MARYLAND STATE HIGHWAY ADMINISTRATION
WORK ZONE LANE CLOSURE ANALYSIS GUIDELINES

November 6, 2006

BACKGROUND AND PURPOSE:

The Maryland State Highway Administration (SHA) is committed to the continuous movement of traffic through all work zones by the elimination or reduction of delays. To minimize the severity and duration of mobility impacts[1] on the traveling public resulting from the work zone, all roadwork projects shall be adequately evaluated and analyzed. Planned lane closures that do not cause traffic flow bottlenecks and result in only minor levels of congestion are an effective traffic management strategy.

Compliance with these guidelines will likely benefit the traveling public and the construction industry by reducing work zone crashes and delays. Because of its impact on project development, the determination and evaluation of alternatives for maintenance of traffic should start during the planning process.

These guidelines outline the procedures to be followed and the parties responsible for its fulfillment. SHA can waive mandatory conditions contained in the guidelines upon approval by the Chief Engineer (or appropriate designee).

SCOPE:

These guidelines apply to all work performed on SHA maintained roads.

EXCEPTIONS:

Emergency Repairs. All emergency repairs are exempt. Such repairs include, but are not limited to, pavement or bridge deck failures, bridge structure impact damage, roadside appurtenances, and slope stability. Notification of the lane closure shall satisfy current SHA procedures.

Routine Maintenance. For some routine maintenance activities, such as crack sealing, pavement markings, landscaping, guardrail repair, etc., single lane closures during non-peak hours (as determined by SHA) are allowable. Notification of the lane closure shall satisfy current SHA procedures.

GUIDELINES:

SHA strongly recommends performing a quantitative analysis to determine the impact of all lane, shoulder and ramp restrictions. Analysis shall be performed for all significant projects. The following acceptable thresholds for freeways and arterials shall be used for the evaluation of work zone mobility impacts.[2,3]

[1] The focus of these guidelines is on mobility impacts; however, safety impacts should also be considered during evaluation of lane closures.

[2] In addition to corridor impacts, engineering judgment should be used to ensure that roadwork does not result in negative traffic impacts on ramp, network, or emergency service operations.

[3] As part of the evaluation, impacts on public/private access should be considered. Delays on proposed detour routes should also be investigated.

A. Freeways

1. Normal work hours can vary from project to project. Work hours and work zone traffic control plans shall be developed using the following table or other current acceptable information (or practice):

NUMBER OF LANES		**WORK ZONE CAPACITY**	
NORMAL (existing)	OPEN (to traffic)	VPH	VPHPL
3	1	1170	1170
2	1	1340	1340
5	2	2740	1370
4	2	2960	1480
3	2	2980	1490
4	3	4560	1520

Reference: Transportation Research Board, National Research Council, **Highway Capacity Manual**, 1997 Update

2. If the most recent traffic data (that falls within the proposed work schedule) exceeds the numbers presented in the chart then the designer must perform a queue or delay analysis to determine average delays that could result based on the proposed construction staging. If the resulting queue does not meet the following thresholds, alternatives for construction shall be developed or work zone impact management strategies shall be employed.

   a. For queues less than 1.0 mile, the work zone impacts are acceptable.

   b. For queues greater than 1.0 mile and less than 1.5 miles, the work zone impacts are acceptable if the queue exceeds 1.0 mile for two hours or less. Where queues are expected, additional advanced work zone warning signing should be specified.

   c. For queues longer than 1.0 mile for more than two hours or longer than 1.5 miles for any period of time, the work zone impacts are unacceptable.

B. Arterials

1. Roadway segments

   a. Travel delays of over 15 minutes beyond what are considered the normal travel delays for the affected roadway segment shall be considered unacceptable.

2. Signalized intersections[4]

    a. If the existing level of service is between ‘A’ and ‘C’, then the level of service during work zone operations shall not be reduced below a ‘D’ with a control delay of 45 seconds.

    b. If the existing level of service is a ‘D’, then the control delay during work zone operations shall not increase more than 30%.

    c. If the existing level of service an ‘E’, then the control delay during work zone operations shall not increase more than 30% with a maximum control delay of 80 seconds.

    d. Additional control delay is unacceptable at intersections performing at level of service ‘F’.

