Chapter 11
SPECIAL PLAN ELEMENTS

Introduction

There are a number of special plan elements referenced in earlier chapters that are routinely included in projects or constructed as individual projects. These include elements such as: conformance with ADA requirements; pedestrian and bicycle transportation accessibility; roadside barriers; roadway and roadside improvements; improving traffic operations; and protecting the environment. Other bureaus in the NHDOT design several of these special plan elements. However, the Bureau of Highway Design coordinates most of these elements, if designated as the Lead Bureau.

While not used on all projects, special plan elements should be considered early, and in every design, to eliminate potential re-work at the end of a project. Some elements vary by roadway classifications or tiers, for guidance relative to roadway tiers see Chapter 3, "Design Considerations and Criteria".

Although not specifically discussed in this chapter, design consideration should also be given to the proximity to unique features, such as airports or dams. For example, the proximity of an airport to a project could effect the glide path of aircraft, which could be crucial to the design and constructability of the project, or could have additional requirements such as Federal Aviation Administration (FAA) notifications and approvals. Contact the Bureau of Aeronautics for additional guidance for airports or projects near airports.

Any work near or on dams should be coordinated with the Dam Bureau at the Department of Environmental Services. Other considerations may also include vibration monitoring needs, or for work in or adjacent to the water body, where there may be the ability to lower the water level to perform work.

Special Plan Element Items

Items used for some special plan elements may be found in the Master Item List – Standard (https://www.dot.nh.gov/documents/master-item-list-672021), but not in all cases. Some items can be found on the Qualified Products List, which is updated as existing products are upgraded or new technology evolves. This can be found at: https://www.dot.nh.gov/about-nh-dot/divisions-bureaus-districts/materials-research/qualified-product-information.

As new items and construction techniques are included into projects, Special Provisions must be included in the Proposal to reflect the current requirements. Normally, the Specifications Section of Highway Design, the designer, or the Consultant responsible for the design, provides this information.

In most cases a Generic or Performance Specification is written that describes the criteria for acceptance of a particular product. Sometimes, a specific product name by manufacturer is noted along with the words "or approved equal". Typically, there are at least three equivalent products listed. However, there may not be a known equal in all cases. When this

occurs, a proprietary item (i.e., that which is protected by patent rights, is a brand name, or is a trade name) may need to be considered.

The NHDOT and the Department of Transportation Federal Highway Administration (FHWA) do not promote the use of proprietary products unless there is no other feasible alternative as it may limit competitive bidding. FHWA previously required documentation known as a Public Interest Finding (PIF) if a proprietary product (sole source) was the preferred, or only, option. This documentation needed to include valid supporting documentation and justification for the need to use one of these items. FHWA rescinded the requirement of 23 CFR Part 635 in 2019 that discouraged the use of these types of products. The Department will still track the use of proprietary products using the same process as the PIF, but will use a revised form (Proprietary/Patented Products Use Form (PPUF)).

For additional information on Special Provisions, Specifications, PIFs, PPUFs, and Proprietary Items, see Chapter 13, "Plans, Specifications and Estimate".

ADA Compliance and Accessible Features

Although compliance with the American's with Disabilities Act (ADA) is not, in itself, a specific special plan element as defined by this chapter, it should be considered in every aspect of the design including construction phasing. The design, construction, or alteration of facilities for pedestrians should be compatible with the ADA by complying with the criteria provided in the *Americans with Disabilities Act Accessibility Guidelines for Buildings and Facilities (ADAAG)* (1).

The United States Access Board is responsible for developing and updating the guidelines in the *ADAAG* (1). These guidelines are used by the Department of Justice (DOJ) and FHWA. The DOJ is responsible for all facilities covered by the ADA, except public transportation facilities, which are subject to FHWA standards. As of the writing of this chapter, the DOJ's ADA standards (2010) are mandatory (effective March 15, 2012); and the FHWA's ADA standards (Public Rights-of-Way Accessibility Guidelines (PROWAG) 2023 apply as a best practice.

The primary purpose of the FHWA ADA/Program Section 504 of the Rehabilitation Act of 1973 is to ensure that pedestrians with disabilities have the opportunity to use the transportation system in an accessible and safe manner.

The scope of that act was also a key component in determining what should be included in the design of a project to meet ADA requirements. FHWA has indicated it is a requirement to provide curb ramps in areas of existing sidewalks through resurfacing projects. However, pavement treatments are broken into two categories: maintenance and alteration. See Figure 11-1 – Pavement Treatment Types (Maintenance vs. Alteration) for a clarification on maintenance activities versus alteration activities as provided by FHWA. In some cases, the combination of several maintenance treatments occurring at or near the same time may qualify as an alteration and would trigger the obligation to provide curb ramps. See also Figure 11-2 – Flow Chart for Pavement Rehabilitation Work Process for a flow chart depicting the work process for these determinations specific to ADA requirements.

Figure 11-1
PAVEMENT TREATMENT TYPES (MAINTENANCE VS. ALTERATION)

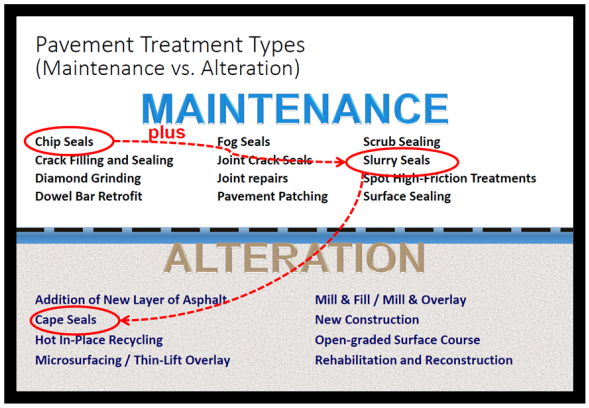
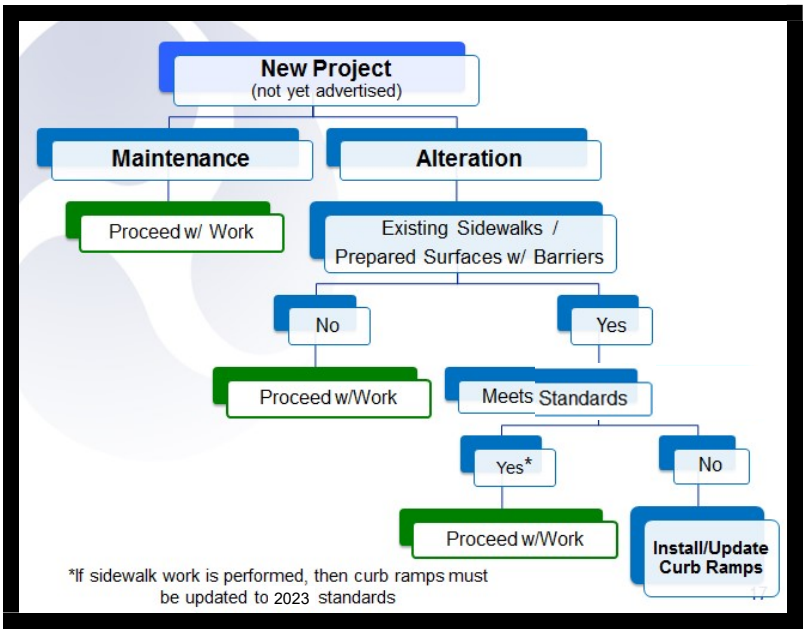


Figure 11-2
FLOW CHART FOR PAVEMENT REHABILITATION WORK PROCESS



** DOT's Section 504 "safe harbor" allows curb ramps that were newly constructed or altered prior to November 29, 2006, and that meet the 1991 ADAAG (https://www.ada.gov/assets/_pdfs/1991-design-standards.pdf) to be considered compliant. Elements not covered under the safe harbor provisions may need to be modified to provide program access and should be incorporated into a program access plan for making such modifications.

*** If curb ramps constructed prior to March 15, 2012 already comply with the curb ramp requirements in the 1991 Standards, they need not be modified in accordance with the 2010 Standards (https://www.ada.gov/2010ADAstandards_index.htm) in order to provide program access, unless they are altered after March 15, 2012.

Active Transportation and Non-Highway Users

Active transportation is any self-propelled, human-powered mode of transportation, such as walking or bicycling. Non-highway users, typically consider for trail designs, include cross-country skiers, snowmobile operators, ATVs, dirt bikes, dog sleds, horse riders and active transportation.

During Ten Year Plan (TYP) project scoping or the scoping phase of non TYP projects throughout the design and construction phases of a project, all modes of transportation, such as pedestrians and bicyclists, are considered. The incorporation of these design features are discussed and evaluated as a part of the design process and further assessed as a part of the public input process. The preliminary design should include consideration for existing and proposed pedestrian and bicycle routes to provide a safe and efficient network of travel.

Design considerations for sidewalks that are included in the Scoping and Preliminary Design Phases are the location of and offset to the sidewalk, surfacing type, limits of sidewalk and width of sidewalk. Sidewalk details can be found on the typical plans in Volume II of the Highway Design Manual and in the details provided on the Department's website. See also Chapter 3, "Design Considerations and Criteria" for additional information on ADA requirements.

Bicycle and pedestrian accommodations should be considered, not only for the final constructed condition, but also throughout the construction phases by perpetuating existing sidewalks or routes. Pedestrian facilities should be constructed of suitable materials and should be ADA accessible. (See also the Maintenance of Traffic section below for traffic control considerations.) The language is better defined in the *Manual on Uniform Traffic Control Devices (MUTCD)* (2) with respect to the Temporary Traffic Control (TTC) zones: "If the TTC zone affects the movement of pedestrians, adequate pedestrian access and walkways shall be provided. If the TTC zone affects an accessible and detectable pedestrian facility, the accessibility and detectability shall be maintained along the alternate pedestrian path." (*MUTCD* (2), Section 6D.01, paragraph 04.) For assistance in developing appropriate pedestrian access in a TTC Zone, coordinate with the Department's ADA Coordinator. Any pedestrian access issues should also be discussed as part of the presentation to the Traffic Control Committee (see below).

Certain projects may include, or specifically be intended to provide pedestrian and/or bicycle paths or facilities. The specific projects may be part of, but not limited to, a Ten Year Plan project, a Transportation Alternatives Program (TAP) under Moving Ahead for Progress in the 21st Century Act (MAP-21), a federal authorization bill to govern transportation spending. The TAP program replaced the former Transportation Enhancement (TE) Program. For additional information on the TAP see:
http://www.fhwa.dot.gov/environment/transportation_enhancements/

The goal of constructing these facilities is to provide safe and convenient accommodations that will encourage alternative modes of transportation and reduce the number of vehicles on the road. It will also allow children and others who have no access to a motor vehicle to access or reach certain locations or destinations without the need for a vehicle.

Approved criteria for pedestrian facilities can be found in the *Guide for the Planning, Design and Operation of Pedestrian Facilities (AASHTO)* (3), *American Association of State*

Highway and Transportation Officials (AASHTO) Guide for the Development of Bicycle Facilities (4), and the *New Hampshire Statewide Bicycle and Pedestrian Plan* (5).

The NHDOT has Active Transportation subject matter experts located within the Bureau of Highway Design working under the Safety Section. This section has a library of reference materials and guides that can be used in developing bicycle and pedestrian facilities. This section will review designs and make recommendations on all transportation facilities within the public way where bicycle or pedestrian travel is allowed. The Active Transportation Section should be included in all stages of design regarding bicycle and pedestrian accommodations on roadway and bridge projects. Be cognizant that the Bureau of Traffic must approve midblock or uncontrolled crosswalk locations and any new signs and pavement markings related to bicycle and pedestrian facilities. In most cases, maintenance of bicycle specific markings and crosswalks is performed by the requesting municipality. As a result, a maintenance agreement needs to be in place prior to construction of these features.

During the design phase, and prior to the project being advertised for bids, ensure that all operation and maintenance responsibilities, both now and in the future, such as pavement markings, signals, sidewalks and landscaping maintenance agreements, are addressed via a signed Memorandum of Agreement (MOA) or Memorandum of Understanding (MOU) with the appropriate municipalities, see the Agreements Section below for additional information. The Bureau of Traffic drafts and stores all Rectangular Rapid Flashing Beacons (RRFB), Pedestrian Hybrid Beacons (PHB), and Midblock/Uncontrolled crosswalk maintenance agreements.

Pedestrian and bicycle barriers or rails should be considered adjacent to facilities where there could be steep slopes or obstacles that could be a hazard (e.g., water). There are minimum height requirements for barrier based on location and need. Typically, per FHWA guidance, the minimum rail height is 42 inches where bicycle users could be present. Barriers should meet the requirements of *ADAAG* (1) 4.26 (http://www.fhwa.dot.gov/environment/bicycle_pedestrian/publications/sidewalk2/sidewalks214.cfm). See the *AASHTO Guide for the Development of Bicycle Facilities* (4) for guidance on height and location on structures as well as the NHDOT *Bridge Design Manual* (6), *Chapter 2*. See Appendix 11-1 (Bicycle Railing for Highway Applications Memo) for the latest guidance on the installation of bicycle rail that is not located on a structure; this guidance is somewhat dated noting there have been 2 AASHTO guide updates since 1997. Since that time, the Active Transportation Section has requested, in conformance with AASHTO, if bicycle or pedestrian activity is expected in close proximity to a steep slope or drop-off, that a fence or rail system be provided that is at least 42 inches high. For bicycle activity, designers should further consider a 48-inch high rail for certain conditions such as at a curve at the foot of a long descending grade where the curve radius is less than that appropriate for the design speed or anticipated speed.

Safety rail for vertical drop-offs of 30 inches or greater within a 36 inches clear distance is required by the *International Building Code* (IBC) (7). The designer should also consult with the latest version of the NH Building Code, (https://www.nh.gov/safety/boardsandcommissions/bldgcode/nhstatebldgcode.html), the most stringent rule applies. Designs with slopes steeper than 2:1 that are within a reasonable clear distance from path users should also consider the use of safety rail. The rail height of the safety rail should be considered for bicycle and pedestrian traffic, see above. Other

considerations for ramps and the needs for handrails can be found in the IBC and the NH Building Code.

Sidewalk Surfacing Materials

The typical surfacing material used by the Department for sidewalks is bituminous pavement that transitions to concrete sidewalks with uncoated steel detectable warning devices at the curb ramp (tip down) and platform areas prior to a crosswalk; see below for additional information on crosswalks. This is a change in color and texture for the visually impaired user. Transitions at driveways are typically the same surfacing material as the remainder of the sidewalk (bituminous pavement), and do not include concrete or detectable warning devices. If a municipality has requested a different surfacing material for the sidewalks, consult with the Project Manager to determine payment responsibilities. Typically, the municipality will be responsible for additional costs for the specialized treatment in the absence of a signed municipal policy for a different type of sidewalk or detectable warning surfaces. If the Municipality has a signed policy for different sidewalk type or detectable waring surface, the payment responsibility could fall on the Department. See below for additional guidance pertaining to the need to execute a Municipal Sidewalk Maintenance Agreement before a sidewalk may be included as a part of the project.

Crosswalk Markings

Prior to including any crosswalk markings on a project, consult with the Bureau of Traffic.

The following excerpt is from the *MUTCD* (2):

> Support:
>
> 02 In conjunction with signs and other measures, crosswalk markings help to alert road users of a designated pedestrian crossing point across roadways at locations that are not controlled by traffic control signals or STOP or YIELD signs.
>
> 03 At non-intersection locations, crosswalk markings legally establish the crosswalk.

Crosswalk markings are an optional traffic control device that provide guidance for pedestrians who are crossing roadways by defining and delineating paths on approaches to and within signalized intersections, and on approaches to other intersections where traffic stops. In conjunction with signs and other measures, crosswalk markings help to alert road users of a designated pedestrian crossing point across roadways at locations that are not controlled by traffic control signals or STOP signs. At non-intersection locations, crosswalk markings legally establish the crosswalk.

The use of crosswalk markings shall be approved by the Bureau of Traffic. Crosswalk lines should not be used indiscriminately. An engineering study should be performed before a marked crosswalk is installed at a location away from a traffic control signal or an approach controlled by a STOP or YIELD sign. The engineering study should follow current Bureau of Traffic practices which consider such criteria as the number of lanes, the presence of a median, the distance from adjacent signalized intersections, the pedestrian volumes and delays, the average daily traffic (ADT), the posted speed limit, the geometry of the location, the possible consolidation of multiple crossing points, the availability of street lighting, and other appropriate factors. New marked crosswalks alone, without other measures designed to reduce traffic speeds, shorten crossing distances, enhance driver awareness of the crossing,

and/or provide active warning of pedestrian presence, should not be installed across uncontrolled roadways with high speeds, high traffic volumes, and multiple lanes in one or more directions. Avoid placing crosswalks at mid-block locations. Mid-block crossing locations do not meet driver expectation and can lead to a false sense of security for the pedestrian. The NHDOT does not maintain crosswalk markings unless they are a part of a school crossing or a signalized intersection. Contact the Bureau of Traffic to initiate a crosswalk evaluation and for additional guidance (note: the Bureau of Traffic may require additional conspicuity enhancements such as Rectangular Rapid Flashing Beacons (RRFB) or Pedestrian Hybrid Beacons (PHB) in order to approve crosswalks in certain locations. FHWA-compliant street lighting is required for all new uncontrolled marked crosswalks, and all uncontrolled marked crosswalks (new or existing) require the municipality to sign a maintenance agreement for the supporting elements of the pedestrian crossing such as curb ramps, street lights, beacon devices, and in most cases crosswalk markings.

Regarding pedestrian facilities at roundabouts, crosswalk markings are included only when the municipality has agreed to the maintenance responsibilities. Officially, the Department has adopted PROWAG which requires that pedestrian crossings at 2-lane roundabouts be signalized (either with a traffic signal or pedestrian hybrid beacon). NH is a "yield state", so when the pedestrian is in a crosswalk, only the specific lane they happen to be in is effected and the other lanes can legally continue travel. For blind pedestrians, this means they can still hear the sound of moving traffic perpendicular to their direction of travel. Thus, the need to create a "stop" condition which is accomplished either with a signal or PHB. Consult the Bureau of Traffic for all pedestrian crossings at single or multilane roundabouts for the appropriate treatments.

There are other reference documents that discuss pedestrian safety at roundabouts and other alternative intersection designs such as NCHRP (834, 674, 948, 926 and Documents 222, (http://www.trb.org/PedestriansandBicyclists/TRBPublications.aspx), discussion on RRFBs at roundabouts can be found at https://safety.fhwa.dot.gov/intersection/innovative/roundabouts/docs/fhwasa15069.pdf.

Detectable Warning Surfaces

Detectable warning surfaces are required as a part of the *ADAAG* (1) Advisory R221 in conformance with Technical Provision R304. The follow excerpt is from the *ADAAG* (1):

> "Advisory R221 Detectable Warning Surfaces. Detectable warning surfaces are required where curb ramps, blended transitions, or landings provide a flush pedestrian connection to the street. Sidewalk crossings of residential driveways should not generally be provided with detectable warnings, since the pedestrian right-of-way continues across most driveway aprons and overuse of detectable warning surfaces should be avoided in the interests of message clarity. However, where commercial driveways are provided with traffic control devices or otherwise are permitted to operate like public streets, detectable warnings should be provided at the junction between the pedestrian route and the street."

