RHODE ISLAND DEPARTMENT OF TRANSPORTATION

RIDOT

HIGHWAY

Design Manual

2008

Rhode Island Department of Transportation
Highway Design Manual

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100 Manual Description

100.01 Introduction

This manual was developed by the Rhode Island Department of Transportation to present current Departmental guidelines for the highway design engineer.

This manual is intended to be utilized as an aid and is not meant to be a substitute for good engineering judgment. The designer should consider all factors during the design phase to develop solutions that address operational and safety requirements, while keeping in mind other factors such as cultural resources, environmental resources, and socio-economic impacts that may play a role in the final design.

This document is meant to supplement those guidelines and practices found in the documents mentioned in Subsection 110.03 - References.

100.02 Purpose and Objective

The purpose of this manual is to provide guidance aimed at producing uniformity in highway design and to aid the designer to ensure that all factors are considered during the design process. Additionally, this document sets forth in writing the Department's policies that have been developed with regard to geometric design standards.

This manual also serves to stress certain standards and practices that the Department feels should be followed to achieve the design goals presented in this manual.

Finally, this manual, in combination with the *Design Policy and Procedures Manual*, provides an outline of those procedures that are critical at certain stages of design. By providing a set of uniform procedures, it is expected that review times by outside agencies and other entities will be reduced.

100.03 Revisions

It is anticipated that this manual will be updated on a regular basis. Input from those persons who use the manual is encouraged. Input may be in the form of content that may be included or expanded upon to make the manual more complete or changes that better reflect the current Departmental guidelines.

Comments and recommendations should be submitted to the department via e-mail at the following address: ridotdesign@dot.ri.gov.

All comments that are received will be reviewed and considered by the appropriate personnel for inclusion in future releases.

110 Nomenclature and References

110.01 Definition of Terms

Acceleration Lane: An auxiliary lane used by an entering vehicle to accelerate before entering the traveled way.

Acceptable: Design criteria value(s) considered to be reasonable and safe for design purposes.

Access Control: The condition where the public authority fully or partially controls the right of abutting owners to have access to and from the public highway.

Auxiliary Lane: The portion of the roadway adjoining the through traveled way for purposes supplementary to through traffic movement, including parking, speed change, turning, storage for turning, weaving or truck climbing.

Accessible Route: An accessible route is a continuous, unobstructed path connecting all accessible elements and spaces in a building, facility or site, as defined in the Americans with Disabilities Act of 1990 (ADA).

Arterials: Highways that are characterized by a capacity to quickly move relatively large volumes of traffic but often provide limited access to abutting properties. The arterial system typically provides for high travel speeds and the longest trip movements.

Average Annual Daily Traffic (AADT): The total yearly volume in both directions of travel divided by the number of days in a year.

Average Daily Traffic (ADT): The average daily volume of traffic for a period between one day and one year. The ADT is calculated by dividing the total traffic volume in both directions of travel during a given time period by the number of days in that time period.

Back Slope: The side slope created by the connection of the ditch bottom, upward and outward, to the natural ground.

Bicycle Lane: A portion of a roadway that has been designated by striping, signing and pavement markings for the preferential or exclusive use of bicyclists.

Bicycle Path: A bikeway physically separated from motorized vehicular traffic by an open space or barrier, either within the highway right-of-way or within an independent right-of-way.

Broken Back Curve: Two horizontal curves in the same direction joined by a short tangent section.

Capacity: The maximum number of vehicles which can reasonably be expected to traverse a point or uniform section of a road during a given time period under prevailing roadway, traffic, and control conditions.

Categorical Exclusion (CE): An environmental classification of projects that will not induce significant environmental impacts or foreseeable alterations in land use, planned growth, development patterns, traffic volumes, travel patterns, or natural or cultural resources.

Collector-Distributor Roads: A set of roadways at an interchange used to eliminate weaving and reduce the number of exit and entrance points from the main through lanes of a freeway.

Compound Curves: A series of two or more simple curves with deflections in the same direction immediately adjacent to each other.

Criteria: A term typically used to apply to design values, usually with no suggestion on the criticality of the design value. Because of its neutral implication, this manual frequently uses "criteria" to refer to the design values presented.

Cross Slope: The slope in the cross section view of the travel lanes, expressed as a percent based on the change in vertical compared to the change in horizontal.

Cross Slope Rollover: The algebraic difference between the slope of the through lane and the slope of the adjacent lane or shoulder within the traveled way or gore.

Cuts: Sections of highway located below natural ground elevation thereby requiring excavation of earthen material.

Deceleration Lane: An auxiliary lane used by an exiting vehicle to reduce its speed.

Decision Sight Distance: Sight distance, which may be required in a complex environment, which is based on the driver's reaction time.

Delay: The criteria performance measure on interrupted flow facilities, especially at signalized intersections. For this element, average total delay is measured, which is expressed in seconds per vehicle.

Density: The number of vehicles occupying a given length of lane, averaged over time. Lane density is usually expressed as vehicles per mile per lane (vpmpl).

Department: Rhode Island Department of Transportation (RIDOT).

Design Exception: The process of receiving approval from the Federal Highway Administration (FHWA) or RIDOT for using design criteria that does not meet the criteria set forth in this manual or other accepted design standard.

Design Hourly Volume (DHV): The 1-hour volume for both directions of travel in the design year selected for determining the highway design, generally considered the 30th highest hourly volume.

Design Service Flow Rate: The maximum hourly vehicular volume that can pass through a highway element at the selected level of service.

Design Speed: The selected speed used to determine the various geometric and roadside design features of the roadway.

Design Vehicle: The vehicle used to determine turning radii, off-tracking characteristics, pavement designs, climbing lanes, etc.

Desirable, Preferred: An indication that the designer should make every reasonable effort to meet the criteria and should only use a less desirable design after due consideration of the better design.

Directional Design Hourly Volume (DDHV): The 1-hour volume in the heavier direction of travel during the DHV.

Directional Distribution (D): The percentage of the traffic in the heaviest direction of travel during the design year peak hour.

Divided Highway: A highway with separated roadways for traffic moving in opposite directions.

Driveway: A point of access/egress between a public way, highway, street, or road, and an abutting property.

85th-Percentile Speed: The speed that 85-percent of vehicles travel below on a given section of highway.

Environmental Assessment (EA): A document which is prepared to determine if the environmental impacts of a project are significant, thus requiring the preparation of an EIS.

Environmental Impact Statement (EIS): A document which is prepared when it has been determined that a project will have a significant impact on the environment.

Expressways: Divided highway facilities that are characterized by full or partial control of access.

Fill Slopes: Slopes extending outward and downward from the hinge point to intersect the natural ground line.

Finding of No Significant Impact (FONSI): A result of an EA that shows a project will not cause a significant impact to the environment.

Freeways: The highest category of arterial roadway. Full control of access, high design speeds, and a high level of driver comfort and safety characterize these facilities.

Frontage Road: A road constructed adjacent and parallel to, but separated from, the highway for service to abutting property and for control of access.

Full Access Control: Full control of access is achieved by giving priority to through traffic by providing access only at grade-separated interchanges with selected public roads. No at-grade crossings or approaches are allowed. The freeway is the common term used for this type of highway. Full control of access maximizes the capacity, safety and vehicular speeds on the freeway.

Gore Area: The graded area beyond the gore nose.

Grade Slopes: The rate of slope between two adjacent PVIs expressed as a percent. The numerical value for percent of grade is the vertical rise or fall in feet for each 100 feet of horizontal distance. Upgrades in the direction of stationing are identified as plus (+). Downgrades are identified as minus (-).

Grade Separation: A crossing of two highways, or a highway and a railroad at different levels.

High Speed: For geometric design applications, high speed is defined as above 40 mph.

Highway, Street or Road: The entire width between boundary lines of every way when any part of it is open to the use of the public for the purpose of vehicular traffic.

Horizontal Sight Distance: The sight distance required across the inside of a horizontal curve.

Ideal: Indicating a standard of perfection (e.g., traffic capacity under “ideal” conditions).

Insignificant, Minor: Indicating that the consequences from a given action are relatively small and not an important factor in the decision-making for road design.

Interchange: A system of interconnecting roadways in conjunction with one or more grade separations, providing for the movement of traffic between two or more roadways on different levels.

Intersection: The general area where two or more highways join or cross, within which are included the roadway and roadside facilities for traffic movements in that area.

Intersection Sight Distance: The sight distance required within the corners of intersections to safely allow a variety of vehicular maneuvers based on the type of traffic control at the intersection.

K Factor (K): Ratio of DHV to AADT.

Level of Service (LOS): A qualitative concept that has been developed to characterize acceptable degrees of congestion as perceived by motorists.

Local Roads and Streets: All public roads and streets not classified as state highways.

Low Speed: For geometric design applications, low speed is defined as 40 mph or less.

May, Could, Can, Suggest, Consider: A permissive condition. Designers are allowed to apply individual judgment and discretion to the criteria when presented in this context. The decision will be based on a case-by-case assessment.

Minimum, Maximum: Representative of generally accepted limits within the design community, but not necessarily suggesting that these limits are inviolable. However, where the criteria presented in this context will not be met, the designer will in many cases need approval or a design exception.

Maximum Side Friction (f_{max}): Limiting values selected by AASHTO for use in the design of horizontal curves. The designated f_{max} values represent a threshold of driver discomfort and not the point of impending skid.

Maximum Superelevation (e_{max}): The overall superelevation control used on a specific facility. Its selection depends on several factors including overall climatic conditions, terrain conditions, type of area (rural or urban) and highway functional classification.

Median: The portion of a divided highway separating the two traveled ways for traffic in opposite directions. The median width includes both inside shoulders.

Median Opening: An at-grade opening in the median to allow vehicles to cross from one roadway to the next or make a U-turn where permitted.

National Highway System (NHS): A system of highways determined to have the greatest national importance to transportation, commerce, and defense in the United States. It consists of the Interstate highway system, selected other principal arterials, and other facilities which meet the requirements of one of the subsystems within the NHS.

Noise Barrier: A structure designed to reduce the noise level of traffic adjacent to an existing building to an acceptable level.

Normal Crown (NC): The typical cross section on a tangent section (i.e., no superelevation).

Parking Lane: An auxiliary lane used primarily for the parking of vehicles.

Partial Access Control: The authority to control access is exercised to give preference to through traffic to a degree that, in addition to access connections with selected frontage or local roads, there may be some control of certain vehicular movements.

PC: Point of curvature (beginning of curve).

PCC: Point of compound curvature.

PI: Point of intersection of tangents.

Point of Applied Grade (POAG): The point on the cross section where the elevation of the calculated profile grade line is located.

Policy: Indicating RIDOT practice that the Department generally expects the designer to follow, unless otherwise justified.

Posted Speed Limit: The recommended speed limit for a highway as determined by the State Traffic Commission in accordance with the General Laws of Rhode Island (31-14-4).

PRC: Point of reverse curvature.

PT: Point of tangency (end of curve).

PVC (Point of Vertical Curvature): The point at which a tangent grade ends and the vertical curve begins.

PVI (Point of Vertical Intersection): The point where the extension of two tangent grades intersect.

PVT (Point of Vertical Tangency): The point at which the vertical curve ends and the tangent grade begins.

Ramp: A roadway connecting two or more legs of an intersection or interchange.

Reverse Curve: Two simple curves with deflections in opposite directions that are joined by a relatively short tangent distance.

Right-of-Way: A general term denoting land, property, or other interest therein, acquired for or devoted to a highway or transportation use.

Roadside: A general term denoting the area adjoining the outer edge of the roadway. Extensive areas between the roadways of a divided highway may also be considered roadside.

Roadway: The portion of a highway, including shoulders, for vehicular use.

Roadway Section: The combination of the traveled way, both shoulders and any auxiliary lanes on the highway mainline.

Roundabout: A circular intersection design that incorporates specific design features such as yield at entry, channelized approaches, and geometric curvature to slow speeds.

Running Speed: The average speed of a vehicle over a specified section of highway. It is equal to the distance traveled divided by the running time.

Rural Areas: Those places outside the boundaries of urban areas as defined by *Technical Paper 155, Highway Functional Classification System for the State of Rhode Island 2005 – 2015, January 2005* published by the Statewide Planning Program.

Shall, Require, Will, Must: A mandatory condition, designers are obligated to adhere to the criteria and applications presented in this context or to perform the evaluation indicated. For the application of geometric design criteria, this manual limits the use of these words.

Shared Roadway: Any roadway upon which a bicycle lane is not designated, which may be legally used by bicycles regardless of whether such facility is specifically designated as a bikeway.

Should, Recommend: An advisory condition. Designers are strongly encouraged to follow the criteria and guidance presented in this context, unless there is reasonable justification not to do so.

Shoulder: The portion of the roadway contiguous to the traveled way for accommodation of stopped vehicles, for emergency use, and for lateral support of base and surface courses.

Shoulder Width: The width of the shoulder measured from the edge of travelway to the outside edge of shoulder or face of curb.

Sidewalk: That portion of the highway section constructed for the use of pedestrians.

Signalized Intersection: An intersection where all legs are controlled by a traffic signal.

Significant, Major: Indicating that the consequences from a given action are obvious to most observers and, in many cases, can be readily measured.

Simple Curves: These are continuous arcs of constant radius that achieve the necessary highway deflection without an entering or exiting transition.

State Highway System: The highway system under the jurisdiction of the Rhode Island Department of Transportation.

Stopped Controlled Intersection: An intersection where one or more legs are controlled by a stop sign.

Surface Transportation Program (STP): A block-grant program that provides Federal-aid funds for any public road not functionally classified as a minor rural collector or a local road or street.

Stopping Sight Distance (SSD): The sum of the distance traveled during a driver's perception/reaction or brake reaction time and the distance traveled while braking to a stop.

Superelevation (e): The amount of positive cross slope or "bank" provided on a horizontal curve to help counterbalance, in combination with side friction, the centrifugal force of a vehicle traversing the curve.

Superelevation Rollover: The algebraic difference (A) between the superelevated travel lane slope and shoulder slope on the outside of a horizontal curve.

Superelevation Runoff: The distance needed to change the cross slope from the end of the tangent runout (adverse crown removed) to a section that is sloped at the design superelevation rate, or vice versa.

Superelevation Transition Length: The distance required to transition the roadway from a normal crown section to the full superelevation. Superelevation transition length is the sum of the tangent runout and superelevation runoff distances.

Tangent Runout (TR): The distance needed to change from a normal crown section to a point where the adverse cross slope of the outside lane or lanes is removed, or vice versa.

Toe of Slope: The intersection of the fill slope with the natural ground or ditch bottom.

Top of (Cut) Slope: The intersection of the back slope with the natural ground.

Travel/Traffic Lane: The portion of the traveled way for the movement of a single line of vehicles.

Traveled Way: The portion of the roadway for the movement of vehicles, exclusive of shoulders and auxiliary lanes.

Turning Roadways: Channelized (painted or raised) turn-lanes at at-grade intersections.

Turn Lane: A type of auxiliary lane. The portion of roadway adjoining the through traveled way for speed change, turning, and storage for turning vehicles.

Two Way Left Turn Lane (TWTL): Auxiliary lane for the storage of left turning vehicles. Lane usage is shared by both directions of traffic.

Typical: Indicating a design practice which is most often used in application and which is likely to be the "best" treatment at a given site.

110.02 Abbreviations

AASHTO	American Association of State Highway and Transportation Officials
ADA	Americans with Disabilities Act of 1990
FHWA	Federal Highway Administration
HCM	Highway Capacity Manual
MUTCD	Manual on Uniform Traffic Control Devices
NCHRP	National Cooperative Highway Research Program
NHS	National Highway System.
PM	RIDOT Project Manager
RIDOT	Rhode Island Department of Transportation
RIDEM	Rhode Island Department of Environmental Management
STC	State Traffic Commission
STP	Surface Transportation Program
TIP	Transportation Improvement Program
TRB	Transportation Research Board

110.03 References

In addition to this document, the designer should refer to the latest edition of the following documents and publications.

- AASHTO. *A Policy on Geometric Design of Highways and Streets*
- AASHTO. *A Guide for Achieving Flexibility in Highway Design*
- AASHTO. *Roadside Design Guide*
- AASHTO. *Highway Safety Design and Operations Guide*
- AASHTO. *Roadway Lighting Design Guide*
- AASHTO. *Guide for Design of Pavement Structures*
- AASHTO. *Guide for the Planning, Design, and Operation of Pedestrian Facilities*
- AASHTO. *Guide for the Development of Bicycle Facilities*
- FHWA. *Manual on Uniform Traffic Control Devices for Highways and Streets*
- *Rhode Island Standard Specifications for Road and Bridge Construction*
- RIDOT. *Bridge Design Manual*
- RIDOT. *CAD Standards Manual*
- RIDOT. *Design Policy and Procedures Manual*
- RIDOT. *Guidelines for Geotechnical Site Investigations in Rhode Island*
- RIDOT. *Rules and Regulations Concerning Permission for Use of State Highway Rights-of-Way* (PAPA Manual)
- RIDOT. *Rhode Island Standard Details*
- RIDOT. *Traffic Design Manual*
- TRB. *Highway Capacity Manual*

- FHWA. *Technical Advisory T6640.8A: Guidance for Preparing and Processing Environmental and Section 4(f) Documents* (dated October 30, 1987).

- Architectural and Transportation Barriers Compliance Board (Access Board). *Americans with Disabilities Act Accessibility Guidelines* (ADAAG)

Division 2 - Project Engineering Development

210 General

210.01 Design Principles

The guiding principle of highway design is to produce a roadway design that meets all relevant criteria for cross section, horizontal and vertical geometry, traffic volumes, and hydrology and drainage, while concurrently minimizing impacts to specific social, environmental, cultural, and economic resources in a satisfactory manner.

In order to implement this principle, highway designs are typically developed in two distinct stages: a conceptual design stage and a final design stage. Each of these stages is discussed in detail in the following sections of this division.

210.02 Design Standards

Designers are called upon to make numerous decisions as to the geometric and structural characteristics of highway improvements. Without some basic framework of design standards, the judgments of individual designers may vary considerably. The purpose of design standards is to ensure that highway improvements are consistently designed with due consideration given to appropriate levels of traffic service, safety, and economy.

210.02.1 Basis for Standards

The concept of design standards has evolved from extensive highway agency research and experience. The findings and conclusions are documented in many publications which serve as guides for highway design.

210.02.2 AASHTO Policies and Guides

The American Association of State Highway and Transportation Officials (AASHTO) is the recognized authority on American highway design policies and standards. Since 1938, AASHTO has been developing and publishing design policies and guides for use by highway agencies and continues to update the information to reflect new findings and the current state of knowledge.

While this manual cannot attempt to cover the entire scope of important published information related to highway design policies, a list of the more significant AASHTO design standards publications is contained in section 110.03 - References of this manual.

210.02.3 Application of Standards

The majority of the AASHTO design criteria are expressed as minimum values or as ranges of values for particular conditions, allowing for some degree of flexibility in the specific practices that might be adopted by an individual agency.

Two different categories of standards should be recognized in relation to their manner of application:

1. Fixed Standards. Certain standards are defined in terms of fixed values which are not directly related to design speed, examples of which include standards for elements such as lane width, shoulder width and bridge width. In these cases widths less than standard would not provide adequate levels-of-service and safety, while widths greater than standard usually would not be economically or environmentally prudent. Fixed standards apply principally to projects of new construction. These standards are also desirable for rehabilitation and resurfacing projects, though it is sometimes necessary to accept a reduced standard due to economic, social, and/or environmental considerations.