3. Unsignalized intersections[4]

    a. If the existing level of service is between ‘A’ and ‘C’, then the level of service during work zone operations shall not be reduced below a ‘D’ with a control delay of 30 seconds.

    b. If the existing level of service is a ‘D’, then the control delay during work zone operations shall not increase more than 30%

    c. If the existing level of service is an ‘E’, then the control delay during work zone operations shall not increase more than 30% with a maximum control delay of 50 seconds.

    d. Additional control delay is unacceptable at intersections performing at level of service ‘F’.

COMPLIANCE PROCESS:

Organization and Responsibilities

A. District Traffic

1. Provide guidance to District personnel and consultants on the application of these guidelines.

2. Review all proposed lane closures and Traffic Control Plans for conformance to these guidelines. Submit Maintenance of Traffic Alternatives Analysis and recommended alternative to ADE-Traffic for queues/delays that exceed the allowable threshold.

[4] Control delay at each approach should be reviewed to confirm that one or more approaches do not have an unacceptable increase in delay.

3. Coordinate and monitor all projects that may affect traffic flow on all State roads within a District. Maintain communication with adjoining Districts and advise them of potential impacts.

4. Coordinate with the appropriate Public Information Officer to provide all information needed for the public information/relations campaign.

5. Where actual work zone mobility impacts exceed those generated during analysis, the cause of differences shall be determined. For projects where impacts are generated that exceed the acceptable thresholds, determine probable cause in partnership with the Office of Traffic and Safety (OOTS).

6. Review and monitor work zone safety through the review and analysis of crash reports in partnership with OOTS.

B. ADE-Traffic (ADE-T)

1. Review Maintenance of Traffic Alternatives Analysis (MOTAA) and solicit comments from other offices as needed.

2. Request additional information, or approve or reject the recommended option from the MOTAA.

C. Office of Traffic and Safety (OOTS)

1. Provide training for traffic modeling upon request.

2. Assist with the analysis of work zone alternatives upon request.

3. Provide review and comment on traffic analyses upon request.

4. Perform field evaluations and reviews of the application of these guidelines.

5. Continually monitor and improve the analysis procedures and update the processes of these guidelines as needed.

D. Contractor

1. Contractors shall adhere to the work hour schedule requirements specified in the contract. The Contractor may submit an alternate work hour schedule for consideration by the District prior to the start of work. Work cannot begin until the alternate schedule is approved. The alternate schedule shall be processed for approval in accordance with the SHA requirements.

2. Abide by the requirements set forth by SHA in the Lane Closure Notification Procedures.

Procedure

Traffic Analysis. For projects where traffic impacts are expected to exceed allowable thresholds, traffic analyses shall be performed. Analysis shall occur during the planning or early design stages of the project development process. For routine district maintenance projects, this analysis shall occur prior to the implementation of any lane restrictions.

A. *Projected impacts are less than thresholds.* If the traffic analysis indicates that projected impacts will be below allowable thresholds, the final development process may commence. Documentation of this analysis must be retained in the project files.

B. *Projected impacts exceed thresholds.* Explore other work zone options and impact management strategies through a Maintenance of Traffic Alternative Analysis.

Maintenance of Traffic Alternative Analysis. The intent of a Maintenance of Traffic Alternative Analysis (MOTAA) is to compare work zone options, including staging/phasing options as well as temporary traffic control options, and document benefits and constraints of each option.

A. *Projected impacts are less than thresholds.* If the MOTAA produces a work zone option that reduces projected impacts below allowable thresholds, the final development process may commence. Documentation of this analysis must be retained on the project files.

