Technical Report Documentation Page

1. Report No. FHWA/TX-02/4023-1	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle DMS MESSAGE DESIGN AND DISPLAY PROCEDURES		5. Report Date November 2001 6. Performing Organization Code
7. Author(s) Melisa D. Finley, Timothy J. Gates, and Conrad L. Dudek		8. Performing Organization Report No. Report 4023-1
9. Performing Organization Name and Address Texas Transportation Institute The Texas A&M University System College Station, Texas 77843-3135		10. Work Unit No. (TRAIS) 11. Contract or Grant No. Project No. 0-4023
12. Sponsoring Agency Name and Address Texas Department of Transportation Research and Technology Implementation Office P. O. Box 5080 Austin, Texas 78763-5080		13. Type of Report and Period Covered Research: September 2000 – August 2001 14. Sponsoring Agency Code

15. Supplementary Notes

Research performed in cooperation with the Texas Department of Transportation and the U.S. Department of Transportation, Federal Highway Administration.

Research Project Title: Automated Dynamic Message Sign (DMS) Message Design and Display

16. Abstract Project

Dynamic message signs (DMSs) are permanent or portable traffic control devices with the flexibility to display a variety of messages. DMSs are being deployed extensively in major metropolitan areas in Texas; however, proper message design and application on these signs is a complex process. Although many messages can be pre-designed and called up from a message library when needed, transportation management center (TMC) operators must often modify existing messages or develop new messages in real-time to deal with the unique aspects of an incident or other special situation. The purpose of this project is to develop the logic and prototype of an automated message design system so as to assist center operators in their real-time traffic management efforts using DMSs.

The research completed during the first year of a three-year project is documented in this report. During the first year, the research team visited five TMCs in Texas to review the DMS operations and the manner in which DMS messages are designed and displayed at each TMC. The information received as part of these visits is summarized in this report. In addition, the Texas Transportation Institute (TTI) research team developed preliminary DMS operations procedures, decision models, and flowcharts. These processes, along with a short discussion of DMS message design principles, are also contained in this report.

17. Key Words Dynamic Message Signs, Advanced Traveler Information Systems, Intelligent Transportation Systems		18. Distribution Statement No restrictions. This document is available to the public through NTIS: National Technical Information Service 5285 Port Royal Road Springfield, Virginia 22161	
19. Security Classif.(of this report) Unclassified	20. Security Classif.(of this page) Unclassified	21. No. of Pages 94	22. Price

Form DOT F 1700.7 **(8-72)** **Reproduction of completed page authorized**

DMS MESSAGE DESIGN AND DISPLAY PROCEDURES

by

Melisa D. Finley
Associate Transportation Researcher
Texas Transportation Institute

Timothy J. Gates
Assistant Transportation Researcher
Texas Transportation Institute

and

Conrad L. Dudek, Ph.D., P.E.
Professor of Civil Engineering
Texas A&M University
Research Engineer
Texas Transportation Institute

Report 4023-1
Project Number 0-4023
Research Project Title: Automated Dynamic Message Sign (DMS)
Message Design and Display

Sponsored by the
Texas Department of Transportation
In Cooperation with the
U.S. Department of Transportation
Federal Highway Administration

November 2001

TEXAS TRANSPORTATION INSTITUTE
The Texas A&M University System
College Station, Texas 77843-3135

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ACKNOWLEDGMENTS

The authors would like to thank the Texas Department of Transportation (TxDOT) and the Federal Highway Administration (FHWA) who sponsored the research, and the following individuals who provided guidance and expertise during the first year of the project: Bubba Needham, Jimmie Blackwell, and Brian Burk of the TxDOT Austin District; Terry Sams, Robert Bacon, and Rick Cortez of the TxDOT Dallas District; Wallace Ewell, Tai Nguyen, Steve Connel, and David Jackson of the TxDOT Fort Worth District; Sally Wegmann and Carlton Allen of the TxDOT Houston District; Pat Irwin, Brian Fariello, and David Rodriquez of the TxDOT San Antonio District; and Cesar Quiroga and Rene Arredondo of the Texas Transportation Institute San Antonio office.

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1. INTRODUCTION

Dynamic message signs (DMSs) are permanent or portable traffic control devices with the flexibility to display a variety of messages. Through the use of DMSs, motorists are provided with information regarding upcoming traffic and roadway conditions. In contrast to static signing, DMSs convey dynamic information in a variety of applications such as work zones, incident management, traffic management, and warning of adverse conditions.

NEED FOR RESEARCH

DMSs are being deployed extensively in major metropolitan areas in Texas. Travel by drivers from Texas and other states must be seamless within each district and among districts. Therefore, DMS messages should be consistently designed and applied. Although they are complex processes, proper message design and application require the use of proven concepts and principles that form the foundation for effective DMS messages. The messages should be designed based on existing human factors design guidelines, while taking into account local sight distance constraints and limitations of the DMS.

The proven concepts and principles must be used to design DMS messages that are stored in transportation management center (TMC) message libraries. In addition, these concepts and principles must be used when TMC operators modify existing messages or develop new messages in real-time to deal with the unique aspects of an incident or other special situation. The purpose of this project is to explore the possibility of automating all or parts of the message design process so as to assist center operators in their traffic management efforts using DMSs. As part of this project, researchers will:

- develop the logic (flowcharts, conditional rules, etc.) needed to automate or provide decision support to the various parts of the DMS message design process,
- develop a proof-of-concept prototype of an automated DMS message design and display system, and
- conduct feasibility and validation testing of the message logic and the prototype using operators from selected TxDOT TMCs.

WORK PLAN

The work plan for this project consists of nine main tasks:

- Task 1: Organize and Meet with TxDOT Project Advisory Committee;
- Task 2: Visit and Review DMS Operations at Traffic Management Centers;
- Task 3: Develop DMS Operations Procedures, Decision Flowcharts, and Models to Assist DMS Operators in Selecting the “Best” Messages;
- Task 4: Develop and Test a DMS Operations Manual for Use by DMS Operators in Texas;

- Task 5: Determine Requirements of a Computerized Prototype to Assist Operators in DMS Message Design;
- Task 6: Develop Computer Prototype;
- Task 7: Test Prototype;
- Task 8: Revise Prototype; and
- Task 9: Prepare Project Documentation.

Tasks 1, 2, and most of Task 3 were completed during the first year of the project and are documented herein. Tasks 4, 5, and 6 will begin during the second year of the project. Finally, Tasks 7 through 9 will be performed during the third year of the project.

REPORT ORGANIZATION AND SCOPE

In Task 2, the TTI research team visited five TMCs in Texas to review the DMS operations and the manner in which DMS messages are designed and displayed at each TMC. The visits were followed with telephone conversations and exchange of information via e-mail. The information received as part of these visits is summarized in Chapter 2.

In Task 3, the TTI research team developed preliminary DMS operations procedures, decision models, and flowcharts. These processes, along with a short discussion of DMS message design principles, are contained in Chapter 3.

A summary of the tasks completed during the first year of the project and a discussion of the tasks to be accomplished in the second year of the project are located in Chapter 4.

2. REVIEW OF DMS OPERATIONS AT TRAFFIC MANAGEMENT CENTERS

DMSs are one of the primary communication links a transportation agency has to the motoring public it services. Due to the fact that DMSs are an expensive high-profile communications tool between a traffic management center and motorists, the quality of the messages displayed on these signs will often influence motorists' opinions towards TxDOT and intelligent transportation systems (ITS) in general.

To develop a better understanding of the TMC operations and specifically DMS message design and display procedures within five TMCs in TxDOT districts, a series of TMC visits and interviews were administered by TTI. The TMC visits took place in February 2001, during which TTI researchers met with and interviewed TxDOT personnel from five major TMCs in Texas. The TMCs visited were: Austin, Dallas (DalTrans), Fort Worth (TransVision™), Houston (TransStar), and San Antonio (TransGuide®). E-mail and telephone follow-up interviews were conducted between June and August 2001.

The information obtained from the visits and interviews has allowed TTI researchers to understand the similarities and differences among each center's DMS operating procedures. This information is invaluable to future research tasks for this project because it provides researchers with knowledge of the current practice and capabilities at each TMC. The information obtained from these visits and/or interviews was summarized and is presented herein. The complete interview responses in side-by-side format are fully summarized in Tables A1 – A5 of Appendix A. The following is a summary of the information obtained and the similarities and differences among each center's DMS operating procedures.

SUMMARY OF DISTRICT DMS OPERATIONS

The major focus of this portion of the district review was to determine the operational policies, guidelines, practices, and/or procedures for each TMC concerning the display of DMS messages including:

- incident information,
- non-incident related congestion information during peak periods,
- planned roadwork,
- planned special events,
- public service announcements,
- blank signs,
- travel-time information,
- diversion information,
- regulatory or warning speed information,
- special event information,
- severe weather or hazardous pavement condition information,

- advertisements, and
- inter-modal information.

Information obtained from the TMC visits and interviews regarding DMS operations is summarized in Tables A1 – A5 of Appendix A. Portions of these tables have been condensed further and are included in the text in Tables 1 – 4. Similarities and differences among the TMCs regarding general TMC operations and DMS message display practices, based on the answers provided by TxDOT district personnel, are presented in the sections that follow.

Comparison of DMS Operations

DMS Policy and Guidelines

To ensure that messages are uniformly designed and operated, the TMCs should have an established policy or a set of guidelines concerning the practices and procedures of designing and displaying DMS messages. Currently none of the five TMCs surveyed operate DMSs under an established written policy. Four of the five TMCs (Dallas, Fort Worth, Houston, and San Antonio), however, do follow a set of written guidelines for design and display of DMS messages. The guidelines, which vary in detail from a set of memorandums to procedural manuals, are intended to provide the DMS operators with a set of procedures to follow when posting messages. However, they do not provide the level of operational consistency that a DMS message policy or standard would establish. The level of detail of the guidelines appears to be directly proportional to the size of the TMC and the area under surveillance. The smaller TMCs (Austin and Dallas) have few or no guidelines to follow, while the larger TMCs (Fort Worth, Houston, and San Antonio) use DMS operations manuals that include message design and display procedures. It should be pointed out, however, that very few inter-district or statewide operating guidelines exist within TxDOT, which leads each TMC to, in many ways, operate autonomously from the others. As the number of districts with TMCs continues to increase throughout Texas, providing consistent use of DMSs among districts will become increasingly important.

DMS Messages for Incidents

Incident messages are generally regarded by transportation agencies nationwide as the highest priority messages for posting on DMSs. This is certainly the case within TxDOT. Each district surveyed considers incident-related messages to be the highest priority message and posts such messages accordingly. This high priority is based on the safety and congestion implications that arise when incidents occur compared to normal or recurring congestion. When competing incidents arise, districts either give priority to the upstream incident or make decisions based on competing scenarios as they arise.

Although all TMCs consider incident-related messages to be the highest priority, there is much variability among the districts in the way that incidents are detected, the design of the incident messages, and the way that the incident messages are posted. The incident messaging practices of each district surveyed are presented in Table 1.

Table 1. Comparison of District Practices Regarding DMS Messages for Incidents.

		Austin	Dallas	Fort Worth	Houston	San Antonio
Written Policy						
Written Guidelines			X	X	X	X
Incident Detection	Call-ins	X	X	X	X	X
Incident Detection	Cameras	X	X	X	X	X
Incident Detection	Sensors	X				X
Incident Verification	Call-ins	X				
Incident Verification	Cameras	X	X	X	X	X
Incident Messages Are Highest Priority		X	X	X	X	X
Highest Priority Message When Competing Messages Arise	Upstream Incident		X	X		
Highest Priority Message When Competing Messages Arise	Scenario Specific	X			X	X
Message Library		X		X	X	X
Operator Has Option to Modify Message		X	X	X	X	X
Messages Designed by Operator			X			
Automated Incident Messages		X				X
Hard Diversion						
Soft Diversion			X	X	X	X

X = Affirmative

Incident detection methods vary among the districts. Call-ins from motorists are a steadily increasing mode of detection nationwide and are the usual mode of detection for the Austin District TMC. The Dallas, Fort Worth, and Houston TMCs all use closed circuit television cameras as their primary means of incident detection and verification. San Antonio detects incidents based on lane occupancy data from permanent sensors, which are then verified by DMS operators who view the scenes from the field cameras before messages are posted.

For all districts except Dallas, messages are selected from a pre-existing message library. (In the Dallas District TMC, DMS operators design the incident messages based on district guidelines.) In most cases new messages are added only after review from district management. For Austin, Fort Worth, and Houston, operators select the messages and the appropriate DMSs from a library. Operators in each of these districts, however, have the option to override or modify library messages for a given scenario before they are displayed. This message modification or overriding process in most cases requires the DMS operator to obtain supervisor approval and in some cases, no approval at all.

The San Antonio District TMC has a highly automated message and sign selection process for incident signing including a large database of preset incident scenarios. These incident scenarios include appropriate messages and signs on which they should be displayed. Scenarios are generated from the database based on lane occupancy data algorithms and simple inputs from the DMS operator as to the nature of the incident. The operator verifies the incident and previews the scenario on the computer screen before the messages are sent out. Operators may modify messages, but only with approval from an operations supervisor. A written incident management plan is currently being developed for TransGuide®. Houston already has an incident traffic management plan for the I-10 corridor consisting of a detour plan and team to respond to major incidents with placement of static detour signs.

One incident-related DMS message practice that is constant among the five TMCs surveyed is that none of the TMCs post hard diversion messages (messages with a specific alternative route) for any type of incident. (Houston and Dallas often use hard diversion in cases where there is a major closure due to construction.) Many districts cited jurisdictional and political issues that inhibit them from posting hard diversion messages. All districts except Austin do use soft diversion messages (non-specific suggestion to use alternative routes) often as the second frame of a two-frame incident message. Soft diversion messages have an intentionally lessened effect on freeway traffic diversion. Although it is generally avoided nationwide, hard diversion if used properly may work to balance the traffic demand over the roadway network surrounding a major incident. In a 1998 study of TMC diversion messaging practices in the U.S., Durkop (*1*) found that most agencies do not display hard diversion messages due to one or more of the following factors:

- lack of roadway capacity on the surrounding network,
- lack of traffic management capabilities on the diversion roadways,
- lack of traffic management coordination between agencies, or
- lack of alternative routes on which to divert.

In addition, motorist compliance and safety issues pertaining to hard diversion are other factors working against its use.

DMS Messages for Non-Incidents

Major discrepancies exist among the districts' DMS operating procedures when no incidents have occurred during both the peak and off-peak hours. In 1996, TxDOT Traffic Operations Division developed a set of guidelines for DMS message posting for non-incident related messages that were distributed to district personnel in each of the TMCs in Texas (*2*). This memorandum was developed by TxDOT Traffic Operations staff through consultation with traffic management specialists. It contained a list of the following advantages and disadvantages of leaving the DMS blank in the absence of incidents or roadwork:

Advantages:
- energy cost savings,
- maintenance cost savings,

- motorists are not subjected to information overload, and
- when a message is displayed, it will attract the motorist's attention.

Disadvantages:

- perceived waste of taxpayers' money and
- motorists' perception that the DMS is malfunctioning or not operating.

Included in this memorandum was a flowchart for DMS operations under non-incident management conditions. This flowchart is shown in Figure 1. The flowchart clearly suggests that non-incident related messages should be avoided unless they are warranted. The flowchart was developed prior to two districts (Houston and San Antonio) developing the capability for measuring and displaying travel-time information. Information about travel time is very useful to motorists and provides the district the opportunity to display information in the absence of incidents or roadwork. Table 2 provides a comparison of district practices for posting of non-incident related messages.

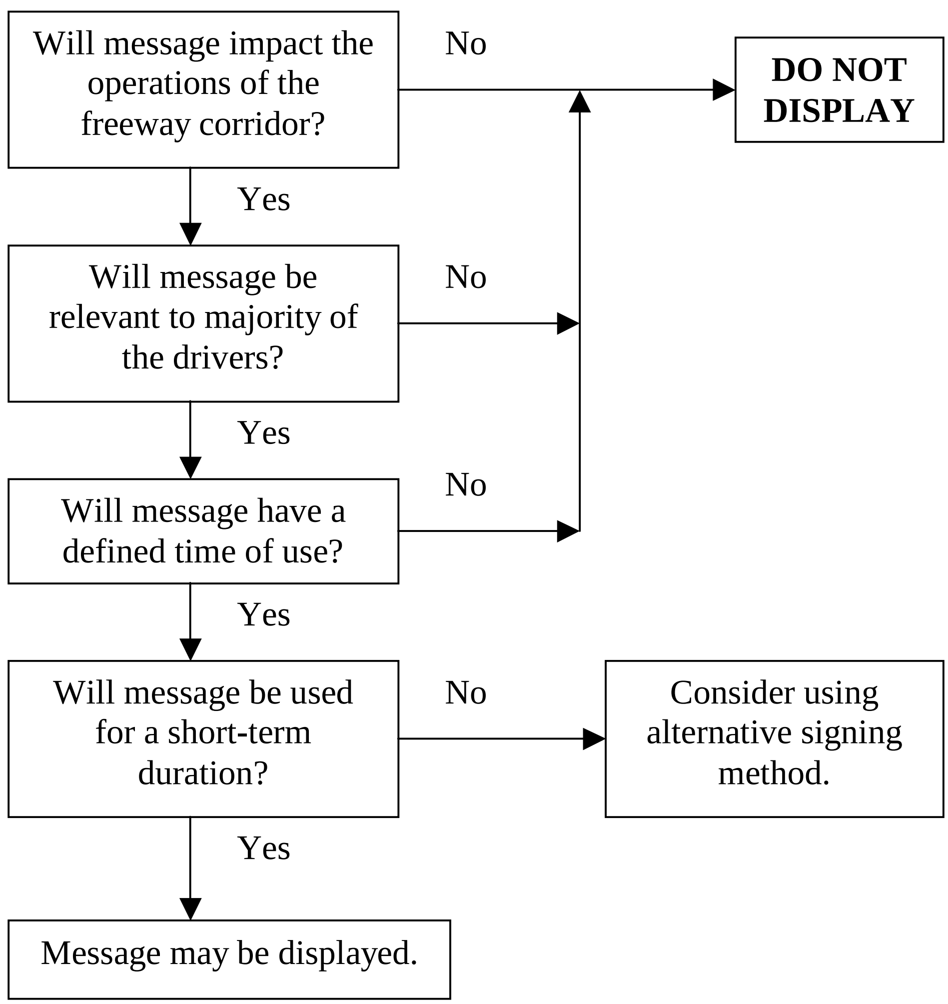


Figure 1. TxDOT Guidelines for Posting Non-Incident DMS Messages (*2*).

Table 2. Comparison of District Practices Regarding DMS Messages for Non-Incidents.

		Austin	Dallas	Fort Worth	Houston	San Antonio
Written Policy						
Written Guidelines			X	X	X	X
Non-Incident Related Congestion Messages	"Congestion"			X		
Non-Incident Related Congestion Messages	Travel Time				X	X
Non-Incident Related Congestion Messages	Manually Entered				X	
Non-Incident Related Congestion Messages	Automated			X		X
Planned Roadwork		X	X	X	X	X
Planned Special Events			X	X	X	X
Public Service Announcements		X	X	X	X	X
Blank Signs	Avoid Blank Signs				X	X
Blank Signs	Blank Unless Message Warranted	X	X	X		
Speed Messages						
Advertisements						
Inter-modal Information					X	
Severe Weather or Hazardous Pavement Conditions			X	X	X	X

X = Affirmative

As previously stated, district personnel are divided as to the use of non-incident related messages, especially when no prudent message is warranted. For example, two districts (Houston and San Antonio) attempt to have messages posted on the DMSs at all times to avoid a potential negative public perception that is sometimes associated with blank signs. For one district (Houston), avoidance of blank signs is such a high priority that time of day messages may be posted. While avoidance of blank signs may work to eliminate the potential negative public perception, the effect on traffic safety is not well known. The other three TMCs that were interviewed (Austin, Dallas, and Fort Worth) follow the previously referenced TxDOT memorandum and leave signs blank unless a message is warranted.

Guidelines as to the types of non-incident messages that may be posted vary among districts, as well. All districts post messages pertaining to planned roadwork, assuming that sufficient notice is given. Roadwork messages are usually the second highest priority message type, although portable DMSs are often provided in the vicinity for dedicated support of roadwork activities.

Another high priority message type for those districts that possess traffic flow sensing capabilities is that of non-incident related congestion or travel-time information. These types of messages are used to inform motorists about normal or recurring congestion during both the peak and off-peak periods and in some cases are posted automatically. These automated messages are overridden by incident or construction information when the need arises. Each of the three districts that have traffic-sensing capabilities (Fort Worth, Houston, and San Antonio) display non-incident related congestion messages, but each displays such messages in a different way. Fort Worth TransVision displays automated information as to the level of congestion based on loop detector data. Houston TranStar displays manually entered travel-time information based on automatic vehicle identification (AVI) data; however, because of the manual data entry, these messages often get neglected during the peak period due to the large number of incidents that occur. San Antonio's TransGuide utilizes the most advanced traffic detection and automated travel-time display of any TMC in Texas. Travel time ranges to landmarks or other highways are automatically displayed (based on detector data, average speed per segment) and are the default messages during the day. Major incidents will completely override travel-time messages, while minor incidents will include an incident message frame split with an automated travel-time frame.

Four of the five districts (Dallas, Fort Worth, Houston, and San Antonio) also post messages for large planned special events. Because many of these special events occur on weekends or holidays, interference with normal weekday commuter traffic messaging is often avoided. Public service announcements are also allowed by all of the districts, provided that the district approves the messages. These messages are usually restricted to traffic safety or air pollution related messages. It should be noted that under no circumstances do any of the districts allow advertisements to be posted on their DMSs. Regulatory or warning speed messages are also not posted on permanent DMSs in any of the TMCs. (Speed-related messages are often placed on portable DMSs in construction zones.) Severe weather or hazardous pavement condition messages are posted by four of the five TMCs that were interviewed (Dallas, Fort Worth, Houston, and San Antonio). Most of these messages pertain to pavement/weather conditions involving flooding or ice on the roadway. The districts generally do not post messages pertaining to inter-modal information, except in Houston where park-and-ride information for special event traffic is posted.

Other Message Posting Practices

To fully describe the use of DMS messages within the districts, one must consider not only the content of the message, but also the characteristics of the message when it is placed. Table 3 provides a comparison of the district practices regarding message characteristics.

All districts use two-frame messages with varying exposure times (average of two seconds per frame) when long messages are needed. Three districts (Dallas, Fort Worth, and Houston) also change one line of a message while leaving the other two static in situations where a certain subject of the message is to be emphasized, such as the specific message audience. It should be noted that based on recent findings from TxDOT Project 0-1882, TTI researchers recommended that this approach not be used because it takes drivers longer to read the message (*3*). Flashing messages or certain lines within messages is practiced only in the Fort Worth District and only in situations that are determined to be significant, but not urgent enough to use flashing beacons. It should be noted that recent results from TxDOT Project 0-1882 showed that it takes drivers longer to read flashing messages. TTI researchers recommended that flashing messages not be used (*3*). Flashing beacons are used by all districts although warrants for their use vary, usually involving messages pertaining to driver safety or the ability to avoid substantial delay, such as for major incidents or construction.

Table 3. Comparison of District Practices Regarding DMS Message Characteristics.

		Austin	Dallas	Fort Worth	Houston	San Antonio
Written Policy						
Written Guidelines			X	X	X	X
Two-Frame Messages		X	X	X	X	X
Changing Only Specific Lines in Two-Frame Messages			X	X	X	
Flashing Messages or Lines				X		
Beacons		X	X	X	X	X
Message Posting by Other Agencies	Allowed by District	X			X	
	Message Library Used	X			X	
Message Modification for Local Conditions		X			X	X

X = Affirmative

Message posting on TxDOT-owned DMSs by agencies other than TxDOT is a very uncommon practice, although it is allowed by the Houston District for use by the Houston Metro transit authority on DMSs in the high-occupancy vehicle (HOV) lanes and park-and-ride lots; and by the Austin District for use by the city law enforcement agency during after-hours. In each case, a message library is recommended for use.

Occasionally DMSs have been placed in locations where the message legibility distance is reduced. Such locations include DMS placement at extreme horizontal and vertical curves, overpasses and locations where glare from the sun is common. For these cases, message length and content should be reduced to accommodate for the reduction in readability distance. Three districts (Austin, Houston, and San Antonio) make such modifications to DMS messages.

Message Posting Procedures on Portable DMSs

While the district messaging practices on permanent DMSs generally follow the established district operating guidelines, messaging practices on portable DMSs are entirely different. The control of portable DMS messaging while in TxDOT right-of-way is an issue of great importance and applies to all districts, not just to those districts with TMCs. Portable DMSs may either be state owned or privately owned. TxDOT-owned portable DMSs are used extensively for maintenance activities and short-term work zones and occasionally for special events and support of permanent DMSs for major incidents. Privately owned DMSs are generally used in and around construction work zones. Table 4 provides a comparison of the district practices concerning the use of portable DMSs.

Table 4. Comparison of District Practices Regarding Portable DMS Messages.

