate the roadway alignment and the intended path through the construction zone. Delineators are used along the pavement edge in a runaround operation and are attached to the TCB.

8. Longitudinal Pavement Markings. The application of pavement markings is provided in Section 83-4.0. Longitudinal pavement markings should only be used in combination with other primary channelization devices to delineate the desired travel path. A temporary double solid yellow line should be used in conjunction with tubular markers or vertical panels or TCB. Markings should also be used on each undivided roadway of 4 or more lanes. Revisions to existing pavement markings are not required for a temporary daylight lane closure.

Channelization devices are used in a construction zone to warn the motorist of work activities in or near the traveled way, to protect workers in the area, and to guide the motorist or pedestrian safely through and around the work site. Because each construction project differs, the selection, application, and location of these devices should be determined on a project-by-project basis.

83-3.02 Taper Length

The required length of tapered section delineated by channelization devices is shown on the INDOT *Standard Drawings*. Figures 83-3B and 83-3C provide the minimum taper requirement for each taper application in a construction zone (e.g., lane closure, lane shift).

83-3.03 Spacing

As with a transition taper, the longitudinal spacing of channelization devices is dependent on vehicular speed. In a 1-lane, two-way traffic operation, the spacing at a tapered section should be 10 ft for a 50-ft taper length, or 20 ft for a 100-ft taper length. A device spacing of 20 ft should be used for an Interstate-route taper. Tubular markers should be at 50-ft spacing. Figure 83-3D provides suggested spacing of channelization devices for other conditions. Unless otherwise specified, the maximum spacing of drums, cones, or vertical panels should be based on Figure 83-3D.

83-3.04 Type III Barricade

The Department uses a type III-A or type III-B barricade for a road closure□. The Type III-A barricade is used where traffic is not allowed behind the barricade. Reflectorized rails are used only on the side facing traffic. The Type III-B barricade is used where traffic is allowed behind the barricade. Reflectorized rails are required on both sides of the barricade. The designer should also consider the following.

1. Materials. A type III barricade is constructed with three 12-ft sections mounted on skid-type supports or on posts driven into the ground. Use a skid-mounted barricade where the barricade is to be located on the traveled way or shoulder. Use a post-driven barricade where the barricade is to be outside of the paved portion of the roadway.

2. Complete Closure. A type III-A barricade should extend completely across the roadway and across a roadway side slope that is 3:1 or flatter within the right of way. During non-working hours, openings are not allowed within the barrier assembly.

3. Divided Highway. Where one set of lanes of a divided facility is closed to traffic, a type III-A barricade will be required across the pavement area and on slopes which are 3:1 or flatter from the right-of-way line to the centerline of the median. An additional barricade will be required across the closed portion where the facility intersects with a local road (e.g., county road, drive). An additional barricade will be required where a bridge or pipe is to be removed; see Item 6.

4. Crossover. Specify a type III-B barricade where a crossover on a divided facility is required because one set of lanes is closed for construction and two-way traffic is being maintained on the other set.

5. Local Traffic. If local traffic is allowed to use the facility under construction, use a type III-B barricade at the beginning and end portions of the closed road. Each barricade should extend onto side slopes of 3:1 or flatter, within the highway right-of-way. An additional barricade will be required where a bridge or pipe is to be removed, see Item 6.

6. Bridge or Pipe Removal. Where there is a possibility that a vehicle could be on a closed facility and where there is a bridge removal, pipe removal, or other hazard location, provide an additional type III barricade within 150 ft of the hazard.

7. <u>Road-Closure-Sign Assembly</u>. Where a type III barricade is used, the designer is required to show a road-closure-sign assembly on the plans. However, do not use such a sign assembly next to a lane closure where adjacent lanes remain open to traffic, or where a barricade is specified for closure of a lane on an undivided facility of 4 or more lanes where the remaining lanes are being used to maintain traffic.

83-4.0 PAVEMENT MARKINGS [Rev. May 2018]

The INDOT *Standard Drawings* and the *MUTCD* provide the Department's criteria for the selection, application, and placement of pavement markings in a construction zone. The INDOT *Standard Specifications* provides additional information on temporary-pavement-marking material usage. The following provides supplemental guidelines to these sources.