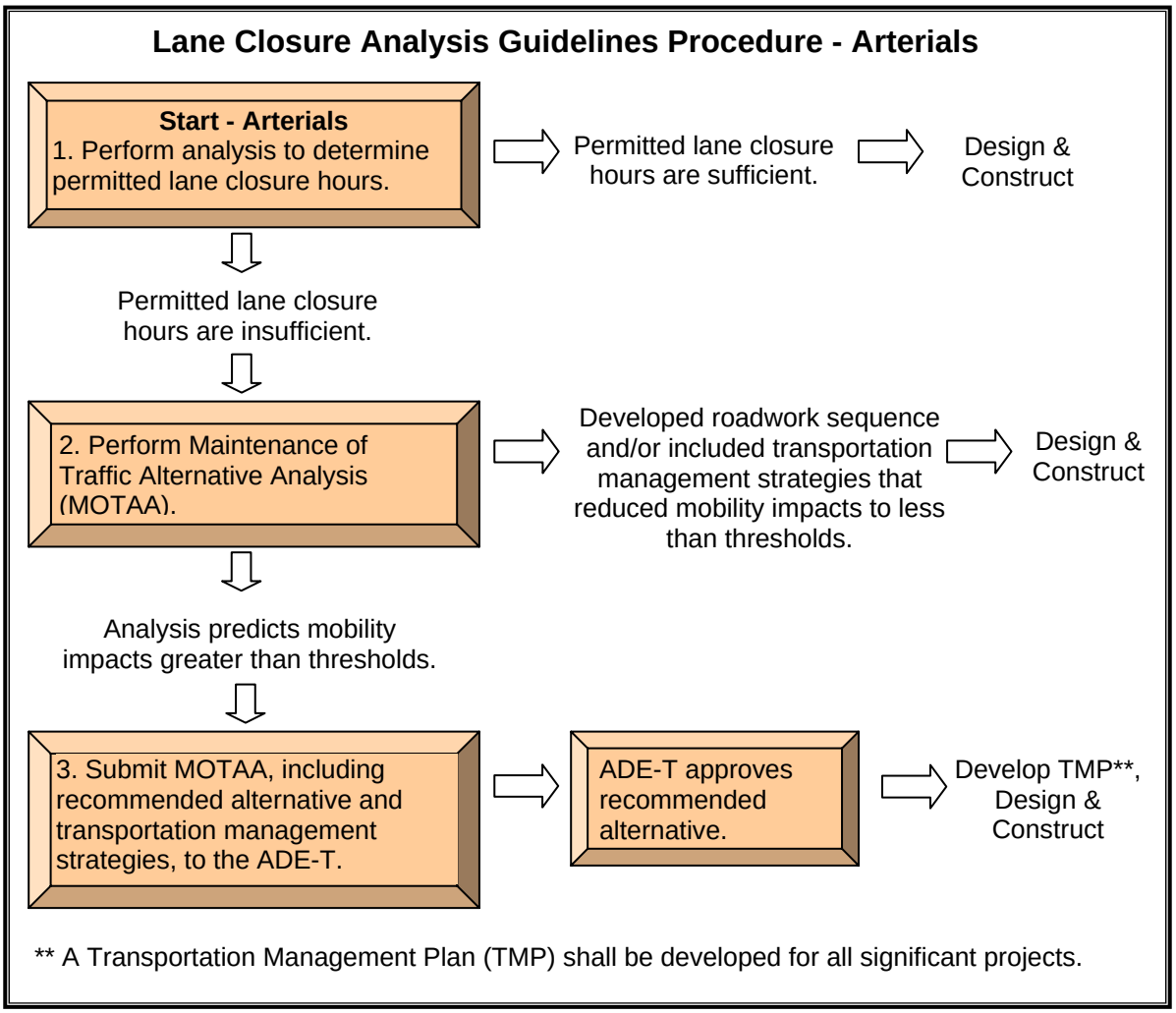
B. *Projected impacts exceed thresholds.* If, after examining multiple alternatives, the MOTAA does not produce a work zone option that reduces mobility impacts below thresholds, provide the analysis, including a recommended alternative based on factors such as queue lengths, queue durations, construction costs, construction schedules, and mitigation strategies, to the ADE-T. The ADE-T will approve the recommended alternative or request further information and/or analysis.

