Washington State Department of Transportation

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Remarks and Instructions

Remarks:

1. This revision is provided in English (US common) units only. The metric *Design Manual* is out-of-date and must not be used with respect to the English chapters dated February 2002 or later.
2. Manual holders are reminded that the Internet is updated when a revision is printed. CDs are up-to-date at the time of production-order only. Subsequent revisions can occur in the six months between orders for new CDs.
3. The WSDOT Design Policy home page has several new features including "Contact Information." The new What's New "*Design Manual* Errata" page lists corrections for known "technical" errata and incorrect reference's. The new Other Items "*Design Manual* Forms" page offers access to page iii and Chapter 140's Managing Project Delivery Worksheet as Word documents. This will take you there: http://www.wsdot.wa.gov/eesc/design/policy/designpolicy.htm

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Instructions:
Page numbers and corresponding sheet-counts are given in the table below to indicate portions of the *Design Manual* that are to be removed and inserted to accomplish this revision.

Chapter	Remove		Insert	
	Pages	Sheets	Pages	Sheets
Foreword	i-ii	1	i-ii	1
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Foreword

This *Design Manual* is for use by our engineering personnel. It provides policies, procedures, and methods for developing and documenting the design of improvements to the transportation network in Washington State. The *Design Manual* is developed for state facilities and may not be appropriate for all county roads or city streets that are not state highways.

The manual supplements the engineering analyses and judgment that must be applied to improvement and preservation projects. It provides uniform procedures for documenting and implementing design decisions. When proposed designs meet the requirements contained in the *Design Manual*, little additional documentation is required.

The designer must understand that the design environment changes rapidly, and often without warning to the practitioner. To track every change, and to make improvements based upon each, is not feasible. The intent of this manual is to provide recommended values for critical dimensions. Flexibility is permitted to encourage independent design that is tailored to particular situations. When flexibility is applied, and critical dimensions of a proposed design do not meet the *Design Manual* criteria, additional documentation is required to record the decision making process.

The fact that new or modified design criteria are added to the *Design Manual* through the revision process does not imply that existing features are deficient or inherently dangerous. Nor does it suggest or mandate immediate engineering review or initiation of new projects.

Cost-effective and environmentally conscious design is emphasized, and consideration of the use of the highway corridor by transit, pedestrians, and bicyclists is included. Designers are encouraged to view the highway corridor beyond the vehicular movement context. To accommodate multimodal use, the criteria provided for one mode is to be appropriately adapted, as needed, at a specific location.

The complexity of transportation design requires the designer to make fundamental tradeoff decisions that balance competing considerations. Although weighing these considerations adds to the complexity of design, it accounts for the needs of a particular project and the relative priorities of various projects and programs. Improvements must necessarily be designed and prioritized in light of finite transportation funding.

Updating the manual is a continuing process, and revisions are issued periodically. Questions, observations, and recommendations are invited. Page iii is provided to encourage comments and to assure their prompt delivery. For clarification of the content of the manual, contact the Headquarters Design Office. The e-mail address is DesignManual@wsdot.wa.gov.

Harold Peterfeso, P.E.
State Design Engineer

Washington State Department of Transportation

Design Manual Supplements and Instructional Letters

September 2002

In Effect	Chapter	Date	Type	Subject/Title
Yes	150	01/18/99	IL 4015.00	Right of Way Plan Development Process Improvements
No	330			(Chapter 330 revised June 1999)
No	1410			(Chapter 1410 revised June 1999)
Yes	1050	9/28/99	DM Supplement	Left-Side HOV Direct Access Connections
Yes	HOV*			
No	**940**			
Yes	1050 HOV*	05/03/00	DM Supplement	Left-Side HOV Parallel On-Connection
Yes	915	07/03/00	IL 4019.01	Roundabouts (expiration extended)
Yes	**700**	**08/01/01**	**DM Supplement**	**Median Barrier Guidelines**

* The *HOV Direct Access Design Guide*, Draft M 22-98

Notes:

- Changes since the last revision to the *Design Manual* are shown in bold print.
- Items with **No** in the **In Effect** column were superseded by the latest revision and will be dropped from the next printing of this list.
- The listed items marked *yes* have been posted to the web at the following location:
http://www.wsdot.wa.gov/fasc/engineeringpublications/DesignLettersMemInstruction.htm

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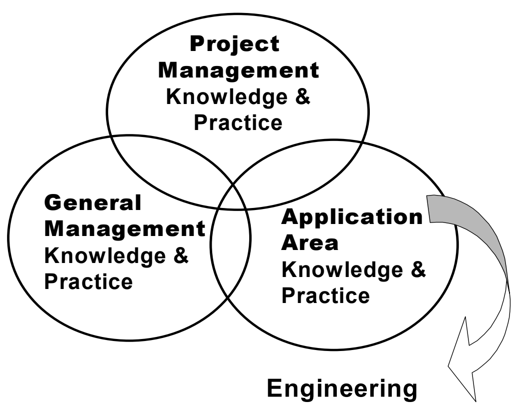
140 Managing Project Delivery

140.01 General

This chapter presents an overview of the process, tools, and resources used by the Washington State Department of Transportation (WSDOT) to effectively deliver projects.

Project delivery — The challenge is to get the job done: on time, within budget, and according to specifications. This includes meeting or exceeding customer and stakeholder expectations. Successful project delivery results from the effective employment of three overlapping discipline areas as shown in Figure 140-1.

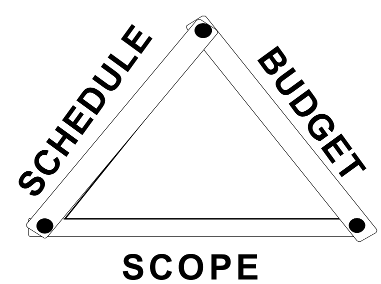


Overlapping Disciplines for Successful Project Delivery
Figure 140-1

Working together — Virtually all public transportation projects are inherently complex and require the coordination of interrelated activities. Clarity of communication between the project manager, team members, sponsor, and customers is necessary. A skilled, coordinated, and collaborative group will find effective solutions and deliver projects more successfully than individuals working alone. The Managing Project Delivery process and tools facilitate alignment of the project participants through establishment of a commonunderstanding. They enable development and execution of a collaborative work plan that is comprehensive, realistic, and deliverable.

Customer focus — A key to successful project delivery is the effective involvement of project customers. Providing and operating a statewide transportation infrastructure is relevant to virtually every aspect of society. As a result, the WSDOT customer base is very diverse. Customers are the users of, and those directly affected by, the product that the project produces. Project customers will be mobility, safety, and community oriented. Identification of appropriate customer representatives is necessary for each project. Meaningful customer representation involves individuals whom the project team can communicate with directly.

Managing scope, schedule, and budget — Ongoing and active management of the project's "triple constraints" (scope, schedule, and budget as shown in Figure 140-2) is a primary focus of project management.



Project Management Trade-Off Triangle
Figure 140-2

Implementation of the Project Delivery Information System (PDIS), using project scheduling software, provides a tool for effective management of project schedules, assigned resources, and the resulting cost to complete projects. The purpose of using PDIS is to enhance communication and coordination between staff engaged in project and program delivery at the project team, office, region, and statewide levels. See the PDIS definition for a web address.

Key features of effectively managing project delivery include the following:

- Building an interdisciplinary team having the skills necessary for the project.
- Including the customers in the project delivery process.
- Communicating.
- Managing customer expectations.
- Managing change.

The material in this chapter is provided to better enable participants in the WSDOT Highway Construction Program to work together to develop and deliver quality projects on time and within budget through active management of scope, schedule, and budget.

140.02 References

WSDOT Policy Number P 2010.00, "Managing Project Delivery – Using Quality Principles"

WSDOT Policy Number P 2011.00, "Managing Project Delivery – Providing Resources"

A Guide to the Project Management Body of Knowledge (PMBOK), 2000, The Project Management Institute

"Managing Project Delivery" training manual, 1998, CH2M HILL

140.03 Definitions

customers The customers for a project are the users of, and those directly affected by, the project's product.

CIPP The Capital Improvement and Preservation Program for which change management procedures are in place including the Change Management Form at wwwi.wsdot.wa.gov/ppsc/pgmmgt/dpsb/4ChangeManagementForm.doc.

CMP Change Management Plan. See 140.05(2)(g).

MDL The Master Deliverables List (for this chapter MDL) implemented as part of the PDIS, is a standardized work breakdown, down to the deliverable level.

MPD The process called Managing Project Delivery that is described in this chapter.

PDIS The Project Delivery Information System, using project scheduling software, for project planning, scheduling, resource balancing, and cost management. See wwwi.wsdot.wa.gov/projects/PDIS/

project A temporary endeavor undertaken to create a unique product or service.

project manager The person responsible for conducting the project's effort and delivering the end product.

project sponsor The person assigning the project manager the responsibility to conduct the project's effort and deliver the end product.

stakeholders Those with a particularly significant interest in the project's outcome including those providing funding or right of way for the project and property owners who are affected by the project. Stakeholders are unique for each project.

team A designated group of people working together with a common purpose.

WBS Work Breakdown Structure. See 140.05(2)(a).

work plan A comprehensive, realistic, and deliverable plan to accomplish the team mission and deliver the project. It includes a schedule and a budget.

140.04 Resources

In addition to the publications listed under 140.02, References and web sites mentioned in this chapter, the Headquarters Design Office provides training, and assistance in implementing the principles of Managing Project Delivery.

140.05 Process and Tools

Successful project delivery results from active project management and a team that acts with a common purpose. The Managing Project Delivery process is applied by project managers and teams. It includes five basic steps, each with supporting elements, as shown in Figures 140-3 and 140-4. Each of these steps and elements is described below.

The five steps of Managing Project Delivery can be further simplified into two basic phases:

- Preparation – "Plan the Work"
- Execution – "Work the Plan."

In a typical project application, planning the work, (the first three steps) will constitute approximately 10% of the total project effort and time. Steps four and five will constitute approximately 90% of the project effort and time.

The need for some project tasks to start immediately can be so apparent that "working while planning" is, at times, both necessary and appropriate: site surveying, aerial photography, and traffic counts, for example.

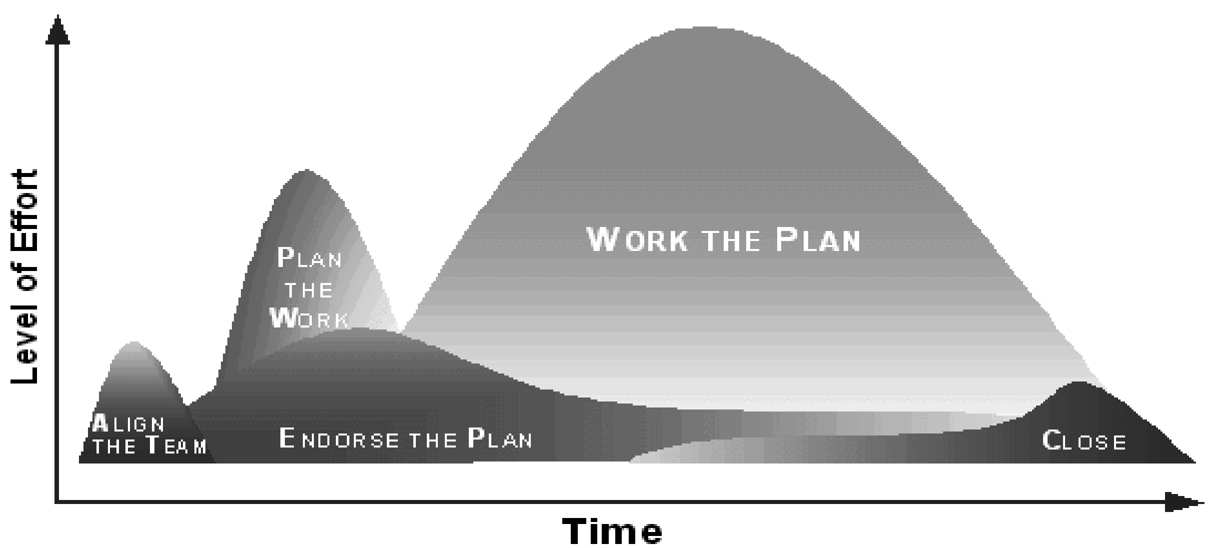
Adapt the Process and Tools to Your Project and Team — The manner and extent of use of each process step and element is determined on an individual project basis by the project manager and team. This is based on the degree of benefit to be realized by their project through application of each element.

An efficient approach to developing a project work plan is to have a core group develop initial drafts of the various alignment elements (project vision and team mission, for example). The full project team can then review and alter them as appropriate. This reduces the need for personal involvement by specialty staff who participate in numerous project teams.

What is scalability?

Scalability is the ability to apply each of the Managing Project Delivery steps and elements in proportion to the project and team size and complexity and to the value that can be derived. See Figure 140-4.

Typically, all steps and elements are applied to large projects. They directly contribute to a common understanding and the development of a comprehensive work plan. Some project types have main activities that have been repeated many times and costs are accurately predictable: cost per lane mile for resurfacing, for example. Value would not likely be added by conducting a detailed estimation of commonly used project task costs.



Relative Effort
Figure 140-3

(1) Initiate and Align the Team

- Initiate the project.
- Build the project team.
- Align the participants toward a common goal.

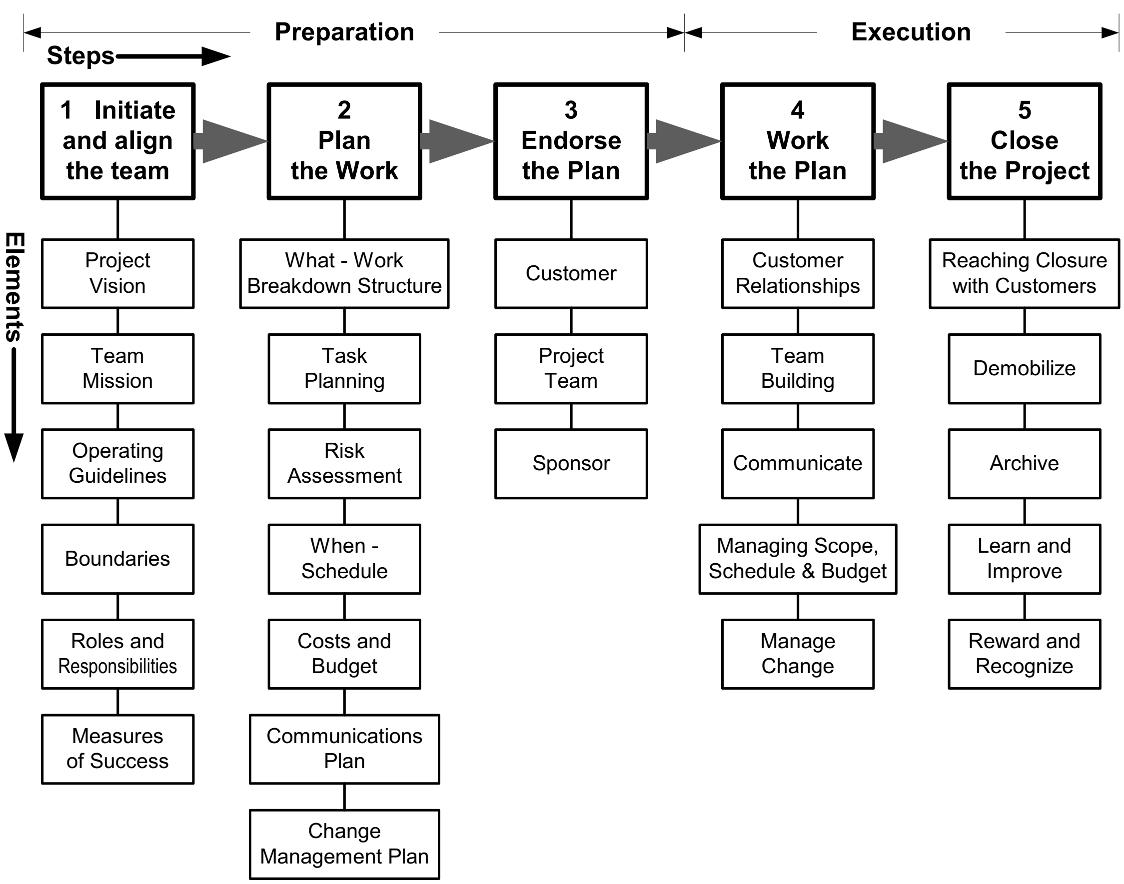
While the assignment of organizations and individuals to a project is an essential first step, mere assignment does not result in an effective team. Teams must be built and sustained. (See 140.04(4)(b), Team Building.) For successful project delivery, the participants must conduct their efforts in a coordinated and complimentary manner. Establishing communication among the people who will develop and deliver the project is the most important function of this first step of Managing Project Delivery. Successful project delivery starts with mobilizing the necessary resources and aligning the participants toward a common goal.

Building and sustaining an effective project team involves initiating the project by developing a common understanding of:

- Project vision
- Team mission
- Participant roles and responsibilities
- Project boundaries
- Critical success factors

What is a project team?

The project team is a designated group of people working together with a common purpose related to a specific project. A critical aspect of project success is mobilizing and aligning people around a project to effectively deliver the product.



Managing Project Delivery
Steps and Elements
Figure 140-4

Who should be on the team?

The project manager assesses what skills are required for the specific project and secures people with those skills to accomplish the project effort. Many projects require multidisciplinary participation. The project manager must secure individuals from the appropriate functional specialty groups (potentially including Bridge, Environmental, Geotechnical, Local Programs, Materials, Real Estate Services, Traffic, Utilities, and others). This is necessary to overcome the established tendency of large organizations to segregate or compartmentalize. Compartmentalization commonly results in disjointed and conflicting deliverables.

Depending on the scope of the project, participation on the team by "partners" is appropriate and can serve to ensure that the product meets customer expectations. Identification of appropriate representatives is necessary for each project and, to be meaningful, needs to be individuals who can communicate directly with the project team. Examples are:

- Elected officials at the federal, state, and local level
- Representatives of Indian tribes
- Staff from appropriate agencies or jurisdictions
- Staff from permitting agencies
- Stakeholders
- Neighborhood residents
- Individuals who regularly use the facility

To be both effective and efficient, the participants' efforts need to complement one another in support of accomplishing a common purpose, in other words, to function as a collaborative team. This does not mean that all team members must participate in every team meeting or project work session. Active project management includes ongoing determination of necessary participants to be effective and efficient.

Some project managers have found that a designated project Leadership/Management Team is an effective supplement to a Production Team. This approach is particularly useful for very large projects. Communicating with and seeking endorsement from customers is an essential aspect of successfully managing project delivery. Some project managers have determined that forming these participants into a Steering Team or Citizen Advisory Committee is the most effective format.

(a) **Project Vision**

What will be the result of this project?

The project vision establishes the common goal toward which all project activities and efforts strive. It is a statement of the desired Highway Construction Program project product (facility or service). The project vision describes an outcome (the final product, not a process) and is intended to incorporate customer and stakeholder needs and expectations as well as team input.

(b) **Team Mission**

How will the team accomplish the project?

The Team Mission statement serves to establish the common understanding of what a specific team is to accomplish. It is a statement of the overall actions the team will take to accomplish the project. It is usually a short paragraph developed with input from the team, including participating stakeholders and customers, as well as from the project sponsor.

In this chapter, "the project" means the Team Mission — The word project is used throughout this chapter. It is imperative to understand and communicate the distinction between the defined Team Mission ("the project" for purposes of this chapter) and a "Highway Construction Program project." A Highway Construction Program project is developed in phases (scoping, design, PS&E, right of way, and construction.) A specific Team Mission may be constrained to a specific phase or phases of a Highway Construction Program project. It is entirely likely that the Team Mission of any given project team will not attain the ultimate end product of the Highway Construction Program project, "the project vision."

The Team Mission statement is of particular importance during project work planning as it determines the scope of the Work Breakdown Structure, (starting with project specific tailoring of the Master Deliverables List [140.04(2)(a)], which is the basis of the schedule and estimated cost to complete.

(c) **Operating Guidelines**

How will the team govern itself?

The operating guidelines describe how the team will govern itself both within and outside of team meetings. The functions most commonly performed by the team and guidelines to steer it in those functions are identified. Listed below are some guidelines the team might wish to develop:

- Team decision process.
- Team meetings (such as structure, timing).
- Communication (such as methods, uses, frequency, protocols).
- Measuring team performance (such as team surveys, self-assessments/evaluations).
- Managing team disagreement and conflict.
- Managing team change (such as changes in team membership).

(d) **Boundaries**

What do boundaries define?

Boundaries define the limits relevant to the project and the team's mission. Boundaries are usually set by the organization and transmitted to the team by the project sponsor. Some boundaries are established by other entities beyond the team. Boundaries might fall within the following areas:

- Geographic.
- Financial.
- Legal and regulatory.
- Mandatory product delivery dates.
- Required project activities.
- Excluded project activities.

What benefit is derived from identifying boundaries?

The identification of project boundaries provides a valuable opportunity for the team, the sponsor, and appropriate customers to enhance their common understanding of the project environment. Well defined project boundaries can be very useful for identifying potential change. Teams frequently find it valuable to distinguish goals (desirable but not mandatory elements) from absolute boundaries.

(e) **Roles and Responsibilities**

What are roles and responsibilities?

Roles and responsibilities can be defined for each organization participating in the project or down to the level of each individual on the project team. The definition and mutual acceptance of organizational and individual roles and responsibilities expedites arrival at a common understanding of "who will do what."

The team member's *roles* are the specific titles or positions occupied, such as team leader, designer, permit coordinator, drafter, etc. The *responsibility* is the output or outcome expected of the team or individual, such as plan sheets, hydraulic analysis, schedules, etc.

A project-specific table of organization chart is a good tool for visualizing needed and assigned human resources, their roles and responsibilities, and the relationships or linkages between the participants.

(f) **Measures of Success**

How will accomplishment of the team's mission be measured?

Measures of success are tools to assess the accomplishment of critical success factors. Critical success factors define the most important things the team must accomplish to fulfill its mission and achieve project success. These factors are tied to the team mission and project vision.

The first step is to define critical success factors. Once these factors are defined, ways to measure their attainment are developed. Attainment of the critical success factors is measured incrementally "along the way," not just at the point of project completion. This allows for corrective action (changes) to get "back on track."

(2) Plan the Work

What is the goal of planning the project work?

The goal is a work plan that is comprehensive, realistic, deliverable, and endorsed by all team members.

Planning the work to accomplish the Team Mission — It is imperative to understand and communicate the distinction between the work plan (including schedule and cost to complete) to accomplish the defined Team Mission and the entire effort to deliver the Highway Construction Program project in terms of preliminary engineering (PE), right of way (ROW), and construction (CN) phases.

The following are examples:

- For a Team Mission to conduct the scoping phase of a Highway Construction Program project, work planning elements for the design, PS&E, ROW, and CN phases (including schedule and cost to complete) will be deliverables accomplished as part of fulfilling the Scoping Team's Mission. These later phase schedules and cost estimates will be output from "working the plan" to scope the project. The "plan the work" schedule and budget in this example are only for accomplishing the Team Mission to scope the project.

  The scope of work, schedule to deliver, and the estimated cost to complete a Highway Construction Program project (including PE, ROW, and CN phases) are developed by a region project team during the scoping phase, and become commitments upon signature of the Project Definition and entry into the Capital Improvement & Preservation Program (CIPP).

  Once a Highway Construction Program project's scope, schedule, and estimated cost (PE, ROW, CN) have been committed to in the CIPP, if at any point in the further development of that project the delivery date or estimated cost exceed the commitments in the CIPP, the Change Management Plan will be implemented by the Project Manager. (See 140.05(2)(g), Change Management Plan.)

- When the Team Mission is to conduct the design or PS&E subphases of a project, the "plan the work" schedule and cost estimate are a test or verification of the project PE schedule and cost estimate commitment in the CIPP. In the case of a Team Mission to conduct the design or PS&E of a project, a construction phase schedule and cost estimate will be "working the plan" deliverables.

(a) What — Work Breakdown Structure

What needs to be done to accomplish the team mission and deliver this project?

The Work Breakdown Structure (WBS) is a systematic mapping out of the hierarchical project tasks (necessary to accomplish the Team Mission) to the lowest level of detail necessary to describe and assign the tasks. The WBS tool is useful toward developing a project scope, schedule, and budget. The team develops the WBS with input from project customers and stakeholders. The WBS includes all tasks necessary to accomplish the team mission.

A task is an assignable item of work that has:

- A definable beginning and end.
- A finite duration.
- An associated level of effort (such as labor, money, equipment, and materials).
- A state of completion that can be estimated at any time.
- A reviewable internal or external deliverable at the task's completion.

Master Deliverables List – Implementation of the PDIS, using project scheduling software, includes establishment of an agency wide standard Master Deliverables List (MDL). The MDL is a work breakdown, down to the deliverable level, and is to be used by all projects in the Highway Construction Program. It serves as the starting point for development of each project-specific Work Breakdown Structure. With only a few exceptions, the MDL does not include tasks. Tasks must be defined for each project. The tasks developed at the project level must roll up into the deliverables in the standardized MDL, which is available on the WSDOT Internet site. See the PDIS definition for a web address.

(b) **Task Planning**

How is the project work plan developed from the tasks (WBS) to a comprehensive and realistic schedule and then a budget?

Task planning serves as an essential intermediate step between the WBS and schedule layout. Developing the schedule directly from the WBS has an extremely high risk of resulting in an inaccurate schedule due to incompletely defined tasks. Figures 140-7a and 140-7b are a Task Planning Worksheet available for use in accomplishing this step. This worksheet is also available at www.wsdot.wa.gov/eesc/design/policy/designpolicy.htm

Task planning includes the following:

- **Task scope definition.** Just as the overall project requires a well developed and communicated scope, so do the supporting tasks. For example, for "Public Information Newsletters" task, will there be 1, 3, or 5 mailings, to 500, 5000, or 10,000 addresses, and will they be 1, 3, or 5 pages in length? How will they be distributed?
- **Task sequencing.** The accurate sequencing of tasks is critical to the later effective development of a realistic and deliverable schedule. The recurring question asked in this process is "To execute this task, what do I need from some other task, and when do I need it?" Identifying task dependencies between functional areas is of critical importance (Design and Bridge, Environmental and Design, Hydraulics and Right of Way, etc.)
- **Resource assignments.** What organization and what specific individuals will conduct this task? Will 1 or 3 drafters be assigned to this task? Are the specific individuals highly experienced or "first timers"? What availability constraints apply to the individuals assigned to this task: other project assignments, percentage of time committed to this project, training needs, vacations, and the like?

  Accomplishing this work planning element is a key to ultimately attaining a resource loaded schedule. The software entry of resources is dependent on this task planning function.
- **Task duration estimates.** Those individuals with the applicable expertise can make the most accurate estimates for completion of tasks. Expert judgment guided by historical information is used whenever possible. Project managers must seek input from those who will accomplish specific tasks to estimate the realistic duration.

(c) **Risk Assessment**

What risks does this project face and how can they best be managed to ensure successful delivery?

Project risks can be opportunities (positive events) as well as threats (negative events) that might affect scope, schedule, or budget. Risk assessment is the first phase of project risk management, the purpose of which is to maximize the results of positive events and minimize the consequences of adverse events. See *A Guide to the Project Management Body of Knowledge* for more details. Risk assessment includes the following:

1. **Risk Identification** is determining which risks are likely to affect the project and the characteristics of each. This includes both internal (things the project team can control) and external (beyond the control or influence of the team) risks. Identify risks from historical information, interviewing of stakeholders, subject matter experts, and team brainstorming.
2. **Risk Quantification** is identifying the risks for which a contingency plan will be developed.

   An effective tool for quantifying project risks is the Risk Probability – Impact Matrix shown in Figure 140-5. Each identified risk is assessed for probability of occurrence and degree of impact to the project, should it occur. Assessment of risks is a judgment call based on the best available insight. Risks identified as both high probability and high impact (red risk) are potential "show stoppers" and must be further addressed immediately. All risks determined to be medium to high in both probability and impact (yellow risk) are given continuous management and, probably, development of contingency plans.

3. **Risk Response Development.** Responses to risk threats include the following:
   - Avoidance — eliminating the threat, usually by eliminating the cause.
   - Mitigation — reducing the potential probability of occurrence.
   - Acceptance — accepting the consequences either actively (with a contingency plan) or passively.

The reason for conducting risk assessment before schedule and budget building is to provide the opportunity to develop and incorporate schedule and budget contingencies for "at risk" tasks.

Impact			
High	Gray Area	Yellow Risk	Red Risk
Med.		Yellow Risk	Yellow Risk
Low			Gray Area
	Low	**Med.**	**High**

Probability

Risk Probability – Impact Matrix
Figure 140-5

(d) **When — Schedule**

When will the project tasks be conducted?

All projects in the WSDOT Highway Construction Program are managed using a schedule of required activities that is based on the standardized Master Deliverables List.

The schedule to complete the Team Mission is developed from the Work Breakdown Structure and the subsequent task planning. The schedule is a dynamic tool. It defines the start, order, and duration of project tasks and milestones. A collaboratively developed and comprehensive schedule is a fundamental tool for the subsequent management and delivery of the project. It is used to communicate, coordinate, and measure project progress.

Identifying and managing task dependencies between functional areas (Design to Environmental, Geotechnical to Bridge, Traffic to Design, etc.) are of major importance to successful project delivery. Milestones and interim deliverables make schedule, and thus project management, much easier and more effective by providing both short-term goals and clear measurements of progress.

When schedules are resource loaded it becomes possible to balance the assignment of resources and identify over-allocated resources using the schedule. Resource balancing can be accomplished within an individual project and across multiple projects when all involved schedules are resource loaded. The development of a schedule-based budget is also feasible once a schedule is fully resource loaded.

(e) **Costs and Budget**

How much will it cost to accomplish the Team Mission in accordance with the project schedule?

The estimated cost to complete the Team Mission is developed from the Work Breakdown Structure, assigned project resources, and the resultant comprehensive schedule. This estimate is broken down by participating functional area (Bridge, Environmental, Real Estate, etc.), as well as by month ("aged"). It includes an appropriate contingency allowance for identified risk areas and inaccuracies in the cost estimating process.

The estimated cost to accomplish the Team Mission includes all activities that will be directly or indirectly charged against the project such as "planning the work," quality assurance and control, project management, and project closure.

(f) **Communication Plan**

Communication, the exchange of information to the relevant parties (including ideas, expectations, goals, requirements, and status), is vital to project success. To be effective, communication cannot be left to chance. While the theme of communication permeates the entire Managing Project Delivery process, a specific communication plan is an essential tool for successful project delivery. See Chapter 210, "Public Involvement and Hearings."

Communication has many dimensions:

- Internal (within the project)
    1. Vertical (up & down the organization)
    2. Horizontal (with peers)
- External (to stakeholders, the media, the customers)
- Written, oral, and various media
    1. Letters, memos, e-mail
    2. Internet
    3. Media (radio, TV, newspapers)
    4. Personal contacts
    5. Public meetings and hearings

Every project develops or adopts a communication plan. Communication plan elements include the following:

- Requirements — Determining the information and communication needs of the project stakeholders and participants: who needs what information, when will they need it, and how will they get it.
- Distribution Structure – Defining the following:
    1. To whom information will flow (status reports, data, schedule, etc.).
    2. What methods will be used to distribute various types of information (written reports, letters, meetings, e-mail, Internet).
    3. When each type of communication will be produced.
    4. Who, in the project organizational structure, is responsible for preparing and distributing the identified items.

(g) **Change Management Plan**

Successful project delivery requires active identification and analysis of encountered change, leading to effective decisions. A common human tendency is to deny that change is occurring until it becomes overwhelming. A Change Management Plan (CMP) provides the framework for decision making when change occurs. Since it is not possible to foresee all potential changes, a project manager plans the methods by which change will be addressed when encountered.

The CMP includes the following elements:

- A means to anticipate and identify potential changes.
- A process for assessing the effects of a change.
- Techniques and procedures for developing a response strategy.
- A change endorsement process, including identification of the level of endorsement necessary for various types of change. Endorsement is by definition proactive such that endorsement of any change is necessary before resources are expended to implement the change.
- A process for revising the work plan and monitoring performance in accordance with the revised work plan.
- A communication strategy to inform all affected parties of the project changes.

WSDOT has adopted standardized change management procedures for the Capital Improvement and Preservation Program (CIPP). These procedures, including a standardized Change Management Form, are used by both Project Development and Program Management. Detailed information on this CIPP change management process, including the Change Management Form, are available on the web. See Figure 140-6, and the definition for CIPP for the web address.

(3) Endorse the Plan

What is endorsement, how is it different from approval, and who are the key parties to endorse the plan?

Endorsement constitutes both buy-in and commitment to the work plan and project effort by the key participants. Endorsement is proactive, whereas approval is typically reactive, frequently meaning no more than a lack of objection. Endorsement is the key participants taking ownership of the project goals and the agreed upon method by which the goals will be delivered.

The optimal method to gain endorsement of the project work plan is by inclusion of the participants in the collaborative development of the work plan. This will provide ownership of the plan by the participants and help to reach endorsement by consensus.

The project manager determines whether endorsement for the project work plan will be achieved verbally or documented.

(a) **Customers**

A primary purpose of endorsement is to gain customer commitment to support the project team and work plan. Endorsement by the customers is intended to ensure their understanding of the project and acceptance of the project scope, schedule, and budget.

(b) **Project Team**

The purpose for endorsement by the project team is to:

- Share a mutual understanding of the work plan.
- Actively concur that the plan is comprehensive, realistic, and deliverable.
- Demonstrate that the team is committed to completing the project as described in the plan.