<u>83-4.01 Types</u>

83-4.01(01) Paint

Quick-drying traffic paint is a low-cost, temporary pavement marking. To improve reflectivity, glass beads are required. Temporary paint is a non-removable type of temporary pavement marking. The Department does not desire the use of temporary paint markings on a final pavement surface. However, temporary paint may be the most suitable choice under certain conditions, particularly if temporary markings are anticipated to be in place through the winter months.

83-4.01(02) Temporary Raised Pavement Markers

In a high-traffic-volume location, raised temporary pavement markers should be considered as a supplemental device to improve delineation through the construction zone. Typical locations include canter line, lane line, gore area, or where there are changes in the alignment (e.g., lane closure, lane shift). For a center line or lane line, temporary raised pavement markers are placed at the midpoint in the each gap, i.e., every 40 ft. For a taper, gore, etc., the raised markers should be spaced at 20 ft. Temporary raised pavement markers must be removed prior to the placing of the next pavement course.

83-4.01(03) Temporary Pavement-Marking Tape [Rev. May 2018]

Temporary pavement-marking tape is an excellent material choice where there is a change to the traffic pattern during construction (e.g., crossover switch). Temporary tape can be easily and quickly installed and, if necessary, easily removed. Disadvantages of temporary tape are that it tends to move or break up under heavy traffic volume, and that it is not suitable for usage during the winter months. Temporary pavement-marking tape requires significant maintenance in comparison to temporary paint. The following describes the temporary pavement-marking tapes used by the Department.

1. Type I. Type I tape may be used as a temporary center line, lane line, or no-passing-zone line that is placed parallel to the normal pavement marking pattern, or as a temporary transverse marking or pavement-message marking. It should also be used where pavement markings are placed at an angle to the normal pavement-marking pattern (e.g., taper for lane closure, lane shift). Type I tape is a removable type of temporary pavement marking. When black Type I tape is used to cover conflicting markings, the width specified should be at least 1 in. wider than the existing marking to be covered.

2. Type II. Type II tape is used on a pavement which is expected to be removed or covered by additional pavement courses. It may be used as a center line, lane line, or edge line that is parallel to the normal pavement markings. It also may be used as a center line or lane line on a resurfacing overlay course. Type II tape is a non-removable type of temporary pavement marking.

83-4.01(04) Thermoplastic or Epoxy Markings

Thermoplastic or epoxy markings are used in a construction zone only if the traffic volume is high, and the temporary traffic pattern will be in place for over one year. Thermoplastic or epoxy markings are non-removable types of pavement markings.

83-4.01(05) Buzz Strips

Buzz strips are used on a high-speed facility of 4 lanes or more in advance of a lane closure, alignment change, or stop condition to warn the motorist of the impending change. They are made with extruded material or repeated passes of pavement-marking tape to reach a ¼-in. height. Figure 83-4A illustrates the typical layout for buzz strips with a lane closure. The spacing criteria are also applicable to the other conditions listed above.

83-4.02 Application [Rev. May 2018]

The application of temporary pavement markings in a construction zone depends on facility type, project duration, project length, and anticipated traffic volume. The phasing of temporary traffic control during construction should be considered. The temporary pavement markings should be selected that are best suited to the anticipated conditions and are most economical for the project.

The removal of a removable temporary pavement marking is included in the removable-temporary-pavement-marking quantity. If non-removable markings that must be removed are selected as part of the planned traffic-maintenance plan, a quantity for removal of the non-removable markings is required, or type I black temporary tape should be specified to cover the existing markings. Black temporary tape, type I, should be specified to temporarily cover conflicting markings where the pavement will not be replaced or resurfaced. When used, black temporary tape, type I, should be at least 1 inch wider than the existing marking to be covered. If non-removable temporary pavement markings are necessary on a final surface, placement of the temporary markings should be indicated to be as near as possible to the location of the final permanent pavement markings.

83-5.0 TEMPORARY TRAFFIC SIGNAL [Rev. Mar. 2016]

83-5.01 Location

The use of a temporary traffic signal in a construction zone will be determined on a project-by-project basis. The warrant criteria for permanent installations in Section 502-3.02 should be used to help determine if a temporary traffic signal is warranted. However, the traffic volume expected during construction should be used for the warrant analysis. An Official Action, as described in Section 83-1.03, must be coordinated through the district traffic engineer. Locations where a temporary signal installation may be used include the following:

1. intersection where an existing signal must be maintained;
2. existing non-signalized intersection or drive where construction patterns and traffic volume now warrant a signal;
3. temporary haul road or other temporary access point;
4. long-term one lane, two-way traffic operation (e.g., bridge lane closure); or
5. crossroad or ramp intersection where there is an increase in traffic or there is a decrease in capacity due to the construction.

