C12 Bridge and culvert repair

C12.1.6 Field exams

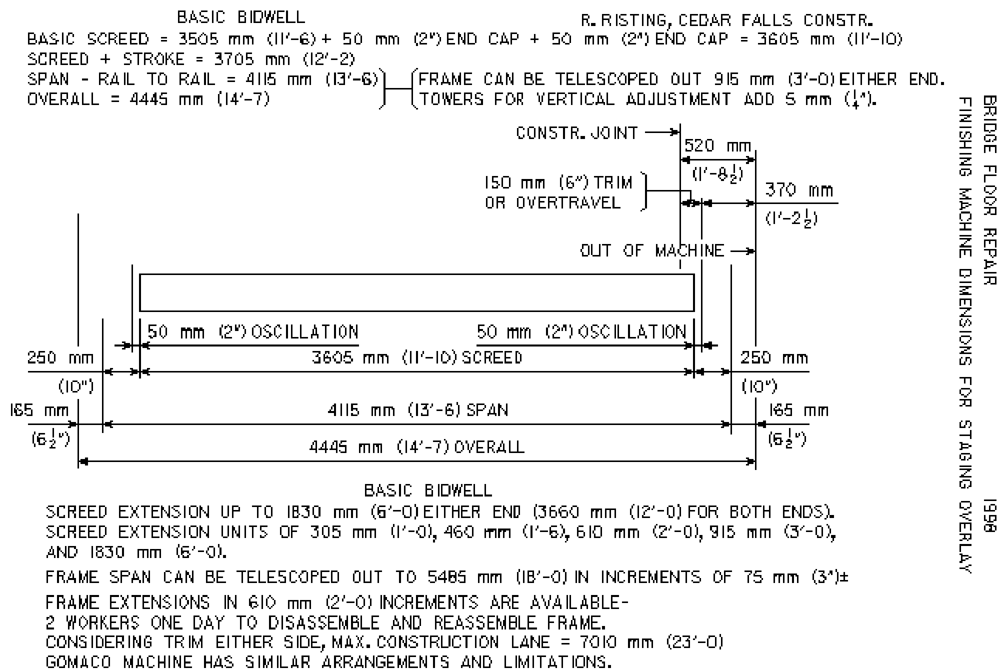
2011 ~ Pedestrian and Bicyclist Access During Repair Projects

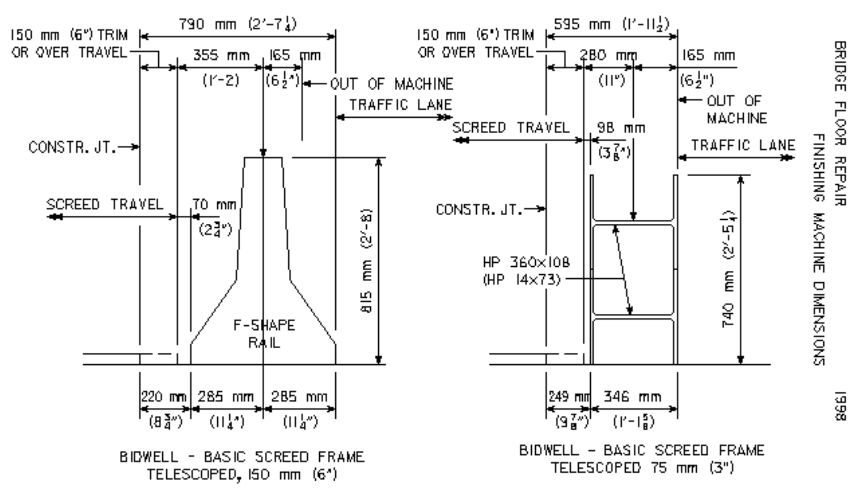
Unless a bridge can be closed during a repair project, vehicular access on the bridge must be maintained, but the bridge repair designer also needs to consider the needs of other users, including pedestrians and bicyclists on bridges with existing sidewalks, bicycle lanes, or shared use paths. For pedestrian and bicyclist access the designer cannot use the suggested temporary barrier rail layouts given in the Bridge and Culvert Repair section commentary [BDM C12.1.8.3] when developing a traffic control plan and should consult with the Design Bureau and, in complex situations, also with the Traffic and Safety Bureau. Along with pedestrian access the designer will need to address Americans with Disabilities Act (ADA) requirements. Although the Design Bureau intends to consider all users and ADA when developing traffic control plans for work zones [DB DM 9A-1 and 9A-5] the bridge repair designer needs to be aware of the issues and consult with the Design Bureau as soon as possible in special situations.