The FHWA's ADA standards (Public Rights-of-Way Accessibility Guidelines (PROWAG) 2023) apply as a best practice. https://www.federalregister.gov/documents/2023/08/08/2023-16149/accessibility-guidelines-for-pedestrian-facilities-in-the-public-right-of-way) Chapter 3 provides specific guidance on the placement, size, material, etc. of the devices. This section

also includes the required color contrast between the sidewalk and the detectable warning surface. This guidance has been incorporated into the NHDOT Sidewalk Curb Ramp Details and Detectable Warning Device (DWD) Decision Making Flowchart. Both can be found at: https://www.dot.nh.gov/doing-business-nhdot/engineers-consultants/highway-design-special-details.

Recreational Trails

Pedestrian and bicycle facilities may be used, if permitted, by other users including cross-country skiers, snowmobile operators, ATVs, dirt bikes, dog sleds, and horse riders. Drainage considerations, openness considerations, and considerations for the various users expected along a trail dictate that a facility constructed with a roadway underpass may also need to be large enough to accommodate a horse with rider or a snowmobile trail groomer. Typical construction sections showing the recommended widths for trails may be found in the New Hampshire State Trails Plan dated August 2022, by the NHDOT and Department of Natural and Cultural Resources (DNCR), (formerly the Department of Resources and Economic Development (DRED)), can be found at: https://mm.nh.gov/files/uploads/dot/remote-docs/2022-rail-trails-plan-web.pdf. The document suggests the minimum height of a trail should be 10 feet and at least 10 feet wide; however, it further indicates that horseback riders require 15 feet of height, so the height will need to be addressed on a case by case basis. The Department is working on updating the State Rail Trail Plan in a GIS layer that the Bureau of Planning's GIS section will maintain. The intention of the State Rail Trails Plan and the trails map will be state-owned trails only (that NHDOT or another State agency, i.e., DNCR owns).
There are other local areas and trails that have specific revised maps for their trail systems that should be consulted prior to any final design decisions. Coordination with the local public officials and DNCR will usually identify whether the trails are groomed and any height or width requirements of the groomers. There are also many miles of specific snowmobile trails throughout New Hampshire, and, because of this, there are instances where specific "snowmobile underpasses" are constructed. See Appendix 11-2 (Size of Snowmobile Underpass Letter) for a memorandum regarding the minimum sizes of underpasses. Although older guidance, this would still apply to most areas however, DNCR has been working to get any new underpasses done as square box culverts as there is typically a need for a 10-foot by 10-foot clear opening to have the grooming equipment travel through them. In some areas, where room allows, DNCR has been installing 12-foot by 12-foot concrete box culverts as DNCR has found the designs of the grooming tractors are now wider at the top, to accommodate updated safety lights/beacons and the curved culvert edges are preventing some equipment from getting through the culverts.

In certain bridge crossing areas, consideration should be given to snowmobile operators if a known snowmobile system exists. Other uses should also be explored to ensure the proper dimensions are used for all trail users. The Active Transportation Section works closely with NH Parks and Recreation's Trails Bureau, so any trail related questions should be directed to the Bureau of Rail and Transit first, then the Active Transportation Section.

The Active Transportation Section suggests that for underpasses where snowmobile activity is expected, designers may want to consider the dimensions required for modern snowmobile grooming equipment. On all trails, underpass dimensions should be wide enough so that any trail surface need not convey surface runoff or ditch flows through the underpass. Underpass

openings should be large enough to consider wildlife passage with a satisfactory Openness Ratio (Openness Ratio = (Height x Width)/Length), which for large mammals should be at least 0.75, but preferably 0.9. Tunnel or underpass openings should additionally invite adequate light into the underpass and provide a gateway with a reassuring view-shed for trail user security.

If recreational trails are included in a project, considerations for vehicle use and type should be made, such as snowmobiles or ATVs. NH State Parks and Recreation's Trail Bureau has a manual on design criteria that focuses on designs to eliminate erosion, and offers some guidance on maximum grades and other design criteria. This can be found at: https://www.nhstateparks.org/getmedia/9da5f217-1f28-4c06-84f0-39bee7324e06/Best-Management-Practices-for-Erosion-Control-During-Trail-Maintenance-and-Construction1.pdf . A resource that can be used as guidance suggestions from FHWA is the *Pennsylvania Trail Design Manual for Off-Highway Recreational Vehicles* (8). The *Vermont Agency of Transportation Pedestrian and Bicycle Facility Design Manual* is another resource: https://vtrans.vermont.gov/sites/aot/files/highway/documents/publications/PedestrianandBicycleFacilityDesignManual.pdf.

Roadside Barrier

A Roadside Barrier, as defined by the *Roadside Design Guide* (9), "is a longitudinal barrier used to shield motorists from natural or man-made obstacles located along either side of a roadway. The primary purpose is to prevent a vehicle from striking a fixed object or a roadside feature that is less forgiving than the barrier itself by containing and redirecting the impacting vehicle. Barriers are also used to separate pedestrians and bicyclists from vehicular traffic when appropriate."

Rail (bridge rail, cable guardrail, beam guardrail, etc.); concrete safety shapes; median dividers of several types; and impact attenuation devices are all considered roadside barriers. These all perform the functions of visual warning and physical containment. The objective of roadside barriers is to slow and stop an errant vehicle to minimize occupant injury. The primary purpose of all roadside barriers, as noted above, is to prevent a vehicle from leaving the roadway and striking a fixed object or terrain feature that would have more severe results than striking the roadside barrier itself. All proposed roadside barrier systems should be carefully considered since the roadside barriers themselves may constitute a hazard.

Clear Zone

The clear zone is defined as an unobstructed, traversable area provided beyond the edge of the traveled way for the recovery of errant vehicles. The size of the zone is based on traffic volumes and speeds. Refer to the *Roadside Design Guide* (9) for additional information and specific design procedures involving roadside barriers and the application of the clear zone concept.

The NHDOT uses the principles of the *Roadside Design Guide* (9) for the design of roadside barriers and also uses the following additional guidelines:

1. See Chapter 3, "Design Considerations and Criteria" for additional guidance on interstate and ramp clear zones.

2. The clear zone should be determined based upon the foreslope condition. See the *Roadside Design Guide* (9) Table 3-1 (Suggested Clear-Zone Distances in feet from Edge of Through Traveled Lane) for suggested clear zone distances.

    a. The clear zone distance is determined by the following foreslope conditions: 1V:6H or flatter; or 1V:5V to 1V:4H. To provide consistent application of the clear zone for project designs, the desired clear zone should be set based upon the column in Table 3-1 for foreslopes 1V:5H to 1V:4H. Foreslope conditions steeper than 1V:4H are considered non-recoverable slopes.

    b. There are a range of clear zones listed in Table 3-1 based upon the foreslope condition. The maximum distance should be considered unless other site conditions in the area warrant flexibility for the clear zone.

3. Clear zones may be limited to 30 feet for practicality and to provide a consistent roadway template if previous experience with similar projects or designs indicates satisfactory performance. The use of clear zones greater than 30 feet should be vetted through the Section Chief.

4. When completing guardrail warrant evaluations, the Department typically does not consider protection of steep backslopes within the clear zone. Exceptions to this can be for interstate use.

5. When completing guardrail warrant evaluations with respect to passing zones, the designer should take into account the potential for additional length of need on the departure side for the passing maneuver.

6. The Shy Line concept is used when there are no shoulders on a roadway; see the *Roadside Design Guide* (9) for additional explanation on shy lines.

7. When choosing flare rates for roadside barrier, refer to the *Roadside Design Guide* (9), Table 5-9 (Suggested Flare Rates for Barrier Design). The Department typically applies the guidance under the "Flare Rate for Barrier at or Beyond Shy Line" columns. Flares are typically not used on the outside of superelevated horizontal curves.

8. When designing roadway ditches within the clear zone, it is desirable to have traversable foreslope and backslope having an algebraic differential of 10 or greater. For example, a 1V:6H foreslope and a 1V:4H backslope would equal an algebraic difference of 10 and would be a desirable layout.

9. Drainage inlets, outlets and headwalls should be placed outside of the clear zone whenever practical.

A roadway barrier is considered a hazard as it will cause vehicle damage and potential injury to occupants. As a result, there are several design considerations for addressing obstacles within the clear zone prior to installing any barrier:

- Remove the obstacle.

- Redesign the obstacle so it can be traversed (e.g., flatten the slopes).
- Relocate the obstacle to a point where it is less likely to be struck.
- Reduce the impact severity by using an appropriate breakaway device.

Where a barrier is warranted, the beginning and ending points for a specific roadside barrier segment should be considered in the evaluation of the adjoining areas to ensure short gaps are not created resulting in the installation of multiple terminal units which may be more costly than a continuous segment of rail. This evaluation should also consider available Right-of-Way to terminate the roadside barrier, access points such as drives, and snow removal operations.

Zone of Intrusion

The zone of intrusion is defined as the vehicle overhang beyond the face of the barrier during an impact. This should be considered as part of the barrier layout and the design. A high center of gravity vehicle, such as a single unit truck or a tractor trailer, may lean over the barrier upon impact, which could require an increased offset to lessen the likelihood of contact with a shielded object. The test level, height of the barrier, or rigidity of the barrier may need to be increased to protect the motorists from the hazard. Examples of situations where the zone of intrusion could significantly affect a design are a roadside barrier adjacent to a bridge pier, noise abatement barrier, overhead sign structure, CCTV camera pole, RWIS station, a ground mounted Dynamic Message Board (DMS), portable ITS trailer, smart work zone trailer, or light pole.

Roadway Design Considerations

Roadside barrier is used on embankments, in medians and to protect vehicles from obstructions within the clear zone. The face of rail is commonly set at the edge of the shoulder, i.e., edge of pavement. When space is available, an additional 2 foot (paved) offset is sometimes included from the edge of pavement, such as on high speed facilities. On 11'-4' or 12'-4' typical section roadways in guardrail areas consider adding a one foot (paved or unpaved) shoulder in guardrail areas so the typical would become 11'-5' or 12'-5' where feasible (consider available ROW, environmental impacts, etc.). This added distance from the shoulder to the travel way is used for plowing and bicycles, but also allows an extra distance to recover the vehicle before impacting the guardrail as well as providing a wider area for a disabled vehicle in the shoulder. See the typical sections in the Highway Design Manual, Volume II for additional details relating to the use of wider shoulders at barrier locations.

Side slopes on embankments should provide a reasonable opportunity for recovery of an errant vehicle. There may be instances, however, where construction of 4H:1V or flatter slopes is not feasible or practical. This situation may require roadside barrier. Warrants are based on the premise that a roadside barrier should be installed only if it reduces the severity of potential crashes.

The Department's typical warrant for roadside barrier, under rural conditions, is on any slope steeper than 4:1. Embankment heights of approximately 5 feet or less at slopes steeper than 4:1 may not necessarily require barrier, especially if the area at the toe of the slope does not appear to have other roadside obstacles e.g., trees or water. The 4:1 typical warrant is

conservative criteria that NHDOT has adopted as compared to the information shown in Figures 5.1 through 5.3 of the *Roadside Design Guide* (9). The "length of need" is as determined by the procedures outlined in the *Roadside Design Guide* (9).

In urban conditions and other special locations, roadside barrier warrants may need to be evaluated on an individual basis. Carefully consider any variation from the typical treatment and review it with your supervisor.

There are times when roadside barrier may be required to protect vehicles from areas containing water or other hazards even though the sideslope is 4:1 or flatter. These and other roadside conditions involving consideration of, or requirements for, shielding are addressed in Table 5.1 of the *Roadside Design Guide* (9).

The Department has developed documents for review procedures for guardrail projects and guidance for guardrail design applications. See Appendix 11-3 and Appendix 11-4, respectively, which should be used as guides.

Test Levels and Performance Standards

Roadside barriers are developed based upon crash performance under test level conditions for particular vehicle specifications, speed, and angle of impact. For example, the common roadside longitudinal barrier (w-beam) contains and redirects passenger vehicles weighing up to 4,400 pounds, traveling at speeds of up to 62 MPH and impacting the roadside barrier at shallow angles (less than 25 degrees). Higher performing barriers are available for larger vehicles with a higher mass and higher center of gravity. Crash performance criteria were previously established in the *National Cooperative Highway Research Program (NCHRP) Report 350, Recommended Procedures for the Safety Performance Evaluation of Highway Features* (10). The *AASHTO Manual for Assessing Safety Hardware (MASH) 2016* (11) is the current report for crash performance criteria, see Appendix 11-5 (Summary Listing of MASH Tested Hardware) for additional guidance on the implementation plan.

The MASH performance standards require that all new safety hardware be crash tested by specific test levels (TL) which include specific test conditions such as type of vehicle, vehicle weight, speed, and impact angle. These standards include test levels 1 through 6, where a TL-1 is at a lower speed with a smaller design vehicle (passenger car to pick-up truck weighing up to 5,000 pounds and at a speed of 31 MPH), and a TL-6 is at a higher speed with a larger design vehicle (passenger car to tractor-trailer weighing up to 79,300 pounds and up to speeds of 62 MPH and 50 MPH respectively). A matrix with the test levels, test vehicle requirements, and other test criteria can be found in the *Roadside Design Guide* (9) and the *Manual for Assessing Safety Hardware* (11).

These guidelines include impact performance evaluations for both permanent and temporary roadside safety systems features including:

- Longitudinal roadside barriers such as bridge rail, guardrail, median barrier, and barrier transitions;
- Terminal units;
- Impact attenuators (redirective and non-redirective);
- Truck-mounted attenuation devices;

- Support structures such as breakaway supports for luminaires and signs, utility poles and work zone traffic control devices;
- Work zone attenuation and channelization devices;
- Other devices such as traffic gates; and
- Drainage and geometric features.

The following chart provides guidance for test level application for speed and expected longitudinal barrier height.

Speed (MPH)	Test Level	Height of Rail	Minimum Height of Concrete Barrier**	Comments
25-40	TL-2	31" *	18"	
45-70	TL-3	31" *	27"	Standard Applications
45-70	TL-4	-	36"	
45-70	TL-5	-	42"	Median Applications
45-70	TL-6 ****	-	54" - 90"	Bridge Piers *** Open Road Tolling (at gantry)

* New guardrail installations should be at 31", existing installations can be as low as 28 ¾". Additional consideration is also required for deflection.

** Excluding embedment.

*** For use with bridge piers, consult with the Bureau of Bridge Design to determine the design application.

**** There has not been a MASH crash test for a 55" single slope barrier, so it may not pass a TL-6 loading, verify prior to use.

Design Speed

For projects where no previous design speed has been set, and the project is setting a design speed, it would be advised to have the guardrail design match the proposed design speed for the project. For projects or locations that were not built to a specific design speed, guidance provided here is to use the posted speed plus 5 MPH. It is recognized that observed average speeds can be higher than the posted speed. The added 5 MPH gives a factor of safety in many cases resembling the design speed on a typical project built roadway.

FHWA Requirements on the NHS (MASH Compliant Hardware)

In a joint agreement, AASHTO and FHWA set dates of compliance to transition from NCHRP tested hardware to using MASH tested hardware for new installations and full replacements.

- W-beam barriers, concrete barriers, w-beam terminals, cable barriers, cable barrier terminals, and crash cushions were the first to require compliance.
- All remaining hardware, (bridge rails, transitions, sign supports, etc.) were required to be compliant by December 31, 2019.

For a summary listing of MASH tested hardware, see Appendix 11-5.

If Non-MASH compliant hardware, such as the E-2 or CRT, is used on the National Highway System (NHS), it must receive approval for its use prior to installation. There is a

two-part approval process as identified below:

1. The Department must approve the hardware for use. On February 27, 2020 NHDOT agreed on a "Revised Process for Crashworthiness" (see Appendix 11-6) with FHWA. Within it, a process for using non-compliant hardware (CRT, for example) was established.

2. A formal written approval. The approval is site and project specific and requires written approval, this process is similar to a design exception. In general, the lead designer would write and send the request for the exception through the Project Manager, the Bureau Administrator, the Assistant Director of Project Development, the Director of Project Development and the Chief Engineer (Assistant Commissioner). See Appendix 11-7 for a sample request memorandum.

Guardrail and Cable Rail

The majority of the guardrail that is on the roadway today is metal beam guardrail. Guardrail comes in several varieties such as thrie beam, w-beam, and steel backed wood rail. The rail may be attached to wood posts or steel posts.

The standard guardrail post is a W6x9 steel post. In 2008, the NHDOT transitioned the standard installation of guardrail from galvanized w-beam guardrail on wood posts to galvanized w-beam guardrail on steel posts with composite offset blocks; see Appendix 11-8 (NHDOT Memorandum: Recommendations for the Installation of Steel Post Guardrail on NH Highways).

The Nu-guard steel post (5 lb/ft u-channel) is a proprietary item that can be used with or without an offset block (in uncurbed areas only). The intent of this item is to be able to use it in tight areas where there is limited support material behind the post. As this is a propriety item, it should only be considered after all other alternatives have been exhausted.

Metal rail is typically galvanized. For special applications, such as historic and/or scenic areas, where consideration for a non-galvanized appearance is desired, the use of anodized colored rail could be recommended. Use of anodized rail must be approved by the Chief Engineer due to the higher cost and added long term maintenance.

Cor-ten guardrail (often called "rusty rail", A588 guardrail, or weathering steel) was previously used in areas that were historically or environmentally sensitive. However, this practice is no longer supported by the Department (effective 2002). In addition, the FHWA does not support the use of this type of rail unless the agency using the rail adopts a frequent periodic inspection and replacement schedule. See Appendices 11-9 and 11-10 for memorandums from FHWA and NHDOT allowing the discontinuance of this product.

Although rarely used, there are two types of cable rail systems, high tension and low tension cable systems. When used, the Department's preference has been the installation of low tension cable rail systems due to the higher maintenance for re-tensioning (maintaining) on the high tension cable systems.

The standard types of guardrail and guardrail terminals approved for use by NHDOT along with details, platforms, and appurtenant hardware are shown in the *Standard Plans for Road Construction* (12), *Bridge Detail Sheets* (13), Special Details or the Qualified Products List. The type of guardrail, guardrail platform, and guardrail terminal will be specified on the

Plans in the Guardrail Summary Table. See the section on Guardrail Terminals below for additional information.

Standard guardrail is used in roadside and median applications. In narrow median applications (see the *Roadside Design Guide* (9)), median barrier is used. Standard guardrail can also be used in wide medians to keep vehicles from striking bridge piers or other median hazards. Coordinate bridge pier protection with the Bureau of Bridge Design.

In some situations, where a limited deflection distance is available or required, a stiffer guardrail system may be necessary. The post spacing, rail reinforcement (i.e., nesting rail), speed and the impact angle determines the deflection. For the older standard strong (steel) post W-beam guardrail (splice at the post) and or the current MGS single W-beam guardrail (splice between posts), the lateral deflection for single nested rail can be up to 44" for TL-3 performance whereas, thrie beam deflection is up to 35"-42"(modified to short block), and nested single beam rail is up to 36". See Table 5-6, Chapter 5 of the *Roadside Design Guide* (9) for dynamic lateral deflection of the different types of guardrail.

