I-06.01 Design Philosophy

The basic philosophy to consider when designing new or existing roadway facilities is to do so in accordance with AASHTO A Policy on Geometric Design of Highways and Streets; hereinafter referred to as *A POLICY.* In using *A POLICY,* generally start with the minimum values provided and then adjust them as the need would dictate. There may be circumstances where it may be in the best interest to use the minimum or desirable values. There may be circumstances where it may not be in the best interest to use the values in *A POLICY.* In those instances, it would be necessary to develop different values and process a design exception. Design exceptions are defined in more detail in Section I-06.04 of the Design Manual.

The philosophy to consider when applying *A POLICY* design values is to do so in accordance with NDDOT DESIGN GUIDELINES for Preventive Maintenance, Minor Rehabilitation, Structural Improvement, Major Rehabilitation, and New/Reconstruction Projects*,* March 2007; hereinafter referred to as *DESIGN GUIDELINES.* The *DESIGN GUIDELINES* are FHWA approved and recognized as of March 19, 2007. The *DESIGN GUIDELINES* have been referenced in the Design Manual in Section I-06.03 of the Design Manual.

The Director may designate and post special areas of state highways where lower speeds are required by condition. The design speeds for those segments are to be determined during the Project Development process.

Safety measures and issues will be identified and addressed as part of the Statewide Safety Program. The Statewide Safety programs will consist of four different types of analysis: Critical Rate Analysis, High Crash Analysis, Project Level Analysis, and Strategic Highway Safety Plan. Safety measures will be implemented with a safety project that will be scheduled and included in the Statewide Transportation Improvement Program (STIP), or if cost effective to be included with other projects. The Statewide Safety Program is defined in more detail in Section I-06.05 of the Design Manual.

I-06.02 Investment Strategies

The North Dakota Department of Transportation, NDDOT, in conjunction with the Federal Highway Administration, FHWA, has developed a series of investment strategies outlined in the *DESIGN GUIDELINES* that will ensure the life expectancy of the roadway is met. These investment strategies are Preventive Maintenance, Minor Rehabilitation, Structural Improvement, Major Rehabilitation, and New/Reconstruction Projects. Below is a brief summary of each investment strategy:

Preventive Maintenance – The intended purpose of this strategy is to protect the pavement structure, slow the rate of pavement deterioration, and/or correct deficiencies in the pavement surface. The surface defects may be caused by the environment, and by daily wear and tear of traffic. This type of project may occur on the same roadway as frequently as supported by a cost effectiveness determination. A detailed definition of Preventive Maintenance can be found in Section I-06.03.01, which also includes examples of projects that can be considered Preventive Maintenance. An overlay is considered to be Preventive Maintenance when the maximum thickness is two inches (no allowance for rut filling).

Minor Rehabilitation – This strategy aims to correct the structural integrity of the pavement without necessarily changing the existing alignment and profile geometrics. A detailed definition of Minor Rehabilitation can be found in Section I-06.03.02, which also includes examples of projects that can be considered Minor Rehabilitation. When an overlay is between two and three inches the project is considered to be Minor Rehabilitation.

Structural Improvement – A Structural Improvement restores the structural integrity of the pavement without necessarily changing the existing alignment and profile geometrics. In addition, the load carrying capacity should be increased to meet the HPCS guidelines. A detailed definition of Structural Improvement can be found in Section I-06.03.03. A Structural Improvement is a surfacing/base material recommendation based upon an engineering analysis.

Major Rehabilitation – Major Rehabilitation requires a large amount of work to bring the condition of the highway up to a level that will extend the service life. This strategy also provides the opportunity to perform operational improvements. A detailed definition of Major Rehabilitation can be found in Section I-06.03.04, which also includes examples of projects that can be considered Major Rehabilitation.

New/Reconstruction – There may be extensive changes to the existing route such as relocating on a new alignment, or completely removing the roadway down to the subgrade and rebuild from the bottom up. Everything from ADA requirements to signing must be addressed when performing a new or reconstruction project. A detailed definition of New/Reconstruction can be found in Section I-06.03.05.

I-06.03 Design Guidelines

These guidelines apply to linear rural roadway corridor projects.

The intent of the roadway width guidelines is not to reduce the roadway width to the minimum width shown in the guidelines, but rather to maintain or enhance based upon corridor needs. Select the appropriate strategy for the desired width.

1. If a District Corridor is on the NHS system the roadway will be designed to meet the minimum design guidelines for a State Corridor.

2. Design features that do not meet the minimum design guidelines but are incorporated into a project will require a design exception or appropriate documentation.

3. Safe pavement sloughs will be maintained as described in the Department's shoulder/slough guidelines. If there is no shoulder the slough should have a minimum slough of 3:1.

4. The traffic volumes shown are general guidelines. A 10% tolerance in the volumes may be allowed without requiring the designer to move to the next level of standard or the need for a design exception.

5. If a rural community or a location(s) with different needs fall within a corridor project and is identified in the scoping process, another strategy may be used. Rural communities may include items such as Complete Streets concepts, Rural Community Enhancements Projects (RCEP) or other enhancements that federal funding may allow.

6. A rail system is defined as both the bridge and/or roadway facility rail system servicing as one entire rail system protecting an individual structure or obstruction, which may include the following items:

    - end treatments and end terminals
    - linear guardrail runs
    - transition sections
    - bridge rails

    A mainline roadway strategy and individual structure strategy within the mainline project limits may be different. The mainline roadway strategy dictates the minimum safety work throughout the corridor unless a structure strategy is higher. The higher structure strategy safety work shall be used for that structure's rail system.

    If the roadway strategy requires the bridge rail to be in compliance with MASH, the bridge rail at a minimum shall comply with MASH Test
    Level 3. However, if a portion of the bridge deck needs to be removed in order to upgrade the bridge rail to be in minimum compliance with MASH Test Level 3, the bridge rail will instead be required to be in minimum compliance with NCHRP Report

350 Test Level 3.

On Minor Rehabilitation and Structural Improvement roadway projects, the rail system may be left in place if the rail system was originally installed in compliance with NCHRP
Report 350 or MASH performance criteria, and has been maintained in a condition that is in reasonably close conformity to NCHRP Report 350 or MASH performance criteria.

I-06.03.01 Preventive Maintenance

Design Guidelines for Preventive Maintenance Projects

Traffic Data	Use current ADT
Roadway Width	Use appropriate width to meet or exceed NDDOT Guidelines for Minimum Roadway Width.
Superelevations	Use existing.
Design Speed	Use posted speed limit.
Cross Slope	Use existing.
Horizontal Curvature	Use existing.
Vertical Curvature	Use existing.
Obstruction Clearance	Use existing.
Foreslope	Use existing.
Roadway Shoulder/Slough Cross Slope	Use Department Shoulder/Slough Guidelines.
Safety	Safety issues will be identified and addressed as part of the Statewide Safety Program. Safety features will remain as they exist unless a need is identified.
ADA	Curb ramps adjacent to the project shall be addressed in accordance with the Departments “ADA Transition Plan” and decision document for “Curb Ramp Improvements on Alteration Projects”.

The purpose of the Preventive Maintenance program is to protect the pavement structure, slow the rate of pavement deterioration and/or correct pavement surface deficiencies. Surface treatments used for preventive maintenance are targeted at pavement surface defects primarily caused by the environment and by the daily wear and tear of traffic. Structural deficiencies caused by traffic loading are not corrected by using these treatments.

Preventive Maintenance treatments may be applied as frequently as supported by a cost effectiveness determination Most preventive maintenance projects will be conducted on the top of the existing roadway and will have no impact to wetlands or cultural resources. Miscellaneous features such as mailboxes, signing, delineators and others will not be required to be upgraded as part of these projects unless identified by the Statewide Safety Program. Signage not in compliance with the MUTCD will be updated if engineering judgment indicates that:

- One compliant device in the midst of a series of adjacent non-compliant devices could potentially be confusing to road user.
- The anticipated schedule for replacement of the whole series of non-compliant devices will result in achieving timely compliance with the MUTCD.

All railroad crossings will have adequate warning/protective devices in place or be otherwise addressed in the State Railroad Crossing Improvement Program.
Typical scope of work items, including but not limited to, for Preventive Maintenance treatments are: Crack Pouring/Sealing, Route and Seal, Seal Coats, Micro-Milling, Micro-Surfacing, Pavement Patching, Milling and/or Asphalt Overlay 2" Maximum with or without Full Depth Pavement Repair*, Repair of depressed cracks, Minor Concrete Pavement Repair (less than 10% of the pavement surface area per mile), Dowel Bar Retrofit, Diamond Grinding, Rumble Strips, Pavement Marking, Signals, etc.

*Milling and/or Asphalt Overlay 2" Maximum except at full depth pavement repair areas. These areas are limited to matching the existing pavement depth plus the 2" overlay.

- The full depth pavement repair shall be limited to a maximum of 2% of the total square yards of the project, and a maximum of 1000 square yards per mile.
- The full depth pavement repair shall be limited to 12" maximum depth below the bottom of existing asphalt layer.
- The full depth pavement repair will not be allowed at reoccurring frost heaves or in areas with an existing pipe.
- The full depth pavement repair work shall be performed from on top of the roadway. The adjacent foreslope topsoil shall not be disturbed, and no construction equipment or traffic is allowed in the ditch bottom. The pavement/aggregate slough shall be re-established to match existing.
- No allowance for rut filling. Consider milling. If rut filling is needed, the quantity shall be taken from the overall mainline quantity.

I-06.03.02 Minor Rehabilitation

Design Guidelines for Minor Rehabilitation Projects

Traffic Data	Use current ADT
Roadway Width	Use appropriate width to meet or exceed NDDOT Guidelines for Minimum Roadway Width. May widen each side 2' to 4' based upon corridor needs.
Superelevations	Use existing.
Design Speed	Use posted speed limit
Cross Slope	Use existing.
Horizontal Curvature	Use existing.
Vertical Curvature	Use existing.
Obstruction Clearance	Use existing.
Foreslope	Use existing when not widening. Use 4:1 or flatter when widening.
Roadway Shoulder/Slough Cross Slope	Use Department Shoulder/Slough Guidelines.
Safety	Safety issues will be identified and addressed as part of the Statewide Safety Program. Safety features will remain as they exist unless a need is identified. Safety hardware that is not in compliance with NCHRP Report 350 performance criteria will be upgraded to be in compliance with MASH* performance criteria. Existing guardrail that is in compliance with NCHRP Report 350 except for rail height, may be reset to correct rail height for compliance with NCHRP Report 350.
ADA	Curb ramps adjacent to the project shall be addressed in accordance with the Departments "ADA Transition Plan" and decision document for "Curb Ramp Improvements on Alteration Projects".

***** *If safety hardware is not available for MASH performance criteria, safety hardware shall instead be required to be in compliance with NCHRP Report 350 performance criteria.*

Minor Rehabilitation is a planned strategy to extend the useful life of a highway by restoring the pavement structure without necessarily improving existing alignment and profile geometrics. The minor rehabilitation of roadways will use repair techniques designed to repair pavement distress areas primarily caused by the environment and by the daily wear and tear of traffic. A minor rehabilitation strategy will restore the load carrying capacity to its original condition. The appropriate NEPA process will be followed to address any environmental impacts.

Miscellaneous features such as mailboxes, signing, delineators and others will not be required to be upgraded as part of these projects unless identified by the Statewide Safety Program. Signage not in compliance with the MUTCD will be updated if engineering judgment indicates that:

- One compliant device in the midst of a series of adjacent non-compliant devices could potentially be confusing to road user.
- The anticipated schedule for replacement of the whole series of non-compliant devices will result in achieving timely compliance with the MUTCD.

All railroad crossings will have adequate warning/protective devices in place or be otherwise addressed in the State Railroad Crossing Improvement Program.