C12.1.8 Staging

C12.1.8.2 Construction considerations

1998 ~ Finishing machine dimensions for overlay and barrier rail





C12.1.8.3 Temporary barrier rail

2011 ~ Pedestrian and Bicyclist Access During Repair Projects

Unless a bridge can be closed during a repair project, vehicular access on the bridge must be maintained, but the bridge repair designer also needs to consider the needs of other users, including pedestrians and bicyclists on bridges with existing sidewalks, bicycle lanes, or shared use paths. For pedestrian and bicyclist access the designer cannot use the suggested temporary barrier rail layouts given in the Bridge and Culvert Repair section commentary [BDM C12.1.8.3] when developing a traffic control plan and should consult with the Design Bureau and, in complex situations, also with the Traffic and Safety Bureau. Along with pedestrian access the designer will need to address Americans with Disabilities Act (ADA) requirements. Although the Design Bureau intends to consider all users and ADA when developing traffic control plans for work zones [DB DM 9A-1 and 9A-5] the bridge repair designer needs to be aware of the issues and consult with the Design Bureau as soon as possible in special situations.

1998 ~ Example TBR layouts

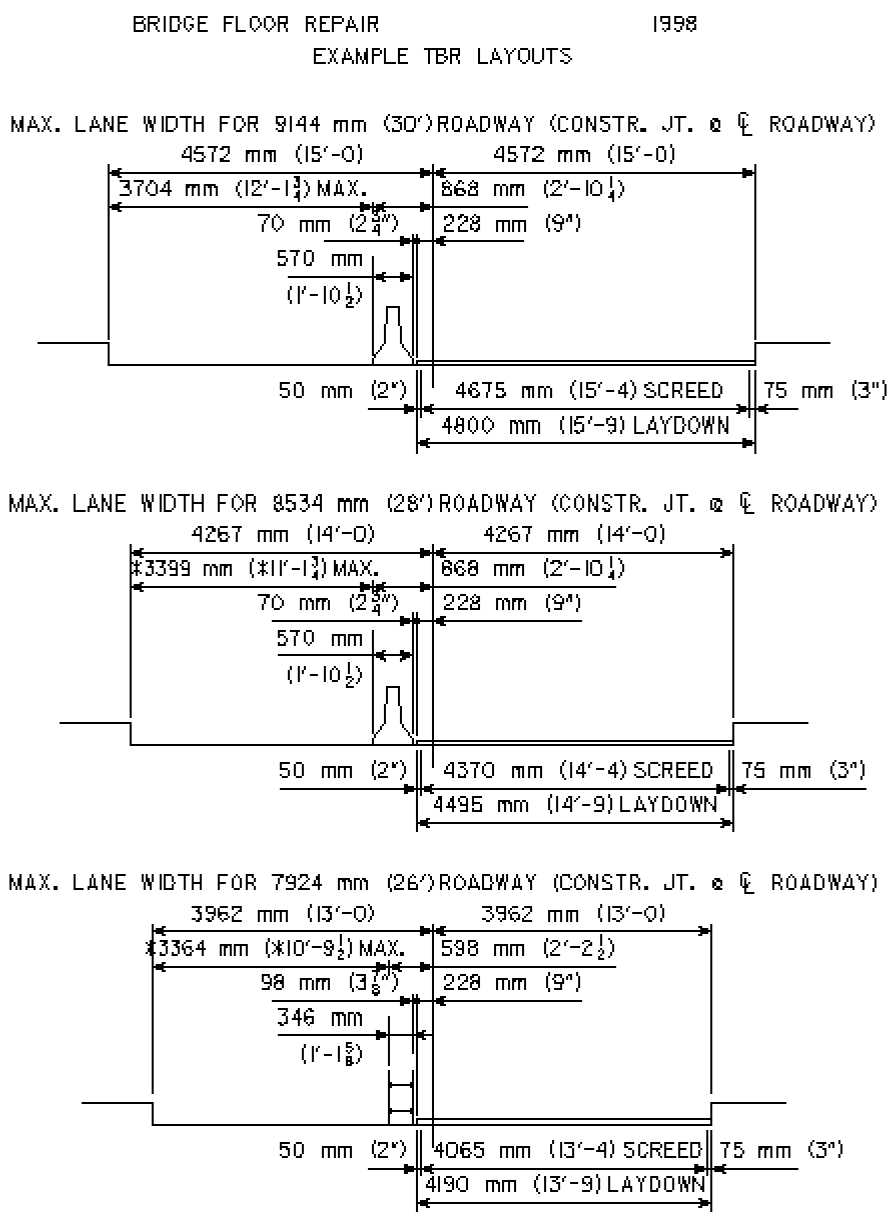


Figure note: All cases illustrated above require special signing because the roadway width is less than 14.50 feet between barriers. If the lane width is less than 10.50 feet the Traffic and Safety Bureau also will need to review the TBR design. See the manual text [BDM 12.1.8.3].