		Austin	Dallas	Fort Worth	Houston	San Antonio
When Used	Construction	X	X	X	X	X
	Maintenance	X	X			
	Special Events	X		X	X	X
	Incident Support			X	X	X
Controlled From TMC (State-Owned DMS Only)						X
Messages Designed by TMC (State-Owned DMS Only)			X		X	X
TMC Not Involved with Portable DMS Messages		X		X		

X = Affirmative

The major issue at hand is not who owns the portable DMS, but rather who is responsible for designing and placing the messages that are used. Although they are only for temporary use, portable DMSs must still maintain the same message integrity as the permanent DMSs and should be programmed and placed accordingly. Ideally, all portable DMSs would be controlled and monitored from a TMC. However, portable DMSs pose problems because they are easily moved and are often placed outside of the surveillance or sensor boundaries. These issues make it difficult for the TMC personnel to monitor both the location of the sign and the messages placed, and therefore TMCs either rely heavily on field personnel to monitor the messages or choose to assign control of the portable DMSs to other offices.

Due to the difficulties associated with control of portable DMSs, only San Antonio TransGuide controls its portable DMSs from the TransGuide control room. Messages are designed at TransGuide based on the scenario and are generally chosen from the message library. Messages are posted on portable DMSs with the approval of the floor manager, although field personnel assist heavily in assuring that the messages are updated with changing site conditions. The Dallas and Houston districts design the messages based on input from the requesting agency and program the state-owned portable DMSs at the TMC. TxDOT TMCs are not, however, involved with the message design and posting on privately owned portable DMSs used in construction sites. These responsibilities lie with the TxDOT area office project staff, such as the inspector or project engineer, to approve the messages. Occasionally, other agencies, such as the local transit authority, will place portable DMSs on state right-of-way. In these cases, the owning agency is required to obtain permission and message approval through the office of the District Transportation Operations Engineer. The Fort Worth and Austin District TMCs are not involved with the design and control of portable DMS messages.

CONCLUSIONS

The TxDOT TMC reviews have assisted the researchers in identifying the similarities and differences in the message posting practices of the TMCs and the automated message posting capabilities of each. Some of the main points from the TMC visits regarding DMS operations are as follows:

- DMS message posting procedures vary widely from district to district.
- No TxDOT TMC currently operates under a written policy for posting of DMS messages.
- Four of five TxDOT TMCs operate under a written set of operating guidelines.
- No TxDOT TMC uses hard diversion for incidents although soft diversion is used by most.
- Advanced traffic-sensing capabilities exist in the Fort Worth, Houston, and San Antonio Districts.
- Automated message-posting capabilities currently exist in the Fort Worth and San Antonio TMCs.

The information gained from the TMC reviews will provide valuable information for upcoming tasks in this project and shall be used accordingly to assist in the development of a standardized operators manual and automated messaging system prototype for TxDOT. The detailed results of the TxDOT TMC reviews are reported in Appendix A Tables A1 – A5.

3. DECISION FLOWCHARTS AND MODELS

In this chapter, the logic and procedure for the design of DMS messages when incidents and roadwork occur are presented in the *DMS Message Design Flowchart for Incidents* and *DMS Message Design Flowchart for Roadwork*, respectively. Time-tested DMS message design principles were used in the development of these DMS message design processes.

As a prelude to the use of the DMS message design flowcharts, some basic DMS message design principles are provided in the following section.

SOME DMS MESSAGE DESIGN PRINCIPLES

To be effective, a DMS must communicate a meaningful message that can be read and comprehended by motorists within a very short period. To accomplish this task, the following message design factors should be considered:

- content – the specific information displayed,
- length – number of words or characters and spaces,
- load – number of units of information in message, and
- format – order and arrangement of the units of information.

Message Content

The essential elements to message content are: what is wrong ahead, where is the problem located, and what action the motorist should take. Thus, the content must provide information relative to the motorists' needs. Motorists expect the problem or reason to appear first, followed by where the problem occurs. Advice, such as "use other routes," should be presented at the end of the brief message.

In urban areas where the crossroads are relatively close and the motorists are familiar with the area, the location of the problem should be referenced to a crossroad, ramp, or landmark. In contrast, motorists who are unfamiliar with the area prefer to have the problem referenced in terms of distance from the DMS. In rural areas where crossroads are infrequent, it becomes necessary to reference the location of the problem in terms of distance even for familiar motorists.

When motorists are advised by the DMS message to divert and take a specific highway or route, it is essential that the destination names and routes used in the message are the same as those displayed on the existing guide signs. Inconsistency between the DMS message and the existing guide signs will lead to motorist confusion and may cause some motorists to take incorrect routes. Therefore, the message designer must have a full knowledge of the wording and route markers on the existing guide signs before diversion messages directing motorists to a specific highway or route are used in a DMS message.

Message Length

The maximum length of a DMS message is controlled in part by the reading time – the time the motorist has available to read the message. Thus, the entire message must be short enough to allow motorists to glance at the sign, read, and comprehend the sign while attending to the complex driving environment. Below are some of the items that need to be considered when determining message length:

- It takes unfamiliar motorists longer to read a DMS message than familiar motorists who see the sign regularly.
- Motorists time-share their attention to the roadway and traffic with reading signs.
- Motorists must read the entire message on a DMS to obtain relevant information.
- There is evidence that an eight-word message (excluding prepositions) is approaching the processing limits of motorists traveling at speeds of 55 mph or more.
- It takes motorists longer to read: 1) flashing messages, 2) messages in which one of the lines is flashed, and 3) alternating text on one line of a three-line CMS while keeping the other two lines of text the same.

Message Load

An informational unit refers to each separate data item given in a message which a motorist could recall and which could be a basis for making a decision. The following example serves to illustrate the concept of units of information:

Question	Answer	Informational Units
1. What happened?	1. Accident	1 unit
2. Where?	2. At Exit 45	1 unit
3. What and how many lanes are affected?	3. Left Lane Closed	1 unit
4. What is the effect on traffic?	4. Major Delay	1 unit
5. Who is the audience for action statement?	5. Galveston Traffic	1 unit
6. What action should motorists take?	6. Use Loop 610	1 unit

Research and experience (*4*, *5*) have shown that on urban freeways, DMS messages must not exceed four units of information when the freeway operating speed is greater than 35 mph. When speeds are equal to or less than 35 mph, no more than five units should be displayed on a single DMS.

The *Basic DMS Message* is the totality of information that the motorists will need on the DMS in order to make a rational driving decision and consists of the following message elements:

- incident or roadwork descriptor,
- incident or closure location,
- lanes affected or closed,
- effect on travel,
- action,

- audience for action, and
- one good reason for following action statement.

However, in most cases the *Basic DMS Message* will exceed the informational unit maximum of four or five units. Therefore, priorities must be set to ensure that the most relevant information is displayed, albeit sub-optimal.

Message Format

The order and arrangement of the units of information is important to allow motorists to easily read and interpret the information and make rational decisions based on that information. Placement of message elements on the wrong line or in the wrong sequence will result in driver confusion and will increase message reading times.

In many cases, messages are too long to display at one time. Therefore, the message must be divided into two parts and displayed on two frames. In no case, should the message be longer than what can be displayed on two frames. Each message frame must be cohesive and understandable, and the information units on a specific frame must be compatible.

When a specific unit of information does not fit on a DMS line because of the limitation in the number of characters that can be displayed on a line, it sometimes becomes necessary to use abbreviations. Some abbreviations take longer to read and comprehend and thus must be used with care. There is a library of words and phrases of acceptable abbreviations that have been tested via human factors studies in Texas and elsewhere.

DMS MESSAGE DESIGN FLOWCHARTS

Figure 2 contains the *DMS Message Design Flowchart for Incidents* while Figure 3 contains the *DMS Message Design Flowchart for Roadwork.* The user of the DMS message design flow-charts will find a degree of repetition; however, this repetition is necessary to allow the user to reference successive pages when designing a message for the specific DMS location relative to the incident or roadwork. The reference materials for the flowcharts (e.g., tables for each scenario and DMS location) will be created in the second year of the project; thus, currently the table numbers in the flowcharts are denoted with an asterisk.

Incidents

The *DMS Message Design Flowchart for Incidents* includes detailed guidelines for the following three scenarios (Figure 2 Part a, b, and c, respectively):

1. lane-closure (blockage) incidents,
2. incidents that block all lanes, and
3. incidents that require closing the freeway.

The guidelines are further subdivided with respect to the DMS location:

- same freeway and relatively close to the incident,
- same freeway but relatively far from the incident, and
- a different freeway than the incident.

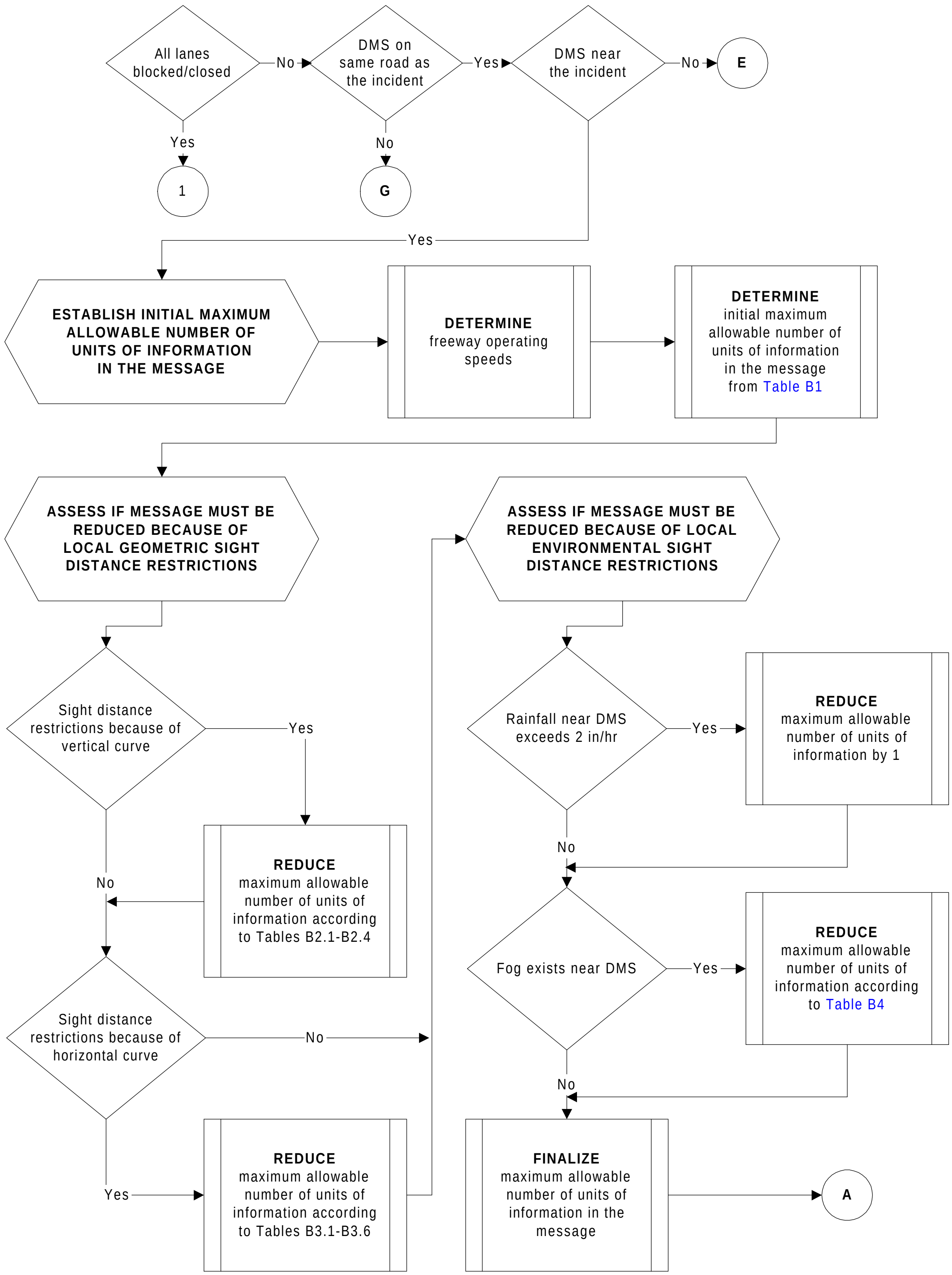
Roadwork

The *DMS Message Design Flowchart for Roadwork* includes detailed guidelines for the following two scenarios (Figure 3 Part a and b, respectively):

1. lane closures and
2. closing the freeway.

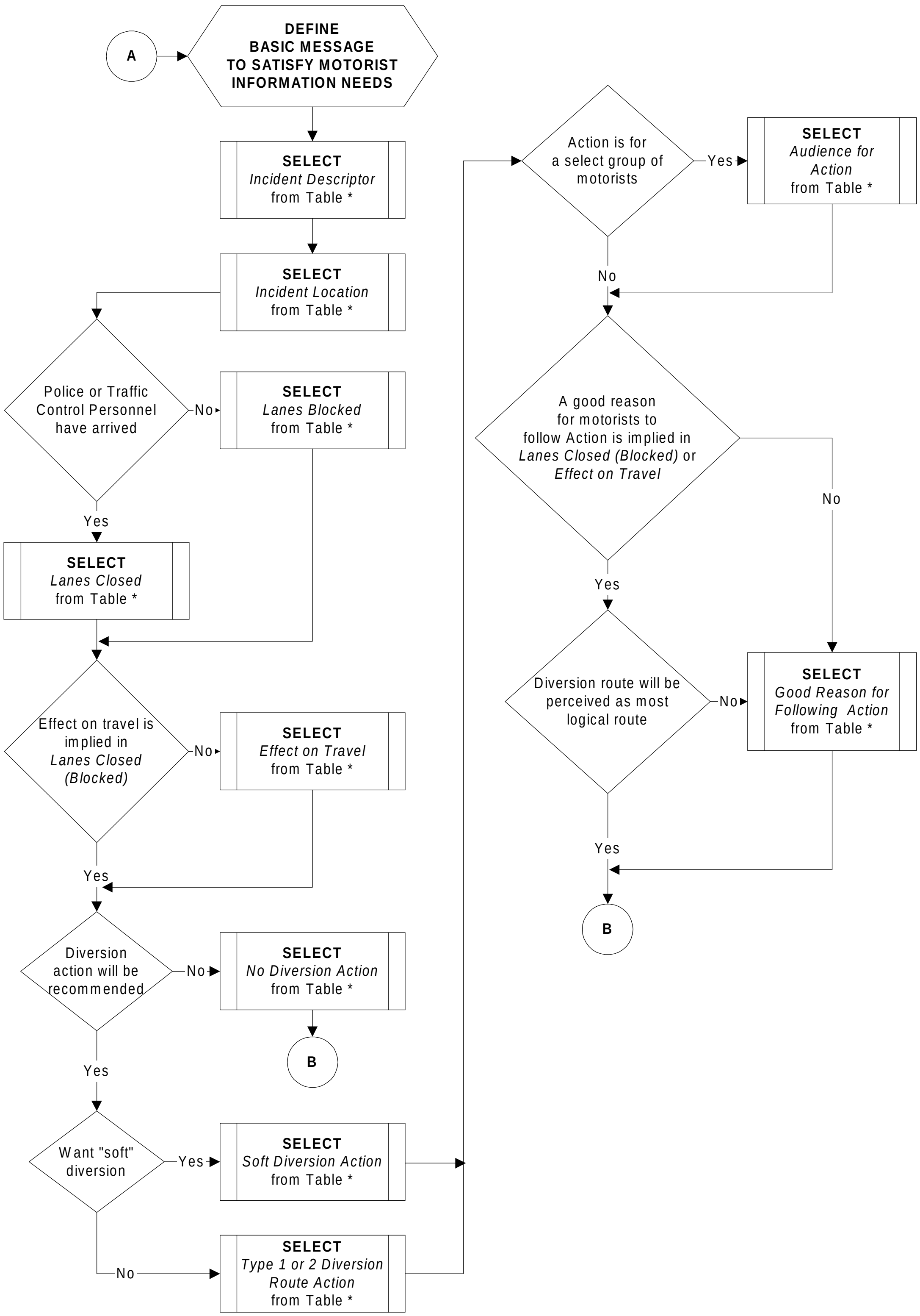
As with the flowchart for incidents, the guidelines are further subdivided with respect to the DMS location:

- same freeway and relatively close to the incident,
- same freeway but relatively far from the incident, and
- a different freeway than the incident.



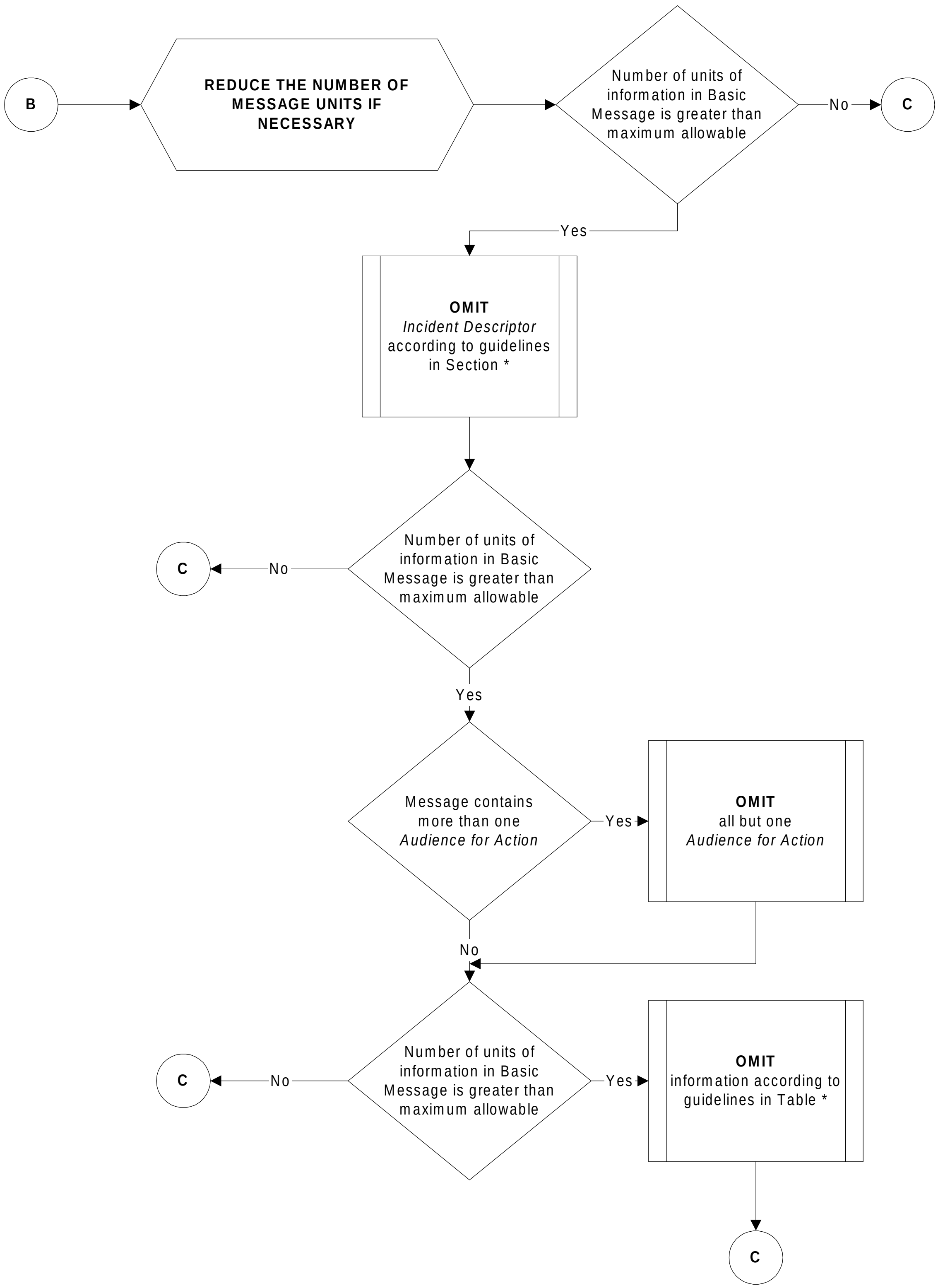
(a) Lane-Closure (Blockage)

Figure 2. DMS Message Design Flowchart for Incidents.



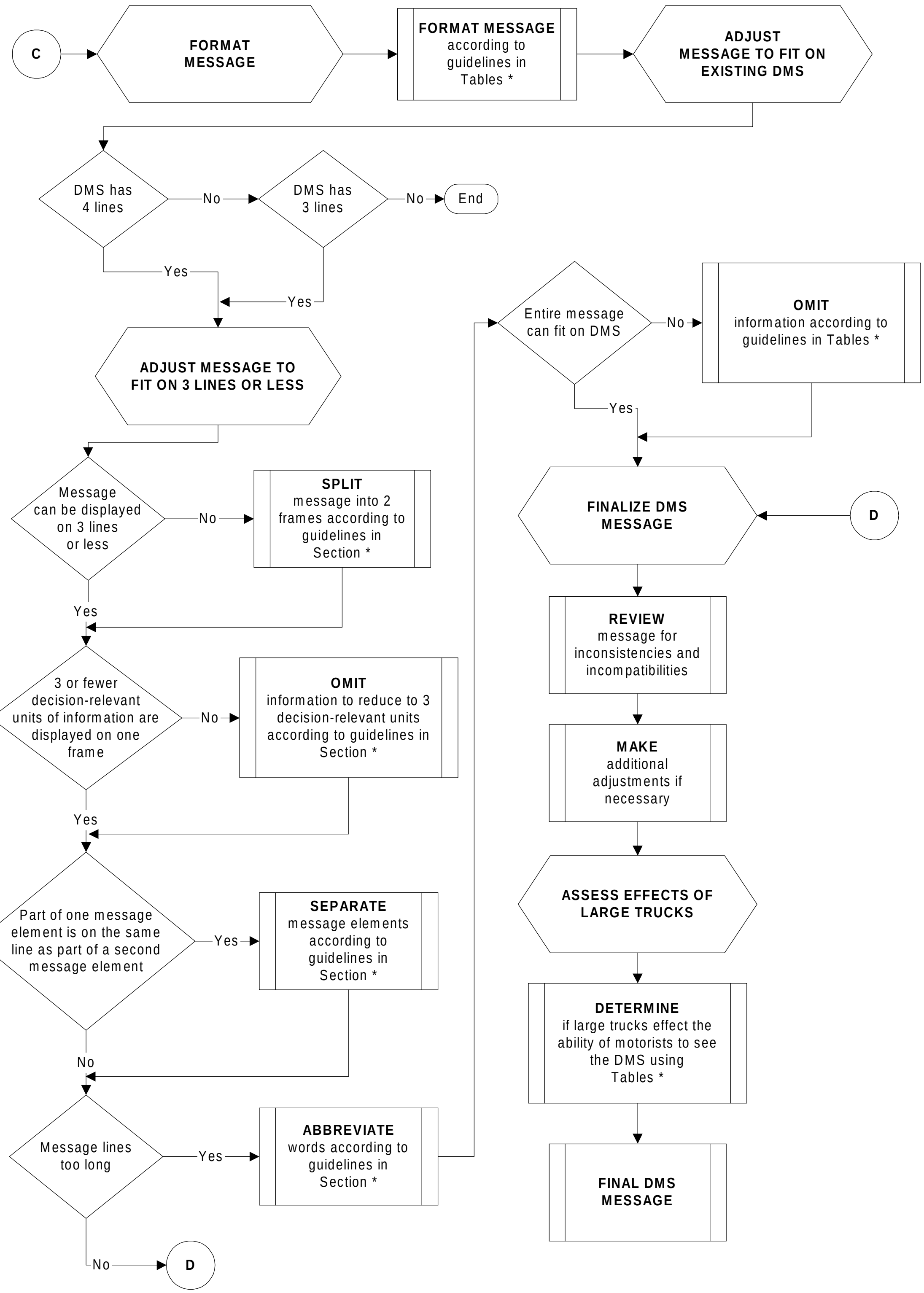
(a) Lane-Closure (Blockage)

Figure 2. DMS Message Design Flowchart for Incidents (continued).