Typical scope of work items, including but not limited to, for Minor Rehabilitation treatments are: Asphalt Overlay up to 3”, Distress Area Repairs and Asphalt Overlay, Mill & Overlay up to 3”, Cold In-Place Recycling (CIR), Widening 2’ to 4’ on each side of the roadway to meet or exceed NDDOT Guidelines for Minimum Roadway Width, etc.

The intent of this strategy is to fit widening within the right of way and limit ditch widening to addressing wetland mitigation, borrow, snow problem areas, etc.

I-06.03.03 Structural Improvements

Design Guidelines for Structural Improvements Projects

Traffic Data	Use 20 year projected
Roadway Width	Use appropriate width to meet or exceed NDDOT Guidelines for Minimum Roadway Width. May widen each side based upon corridor needs.
Superelevations	Attempt to correct to AASHTO Standards. (6% max superelevation)
Design Speed	Use posted speed limit
Cross Slope	Driving Lanes 1.5% - 2.5%.
Horizontal Curvature	Use existing, sign when less than posted speed.
Vertical Curvature	Use existing.
Obstruction Clearance	20 feet.
Foreslope	Use existing when not widening unless a need is identified in the Safety Review. Use 4:1 or flatter when widening.
Roadway Shoulder/Slough Cross Slope	Use Department Shoulder/Slough Guidelines.
Safety	Safety issues will by identified and addressed as part of the Statewide Safety Program. Safety features will remain as they exist unless a need is identified. Safety hardware that is not in compliance with NCHRP Report 350 performance criteria will be upgraded to be in compliance with MASH* performance criteria. Existing guardrail that is in compliance with NCHRP Report 350 except for rail height, may be reset to correct rail height for compliance with NCHRP Report 350. Replace mailbox supports where necessary.
ADA	Curb ramps adjacent to the project shall be addressed in accordance with the Departments “ADA Transition Plan” and decision document for “Curb Ramp Improvements on Alteration Projects”.

***** *If safety hardware is not available for MASH performance criteria, safety hardware shall instead be required to be in compliance with NCHRP Report 350 performance criteria.*

Structural improvement is a planned strategy to extend the useful life of a highway by restoring or enhancing the pavement structure without necessarily improving existing alignment and profile geometrics.

Typical scope of work items, including but not limited to, for Structural Improvement treatments are: white topping, major concrete repair (greater than 10% of the pavement surface area per mile), full depth reclamation, crack and seat or break and seat and HMA overlay or an HMA overlay based on an engineering analysis. Structural Improvements also include widening each side of the roadway to meet or exceed NDDOT Guidelines for Minimum Roadway Width. A structural improvement will increase the load carrying capacity to meet the HPCS guidelines. The appropriate NEPA process will be followed to address any environmental impacts. All regulatory and warning signs and pavement markings will be verified to comply with current MUTCD standards or brought up to MUTCD standards if necessary, and all railroad crossings will have adequate warning/protective devices in place or be otherwise addressed in the State Railroad Crossing Improvement Program.

I-06.03.04 Major Rehabilitation

Design Guidelines for Major Rehabilitation Projects

Traffic Data	Use 20 year projected
Roadway Width	Use appropriate width to meet or exceed NDDOT Guidelines for Minimum Roadway Width.
Superelevations	Correct to AASHTO Standards. (6% max superelevation)
Design Speed	Use posted speed limit.
Cross Slope	Driving lanes 1.5 – 2.5%.
Horizontal Curvature	Use existing, sign when less than posted speed. On State and Interregional Corridors with ADT >750, if existing horizontal curvature is designed for less than 15 mph less than the posted speed make cost effective improvement or sign accordingly.
Vertical Curvature	**Interregional System:** ADT < 2000 maintain existing. ADT > 2000 use stopping sight distance for crest curve design and comfort curve design for sag curves. Decision sight distance should be considered in areas where complex driver decisions are required such as intersections with major collectors or higher, interchanges, lane drops or additions, etc. Passing areas should be provided at reasonable intervals based on terrain and traffic volumes. A rule of thumb would be a passing area every 3 to 5 miles when the ADT <2000 and every 3 miles when the ADT >2000. **State Corridors, District Corridors & Collectors:** ADT < 2000, existing vertical curves should meet a design speed of no less than 20 mph below the overall project design speed. ADT > 2000 use stopping sight distance for crest curve design and comfort curve design for sag curves. Passing areas should be provided at reasonable intervals based on terrain and traffic volumes. A rule of thumb would be a passing area every 3 to 5 miles when the ADT <2000 and every 3 miles when the ADT >2000.
Obstruction Clearance/Clear Zone	Upgrade safety work to 20 feet obstruction clearance except when ADT >2000 use AASHTO roadside design clear zone.
Foreslope	4:1** minimum, on Interregional system > 2000 ADT a 6:1 foreslope is desirable where grading or roadway widening is required.
Roadway Shoulder/Slough Cross Slope	Use Department Shoulder/Slough Guidelines.
Safety	A 90-1 survey will be completed and areas needing safety improvements will be addressed. Upgrade safety hardware

	to be in compliance with MASH* performance criteria.
ADA	Curb ramps adjacent to the project shall be addressed in accordance with the Departments "ADA Transition Plan" and decision document for "Curb Ramp Improvements on Alteration Projects".

** If safety hardware is not available for MASH performance criteria, safety hardware shall instead be required to be in compliance with NCHRP Report 350 performance criteria.*

***Foreslope rates often have variations along the existing slope due to normal wear and tear, flexibility is allowed in determining the overall foreslope rate to account for these variations.*

Major Rehabilitation is a planned strategy in which major work is performed to bring a highway up to an acceptable condition to extend the service life and provide operational improvements (i.e., adding turn lanes).

Major rehabilitation projects may include reclaiming the existing surface material and base along with the placement of additional surface material and/or other work necessary to return an existing roadway, including shoulders, bridges, the roadside, and appurtenances to a condition of structural or functional adequacy. On these projects the roadway elevation may change, shoulders may be added, and foreslope corrections may be made. The roadway will be resurfaced and safety improvements will be completed as required. A crash analysis will be completed and cost-effective enhancements will be addressed. All regulatory and warning signs and pavement markings will be verified to comply with current MUTCD standards or brought up to MUTCD standards if necessary, and all railroad crossings will have adequate warning/protective devices in place or be otherwise addressed in the State Railroad Crossing Improvement Program.

Typical scope of work items, including but not limited to, for Major Rehabilitation treatments are: HMA, Widening, Geometric Upgrades, etc.

I-06.03.05 New/Reconstruction Projects

Design Guidelines for New/Reconstruction Projects

Traffic Data	Use 20 year projected
Roadway Width	Use AASHTO Standards.
Superelevations	Use AASHTO Standards. (6% max superelevation)
Design Speed	Use posted speed limit.
Cross Slope	Driving lanes 1.5 – 2.5%.
Horizontal Curvature	Use AASHTO Standards.
Vertical Curvature	**Interregional System:** Use stopping sight distance for crest curve design and comfort curve design for sag curves. Decision sight distance should be considered in areas where complex driver decisions are required such as intersections with major collectors or higher, interchanges, lane drops or additions, etc. Passing areas should be provided at reasonable intervals based on terrain and traffic volumes. A rule of thumb would be a passing area every 3 to 5 miles when the ADT <2000 and every 3 miles when the ADT >2000. **State Corridors, District Corridors & Collectors:** Use stopping sight distance for crest curve design and comfort curve design for sag curves. Passing areas should be provided at reasonable intervals based on terrain and traffic volumes. A rule of thumb would be a passing area every 3 to 5 miles when the ADT <2000 and every 3 miles when the ADT >2000.
Clear Zone	Use AASHTO roadside design clear zone.
Foreslope	Use 4:1 except Interregional system > 2000 ADT and Interstate use 6:1
Pavement Shoulder/Slough Cross Slope	Use AASHTO Standards.
Safety	Safety hardware will be in compliance with MASH* performance criteria.
ADA	Pedestrian facilities adjacent to the project shall be addressed in accordance with the Departments “ADA Transition Plan”.

***** *If safety hardware is not available for MASH performance criteria, safety hardware shall instead be required to be in compliance with NCHRP Report 350 performance criteria.*

New/Reconstruction is a planned strategy in which a new road is constructed. This work may include work items such as relocating an existing route on new alignment, or completely removing the old pavement structure and restoring the roadbed and surfacing, or major widening on an existing roadway to increase traffic capacity

(excludes realigning horizontal curves).

On New/Reconstruction projects a crash analysis will be completed and cost-effective enhancements will be addressed. All safety hardware will be in compliance with MASH* performance criteria. All regulatory and warning signs and pavement markings will be verified to comply with current MUTCD standards or brought up to MUTCD standards if necessary, and all railroad crossings will have adequate warning/protective devices in place or be otherwise addressed in the State Railroad Crossing Improvement Program.

I-06.03.06 Minimum Roadway Width on Four Lane Highways

Minimum Roadway Width on Four Lane Highways

Interstate 4 - Lane	<400	400-750	750-1500	1500-2000	>2000
New / Reconstruction	AASHTO STDS	AASHTO STDS	AASHTO STDS	AASHTO STDS	AASHTO STDS
Major Rehabilitation	AASHTO STDS	AASHTO STDS	AASHTO STDS	AASHTO STDS	AASHTO STDS
Structural Improvement	Maintain Existing	Maintain Existing	Maintain Existing	Maintain Existing	Maintain Existing
Minor Rehabilitation	Maintain Existing	Maintain Existing	Maintain Existing	Maintain Existing	Maintain Existing
PM	Maintain Existing	Maintain Existing	Maintain Existing	Maintain Existing	Maintain Existing

Interregional 4 - Lane	<400	400-750	750-1500	1500-2000	>2000
New / Reconstruction	AASHTO STDS	AASHTO STDS	AASHTO STDS	AASHTO STDS	AASHTO STDS
Major Rehabilitation	36	36	36	36	36
Structural Improvement	32	32	32	32	32
Minor Rehabilitation	32	32	32	32	32
PM	31	31	31	31	31

I-06.03.07 Minimum Roadway Width on Two Lane Highways
Minimum Roadway Width on Two-Lane Two-Way Highways

Interregional 2 - Lane	<400	400-750	750-1500	1500-2000	>2000
New / Reconstruction	32	36	36	36	40
Major Rehabilitation	30	30	36	36	36
Structural Improvement	26	26	28	30	32
Minor Rehabilitation	26	26	28	30	32
PM	26	26	28	28	30

State Corridor	<400	400-750	750-1500	1500-2000	>2000
New / Reconstruction	32	36	36	36	40
Major Rehabilitation	*28	*28	*32	36	36
Structural Improvement	24	24	28	28	32
Minor Rehabilitation	24	24	26	28	32
PM	24	24	26	26	28

District Corridor	<400	400-750	750-1500	1500-2000	>2000
New / Reconstruction	32	36	36	36	40
Major Rehabilitation	*26	*28	*30	32	36
Structural Improvement	22	24	26	26	28
Minor Rehabilitation	22	24	26	26	28
PM	22	24	24	26	26

District Collector	<400	400-750	750-1500	1500-2000	>2000
New / Reconstruction	32	36	36	36	40
Major Rehabilitation	*26	*26	*28	30	30
Structural Improvement	22	22	24	26	26
Minor Rehabilitation	22	22	24	26	26

PM	22	22	24	26	26

- The intent of these guidelines is not to reduce the roadway width to the minimum guidelines, but rather to maintain the width as close as possible to the existing width. Roadway widths shown are the minimum recommended widths, actual allowable widths should be determined on a case-by-case basis.
- A design exception is only needed on a Preventive Maintenance Thin Lift Overlay (TLO) that does not meet the minimum roadway width requirement. All other Preventive Maintenance types of work do not require a design exception for minimum roadway width.
- District Corridor routes on the National Highway System (NHS) will be designed to State Corridor Guidelines
- Numbers in the shaded areas are ADT. Roadway widths are in feet.