2. Minimum Standards. Several standards will be expressed in terms of minimum values. Examples are criteria for elements such as sight distance, degree of curvature, median width, vertical and lateral clearances, and slopes. Many of these elements are closely related to traffic safety, and often the designer can employ standards considerably higher than the minimum without significant increase in cost (in most cases this is encouraged by the Department).

While it is normally required that at least the minimum design standards are provided, there may on occasion be conditions that warrant consideration of a reduced standard. In such cases, the departure from design standards must be thoroughly documented for review and approval by the chief engineer. Where federal oversight is involved, FHWA review and approval is also required.

The need for exceptions to the standards must be identified early in the design phase so approvals or denials will neither delay completion of the design nor require extensive redesign. Thorough documentation is essential in this regard. Refer to **Division 5 - Design Exceptions** for a full consideration of the Department's policy in granting design exceptions.

210.03 Context-Sensitive Solutions

210.03.1 General

A context-sensitive solution (CSS) is a design philosophy that balances safety and mobility with the community objectives, historic resources, and the natural environment. Design professionals, planners, and stakeholders contribute to the design during the planning process.

The incorporation of CSS into a project can, in many cases, be accomplished without the need to reduce design criteria. The designer must consider the input from the stakeholders; however, not all recommendations can be incorporated into the design. The final decisions on design matters will ultimately be made by RIDOT and FHWA.

The designer should refer to Design Policy Memo 410.04 for additional information.

210.03.2 Policy

It is the Department's policy that CSS be considered for all projects, except resurfacing and crack sealing, from their inception through construction. The degree to which CSS is applied is dependant on the project type and location. For example, 1R projects will typically require only limited application of CSS, whereas a full reconstruction or new alignment project may require significant application.

210.03.3 Procedures

As detailed in DPM 410.04, the basic concept governing the development of a context-sensitive solution is to conduct the design from the "outside-in."

This procedure outlines the necessary steps involving the professional design team members, resource agency experts, elected officials, local government representatives, and interested citizens. The project scope of work will need to be considered when determining how intensely the process must be applied to a particular project.

210.03.4 Public Involvement Policy

It is the Department's policy to work with the local communities to achieve a successful design. Public participation is a crucial component in meeting this goal.

Public participation may take the following forms:

- correspondence with elected officials and municipal staff

- public hearings, workshops or meetings
- CSS design team sessions

210.03.5 Context-Sensitive Solutions Process

A. Review of Existing Conditions

The following existing conditions relative to the proposed project should be established:

1. engineering elements
2. historical and archaeological elements
3. natural environmental elements
4. landscape architectural elements
5. community based elements, including:
    - homes
    - businesses
    - hospitals
    - schools
    - places of worship
    - playgrounds and recreation sites
    - libraries
    - elderly housing
    - any other elements of local concern along or in close proximity to the project

The results of this existing conditions investigation should be presented at the initial public hearing or meeting along with the project background. This should be accompanied by a visual analysis of the area by the project landscape architect, which identifies key natural and cultural features as well as other elements of distinctive local character. Comment should be solicited from citizens and elected officials and considered accordingly.

B. Development of the Basic Project Design Concept

The professional team should work with the citizens group to identify roadway and transportation infrastructure deficiencies and to develop the project design concept for necessary improvements. Conceptual landscape designs should be developed as part of the conceptual project design.

Any concerns or issues raised by elected officials, municipal professionals, and the public through the public hearing or meeting should be reviewed and evaluated.

The citizen's group should be consulted as to whether any additional issues may exist which were not raised through the public hearing or meeting. As it is possible that unanticipated issues will become known, the professional team should be prepared to consider these issues.

The design alternatives under consideration should be brought to the citizen's group to develop a consensus on a preferred alternative. The agreed-upon preferred alternative should be used as the basis for development of the conceptual design. At this stage the concerns and opinions of resource agencies having jurisdictional authority over the project (e.g., RIDEM, State and local historic preservation) should be sought and considered accordingly.

The continued consideration of physical features, usage, project concepts, and project goals should be ensured:

- The project design and details should have continuity within logical limits.
- Sound engineering practice must be adhered to and safety considerations must be addressed.
- Project budgets must be maintained in a reasonable manner.
- Constructability and maintenance needs must be considered and addressed in a practicable way.

Engineering and design considerations should be explained to the citizen's group in a non-technical manner to ensure complete understanding of the design process by all parties involved.

A multidisciplinary approach should be used when investigating design options. The design team should work as an integrated unit in the development of design alternatives. Design problems are likely to have several alternative solutions.

The concerns of the citizen's group and the public should be validated and addressed in a serious and patient manner. The design and construction of transportation facilities is often complicated and intrusive, and people may be wary of change and/or may not be able to visualize how a project will look or function. Realistic visual aids should be used whenever possible.

Efforts should be made to locate/obtain old photographs of the area to assist in the preservation of natural and cultural character in the project design.

The project development and CSS process should periodically be reviewed and the agreed-upon issues summarized. All design elements should work together to create a cohesive and consistent transportation facility that is harmonious with its surrounding environment.

Alternative concepts should be prepared in the event that the citizen's group is split in opinion or cannot reach consensus with the professional team. These alternatives should then be presented to elected officials, local government professionals, and the public at subsequent public hearings/meetings to gauge public reaction and acceptance. Based on the results of this effort, the professional team should work with the citizen's group to resolve any remaining differences.

Official endorsement of the conceptual design from the chief elected governing body or official should be secured before proceeding to final design.

C. Final Design

At the benchmark design stages of 30% and 90%, the project should again be reviewed to ensure project concepts and goals are being addressed.

- The project design and details should have continuity within logical limits.
- Sound engineering practice must be adhered to and safety considerations must be addressed.
- Project budgets must be maintained in a reasonable manner.
- Constructability and maintenance needs must be considered and addressed in a practicable way.

When applicable, final design may only begin upon endorsement by the local municipality and FHWA.

Working with the professional team and the citizen's group, the designer shall develop the conceptual plans for the project to the requisite engineering detail. This should include the solicitation of input from the Construction Section and Maintenance Division, as their input on constructability and maintainability is essential to successful project implementation.

When appropriate, the project design should be developed from the outside-in. Sensitive features such as historic buildings, historic hardscape (brick or stone sidewalks, hitching posts, fences, walls, monuments, cobblestone pavement, gravel pathways, etc.), trees and landscaping (both natural and manmade) should be accommodated.

This effort should be coordinated with landscape architects and historical specialists in an effort to blend the new project into the existing culture.

The impact of changes on existing features should be recognized. In the event that existing features are in conflict with the implementation of safe design standards, such conflicting features should be relocated or modified as minimally as necessary to resolve the conflict. Full effort should be made to retain the positive aspects and attributes of a given feature.

Construction materials should be selected with regard to the context and surrounding environment. The designer should attempt to match existing and adjacent materials to the greatest extent practicable.

The primary goal of the landscape design is to preserve existing landscape features. All plantings must be within the highway right-of-way and there will be no land acquisition for landscaping. Plantings will be allowed on private property only for the purposes of mitigation in lieu of monetary compensation.

For rural roads, mitigation plantings (native vegetation) can be added to the disturbed areas resulting from grade changes and/or shift in alignment. The cost of the landscape architectural elements on a rural road project should not exceed six percent of the total project cost.

For urban roads, the landscape design elements must be compatible with the adjacent areas and with the community's Comprehensive Plan. Special pavement treatments or ornaments can be provided if the need is established. The inclusion of ornamental lighting into a project will be based on pedestrian traffic, character of the area, community acceptance of operating and maintenance costs, and availability of existing funds.

All curbing must be replaced in kind unless a community ordinance specifically requires the installation of granite curbing. Landscape architectural elements for an urban road should not exceed six percent of the total project cost.

The conceptual layout should be sensitive to the fact that even small changes to the vertical or horizontal geometry of the roadway can have significant impacts on building entrances, driveways, landscaping, and drainage.

The design must recognize that the colors, materials, and aesthetic design of elements such as guardrail, railings, traffic signal supports, paving materials, sign posts, light posts, signage and lighting, and parapet walls have a significant impact on the public's perception of the project.

Artist or computer renderings should be used (along with catalog cuts, photographs of existing elements, etc.) to illustrate what the completed feature/project will look like. Where possible, samples should be obtained from suppliers for this purpose.

The design plans should clearly indicate all areas that are not to be disturbed (i.e., limits of disturbance).

D. Pre-Construction and Construction

The design process and contextual concerns should be reviewed with the resident engineer prior to the pre-construction meeting.

A best strategy for control of construction practices that will affect the site and adjacent areas should be developed.

A process for on-site decision making that involves a multi-disciplinary approach should be determined.

The contract documents (plans, specifications) should clearly indicate and note all significant and sensitive historic, cultural, and environmental areas and features, including trees and vegetation that are not to be disturbed.

All project issues should be discussed during a mandatory pre-construction field meeting. Attendees should include project managers from the RIDOT Engineering and Construction Sections, the designer, and the contractor, as well as representatives from RIDOT Environmental, Landscape, and Cultural/Historical Units, as applicable.

220 Project Types and Submission Identification

The intent of this section is to establish submission requirements and schedule for each type of RIDOT project.

Projects can either be dedicated to one RIDOT section (e.g., Highway) or be comprised of several sections, as is often the case with complex programs. In all cases, an assigned RIDOT PM will lead the project, with whom the designer must coordinate for all project submissions and correspondence.

220.01 Definitions

Definitions are divided into three (3) major sections: *Submission Stage* (stage of the project life cycle), *Project Types* (level of improvement proposal for a project), and *Project Submission Types* (all possible reports and submissions that are made during development of a project).

220.01.1 Submission Stage

The following submission stages are ordered by the timing of submissions.

Submission Stage	**Description**
10%	The 10% stage is typically used to determine the location of the proposed improvements, such as centerline location/roadway alignment and the roadway profile.
30%	Upon completion of the 30% stage, the location and profile of the roadway will be established and typical sections will be developed. The subsurface exploration program (borings) and resultant project soils report should also be complete. The 30% plans should show all proposed major drainage systems, sedimentation pools and any required drainage agreements; all major traffic signs with proposed legends as well as basic traffic signal system designs; and locations of guardrail, fencing, selective clearing, walls, and pavement striping.
75%	Upon completion of the 75% stage, the drainage and utility plans and the drainage and temporary erosion control details should be, at a minimum, 75% complete, with all pipes sizes and inverts established. Quantities for site preparation, earthwork, base courses, pavement, and drainage should be sufficiently complete (for subsequent development of the engineer's estimate).
90%	Upon completion of the 90% stage, the engineer's estimate, distribution of quantities, and location plan requirements should be complete. The status of the project should be considered almost 100% complete, with the remaining 10% of the project consisting of corrections and revisions to the contract documents (plans, specifications, estimates) arising from review.
Plans, Specifications & Estimate (PS&E)	The PS&E stage should be used as a funding submission. All prior comments should be address/incorporated and the contract documents should be complete in all regards.
Addenda	Contract addenda are issued when changes must be made to the PS&E submission during advertising (prior to bid).

220.01.2 Project Types

Project types have are grouped by discipline and ordered alphabetically.

Project Type	**Description**
1R Improvement	In addition to improving the riding surface, a 1R project is intended to provide maintenance-level modifications to a highway segment. Typically, 1R improvements are limited to surface-level work within the existing right-of-way, including (where applicable): intersection channelization modifications; traffic signal installations and/or replacements; minor storm drainage improvements or system modifications; curb and sidewalk replacement, including isolated new installations in limited areas; guardrail improvements and replacement; pavement rehabilitation; signing and striping; and limited landscaping.
ADA	These projects involve new construction or rehabilitation of existing sidewalks to accommodate access for persons with disabilities. To ensure crosswalk ramp access, adequate clearance from obstructions such as fire hydrants, utility poles, ground-mounted traffic signal controls, retaining walls, etc. should be provided.
Bicycle Facilities	These projects involve new construction or rehabilitation of existing bike paths, trails or greenways and/or the addition of bike lanes and bike routes (by signing and striping).
Crack Sealing	The purpose of a crack sealing project is to prevent water from passing into the pavement structure. Cracks within an existing pavement structure are filled and over-banded with a rubberized asphalt compound often containing fiber reinforcement. The compound is heated sufficiently to be applied in a liquid state.
Drainage Improvement	A drainage improvement project typically involves the removal/replacement of deteriorated drainage systems, the installation of environmental controls (e.g. water quality structures), and/or construction of new drainage systems. This type of project is usually initiated when existing drainage systems are determined to be inadequate.

Project Type	Description
Enhancement	These projects consist of improvements beyond those considered typical of a highway improvement project. Such elements may include, but are not limited to, streetscape improvements, new sidewalks, signage, minor landscape enhancements, bicycle paths/trails, stormwater retrofits, and water access projects.
Full Reconstruction	A full reconstruction project involves the implementation of higher-level improvements, generally within existing roadway corridors. This type of project typically includes a new, full-depth pavement structure; horizontal and/or vertical alignment improvements; highway widening; the addition of travel and/or turning lanes; intersection upgrading and reconfiguration; curb and sidewalk installations or replacement; replacement of or improvements to the drainage system(s); utility relocation; landscaping; and right-of-way acquisition.
Landscape	Separate landscape contracts typically consist of plantings and landscape architecture elements only. Landscape architecture elements include preserving existing landscape features, wetland mitigation/restoration plantings, new plant material (street trees), and any other special project considerations.
Landscape Maintenance	Landscape maintenance contracts are used on completed landscape contracts in high visibility areas, and/or where the survivability of the landscaping is important to the overall success of the project.
New Alignment	A new alignment project is one where all or part of the proposed improvements involve either the construction of a highway or relocation of an existing facility to a new location.
Rubberized Asphalt Chip Sealing	These projects involve the application of a pavement surface treatment consisting of a uniformly sprayed coating of rubberized asphalt, which is immediately covered with a layer of single-size stone. The rubberized asphalt seals the surface, and the stone layer prevents contact of vehicle tires with the rubberized asphalt.
Resurfacing	The purpose of a resurfacing project is to improve the riding surface of a highway. These type of projects typically involve little to no modifications to other major elements of the highway.

Project Type	**Description**
Structural Facilities	Structural facilities projects generally involve the construction or reconstruction of a structure that is transportation-related. Examples include salt storage facilities, rest areas/visitor centers, train stations, bus stations, bus shelters, inspection/weigh stations, stormwater/sanitary pumping stations, maintenance garages, electrical/utility buildings, gate houses, parking garages, ferry docks, and airport terminals.
Thin Overlays	These projects involve the application of a plant-mixed asphalt concrete having a coarse aggregate texture and a chemically modified crumb rubber asphalt binder, placed on a tack-coated surface at a thickness of about one (1) inch.
Tree Trimming	Tree trimming contracts are utilized for any necessary tree trimming work and utility relocations.

220.01.3 Project Submission Types

Study and Development / Preliminary Design:

Submission Type	**Description**
Planning/Feasibility Study	This type of study involves an in-depth analysis of a potential alternative mode of transportation (e.g., rail, water, people-movers, and other modes). A Planning/Feasibility Study can include operational analysis, operating cost development, preliminary site assessment, and identification of potential funding sources, though they normally do not include any engineering beyond conceptual or master plan level. A final report is submitted to RIDOT for review and is distributed to the affected local communities for input.
Visual Analysis	Upon commencement of a project, the landscape architect will conduct a visual inventory of the entire project area and prepare a visual analysis for presentation at the first public hearing/meeting. The visual analysis submission will generally apply to larger-scale highway, bridge, or traffic engineering projects.
Initial Project Assessment (IPA) Report	For 1R, ADA, and drainage improvement type projects, an Initial Project Assessment Report is prepared to evaluate the existing project conditions and develop a set of recommendations for improvements consistent with the intent of these types of projects. Guidance regarding the format and content of the report is typically provided in the scope of work issued for each project by RIDOT. Upon completion of this report, the project can proceed directly to final design.
Subsurface Exploration	A subsurface exploration program includes borings, geotechnical investigations, and reports which are conducted for projects when included in the scope of work. Two series of tests are performed within the projects limits: (1) pilot - random locations; and (2) final - grid locations.

Submission Type	Description
Design Study Report (DSR)	The concept of the proposed improvements and the evaluation of alternatives (where appropriate) shall be addressed and summarized in the Design Study Report (DSR). The report shall provide a complete analysis of the existing conditions and develop a set of recommendations for improvements consistent with the intent of the project as defined in the scope of work. Guidance on the format and content of the DSR is typically provided in the scope of work for each project. The Draft DSR describes in considerable detail all various activities undertaken during the Study & Development phase of the project, up to and including the first and second public hearing/meeting. The process of evaluating alternative solutions is described and concluded with a recommendation of the preferred alternative for subsequent implementation. If a project includes all intersections being considered for a traffic signal installation or modification, the DSR shall include a summary of data collected, a traffic signal warrant analysis (to be conducted in accordance with the MUTCD), capacity analyses, and conceptual improvement plans. These plans are typically considered the 10% plans for a traffic signal. Accident reports should be used to develop the accident analyses and prepare the collision diagrams. These accident reports should not however be included as part of the DSR.
10% Submission	The 10% submission describes the recommended alternative and is often developed concurrently with the preparation of the DSR. This includes full-size plans of recommended improvements, a preliminary cost estimate, geotechnical report, and special design features when applicable. The 10% plans are generally appropriate for display at the second public hearing/meetings. For highway engineering projects, the timing of this submission will be coordinated with the highway managing engineer early in the Study & Development phase. The conceptual landscape design plans, if applicable, will also be part of this 10% submission. The RIDOT Supervising Landscape Architect will coordinate this work.

Submission Type	**Description**
30% Submission	For most highway engineering projects, a 30% submission will be required. The 30% submission builds upon the approved alignment of the 10% submission, establishing State highway rights-of-way and private property lines in those areas where right-of-way actions are to occur. The 30% submission is the final step in the Study & Development process. To determine the project's final design status, an updated preliminary estimate shall be prepared and utilized for programming purposes. The 30% plans are typically used for utility coordination, cultural and environmental review, and municipal public works review. The plans shall show the location of the traffic signal hardware, traffic signal phasing and sequencing, and a loop detector chart. These plans shall also include graphic presentation of the proposed pavement markings with appropriate callouts for the location and type of proposed signage. The maintenance and protection of traffic (concept and plans) is typically developed at the 30% stage. For projects involving landscaping, 30% landscape plans shall be provided as part of the 30% submission. If the project is on a designated scenic roadway, coordination and approval from the Rhode Island Scenic Roadways Board will be necessary. For major projects, coordination should begin at the 30% stage.