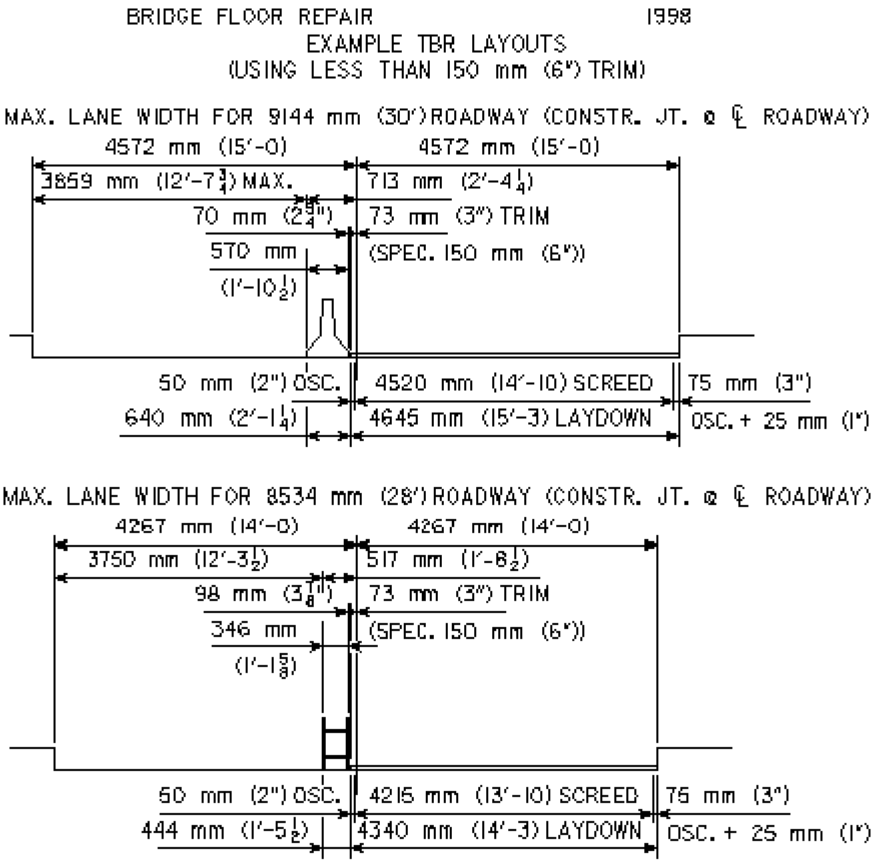


Figure notes: When less trim is used than required by the Standard Specifications, include deck repair note E432 [BDM 13.5.2]. Reduce trim only when needed to maximize roadway width.

All cases illustrated above require special signing because the roadway width is less than 14.50 feet between barriers. If the width is less than 10.50 feet the Traffic and Safety Bureau also will need to review the TBR design. See the manual text [BDM 12.8.1.3].

C12.1.9.2 Retrofit

C12.1.9.2.1 Doweled bars

Prior to 25 August 1993 ~ Iowa DOT Pullout Test Results

Plain and epoxy coated No.6 rebars were installed in 7/8" diameter holes in 4000 psi concrete at 4-inch and 6-inch depths, and pull-out loads were determined after a seven day epoxy cure. Results are as follows:

4-inch embedment depth

Bar type	Plain No. 6	Epoxy-coated No. 6

Test result	15,100 lb	12,750 lb
		11,000 lb
		10,100 lb
Average test result	15,100 lb	11,312 lb
With factor of safety of 4	3,775 lb	2,828 lb

6-inch embedment depth

Bar type	Plain No. 6	Epoxy-coated No. 6
Test result	20,000 lb	16,000 lb
		15,750 lb
		13,150 lb
Average test result	20,000 lb	14,975 lb
With factor of safety of 4	5,000 lb	3,744 lb

C12.1.9.2.2 TL-4 barrier rails

C12.1.9.2.2.2 End sections

May 2013 ~ Sloped transitions for rigid barrier rail

The following information is from University of Nebraska via the Design Bureau.

> When transitioning the height of a rigid barrier, a taper rate of 10:1 is preferred. Where a more aggressive rate is needed, apply the following:
>
> - Where the height of the lower barrier is less than 32 inches, use a maximum taper rate of 8:1.
> - Where the height of the lower barrier is 32 inches or greater, use a maximum taper rate of 6:1.

C12.1.9.4.2 Decks

2011 ~ Deck replacement

As the inventory of Iowa bridges ages, a deck overlay is not always sufficient for repair of a deteriorated deck, and the deck may need to be replaced. Generally deck replacements are the responsibility of final design, but the preliminary designer needs to be involved in projects that include significant bridge widening. There have been problems with deck replacement projects when bridges settled in service. Without surveys of the existing decks, the project plans showed deck elevations that would have resulted in very thick decks. Therefore the final designer needs to request a deck survey and base the deck elevations on the survey rather than on the original bridge plans.

A second issue with deck replacements is the resistance of existing angle-plus-bar shear lugs that were used in composite steel beam-deck design from about 1947 to about 1970. The ultimate strength (nominal resistance) of those lugs can be determined approximately from a modified AASHTO Standard Specifications channel connector formula. The formula is mentioned (but not given) in Part I of the final report for Iowa Highway Research Board project HR-238 and is as follows:

$$S_u = (550)\ (1.5\ t)\ (W)\ (f'_c)^{0.5}$$

S_u = ultimate strength (nominal resistance), pounds
t = angle thickness, inches
W = angle width perpendicular to centerline of beam, inches
f'_c = 28-day strength of concrete in the new deck, psi

Shear resistance may be augmented with new shear studs if the existing angle-plus-bar lugs are insufficient based on design computations.