<u>83-5.02 Application [Rev. Mar. 2016]</u>

The designer should consider the following.

1. <u>Existing Signals</u>. The designer should determine the impacts that a construction activity has on existing signal operations and should attempt to maximize the level-of-service. For example, the designer should consider the following:

    a. recommend re-timing or re-phasing the signal to compensate for changes in traffic volume, mix, or patterns, and for changes in lane designation or intersection-approach geometrics; and

    b. physically relocating poles or adjusting signal heads to maintain compliance with the *IMUTCD*.

    c. if temporary signals will be used, the designer should develop the signal timing plan and show placement locations on the plans.

Section 502-3.0 and the *IMUTCD* provide design information for a traffic signal.

2. <u>Bridge</u>. If a lane is expected to be closed overnight, a temporary signal should be considered.

3. <u>Type of Temporary Signal – One Lane, Two-Way Traffic Control</u>. A temporary traffic signal may either be fixed or portable, the type selected should be detailed on the plans and the appropriate pay item included in the cost estimate.

    a. If a temporary traffic signal is chosen as an element of a temporary traffic control plan the designer should consider whether it may be more cost effective to use a portable signal. Portable signals are mounted on trailers rather than wood poles and are generally rented by the contractor. When the need for a temporary traffic signal is expected to be less than six weeks, or the cost to bring electric service to the location is more than $10,000, portable traffic signals will typically be less expensive. Portable signals require a relatively flat area, approximately 8 ft by 8 ft in size, to accommodate the trailer. If necessary, a temporary landing area for the trailer may be constructed, using suitable material, on the side slope. If a temporary landing area is needed it should be shown on the plans.

b. In order to include the portable signal pay item into a contract the designer must obtain concurrence from the district Traffic Office that the portable type is the best option. The Temporary Traffic Signal Type Determination form is available from the Department's Editable Documents webpage, under Traffic Maintenance. The form should be submitted to the district Traffic Engineer as early as possible in the plan development process but at least prior to Stage 1 plan submittal.

4. Type of Temporary Signal - Intersection Traffic Control. In accordance with the *IMUTCD*, Section 4D.32 temporary signals for intersection traffic control must be fixed. However, roads and drives within a one lane, two-way work zone may be controlled by portable signals.

5. Vehicle Detection. Whether fixed temporary or portable, the signal should include vehicle detection. The detection area should be shown on the plans. See Figure 83-5A, Vehicle Detection Typical Placement Areas. The *Standard Specifications* allow the contractor to use either inductive loop or wireless detection for fixed temporary signals, but only wireless for portable. Where it is determined that another type of detection is needed, a unique special provision should be included in the contract.

6. Phasing/Timing Plans for Portable Signals. If portable signals will be used, the designer should develop the signal phasing and timing plan in accordance with the FHWA *Signal Timing Manual* and complete the Temporary Signal Timing Plan (RSP 801-T-212) and include this in the contract documents.

   a. For consultant designs the consultant shall be prequalified in Category 10.1, Traffic Signal Design.

   b. For in-house projects the designer should discuss the phasing and timing plan with district Traffic Engineer or the Systems Engineer in the Traffic Management Division.

   c. Total cycle length should be limited to 255 seconds and the all red clearance interval to 99 seconds. The following parameters may be used:

      i. Actuation should be provided and shown on the plans. See Figure 83-5A, Vehicle Detection Typical Placement Areas.

      ii. The minimum green time for both phases is based on driver expectation and may be set at 15 seconds for major arterials regardless of speed and 10 seconds for minor arterials or collectors. The *Signal Timing Manual* allows for lower values based on engineering judgment (see Table 5-3).

iii. The maximum green time for each phase should be exceed the time it takes to clear a peak hour queue but should be limited to no more than 90 seconds for arterials and 40 seconds for collectors. This queue clearance time can be estimated by this equation:

$G_q = 3 + 2n$

where, G_q = green time to clear queue

n = the number of vehicles in the queue

To determine the number of vehicles in queue, the peak hour volume is divided by the number of cycles per hour so establishing G_q is an iterative process.

iv. Yellow change interval should be based on the approach speed. Yellow change intervals on rural state highways may be set at 4 seconds for 40 mph and 5 seconds for 45 mph or greater.

v. All red clearance phase must be established by calculating the travel time from signal to signal, which is the distance from signal to signal divided by the operating speed.