Final Design:

Submission Type	**Description**
75% Submission	As it is intended as an interim submission for more complex projects, the need for a 75% submission will addressed during proposal preparation and reflected in the scope of work. For highway engineering projects, depending on the nature and extent of storm drainage improvements and utility installations or modifications, it is possible that the 75% submission will be omitted. If required, this submission includes the drainage and utility plans, drainage and temporary erosion control details, and near-completed cross sections with earthwork calculations. The drainage design should also be completed, computed, and checked, and all landscape design shall be included and should be sufficiently complete. If an Environmental Permit Submission (EPS) is being submitted during this phase, it must include all the plan sheets, reports, and supporting documentation as requested by the RIDOT Natural Resources Unit (NRU) for each permit type.
Right-of-Way (ROW) Submission	The right-of-way submission shall be submitted within 45 days following approval to proceed to the 90% submission stage, unless otherwise directed by the PM. Right-of-way plans are prepared for use by RIDOT Real Estate to appraise the value of the various types of acquisitions required. Refer to DPM 450.10 for content requirements of right-of-way submissions.

Submission Type	Description
90% Submission	At the 90% submission, the contract-specific documents (plans, specifications) are near completion, including the distribution of quantities (DOQ) and engineer's estimate. The location plan requirements checklist shall also be completed. The general plans, location plans, and drainage and utility plans should reference existing and/or assigned condemnation plat designations. Where applicable, landscape plans shall be provided as part of the 90% submission. Resurfacing projects will proceed directly to the 90% submission stage. Plans are generally not required; rather the 90% submission for resurfacing projects will consist of a contract document containing schematic drawings of the highway segments with any applicable details, as well as the DOQ, and engineer's estimate. If it has been determined that the landscaping will become a separate contract, the landscape plans along with a separate estimate will still be submitted as part of the 90% submission. In this case these plans should be provided separately from the main project set.

220.02 Policy

It is the policy of RIDOT to categorize highway improvement projects according to the objectives of each project and the level of improvement required to achieve those objectives. The assignment of each project to one of the above categories is the first step in establishing uniformity among similar projects as it relates to the process to be followed throughout the design of the improvements (i.e., from Study & Development through PS&E).

220.03 Procedures

The appropriate category for a proposed highway improvement project will be assigned by RIDOT during the preparation of the scope of work for the design effort. RIDOT engineers will conduct field reviews, establish the level of improvement required to meet the project objectives, and assign the project to the appropriate category. Reference to that category will be part of the project definition as presented in the scope of work.

It is the responsibility of the PM to coordinate with all sections and units (Highway, Bridge, Traffic, Construction, Real Estate, Environmental/Natural Resources, Intermodal, Research & Technology, Landscape, and Maintenance) and affected parties, based upon the project schedule, so that the timing of the submissions coincides with all other project requirements. Some of the common governing factors associated with project submissions include, but are not limited to, the following:

- TIP status
- Local city and town requirements
- Utilities
- Environmental
- Historical and archaeological requirements
- Right-of-way
- Scheduled advertising date
- Construction requirements
- Scenic Roadways Board (if applicable)
- Railroads (if applicable)

It is the responsibility of the PM to ensure that submissions are made in accordance with the project schedule, include the proper contents, and are delivered to the correct parties as specified in DPM 450.01.

220.04 Submission Distribution Matrix

The PM shall use the distribution matrix contained in DPM 450.01 and good judgment to identify and develop a schedule of deliverables for each submission for each project. This matrix should be used only as a guide; the PM should coordinate and confirm with each section/unit to determine the reviewer's needs prior to ordering the deliverables.

Prior to handing off the responsibility to the designer for follow-through, the PM should use the above Submission Distribution Matrix to confirm and document any exceptions with all affected RIDOT units, sections, and divisions as well as external agencies. It may be beneficial to meet with all entities together or separately to confirm their deliverables, discuss timing of submissions, resolve any conflicts or issues, and discuss contingency planning (if applicable).

As a result of project design elaboration, the contents of deliverables may change to include (or exclude) additional requirements, such as additional plan sheets or documents not originally specified. Prior to proceeding to the next submission stage, the Submission Distribution Matrix should be reviewed by both the PM and designer to ensure that it reflects any additional requirements made by the entities represented and any others that may now be affected.

220.05 Analysis of Existing Conditions

220.05.1 Review of Available Data and Plans

- Existing Project Data. A rigorous effort must be undertaken to compile as much existing data and information as possible on the project. Existing plans, survey books, subsurface information, prior reports, maintenance logs, and environmental data should be obtained from the Department files. Where applicable, other State agencies such as the Rhode Island Department of Environmental Management (RIDEM), the Coastal Resources Management Council, and the Rhode Island Historical Preservation and Heritage Commission (RIHPHC) should be contacted to obtain additional information.

  Public utilities such as electrical power, telephone, gas, cable television, and municipal sewer should likewise be contacted for any information that may be of value to the project.

- Pavement Cores and Soil Classifications. Following the review of the requirements for the new pavement, the designer shall request that the Department's Materials Section obtain new pavement cores and soil classifications for use in the design of the new pavement structure.

220.05.2 On-Site Project Reviews

- Initial Review. The designer shall conduct an initial field review that includes a walkthrough of the project area to identify any apparent deficiencies and note possible alternatives.

- Safety Related Hardware. During the initial field review, the designer shall note the location and condition of crash cushions, break-away signs, and luminaires, including all supports, delineators, guardrail (including end treatments), bridge railings, concrete median barriers, and any other safety-related devices.

220.05.3 Existing Right-of-Way

Once all existing right-of-way plans, tax assessor maps, and deeds have been assembled, the designer shall graphically establish the existing right-of-way and inscribe same on the newly acquired base mapping. Graphic property lines are used to aid the designer to identify potential right-of-way impacts.

220.05.4 Americans with Disabilities Act (ADA) Evaluation

- ADA Inventory. The designer shall compile an inventory of all elements within the project limits that constitute possible obstructions to persons with disabilities. Such obstructions may include fire hydrants, utility poles, ground-mounted traffic signal equipment, retaining walls, curbing, the absence of crosswalk ramps, and ramps that do not meet current design standards.

- Non-Compliant Elements. The designer shall locate by survey all apparent non-compliant elements within the project limits and record this survey in field books. This data shall subsequently be added to the base mapping for evaluation.

- ADA Compliance of Proposed Improvements. The designer shall evaluate each element identified in the above inventory for non-compliance with ADA standards. Those elements determined to be non-compliant shall be appropriately modified or removed and replaced if possible. All new design features shall be developed in accordance with ADA standards. Refer to **Division 9 – Pedestrian and Bicycle Facilities** for a full consideration of the Department's policy on ADA requirements.

220.06 Design Studies

In the most general terms, "design studies" constitute the initial, conceptual design stage of the two-stage procedure introduced in subsection 210.01 of this Division. The scope of any particular design study is directly related to the highway category under consideration. The following subsections describe the design study efforts required for each of the highway design categories.

220.06.1 Resurfacing Projects

Resurfacing projects do not require a design study.

220.06.2 1R Improvement Projects

The design study for a 1R improvement project is referred to as an *Initial Project Assessment Report*. The purpose of the Initial Project Assessment Report is to evaluate the existing conditions on the project and to develop a set of recommendations for improvement consistent with the intent of the 1R program. Guidance regarding the format and content of the report are typically provided in the scope of work issued by the Department for the project. Upon completion of this report, the project can proceed directly to final design.

220.06.3 Full Reconstruction Projects

The design study for a full reconstruction project is referred to as a *Design Study Report (DSR)*. The concept of the proposed improvements and the evaluation of alternatives (if applicable) shall be addressed and reported in a DSR. The report should provide a complete analysis of the existing conditions and develop a set of recommendations for improvement, consistent with the intent of the project as defined in the Department's scope of work. Guidance regarding the format and content of the report are typically provided in the scope of work for each project. Since a reconstruction project is typically designated as Categorical Exclusion with respect to the National Environmental Policy Act (NEPA), the DSR should include the Environmental Evaluation documentation necessary to secure that designation for the proposed improvements.

220.06.4 New Alignment Projects

The design study for a new alignment project may result in a *Design Study Report* (DSR), *Environmental Assessment* (EA), or *Environmental Impact Statement* (EIS) depending on the nature and extent of the proposed improvements. Any of these report types may be called for by the RIDOT in the scope of work. Should the scope of work call for a DSR, this document shall be prepared in a manner identical to that for a full reconstruction project (see Subsection 220.03.3, above). If an EA or an EIS is required, the report shall be prepared in accordance with the applicable State and federal guidelines.

220.07 Public Participation

The PM will coordinate with RIDOT Community Affairs to determine the scope of public participation for a particular project. The public participation process will typically conform to the Subsection 210.03 Context-Sensitive Solutions of this Division, and the designer will be directed by the PM as to the work and deliverables required for this process.

Division 3 - Design Controls

310 Introduction

A number of factors must be considered in applying appropriate design standards to a project design, including functional classification, level of improvement, traffic volumes and projections, level-of-service, topography, environmental features, and economics. This division aims to familiarize the designer with these considerations in the application of design standards to a particular project.

320 Design Parameters

320.01 Design Speed

The establishment of a design speed affects basic design criteria for a highway, including:

- Horizontal and vertical curvature
- Superelevation
- Sight distance values
- Lane and shoulder widths
- Clear zone values

For new highways or reconstruction of existing highways, design speed should be based on anticipated operating speed, topography, functional classification, and adjacent land use(s). In no case should the design speed be less than the legal posted speed limit. Designers should refer to the latest version of the AASHTO publication *A Policy on Geometric Design of Highways and Streets* (commonly referred to as the "Green Book") for a comprehensive discussion on the various design speed considerations integral to highway design, including the theory and concepts behind design elements.

For reconstructed roadways, in addition to the above, it is the Department's policy to set the design speed 5 to 10 miles per hour (mph) above the posted speed limit. This accounts for motorists traveling above the legal speed limit, thus providing for a more forgiving design.

The following general guidelines should be followed in determining a design speed:

- <u>Roadways with a posted speed limit 40 mph or greater</u>: posted speed limit plus 10 mph;

- <u>Roadways with a posted speed limit less than 40 mph</u>: posted speed limit plus 10 mph in rural areas, posted speed limit plus 5 mph in urban areas;

- Roadways without a posted speed limit: State Traffic Commission (STC) records must be researched to determine if a legal speed limit has been established. Records can be accessed through the RIDOT Traffic Engineering Section. If a legal speed limit has been established, the design speed should be set as noted above. If a legal speed limit has not been established by the STC, prima facie speed limits apply. In these cases, the design speed should be the prima facie speed limit plus 5 or 10 mph as applicable.

  Prima facie speed limits are:

  - 25 mph in business and residential districts
  - 50 mph during daytime and 45 mph during nighttime in other areas (50 mph should be used)
  - 55 mph on interstate highways

For existing facilities, the geometry should be evaluated to determine if any locations do not meet design criteria based on design speed.

320.02 Level-of-Service

The design engineer should strive to design a facility to best-serve projected traffic volumes. Caution should be taken not to over-design a facility, which would result in the expenditure of funds that could be spent more effectively on other projects. The objective is to strike a balance between an acceptable level of delay and congestion during the peak periods in the design year and the incremental costs to reduce those delays.

The *Highway Capacity Manual* (HCM) defines the various levels-of-service of traffic conditions, a brief summary of which is provided below.

- Level-of-Service A: This level-of-service represents free-flow conditions where drivers are free to choose speed and maneuver with little or no impedance.
- Level-of-Service B: This level-of-service represents nearly free-flow conditions. Free-flow speeds are maintained and drivers can maneuver within the traffic stream with ease. Minor events in the traffic stream are easily absorbed.
- Level-of-Service C: This level-of-service represents traffic traveling at or near free-flow speed. Maneuvers are more difficult and events within the traffic stream may result in a deterioration of service.

- Level-of-Service D: At this level-of-service, speeds are below those of free-flow conditions and decline as density increases. Maneuvers within the traffic stream are difficult, and even minor incidents may result in queues forming upstream.

- Level-of-Service E: This level-of-service represents a condition at or near capacity. Maneuverability is limited and flow is unstable. Even minor incidents can be expected to cause disruption and queuing.

- Level-of-Service F: This level-of-service represents a breakdown in flow where demand exceeds capacity.

AASHTO provides guidance on selecting an appropriate design level-of-service based on facility type and terrain. It should be noted that these values are minimums and, where possible, higher levels-of-service should be sought.

320.03 Terrain

AASHTO recognizes three types of topography that influence vehicle performance, specifically as they relate to truck traffic. These general classifications are level terrain, rolling terrain, and mountainous terrain. Based on the topography of the State, only level and rolling terrains are applicable to roadway design and analysis in Rhode Island.

- Level Terrain: Any combination of grade, horizontal, and vertical alignment that allows for generally long sight distances and little effect on truck speed.

- Rolling Terrain: A combination of horizontal and vertical alignment that consistently changes, thereby limiting sight distance and reducing the speed of trucks below that of passenger cars.

The determination of a terrain category should be based on an analysis of the roadway as a whole rather than by its constituent segments. Averaging the terrain over a longer distance will provide a more consistent design.

320.04 Functional Classification

The Rhode Island Statewide Planning Program (RISPP) has developed a functional classification system for the roadways throughout the State. Each roadway is classified based on the intended use, and classifications are further broken down by urban and rural location.

The design engineer should refer to the *Highway Classification System for the State of Rhode Island, 2005 – 2015; Technical Paper 155* by the RISPP for a listing of the functional classification of an individual roadway and the methodology used in determining the classification. The report is available on the web at www.planning.ri.gov. The report is also available on compact disc by contacting the Statewide Planning Program, One Capitol Hill, Providence, RI 02908-5870.

Arterials, which include freeways and expressways, are intended to serve traffic at relatively higher speeds, at higher levels-of-service, and with greater mobility. Conversely, local roads and streets serve as a means to access property, with lower speeds and trips of shorter length. Levels-of-service on local roads and streets are not a high priority, and in most cases, speed reduction is promoted. Collector roads bridge the gap between arterials and local roads, providing some degree of mobility and while still providing property access.

320.05 Type of Improvement

In addition to the project limits, the type of improvement to be undertaken will largely determine the scope of work. For example, design standards for new construction may be economically impractical to achieve as part of a 1R improvement. A discussion of the various RIDOT highway project types is provided in **Division 2 - Project Engineering Development**.

The type of improvement selected for an individual roadway should be that which both adequately serves the design volume and realizes the intended enhancement in the most cost-effective manner. Other limiting factors may occasionally require certain trade-offs between optimal design standards and practicality.

320.06 Control of Access

Highway design should consider access control based on the functional classifications of the facility as outlined in section 320.04. Access control is defined as follows:

- Full Access Control: Access is to the highway facility is limited to select locations, generally by a ramp/interchange system. Highways (or portions thereof) with full access control are defined by State Freeway Lines.

- Partial Access Control (Access Management): Access to abutting properties along a highway facility is controlled to improve safety or capacity. Access control may take the form of limiting or eliminating certain driveway movements, requiring access from a side street, or the consolidation of driveways.

- No Access Control: Provide full access from the abutting properties to the highway. All driveways should be designed in accordance with the standards set forth in the Department's latest edition of the *Rules and Regulations Concerning Permission for Use of State Rights-of-Way*.

320.07 Design Vehicles

For the purpose of geometric design, the selected design vehicle should be one that will accommodate most all vehicles anticipated to use the facility (i.e., the most conservative or "worst-case" vehicle). Design criteria influenced by the selection of a design vehicle include:

- Alignment
- Minimum curve radius
- Turning roadway width
- Vertical clearances
- Lane widening on curves

Particular care should be taken at intersections to ensure that large vehicles can complete allowed turning movements (without encroaching upon opposing traffic lanes, mounting sidewalks and islands, etc.).

330 Traffic-Related Design Controls

330.01 Traffic Volumes

Traffic volumes are expressed in a number of ways that may be used in design. These numbers are defined in section 110.01 - Definition of Terms of this manual.

The Department continually collects traffic volume data from stations throughout the state. Adjustment factors are developed from the count data that allows the designer to extrapolate AADT values from ADT and hourly counts. As new count data is received, the Department's Traffic Research Section periodically updates the factors.

The designer should contact the Traffic Research Section for the most up-to-date factors relating to roadway's functional classification.

330.02 Traffic Composition

Because of their different operating characteristics from passenger cars, the percentage of trucks in the traffic stream is an important factor in the design of transportation facilities. Highway capacity, geometry, and pavement structural capacity are all affected by the composition of traffic.

330.03 Traffic Projections

All new alignment and full reconstruction projects should be designed based on projected 20-year future projected traffic volumes. For other projects types such as to 1R improvements or intersection capacity improvements, 10-year future projected traffic volumes should be used.

In all cases, the forecast year is calculated from the anticipated construction completion date.

330.04 Capacity

By definition, capacity is the maximum number of vehicles that can pass a given point during a specified period under prevailing roadway, traffic and control conditions. Designers should refer to the *Highway Capacity Manual* for further discussion on capacity and methodologies for determining the capacity for various facilities or portions thereof. Highways, intersections, ramps, and other such transportation facilities should be designed to meet the design level-of-service for the design hourly volume. In no case should the design volume exceed capacity.

340 Other Design Controls

Other design controls may exist which conflict with those discussed in the previous section. These variables must be addressed and resolved early in the design process in order to define an appropriate and acceptable scope of work for a project.

340.01 Economics

Given the financial resource constraints of the Department, the prudent balance and management of expenditures is an important consideration of the design process. While designing the safest possible facility is the foremost priority, in some cases the cost to mitigate certain impacts may not be economically feasible. Where minimum design standards cannot be met, an economic analysis must be performed to determine the cost to achieve the desired benefit.

The incremental benefits realized at different levels of expenditures should also be considered through a cost/benefit analysis. Where a certain design may not fully conform to the desired design standards, the increased cost to reach those standards may be more effectively applied to improving other element or sections of roadway. Alternately, the situation may arise where higher design standards can be applied at a minimal additional cost, in which case strong consideration should be given to incorporating such higher standards.

340.02 Safety

As previously noted, the provision of safety in the design of a facility is of paramount importance. Relative to safety, design criteria such as design speed, sight distances, and horizontal geometry are generally represented as minimum values, whereas other criteria such as cross sectional elements are somewhat variable and require prudent engineering judgment in application. The designer should strive to establish values that will maximize safety within the confines of the other variables mentioned in this section.

A detailed accident analysis should be conducted for each roadway segment and each intersection under design. Additionally, the designer should solicit input from the local police department to identify any locations that may be particularly hazardous. At a minimum, accident analyses should evaluate at least three (3) years of data (preferably data from actual accident reports), taking into account the following:

- Accident type (angle, sideswipe, rear end, etc.)
- Severity of accident (e.g., property damage, injury, fatality)
- Weather (rain, snow, etc.)
- Light conditions (light, dark, dusk)
- Type(s) of traffic controls in place

A careful review of the accident analysis may identify locations requiring additional safety measures that should be incorporated into the design.

340.03 Environment

The designer must coordinate with the PM to determine the appropriate level of environmental study based on the level of improvement being proposed. Because environmental considerations may have a considerable impact on decisions that are made regarding the design, it is important that the coordination begin early in the design stage. Any commitments made during the environmental assessment stage as well as any stipulations to any permit approvals must be fully incorporated into the design.

Many projects may be eligible for a Categorical Exclusion (CE) based on the type of project, level of improvement, and/or impacts to the surrounding environment. There are two types of CE's; an Exempt Action CE (Type I) and a Documented CE (Type II).