This endorsement validates the working relationship between members of the team and between the team and the project manager.

(c) **Sponsor**

Endorsement of the project work plan by the project sponsor, and other managers designated by the project sponsor, provides:

- Sponsor commitment to the defined scope, schedule, and budget.
- Necessary staff (skill base, knowledge, experience).
- Required tools and resources (computers, technology, office space).
- Sponsor acknowledgement of known risks and associated contingencies.
- Sponsor commitment to advising and assisting in executing the project.
- Sponsor commitment to applying management's authority toward successful accomplishment of the work plan and project.

In order to facilitate sponsor/management endorsement, it is advisable to involve management in the project work plan development to some degree. The level of involvement will vary by project.

(4) Work the Plan

(a) **Customer Relationships**

- Know the customer's expectations.
- Involve the customers as they wish to be involved.
- Communicate progress to customers as they desire.
- Resolve conflict as necessary.
- Manage customer expectations.

(b) **Team Building**

A team must be both built and sustained. Teams are dynamic. Their movement across the spectrum of team development (forming, storming, norming, performing, excelling) is ongoing and must be continually managed to attain high performance, produce results, and deliver the project.

- A team is a group of individuals who work for a common purpose to produce a specific outcome.
- A team continuously develops group and individual skills to enhance team performance on the project.
- An effective team develops and implements a reward and recognition strategy.
- A team works together to correct mistakes in ways that minimize negative impacts on the project.
- A team works together to learn from mistakes.

(c) **Communicate**

Effectively exchanging the necessary information between project participants and interested parties is essential for project delivery. Project managers and teams apply the Communications Plan adopted for the project.

(d) **Managing Scope, Schedule, and Budget**

Successful project delivery (on time, within budget, and meeting requirements – including meeting or exceeding customer expectations) requires active management of scope, schedule, and budget including the following:

- An endorsed base line scope, schedule, and budget.
- Ongoing communication with all team members to get frequent and accurate data on progress.
- Regular schedule and budget monitoring and evaluation with revisions to reflect actual progress, as appropriate.
- Regularly reporting progress to customers and stakeholders.

All projects in the WSDOT Highway Construction Program will maintain current schedules in the PDIS. Project schedules will be updated frequently enough to ensure the project delivery date shown in PDIS is accurate and can be met.

The scope, schedule, and budget tradeoff triangle functions as a link and pin truss where the sides must remain connected. See Figure 140-2. When one side changes, the influences or impacts of that change on the other two sides must be managed. A cardinal rule in project management is that, whenever scope, schedule, or assigned project resources change, a corresponding budget change is mandatory. The application of this rule often requires involvement and assistance from others who will be expected to endorse the resulting updated plan.

(e) **Manage Change**

Recognizing and confronting change rather than avoiding it is key to successful project delivery. Value can be added through appropriate change management. Changes can save money and time. Active change management, through use of an established Change Management Plan, can minimize adverse effects on project delivery.

Proactive endorsement (by the necessary authority) of changes to project scope, schedule, or budget must be obtained before resources are expended to implement the change. See 140.05(2)(g), Change Management Plan; Figure 140-6; and the associated web page for additional information on the change management process for projects in the CIPP. See the definition for CIPP for the web address.

Frequent and meaningful communication between project participants (including team members, sponsor, and customers/stakeholders) is an essential element of actively managing change. It is the responsibility of the team members familiar with the scope, schedule, and budget to continuously identify potential changes in those areas.

(5) Close the Project

To conduct an effective closure, or phase transition, it is important for the project manager and team to define what closure means for this team and project. The following are common closure situations:

- Final closure. The final project vision has been attained. If so, this is probably an ultimate closure for the overall project effort.
- Transition. One team has accomplished its mission, but a transition or handoff must be made to a subsequent team tasked with

furthering the overall effort toward attainment of the project vision. This is typical between major project development phases such as between design and construction. A thoroughly conducted transition is critical for being ultimately successful in delivering the product for the customers.

- Shelf. A project effort that has reached a temporary closure point and is being put "on the shelf" is a transitional event to a future team that probably has not even been assigned. Comprehensive documentation of the project status, backup, and decisions (with justifications) is especially critical in this situation to minimize rework when the effort is restarted.

(a) **Reaching Closure With Customers**

This is the process of following up with the customers of the project and all affected parties. This includes the review of successes and failures in the eyes of the customers in relation to the project. This is planned for throughout the project and might occur at multiple intermediate stages of the project.

(b) **Demobilize**

This is a planned strategy for the reassignment or redistribution of project staff and resources. A demobilization/remobilization strategy is tied to the project schedule and evaluated and updated accordingly.

(c) **Archive**

The team addresses archiving as follows:

- Plan archiving at the beginning of the project.
- Plan the documentation for the permanent design file as required by other *Design Manual* chapters and consider also documenting selected MPD documents.
- Include archiving in the project schedule.
- Budget for archiving effort.
- Tailor archiving effort to project size and complexity to comply with legal requirements (including preparedness for Freedom of Information Act requests) and to provide an administrative record of the project.
- Archive throughout the project.
- Adhere to agency-wide archiving process and standards. Communicate guidelines to team through the closure plan.

(d) **Learn and Improve**

The purpose of this element is to build corporate knowledge and skills and minimize the need for those in the future to "reinvent the wheel." This evaluation element is valuable for sharing with others (including other WSDOT staff and potential future team members) what was learned on this project: "What went well, what didn't, and why." The areas of evaluation usually include:

- Staff evaluation and development.
- Comparison of initial objectives with results.
- Review of significant changes, reasons, and results.
- Effectiveness of the work plan.
- Budget assessment.
- Customer satisfaction.
- Comparison to measures of success as established in the work planning process.

(e) **Reward and Recognize**

Rewarding and recognizing team members and customers, as well as celebrating overall team success, are important steps and contribute toward the success of future project team endeavors.

140.06 Responsibilities

(1) Project Sponsor

The project sponsor provides the direction, authority, and resources for implementing Managing Project Delivery on projects. Typically, the project sponsor is a department executive, office manager, or organizational unit manager who assigns the project manager.

(2) Project Manager

The project manager follows the Managing Project Delivery process and applies specialized knowledge, skills, tools, and techniques to carry out the project sponsor's direction through project completion. A project manager has the following responsibilities:

(a) **To the project sponsor**

- Come to a mutual understanding of the project work plan (including scope, schedule, budget, and other primary elements of the project) to obtain the endorsement of the project sponsor.
- Communicate project progress using appropriate project status reports and meetings.
- Identify when project sponsor endorsement will be required throughout the project.
- During the project, communicate any significant changes in scope, schedule, budget, or customer satisfaction.
- Deliver the project in accordance with the endorsed work plan, including schedule and budget.

(b) **To the project customers**

- Understand customer needs and expectations (listen).
- Communicate progress to customers (keep them informed).
- Communicate change and provide options to gain endorsement of preferred choices.
- Deliver the project in accordance with the endorsed project work plan.
- Solicit and incorporate customer feedback in project closure.

(c) **To the project team members**

- Provide leadership and management.
- Be an advocate for the team.
- Obtain team endorsement on the project work plan, and major changes.
- Facilitate internal and external communication.
- Manage change in scope, schedule, and budget.
- Initiate ongoing team building.
- Mentor team members in project management.

(d) **To other project managers**

- Mentor each other by sharing experiences and knowledge.
- Encourage each other to achieve project management excellence.
- Share resources when appropriate.
- Coordinate project work plans.

(3) Project Manager and Team

The project manager and team apply the five steps of the Managing Project Delivery process to the project. See Figure 140-4.

140.07 Documentation

Is documentation of a project work plan required?

Preparation of a project work plan document is not mandatory. However, documentation of these elements is an effective means of attaining a common understanding among team members, the project sponsor, and customers. Such documentation can be in the form of a team charter or agreement or it can be a project work plan, including the team alignment elements. An additional benefit of such documentation is for ready communication to new team members and outside parties concerning what the team organization and work plan are for this specific project.

See 140.05(5)(c), Archive, regarding documenting to the permanent Design Documentation File.

Date Submitted: _________

Change Management Form

For:
- ❑ Unprogrammed Project
- ❑ Scope Change
- ❑ Cost Change
- ❑ Schedule Change

1. **Project Title:**

SR, Title, MP to MP

Location: Transportation Region:
Program Item No.: Legislative District:
Work Item No: Subprogram:
Project Summary Approved (or status):
Project Summary Cost Estimate: Confidence Factor:

2. **Project Description:**

3. **Summary of Change Proposal:**
- Description of Change (Reason, What, Why, How):
- Proposed program adjustments to accommodate unprogrammed project or cost/scope/schedule change:

5. **Project Status Summary ($ in 1000s):**

	CN Start Date	PE	RW	CN	01-03 Exp.	Total Cost
CIPP						
Last Approved						
Proposed						
Total Change						

New Confidence Factor: +/- %

6. **Approval Concurrence & Authority (See attached thresholds):**

	Initials	Date
❑ Project Engineer	____	________
❑ Region Project Development Engineer	____	________
❑ Region Program Manager / Region Administrator	____	________
❑ HQ ASDE	____	________
❑ Other: __________________________	____	________
❑ HQ Program Manager	____	________
❑ HQ Program Delivery Manager	____	________
❑ Director, Planning & Capital Program Management	____	________
❑ Department Project Screening Board	____	________

7. **Comments:**

8. **Approving Authority's Response:**
- ❑ Approved
- ❑ Approved with conditions (see comments)
- ❑ Needs additional evaluation or information (see comments)

9. **Approving Authority's Comments:**
10. **Approving Authority's Signature(s)**

Approval Date: ________________

==============================**(For publication:)**==================================

11. **Program delivery issues** that address the cause of the unprogrammed project or cost/scope change – the focus is to identify lessons learned

12. **Action plan outlining corrective actions implemented**/proposed to address the identified program delivery issues – the focus is to preclude recurrence of the same issues

Notification of Submitter on (Date): _______________

Change Management Form

Figure 140-6

WBS Code (use MDL)	Task Name	Task # (Optional)

Task Dependencies and Sequencing:

Predecessor Tasks – Identify as Finish-Start (FS), Start-Start (SS), Finish-Finish (FF)

Concurrent (parallel) Tasks

Successor Task– Identify as Finish - Start (FS), Start-Start (SS), Finish-Finish (FF)

Task Planning Worksheet
Figure 140-7a

Resource Considerations:

Resource Assignments (organization, individuals, equipment)

Resource Constraints (availability, experience level, training needed, etc.)

Estimates for Task Duration, Hours, & Cost:

	Pessimistic	**M**ost **L**ikely	**O**ptimistic
Calendar **Time** to Complete Task (start to finish)			
Staff **Hours** to Complete Task			
Cost to Complete Task			

PERT (Program Evaluation and Review Technique) Task Duration Estimate

$$\text{Expected Duration} = \frac{(O_D \times O_{WF}) + (M_D \times M_{WF}) + (P_D \times P_{WF})}{O_{WF} + M_{WF} + P_{WF}}$$

O_D = Optimistic Duration

O_{WF} = Optimistic Weighting Factor = 1

M_D = Most Likely Duration

M_{WF} = Most Likely Weighting Factor = 4

P_D = Pessimistic Duration

P_{WF} = Pessimistic Weighting Factor = 1

Task Planning Worksheet

Figure 140-7b

325.01 General

This highway *Design Manual* provides guidance for three levels of design for highway projects: the basic, modified, and full design levels. The design matrices in this chapter are used to identify the design level(s) for a project and the associated processes and approval authority for allowing design variances. The matrices address the majority of preservation and improvement projects and focus on those design elements that are of greatest concern in project development.

The design matrices are five tables that are identified by route type. Two of the matrices apply to Interstate highways. The other three matrices apply to preservation and improvement projects on non-Interstate highways.

325.02 Terminology

The **National Highway System (NHS)** consists of highways designated as a part of the Interstate System, other urban and rural principal arterials, and highways that provide motor vehicle access to facilities such as a major port, airport, public transportation facility, or other intermodal transportation facility. The NHS includes a highway network that is important to the United States strategic defense policy and provides defense access, continuity, and emergency capabilities for the movement of personnel, materials, and equipment during times of war and peace. It also includes major network connectors that provide motor vehicle access between major military installations and other highways that are part of the strategic highway network.

The **Preventive Maintenance** mentioned under project type on Interstate Design Matrices 1 and 2 includes roadway work such as pavement patching; restoration of drainage system; panel replacement; joint and shoulder repair; and bridge work such as crack sealing, joint repair, seismic retrofit, scour countermeasures and painting. Preventive maintenance projects must not degrade any existing safety or geometric aspects of the facility.

In Design Matrices 1 and 2 and in Figure 330-1, the term ***New/Reconstruction*** includes the following types of work:

- Capacity changes: add a through lane, convert a general purpose (GP) lane to a special purpose lane (such as an HOV lane), or convert a high occupancy vehicle (HOV) lane to GP.
- Other lane changes: add or eliminate a collector-distributor or auxiliary lane. (A rural truck climbing lane that, for its entire length, meets the warrants in Chapter 1010 is not considered new/reconstruction.)
- Pavement reconstruction: full depth PCC or AC pavement replacement.
- New interchange
- Changes in interchange type such as diamond to directional
- New or replacement bridge (main line)

The **HAL, HAC, PAL, and Risk location** mentioned in the notes on Design Matrices 3, 4, and 5 are high accident locations (HAL), high accident corridors (HAC), pedestrian accident locations (PAL), and locations that have a high probability of run-off-the-road accidents based on existing geometrics (Risk).

The **Non-Interstate Freeway** mentioned on Design Matrices 3, 4, and 5 is a multilane, divided highway with full access control.

The **Master Plan for Access Control** mentioned in the notes on Design Matrices 3, 4, and 5 is available from the Headquarters, Design Office, Access and Hearings Unit.

The **corridor or project analysis** mentioned in notes 2 and 4 (on Design Matrices 3, 4, and 5) is the justification needed to support a change in design level from the indicated level. The analysis can be based on route continuity, and other existing features, as well as the recommendations for future improvements in an approved Route Development Plan. See Chapter 330 for a sample project analysis.

(1) Project Types

Diamond Grinding is grinding a concrete pavement to remove surface wear or joint faulting.

Milling with AC Inlays is removal of a specified thickness of asphalt surfacing, typically from the traveled lanes, and then overlaying with asphalt concrete at the same specified thickness.

Nonstructural Overlay is an asphalt concrete pavement overlay that is placed to minimize the aging effects and minor surface irregularities of the existing asphalt concrete pavement structure. The existing pavement structure is not showing extensive signs of fatigue (longitudinal or alligator cracking in the wheel paths). Nonstructural overlays are typically less than 0.13 ft thick.

AC Structural Overlay is an asphalt concrete pavement overlay that is placed to increase the load carrying ability of the pavement structure. Structural overlay thickness is greater than or equal to 0.13 ft.

PCC Overlay is a Portland cement concrete pavement overlay of an existing PCC or AC pavement.

Dowel Bar Retrofit is re-establishing the load transfer efficiencies of the existing concrete joints and transverse cracks by the cutting of slots, placement of epoxy coated dowel bars, and placement of high-early strength, non-shrink concrete.

Bridge Deck Rehabilitation is repair of any delaminated concrete bridge deck and adding a protective overlay that will prevent further corrosion of the reinforcing steel.

Safety, All Others includes collision reduction, collision prevention, channelization, and signalization projects.

Safety, At Grade is a project on a multilane highway to build grade separation facilities that replace the existing intersection.

Bridge Restriction projects are listed under economic development because these bridges do not have any structural problems. However, if the vertical or load capacity restrictions are removed, then it will benefit the movement of commerce.

(2) Design Elements

The following elements are shown on the Design Matrices. If the full design level applies, see the chapters listed below. If basic design level applies, see Chapter 410. If the modified design level applies, see Chapter 430.

Horizontal Alignment is the horizontal attributes of the roadway including horizontal curvature, superelevation, and stopping sight distance; all based on design speed. (See Chapter 620 for horizontal alignment, Chapter 640 for superelevation, Chapter 650 for stopping sight distance, and Chapter 440 for design speed.)

Vertical Alignment is the vertical attributes of the roadway including vertical curvature, profile grades, and stopping sight distance; all based on design speed. (See Chapter 630 for vertical alignment, Chapters 440 and 630 for grades, Chapter 650 for stopping sight distance, and Chapter 440 for design speed.)

Lane Width is the distance between lane lines. (See Chapter 640.)

Shoulder Width is the distance between the outside or inside edge line and the edge of in-slope, or face of barrier. (See Chapter 640.)

Lane Transition (pavement transitions) are the rate and length of transition of changes in width of roadway surface. (See Chapters 440 and 620.)

Median Width is the distance between inside edge lines. (See Chapters 440 and 640.)

Cross Slope, Lane is the rate of elevation change across a lane. This element includes the algebraic difference in cross slope between adjacent lanes. (See Chapter 640.)

Cross Slope, Shoulder is the rate of elevation change across a shoulder. (See Chapter 640.)

On/Off Connection is the widened portion of the main line beyond the ramp terminal. (See Chapter 940.)

⇩ Project Type																Bridges			Barriers		
Design Elements ⇨	Horiz. Align.	Vert. Align.	Lane Width	Shldr Width (13)	On/Off Conn't.	Median Width	Cross Slope Lane	Cross Slope Shldr	Fill/Ditch Slopes	Clear Zone	Sign. (10)	Delini. (9)	Illumin.	Vert. Clear. (11)	Bike & Ped.	Lane Width	Shldr Width	Structural Capacity	Term. & Trans. Section (12)	Std Run	Bridge Rail (14)
(1-1) Preventive Maintenance																					
Pavement Restoration																					
(1-2) Diamond Grinding										EU	EU	F		DE					F	EU	F
(1-3) Milling with ACP Inlays									EU	F	EU	F		DE					F	EU	F
(1-4) Nonstructural Overlay				DE			EU	EU	EU	F	EU	F		EU					F	F	F
Pavement Rehab./Resurf.																					
(1-5) ACP Structural Overlays	EU	DE	F	F	F(17)	DE	F	EU	F	F	EU	F	F	F		F	DE		F	F	F
(1-6) PCCP Overlays	EU	DE	F	F	F(17)	DE	F	EU	F	F	EU	F	F	F		F	DE		F	F	F
(1-7) Dowel Bar Retrofit	EU	DE	F	F	F(17)	DE	DE		F	F	EU	F	F	DE			DE		F	F	F
Bridge Rehabilitation																					
(1-8) Bridge Deck Rehabilitation												F		F		F	DE	(11)	F (6)		F
Reconstruction (16)																					
(1-9) New/Reconstruction	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F

☐ Not Applicable
F Full design level
M Modified design level. See Chapter 430.
DE Design Exception to full design level.
EU Evaluate Upgrade to full design level.

(6) Applies only to bridge end terminals and transition sections.
(9) Continuous shoulder rumble strips required in rural areas. See Chapter 700.
(10) See Chapter 820.
(11) See Chapter 1120.
(12) Impact attenuators are considered as terminals.
(13) See Chapter 440 and 640.
(14) Includes crossroad bridge rail.
(16) For design elements not in the matrix headings, apply full design level as found in the applicable chapters.
(17) DE for existing acceleration/deceleration lanes when length meets posted freeway speed and no significant accidents. See Chapter 940.

English Version

Design Matrix 1
Interstate Routes (Main Line)
Figure 325-4

⇩ Project Type	Ramps and Collector Distributors																				Cross Road										
															Ramp Terminals			Barriers											Barriers		
Design Elements ⇨	Horiz. Align.	Vert. Align.	Lane Width	Shldr Width	Lane Tran-sition	On/Off Conn't.	Cross Slope Lane	Cross Slope Shldr	Fill/ Ditch Slopes	Limited Access	Clear Zone	Vertical Clear. (11)	Sign., Del., Illumin.	Bike & Ped.	Turn Radii	Angle	I/S Sight Dist.	Term. & Trans. Section (12)	Std Run	Bridge Rail	Lane Width	Shldr Width	Vert. Clear.	Ped. & Bike	Limited Access	Fill/ Ditch Slopes	Clear Zone	Sign., Del., Illumin.	Term. & Trans. Section (12)	Std . Run	Bridge Rail
(2-1) Preventive Maintenance																															
Pavement Restoration																															
(2-2) Diamond Grinding											EU		F (15)					F	EU	F							EU	F (15)	F	EU	F
(2-3) Milling with ACP Inlays									EU		F	F	F (15)					F	F	F						EU	F	F (15)	F	F	F
(2-4) Nonstructural Overlay							EU	EU	EU		F	F	F (15)					F	F	F						EU	F	F (15)	F	F	F
Pavement Rehab./Resurf.																															
(2-5) ACP Structural Overlays	EU	DE	F	F	F	F(17)	F	EU	F	F	F	F	F (15)		F	F	F	F	F	F	DE	DE	F	DE	F	DE	F	F (15)	F	F	F
(2-6) PCCP Overlays	EU	DE	F	F	F	F(17)	F	EU	F	F	F	F	F (15)		F	F	F	F	F	F	DE	DE	F	DE	F	DE	F	F (15)	F	F	F
(2-7) Dowel Bar Retrofit	DE		DE	DE	F	F(17)	DE		F	F	F	DE	F (15)		F	F	F	F	F	F					F			F (15)	F	F	F
Bridge Rehabilitation																															
(2-8) Bridge Deck Rehabilitation												F						F (6)		F			F						F (6)		F
Reconstruction (16)																															
(2-9) New/Reconstruction	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F

☐ Not Applicable
F Full design level
M Modified design level. See Chapter 430.
DE Design Exception to full design level.
EU Evaluate Upgrade to full design level.

(6) Applies only to bridge end terminals and transition sections.
(10) See Chapter 820.
(11) See Chapter 1120.
(12) Impact attenuators are considered as terminals.
(15) EU for signing and illumination.
(16) For design elements not in the matrix headings, apply full design level as found in the applicable chapters.
(17) DE for existing acceleration/deceleration lanes when length meets posted freeway speed and no significant accidents. See Chapter 940.

English Version

Design Matrix 2
Interstate Interchange Areas
Figure 325-5

⇩ Project Type																BRIDGES				INTERSECTIONS			BARRIERS		
Design Elements ⇨	Horiz. Align.	Vert. Align.	Lane Width	Shldr Width	Lane Tran-sition	Median Width	Cross Slope Lane	Cross Slope Shldr	On/Off Conn.	Fill/ Ditch Slopes	Access (3)	Clear Zone	Sign., Del., Illumin.	Basic Safety	Bike & Ped.	Lane Width	Shldr Width	Vertical Clear-ance	Structural Capacity	Turn Radii	Angle	Sight Dist.	Term. & Trans. Section (12)	Std Run	Bridge Rail
Preservation																									
Roadway																									
(3-1) Non-Interstate Freeway	DE/F	DE/F	DE/F	DE/F	DE/F	DE/F	DE/F	DE/F	DE/F	DE/F	DE/F		B	B		DE/F	DE/F	F					B	B	F
(3-2) ACP/PCCP/BST Overlays	DE/M	DE/M	DE/M	DE/M	DE/F	DE/M	DE/M	DE/M	DE/F	DE/M			B	B		DE/M	DE/M	F				B	B	B	F
(3-3) Repl. ACP w/ PCCP at I/S	DE/M	DE/M	EU/M	EU/M	DE/F	DE/M	EU/M	DE/M		DE/M			B	B		DE/M	DE/M	F				B	B	B	F
Structures																									
(3-4) Bridge Replacement	F (2)	F (2)	F (2)	F (2)	F	F (2)	F (2)	F (2)	F (2)	F (2)		F	F		F	F (2)	F (2)	F	F (11)	F (2)	F (2)	F	F	F	F
(3-5) Bridge Deck Rehab.													B	B				F					B (6)		F
Improvements (16)																									
Mobility																									
(3-6) Non-Interstate Freeway	F	F	F	F	F	F	F	F	F	F	F	F	F		F	F	F	F	F (11)	F	F	F	F	F	F
(3-7) Urban	F (2)	F (2)	F (2)	F (2)	F	F (2)	F (2)	F (2)	F (2)	F (2)	F	F	F		F	F (2)	F (2)	F	F (11)	F (2)	F (2)	F	F	F	F
(3-8) Rural	F (2)	F (2)	F (2)	F (2)	F	F (2)	F (2)	F (2)	F (2)	F (2)	F	F	F		F	F (2)	F (2)	F	F (11)	F (2)	F (2)	F	F	F	F
(3-9) HOV	F (2)	F (2)	F (2)	F (2)	F	F (2)	F (2)	F (2)	F (2)	F (2)	F	F	F		F	F (2)	F (2)	F	F (11)	F (2)	F (2)	F	F	F	F
(3-10) Bike/Ped. Connectivity	(5)	(5)	(5)	(5)	(5)		(5)	(5)		(5)	(5)	(5)	(5)		F	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)
Safety																									
(3-11) Non-Interstate Freeway	F	F	F	F	F	F	F	F	F	F	F	F	F		F	F	F	F		F	F	F	F	F	F
(3-12) All Others (1)	M (4)	M (4)	M (4)	M (4)	F	M (4)	M (4)	M (4)	M (4)	M (4)	EU/F	F	F		F	M (4)	M (4)	F		M (4)	M (4)	F	F	F	F
Economic Development																									
(3-13) Freight & Goods (Frost Free) (8)	F (2)	F (2)	F (2)	F (2)	F	F (2)	F (2)	F (2)	F (2)	F (2)	EU/F	F	B		EU	DE/F	DE/F	F	F (11)	EU/F	EU/F	EU/F	F	F	F
(3-14) 4-Lane Trunk System	F	F	F	F	F	F	F	F	F	F	F	F	F		F	F	F	F	F (11)	F	F	F	F	F	F
(3-15) Rest Areas (New)	F	F	F	F	F	F	F	F	F	F	F	F	F		F	F	F	F	F (11)	F	F	F	F	F	F
(3-16) Bridge Restrictions	F (2)	F (2)	F (2)	F (2)	F	F (2)	F (2)	F (2)	F (2)	F (2)		F	F		EU	F (2)	F (2)	F	F (11)	F (2)	F (2)	F	F	F	F
(3-17) Bike Routes (Shldrs)			EU/M	(7)	EU/F			EU/M		EU/M			B	B	F	EU/M	EU/M	F				B	F	B	EU/F

☐ Not Applicable
F Full design level
M Modified design level. See Chapter 430.
B Basic design level. See Chapter 410.
DE Design Exception
EU Evaluate Upgrade

(1) Collision Reduction (HAL, HAC, PAL), or Collision Prevention (Risk, At Grade Removal, Signalization & Channelization). Specific deficiencies that created the project must be upgraded to design level as stated in the matrix.
(2) Modified design level may apply based on a corridor or project analysis. See 325.02.
(3) If designated in Limited Access Master Plan apply limited access standards, if not access management standards apply. See Chapter 920.
(4) Full design level may apply based on a corridor or project analysis. See 325.02.
(5) For bike/pedestrian design see Chapters 1020 and 1025.
(6) Applies only to bridge end terminal and transition sections.
(7) 4 ft minimum shoulders.
(8) If all weather structure can be achieved with spot digouts and overlay, Modified Design Level Applies.
(11) See Chapter 1120.
(12) Impact attenuators are considered as terminals.
(16) For design elements not in the matrix headings, apply full design level as found in the applicablechapters.

English Version

Design Matrix 3
NHS Routes (Main Line)
Figure 325-6

Ramps and Collector Distributors

⇩ Project Type / Design Elements ⇨	Horiz. Align.	Vert. Align.	Lane Width	Shldr Width	Lane Tran-sition	On/Off Conn.	Cross Slope Lane	Cross Slope Shldr	Fill/ Ditch Slopes	Access (3)	Clear Zone	Sign, Del., Illumin.	Basic Safety	Bike & Ped.	Ramp Terminals: Turn Radii	Ramp Terminals: Angle	Ramp Terminals: I/S Sight Dist.	Barriers: Term. & Trans. Section (12)	Barriers: Std Run	Barriers: Bridge Rail
Preservation																				
Roadway																				
(4-1) Non-Interstate Freeway	DE/F	DE/F	DE/F	DE/F	DE/F	DE/F	DE/F	DE/F	DE/F	DE/F		B	B		DE/F	DE/F	DE/F	B	B	F
(4-2) ACP/PCCP/BST Overlays Ramps												B	B				B	B	B	F
Structures																				
(4-3) Bridge Replacement	F (2)	F (2)	F (2)	F (2)	F	F (2)	F (2)	F (2)	F (2)	F	F	F		F	F	F	F	F	F	F
(4-4) Bridge Deck Rehab												B	B					B (6)		F
Improvements (16)																				
Mobility																				
(4-5) Non-Interstate Freeway	F	F	F	F	F	F	F	F	F	F	F	F		F	F	F	F	F	F	F
(4-6) Urban	F (2)	F (2)	F (2)	F (2)	F	F (2)	F (2)	F (2)	F (2)	F	F	F		F	F (2)	F (2)	F	F	F	F
(4-7) Rural	F (2)	F (2)	F (2)	F (2)	F	F (2)	F (2)	F (2)	F (2)	F	F	F		F	F (2)	F (2)	F	F	F	F
(4-8) HOV By Pass	F (2)	F (2)	F (2)	F (2)	F	F (2)	F (2)	F (2)	F (2)	F	F	F		F	F (2)	F (2)	F	F	F	F
(4-9) Bike/Ped. Connectivity	(5)	(5)	(5)	(5)	(5)		(5)	(5)	(5)	(5)	(5)	(5)		F	(5)	(5)	(5)	(5)	(5)	(5)
Safety																				
(4-10) Non-Interstate Freeway	F	F	F	F	F	F	F	F	F	F	F	F			F	F	F	F	F	F
(4-11) At Grade (1)	F (2)	F (2)	F (2)	F (2)	F	F (2)	F (2)	F (2)	F (2)	F	F	F		F	F (2)	F (2)	F	F	F	F
(4-12) All Others (1)	M (4)	M (4)	M (4)	M (4)	F	M (4)	M (4)	M (4)	M (4)	EU/F	F	F			M (4)	M (4)	F	F	F	F
Economic Development																				
(4-13) Four-Lane Trunk System	F	F	F	F	F	F	F	F	F	F	F	F		F	F	F	F	F	F	F

Cross Road

⇩ Project Type / Design Elements ⇨	Lane Width	Shldr Width	Vert. Clear.	Ped. & Bike	Access (3)	Sign., Del., Illumin.	Fill/ Ditch Slopes	Clear Zone	Basic Safety	Barriers: Term. & Trans. Section (12)	Barriers: Std . Run	Barriers: Bridge Rail
Preservation												
Roadway												
(4-1) Non-Interstate Freeway	DE/F	DE/F	F			B	DE/F		B	B	B	F
(4-2) ACP/PCCP/BST Overlays Ramps			F			B			B	B	B	F
Structures												
(4-3) Bridge Replacement	F (2)	F (2)	F	F	F	F	F (2)	F		F	F	F
(4-4) Bridge Deck Rehab			F			B			B	B (6)		F
Improvements (16)												
Mobility												
(4-5) Non-Interstate Freeway	F	F	F	F	F	F	F	F		F	F	F
(4-6) Urban	F (2)	F (2)	F	F	F	F	F (2)	F		F	F	F
(4-7) Rural	F (2)	F (2)	F	F	F	F	F (2)	F		F	F	F
(4-8) HOV By Pass	F (2)	F (2)	F	F	F	F	F (2)	F		F	F	F
(4-9) Bike/Ped. Connectivity	(5)	(5)	(5)	F		(5)	(5)			(5)	(5)	(5)
Safety												
(4-10) Non-Interstate Freeway	F	F	F		F	F	F	F		F	F	F
(4-11) At Grade (1)	F (2)	F (2)	F	F	F	F	F (2)	F		F	F	F
(4-12) All Others (1)	F (2)	F (2)	F		EU/F	F	M (4)	F		F	F	F
Economic Development												
(4-13) Four-Lane Trunk System	F	F	F		F	F	F	F		F	F	F

☐ Not Applicable
F Full design level
M Modified design level. See Chapter 430.
B Basic design level. See Chapter 410.
DE Design Exception
EU Evaluate Upgrade

(1) Collision Reduction (HAL, HAC, PAL), or Collision Prevention (Risk, Signalization & Channelization). Specific deficiencies that created the project must be upgraded to design level as stated in matrix.
(2) Modified design level may apply based on a corridor or project analysis. See 325.02.
(3) If designated in limited access master plan apply limited access standards, if not access management standards apply. See Chapter 920.
(4) Full design level may apply based on a corridor or project analysis. See 325.02.
(5) For bike/pedestrian design see Chapters 1020 and 1025.
(6) Applies only to bridge end terminals and transition sections.
(7) 4 ft minimum shoulders.
(12) Impact attenuators are considered as terminals.
(16) For design elements not in the matrix headings, apply full design level as found in the applicablechapters.