The use of low and high tension cable systems will result in greater deflections that can be up to 12 feet of deflection for the low tension cable systems and up to 9.2 feet for high tension cable systems (see Chapter 6 of the *Roadside Design Guide* (9)).

Deflection is more critical where guardrail/barrier is used to protect vehicles from bridge piers, abutments or similar hazards (i.e., overhead sign structures). In these cases, consideration of a higher test level barrier (i.e., TL-4 and/or TL-5) should be made as the TL-4/TL-5 test vehicles have a higher center of gravity and greater preponderance for the cargo box overriding the top of the concrete barrier and entering the zone of intrusion, which should be kept clear. The higher test level also accommodates an impact condition for a single unit truck and a tractor trailer respectively. Barriers that accommodate redirection for truck impacts are typically concrete barrier systems. There is no observed deflection on embedded permanent concrete barrier (temporary traffic control barrier does deflect).

When practical, guardrail can be offset from the edge of pavement in order to accomplish three things:

- Provide a wider area for winter maintenance to perform their operations without encroaching into oncoming lanes. Typically, 16' from centerline to face of rail is requested.
- Allows the terminals to be placed in a location where they are less likely to be struck.
- Reduce the overall length of guardrail required.

There are instances where tapering or flaring the approach end of guardrail may be necessary. A roadside barrier is considered flared or tapered when it is not parallel to the edge of the traveled way. Flaring is often used to locate the roadside barrier terminal away from the roadway. The benefit of flaring allows for consideration of shorter runs of rail (reduced length of need), and further offset of the terminal from traffic. The maximum recommended flare rates are a function of the design speed and roadside barrier type. See the *Roadside Design Guide* (9) for more information. It is important to note that NHDOT specified Energy-Absorbing Guardrail Terminals (EAGRTs) are tangential and cannot be placed any steeper than a 25:1 taper, regardless of the flare rate of the longitudinal rail.

Reducing the length of need is the most common reason to flare guardrail. The designer should be aware that there are disadvantages to flaring roadside barrier, i.e., with a flare, there is a higher probability of a greater impact angle and a greater deflection. As the angle of impact increases, the severity of the crash increases, particularly for rigid and semi-rigid barrier systems.

Flared rail should not be used along the outside of a superelevated horizontal curve unless the curvature is so flat that superelevation is not required, i.e., the cross slope should be at or near normal crown to consider using flared rail. This is due to the cross slope transition and the vehicle suspension system that could result in the potential for the vehicle to impact the guardrail at a higher elevation. With curves having the maximum superelevation, vehicle vaulting could be a risk. Additionally, consideration should be made for the placement of the terminal unit on the outside of the horizontal curve's departure end for the opposing traffic. This location has a higher run off the road risk due to the geometric condition, therefore consider placement of the terminal unit along the tangent approach section.

Curved rail used on a tight radius, may also be considered in the design of low volume roadways, see Terminal Units (End Treatment Sections) below for more information.

Guardrail should be designed using the mathematical formulas in the *Roadside Design Guide* (9) versus the graphical method. Note there are curve adjustment factors in the *Roadside Design Guide* (9) that should be included for horizontal curvature.

The typical guardrail installation consists of a 7-foot-long post with 2.5 feet (3 feet on interstates) of support material behind the face of the rail. In instances where guardrail may not fit the standard installation application shown in the *Standard Plans for Road Construction* (12) other acceptable alternatives could be considered. The following are examples of possible applications for consideration beyond the typical installation:

- For applications where there is less than 2.5 feet of support material behind the face of the rail, a longer post could be considered (see Washington State Design Manual Section 1610, https://www.wsdot.wa.gov/publications/manuals/fulltext/M22-01/1610.pdf, under Beam Guardrail Placement (Appendix 11-11) or consider a longitudinal barrier that allows for no block out (e.g. MGS, Nu-Cor, etc.).
- For applications where post embedment is in conflict with small underground structures (i.e., catch basin, manhole, etc.), the conflicting post may be omitted as long as the following criteria are satisfied:
    - No curbing may be present through the area with the omitted post. Some exceptions may be made, review any specific cases with the Specialty Section.
    - The guardrail system requires an offset block; 8" and 12" blocks are considered to behave similarly for this application.
    - The omitted post must be at least 12.5' from the end of an EAGRT (the third post beyond the EAGRT may be omitted).
    - Only allowed within 2:1 slope areas if standard panel backup (2.5' (3' for interstates)) behind the post is available.
- For applications where post embedment is in conflict with larger structures (i.e., box

culverts where the post spacing is less than 25 feet), a MASH tested alternate post spacing layout is available for consideration (see the Specialty Section for Long Span Guardrail detail).

Terminal Units (End Treatment Sections)

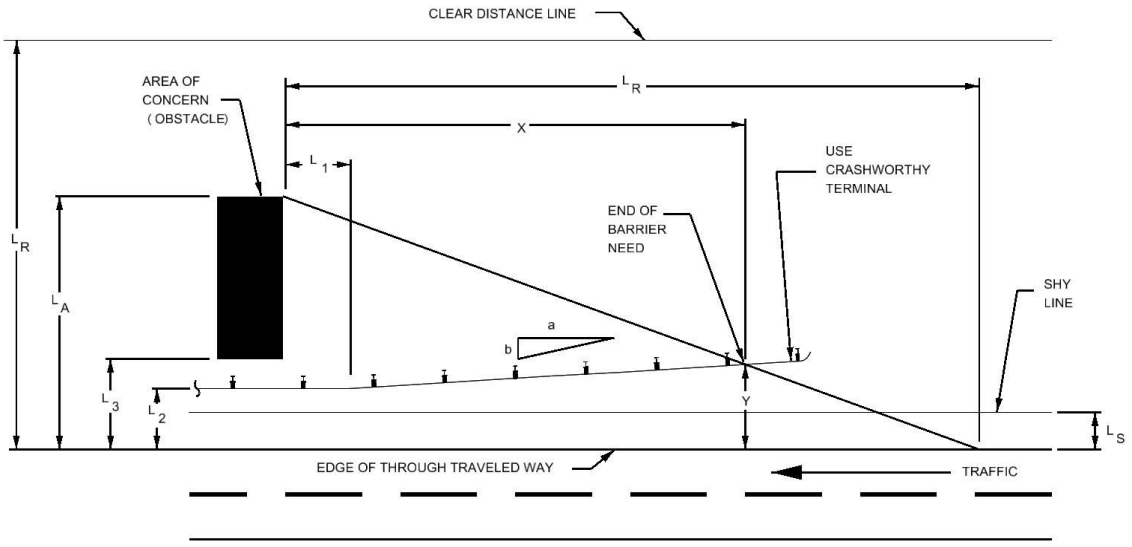
All roadside barrier installations should end using an appropriate terminal (end treatment). The common choices currently available for terminals include the Energy-Absorbing Guardrail Terminal (EAGRT), the terminal section type E-2 (buried in backslope), the Controlled Releasing Terminal (CRT), and the terminal unit type G-2. The EAGRT and the E-2 are the typical units that are used for approaching traffic, the CRT and the G-2 are terminals that have limited use and special requirements, see below for additional information. See also Chapter 8 of the *Roadside Design Guide* (9) for a more comprehensive explanation of guardrail end treatments, some of which are proprietary.

There is additional guidance on the use of specific EAGRT units as well as other terminals, see Appendix 11-12 (Energy Absorbing Guardrail and Older Legacy Terminals (April 2021)) for additional information.

New hardware is subject to review and acceptance by the Department before use. Most often this can be proprietary or terminal units; check with the Specialty Section regarding new MASH approved terminal units.

Terminals should be located beyond the length of need in advance of the hazard (area of concern), see below for Figure 11-3 – Approach Barrier Layout; Figure 5-39 from the *Roadside Design Guide* (9) and Chapter 5 of the *Roadside Design Guide* (9). In some applications, the length of the terminal unit may be considered within the length of need "X" where the terminal allows for full redirection, for more information see Chapter 8 of the *Roadside Design Guide* (9).

Figure 11-3
APPROACH BARRIER LAYOUT;
FIGURE 5-39 from the *ROADSIDE DESIGN GUIDE* (9)



Due to the agreement with FHWA, see above, only MASH approved terminals are allowed on the NHS. However, the CRT current has no MASH equivalent for its application and is allowed with an approved exception memo, see above, and Chapter 3, "Design Considerations and Criteria". The CRT, due to its crash performance, can be used on low speed (less than 40 MPH), low volume (6,000 ADT maximum) facilities. In April 1992 FHWA released Technical Advisory T 5040.32 (see Appendix 11-13), which allows for the use of the CRT and provides further insight into its use. See also Chapter 5 of the *Roadside Design Guide* (9). The CRT end units were successfully crash tested at that time under NCHRP Report 230 with allowable radii from 8.5 feet to 35 feet. These units are not appropriate for all situations. When used, the designer needs to accommodate a flat, unobstructed area behind the rail. These systems should not be used in close proximity to rigid rail (bridge rail, concrete barrier, etc.). There should be a transition unit from the rigid barrier to a semi-rigid barrier. Refer to Section 5 of the Technical Advisory T 5040.32 (Appendix 11-13) for additional information.

It should be stated that some projects require the bridge approach railing to be on a radius and is shown on a Rail Layout Plan. The steel tubes and the nested thrie beam of the bridge approach railing can be shop bent to a radius. However, two portions of the bridge approach railing cannot be bent to a radius: the connection plate (2'-5 1/8" section) and thrie-beam to w-beam transition section (6'-3"). If the bridge approach railing is laid out on a radius, these sections must be shown laid out on a tangent. The T2, T3, and T4 Bridge Approach Railing Detail Sheets note "DO NOT BEND" for the two sections noted above. These Detail Sheets can be found on the Bridge Design Website: https://www.dot.nh.gov/about-nh-dot/divisions-bureaus-districts/bridge-design/bridge-detail-sheets. The steel tubing of the bridge railing can be bent to a radius as noted in the Standard Specifications 2016 Section 563.3.2. For more information see the NHDOT *Bridge Design Manual* (6).

The G-2 end terminals are essentially anchors that are used on the departure end of guardrail along divided roadways, such as interstate facilities. It should be noted that the term "divided" in this context means that there is a roadside barrier separating the two directions of travel or has a wide median to not warrant median barrier between the two directions of travel (see Figure 6-1 errata in Chapter 6 of the *Roadside Design Guide* (9) for the width and ADT criteria for median barrier warrants). For other divided highways (arterial roadways) where concrete barrier or guardrail barrier separates traffic, a G-2 unit may be used. For slope curb medians separating traffic, the G-2 shall not be used.

Platforms

The platform is an integral component of the performance of the guardrail terminal unit. Proper grading for each guardrail platform is necessary; these are typically included as contract bid items and are shown in the *Standard Plans for Road Construction* (12). The earthwork required for the platform is a unit pay item quantified separately from the earthwork calculations. The platforms should be drawn as a dashed line style on the cross sections. This differentiates the platform from the earthwork items ensuring the quantity is not double counted. See the Highway Design Manual Volume II for a sample.

Transition Sections

"A transition section is needed where a semi-rigid approach barrier joins a rigid bridge railing... the transition design should produce a gradual stiffening of the overall approach

protection system so that vehicular pocketing, snagging, or penetration can be reduced or avoided…", *Roadside Design Guide* (9), Chapter 7. This concept also carriers through to a semi-rigid approach barrier joining a rigid barrier other than a bridge railing (such as concrete barrier). These transition units are included in the *Standard Plans for Road Construction* (12).

A guidance memo on the connection of transitions to existing bridge structures is located in Appendix 11-14.

Bridge Rail

Bridge rail is typically placed on the bridge and connects to the roadway guardrail with a transition unit. The design of the bridge and approach rail will need to be coordinated with the Bureau of Bridge Design. Bridge rail is considered a rigid, re-directive barrier that needs to transition to a semi-rigid barrier prior to the terminal unit meeting the appropriate length of need; see *Roadside Design Guide* (9), Chapters 6 and 7. Typically, the bridge rail transitions are thrie beam segment between the w-beam rail and the bridge rail, similar to the transition from a concrete barrier shown in the *Standard Plans for Road Construction* (12). Granite bridge approach curb is typically part of the transition off the bridge and is quantified as a roadway item. For bridge and approach rail details see the Bridge Details located at: https://www.dot.nh.gov/about-nh-dot/divisions-bureaus-districts/bridge-design/bridge-detail-sheets.

Concrete Barrier

Concrete barriers are commonly used in narrow medians, in front of bridge piers, and in other areas requiring limited deflection or higher performance. Barrier redirects vehicles with limited to no deflection based on the test level used. The reason for using barrier is to redirect vehicles from possible head-on collisions and collisions with a fixed object. Typical concrete safety shapes include the F-Shape barrier, the Jersey-Shape barrier, and the single slope barrier. The single slope barrier is used in New Hampshire and is detailed the *Standard Plans for Road Construction* (12).

The F-Shape and Jersey-Shape barriers have been used within the state's roadway system and are being replaced by the single slope barrier as roadside safety barriers are upgraded. These older barriers are typically 33" to 45" tall and 24" wide at the base. The face of each barrier has a slightly different step at the bottom of the barrier that tapers inward progressing up the barrier. The barrier is typically embedded 3" into the pavement for permanent installations. The Jersey-Shape barrier is still used as a temporary, portable concrete barrier in work zones. See Portable Concrete Barrier below for additional information for temporary use.

Single slope barrier is typically 36", 48" or 54" tall and 24" wide at the base. The barrier height is determined by the application. For TL-3 performance a 36" barrier would be used; for TL-4 performance a 48" barrier would be used; and for TL-5 performance a 54" tall barrier would be used. The barrier is typically embedded 3" into the pavement for permanent installations. The details for the single slope barrier can be found in the *Standard Plans for Road Construction* (12). For protection of bridge piers, this single slope barrier can also be constructed as a single face barrier. In this application, the designer should also take into account the zone of intrusion (see the *Bridge Design Manual* (6)*, Chapter 6.6.5* and *Bridge Detail Sheets* (13)*, Vehicular Collision Pier Protection* and Chapter 5 of the *Roadside Design*

Guide (9)).

Concrete barrier deflections are different from guardrail deflections and can be found in Chapter 6 of the *Roadside Design Guide* (9).

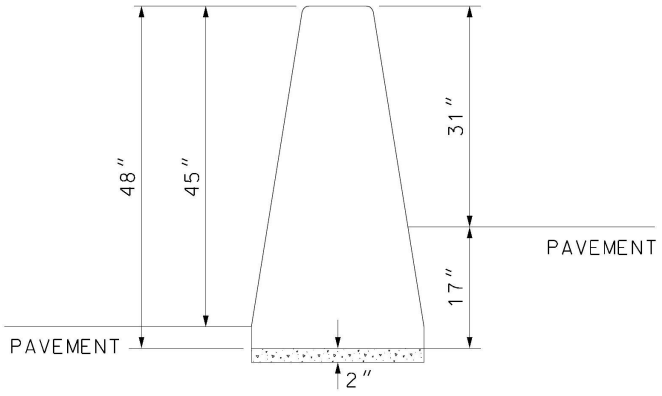
Median Barrier

For all divided highways, regardless of median width, the median roadside must be examined for barrier warrants. Where a warrant area has been identified (i.e., steep slopes, bridge piers, fixed objects within the clear zone, etc.) a barrier on the median side should be considered regardless of the median width. Divided highways having an unobstructed and traversable median width of less than 50 feet and a posted speed of 45 MPH or more, a median barrier shall be considered. Design of median widths is discussed in Chapter 3, "Design Considerations and Criteria" and Chapter 6 of the *Roadside Design Guide* (9).

The typical median barrier application consists of single slope concrete barrier, W-beam rail, and cable barriers. Each system has specific crash performance as noted above. The selection of the barrier type is based on median characteristics, performance requirements, and deflection limitations.

When designing the single slope concrete barrier in a paved median application (typically 26 feet or less) consideration should be given to the barrier height, constructability, drainage layout and the differential elevation in opposing shoulders. Within the influence of a superelevated curve, consideration should be given for profile adjustments to allow the differential in shoulder elevation to accommodate the barrier design, or consideration for a specially designed single slope concrete barrier to accommodate the differential in the shoulder height. For example, accommodating a minimum of TL-3 performance with a 42" single slope concrete barrier allows for a superelevation differential of 11"; see below for Figure 11-4 Barrier and Vertical Elevation Difference. For greater differential, the single slope concrete barrier needs to be specially designed for the particular design application.

Figure 11-4
BARRIER AND VERTICAL ELEVATION DIFFERENCE

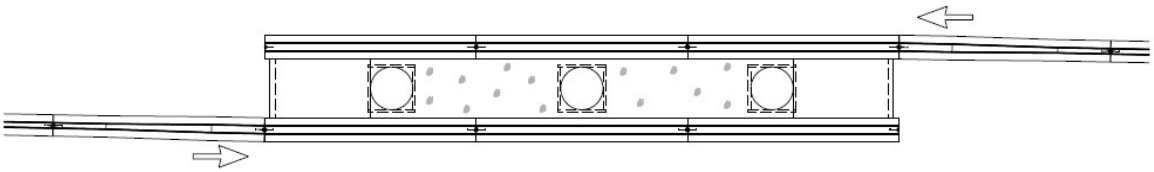


The beginning or ending point of a median barrier used for narrow median conditions will normally occur where there is a transition in median width. In certain situations, a break in the median barrier may be necessary to accommodate a maintenance crossover. The designer should review how the barrier terminates with consideration for vertical, horizontal and transitions of applicable crash performance. Further attention should be given to drainage,

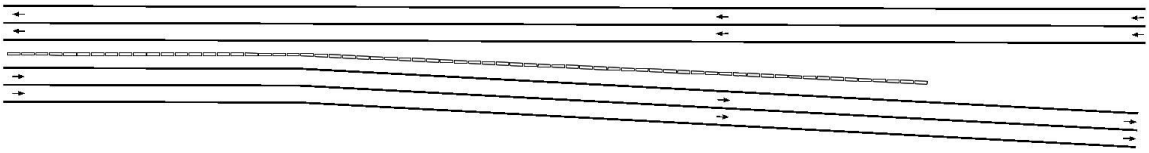
constructability (such as size, weight, pre-cast or cast-in-place), and long-term maintenance.

For converging or diverging longitudinal barrier runs, see Figure 11-5 Barrier Transitions at Median Width Changes, consideration should be given for accumulation of debris and pockets of water between the barriers. To reduce the need for field maintenance or damage from freeze-thaw cycles, where median concrete barriers are used, this may require weep holes in the base of the barrier for drainage, and barrier caps between barriers and piers to prevent water and debris accumulation. Longitudinal transitions for concrete barrier require special design details.

Figure 11-5
BARRIER TRANSITIONS AT MEDIAN WIDTH CHANGES



For specific details, see the Bridge Design Detail Sheets at https://www.dot.nh.gov/about-nh-dot/divisions-bureaus-districts/bridge-design/bridge-detail-sheets



Typical Barrier Termination in wide median, high speed areas outside the clear zone.
In this case, the barrier follows one barrel of the roadway until the barrier is outside the clear zone for opposing traffic.