In addition, because the existing lugs and top flanges may be damaged during deck removal, there should be a field inspection to determine damage to the lugs and flanges. Any cracks in lugs above tension flanges need to be ground out so that cracks do not progress into the flanges. Also, gouges, nicks, and cuts in the tension flanges need to be repaired. After all damage has been addressed new shear studs need to be added to replace any shear resistance lost due to damage and repair of damage.

There is no specific information available for fatigue resistance of angle-plus-bar shear lugs.

During design the designer also needs to address potential lateral buckling of steel beams in superstructures with integral abutments. During service conditions the closely spaced shear connections to the deck prevent lateral buckling of beams in compression but, when the deck is removed, the lateral support is widely spaced at diaphragms only. In another state, the summer sun increased temperature in the steel beams, the beams expanded, pushed against the integral abutments, were unable to move the abutments back into the approach fills, and buckled laterally between diaphragms.

Reference: Klaiber, F.W., D.J. Dedic, K.F. Dunker, and W.W. Sanders, Jr. (1983). *Strengthening of Existing Single Span Steel Beam and Concrete Deck Bridges, Final Report Part I.* Engineering Research Institute, Iowa State University, Ames, Iowa. (Available on the Iowa DOT web site at:

https://iowadot.gov/research/reports/Year/2003andolder/fullreports/HR-238.pdf)

C12.1.9.5.2 Cleaning and painting

1 November 2005 ~ Removal of Hazardous Paint (Comments regarding EPA number from Brad Azeltine, Location and Environment Bureau, edited and added 27 December 2005)

Brad Azeltine’s clarification on the timing of obtaining the EPA ID number: We need to wait until the painting contractor has generated some blast waste so it can be sampled and analyzed before we request a generator ID number from EPA (to confirm we have a hazardous waste). We also need the contractor to provide the quantity of waste expected to be generated, the estimated time period of the waste generation, and the expected number and timing of waste shipments. In other words, we typically won't have an ID number until the work is actually in progress. However, this is a moot point for those bridges that already have an EPA ID number (e.g. US20 J.D. Bridge, Allamakee IA9 over the Mississippi, Pottawattamie I-80 over the Missouri, etc.) In those cases, the ID number could be placed on the plans.)

C12.1.11 Concept statements

2024 ~ Process for Determining Traffic Management Strategies for Narrow Bridges

In 2022, several stakeholders at the Iowa DOT identified the need to address traffic management on “narrow bridges” on I-80, as increasing traffic volumes rendered our historical traffic management strategies inefficient. A “narrow bridge” is defined as a bridge on a four-lane highway having a deck width of 39 feet or less, since our traffic control options are significantly limited at or below this width. A survey of our bridge records indicates there are 120 narrow bridges on I-80, let alone the rest of Iowa’s interstate network. As such, the Transportation Development and Systems Operations Divisions asked for a metric and process to help determine the best traffic safety and mobility mitigation for projects that include narrow bridges. The goal was to develop a uniform process that is easy to use to determine the best mitigations for these projects. A task force was established to develop better tools to make these decisions for narrow bridges. After working through several scenarios, the task force determined that the preferred traffic control strategy should be selected when the concept is completed. To best support the concept writers, the task force determined that a process flow chart supported by a matrix of bridge maintenance and construction work types and traffic control strategies would provide the desired guidance. The writeup that follow serves as an outline and instructions for the use of the flow chart and matrix.

Refer to “Traffic Evaluation Flow Chart for Narrow Bridges” below.

Project Work Type

As a first step in this process, select the work type to accomplish the needed repair. For this first step, do not take traffic management into account; that will be accounted for throughout this process. This step identifies the minimum work type needed to complete the repair as cost-effectively as possible.

Traffic Management Options

The Traffic Management Matrix (TMM) presents options for traffic control depending on the work duration for a given work type. The options are graded from most cost effective to least cost effective. Refer to the instructions below.

When selecting an initial traffic control option, start with the most cost effective. If that option proves to be feasible, the process is complete. If it is not, then revisit the options in the matrix and select the next possibility. Continue in this fashion until a solution is found or it is time to consider a different work type for the traffic and bridge needs.

Closure Review

- Find Allowable Closures

When developing the traffic control options for a project, navigate to the Work Zone Reference Library (WRL: https://iowadot.gov/workzonereferencelibrary) and locate the "District Static Lane Closure Maps" link on the left-hand side. Click the map for the appropriate district and the map will open. Note: some maps have more than one page.

- Review Closure Maps

Locate your project location on the map. If your route is not shown (or it is shown but not shaded), there are no restrictions on the duration of lane closures; move on to "Check for Unique Restrictions." If the route is shown and shaded, move on to the "Review Work

Durations" step. Note: these maps focus on the higher-volume roadway network (all Interstates, some expressways, and some primary routes in Metro areas or other areas of high traffic volumes). Not all routes are shown for a district if they don't meet the criteria.

- Review Work Durations

Locate the closure restriction information matching the color of the shading at the project location. If the chosen work type and traffic control scenario falls within the allowable closures, the step is complete; move on to "Check for Unique Restrictions." If not, additional analysis will be needed; proceed to "Advanced Closure Review." Note: If there are questions about the restriction information, contact the TSMO Engineer for the area in question.