* Minimum roadway widths for “Major Rehabilitation” strategies will be the same as “Minor Rehabilitation” strategies, unless widening is required. If widening is required to meet “Minor Rehabilitation” strategies minimum widths, widening will be sufficient to meet “Major Rehabilitation” strategies minimum widths.

I-06.03.08 Minimum Interstate and Four Lane Divided Highway Bridge Widths

Interstate & Four Lane Divided Highway	All ADT
*New or Reconstructed	40'
*Rehabilitation	Approach Roadway Width
Preventive Maintenance	Existing Bridge Width

* This bridge width is for a two-lane roadway. Bridge widths will be determined on an individual bases, where there are 3 lanes or more, ramps or auxiliary lanes impacting the bridge.

The bridge widths in the above table are dimensions measured from face-to-face of curb or face-to-face of rail whichever is less.

The minimum bridge width shall be as shown in the table or the approach roadway width (traveled lanes plus shoulders), whichever is greater.

Deck replacements and deck overlays are in the Rehabilitation category.

Any new or reconstructed two lane bridge over railroad tracks shall be a minimum of 40’ wide.

For Interstate System bridges longer than 200’, the traveled lanes plus 4’ on each side is an acceptable bridge width when considering new or reconstruction.

In assessing acceptable Interstate System bridge widths for rehabilitation of bridges or bridges to remain in place without rehabilitation within the limits of paving or re-grading projects: 1) bridges longer than 200’, that are as wide as the traveled lanes plus 3.5’ on each side are acceptable, 2) bridges shorter than 200’, that are as wide as the table less 4’ are acceptable, if there are no reported crash problems at that site.

For other four lane divided rural bridges longer than 200’, the traveled lanes plus 4’ on each side is an acceptable bridge width when considering new or reconstruction.

In assessing other four lane rural divided bridge widths for rehabilitation of bridges or bridges to remain in place without rehabilitation within the limits of paving or regarding projects: 1) bridges longer than 200’, that are as wide as the traveled lanes plus 2’ on each side are acceptable, 2) bridges shorter than 200’, that are as wide as the table less 4’ are acceptable, if there are no reported crash problems at that site.

Bridge Rail:

- For bridge New or Reconstruction category projects, the bridge rail shall be in compliance with MASH Test Level 4 performance criteria.
- For bridge Rehabilitation category projects, the existing bridge rail can remain in place if in minimum compliance with NCHRP Report 350 Test Level 3 performance criteria. If the existing bridge rail is not in minimum compliance with NCHRP Report 350 Test Level 3 performance criteria, the bridge rail will be upgraded to be in minimum compliance with MASH Test Level 3 performance criteria. However, if a portion of the bridge deck needs to be removed in order to upgrade the bridge rail to be in minimum compliance with MASH Test Level 3 performance criteria, the bridge rail will instead be required to be in minimum compliance with NCHRP Report 350 Test Level 3 performance criteria. Bridge Approach Repair, Bridge Rail Repair, Deck Overlay, Deck Replacement, etc. are all examples of bridge rehabilitation.
- For bridge Preventive Maintenance category projects, the existing bridge rail can remain. Slope Protection repair, joint repair, painting, scour repair, abutment repair, pier repair, damaged railing repair, etc. are all examples of bridge preventive maintenance.

I-06.03.09 Minimum State Route Bridge Widths

Interregional 2 Lane	< 400**	400-750**	750-1500**	1500-2000**	> 2000**
New or Reconstructed	32'	36'	36'	36'	40'
Rehabilitation	28'	30'	30'	32'	32'
Preventive Maintenance	Existing Bridge Width				

State Corridor	< 400*	400-750*	750-1500*	1500-2000**	> 2000**
New or Reconstructed	32'	36'	36'	36'	40'
Rehabilitation	28'	30'	30'	32’	32'
Preventive Maintenance	Existing Bridge Width				

District Corridor	< 400*	400-750*	750-1500*	1500-2000**	> 2000**
New or Reconstructed	32'	36'	36'	36'	40'
Rehabilitation	28'	30'	30'	32'	32'
Preventive Maintenance	Existing Bridge Width				

District Collector	< 400*	400-750*	750-1500*	1500-2000**	> 2000**
New or Reconstructed	32'	36'	36'	36'	40'
Rehabilitation	28'	30'	30'	32'	32'
Preventive Maintenance	Existing Bridge Width				

* Existing bridge widths can remain if there is no crash history.

** For rehabilitation strategies or for bridges to remain in place within paving or re-grading projects, bridge widths are acceptable if the following criteria are met and there is no crash history

1. The existing width is no more than 4’ less than shown in the table; and,
2. The existing width is no more than 6’ less than the approach roadway.

All bridge widths in the above table are dimensions measured from face-to-face of curb or face-to-face of rail whichever is less.
Deck replacements and deck overlays are in the Rehabilitation category.
Any new or reconstructed two lane bridge over railroad tracks shall be a minimum of 40’ wide.

For bridges longer than 200', the traveled lanes plus 4' on each side is an acceptable bridge width when considering new or reconstruction.

Bridge Rail:

- For bridge New or Reconstruction category projects, the bridge rail shall be in compliance with MASH Test Level 4 performance criteria.
- For bridge Rehabilitation category projects, the existing bridge rail can remain in place if in minimum compliance with NCHRP Report 350 Test Level 3 performance criteria. If the existing bridge rail is not in minimum compliance with NCHRP Report 350 Test Level 3 performance criteria, the bridge rail will be upgraded to be in minimum compliance with MASH Test Level 3 performance criteria. However, if a portion of the bridge deck needs to be removed in order to upgrade the bridge rail to be in minimum compliance with MASH Test Level 3 performance criteria, the bridge rail will instead be required to be in minimum compliance with NCHRP Report 350 Test Level 3 performance criteria. Bridge Approach Repair, Bridge Rail Repair, Deck Overlay, Deck Replacement, etc. are all examples of bridge rehabilitation.
- For bridge Preventive Maintenance category projects, the existing bridge rail can remain. Slope Protection repair, joint repair, painting, scour repair, abutment repair, pier repair, damaged railing repair, etc. are all examples of bridge preventive maintenance.

OTHER ROUTES

For county route traffic bridges that are State owned bridges that do not carry state route traffic, widths will be addressed on an individual basis.

For State owned bridges on county roads. i.e., county roads over the Interstate:

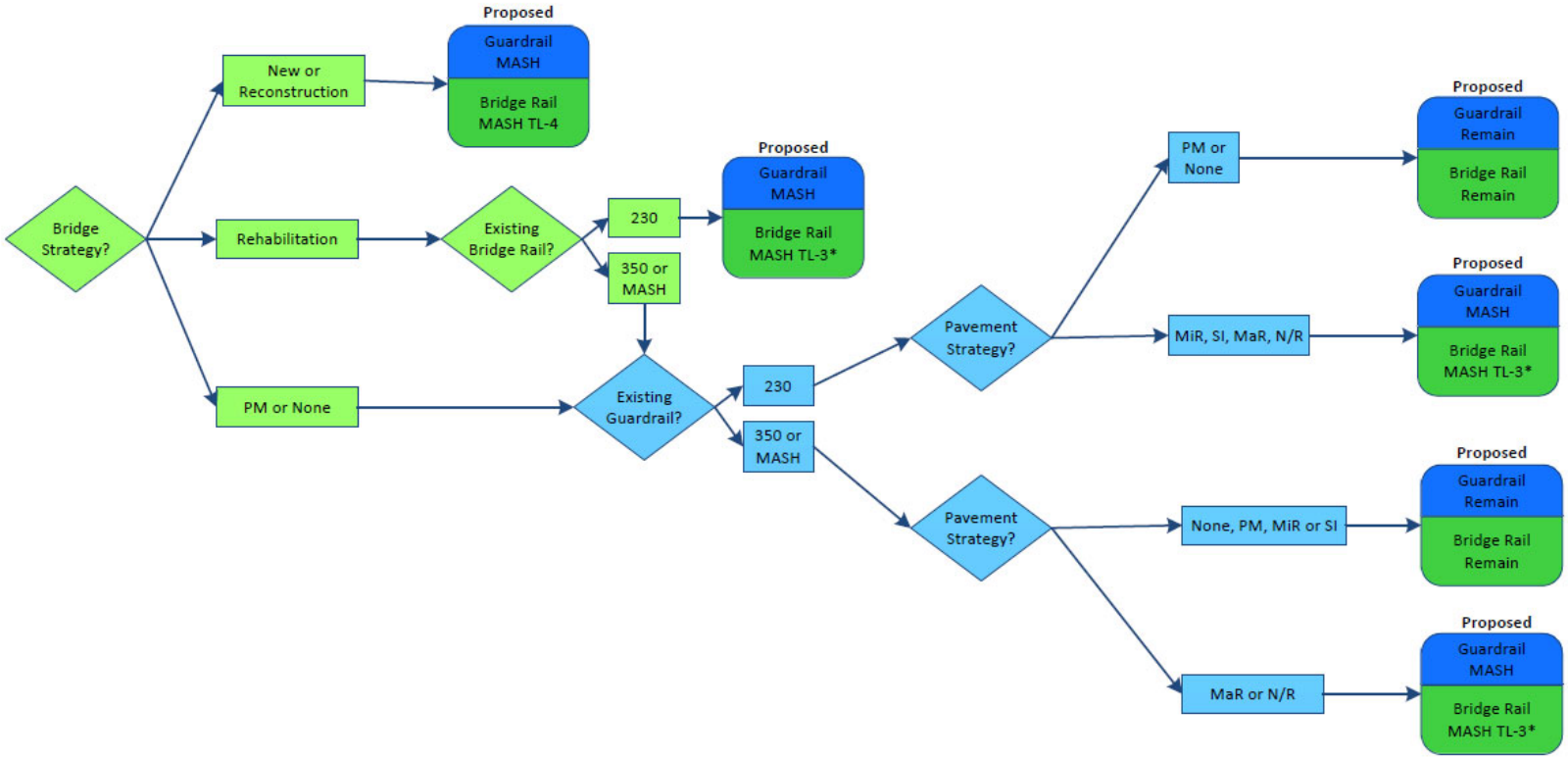
<= 750 ADT, existing width adequate, if no crash history

> 750 ADT, existing width adequate if no more than 6' less than the width of the approach roadway, if no crash history.

For Preventive Maintenance projects existing bridge widths can remain.

Slope Protection repair, joint repair, painting, scour repair, abutment repair, pier repair, damaged railing repair, etc. are all examples of bridge preventive maintenance. For these types of preventive maintenance projects, the existing railing system can remain.