Impact Attenuation Devices/Crash Cushions

Crash cushions and impact attenuation devices are protective devices attached to, or placed prior to, a rigid barrier (i.e., median barriers, roadside barriers, bridge railings) or other fixed objects such as bridge piers. The function of these devices is to gradually decelerate a vehicle to a safe stop for head-on impacts and by redirecting a vehicle away from the fixed object for side impacts. These devices are designed to reduce the intensity of head-on impacts, while accommodating redirection for side impacts. Impact attenuation devices, like longitudinal barrier systems, must be designed to either redirect or safely cushion angular impacts up to 25 degrees. These devices are used in permanent and temporary construction applications.

Permanent impact attenuators are costly, complex systems that require intricate maintenance. Therefore, emphasis is placed on using them only after careful consideration.

Some highway features, which may qualify for installation of impact attenuators, are:

- Narrow median crossovers;
- Exit gores and diverges with insufficient recovery area; and
- Bridge piers, railings, abutments and other hazards within the clear zone.

An appropriate attenuation system for a given site is selected after considering the following:

- Temporary versus permanent application;
- Type, width and location of the hazard;
- Space available for the installation of the system;
- Cost of installation and maintenance;
- Ease or difficulty of accessing and restoring the system after impact; and
- Manufacturer's recommendations (e.g., sand and or water filled barrels will not perform in a New England winter).

Another special use for crash cushions is for the protection of construction and maintenance personnel as well as motorists in work zones. The devices used for construction activities are typically only in place for temporary durations, typically do not require special concrete anchor systems, and are more modular and portable.

Truck mounted attenuation devices (TMAs) are typically for short term or mobile work operations. TMAs are crash tested to accommodate a vehicle impact into the rear of the attenuation device mounted to the truck and are not crash tested for side impact redirection. TMAs should not be used as a substitute device for impact attenuators and or crash cushions in front of concrete barrier or guardrail. For additional information on the placement, acceptable uses, and appropriate test level of TMAs, see the *Roadside Design Guide* (9), *Manual for Assessing Safety Hardware* (MASH) (11), *NHDOT Positive Protection Guidance for Work Zones* (14), and in manufacturer's design criteria.

Consult the *Roadside Design Guide* (9) before recommending the type of cushion for a particular location. The actual selection of the type of attenuator as a bid item should be carefully considered and reviewed for approval. Since most impact attenuators are proprietary, a "performance specification" is usually written by the Bureau's Specifications Section that identifies the criteria that must be achieved for the product to be acceptable. This practice promotes competitive bidding while satisfying the safety requirements of the design. For additional information on Special Provisions, Specifications, and Proprietary Items, see Chapter 13, "Plans, Specifications and Estimate".

Redirective, Non-Redirective, Gating, and Non-Gating

Terminal units and impact attenuation devices may exhibit redirective and/or non-redirective characteristics. Redirective components of devices will redirect the vehicle when impacted if the system is struck on the side. The non-redirective components of devices will either decelerate a vehicle to a stop when impacted at the beginning of the system or break away when impacted along the side of the system to the point where redirection occurs. When the device is impacted at the beginning of the system the vehicle continues in approximately the same direction it was traveling prior to the impact. The redirective and non-redirective characteristics are unique to each system. As an example, the energy absorbing terminal

(EAGRT) displays both redirective and non-redirective characteristics. A vehicle impacting an EAGRT typically at or past post 3 (in the direction of travel) will likely result in a redirective impact. A vehicle impacting an EAGRT at the impact head will likely result in a non-redirective impact. Impact attenuators can display similar characteristics.

Gating systems, similar to non-redirective systems, allow vehicles impacting near the beginning or nose of the system to pass through the unit and travel behind the system. Non-gating systems are designed to capture and absorb the energy of the vehicles striking the system at the end or on the side of the device. Impact attenuation devices can be gating or non-gating systems depending on the location of impact. All existing guardrail terminal units are considered gating systems. Redirective gating systems typically have some type of anchor system. A sand barrel array is an example of a non-gating, non-redirective system and is designed to be wider than the system to be shielded.

Temporary Traffic Control Barrier

Traffic control barrier is typically used in a temporary application in construction zones to protect the motorists and workers. This temporary traffic control barrier consists of longitudinal barrier such as w-beam guardrail, steel barrier, concrete barrier, etc. Cones, barrels and flexible delineators are not considered traffic control barriers; these are considered traffic control or channelizing devices that have no redirective capabilities.

When selecting a barrier system consideration should be given to work zone speed, the offset to the worker and equipment within the work zone, complexity of traffic control, duration of use, construction phasing (ability to reset within the contract), and any offset to a hazard (i.e., vertical drop off). The horizontal placement of the temporary traffic control barrier within the work zone should accommodate the expected barrier deflection without impacting workers, equipment or other vehicles.

Portable concrete barrier has been the typical longitudinal barrier used on construction projects because of the ability for re-use during multiple construction phases, limited maintenance requirements, ease of use, and limited deflection. The use of longitudinal w-beam guardrail as temporary barrier may be considered where the construction phase is a longer term duration that spans one or more construction seasons and where the guardrail posts would not be installed in the ultimate select material base course. For example, the use of temporary longitudinal w-beam guardrail may be used in temporary traffic control diversions such as crossovers, temporary widenings, or temporary bridge diversions.

The designer should evaluate the ability to use a contractor's option barrier when specifying temporary traffic control barriers. Multiple temporary traffic control barriers may meet the needs of the project, allowing the use of contractor's option provides flexibility in the choice of system and could result in a more cost effective solution. If this is the case, the designer may choose to use a contractor's option specification, which allows the use of temporary guardrail, temporary concrete barrier, or temporary traffic control barrier that is compliant with the crash test standards for the application and deflection requirements.

Portable Concrete Barrier

Temporary portable concrete barriers are widely used in work zones to shield motorists as well as workers. These barriers are free standing, precast concrete segments ranging from 10 feet to 30 feet in length, with built-in connecting devices. The amount of deflection

experienced with a concrete barrier is dependent upon the length of the barrier and the connection between the concrete barrier sections. Many projects could still be using the older NCHRP-350 standard portable concrete barrier (PCB), 10-foot long "Jersey-Shape" barrier with a 3-loop connection, (see the *Standard Plans for Road Construction* (12), GR-23). This barrier saw up to 6 feet of deflection in NCHRP-350 testing.

Beginning in 2030, approximately 25% of the construction projects to be advertised will require the use of MASH compliant PCB (see the *Standard Plans for Road Construction* (12), GR-24 & GR-25) and the requirement will increase incrementally until the 2034 construction season, when all new construction projects will specify the use of only MASH compliant PCB. MASH testing saw deflection of up to 5.3 feet for this barrier.

MASH compliant PCB, or temporary barrier, other than the state standard (see the *Standard Plans for Road Construction* (12), GR-24 & GR-25) may be used on a project-by-project basis, with approval of the Engineer, and only if documentation of its MASH-compliance is provided.

With the placement of temporary concrete barrier, consideration for drainage is necessary such that any runoff is not trapped or directed into the work zone or roadway during storm events. Additional consideration is needed if the barrier is to be used in the winter months when the slots beneath the barrier could clog with ice. Further considerations may include the use of larger slot openings at the base of the barrier, this would allow for alleviating or mitigating the drainage concern, see the Standard Plans (https://www.dot.nh.gov/doing-business-nhdot/contractors/standard-plans-road-construction) for more information of portable concrete barrier. Although the drainage slot barrier has been used within the older NCHRP-350 PCB, there is not a successful crash test for that barrier. This older drainage barrier has one 2" high x 48" long slot per 10' length of barrier. The GR-24 & GR-25 MASH PCB has a drainage slot option now, that passed a MASH TL 3-11 (pickup truck) crash test. A detail should be developed in the near future, which will show two 6" high x 28" long slots per 12.5' length of barrier.

When using portable concrete barrier for construction projects, it is required to illuminate the angle points of the barrier when it is adjacent to the traveled way in the direction of travel. See below for additional information on lighting.

In situations where reduced deflection is needed, accepted practice includes using low deflection barrier, braced barrier, or Texas Restrained Barrier (Texas X-Bolt), which deflects 27 inches and meets MASH TL-3 testing requirements, see *Bridge Detail Sheets* (13), *Portable Concrete Barrier* for details and required layout of the barrier at: https://www.dot.nh.gov/about-nh-dot/divisions-bureaus-districts/bridge-design/bridge-detail-sheets. In any case, the pins or bolts should not protrude beyond the face of the barrier on the side adjacent to traffic. Attaching barrier to a bridge deck is a practice that the Department no longer allows.

Braced barrier has a horizontal metal plate that attaches and overlaps the segments of the barrier over the joints; this brace is on the back side of the barrier from the traffic. Braced barrier reduces deflection to approximately 1 foot. This bracing requires an extension of at least 20 feet past the needed limited deflection area of barrier on both ends of the barrier run to achieve the proper transition.

Guardrail Note Format

For consistency purposes, a standard guardrail note has been developed. Guardrail notes shall be written starting with the end encountered first by the lane of traffic closest to the proposed guardrail. This shall be referred to as the 'approach' end, with the opposite end of the guardrail run being referred to as the 'departure' end. The note shall then follow the order in which the Contractor would install the guardrail and construct any subsequent work, such as curbing.

In order to maintain structure of the note, portions of the note that extend onto additional line(s) shall be indented. (On surveyed projects, stationing should be included within the notes for clarity.)

Standard Guardrail Note:

REMOVE XXX' OF (GUARDRAIL TYPE) GUARDRAIL (INCLUDING TERMINAL TYPE – if applicable)
CONSTRUCT (TERMINAL UNIT TYPE) WITH (PLATFORM TYPE) PER DETAIL XXX' BACK FROM/AHEAD OF/AT EXISTING FIRST POST
INSTALL XXX' OF (GUARDRAIL TYPE – BGR, NU-GUARD-31, etc.) AT EP, OFFSET X' FROM EP, etc.
- Include anything that happens during the longitudinal rail length under the beam guardrail installation line and tabbed in, such as stiffening, long spans, or omitted posts.

CONSTRUCT XXX' OF (CURB TYPE WITH LIMITS OF WORK)
CONSTRUCT (TERMINAL UNIT TYPE) WITH (PLATFORM TYPE) PER DETAIL

Example Guardrail Note:

REMOVE 1,575' OF BEAM GUARDRAIL INCLUDING F TERMINALS
CONSTRUCT TL-2 EAGRT UNIT WITH PREFERRED PLATFORM PER DETAIL 75' BACK FROM EXISTING FIRST POST
INSTALL 1,550' OF BEAM GUARDRAIL 5' FROM EP
CONSTRUCT MIDSPLICE GUARDRAIL STIFFENING AT POLES NHEC 10/81 & NETT 58 (PER DETAIL)
OMIT POST AT CULVERT APPROXIMATELY 400' FROM APPROACH
CONSTRUCT 625' OF BITUMINOUS CURB BEGINNING AT FIRST CATCH BASIN AT APPROACH
CONSTRUCT TL 2 EAGRT UNIT WITH PREFERRED PLATFORM PER DETAIL

Roadway Improvements

Roadway improvements, generally treated as special plan elements, include:

- Glare Screens; and
- Rumble strips/rumble stripes and transverse rumble strips.

Glare Screens

There are many solutions to glare that can be used in different applications such as plantings, fencing, barriers, berms, and glare screens. This section will focus on the use of glare screens. Glare screen use atop the current standard single slope barrier is not as commonly required as with former standard shorter barriers, therefore this item is rarely used.

Glare screens are a way to shield headlight beams from oncoming traffic during nighttime driving conditions. Usually this problem exists on high-speed, high-volume, unlit divided highways with narrow medians, but it can also occur in work zones, at toll plazas, at ramps, and between parallel facilities.

The magnitude and severity of headlight glare depends on a variety of factors including:

- Types of headlight system, which includes the headlight configuration, height of beam, and output intensity;
- Roadway features, which include the roadway alignment, geometrics (e.g., horizontal and vertical curvature), horizontal separation, and pavement reflectance (wet pavement reflects more glare);
- Location (high levels of background illumination will reduce or eliminate glare due to limited eye adaptation);
- Human variables, which include driver's age, visual ability, and state of fatigue; and
- Speed.

The decision to install a glare screen and the type of glare screen to be used requires careful consideration. There have been no specific warrants for the installation of glare screens established, however some factors to consider are as follows:

- Crash history, relative to night time crashes;
- Traffic volumes;
- Construction zones;
- Aesthetics;
- Deterring pedestrian cross over; and,
- Resistance to damage from passing vehicles, vandalism, and environmental loads.

There are combinations of features and situations to which glare screens may be a solution. Glare screens can also be expensive to install and require considerable maintenance due to

the potential for impaired function as a result of snow removal operations, depending on the type of glare screen installed.

To be effective, glare screens should block out all glare from headlight beams of vehicles in opposing traffic lanes. In order to accomplish this ideally, the upper and lower edges of the screen should be set to prevent light from the largest design vehicle from shining over the screen. Conversely, the lower edge must be low enough to prevent light from the lowest design vehicle from shining under the screen. The screen should also block out all light up to an angle of 20 degrees in relation to the centerline of the highway.

Suggested mounting heights and additional information on glare screen applications are found in the *Glare Screen Guidelines*, *NCHRP Synthesis 66* (15).

If glare screens are to be used in conjunction with a barrier, the barrier should be tested with these devices in place.

Rumble Strips/Stripes and Transverse Rumble Strips

The installation of rumble strips/stripes and transverse rumble strips is determined based on the February 5, 2008, guideline entitled "*Guidelines for the Installation of Rumble Strips on New Hampshire Highways*" which was revised on May 22, 2019, see Appendix 11-15, Guidelines for the installation of Milled Rumble Strips/Stripes. The use of the rumble strips/stripes, placement and process for the installation of rumble strips/stripes is contained in this guideline. Further information on the placement and installation of strips/stripes is found in the *Standard Plans for Road Construction* (12).

The design and installation of rumble strips/stripes should consider the road users such as motorists, and bicyclists. Rumble strips are most effective when they are used sparingly and catch the user by surprise. They should not be used as traffic calming devices and should be used as a last resort after other conventional traffic devices have failed.

Until recently, new installations of rumble strips/stripes were not typically installed on a project by project basis as the cost for mobilization for this activity was high. The work effort is very specialized and there were limited contractors throughout the country that performed this work. Since this is becoming a more prevalent treatment there are more contractors that perform this work, if a project removes rumble strips/stripes it will replace the rumble strips/stripes under that project. In addition, there is an annual statewide rumble strip project advertised to install rumble strips throughout the state.

When there are existing rumble strips or stripes on a project, and they will be removed as a part of the project scope due to the nature of the work, (i.e., repaving or reconstruction of the roadway) then bid items may need to be added to the project to account for their removal, depending on the work to be performed, or the phasing of the construction. Consideration should be given to the traffic control phasing, and if it is required to fill or remove the rumble strips to accommodate traffic.

Considerations should be given to the reflective damage in the pavement caused by the rumble strips or transverse rumble strips if they are removed. Pavement cuts reflect into the new pavement, and although they can be cold planed and repaved, there will typically always be a residual rumble strip left in place. Using permanent rumble strips in a temporary application should be avoided.

Traffic Operations

Traffic operation is improved through the use of street lighting, traffic signs, signals, pavement markings, Intelligent Transportation Systems (ITS), and Road Weather Information Systems (RWIS). Street lighting is typically designed by the Design Services Section of the Bureau of Highway Design. Traffic signs, signals and pavement markings are designed cooperatively by the Bureaus of Traffic and Highway Design. If consultants prepare the plans, either the consultant will provide the design of the signs, signals and pavement markings and the Bureau of Traffic will review it along with design staff, or the consultant will provide a base plan to the Bureau of Traffic who will provide the design to the consultant to incorporate into the plans. ITS and RWIS designs are provided by the Bureaus of Transportation Systems Management and Operations (TSMO), Materials and Research and Bridge Design. See Chapter 2, "Project Development", regarding submittals to the Bureaus of Traffic and TSMO for these devices. See also the *Bridge Design Manual* (6)*, Chapter 10.6* for additional information on coordination for IT systems.

There are instances where the contractor will design the Traffic Control Plan (TCP) as a part of the project. This is very rare, therefore this section is intended to identify and guide the designer, so the contractor's obligations and requirements are not identified here.

The stipulations of the TCP, including detours, construction signing, and operational Smart Work Zones (SWZ) are components of the plan designed to promote safe travel while the project is being constructed (see the sample TCP narrative in Chapter 13, "Plans, Specifications and Estimate"). The permanent signs, signals, pavement markings, and other devices installed as part of the project or by the Bureau of Traffic, will provide traffic control after the project is completed.

All traffic control devices should be in conformance with the latest edition of the *MUTCD* (2) as adopted by the Department as Policy #402.01, and Policy #402.06 Flagger and Uniformed Officer Use in Work Zones (Policy and Guidelines) see: https://mm.nh.gov/files/uploads/dot/remote-docs/flagger-police-use-policy.pdf https://mm.nh.gov/files/uploads/dot/remote-docs/flagger-police-use%20guidelines.pdf.

Street Lighting

The primary objective of street lighting is to increase highway safety. Lighting enables the driver to determine the geometry and condition of the roadway at extended distances, thereby simplifying the task of driving. This, in turn, increases driver comfort level and reduces driver fatigue. The use of different light sources or types of luminaires should not be mixed in a common area since it may create an irregular light pattern and be distracting to the driver. Considering the improved retroreflectivity of signs and pavement markings and better automobile headlights, the need for street lighting has reduced.

The Design Services Section of Highway Design normally provides the lighting design. However, if a consultant is involved, the consultant may design the lighting, and Design Services will review it before it is included on the final plans. Early in project plan development, a set of plans and cross sections should be furnished to Design Services to determine the need for roadway lighting and to conceptualize the preliminary lighting layout. When roadway (and bridge) plans (including traffic control plans) have progressed to near PPS&E stage, the lighting design is finalized in coordination with the utility pole relocation

needs and signal work, if involved. The information is then added to the plans. Lighting quantities, e.g., conduit, pull boxes, concrete light pole bases, and in some instances light poles, are computed by the highway (or bridge) designer or the consultant. The lighting quantities are placed in the Lighting and Conduit summary table; see the Highway Design Manual, Volume II for an example. See Chapter 9, "Utilities", for the procedure flow diagram.

Normally, permanent roadway lighting is installed under a Utility Agreement between the electric utility involved and the State, this should be included as a line entry in the estimate, see Chapter 13, "Plans, Specifications and Estimate", for additional guidance on the estimate process. The roadway/bridge contractor usually installs the conduit, pull boxes, and light poles bases and, in some instances, light poles as part of the roadway/bridge project. The electric company erects the light poles, mast arms, luminaires, installs the wiring, and energizes the lights under the Utility Agreement.

If the lighting plan is to be a separate project, the Design Services Section will initiate the proposal documents and coordinate with the Contracts and Specifications Section for advertising. This is a rare occurrence.

When future roadway lighting is being considered through a project area, it may be beneficial to install the conduit and pull boxes as part of the project, thereby avoiding the future expense of disturbing the pavement, curbing, and other features of the new construction.