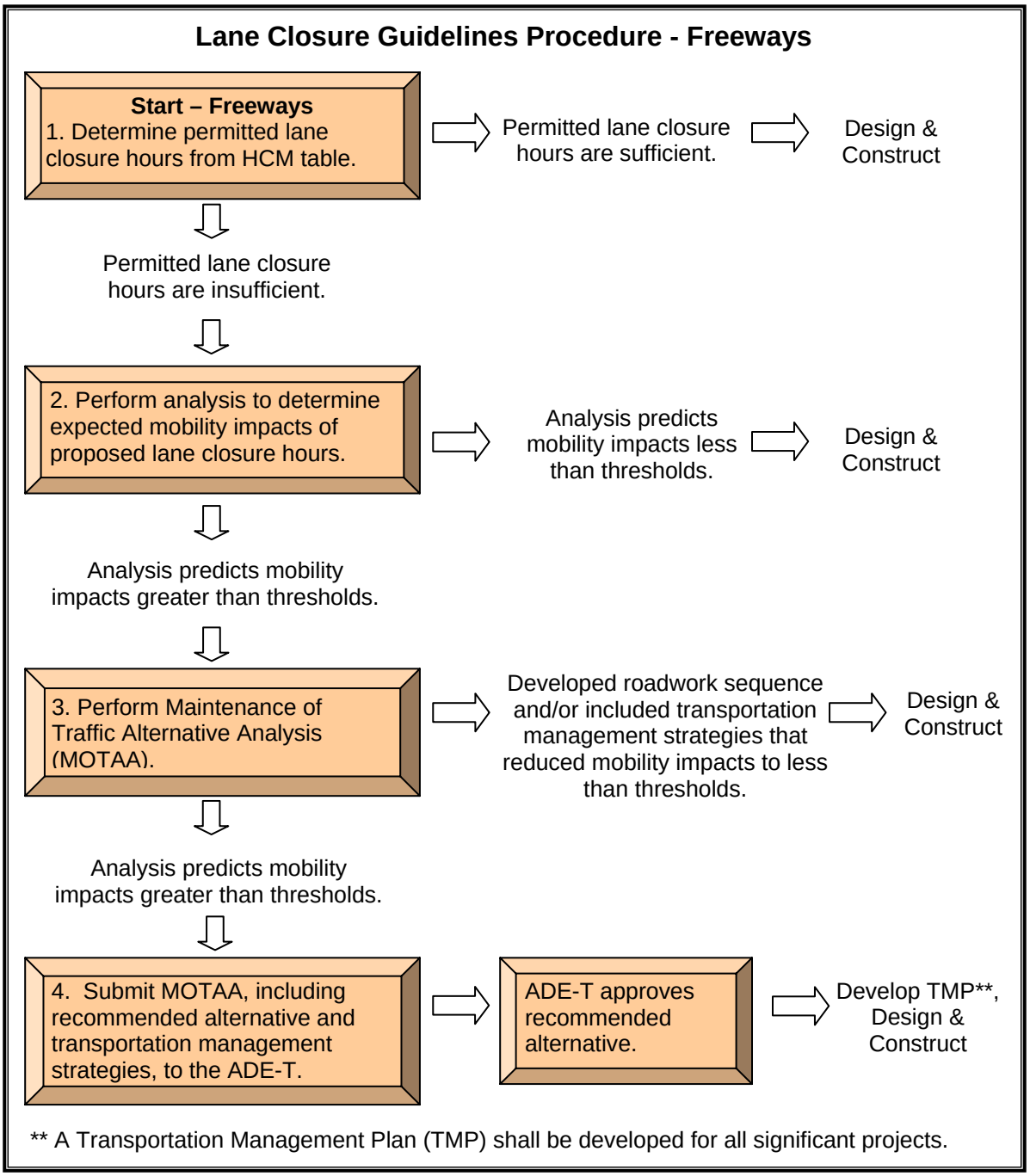
Implementation and Evaluation.

A. *Compare work zone impacts to expected impacts generated by traffic analysis.* Work zone impacts shall be monitored and compared against the expected impacts generated by the analysis. Unless the new work zone or construction phase causes extremely long queues/delays, the impact measurements should be made about one week after a project or phase change begins in order to allow drivers to become accustomed to navigating the new conditions. Should the impacts measured after one week exceed the expected impacts, District Traffic shall inform the ADE-T of the situation and of proposed corrective action. The cause for the discrepancy between the expected impacts generated by the analysis and the actual conditions will be determined by the District Traffic in coordination with OOTS. The Contractor may be required to implement mitigation strategies to reduce delay in the subject work zone.

B. *Review Traffic Control Plans and Impact Management Strategies.* When certain construction operations result in repeated travel delays, the SHA Construction Project Engineer shall inform District Traffic. District Traffic shall review the Traffic Control Plan (or Transportation Management Plan) for those operations and explore the possibility of revising the Traffic Control Plan (or Transportation Management Plan) or work schedule to minimize travel delays, in consultation with the appropriate persons (ADE-T, Traffic Manager, Project Engineer, etc.).