Type I – Exempt Action CE's

Exempt action CE's are those projects that usually do not require environmental documentation based on experience with similar actions. The projects are standard stand-alone transportation activities that, based on FHWA's and RIDOT's experience, will not result in any significant impacts to the human or natural environment. The following types of projects are eligible for a CE under this section:

- Pavement management (1R) type projects which typically involve cold planning and resurfacing of pavement, existing curb and sidewalk replacement, signing, striping, and traffic signal upgrades
- Microsurfacing, thin overlays, and crack sealing of pavement projects
- bridge deck overlays, bridge deck replacements, bridge painting, joint repair and all other bridge maintenance activities, provided the project does not involve work within wetlands, or an historic district (Any bridge listed on the Historic Bridge Inventory is a Type II);
- Replacement of traffic signals within existing ROW, provided no work takes place within any historic districts
- Installation or maintenance of signs, pavement markings, raised pavement markers, sensors, and the replacement fencing within existing ROW
- Tree trimming, mowing or brush removal projects
- Improvements to existing rest areas and weight stations for maintenance, projects involving new ROW or major construction require a higher level of documentation
- Alterations to facilities in order to make them accessible to elderly and handicapped persons
- Improvements to or installation of railroad warning devices, provided the project is not within wetlands jurisdiction, an historic district, and is within existing ROW
- Installation of noise barriers, provided the project is not within wetlands jurisdiction, an historic district, and is within existing ROW
- Emergency repairs
- Approvals for disposal of excess right-of-way
- Approval of utility installations along or across a transportation facility
- Planning and technical studies
- Beautification or facility improvement projects (i.e. landscaping, curb and gutter replacement, installation of park benches, decorative lighting, etc.) that are covered by other agreements

- Bicycle and pedestrian lanes, paths and facilities, provided the project does not involve work within wetlands jurisdiction or a historic district
- Enhancement projects provided there are no wetlands or coastal resource involvement and no involvement with historic properties, districts, or known archaeological sites

TYPE II - <u>Documented CE's</u>

A documented CE should be considered for all project types <u>not</u> listed above as an exempt action CE. Documented CE's are for those projects typically requiring environmental documentation that also would not normally require the preparation of an EA or an EIS, which demonstrate that the criteria for CE's have been met and that significant environmental effects will not result.

Projects that are beyond the scope of those that qualify for a Type I CE will most likely require some form(s) of determination or permit(s) from an environmental regulatory agency such as the Department of Environmental Management (RIDEM) or Coastal Resources Management Council (CRMC). The designer should coordinate through the PM and the RIDOT Office of Environmental Programs (Natural Resources Unit) all such activity and permit submissions. Any stipulations contained in a formally issued permit must be incorporated into the design.

340.04 Right-of-Way

Many projects require the acquisition of right-of-way to achieve the necessary transportation improvements. The right-of-way action may take the form of a permanent acquisition, a permanent easement, or a temporary easement. Refer to **Division 12 – Right-of-Way Considerations** of this manual for additional information.

The highway right-of-way should be sufficient to:

- Develop the desired cross section, including sidewalks of adequate width to provide handicap accessibility
- Accommodate public utilities; where possible, utility poles should be placed at the back of sidewalk. This may also require permanent aerial easements (see **Division 11 - Utilities**)
- Develop adequate turning radii at intersections
- Where applicable include permanent easements on private property at signalized intersections for traffic signal loop installation and maintenance
- Provide for grade adjustments to allow smooth transitions to private property; this may be particularly important where matching to driveway grades or in areas where proper drainage may be a concern

- Include the area required to develop all cuts and fills (e.g., highway side-slopes) for highways on new alignment

The designer should refer to the *Design Policy and Procedures Manual* (DPMs) for guidance on procedures regarding the acquisition of necessary rights-of-way.

340.05 Historic Resources

As Rhode Island is rich in historic resources, it is important that the designer determine early in the design phase whether the project will potentially affect any historic sites within the project limits. For all RIDOT projects, the designer should coordinate with the Department's Historic Preservation Specialist to determine if any special design considerations are warranted.

Division 4 - Alignment and Cross Section

410 Sight Distance

410.01 Introduction

The ability to see along a highway is critical to a driver's ability to react, maneuver, control vehicle speed, or stop to avoid an unexpected or hazardous condition. Available sight distance is the length of the highway ahead that is continuously visible to the driver (as measured according to accepted methods and criteria).

Designers should refer to the latest version of the AASHTO publication *A Policy on Geometric Design of Highways and Streets* (commonly referred to as the "Green Book") for a comprehensive discussion on the various sight distance considerations integral to highway design, including the theory and concepts behind design elements. For conciseness, this Division provides only a general overview of these design criteria and applicable RIDOT design policies.

410.02 Stopping Sight Distance

The available sight distance on a roadway must always be sufficient to allow a vehicle traveling at or near the design speed to come to a complete stop before reaching a stationary object in its path. The "design" values for stopping sight distance provided by AASHTO (Exhibit 3-1 in the 2004 version of the Green Book, adjusted as appropriate for grades), shall be considered the minimum values in the design of any RIDOT highway project. The appropriate stopping sight distance for the design speed must be provided at every point along the roadway. If the minimum stopping sight distance cannot be provided in the design due to certain constraints, conditions must be sufficiently documented and a design exception request must be submitted in accordance with **Division 5 - Design Exceptions**.

The criteria applicable to the measurement of safe stopping sight distance are as follows:

Height of driver's eye: 3.5 feet
Height of object: 2.0 feet
(Source: AASHTO, *A Policy on Geometric Design of Highways and Streets*, 2004)

Measurement shall be in accordance with the methods presented in the Green Book.

410.03 Passing Sight Distance

Passing sight distance criteria are applicable to two-lane, bidirectional highways on which vehicles frequently overtake slower-moving vehicles. These passing maneuvers require the use of the opposing travel lane by the passing vehicle.

For consistency with the AASHTO guidelines for the various roadway functional classifications, passing sight distance should be provided on two-lane rural highways at intervals as frequent as possible and over as high a portion of the overall highway as possible. Consideration of passing sight distance on two-lane urban or suburban streets and arterial highways often has little practical value, as passing is typically prohibited on these roadways. The AASHTO Green Book provides passing sight distance design criteria.

Measurement of passing sight distance shall be based on the following:

Height of driver's eye: 3.5 feet
Height of object: 3.5 feet
(Source: AASHTO, *A Policy on Geometric Design of Highways and Streets*, 2004)

The AASHTO criteria for passing sight distance shall apply to alignment design on RIDOT highway projects. As AASHTO values may differ from criteria presented in the *Manual on Uniform Traffic Control Devices* (MUTCD) for the placement of pavement markings, caution should be taken to avoid confusion.

410.04 Decision Sight Distance

As noted in Section 410.02, stopping sight distance must be provided throughout a given roadway to allow the motorist sufficient sight distance to bring the vehicle to a safe stop in the event of an obstruction. Additionally, there are certain circumstances where greater distances are desired. As noted in the AASHTO Green Book, stopping sight distance is often inadequate when drivers must make complex or instantaneous decisions, when information is difficult to perceive, or when unexpected or unusual maneuvers are required. Where feasible, distances greater than those required for stopping sight distance should be provided at key decision locations.

The AASHTO Green Book provides a thorough discussion on design values for decision sight distance. Although the minimum design criteria relate to stopping sight distance, the need for greater values in decision situations should be recognized. The designer must review any given design project to identify key decision locations and strive to achieve the AASHTO-recommended values for decision sight distance within those roadway sections.

While it is highly desirable to achieve decision sight distance at these key locations, the inability to achieve the AASHTO-recommended values does not require a design exception.

420 Horizontal Alignment

420.01 General

The horizontal alignment for any given roadway consists of a series of tangent (straight) and curved sections. The final design alignment influenced by several factors, including terrain/topography, side-of-road features, existing infrastructure and right-of-way, the type of facility, and construction cost. The objective is to provide a horizontal alignment that achieves the proper balance among safety, comfort and convenience, harmony with the surrounding environment, cost effectiveness, and adequate design for the roadway's functional classification. Consistency and the avoidance of frequent changes and/or short curves are critical issues in alignment design.

420.02 Curvature

The horizontal alignment design for all RIDOT highway design projects shall be developed in accordance with the guidelines set forth in the AASHTO Green Book. Additionally, every effort should be made to exceed the minimum radius criteria wherever possible. If the minimum required radius cannot be achieved in the alignment design at a given location, conditions must be sufficiently documented and a design exception request must be submitted in accordance with **Division 5 - Design Exceptions**.

The minimum radius for a given design speed will vary depending on the degree of superelevation that can be achieved. The radius of any horizontal curve on a project may also be affected by the minimum stopping sight distance criteria. At locations where a roadside object located on the inside of a curve restricts sight distance, the designer must consider increasing the offset to the sight obstruction, increasing the radius of the curve, or providing some combination of these two adjustments. Where longitudinal median barrier is provided, an above-minimum radius or a widening of the shoulder may be needed to achieve the required safe stopping sight distance. If the required stopping sight distance cannot be achieved within any given horizontal curve, a design exception will be required.

Changes in direction along a roadway are generally achieved through the use of simple curves, compound curves, or reverse curves. In the case of reverse curves, it is always more desirable to provide a tangent section between the curves of opposite direction. Wherever possible, the length of tangent section between curves should be sufficient to provide the required superelevation runoff and tangent runout for each curve (Reference Section 420.03 -

Superelevation). Reverse curves that transition at a point of reverse curvature (P.R.C.) are discouraged due to the difficulty of providing transition from full superelevation in one direction to full superelevation in the opposite direction.

Where compound curves must be used in a design, the relationship between the radii of the adjacent curves shall be in accordance with the guidelines provided in the Green Book. Broken back curves are not desired.

It is the Department's policy to avoid the use of spiral curves. The use of a spiral curve must be approved by RIDOT on a case-by-case basis.

420.03 Superelevation

The centrifugal force that occurs when a vehicle travels in a horizontal curve is counterbalanced by (a) the side friction between the roadway and the vehicle's tires and (b) the roadway's superelevation (roadway banking). The degree of superelevation required in a roadway design is directly related to the design speed and the curve radius. Conversely, the minimum radius required for a design speed is related to the degree of superelevation that can be achieved.

While the AASHTO Green Book indicates that superelevation rates (cross-slopes) can range up to a maximum of 12 percent (0.12 feet vertical/feet horizontal), a maximum of 6 percent (0.06 V/H) shall be used on RIDOT projects, due to seasonal climate conditions in Rhode Island (i.e., common snow and ice conditions in winter). This 0.06 V/H rate should generally be used on rural highways; however in more urbanized settings, where roadside features and intersecting streets often affect the designer's ability to match existing grades, a maximum superelevation rate of 0.04 V/H shall apply. Acceptable superelevation rates for a project shall be developed through coordination with the PM during the preliminary design process.

The transition from a normal crown section to a fully-superelevated section, and from full superelevation back to a normal crown, is accomplished through a combination of superelevation runoff and tangent runout. Superelevation runoff is the transition of the outside-lane cross slope from flat (zero percent) to full superelevation, and vice versa. Tangent runout is the transition of the outside-lane cross slope from normal crown to flat, and vice versa. For safety and comfort reasons, the length of roadway over which the runoff and runout transitions are made should be sufficient to make those transitions imperceptible to the driver. While designers should refer to the Green Book for guidance on the required length of runoff and runout, a general rule is that the transition in the cross slope should be accomplished at a rate less than or equal to 1 percent (0.01 V/H) per 50 feet longitudinally along the roadway.

Concerning the design of the runoff/runout longitudinally with respect the point of curvature (P.C.) and the point of tangency (P.T.) of a curve, it is preferable to split the runoff/runout between the tangent and curved sections of the roadway. For example, if the runoff and runout were applied entirely on the tangent such that the road was fully superelevated at the beginning of the curve (P.C.), then the motorists would travel along a superelevated cross section where one is not needed (i.e., on the tangent). Conversely, if the entire runoff and runout were applied on the curve, then the motorists would enter the curve with no superelevation at all; in such a case the roadway would have an adverse crown in the outside lane. It is therefore the Department's policy to require that the transition from normal crown to full superelevation be achieved partially on the tangent and partially on the curve. While individual circumstances will dictate how the full superelevation transition is developed along a given curve, a general rule is that two-thirds of the runoff should be on the tangent and one-third of the runoff on the curve as shown in Figure 4-1.

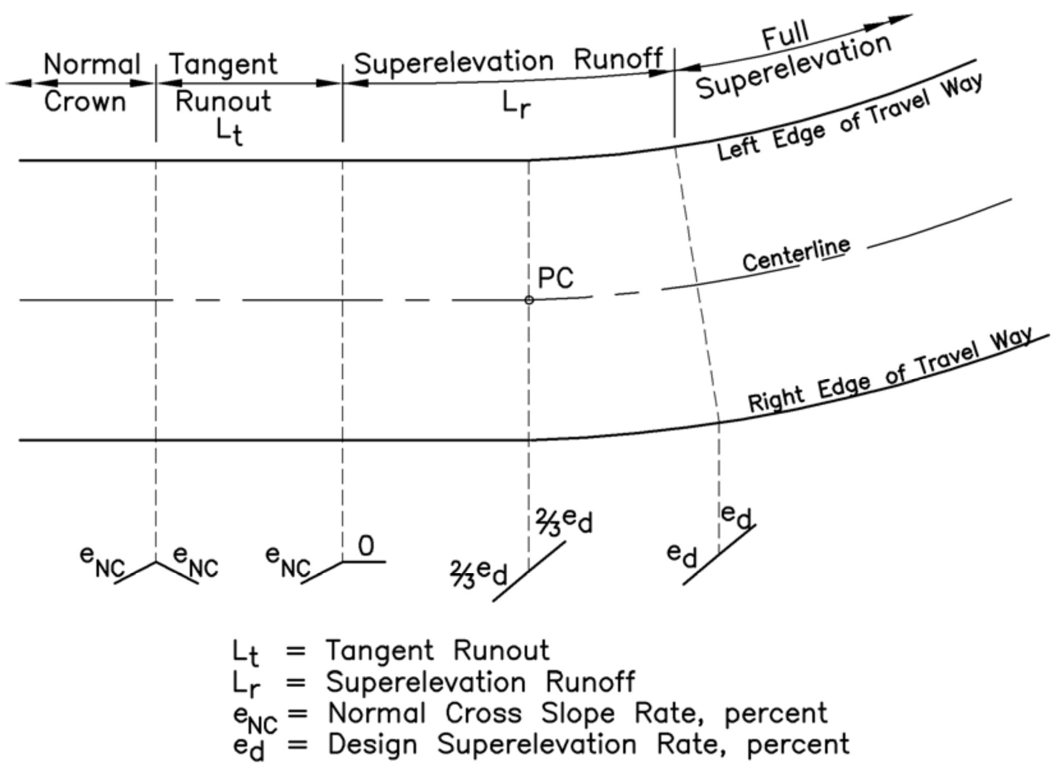

Figure 4-1. Typical Superelevation Transition

The minimum lengths of superelevation runoff and tangent runout shall be calculated using equations 3-25 and 3-26 in the Green Book.

The Green Book describes four basic methods of transitioning the cross section slope to attain the necessary superelevation in a given curve. Revolution about the centerline is the most common method for a roadway with a normal crown approach sections, although any of the transitional methods described in the Green Book are acceptable. The designer should determine the most appropriate method of attaining superelevation for each individual superelevated curve on a project.

430 Vertical Alignment

430.01 General

The existing topography of a project area or corridor greatly influences the vertical alignment design of a roadway. AASHTO recognizes three types of topography that influence vehicle performance, specifically as they relate to truck traffic. These general classifications are level terrain, rolling terrain, and mountainous terrain. Based on the topography of the State, only level and rolling terrains are applicable to roadway design and analysis in Rhode Island. The determination of a terrain category should be based on an analysis of the roadway as a whole rather than by its constituent segments. Averaging the terrain over a longer distance will provide a more consistent design.

Vertical alignment is represented in design by the profile grade line for the roadway. The profile grade line is a longitudinal reference line by which the elevation of the pavement and other roadway elements are established. While the location of the profile line (in the roadway cross section) may vary from one highway type to another, the following general guidelines apply to RIDOT projects:

- For undivided highways, the profile grade line should generally coincide with the roadway centerline. It should also generally coincide with the axis of rotation for the transition into and out of superelevated sections.

- For freeways or other divided highways with medians of 30 feet or less with similar grade, the profile grade line should generally be along the centerline of the median.

- For freeways where the two opposing directional travel roadways differ by grade and/or by a median of significant width, it may be more appropriate to establish separate profile lines for each directional roadway, in which case the profile line for each roadway should generally be as follows:

    - For a directional roadway having two travel lanes, the profile grade line should be the lane line between the travel lanes.

- ◻ For a directional roadway having three travel lanes, the profile grade line should be the lane line between the median lane and the second lane from the median.
- ◻ For a directional roadway having four travel lanes, the profile grade line should be the lane line between the two middle lanes.

- For freeway ramps, the profile line will generally be the right edge of pavement in the direction of travel.

As with horizontal alignment, the factors which affect profile grade design include design speed, terrain, functional classification, surrounding environment, construction costs, safety, and motorist comfort. Designers should refer to the AASHTO Green Book for vertical geometry design guidelines with respect to the above considerations.

430.02 Grades

Both minimum and maximum profile grades will apply to project designs. For new alignment and full reconstruction projects, a minimum profile grade of no less than 0.5 percent (0.005 V/H) shall be provided on vertical tangents. This minimum is necessary to ensure that proper drainage is achieved along the roadway.

Maximum profile grades are established to ensure safety and will be dependent upon the type of roadway under design (functional classification). The maximum allowable profile grade for a project shall be established based on the guidelines set forth in the AASHTO Green Book.

Table 4-1
Maximum Profile Grades - Local Roads

Roadway Type	Maximum grade (%)
Local	15% maximum (Steeper than 4% drainage and erosion may become critical and need to be considered)
Industrial/ Commercial	8% maximum (5% desirable)

Table 4-2
Maximum Profile Grades - Rural Collectors

Type of terrain	Maximum grade (%) for specified design speed (mph)								
	20	25	30	35	40	45	50	55	60
Level	7	7	7	7	7	7	6	6	6
Rolling	10	10	9	9	8	8	7	7	7

Note: Short lengths of grade in rural areas, such as grades less than 500 ft in length, one-way downgrades, and grades on low-volume rural collectors may be up to 2% steeper than the grades shown above

Table 4-3
Maximum Profile Grades - Urban Collectors

Type of terrain	Maximum grade (%) for specified design speed (mph)								
	20	25	30	35	40	45	50	55	60
Level	9	9	9	9	9	8	7	7	6
Rolling	12	12	11	10	10	9	8	8	7

Note: Short lengths of grade in urban areas, such as grades less than 500 ft in length, one-way downgrades, and grades on low-volume urban collectors may be up to 2% steeper than the grades shown above

5% maximum where sidewalks are adjacent to the roadway to meet the American with Disabilities Act Accessibility Guidelines (ADAAG)

Table 4-4
Maximum Profile Grades - Rural Arterials

Type of terrain	Maximum grade (%) for specified design speed (mph)					
	40	45	50	55	60	65
Level	5	5	4	4	3	3
Rolling	6	6	5	5	4	4

Table 4-5
Maximum Profile Grades - Urban Arterials

Type of terrain	Maximum grade (%) for specified design speed (mph)					
	30	35	40	45	50	55
Level	8	7	7	6	6	5
Rolling	9	8	8	7	7	6

430.03 Vertical Curves

Vertical curves are parabolic in nature and are used to achieve a gradual transition between tangent grades. Properly designed vertical curves provide adequate sight distance, safety, comfort, adequate drainage, and general appearance. The two types of vertical curves are crest vertical curves (convex) and sag vertical curves (concave).