Applying the NDDOT Design Guidelines to Rail Systems
Section I-06 of the NDDOT Design Manual

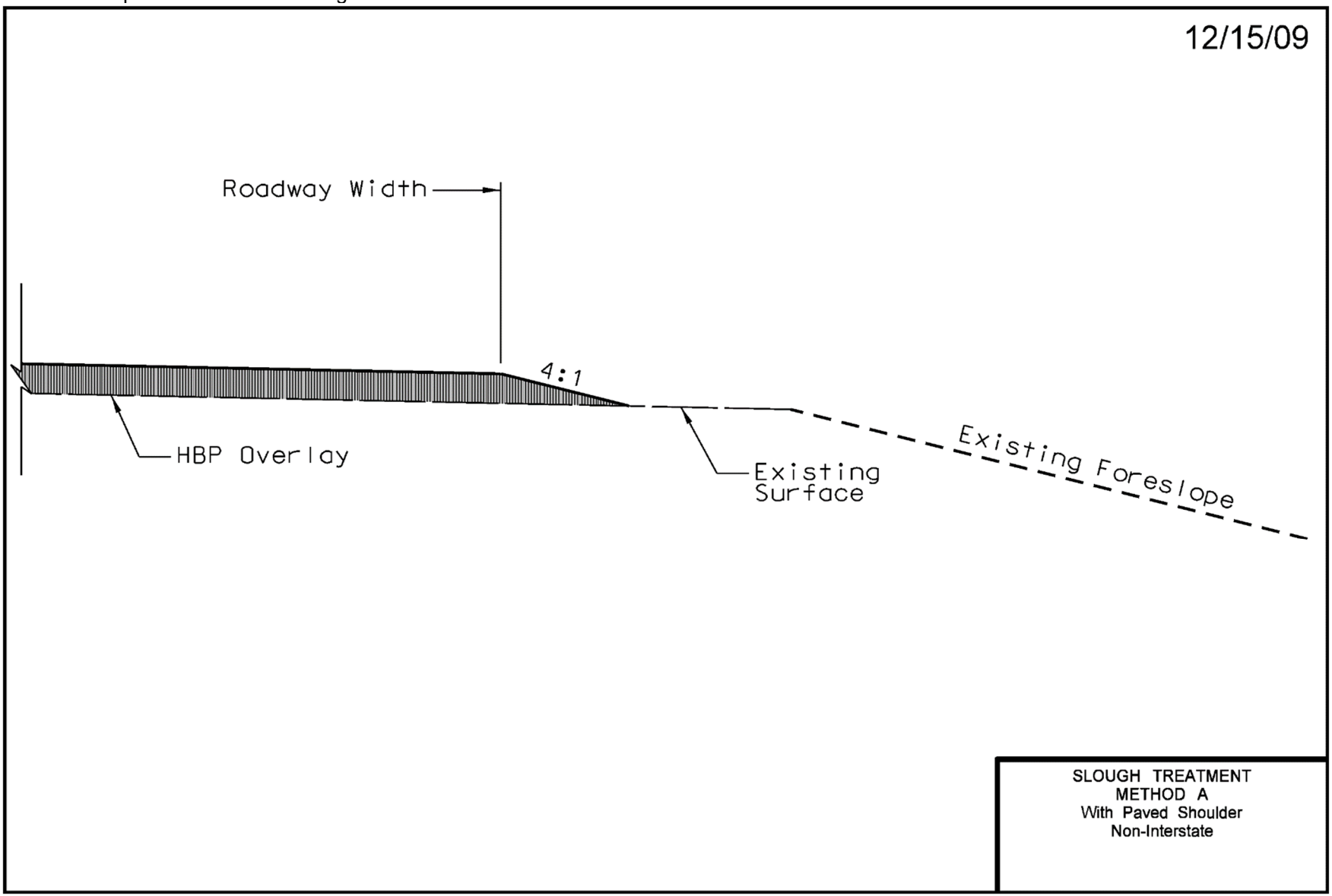


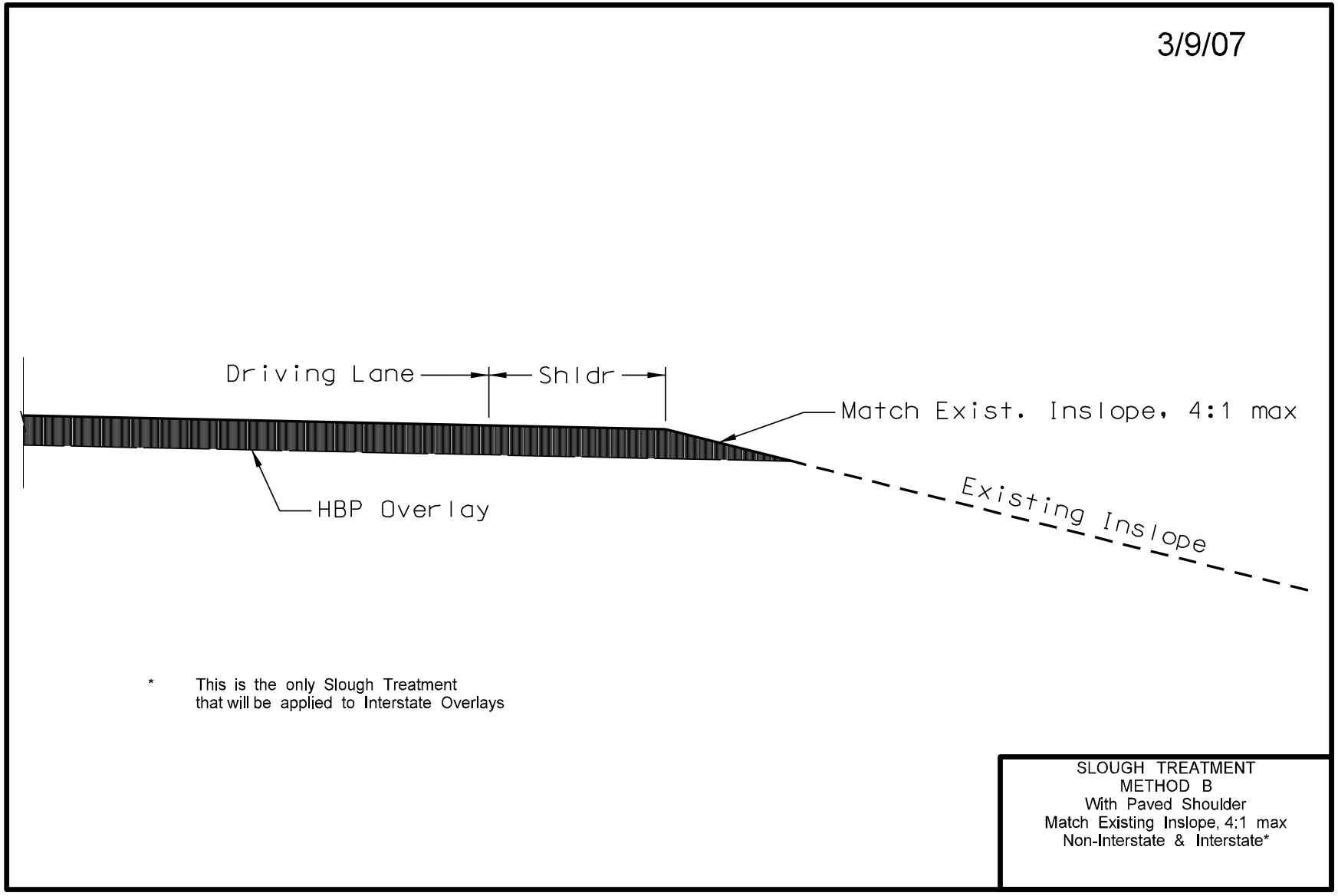
*Note 1: If bridge rail retrofit to MASH TL-3 is not available, update to NCHRP Report 350 TL-3
*Note 2: If Jersey Barrier is in place, the Jersey barrier may remain in place since it meets MASH TL-3

Acronyms:
230 = NCHRP Report 230
350 = NCHRP Report 350
PM = Preventive Maintenance
MiR = Minor Rehab
SI = Structural Improvement
MaR = Major Rehab
N/R = New/Reconstruction

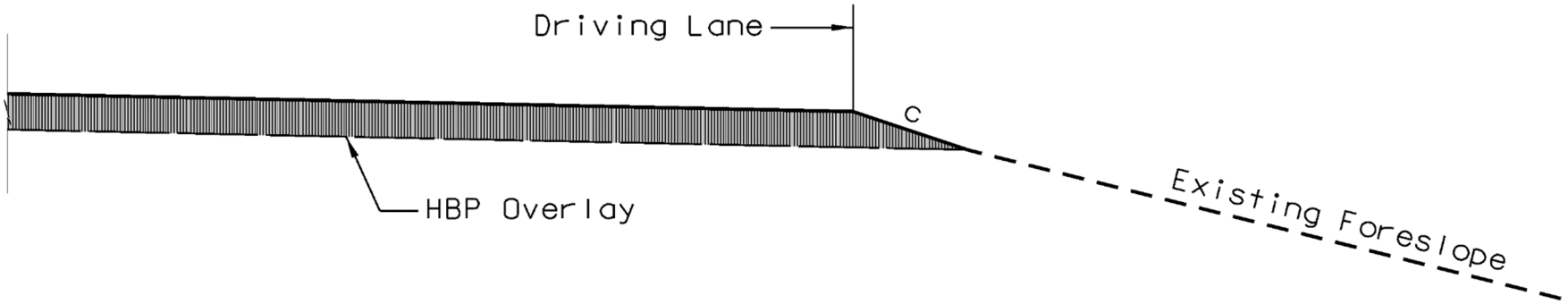
May 10, 2017

I-06.03.10 Department Shoulder/Slough Guidelines




3/9/07
Driving Lane
Shldr
Match Exist. Inslope, 4:1 max
HBP Overlay
Existing Inslope
* This is the only Slough Treatment that will be applied to Interstate Overlays
SLOUGH TREATMENT
METHOD B
With Paved Shoulder
Match Existing Inslope, 4:1 max
Non-Interstate & Interstate*

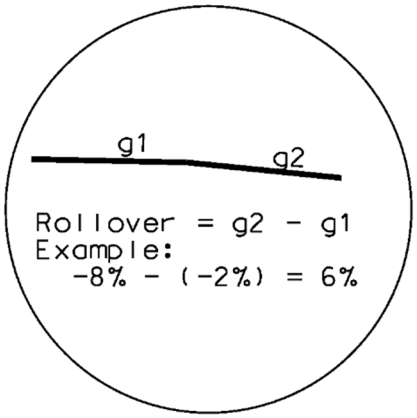
12/15/09



Existing Foreslope	Slough (c)
4:1 or flatter	4:1 max
< 4:1 to 3:1	match existing

SLOUGH TREATMENT
METHOD C
No Paved Shoulder
Non-Interstate

12/15/09



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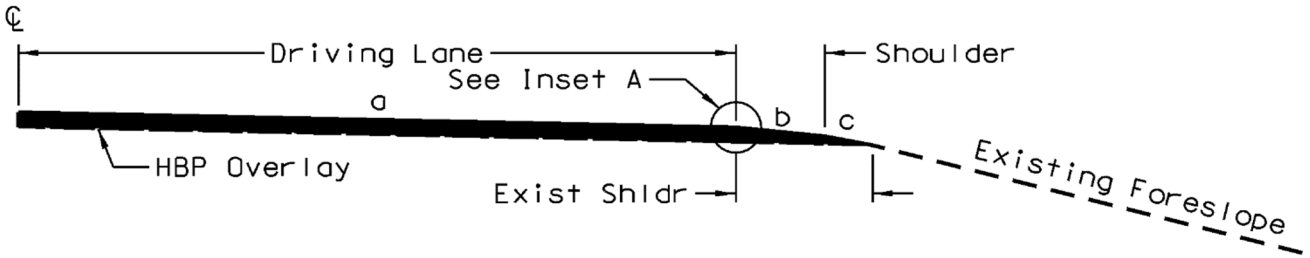


1. a = Driving lane cross-slope

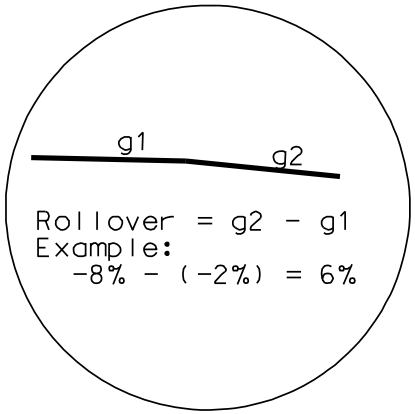
2. b = PM, Mir, SI: Non-Interstate: 8% max, with 6% max rollover
   Mar: 6% max, with 5% max rollover
   Interstate: 6% max, with 5% max rollover