C. *Lifting Lane Closures for Unacceptable Traffic Delays.* When the suspension of construction operations due to unacceptable travel delays will cause a negative impact on public safety, such as when there are open trenches or a lack of proper delineation, the SHA Construction Project Engineer, may allow the operations to continue until the negative impact can be resolved. The Project Engineer shall immediately notify District Traffic of such situations and shall keep him/her briefed on the status of the work. This type of situation should be avoided to the greatest extent possible though careful planning and monitoring of construction operations.




Lane Closure Guidelines Procedure - Freeways
Start – Freeways
1. Determine permitted lane closure hours from HCM table.
Permitted lane closure hours are sufficient.
Design & Construct
Permitted lane closure hours are insufficient.
2. Perform analysis to determine expected mobility impacts of proposed lane closure hours.
Analysis predicts mobility impacts less than thresholds.
Design & Construct
Analysis predicts mobility impacts greater than thresholds.
3. Perform Maintenance of Traffic Alternative Analysis (MOTAA).
Developed roadwork sequence and/or included transportation management strategies that reduced mobility impacts to less than thresholds.
Design & Construct
Analysis predicts mobility impacts greater than thresholds.
4. Submit MOTAA, including recommended alternative and transportation management strategies, to the ADE-T.
ADE-T approves recommended alternative.
Develop TMP**, Design & Construct
** A Transportation Management Plan (TMP) shall be developed for all significant projects.

GUIDANCE ON ANALYSIS:

QuickZone, Quewz-98, Synchro/Simtraffic, Corsim or similar programs may be used to model the expected impacts that will be generated. Work zone mobility impacts shall be analyzed no later than the PI stage (30%) for each of the maintenance of traffic phases. Engineering judgment should be used to determine the appropriate speed to be used in analysis (e.g., reduced work zone speed, posted speed limit, prevailing speed, etc.). Volume data supplied by SHA for input into the models should be current (not older than three years), should account for seasonal traffic surges that may occur during construction, should reflect current regional traffic patterns, and should be adjusted to account for heavy vehicles. Traffic volumes should be expanded to construction year levels through the use of growth factors. If the project will involve lane closures on the weekend, separate analysis should be developed for the weekday and weekend traffic. Where congestion occurs under normal unrestricted conditions, the recurring queue length shall be considered in analysis.

Contact the appropriate District and County to determine if there are any other projects scheduled or in progress on the surrounding roadway network that may impact work zone operations. Impacts of other projects in the area of the work zone should be included in the analysis. Construction phasing between projects should be coordinated.

For simple freeway analysis, the use of QuickZone or Quewz-98 is suggested. For simple arterial analysis, the use of Synchro is suggested. Use of microscopic models, such as Simtraffic, Corsim, Vissim, etc., is encouraged for modeling of complex work zones.

A vehicle shall be considered part of a queue if its average operating speed is approximately 10 mph or less. Discretion is required during both the analysis portion and field evaluation of the implemented work zone in determining what constitutes a queue. In general a condition that may cause driver frustration due to stop and go operations should be considered a queue. Delay is defined as the additional travel time experienced by the driver on the corridor.

Documentation of the analysis shall be in the form of a written report that includes the following:

1. Project Location and Description **–** Include project background, purpose, type of work, description of project area and surrounding roadway network, project goals and constraints, and the general schedule and timeline. Provide general information on lane width and configuration, grade, pedestrian and bike facilities, heavy vehicle impacts, etc.

2. Data Collection and Modeling Approach – Discuss how existing traffic data and information was obtained, including source, location, and date of volume data. Include a brief summary and justification of the analysis tool(s) chosen.

3. Existing and Future Conditions – Provide information on existing and future (i.e., during construction) conditions. Describe the approach that was used to estimate traffic conditions during construction, including truck percentages, growth factors, seasonal adjustments, day of week factors, work zone capacity, etc. While the level of detail will vary based on the project, it should consider existing roadway characteristics, existing/historical traffic data, traffic operations, accident history, and mobility issues.

4. Results of Traffic Analysis – Discuss results of traffic analysis, including mobility impacts (max. queue length, delay, etc.), recommendations for lane/ramp restrictions and/or closures, work hour restrictions, and potential detours. Include information for holidays, weekend restrictions and/or special events. Analysis should take into consideration impacts on network operations.

Sample reports can be obtained from the Office of Traffic and Safety. Changes to the project throughout the design process may require additional analysis to be performed.