The principal controlling factor in the design of crest vertical curves is the provision of adequate sight distance for the design speed. For RIDOT projects, the minimum required length of a crest vertical curve is that necessary to achieve the stopping sight distance corresponding to the design speed. This necessary curve length should be established by the methodology provided in the AASHTO Green Book. While the Green Book also provides discussion and methodology for the design of crest vertical curves based on passing sight distance, the lengths of such curves may become many times greater those required based on stopping sight distance and are likely to be impractical or unfeasible. Thus, while it is the Department's policy to use the stopping sight distance criteria for the design of crest vertical curves, curve lengths greater than the minimum should always be provided where practicable. If the minimum curve length cannot be provided at a given location, conditions must be sufficiently documented and a design exception request must be submitted in accordance with **Division 5 - Design Exceptions**.

Where a crest vertical curve is located at or near a side street intersection, the required intersection sight distance (per the AASHTO Green Book) will likely control the profile design. In most cases, the vertical curves of length greater than required for stopping sight distance will be required to provide safe intersection sight distance at such project locations.

The designer should pay particular attention to the drainage requirements in those areas where the length of crest vertical curve exceeds the drainage maximum shown in Exhibit 3-71 of the Green Book.

Sag vertical curves have different controlling criteria, including headlight sight distance, passenger comfort, drainage control and general appearance. The minimum sag vertical curve lengths to be used on RIDOT projects shall be in accordance with the AASHTO Green Book. Although sag vertical curves are not designed based on stopping sight distance, they are considered critical components of the vertical geometry and their design is directly related to design speed. If the minimum required sag curve length cannot be provided at a given location, conditions must be sufficiently documented and a design exception request must be submitted.

440 Combination of Horizontal and Vertical Geometry

Due to their complementary relationship, the horizontal and vertical alignments of a roadway must not be designed independently. Although it is possible for each to be individually designed properly, poor combinations of these two elements can diminish the overall design of the highway facility. An awareness of the relationship between the horizontal geometry and the roadway profile is therefore essential.

Although there are no specific design criteria that apply to the joint consideration of horizontal and vertical geometry, the Green Book provides extensive discussion and a series of general guidelines relating to this issue. In an effort to achieve the optimal overall geometric design, these AASHTO guidelines should be followed in the development of the project design.

450 Cross Section Elements

450.01 Pavement

It is the Department's policy to require full-depth bituminous pavements in both full reconstruction and new alignment projects. As the use of Portland cement concrete in roadway pavement is discouraged, any design proposing its use requires advance approval from the Department. Highway projects other than full reconstruction and new alignment (e.g., 1R improvements, resurfacing) require the combination of the existing and new bituminous pavements be designed to provide the necessary structural strength. All pavement structures are to be designed in accordance with the procedures specified in **Division 6 - Soils and Paving**. The pavement design shall call for the appropriate combination of base, surface, and friction courses (within all minimum and maximum thicknesses) as specified in the most current edition of the RIDOT *Standard Specifications for Road and Bridge Construction*. For projects involving the replacement, rehabilitation, or resurfacing of bridges, the RIDOT *Bridge Design Manual* should be referred to for riding surface requirements and guidelines.

450.02 Lane and Shoulder Widths

The lane width on a roadway is critical design element, influencing both the safety and comfort for the motorist as well as affects the level-of-service provided under a given set of traffic conditions. Although the AASHTO Green Book acknowledges lane widths ranging from 9 to 12 feet, it is RIDOT policy to require a minimum width of 11 feet for travel lanes.

A 12-foot travel lane width is required on all controlled access and divided highways and should be provided on other highway types where feasible. Where possible, wider lanes should be provided along horizontal curves in accordance with AASHTO Green Book recommendations. Exclusive turn lanes at intersections should generally be the same width as the adjacent travel lane(s), however where necessary these lanes may be reduced to 10 feet in width. For continuous two-way left turn lanes along urban arterial streets, a minimum width of 12 feet should be provided, although widths up to 16 feet are common. On-street parking lanes along urban streets should be a minimum of 8 feet and a maximum of 10 feet in width, as parking lanes greater than 10 feet wide can appear to be travel lanes and cause confusion to motorists.

The term "shoulder" is used by AASHTO to refer to the paved and/or graded area beyond, and contiguous with, the traveled way that is provided for stopped vehicles, emergency use, and lateral support for the subbase, base, and surface courses of the pavement structure. Shoulders should be flush with the roadway surface and abut the traveled way. Paved shoulder widths can range from 1 to 12 feet, with paved shoulders typically constructed using the same pavement structure as that for the travel lanes. The standard paved shoulder width of 10 feet must be provided on the right (outer) side of all controlled-access freeways and is also desirable on all other divided highways. For facilities other than freeways, the width of the paved shoulder will be established through coordination with the Department on a project-by-project basis. Total graded shoulder widths that do not meet the AASHTO minimums (for the traffic volumes and highway type) require a design exception in accordance with **Division 5 - Design Exceptions**.

The minimum paved median shoulder width on freeways is 4 feet.

On curbed urban streets and curbed sections of rural highways, a shoulder width (also commonly referred to as a curb offset) of at least 1 foot must be provided between the travel lane and the curb, with a 2-foot curb offset being preferable. For roadway locations where bicycles can be accommodated, a minimum 4-foot paved shoulder is required regardless of whether the roadway section is curbed (see **Division 9 - Pedestrian and Bicycle Facilities**).

450.03 Cross Slope

Proper roadway cross slope is essential for the conveyance of stormwater runoff away from travel lanes. For portions of roadway that are not superelevated (i.e., straight tangent horizontal geometry), the design shall provide a “crowned” roadway cross section with a standard cross slope of 2 percent (0.02 V/H). Where the paved shoulder is 4 feet or greater in width, it is desirable to increase the cross slope within the shoulder to 3 percent (0.03 V/H) to further facilitate proper drainage.

On superelevated sections of roadway with paved shoulders of 4 feet or greater, the shoulder on the outside of the horizontal curve should slope in the opposite direction from the traveled way to prevent storm water and snow melt from flowing across the travel lanes. In such cases the algebraic difference between the cross slope of the travel lanes and the cross slope in the opposite direction of the shoulder shall not exceed 8 percent.

On curbed streets with paved sidewalks, the typical sidewalk cross slope is 2 percent (0.02 V/H) in the direction of the street, such that runoff is conveyed into the roadway gutter. Refer to **Division 9 - Pedestrian and Bicycle Facilities** for additional information on sidewalk design.

Division 5 - Design Exceptions

It is RIDOT policy to conduct all highway design projects with the utmost consideration of the surrounding environment and the potential of impacts thereto. Based on the heightened importance of and sensitivity to environmental preservation, many reconstruction projects must be designed to the minimum standards to avoid excessive impacts. In some cases, these constraints may result in designs that require design exceptions.

If good engineering judgment dictates that a design exception may be warranted, then the situation should be investigated, and appropriate documentation shall be prepared as described below. The designer should not "stretch" interpretations of the design standards to avoid the need for design exceptions. Should there be any question as to the necessity of obtaining a design exception, appropriate documentation should be prepared. The following guidelines are intended to illustrate the requirements for the presentation of design criteria, and the documentation necessary to support design exceptions.

Through coordination with the Federal Highway Administration (FHWA), the following list of controlling criteria has been developed. When minimum standards for these design elements cannot be achieved, a formal design exception shall be required.

1. Design speed
2. Minimum stopping sight distance
3. Maximum percent grade
4. Horizontal alignment
5. Vertical alignment
6. Cross slope
7. Maximum superelevation
8. Lane width
9. Shoulder or parking lane width
10. Structural capacity
11. Minimum roadway width of structure
12. Minimum vertical clearance

A thirteenth controlling criterion, horizontal clearance (clear zone), does not require a formal design exception. Should the horizontal clearance to obstructions be less than the recommended minimum, the consultant must still document and justify the substandard clear zone distance in a manner similar to that required for a design exception, however approval from FHWA or the chief engineer will not be required.

To aid in identifying the need for a design exception, a summary sheet of all controlling criteria is required in the Design Study Report. This summary sheet will compare AASHTO minimum guidelines with the design data recommended for the project, clearly identifying any design exceptions needed. A sample summary sheet is provided in Table 5-1.

In addition to this summary sheet, each Design Study Report shall include a section entitled "Design Exceptions." For each design exception referenced in the summary sheet, the following supporting information shall be required, where applicable:

1. An analysis of accident data as relates to the criteria for which an exception is being requested.

2. A discussion on compatibility with the adjacent sections of roadway and the future expectations of the route.

3. A preliminary cost estimate comparing the options available and/or increments of improvements. A cost-benefit analysis, which weighs the cost of the improvements versus the benefits to be derived, may also be considered when appropriate data are readily available. (A cost analysis is not required for each design exception, but is necessary only where determined to be relevant.)

4. Consideration of any other factors such as right-of-way, environmental constraints, historical and archaeological constraints, public support or objection, etc., which have a significant bearing on the proposed activity. It is important to note that environmental considerations are not limited to wetlands, floodplains, etc. (permitted conditions), but also include trees, walls and/or any other elements that may be deemed sensitive to the local environment. Documentation of the relative importance of these features from the local community is helpful in this regard.

Written documentation should be brief (limited to a few pages) and should address all of the above where applicable, with a rationale to support the recommendations based on good engineering judgment. Plans, profiles and cross sections of the existing and proposed conditions may be required in certain situations to assist in justification of a design exception. Additional relevant information, such as spot-speed studies, drainage considerations, mitigations, etc., should also be taken into consideration.

Table 5-1
Sample Project Summary Sheet

Functional Classification: Rural Major Collector (Tech. Paper 155, RISPP, January 2005)
Design Year: 2020 Terrain: Rolling % Trucks: 5%
AADT (Present): 2140 AADT (Design): 2950
DHV (Present): 320 DHV (Design): 444

Controlling Criteria	Parameter Value	Reference Document	Utilized Value	Design Exception Required?
Design Speed	50 MPH	2004 AASHTO pp ____	50 MPH	No
Minimum Stopping Sight Distance	400-475 Feet	2004 AASHTO pp ____	400 Feet	No
Maximum Percent Grade	7%	2004 AASHTO pp ____	8%	Yes
Horizontal Alignment	6.75	2004 AASHTO pp ____	6.75	No
Vertical Alignment	84	2004 AASHTO pp ____	84	No
Cross Slope	2%	2004 AASHTO pp ____	2%	No
Maximum Superelevation	6%	2004 AASHTO pp ____	4%	No
Lane Width	12 Feet	2004 AASHTO pp ____	12 Feet	No
Shoulder or Parking Lane Width	8 Feet	2004 AASHTO pp ____	6 Feet	Yes
Structural Capacity	HS-20	2004 AASHTO pp ____	HS-20	No
Minimum Roadway Width of Structure	32 Feet	2004 AASHTO pp ____	32 Feet	No
Minimum Vertical Clearance	14 Feet	2004 AASHTO pp ____	14 Feet	No
Horizontal Clearance to Obstructions	17 Feet	2006 ROADSIDE DESIGN GUIDE pp ____	8 Feet	No; Documentation Provided

Division 6 Soils and Paving

610 Geotechnical Investigations

610.01 Introduction

Proper geotechnical site investigations are essential to ensure a successful highway design project. Site investigations can provide the following information:

- Soil and rock types and characteristics
- Location of unsuitable soils (fill, organics, etc.)
- Depth to bedrock
- Depth to groundwater

The above factors may affect the design and constructability of a project based on the type of project. Constructability issues that may need to be addressed include:

- Soil bearing capacity
- Depth to ledge in cut areas and utility and drainage trenches
- Depth to groundwater in cut areas, dewatering during excavation, water quality basins, and permanent subdrain installations
- Location and extents of unsuitable materials

The designer should refer to *Guidelines for Geotechnical Site Investigations in Rhode Island* for a more complete discussion on the geology in the state and the potential impacts on highway and bridge projects.

610.02 Subsurface Exploration Program

610.02.1 Planning

Ideally, a subsurface exploration program would be developed and performed early in the design process, typically during the 10 percent design phase. The findings of the geotechnical report should be incorporated into the design study report. Early planning may prevent costly redesign during the later stages of project development.

The results of the initial findings may result in need to collect additional information.

610.02.2 Types of Investigations

Investigations should consist of a combination of field and laboratory testing to determine the characteristics to the soil and rock in the project area.

Various types of investigations are outlined in Chapter 3 of the *Guidelines for Geotechnical Site Investigations in Rhode Island.*

610.02.3 Groundwater

The depth to groundwater can influence both design and construction activities. Temporary and/or permanent dewatering systems may be required to reduce the hydrostatic pressures.

Seasonal groundwater levels may require extensive dewatering by the contractor during construction.

Groundwater monitoring wells should be considered at structures, detention/retention ponds, and at areas where excavations may require dewatering such as drain line installations. Monitoring wells should be used to determine seasonal fluctuations in the groundwater elevations as well as possible effects of major storm events. To further understand the soils, and aid in the design of dewatering systems, pump tests may be required.

610.02.4 Ledge

When design projects have borings that indicate ledge within the excavation limits, additional borings should be taken in a closer grid sequence to provide higher precision when plotting the top of ledge. This may reduce the number of contractor’s claims due to insufficient borings and should result in a more accurate ledge profile for estimating overburden and ledge removal.

610.02.5 Number and Spacing of Borings

The designer should refer to Table 3.3 Minimum Requirement for the Number and Spacing of Borings in the *Guidelines for Geotechnical Site Investigations in Rhode Island* as a guide when planning a boring program.

610.02.6 Boring Logs

In accordance with Design Policy Memo; 480.01 Geotechnical/Environmental Boring Logs and GeoInfo Database, RIDOT requires all designers to submit all subsurface boring logs in electronic format using the RIDOT borehole log template.

The designer shall refer to the design policy memo for complete details and procedures.

610.03 Geotechnical Report

Geotechnical reports will be prepared by a geotechnical engineer or qualified geologist to report the findings of the subsurface investigation program and provide recommendations based on the findings. Geotechnical reports submitted to the Department for highway projects should contain the following information:

1. Qualifications and resume of the geotechnical engineer or qualified geologist responsible for preparing the report

2. General geologic information of area under investigation

3. Summary of specific conditions and discussions of how the conditions differ from the general area

4. Comments on any boring logs available with a detailed explanation of any variations in procedures that differ from the Departments procedures (All boring data should be submitted with the report and accompanied by a location plan including data on the proposed finish grade above and/or below original ground elevation at each boring location.)

5. Data and description of any other test that may be performed

6. An analysis of the foundation conditions as they exist with emphasis on any problem areas

7. Detailed foundation recommendations with a description of any special procedures that may be necessary to accomplish a satisfactory design.

620 Design of Pavement Structures

620.01 Design of Full Depth Pavement Structures

Design of pavement structures will be based on design-year traffic projections including truck percentages. For reconstruction projects, RIDOT materials section will perform pavement cores to determine the existing pavement makeup. Sieve analyses will be performed on the gravel samples retrieved from the cores to determine if the existing gravel base meets the specification.

620.01.1 Bituminous Pavement

A typical pavement structure for new construction or reconstruction will consist of 2 inches of Class I-1 bituminous surface course, modified bituminous base course, and 12 inches gravel borrow base course. The thickness of the bituminous base course will be dependant on a pavement design performed by the RIDOT Materials Section.

The gravel borrow base course shall be increased to 18 inches in cut areas and to 24 inches in rock cut areas.

Freeways shall include a 1 1/2 inch dense friction course. Ramps should include a 1 1/2 inch ramp mix layer if they are paved separately from the main line. If the ramps and the main line are paved under the same contract, dense friction course should be used for both applications.

Bike paths should be paved with 2 inches of Class I-2 surface course on 2 inches of Class I-1 surface course.

The following minimum and maximum lift thicknesses should be used for each type of mix on all RIDOT projects to minimize segregation and allow rollers adequate time to achieve proper compaction.

- Base course Not less than 2 1/4 inches and no greater than 4 1/2 inches
- Binder Not less than 2 1/4 inches and no greater than 4 1/2 inches
- Class I-1 Not less than 1 1/2 inches and no greater than 3 inches

- Class I-2 Not less than 1 1/2 inches and no greater than 2 1/2 inches

Ambient air and surface temperature may influence the number of lifts and lift thickness; if the paving course is not typical or if the temperature is not consistent with the specifications, the Materials Section should be contacted for further guidance.

620.01.2 Portland Cement Concrete Pavement and Rigid Base

In general, the Department does not use Portland cement concrete pavement. Rigid pavement may be used under special circumstances at the direction of the Department or as a rigid base to match existing conditions.

620.02 In-place Pavement Rehabilitation

In-place pavement rehabilitation is the process of crushing and blending the existing asphaltic pavement with a pre-determined portion of the gravel base into an asphalt-stabilized base course. However, this process cannot be used if any of the following conditions exist:

1. When a profile change of 12 inches occurs for more than 25% of the project length

2. When there is ledge/rock within 24 inches of the existing riding surface

3. When there is unsuitable material (i.e. peat, muck, silty sand, etc.) found within the roadway proper

4. When the existing pavement has become brittle

5. When there is major widening or significant modifications to the existing alignment

6. When the roadway has a concrete base

7. When a project has numerous underground utility appurtenances or utility relocations within the roadway proper

8. Any roadway with an existing width of 28 feet or less must be evaluated on a case-by-case basis to determine if in-place pavement rehabilitation is practical. This shall include an evaluation of detour routes and safe passage of vehicles through the construction zone.

620.03 Trench Patches

620.03.01 Permanent Trench Patches

Permanent trench patches should meet or exceed the quality and the pavement makeup of the pavement structure that it replaces. Gravel borrow subbase shall be provided in all permanent trench patches.

If proper compaction of the trench cannot be attained, the appropriate class of controlled low strength material (CLSM) shall be used to backfill the trench to the bottom of the gravel borrow subbase course.

The designer shall coordinate with the city or town to determine if there is a written policy regarding repairs to local streets.

620.03.02 Temporary Trench Patches

Temporary trench patches must be provided on all roadways with active traffic.

Trenches may be covered with steel plates at locations where traffic must be restored immediately such as staged construction. Steel plates will generally only be used for the duration until a more permanent patch can be installed.

Gravel fill of a trench with a temporary bituminous patch should be used when compaction of subgrade is possible. The depth of bituminous patch will be dependant upon the anticipated duration of the patch, the season the patch is placed, the traffic volumes and classifications, roadway classification and anticipated speeds.

In locations where compaction cannot be attained, the designer should specify CLSM as backfill. If the temporary patch is to be replaced with a permanent patch, the CLSM shall be placed to the bottom of the gravel borrow subbase. In locations where the entire pavement structure will be replaced, the trench may be filled with excavatable CLSM to the bottom of the bituminous patch.