- Check for Unique Restrictions

If the work type, work duration, and permissible closure windows align, the last check is to look for special circumstances. This must be done in collaboration with District staff (most likely the TSMO Engineer). Any restrictions regarding holidays, special events, other projects, and/or other circumstances should be reviewed to affirm the selected method of traffic control will be successful.

- Advanced Closure Review

This step will be needed if the work type, work duration, and permissible closure windows do not align. The starting point for this on is the Lane Closure Planning Tool (LCPT: https://apps.iowadot.gov/lcpt/).

The LCPT can show seasonal, time of day, and day of week travel patterns. There may be opportunities to complete the work within these additional windows.

The TSMO Engineer can assist with utilization of the LCPT if necessary. Additionally, the TSMO Engineer should be consulted if the project is within an interchange (system or service), or the traffic control may spill into the influence area of a systems interchange. This type of evaluation may require a review beyond the capabilities of the LCPT.

- Work Zone Mitigation Team Meeting

A Work Zone Mitigation Team may be assembled for the project if an Advanced Review is necessary. This optional step should be included if the project requires advanced traffic control scenarios and is the best way to achieve consensus from a wide variety of staff before completing the project concept.

Members of this team should include:

- Work Zone Operations Engineer, Bureau of Construction & Materials
- Special Projects Engineer, Bureau of Traffic & Safety
- Work Zone Design Engineer, Bureau of Design
- Assistant District Engineer, District Staff
- District Construction Engineer, District Staff
- Traffic Technician, District Staff
- Regional TSMO Engineer, District Staff

The concept writer should work through traffic management options and find at least the first option for the team to review. It would be recommended to have one additional option prepared as well. When scheduling the team meeting, an agenda will be helpful to discuss the issues at hand and guide the team to a decision.

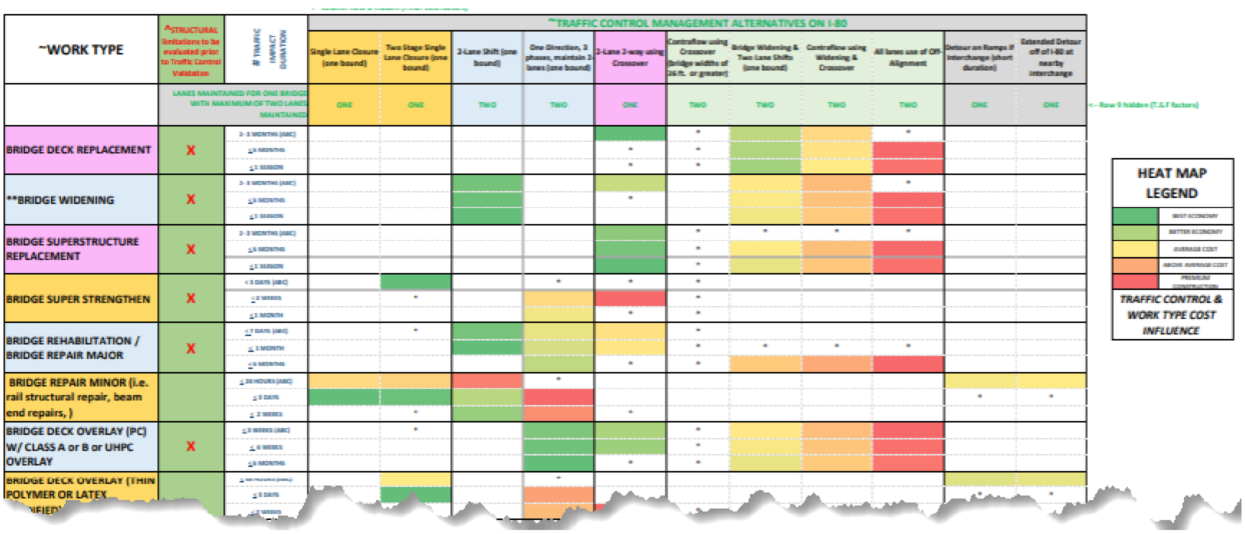
- Start Iteration

If the Advance Closure Review fails to yield a successful traffic management strategy, the concept writer should review other options available in the Traffic Management Matrix. It is possible some projects may be required to reconsider the work type in order to address traffic needs.

Acceptable Traffic Approach

After an acceptable traffic management solution is found, the next steps are to include the proposed solution in the project concept and to complete the Traffic Critical Project (TCP) Checklist (https://webapps.srfconsulting.com/idottcp/). If a Work Zone Mitigation Team was used be sure to distribute meeting notes to the team.

Using the Traffic Management Matrix (TMM)



The objective of the narrow bridge Traffic Management Matrix (TMM) is to provide designers, or concepting engineers, a preliminary guidance tool to select an acceptable traffic control option to implement for the project work type on multi-lane divided highways and interstates. The overarching goal is to find a traffic control strategy that reduces the risk of work zone accidents at the site, but also to optimize the project cost and duration of traffic interruption as appropriate for the project site.