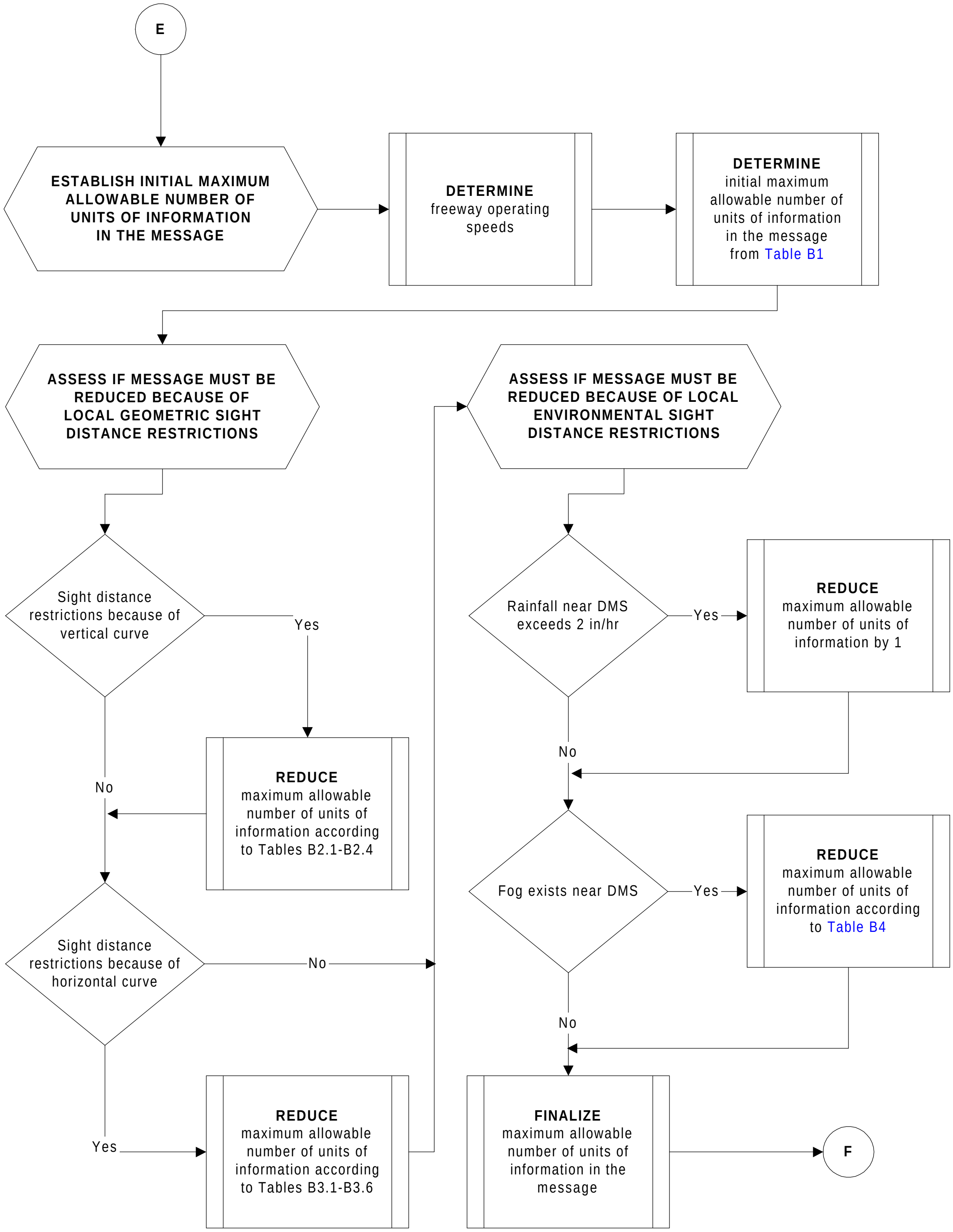
(a) Lane-Closure (Blockage)

Figure 2. DMS Message Design Flowchart for Incidents (continued).



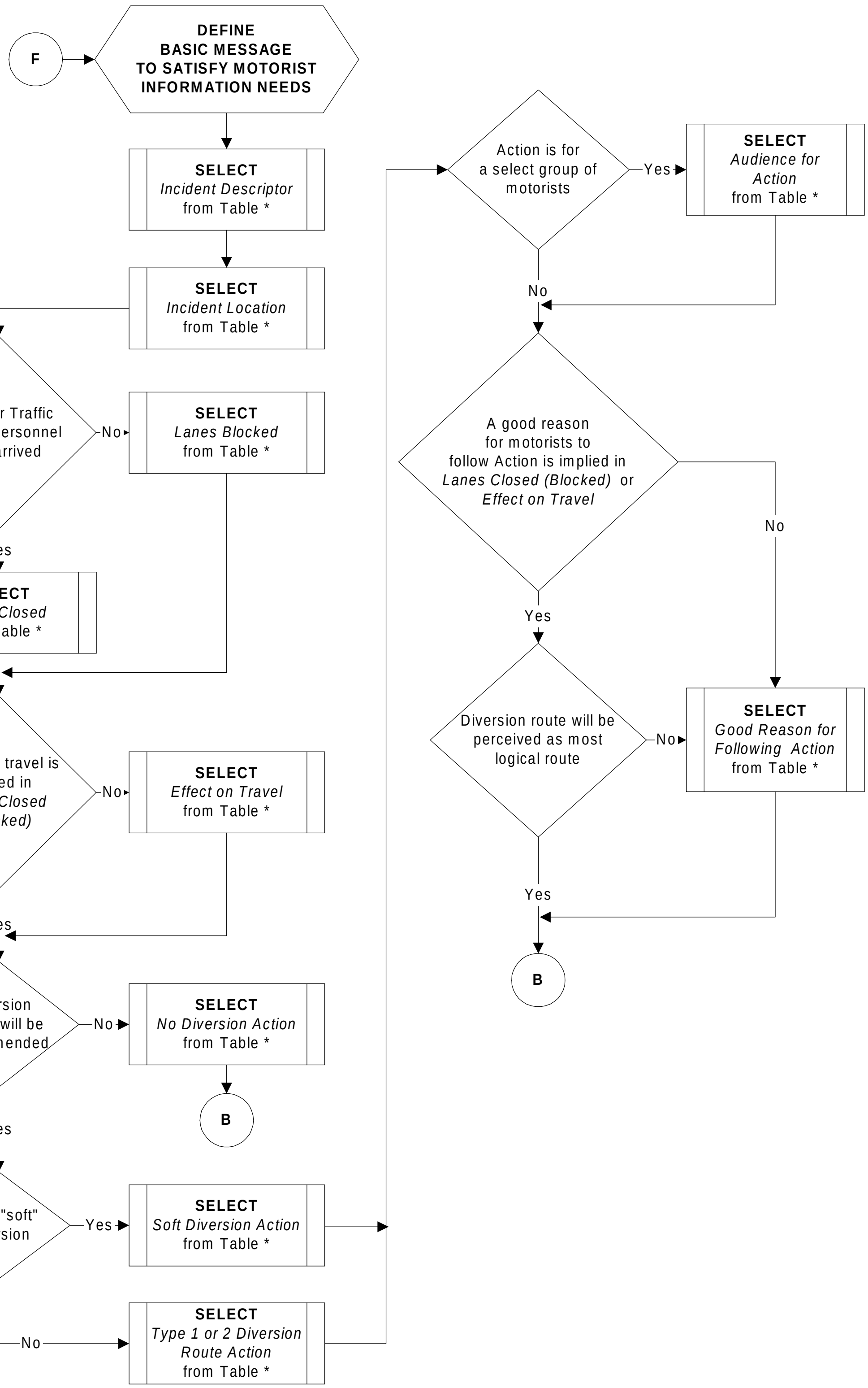
(a) Lane-Closure (Blockage)

Figure 2. DMS Message Design Flowchart for Incidents (continued).



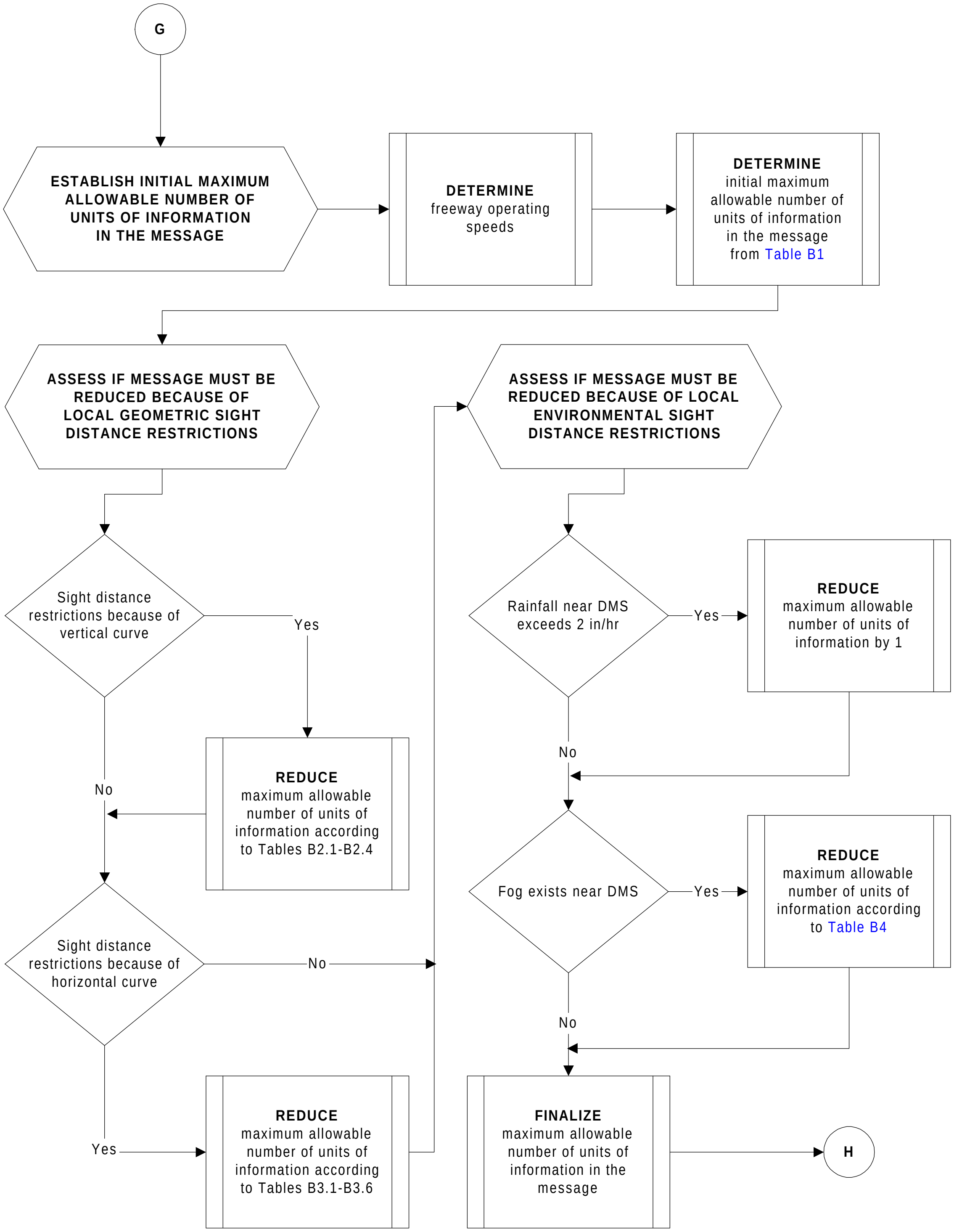
(a) Lane-Closure (Blockage)

Figure 2. DMS Message Design Flowchart for Incidents (continued).



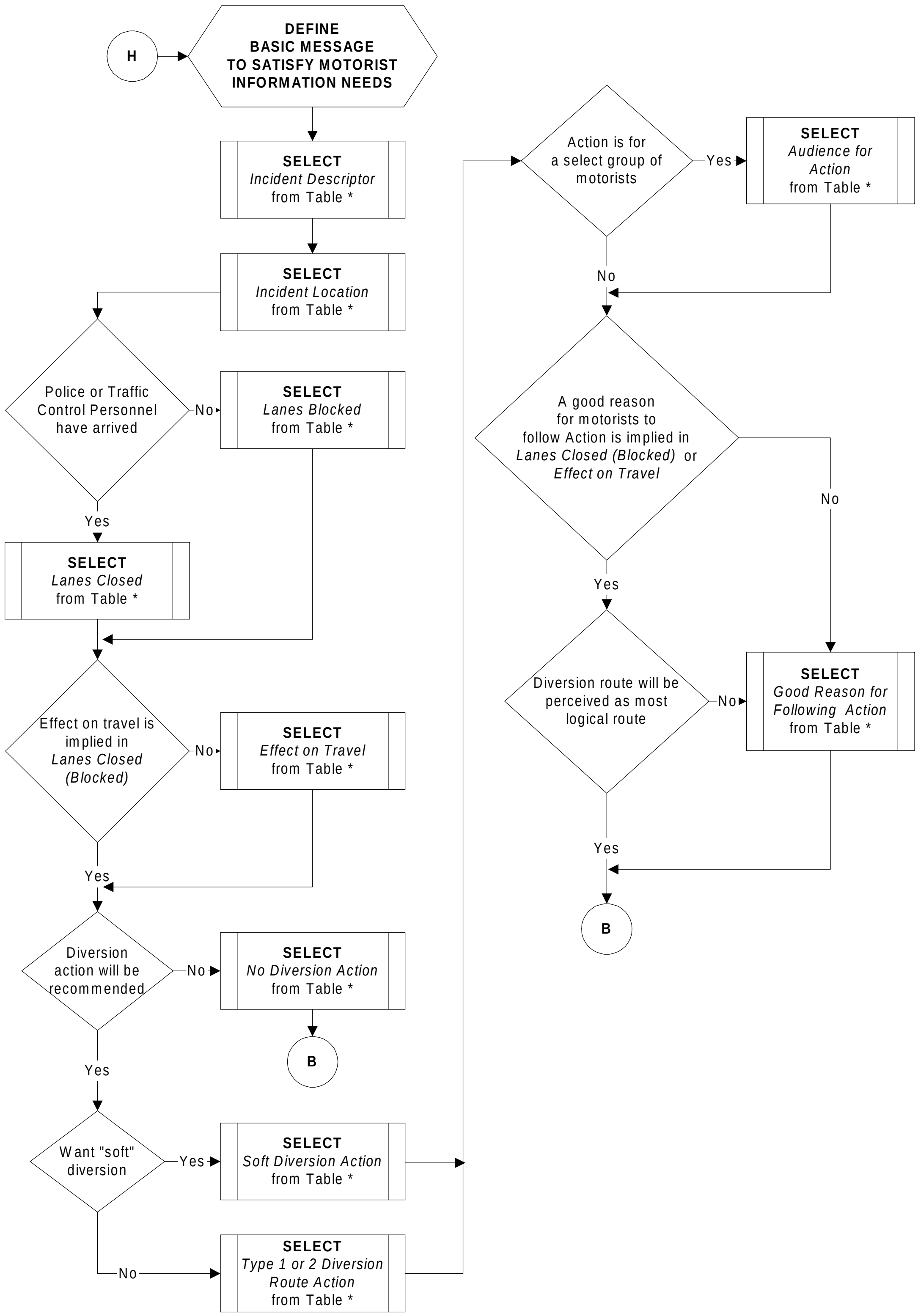
(a) Lane-Closure (Blockage)

Figure 2. DMS Message Design Flowchart for Incidents (continued).



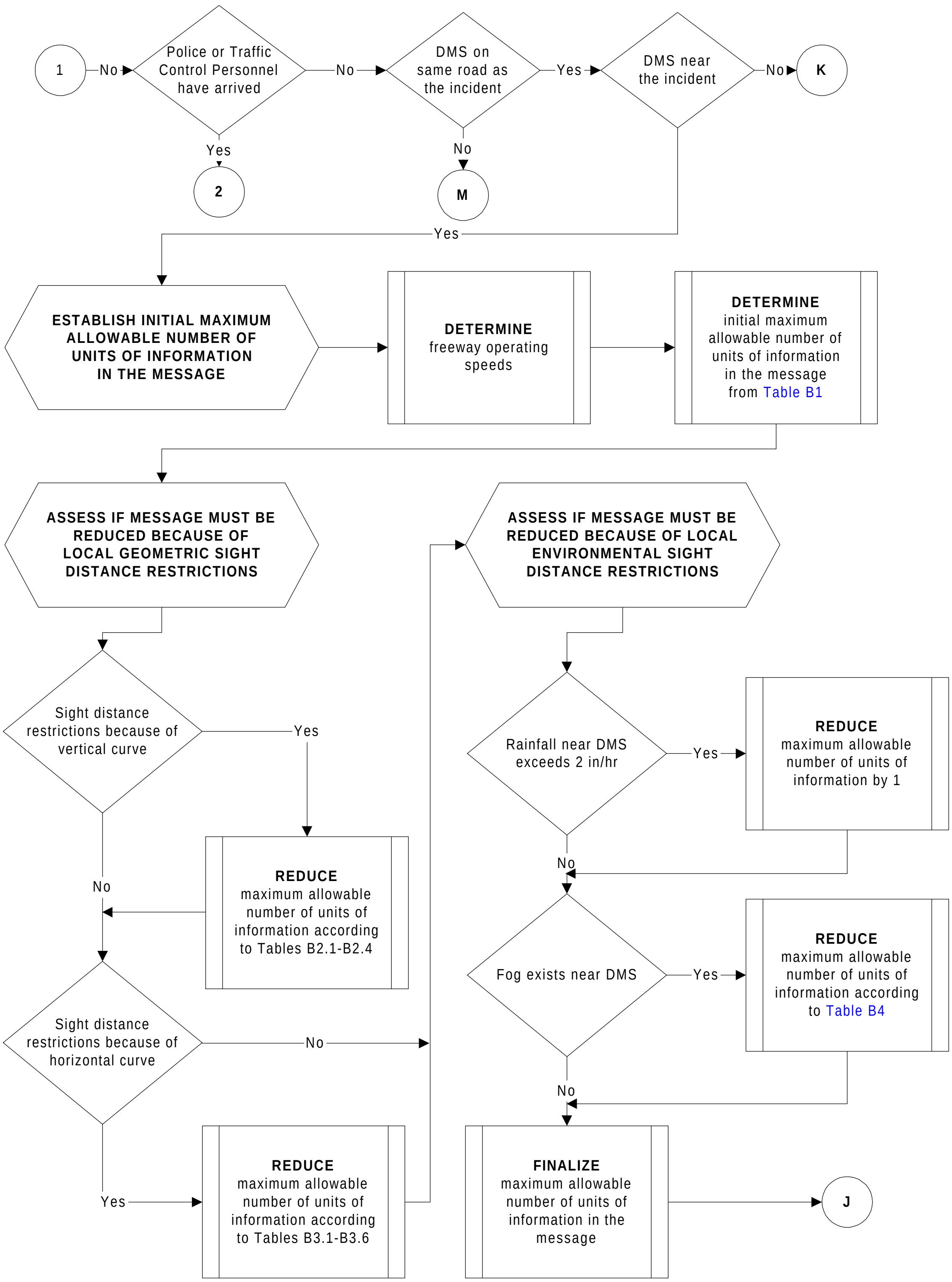
(a) Lane-Closure (Blockage)

Figure 2. DMS Message Design Flowchart for Incidents (continued).



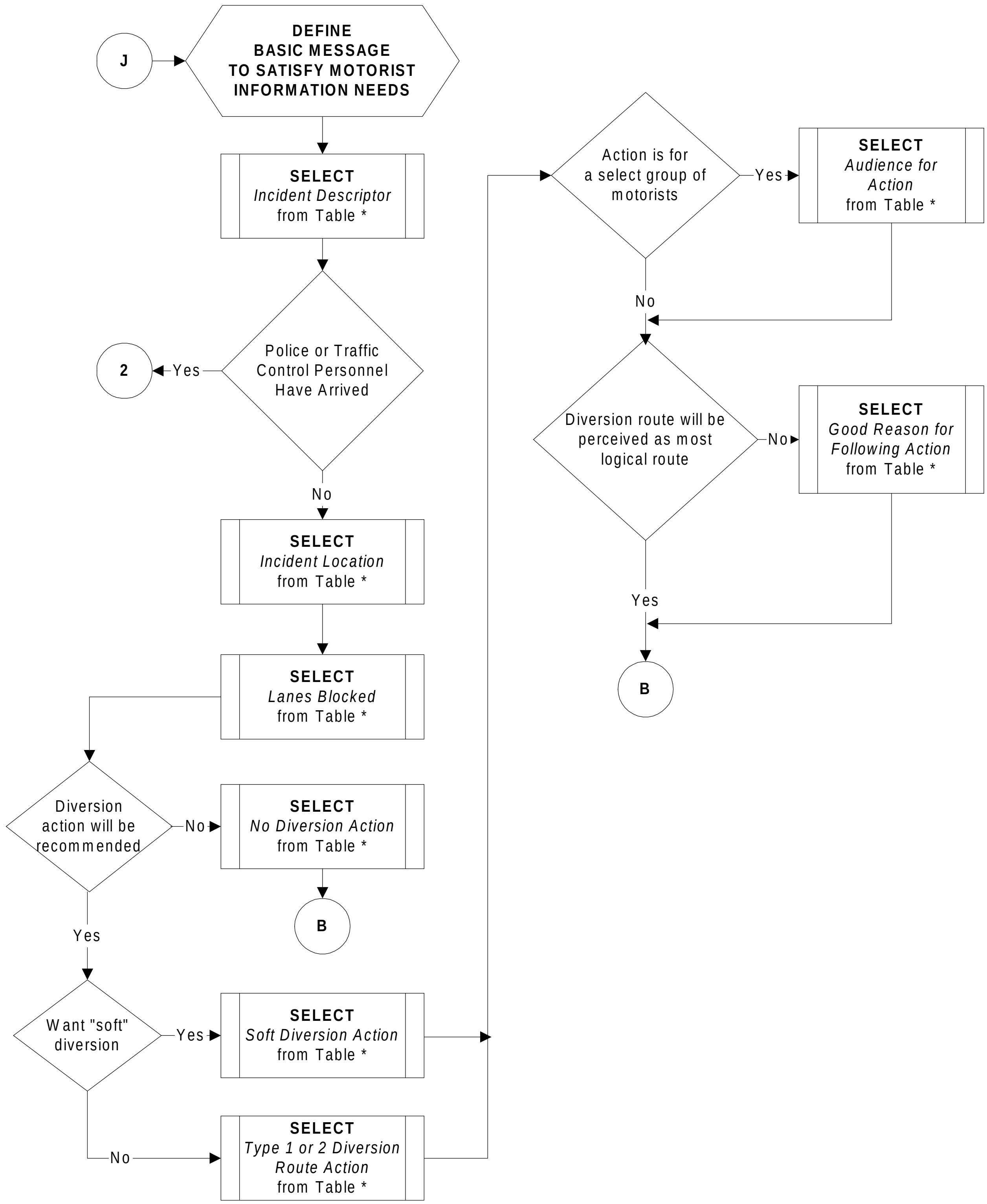
(a) Lane-Closure (Blockage)

Figure 2. DMS Message Design Flowchart Incidents (continued).



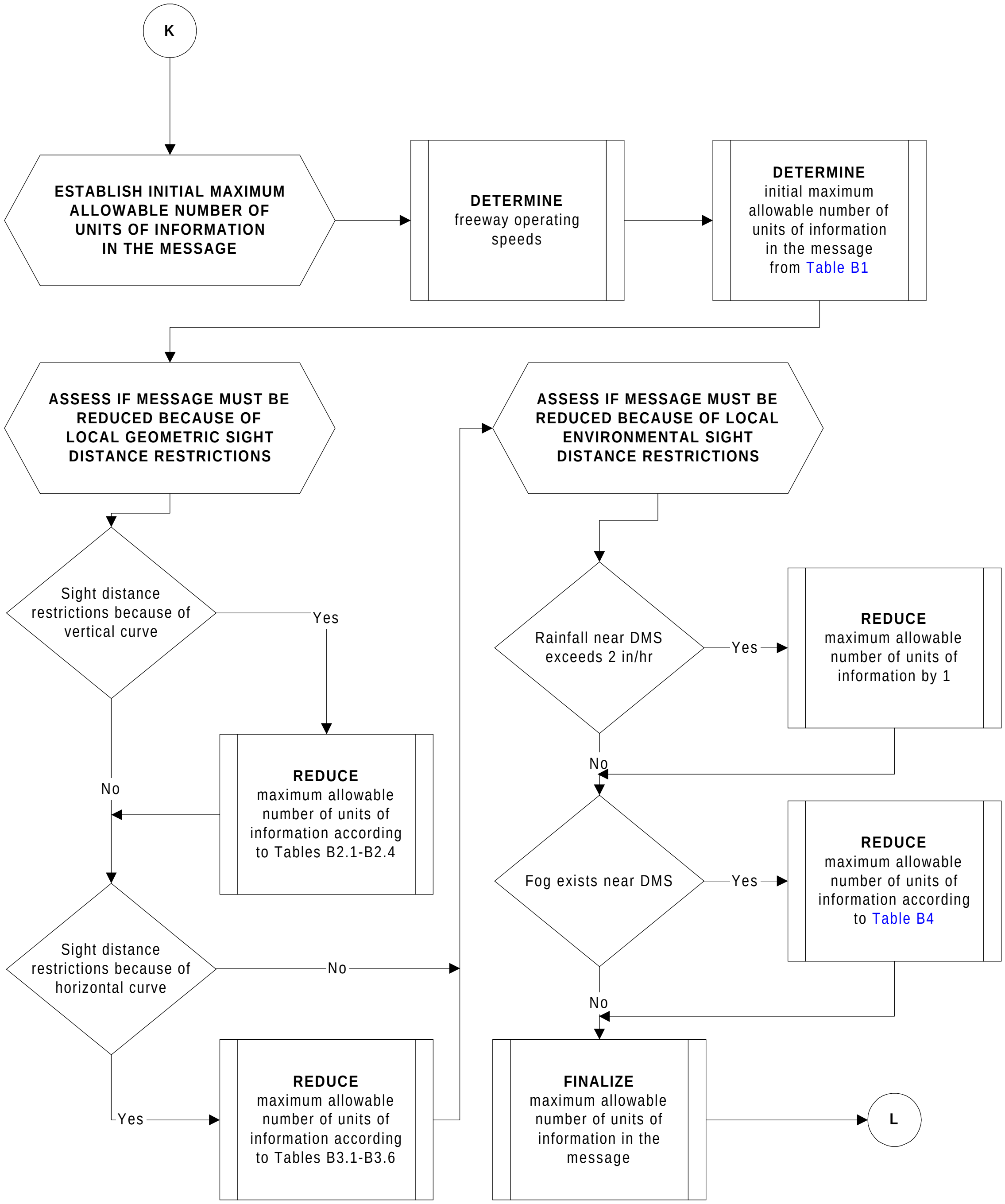
(b) Block All Lanes

Figure 2. DMS Message Design Flowchart for Incidents (continued).