$T = d \div$ avg. operating speed

where, T = travel time for red clearance (seconds);

d = distance between signals (ft)

avg. operating speed (ft/sec) = 1.467 x avg. operating speed (mph)

The average operating speed through the work zone will depend on many conditions, e.g. truck volume, length of the work zone, lane width, shoulder width, offset to barriers, and pavement condition, but can be estimated at 25 mph.

d. The designer should confirm that the anticipated queue will not encroach upon adjacent intersections. If encroachment is expected additional planning will be needed, e.g. the portable signal may need coordinated with the adjacent signal.

7. Plan Sheets. Show each temporary-signal installation, whether fixed or portable, in the traffic-maintenance plan. The placement locations for temporary signals should conform to the *IMUTCD* requirements for lateral and longitudinal signal positioning. For portable signals the designer should indicate if both signal heads must be mounted overhead.

8. Pay Items. A supplemental description noting the location, by intersection or route number and reference post for one lane, two-way operations, must be included with the use of the fixed temporary signal or portable signal pay item. Vehicle detection is included in the cost of the pay item.

83-6.0 HIGHWAY LIGHTING

83-6.01 Types

The lighting devices that are used in a construction zone are as follows:

1. hazard-identification beacons (flashing warning lights);
2. steady-burning warning lamps;
3. warning lights;
4. floodlights; and
5. conventional highway lighting.

83-6.02 Warrants

Hazard-identification beacons, steady-burning electric lamps, and warning lights are used to supplement signs, barriers, or channelization devices, and emphasize specific signs, hazard areas, and the desired travel path. The warrants for lighting devices should satisfy the *MUTCD*. Floodlights are used to illuminate the work area during a nighttime operation (e.g., flagger station, equipment crossing, area requiring supplemental lighting).

For conventional highway lighting, the need for temporary lighting will be determined on a project-by-project basis. Existing highway illumination should be maintained unless discontinuance of the highway illumination is specifically permitted. The warrants provided in Section 502-4.02 for permanent highway lighting should be reviewed to assist in determining the need for temporary lighting. The designer should consider the use of temporary lighting with the characteristics as follows:

1. high traffic volume;

2 high traffic speed;
3. heavy queuing or congestion;
4. area with complicated traffic maneuvers (e.g., freeway crossover, intersection); and
5. other area where a hazardous location may exist.

If existing light standards are removed or if bulbs are shut off during construction, the designer should consider providing temporary lighting until permanent lighting is reinstalled. In a construction zone, the Department uses high-pressure sodium lamps mounted on temporary wood posts. However, the designer may consider portable lighting as an option. Section 502-4.0 provides additional information on the design of highway lighting.

English-Units Value	Metric-Units Equivalent
SPEED LIMIT	
30	50
35 or 40	60
45	70
50	80
55	90
60 or 65	100
70	110
LONGITUDINAL DISTANCE	
500 ft	150 m
1000 ft	300 m
1500 ft	450 m
¼ mi	400 m
½ mi	800 m
1 mi	1.5 km
2 mi	3 km

ENGLISH-TO-METRIC UNITS CONVERSION

Figure 83-2A

Existing Facility and Construction Type	Existing Posted Speed		
	50 mph	55 mph	65 mph
4-lane Interstate with crossover to a 2-lane facility	n/a	WZ 45 mph with TCB WS 45 mph	WZ 55 mph with TCB WS 45 mph
4-lane Interstate with lane closure without a crossover	n/a	WS 45 mph	WZ 55 mph WS 45 mph
6-lane Interstate with crossover to a 4-lane facility with TCB	WS 40 mph	WS 45 mph	WZ 55 mph WS 45 mph
6-lane Interstate with lane closure without a crossover	WS 40 mph	WS 45 mph	WZ 55 mph WS 45 mph
Non-Interstate divided highway with crossover	Project-by-project	WZ 45 mph with TTM & TDSYL WS 45 mph	WZ 55 mph with TCB or TTM & TDSYL. WS 45 mph
Non-Interstate divided highway with lane closure without a crossover	Project-by-project	WS 45 mph	WZ 55 mph WS 45 mph