3. If final shoulder < 2',
   then use driving lane cross-slope

Existing Foreslope	c = Non-Interstate	c = Interstate
4:1 or flatter	4:1 max	4:1 max
< 4:1 to 3:1	match existing	N/A

SHOULDER TREATMENT
METHOD 1
PM, MiR, SI, MaR
Non-Interstate & Interstate

3/9/07



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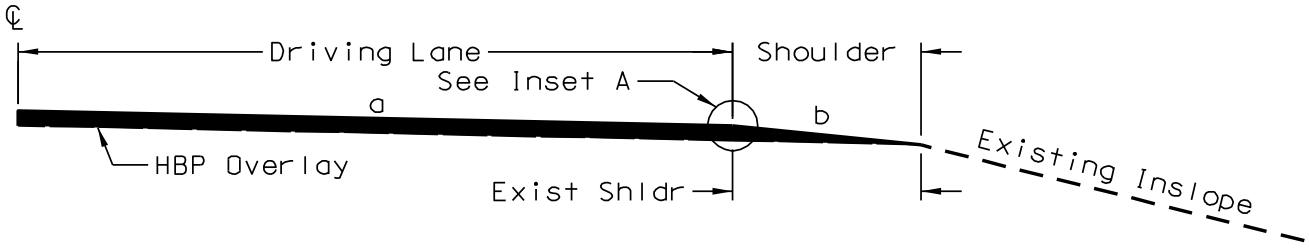
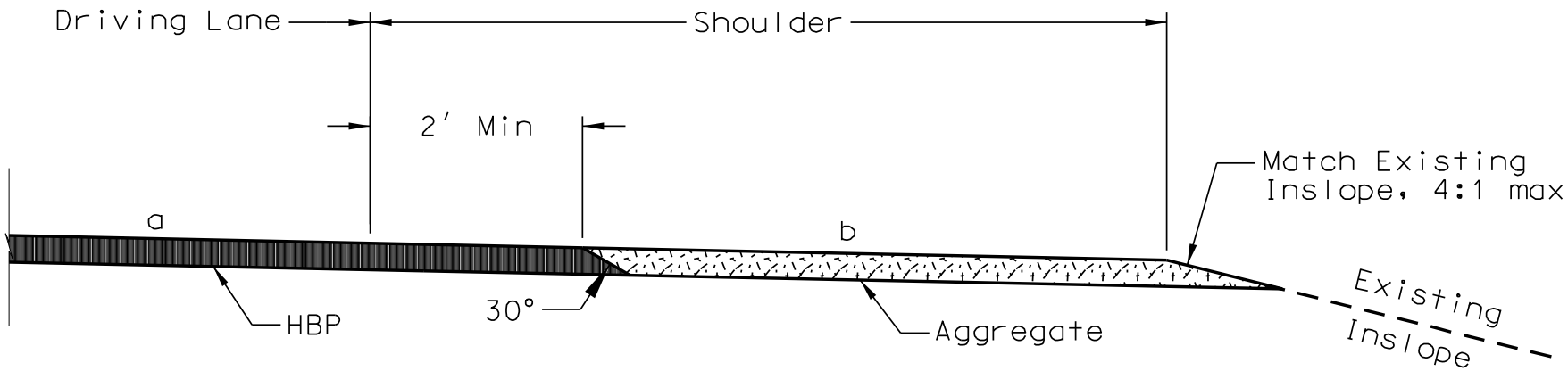


1. a = Driving lane cross-slope

2. b = Non-Interstate: 8% max, with 6% max rollover
   Interstate: 6% max, with 5% max rollover

SHOULDER TREATMENT
METHOD 2a
PM, MiR, SI
Non-Interstate & Interstate

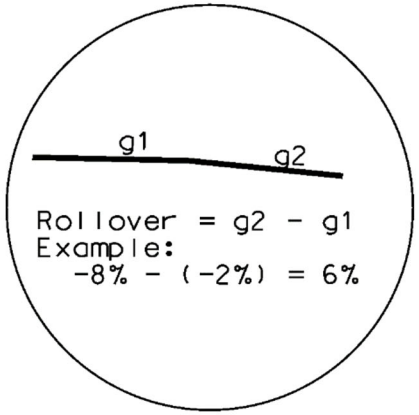
3/9/07



1. a = Driving lane cross-slope
2. b = PM, Mir, SI: Non-Interstate: 8% max, with 6% max rollover
   Mar: 6% max, with 5% max rollover

SHOULDER TREATMENT
METHOD 2b
SI, MaR
Aggregate Shoulders
Non-Interstate

12/15/09



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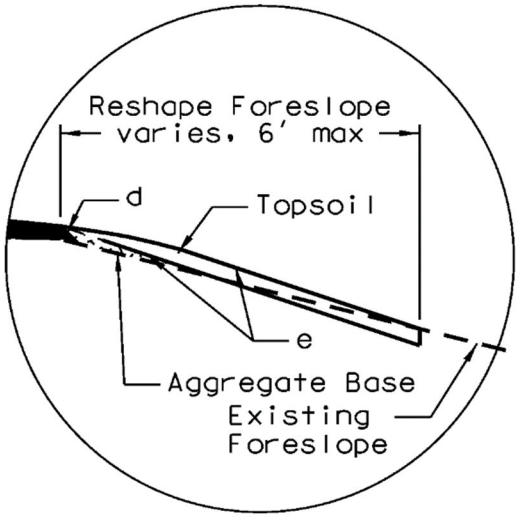
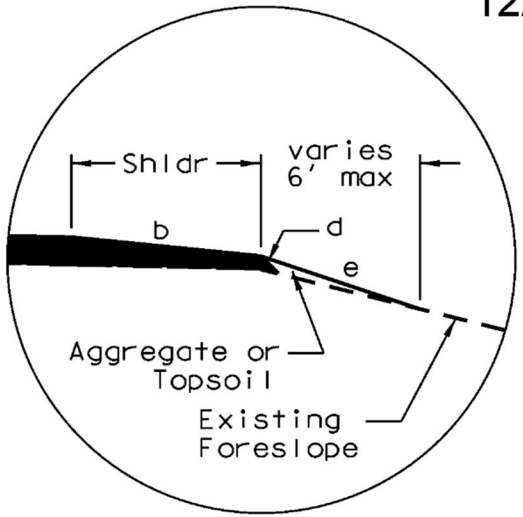


Option A



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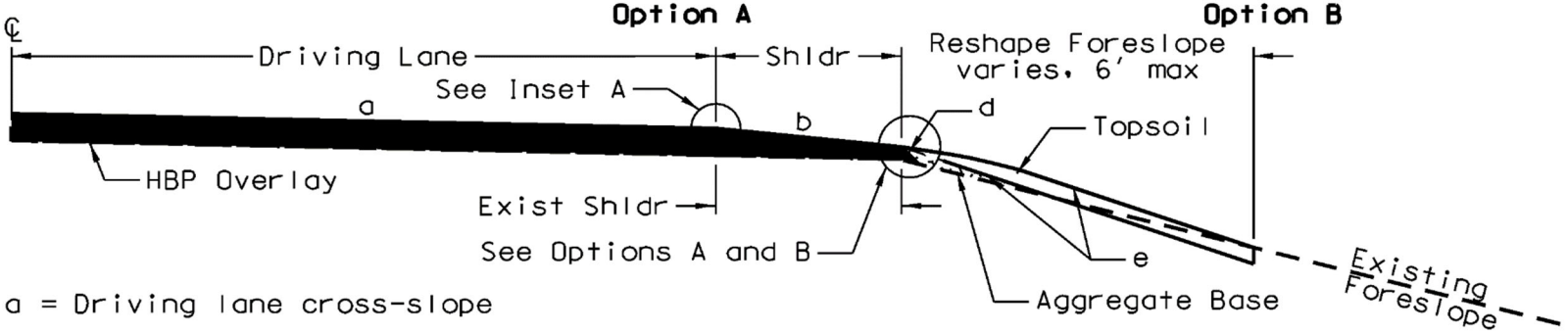
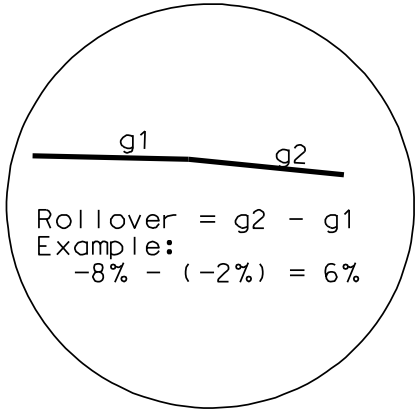


1. a = Driving lane cross-slope
2. b = Non-Interstate: 8% max, with 6% max rollover
   Interstate: 6% max, with 5% max rollover
3. If final shoulder < 2',
   then use driving lane cross-slope
4. d = 30°
5. e = Non-Interstate: 4:1 max
   Interstate: 4:1 max

SHOULDER TREATMENT
METHOD 3
PM, MiR, SI
Non-Interstate & Interstate
Original Overlay
Existing shoulder is flush

3/9/07



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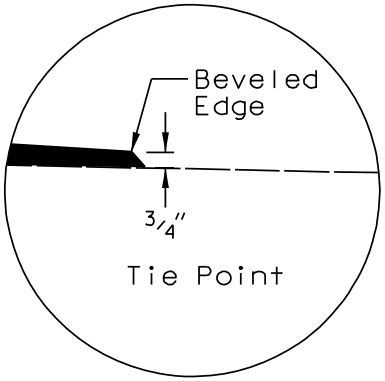