English Version

Design Matrix 4
Non-Interstate Interchange Areas
Figure 325-7

⇩ Project Type															Bridges				Intersections			Barriers		
Design Elements ⇨	Horiz. Align.	Vert. Align.	Lane Width	Shldr Width	Lane Tran-sition	Median Width	Cross Slope Lane	Cross Slope Shldr	Fill/ Ditch Slopes	Access (3)	Clear Zone	Sign, Del., Illumin.	Basic Safety	Bike & Ped.	Lane Width	Shldr Width	Vertical Clear.	Structural Capacity	Turn Radii	Angle	Sight Dist.	Term. & Trans. Section (12)	Std Run	Bridge Rail
Preservation																								
Roadway																								
(5-1) ACP/PCCP												B	B				F				B	B	B	F
(5-2) BST																								
(5-3) BST Routes/Basic Safety												B	B								B	B	B	F
(5-4) Replace ACP with PCCP at I/S			EU/M	EU/M		EU/M	EU/M					B	B				F					B	B	F
Structures																								
(5-5) Bridge Replacement	M	F	M	M	F		M	M	M		F	F		F	F (2)	F (2)	F	F (11)	M	M	F	F	F	F
(5-6) Bridge Repl. (Multi-Lane)	F (2)	F (2)	F (2)	F (2)	F	F (2)	F (2)	F (2)	F (2)		F	F		F	F (2)	F (2)	F	F (11)	F (2)	F (2)	F	F	F	F
(5-7) Bridge Deck Rehab												B	B									B (6)	F	F
Improvements (16)																								
Mobility																								
(5-8) Urban (Multilane)	F (2)	F (2)	F (2)	F (2)	F	F (2)	F (2)	F (2)	F (2)	F	F	F		F	F (2)	F (2)	F	F (11)	EU/F	EU/F	F	F	F	F
(5-9) Urban	M	M	M	M	F		M	M	M	F	F	F		F	M	M	F	F (11)	EU/M	EU/M	F	F	F	F
(5-10) Rural	M	M	M	M	F	M	M	M	M	F	F	F		F	M	M	F	F (11)	EU/M	EU/M	F	F	F	F
(5-11) HOV	M	M	M	M	F	M	M	M	M	F	F	F		F	M	M	F	F (11)	EU/M	EU/M	F	F	F	F
(5-12) Bike/Ped. Connectivity	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)		F	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)
Safety																								
(5-13) Non-Interstate Freeway	F (2)	F (2)	F (2)	F (2)	F (2)	F (2)	F (2)	F (2)	F (2)	F	F	F		F	F (2)	F (2)	F		F (2)	F (2)	F	F	F	F
(5-14) All Others (1)	EU/M	EU/M	EU/M	EU/M	EU/F	EU/M	EU/M	EU/M	EU/M	EU/F	F	EU/F		EU	EU/M	EU/M	EU/F		EU/M	EU/M	EU/F	F	F	EU/F
Economic Development																								
(5-15) Freight & Goods (Frost Free) (8)	EU/M	EU/M	EU/M	EU/M	EU/F	EU/M	M	M	EU/M		F	B	B	EU	EU/M	EU/M	F		EU/M	EU/M	EU/F	F	B	F
(5-16) Rest Areas (New)	F	F	F	F	F	F	F	F	F	F	F	F		F	F	F			F	F	F	F	F	F
(5-17) Bridge Restrictions	M	F	M	M	F	M	M	M	M		F	F		EU	M	M	F	F (11)	M	M	F	F	F	F
(5-18) Bike Routes (Shldrs)			EU/M	(7)	EU/F			EU/M	EU/M			B	B	F	EU/M	EU/M					B	F	B	EU/F

☐ Not Applicable
F Full design level
M Modified design level. See Chapter 430.
B Basic design level. See Chapter 410.
EU Evaluate Upgrade

(1) Collision Reduction (HAL, HAC, PAL), or Collision Prevention (Risk, Signalization & Channelization). Specific deficiencies that created the project must be upgraded to design level as stated in matrix.
(2) Modified design level may apply based on a corridor or project analysis. See 325.02.
(3) If designated in Limited Access Master Plan, apply limited access standards. If not, access management standards apply. See Chapter 920.
(5) For bike/pedestrian design see Chapters 1020 and 1025.
(6) Applies only to bridge ends terminal and transition sections.
(7) 4 ft minimum shoulders.
(8) If all weather structure can be achieved with spot digouts and overlay, basic design level applies.
(11) See Chapter 1120.
(12) Impact attenuators are considered as terminals.
(16) For design elements not in the matrix headings, apply full design level as found in the applicablechapters.

English Version

Design Matrix 5
Non-NHS Routes
Figure 325-8

340 Minor Operational Enhancement Projects

340.01 General

This chapter complements Chapter 325 by providing guidance for development of minor operational enhancement projects. Refer to Chapter 325 for guidance in development of preservation and improvement projects. The minor operational enhancement matrices contained in this chapter identify the design level(s) for a project, the associated approval level, and the documentation requirements for the various project elements. These matrices address the most common minor operational enhancement projects and focus on the elements of greatest concern during project development.

Minor enhancement projects are often categorized as low-cost, quick-fixes to improve the operation of the highway system. These enhancements are most often installed by state forces through work orders, but may be accomplished through: a change order to an existing state contract, agreements with local agencies, a Q Program funded bid item within a larger improvement project, or a stand-alone state contract funded entirely through the Q Program. An important characteristic of these projects is the ability to quickly develop and implement them without a cumbersome approval process. Balanced with that is a need to apply consistency in design policies and guidelines in the development and approval processes. Therefore, the intent of this chapter is to clarify the design guidelines and documentation requirements for minor operational enhancement projects without unduly impeding the process.

The objective of the Q Program is to maximize highway transportation system safety and efficiency through a statewide program focused on the WSDOT business function for "Traffic Operations." It is the smallest of the four major highway programs that comprise the Highway System Plan (i.e. Improvement, Maintenance, Preservation, and Traffic Operations). Elements within the Q Program include: Q1 - Management Support, Q2 - Operations and Low Cost Enhancements, and Q3 - Special Advanced Technology Projects. Large capital improvement projects developed for the Q3 subprogram are beyond the scope of this chapter. Normally, these projects are developed using *Design Manual* guidelines for Preservation and Improvement Program projects. Consult the <u>Headquarters</u> Traffic Office for guidance when designing Q3 subprogram projects.

The minor operational enhancement matrices consisting of three tables are identified by route type. One of the matrices applies to Interstate and NHS freeways, one applies to NHS Nonfreeway routes, and the third matrix applies to Non-NHS routes.

340.02 References

Revised Code of Washington (RCW) 47.28.030, Contracts —State forces —Monetary limits — Small businesses, minority, and women contractors —Rules.
<u>*Chart of Accounts*, M 13-02, WSDOT</u>

340.03 Definitions

The **National Highway System (NHS)** routes are identified in Chapter 325.

The term **freeway** applies to multilane, divided highways with full access control.

The **minor operational enhancement projects** usually originate from the Q2 component of the Q Program and are quick responses to implement low cost improvements.

Projects are typically narrow in scope, and focus on improvements to traffic operations, and modifications to traffic control devices. Guidance on the type of work included in the Q subprograms is in the *Chart of Accounts* (M 13-02).

(1) Project Types

Regulatory projects include actions undertaken to manage or regulate traffic conflict, movements, and use of the roadway. Potential project types in this category include revisions to speed limits, parking restrictions, turn restrictions, truck restrictions, signal operations, unsignalized intersection control, intersection lane use control, ramp meters, no passing zones, crosswalks, special traffic control schemes, and lane use restrictions.

Driver guidance projects are actions to improve driver guidance, clarify options, or reduce hazard in the roadway setting. Potential project types include revisions to, informational signs, warning signs, lighting and supplemental illumination, supplemental delineation, glare screen, signals, roadside guidance, and intelligent transportation systems (ITS).

Pavement widening projects are expansion of the roadway surface for vehicular use and may involve earthwork, drainage, and paving elements. Potential project types are:

- Turn lane — Addition of a new channelized turn bay at an intersection.
- Pullout — Pavement widening to provide auxiliary highway uses including transit stops, Washington State Patrol (WSP) enforcement pullouts, snow chain-up areas, and maintenance vehicle turnouts.
- Expansion — Widen at intersection corners, lengthen existing channelized turn bay, widening shoulders, and flattening approach taper. This type of work is not anticipated for main line sections on Interstate freeways.
- Median crossover — Restricted-use median crossover on separated highways for emergency or maintenance use.

Rechannelize existing pavement projects alter the use of the roadway without additional widening. These projects may add, delete, or modify channelization features, and may include reduction of existing shoulder or lane widths. Potential project types are:

- Pavement markings — Develop added storage, additional lanes, or altered lane alignment. This work may modify tapers or radii, modify painted islands, channelize bicycle lanes, or preferential-use lanes or shoulders.
- Raised channelization — New or altered raised curbing to channelization islands to enhance guidance, curtail violation or misuse, or introduce access control.

Nonmotorized facilities projects add adjacent roadside features for bicycle or pedestrian use. Potential project types are:

- Sidewalk — Installation of sidewalks, which might involve preserving existing shoulder, or converting some portion of existing shoulder for use as a new sidewalk.
- Walkway — Adds to the existing roadway's overall width to provide a wider walkable shoulder.
- Separated Trails — Class 1 separated bike lane or pedestrian paths on independent alignment or parallel to the highway.
- Spot Improvement — Installation of ADA sidewalk curb cuts, new pedestrian landings, sidewalk bulbs at intersections, or new or revised trailhead features.

Roadside projects are modifications to roadside features for safety purposes. Potential project types are:

- Cross section — Altering roadway cross sections to address clear zone hazard or sight distance concern such as slope flattening, recontour a ditch, closing a ditch with culvert, or removal of hazard.
- Protection — Installation of hazard protection for clear zone mitigation including guardrail, barrier, earth berm, and impact attenuator.
- New object — Placement of new hardware or fixed object within clear zone unable to meet breakaway criteria.

(2) Design Elements

The following elements are shown on the minor operational enhancement matrices. If full design level applies see the chapters listed below. If modified design level applies, see Chapter 430.

Sight Distance Refers to any combination of stopping sight distance, decision sight distance, passing sight distance, and intersection sight distance. See Chapters 650 and 910 for definitions and guidance.

Lane Width See Chapter 325 for definition.

Lane Transition See Chapter 325 for definition.

Shoulder Width See Chapter 325 for definition.

Fill/Ditch Slope See Chapter 325 for definition.

Clear Zone See Chapter 325 for definition.

Ramp Sight Distance Refers to any combination of stopping sight distance, decision sight distance, and intersection sight distance. See Chapters 650 and 910 for definitions and guidance.

Ramp Lane Width is the lane width for ramp alignments. See Lane Width definition.

Ramp Lane and Shoulder Taper is the lane and shoulder taper applied to a ramp alignment. See definition for Lane and Shoulder Taper. Also see Chapter 940.

Ramp Shoulder Width is the shoulder width for a ramp alignment. See Shoulder Width definition.

Ramp Fill/Ditch Slopes is the fill/ditch slope along a ramp alignment. See Fill/Ditch Slope definition in Chapter 325.

Ramp Clear Zone is the clear zone along a ramp alignment. See Clear Zone definition in Chapter 325.

Ramp Terminals or Intersections Turning Radii See Chapter 910 for definition.

Ramp Terminals or Intersections Angle See Chapter 910 for definition.

Ramp Terminals or Intersections Sight Distance See Chapter 910 for definition.

Pedestrian and Bike refers to the facilities along a route for accommodation of pedestrians and/or bicycles. See Chapter 1020 for bicycles and Chapter 1025 for pedestrians.

Crossroads at Ramps Lane Width is the lane width on a crossing alignment intersected by a ramp. See Lane Width definition.

Crossroads at Ramps Shoulder Width is the shoulder width on a crossing alignment intersected by a ramp. See Lane Width definition.

Crossroads at Ramps Pedestrian and Bike refers to the facilities on a crossing alignment intersected by a ramp, for accommodation of pedestrians and/or bicycles. See Pedestrian and Bike definition.

Crossroads at Ramps Fill/Ditch Slopes is the fill/ditch slope along a crossroad intersected by a ramp. See Fill/Ditch Slope definition.

Crossroads at Ramps Clear Zone is the clear zone along a crossroad intersected by a ramp. See Clear Zone definition.

Barriers Terminal and Transition Section See Chapter 325 for definition.

Barriers Standard Run See Chapter 325 for definition.

340.04 Minor Operational Enhancement Matrix Procedures

During project definition and design, the following steps are used to select and apply the appropriate minor operational enhancement matrix. Each step is further explained in this chapter.

- *Select a minor operational enhancement matrix* by identifying the route: Interstate/NHS Freeway, NHS nonfreeway, or non-NHS.
- Within the minor operational enhancement matrix, *select the row* by the type of work.
- Use the minor operational enhancement matrix to *determine the documentation and approval levels for the various design elements* in the project. Apply the appropriate design levels and document the design decisions as required by this chapter and Chapter 330.

340.05 Selecting a Minor Operational Enhancement Matrix

Selection of a minor operational enhancement matrix is based on highway system (Interstate/NHS Freeway, NHS nonfreeway, Non-NHS). (See Figure 340-1.) Figures 325-2a and 2b provide a list of the NHS and the Interstate routes in Washington. The minor operational enhancement matrices are shown in Figures 340-2 through 340-4. Follow *Design Manual* guidance for all projects except as noted in the minor operational enhancement matrices.

Route	Project	
	Freeway	**NonFreeway**
Interstate	Matrix 1	
NHS	Matrix 1	Matrix 2
Non-NHS	Matrix 1	Matrix 3

Minor Operational Enhancement Matrix Selection Guide
Figure 340-1

340.06 Project Type

Row selection in the design matrices is based on project type or type of work. See 340.03(1). For projects not listed in the matrices, consult the Headquarters Traffic Office and the Headquarters Design Office.

Some projects might include work from several project types. In such cases, identify the design and approval level for each project element. In all cases, select the higher design level and approval level where overlaps are found.

340.07 Using a Minor Operational Enhancement Matrix

The column headings on a minor operational enhancement matrix are design elements. They are based on the following thirteen FHWA controlling design criteria: design speed, lane width, shoulder width, bridge width, structural capacity, horizontal alignment, vertical alignment, grade, stopping sight distance, cross slope, superelevation, vertical clearance, and horizontal clearance. For the column headings, some of the controlling criteria are combined (for example design speed is part of horizontal and vertical alignment).

Unlike the design matrices described in Chapter 325, designers using a minor operational enhancement matrix are not required to inventory deficiencies for elements not improved by the minor enhancement project. Similarly, they are not required to justify existing deficiencies not addressed by minor enhancement projects. In the case where improvements to existing features surpass the existing condition but do not meet the design guidelines, only Basic Documentation plus Supplemental Coordination (BD+) is required. See 340.09(1).

A **blank cell** on a minor operational enhancement matrix signifies that the design element is beyond the scope of the project and need not be addressed.

For work on ramps on Interstate or NHS freeway routes, there is a requirement to provide assurance of no adverse effect to main line flow. Provide FHWA a copy of the documentation providing assurance or process a deviation through FHWA if there is an adverse effect.

(1) Design Level

The minor operational enhancement matrices specify the appropriate design level for the various project elements. The design levels specified are Full and Modified.

Full design level (F) improves roadway geometrics, safety, and operational elements. See Chapter 440 and other applicable chapters for design guidance. Use the current traffic volume with Chapter 440 to evaluate Design Classification for Q Program projects.

Modified design level (M) preserves and improves existing roadway geometrics, safety, and operational elements. See Chapter 430.

Design levels specified in a matrix cell are supplemented with notations for design variances.

(2) Design Variances

Design variances are information packages that justify the introduction of features that are not in accordance with design guidelines. Variances specified in minor operational enhancement project cells include: Design Justification, Level 2, Level 3, or Level 4. See 340.09 for detail on documentation requirements.

340.08 Project Approval

Project approval for minor operational enhancement projects authorizes expenditures for the project. The state and/or region Traffic Engineer have the responsibility and authority to authorize all expenditures for Q2 Low Cost Enhancements. Delegation of design and/or expenditure approval authority for Q Program funded projects must be identified in writing from the appropriate Traffic Engineer to the person receiving the delegated authority. Such written delegation must identify the specific conditions for which approval authority has been delegated. Design approval authority for PS&E contracts cannot be delegated.

Mechanisms for project expenditure approval vary with the types of projects and the costs involved.

- **Minor-cost projects** are projects normally implemented by state forces directed through maintenance task orders, within the monetary limits established in RCW 47.28.030. Expenditure authority is granted by initialing the work order.
- **Mid-range projects** include: all contract change orders, local agency agreements, or Q Program bid items included in an Improvement or Preservation project, regardless of cost. Maintenance task orders exceeding the monetary limits established in RCW 47.28.030 are included in this category. Expenditure authority is granted by initialing the task order, change order, or agreement memo.
- **PS&E contracts** are stand-alone contracts funded through the Q Program for minor operational enhancement projects. A Design Summary/Approval memorandum must be prepared and signed by the region's Traffic Engineer to approve a project in this category. Figures 340-5a and 340-5b provide a template for the approval memo.

Project development decisions and approvals for "Regulatory" and for "Driver Guidance" projects reside within region or Headquarters Traffic Offices. Projects impacting roadway geometric features in the "Pavement Widening," "Rechannelizing Existing Pavement," "Nonmotorized Facilities" or "Roadside" categories are developed jointly by the region's Traffic Office and the region's project Development Office. Depending on the route type, the approval authority may involve the Assistant State Design Engineer and the FHWA.

340.09 Documentation

The minor operational enhancement matrices include a column that specifies the documentation levels for each project type listed. The documentation levels are categorized as Basic Documentation (BD) and Basic Documentation plus Supplemental Coordination (BD+).

In all cases, the documentation must outline the rationale for the project and include backup information sufficient to support the design decisions. Document the roadway configuration prior to implementation of a minor operational enhancement project. Documentation is to be retained in a permanent retrievable file at a central location in each region.

(1) Projects

Basic Documentation (BD) level applies to regulatory or driver guidance projects. Documentation consists of an unstructured compilation of materials sufficient to validate the designer's decisions. Materials may include: meeting notes, printed e-mails, record of phone conversations, copies of memos, correspondence, and backup data such as level of service modeling, accident data, and design drawings. A single narrative outlining the decision-making process from start to finish is not required, provided that the materials retained in the file can be traced to a decision consistent with the project design. This level of documentation includes a requirement for inputting the project information into the TRaffic ACtion Tracking System (TRACTS) database at the conclusion of the project.

Basic Documentation plus Supplemental Coordination (BD+) level applies to all projects except regulatory or driver guidance projects. A more comprehensive evaluation of options and constraints is required for this documentation level. Documentation includes basic documentation with additional information describing coordination efforts with other WSDOT groups having a stake in the project. Document the coordination efforts with the following disciplines: The Public, Environmental, Hydraulics, Local Programs, Maintenance, Materials, Program Management, Real Estate Services, Urban Mobility, and Utilities. This level of documentation also includes a requirement for inputting the project information into the TRACTS database at the conclusion of the project.

(2) Design Deviations

Design Justification (DJ) is a written narrative summarizing the rationale for introduction of a feature that varies from the applicable *Design Manual* guidelines. Include in the narrative sufficient information to describe the problem, the constraints, and the trade-offs at a level of detail that provides a defendable professional judgment. DJs are not intended to have the same level of formality as the Level 2, 3, and 4 deviations. DJs may use written memos, e-mails, or documented discussions with the approving traffic authority. The region's Traffic Engineer has responsibility for approving Design Justifications. The DJ documentation must include the name and date of the approving authority. At the time the work order is approved, the region's Project Development Engineer and the Assistant State Design Engineer are to be sent informational copies of the Design Justification, to provide them an opportunity to communicate their concerns. Comment on the informational copy is not mandatory and progress toward project implementation does not wait on a response.

Level 2 documentation serves to justify a deviation to the specified design guidance. Within the document, summarize the project, the design guidelines, the proposed elements that vary from design guidelines, alternatives analyzed, constraints and impacts of each alternative, and the recommended alternative. Level 2 documentation requires joint approval of the region's Traffic Engineer and region's Project Development Engineer. At the time the work order is approved, the Assistant State Design engineer is to be sent an informational copy of the Level 2 documentation to provide an opportunity to communicate concerns. Comment on the informational copy is not mandatory, and progress toward project implementation does not wait on a response.

Level 3 documentation requirements include the level 2 requirements, however the approval process is through the region's Traffic Engineer, and region's Project Development Engineer with final approval from the Assistant State Design Engineer.

Level 4 documentation requirements include the level 3 requirements, however the approval process is through region's Traffic Engineer, region's Project Development Engineer, and the Assistant State Design Engineer with final approval from the Federal Highway Administration on Interstate routes.

Level 2, 3, and 4 design deviation requests are intended to be stand-alone documentation describing the project, design criteria, proposed element(s), why the desired standard was not or can not be used, alternatives evaluated, and a request for approval. Include funding source(s), type of route, project limits, design classification, posted speed, current ADT, and percent truck traffic in the project description. Justification for the design deviation can include project costs, but must be supported by at least two of the following:

- Accident history or potential.
- Engineering judgment.
- Environmental issues.
- Route continuity (consistency with adjoining route sections).
- The project is an interim solution (covering a 4 to 6 year time horizon).

⇩ Project Type	MAIN LINE						RAMPS *						RAMP TERMINALS OR INTERSECTIONS			CROSSROADS AT RAMPS					BARRIERS ALL		Doc. Level
Design Elements ⇨	Sight Dist.	Lane Width	Lane Tran-sition	Shldr Width	Fill/ Ditch Slopes	Clear Zone	Sight Dist.	Lane Width	Lane Trans-itions	Shldr Width	Fill/ Ditch Slopes	Clear Zone	Turn Radii	Angle	Sight Dist.	Lane Width	Shldr Width	Ped & Bike	Fill/ Ditch Slopes	Clear Zone	Term. & Trans. Section	** Std Run	
Regulatory - (Traffic Office Authority)																							**BD**
Driver Guidance - (Traffic Office Authority)																							**BD**
Pavement Widening																							
Turn Lane								F/DJ	F/DJ	F/DJ			M/DJ	M/DJ	F/DJ	M/DJ	M/DJ	F/DJ	M/DJ	F/DJ	F/3	F/3	BD+
Pullout							F/DJ	F/DJ	F/DJ	F/DJ	F/DJ	F/DJ	M/DJ		F/DJ	M/DJ	M/DJ	F/DJ	M/DJ	F/DJ	F/3	F/3	BD+
Expansion	F/3	F/4	F/3	F/4	F/3	F/3		F/DJ	F/DJ	F/DJ	F/DJ	F/DJ	M/DJ		F/DJ	M/DJ	M/DJ	F/DJ	M/DJ	F/DJ	F/3	F/3	BD+
Median Crossover	F/3	F/4	F/3	F/4	F/3	F/3															F/3	F/3	BD+
Rechannelize Existing Pavement																							
Pavement Markings	F/3	F/4	F/3	F/4		F/3	F/DJ	F/DJ	F/DJ	F/DJ		F/DJ	M/DJ	M/DJ	F/DJ	M/DJ	M/DJ	F/DJ		F/DJ	F/3	F/3	BD+
Raised Channelization							F/DJ	F/DJ	F/DJ	F/DJ		F/DJ	M/DJ	M/DJ	F/DJ	M/DJ	M/DJ	F/DJ		F/DJ	F/3	F/3	BD+
Nonmotorized Facilities																							
Sidewalk/Walkway													M/DJ	M/DJ	F/DJ	M/DJ	M/DJ	F/DJ	M/DJ	F/DJ	F/3	F/3	BD+
Separated Trails																		F/DJ			F/3	F/3	BD+
Spot Improvement													M/DJ	M/DJ	F/DJ	M/DJ	M/DJ	F/DJ		F/DJ			BD+
Roadside																							
Cross Section	F/3				F/3	F/3	F/DJ				F/DJ	F/DJ			F/DJ				M/DJ	F/DJ	F/3	F/3	BD+
Protection	F/3			F/4	F/3	F/3	F/DJ			F/DJ	F/DJ	F/DJ			F/DJ		M/DJ		M/DJ	F/DJ	F/3	F/3	BD+
New Object	F/3					F/3	F/DJ					F/DJ			F/DJ					F/DJ	F/3	F/3	BD+

☐ Not Applicable
F Full design level
M Modified design level. See Chapter 430.
DJ Design Justification required and Project Approval by region Traffic, with notification to Headquarters Design.
2 Deviation approval through the region Traffic and Project Development Engineer, with notification to Headquarters Design.
3 Deviation approval through level **2** and the Assistant State Design Engineer.
4 Deviation approval through level **3,** and FHWA on Interstate routes.
BD Basic Documentation required.
BD+ Basic Documentation plus supplemental coordination required.

If a project impacts any design element, the impacted elements are addressed. Elements not impacted, are not addressed.

For items not meeting the standard provided in the matrix, justification or deviation is required and is processed through the designated approval level, DJ, 2, 3, or 4

For at-grade intersections on NHS routes, apply Matrix 2.

* Documentation must provide assurance of no adverse effect to main line flow. Otherwise process a deviation through level 4

** If existing shoulder width is decreased below minimum values, when placing new guardrail or concrete barrier, a deviation request justifying the proposal is required.

Minor Operational Enhancement Matrix 1
Interstate & NHS Freeway Routes
Figure 340-2

⇩ Project Type	MAIN LINE						INTERSECTIONS				BARRIERS ALL		Doc. Level
Design Elements ⇨	Sight Dist.	Lane Width	Lane Tran-sition	Shldr Width	Fill/ Ditch Slopes	Clear Zone	Turn Radii	Angle	Sight Dist.	Ped & Bike	Term. & Trans. Section	** Std Run	
Regulatory - (Traffic Office Authority)													**BD**
Driver Guidance - (Traffic Office Authority)													**BD**
Pavement Widening													
Turn Lane	**M/2**	**M/3**	**F/2**	**M/3**	**M/2**	**F/2**	**M/DJ**	**M/DJ**	**F/DJ**	**F/DJ**	**F/3**	**F/3**	**BD+**
Pullout	**M/2**	**M/3**	**F/2**	**M/3**	**M/2**	**F/2**	**M/DJ**	**M/DJ**	**F/DJ**	**F/DJ**	**F/3**	**F/3**	**BD+**
Expansion	**M/2**	**M/3**	**F/2**	**M/3**	**M/2**	**F/2**	**M/DJ**	**M/DJ**	**F/DJ**	**F/DJ**	**F/3**	**F/3**	**BD+**
Rechannelize Existing Pavement													
Pavement Markings	**M/2**	**M/3**	**F/2**	**M/3**		**F/2**	**M/DJ**	**M/DJ**	**F/DJ**	**F/DJ**	**F/3**	**F/3**	**BD+**
Raised Channelization	**M/2**	**M/3**	**F/2**	**M/3**		**F/2**	**M/DJ**	**M/DJ**	**F/DJ**	**F/DJ**	**F/3**	**F/3**	**BD+**
Nonmotorized Facilities													
Sidewalk/Walkway	**M/2**	**M/3**	**F/2**	**M/3**	**M/2**	**F/2**	**M/DJ**	**M/DJ**	**F/DJ**	**F/DJ**	**F/3**	**F/3**	**BD+**
Separated Trails	**M/2**				**M/2**	**F/2**				**F/DJ**	**F/3**	**F/3**	**BD+**
Spot Improvement	**M/2**	**M/3**	**F/2**	**M/3**	**M/2**	**F/2**	**M/DJ**	**M/DJ**	**F/DJ**	**F/DJ**	**F/3**	**F/3**	**BD+**
Roadside													
Cross Section	**M/2**				**M/2**	**F/2**			**F/DJ**		**F/3**	**F/3**	**BD+**
Protection	**M/2**				**M/2**	**F/2**			**F/DJ**		**F/3**	**F/3**	**BD+**
New Object	**M/2**				**M/2**	**F/2**			**F/DJ**		**F/3**	**F/3**	**BD+**

☐ Not Applicable

F Full design level

M Modified design level. See Chapter 430.

DJ Design Justification required and Project Approval by region Traffic, with notification to Headquarters Design.

2 Deviation approval through the region Traffic and Project Development Engineer, with notification to Headquarters Design.

3 Deviation approval through level **2** and the Assistant State Design Engineer.

BD Basic Documentation required.

BD+ Basic Documentation plus supplemental coordination required.

If a project impacts any design element, the impacted elements are addressed. Elements not impacted, are not addressed.

For items not meeting the standard provided in the matrix, justification or deviation is required and is processed through the designated approval level, **DJ**, **2** or **3**

For interchange features, apply Matrix 1.

** If existing shoulder width is decreased below minimum values, when placing new guardrail or concrete barrier, a deviation request justifying the proposal is required.

Minor Operational Enhancement Matrix 2
NHS Nonfreeway Routes
Figure 340-3

⇩ Project Type / Design Elements ⇨	MAIN LINE						INTERSECTIONS				BARRIERS ALL		Doc. Level
	Sight Dist.	Lane Width	Lane Tran-sition	Shldr Width	Fill/ Ditch Slopes	Clear Zone	Turn Radii	Angle	Sight Dist.	Ped & Bike	Term. & Trans. Section	** Std Run	
Regulatory - (Traffic Office Authority)													**BD**
Driver Guidance - (Traffic Office Authority)													**BD**
Pavement Widening													
Turn Lane	**M/DJ**	**M/2**	**F/DJ**	**M/2**	**M/DJ**	**F/DJ**	**M/DJ**	**M/DJ**	**F/DJ**	**F/DJ**	**F/2**	**F/2**	**BD+**
Pullout	**M/DJ**	**M/2**	**F/DJ**	**M/2**	**M/DJ**	**F/DJ**	**M/DJ**	**M/DJ**	**F/DJ**	**F/DJ**	**F/2**	**F/2**	**BD+**
Expansion	**M/DJ**	**M/2**	**F/DJ**	**M/2**	**M/DJ**	**F/DJ**	**M/DJ**	**M/DJ**	**F/DJ**	**F/DJ**	**F/2**	**F/2**	**BD+**
Rechannelize Existing Pavement													
Pavement Markings	**M/DJ**	**M/2**	**F/DJ**	**M/2**		**F/DJ**	**M/DJ**	**M/DJ**	**F/DJ**	**F/DJ**	**F/2**	**F/2**	**BD+**
Raised Channelization	**M/DJ**	**M/2**	**F/DJ**	**M/2**		**F/DJ**	**M/DJ**	**M/DJ**	**F/DJ**	**F/DJ**	**F/2**	**F/2**	**BD+**
Nonmotorized Facilities													
Sidewalk/Walkway	**M/DJ**	**M/2**	**F/DJ**	**M/2**	**M/DJ**	**F/DJ**	**M/DJ**	**M/DJ**	**F/DJ**	**F/DJ**	**F/2**	**F/2**	**BD+**
Separated Trails	**M/DJ**				**M/DJ**	**F/DJ**				**F/DJ**	**F/2**	**F/2**	**BD+**
Spot Improvement	**M/DJ**	**M/2**	**F/DJ**	**M/2**	**M/DJ**	**F/DJ**	**M/DJ**	**M/DJ**	**F/DJ**	**F/DJ**	**F/2**	**F/2**	**BD+**
Roadside													
Cross Section	**M/DJ**				**M/DJ**	**F/DJ**			**F/DJ**		**F/2**	**F/2**	**BD+**
Protection	**M/DJ**				**M/DJ**	**F/DJ**			**F/DJ**		**F/2**	**F/2**	**BD+**
New Object	**M/DJ**				**M/DJ**	**F/DJ**			**F/DJ**		**F/2**	**F/2**	**BD+**

☐ Not Applicable
F Full design level
M Modified design level. See Chapter 430.
DJ Design Justification required and Project Approval by region Traffic, with notification to Headquarters Design.
2 Deviation approval through the region Traffic and Project Development Engineer, with notification to Headquarters Design.
3 Deviation approval through level **2** and the Assistant State Design Engineer.
BD Basic Documentation required.
BD+ Basic Documentation plus supplemental coordination required.

If a project impacts any design element, the impacted elements are addressed. Elements not impacted, are not addressed.

For items not meeting the standard provided in the matrix, justification or deviation is required and is processed through the designated approval level, DJ, 2 or 3

For interchange features, apply Matrix 1.

** If existing shoulder width is decreased below minimum values, when placing new guardrail or concrete barrier, a deviation request justifying the proposal is required.

Minor Operational Enhancement Matrix 3
Non-NHS Routes
Figure 340-4

DatePlaceholder

TO: Region Traffic Engineer

THRU:

FROM:

SUBJECT:

Design Approved By:

____

Region Traffic Engineer

____

Date

General Information

SR__________ is a *(NHS or Non-NHS*) route, and classified as a *(Urban or Rural) (Interstate, Principle Arterial, Minor Arterial, or Collector)* in _________ County. The posted speed limit is mph. The ADT is, __________ with _________ percent trucks. The project is within a *(full, partial, or modified limited access control, or Class 1 - 5 managed access controlled)* area.

Project Initiation

How did the project get started? Accident history, constituent call, or letter?

Existing Geometrics

What is out there today? Lane, shoulder, sidewalk widths? Turn pockets, etc.?

Project Description

How did you come to the design decision being proposed? What does it resolve for the situation at hand? What options have you looked at? Why were other options not selected?

Proposed Geometrics

What will be out there when you are through? Lane, shoulder, sidewalk widths? Turn pockets, etc.?

Q Project Design Summary/Approval Template

Figure 340-5a

Resurfacing

If pavement is involved what does the resurfacing report say to use?

Pavement Marking/Traffic Control Devices

What happens with the pavement markings? Signing? Illumination? Signals? Etc.?

Environmental Approval

Did you check with the Environmental Affairs Office? Are there any issues or permits that need to be addressed? Hydraulics?

Deviations

Are there any deviations? Describe briefly what features are deviated and the date of approval.

Permits

Are there any permits or easements needed? Construction permits? Noise variances? Utility relocations? Detours? Others?