620.03.03 Trench Patches on City Streets Having a Portland Cement Concrete Pavement Base

On streets with a concrete base, the following shall be used to patch trenches:

- High early strength Portland cement concrete base course

- 2 inch Class I-1 bituminous surface course

To allow traffic to safely pass over the trench, steel plates shall be used during the curing time. Steel plates shall be capable of supporting an H-20 load.

620.03.04 Concrete Curb Lock

Concrete curb lock should be used at all locations where curb is set such that proper compaction of the adjacent base course cannot be achieved. Generally, 10 feet is required for a roller fit between curb and the match line. Careful consideration must be given to construction sequencing and maintenance of traffic when determining if curb lock will be used.

620.04 Estimating Tables

Per the Rhode Island Standard Specifications, the contractor is allowed a tolerance of plus or minus 1/4 inch per lift of pavement. For estimating purposes, the designer should include the additional material that may be supplied in the quantity estimate. Table 6-1 below provides factors that ensure consistency between designers when estimating the amount of bituminous material required for a project.

Table 6-1
Bituminous Estimating Factors

	I-1, I-2, & Base Courses		Dense Ramp & Friction Courses	
Pavement Lift Depth (in)	**SY/TON**	**TON/SY**	**SY/TON**	**TON/SY**
1	13.92	0.07184	14.71	0.06797
1 1/4	11.60	0.08621	12.26	0.08156
1 1/2	9.94	0.10057	10.51	0.09516
1 3/4	8.70	0.11494	9.20	0.10875
2	7.73	0.12931	8.17	0.12234
2 1/2	6.33	0.15805		
3	5.35	0.18678		
3 1/2	4.64	0.21552		
4	4.09	0.24425		

620.05 Roadway Shoulder Rumble Strips

620.05.01 Policy

It is the policy of the Rhode Island Department of Transportation to install shoulder rumble strips to reduce the incidence and severity of run-off-road (ROR) crashes due to inattention, fatigue, or sleepiness. Should rumble strips should be considered on all freeway and other high-speed rural facilities in accordance with the guidance provided below.

The designer should also be familiar with the FHWA Technical Advisory: *Roadway Shoulder Rumble Strips* dated December 20, 2001.

620.05.02 Description and Details

Rumble strips shall be formed by milling into the pavement grooves and depressions to provide an audible and vibratory warning intended to alert drivers that their vehicles have drifted from the travel lane. Rumble strips shall be formed and installed as shown in the details.

620.05.03 Installation Criteria

The designer should consider the installation of shoulder rumble strips at the following locations. In all cases, the designer should coordinate with the RIDOT PM to determine which sections of highways may be excluded.

1. Rumble strips shall be installed on new, reconstructed, and resurfaced shoulders of designated highways either in conjunction with a construction project or as a retrofit on existing shoulders through a separate project exclusively for that purpose. A list of limited access roadways is provided in Table 6-2.

2. Rumble strips shall be installed on sections of highways with a high incident of ROR crashes.

3. Rumble strips should not be installed on highway sections adjacent to densely settled residential areas where noise may be objectionable to the abutters.

4. Rumble strips shall not be installed on bridges.

5. Rumble strips should generally not be installed on existing shoulders with a projected service life of less than three years.

6. Rumble strips should be deferred on highway sections with construction work zones where traffic is allowed to use the shoulder, until all lane shifts are completed.

Table 6-2
Limited Access Highways

Roadway	Limits
I-95	CT S/L to MA S/L
I-195	I-95 to MA S/L
I-295	I-95 to MA S/L
Route 1	Prosser Trail to Wakefield Cut-off
Route 4	Route 138 to I-95
Route 6	Route 102 to Route 101
Route 6	I-295 to I-95
Route 10	Park Avenue to Route 6
Route 24	Route 114 to MA S/L
Route 37	Natick Avenue to Post Road
Route 78	Route 1 to CT S/L
Route 99	Route 146 to Mendon Road
Route 114	East Shore Expressway to Forbes Street
Route 138	Route 1 to Admiral Kalbfus Road
Route 146	I-95 to Reservoir Road
Route 146	Route 146A to MA S/L
Route 403	Route 4 to Roger Williams Way
Airport Connector	I-95 to Post Road
East Shore Expressway	I-195 to Wampanoag Trail
Red Bridge Extension	Waterman Street to Taunton Avenue

Division 8 - Drainage and Erosion Control

810 General

The proper design of drainage and erosion control measures is integral to any highway construction project. A design should focus on providing an economical means of managing surface runoff and controlling erosion while mitigating any potential negative impacts to highway safety, right-of-way, private property, and the environment.

All design elements described in this Division shall be developed in accordance with the latest editions of the following documents:

- *State of Rhode Island Stormwater Design and Installation Standards Manual*, by the Rhode Island Department of Environmental Management (RIDEM) and the Rhode Island Coastal Resources Management Council (CRMC).

- *Rhode Island Soil Erosion and Sediment Control Handbook*, by the Rhode Island Department of Environmental Management (RIDEM), USDA Soil Conservation Service, and Rhode Island State Conservation Committee.

Additionally, it is recommended that designers consult the following guidance documents in the development of the drainage and erosion control elements of a project design.

- *Model Drainage Manual*, by the American Association of State Highway Transportation Officials (AASHTO).

- *Hydraulic Design Series* (HDS) and *Hydraulic Engineering Circulars* (HEC) published by the U.S. Department of Transportation, Federal Highway Administration (FHWA), including, but not limited to, the most recent editions of following publications:
  - □ HDS-2 - *Highway Hydrology*
  - □ HDS-3 - *Design Charts for Open-Channel Flow*
  - □ HDS-4 - *Introduction to Highway Hydraulics*
  - □ HDS-5 - *Hydraulic Design of Highway Culverts*
  - □ HEC-12 - *Drainage of Highway Pavements*
  - □ HEC-14 - *Hydraulic Design of Energy Dissipators for Culverts and Channels*
  - □ HEC-22 - *Urban Drainage Design Manual*

- Engineering guidance documents developed by the RIDEM Office of Water Resources:
  - □ *Hydrologic & Hydraulic Modeling Guidance*
  - □ *Guidance for the Preparation of Stormwater Best Management Practices* (BMPs)

- *Guidance for Preparation of Subwatershed Maps*
- *Floodplain Impacts: Regulatory Provisions Pertaining to Floodplains and Floodways*

This division outlines the procedures and policies of the Department to be considered in the development of a project's drainage, stormwater management, hydraulic, and erosion and sediment control design. Included in this section are the Department's procedures and policies regarding closed drainage systems, stormwater best management practices (BMPs), culvert and channel design, and temporary/permanent erosion control measures.

820 Drainage System Design

This section outlines the procedures and polices for the design of closed drainage systems for the collection and conveyance of stormwater runoff from roadways and associated subwatershed areas. While inherently related, the stormwater management design (control of peak discharge rates, reduction of runoff volumes, and improvement of water quality leaving the site) is a separate, parallel design process and is addressed in Section 830 of this Division.

820.01 Surface Runoff Determination

The amount of surface water runoff collected by a drainage system will be dependent upon, the rainfall intensity/duration for a given storm return frequency, the size of the drainage area, and the characteristics of the drainage area (including surface/cover conditions, topography, etc.).

In developing the design of a closed drainage system (including the grade design; sizing, spacing, and layout of structures and piping; etc.), the Rational Method ($Q = CiA$) shall be employed to estimate the flow of surface runoff into the system. Designers shall use accepted runoff coefficients (C) from available literature (such as HEC-22 - *Urban Drainage Design Manual*) and values for rainfall intensity (i in inches/hour) established from precipitation data contained in U.S. Department of Commerce *Technical Paper No. 40* and NOAA *Technical Memorandum NWS HYDRO-35*. Derived from these publications, Figure 8-1 provides intensity-duration-frequency (I-D-F) curves for Providence and vicinity.

The following design storm frequencies shall be used in the design of drainage system elements for reconstruction and new alignment projects:

Inlet Spacing ....10-year Storm Event
Pipe Sizing ....25-year Storm Event
Cross Culvert Sizing ....50-year Storm Event

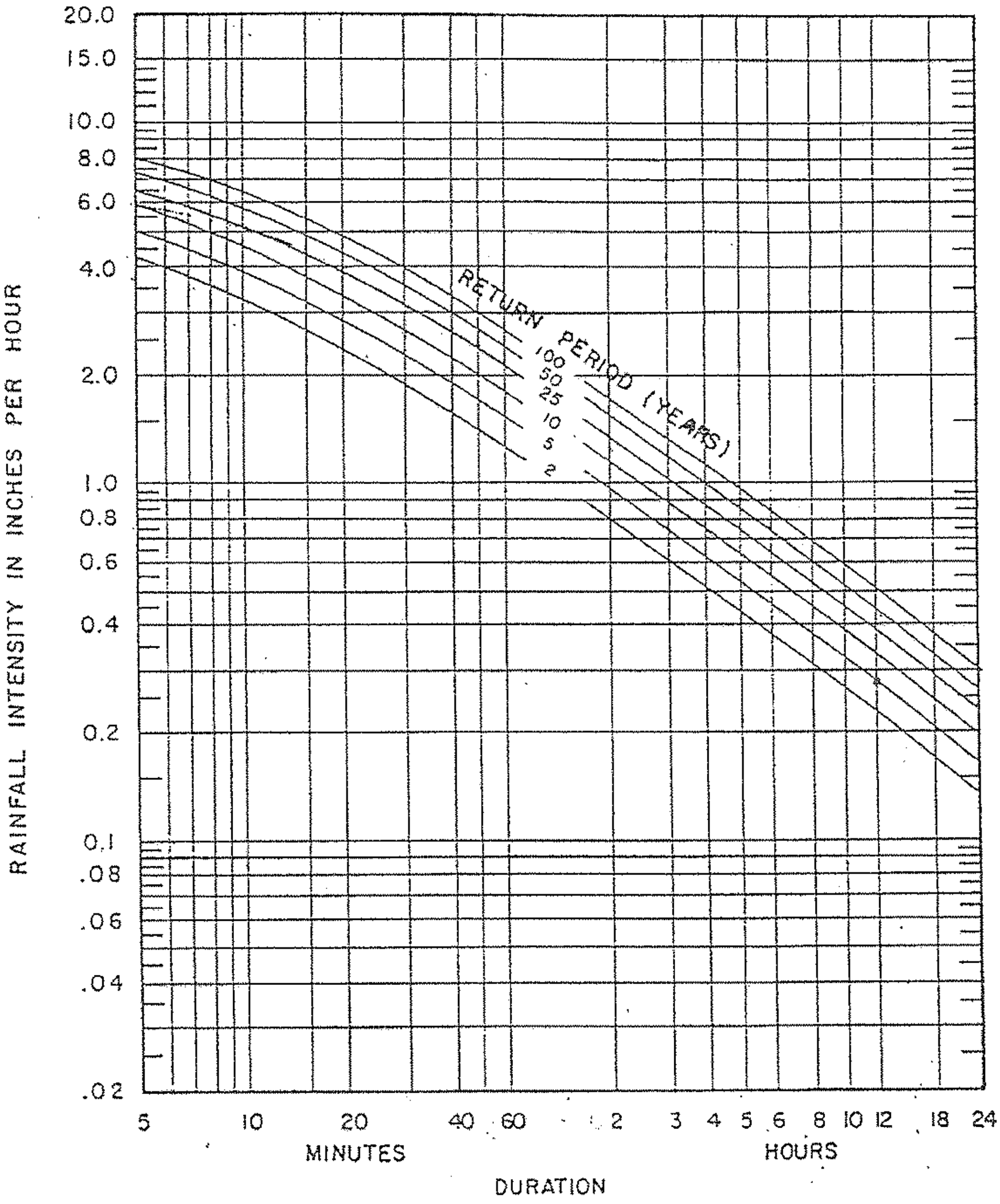

Figure 8-1. Rainfall Intensity-Duration-Frequency Graph for Providence, RI and Vicinity (derived from U.S. Department of Commerce *Technical Paper No. 40* and NOAA *Technical Memorandum NWS HYDRO-35*).

By definition, Resurfacing and 1R improvements projects do not involve the design of new drainage elements.

It is important to note that environmental regulatory agencies having jurisdiction over a project may require that drainage system elements be designed to longer duration design storms (e.g., to convey flow to a stormwater basin designed to detain the 100-year event).

820.02 Design Criteria for Drainage System Elements

820.02.1 Gutter Spread

Stormwater that is allowed to remain on the roadway presents a potential hazard to motorists, as ponding that encroaches on the travel lane could potentially result in vehicles hydroplaning. To mitigate potential impacts to highway safety, gutter spread (width of gutter flow in cross-section) must be limited to tolerable widths.

The amount of water that can be conveyed via gutter flow will be dependent on:

- roadway cross section / cross slope
- roadway profile grade
- Manning's Roughness Coefficient (*n*)

In designing the collection system (inlet spacing) to ensure that gutter spread is adequately limited, the designer shall employ the appropriate adaptation of Manning's Equation for open channel flow for the proposed gutter cross section. For design purposes the roughness coefficient to be used for asphalt surfaces shall be 0.016. The Department's policy for maximum allowable spread in a gutter is as shown in Table 8-1.

Table 8-1
Maximum Gutter Spread

Functional Classification		Maximum Gutter Spread (Width)
Rural	*Freeway/Expressway*	Full Shoulder
	Principal and Minor Arterial	2-Lane: Shoulder + 2 feet 4-Lane: Shoulder + 1/3 width of lane
	Major and Minor Collector	Shoulder + 1/2 width of lane
Urban	*Freeway/Expressway*	Full Shoulder
	Principal and Minor Arterial	2-Lane: Shoulder + 2 feet 4-Lane: Shoulder + 1/3 width of lane
	Collector	Shoulder + 1/2 width of lane

820.02.2 Inlet Spacing and Location

Drainage inlets shall be sited and spaced based according to the following criteria:

- The number, location, and spacing of inlets should prevent the maximum allowable gutter spread from being exceeded. The designer should refer to the *Urban Drainage Design Manual* (HEC-22) for accepted methods equations for computing gutter flow and spread under a variety of geometric, roadway and catchment conditions.

- Inlets should be located up-gradient of bridge structures.

- Inlets should be located up-gradient of major intersections.

- Inlets should be located up-gradient of changes in cross-slope (when transitioning to a superelevated section) to prevent sheet flow across the roadway.

- The maximum spacing between structures should be limited to 300 feet to facilitate pipe cleaning.

- Additional "flanking" inlets should be provided at low points in the profile grade (sag curves) to prevent ponding should inlets become blocked. Flanking inlets should be located so that they prevent the maximum allowable gutter spread from being exceeded in the event that the low point inlet becomes fully blocked. The designer should refer to the *Urban Drainage Design Manual* (HEC-22) for accepted procedures in establishing the spacing of flanking inlets.

- Inlets should be located up-gradient of pedestrian crossings and handicap ramps.

- Inlets and depressed grates should be placed outside of through travel lanes.

820.02.3 Pipe Design

It is the general policy of the Department to use reinforced concrete pipe (RCP) and high density polyethylene (HDPE) pipe in the construction of closed drainage systems. In some cases where the structural capacity of Class III concrete pipe or HDPE pipe is a concern (e.g., shallow cover, within large fills, increased design load) the designer should consider alternatives such as Class V RCP or ductile iron (DI) pipe.

All pipe sizing should be based on Manning's Equation for circular channel flow. The Manning's Roughness Coefficients for RCP to be used in the design of drainage systems are as follows:

12" and 15" RCP............. $n = 0.015$

18" and greater RCP .... $n = 0.012$

HDPE (12" to 60")........... $n = 0.012$

Corrugated Metal Pipe .... $n = 0.025$

Ductile Iron Pipe .... $n = 0.013$

In establishing the profile of the drainage system, pipe slopes should be set to follow the profile grade of the road to the greatest extent possible; this will serve to reduce construction costs by minimizing excavation. Wherever possible, gradients should be sufficient to develop a minimum velocity of 3 feet per second to prevent sediment buildup within pipes.

While maximum velocities are not critical to storm drainage design, high velocities can result in erosion at outfall locations. Certain pipe materials may also be susceptible to durability issues resulting from high velocities. The designer should try to maintain velocities below 12 feet per second.

820.02.4 Bituminous Berm

In areas with closed drainage systems, the Department will continue to require the use of berm where vertical or slope faced curb is not proposed. These guidelines were developed in an effort to eliminate long-standing problems of shoulder and slope stabilization and are based on geometric, hydraulic, and aesthetic considerations.

In general, berm will also be required where the centerline profile grade is equal to or greater than one-half (1/2) the roadway cross slope for roadway lengths of 1,000 feet or greater. On such segments of roadway, the beginning location for the berm will be based on the accumulation of storm runoff from the pavement section. The recommended starting point is where the accumulation of runoff reaches 0.65 cubic feet per second (assuming gutter flow).

In superelevated sections, berm is recommended on the low side (interior of horizontal curve) to divert flows for discharge at a preferred location with proper erosion control measures. This will minimize the severe slope erosion commonly occurring in such areas.

The designer should exercise prudent engineering judgment when selecting locations for berm placement. Short sections of berm should be avoided except in areas where non-usage would result in adverse impact to an adjacent property owner (note that this is not applicable to limited access highways). Short gaps between bermed sections are also considered undesirable. For example, in the interest of facilitating construction operations and maintaining an aesthetically pleasing cross section, it is suggested that berm be continued over a crest vertical curve if berm is warranted on both tangents.

820.02.5 Drainage Structure Grates

This subsection presents guidelines to aid the designer when choosing the appropriate grates for catch basins on highway projects.

In general, all areas that are subject to either bicycle and/or pedestrian traffic shall utilize grates for catch basins that are considered bicycle safe. All non-bicycle safe grates within the limits of a project shall be replaced with the appropriate grate, regardless of whether or not catch basins are being replaced or reconstructed as part of the project. The use of non-bicycle safe grates is to be restricted to limited access highways.

High capacity grates (both bicycle safe and non-bicycle safe) should only be used in areas of heavy gutter flow and/or steep grades. Figure 8-2 provides efficiency curves for standard RIDOT grates.

The designer should refer to the Rhode Island Standard Details for specific grate requirements. The *Urban Drainage Design Manual* (HEC-22) should also be consulted for additional efficiency charts and design guidance for inlet grate and inlet type selection.

820.02.6 Underdrains and Combination Drains

The minimum diameter of any underdrain to be used on a project is 6 inches.

The minimum diameter of any combination drain to be used on a project is 12 inches.