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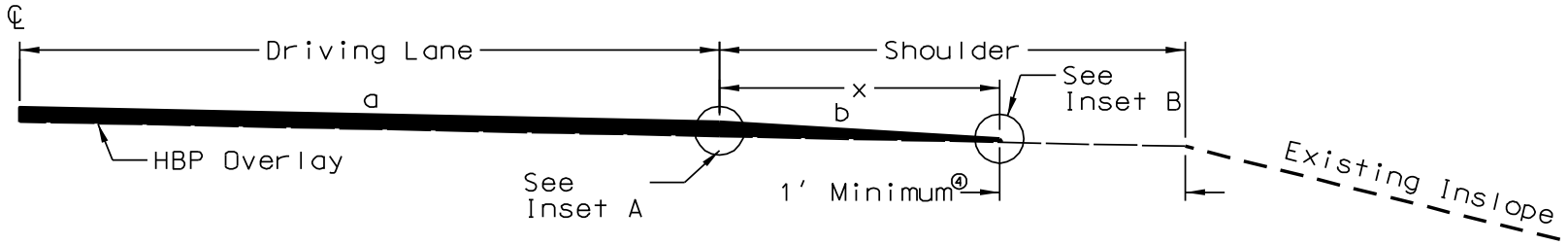
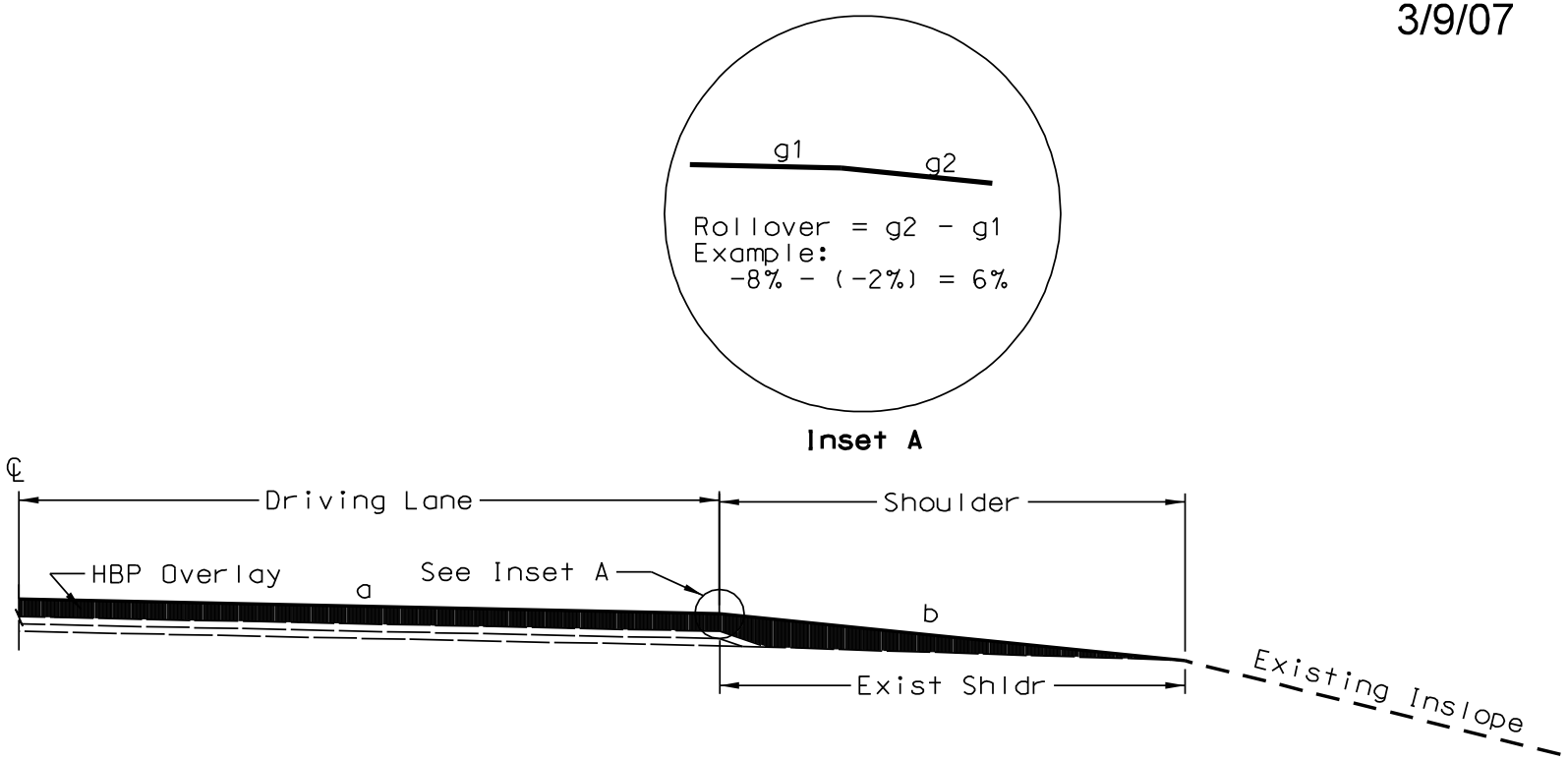


1. a = Driving lane cross-slope
2. b = Proposed shoulder cross-slope
3. $x = x(ft) = \frac{\text{overlay thickness (ft)} - (3/4'' \times 1'/12'')}{\text{"b" ('/') - slope of existing shoulder ('/')}}$
4. If the distance from the edge of the overlay to the pavement is less than 1' then consider a different Shoulder Treatment.

SHOULDER TREATMENT
METHOD 4
PM, MiR
Non-Interstate & Interstate

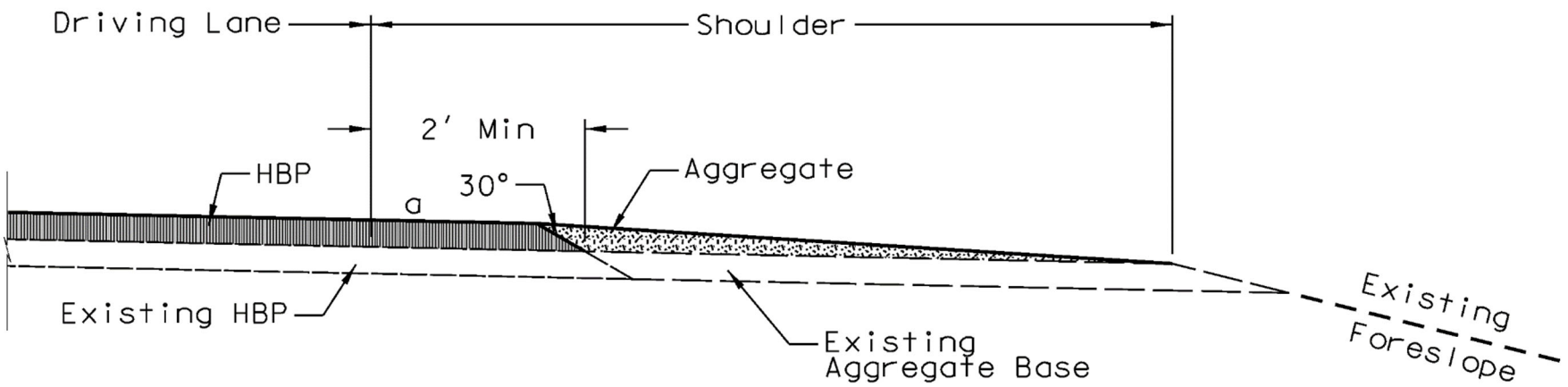
3/9/07



1. a = Driving lane cross-slope
2. b = PM, MiR, SI: 8% max, with 6% max rollover
   MaR: 6% max. with 5% max rollover

SHOULDER TREATMENT
METHOD 6a
PM, MiR, SI, MaR
Non-Interstate

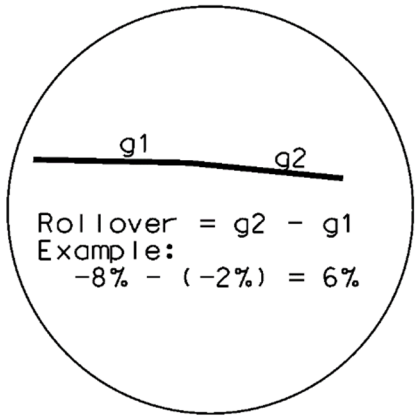
12/15/09



1. a = Driving lane cross-slope

SHOULDER TREATMENT
METHOD 6b
PM, MiR, SI, MaR
Aggregate Shoulders
Non-Interstate

12/15/09



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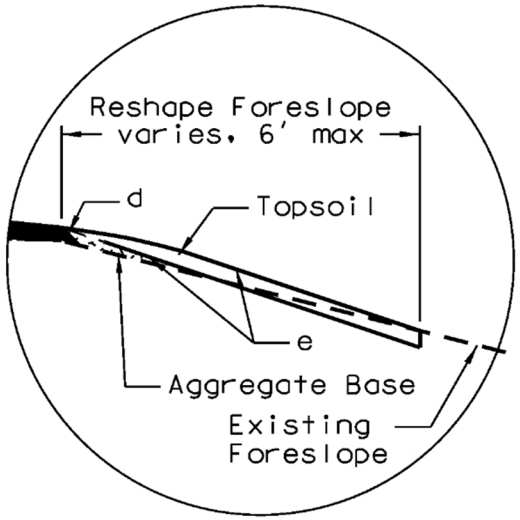
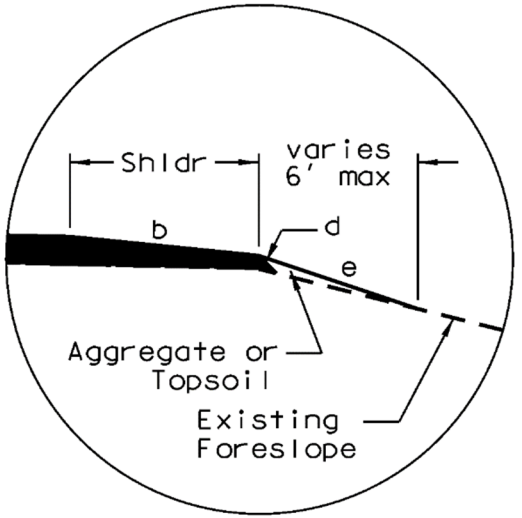
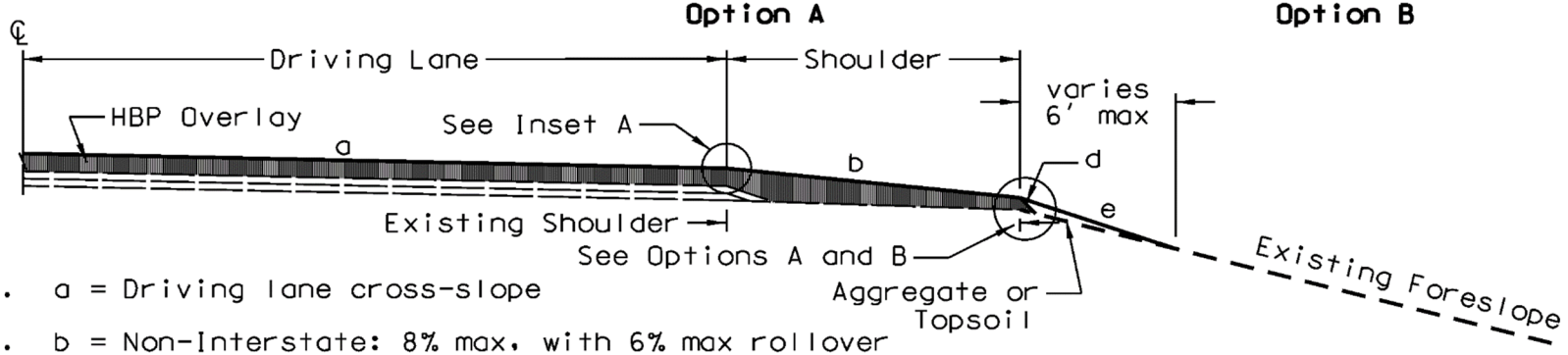


Option A



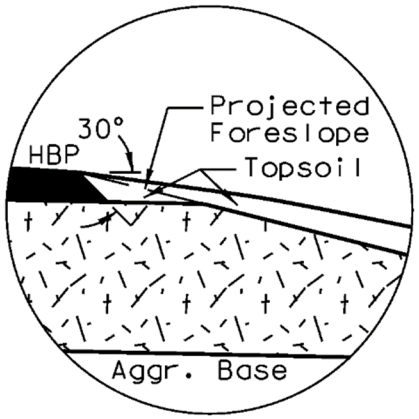
Option B



1. a = Driving lane cross-slope
2. b = Non-Interstate: 8% max, with 6% max rollover
   Interstate: 6% max, with 5% max rollover
3. If final shoulder < 2',
   then use driving lane cross-slope
4. d = 30°
5. e = Non-Interstate: 4:1 max
   Interstate: 4:1 max

SHOULDER TREATMENT
METHOD 7
PM, MiR, SI
Non-Interstate & Interstate
Multiple Overlays
Existing shoulder not flush