Project Cost and Schedule

How much do you anticipate spending? When is the project scheduled for advertisement? When do you anticipate the project will be completed?

Sole Source Justification

Some traffic items are sole source and require justification. Have you completed the process?

Work Zone Traffic Control

What happens to traffic, pedestrians, and bicyclists during construction? Is a lane taken or reduced in width? Night work? Shoulder work? Duration? Does Washington State Patrol (WSP) need to be involved?

Local Agency Coordination

Do we need to coordinate with, or notify the city or county? WSP?

We are requesting approval for the Subject project. This project was designed in accordance with Q Program guidelines for Minor Operational Enhancements, Matrix ________ *note matrix title and project type line.*

Typist's Initials Placeholder

Attachments: Channelization Plan?
Permits?
Deviations?

cc: Headquarters Design 47329

Q Project Design Summary/Approval Template
Figure 340-5b

720.01 Impact Attenuator Systems

Impact attenuator systems are protective systems that prevent an errant vehicle from impacting a hazard by either gradually decelerating the vehicle to a stop when hit head-on or by redirecting it away from the hazard when struck on the side. These barriers are used for rigid objects or hazardous conditions that cannot be removed, relocated, or made breakaway.

Approved systems are shown on Figures 720-2a through 4b and on the Design Office web page at:

http://www.wsdot.wa.gov/EESC/Design/Policy/RoadsideSafety/Chapter720/Chapter720B.htm

(1) Permanent Installations

A description of each permanent installation system's purpose, parts, and function as well as requirements for; transition, foundation, and slope are provided as follows and in Figure 720-5:

(a) **Crash Cushion Attenuating Terminal (CAT)**

1. **Purpose**: The CAT is an end treatment for W-beam guardrail. It can also be used for concrete barrier if a transition is provided.

2. **Description**: The system consists of slotted W-beam guardrail mounted on both sides of breakaway timber posts. Steel sleeves with soil plates hold the timber posts in place. See Figure 720-2a.

3. **Function**: When hit head-on, the slotted guardrail is forced over a pin that shears the steel between the slots. This shearing dissipates the energy of the impact.

4. **Foundation:** Concrete footings or foundations are not required.

5. **Slope:** 10H:1V or flatter slope between the edge of the traveled way and the near face of the unit.

6. **Manufacturer/Supplier:** Trinity Industries, Inc.

(b) **Brakemaster**

1. **Purpose:** The Brakemaster system is an end treatment for W-beam guardrail. It can also be used for concrete barrier if a transition is provided.

2. **Description:** The system contains an embedded anchor assembly, W-beam fender panels, transition strap, and diaphragm. See Figure 720-2a.

3. **Function:** The system uses a brake and cable device for head-on impacts and for redirection. The cable is embedded in a concrete anchor at the end of the system.

4. **Foundation:** A concrete foundation is not required for this system but a paved surface is recommended.

5. **Slope:** 10H:1V or flatter slope between the edge of the traveled way and the near face of the unit.

6. **Manufacturer/Supplier:** Energy Absorption Systems

(c) **QuadTrend 350**

1. **Purpose:** The QuadTrend 350 is an end treatment for 32 in high concrete barriers. The system's short length allows it to be used at the ends of bridges where the installation of a beam guardrail transition and terminal is not feasible.

2. **Description:** This system consists of telescoping quadruple corrugated fender panels mounted on steel breakaway posts. See Figure 720-2a.

3. **Function:** Sand-filled boxes attached to the posts dissipate a portion of the energy of an impact. An anchored cable installed behind the fender panels directs the vehicle away from the barrier end.

4. **Foundation:** The system is installed on a concrete foundation to support the steel posts.

5. **Slope:** A 6H:1V or flatter slope is required behind the barrier to allow for vehicle recovery.

6. **Manufacturer/Supplier:** Energy Absorption Systems

(d) *TAU-II*

1. **Purpose:** The TAU-II crash cushion system is an end treatment for concrete barrier and beam guardrail and is also used for narrow fixed objects.

2. **Description:** The system is made up of independent collapsible bays containing energy absorbing cartridges that are guided and supported during a head-on hit by high strength galvanized steel cables and thrie beam rail panels. Each bay is composed of overlapping thrie beam panels on the sides and structural support diaphragms on the ends. Structural support diaphragms are attached to two cables running longitudinally through the system and attached to foundations at each end of the system. See Figure 720-2c.

3. **Function:** Overlapping panels, structural support diaphragms, cable supports, cables, and foundation anchors allow the system to resist angled impacts and mitigate head-on impacts.

4. **Foundation:** The system is installed on a concrete foundation.

5. **Slope:** 10H:1V or flatter slope between the edge of the traveled way and the near face of the unit.

6. **Manufacturer/Supplier:** Barrier Systems, Inc.

(e) QuadGuard, Wide QuadGuard

1. **Purpose:** The QuadGuard is an end treatment for concrete barrier and beam guardrail and is also used to mitigate fixed objects up to 7.5 ft wide.

2. **Description:** The system consists of a series of Hex-Foam cartridges surrounded by a framework of steel diaphragms and quadruple corrugated fender panels. See Figure 720-2b.

3. **Function:** The internal shearing of the cartridges and the crushing of the energy absorption material absorb impact energy from end-on hits. The fender panels redirect vehicles impacting the attenuator on the side.

4. **Foundation:** The system is installed on a concrete foundation.

5. **Slope:** If the site has excessive grade or cross slope, additional site preparation or modification to the units in accordance with the manufacturer’s literature is required. Excessive is defined as steeper than 8% for the QuadGuard.

6. **Manufacturer/Supplier:** Energy Absorption Systems

(f) QuadGuard Elite

1. **Purpose:** The QuadGuard Elite is an end treatment for concrete barrier and beam guardrail and is also used for fixed objects up to 7.5 ft wide.

2. **Description:** The system consists of telescoping quadruple corrugated fender panels mounted on both sides of a series of polyethylene cylinders. See Figure 720-2b.

3. **Function:** The cylinders are compressed during a head-on impact and will return to their original shape when the system is reset. The advantage of this system is that it can withstand numerous impacts without requiring extensive repair.

4. **Foundation:** The system is installed on a concrete foundation.

5. **Slope:** If the site has excessive grade or cross slope, additional site preparation or modification to the units in accordance with the manufacturer's literature is required. Excessive is defined as steeper than 8% for the QuadGuard Elite.

6. **Manufacturer/Supplier:** Energy Absorption Systems

(g) **Reusable Energy Absorbing Crash Terminal (REACT 350), Wide REACT 350**

1. **Purpose:** The REACT 350 is an end treatment for concrete barriers and is also used for fixed objects up to 9 ft wide.

2. **Description:** The system consists of polyethylene cylinders with varying wall thickness, redirecting cables, a steel frame base, and a backup structure. See Figure 720-2d.

3. **Function:** The redirecting cables are anchored in the concrete foundation at the front of the system and in the backup structure at the rear of the system. When hit head-on, the cylinders compress and absorb the impact energy, but the system returns to approximately 80% of its original length immediately. For side impacts, the cables restrain the system enough to prevent penetration and redirect the vehicle. It is anticipated that this system will require very few replacement parts or extensive repair.

4. **Foundation:** The system is installed on a concrete foundation.

5. **Slope**: If the site has excessive grade or cross slope, additional site preparation or modification to the units in accordance with the manufacturer's literature is required. Excessive is defined as steeper than 8% for the REACT 350.

6. **Manufacturer/Supplier:** Energy Absorption Systems

(h) **Inertial Barrier**

Inertial barrier configurations are shown in the Standard Plans. If a situation is encountered where configurations in the Standard Plans are not appropriate, contact the Headquarters Design Office for further information.

1. **Purpose:** Inertial barrier is an end treatment for concrete barrier and to mitigate fixed objects. This system does not provide redirection from a side impact.

2. **Description:** This system consists of an array of plastic containers filled with varying weights of sand. See Figure 720-2d.

3. **Function:** The inertial barriers slow an impacting vehicle by the transfer of the momentum of the vehicle to the mass of the barrier. This system is not suitable where space is limited to less than the widths shown in the Standard Plans. Whenever possible, align inertial barriers so that an errant vehicle deviating from the roadway by 10 degrees would be on a parallel path with the attenuator alignment (See the Standard Plans). In addition, inertial barriers do not provide any redirection and are not appropriate where high angle impacts are likely.

4. **Foundation**: A paved surface is not required.

5. **Slope**: If the site has excessive grade or cross slope, additional site preparation or modification to the units in accordance with the manufacturer's literature is required. Excessive is defined as steeper than 5% for inertial barriers.

(2) Work Zone (Temporary) Installation

A description of each work zone (or other temporary) system's purpose, parts and functionality as well as requirements for; transition, foundation, and slope are provided as follows and in Figure 720-5:

(a) **ABSORB 350**

1. **Purpose:** The ABSORB 350 is an end treatment limited to temporary installations for both concrete barrier and the Quickchange Moveable Barrier (QMB).

2. **Description:** The system contains water filled Energy Absorbing Elements. Each element is 24 inches wide, 32 inches high, and 39 ½ inches long. See Figure 720-3.

3. **Function:** The low speed (below 45 mph) system uses 5 Energy Absorbing Elements and the high-speed (45 mph and above) system uses 8. The energy of an impact is dissipated as the elements are crushed.

4. **Foundation:** The system does not require a paved foundation.

5. **Slope:** 10H:1V or flatter slope between the edge of the traveled way and the near face of the unit.

6. **Manufacturer/Supplier:** Barrier Systems, Inc.

(b) **Advanced Dynamic Impact Extension Module 350 (ADIEM 350)**

1. **Purpose:** The ADIEM 350 is an end treatment for concrete barrier. At this time, it is limited to temporary installations. Existing permanent installations are experimental and are being used to evaluate long-term durability. Existing permanent units may be reset.

2. **Description:** The system is 30 ft long and consists of 10 lightweight concrete modules on an inclined base. See Figure 720-3.

3. **Functionality:** An inclined base provides a track for placement of the modules and provides redirection for side impacts for roughly half the length. The energy of an impact is dissipated as the concrete modules are crushed.

4. **Foundation:** The system does not require a paved foundation.

5. **Slope:** If the site has excessive grade or cross slope, additional site preparation or modification to the units in accordance with the manufacturer's literature is required. Excessive is defined as steeper than 8% for the ADIEM 350.

6. **Manufacturer/Supplier:** Trinity Industries, Inc.

(c) **QuadGuard cz**

This system is like the permanent QuadGuard listed for permanent systems above except that it can be installed on a 6 in minimum depth asphalt concrete surface that has a 6 in minimum depth compacted base. See Figure 720-2b.

(d) **Reusable Energy Absorbing Crash Terminal (REACT 350)**

This is the same system listed for permanent systems above except that it can be installed on a 4 in minimum depth asphalt concrete surface that has a 6 in minimum depth compacted base. See Figure 720-2d.

(e) **Non-Redirecting Energy Absorbing Terminal (N-E-A-T)**

1. **Purpose:** The N-E-A-T system is an end treatment for temporary concrete barrier where vehicle speeds are 45 mph or less.

2. **Description:** The N-E-A-T System's cartridge weighs about 300 pounds and measures 9.7 ft in length. The system consists of aluminum cells encased in an aluminum shell with steel backup, attachment hardware, and transition panels. It can be attached to the ends of New Jersey shaped portable concrete barrier and the moveable QuickChange Barrier. See Figure 720-3.

3. **Functionality:** The energy of an impact is dissipated as the aluminum cells are crushed.

4. **Foundation:** The system does not require a paved foundation.

5. **Slope:** 10H:1V or flatter slope between the edge of the traveled way and the near face of the unit.

6. **Manufacturer/Supplier:** Energy Absorption Systems

(f) **Trinity Attenuating Crash Cushion (TRACC)**

1. **Purpose:** The TRACC is an end treatment for concrete barriers. It is limited to use in construction or other work zones on a temporary basis.

2. **Description:** The 21 foot long TRACC includes four major components: a pair of guidance tracks, an impact sled, intermediate steel frames, and 10 gauge W-beam fender panels. See Figure 720-3.

3. **Functionality:** The sled (impact face) is positioned over the upstream end of the guidance tracks and contains a hardened steel blade that cuts the metal plates on the sides of the guidance tracks as it is forced backwards when hit head-on.

4. **Foundation:** The system requires a concrete foundation.

5. **Slope:** 10H:1V or flatter slope between the edge of the traveled way and the near face of the unit.

6. **Manufacturer/Supplier:** Trinity Industries, Inc.

(g) **Inertial Barrier**

This is the same system listed for permanent systems above. It is not suitable where space is limited to less than the widths shown in the Standard Plans. See Figure 720-2d.

(h) **Truck Mounted Attenuator (TMA)**

TMAs are portable systems mounted on trucks. They are intended for use in work zones and for temporary hazards.

(3) Older Systems

The following systems are in use on Washington State highways and may be left in place or reset. New installations of these systems require approval from the Headquarters (HQ) Design Office.

(a) **Sentre**

The Sentre is a guardrail end treatment. Its overall length of 17 ft allowed it to be used where space was not available for a guardrail transition and terminal. The system is very similar to the QuadTrend-350 in both appearance and function except that it uses thrie beam fender panels instead of the quadruple corrugated panels. This system requires a transition when used to terminate rigid barriers. See Figure 720-4a.

(b) **TREND**

The TREND is an end treatment with a built-in transition and was used at the end of rigid barriers including bridge rails. The system is similar to the QuadTrend-350 except that it uses thrie beam fender panels. See Figure 720-4a.

(c) **G-R-E-A-T (Guard Rail Energy Absorption Terminal)**

This system was primarily used as an end treatment for concrete barrier. It is similar to the QuadGuard except that it uses thrie beam fender panels. See Figure 720-4a.

(d) **Low Maintenance Attenuator System (LMA)**

The LMA is an end treatment for concrete barrier and beam guardrail and was used for fixed objects up to 3 ft wide. The system is similar to the QuadGuard Elite except that it uses thrie beam fender panels and rubber cylinders. See Figure 720-4b.

(e) **Hex-Foam Sandwich**

The Hex-Foam Sandwich system is an end treatment for beam guardrail and concrete barrier and was also used for fixed objects 3 ft or more in width. This system consists of a number of Hex-Foam cartridges containing an energy absorption material separated by a series of diaphragms and restrained by anchor cables. It is installed on a concrete slab. Impact energy is absorbed by the internal shearing of the cartridges and crushing of the energy absorption material. The lapped panels on the perimeter serve to redirect vehicles for side impacts. If the site has grade or cross slope in excess of 5%, additional site preparation or modification to the units in accordance with the manufacturer’s literature is required. See Figure 720-4b.

720.02 Design Criteria

The following design criteria applies to all new or reset permanent and temporary impact attenuators. The design criteria also applies to existing systems to be left in place when the Barrier Terminals and Transition Sections columns on a design matrix applies to the project. (See Chapter 325.)

Impact attenuators must be placed so that they do not present a hazard to opposing traffic. For median and reversible lane locations, the backup structure or attenuator-to-object connection must be designed to prevent opposing traffic from being snagged. It is desirable that all existing curbing be removed and the surface smoothed with asphalt or cement concrete pavement before an impact attenuator is installed. However, curbs 4 in or less in height, may be retained depending on the practicality of their removal.

In general, attenuators are aligned parallel to the roadway except the inertial barriers.

720.03 Selection

When selecting an impact attenuator system, consider the following:

- Posted speed
- Available space (length and width)
- Maintenance costs
- Initial cost
- Duration (permanent or temporary use)

The posted speed is a consideration for the QuadGuard, REACT 350 (narrow model only), TAU II and the inertial barrier systems. Use Figure 720-1 to select permanent system sizes required for the various posted speeds.

Posted Speed (mph)	Quad Guard (Bays)	TAU-II (Bays)	REACT 350 (Cylinders)	Inertial Barrier (Type)
40 or less	3	4	4	1
45	4	8	6	2
50	5	8	6	3
55	6	8	9	4
60	6	8	9	5
65	8	8	9	6
70	9	8	11	6

Impact Attenuator Sizes
Figure 720-1

If it is anticipated that a large volume of traffic will be traveling at speeds greater than the posted speed limit, then the next larger unit may be specified.

See Figure 720-5 for a summary of space and initial cost information related to the impact attenuator systems.

When considering maintenance costs, anticipate the average annual impact rate. If few impacts are anticipated, lower cost devices such as inertial barriers might meet the need. Inertial barriers have the lowest initial cost and initial site preparation. However, maintenance will be costly and necessary after every impact. Labor and equipment are necessary to clean up the debris and install new containers (barrels). Also, inertial barriers must not be used where flying debris might be a danger to pedestrians.

The REACT 350 and the QuadGuard Elite have a higher initial cost, requiring substantial site preparation, including a backup or anchor wall in some cases and cable anchorage at the front of the installation. However, repair costs are comparatively low, with labor being the main expense. Maintenance might not be required after minor side impacts with these systems.

For new installations where at least one impact is anticipated per year, limit the selection of impact attenuators to the low maintenance devices (QuadGuard Elite and REACT 350). Consider upgrading existing ADIEM, G-R-E-A-T, and Hex-Foam impact attenuators with these low maintenance devices when the repair history shows one to two impacts per year over a three to five year period.

In selecting a system, one consideration that must not be overlooked is how dangerous it will be for the workers making repairs. In areas with a high exposure to danger, a system that can be repaired quickly is most desirable. Some systems require nearly total replacement or replacement of critical components (such as cartridges or braking mechanisms) after a head-on impact, while others only require resetting.

When specifying the system or systems that can be used at a specific location, the list shown in Figure 720-5 is to be used as a starting point. As the considerations discussed previously are analyzed, inappropriate systems may be identified and eliminated from further consideration. Systems that are not eliminated may be appropriate for the project. When the site conditions vary, it might be necessary to have more than one list of acceptable systems within a contract. Systems are not to be eliminated without documented reasons. Also, wording such as *or equivalent* is not to be used when specifying these systems. If only one system is found to be appropriate, then approval from the Assistant State Design Engineer of a public interest finding for the use of a sole source proprietary item is required.

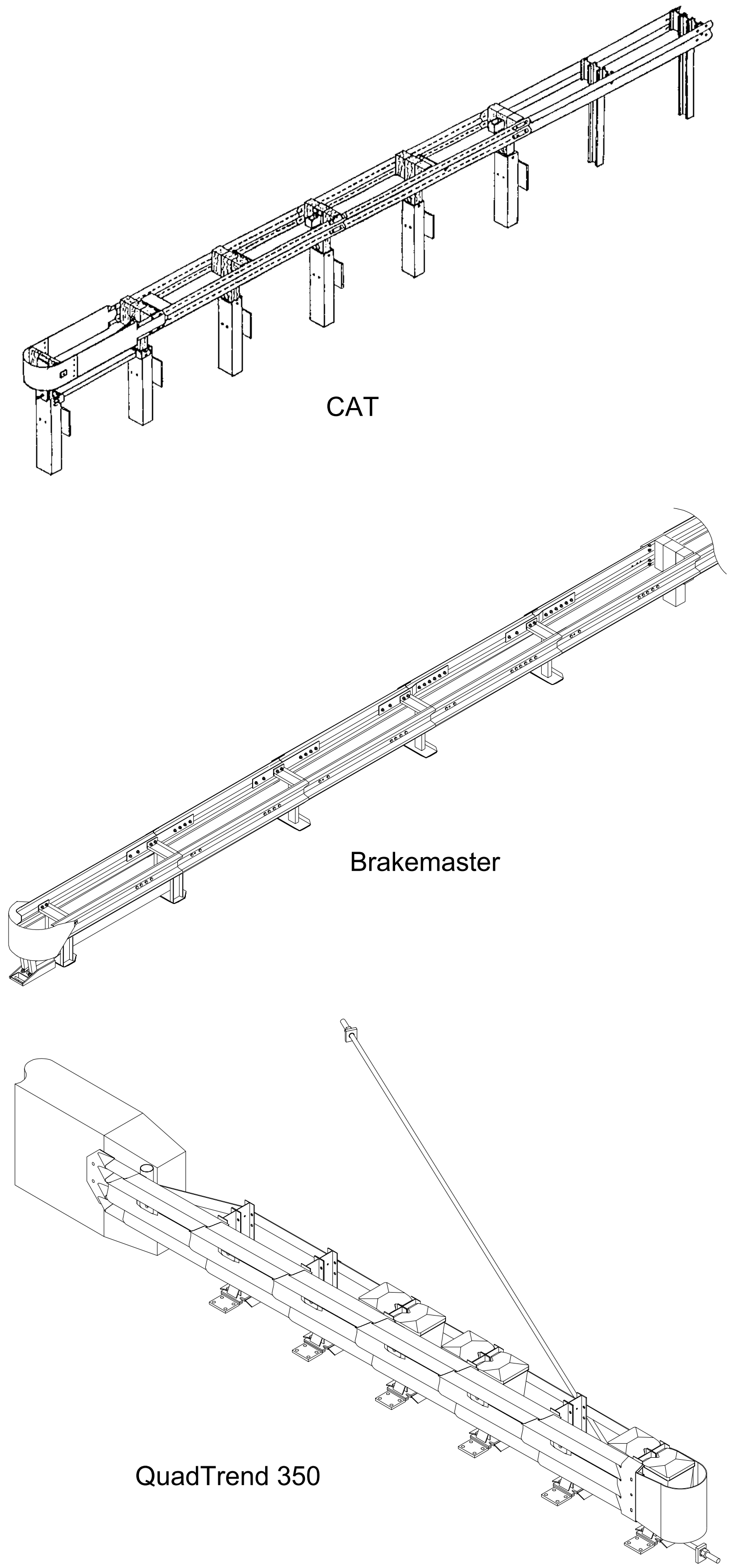
When a transition to connect with a concrete barrier (see Figure 720-5) is required, the transition type and connection must be specified and are included in the cost of the impact attenuator. See Chapter 710 for information on the transitions and connections to be used.

Contractors can be given more flexibility in the selection of work zone (temporary) systems, since long-term maintenance and repair are not a consideration.

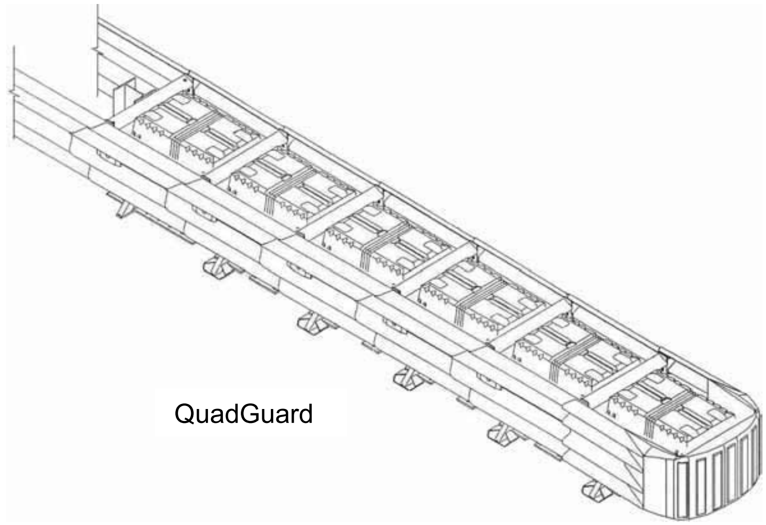
720.04 Documentation

The following documents are to be preserved in the project's design documentation file. See Chapter 330.

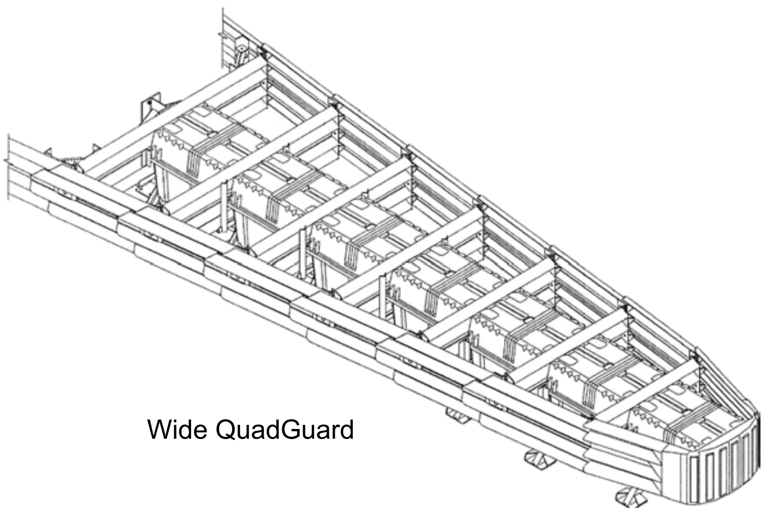
- ☐ Approvals for use of older systems.
- ☐ Documentation of reasons for eliminating attenuator options.
- ☐ Approvals of public interest findings regarding sole source proprietary systems.



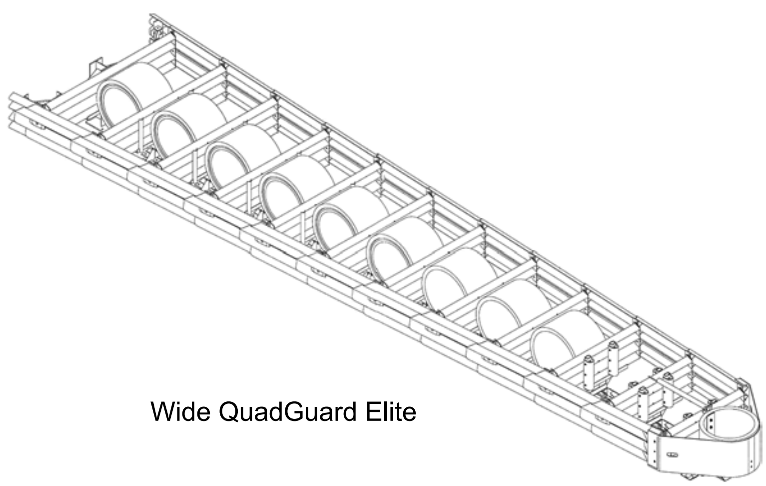
Impact Attenuator Systems — Permanent Installations
Figure 720-2a



QuadGuard



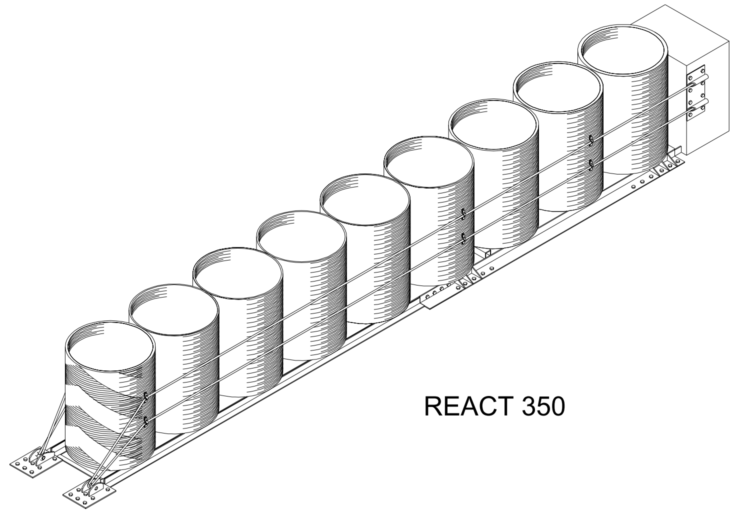
Wide QuadGuard

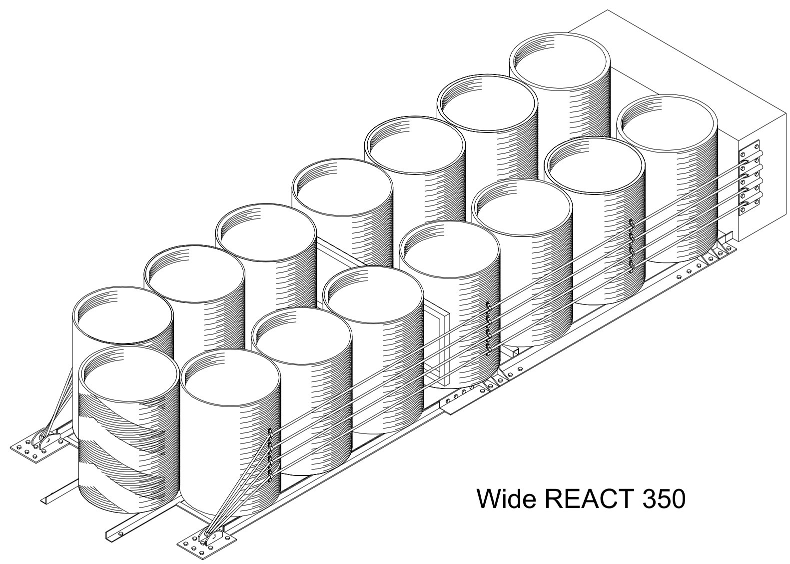


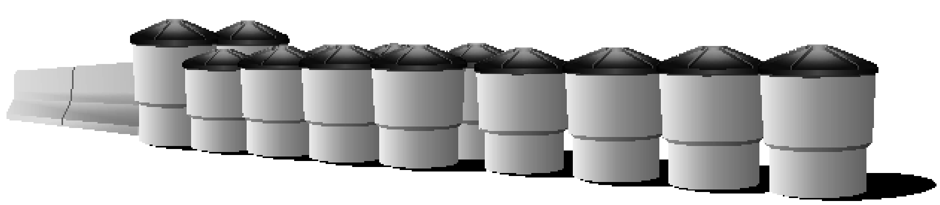
Wide QuadGuard Elite

Impact Attenuator Systems — Permanent Installations
Figure 720-2b

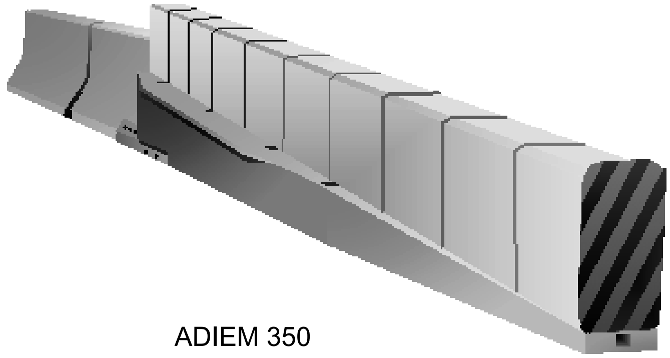
Impact Attenuator Systems — Permanent Installations
Figure 720-2c


REACT 350

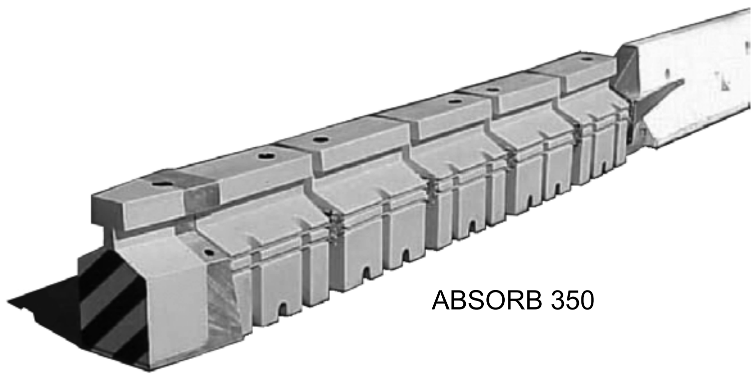

Wide REACT 350


Inertial Barrier

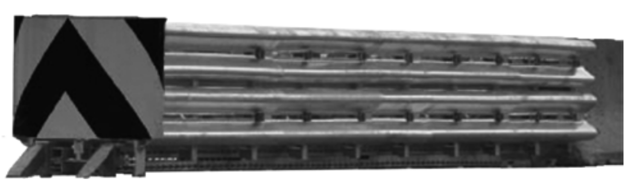
Impact Attenuator Systems — Permanent Installations
Figure 720-2d