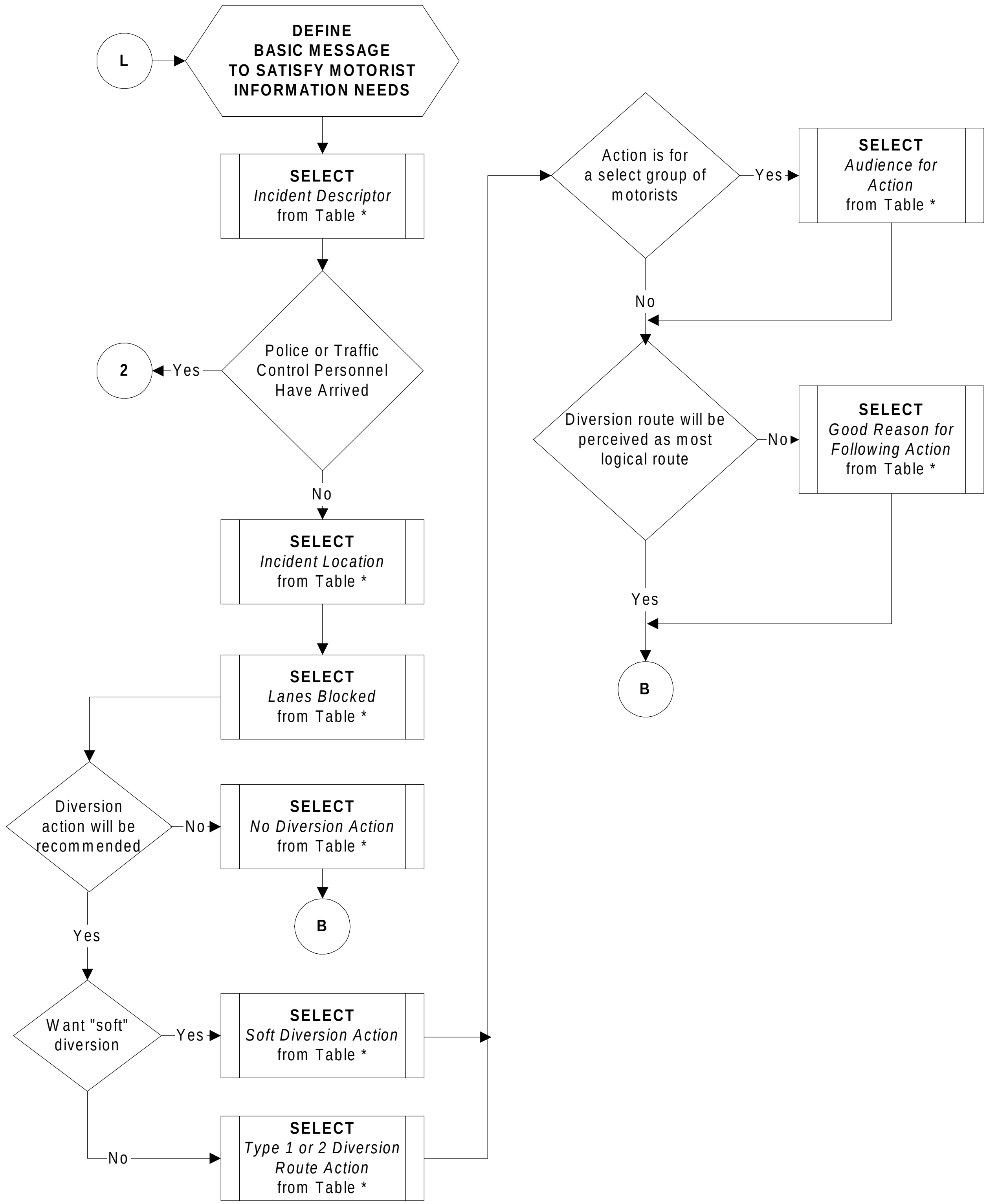
(b) Block All Lanes

Figure 2. DMS Message Design Flowchart for Incidents (continued).



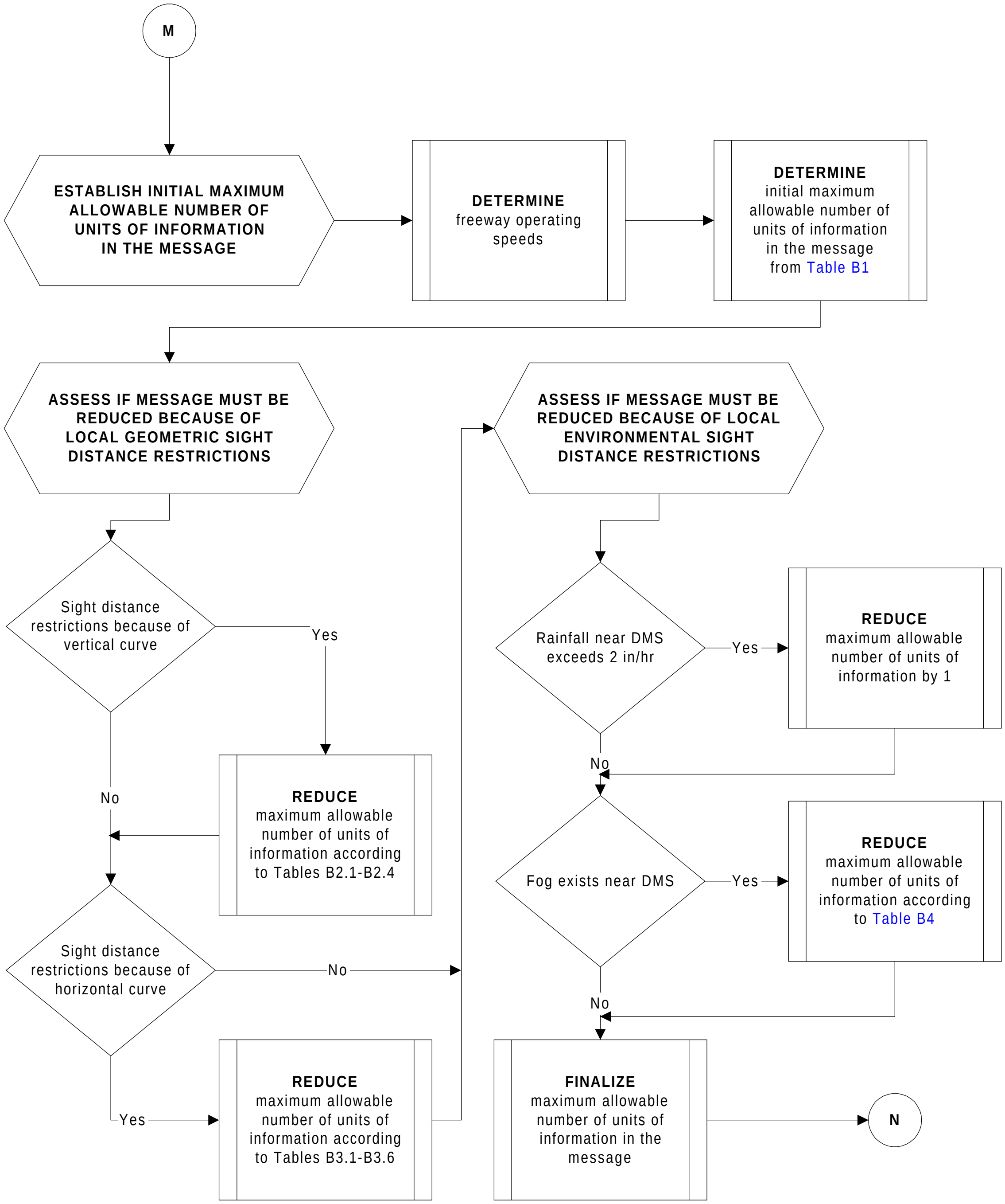
(b) Block All Lanes

Figure 2. DMS Message Design Flowchart for Incidents (continued).



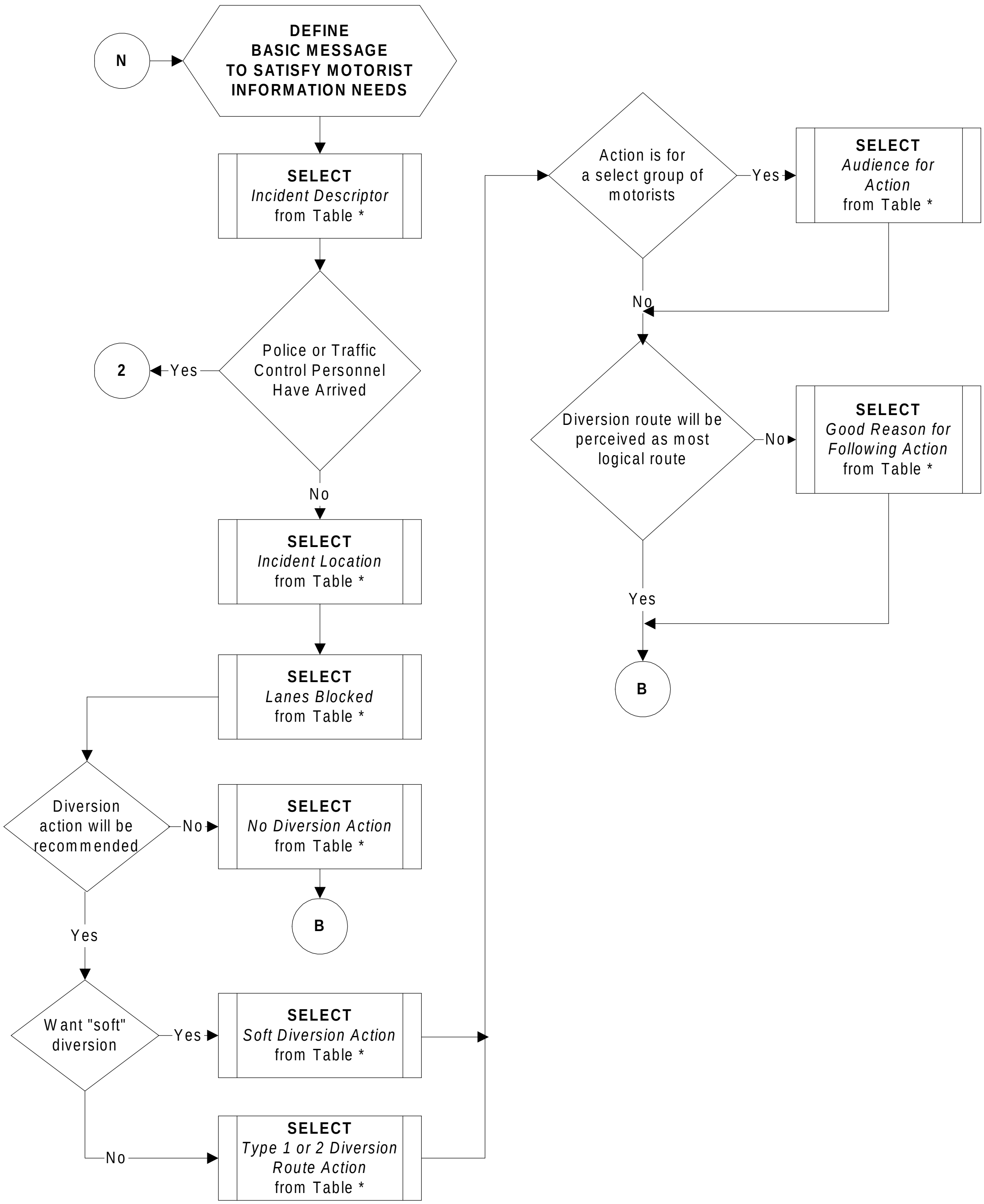
(b) Block All Lanes

Figure 2. DMS Message Design Flowchart for Incidents (continued).



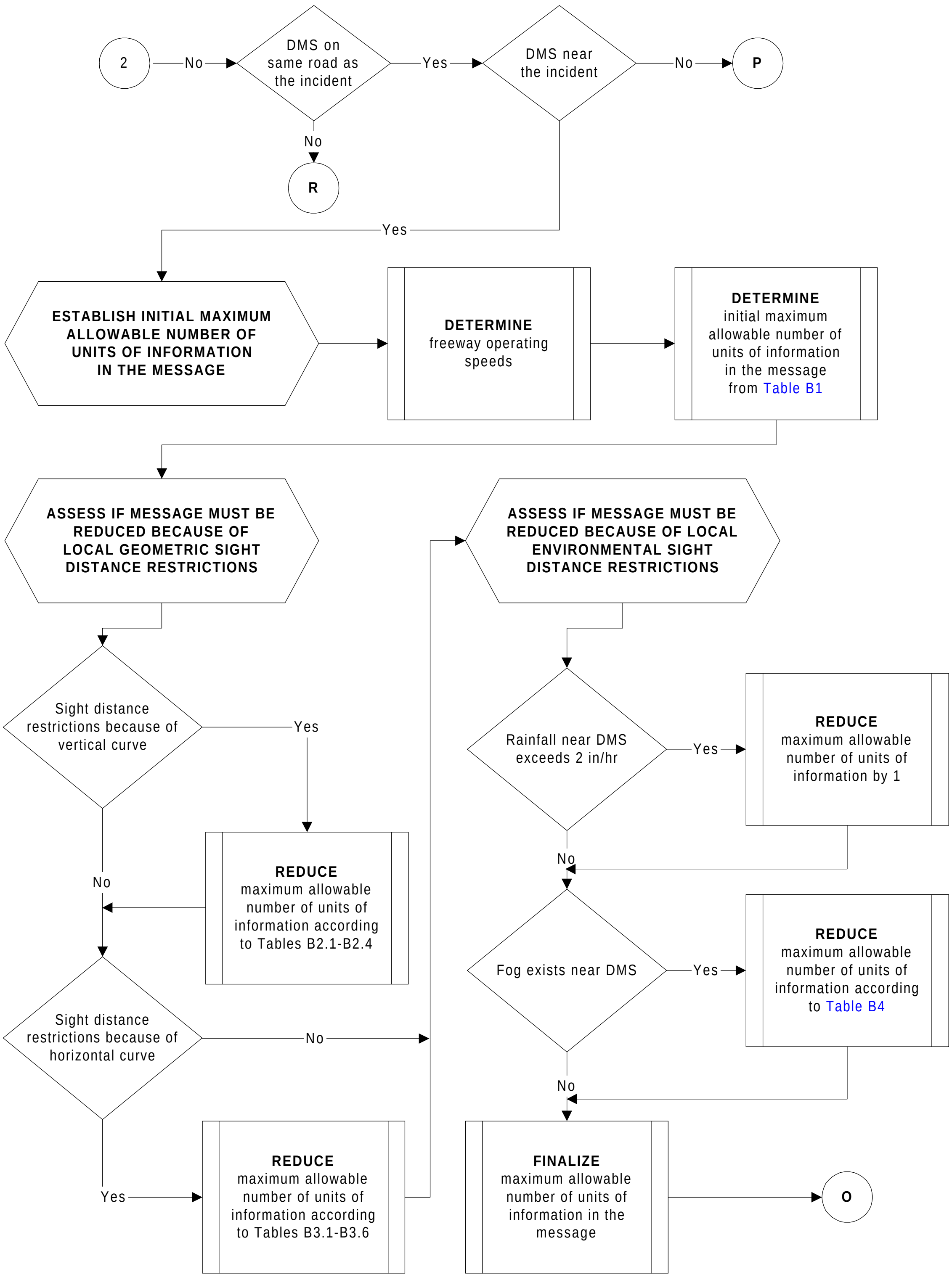
(b) Block All Lanes

Figure 2. DMS Message Design Flowchart for Incidents (continued).



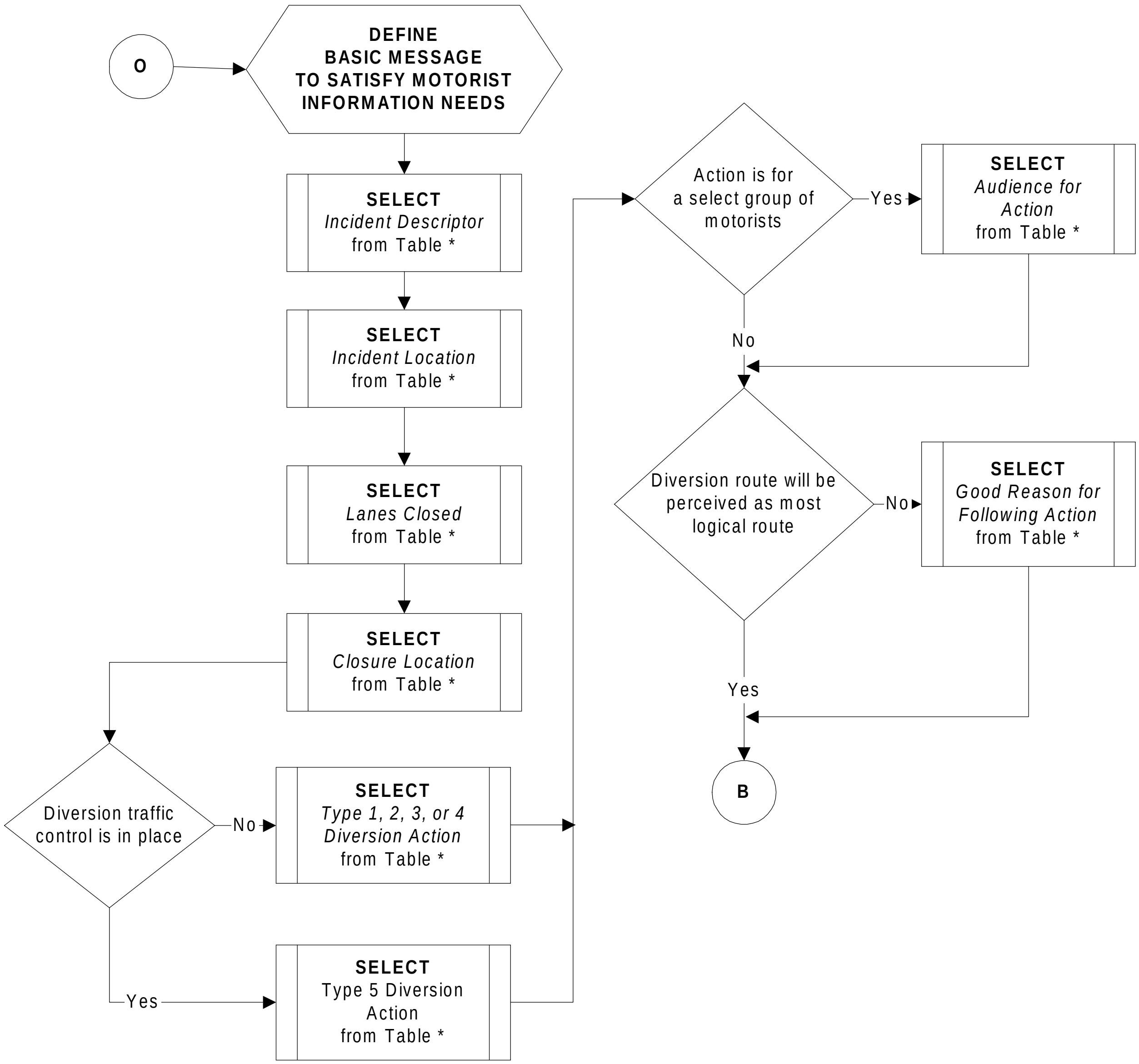
(b) Block All Lanes

Figure 2. DMS Message Design Flowchart for Incidents (continued).



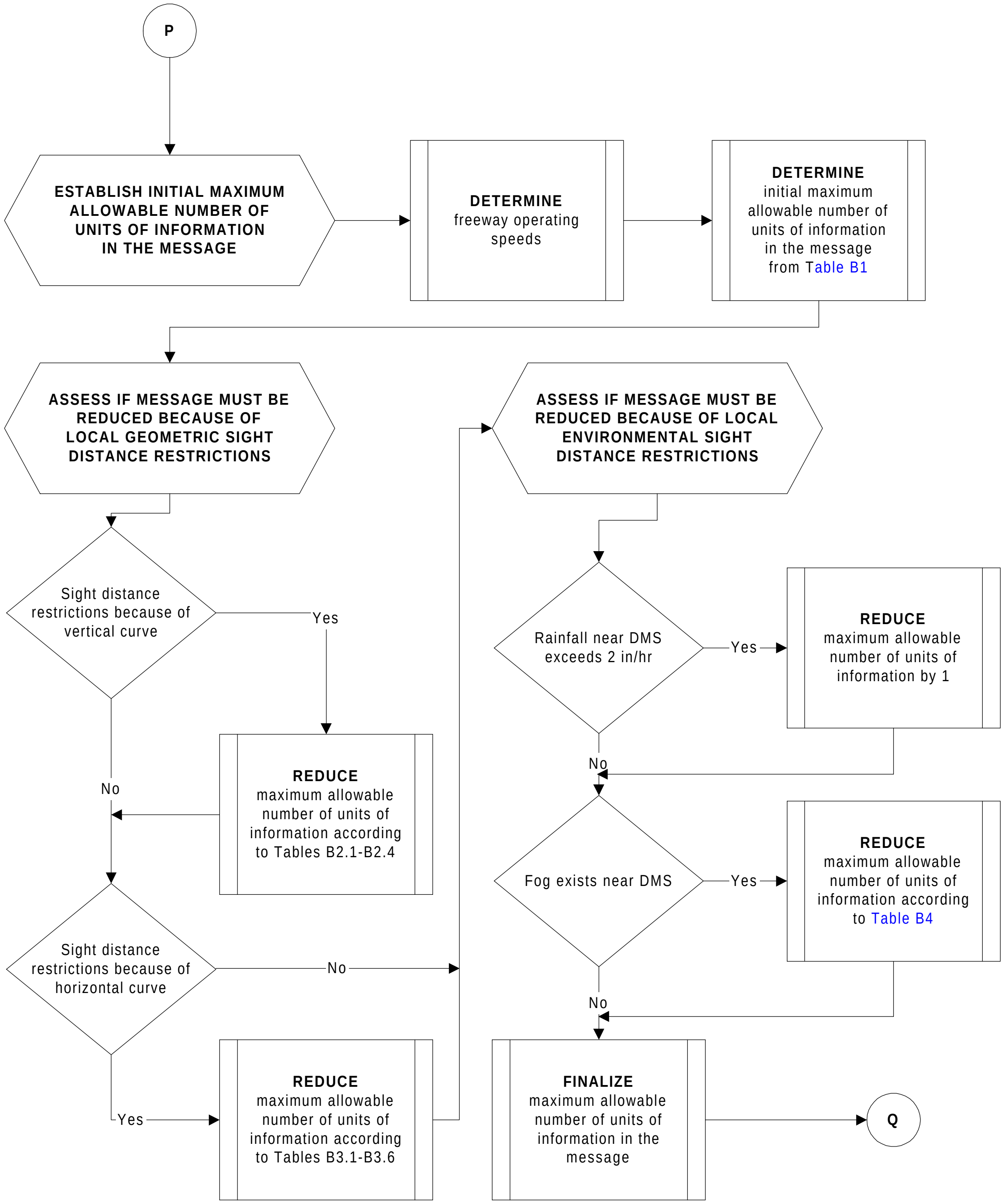
(c) Closing the Freeway

Figure 2. DMS Message Design Flowchart for Incidents (continued).



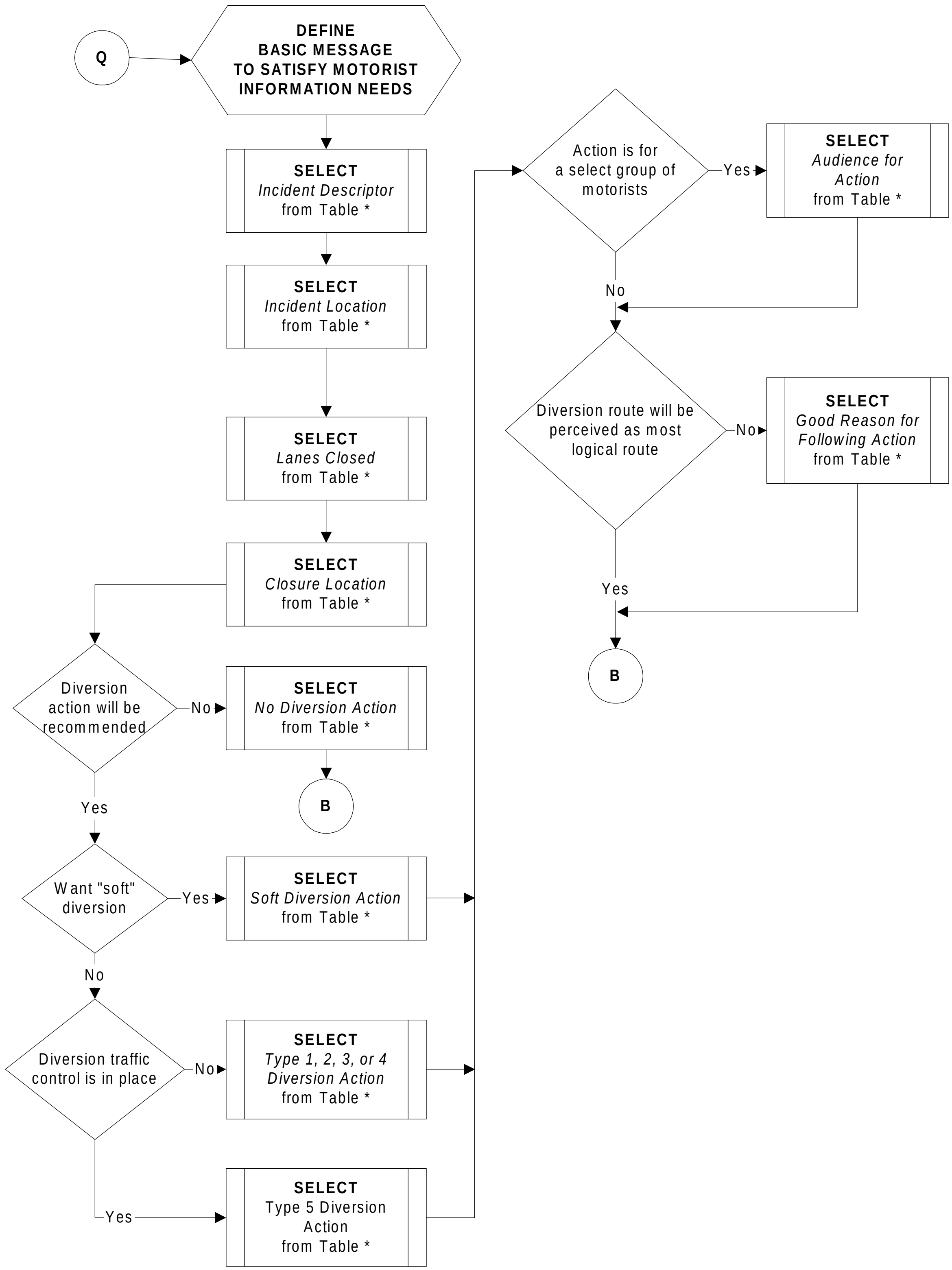
(c) Closing the Freeway

Figure 2. DMS Message Design Flowchart for Incidents (continued).