12/15/09



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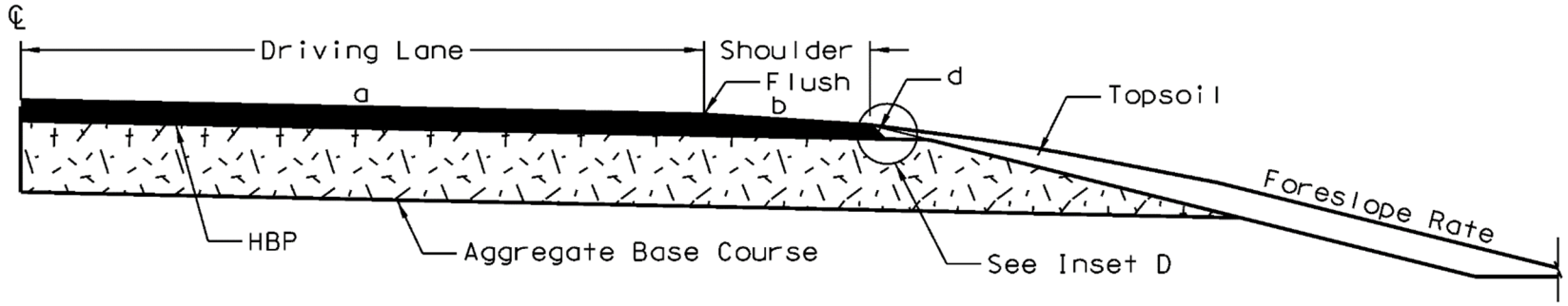
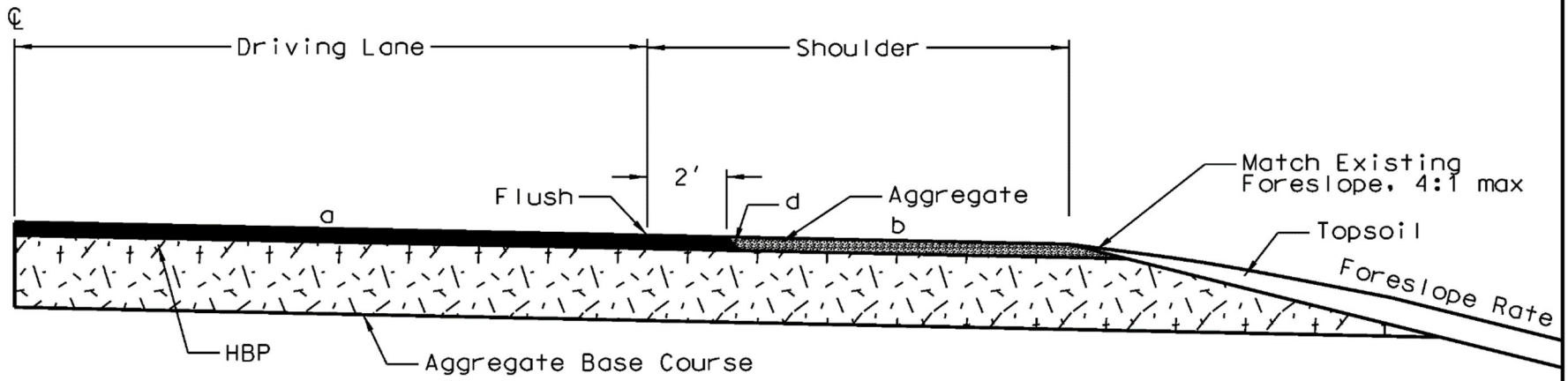


1. a = 1.5% to 2.5% Driving lane cross-slope
2. b = Recommend 3%. 6% max. with 5% max rollover
3. d = 30°

SHOULDER TREATMENT
METHOD 8a
NR
Non-Interstate

12/15/09



1. a = 1.5% to 2.5% Driving lane cross-slope
2. b = 4%-6%
3. d = 30°

SHOULDER TREATMENT
METHOD 8b
NR
Non-Interstate
Aggregate Shoulders

I-06.04 Design Exceptions

Designers contemplating the need for the use of design values, on a specific project, which are not in compliance with the accepted *DESIGN GUIDELINES* listed earlier in this chapter, must document and obtain approval of a formal design exception.

The Design Exception will be a standalone document, and will not be included within the environmental document. However, Design Exceptions will typically be submitted to the DDE for approval at the same time as the environmental document. Design Exceptions will only be submitted to FHWA for approval if required by a RBSO plan.

Design exceptions are not required on Interstate projects utilizing a Major Rehabilitation strategy or less for horizontal or vertical alignments, widths of median, traveled way, and shoulders provided these features met standards when they were built and are not reduced by the project. The remaining design criteria, including traffic barriers, must meet current standards or undergo the design exception process. Where the type of work is reconstruction, current standards are to be applied throughout the project including bridges to remain in place.

Design Exceptions shall be written and presented in the format shown in the Design Exception Form found on the web at http://www.dot.nd.gov/manuals/design/designmanual/designmanual.htm under Design Manual Reference and Forms in the "Design Exception Form" table.

A Design Exception must be written for each design element that does not meet standards. Multiple design elements cannot be combined in a single Design Exception.

Supplemental items to consider when evaluating a design exception:

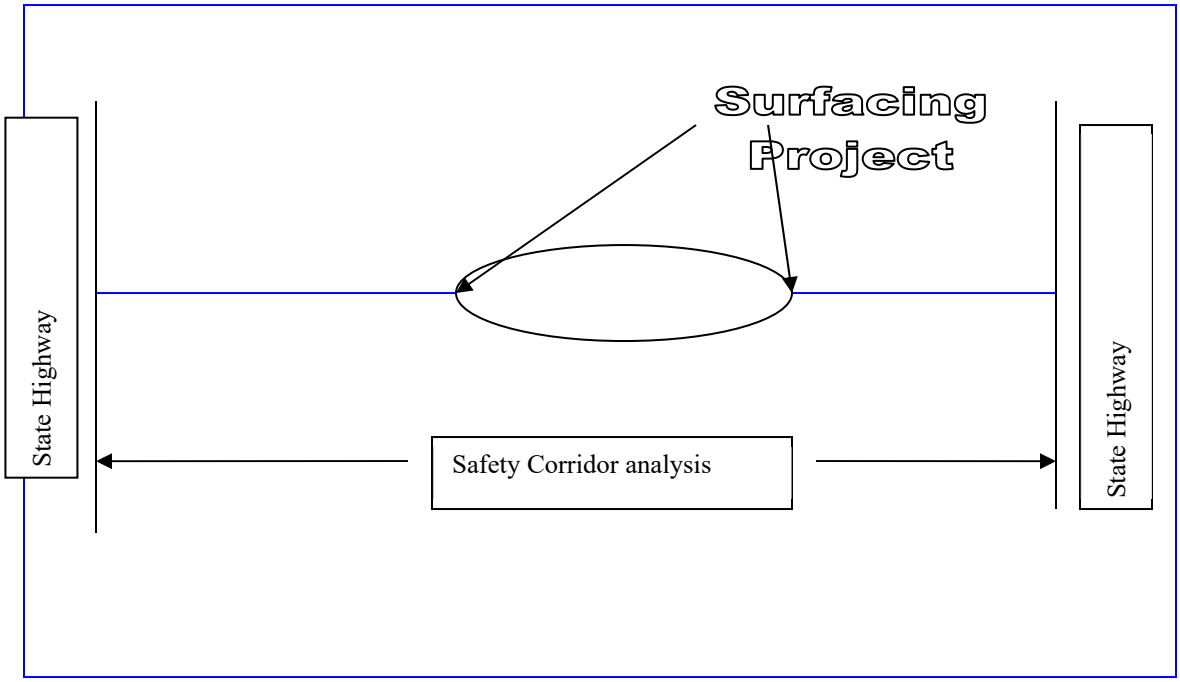
- Crash history to determine any history of operational problems.
- Functional classification of the roadway.
- Effect of the variance from the design standard on safety and operations.
- The degree of the variance from the standard.
- Compatibility with adjacent sections of roadway.
- Should not degrade the relative safety of the roadway.
- Amount and character of the traffic.
- Posted and actual speed on the route.
- Type of project contemplated.
- Cost of attaining full standards (including environmental impacts).
- Cost-effective means of mitigating the reduction in standard.
- Program of future projects, in particular, whether future improvements may more be economically correct the design feature at a later date.
- Engineering discretion

I-06.05 Statewide Safety Program

STATEWIDE SAFETY PROGRAM

ANALYSIS STRATEGIES

The Statewide Safety program will consist of four different types of analysis. Safety projects will be based on corridor improvements. A corridor is defined as the intersection of State Highway to State Highway as shown in the figure below.



1. Critical Rate Analysis

The NDDOT will review the entire state highway system on a yearly basis in an effort to identify the sections of roadway corridor that exhibit the highest crash rates. Those corridors of highways that exhibit a crash rate higher than the critical rate for their particular Highway Performance Classification System (HPCS) will be reviewed in greater detail to determine if there are cost effective measures that can be made or if engineering judgment determines that improvements should be made.

The Concept of “Critical Crash Rate” suggests that any sample or category of intersections or roadway corridors can be divided into three basic parts:

- Locations with a crash rate below the average will be eliminated from further review.
- Locations with a crash rate above the average, but below the critical rate are locations where there is a very high probability (90-95%) that the higher than average crash rate is due to the random nature of crashes.

- Locations with a crash rate above the critical rate will be reviewed because there is a high probability (90-95%) that conditions at the site are contributing to the higher crash rate

Critical crash rate is calculated: $R_c = R_a + K(R_a/m)^{1/2} – 0.5/m$
(Critical crash rate is based on MnDOT Methodologies)

R_c = Critical Crash Rate for:
Intersections: crashes per MEV
Corridors: crashes per MVM

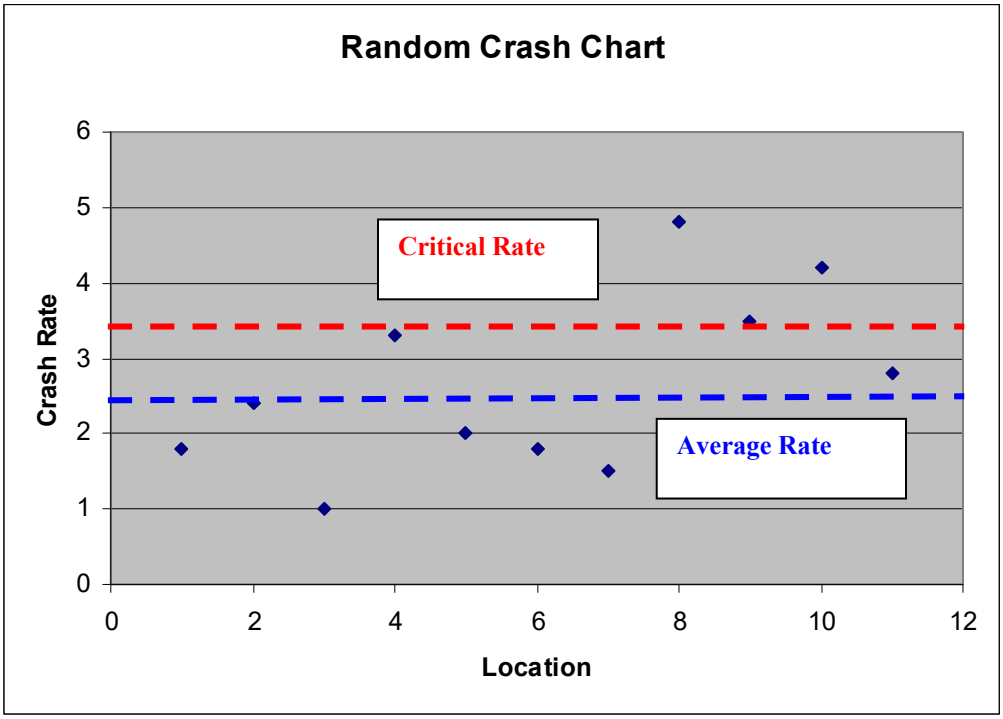
R_a = HPCS Average Crash Rate by intersection or HPCS type.

M = Vehicle Exposure During Study Period for:
Intersections: ADT $(365/10^6)$
Corridors: ADT $(365/10^6)$ length

K = Constant based on Level of Confidence

Level of Confidence	0.995	0.950	0.900
K	2.576	1.645	1.282

Sample Graph



2. High Crash Analysis

The High Crash Analysis will be done on a yearly basis for the entire state highway system. Those intersections or sections of roadway that are identified in this report will be reviewed in greater detail to determine if there are cost effective measures that can be made or if engineering judgment determines that improvements should be made.