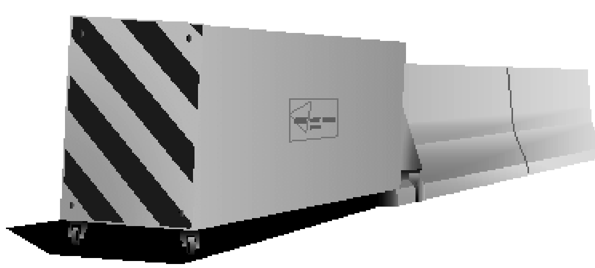
ADIEM 350



ABSORB 350

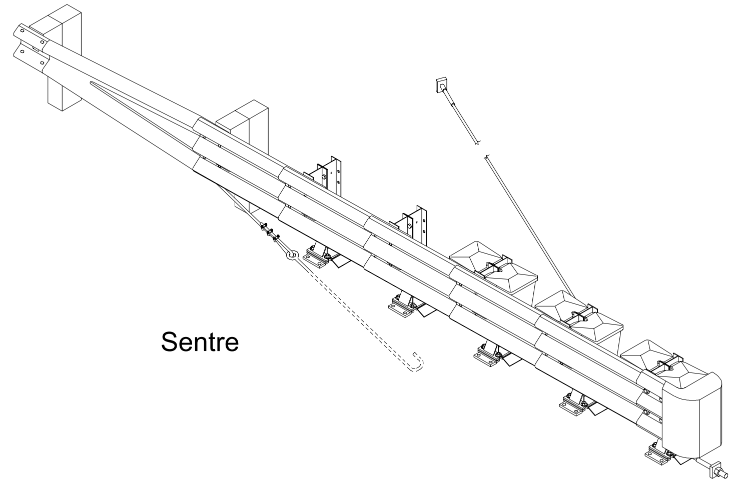


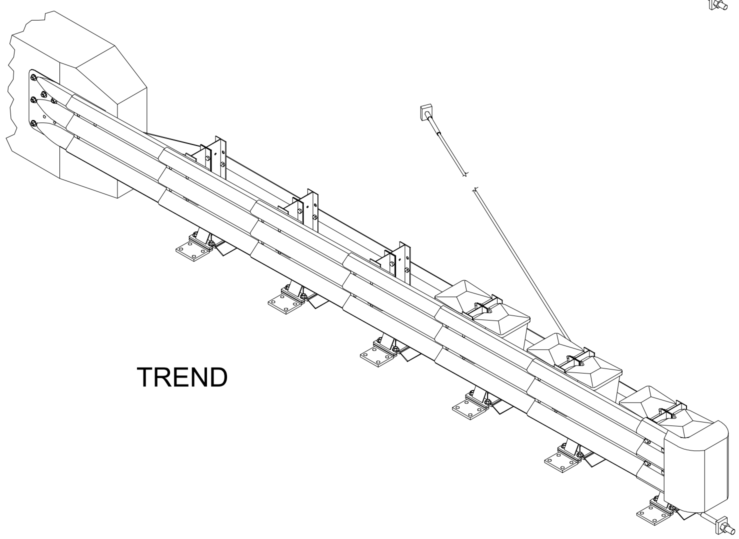
TRACC

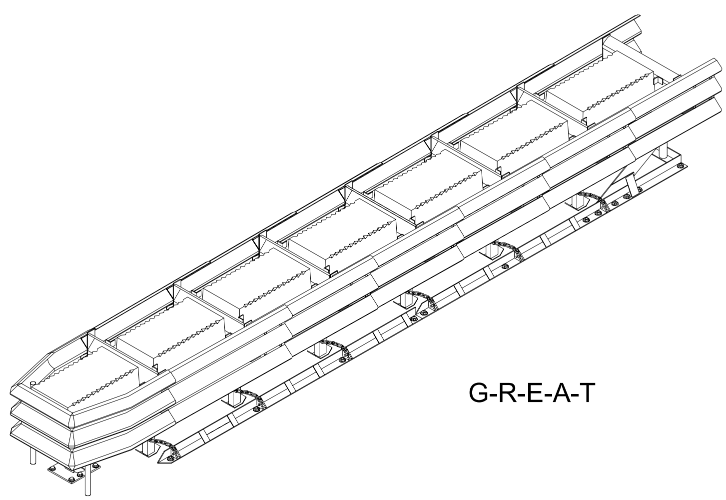


N-E-A-T

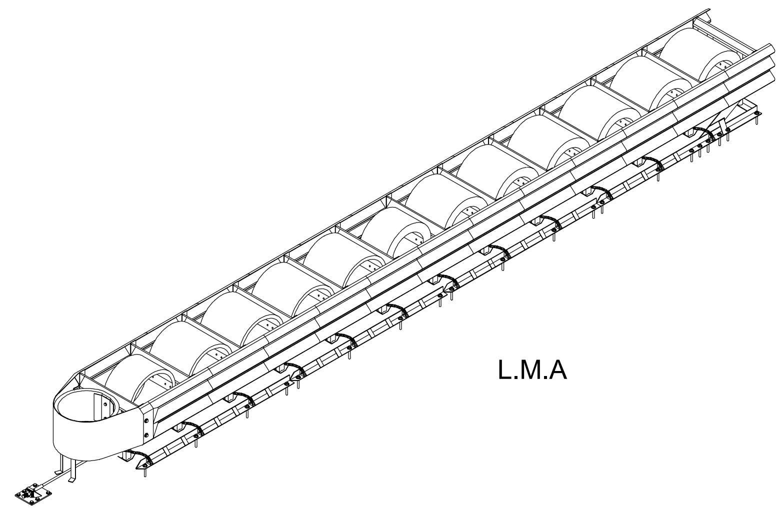
Impact Attenuator Systems — Work Zone Installations
Figure 720-3

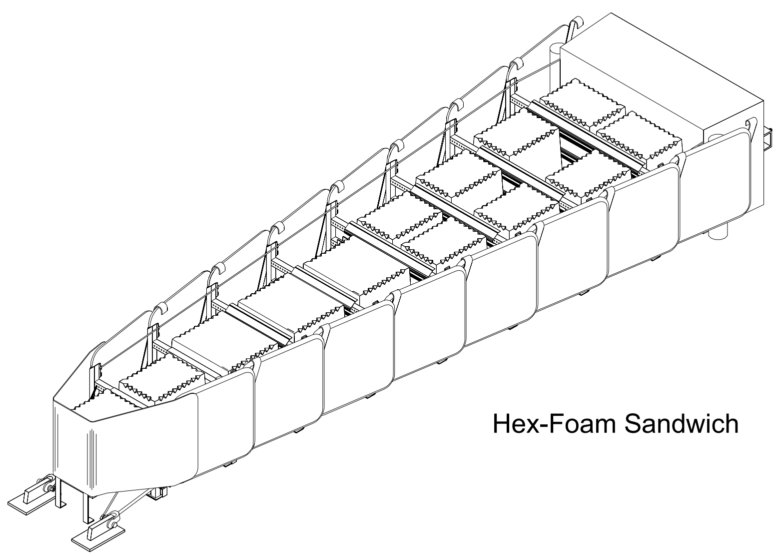






Impact Attenuator Systems — Older Systems
Figure 720-4a





Impact Attenuator Systems — Older Systems
Figure 720-4b

Impact Attenuator Systems

(All dimensions are in feet)

System	(P) permanent, (T) temporary, (B) both	Width	Length	Transition to Rigid System Required	Distance Beyond Length of Need	Initial Cost Category(1)
CAT(2)	P	2	31.25	Y	18.8	A
Brakemaster(2)	P	2	31.5	Y	15.8	A
QuadTrend - 350(6)	P	2	20.7	N	10.5	A
TAU-II	P	2.9	14 -26(4)	N	3	B(5)
QuadGuard	B	2, 2.5, 3, 5.75, 7.5	12 - 30(4)	N	3.3	C(5)
QuadGuard Elite	B	2, 2.5, 3, 5.75, 7.5	35.5	N	3.3	D
REACT 350	B	3	15.25 - 36.25(4)	N	4.3	C(5)
Wide REACT 350	B	6-9	23.25	N	4.3	D(5)
Inertial Barriers	B	7	17 - 30(4)	N	(3)	A(5)
ABSORB 350(9)	T	2	17.7/27	Y	17.7/27(3)	A(5)
ADIEM 350(7)	T	2	30	N	14.1	B
QuadGuard cz	T	2, 2.5, 3, 5.75, 7.5	22	N	3.3	C(5)
N-E-A-T(8)	T	1.9	9.7	N	(3)	C(5)
TRACC	T	2.6	21	N	8	B

1) A ($5,000 to $10,000); B ($10,000 to $15,000); C ($15,000 to $25,000); D ($25,000 to $40,000). These are rough initial cost estimates - verify actual costs through manufacturers/suppliers. Some products are priced very close to the margin between cost categories.
2) Generally for use with double-sided beam guardrail. Use as an end treatment for concrete barrier requires a transition.
3) The N-E-A-T, inertial barriers, and ABSORB 350 may only be used beyond the required length of need.
4) See Figure 720-1 for sizes or configuration type.
5) The length of the QuadGuard, REACT 350, TAU-II, ABSORB 350, and inertial barriers varies since their designs are dependent upon speed. For a typical 60 mph design: the QuadGuard = 21 ft, the REACT 350 = 31 ft, the ABSORB 350 = 27 ft, the TAU II = 26 ft, and the inertial barrier = 30 ft. Costs indicated are for a typical 60 mph design. (except N-E-A-T)
6) Generally for use at the ends of bridges where installation of a beam guardrail transition and terminal is not feasible.
7) Generally for use with concrete barrier. Other uses may require a special transition design.
8) Use limited to highways with posted speeds of 45 mph or less.
9) The ABSORB 350 was primarily intended for the Quickchange Moveable Barrier (QMB) but may be used with other temporary barrier if beyond the length of need.

Impact Attenuator Comparison

Figure 720-5

940 Traffic Interchanges

940.01 General

The primary purpose of an interchange is to eliminate conflicts caused by vehicle crossings and to minimize conflicting left-turn movements. Interchanges are provided on all Interstate highways, freeways, other routes on which full access control is required, and at other locations where traffic cannot be controlled safely and efficiently by intersections at grade.

See the following chapters for additional information:

Chapter	Subject
640	Superelevation
640	Turning Widths
640	Ramp Sections
910	Intersections
1050	HOV Lanes
1420	Access Control
1425	Access Point Decision Report

940.02 References

Standard Plans for Road, Bridge, and Municipal Construction (Standard Plans), M 21-01, WSDOT

Plans Preparation Manual, M 22-31, WSDOT

HOV Direct Access Design Guide, Draft M 22-98, WSDOT

Standard Specifications for Road, Bridge, and Municipal Construction (Standard Specifications), M 41-10, WSDOT.

A Policy on Geometric Design of Highways and Streets (Green Book), 2001, AASHTO

A Policy on Design Standards - Interstate System, 1991, AASHTO

Highway Capacity Manual (Special Report 209), Transportation Research Board

Procedure for Analysis and Design of Weaving Sections, A User's Guide, October 1985, Jack E. Leisch.

940.03 Definitions

auxiliary lane The portion of the roadway adjoining the traveled way for parking, speed change, turning, storage for turning, weaving, truck climbing, passing, and other purposes supplementary to through traffic movement

basic number of lanes The minimum number of general purpose lanes designated and maintained over a significant length of highway.

collector distributor road (C-D road) A parallel roadway designed to remove weaving from the main line and to reduce the number of main line entrances and exits.

decision sight distance The sight distance required for a driver to detect an unexpected or difficult-to-perceive information source or hazard, interpret the information, recognize the hazard, select an appropriate maneuver, and complete it safely and efficiently.

frontage road An auxiliary road that is a local road or street located on the side of a highway for service to abutting properties and adjacent areas, and for control of access.

gore The area downstream from the intersection of the shoulders of the main line and exit ramp. Although generally the area between a main line and an exit ramp, the term may also be used to refer to the area between a main line and an entrance ramp.

intersection at grade The general area where a state highway or ramp terminal is met or crossed at a common grade or elevation by another state highway, a county road, or a city street.

Interstate System A network of routes selected by the state and the FHWA under terms of the federal aid acts as being the most important to the development of a national transportation system. The Interstate System is part of the principal arterial system.

lane A strip of roadway used for a single line of vehicles.

median The portion of a divided highway separating the traveled ways for traffic in opposite directions.

outer separation The area between the outside edge of traveled way for through traffic and the nearest edge of traveled way of a frontage road.

painted nose The point where the main line and ramp lanes separate.

physical nose The point, upstream of the gore, with a separation between the roadways of 16 to 22 ft. See Figures 940-11a and 11b.

ramp A short roadway connecting a main lane of a freeway with another facility for vehicular use such as a local road or another freeway.

ramp connection The pavement at the end of a ramp, connecting it to a main lane of a freeway.

ramp meter A traffic signal at a freeway entrance ramp that allows a measured or regulated amount of traffic to enter the freeway.

ramp terminal The end of a ramp at a local road.

roadway The portion of a highway, including shoulders, for vehicular use. A divided highway has two or more roadways.

sight distance The length of highway visible to the driver.

shoulder The portion of the roadway contiguous with the traveled way, primarily for accommodation of stopped vehicles, emergency use, lateral support of the traveled way, and (where permitted) use by bicyclists and pedestrians.

stopping sight distance The sight distance required to detect a hazard and safely stop a vehicle traveling at design speed.

traffic interchange A system of interconnecting roadways, in conjunction with one or more grade separations, providing for the exchange of traffic between two or more intersecting highways or roadways.

traveled way The portion of the roadway intended for the movement of vehicles, exclusive of shoulders and lanes for parking, turning, and storage for turning.

940.04 Interchange Design

(1) General

All freeway exits and entrances, except HOV direct access connections, are to connect on the right of through traffic. Deviations from this requirement will be considered only for special conditions.

HOV direct access connections may be constructed on the left of through traffic when they are designed in accordance with the *HOV Direct Access Design Guide*.

Provide complete ramp facilities for all directions of travel wherever possible. However, give primary consideration to the basic traffic movement function that the interchange is to fulfill.

Few complications will be encountered in the design and location of rural interchanges that simply provide a means of exchanging traffic between a limited access freeway and a local crossroad. The economic and operational effects of locating traffic interchanges along a freeway through a community requires more careful consideration, particularly with respect to local access, to provide the best local service possible without reducing the capacity of the major route or routes.

Where freeway to freeway interchanges are involved, do not provide ramps for local access unless they can be added conveniently and without detriment to safety or reduction of ramp and through-roadway capacity. When exchange of traffic between freeways is the basic function and local access is prohibited by access control restrictions or traffic volume, it may be necessary to provide separate interchanges for local service.

(2) Interchange Patterns

Basic interchange patterns have been established that can be used under certain general conditions and modified or combined to apply to many more. Alternatives must be considered in the design of a specific facility, but the conditions in the area and on the highway involved must govern and rigid patterns must not be indiscriminately imposed.

Selection of the final design must be based on a study of projected traffic volumes, site conditions, geometric controls, criteria for intersecting legs and turning roadways, driver expectancy, consistent ramp patterns, continuity, and cost.

The patterns most frequently used for interchange design are those commonly described as directional, semidirectional, cloverleaf, partial cloverleaf, diamond, and single point (urban) interchange. (See Figure 940-4.)

(a) **Directional** A directional interchange is the most effective design for connection of intersecting freeways. The directional pattern has the advantage of reduced travel distance, increased speed of operation, and higher capacity. These designs eliminate weaving and have a further advantage over cloverleaf designs in avoiding the loss of sense of direction drivers experience in traveling a loop. This type of interchange is costly to construct, commonly using a four-level structure.

(b) **Semidirectional** A semidirectional interchange has ramps that loop around the intersection of the highways. This requires multiple single-level structures and more area than the directional interchange.

(c) **Cloverleaf** The full cloverleaf interchange has four loop ramps that eliminate all the left-turn conflicts. Outer ramps provide for the right turns. A full cloverleaf is the minimum type interchange that will suffice for a freeway-to-freeway interchange. Cloverleaf designs often incorporate a C-D road to minimize signing difficulties and to remove weaving conflicts from the main roadway.

The principal advantage of this design is the elimination of all left-turn conflicts with one single-level structure. Because all movements are merging movements, it is adaptable to any grade line arrangement.

The cloverleaf has some major disadvantages. The left-turn movement has a circuitous route on the loop ramp, the speeds are low on the loop ramp, and there are weaving conflicts between the loop ramps. The cloverleaf also requires a large area. The weaving and the radius of the loop ramps are a capacity constraint on the left-turn movements.

(d) **Partial Cloverleaf (PARCLO)** A partial cloverleaf has loop ramps in one, two, or three quadrants that are used to eliminate the major left-turn conflicts. These loops may also serve right turns for interchanges that have one or two quadrants that must remain undeveloped. Outer ramps are provided for the remaining turns. Design the grades to provide sight distance between vehicles approaching these ramps.

(e) **Diamond** A diamond interchange has four ramps that are essentially parallel to the major arterial. Each ramp provides for one right and one left-turn movement. Because left-turns are made at grade across conflicting traffic on the crossroad, intersection sight distance is a primary consideration.

The diamond design is the most generally applicable and serviceable interchange configuration and usually requires less space than any other type. Consider this design first when a semidirectional interchange is required unless another design is clearly dictated by traffic, topography, or special conditions.

(f) **Single Point (Urban)** A single point urban interchange is a modified diamond with all of its ramp terminals on the crossroad combined into one signalized at-grade intersection. This single intersection accommodates all interchange and through movements.

A single point urban interchange can improve the traffic operation on the crossroad with less right of way than a typical diamond interchange; however, a larger structure is required.

(3) Spacing

To avoid excessive interruption of main line traffic, consider each proposed facility in conjunction with adjacent interchanges, intersections, and other points of access along the route as a whole.

The minimum spacing between adjacent interchanges is 1 mi in urban areas and 2 mi in rural areas. In urban areas, spacing less than 1 mi may be used with C-D roads or grade separated (braided) ramps. Generally, the average interchange spacing is not less than 2 mi in urban areas and not less than 4 mi in suburban areas. Interchange spacing is measured along the freeway center line between the center lines of the crossroads.

The spacing between interchanges may also be dependent on the spacing between ramps. The minimum spacing between the noses of adjacent ramps is given on Figure 940-5.

Consider either frontage roads or C-D roads when it is necessary to facilitate the operation of near-capacity volumes between closely spaced interchanges or ramp terminals. C-D roads may be required where cloverleaf loop ramps are involved or where a series of interchange ramps requires overlapping of the speed change lanes. Base the distance between successive ramp terminals on capacity requirements and check the intervening sections by weaving analysis to determine whether adequate capacity and sight distance and effective signing can be ensured without the use of auxiliary lanes or C-D roads.

(4) Route Continuity

Route continuity refers to the providing of a directional path along the length of a route designated by state route number. Provide the driver of a through route a path on which lane changes are minimized and other traffic operations occur to the right.

In maintaining route continuity, interchange configuration may not always favor the heavy traffic movement, but rather the through route. In this case, design the heavy traffic movements with multilane ramps, flat curves, and reasonably direct alignment.

(5) Drainage

Avoid interchanges located in proximity to natural drainage courses. These locations often result in complex and unnecessarily costly hydraulic structures.

The open areas within an interchange can be used for storm water detention facilities when these facilities are required.

(6) Uniformity of Exit Pattern

While interchanges are of necessity custom designed to fit specific conditions, it is desirable that the pattern of exits along a freeway have some degree of uniformity. From the standpoint of driver expectancy, it is desirable that each interchange have only one point of exit, located in advance of the crossroad.

940.05 Ramps

(1) Ramp Design Speed

The design speed for a ramp is based on the design speed for the freeway main line.

It is desirable for the ramp design speed at the connection to the freeway be equal to the free-flow speed of the freeway. Meet or exceed the upper range values from Figure 940-1 for the design speed at the ramp connection to the freeway. Transition the ramp design speed to provide a smooth acceleration or deceleration between the speeds at the ends of the ramp. However, do not reduce the ramp design speed below the lower range speed of 25 mph. For loop ramps, use a design speed as high as practical, but not less than 25 mph.

These design speed guidelines do not apply to the ramp in the area of the ramp terminal at-grade intersection. In the area of the intersection, a design speed of 15 mph for turning traffic or 0 mph for a stop condition is adequate. Use the allowed skew at the ramp terminal at-grade intersection to minimize ramp curvature.

For freeway-to-freeway ramps and C-D roads, the design speed at the connections to both freeways is the upper range values from Figure 940-1; however, with justification, the midrange values from Figure 940-1 may be used for the remainder of the ramp. When the design speed for the two freeways is different, use the higher design speed.

Existing ramps meet design speed requirements if acceleration or deceleration requirements are met (figure 940-8 or 940-10) and superelevation meets or will be corrected to meet the requirements in Chapter 640.

	Main Line Design Speed mph	50	55	60	65	70	80
Ramp Design Speed (mph)	Upper Range	45	50	50	55	60	70
	Midrange	35	40	45	45	50	60
	Lower Range	25	25	25	25	25	25

Ramp Design Speed
Figure 940-1

(2) Sight Distance

Design ramps in accordance with provisions in Chapter 650 for stopping sight distances.

(3) Grade

The maximum grade for ramps for various design speeds is given in Figure 940-2.

Ramp Design Speed (mph)	25-30	35-40	45 and above
Desirable Grade (%)	5	4	3
Maximum Grade (%)	7	6	5
On one-way ramps down grades may be 2% greater.			

Maximum Ramp Grade
Figure 940-2

(4) Cross Section

Provide the minimum ramp widths given in Figure 940-3. Ramp traveled ways may require additional width to these minimums as one-way turning roadways. See Chapter 640 for additional information and roadway sections.

Number of Lanes		1	2
Traveled Way[1]		15[2]	25[3]
Shoulders	Right	8	8
	Left	2	4
Medians[4]		6	8

(1) See Chapter 640 for turning roadway widths. See Chapter 1050 for additional width when an HOV lane is present.
(2) May be reduced to 12 ft on tangents.
(3) Add 12 ft for each additional lane.
(4) The minimum median width is not less than that required for traffic control devices and their respective clearances.

Ramp Widths (ft)
Figure 940-3

Cross slope and superelevation requirements for ramp traveled way and shoulders are as given in Chapter 640 for roadways.

Whenever feasible, make the ramp cross slope at the ramp beginning or ending station equal to the cross slope of the through lane pavement. Where space is limited and superelevation runoff is long or when parallel connections are used, the superelevation transition may be ended beyond (for on-ramps) or begun in advance of (for off-ramps) the ramp beginning or ending station, provided that the algebraic difference in cross slope at the edge of the through lane and the cross slope of the ramp does not exceed 4%. In such cases, ensure smooth transitions for the edge of traveled way.

(5) Ramp Lane Increases

When off-ramp traffic and left-turn movement volumes at the ramp terminal at-grade intersection cause congestion, it may be desirable to add lanes to the ramp to reduce the queue length caused by turning conflicts. Make provision for the addition of ramp lanes whenever ramp exit or entrance volumes, after the design year, are expected to result in poor service. See Chapter 620 for width transition design.

(6) Ramp Meters

Ramp meters are used to allow a measured or regulated amount of traffic to enter the freeway. When operating in the "measured" mode, they release traffic at a measured rate to keep downstream demand below capacity and improve system travel times. In the "regulated" mode, they break up platoons of vehicles that occur naturally or result from nearby traffic signals. Even when operating at near capacity, a freeway main line can accommodate merging vehicles one or two at a time, while groups of vehicles will cause main line flow to break down.

The location of the ramp meter is a balance between the storage and acceleration requirements. Locate the ramp meter to maximize the available storage and so that the acceleration lane length, from a stop to the freeway main line design speed, is available from the stop bar to the merging point. With justification, the average main line running speed during the hours of meter operation may be used for the highway design speed to determine the minimum acceleration lane length from the ramp meter. See 940.06(4) for information on the design of on-connection acceleration lanes. See Chapter 860 for additional information on the design of ramp meters.

Driver compliance with the signal is required for the ramp meter to have the desired results. Consider enforcement areas with ramp meters.

Consider HOV bypass lanes with ramp meters. See Chapter 1050 for design data for ramp meter bypass lanes.

940.06 Interchange Connections

Provide uniform geometric design and uniform signing for exits and entrances, to the extent possible, in the design of a continuous freeway. Do not design an exit ramp as an extension of a main line tangent at the beginning of a main line horizontal curve.

Provide spacing between interchange connections as given by Figure 940-5.

Avoid on-connections on the inside of a main line curve, particularly when the ramp approach angle is accentuated by the main line curve, the ramp approach requires a reverse curve to connect to the main line, or the elevation difference will cause the cross slope to be steep at the nose.

Keep the use of mountable curb at interchange connections to a minimum. Justification is required when it is used adjacent to traffic expected to exceed 40 mph.

(1) Lane Balance

Design interchanges to the following principles of lane balance:

(a) At entrances, make the number of lanes beyond the merging of two traffic streams not less than the sum of all the lanes on the merging roadways less one. (See Figure 940-6a.)

(b) At exits, make the number of approach lanes equal the number of highway lanes beyond the exit plus the number of exit lanes less one. (See Figure 940-6a.) Exceptions to this are at a cloverleaf or at closely spaced interchanges with a continuous auxiliary lane between the entrance and exit. In these cases the auxiliary lane may be dropped at a single-lane, one lane reduction, off-connection with the number of approach lanes being equal to the sum of the highway lanes beyond the exit and the number of exit lanes. Closely spaced interchanges have a distance of less than 2,100 ft between the end of the acceleration lane and the beginning of the deceleration lane.

Maintain the basic number of lanes, as described in Chapter 620, through interchanges. When a two-lane exit or entrance is used, maintain lane balance with an auxiliary lane. (See Figure 940-6b.) The only exception to this is when the basic number of lanes is changed at an interchange.

(2) Main Line Lane Reduction

The reduction of a basic lane or an auxiliary lane may be made at a two-lane exit or may be made between interchanges. When a two-lane exit is used, provide a recovery area with a normal acceleration taper. When a lane is dropped between interchanges, drop it 1,500 to 3,000 ft from the end of the acceleration taper of the previous interchange. This will allow for adequate signing but not be so far that the driver will become accustomed to the number of lanes and be surprised by the reduction. (See Figure 940-7.)

Reduce the traveled way width of the freeway by only one lane at a time.

(3) Sight Distance

Locate off-connections and on-connections on the main line to provide decision sight distance for a speed/path/direction change as described in Chapter 650.

(4) On-Connections

On-connections are the pavement at the end of on-ramps, connecting them to the main lane of a freeway. They have two parts, an acceleration lane and a taper. The acceleration lane allows entering traffic to accelerate to the freeway speed and evaluate gaps in the freeway traffic. The taper is for the entering vehicle to maneuver into the through lane.

On-connections are either taper type or parallel type. The tapered on-connection provides direct entry at a flat angle, reducing the steering control needed. The parallel on-connection adds a lane adjacent to the through lane for acceleration with a taper at the end. Vehicles merge with the through traffic with a reverse curve maneuver similar to a lane change. While the taper requires less steering control, the parallel is narrower at the end of the ramp and has a shorter taper at the end of the acceleration lane.

(a) Provide the minimum acceleration lane length, given on Figure 940-8, for each ramp design speed on all on-ramps. When the average grade of the acceleration lane is 3% or greater, multiply the distance from the Minimum Acceleration Lane Length table by the factor from the Adjustment Factor for Grades table.

For existing ramps that do not have significant accidents in the area of the connection with the freeway, the freeway posted speed may be used to calculate the acceleration lane length for preservation projects. If corrective action is indicated, use the freeway design speed to determine the length of the acceleration lane. Document existing ramps to remain in place with an acceleration lane length less than to the design speed as a design exception. Also, include the following documentation in the project file: the ramp location, the acceleration length available, and the accident analysis that shows that there are not significant accidents in the area of the connection.

The acceleration lane is measured from the last point designed at each ramp design speed (usually the PT of the last curve for each design speed) to the last point with a ramp width of 12 ft. Curves designed at higher design speeds may be included as part of the acceleration lane length.

(b) For parallel type on-connections, provide the minimum gap acceptance length (L_g) to allow entering traffic to evaluate gaps in the freeway traffic and position the vehicle to use the gap. The length is measured beginning at the point that the left edge of traveled way for the ramp intersects the right edge of traveled way of the main line to the ending of the acceleration lane. (See Figures 940-9b and 9c.) The gap acceptance length and the acceleration length overlap with the ending point controlled by the longer of the two.

(c) Single-lane on-connections may be either taper type or parallel type. The taper type is preferred; however, the parallel may be used with justification. Design single-lane taper type on-connections as shown on Figure 940-9a and single lane parallel type on-connections as shown on Figure 940-9b.

(d) For two-lane on-connections, the parallel type is preferred. Design two-lane parallel on-connections as shown on Figure 940-9c. A capacity analysis will normally be the basis for determining whether a freeway lane or an auxiliary lane is to be provided.

When justification is documented, a two-lane tapered on-connection may be used. Design two-lane tapered on-connections in accordance with Figure 940-9d.

(5) Off-Connections

Off-connections are the pavement at the beginning of an off-ramp, connecting it to a main lane of a freeway. They have two parts, a taper for maneuvering out of the through traffic and a deceleration lane to slow to the speed of the first curve on the ramp. Deceleration is not assumed to take place in the taper.

Off-connections are either taper type or parallel type. The taper type is preferred because it fits the path preferred by most drivers. When a parallel type connection is used, drivers tend to drive directly for the ramp and not use the parallel lane. However, when a ramp is required on the outside of a curve, the parallel off-connection is preferred. An advantage of the parallel connection is that it is narrower at the beginning of the ramp.

(a) Provide the minimum deceleration lane length given on Figure 940-10 for each design speed for all off-ramps. Also, provide deceleration lane length to the end of the anticipated queue at the ramp terminal. When the average grade of the deceleration lane is 3% or greater, multiply the distance from the Minimum Deceleration Lane Length table by the factor from the Adjustment Factor for Grades table.

For existing ramps that do not have significant accidents in the area of the connection with the freeway, the freeway posted speed may be used to calculate the deceleration lane length for preservation projects. If corrective action is indicated, use the freeway design speed to determine the length of the deceleration lane.

Document existing ramps to remain in place with a deceleration lane length less than to the design speed as a design exception. Also, include the following documentation in the project file: the ramp location, the deceleration length available, and the accident analysis that shows that there are not significant accidents in the area of the connection.

The deceleration lane is measured from the point where the taper reaches a width of 12 ft to the first point designed at each ramp design speed (usually the PC of the first curve for each design speed). Curves designed at higher design speeds may be included as part of the deceleration lane length.

(b) Gores, Figures 940-11a and 11b, are decision points that must be clearly seen and understood by approaching drivers. In a series of interchanges along a freeway, it is desirable that the gores be uniform in size, shape, and appearance.

The paved area between the physical nose and the gore nose is the reserve area. It is reserved for the installation of an impact attenuator. The minimum length of the reserve area is controlled by the design speed of the main line. (See Figures 940-11a and 11b.)

In addition to striping, raised pavement marker rumble strips may be placed for additional warning and delineation at gores. See the Standard Plans for striping and rumble strip details.

The accident rate in the gore area is greater than at other locations. Keep the unpaved area beyond the gore nose as free of obstructions as possible to provide a clear recovery area. Grade this unpaved area as nearly level with the roadways as possible. Avoid placing obstructions such as heavy sign supports, luminaire poles, and structure supports in the gore area.

When an obstruction must be placed in a gore area, provide an impact attenuator (Chapter 720) and barrier (Chapter 710). Place the beginning of the attenuator as far back in the reserve area as possible, preferably after the gore nose.

(c) For single-lane off-connections, the taper type is preferred. Use the design shown on Figure 940-12a for tapered single-lane off-connections. When justification is documented, a parallel single-lane off-connection, as shown on Figure 940-12b, may be used.

(d) The single-lane off-connection with one lane reduction, Figure 940-12c, is only used when the conditions from lane balance for a single lane exit, one lane reduction, are met.

(e) The tapered two-lane off-connection design shown on Figure 940-12d is preferred where the number of freeway lanes is to be reduced, or where high volume traffic operations will be improved by the provision of a parallel auxiliary lane and the number of freeway lanes is to be unchanged.

The parallel two-lane off-connection, Figure 940-12e, allows less operational flexibility than the taper, requiring more lane changes. Use a parallel two-lane off-connection only with justification.

(6) Collector Distributor Roads

A C-D road can be within a single interchange, through two closely spaced interchanges, or continuous through several interchanges. Design C-D roads that connect three or more interchanges to be two lanes wide. All others may be one or two lanes in width, depending on capacity requirements. Consider intermediate connections to the main line for long C-D roads. See Figure 940-13a for designs of collector distributor outer separations. Use Design A, with concrete barrier, when adjacent traffic in either roadway is expected to exceed 40 mph. Design B, with mountable curb, may be used only when adjacent traffic will not exceed 40 mph.

(a) The details shown in Figure 940-13b apply to all single-lane C-D road off-connections. Where conditions require two-lane C-D road off-connections, a reduction in the number of freeway lanes, the use of an auxiliary lane, or a combination of these, design it as a normal off-connection per 940.06(5).

(b) Design C-D road on-connections as required by Figure 940-13c.

(7) Loop Ramp Connections

Loop ramp connections at cloverleaf interchanges are distinguished from other ramp connections by a low speed ramp on-connection followed closely by an off-connection for another low speed ramp. The loop ramp connection design is shown on Figure 940-14. The minimum distance between the ramp connections is dependent on a weaving analysis. When the connections are spaced far enough apart that weaving is not a consideration, design the on-connection per 940.06(4) and off-connection per 940.06(5).

(8) Weaving Sections

Weaving sections are highway segments where one-way traffic streams cross by merging and diverging. Weaving sections may occur within an interchange, between closely spaced interchanges, or on segments of overlapping routes. Figure 940-15 gives the length of the weaving section for preliminary design. The total weaving traffic is the sum of the traffic entering from the ramp to the main line and the traffic leaving the main line to the exit ramp in equivalent passenger cars. For trucks, a passenger car equivalent of two may be estimated. Use the *Highway Capacity Manual* for the final design of weaving sections.

Because weaving sections cause considerable turbulence, interchange designs that eliminate weaving or remove it from the main roadway are desirable. Use C-D roads for weaving between closely spaced ramps when adjacent to high speed highways. C-D roads are not required for weaving on low speed roads.

940.07 Ramp Terminal Intersections at Crossroads

Design ramp terminal intersections at grade with crossroads as intersections at grade. (See Chapter 910.) Whenever possible, design ramp terminals to discourage wrong way movements. Review the location of ramp intersections at grade with crossroads to ensure signal progression if the intersection becomes signalized in the future. Provide intersection sight distance as described in Chapter 910.

In urban and suburban areas, match design speed at the ramp terminal to the speed of the crossroad. Provide steeper intersection angles between the ramp terminal and crossroad to slow motor vehicle traffic speeds and reduce crossing distances for bicyclists and pedestrians.

The intersection configuration requirements for ramp terminals is normally the same as for other intersections. One exception to this is an angle point is allowed between an off ramp and an on ramp. This is because the through movement of traffic getting off the freeway, going through the intersection, and back on the freeway is minor.