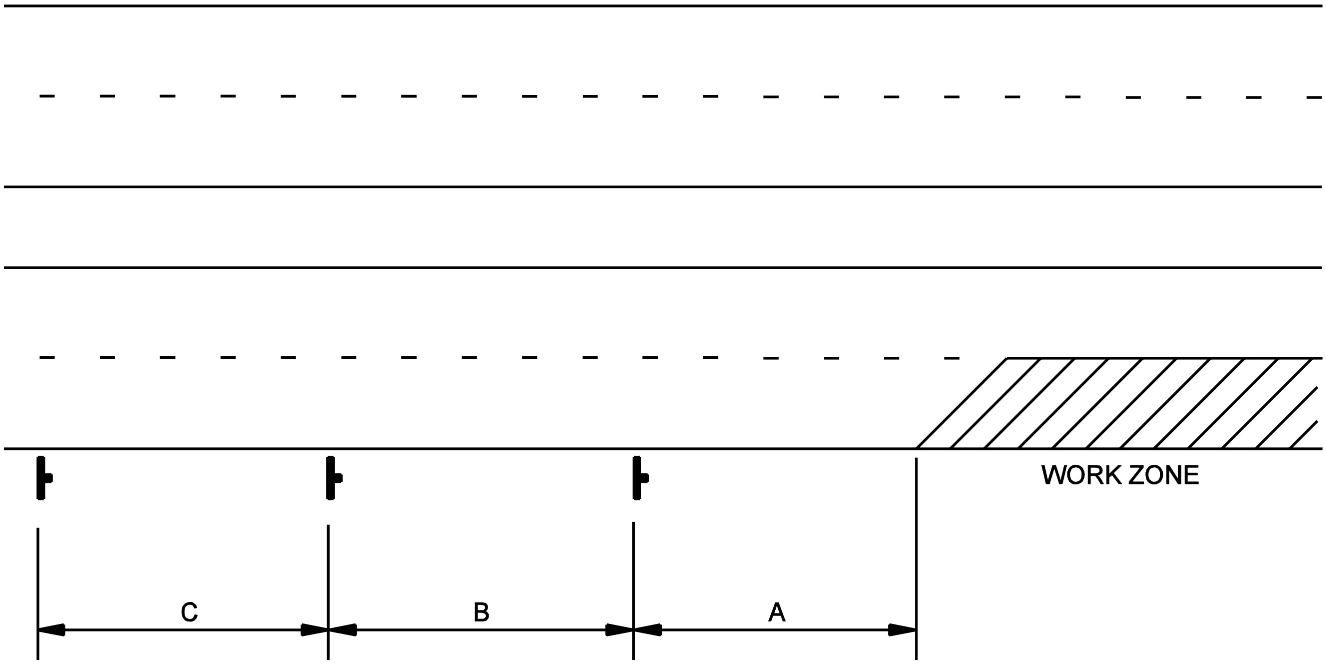
Where:

WS = Work-Site Speed Limit (Indiana Statutes)
WZ = Work-Zone Speed Limit (Official Action)
TCB = Temporary Concrete Barrier
n/a = Not Applicable
TTM = Temporary Tubular Markers
TDSYL = Temporary Double Solid Yellow Line

Note: Speed limit may vary based on circumstances and actual field conditions.

SUGGESTED DIVIDED-HIGHWAY SPEED LIMIT IN WORK ZONE OR WORK SITE

Figure 83-2B



Road Type	Distance Between Signs (ft)		
	A	B	C
Urban (45 mph or lower)*	200	200	200
Urban (50 mph or higher)*	350	350	350
Rural	500	500	500
Freeway/Expressway	1000	1600	2600

* Posted Speed Limit of Facility

Notes:

1 *Distance "A" is for marking the locationof warning sign "A" up stream from the transition or point of restriction in the construction zone.*

2 *Distance "B" is the location of warning sign "B" upstream from the location of "A" in two and three sequence signing arrangements.*