Lighting design must also incorporate safety considerations within the system itself. For instance, the placement of (aluminum) lighting standards (light poles) should not constitute a hazard to errant vehicles. The use of breakaway connections between the light pole and the base generally will suffice to ensure a safe design.

High-mast lighting had its advantages, particularly in urban interchange and surrounding areas. The concept was to elevate the light source high enough, and make it sufficiently bright, in order to replace many other lights mounted at conventional heights. The high-mast lighting was a high energy user with inefficient light. The increased efficiency of today's luminaires, and the use of LED lighting instead of high-pressure sodium lighting also provides the additional benefit of reduced energy consumption for a comparable level of lighting. The current practice is that the Department no longer installs high-mast lighting.

Lighting should provide the intended benefits while not creating adverse effects, e.g., to the environment. Lighting is an advantage to the driver in rural areas, but "spill-over" light can have undesirable environmental effects in terms of "light pollution". Urban street lighting is generally desirable for both pedestrian and vehicular movements, but there may be instances where excessive light adversely affects the living environment.

In 2009 the New Hampshire Legislature modified Chapter 9 of the State Statutes by adding Title I, Chapter 9-E: Sections 1 – 5; Outdoor Lighting Efficiency, which requires the Department to revise its lighting design standards and establish new reporting criteria for all outdoor lighting that is funded by State monies. See the NHDOT *Utility Accommodation Manual (UAM)* (16) for additional information on the Lighting Policy, and cost responsibilities for installation, operation and maintenance.

Traffic Control Devices

Traffic control devices are defined by the *MUTCD* (2) as "a sign, signal, marking or other device used to regulate, warn or guide traffic, placed on, over, or adjacent to a street, highway…". The placement and use of traffic control devices should be uniform such that they provide a consistent message.

Traffic control devices can be temporary or permanent in nature. See below for additional information on permanent installations, and the section on Maintenance of Traffic below for temporary installations.

Signs and Pavement Markings

Permanent traffic sign and pavement marking designs are normally prepared by the Bureau of Traffic or a consultant to be included into the project plans.

It is often a misconception that the Bureau of Traffic is responsible for roadside delineation. Quantities for roadside delineators and barrier delineators are estimated by the designer according to guidelines in the NHDOT *Standard Plans for Road Construction* (12). (See also Chapter 8, "Quantity Computations", for additional information regarding calculating these quantities.)

Signs to be erected and pavement markings to be applied are shown on the plans whether the work is performed by the contractor as part of the project, or by the Bureau of Traffic. It is a rare occurrence that the Bureau of Traffic installs signs or pavement markings on a project.

The pavement marking designs should consider the use of thermoplastic, paint, or other marking types based on the current Bureau of Traffic Guidelines.

Early coordination with the Bureau of Traffic is essential to avoid delays in obtaining information, particularly where overhead signs or other special designs are required that may affect others, e.g., the Bureau of Materials and Research is involved to provide subsurface information for the foundations, and the Bureau of Bridge Design is involved in overhead sign structure and foundation design. See the *Bridge Design Manual* (6)*, Chapter 10.3* for information on coordination for overhead sign structures.

In addition to coordination responsibility, the designer should check sign locations for interference with other highway features, for vehicular safety, sight distance, and for right-of-way (ROW) implications. All signing installation, permanent or temporary, must comply with the *MUTCD* (2). It is important to note that adequate space (within the ROW) should be provided for sign placement and maintenance that does not interfere with pedestrian accommodations or extend beyond the ROW (e.g., 2 feet behind the sidewalk in the utility strip is not wide enough to install a typical 36" warning sign).

Signs are required to be placed on all overpass bridges and signal mast arms indicating the street names. See the *Bridge Design Manual* (6)*, Chapter 10.4* for information on bridge mounted signs.

Include Overhead Sign Structure Inspection costs in the estimate for projects that install overhead sign structures. See Chapter 13, "Plans, Specifications and Estimate", for additional guidance on the estimate process.

Signals

Traffic signal design is provided by the Bureau of Traffic (or a consultant) and is included in the final plans by the lead bureau (Highway Design or Bridge Design). Coordination between the Bureaus of Bridge, Highway Design and Traffic is maintained throughout design and particularly when assembling the plans with other elements for final review.

As part of the request for the Geotechnical Report, the preliminary signal pole locations are identified on the plans and forwarded to the Bureau of Materials and Research to determine the type of signal foundation(s) to be used, and whether there should be any deviation from standard practice when installing the foundation(s).

The designer should be concerned with the visibility and placement of the signal heads as well as the signal pole(s) and mast arm(s). For example, the signal heads should "line up" with the center of the traffic lane they control, be properly located longitudinally from the stop bar, and not be obstructed such as by utility wires, or overhead bridges, see the *MUTCD* (2) for specific distances and cone of vision requirements. Consideration should also be given to the available sight line to the signal head. For example, if the signal is placed on the inside of a sharp curve, consideration should be given to the placement of a signal head on a pedestal mount or on the back of an adjacent pole to give more advance notice of the signal. Intersection geometry should be designed to minimize the need for such measures.

Signal poles, controller cabinets, traffic signal conduit, and vehicle detection must be located preferably within the right-of-way or, at a minimum, within a permanent easement. The placement of the poles is also contingent upon the location of the sidewalk, if applicable, and the push buttons location for pedestrian activation that needs to be within reach of an accessible user from the sidewalk, see *NCHRP Research Results Digest 278* (17) for additional guidance on the placement of pedestrian push buttons.

In some instances, pedestrian signals may be desirable for locations such as roundabouts, however these are not required. Consult with the Bureau of Traffic for signal requirements.

To minimize the required length of mast arms, signal poles are often intentionally placed within the clear zone without barrier protection. The typical rule of thumb for placement of traffic signal mast arms is 10 feet beyond the edge of pavement without curbing and 7 feet beyond the edge of pavement with curbing.

The signal mast arms have a length limit beyond which a different size foundation is required. Adding the weight of street lighting or a traffic sign to a signal pole may also require changes to the foundation. For additional information regarding specific design elements, and limiting criteria, see the Traffic Signal Mast Arm Foundation Standards. If the design exceeds the criteria included in these Standards, Bridge Design should be consulted for modifications that may be required. Note that mast arms are typically in 5 foot increments.

The signal design should also include road name signing on the mast arms, fire pre-emption devices (if requested by the municipality), and any necessary interconnection between the signals based on intersection spacing. The municipality requesting the pre-emption is responsible for the maintenance of the pre-emption equipment once installed, even if it has been installed as a part of the project. A separate municipal agreement is not needed for

Opticom devices; see Appendix 11-16 (Fire Lane Preemption Systems Memo) for additional information.

The preparation of Traffic Signal Plans is preceded by a capacity analysis (see Chapter 5, "Geometrics") and an examination of the qualifying signal warrants described in the *MUTCD* (2). The decision to install a signal is based upon a signal warrant analysis. The design of the intersection geometrics is based upon the capacity analysis. The intersection geometrics and the signal layout must be complimentary. It is essential that they be designed together, although separate plan elements will be assembled in the contract plans. In some cases, conduit and pull boxes may be installed at intersections for future signal installation, as with lighting, to avoid the future expense of disturbing pavement, curbing and other features of the new construction.

Shop drawing review and final installation inspection is performed by the Bureaus of Traffic and Bridge Design.

Intelligent Transportation Systems (ITS)

The Bureau of Transportation Systems Management and Operations (TSMO) is responsible for establishing, designing, deploying and maintaining the Intelligent Transportation Systems (ITS) throughout the State. The purpose of ITS devices are to improve the Department's situational awareness and to improve mobility on the State's highway corridors when delays occur due to unplanned incidents, planned construction events, weather related events, and recurring congestion. From a Project Development standpoint, the goal of this bureau is to design and install ITS devices at key locations where recurring incidents are prevalent in order to establish a statewide architecture that works as the framework to interconnect the roadway user to the roadway and traffic conditions through the Transportation Management Center (TMC) via hardware and software. For example, the TMC uses traffic cameras to view roadway problems, which are then conveyed via dynamic message boards to alert motorists of potential situations.

Utility verification of ITS devices is not the responsibility of the Design Services Section of Highway Design. This effort is the responsibility of the TSMO.

ITS is an ever emerging and growing area, especially as technology evolves. It is easily defined as one transportation-related system communicating electronically with another system (now or planned in the future).

The layout and planning of ITS needs to occur early in the design process to accommodate the design and placement of various ITS infrastructure features. These structures can be large items such as overhead sign structures and camera poles that require coordination with other Bureaus such as Bridge Design, Materials and Research, Right-of-Way, Environment, Rail & Transit, Aeronautics, Traffic, Turnpikes, or Districts. For projects involving state-owned park-and-rides or bus terminals, the Bureau of Rail and Transit must be consulted. Other ITS infrastructure can be as simple as fiber optic signal interconnection. See Chapter 2, "Project Development", for the timing of, and requirements for, the coordination with the Bureau of TSMO.

ITS devices are specialized items that can be quite costly and require specialized contractors to install. For this reason, in order to determine the most cost effective solution, there is an ITS funding approval process to determine if the requested ITS devices will be installed as a

part of a project, or if these devices should be a standalone project. When a construction estimate for ITS devices (including all conduit, devices, and inspections) exceeds 1.5% of the construction costs for a non-stand-alone ITS projects, it requires the approval of the Director of Project Development (see Appendix 11-17, ITS Mainstreaming Funding Approval Process).

Some examples of ITS devices include Road Weather Information System (RWIS) (see below for additional information), Dynamic Message Signs (DMS), Closed Circuit Television (CCTV), Variable Speed Limit signs (VSLs), and Motor Vehicle Detection Systems (MVDS). RWIS are used to collect weather information, DMS are used to convey various forms of safety messages, CCTVs allow for situational awareness, VSLs are used to change speeds when appropriate for different driving conditions, and MVDS provide valuable real time speed and volume data. The Department has numerous ITS devices throughout the State. All of these devices and other sources of information all feed into the Department's Advanced Traveler Management System (ATMS), which is the platform that allows the flow of mobility information from all parts of the Department to be shared with the public.

All projects need to submit an ITS Initial Request Form https://nhtmc.com/Assets/Documents/forms/ITS%20Project%20Checklist%20-%20System%20Engineering%20and%20Architecture%20Compliance.docto the Bureau of TSMO prior to going to the Traffic Control Committee. TSMO will then determine if there are any existing ITS devices within the limits of a project that could be impacted, or if new devices will be added within the project. Design Services is responsible to perform the utility verification as it relates to the installation of new ITS devices, but does not verify the location of existing devices, conduits, fiber, etc. The designer should coordinate the required action with the Bureau of TSMO as early as practicable so that the appropriate funding can be added to the project should ITS be proposed.

Road Weather Information System (RWIS)

The Bureau of Transportation Systems Management and Operations (TSMO) is responsible for establishing, designing, deploying and maintaining the Road Weather Information Systems (RWIS) throughout the State.

FHWA defines a RWIS as being "comprised of Environmental Sensor Stations (ESS) in the field, a communication system for data transfer, and central systems to collect field data from numerous ESS. These stations measure atmospheric, pavement and water level conditions. Central RWIS hardware and software are used to process observations from ESS to develop nowcasts or forecasts, and display or disseminate road weather information in a format that can be easily interpreted by a manager. RWIS data are used by road operators and maintainers to support decision making."

Maintenance of Traffic

Maintenance of Traffic is becoming a bigger part of construction projects. The designer should consider and be aware of all the issues involved throughout the design and construction of the project. There are also many resources for Work Zone Safety on the NHDOT webpage https://www.dot.nh.gov/doing-business-nhdot/engineers-consultants that should be reviewed.

Traffic Control Committee Review and Level of Significance

The Traffic Control Committee (TCC) is a committee comprised of members of many NHDOT Bureaus, as well as FHWA. The committee is tasked with providing greater awareness of work zone safety and mobility issues, and functions in accordance with the NHDOT Policy #601.01 – *Guidelines for Implementation of the Work Zone Safety and Mobility Policy (18)* written in reference to the FHWA published Work Zone Safety and Mobility Rule in the Federal Register (69 CFR 54562). The policy is located at: https://mm.nh.gov/files/uploads/dot/remote-docs/work-zone-safety-policy.pdf

The committee is tasked with four major objectives: providing work zone safety and mobility training for Department staff; compiling relevant safety and operational data and information; reviewing the process for improvements; and reviewing Transportation Management Plans (TMPs) for each project.

To meet the compilation of data requirement, the committee performs such tasks as reviewing work zone crash reports; completing daytime and nighttime reviews of traffic control plans in action (in the field); performs evaluation of tools and policies; reviews TMPs; and reviews of Traffic Control Standard Plans, (https://www.dot.nh.gov/doing-business-nhdot/contractors/standard-plans-road-construction).

To improve the process and to develop TMPs for each project, the committee meets to review the proposed traffic control plan for all projects receiving federal-aid highway funding, and those receiving state-aid funding (including Betterment Projects and Turnpike Projects); an exception is those projects that qualify under the presentation exemption for the TCC, see Appendix 11-18.

The projects that do not qualify for a presentation exemption are required to be presented to the TCC through the various stages of design, including early in the Preliminary Design, at the end of Preliminary Design, in Final Design, and Post Construction. As the projects progress in design, the designer is required to submit a memorandum to the chairperson (the NHDOT Assistant Director of Project Development) detailing the project and specific criteria. This is used to assist the TCC in the determination of work zone significance and includes information such as the nature of the work, duration, traffic volumes, regional significance, roadway type (see Appendix 11-19 for the TCC Memorandum Template). Submission of the memorandum signifies a request to be placed on the TCC agenda for project review.

The TCC memorandum requires that a "Construction Work Zone ITS Needs Assessment" for temporary ITS during construction and a "Permanent ITS Installation Assessment" are completed prior to the TCC meeting. The turnaround period for these reviews is a minimum of 30 days. See Appendix 11-20 and TSMO's webpage for additional details and forms.

The designer is required to present details of the project primarily relating to the proposed traffic control plan. The committee then determines the level of significance for the project, which dictates the major strategy components that will be required as part of the Traffic Control efforts. If the project is deemed "significant", a formal Transportation Management Plan (TMP) or detailed memorandum is required (see the Transportation Management Plan section below). A "significant" project is one that alone, or in conjunction with other projects, is anticipated to cause sustained work zone impacts. The levels of significance, and project implications, are as listed below:

- Presentation Exemption:
    - A written TCP will be provided in the Proposal by the designer.
- Non-Significant:
    - A written TCP will be provided in the Proposal by the designer.
- Significant, Level I (see the instruction for Level I and Level II TMP Development, Appendix 11-21)
    - A written TCP will be provided in the Proposal by the designer.
    - A separate TMP document will be developed and will include a detailed discussion of the three TMP components: TCP, Transportation Operations, and Public Outreach.
    - The Project Manager or Project Lead will be required to present the TMP to the TCC.
    - This is a living document that will require revisions during construction and monitoring.
    - This approved documents (signed and dated by the TCC Chair) will be made available during the bid period for informational purposes.
- Significant, Level II (see the instruction for Level I and Level II TMP Development, Appendix 11-21, and Appendix 11-22 – Draft Level II Significance memorandum):
    - A written TCP will be provided in the Proposal by the designer.
    - A detailed memorandum will be developed by the Project Manager or Lead Person that includes a discussion of the three TMP components: TCP, Transportation Operations, and Public Outreach.

Transportation Management Plan (TMP)

The major strategy components for a Transportation Management Plan (TMP) are determined by the Traffic Control Committee (TCC). The TMP contains some or all of the following components, based on the level of significance. The following definitions are an excerpt from *NHDOT Policy #601.01* (18):

- Traffic Control Plans (TCP) – provides detailed construction sequencing as well as illustrating measures that will be used to help guide and direct road users through a work zone.
- Transportation Operations (TO) – identification of strategies that will mitigate impacts of the work zone on the Transportation Network. Example strategies may include Intelligent Transportation Systems (using existing ITS) devices, employing Smart Work Zones (SWZ), revised traffic signal timings, and coordination with the Transportation Management Center (TMC).
- Public Outreach (PO) – communication strategies that inform affected road users, the general public, area businesses, and appropriate public entities about the project.

A (Significant, Level I) TMP is a formal, structured, living document that should be reviewed and updated as necessary. The document contains components such as (see *NHDOT Policy #601.01* (18) for the complete list and description of each item):

- Introductory materials (cover page, table of contents, lists of tables and figures, etc.);
- Executive summary;
- TMP roles and responsibilities;
- Project description (project constraints, phasing, construction schedule, etc.);
- Existing and future conditions;
- Work zone impacts assessment report (selected work zone management strategies and crash reporting criteria, etc.);
- TMP monitoring;
- Public information and outreach plan;
- Incident management plans;
- TMP implementation costs (this should not be included in the version posted with the bid proposal package);
- Special considerations; and
- Attachments.

The TMP documents created by the design staff or consultant and are available for viewing (without the estimated costs) as a part of the bid package; however, it is implemented and monitored by the Bureau of Construction and the TMP Manager. The Bureau of Construction should be part of the team that develops and reviews the TMP. This is to ensure the strategies are feasible and everyone is in agreement with the needs and design, and that all appropriate items and quantities are included in the construction plans and appropriate bid items.

It is an FHWA requirement that the entire TMP be evaluated by the TMP Team Leaders and core group (e.g., TMP Manager, Bureau of Construction, Project Manager, etc.) at least every other year and at the completion of the project. The results of this review should be a part of the final review with the TCC. Although it is not a requirement to review TMPs on non-Federal projects every two years, it is a good business practice that should be followed.

Traffic Control Plan (TCP)

The Traffic Control Plan (TCP) narrative, prepared by the designer, is included in the Proposal and describes the manner in which traffic will be maintained through the project, and contains specific information about control of the traffic operations. This document compliments Section 619 of the Standard Specifications titled Maintenance of Traffic. This document is developed from the "Base TCP" that is maintained and regularly updated by the Specifications Section. This document has several examples of the common traffic control requirements. See Chapter 13, "Plans, Specifications and Estimate", for additional guidance on the development and requirements for the TCP narrative.

The remainder of this section refers to the development of the traffic control plan sheets and the phasing concept, even if separate TCP sheets are not included in the Plan set.

It is important that a conceptual TCP, including any required plan or cross section work, is developed early enough in the design stage to identify ancillary issues that may require follow-up such as, Right-of-Way acquisitions, wetland impacts, utility relocations or the need for a temporary detour, a temporary diversion (roadway and bridge) or temporary widening(s). Any changes requiring additional right-of-way (ROW) easements or wetland impacts should be identified at the Preliminary Design stage. This is especially important if a Public Hearing is required, in which case, the easements must be shown on the Public Hearing plan and the environmental impacts must be shown in the environmental document. Other items that should be considered are: the permanent and construction speed limit determinations through the Bureau of Traffic, this could determine the length of the overall work zone; determining minimum roadway widths and vehicle sizes; temporary drainage, as it may involve information necessary to be shown on the Wetlands Permit application; impacts to existing lighting and the need for temporary lighting, which may involve a utility agreement; and, coordination with the communities involved if it is necessary to detour traffic over local roads. Detouring traffic over local roads should be avoided, if possible, as it may involve localized roadway improvements to allow for truck turns at intersections, or to address the pavement condition on the detour route to prepare it before it is used or repair it after it is used.