3. Project level Analysis

On Structural Improvement, major rehabilitation and new construction projects, each project will be reviewed to determine if there are cost effective measures that can be made or if engineering judgment determines that improvements should be made.

4. Strategic Highway Safety Plan (SHSP)

On Structural Improvement, major rehabilitation and new construction projects, each project will be reviewed to determine if there are cost effective measures that can be made that are related to the emphasis areas identified in the SHSP.

COUNTER MEASURES

Appendix A provides examples of how identified “Areas of Concerns” and “Alternative Safety Measures” can be developed. The Alternative Safety Measures would be those measures that would be evaluated for cost effective improvements.

IMPLEMENTATION MEASURES

Cost effective measures will be implemented one of two ways.

1. If the improvement is an improvement that should be made throughout the corridor, a safety project will be scheduled and included in the STIP. The goal would be to make the necessary improvements within three years of the highway improvement project or when safety funds are available.

2. If the improvement is specific to a feature that is contained within the limits of the project. The cost effective measure will be included with that project.

   Example: If the superelevation on a curve is identified as a hazard, a cost effective measure as identified in Appendix A will be used to correct the hazard during construction of the project.

COUNTER MEASURES

Crash Type	Possible Cause	Possible Study	Possible Safety Enhancement
Run-Off-Road	Slippery pavement/ ponded water	Check skid resistance Check for adequate drainage Perform spot speed study	Reduce speed limit if justified by spot speed study Provide “SLIPPERY WHEN WET” signs Provide adequate drainage Groove existing pavement Overlay existing pavement
	Roadway design inadequate for traffic conditions	Check roadside shoulders and road maintenance Check superelevations Perform ball-bank study	Install/improve traffic barriers Close curb lane Flatten slopes/ditches Relocate islands Improve alignment/grade Provide proper superelevations Provide escape ramp Widen lanes/shoulders
	Poor delineation	Review pavement markings Review signs and placement	Install roadside delineators Install advance warning signs Improve/install pavement markings
	Poor visibility	Check roadway illumination	Increase sign size Improve roadway lighting
	Improper channelization	Review channelization	Improve channelization
Collision at driveways	Left-turning vehicles	Perform turning counts	Install median divider Install two-way left-turn lanes
	Improperly located driveway	Review driveway placement	Regulate minimum spacing of driveways Regulate minimum corner clearance Move driveway to side street Install curbing to define driveway location Consolidate adjacent driveways
	Right-turning vehicles	Perform turning counts Review Parking Check driveway and lane width Check curb radii	Restrict parking near driveways Increase the width of the driveway Increase curb radii Provide right-turn lanes Widen through lanes
	Large volume of through	Perform volume count	Move driveway to side street

Crash Type	Possible Cause	Possible Study	Possible Safety Enhancement
	traffic	for thru traffic	Construct a local service road Reroute through traffic
	Large volume of driveway traffic	Perform volume count for driveway traffic Perform gap study	Signalize driveway Provide acceleration and deceleration lanes Channelize driveway
	Restricted sight distance	Field observation for sight obstructions Review parking Check roadway illumination Perform spot speed study	Restrict parking near driveways Reduce speed limit if justified by spot speed study Install/improve street lighting Remove sight obstruction
Sideswipe or head-on	Inadequate road design and/or maintenance	Review lane width Check alignment Perform no passing study Check road surface for proper maintenance	Perform necessary road surface repairs Sign and mark unsafe passing areas Provide roadside delineators Improve alignment/grade Provide wider lanes Provide passing lanes
	Inadequate shoulders	Review road shoulders	Improve shoulders
	Excessive vehicle speed	Perform spot speed study	Reduce speed limit if justified by spot speed study Install median devices
	Inadequate pavement markings	Review pavement markings	Install/improve centerlines, lane lines, and edgelines Install reflectorized markers Install centerline rumble strips
	Inadequate channelization	Review channelization	Install/improve channelization Install acceleration and deceleration lanes Provide turning bays
	Inadequate signing	Review signing and placement	Provide advance direction and warning signs Add illuminated name signs
Pedestrian/ bicycle	Limited sight distance	Check sight distance	Remove sight obstruction Install/improve pedestrian crossing signs and markings Reroute pedestrian paths
	Inadequate protection	Check existing	Add pedestrian refuge islands

Crash Type	Possible Cause	Possible Study	Possible Safety Enhancement
		protection	
	Inadequate signal/signs	Review signal/signs	Install/upgrade signals/signs
	Inadequate signal phasing	Review signal phasing	Change timing of pedestrian phase Add pedestrian “Walk” phase
	Inadequate pavement markings	Review pavement markings	Supplement markings with signing Upgrade pavement markings
	Inadequate lighting	Check roadway illumination	Improve lighting
	Driver has inadequate warning of frequent mid-block crossing	Review existing parking Perform spot speed study	Prohibit parking Install warning signs Reduce speed limit if justified by spot speed study Install pedestrian barriers
	Lack of crossing opportunity	Perform gap study	Install traffic/pedestrian signals Install pedestrian crosswalk and signs
	Excessive vehicle speed	Perform spot speed study	Reduce speed limits Install proper warning signs
	Pedestrians/bicycles on roadways	Review existence of sidewalks	Eliminate roadside obstructions Install curb ramps with detectable warning panels Install sidewalks Install bike lanes/paths
	Long distance to nearest crosswalk	Check distance and travel time to nearest crosswalk	Install pedestrian crosswalk Install pedestrian actuated signals
	Sidewalk too close to traveled way	Review existing sidewalks	Move sidewalk laterally away from roadway
	School crossing area	Check pedestrian crossing time and available gaps Check school’s safe route to and from school program Check school’s student awareness program	Establish save route and awareness program Use school crossing guards Install crosswalks and traffic signal

Crash Type	Possible Cause	Possible Study	Possible Safety Enhancement
Bridges	Alignment	Check alignment	Install advance warning sings Improve delineation/markings Realign bridge/roadway
	Narrow roadway	Review lane width Review signing	Improve delineation/markings Install signing/signals Widen structure
	Visibility	Field observation for site obstruction	Improve delineation/markings Install advance warning sings Remove obstruction
	Vertical clearance	Check clearance	Improve delineation/markings Install advance warning sings Provide height restrictor/warning device Rebuild structure/adjust roadway grade
	Slippery surface (wet/icy)	Check skid resistance Check for adequate drainage	Provide special signing Provide adequate drainage Improve skid resistance Resurface deck
	Rough surface		Rehabilitate joints Resurface deck Regrade approaches
	Inadequate barrier system	Field observation and checks against established barrier standards	Improve delineation/markings Remove hazardous curb Upgrade bridge rail Upgrade bridge approach rail connections Upgrade approach rail/terminals
Collisions at railroad crossings	Restricted sight distance	Review sight distance	Install advance warning signs Remove sight obstructions Install train actuated signals Install gates Reduce grades
	Poor visibility	Check roadway illumination Review signing	Increase size of signs Improve roadway lighting
	Inadequate pavement	Review pavement	Install advance markings to supplement signs

Crash Type	Possible Cause	Possible Study	Possible Safety Enhancement
	marking	markings	Install stop bars Install/improve pavement markings
	Rough crossing surface	Check crossing surface	Improve crossing surface
	Sharp crossing angle	Check crossing angle	Rebuild crossing with proper angle
	Improper pre-emption timing of traffic signals, railroad signals, or gates	Review traffic signal timing Review railroad signal and gate timing	Retime traffic signals Retime railroad signals and gates
Nighttime	Poor visibility or lighting	Check roadway illumination	Install/improve warning sings Install/improve delineation/markings Install/improve street lighting
	Poor sign quality	Review signing	Upgrade signing Provide illuminated reflectorized signs
	Inadequate channelization of delineation	Review channelization/delination	Install pavement markings Improve channelization/delination
Wet pavement	Slippery pavement	Check skid resistance Check for adequate drainage Perform spot speed study	Provide “SLIPPERY WHEN WET” signs Reduce speed limit if justified by spot speed study Provide adequate drainage Groove existing pavement Overlay existing pavement
	Inadequate pavement marking	Review pavement markings	Install raised/reflectorized pavement markings
Rear-end collisions at unsignalized intersections	Pedestrian crossing	Review pedestrian signing and crosswalk marking	Install/improve signing or marking for pedestrian crosswalks Relocate crosswalk
	Driver not aware of intersection	Review signing	Install/improve warning signs
	Slippery surface	Check skid resistance Check for adequate drainage Perform spot speed study	Provide “SLIPPERY WHEN WET” signs Reduce speed limit if justified by spot speed study Groove existing pavement Overlay existing pavement

Crash Type	Possible Cause	Possible Study	Possible Safety Enhancement
	Large number of turning vehicles	Perform turning counts Perform volume count for thru traffic	Prohibit turns Increase curb radii Create left-of-right-turn lanes
Collisions with parked cars or cars being parked	Inadequate road design	Check lane width Review parking angle	Change from angle to parallel parking Prohibit parking Widen lanes/shoulders
	Large parking turnover	Perform paring turnover study	Prohibit parking Change from angle to parallel parking Create one-way streets Create off-street parking
	Improper pavement markings	Review pavement markings	Correct pavement markings
	Illegal parking	Law observance study	Enforcement
Overturn	Roadside features	Determine sideslope Investigate recovery zone	Provide traversable culvert end treatments Extend culverts Install/improve traffic barriers Flatten slopes and ditches Relocate drainage facilities
	Inadequate shoulder	Determine shoulder dimensions and composition Check for shoulder drop offs	Upgrade shoulder surface Remove curbing obstruction Widen lane/shoulder
	Pavement feature	Check for potholes Check for water ponding	Eliminate edge drop off Improve superelevation/crown
Fixed object	Obstruction in or too close to roadway	Field observation to locate obstruction	Delineation/reflectorize safety hardware Remove/relocate obstacles Install breakaway features to light poles, signposts, etc. Protect objects with guardrail Install crash cushions
	Inadequate lighting	Check illumination	Improve roadway lighting
	Inadequate pavement	Review pavement	Install reflectorized pavement lines/raised markers

Crash Type	Possible Cause	Possible Study	Possible Safety Enhancement
	marking	markings	
	Inadequate signs, delineators and guardrail	Review signs, delineators and guardrails	Install reflectorized paint, and/or reflectors on the fixed object Add special signing Upgrade barrier system
	Inadequate road design	Check roadside shoulders and maintenance Check superelevation Perform ball-bank study	Install Warning signs/delineators Improve alignment/grade Provide proper superelevation Provide wider lanes
	Slippery surface	Check skid resistance Check for adequate drainage	Reduce speed limit if justified by spot speed study Provide adequate drainage
Right-angle collisions at unsignalized intersections	Restricted sight distance	Filed observations for sight obstructions Check roadway illumination Perform spot speed study	Install warning signs Install stop signs Install yield signs Restrict parking near corners Reduce speed limit if justified by spot speed study Remove sign obstructions Install signals Install/improve street lighting Channelize intersection
	Large total intersection volume	Volume count on all approaches	Install signals
	High approach speed	Perform spot speed study	Reduce speed limit if justified by spot speed study Install rumble strips
Right-angle collisions at signalized intersections	Poor visibility of signals	Review existing signals and placement Field observation for sight obstructions Perform spot speed study	Install advanced warning devices Install visors Install back plats Reduce speed limit if justified by spot speed study Remove sight obstructions Add additional signal heads Install 12-inch signal lenses Improve location of signal heads

Crash Type	Possible Cause	Possible Study	Possible Safety Enhancement
			Install overhead signals
	Inadequate signal timing	Volume count on all approaches Review signal timing	Adjust amber phase Provide all-red clearance phases Add multi-dial controller Install signal actuation Retime signals Provide progression through a set of signalized intersections