3 *Distance "C" is the location of warning sign "C" upstream from sign "B" when three or more signs are used within the advanced warning area.*

4 *For for or more signs, the spacing will be determined on a case-by-case basis.*

ADVANCED WARNING SIGNS

Figure 83-2C

Panel Type [1]	Permitted Use	Minimum Legibility Distance [2]
A	Permitted on facility with speed lower than 35 mph. Appropriate for use on low-speed urban facility.	2600 ft
B	Appropriate for intermediate-speed facility, or for maintenance or mobile operation on high-speed roadway. Not used by INDOT.	4000 ft
C	Permitted on every facility. Appropriate for use on a high-speed, high-volume traffic-control project.	5200 ft

Notes:

1. *For panel type, see the INDOT* Standard Specifications *and* Federal MUTCD *Part VI.*
2. *Minimum legibility distance under ideal day or night conditions.*

SUGGESTED USE AND LOCATION OF FLASHING-ARROW SIGN

Figure 83-2D

LOCATION OF PCMS:

MESSAGE TO BE DISPLAYED DURING MOT PHASE, EVENT, ETC.:

CREATED BY:

MESSAGE, PHASE 1

MESSAGE, PHASE 2

PROGRAMMING INFORMATION FOR
PORTABLE CHANGEABLE MESSAGE SIGN

Figure 83-2E

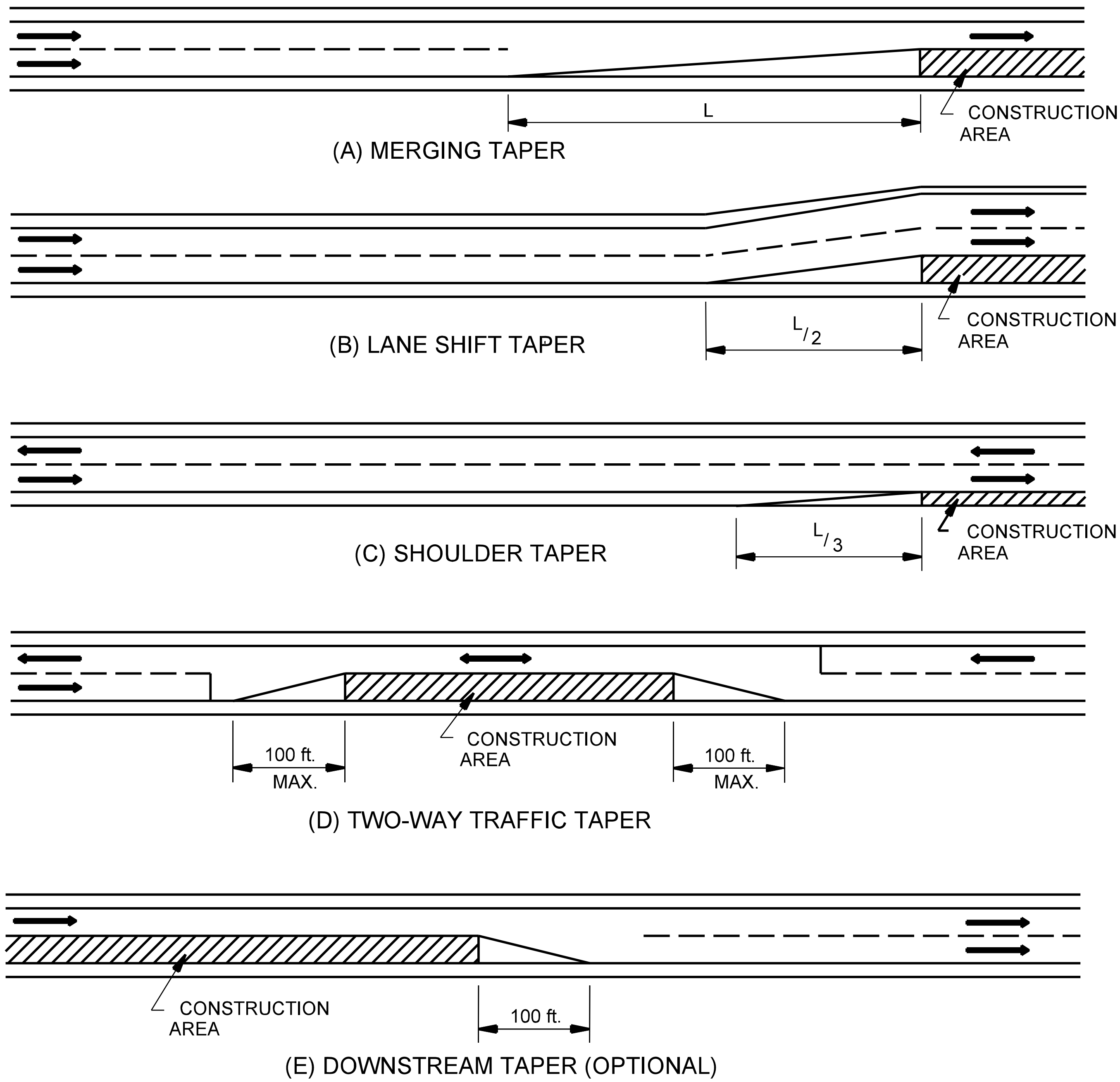
Taper Type		Minimum Length
Upstream	Merging	*L*
	Shifting [3]	½ *L*
	Shoulder	$^{1}/_{3}$ *L*
	Two-Way Traffic	100 ft
Downstream (optional)		100 ft per Lane