GUIDANCE FOR PROJECTS THAT EXCEED THRESHOLDS:

SHA recognizes that specific work activities and time periods may make it infeasible to meet the threshold levels on a particular corridor. Some conditions where this may occur are noted below:

A. Work zones located in areas where the existing freeway is operating at or near capacity but where the existing traffic flow is relatively stable. At these locations, a slight reduction in capacity resulting from construction activities (e.g., a lane shift rather than a lane drop) could have a significant impact on traffic operations.

B. Work zones where lane restrictions are unavoidable for reasons such as limited right-of-way, environmental concerns, etc.

C. Special construction related activities of short duration, such as girder placement, traffic control implementation, etc.

D. High traffic volume periods related to seasonal traffic, holidays and special events.

E. Significant safety risks to motorists and/or construction workers.

In these cases, a Maintenance of Traffic Alternative Analysis (MOTAA) should be performed. The purpose of a MOTAA is to compare work zone options, including staging/phasing options as well as temporary traffic control options, and to identify potential impacts of each option. The MOTAA should be submitted to the ADE-T for review and approval. Documentation of the MOTAA should include the following:

1. Project Location and Description **–** Include project background, purpose, type of work, description of project area and surrounding roadway network, project goals and constraints, and the general schedule and timeline. Provide general information on lane width and configuration, grade, pedestrian and bike facilities, heavy vehicle impacts, etc. Also provide reasons for not meeting mobility thresholds.

2. Maintenance of Traffic Options – Describe all potential options for MOT. These may include full closure, permanent/temporary lane closures, temporary structures, lane shifts, reversible lanes, etc.

3. Requirements/Objectives Considered – Describe the requirements and objectives considered for all MOT alternatives. Traffic requirements/objectives may include maximum queue length or delay, number of open lanes, delay, ability to maintain access (business, community, pedestrian and bicycle), emergency vehicle response time, etc. Other requirements/objectives for analysis may include construction duration, constructability, right-of-way impacts, environmental impacts, utility impacts, construction and/or user costs, geometrics, etc. Refer to “Guidance on Maintenance of Traffic Alternatives Analysis” for more details.

4. Details of Traffic Analysis - Provide a summary of the traffic analysis performed as part of the MOTAA, including the following:

- Data Collection and Modeling Approach – Discuss how existing traffic data and information was obtained, including source, location, and date of volume data. Include a brief summary and justification of the analysis tool(s) chosen.

- Existing and Future Conditions – Provide information on existing and future (i.e., during construction) conditions. Describe the approach that was used to estimate traffic conditions during construction, including truck percentages, growth factors, seasonal adjustments, day of week factors, work zone capacity, etc. While the level of detail will vary based on the project, it should consider existing roadway characteristics, existing/historical traffic data, traffic operations, accident history, and mobility issues.

- Results of Traffic Analysis – Discuss results of traffic analysis, including mobility impacts (max. queue length, delay, etc.), recommendations for lane/ramp restrictions and/or closures, and work hour restrictions. Include information for holidays, weekend restrictions and/or special events. Analysis should take into consideration impacts on network operations.

- Potential Detours – If a detour is proposed, provide detour route description and map(s). Include additional user cost created to travel the extra distance. Provide capacity, volume and queue/delay calculations for the detour route. Suggest improvements to the detour route to improve traffic flow.

5. Results of MOTAA – Summarize the alternatives in table format, including important comparison items from these requirements/objectives. Describe advantages/ disadvantages of each alternative. Also, recommend potential transportation management strategies for each alternative. These may include transportation operations or public information and outreach strategies.

6. Summary and Recommendations – List the alternatives in order of preference and explain why the alternative is/is not preferred. If none of the MOT alternatives are recommended, suggest other options for further analysis.

If it is anticipated the allowable threshold cannot be met, maintenance of traffic alternatives should be considered and processed during the planning and preliminary design stages of a project and not immediately before construction is to begin.

For significant projects, a **Transportation Management Plan** shall be developed for the approved alternative, incorporating minimally the following elements:

A. Consideration of stakeholders' needs during the decision making process
B. Public information and outreach strategies
C. Mitigation strategies, including demand management strategies, accelerated construction strategies, and transportation operations strategies as appropriate.
D. Incident management strategies

For guidance on developing TMPs, refer to "Transportation Management Plans – Guidelines for Development, Implementation and Assessment".