When designing the TCP, consider all elements of the phasing such as the season, worker location, access or egress, staging areas, bicycle travel, pedestrian access, traffic direction, traffic control (TC) devices, and temporary drainage.

When designing, consider that a particular phase may be in place over the winter, so adequate width for snow storage and removal must be considered. Note that some devices, such as sand barrels filled with water, will not function in winter.

When determining placement and type of longitudinal barriers to be used, consideration should be given to: the deflection of the barrier to provide adequate space for workers if the barrier is impacted; provisions for the zone of intrusion; and the direction of traffic in a lane with any necessary modifications that may be needed. (See the Temporary Traffic Control Barrier Section above.) For example, if there is an interstate project that will use a median cross over diversion, such that traffic is going in the opposite direction that the roadway was designed for (contra flow), then the guardrail terminal units will need to be changed and the lengths of need for rail should be reviewed. Additionally, if there is existing guardrail, the splices (overlaps) will need to be reset such that there are no snag points on the face of the guardrail.

Temporary drainage should be considered for each TCP phase and should accommodate TC device scenarios such as barrier. Temporary drainage placement should consider the ultimate condition (e.g., the design should avoid placement of temporary drainage structures in the ultimate roadway layout if possible).

If concrete barrier is to be used as a longitudinal device, consideration for the water flow through the base of the barrier should be considered. Temporary concrete barrier typically comes in three types: with no slots in the base, with two slots on the base (where a fork lift may pick up the barrier), or with one wide slot. Each has a purpose depending on the

situation. For example, if it is desired that water not flow under the barrier (say, to keep a work area dry), then specifying a barrier without slots in the base or blocking the holes in the base of the barrier may need to be evaluated. Other considerations may warrant a wider slot at the base allowing more flow underneath the barrier to minimize the drainage spread along the roadway.

The traffic control plan should be in near final format at the Slope and Drain phase to allow enough time for coordination with others that may be involved, to address ROW impacts, to address any needed temporary drainage, etc.

The Traffic Control Plans or TCP concept is intended to represent one viable way for the contractor to complete the work within a given time frame. This concept is further used to estimate quantities, and cost for traffic control. This is not intended to dictate the Contractor's means and methods. This is also likely not the only viable means of construction. The Contractor has the option to request a Variation From the Traffic Control Plan, as noted in the last line of the TCP narrative. All such requests must be submitted in writing and are reviewed by the District Construction Engineer. When a significant variation of the TCP is requested, the designer may be contacted for input and at times, a project specific TCP Committee (composed of a representative from Construction, Highway Design, Bridge Design and Traffic) may convene to review the request. As Variations from the Traffic Control Plan are allowed, these variations to the TCP are not considered Value Engineering Proposals.

Incident Management Plan (IMP)

An Incident Management Plan (IMP) is intended to be a planning tool to develop alternatives for traffic control scenarios prior to incidents occurring so they can quickly and easily be deployed in the event of an incident. These predetermined planning scenarios are intended to cover a range of situations for road or bridge closures, and are typically based on different time frames for incident clearance intervals and the numbers of lanes affected, if not all lanes. The IMP includes lane closure or detour routes and required operational devices (e.g., signs or channelizing devices). In some instances, IMPs are developed and operational controls are staged in trailers or small structures in close proximity to the needed location awaiting deployment.

IMPs have been developed for many high vulnerability, high risk assets, and integral routes; copies of these plans are provided to the Bureaus of Highway Maintenance/Turnpikes) and TSMO. (Highway Maintenance/Turnpikes needs these plans to set up necessary traffic control devices, if needed, and TSMO needs them to establish messages and detour routes through the use of ITS devices). The routes with existing IMPs were selected based on locations which may or may not have an easy detour route, may have limited redundancy in the event of closure, have high traffic volume, or are high profile routes. The IMPs were typically developed in conjunction with reconstruction projects in the area of concern.

IMPs are developed and reviewed in conjunction with Highway Maintenance or Turnpike Maintenance staff, traffic operations personnel, and incident responders.

There are two applications for an IMP. The first is noted above for incidents that occur under normal traffic operations, and is called an Incident Management Plan (IMP). The second application is used for work zones, and is called a Work Zone Incident Management Plan

(Work Zone IMP). The Work Zone IMP can be used in instances with or without a pre-existing IMP.

When a Work Zone IMP is developed for a project with a pre-existing IMP, the IMP should be used as the basis for the Work Zone IMP. The designer is required to ensure that the proposed traffic control phasing will work in concert with these IMPs, otherwise, new plan scenarios need to be developed prior to the start of the work. If there are, or are not, any revisions to the plans, the designer should still coordinate with the maintenance personnel, traffic operations personnel and incident responders to discuss how, or if, the work zone will affect the proposed scenarios or incident response. The design will use the same scenarios (closure time frames, detour routes, etc.) and will require inclusions of modifications to match into the traffic control phasing for the construction project. For example, each construction phase will have to be evaluated to determine what, if anything, will need to change in the original IMP to continue with a fluid operation if it is needed during construction or post construction. In some instances, this could mean using temporary median barrier that is not embedded so contra flow traffic could be established quickly.

Consideration for a Work Zone IMP is typically associated with the development of a TMP for Significant Level I projects only. If the Traffic Control Committee requests the development of a Work Zone IMP, the Project Manager should be consulted to set up an interdisciplinary team for that purpose.

Active Transportation and Non-Highway User Facilities During Construction

Maintenance of Traffic during the design and construction of a project should provide continued access through the project area for active transportation (such as pedestrians and bicyclists) and non-highway users at all times once a route is established. The design should provide ADA compliant temporary routes, devices, and connections (e.g., crosswalks, ramps, detectable warning devices) from the existing sidewalk through the temporary route until the new sidewalks are constructed and operational. The temporary facilities shall include accessibility features consistent with the features present on the existing facility. Any revised routes should include installation of the appropriate warning and guide signs such as "SIDEWALK CLOSED" during these closures or detours. Signs shall be placed far enough in advance of the closure to warn pedestrians prior to entering the work zone, see the *MUTCD* (2) Typical Applications 28 and 29 for additional references.

As previously noted, the *MUTCD* (2) language is much stronger: "If the TTC zone affects the movement of pedestrians, adequate pedestrian access and walkways shall be provided. If the TTC zone affects an accessible and detectable pedestrian facility, the accessibility and detectability shall be maintained along the alternate pedestrian path." (Section 6D.01 paragraph 04.)

Oversize, Overweight, Overlength or Overheight Vehicles

When considering proposed roadway lane and shoulder widths and TCP layouts, the designer should consider the types of vehicles that could be traveling through the project during construction.

The Bureau of Highway Maintenance issues oversize/overweight permits to vehicles that require permitting. This effort is in conjunction with any required reviews by the Bureau of Bridge Design for any proposed route that involves bridges. For additional guidance on

oversize/overweight vehicles and permitting requirements, see: https://www.nhdotpermits.org/.

The Department's Oversize/Overweight Permit section issues permits for wider mobile homes up to 16 feet; anything over 15 feet wide is considered a supermove that requires an engineering review. Engineering reviews are performed by the District and Turnpike offices, the Bureau of Traffic, the Bureau of Bridge Design, and the Bureau of Construction prior to issuing a permit.

Annual permits are issued for up to 13 feet 6 inches in height, 10 feet 6 inches in width, and 75 feet in length. Annual permit holders can move loads up to these dimensions without notification to the Department.

See also Chapter 3, "Design Considerations and Criteria", regarding the appropriate design vehicles to be used for design, and those routes that are within one mile of an Interstate interchange.

New England Transportation Consortium (NETC) Route

The New England Transportation Consortium (NETC) is a research cooperative between the state DOTs of Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island and Vermont. The States of New Hampshire, Maine, Vermont and Massachusetts were previously members of the NETC Oversize/Overweight Permit Program. This program allowed one state to issue an oversize/overweight permit for an interstate move in two or more states using NETC routes, with one requirement being that these routes had to maintain a minimum travel way width. Effective November 2013, Massachusetts and Vermont withdrew from the Consortium; New Hampshire withdrew effective September 1, 2017. As such, there is no longer a requirement to maintain a 16-foot wide route on these roadways at all times.

Previously, the minimum required width for an NETC route was 14 feet wide with 6 inches for the eaves. However, it was preferable to provide a little "wiggle" room for the vehicle box if there was a hard obstruction adjacent to the route, such as guardrail or other barrier. Any lane restriction less than 14 feet on an NETC route required notification to the permit office.

Although the NETC routes no longer apply, to determine the minimum required roadway widths to use when designing traffic control plans during construction, consult with the Section Chief and consider coordination with the Bureau of Highway Maintenance's Oversize/Over Weight Program Coordinator and the Traffic Control Committee.

Speed Limits

The design speed for the TCP is determined by the State Traffic Engineer and should appear on the Traffic Control Plan sheets. See Chapter 2, "Project Development", for additional information on when the request for design speed determination should be submitted to the Bureau of Traffic. The speed limit should be determined early in the design process to allow for the appropriate design speed during the ultimate design, to initiate TCP design elements and to progress the traffic control design to near final format by the Slope and Drain submission.

The speed limit can be either permanently or temporarily reduced during construction based on work efforts and traffic impacts. This should be discussed with the Bureau of Traffic as well as with the Bureau of Construction. Although the Commissioner of Transportation is responsible to set the speed limit per RSA 265:62, this task has been delegated to the State Traffic Engineer (the Administrator of the Bureau of Traffic). As a result, the Bureau of Traffic ultimately sets the speed limit. See Chapter 3, "Design Considerations and Criteria", for additional information on speed limits.

Construction Signs and Warning Devices (CSWD)

Traffic is maintained through the construction work zone by using traffic control devices for daily construction activities and for non-work hours. For example, construction signs mounted "permanently" on posts remain in place throughout the duration of the contract. Operational controls such as construction signs on temporary supports (e.g., easels), cones, drums and barricades are used for daily construction activities, all of which are placed according to Part 6 of the *MUTCD* (2) and the "Work Zone Traffic Control Standard Plans" (TC series).

The designer will request the design and an estimated cost of the Construction Signs and Warning Devices (CSWD) from the Bureau of Traffic (or the Consultant if they are responsible for the task). See Chapter 2, "Project Development" for the timing of the request. Highway Design and the Bureau of Construction staff review the recommended "Construction Sign and Warning Device Package" and the worksheets for the Use of Uniformed Officers and Flaggers (Item 618 Calculation Sheets found in Chapter 8, "Quantity Computations"). Changes are made, if necessary, and the costs are revised accordingly. The cost provided for the CSWD is based on the cost of all new traffic control devices. Most contractors own these devices and use them from project to project and replace items only as they become warn or require upgrading. Rarely does the bid price for Item 619.1 – Maintenance of Traffic, reflect the cost of new traffic control devices.

The contractor is responsible for traffic control throughout the construction project. This includes complying with the requirements of the *MUTCD* (2) and using flaggers and uniformed officers appropriately and ensuring they have the proper training.

Smart Work Zone/ITS

A Smart Work Zone (SWZ) System consists of mobile ITS technology that is used to help aid mobility and safety through construction work zones on all types of roadways within New Hampshire. This technology possesses the following general characteristics:

- Real-time: The system obtains and analyzes traffic data in real-time, providing frequently updated information to motorists.
- Portable: The system is portable, hence allowing its installation (with minor modifications as necessary) at different locations.
- Automated: The system operates in an automated manner with as minimal supervision as possible by human operators.
- Reliable: The system provides accurate and reliable information, keeping in mind the serious consequences of misinforming motorists in work zone situations.

These systems are intended to:

- Better inform motorists;
- Inform the driver of expectations relative to delay or changed traffic pattern;
- Improve mobility by encouraging motorists to take alternate routes;
- Provide accurate information;
- Reduce congestion and allow more freely flowing traffic; and
- Clear incidents more quickly, thereby reducing secondary incidents.

All projects need to submit a Smart Work Zone Program Scoring Sheet https://nhtmc.com/Assets/Documents/forms/Smart%20Work%20Zone%20Program%20Scoring%20Sheet.dotm to the Bureau of TSMO prior to going to the Traffic Control Committee. The need for the inclusion of a SWZ in the contract is based on the scoring sheet and review by the ITS Project Manager, the Design Team, and the District Construction Engineer. This should be presented to the Traffic Control Committee during the review of the Level of Significance. If a SWZ is warranted, the design will be completed by the Bureau of TSMO or a consultant.

The use of ITS on construction projects is quite diverse and rapidly changing. Some examples of ITS or SWZ devices used to aid in construction are the Automated Flagger, Portable Message Signs (often with communications to the TMC), variable speed limit signs, CCTV cameras, and portable queue sensors. Some innovational uses of a SWZ include setting up a dynamic late lane merge, providing real time travel times through the work zone, and providing congestion related messages.

Haul Roads and Temporary Roads

Haul road and temporary road designations are used where large amounts of material are trucked to or through the project. The purpose is to limit material haulers to use roads and bridges that can sustain the heavy loads. Haul roads and temporary roads to be designated on a project should be described in the Prosecution of Work, the TCP or shown on the plans. As with the conceptual level TCP, the requirements for and location of haul roads are necessary to identify early in the design of the project because of the ancillary issues that may require follow-up or have special requirements such as environmental constraints.

A haul road could require an access point through a control of access right-of-way, in these instances an access point must be applied for and received, see the Interstate or Turnpike Access Points Section below.

Haul roads and temporary access roads may be eligible for Federal participation; however Federal Funds cannot be used to participate in maintenance or repair of highways under ordinary conditions. See Appendix 11-23 (FHWA Memorandum: Federal Participation on Haul Roads and Detours) for clarification on what is and is not a potentially reimbursable expense.

If a haul road will require the use of an existing roadway, the entity that is responsible for maintaining and operating the facility (municipality, District or Turnpike) should be contacted for their approval prior to inclusion in the design. If approved, there should be a

written agreement between the entity maintaining and operating the facility and the Department to document any agreements made, inspections, final condition of the roadway, etc. The documentation should include all pertinent information including field review time frames prior to and during hauling, the required attendees for the reviews, a standardized inspection report, the final condition of the roadway, etc. This is in addition to the Municipal Work Zone Agreement.

If FHWA is involved in the project, their level of oversight should be considered when developing any agreements, inspection report distributions, attendance at the field meetings, and the review time frames. The final evaluation and inspection of the haul road prior to the first use should occur no later than 30 days prior to use.

Median Crossover Use

Median crossover use by staff working in the field is prohibited by Department policy, see Appendix 11-24.

Median crossover use during construction activities should be addressed as a part of the Prosecution of Work (POW) during the design phase. Communication should occur between design, the Bureau of Construction, and Highway Maintenance (or Turnpikes) if a crossover will be considered during Construction. If it is deemed undesirable or inappropriate for the project, a note should be included in the POW to indicate it will not be allowed on the project. If it will be allowed, include the appropriate Special Attention in the contract, see Appendix 11-25 (Sample Special Provision for the Use of Median Crossovers).

If there are existing crossovers within the project limits, these should be reviewed. This review should include all pertinent parties including Highway Maintenance (Turnpikes), emergency responders, and the police department (local and/or State) as is appropriate. The review should assess the continued need for the crossover and appropriate design controls such as sight distance.

Interstate and Turnpike Access Points

Interstate and Turnpike access points can be permanent or temporary access points. Permanent access points are typically exits, or maintenance access points (not median crossovers). Temporary access points are usually associated with TCP operations for haul roads or construction vehicle access. The addition of any access point or any modification to an existing access point on any interstate or Turnpike facility through a controlled access right-of-way, whether it is permanent or temporary, needs to be submitted to FHWA for consideration, regardless of funding source, or route type. As a result, Turnpike facilities would fall under this requirement as well as any “locked gate” access.

There should be enough substantiated information and justification for FHWA to independently evaluate and approve the request. FHWA is interested in ensuring that all new or revised access points are considered using a decision-making process that is based on information and analysis for the planning, environmental, design, safety and operational affects of the proposed change. They are also ensuring the changes support the intended purpose of the interstate, do not have adverse impacts on the operation of the interstate or local roadways and lastly that they are designed to the proper standards.

The format and information required should be discussed with FHWA prior to submission; however there is guidance available to start the process that can be found at:

- FHWA's Interstate System Access Informational Guide memo: https://www.fhwa.dot.gov/design/memos/100831.cfm
- FHWA's Interstate System Access Informational Guide: https://www.fhwa.dot.gov/design/interstate/pubs/access/access.pdf.
- FHWA general Interstate and access information: https://www.fhwa.dot.gov/programadmin/interstate.cfm#
- FHWA's Delegation of Authority regarding interstate access to the Division Offices: https://www.fhwa.dot.gov/legsregs/directives/notices/n11004.cfm
- FHWA's Interstate access policy: https://www.fhwa.dot.gov/programadmin/fraccess.cfm

In some cases it may require an Interstate Justification Report (IJR). This is in conformance with 23 CFR part 450, and 40 CFR parts 51 and 93. See the NH Division of FHWA's Standard Operating Procedure for New or Revised Interstate Access Points, Appendix 11-26.

A formal request from NHDOT to the FHWA NH Division office is also required to obtain temporary construction access. The request letter shall address the information contained in the FHWA document entitled "SOP – Temporary Interstate Access Request", see Appendix 11-27.

Detours

A detour, as defined by the *MUTCD* (2), is a temporary rerouting of road users on an existing facility to a different facility in order to avoid a traffic control zone. If it is deemed that a detour is the best method to complete the construction of the project, the use of State or Turnpike operated and maintained facilities should be considered as the primary route. Utilizing non-State or non-Turnpike operated and maintained routes would require approvals and agreements to be obtained and executed between the Department and the operating and maintaining entity (i.e., municipality), similar to the haul road process noted above. FHWA should be consulted for approval if there is Federal funding involved.

As a part of the evaluation of the viability of the detour route, length of the detour route, condition of the existing roadway, and design vehicle should be considered. For example, if the route to be detoured contains truck traffic, the detour route should accommodate truck traffic. This may result in the need to modify intersections or roadway features (e.g., intersection radii) along the detour route.

The Bureaus of Traffic and Construction will cooperate with Highway Design to establish the by-pass arrangements. Sometimes, temporary bridges or existing bridges must be used, in which case Bridge Design must be consulted.

If major detours are a part of the project, conceptual detour plans should be developed at the preliminary design stage for presentation to the Traffic Control Committee. The use of a detour route will also require special consideration during the design of the construction signing and warning device package and should be included in the plan set or the bid documents. The route should be field verified before the design is complete to ensure that it is a viable route. During the review, consideration for the sign placement should be evaluated.

Diversions

A diversion, as defined by the *MUTCD* (2), is a temporary rerouting of road users onto a temporary facility or alignment placed around the work area. Use of diversions for the construction phases should be considered prior to the Hearing phase of the project, especially if right-of-way width will be a control.

Diversions should be discussed with the Traffic Control Committee as part of the TCC review process.