Another exception is at ramp terminals where the through movement is eliminated (for example at a Single Point interchange). For ramp terminals that have two wye connections, one for right turns and the other for left turns and no through movement, the intersection angle has little meaning and does not need to be considered.

940.08 Interchanges on Two-Lane Highways

Occasionally, the first stage of a conventional interchange will be built with only one direction of the main roadway and operated as a two-lane two-way roadway until the ultimate roadway is constructed.

The design of interchanges on two-lane two-way highways may vary considerably from traditional concepts due to the following conditions:

- The potential for center-line-crossing related accidents due to merge conflicts or motorist confusion.
- The potential for wrong way or U-turn movements.
- Future construction considerations.
- Traffic type and volume.
- The proximity to multilane highway sections that might influence the driver's impression that these roads are also multilane.

The deceleration taper is required for all exit conditions. Design the entering connection with either the normal acceleration taper or a "button hook" type configuration with a stop condition before entering the main line. Consider the following items:

- Design the stop condition connection in accordance with the requirements for a Tee intersection in Chapter 910. Use this type of connection only when an acceleration lane is not possible. Provide decision sight distance as described in Chapter 650.
- Since each design will probably vary from project to project, analyze each project for most efficient signing placement such as one way, two way, no passing, do not enter, directional arrows, guide posts, and traffic buttons.
- Prohibit passing through the interchange area on two lane highways by means of signing, pavement marking, or a combination of both. A 4 ft median island highlighted with raised pavement markers and diagonal stripes is the preferred treatment. When using a 4 ft median system, extend the island 500 ft beyond any merging ramp traffic acceleration taper. The width for the median can be provided by reducing each shoulder 2 ft through the interchange. (See Figure 940-16.)
- Inform both the entering and through motorists of the two-lane two-way characteristic of the main line. Include signing and pavement markings.
- Use as much of the ultimate roadway as possible. Where this is not possible, leave the area for future lanes and roadway ungraded.
- Design and construct temporary ramps as if they were permanent unless second stage construction is planned to rapidly follow the first. In all cases, design the connection to meet the safety needs of the traffic. (See Figure 940-16.)

940.09 Interchange Plans

Figure 940-17 is a sample showing the general format and data required for interchange design plans.

Compass directions (W-S Ramp) or crossroad names (E-C Street) may be used for ramp designation to realize the most clarity for each particular interchange configuration and circumstance.

Include the following as applicable:

- Classes of highway and design speeds for main line and crossroads (Chapter 440).
- Curve data on main line, ramps, and crossroads.
- Numbers of lanes and widths of lanes and shoulders on main line, crossroads, and ramps.

- Superelevation diagrams for the main line, the crossroad, and all ramps (may be submitted on separate sheets).
- Channelization (Chapter 910).
- Stationing of ramp connections and channelization.
- Proposed right of way and access control treatment (Chapter 1420).
- Delineation of all crossroads, existing and realigned (Chapter 910).
- Traffic data necessary to justify the proposed design. Include all movements.
- For HOV direct access connections on the left, include the statement that the connection will be used solely by HOVs or will be closed.

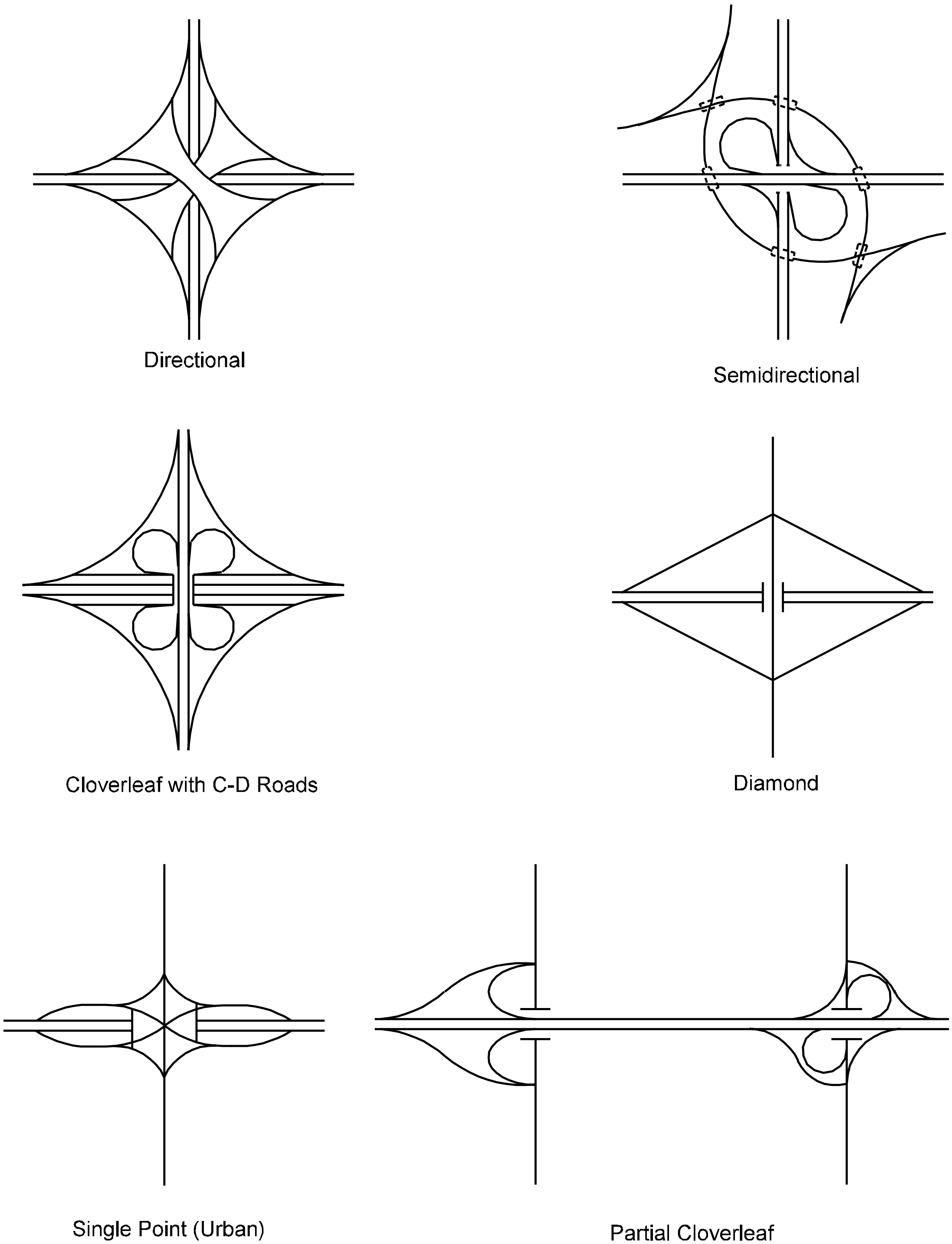
Prepare a preliminary contour grading plan for each completed interchange. Show the desired contours of the completed interchange including details of basic land formation, slopes, graded areas, or other special features. Coordinate the contour grading with the drainage design and the roadside development plan.

Alternative designs considered, studied, and rejected may be shown as reduced scale diagrams with a brief explanation of the advantages and disadvantages of the alternative designs, including the recommended design.

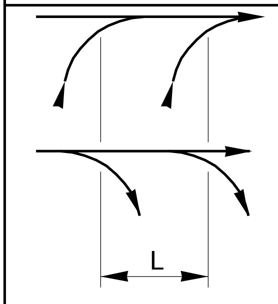
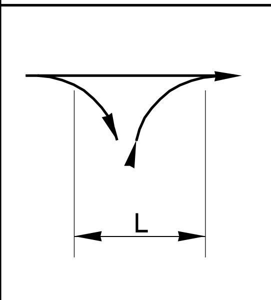
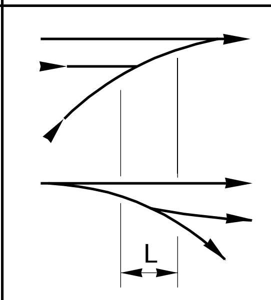
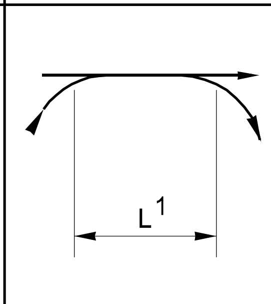
940.10 Documentation

The following documents are to be preserved in the project design documentation file. See Chapter 330.

- ☐ Interchange plan
- ☐ Access Point Decision Report (Chapter 1425)
- ☐ On-connection type justification
- ☐ Off-connection type justification
- ☐ Justification for ramp metering main line speed reduction
- ☐ Weaving analysis and design
- ☐ Alternative discussion and analysis
- ☐ Documentation for acceleration/ deceleration lane length based on a speed less than design speed.



Basic Interchange Patterns
Figure 940-4

On - On or Off - Off		Off - On		Turning Roadways		On - Off (weaving)			
									
Freeway	C-D Road	Freeway	C-D Road	System[2] Interchange	Service[3] Interchange	A	B	C	D
1000	800	500	400	800	600	2000	1600	1600	1000

L = Minimum distance in feet from nose to nose. The nose is the beginning of the unpaved area within the gore for an exit and the ending of the unpaved area for an entrance.

A Between two interchanges connected to a freeway, a system interchange[2] and a service interchange[3].

B Between two interchanges connected to a C-D road, a system interchange[2] and a service interchange[3].

C Between two interchanges connected to a freeway, both service interchanges[3].

D Between two interchanges connected to a C-D road, both service interchanges[3].

Notes:

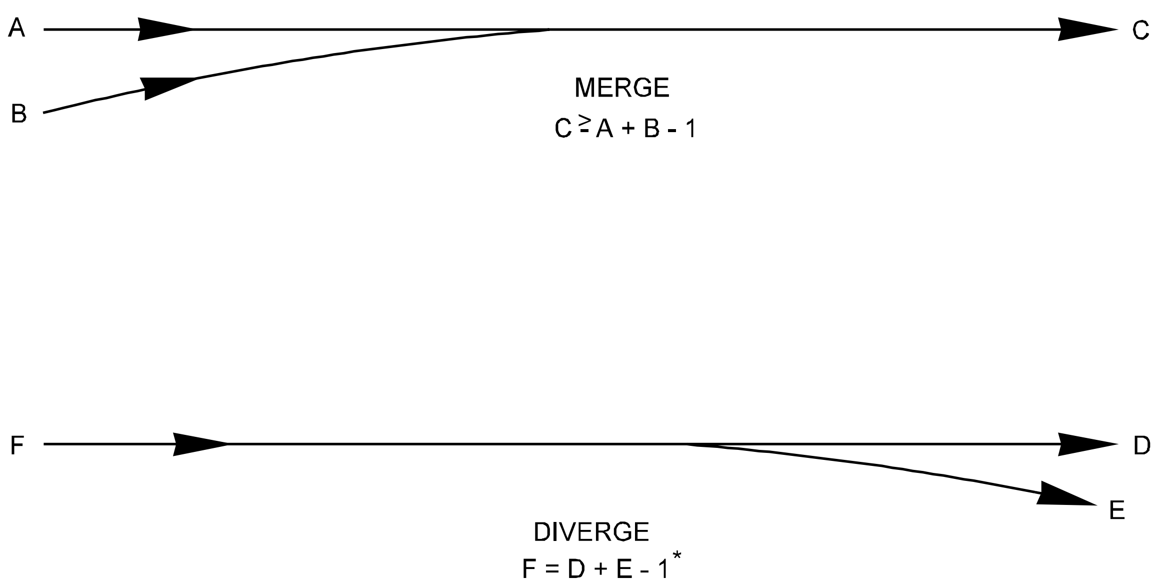
These recommendations are based on operational experience, need for flexibility, and adequate signing. Check them in accordance with Figure 940-15 and the procedures outlined in the *Highway Capacity Manual* and use the larger value.

(1) With justification, these values may be reduced for cloverleaf ramps.

(2) A system interchange is a freeway to freeway interchange.

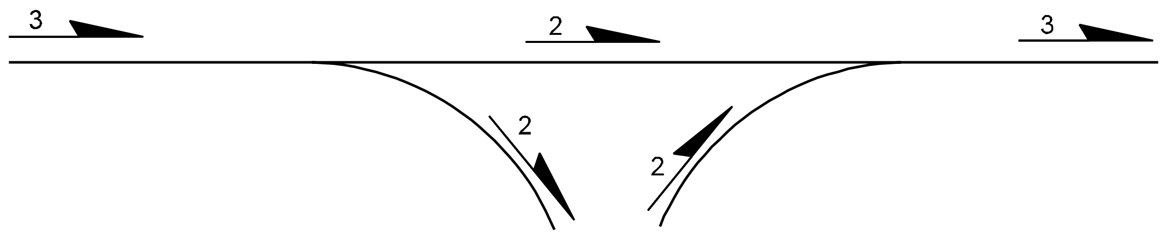
(3) A service interchange is a freeway to local road interchange.

Minimum Ramp Connection Spacing
Figure 940-5

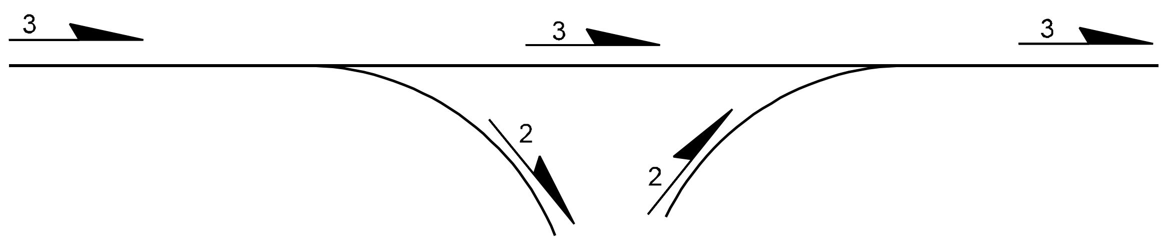


* Number of lanes, F, may be more by one lane only, provided the lane dropped is an auxiliary lane between closely spaced entrance and exit ramps.

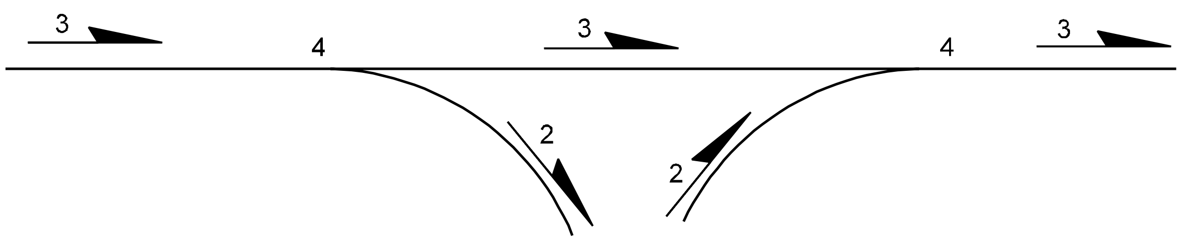
Lane Balance
Figure 940-6a



UNDESIRABLE Lane balance but no compliance with basic number of lanes.

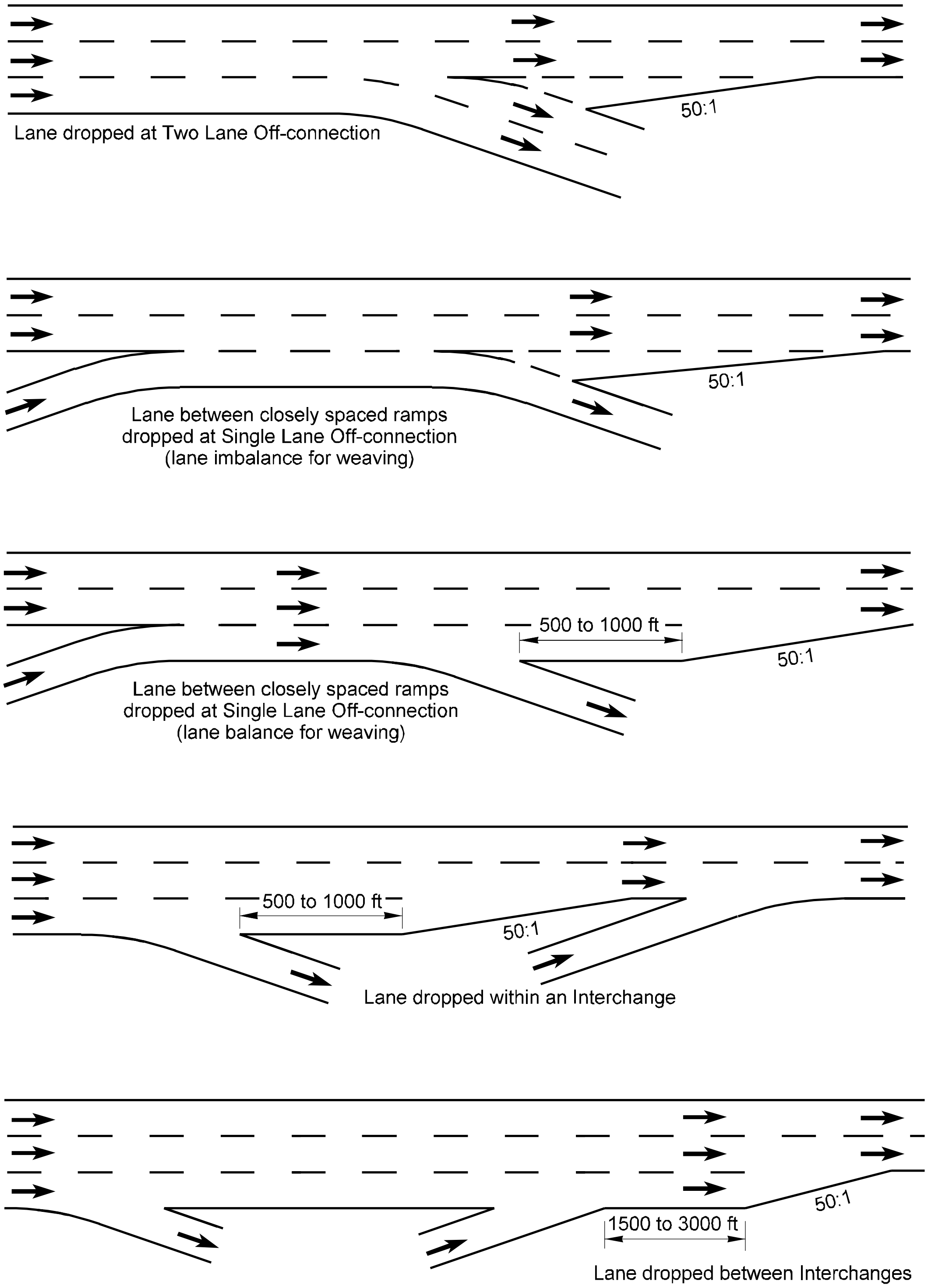


UNDESIRABLE No lane balance but compliance with basic number of lanes.

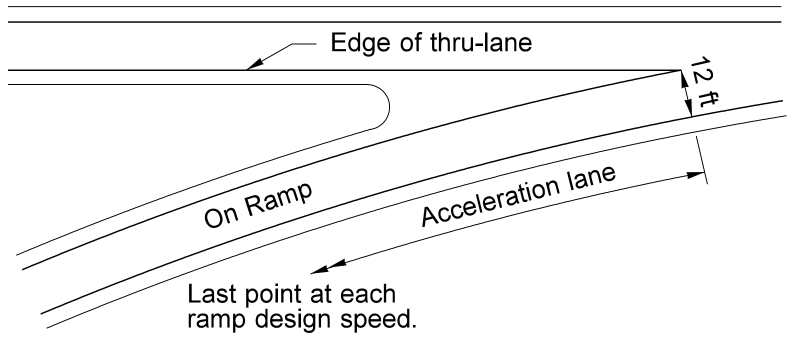


DESIRABLE Compliance with both lane balance and number of lanes.

Lane Balance
Figure 940-6b



Main Line Lane Reduction Alternatives
Figure 940-7



Highway Design Speed (mph)	Ramp Design Speed (mph)										
	0	15	20	25	30	35	40	45	50	60	70
30	180	140									
35	280	220	160								
40	360	300	270	210	120						
45	560	490	440	380	280	160					
50	720	660	610	550	450	350	130				
55	960	900	810	780	670	550	320	150			
60	1200	1140	1100	1020	910	800	550	420	180		
65	1410	1350	1310	1220	1120	1000	770	600	370		
70	1620	1560	1520	1420	1350	1230	1000	820	580	210	
80	2000	1950	1890	1830	1730	1610	1380	1200	970	590	210

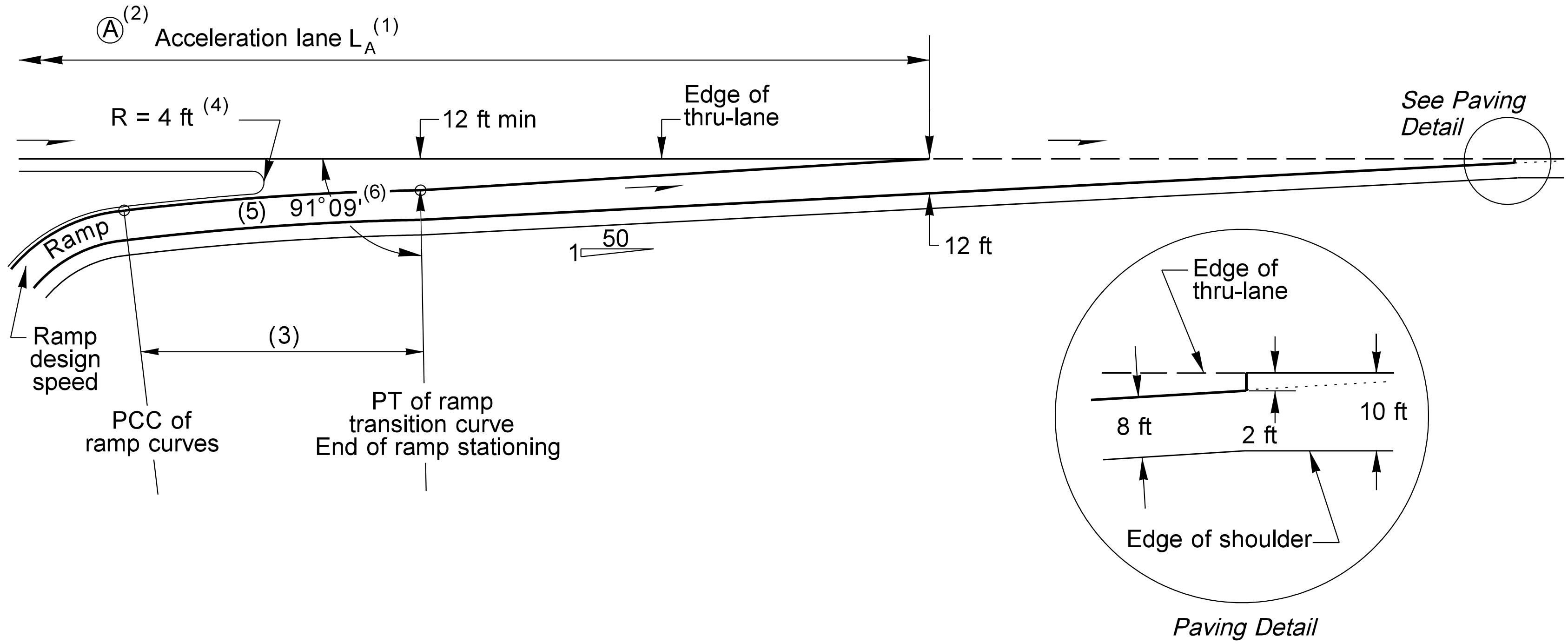
Minimum Acceleration Lane Length (ft)

Highway Design Speed (mph)	Grade	Up Grade				Down Grade
		Ramp Design Speed				All Ramp Design Speeds
		20	30	40	50	
40	3% to less than 5%	1.3	1.3			0.70
45		1.3	1.35			0.675
50		1.3	1.4	1.4		0.65
55		1.35	1.45	1.45		0.625
60		1.4	1.5	1.5	1.6	0.60
70		1.5	1.6	1.7	1.8	0.60
40	5% or more	1.5	1.5			0.60
45		1.5	1.6			0.575
50		1.5	1.7	1.9		0.55
55		1.6	1.8	2.05		0.525
60		1.7	1.9	2.2	2.5	0.50
70		2.0	2.2	2.6	3.0	0.50

Adjustment Factors for Grades Greater than 3%

Acceleration Lane Length

Figure 940-8



Notes:

(1) See Figure 940-8 for acceleration lane length L_A.

(2) Point A is the point controlling the ramp design speed.

(3) A transition curve with a minimum radius of 3,000 ft is desirable. The desirable length is 300 ft. When the main line is on a curve to the left, the transition may vary from a 3,000 ft radius to tangent to the main line.

(4) Radius may be reduced when concrete barrier is placed between the ramp and main line.

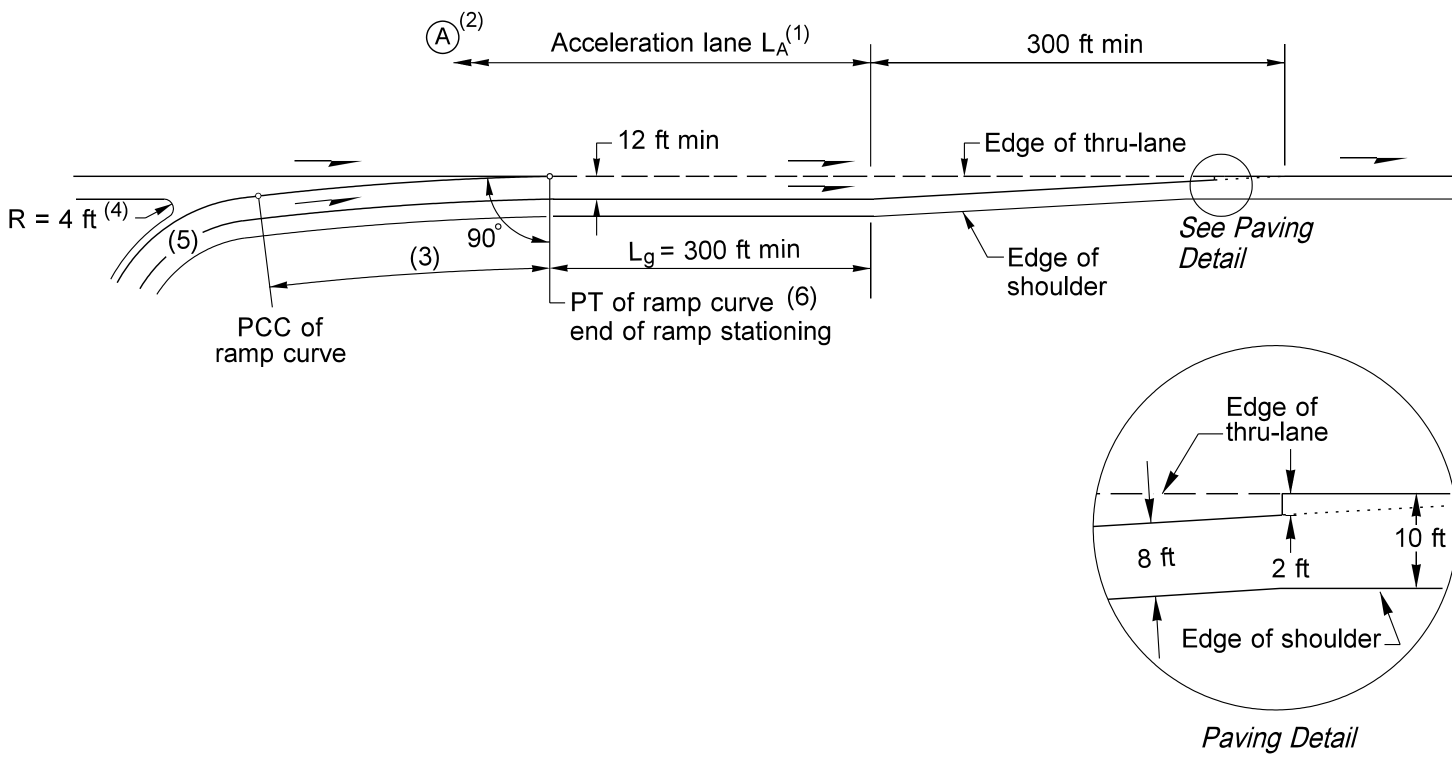
(5) For ramp lane and shoulder widths, see Figure 940-3.

(6) Approximate angle to establish ramp alignment.

(7) For Striping, see the Standard Plans.

On-Connection (Single-Lane, Taper Type)

Figure 940-9a



Notes:

(1) See Figure 940-8 for acceleration lane length L_A.

(2) Point (A) is the point controlling the ramp design speed.

(3) A transition curve with a minimum radius of 3,000 ft is desirable. The desirable length is 300 ft. When the main line is on a curve to the left, the transition may vary from a 3,000 ft radius to tangent to the main line. The transition curve may be replaced by a 50:1 taper with a minimum length of 300 ft.

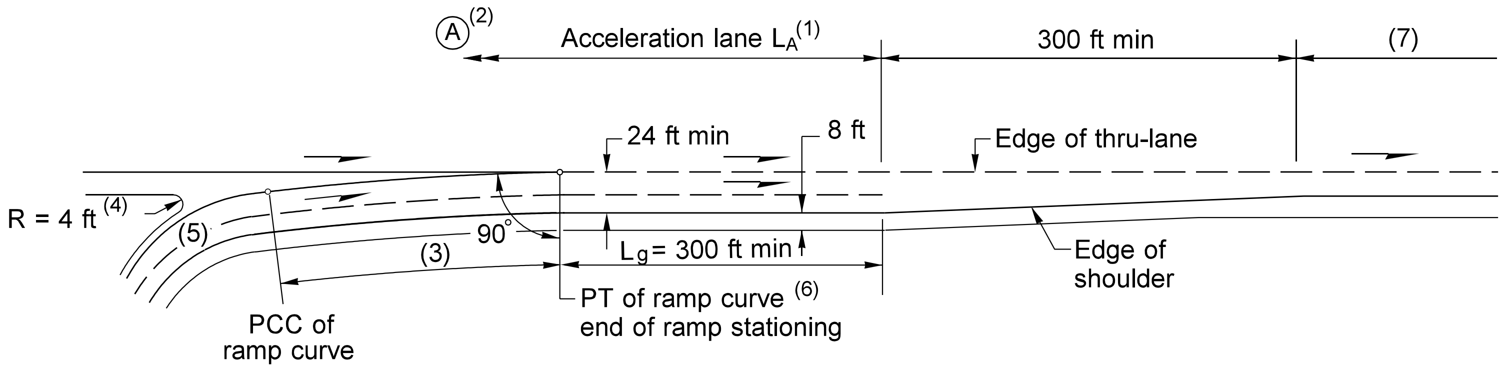
(4) Radius may be reduced when concrete barrier is placed between the ramp and main line.

(5) For ramp lane and shoulder widths, see Figure 940-3.

(6) Ramp stationing may be extended to accommodate superelevation transition.

(7) For striping, see the Standard Plans.

On-Connection (Single-Lane, Parallel Type)
Figure 940-9b



Notes:

(1) See Figure 940-8 for acceleration lane length L_A.

(2) Point Ⓐ is the point controlling the ramp design speed.

(3) A transition curve with a minimum radius of 3,000 ft is desirable. The desirable length is 300 ft. When the main line is on a curve to the left, the transition may vary from a 3,000 ft radius to tangent to the main line. The transition curve may be replaced by a 50:1 taper with a minimum length of 300 ft.

(4) Radius may be reduced when concrete barrier is placed between the ramp and main line.

(5) For ramp lane and shoulder widths, see figure 940-3.

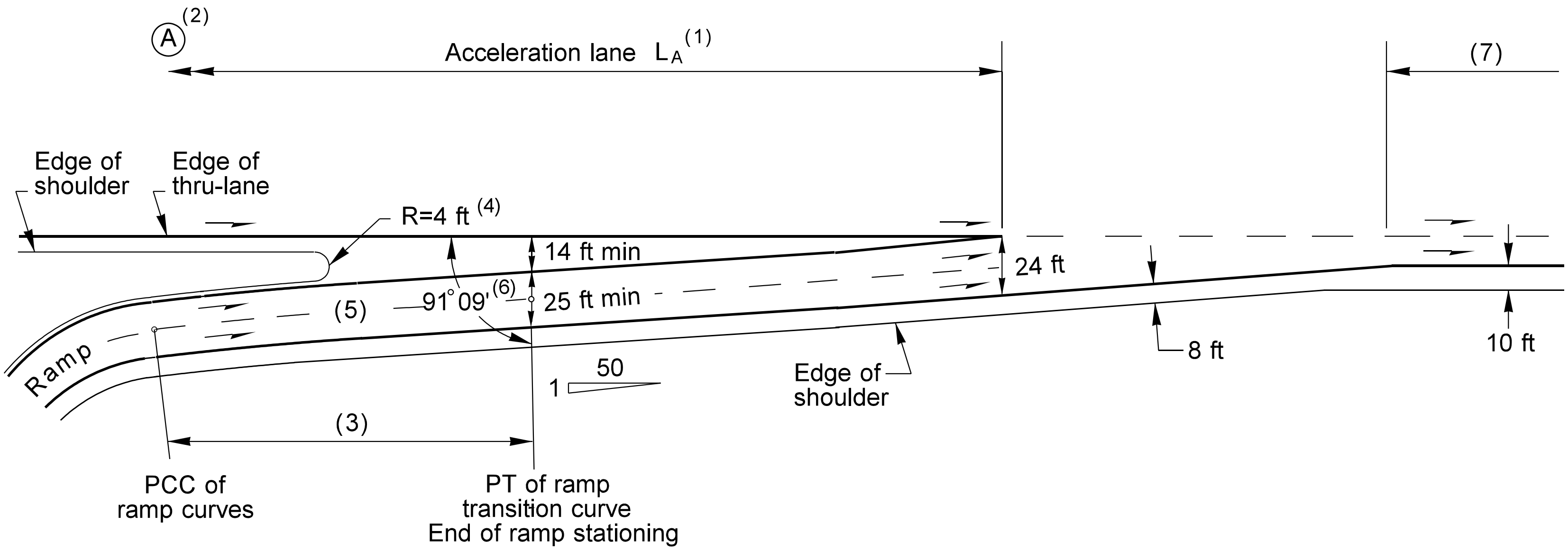
(6) Ramp stationing may be extended to accommodate superelevation transition.