What you need to know about the TMM:

- The matrix is colored coded on a sliding scale for the most economical solution (green cells) and most costly solution (red cells).
- The general pattern will be to start on the left side and use the heat map to balance the appropriate amount of traffic duration impact with the cost.

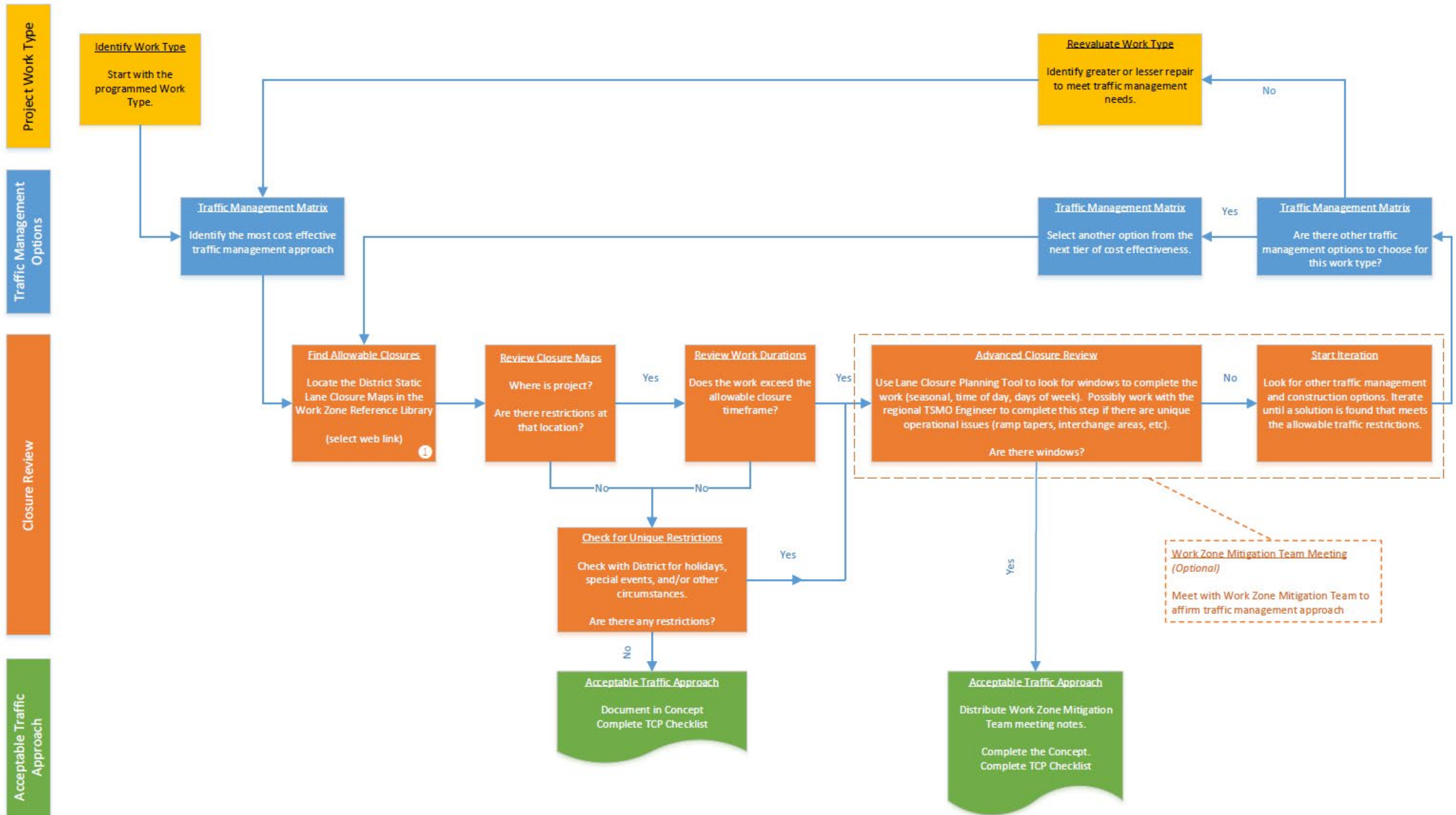
- The traffic control baselines used to predict cost economy are comprised of three criteria: (1) lanes maintained during work activity, (2) duration of traffic impact, and (3) use/no use of detour pavement.
- The work types are color coded to match the traffic control baselines.

Use the TMM to implement the most economical traffic solution possible. Here are some strategies for using the TMM:

- Use the traffic control baseline as the “first option” for that work type because it offers economy and appropriate work zone strategies.
- After selection of a traffic control strategy, return to the "Traffic Evaluation Flow Chart for Narrow Bridges." If that traffic control strategy is unacceptable, select another option from the TMM that is to the right of the previous option.
- The traffic control strategies associated with higher costs on the heat map, or a condensed work period for a work type (i.e. ABC) should be reviewed with the District ADE, Project Delivery Bridge Engineer, and Traffic Mitigation team prior to implementation.
- Some strategies are noted with an asterisk (*) on the heap map because it is viewed to be outside the normal recognized solution, but it is still considered viable if properly researched by the designer and Traffic Mitigation Team.