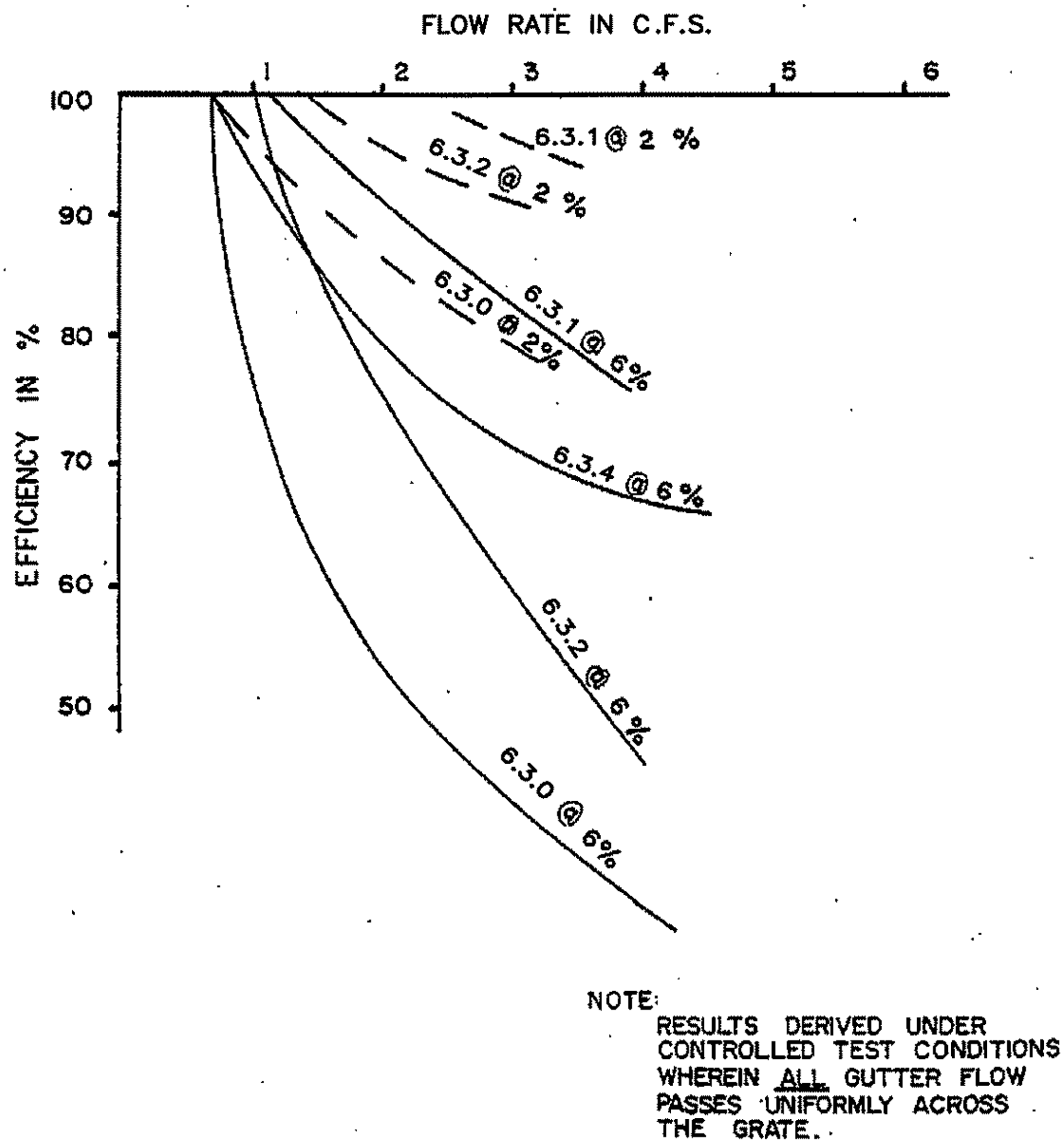

Figure 8-2. Efficiency Curves for RIDOT Standard Grates.

820.03 Design Process Overview

The following is a summary of the general sequence which should be followed in the design of drainage systems for RIDOT construction projects:

1. Prepare a drainage area map using:

    - topographic base mapping of the project area at an appropriate scale and contour interval (preferred) and/or U.S. Geological Survey topographic quadrangle maps;

    - existing drainage structures, including their respective rim and invert elevations (an accurate field investigation must be performed);

    - field data, including surface conditions, outlet and scour conditions, existing flows and flooding characteristics of receiving waters and other hydrologic features in the project vicinity;

    - soil type(s) (as ascertained via the USDA Soil Conservation Service *Soil Survey of Rhode Island*) and groundwater table elevations, if the project is (a) located within a known area of elevated groundwater, or (b) if significant earthwork cuts and/or subsurface discharge measures are proposed;

    - the preliminary project layout and design, including preliminary sections, profiles, areas of earthwork cut/fill, and other proposed work which may affect the existing drainage characteristics of the project area.

2. Based on the preliminary design (topography, proposed flow collection/diversion, etc.) divide the project area into multiple drainage subareas, each of which is tributary to a proposed storm inlet collection point. On a working drainage plan or plans, depict the proposed locations of inlets and their associated drainage subarea limits (including direction of flow) within the preliminary project layout.

3. Compute the gross acreage of each subarea as well as the partial area of each constituent surface type (e.g., impervious and pervious).

4. For each subarea, determine the weighted runoff coefficient (C) for use in Rational Method computations.

5. Determine the appropriate design storm frequency to be used for the drainage element(s) to be designed.

6. Determine the time of concentration (*Tc*) for each subarea using accepted methods, and the rainfall intensity for this *Tc* from the appropriate rainfall intensity-duration-frequency curve. The minimum *Tc* to be used in Rational Method computations is 5 minutes.

7. Based on the preliminary design and existing survey and field data, develop a preliminary drainage system layout, assigning lengths and slopes to pipes, type and number of catch basins/manholes, and the direction of flow. Development of the system profile should begin at the point farthest downstream (e.g., an outfall into a natural or artificial channel, existing drainage structure). Pipe slopes should take into account appropriate cover at all locations, including structures and utilities. All inlet structures should be located within the road gutter and outside of travel lanes. The mainline of the drainage system should also follow the roadway gutter line to the greatest extent practicable. Underground utility locations must also be verified to avoid conflicts with the proposed drainage system(s). Refer to **Division 11 - Utilities** for procedures to locate utilities.

8. Complete a storm drainage design table using the proposed lengths and slopes to determine the proper pipe sizes and structure spacing necessary to accommodate the estimated runoff.

9. Develop and plot a profile of the proposed system using the pipe sizes calculated in the previous step. At all drainage structures, indicate the necessary change in invert elevations. Where there is no change in pipe size through a structure, a drop of 0.1 feet should be used if fall is available. Where the pipe size increases downstream through a structure, the crown (inside top) of the pipes should be aligned when possible, providing an invert drop equal to the difference in the two pipe diameters.

10. Determine the hydraulic gradient for the system by calculating the friction head for each reach and the head loss in each structure. To mitigate the potential for blowout at structures, it is important that this gradient not encroach upon 1.5 feet from the proposed frame finish grade; the system must be modified to eliminate this condition if it exists. This could be accomplished by reducing head losses, increasing the depth of the structure, or both.

11. Analyze the curb, gutter and inlet hydraulics for the proposed types, to determine their capacities, flow depth, and spread. Also compute the probable depths at structure inlets. The ponding and spreading of flow must not exceed the limits specified in this Division.

12. Using sound engineering judgment, and taking into consideration the pipe sizes needed (Step 8), the hydraulic gradient (Step 10) and the cumulative runoff flows entering the system (Step 11), complete the design for the drainage system.

820.04 Roadside Safety

The designer should take into consideration any element of the drainage system that could be potentially hazardous to errant vehicles. These elements may include, but are not limited to, headwalls, flared-end inlets/outlets, non-traversable ditches, and check dams within ditches.

Wherever possible, such potential hazards should be eliminated or relocated to a location outside of the clear zone. If the hazard cannot be eliminated or relocated without adversely affecting the hydraulic performance of the system, then the designer should attempt to appropriately modify the element to reduce the hazard. If the potential hazard cannot be eliminated, relocated, or modified, then proper roadside safety treatment(s) should be provided in accordance with **Division 7 - Roadside Safety Elements** and the *Roadside Design Guide.*

830 Stormwater Management Design

The proper management of stormwater runoff is essential to ensuring that the proposed activity will not result in adverse impacts to receiving waters both on and off-site. Projects involving a net increase in impervious surfaces within the study area sub-watershed (paved roadways, sidewalks, parking lots, etc.) have the potential to increase the volume and discharge rate of surface runoff, as well as the pollutant load (increased nutrients, sediment, and other contaminants), all of which can adversely impact the functions and values of downstream natural resources. These impacts can be effectively mitigated through the prudent incorporation of stormwater best management practices (BMPs) in the project design. BMPs are structural devices that temporarily detain and treat stormwater runoff in order to control peak discharge rates and reduce pollutant loadings. Such devices include wet ponds, extended detention ponds, infiltration basins, grassed swales, and water quality / sediment removal structures.

For all RIDOT projects, the stormwater management design should be developed in accordance with the following:

- The rules and regulations of the State natural resource agency (Rhode Island Department of Environmental Management or the Rhode Island Coastal Resources Management Council) having jurisdiction over the proposed project location or activity.

- *State of Rhode Island Stormwater Design and Installation Standards Manual* (RISDISM), by the Rhode Island Department of Environmental Management (RIDEM) and the Rhode Island Coastal Resources Management Council (CRMC).

In developing and documenting the stormwater management design for a project, it is suggested that designers consult the following engineering guidance documents developed by the RIDEM Office of Water Resources (available via http://www.dem.ri.gov/).

- Hydrologic & Hydraulic Modeling Guidance
- Guidance for the Preparation of Stormwater Best Management Practices (BMPs)
- Guidance for Preparation of Subwatershed Maps
- Floodplain Impacts: Regulatory Provisions Pertaining to Floodplains and Floodways

While developed for informational purposes only, adherence to the guidance provided in these documents will serve to ensure that the design is developed in accordance with established standards and regulatory requirements.

830.01 Analysis of Pre-Development vs. Post-Development Peak Runoff Discharge Rates

In developing a stormwater management design for a proposed project, the designer shall conduct an analysis of pre-development (existing) versus post-development (proposed) peak runoff discharge rates from the project subwatershed. To the greatest extent practicable, the design must ensure that the proposed project will not result in increases to peak discharge rates (which could adversely impact the ability of the receiving wetland/watercourse to store and convey flood flows).

The designer shall calculate the pre- and post-development peak flow rates discharging from the site for the 2-year, 10-year, 25-year, and 100-year storm events using the methods of USDA-NRCS Technical Release 55 (TR-55), *Urban Hydrology for Small Watersheds*. A Type III rainfall distribution is to be used with 24-hour rainfall amounts provided in Table 8-2.

Table 8-2
Rainfall Frequency Values for Rhode Island
Inches of Rainfall for 24-Hour Storm Duration

Region	Storm Event (Years)						
	1	2	5	10	25	50	100
Northern R.I. (Providence County)	2.7"	3.3"	4.2"	4.8"	5.6"	6.2"	7.0"
Eastern R.I. (Bristol and Newport Counties)	2.7"	3.4"	4.3"	4.9"	5.7"	6.3"	7.1"
Southern R.I. (Kent and Washington Counties)	2.7"	3.4"	4.4"	5.0"	5.8"	6.4"	7.2"

For significantly larger development projects, Technical Release 20 (TR-20) should be used instead of TR-55.

Analogous to the drainage system design, the TR-55 analysis and stormwater management design should generally conform to the following sequence:

1. Prepare existing and proposed drainage subarea maps using either topographic base mapping of the project area at an appropriate scale and contour interval (preferred) and/or U.S. Geological Survey topographic quadrangle maps. The RIDEM Office of Water Resources *Guidance for Preparation of Subwatershed Maps* should be consulted for content requirements. The following information should be established and documented for each subarea:

   - the total area in acres;

   - the constituent areas of different surface conditions and/or soil types (including hydrologic group) within the subarea. Soils should be identified using the USDA Soil Conservation Service *Soil Survey of Rhode Island* (1981).

   - the composite runoff curve number (CN) using the methods of TR-55;

   - the time of concentration (*Tc*) using the methods of TR-55.

2. Using the data compiled in the previous step, develop runoff discharge hydrographs for each subarea.

3. Determine the hydrologic network of both existing and proposed conditions, taking into account existing and proposed drainage systems, channels, culverts, best management practices (including the preliminary location of proposed basins and other BMPs), wetland features, etc. Establish the location(s) where stormwater runoff is discharged from the study area that will be used as analysis points for the comparison of existing versus proposed peak discharge rates.

4. Through the hydrologic and hydraulic computation of network analyses, develop and refine the design of stormwater BMPs in accordance with natural resource agency requirements and the RISDISM. For detention basins, infiltration basins, wet ponds, and other similar facilities, elements of this design include (where applicable) basin size, grading, and volume; inflow and discharge structures and inverts; emergency discharge / spillways; calculation/provision of sediment accumulation / water quality / permanent pool volumes; and other design elements required by RIDEM/CRMC regulations and the

RISDISM. Refer to the RIDEM Office of Water Resources *Guidance for the Preparation of Stormwater Best Management Practices* (BMPs).

5. Prepare the appropriate stormwater management design documentation (including, but not limited to: narrative, computations, maintenance plan, subwatershed maps, plans, and details) in accordance with natural resource agency requirements and the RISDISM.

830.02 Water Quality and Pollutant Load Analysis

In accordance with current RIDEM and CRMC regulations, the stormwater management design shall employ best management practices for the removal of suspended solids and other pollutants in stormwater runoff.

For proposed projects located within sensitive natural resource areas (e.g., CRMC Special Area Management Plans) or where an elevated concern for water quality exists, a pollutant load analysis shall be conducted in accordance with the procedures outlined in the RISDISM. The RIDOT Natural Resources Unit should be consulted on issues relative to water quality in the development of a project's stormwater management design.

830.03 Floodplain Impacts

To the greatest extent practicable, the proposed project design should avoid the placement of construction fills within any established 100-year floodplain or floodway as established by the Federal Emergency Management Agency. Where impacts cannot be avoided through revisions to the roadway horizontal and/or vertical alignment, the design shall provide for adequate floodplain compensation in accordance with natural resource agency regulations. In such cases the designer should refer to the RIDEM Office of Water Resources guidance document entitled *Floodplain Impacts: Regulatory Provisions Pertaining to Floodplains and Floodways*.

840 Hydraulic Design of Channels and Culverts

Certain projects will require the construction or reconstruction of drainage channels and/or culverts to maintain the hydrologic characteristics of the subwatershed in which the project is located. In the majority of cases, this design will be subject to the rules and regulations of the natural resource agency having jurisdiction over the proposed location or activity (RIDEM, CRMC). Accordingly, the hydraulic design should be developed to in accordance with the requirements and standards promulgated by the appropriate regulatory authority.

In general, the hydraulic design should be developed in accordance with the AASHTO *Model Drainage Manual* and FHWA *Hydraulic Design Series* and *Hydraulic Engineering*

Circulars. To ensure that hydraulic designs, analyses, and computations are developed in accordance with regulatory requirements, designers should consult the RIDEM Office of Water Resources document entitled *Hydrologic & Hydraulic Modeling Guidance.*

850 Temporary Erosion and Sediment Control

In order to minimize the potential adverse consequences of development on soil erosion and sedimentation, all project designs shall provide temporary erosion and sediment control in accordance with the *Rhode Island Soil Erosion and Sediment Control Handbook,* by the Rhode Island Department of Environmental Management (RIDEM), USDA Soil Conservation Service, and Rhode Island State Conservation Committee.

The project design must provide erosion and sediment control throughout the duration of a construction project or until all slopes are stabilized. Areas requiring such protection include, but are not limited to, the toe of a full slope, drainage ditches and outlets, catch basin inlets, and the limits of disturbance up-gradient of wetland features. The design should pay particular attention to those areas that are adjacent to or drain to nearby watercourses and wetland features.

In addition to the above, the design must take into account all stipulations contained within any permits that were issued for the project by any regulatory agency, including any RIDEM Freshwater Wetlands Permit, CRMC Coastal Assent, RIDEM Water Quality Certification, R.I. Pollutant Discharge Elimination System (RIPDES) Authorization, and/or U.S. Army Corps of Engineers Permit issued for the project.

The *Rhode Island Standard Details* provide typical details for common temporary erosion and sediment control design practices, including such standard elements as baled hay erosion checks, silt fence, dewatering basins, and baled hay catch basin inlet protection. Site conditions may also require that the design incorporate certain erosion and sediment controls beyond those provided in the Standard Details. For example, work proposed within a stream or river (such as that which may be required for a bridge replacement project) may necessitate a heavier-duty silt fence for to contain sediment and turbidity. Such job-specific erosion and sediment controls must be sufficiently detailed and noted on the construction plans.

Planted slopes also require erosion protection until a sufficient stand of grass (which will act as a permanent erosion control) is established. Common forms of temporary erosion control on planted slopes include: temporary seed mix, adhesive mulch stabilizers, hay or straw, and jute mesh. Jute mesh should be used on all slopes adjacent to wetlands and wetland perimeters, ditches, and stormwater management basins.

860 Permanent Erosion Control

The project design shall also provide for permanent erosion and sediment control in accordance with the *Rhode Island Soil Erosion and Sediment Control Handbook.* Permanent erosion controls must be provided on side slopes (proper landscaping/vegetation, geotextile fabric stabilization if required), in drainage ditches (baffles, check dams), at paved waterways, at drainage outfalls (rip-rap outlet protection, level spreaders), and other locations as appropriate. The *Rhode Island Standard Details* provide typical details for common permanent erosion and sediment control design practices, including such standard elements as paved waterways, rip-rap ditches, and concrete flared-end outlet sections.

In selecting the appropriate size and gradation of rip-rap and bedding from Section M.10 of the *RIDOT Standard Specifications for Road and Bridge Construction*, the designer shall use accepted engineering methods based on the calculated flows and velocities. Appropriate design guidance documents for this purpose include HEC-14 - *Hydraulic Design of Energy Dissipators for Culverts and Channels* and the *Rhode Island Soil Erosion and Sediment Control Handbook.*

In conjunction with stormwater best management practices, these permanent erosion measures will ensure that the proposed design will effectively mitigate the potential for long-term adverse impacts to the natural environment as a result of erosion and sedimentation.

Division 9 – Pedestrian and Bicycle Facilities

910 Accommodations for Pedestrians and Bicyclists

910.01 Introduction

Providing for safe and efficient travel for both bicycles and pedestrians should be an integral part of the design process. The facility may vary in form from use of the highway shoulder, to shared lane use for bicycles, to separate facilities. The decision to include either bicycle or pedestrian facilities in any highway project will be dependent on the type of highway, operating speeds, traffic volumes, and bicyclist/pedestrian demand.

Consideration for pedestrian and bicycle accommodations are provided for in RIGL 31-18-21 as stated below:

> Except in the cases of limited access roads, and/or two-way roads of less than twenty-three feet (23') in width, the director of the Department of Transportation is authorized and directed to provide for the accommodation of bicycle and pedestrian traffic in the planning, design, construction, and reconstruction, and to consider this in the resurfacing and striping of any project undertaken by the Department, unless the director or his or her designees, determines that the inclusion of bicycle facilities and pedestrian access would be contrary to acceptable standards of public safety, degrade environmental or scenic quality, or conflict with existing right-of-way. In his or her deliberations, the director shall take into consideration the cost of the facilities in relationship to available funding. Bike facilities may include bicycle lanes, routes, paths or trails; permeable paved shoulders; and/or signing.

910.02 Pedestrian Facilities

Pedestrian facilities in most cases will take the form of paved sidewalks. In some cases pedestrians can be accommodated within the paved or graded shoulder. The decision to include or improve sidewalks will be dependent on many factors such as adjacent land use, scope of highway improvements, and community input.