(7) Added lane or 1,500 ft auxiliary lane plus 600 ft taper.

(8) For striping, see the Standard Plans.

On-Connection (Two-Lane, Parallel Type)

Figure 940-9c



Notes:

(1) See Figure 940-8 for acceleration lane length L_A.

(2) Point (A) is the point controlling the ramp design speed.

(3) A transition curve with a minimum radius of 3,000 ft is desirable. The desirable length is 300 ft. When the main line is on a curve to the left, the transition may vary from a 3,000 ft radius to tangent to the main line.

(4) Radius may be reduced when concrete barrier is placed between the ramp and main line.

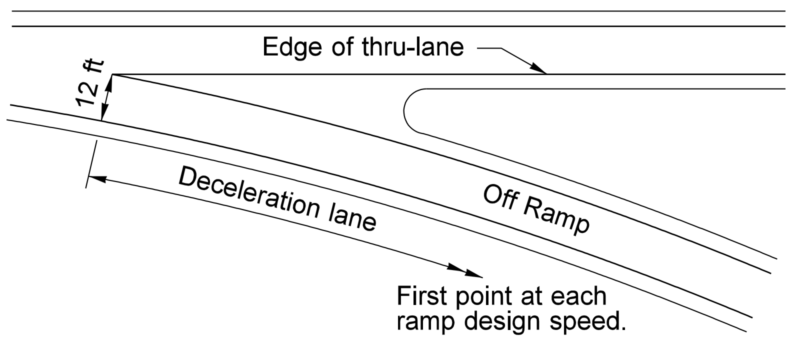
(5) For ramp lane and shoulder widths, see figure 940-3.

(6) Approximate angle to establish ramp alignment.

(7) Added lane or 1,500 ft auxiliary lane plus 600 ft taper.

(8) For striping, see the Standard Plans.

On-Connection (Two-Lane, Taper Type)
Figure 940-9d



Highway Design Speed (mph)	Ramp Design Speed (mph)										
	0	15	20	25	30	35	40	45	50	60	70
30	235	200	170	140							
35	280	250	210	185	150						
40	320	295	265	235	185	155					
45	385	350	325	295	250	220	155				
50	435	405	385	355	315	285	225	175			
55	480	455	440	410	380	350	285	235	180		
60	530	500	480	460	430	405	350	300	240		
65	570	540	520	500	470	440	390	340	280	185	
70	615	590	570	550	520	490	440	390	340	240	
80	735	710	690	670	640	610	555	510	465	360	265

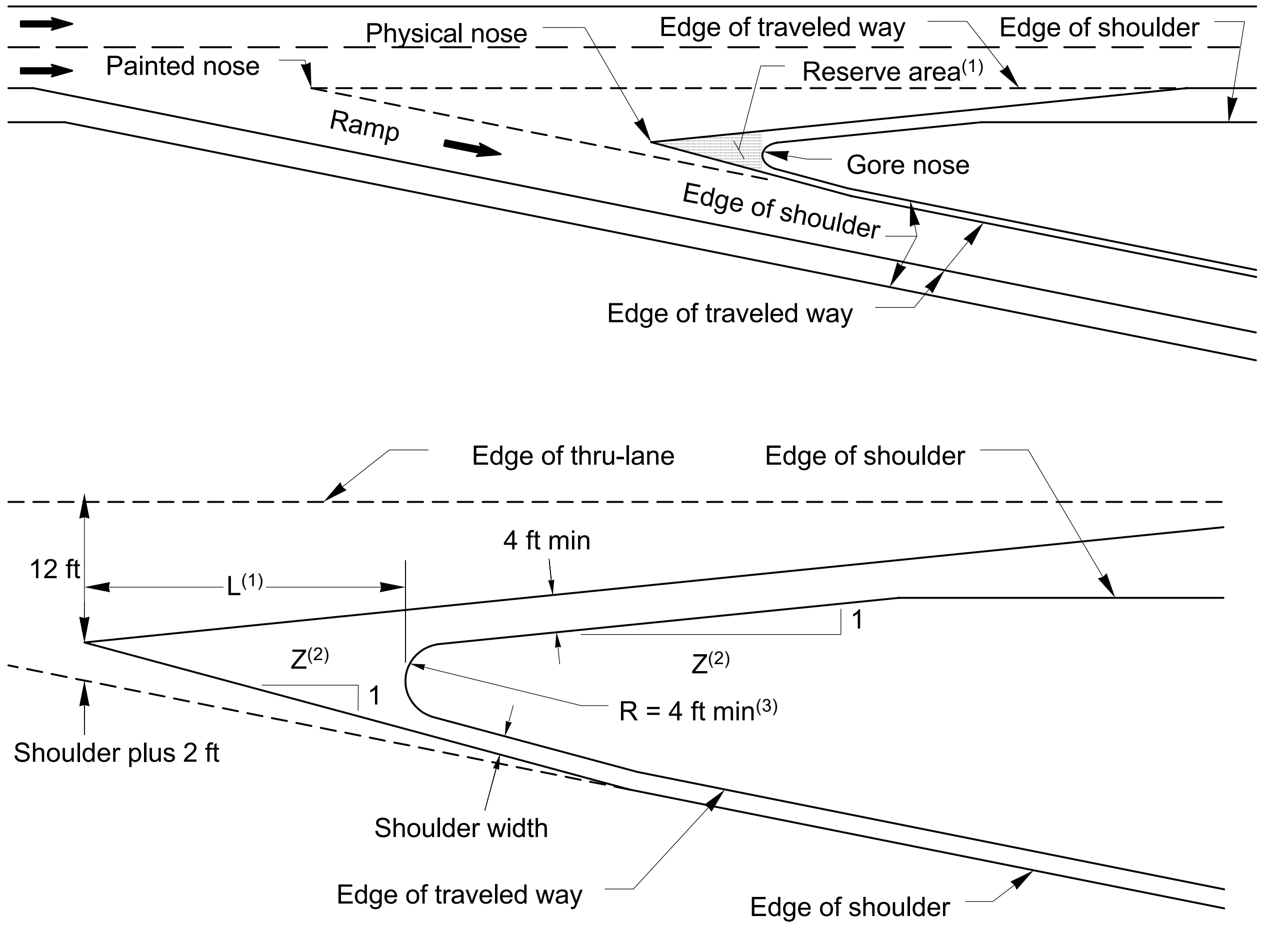
Minimum Deceleration Length (ft)

Grade	Up Grade	Down Grade
3% to less than 5%	0.9	1.2
5% or more	0.8	1.35

Adjustment Factors for Grades Greater than 3%

Deceleration Lane length

Figure 940-10



Single-Lane Off-Connections No Lane Reduction

Notes:

(1) The reserve area length (L) is not less than:

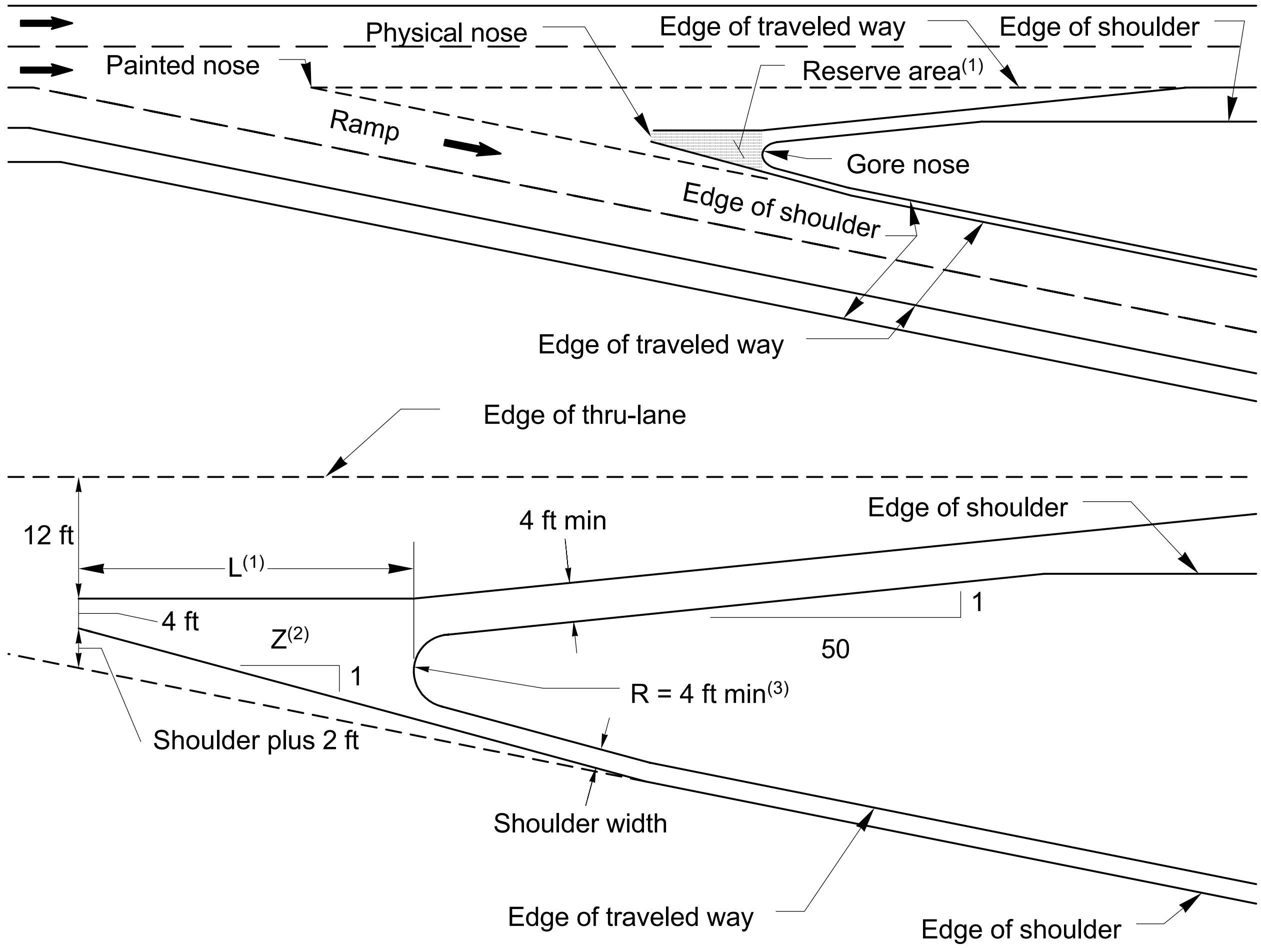
Main Line Design Speed (mph)	40	45	50	55	60	65	70	80
L (ft)	25	30	35	40	45	50	55	70

(2) $Z=\frac{\text{Design Speed}}{2}$, Design speed is for the main line.

(3) R may be reduced, when protected by an impact attenuator.

Gore Area Characteristics

Figure 940-11a



Single-Lane, One-Lane Reduction Off-Connections and All Two-Lane Off-Connections

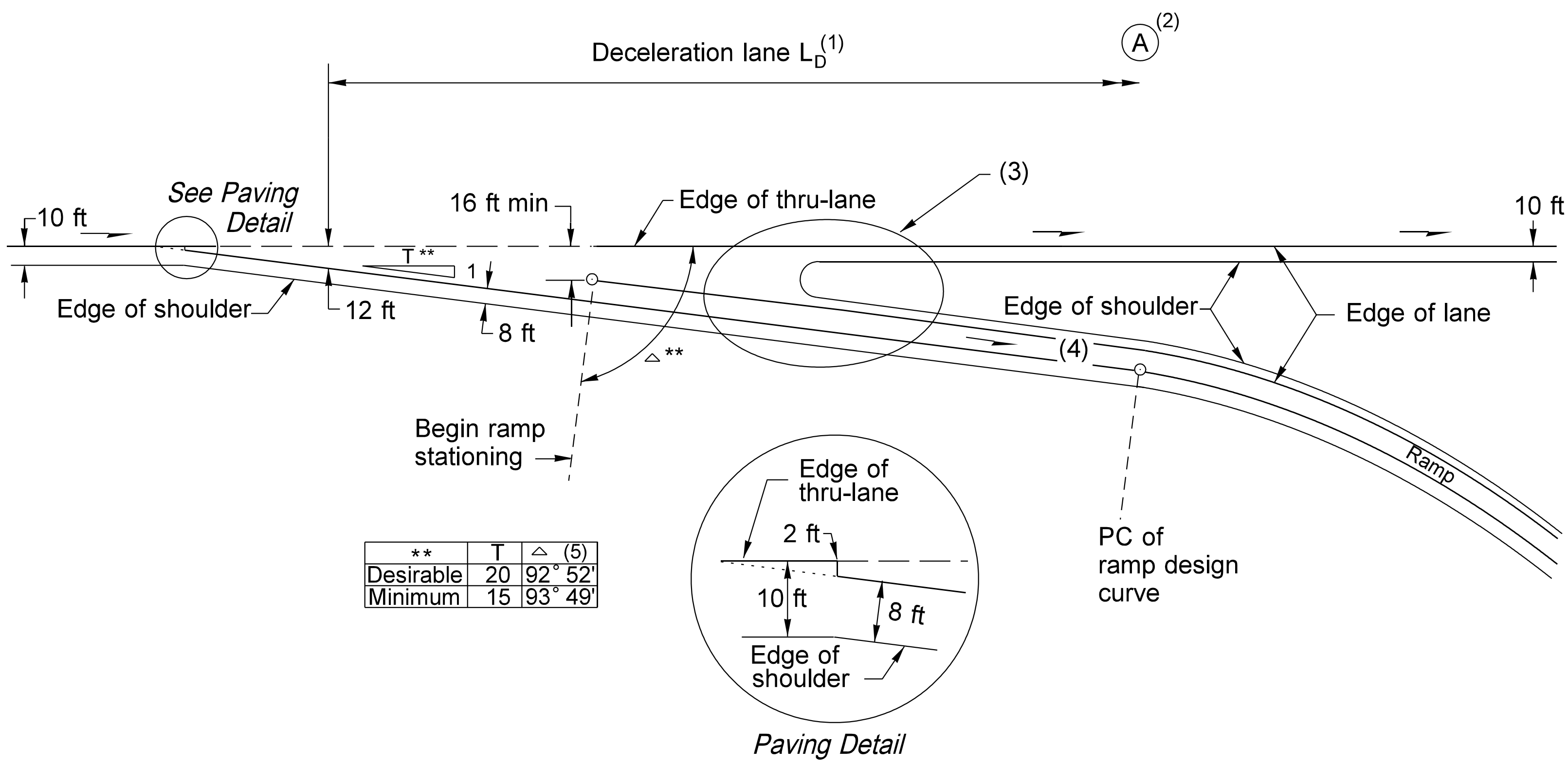
Notes:
(1) The reserve area length (L) is not less than:

Main Line Design Speed (mph)	40	45	50	55	60	65	70	80
L (ft)	25	30	35	40	45	50	55	70

(2) $Z = \frac{\text{Design Speed}}{2}$, Design speed is for the main line.

(3) R may be reduced, when protected by an impact attenuator.

Gore Area Characteristics
Figure 940-11b



**	T	△ (5)
Desirable	20	92° 52'
Minimum	15	93° 49'

Notes:

(1) See Figure 940-10 for deceleration lane length L_D.

(2) Point (A) is the point controlling the ramp design speed.

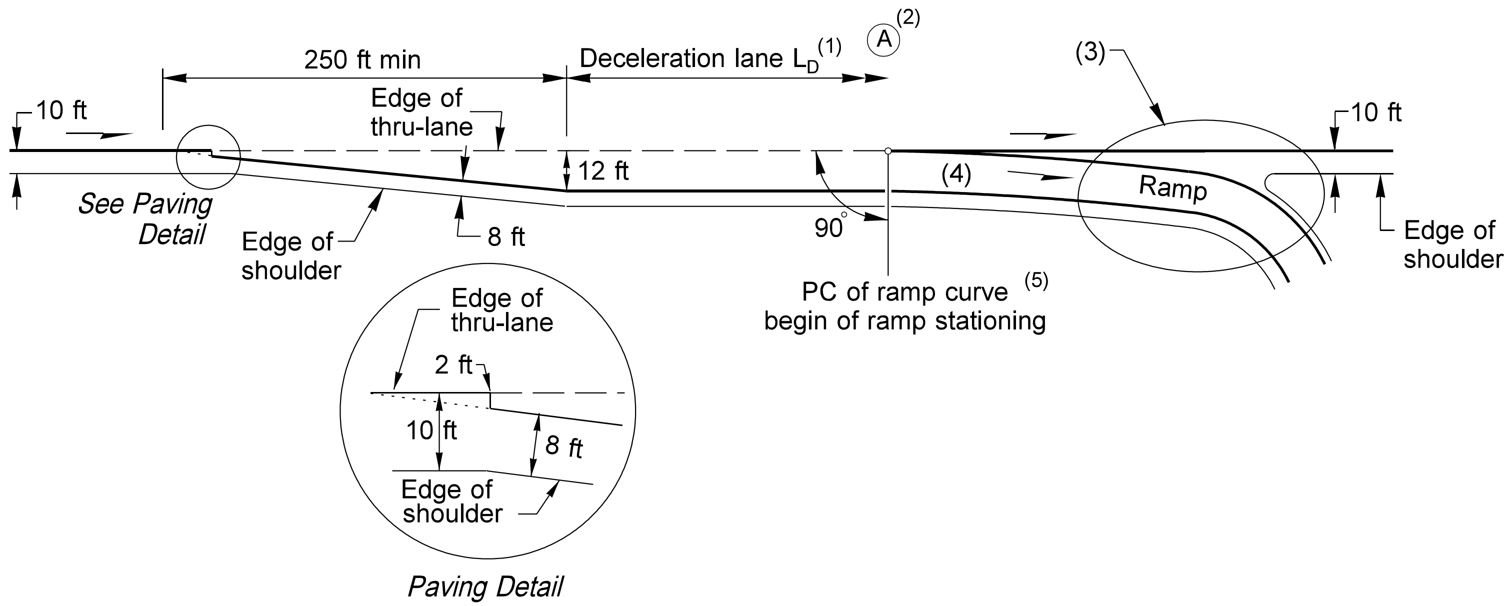
(3) <u>See Figure 940-11a for gore details.</u>

(4) For ramp lane and shoulder widths, see Figure 940-3.

(5) Approximate angle to establish ramp alignment.

(6) For striping, see the Standard Plans.

Off-Connection (Single-Lane, Taper Type)
Figure 940-12a



Notes:

(1) See Figure 940-10 for deceleration lane length L_D.

(2) Point (A) is the point controlling the ramp design speed.

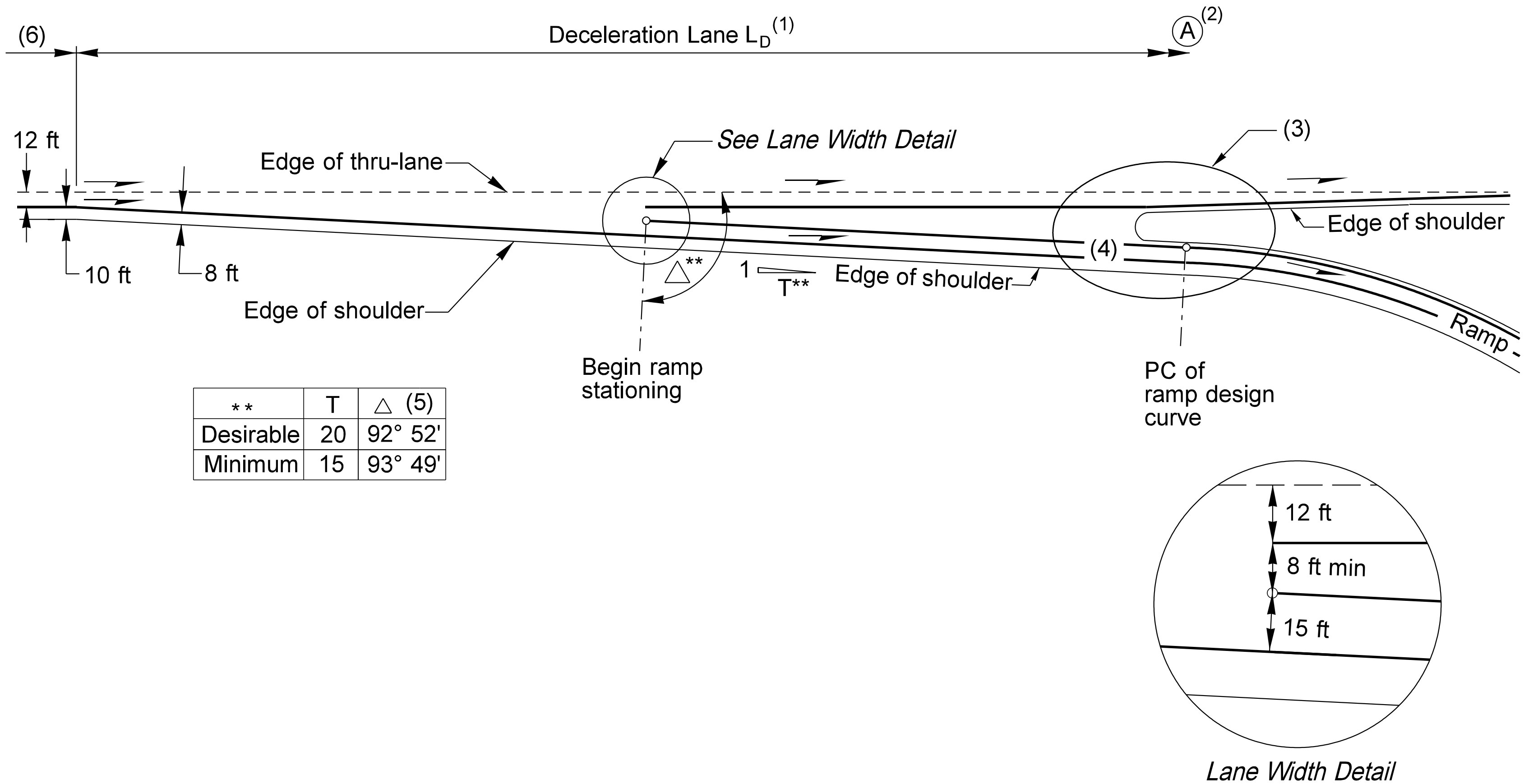
(3) See Figure 940-11a for gore details.

(4) For ramp lane and shoulder widths, see Figure 940-3.

(5) Ramp Stationing may be extended to accommodate superelevation transition.

(6) For striping, see the Standard Plans.

Off-Connection (Single-Lane, Parallel Type)
Figure 940-12b



**	T	△ (5)
Desirable	20	92° 52'
Minimum	15	93° 49'

Notes:

(1) See Figure 940-10 for deceleration lane length L_D.

(2) Point Ⓐ is the point controlling the ramp design speed.

(3) See Figure 940-11b for gore details.

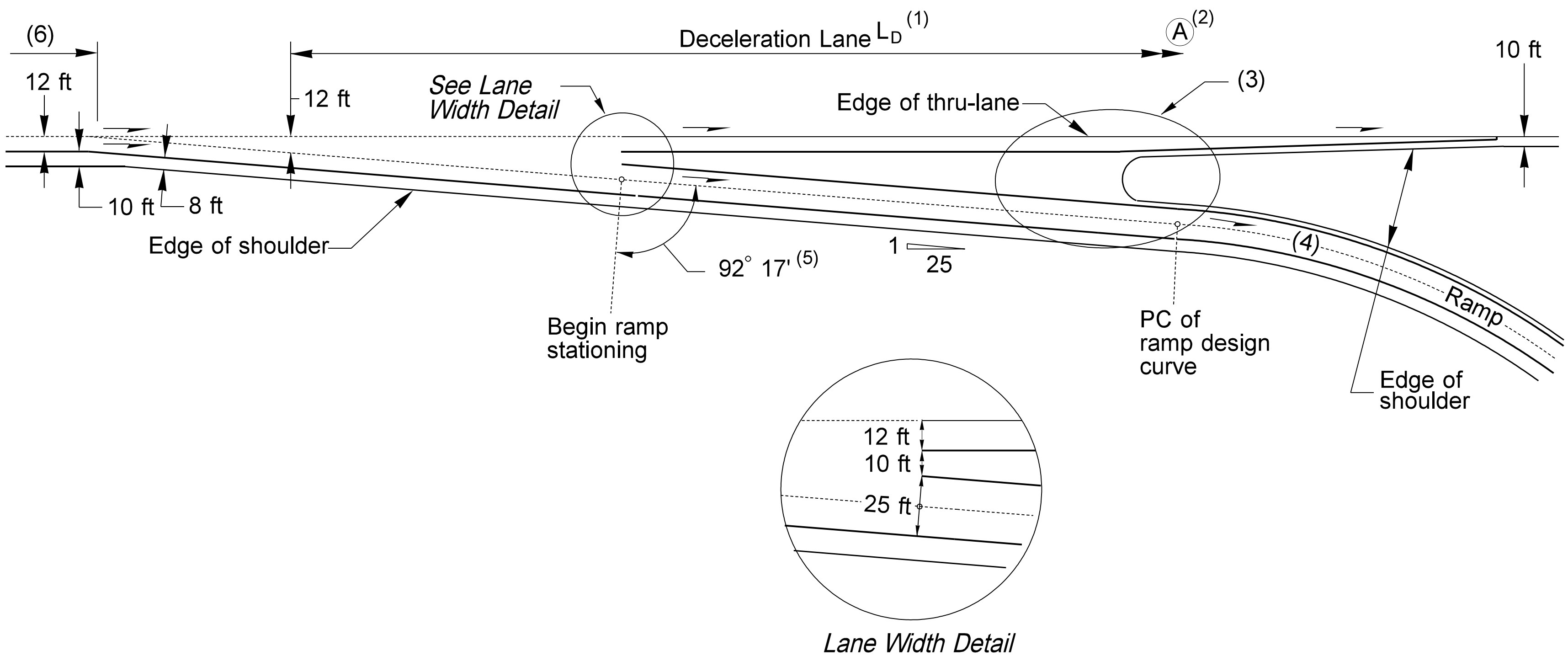
(4) For ramp lane and shoulder widths, see Figure 940-3.

(5) Approximate angle to establish ramp alignment.

(6) Auxiliary lane between closely spaced interchanges to be dropped.

(7) For striping, see the Standard Plans.

Off-Connection (Single-Lane, One-Lane Reduction)
Figure 940-12c



Notes:

(1) See Figure 940-10 for deceleration lane length L_D.

(2) Point (A) is the point controlling the ramp design speed.

(3) See Figure 940-11b for gore details.

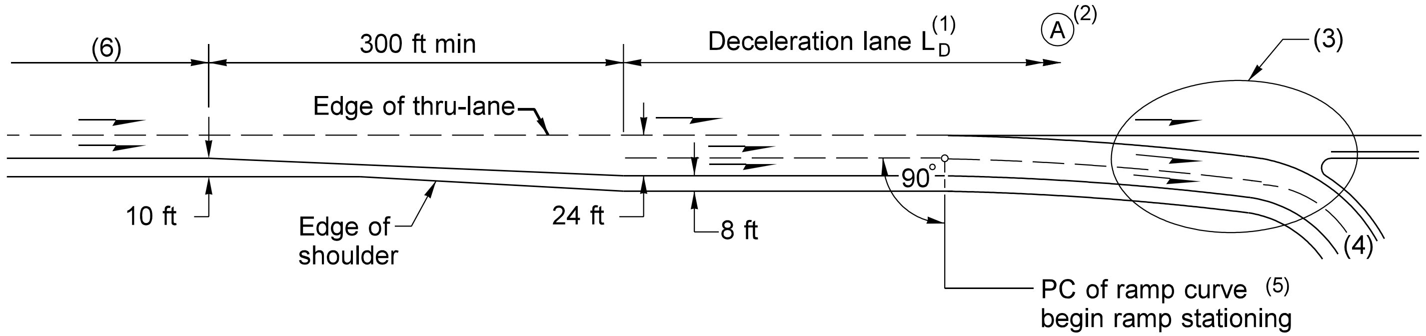
(4) For ramp lane and shoulder widths, see Figure 940-3.

(5) Approximate angle to establish ramp alignment.

(6) Lane to be dropped or auxiliary lane with a minimum length of 1,500 ft with a 300 ft taper.

(7) For striping, see the Standard Plans.

Off-Connection (Two-Lane, Taper Type)
Figure 940-12d



Notes:

(1) See Figure 940-10 for deceleration lane length L_D.

(2) Point (A) is the point controlling the ramp design speed.

(3) See Figure 940-11b for gore details.

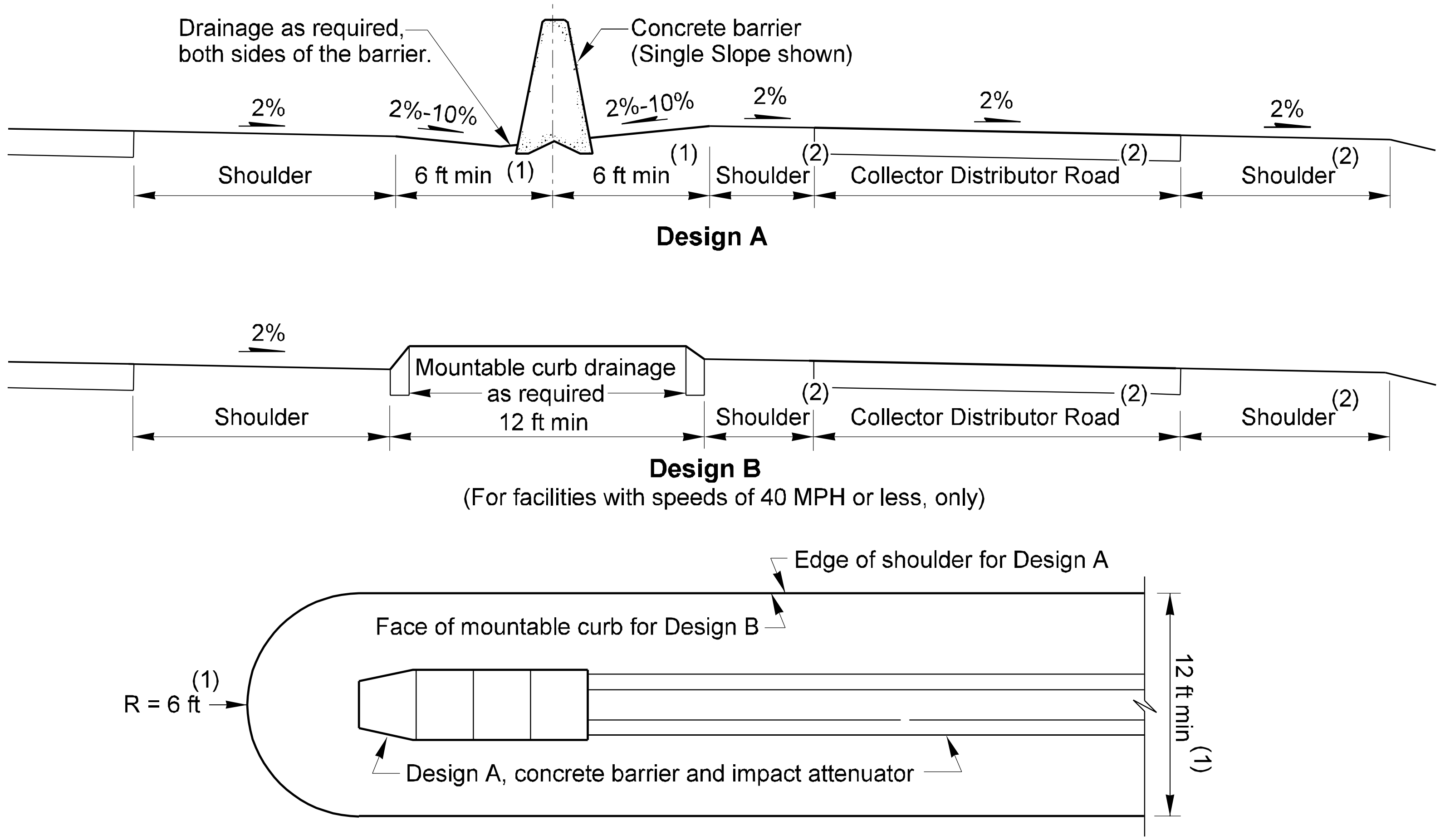
(4) For ramp lane and shoulder widths, see Figure 940-3.

(5) Ramp stationing may be extended to accommodate superelevation transition.