The traffic control management solutions represent the work zone on divided multi-lane roadways (e.g. I-80, I-35, US 30, etc.), but the work type represents the work on one bridge (for one bound of traffic). Potential traffic management solutions may exist beyond this matrix.

Traffic Evaluation Flow Chart for Narrow Bridges



1 Closures refer to impacts to existing lanes

Traffic Management Matrix (TMM) for High Volume Divided Highways and Interstates for Bridge Repairs

Version 7 [05-10-2024]

Advisory Statement for User:
The traffic control management solutions represent the work zone on a high-volume, divided multi-lane roadway (both bounds included) with a total AADT of approximately 15,000 or greater (e.g. I-80, I-35, I-380, urban U.S. 30, urban U.S. 218, etc.), but the work type represents the work on one bridge (for one bound of traffic). The user of the TMM shall strive to implement the most economical traffic solution if possible. The matrix is colored coded on a sliding scale for the most economical solution (green cells) and most costly solution (red cells). The user of the matrix shall note the baselines shown to predict cost economy is based on three criteria: (1) lanes maintained during work activity, (2) duration of traffic impact, and (3) use/no use of detour pavement. The user will notice that work types are color coded to match the baselines for Traffic Control strategies. The baseline traffic strategy is meant to be the "first option" for that work type because it offers economy and appropriate work zone strategies. The general pattern will be to start on the left side and use the heat map to balance the appropriate amount of traffic duration impact with the cost. After the initial selection of the traffic control method, the designer shall proceed to the "Traffic Evaluation Flow Chart for Narrow Bridges." If the traffic control option is rejected by the flow chart evaluation, return to the Traffic Management Matrix and proceed to evaluate more options to the right of the previous option. The traffic control solutions associated with higher costs on the heat map, or a condensed work period for a Work Type (i.e. ABC) may need to be evaluated with the District ADE, Project Delivery Bridge Engineer, and Traffic Mitigation team prior to implementation. Some strategies are noted with an asterisk (*) on the heap map because it is viewed to be outside the normal recognized solution, but it is still considered viable if properly researched by the designer and Traffic Mitigation Team. Potential traffic management solutions may exist beyond this matrix.

HEAT MAP LEGEND	
(green)	BEST ECONOMY
(light green)	BETTER ECONOMY
(yellow)	AVERAGE COST
(orange)	ABOVE AVERAGE COST
(red)	PREMIUM CONSTRUCTION
TRAFFIC CONTROL & WORK TYPE COST INFLUENCE	

~WORK TYPE	^STRUCTURAL limitations to be evaluated prior to Traffic Control Validation	# TRAFFIC IMPACT DURATION	~TRAFFIC CONTROL MANAGEMENT ALTERNATIVES ON HIGH VOLUME MULTI-LANE DIVIDED HIGHWAYS										
			Single Lane Closure (one bound)	Two Stage Single Lane Closure (one bound)	2-Lane Shift (one bound)	One Direction, 3 phases, maintain 2-lanes (one bound)	2-Lane 2-way using Crossover	Contraflow using Crossover (bridge widths of 36 ft. or greater)	**Bridge Widening & Two Lane Shifts (one bound)	Contraflow using **Widening & Crossover	**All lanes use of Off-Alignment	Detour on Ramps if Interchange (short duration)	Extended Detour off of main roadway at nearby interchange
	LANES MAINTAINED FOR ONE BRIDGE WITH MAXIMUM OF TWO LANES MAINTAINED		ONE	ONE	TWO	TWO	ONE	TWO	TWO	TWO	TWO	ONE	ONE
BRIDGE DECK REPLACEMENT	X	2-3 MONTHS (ABC)		*				*			*		
		≤ 6 MONTHS		*			*	*					
		≤ 1 SEASON		*			*	*					
**BRIDGE WIDENING	X	2-3 MONTHS (ABC)	*								*		
		≤ 6 MONTHS	*				*						
		≤ 1 SEASON											
BRIDGE SUPERSTRUCTURE REPLACEMENT	X	2-3 MONTHS (ABC)		*				*	*	*	*		
		≤ 6 MONTHS		*				*					
		≤ 1 SEASON		*				*					
BRIDGE SUPER STRENGTHEN	X	< 3 DAYS (ABC)				*	*	*					
		≤ 2 WEEKS		*				*					
		≤ 1 MONTH		*			*	*					
BRIDGE REHABILITATION / BRIDGE REPAIR MAJOR	X	≤ 7 DAYS (ABC)	*	*				*					
		≤ 1 MONTH	*	*				*	*	*	*		
		≤ 6 MONTHS	*	*			*	*					
BRIDGE REPAIR MINOR (i.e. rail structural repair, beam end repairs,)		≤ 24 HOURS (ABC)				*							
		≤ 3 DAYS										*	*
		≤ 2 WEEKS	*	*			*						
BRIDGE DECK OVERLAY (PC) W/ CLASS A or B or UHPC OVERLAY	X	≤ 3 WEEKS (ABC)		*				*					
		≤ 6 WEEKS		*				*					
		≤ 6 MONTHS		*			*	*					