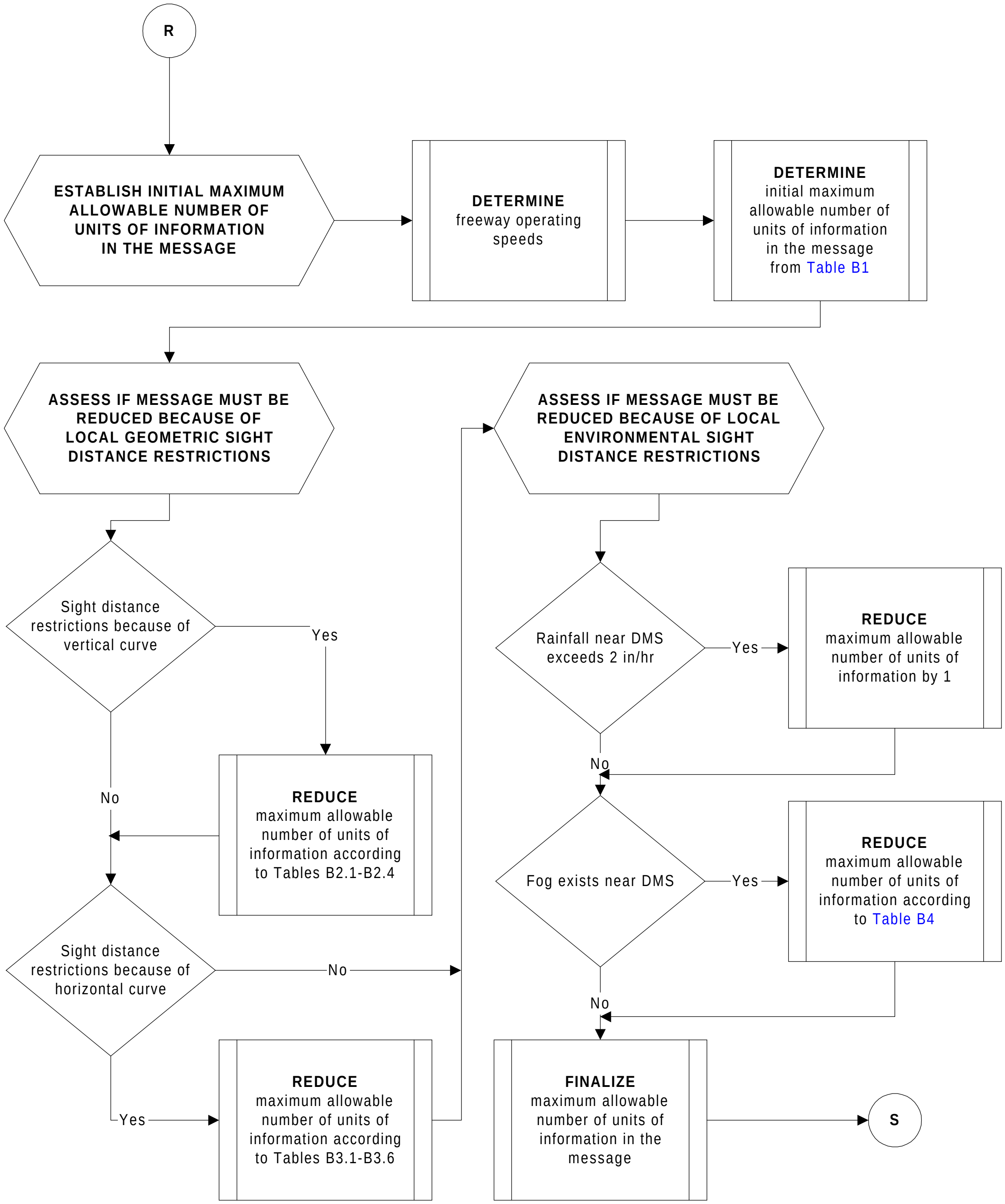
(c) Closing the Freeway

Figure 2. DMS Message Design Flowchart for Incidents (continued).



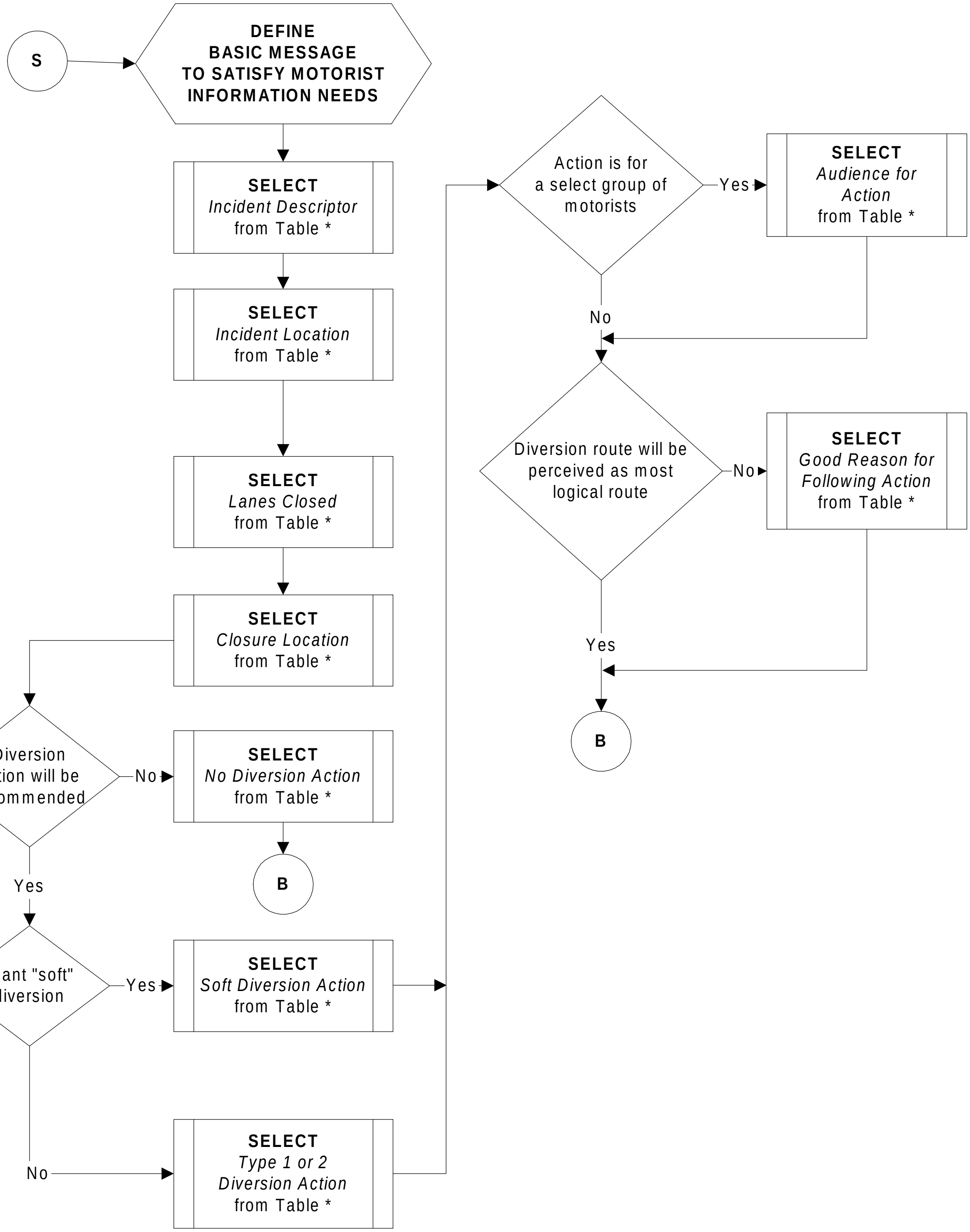
(c) Closing the Freeway

Figure 2. DMS Message Design Flowchart for Incidents (continued).



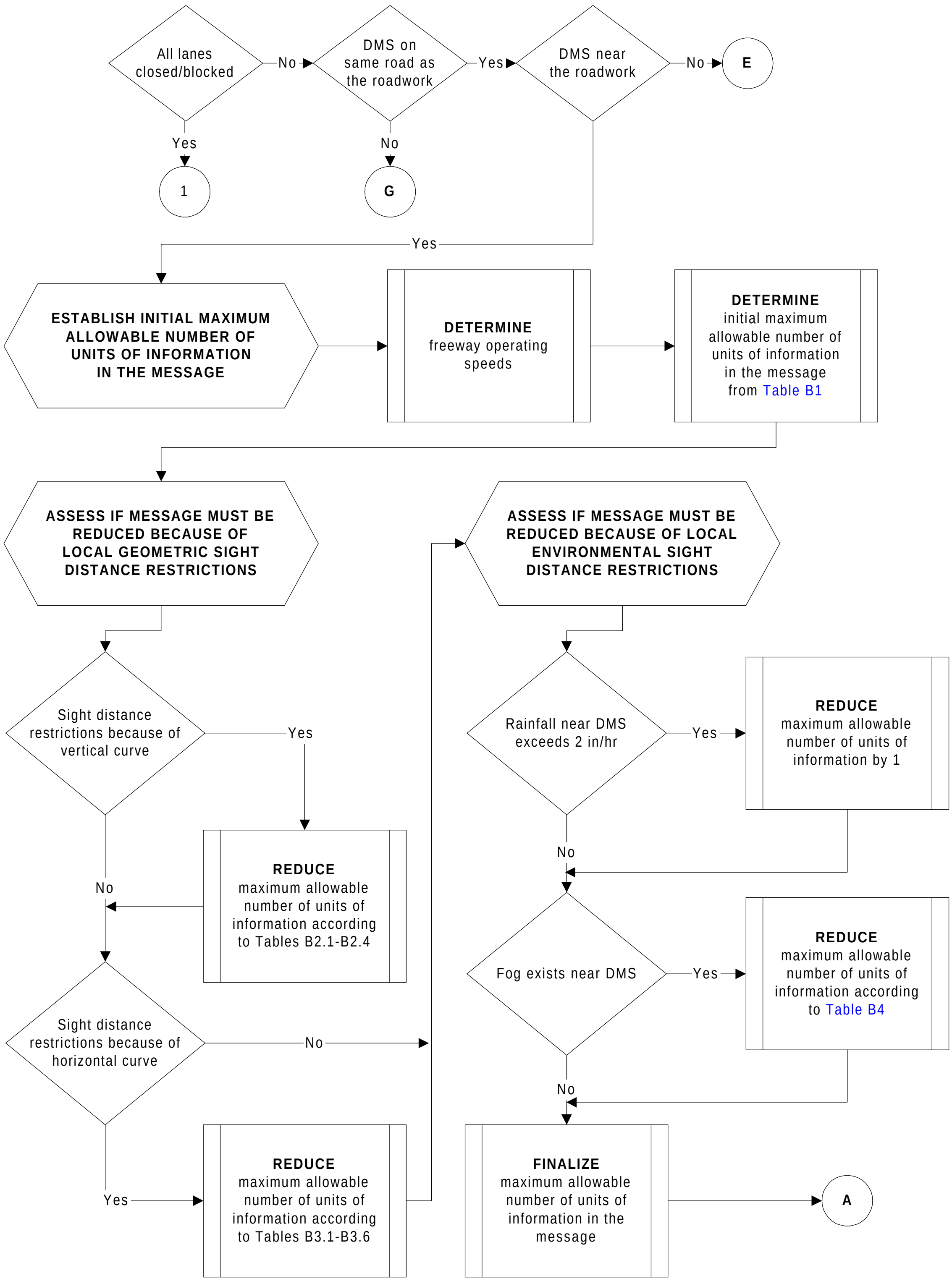
(c) Closing the Freeway

Figure 2. DMS Message Design Flowchart for Incidents (continued).



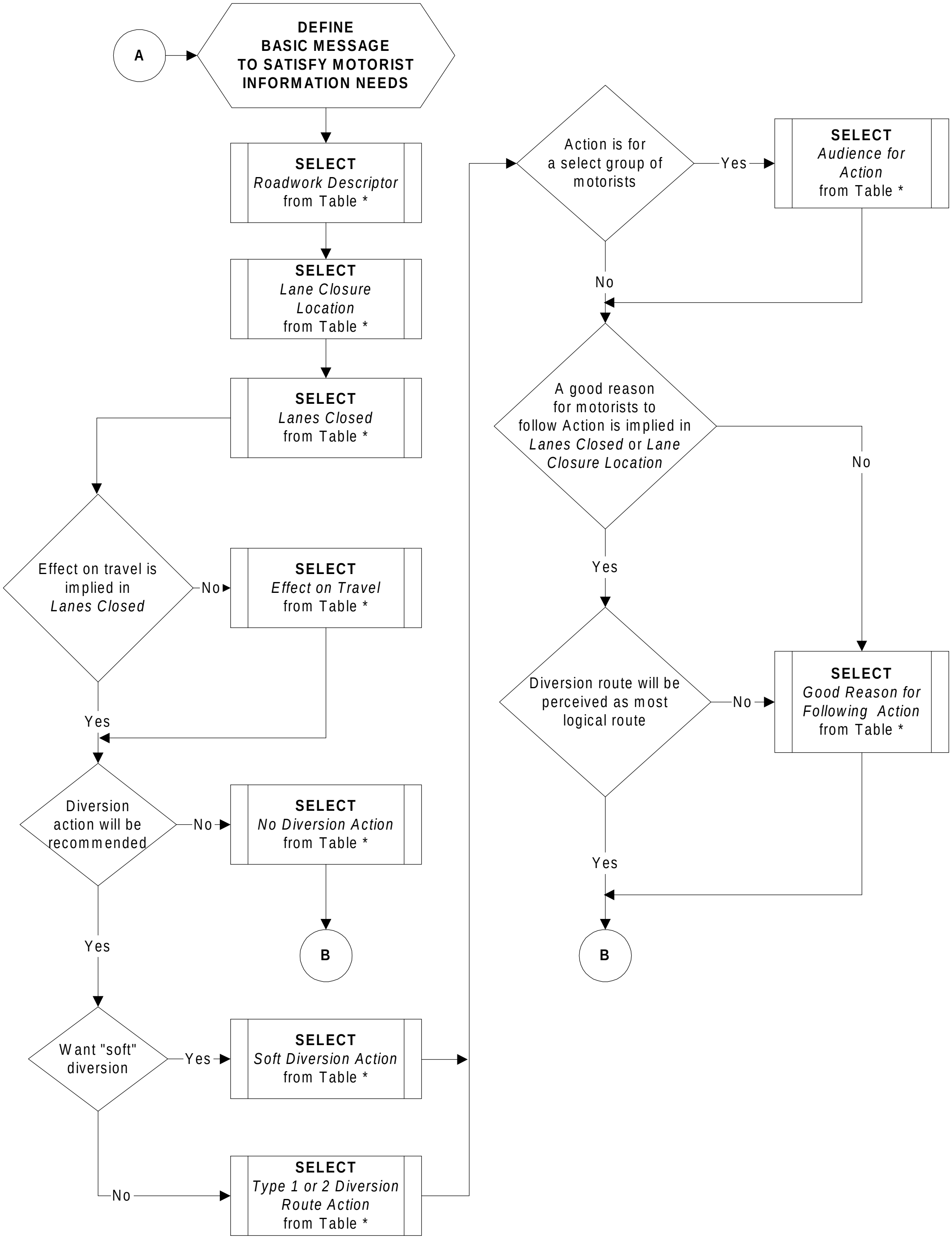
(c) Closing the Freeway

Figure 2. DMS Message Design Flowchart for Incidents (continued).



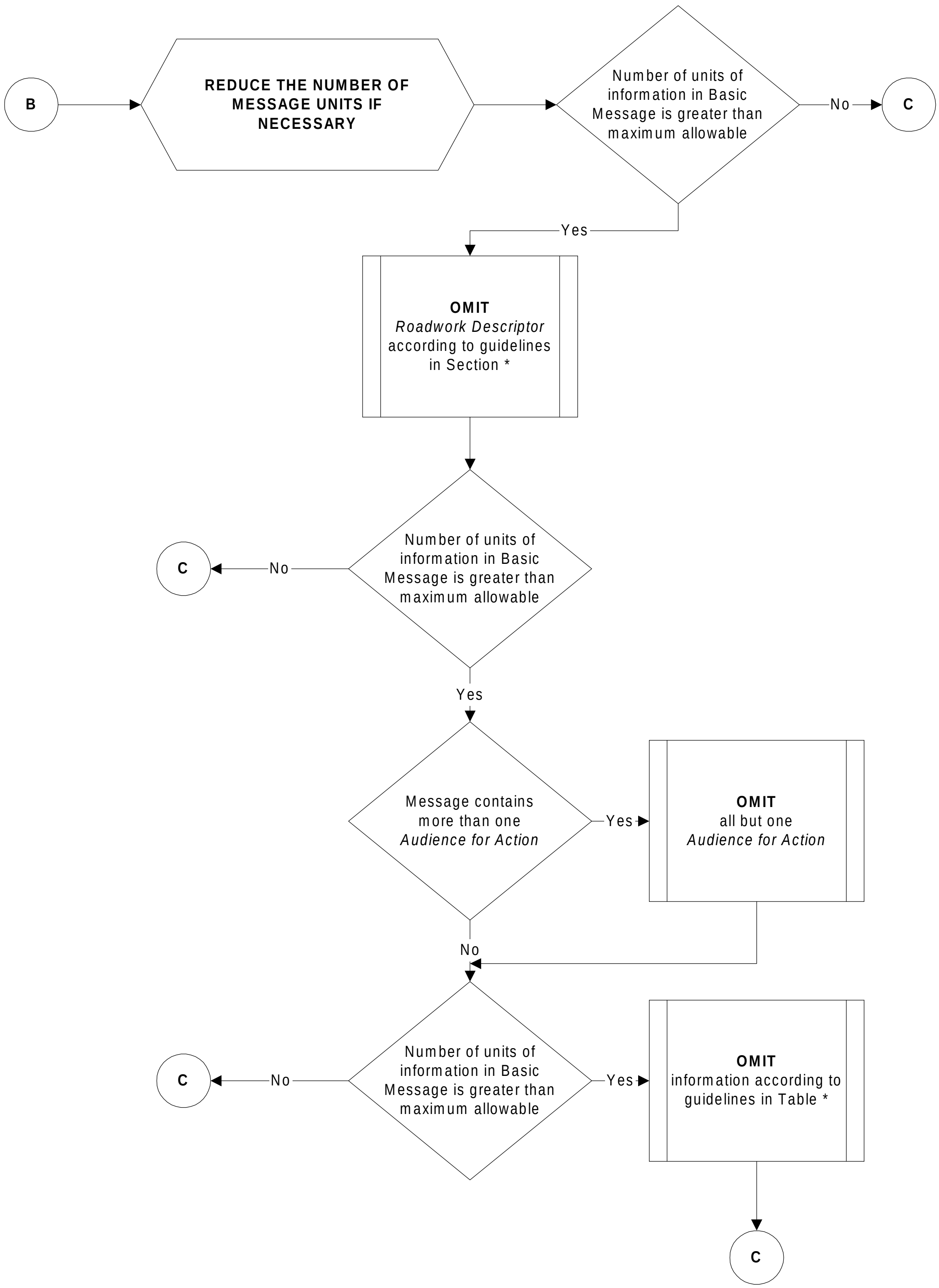
(a) Requiring a Lane Closure(s)

Figure 3. DMS Message Design Flowchart for Roadwork.



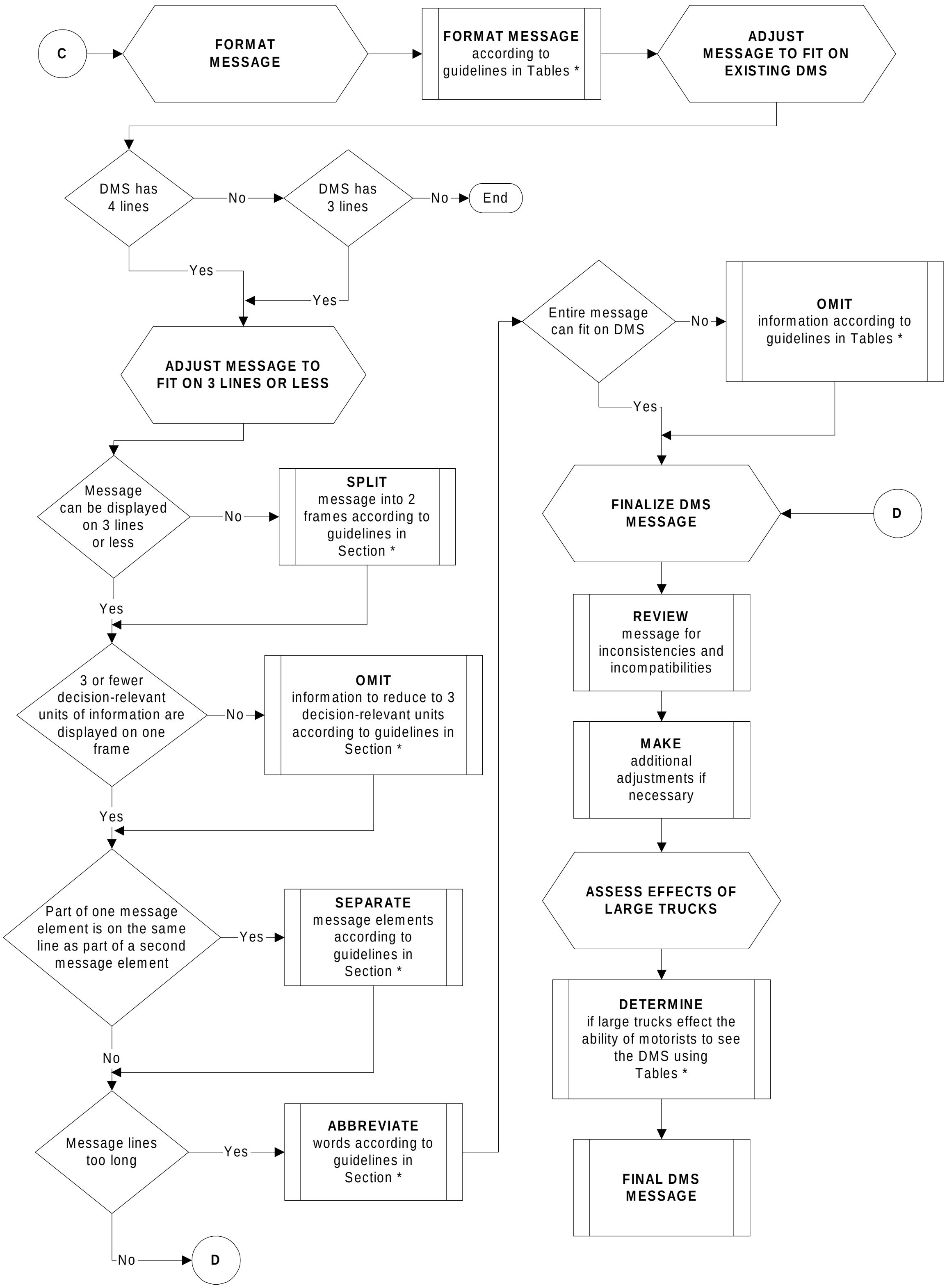
(a) Requiring a Lane Closure(s)

Figure 3. DMS Message Design Flowchart for Roadwork (continued).