Notes:

1. *See the INDOT* Standard Drawings *for* L.
2. *Figure 83-3C illustrates the permissible taper types.*
3. *May be used for determining buffer-zone length.*

TAPER-LENGTH CRITERIA FOR CONSTRUCTION ZONE

Figure 83-3B



Note: See the INDOT Standard Drawing for "L".

TAPER LENGTH CRITERIA FOR CONSTRUCTION ZONES
(Application)

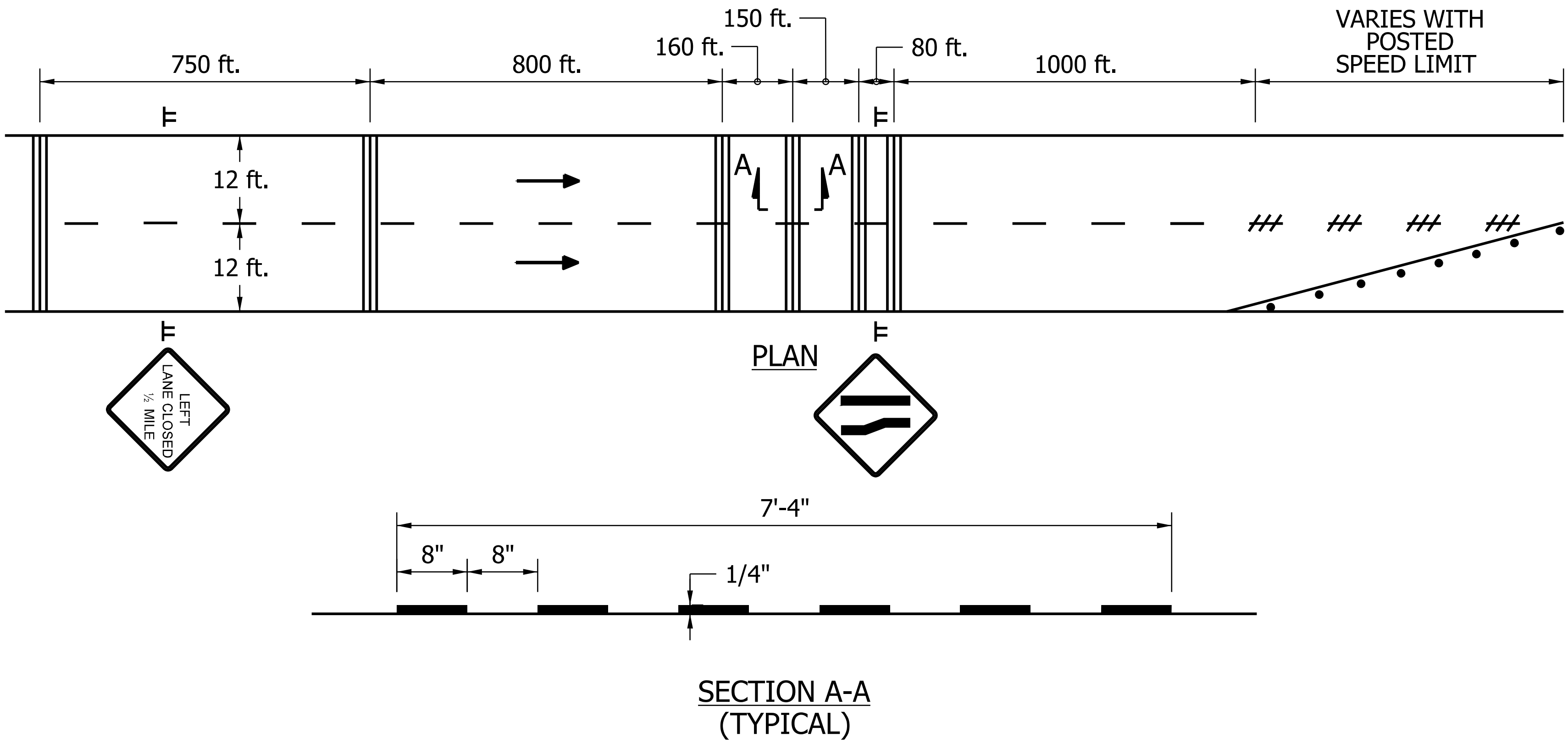
Figure 83-3C

Construction-Zone Design Speed (mph)	Suggested Maximum Spacing (ft)	
	Tapered Section	Tangent Section
25 *	20 *	40
30	30	60
35	35	70
40	40	80