BRIDGE DECK OVERLAY (THIN POLYMER OR LATEX MODIFIED)		≤ 48 HOURS (ABC)				*							
		≤ 3 DAYS					*					*	*
		≤ 2 WEEKS		*				*	*	*	*		
DECK JOINT REPAIR MAJOR	X	≤ 3 DAYS (ABC)		*		*		*					
		≤ 2 WEEKS		*				*				*	*
		≤ 1 MONTH		*				*					
DECK JOINT REPAIR MINOR (no PC concrete work)		≤ 1 SHIFT				*							
		≤ 24 HOURS				*							
		≤ 3 DAYS										*	*
MAINLINE BRIDGE RAISE OVER RD.		≤ 3 DAYS (ABC)									*		
		≤ 1 MONTH										*	*
BRIDGE RAISE OVERHEAD OVER MAINLINE (falsework below)		≤ 3 DAYS											
		≤ 2 WEEKS										*	*
BRIDGE PRESERVATION / PAINTING (i.e. sealer, bridge painting, epoxy injecting)		≤ 24 HOURS				*							
		≤ 3 DAYS											
		≤ 2 WEEKS					*	*					
PPCB/STEEL GIRDER REPAIR (MAJOR) OVERHEAD	X	≤ 2 WEEKS (ABC)	*	*									
		≤ 1 MONTH										*	*
		≤ 2 MONTHS											
PPCB/STEEL GIRDER REPAIR (MINOR) OVERHEAD	X	≤ 3 DAYS						*					
		≤ 2 WEEKS	*	*				*					
PPCB/STEEL GIRDER REPAIR (MAJOR) OVER LOCAL RD	X	≤ 2 WEEKS (ABC)						*			*		
		≤ 1 MONTH	*					*			*		
		≤ 2 MONTHS						*					
PPCB/STEEL GIRDER REPAIR (MINOR) OVER LOCAL RD	X	≤ 3 DAYS						*					
		≤ 2 WEEKS						*					

DECK PATCHING		≤3 DAYS										*	*
		≤2 WEEKS											
BRIDGE DECK GROOVING		≤24 HOURS										*	*
		≤3 DAYS											
RAIL RETROFIT		≤3 DAYS					*	*				*	*
		≤2 WEEKS						*					
BARRIER RAIL REPLACEMENT		≤1 WEEK					*	*				*	*
		≤2 WEEKS						*					
EPOXY INJECTION		≤24 HOURS										*	*
		≤48 HOURS											
ABUTMENT REPAIR (paving notch + short panel approach)	X	≤2 WEEKENDS (ABC)					*	*				*	*
		≤2 WEEKS						*					
BRIDGE APPROACH REPLACEMENT (Full panels + paving notch + guardrail)	X	≤2 WEEKENDS (ABC)					*	*				*	*
		≤2 WEEKS						*					
		≤1 MONTH						*					
****BRIDGE APPROACH REPAIR/PATCHING**	X	≤24 HOURS (ABC)										*	*
		≤3 DAYS				*							
		≤1 WEEK											
****BRIDGE APPROACH HMA OVERLAY (1 course/taper)**		≤48 HOURS										*	*
		≤3 DAYS											
****GUARDRAIL REPLACEMENT (assumed steel beam style)**		≤3 DAYS					*	*				*	*
		≤1 WEEK						*					

Footnotes:

~ Baseline cost for traffic control solutions are based on three criteria which are lanes maintained, duration of traffic impact, and use of detoure pavement:

Baseline 1 -- Traffic interruption no more than 2 weeks, maintaining one lane of traffic, and no significant detour pavement

Baseline 2 -- Traffic interruption that is completed in more than 3 days, but less than one construction season, maintain 2 traffic lanes, and no significant detour pavement

Baseline 3 -- Traffic interruption that is completed in more than 2 months, maintain 1 lane of traffic with a crossover, and use of significant detour pavement

Baseline 4 -- Traffic interruption that is completed in more than 2 months, maintain 2 lanes of traffic, and use of significant detour pavement.

Other TC solutions -- Other traffic management strategies that can be implemented as partial solutions for Work Type as applicable to the site. Not a complete solution.

^DISCLAIMER: All Traffic Control Options tabulated as potential solutions for the work type is subject to Structural Review by Bridges & Structures (Green column)

"Traffic Impact Duration" represents the time normal traffic conditions are affected by the implementation of the traffic control alternative implemented to carry out an activity or work type. Please note that some Work Types may require a group of traffic control alternatives to be implemented to carry out the full scope of the project. Any traffic solutions identified for the time duration need to be verified through Traffic Mitigation Measures and Risk Assessment to ensure the work zone condition is acceptable.

DISCLAIMER: Please note the cost information compiled for the heat map is not based on factual data or research but engineering judgement based on a peer exchange group of Iowa DOT engineers.

* Potential to use option, but cost or duration of work makes option less desirable. Discuss option with an advisory team that includes that Traffic Mitigation team for the Iowa DOT.

** Work Type is not concepted through Bridge Bureau