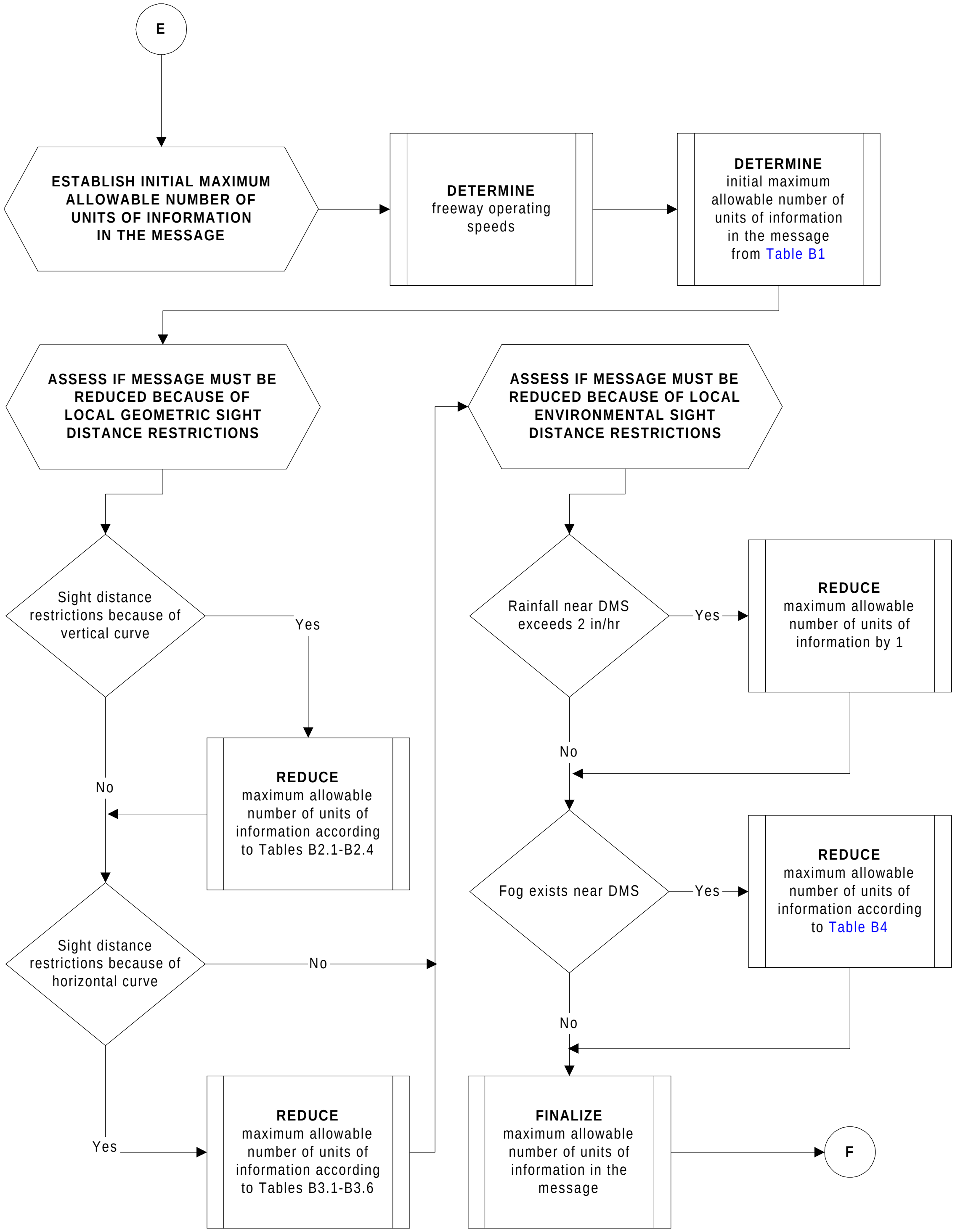
(a) Requiring a Lane Closure(s)

Figure 3. DMS Message Design Flowchart for Roadwork (continued).



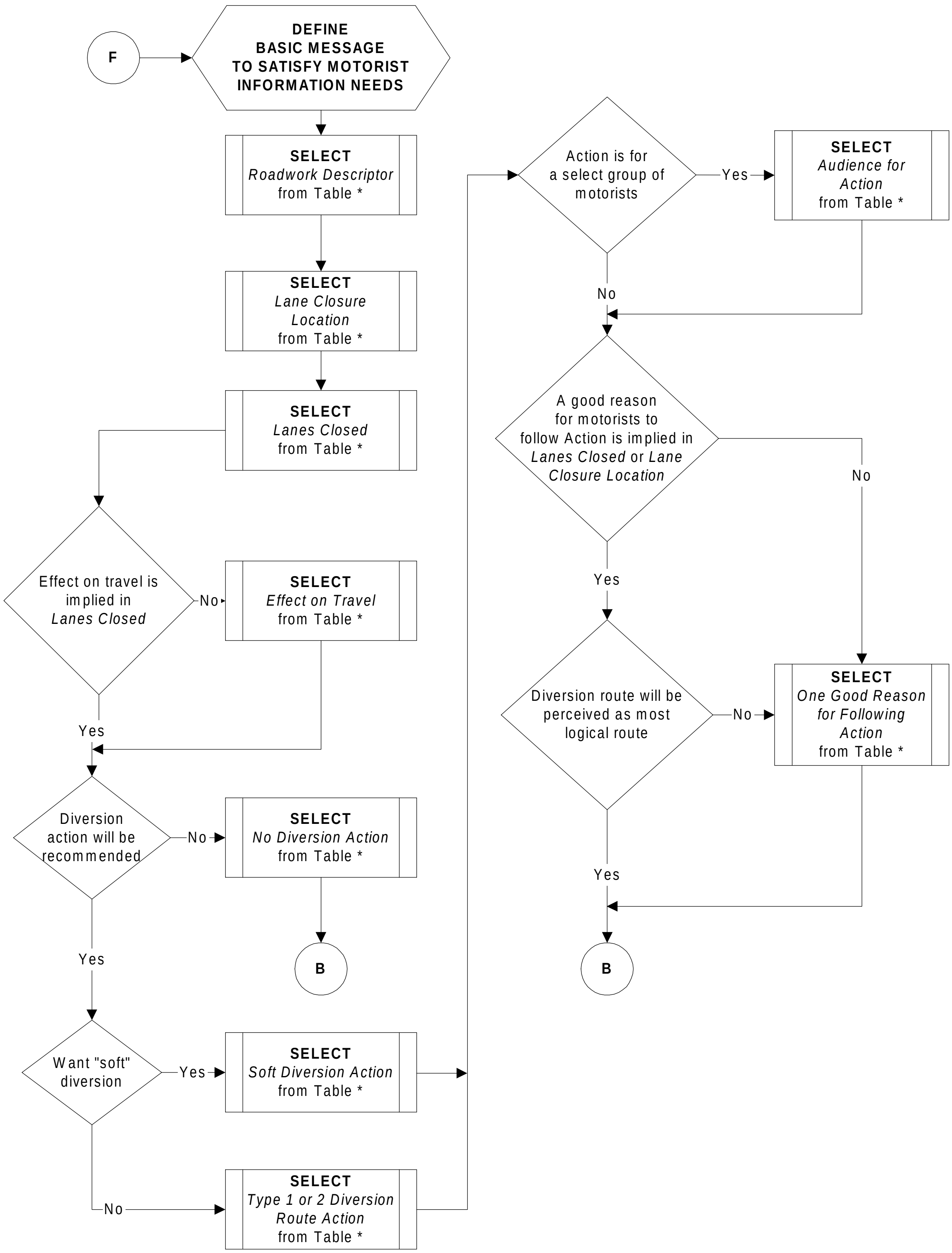
(a) Requiring a Lane Closure(s)

Figure 3. DMS Message Design Flowchart for Roadwork (continued).



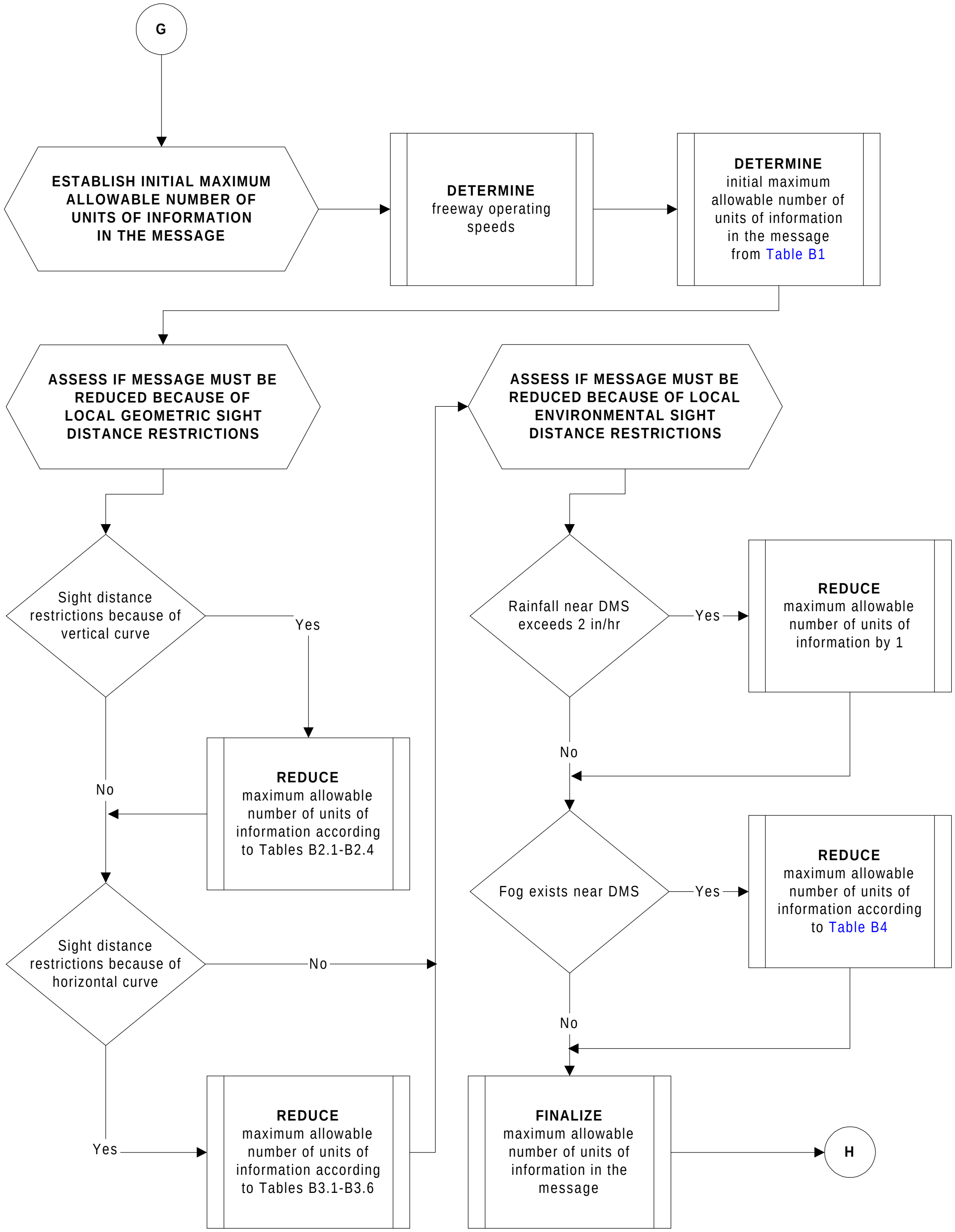
(a) Requiring a Lane Closure(s)

Figure 3. DMS Message Design Flowchart for Roadwork (continued).



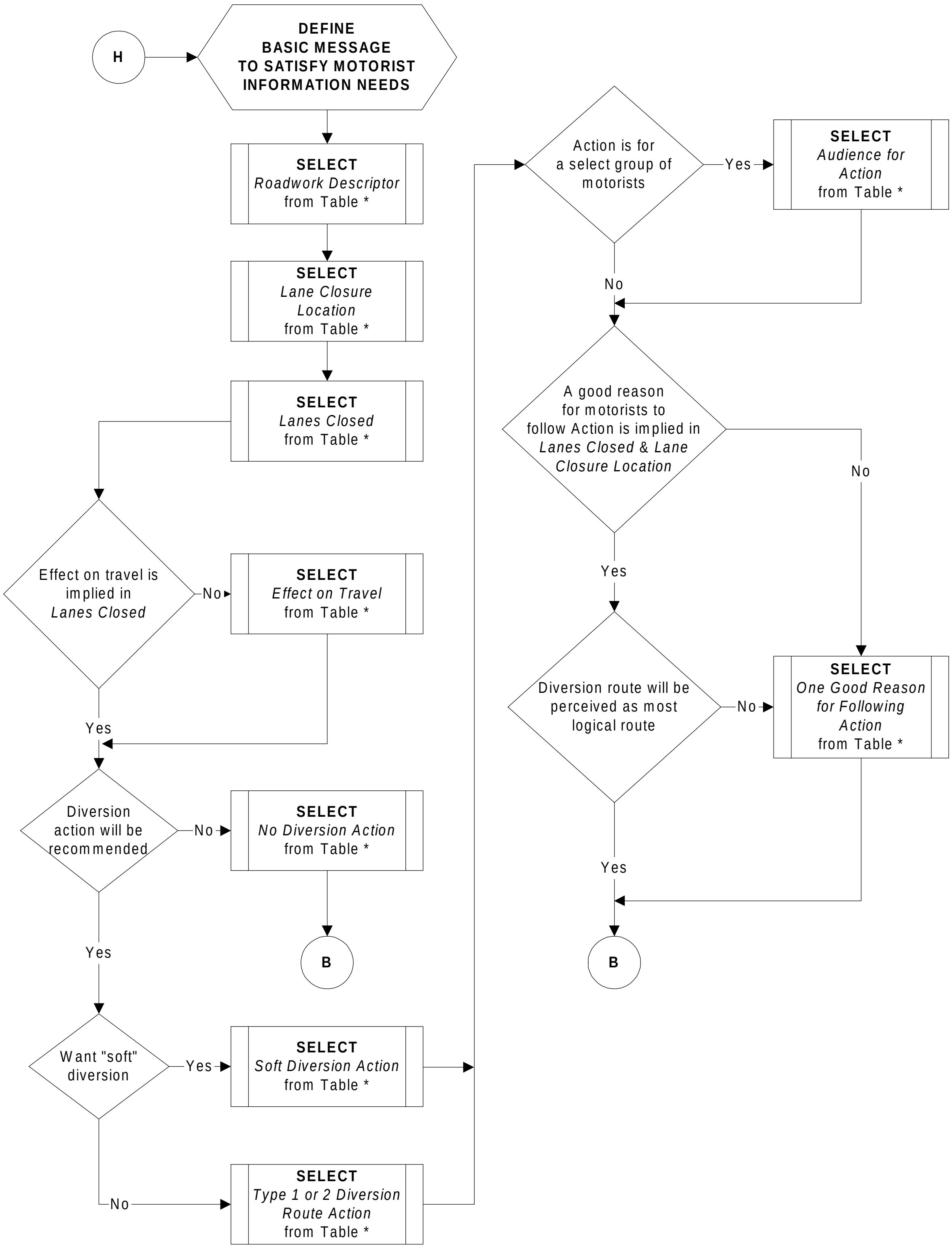
(a) Requiring a Lane Closure(s)

Figure 3. DMS Message Design Flowchart for Roadwork (continued).



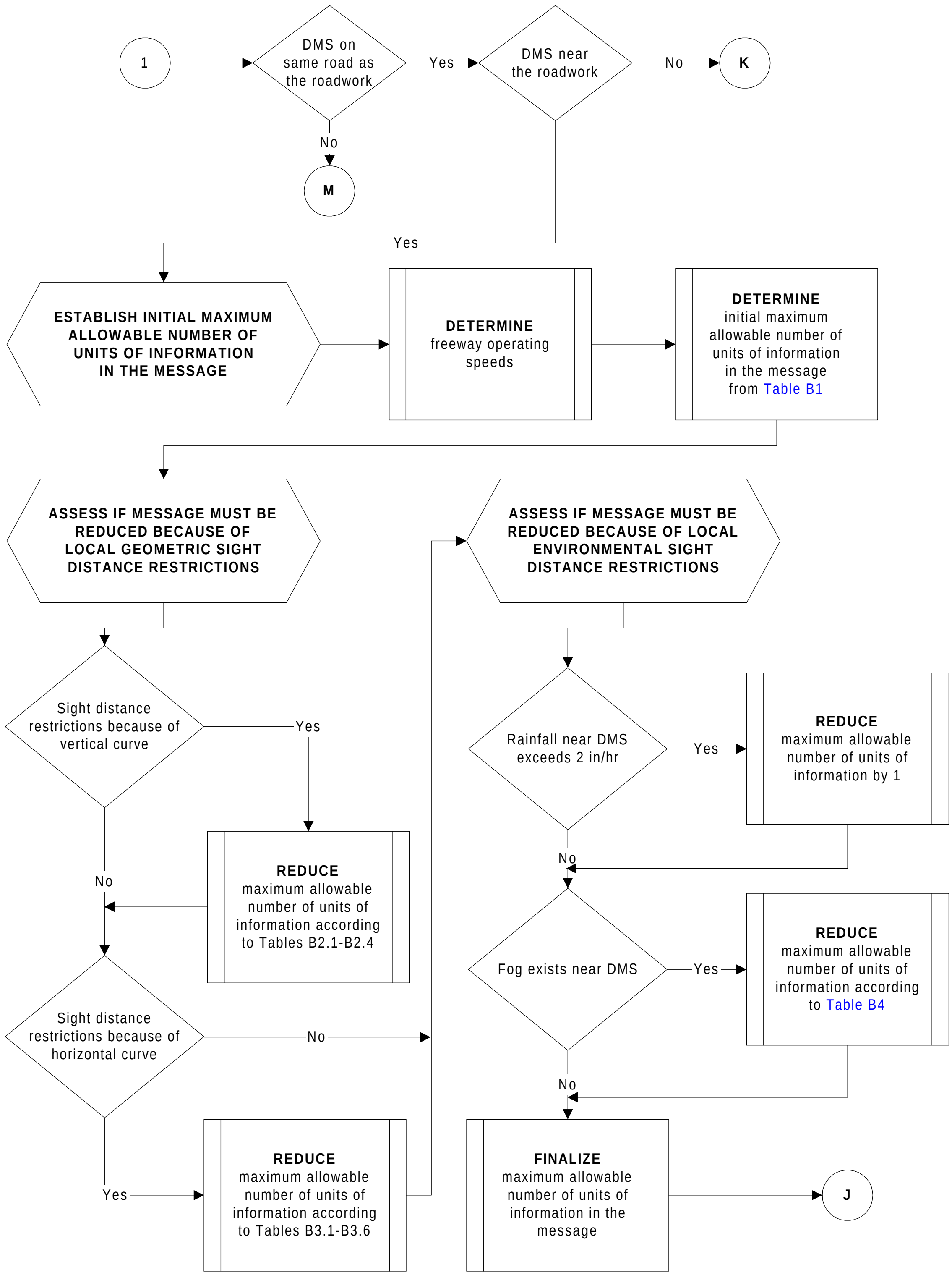
(a) Requiring a Lane Closure(s)

Figure 3. DMS Message Design Flowchart for Roadwork (continued).



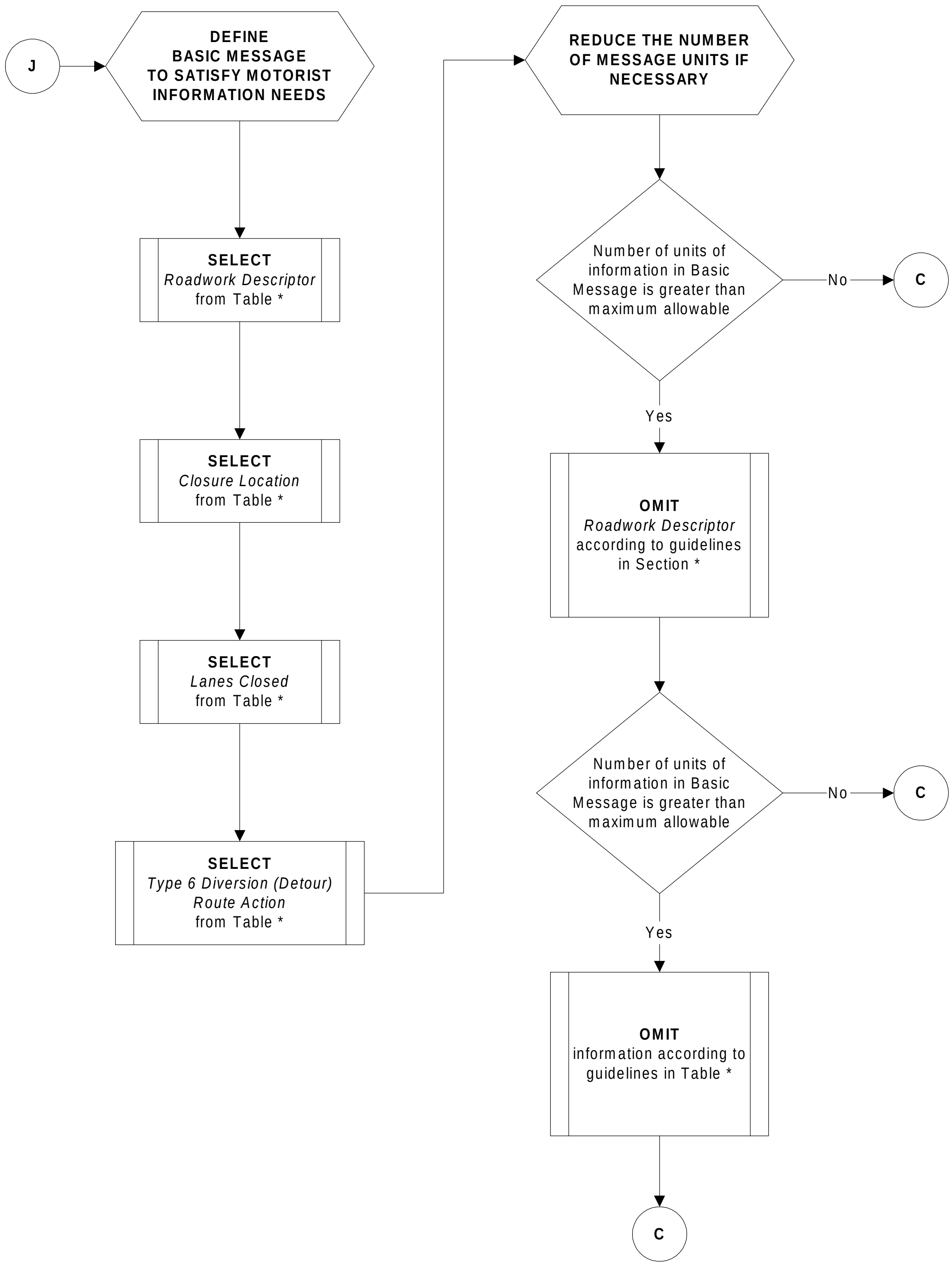
(a) Requiring a Lane Closure(s)

Figure 3. DMS Message Design Flowchart for Roadwork (continued).



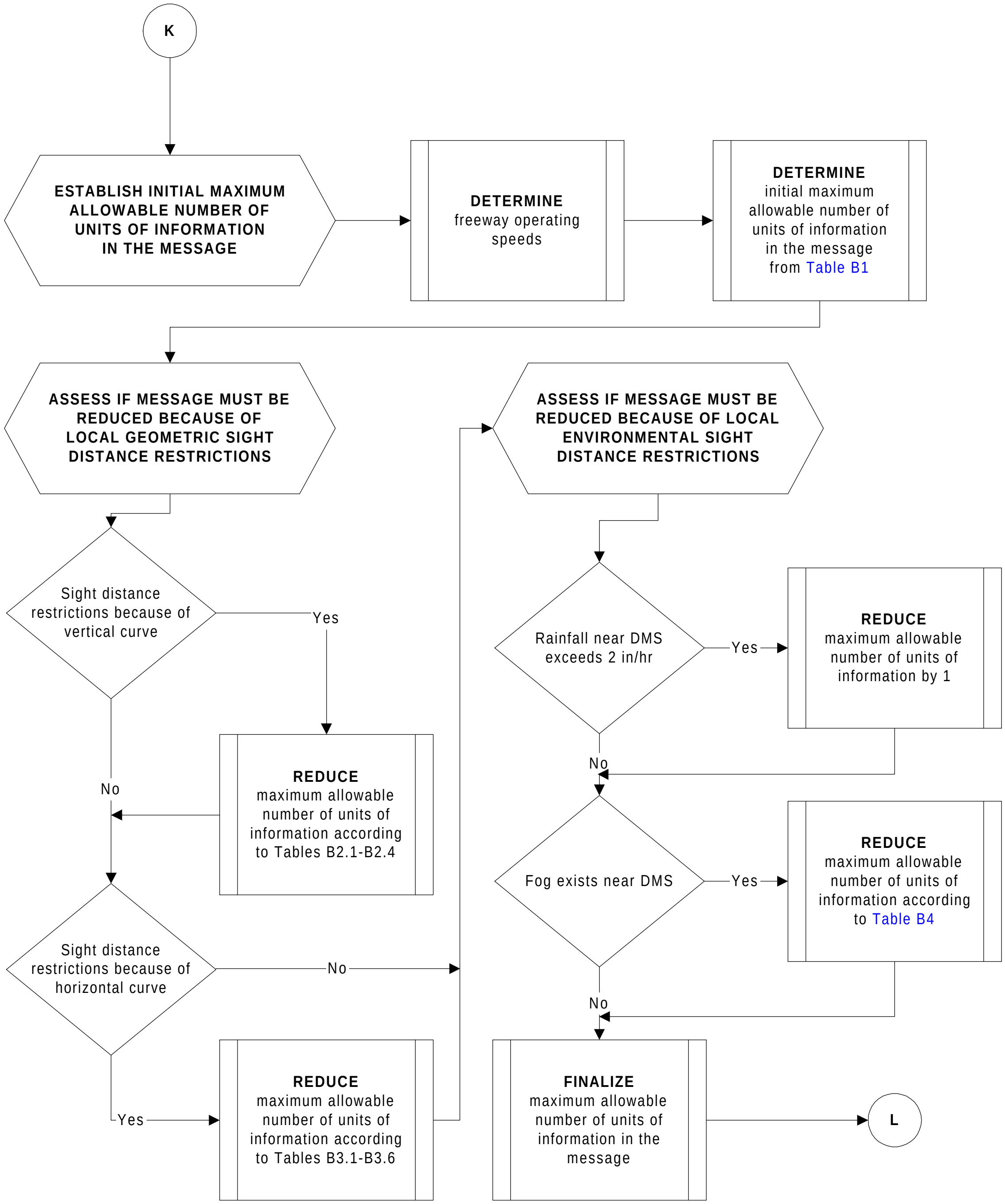
(b) Requiring Closure of Freeway

Figure 3. DMS Message Design Flowchart for Roadwork (continued).