Agreements

Municipal Work Zone Agreement (MWZA)

The Municipal Work Zone Agreement (MWZA) is a temporary agreement that is executed between the Department and the municipality, and is intended to establish that the Department has the full authority to control traffic for Highway and Bridge projects in conformance with RSAs 228:21, 236:1, and 228:37. It identifies that the Department is responsible for the management of operations, including the authority to determine the most appropriate way to control traffic within the work zone limits, and will determine the usage of flaggers versus officers, as appropriate. See Appendix 11-28 for a template of the MWZA.

An MWZA is not required where there is no municipal involvement, such as for interstate paving projects, and interstate only projects, where there is no work off of the Interstate facility (I-89, I-93, I-95, FE Everett Turnpike, Spaulding Turnpike, I-293 and I-393).

The MWZA is drafted by the Project Manager in duplicate for each municipality involved in the project. The document is vetted through the Executive Office prior to sending it to the municipality (see Appendix 11-29 for a sample memo). The Project Manager will typically either meet with, or discuss the MWZA with, the municipality prior to formally sending the document to the municipality for approval and signature. See Appendix 11-30 for a sample letter to the municipality. A self-addressed stamped envelope should be included with these requests to the Municipalities.

Once the document is signed and returned to the Department, the Project Manager will forward the municipally signed documents to the Director of Project Development for signature.

Once both original documents are signed by all parties, the Project Manager will scan the original document for electronic filing, return one original to the municipality for their records (see Appendix 11-31 for a sample letter back to the Municipality), send one original to the Bureau of Construction, and send a copy of the original to the Design Team for inclusion into the Proposal. A project cannot advertise if a MWZA has not been executed, except as noted above.

Temporary agreements do not need to be entered into the Management Tracking System (MTS) (see Chapter 2, “Project Development”); however, should be included in ProMIS, see Chapter 13, “Plans, Specifications and Estimate” for guidance on ProMIS.

Memorandum of Understanding (MOU) and Memorandum of Agreement (MOA)

The Department may enter into a Memorandum of Understanding (MOU) or a Memorandum of Agreement (MOA) with a municipality or other party, for the purpose of establishing a mutual agreement between the entities that is not as formal as a contract.

A Memorandum of Understanding (MOU) is a legal document describing a mutual agreement between parties. It expresses a convergence of will between the parties, indicating an intended common line of action, rather than a legal commitment. It is a more formal alternative to a gentlemen's agreement, but generally lacks the binding power of a contract.

The most common MOU for a project is a Utility Agreement for utility work by or for a utility. See Chapter 9, "Utilities", for addition information and the process for execution of these types of agreements.

A Memorandum of Agreement (MOA) is a document written between parties to cooperatively work together on an agreed upon project or to meet an agreed upon objective. The purpose of the MOA is to have a written understanding of the agreement between parties. The MOA can also be a legal document that is binding and holds the parties responsible to their commitment or just a partnership agreement.

MOAs are used for many things such as for landscaping or sidewalk maintenance. The most common MOA is for sidewalk maintenance, which is required to be signed by the municipality if the State is to install sidewalks on the project. See Appendix 11-32 for a sample sidewalk agreement.

The process for obtaining signatures on an MOU or an MOA, agreement, is similar to the MWZA noted above; however, as these agreements are more detailed and less standardized than a MWZA, the Department works with the other parties to come to a consensus on the content of the agreement prior to Executive Office review, which can take time and coordination including various drafts between the parties. Once the details of the agreement are established, the formal document is placed in a finalized draft form and is vetted through the Front Office for concurrence. Once approved, and after any further negotiations with the other parties, the Department will finalize the document and request the signature of the other parties. Upon receipt of all signatures, the Executive Office signs the agreement. If needed, the agreement will then go to be approved by the Governor and Executive Council. Upon finalization of the agreement, it is distributed with one copy going to the other parties, one copy going to the Bureau of Community Development (this is not needed for temporary agreements) and one copy is sent to the appropriate District or Turnpike Office. If there are funds associated with the agreement, then a copy should be forwarded to the Bureau of Finance. An electronic copy should also be posted to ProMIS. The agreement should also be entered into MTS at the appropriate times, see Chapter 2, "Project Development" for more information on MTS guidelines and process.

If this is a temporary agreement, ensure that it includes an expiration date. Most agreements are between one party and the Department; as a rule, two original copies are needed for temporary agreements, and three original copies are needed for permanent agreements. The number of originals is increased as the number of parties to the agreement is increased.

Roadside Improvements

Roadside improvements that are generally treated as special plan elements include:

- Landscaping;
- Mailboxes;
- Wetland mitigation areas;
- Rest areas;
- Scenic overlooks;
- Safety inspection areas;
- Truck weigh stations;
- Commuter parking lots (Park-and-Rides); and
- Fencing.

Landscaping, some wetland mitigation (plantings), and similar plan elements are developed by the Specialty Section of the Bureau of Highway Design or by a consultant.

Landscaping

Most projects will need some sort of permanent stabilization on the earth slopes at the end of construction, such as grass for ground cover. Both temporary and permanent erosion control measures will also be required during construction, but the beautification work needed to create a more aesthetically pleasing and environmentally sensitive project is performed when the construction work is nearing completion.

Beautification is not included on all projects and is more commonly not included on projects due to high costs and maintenance requirement responsibilities. The Department does not maintain landscaping. If landscaping is requested by a municipality, the municipality must take responsibility for the maintenance of the landscaping which is typically arranged through a Memorandum of Agreement. See the Memorandum of Understanding (MOU) and Memorandum of Agreement (MOA) section above for additional details, and Appendix 11-33 for a sample.

Before any special landscaping is included in a project design, or proposed as a separate project, the concept should be reviewed with the Commissioner's Office. If the Commissioner's Office is amenable to the inclusion in the contract, then the municipality must execute the MOA prior to incorporation of the landscaping design into the contract plans.

The designer should attempt to preserve natural beauty and consult with the Specialty Section regarding ways to minimize detrimental impacts to trees and shrubs within and adjacent to the work area, even if additional beautification features are not included as a part of the design. Early coordination is important to ensure the desired final product.

If a separate landscaping plans are anticipated, a set of landscaping plan sheets should be drafted at about the same time that right-of-way plans are developed. These sheets can be

updated later, if necessary, but they provide a good base plan for landscaping design without the clutter. See Appendix 11-34 for a sample Landscaping Design Request.

Mailboxes

Consideration should be given to relocating impacted mailboxes on a project. Typically this is adding a bid item into the contract. If the project includes new sidewalks or a relocated roadway, the designer needs to consider what will become of the mailbox and to accommodate any needs within the design, prior to the acquisition of the Right-of-Way, if necessary. The mailbox must remain operational during construction so temporary relocation may also be required.

Where a sidewalk is to be constructed, it is important that the mailbox placement avoid a reduction in the overall width of the sidewalk, which could otherwise mean that the sidewalk needs to be widened or a grass panel between the curb and the sidewalk may be needed to accommodate the mailbox. Contact the postmaster to determine: the preferred orientation of the mailbox, such as parallel or perpendicular to traffic; or the preferred placement of the mailbox, such as behind the sidewalk or behind the face of curb. Consider that bicyclists operating to the right within the shoulder, especially at night, could inadvertently strike a mailbox and therefore placing mailboxes between 6 and 8 inches behind the curb is desirable (see https://www.usps.com/manage/mailboxes.htm).

Where a new alignment or relocated roadway is proposed, contact the postmaster to determine how and where the new mailboxes should be located, such as in groups, or all on one side of the street.

Wetland Mitigation Areas

Construction projects may affect or impact areas that have been classified as wetlands. A wetland must meet certain established environmental criteria including plant species and soils types. The Bureau of Environment, or the design consultant, will be responsible for the delineation and identification of the wetlands. The process for when in the design process this should occur can be found in Chapter 2, “Project Development”.

The total wetland area impacted by the project is presented as part of the Natural Resource Agency Meeting. As part of this process, it is decided whether it will be necessary to mitigate for damages to these wetland areas caused by the project.

Mitigation can be accomplished in several ways, e.g., by creating new wetlands, expanding existing wetland areas, enhancing or increasing the ecological value of an existing wetland, providing payment to the Aquatic Resource Mitigation (ARM) Fund or by purchasing a Conservation Easement to protect a wetland or upland area from future development. Each of these strategies results in a different ratio for the amount of wetland impacted, which is not a 1:1 ratio. Mitigation requirements can also be based on the town where the wetland impacts occur.

The NHDOT Stream Passage Improvement Program (SPIP) is an alternative to the ARM fund. The SPIP is a collaborative effort between NHDOT and NHDES where it is the goal to use the planned mitigation funds identified above to address other assets that do not meet stream passage requirements. The SPIP would allow addressing assets that are near the project, as a priority overpaying into the ARM fund. The priority is to use the funds on State infrastructure, then municipal infrastructure and finally, if nothing is available in the area,

meets a minimum dollar threshold, or is not within the mitigation payment range, a payment may still be made to the ARM fund.

The design to develop wetlands involves the Environmental Manager, Specialty Section and, possibly, a consultant. The work will either be included in the construction project or advertised as a separate project. Sometimes, a single wetland mitigation project may replace wetland areas impacted by several construction projects.

Rest Areas and Scenic Overlooks

Rest Areas, including those described as Welcome Centers or Tourist Information Centers, along with scenic overlooks are functional and desirable elements of the complete highway system. A rest area, in the general sense, is a roadside area, with parking facilities separated from the roadway, usually providing restroom facilities. Some may also have services such as food and fuel (such on I-93 in Hooksett) or they may have vending machines and staff to answer questions. These facilities serve the purpose of making the motorist physically more comfortable and mentally more alert.

Rest Areas located in New Hampshire near adjoining State borders are called "Welcome Centers". Rest Areas open year-round are called "Tourist Information Centers", whereas those only open seasonally remain described as "Rest Areas".

Scenic overlooks are, to a certain extent, similar to Rest Areas in that they provide the motorist the opportunity to pull off the roadway, stop and stretch for a while and enjoy a fabulous view of the countryside. Scenic overlooks do not need to contain restroom facilities.

For additional guidance on rest area design see *AASHTO Guide for Development of Rest-Areas on Major Arterials and Freeways (*19*).*

Safety Inspection Areas and Truck Weigh Stations

Safety inspection areas and truck weigh stations are both intended to provide the facility for the Department of Safety to monitor trucks, i.e., to conduct safety inspections on trucks and to discourage unpermitted overweight trucks from using New Hampshire's roadways.

These facilities may be designed as separate projects or included as part of a project. The area provided must be large enough to accommodate truck movements and parking within, as well as providing entering and exiting pavement tapers that follow standard geometric deceleration and acceleration criteria compatible with the design speed of the road.

The decision to incorporate these features into a corridor is a joint decision through the Department of Safety and the Department of Transportation.

Commuter Parking Lots (Park-and-Rides)

Commuter parking lots or "Park-and-Rides" are constructed to reduce the number of passenger vehicles on the road by encouraging motorists to share rides or to use public transportation. Historically, these park-and-rides were usually initiated by the Rideshare Coordinator in the Bureau of Rail & Transit or by a community applying for Congestion Mitigation and Air Quality (CMAQ) funding. As the Rideshare Coordinator position was eliminated in 2011, the Operations Division (Bureau of Highway Maintenance or Bureau of Turnpikes as appropriate) is now responsible to plan and maintain park-and-rides. At several

park-and-ride lots, the NHDOT has contracted with a Facility Operator to manage and maintain the bus terminal/park-and-ride facility.

The park-and-rides are designed on an individual basis, depending upon the land available, the estimated number of vehicle spaces needed and future expansion needs. Some park-and-rides have lighting. The larger park-and-rides may have a shelter or possibly a bus terminal. Refer to Chapter 5, "Geometrics" for additional information and parking layout diagrams.

Fencing

Fencing may be installed on projects for many reasons, including the control of Right-of-Way; prohibiting pedestrian movement across a facility (i.e., placed on top of barrier); snow fencing; replacement fencing due to property impacts; and protecting constructed wetlands/mitigation area or Best Management Practice (BMP).

The Department typically installs fencing along the Limited Access Right-of-Way (LAROW) line and the Controlled Access Right-of-Way (CAROW) line to ensure that the control of access is perpetuated. The type of fence to be used is based on the visibility of the fence and the location. Two primary types of ROW fence are chain link and woven wire fences. Woven wire fence is used in wooded areas, or in areas where it will not be viewed by an abutting property owner. Where the fence is visible to an abutting owner, the fence should be chain link. In either case, the fence is placed along the ROW line. There are instances where the Department has opted to use a stockade fence. In these instances, the fence should be placed 3 feet inside the ROW line (for maintenance purposes) with the decorative side facing the abutter. Seek prior approval from the Project Manager and District (or Turnpikes) before installing such a fence.

The use and installation location of fences combined with noise barriers is typically dealt with on a project by project basis with the assistance of the party responsible for the maintenance of the fence and the barrier (District or Turnpikes). Their decision can be based on previous encroachment issues, proximity from the ROW line to the noise barriers, length of the barrier, access points, fire hydrant access needs, ability to maintain the fence, etc. In general, consult with the maintenance authority to discuss this issue as a part of the design to determine if the fence will be required and, if so, where the fence should be placed and what type of fence should be used.

Fencing is often used for snow protection of delicate features. This can be as simple as protecting a building that is too close to the roadway or, more commonly, used on bridges. Fencing should be placed on overpass bridges to prohibit snow, from removal operations, from entering the traveled way of the roadway or railway below and placed on overpass bridges as a vandal protective screening for overpass bridges with sidewalks. Although this should be included as a part of the Bridge Design efforts, coordinate with Bridge Design staff to ensure this has been incorporated into the project or any transitions are accounted for if the fence extends off the bridge. See the *Bridge Design Manual (6), Chapter 7.6.4* for additional bridge fencing discussion, fence types, heights and details.

Impacts to a property owner's fence should be identified early, as the resultant relocation is commonly dealt with through the ROW process and is noted on the ROW plans. All privately owned fences should be placed at or outside the ROW depending on the type of fence.

Fencing that is constructed around a wetland, wetland mitigation area, or a Best Management Practice (BMP) should be installed with gates (and locks) so they can be accessed by maintenance forces. Fences should be installed to prohibit unauthorized users from entering the site. Consider the proposed contours and the final look of the top line of the fence when locating fences.

Environmental Elements

The following section is intended to give the designer guidance on what they may need to consider on a project. This is not intended to be an all-inclusive list with all environmental elements and does not include all details or nuances of these elements. Coordinate with the Environmental Manager from the Bureau of Environment for additional information and https://www.dot.nh.gov/project-environmental-process-manual

The environmental elements on a project are becoming more prominent and costly components of projects. Early design considerations for environmental elements could reduce potential costs and project delays. The most obvious and objectionable byproducts of highway improvements are noise and erosion; however, these effects can be minimized through responsible design and construction practices. Other environmental issues that should be considered during the design are stone walls, invasive plants, endangered species, wild & scenic rivers, scenic byways, historic areas, archaeologically sensitive areas, cemeteries, contaminated materials, health and safety plans, flood plains/floodway, stream crossings, Alteration of Terrain, soils management plans, wetland impacts, shoreland impacts, White Mountain National Forest impacts, Land and Community Heritage Investment Program (LCHIP) property impacts, historic markers, etc. Consult with the Environmental Manager from the Bureau of Environment for additional concerns specific to the project. Regardless of the type of environmental issue, the Environmental Manger should be the primary point of contact for all environmental project communications, do not coordinate directly with the Program Manager without including the Environmental Manager.

In this chapter, not all of the elements described above are addressed, just the more commonly occurring issues excluding wetlands and shoreland impacts. See Chapter 2, "Project Development", of the Highway Design Manual for specific guidance relative to Environmental Plan development for Wetland Plans, Erosion Control Plans, Shoreland Plans and all environmental permitting requirements. Many of these issues are also reviewed on a project by project basis during monthly interagency meetings for natural and cultural and resources, see https://www.dot.nh.gov/about-nh-dot/divisions-bureaus-districts/environment/project-management-section/natural-resource and https://www.dot.nh.gov/about-nh-dot/divisions-bureaus-districts/environment/project-management-section/cultural-0 for more information on these meetings.
Although not specifically discussed below, controlling dust during construction is also important and can be regulated by provisions included in the contract. Post construction effects on air quality are not within the control of the designer but are considered an environmental matter to be resolved before programming the project.

The information provided here is general in nature. Contact the Environmental Manager from the Bureau of Environment to discuss your individual project and the associated needs and to perform any necessary evaluations.

Noise Impact and Abatement Assessment

Noise impact and abatement assessment is coordinated with the Department's Air & Noise Program Manager through the Environmental Manger. The following is for informational purposes only.

The NHDOT *Policy and Procedural Guidelines for the Assessment and Abatement of Highway Traffic Noise for Type I & II Highway Projects* (20) is referred to in determining the need, feasibility, and reasonableness of noise abatement measures. The policy has been prepared pursuant to the FHWA's Title 23 Code of Federal Regulations, Part 772. The policy is applicable to any project receiving Federal or State-Aid funds, or to projects that are subject to FHWA or NHDOT approval. The policy can be found at:
https://www.dot.nh.gov/projects-plans-and-programs/programs/environmental-management-system/air-noise
There is also information available on the FHWA website at: https://www.fhwa.dot.gov/environment/noise/index.cfm.

The definitions for a Type I, Type II and a Type III project are included in the *Policy and Procedural Guidelines for the Assessment and Abatement of Highway Traffic Noise for Type I & II Highway Projects* (20), but for discussion purposes, are listed here:

- A Type I project is a proposed highway project for the construction of a highway on a new location or the physical alteration of an existing highway which substantially changes either the horizontal or vertical alignment or increases the number of through-traffic lanes. All Type I projects require the assessment of noise impacts on all properties in proximity to the project area. If noise impacts are identified, the assessment and incorporation of all feasible and reasonable noise abatement measures into the project design is mandatory regardless of Federal participation.

- A Type II project involves the construction of noise abatement along an existing Tier 1 highway where no highway improvements are programmed, and where there was no prior determination that a Type I or Type II abatement measure would not be either feasible or reasonable.

- A Type III project is a Federal or Federal Aid highway project that does not meet the classification of a Type I or Type II project. Type III projects do not require a noise analysis and are strictly for FHWA project classification purposes.

Type I and II noise impact and abatement assessments will be conducted during the Preliminary Phase of the design in accordance with the policy as defined below:

- Feasibility is the combination of acoustical and engineering factors considered in the evaluation of a noise abatement measure.

- Reasonableness is the combination of social, economic, and environmental factors considered in the evaluation of a noise abatement measure.

Some considerations for determining feasibility should include: topography; clear zone; redirection of errant vehicles; sight distance; emergency services access; noise reduction (achieving the required decibel reduction); other noise sources in the area; evaluating if there are too many gaps in the wall to be effective; the maximum height of a barrier should not exceed 25 feet; and environmental impacts (wetlands, historic lands, parks, etc.).

There are three criteria for determining reasonableness: cost effectiveness, noise reduction design goals, and views of the benefited receptors.

If walls are deemed feasible and reasonable, the location and conceptual design of proposed noise barriers must be identified to ensure that adequate right-of-way exists or is acquired as a part of the Public Hearing process to construct and maintain the barrier. Coordination with the Bureau of Environment is required to determine where noise barriers are warranted. Always discuss this issue as early as possible with the Commissioner's Office whenever noise barriers are being considered.