It is the Department's policy to use portland cement concrete sidewalks in urban areas and bituminous sidewalks in rural areas unless directed other otherwise.

AASHTO's *Guide for the Planning, Design, and Operation of Pedestrian Facilities* provides the designer guidelines and criteria for developing pedestrian facilities on public rights-of-way.

All newly constructed, reconstructed, or modified pedestrian facilities shall be designed to be accessible to persons with disabilities in accordance with subsection 920.04.

910.03 Bicycle Facilities

Bicycle facilities may include bike lanes, routes or paths, permeable paved shoulders, and/or signage. All projects whether resurfacing, 1R, or reconstruction should consider provisions for bicycles especially in those areas where bicycle usage may be expected to be increased. Areas of increased bicycle demand may include roads near or leading to bike paths, schools, parks, and recreational areas.

AASHTO's *Guide for the Development of Bicycle Facilities* provides the designer guidelines and criteria for developing bicycle facilities. Signing, striping, and accommodations at signalized intersections shall be in accordance with the latest edition of the MUTCD.

All drainage grates, with the exception of those on limited access highways, shall be bicycle safe. The designer shall inventory all existing drainage grates that are proposed to remain within the project limits. Any grates not considered bicycle safe shall be replaced. The designer should refer to **Division 8 – Drainage and Erosion Control** of this manual for additional information.

910.03.1 Shared Roadway Facilities

These types of shared roadway facilities are; a shared roadway with no bikeway designation, a shared roadway signed as a bike route, and designated bicycle lanes. The majority of bicycle travel will take place on roadways using a shared lane/shoulder combination without a formal designation. Providing proper shoulder widths to promote safe bicycle travel should be part of any design where it is determined that promoting the use of a highway by bicycles is appropriate.

The decision to sign shared roadways bike routes will be determined on a case-by-case basis. General technical guidance for the signing of State and local roadways as bike routes that are constructed utilizing federal and State funds is provided below. The intent is to sign such roadways as an aid to navigation for experienced and/or commuter cyclists in determining those roadways that may be designated as bike routes, utilizing the parameters of sound engineering judgment by considering a given roadway's posted speed limit, average annual daily traffic (AADT) volume, minimum useable width in feet and other factors. The designer should review RIDOT's "Guide to Cycling in the Ocean State" bike map with the PM. This resource provides a list of roadways that have been designated as "Most Suitable" or "Suitable" for experienced bicyclists.

A roadway may be signed as a bicycle route providing the roadway meets or exceeds the criteria specified herein.

1. Identify the minimum usable widths for signage as a bicycle route, as listed in the table below. The minimum acceptable width (in feet) is calculated by adding together the shoulder plus adjacent lane widths. Narrower minimum useable widths may be considered with proper justification, in coordination with the PM.

Table 9-1
Minimum Useable Road Widths in Feet (Lane + Shoulder)

POSTED SPEED LIMIT (miles/hour)	Average Annual Daily Traffic (AADT) Volume[1] Vehicles Per Day (vpd)		
	Less than 2,000	2,000 - 10,000	10,000 - 20,000
Less than 30	12'	15'	16'
30-40	14'	15'	16'
40-50	15'	16'	16'

1. Roadways having an AADT greater than 20,000 vpd will be considered on a case-by-case basis.

2. In addition to the minimum criteria listed in the above table, sight distance, the frequency of curb cuts (with particular attention paid to commercial curb cuts), the percent of AADT that is truck traffic, accident rates, and roadway grades should also be considered when evaluating a roadway for signing as a bike route.

3. All signs on State roadways must conform to the MUTCD D11-1 (Bike Route) sign. Signs are typically placed at .5-mile intervals and at intersections where bike routes change direction. In certain cases, a local municipality may design and install a special sign logo for those roadways under city and/or town maintenance responsibility.

4. A "Bicycle Route Suitability Recommendation Report" will be filled out by the section and/or the designer. The report should provide a recommendation regarding the posting of signs. The report will be signed by the reviewing engineer who must be a licensed professional engineer (PE). The report will then be forwarded to the section's deputy chief engineer for signature. The report will then be forwarded to the Chief Engineer who may then approve or disapprove the recommendation. A sample report is included in DPM 920.06.

"Share the Road" sign assemblies should be used in place of the "Bike Route" sign for short roadway segments in otherwise contiguous bike routes that do not meet the minimum criteria, or where sight distance is inadequate.

A "Share the Road" sign assembly will consist of a W11-1 bicycle traffic sign and a W16-1 advisory plaque.

Bicycle lanes are portions of roadways that are designated for the preferential use by bicycles. Bike lane delineation assigns right of way to bicycles and motorists in a shared facility. Bike lanes are designated by a combination of signing, striping, and pavement markings. Designated bike lanes may be considered when demand is high or when there is a need to provide clear instructions and/or expectations of the movements of the bicyclist. This delineation can benefit both the bicyclist and the motorist.

Special consideration should be given to bicycles at roundabout intersections. Recreational riders may be less comfortable when traveling through roundabouts, particularly multilane roundabouts. At these locations, provisions should be made to allow bicyclists to access the sidewalk area at each side of the intersection. The designer should consult the design guides for roundabout intersections for further guidance on this subject.

910.03.2 Shared Use Paths

Shared use paths are designated corridors that generally serve a mix use of non-motorized traffic. These paths are used by bicyclists, pedestrian, joggers, and others and serve both a transportation and recreation function.

In general shared use paths should be designed in accordance with AASHTO's *Guide for the Development of Bicycle Facilities*. Where possible the path should be made accessible to those with disabilities.

Special care should be taken when designing highway intersections with shared use paths. Providing proper sight distance to the point of crossing is essential. The designer should keep in mind that sight distance should be maintained to any curb ramp landing area that is provided as part of the accessibility requirements.

Wood rail fence will be installed based on safety factors as determined by the designer on a case-by-case basis. Fencing is not to be installed along the right-of-way for the sole purpose of defining property lines.

The designer must take into account requirements for emergency and maintenance vehicles on a shared use path. Where vehicles are expected to cross a structure the appropriate design loads shall be used; in most cases, the design load will be H-20. The appropriate vertical clearances shall be maintained for underpasses. Highway grade crossing should be designed to discourage entry non-authorized vehicular traffic with appropriate signing.

920 Handicap Accessibility

Where pedestrians are accommodated on sidewalks, the designer must take into account, to the greatest extent possible, the current Americans with Disability Act Accessibility Guidelines (ADAAG). A pedestrian access route (PAR) is defined as a continuous and unobstructed walkway within a pedestrian circulation path that provides accessibility.

Sidewalks should be designed to meet or exceed the following standards:

> Sidewalk width: For design purposes the minimum sidewalk width should be 60 inches including the curb width. Minimum clearance of 36 inches, excluding the curb width, should be maintained to provide an accessible route. The clearance width may be reduced to 32 inches, excluding the curb width, at locations that do not exceed 24 inches in length. There must be 48 inches minimum separation between points with clearances that are less than 36 inches.
>
> Cross slope: Cross slopes on sidewalks shall be 2 percent maximum.
>
> Surface: The surface of the pedestrian access route shall be firm, stable, and slip resistant.
>
> Surface Discontinuities: Surface discontinuities shall not exceed ½-inch maximum. Discontinuities between ¼ and ½ inch may be beveled at a rate of 1:2 minimum.

Handicap accessible sidewalks shall be provided with curb ramps at all cross walks. Curb ramps shall meet the following standards:

> Running Slope: The running slope shall be 5 percent minimum and 8.3 percent maximum but shall not require the transition length to exceed 15 feet.
>
> Cross Slope: Cross slopes on sidewalks shall be 2 percent maximum.
>
> Width: The minimum width where the ramp meets the gutter grade shall be 36 inches.

Landing: A landing area shall be provided at the top of the curb ramp. The landing shall be 48 inches deep and shall be as wide as the curb ramp exclusive of the flared sides.

Detectable Warning Surfaces: Detectable warning devices shall be provided at all curb ramps. The detectable warning devices are to be yellow unless a specific color is requested by the local community and approved by the Rhode Island Governor's Commission on Disabilities.

Ramps should be located to ensure that proper sight distance is provided for a motorist to see someone waiting to cross, particularly a person confined to a wheelchair.

Curb ramps, including landing areas and approach sidewalk transitions, should be kept clear of all obstructions that may create an accessibility issue or reduce the sight distance of the motorist. These obstructions include but are not limited to utility poles, light poles, traffic signal poles, controller cabinets, and fire hydrants.

Curb ramps should be placed to avoid low points. Catch basins should be placed on the up-gradient side of all curb ramps.

Divison 11 – Utilities

1110 Introduction

The design of utility facilities is an integral part of a highway project. Accommodations for utilities to be placed within the highway rights-of-way should be made whenever possible. For the purpose of this Division a utility is defined as "a privately, publicly, or cooperatively owned line, facility, or system for producing, transmitting, or distributing communications, cable television, power, electricity, light, heat, gas, oil, crude products, water, steam, waste, or other similar commodity, including any fire or police signal system, or street lighting system."

The designer should refer to the AASHTO publication, *Accommodating Utilities Within Highway Right-of-Way* for additional guidance when developing plans to relocate utilities as part of a highway project.

1120 Guide to Placement of Utilities in Sidewalks

This subsection is to be used as a guideline for the placement of relocated utilities on all projects. This design task requires careful coordination with each utility company to develop a design that fits within the highway cross section, provides for handicap accessibility, considers constructability of the project, is economically feasible, and minimizes and/or mitigates impacts to abutting properties. Details on utility submissions and coordination are provided in DPM 450.13. The designer must continue to use sound engineering judgment when locating utilities within State rights-of-way.

The Department prefers to have the back-face of utility poles placed at the back-of-sidewalk for sidewalks that are equal to, or greater than, five feet in width. Where available right-of-way allows, it is preferable to locate utility poles outside the sidewalk area when the sidewalks are less than five feet in width.

When placing poles at the back of the sidewalks, the designer must determine what impact the pole placement will have on the abutting properties. Care must be taken to ensure that proper clearances can be maintained if the wires are to be placed over or near structures and that tree trimming necessary for wire clearance there will not be any major destruction to foliage. The designer may elect to use outriggers for pole top construction or taller poles abutting properties; however, their use will be very limited and should only be considered after coordination with the appropriate utility company has taken place.

If the poles are not able to be set at the back of the sidewalk, then the front face of the utility poles should be placed one-foot from the face of curb for sidewalks that are five feet in width or less. Poles placed one-foot from the face of curb will require a design exception. For sidewalks greater than five feet in width, the face of the utility poles will be placed eighteen-inches from the face of curb.

Fire hydrants are another aboveground utility that may be encountered within the sidewalk area. The local fire department/district will provide the distance from the face of curb to the center of the hydrant. The designer must keep in mind that regardless of the placement of the hydrants, the minimum clear sidewalk corridor must be thirty-two inches, to ensure handicap accessibility. Minimum required clearances to provide an accessible route that complies with the ADAAG is discussed in greater detail in Section 920.04 of this manual.

The designer should not place, or leave in place, any utility poles, light poles, hydrants, or any other aboveground obstacle within any radius- or tangent-wheelchair ramp areas. This area must be clear to ensure handicap accessibility.

To accurately set utilities within the state right-of-way during construction, the designer must obtain the station and offset for all existing aboveground utilities during the design phase and provide the station and offset of utilities that have to be relocated on the project plans. Providing this additional information will ensure that all utilities are properly set during construction and the minimum clearance mentioned above is maintained at all times.

1130 Subsurface and Overhead Utility Location Program

The design engineer must coordinate with all public and private utilities within the project limits to determine their presence. Refer to DPM 450.13 for guidance on utility coordination. If existing underground utilities are present and excavation is proposed, then further investigation may be warranted.

In an attempt to reduce the amount of change orders during construction resulting from conflicts with proposed improvements, the Department requires that all existing underground utilities be located during the design phase. The designer should refer to the American Society of Civil Engineers, *Standard Guidelines for the Collection and Depiction of Existing Subsurface Utility Data* when compiling and preparing utility plans and determining the required utility quality level to be performed for each project. Utility quality levels are defined by the ASCE as follows:

Utility quality level A: Precise horizontal and vertical location of utilities obtained by the actual exposure (or verification of previously exposed and surveyed utilities) and subsequent measurement of subsurface utilities, usually at a specific point.

Minimally intrusive excavation equipment is typically used to minimize the potential for utility damage. A precise horizontal and vertical location, as well as other utility attributes, is shown on plan documents. Accuracy is typically set to 5/8 inch vertical and to applicable horizontal survey and mapping accuracy as defined or expected by the project owner.

Utility quality level B: Information obtained through the application of appropriate surface geophysical methods to determine the existence and approximate horizontal position of subsurface utilities. Quality level B data should be reproducible by surface geophysics at any point of their depiction. This information is surveyed to applicable tolerances defined by the project and reduced onto plan documents.

Utility quality level C: Information obtained by surveying and plotting visible aboveground utility features and by using professional judgment in correlating this information to quality level D information.

Utility quality level D: Information derived from existing records or oral recollections.

Utilities will be plotted to quality level C and D for all projects.

Resurfacing projects will not require quality level A and B utility locating.

For 1R projects, the designer should coordinate with the PM to determine the appropriate quality level and scope based on the project and the proposed improvements.

For all other project types, the location of underground utilities should be determined to quality level A and B. In general, all utilities within the project limits should be located to quality level B. Based on information obtained, utility locations should be confirmed at critical points wherever there are possible conflicts between existing facilities and proposed construction. These locations include:

- drainage structures
- drain line crossings
- foundations for traffic signal structures
- reduced cover over existing utilities

The location of these utilities at these critical points should be determined to a quality level A.

The designer must also consider the potential for overhead utility conflicts. Conflicts include both permanent fixed objects and constructability issues. Examples of potential conflicts with overhead utility lines include:

- traffic signal mast arms
- span poles and span wires
- sign structures
- light poles
- crane operations
- pile driving operations
- guy wire requirements
- stage construction requirements

To evaluate each situation, it is often necessary to identify and survey the heights of the overhead lines. The required clearances to utilities are detailed in TAC-0049 and DPM 450.13. These clearances must be met both vertically and horizontally.

Field reviews must be performed with both the utility company's representative and a member of the RIDOT Electrical Section present. The designer is ultimately responsible for locating and verifying the horizontal and vertical locations of the overhead utilities. Further, the designer shall ensure that the minimum clearances between the proposed structures and the overhead utilities are in accordance with applicable code requirements.

As a minimum, clearance to overhead power and communication facilities shall conform to the National Electric Safety Code (NESC) and Occupational Safety and Health Administration (OSHA) requirements. Particular attention must be paid to the OSHA requirement 29 CFR 1910.333, Subpart C and 29 CFR 1926.550 Subpart N as these requirements govern most cases when dealing with power lines. The subparts require that all persons or objects/equipment that a person is in contact with shall come no closer to any unguarded, energized overhead (primary electrical) line than the following distances:

1. For voltages to ground 50kV or below – 10 feet
2. For voltages to ground over 50kV – 10 feet plus 4 inches for every 10kV over 50kV

In addition, the NESC states that vertical and horizontal clearances of 3 feet must be maintained to insulated communication conductors and cables.

Division 13 – Lighting

1310 General

This document is intended to serve as a general highway lighting design guideline only, and to supplement information in Section T.02, Highway Lighting of the RIDOT Standard Specifications for Road and Bridge Construction.

Lighting levels requirements are to be provided according to the latest revisions of the ANSI/IESNA RP-8-00 publication based on each roadway classification and the latest version of AASHTO's *An Informational Guide for Roadway Lighting*.

Cutoff lighting is to be provided on all underpasses/overpasses containing four (4) lanes or more. Preferred method is over roadway illumination.

All lighting system design shall be performed and stamped by a licensed electrical engineer.

The designer shall verify the location of all overhead and underground utilities. In the case of overhead utilities, both location and height shall be verified to ensure that the required clearances are maintained. The designer should refer to **Division 11 – Utilities** for a more complete discussion on utility location and overhead utility clearances.

1320 Luminaires

All lighting shall be cutoff-style cobra head luminaries. Luminaires mounted over expressways and freeway mainlines shall be 400-watt high-pressure sodium (HPS), mounted at 40 feet. Luminaires mounted over ramps shall be 250-watt HPS mounted at 30 feet.

1330 Lighting Standards

Lighting standards are to be aluminum with single davits. Single davits may range from 4 to 10 feet based on application. Special conditions may allow luminaires to be mounted directly on top of straight standards without the need for a davit.

The minimum lateral offset from the edge of pavement shall be 4 feet. Generally, standards located on ramps should be placed on the inside of curves and/or behind guardrail.

Breakaway couplings are to be installed at all direct buried foundations including behind guardrail up to 4 feet from edge of paved roadway.

Lighting standards on bridges are to include anti-vibration rubber pads between standard base and foundation. Where excessive winds may be present of vehicular vibration exists, consideration is to be given to the application of external dampening on the davits to reduce vibration. Luminaires shall be secured to the davit with through bolts and lock washers.

1340 Service Pedestal

Service pedestal shall consist of a stainless steel enclosure containing a metered 200-amp, 240/480 volt, single-phase, three-wire service. In special cases, 120/240 volt or 120/208 volt single-phase, three wire services are acceptable

Power company approval on voltage and location shall be confirmed by the appropriate power company within the area of work. A letter from the utility company shall be included in the contract documents that confirms the availability of the required voltage at the agreed upon location.

The designer shall provide a foundation layout showing the conceptual layout of the conduit within the foundation.

1350 Conduit and Handholes

1350.01 Conduits.

Conduits and fittings shall be 3-inch PVC Sch. 40 direct buried. Roadway and ramp crossings shall be 3-inch PVC Sch. 80. Main line roadway and ramp crossings shall consist of two 3-inch conduits.

1350.02 Handholes.

Handholes shall be pre-cast concrete Type “A” in shoulders and sidewalks, Type “H” in vehicular traffic areas, or Type “B” when two or more conduits enter any direction, regardless of location.

1360 Lighting Circuits

1360.01 Splices.

Splices are to be semi-permanent, pre-molded, 600-volt submersible type (4-way). There are to be no hand taped splices for permanent installations.

1360.02 Conductors.

Main line conductors to be #2 copper, cross-linked polyethylene, XLPE (XHHW-2), 600-volt class.

Ground conductors to be #6 copper, cross-linked polyethylene, XLPE (XHHW-2), 600-volt class. Insulation shall be green.

1360.03 Lighting Circuits.

Lighting circuits to consist of 3-1/c #2 cu. and 1/c #6 cu. ground (green). Luminaires to be connected at 240 volts, phase-to-ground, using each leg on an alternating basis.

1360.04 Circuit Switching.

All lighting circuits are to be supplied from a lighting panel controlled via a lighting contactor and master photocell.

1360.05 Overcurrent Protection.

Lighting circuits shall be protected by two single pole breakers. Breaker sizes shall be 20 to 50 amps.

1360.06 Fusing.

In-line pre-molded fusing kits shall be used at each handhole at the base of the lighting standard. Underpass lighting fixtures shall be fused with in-line fuses at the nearest junction box.

1360.07 Voltage Drop.

The allowable voltage drop from pedestal to the last luminaire shall not exceed 5 percent. The designer shall submit voltage calculations to RIDOT at the 90 percent stage.