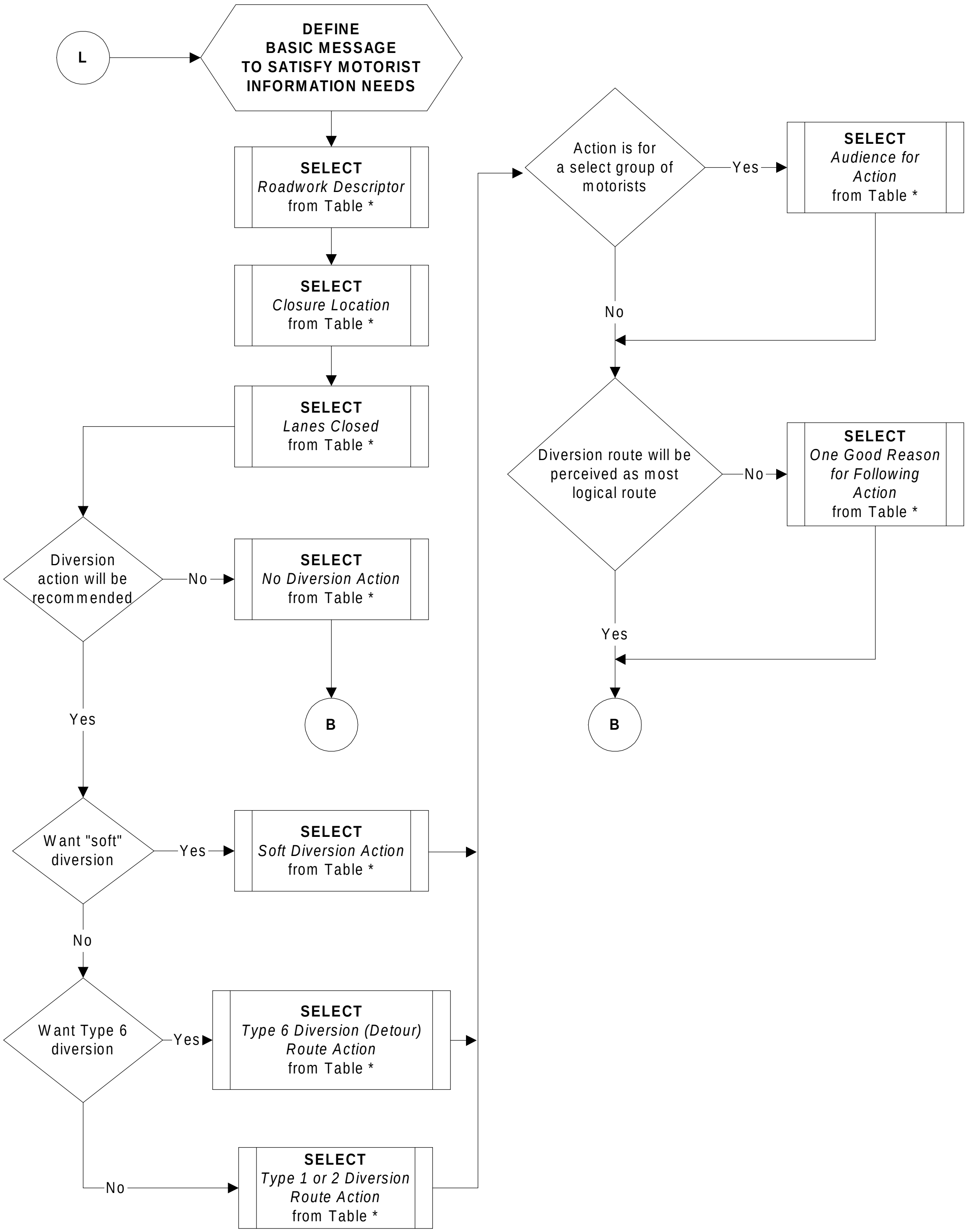
(b) Requiring Closure of Freeway

Figure 3. DMS Message Design Flowchart for Roadwork (continued).



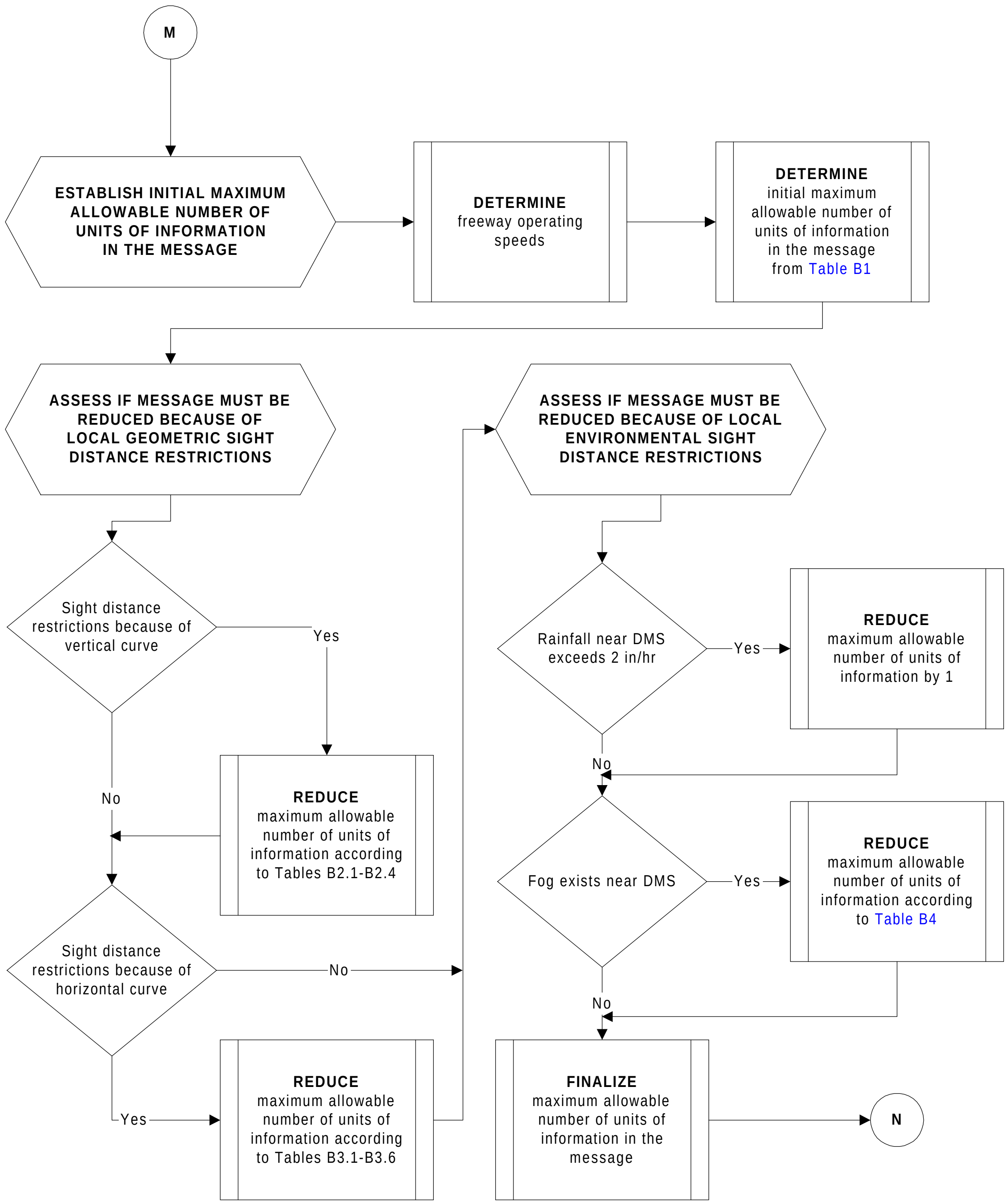
(b) Requiring Closure of Freeway

Figure 3. DMS Message Design Flowchart for Roadwork (continued).



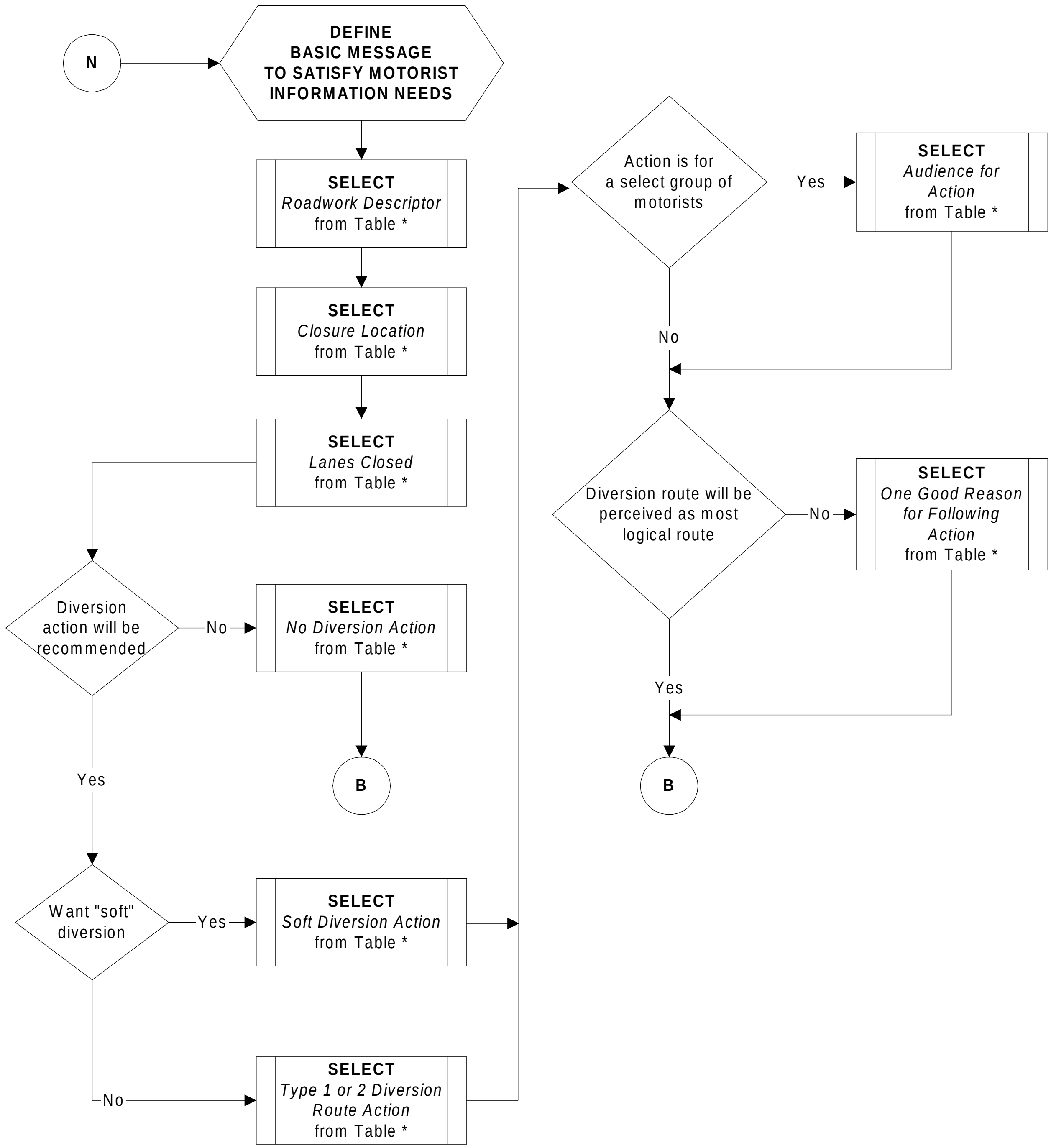
(b) Requiring Closure of Freeway

Figure 3. DMS Message Design Flowchart for Roadwork (continued).



(b) Requiring Closure of Freeway

Figure 3. DMS Message Design Flowchart for Roadwork (continued).



(b) Requiring Closure of Freeway

Figure 3. DMS Message Design Flowchart for Roadwork (continued).

4. ONGOING RESEARCH

During the second year of this project, the TTI research team will focus on the following three tasks:

- Task 4: Develop and Test a DMS Operations Manual for Use by DMS Operators in Texas;
- Task 5: Determine Requirements of a Computerized Prototype to Assist Operators in DMS Message Design; and
- Task 6: Develop Computer Prototype.

In Task 4, researchers will convert the operations procedures, decision models, and flowcharts developed in Task 3 into a format that can be understood and used by all levels of operators (entry level, experienced operators, and operations managers). To accomplish this task, a manual for DMS operations will be developed. The manual will serve as the basis for explaining how and why the computer prototype to be developed in later tasks actually arrives at various decisions.

In Task 5, researchers will develop the functional requirements of a computer prototype to help operators with DMS message design. In addition, researchers will identify the types of database requirements needed to effectively mimic the decision-making process of a human expert in DMS message design.

It is anticipated that both of these tasks will be completed at the end of the second year of the project. In addition to these two tasks, the TTI research team will begin Task 6 (Develop Computer Prototype) during the second year and complete it by the end of the third year of the project.

5. REFERENCES

1. Durkop, B.R. The Use of Dynamic Message Signs for Diverting Traffic During Freeway Incidents. In *Compendium: Graduate Student Papers on Advanced Surface Transportation Systems, 1998*. Southwest Region University Transportation Center, Texas Transportation Institute, Texas A&M University System, College Station, Texas, August 1998.

2. TxDOT Traffic Operations, Internal Agency Memorandum from Carol Rawson to Carlos Lopez, August 30, 1996.

3. Dudek, C.L., N. Trout, S. Booth, and G.L. Ullman. *Improved Dynamic Message Sign Messages and Operations*. Report FHWA/TX-01/1882-2. Texas Transportation Institute. October 2000.

4. Dudek, C.L. *Guidelines on the Selection and Design of Messages for Changeable Message Signs*. Report FHWA/TX-92/1232-10. Texas Transportation Institute. November 1992.

5. Messer, C.J. and R.W. McNees. *Evaluating Urban Freeway Guide Signing – Executive Summary and Level of Service*. Report FHWA/TX-82/31+220-4F. Texas Transportation Institute. August 1981.

APPENDIX A: TMC VISITS

Table A1. TMC Interview Responses – Austin DMS Operations.

	District		**Austin**
	Contact		Bubba Needham [Brian Burk]
	Phone		(512) 832-7053 [(512) 832-7014]
District DMS Operating Policies, Guidelines, Practices, and Procedures	***Written Policy for DMS Operations***		No
	Written Guidelines for DMS Operators to Follow		No
	Incident Information	***Means of Detection***	Call-ins [Cameras and sensors are also used]
		Means of Verification	Many times no verification, cameras and other call-ins if available are used to verify
		Message Design	Pre-existing message library is recommended
		Automated Messages	No [Yes]
	Peak-Period Congestion		No
	Planned Roadwork		Yes
	Planned Special Events		No
	Public Service Announcements		Traffic safety related only
	Blank Signs		Signs are kept blank unless message warranted
	Travel-Time Information		No
	Diversion Messages		No
	Speed Messages		No
	Severe Weather or Hazardous Pavement		No
	Advertisements		No
	Inter-modal Information		No
	Message Prioritizing	***Highest Priority Message***	Incident
		Highest Priority Incident When Concurrent Incidents Occur	Scenario specific

N/A = Not Applicable or No Answer Given

Table A1. TMC Interview Responses – Austin DMS Operations (continued).

District DMS Operating Policies, Guidelines, Practices, and Procedures	***Flashing Messages***	***Are They Used?***	Not Recommended
		Flashing Rates	N/A
	Flashing Specific Lines	***Are They Used?***	Not Recommended
		Flashing Rates	N/A
	Multiple Frames for a Single Message	***Are They Used?***	Yes
		Time Exposure Per Frame	At least 3 seconds per frame. Exposure time depends on roadway geometry and vehicle speeds.
	Only Changing Certain Lines in a Two-Frame Message		No
	Flashing Beacons	***Are They Used?***	Yes
		Conditions for Use	Message that requires immediate driver action or attention
	Message Posting by Other Agencies	***Is This Allowed?***	Yes
		Agencies and Conditions for Use	Local city law enforcement during emergency or outside TMC hours of operation
		Is Message Library Used?	Library messages are recommended, however modification is permitted and modifications may be stored for future use.
	Local Conditions Affecting Message Size (geometrics, sun, etc.)		Yes, roadway/roadside geometrics
	Portable DMSs	***When Are They Used?***	Construction, maintenance, and special events
		Controlled from TMC?	No
		Who Designs Messages?	Construction, maintenance, special event, or contractor personnel
		Who Determines What Is Displayed?	Construction, maintenance, special event, or contractor personnel

N/A = Not Applicable or No Answer Given

Table A1. TMC Interview Responses – Austin DMS Operations (continued).

Description of Traffic Operations Center and Management System			Existing	Planned
	Size of Operations Center		750 sq ft (operating floor only)	7000 sq ft
	Number of Staff Members	***Operators***	2	6
		Supervisors	1	2
		Managers	1	1
		Others	1 database admin, 1 maintenance	1 database admin, 1 maintenance, 1 dispatcher planned
	Centerline Miles Under Surveillance		27	270
	Freeways Under Surveillance		4	7
	Number of DMSs on Each Freeway		2-10, depending on length managed	30-85, depending on length managed
	TMC Operations	***Hours of Operation***	6am-10pm / M-F	24 hrs / 7 days
		Shift Schedule	2 shifts (6a-2, 2-10p)	2 or 3 shifts
		Shift Staffing	1 operator per shift with 1 part-time supervisor	2-6 operators, 1-2 supervisors, 1 dispatcher
	Duties and Responsibilities of Staff	***Operators***	Currently, due to small size of operations, all partake in operation of freeway traffic control devices to manage traffic and incidents, support of courtesy patrol operations, support construction, maintenance, and special event operations	
		Supervisors		
		Managers		
	Miscellaneous		Very small-scale DMS network, but more signs will soon be coming on-line	

N/A = Not Applicable or No Answer Given

Table A2. TMC Interview Responses – Dallas DMS Operations.

	District		**Dallas**
	Contact		Terry Sams
	Phone		(214) 320-6231
District DMS Operating Policies, Guidelines, Practices, and Procedures	***Written Policy for DMS Operations***		No
	Written Guidelines for DMS Operators to Follow		Yes
	Incident Information	***Means of Detection***	Camera, Call-ins
		Means of Verification	Cameras
		Message Design	Operator designs messages based on guidelines, however some messages such as public information are stored in a library
		Automated Messages	No
	Peak-Period Congestion		No
	Planned Roadwork		Yes
	Planned Special Events		Yes
	Public Service Announcements		Traffic safety related only
	Blank Signs		Signs are kept blank unless message warranted
	Travel-Time Information		No
	Diversion Messages		No, except for major construction closures
	Speed Messages		No
	Severe Weather or Hazardous Pavement		Yes
	Advertisements		No
	Inter-modal Information		No
	Message Prioritizing	***Highest Priority Message***	Incident
		Highest Priority Incident When Concurrent Incidents Occur	Upstream incident

N/A = Not Applicable or No Answer Given

Table A2. TMC Interview Responses – Dallas DMS Operations (continued).

<table>
<tr><td rowspan="20">District DMS Operating Policies, Guidelines, Practices, and Procedures</td><td rowspan="2">Flashing Messages</td><td>Are They Used?</td><td>No</td></tr>
<tr><td>Flashing Rates</td><td>N/A</td></tr>
<tr><td rowspan="2">Flashing Specific Lines</td><td>Are They Used?</td><td>No</td></tr>
<tr><td>Flashing Rates</td><td>N/A</td></tr>
<tr><td rowspan="2">Multiple Frames for a Single Message</td><td>Are They Used?</td><td>Yes, max 2 frames per message</td></tr>
<tr><td>Time Exposure Per Frame</td><td>2 seconds</td></tr>
<tr><td colspan="2">Only Changing Certain Lines in a Two-Frame Message</td><td>Yes, top line with highway and directional info stays static - bottom line allowed to change</td></tr>
<tr><td rowspan="2">Flashing Beacons</td><td>Are They Used?</td><td>Yes</td></tr>
<tr><td>Conditions for Use</td><td>When lanes are blocked</td></tr>
<tr><td rowspan="3">Message Posting by Other Agencies</td><td>Is This Allowed?</td><td>No, however message requests are accepted and evaluated for posting based on guidelines</td></tr>
<tr><td>Agencies and Conditions for Use</td><td>N/A</td></tr>
<tr><td>Is Message Library Used?</td><td>N/A</td></tr>
<tr><td colspan="2">Local Conditions Affecting Message Size (geometrics, sun, etc.)</td><td>No</td></tr>
<tr><td rowspan="4">Portable DMSs</td><td>When Are They Used?</td><td>Maintenance, construction, or traffic safety</td></tr>
<tr><td>Controlled from TMC?</td><td>No, messages are preprogrammed from the TMC prior to being used in the field</td></tr>
<tr><td>Who Designs Messages?</td><td>TMC designs the message based on the information provided by the requesting office</td></tr>
<tr><td>Who Determines What Is Displayed?</td><td>TMC designs the message based on the request in accordance with the district message guidelines</td></tr>
</table>

N/A = Not Applicable or No Answer Given

Table A2. TMC Interview Responses – Dallas DMS Operations (continued).

Description of Traffic Operations Center and Management System	***Size of Operations Center***		Currently 2100 sq ft (entire building); new building is being designed
	Number of Staff Members	***Operators***	4
		Supervisors	1
		Managers	N/A
		Others	N/A
	Centerline Miles Under Surveillance		43
	Freeways Under Surveillance		7
	Number of DMSs on Each Freeway		US75 - 4, I635 - 6, I30 - 6, I35 - 9, I20 - 1, I45 - 1, SH183 - 1, Spur 366 - 1
	TMC Operations	***Hours of Operation***	5am-9:30pm / M-F
		Shift Schedule	5am-1:30pm / 1pm-9:30pm
		Shift Staffing	2 operators per shift, supervisor splits between shifts
	Duties and Responsibilities of Staff	***Operators***	Monitoring incident information, creating an appropriate message, ensuring the message is placed on the correct signs, and monitoring lane closure information
		Supervisors	Periodically review the messages being placed on the signs and take corrective actions if necessary
		Managers	N/A
	Miscellaneous		Almost all signs are 1-mile upstream of fwy-to-fwy interchanges

N/A = Not Applicable or No Answer Given

Table A3. TMC Interview Responses – Fort Worth DMS Operations.

<table>
<tr><td rowspan="3"></td><td colspan="2">District</td><td>Ft. Worth</td></tr>
<tr><td colspan="2">Contact</td><td>Wallace Ewell</td></tr>
<tr><td colspan="2">Phone</td><td>(817) 370-6624</td></tr>
<tr><td rowspan="20">District DMS Operating Policies, Guidelines, Practices, and Procedures</td><td colspan="2">Written Policy for DMS Operations</td><td>No</td></tr>
<tr><td colspan="2">Written Guidelines for DMS Operators to Follow</td><td>Yes</td></tr>
<tr><td rowspan="4">Incident Information</td><td>Means of Detection</td><td>Camera, Call-ins</td></tr>
<tr><td>Means of Verification</td><td>Cameras</td></tr>
<tr><td>Message Design</td><td>Pre-existing message library with the option to modify</td></tr>
<tr><td>Automated Messages</td><td>No</td></tr>
<tr><td colspan="2">Peak-Period Congestion</td><td>Automated congestion information messages</td></tr>
<tr><td colspan="2">Planned Roadwork</td><td>Yes</td></tr>
<tr><td colspan="2">Planned Special Events</td><td>Yes</td></tr>
<tr><td colspan="2">Public Service Announcements</td><td>If approved</td></tr>
<tr><td colspan="2">Blank Signs</td><td>Signs are kept blank unless message warranted</td></tr>
<tr><td colspan="2">Travel-Time Information</td><td>No</td></tr>
<tr><td colspan="2">Diversion Messages</td><td>Soft diversion only</td></tr>
<tr><td colspan="2">Speed Messages</td><td>No</td></tr>
<tr><td colspan="2">Severe Weather or Hazardous Pavement</td><td>Yes</td></tr>
<tr><td colspan="2">Advertisements</td><td>No</td></tr>
<tr><td colspan="2">Inter-modal Information</td><td>No</td></tr>
<tr><td rowspan="2">Message Prioritizing</td><td>Highest Priority Message</td><td>Incident</td></tr>
<tr><td>Highest Priority Incident When Concurrent Incidents Occur</td><td>Upstream incident</td></tr>
</table>

N/A = Not Applicable or No Answer Given

Table A3. TMC Interview Responses – Ft. Worth DMS Operations (continued).