45	45	90
50	50	100
55	55	110
60	60	120

* *For a speed of 25 mph or lower, spacing should not be less than 20 ft.*

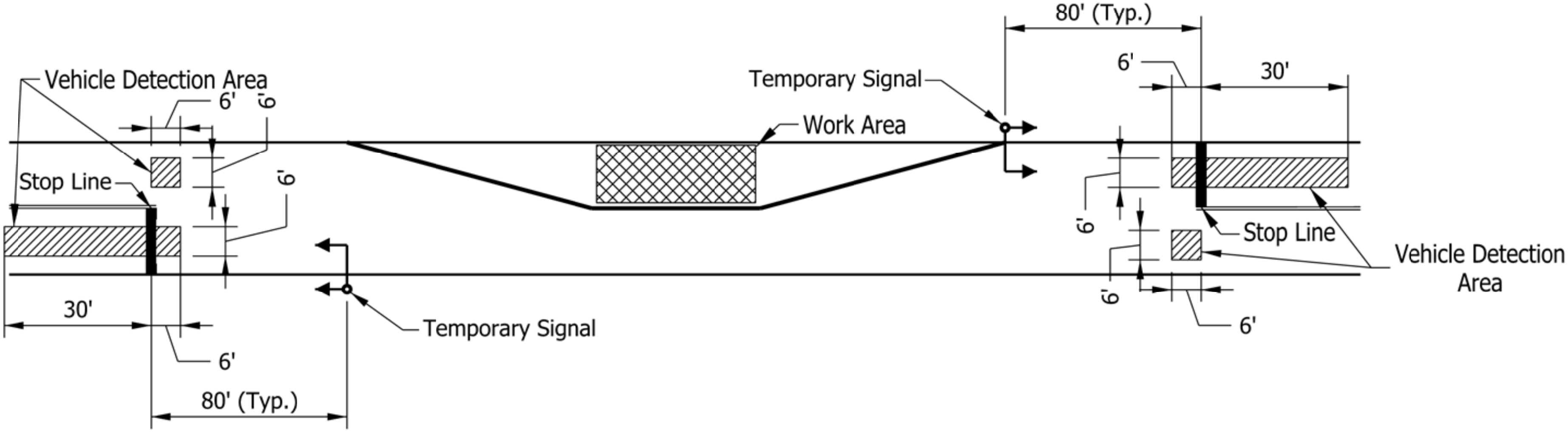
SUGGESTED MAXIMUM SPACING OF CHANNELIZATION DEVICES

Figure 83-3D



BUZZ STRIPS

Figure 83-4A



Note:

1. The contractor may select either inductive loops or wireless vehicle detection for temporary traffic signals. If another detection method is needed, the designer should specify it with a special provision.

VEHICLE DETECTION TYPICAL PLACEMENT AREAS

Figure 83-5A