Barriers may take the form of earth berms or walls of various types. Methods of noise attenuation are listed in *Policy and Procedural Guidelines for the Assessment and Abatement of Highway Traffic Noise for Type I & II Highway Projects* (20). Details of NHDOT standard soundwall can be found on the *Bridge Design Detail Sheets, Soundwalls*: https://www.dot.nh.gov/about-nh-dot/divisions-bureaus-districts/bridge-design/bridge-detail-sheets .

Invasive Plants

Invasive species are non-native plants that are often persistent and spreading. There are two designations of invasive plants, Type I and Type II. The Bureau of Environment, or a consultant, is responsible to identify the type and kind of invasive plants within the project. This information is provided to design in a CAD file. All impacted invasive species are identified and included in the Prosecution of Work. In addition, contract bid items for the removal of the invasive plants, and an Invasive Species Control and Management Plan, are included as bid items in the contract. For more information on Invasive Species see: https://www.dot.nh.gov/projects-plans-and-programs/programs/environmental-management-system/invasive-species

Any delineation that is more than two years old must be updated prior to advertising the contract, as there could be new or expanded invasive species.

Stone Wall Policy

New England is adorned with many stone walls that run along the edges of the roadway or property lines, or that separate farm fields, etc. Stone walls can be ornamental, historic, signs of property or right-of-way boundaries, or archaeological ruins. For this reason, there are several state laws (RSAs), and the 2017 Stone Wall Policy Guidelines (https://mm.nh.gov/files/uploads/dot/remote-docs/2017-stonewall-policy-guidelines.pdf which address and protect stone walls, that should be considered during any design.

Stone walls located within the project limits adjacent to the roadway should be reviewed prior to the Public Hearing, or during Preliminary Design, to determine what walls, if any, will be impacted and how they should be addressed. Specifically, the determination should be made pre-Hearing if an easement is required for any reconstruction or preservation efforts, as these will likely require easements to be acquired.

Typically, the evaluation of the stone walls is spurred by the original requests sent to the Bureau of Environment to evaluate the project, the Green Sheet (see Chapter 2, "Project Development", for additional information). The Bureau of Environment will complete a project wide stone wall rating sheet. If the rating is high enough, all stone walls are subject to replacement. If not, then each wall is individually evaluated. The evaluations will

determine the need for replacement, and the type of easement (permanent stone wall or temporary stone wall) to be obtained.

When stone walls are relocated or reconstructed, they are relocated in kind, with no additional stones added to, or taken, from the original wall. The only stone walls that are relocated or reconstructed are those that are approximately parallel to the work; perpendicular stone walls are not relocated or reconstructed. The stone wall should be placed on the property owner's side of the right-of-way line, at least one foot off the right-of-way line. See Chapter 10, "Right-Of-Way", for easement placement locations.

Municipal Separate Storm Sewer Systems (MS4)

A Municipal Separate Storm Sewer System (MS4) refers to a conveyance or system of conveyances that is: owned by a state, city, town, village, or other public entity that discharges to waters of the U.S.; designed or used to collect or convey stormwater (e.g., storm drains, pipes, ditches); not a combined sewer; and not part of a sewage treatment plant, or publicly owned treatment works. MS4 communities are those that are defined by large populations in urban areas as defined by the US census. These are mapped areas and other information regarding MS4s can be found at: https://www.epa.gov/npdes/stormwater-discharges-municipal-sources. Consult with your Environmental Manager for project specific needs.

Limited Reuse Soils (LRS)

Limited Reuse Soils (LRS) are materials within the project that are likely and/or have been demonstrated to contain concentrations of contaminants such as polycyclic aromatic hydrocarbons (PAHs) due to the presence and breakdown of asphalt pavement, the normal operation of motor vehicles, and other "non-point sources" of pollution. The definition of LRS includes:

- All topsoil within the project limits and within the existing right-of-way, regardless of depth.
    - In instances where topsoil is not present, LRS is defined as soil from the top of ground to a depth of six (6) inches.
- Asphalt pavement that has been ground or pulverized (including milled material and reclaimed stabilized base).
- Street waste (catch basin cleanouts, street sweeping, and ditching material).

Further information on LRS can be found in Appendix 11-35, Limited Reuse Soils Project Development Policy Directive.

Projects that contain LRS are likely to require a Soils Management Plan for the proper handling and treatment of this soil. For projects where LRS is deemed de minimis, soil management will be addressed in the Prosecution of Work and not through a Soils Management Plan.

The designer should be aware of the need to account for this material for reuse as allowed by Appendix 11-35. Considerations should be made for temporary storage during construction,

the reuse limitations, and the cost associated with of any materials that cannot be reused, as well as the cost for the Soils Management Plan.

Per- and Polyfluoroalkyl Substances (PFAS)

Per- and Polyfluoroalkyl Substances (PFAS) are sometimes referred to as PFCs. They are a family of man-made compounds that do not naturally occur in the environment. They have a large number of industrial uses and are found in many commercial products because of their properties to resist heat, oil, grease and water. Once released to the environment, PFCs are persistent and do not biodegrade or breakdown.

Many PFAS, including perfluorooctanoic acid (PFOA), perfluorooctane sulfonic acid (PFOS), and perfluorohexane sulfonic acid (PFHxS), are commonly found in our environment and do not break down easily. These chemicals can move through soil, get into groundwater, and be carried through air. Because they are stable chemicals and move so easily in the environment, PFASs have been found far away from where they were made or used.

The designer should consult with the Bureau of Environment to determine if PFAS is present and the recommended treatment for each project.

Erosion Control

Erosion control measures are usually designed into the project to provide protection against temporary and permanent erosion. Drainage systems, ditches, channels, and slopes are designed to minimize the effects of erosion and are protected with combinations of materials and vegetation. The *Manual on Drainage Design for Highways* (21) and Chapter 6, "Drainage", deal with erosion control.

Erosion control during the vulnerable construction stage is the responsibility of the Contractor. Section 107 of the Standard Specifications titled "Legal Relations and Responsibility to Public", states the general rules that the Contractor must follow. Supplemental Specifications and Special Attentions in the Proposal also direct the Contractor regarding erosion control.

Most projects that contain at least an acre of earth disturbing activities require the design and implementation of a Stormwater Pollution Protection Plan (SWPPP), which is monitored by qualified individual(s). These (the plan and the monitoring) are typically the responsibility of the Contractor and are bid items contained in the contract.

Erosion control for a project should consider constructability, construction activities (truck washout areas, areas for tire scrubbers, etc.), phasing, time of year restrictions, clean water bypass, and proximity to natural resources (water bodies, wetlands, etc.).

Floodplain and Regulatory Floodway

There have been different reasons for development in flood plains over time. The first settlers faced a wilderness without roads. The coasts & rivers provided harbors, transportation routes, fishing, and water sources. Now people enjoy living near water for recreation and pleasant surroundings; however, there are unintended consequences, namely flood losses. House Document 465, (HD 465, dated August 10, 1966), titled "*A Unified National Program for Managing Flood Losses*" declared that "Floods are an act of Good;

flood damages result from the acts of men." The document concluded that flooding causes more damage than all other hazards combined, and it recognized that structural measures were not sufficient to reduce flood losses. This document evaluated the need for and recommended the National Flood Insurance Program, which was instituted under the National Flood Insurance Act of 1968.

Projects may require additional work effort in the vicinity of, or impacting, a floodplain or a regulatory floodway. Compliance with the National Flood Insurance Program (NFIP) is mandatory. Regulatory floodplains provide natural areas to buffer and mitigate flood hazards. Development of floodplains should be avoided if possible. Floodways are regulatory models for the purpose of providing conveyance whereby water surfaces must not rise by more than 1 foot above the Base Flood Elevation (BFE) in the floodplain. The presence of a floodplain or floodway is often determined through the initial environmental review (see Chapter 2, "Project Development" for details on the timing of this request). If impacts are unavoidable, a Letter of Map Revision (LOMR) may be required. The trigger that requires a LOMR is often the amount of change in the BFEs from modeling (typically this is <0.5 feet). The floodway is more stringent, because there must be no change in the BFE. In other words, the analysis is performed to determine if the increase is more than 0.00 feet (CFR 60.3(d)(3)). The Conditional Letter of Map Revision (CLOMR) is only used if comments from FEMA Region I, the Boston office, are requested for the project. If regulatory compliance of individual properties or structures are needed (and not new water surface profiles) a Letter of Map Amendment (LOMA) is submitted by the owner (see also below).

Floodplain management is a dynamic activity that is closely tied to federal, state, and local design guidelines and ordinances. The CLOMR/LOMR procedures may change, however, at the time of this writing the Department follows the same procedures that have been used in recent years. The designer is encouraged to coordinate all efforts relative to any floodplain or floodway with the Bureau of Environment and the Hydraulics Engineer in the Specialty Section to determine the latest procedures and course of action required. Chapter 2 of the *NHDOT Bridge Manual* (6) describes the current procedures for LOMR completion, and the suite of models that are typically required. The FEMA MT-2 instructions explain the forms & acronyms used. The typical trigger for requiring a LOMR in terms of hydraulic modeling is when the "duplicate effective" changes the Flood Insurance Study (FIS) profile more than 0.5 feet (the duplicate effective is a copy of the effective model obtained from the FEMA library reproduced on the requestor's computer). If the effective model is not available, the new model must be calibrated to reproduce the FIS profile within 0.5 feet. The analysis performed according to CFR 60.3(c)(10) is used to determine if BFEs increase more than 1.0 foot.

Revisions may be necessary if federal regulations change the procedures or requirements, such as the design "freeboard". NHDOT is a community in the eyes of the NFIP program. The Department shares similar responsibilities with other communities that have adopted the insurance program. Signatures must be obtained on the FEMA MT-2 "Concurrence Forms" for every LOMR and CLOMR. A certified (stamped) topographic plan is required with a LOMR and a CLOMR.

A regulatory floodway is the channel of a river or other watercourse and the adjacent land areas that must be reserved in order to discharge the base flood without cumulatively

increasing the water surface elevation more than a designated height, defined as a maximum of 1 foot by Federal Emergency Management Agency (FEMA) in 1995. Any change to the floodway could result in an increase or decrease to the flood elevation. For streams and other watercourses where FEMA has provided BFEs, but no regulatory floodway has been modeled, a review of floodplain development should be performed on a case-by-case basis to ensure that changes in water surface elevations do not exceed the existing regulatory parameters.

A floodplain is typically defined as a low, flat area bordering the banks of a waterway that is prone to flooding and is often described as the relatively flat area outside of the waterway (river, stream, lake, etc.). This area has typically been flooded, or has a history of previously flooding, and often requires more flood insurance coverage based on susceptibility of flooding (premiums are defined by the vertical distance separation from the BFE). The land is often comprised of sediment in the form of alluvium (sand, silt, and clay) with nutrient rich soils, such as wetlands and material deposited by receding floodwaters. Not all floodplains have floodways.

The floodplain is the area of the one percent annual exceedance flood. FEMA produces floodplain maps in order to implement the NFIP. BFEs are essentially an elevation for the flood storage capacity and level of risk. The BFEs are available as GIS data in Digital Flood Insurance Rate Maps (DFIRMs). The DFIRMs may not include all the latest information that is available. The FEMA Map Service Center should be checked for all available digital products; maps can also be developed for individual locations from the FEMA website (http://msc.fema.gov) and are called Firmettes. The BFE is the elevation requirement for flood protection of a structure. FEMA maps have evolved since 1968 when the NFIP was created. Earlier maps were called Flood Hazard Boundary Maps (FHBMs), and they did not have BFEs. Old FIRMs do not have floodways. Another old map format is the Flood Boundary and Floodway Map (FBFM). The FBFM has a floodway, but does not have BFEs.

In general, the NFIP involves the following three aspects: 1.) Flood Hazard Identification (mapping); 2.) Floodplain Management (regulations such as building codes and zoning); and 3.) Flood Insurance (for participating communities). Recent changes to the program include the National Flood Insurance Reform Act of 2012 with provisions that include:

- Authorized the National Flood Mapping Program and Technical Mapping Advisory Council
- Consolidated the Severe Repetitive Loss (SRL), Repetitive Flood Claims (RFC), and Flood Mitigation Assistance (FMA) into a streamlined FMA program

A Letter of Map Revision (LOMR) is a modification to a modern FIRM resulting in a change to the floodway or floodplain boundary, or a change in the water surface elevation (BFE) that has been calculated. It will ultimately be incorporated in the Flood Insurance Study. This revision is dealt with through FEMA by the Bureau of Environment and the Hydraulics Engineer from the Specialty Section. In some cases, the Department might submit a plan of proposed changes to FEMA as a Conditional Letter of Map Revision (CLOMR) for projects where there is no regulatory floodway and there is more than a 1-foot raise in the BFE, and for projects where there is a regulatory floodway and there is an increase in the BFE. When a CLOMR is required it must be followed with a LOMR. The procedure for this is to complete an as-built survey at the conclusion of construction and then complete the LOMR

with the revised data. The LOMA process is similar, but it does not involve new water surface profiles and maps. A LOMA is performed using survey grade elevations to clarify actual regulatory compliance and insurance needs.

To complete a CLOMR or a LOMR, a hydraulic study is required. A hydrologic study may also be necessary. The Department will typically need to analyze the hydraulics and hydrology of a project to determine if the regulatory flood profile changes enough to trigger a LOMR. Consult with the Environmental Coordinator and the Hydraulics Engineer for more information if the project will impact a regulatory floodway or floodplain. The State NFIP Coordinator at the Office of Energy & Planning (OEP) is typically notified, and they may be able to provide additional information or an opinion (such as ongoing work in specific watersheds, community participation in the NFIP, or hazard mitigation plans).

Lastly, the FHWA requires compliance with the NFIP. Additional information is available in the latest version of the AASHTO Model Drainage Manual.

References:

1. United States General Services Administration (USGSA), *36 CFR Parts 1190 and 1191 - American Disabilities Act Accessibility Guidelines (ADAAG)*, Code of Federal Regulations, Federal Register: Rules and Regulations, 2004

2. Federal Highway Administration (FHWA), *Manual on Uniform Traffic Control Devices (MUTCD)*, FHWA, Washington, D.C., 2009
https://mutcd.fhwa.dot.gov/kno_2009r1r2r3.htm

3. American Association of State Highway and Transportation Officials, (AASHTO), *Guide for the Planning, Design and Operation of Pedestrian Facilities*, AASHTO, 444 North Capitol Street, N.W., Suite 249, Washington, D.C., 2014

4. American Association of State Highway and Transportation Officials, (AASHTO), *Guide for the Development of Bicycle Facilities, 4th Edition,* AASHTO, 444 North Capitol Street, N.W., Suite 249, Washington, D.C., 2012

5. New Hampshire Department of Transportation (NHDOT), *New Hampshire Statewide Bicycle and Pedestrian Plan*, NHDOT, 7 Hazen Drive, Concord, N.H., August 2023

   https://mm.nh.gov/files/uploads/dot/remote-docs/nh-ped-bike-plan-2023.pdf

6. New Hampshire Department of Transportation (NHDOT), *Bridge Design Manual*, NHDOT, 7 Hazen Drive, Concord, N.H., November 30, 2016
https://www.dot.nh.gov/about-nh-dot/divisions-bureaus-districts/bridge-design/bridge-design-manual

7. International Code Council, Inc. (ICC), *International Building Code (IBC)*, ICC, 4051 Flossmoor Road, Country Club Hills, I.L., 60478, 2018

8. Pennsylvania Department of Conservation and Natural Resources (PDCNR), *Pennsylvania Trail Design Manual for Off-Highway Recreational Vehicles,* PDCNR, 400 Market Street, Harrisburg, P.A., March 2004
https://elibrary.dcnr.pa.gov/GetDocument?docId=1737112&DocName=PA Trail Design Manual.pdf

9. American Association of State Highway and Transportation Officials, (AASHTO), *Roadside Design Guide*, AASHTO, 444 North Capitol Street, N.W., Suite 249, Washington, D.C., 2011

10. National Cooperative Highway Research Program (NCHRP), *NCHRP Report 350, Recommended Procedures for the Safety Performance Evaluation of Highway Features*, TRB, FHWA, Washington, D.C., 1993
https://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_350-a.pdf

11. American Association of State Highway and Transportation Officials, (AASHTO), *Manual for Assessing Safety Hardware (MASH),* AASHTO, 444 North Capitol Street, N.W., Suite 249, Washington, D.C., 2016

12. New Hampshire Department of Transportation *(NHDOT), Standard Plans for Road Construction*, NHDOT, 7 Hazen Drive, Concord, N.H., with current updates https://www.dot.nh.gov/doing-business-nhdot/contractors/standard-plans-road-construction

13. New Hampshire Department of Transportation (NHDOT), *Bridge Detail Sheets*, NHDOT, 7 Hazen Drive, Concord, N.H., November 30, 2016 https://www.dot.nh.gov/about-nh-dot/divisions-bureaus-districts/bridge-design/bridge-details

14. New Hampshire Department of Transportation (NHDOT), *NHDOT Positive Protection Guidance for Work Zones,* NHDOT, 7 Hazen Drive, Concord, N.H., February 25, 2010 https://www.dot.nh.gov/doing-business-nhdot/engineers-consultants

15. Transportation Research Board (TRB), *Glare Screen Guidelines*, NCHRP Synthesis 66, TRB, Washington, D.C., 1979 https://onlinepubs.trb.org/Onlinepubs/nchrp/nchrp_syn_66.pdf

16. New Hampshire Department of Transportation (NHDOT), *Utility Accommodation Manual (UAM)*, NHDOT, 7 Hazen Drive, Concord, N.H., October 2017 https://www.dot.nh.gov/about-nh-dot/divisions-bureaus-districts/highway-design/design-services/utilities

17. Transportation Research Board (TRB), *National Cooperative Highway Research Program (NCHRP) Research Results Digest 278,* NCHRP, Washington, D.C., July 2003 https://trb.org/publications/nchrp/nchrp_rrd_278.pdf

18. New Hampshire Department of Transportation (NHDOT), *Guidelines for Implementation of the Work Zone Safety and Mobility Policy, NHDOT Policy #601.0*1, NHDOT, 7 Hazen Drive, Concord, N.H., October 12, 2007 https://mm.nh.gov/files/uploads/dot/remote-docs/work-zone-safety-policy.pdf

19. American Association of State Highway and Transportation Officials, (AASHTO), Task Force on Geometric Design, *A Guide for the Development of Rest-Areas on Major Arterials and Freeways, 3rd Edition,* AASHTO, Washington, D.C., 2001

20. New Hampshire Department of Transportation (NHDOT), *Policy and Procedural Guidelines for the Assessment and Abatement of Highway Traffic Noise for Type I & II Highway Projects*, NHDOT, 7 Hazen Drive, Concord, N.H., November 30, 2016 https://mm.nh.gov/files/uploads/dot/remote-docs/2016-noise-policy.pdf

21. New Hampshire Department of Transportation (NHDOT), *Manual on Drainage Design for Highways*, NHDOT, 7 Hazen Drive, Concord, N.H., January 2023 https://www.dot.nh.gov/sites/g/files/ehbemt811/files/inline-documents/manual-drainage-design.pdf

Appendix List