District DMS Operating Policies, Guidelines, Practices, and Procedures	***Flashing Messages***	***Are They Used?***	Yes
		Flashing Rates	2 seconds message on-time, 1 second flash
	Flashing Specific Lines	***Are They Used?***	Yes, but only when message is significant, but not urgent enough to use beacons
		Flashing Rates	Not given
	Multiple Frames for a Single Message	***Are They Used?***	Yes
		Time Exposure Per Frame	2.3 to 2.5 seconds
	Only Changing Certain Lines in a Two-Frame Message		Yes
	Flashing Beacons	***Are They Used?***	Yes
		Conditions for Use	Messages pertaining to driver safety or the driver's ability to avoid delay
	Message Posting by Other Agencies	***Is This Allowed?***	No
		Agencies and Conditions for Use	N/A
		Is Message Library Used?	N/A
	Local Conditions Affecting Message Size (geometrics, sun, etc.)		No
	Portable DMSs	***When Are They Used?***	Construction, incident, and special events
		Controlled from TMC?	No, wireless access
		Who Designs Messages?	Special Event Coordinators, Incident Supervisor
		Who Determines What Is Displayed?	Special Event Coordinators, Incident Supervisor

N/A = Not Applicable or No Answer Given

Table A3. TMC Interview Responses – Ft. Worth DMS Operations (continued).

<table>
<tr><td rowspan="16">Description of Traffic Operations Center and Management System</td><td colspan="2">Size of Operations Center</td><td>32000 sq ft (entire center)</td></tr>
<tr><td rowspan="4">Number of Staff Members</td><td>Operators</td><td>4</td></tr>
<tr><td>Supervisors</td><td>1</td></tr>
<tr><td>Managers</td><td>1</td></tr>
<tr><td>Others</td><td>8 maintenance and 5 design</td></tr>
<tr><td colspan="2">Centerline Miles Under Surveillance</td><td>50</td></tr>
<tr><td colspan="2">Freeways Under Surveillance</td><td>7</td></tr>
<tr><td colspan="2">Number of DMSs on Each Freeway</td><td>Varies</td></tr>
<tr><td rowspan="3">TMC Operations</td><td>Hours of Operation</td><td>6am-6pm / M-F</td></tr>
<tr><td>Shift Schedule</td><td>6am - 3pm and 9am - 6pm</td></tr>
<tr><td>Shift Staffing</td><td>N/A</td></tr>
<tr><td rowspan="3">Duties and Responsibilities of Staff</td><td>Operators</td><td rowspan="3">Monitor sensors and TVs for incidents, congestion, disabled vehicles, and unplanned construction; inform motorists via DMSs and lane control signals (LCSs); coordinate motorist assistance for disabled vehicles with courtesy patrol; coordinate information with media and commercial traffic services.</td></tr>
<tr><td>Supervisors</td></tr>
<tr><td>Managers</td></tr>
<tr><td colspan="2">Miscellaneous</td><td>Automation is used for congestion and public information messages</td></tr>
</table>

N/A = Not Applicable or No Answer Given

Table A4. TMC Interview Responses – Houston DMS Operations.

	District		**Houston**
	Contact		Sally Wegmann
	Phone		713-802-5171
District DMS Operating Policies, Guidelines, Practices, and Procedures	***Written Policy for DMS Operations***		No
	Written Guidelines for DMS Operators to Follow		Yes
	Incident Information	***Means of Detection***	Camera, Call-ins
		Means of Verification	Cameras
		Message Design	Pre-existing message library, however situations may arise where specially designed messages are needed
		Automated Messages	No
	Peak-Period Congestion		Non-automated travel-time information messages
	Planned Roadwork		Yes
	Planned Special Events		Yes
	Public Service Announcements		Yes
	Blank Signs		Try to avoid blank signs for public-image purposes
	Travel-Time Information		Yes, Non-Automated
	Diversion Messages		Soft diversion for most incidents, hard diversion for major closures
	Speed Messages		No
	Severe Weather or Hazardous Pavement		Yes
	Advertisements		No
	Inter-modal Information		Yes, park-and-ride for special events
	Message Prioritizing	***Highest Priority Message***	Incident
		Highest Priority Incident When Concurrent Incidents Occur	Scenario specific, but often upstream incident is highest priority

N/A = Not Applicable or No Answer Given

Table A4. TMC Interview Responses – Houston DMS Operations (continued).

District DMS Operating Policies, Guidelines, Practices, and Procedures	***Flashing Messages***	***Are They Used?***	No
		Flashing Rates	N/A
	Flashing Specific Lines	***Are They Used?***	No
		Flashing Rates	N/A
	Multiple Frames for a Single Message	***Are They Used?***	Yes
		Time Exposure Per Frame	2.5 seconds
	Only Changing Certain Lines in a Two-Frame Message		Yes
	Flashing Beacons	***Are They Used?***	Yes
		Conditions for Use	Incidents and Construction
	Message Posting by Other Agencies	***Is This Allowed?***	Yes
		Agencies and Conditions for Use	METRO has had permission to operate the TxDOT owned DMSs on the HOV lanes and in the park-and- ride lots for the last 4 years; however METRO does not utilize this privilege but rather makes requests to TxDOT who creates and posts the messages
		Is Message Library Used?	Yes
	Local Conditions Affecting Message Size (geometrics, sun, etc.)		Yes
	Portable DMSs	***When Are They Used?***	Construction, special events, and incidents (when no permanent DMS exist relative to the incident)
		Controlled from TMC?	No, however programming of the portable DMS is performed by TxDOT TMC staff
		Who Designs Messages?	TMC staff design messages for TxDOT-owned portable DMSs based on the requesting party, however if the portable DMSs are owned by a separate agency or contractor, the message approval responsibility lies with the TxDOT project manager or engineer
		Who Determines What Is Displayed?	TMC staff or project staff depending on situation and sign ownership

N/A = Not Applicable or No Answer Given

Table A4. TMC Interview Responses – Houston DMS Operations (continued).

Description of Traffic Operations Center and Management System	***Size of Operations Center***		56,100 sq ft (entire center)
	Number of Staff Members	***Operators***	12
		Supervisors	3
		Managers	1
		Others	1 engineering assistant
	Centerline Miles Under Surveillance		179
	Freeways Under Surveillance		7
	Number of DMSs on Each Freeway		I610 - 14, SH 288 - 2, SH 255 - 3, SH 146 - 2, I45 - 32, I10 - 14, US 59 - 16, US 290 - 12, Beltway 8 - 3
	TMC Operations	***Hours of Operation***	24 hrs / 7 days
		Shift Schedule	6am - 2pm / 2pm - 10pm / 10pm - 6am
		Shift Staffing	Shifts 1 and 2 - M-F = 4, S-S = 1; shift 3 - M-F = 2, S-S = 1
	Duties and Responsibilities of Staff	***Operators***	Monitor traffic; disseminates traffic information; post messages
		Supervisors	Supervises TMC floor operations; approves DMS messages; provides technical expertise to floor operators; disseminates information to the public through various forms of communication; works under time critical conditions to resolve emergency traffic incidents/situations
		Managers	Oversees development and revisions of new and existing ITS components; oversees and performs highly technical work for advanced traffic management system (ATMS); supervises professional, technical and administrative employees; communication with governmental officials and the general public
	Miscellaneous		Largest DMS network in the state; very much against blank signs for public-image purposes; will soon have expanded message automation capabilities

N/A = Not Applicable or No Answer Given

Table A5. TMC Interview Responses – San Antonio DMS Operations.

	District		**San Antonio**
	Contact		Pat Irwin
	Phone		210-731-5249
District DMS Operating Policies, Guidelines, Practices, and Procedures	***Written Policy for DMS Operations***		No
	Written Guidelines for DMS Operators to Follow		Yes
	Incident Information	***Means of Detection***	Sensors, Cameras, Call-ins
		Means of Verification	Cameras
		Message Design	Pre-existing message library, modify only with supervisor approval
		Automated Messages	Yes
	Peak-Period Congestion		Highly automated travel-time information messages
	Planned Roadwork		Yes
	Planned Special Events		Yes
	Public Service Announcements		Ozone Action Day messages only
	Blank Signs		Try to avoid blank signs during daytime
	Travel-Time Information		Yes, Automated
	Diversion Messages		Soft diversion only
	Speed Messages		No
	Severe Weather or Hazardous Pavement		Yes
	Advertisements		No
	Inter-modal Information		No
	Message Prioritizing	***Highest Priority Message***	Incident
		Highest Priority Incident When Concurrent Incidents Occur	Scenario specific

N/A = Not Applicable or No Answer Given

Table A5. TMC Interview Responses – San Antonio DMS Operations (continued).

District DMS Operating Policies, Guidelines, Practices, and Procedures	***Flashing Messages***	***Are They Used?***	No
		Flashing Rates	N/A
	Flashing Specific Lines	***Are They Used?***	No
		Flashing Rates	N/A
	Multiple Frames for a Single Message	***Are They Used?***	Yes
		Time Exposure Per Frame	Variable from 2 to 6 seconds
	Only Changing Certain Lines in a Two-Frame Message		No
	Flashing Beacons	***Are They Used?***	Yes
		Conditions for Use	To differentiate incident related messages from congestion management messages
	Message Posting by Other Agencies	***Is This Allowed?***	No
		Agencies and Conditions for Use	N/A
		Is Message Library Used?	N/A
	Local Conditions Affecting Message Size (geometrics, sun, etc.)		Yes, influenced by conditions near it
	Portable DMSs	***When Are They Used?***	Construction, support ITS equipment, and special events
		Controlled from TMC?	Yes
		Who Designs Messages?	Usually use pre-developed messages. In the case where one needs to be designed, the manager of the Assignment Plan will develop the message
		Who Determines What Is Displayed?	Manager in the Assignment Plan with input from the TxDOT Inspector

N/A = Not Applicable or No Answer Given

Table A5. TMC Interview Responses – San Antonio DMS Operations (continued).

Description of Traffic Operations Center and Management System	***Size of Operations Center***		3441 sq ft (operating floor only)
	Number of Staff Members	***Operators***	6
		Supervisors	2
		Managers	3
		Others	N/A
	Centerline Miles Under Surveillance		73
	Freeways Under Surveillance		7
	Number of DMSs on Each Freeway		I10 - 52, I35 - 44, I37 - 7, I410 - 42, US 90 - 19, US 281 - 3, US 1604 - 7
	TMC Operations	***Hours of Operation***	4am-midnight / M-F, 5am-midnight / S-S
		Shift Schedule	Operators/supervisors = 6am - 3pm / 11am - 8pm; managers = 4am - 2:30pm / 2pm - 12am
		Shift Staffing	2 operators, 1 manager per shift M-F; 1 manager only S-S
	Duties and Responsibilities of Staff	***Operators***	Assigned specific areas to monitor; respond to ALL incident alarms assigned to them; update lane closure data
		Supervisors	N/A
		Managers	Responsible for any text/display to inform motorists
	Miscellaneous		Very sophisticated operation of sign messages; one of the most highly automated systems in the nation

N/A = Not Applicable or No Answer Given

APPENDIX B: FLOWCHART TABLES

Table B1. Maximum Number of Units of Information in DMS Message (Base Maximum Message Length).

Type of DMS	Speed Range	Condition			
		Mid-Day	Washout	Backlight	Nighttime
Light-Emitting Diode (LED) [A]	0-35 mph	5 units	5 units	4 units	4 units
	36-55 mph	4 units	4 units	4 units	4 units
	56-70 mph	4 units	4 units	3 units	3 units
Fiber-optic	0-35 mph	5 units	5 units	4 units	4 units
	36-55 mph	4 units	4 units	3 units	3 units
	56-70 mph	3 units	3 units	2 units	3 units
Incandescent Bulb	0-35 mph	5 units	5 units	4 units	4 units
	36-55 mph	4 units	4 units	3 units	3 units
	56-70 mph	3 units	3 units	2 units	3 units
Reflective Disk	0-35 mph	5 units	4 units	2 units	3 units
	36-55 mph	4 units	3 units	1 unit	2 units
	56-70 mph	3 units	2 units	1 unit	1 unit

[A] Valid only for the newer aluminum indium gallium phosphide (or equivalent) LEDs.

Table B2.1. Number of Units of Information that Must Be Subtracted from Number Given in Table 1 Due to Vertical Curve PERMANENT LED DMS [A] Mounting Height: 20 feet.

Condition	Vertical Curve Design Speed								
	Overhead			20-Foot Offset			60-Foot Offset		
	30 mph	35 mph	40 mph	30 mph	35 mph	40 mph	30 mph	35 mph	40 mph
Mid-Day	1 unit	0 unit	0 unit	2 units	0 unit	0 unit	5 units	3 units	1 unit
Washout	1 unit	0 unit	0 unit	2 units	0 unit	0 unit	5 units	3 units	1 unit
Backlight	0 unit	0 unit	0 unit	1 unit	0 unit	0 unit	4 units	3 units	1 unit
Nighttime	0 unit	0 unit	0 unit	1 unit	0 unit	0 unit	4 units	3 units	1 unit

[A] Valid only for the newer aluminum indium gallium phosphide (or equivalent) LEDs.

Table B2.2. Number of Units of Information that Must Be Subtracted from Number Given in Table 1 Due to Vertical Curve PERMANENT LED DMS [A] Mounting Height: 25 feet.

Condition	Vertical Curve Design Speed								
	Overhead			20-Foot Offset			60-Foot Offset		
	30 mph	35 mph	40 mph	30 mph	35 mph	40 mph	30 mph	35 mph	40 mph
Mid-Day	0 unit	0 unit	0 unit	2 units	1 unit	0 unit	5 units	4 units	1 unit
Washout	0 unit	0 unit	0 unit	2 units	1 unit	0 unit	5 units	4 units	1 unit
Backlight	0 unit	0 unit	0 unit	1 unit	0 unit	0 unit	4 units	3 units	1 unit
Nighttime	0 unit	0 unit	0 unit	1 unit	0 unit	0 unit	4 units	3 units	1 unit

[A] Valid only for the newer aluminum indium gallium phosphide (or equivalent) LEDs.

Table B2.3. Number of Units of Information that Must Be Subtracted from Number Given in Table 1 Due to Vertical Curve
PORTABLE LED DMS [A]
Mounting Height: 7 feet.

Condition	Vertical Curve Design Speed					
	20-Foot Offset			60-Foot Offset		
	30 mph	35 mph	40 mph	30 mph	35 mph	40 mph
Mid-Day	3 units	2 units	1 unit	5 units	5 units	3 units
Washout	3 units	2 units	1 unit	5 units	5 units	3 units
Backlight	2 units	1 unit	1 unit	4 units	4 units	2 units
Nighttime	2 units	1 unit	1 unit	4 units	4 units	2 units

[A] Valid only for the newer aluminum indium gallium phosphide (or equivalent) LEDs.

Table B2.4. Number of Units of Information that Must Be Subtracted from Number Given in Table 1 Due to Vertical Curve
PORTABLE LED DMS [A]
Mounting Height: 10 feet.

Condition	Vertical Curve Design Speed					
	20-Foot Offset			60-Foot Offset		
	30 mph	35 mph	40 mph	30 mph	35 mph	40 mph
Mid-Day	2 units	2 units	1 unit	5 units	4 units	3 units
Washout	2 units	2 units	1 unit	5 units	4 units	3 units
Backlight	1 unit	1 unit	0 unit	4 units	3 units	2 units
Nighttime	1 unit	1 unit	0 unit	4 units	3 units	2 units

[A] Valid only for the newer aluminum indium gallium phosphide (or equivalent) LEDs.

Table B3.1. Number of Units of Information that Must Be Subtracted from Number Given in Table 1 Due to Horizontal Curve
PORTABLE LED DMS [A]
Offset: 2 feet
Traffic Operating Speeds: 0-35 MPH.

Curve Radii (ft)	Mid-Day and Washout							Backlight and Nighttime						
	Offset of Sight Obstruction from Edge of Travel Lanes (ft)							Offset of Sight Obstruction from Edge of Travel Lanes (ft)						
	10	20	50	100	150	200	250	10	20	50	100	150	200	250
250	4 units	4 units	2 units	1 unit	1 unit	1 unit		3 units	3 units	1 unit				
500	4 units	3 units	1 unit	1 unit				3 units	2 units					
750	4 units	2 units	1 unit	1 unit				3 units	2 units					
1000	3 units	2 units	1 unit					2 units	1 unit					
1250	3 units	2 units	1 unit					2 units	1 unit					
1500	3 units	1 unit	1 unit					2 units	1 unit					
1750	3 units	1 unit						2 units	1 unit					
2000	3 units	1 unit						2 units	1 unit					
2250	2 units	1 unit						1 unit						
2500	2 units	1 unit						1 unit						
2750	2 units	1 unit						1 unit						
3000	2 units	1 unit						1 unit						
4000	1 unit	1 unit												
5000	1 unit													
7500	1 unit													
10000	1 unit													

[A] Valid only for the newer aluminum indium gallium phosphide (or equivalent) LEDs.

Table B3.2. Number of Units of Information that Must Be <u>Subtracted</u> from Number Given in Table 1 Due to Horizontal Curve
PORTABLE LED DMS [A]
Offset: 2 feet
Traffic Operating Speeds: 36-55 MPH.

Curve Radii (ft)	Mid-Day and Washout							Backlight and Nighttime						
	Offset of Sight Obstruction from Edge of Travel Lanes (ft)							Offset of Sight Obstruction from Edge of Travel Lanes (ft)						
	10	**20**	**50**	**100**	**150**	**200**	**250**	**10**	**20**	**50**	**100**	**150**	**200**	**250**
250	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
500	3 units	3 units	2 units	1 unit				3 units	3 units	2 units	1 unit			
750	3 units	3 units	1 unit					3 units	3 units	1 unit				
1000	3 units	2 units	1 unit					3 units	2 units	1 unit				
1250	3 units	2 units						3 units	2 units					
1500	3 units	2 units						3 units	2 units					
1750	3 units	2 units						3 units	2 units					
2000	3 units	1 unit						3 units	1 unit					
2250	3 units	1 unit						3 units	1 unit					
2500	2 units	1 unit						2 units	1 unit					
2750	2 units	1 unit						2 units	1 unit					
3000	2 units	1 unit						2 units	1 unit					
4000	2 units							2 units						
5000	2 units							2 units						
7500	1 unit							1 unit						
10000	1 unit													

[A] Valid only for the newer aluminum indium gallium phosphide (or equivalent) LEDs.
N/A Adequate sight distance not available for any message.

Table B3.3. Number of Units of Information that Must Be Subtracted from Number Given in Table 1 Due to Horizontal Curve
PORTABLE LED DMS [A]
Offset: 2 feet
Traffic Operating Speeds: 56-70 MPH.

Curve Radii (ft)	Mid-Day and Washout							Backlight and Nighttime						
	Offset of Sight Obstruction from Edge of Travel Lanes (ft)							Offset of Sight Obstruction from Edge of Travel Lanes (ft)						
	10	20	50	100	150	200	250	10	20	50	100	150	200	250
250	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
500	N/A	N/A	N/A	N/A	N/A			N/A	N/A	N/A	N/A	N/A	N/A	N/A
750	3 units	3 units	2 units	1 unit				2 units	1 unit					
1000	3 units	3 units	2 units					1 unit	1 unit					
1250	3 units	3 units	1 unit					1 unit	1 unit					
1500	3 units	2 units	1 unit					1 unit						
1750	3 units	2 units	1 unit					1 unit						
2000	3 units	2 units						1 unit						
2250	3 units	2 units						1 unit						
2500	3 units	2 units						1 unit						
2750	3 units	2 units						1 unit						
3000	3 units	2 units						1 unit						
4000	2 units	1 unit												
5000	2 units													
7500	2 units													
10000	2 units													

[A] Valid only for the newer aluminum indium gallium phosphide (or equivalent) LEDs.
N/A Adequate sight distance not available for any message.

Table B3.4. Number of Units of Information that Must Be Subtracted from Number Given in Table 1 Due to Horizontal Curve
PORTABLE LED DMS [A]
Offset: 10 feet
Traffic Operating Speeds: 0-35 MPH.

Curve Radii (ft)	Mid-Day and Washout — Offset of Sight Obstruction from Edge of Travel Lanes (ft)							Backlight and Nighttime — Offset of Sight Obstruction from Edge of Travel Lanes (ft)						
	10	20	50	100	150	200	250	10	20	50	100	150	200	250
250	5 units	4 units	2 units	1 unit	1 unit			4 units	3 units	1 unit				
500	5 units	3 units	1 unit					4 units	2 units					
750	5 units	3 units	1 unit					4 units	2 units					
1000	5 units	3 units	1 unit					4 units	2 units					
1250	5 units	2 units						4 units	1 unit					
1500	5 units	2 units						4 units	1 unit					
1750	5 units	2 units						4 units	1 unit					
2000	5 units	1 unit						4 units						
2250	5 units	1 unit						4 units						
2500	5 units	1 unit						4 units						
2750	5 units	1 unit						4 units						
3000	5 units	1 unit						4 units						
4000	5 units	1 unit						4 units						
5000	5 units							4 units						
7500	5 units							4 units						
10000	5 units							4 units						

[A] Valid only for the newer aluminum indium gallium phosphide (or equivalent) LEDs.

Table B3.5. Number of Units of Information that Must Be <u>Subtracted</u> from Number Given in Table 1 Due to Horizontal Curve
PORTABLE LED DMS [A]
Offset: 10 feet
Traffic Operating Speeds: 36-55 MPH.

Curve Radii (ft)	Mid-Day and Washout							Backlight and Nighttime						
	Offset of Sight Obstruction from Edge of Travel Lanes (ft)							Offset of Sight Obstruction from Edge of Travel Lanes (ft)						
	10	**20**	**50**	**100**	**150**	**200**	**250**	**10**	**20**	**50**	**100**	**150**	**200**	**250**
250	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
500	5 units	4 units	3 units	2 units	1 unit	1 unit		5 units	3 units	2 units	1 unit			
750	5 units	4 units	2 units	1 unit	1 unit			5 units	3 units					
1000	5 units	4 units	2 units	1 unit				5 units	3 units					
1250	5 units	3 units	1 unit					5 units	2 units					
1500	5 units	3 units	1 unit					5 units	2 units					
1750	5 units	3 units	1 unit					5 units	2 units					
2000	5 units	3 units	1 unit					5 units	2 units					
2250	5 units	3 units	1 unit					5 units	2 units					
2500	5 units	3 units	1 unit					5 units	2 units					
2750	5 units	2 units						5 units	1 unit					
3000	5 units	2 units						5 units	1 unit					
4000	5 units	2 units						5 units						
5000	5 units	1 unit						5 units						
7500	5 units	1 unit						5 units						
10000	5 units	1 unit						5 units						

[A] Valid only for the newer aluminum indium gallium phosphide (or equivalent) LEDs.
N/A Adequate sight distance not available for any message.

Table B3.6. Number of Units of Information that Must Be Subtracted from Number Given in Table 1 Due to Horizontal Curve
PORTABLE LED DMS [A]
Offset: 10 feet
Traffic Operating Speeds: 56-70 MPH.

Curve Radii (ft)	Mid-Day and Washout — Offset of Sight Obstruction from Edge of Travel Lanes (ft)							Backlight and Nighttime — Offset of Sight Obstruction from Edge of Travel Lanes (ft)						
	10	20	50	100	150	200	250	10	20	50	100	150	200	250
250	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
500	N/A	N/A	N/A	N/A	N/A	1 unit		N/A	N/A	N/A	N/A	N/A	N/A	N/A
750	5 units	4 units	3 units	2 units	1 unit			4 units	3 units	2 units	1 unit			
1000	5 units	4 units	3 units	1 unit	1 unit			4 units	3 units	2 units				
1250	5 units	4 units	2 units	1 unit	1 unit			4 units	3 units	1 unit				
1500	5 units	4 units	2 units	1 unit				4 units	3 units	1 unit				
1750	5 units	4 units	2 units	1 unit				4 units	3 units	1 unit				
2000	5 units	3 units	1 unit	1 unit				4 units	2 units					
2250	5 units	3 units	1 unit					4 units	2 units					
2500	5 units	3 units	1 unit					4 units	2 units					
2750	5 units	3 units	1 unit					4 units	2 units					
3000	5 units	3 units	1 unit					4 units	2 units					
4000	5 units	3 units	1 unit					4 units	2 units					
5000	5 units	2 units						4 units	1 unit					
7500	5 units	2 units						4 units	1 unit					
10000	5 units	1 unit						4 units						

[A] Valid only for the newer aluminum indium gallium phosphide (or equivalent) LEDs.
N/A Adequate sight distance not available for any message.

Table B4. Number of Units of Information that Must Be Subtracted from Number Given in Table 1 Due to Effects of Fog in Daytime Conditions PORTABLE LED DMS. [A]

Visibility Range in Fog	Overhead			20-Ft Offset			60-Ft Offset		
	0-35 mph	36-55 mph	56-70 mph	0-35 mph	36-55 mph	56-70 mph	0-35 mph	36-55 mph	56-70 mph
1/2 mile	0 unit	0 unit	0 unit	0 unit	0 unit	0 unit	0 unit	0 unit	0 unit
1/4 mile	0 unit	0 unit	1 unit	0 unit	1 unit	1 unit	2 units	2 units	2 units
1/10 mile	2 units	2 units	2 units	3 units	3 units	3 units	N/A	N/A	N/A

[A] Valid only for the newer aluminum indium gallium phosphide (or equivalent) LEDs.

N/A Adequate sight distance not available for any message.