(6) Lane to be dropped or auxiliary lane with a minimum length of 1,500 ft with a 300 ft taper.

(7) For striping, see the Standard Plans.

Off-Connection (Two-Lane, Parallel Type)
Figure 940-12e

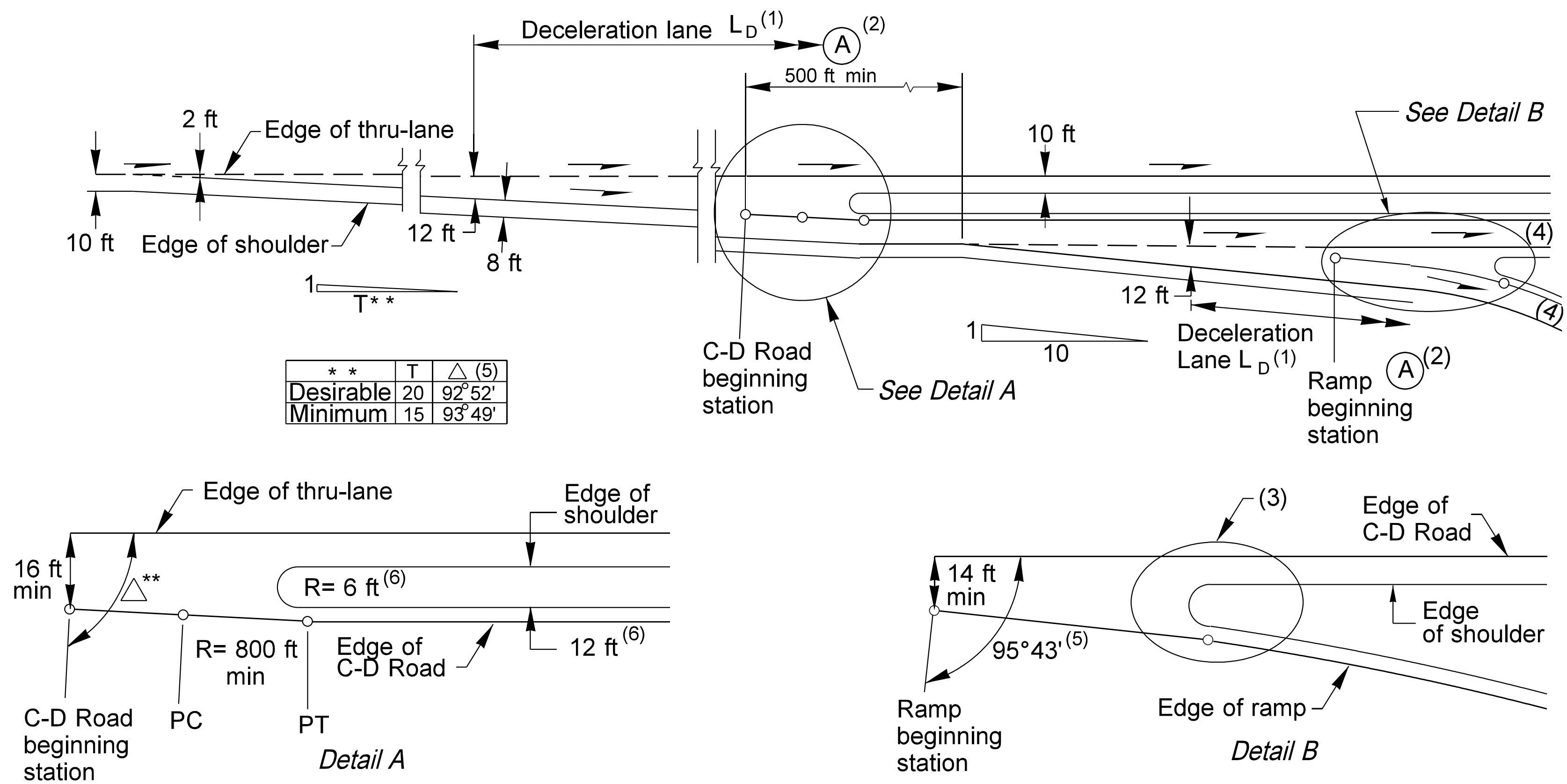


Notes:

(1) With justification, the concrete barrier may be placed with 2 ft between the edge of either shoulder and the face of barrier. The minimum width between the edge of through-shoulder and the edge of C-D road shoulder will be reduced to 6 ft, and the radius at the nose will be reduced to 3 ft.

(2) For collector distributor road lane and shoulder widths, see ramp lane and shoulder widths, Figure 940-3.

Collector Distributor (Outer Separations)
Figure 940-13a



**	T	△ (5)
Desirable	20	92°52'
Minimum	15	93°49'

Notes:

(1) See Figure 940-10 for deceleration lane length L_D.

(2) Point Ⓐ is the point controlling the C-D road or ramp design speed.

(3) See Figure 940-11a for gore details.

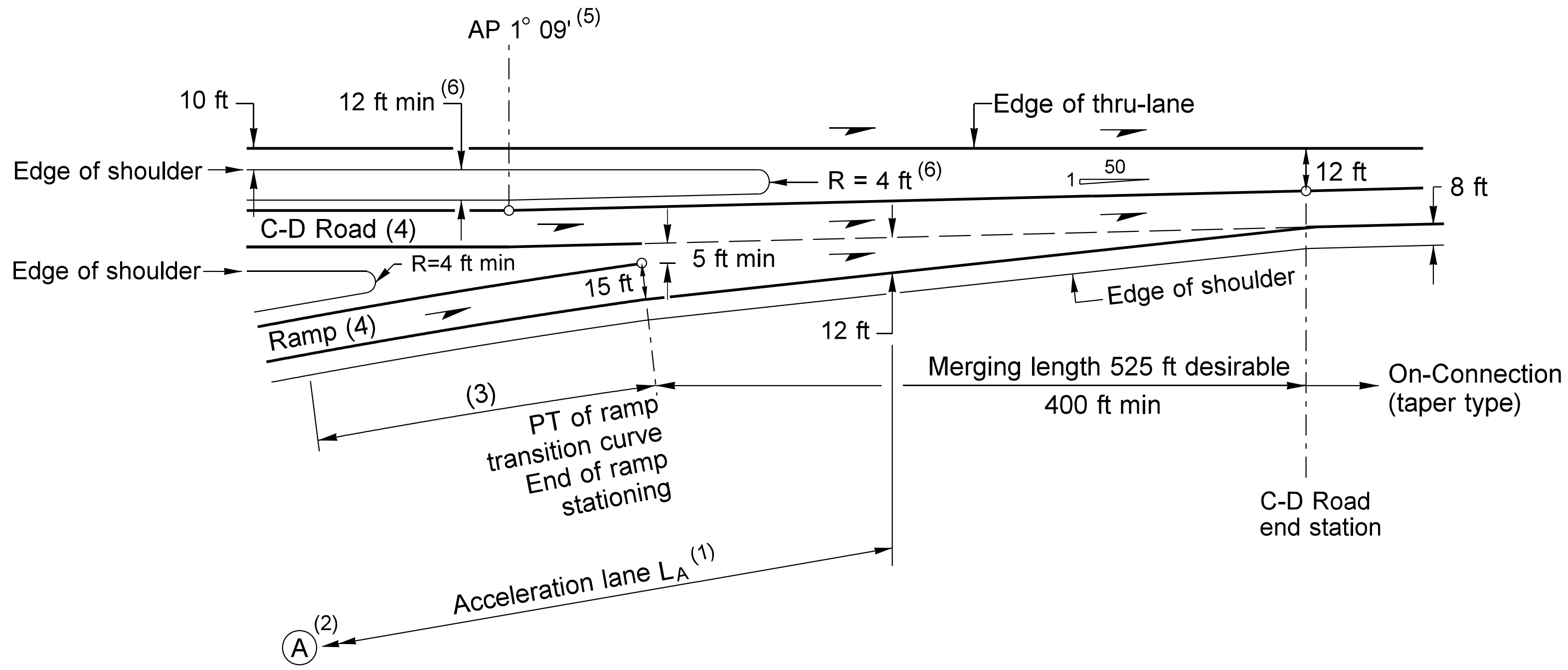
(4) For C-D road and ramp lane and shoulder widths, see Figure 940-3.

(5) Approximate angle to establish alignment.

(6) May be reduced with justification. (See Figure 940-13a.)

(7) For striping, see the Standard Plans.

Collector Distributor (Off-Connections)
Figure 940-13b



Notes:

(1) See Figure 940-8 for acceleration lane length L_A.

(2) Point Ⓐ is the point controlling the ramp design speed.

(3) A transition curve with a minimum radius of 3,000 ft is desirable. The desirable length is 300 ft. When the C-D road is on a curve to the left, the transition may vary from a 3,000 ft radius to tangent to the C-D road.

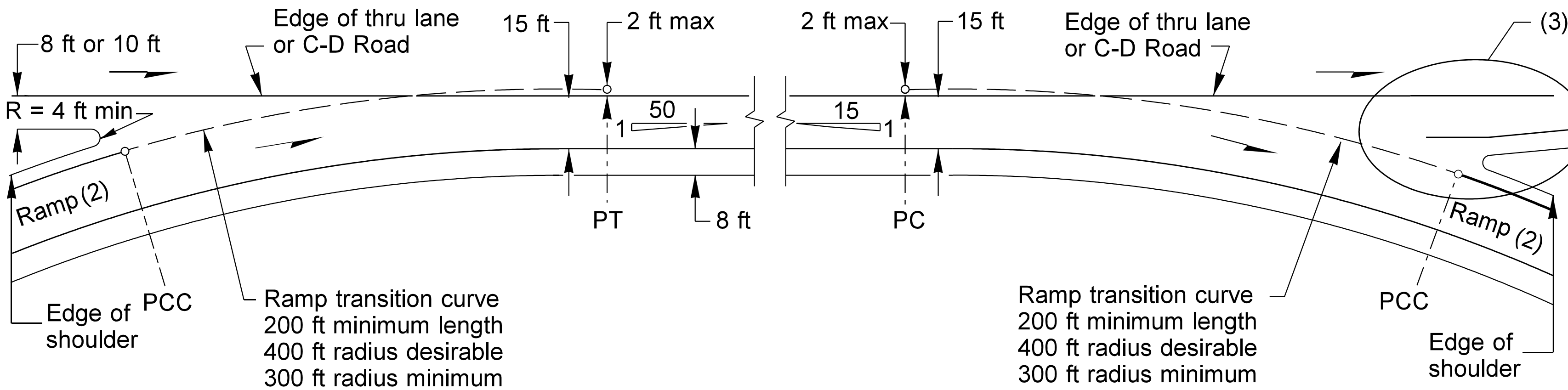
(4) For C-D road and ramp lane and shoulder widths, see Figure 940-3.

(5) Approximate angle to establish alignment.

(6) May be reduced with justification. (See Figure 940-13a.)

(7) For striping, see the Standard Plans.

Collector Distributor (On-Connections)
Figure 940-13c



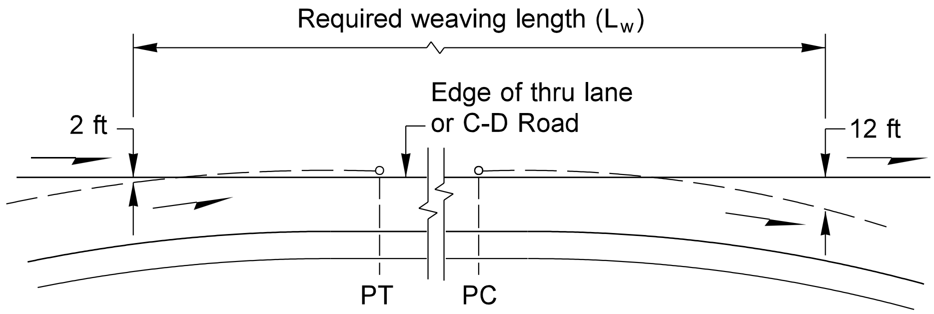
Notes:

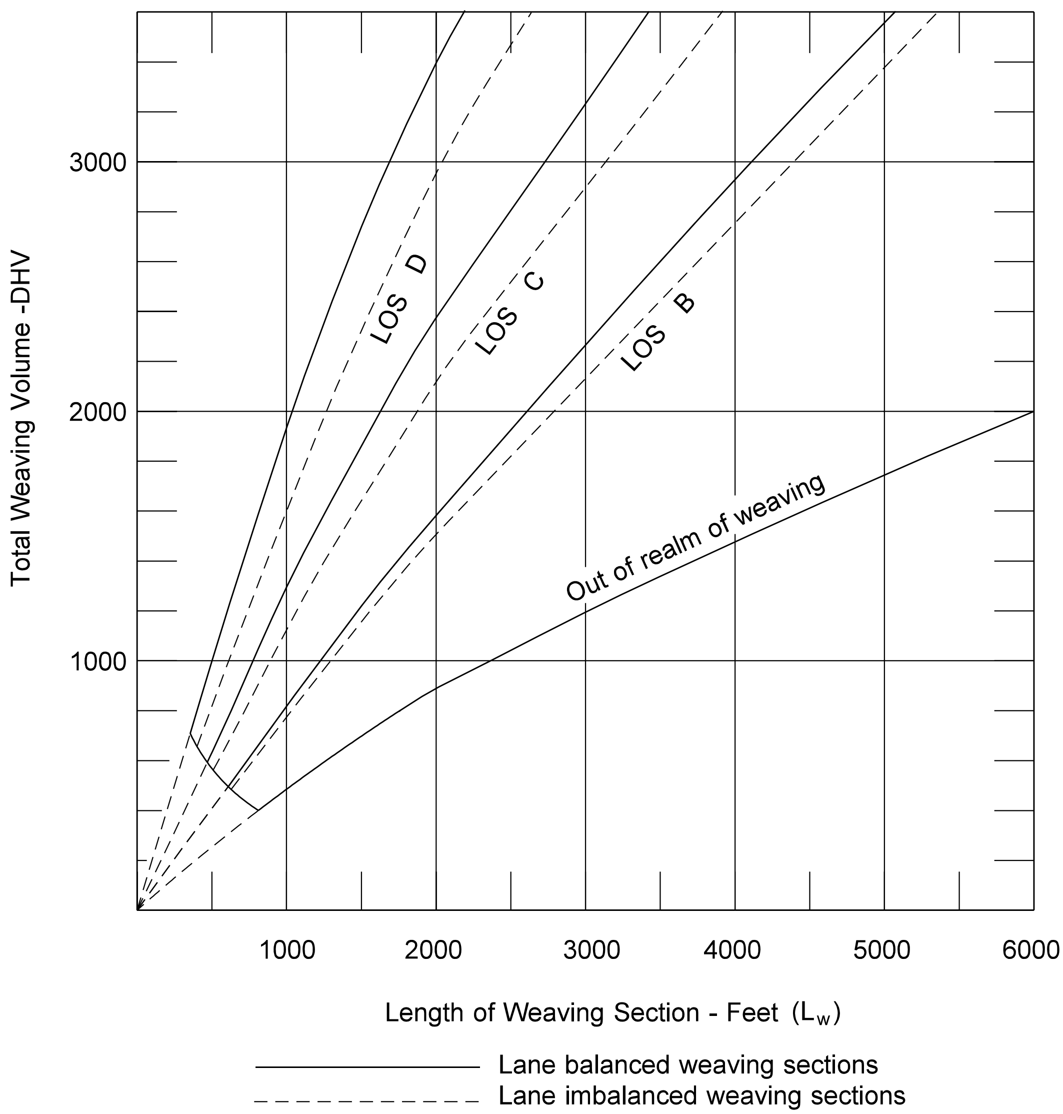
(1) See Figure 940-15 for required minimum weaving length.

(2) For minimum ramp lane and shoulder widths, see Figure 940-3.

(3) See Figure 940-11b for gore details.

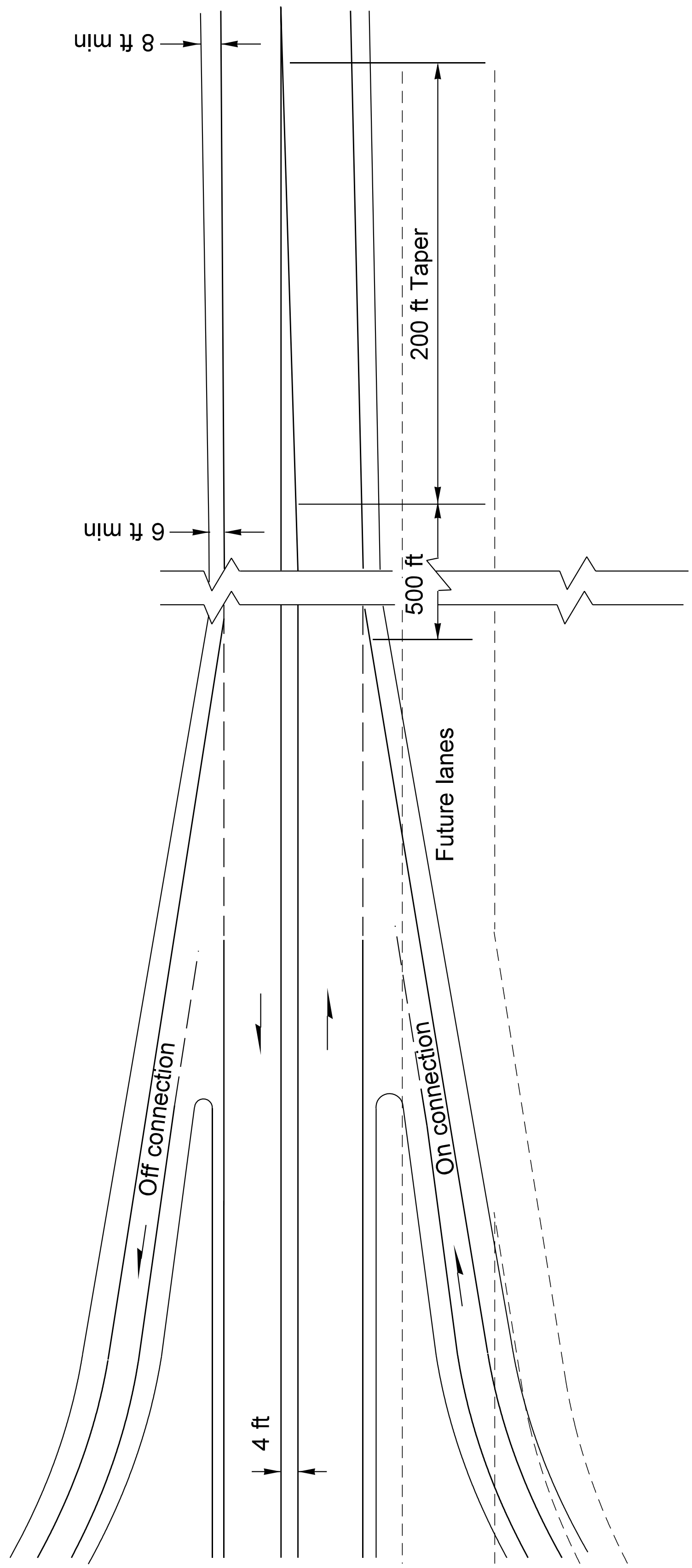
Loop Ramps Connections
Figure 940-14



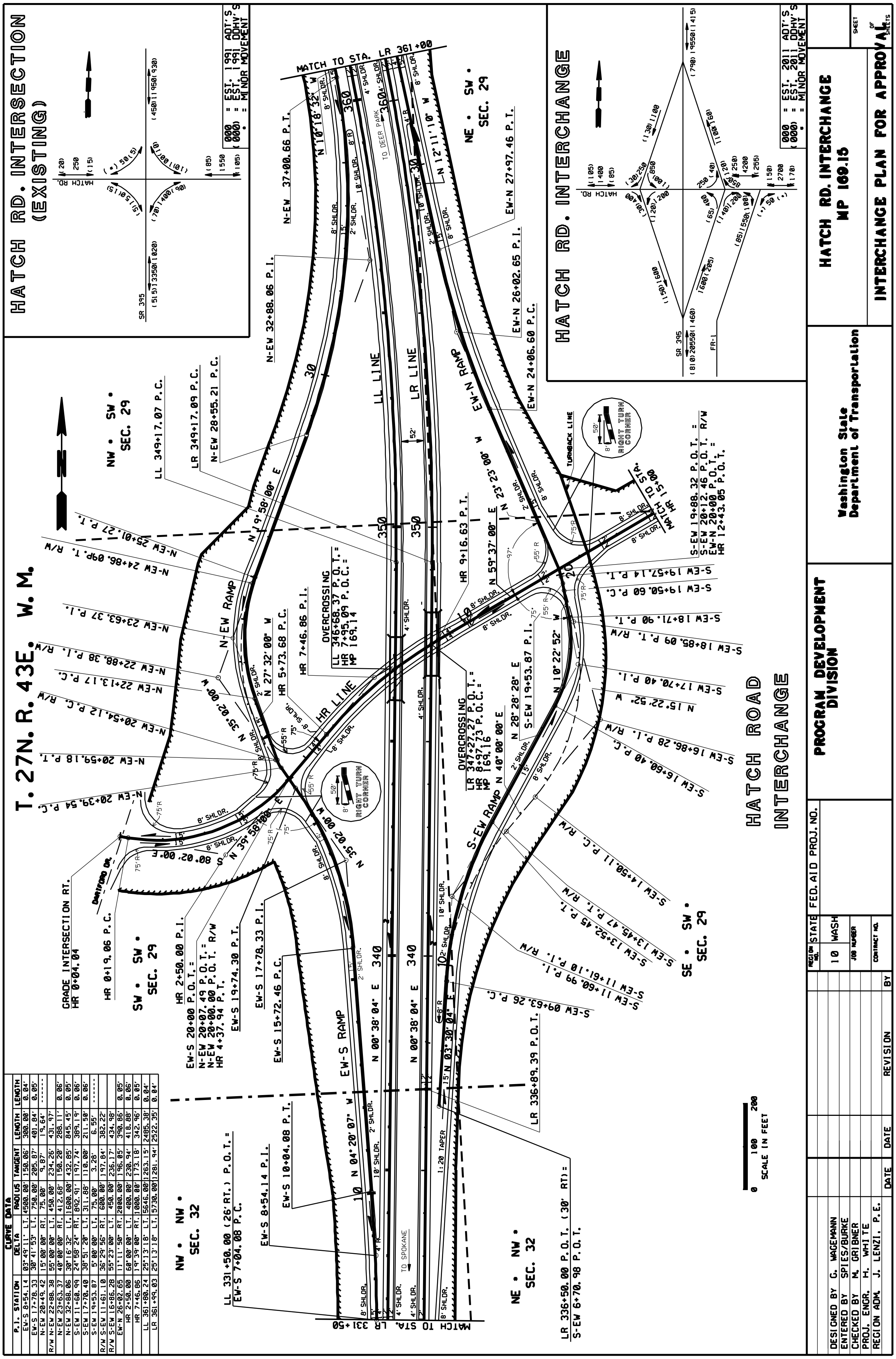


See Figure 940-7 to determine
whether or not lane balance exists

Length of Weaving Sections
Figure 940-15



Temporary Ramps
Figure 940-16



Interchange Plan
Figure 940-17

A	Stopping Sight Distance, S (ft)													
(%)	40	60	80	100	120	140	160	180	200	220	240	260	280	300
2	3	3	3	3	3	3	3	3	3	3	30	70	110	150
3	3	3	3	3	3	3	20	60	100	140	180	220	260	300
4	3	3	3	3	15	55	95	135	175	215	256	300	348	400
5	3	3	3	20	60	100	140	180	222	269	320	376	436	500
6	3	3	10	50	90	130	171	216	267	323	384	451	523	600
7	3	3	31	71	111	152	199	252	311	376	448	526	610	700
8	3	8	48	88	128	174	228	288	356	430	512	601	697	800
9	3	20	60	100	144	196	256	324	400	484	576	676	784	900
10	3	30	70	111	160	218	284	360	444	538	640	751	871	1000
11	3	38	78	122	176	240	313	396	489	592	704	826	958	1100
12	5	45	85	133	192	261	341	432	533	645	768	901	1045	1200
13	11	51	92	144	208	283	370	468	578	699	832	976	1132	1300
14	16	56	100	156	224	305	398	504	622	753	896	1052	1220	1400
15	20	60	107	167	240	327	427	540	667	807	960	1127	1307	1500
16	24	64	114	178	256	348	455	576	711	860	1024	1202	1394	1600
17	27	68	121	189	272	370	484	612	756	914	1088	1277	1481	1700
18	30	72	128	200	288	392	512	648	800	968	1152	1352	1568	1800
19	33	76	135	211	304	414	540	684	844	1022	1216	1427	1655	1900
20	35	80	142	222	320	436	569	720	889	1076	1280	1502	1742	2000
21	37	84	149	233	336	457	597	756	933	1129	1344	1577	1829	2100
22	39	88	156	244	352	479	626	792	978	1183	1408	1652	1916	2200
23	41	92	164	256	368	501	654	828	1022	1237	1472	1728	2004	2300
24	43	96	171	267	384	523	683	864	1067	1291	1536	1803	2091	2400
25	44	100	178	278	400	544	711	900	1111	1344	1600	1878	2178	2500
Minimum Length of Vertical Curve, L (ft)														

$$L = \frac{AS^2}{900} \quad \text{when } S < L$$

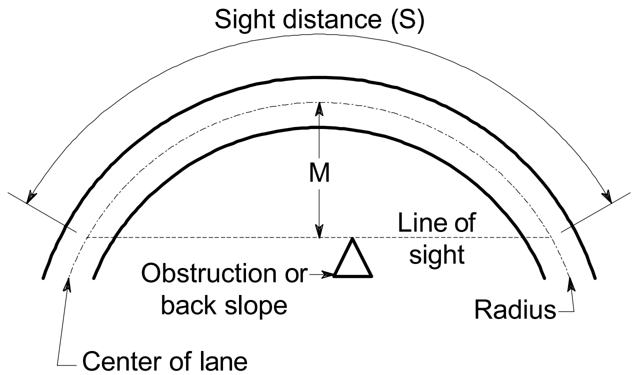
$$L = 2S - \frac{900}{A} \quad \text{when } S < L$$

Where:
S = Stopping sight distance.
A = Algebraic difference in grade.
L = Minimum vertical curve length

Based on an eye height of 4.5 ft and an object height of 0 ft.

Sight Distances for Crest Vertical Curves
Figure 1020-20

Height of eye: 4.50 ft
Height of object: 0.0 ft
Line of sight is normally 2.25 ft above center line of inside lane at point of obstruction provided no vertical curve is present in horizontal curve.



$$M = R\left(1 - \mathrm{COS}\frac{28.65\,S}{R}\right)$$

$$S = \frac{R}{28.65}\left[\mathrm{COS}^{-1}\left(\frac{R-M}{R}\right)\right]$$

$S \leq$ Length of curve
Angle is expressed in degrees

Where:
S = Sight distance in feet
R = Radius of center line inside lane in feet
M = Distance from center line inside lane in feet

R	Stopping Sight Distance, S (ft)													
(ft)	40	60	80	100	120	140	160	180	200	220	240	260	280	300
25	7.6	15.9												
50	3.9	8.7	15.2	23.0	31.9	41.5								
75	2.7	5.9	10.4	16.1	22.7	30.4	38.8	47.8	57.4	67.2				
95	2.1	4.7	8.3	12.9	18.3	24.6	31.7	39.5	47.9	56.9	66.2	75.9	85.8	
125	1.6	3.6	6.3	9.9	14.1	19.1	24.7	31.0	37.9	45.4	53.3	61.7	70.5	79.7
150	1.3	3.0	5.3	8.3	11.8	16.0	20.8	26.2	32.1	38.6	45.5	52.9	60.7	69.0
175	1.1	2.6	4.6	7.1	10.2	13.8	18.0	22.6	27.8	33.4	39.6	46.1	53.1	60.4
200	1.0	2.2	4.0	6.2	8.9	12.1	15.8	19.9	24.5	29.5	34.9	40.8	47.0	53.7
225	0.9	2.0	3.5	5.5	8.0	10.8	14.1	17.8	21.9	26.4	31.2	36.5	42.2	48.2
250	0.8	1.8	3.2	5.0	7.2	9.7	12.7	16.0	19.7	23.8	28.3	33.0	38.2	43.7
275	0.7	1.6	2.9	4.5	6.5	8.9	11.6	14.6	18.0	21.7	25.8	30.2	34.9	39.9
300	0.7	1.5	2.7	4.2	6.0	8.1	10.6	13.4	16.5	19.9	23.7	27.7	32.1	36.7
350	0.6	1.3	2.3	3.6	5.1	7.0	9.1	11.5	14.2	17.1	20.4	23.9	27.6	31.7
400	0.5	1.1	2.0	3.1	4.5	6.1	8.0	10.1	12.4	15.0	17.9	20.9	24.3	27.8
500	0.4	0.9	1.6	2.5	3.6	4.9	6.4	8.1	10.0	12.1	14.3	16.8	19.5	22.3
600	0.3	0.7	1.3	2.1	3.0	4.1	5.3	6.7	8.3	10.1	12.0	14.0	16.3	18.7
700	0.3	0.6	1.1	1.8	2.6	3.5	4.6	5.8	7.1	8.6	10.3	12.0	14.0	16.0
800	0.2	0.6	1.0	1.6	2.2	3.1	4.0	5.1	6.2	7.6	9.0	10.5	12.2	14.0
900	0.2	0.5	0.9	1.4	2.0	2.7	3.6	4.5	5.5	6.7	8.0	9.4	10.9	12.5
1000	0.2	0.4	0.8	1.2	1.8	2.4	3.2	4.0	5.0	6.0	7.2	8.4	9.8	11.2
Minimum Lateral Clearance, M (ft)														

Lateral Clearance on Horizontal Curves
Figure 1020-21

1120.01 General

A bridge is a structure having a clear span of 20 ft or more. Bridge design is the responsibility of the Bridge and Structures Office in Olympia. A project file is required for all bridge construction projects. The Bridge Office develops a preliminary bridge plan for a new or modified structure in collaboration with the region. This chapter provides basic design considerations for the development of this plan. Unique staging requirements, constructibility issues, and other considerations are addressed during the development of this plan. Contact the Bridge Office early in the planning stage on issues that might affect the planned project.

1120.02 References

Bridge Design Manual, M 23-50, WSDOT

Local Agency Guidelines, M 36-63, WSDOT

Manual on Uniform Traffic Control Devices for Streets and Highways (MUTCD), USDOT, Washington DC, 1988, including the Washington State Modifications to the MUTCD, M 24-01, WSDOT, 1996

A Policy on Geometric Design of Highways and Streets, 2001, AASHTO

Traffic Manual, M 51-02, WSDOT

1120.03 Bridge Location

Bridges are located to conform to the alignment of the highway. Providing the following conditions can simplify design efforts, minimize construction activities, and reduce structure costs:

- A perpendicular crossing
- The minimum required horizontal and vertical clearances
- A constant bridge width (without tapered sections)
- A tangential approach alignment of sufficient length to not require superelevation on the bridge
- A crest vertical curve profile that will facilitate drainage
- An adequate construction staging area

1120.04 Bridge Site Design Elements

(1) Structural Capacity

The structural capacity of a bridge is a measure of the structure's ability to carry vehicle loads. For new bridges, the bridge designer chooses the design load that determines the structural capacity. For existing bridges, the structural capacity is calculated to determine the "load rating" of the bridge. The load rating is used to determine whether or not a bridge is "posted" for legal weight vehicles or if the bridge is "restricted" for overweight permit vehicles.

(a) **New Structures.** All new structures that carry vehicular loads are designed to HL-93 notional live load in accordance with AASHTO LRFD Bridge Design Specifications or HS-25 live loading in accordance with the AASHTO Standard Specifications for Highway Bridges.

(b) **Existing Structures.** When the Structural Capacity column of a design matrix applies to the project, request a Structural Capacity Report from the Risk Reduction Engineer in the Bridge and Structures Office at mail stop 47341. The report will state:

- The structural capacity status of the structures within the project limits.
- What action, if any, is appropriate.
- Whether a deficient bridge is included in the six-year or 20 year plans for replacement or rehabilitation under the P2 program and, if so, in which biennium the P2 project is likely to be funded.

Include the Structural Capacity Report in the design documentation file.

The considerations used to evaluate the structural capacity of a bridge are as follows:

1. On National Highway System (NHS) routes (including Interstate routes):

- Operating load rating is at least 36 tons (which is equal to HS-20).
- The bridge is not permanently posted for legal weight vehicles.
- The bridge is not permanently restricted for vehicles requiring overweight permits.

2. On non-NHS routes:

- The bridge is not permanently posted for legal weight vehicles.
- The bridge is not permanently restricted for vehicles requiring overweight permits.

(2) Bridge Widths for Structures

(a) **New Structures.** Full design level widths are provided on all new structures. See Chapter 440. All structures on city or county routes crossing over a state highway must conform to the *Local Agency Guidelines*. Use local city or county adopted and applied criteria when their minimums exceed state criteria.

(b) **Existing Structures.** See the design matrices in Chapter 325 for guidance.

(3) Horizontal Clearance

Horizontal clearance for structures is the distance from the edge of the traveled way to bridge piers and abutments, bridge rail ends, or bridge end embankment slopes. Minimum distances for this clearance vary depending on the type of structure. The *Bridge Design Manual* provides guidance on horizontal clearance.

(4) Medians

For multilane highways, the minimum median widths for new bridges are as shown in Chapters 430 and 440. An open area between two bridges is undesirable when the two roadways are separated by a median width of 26 ft or less. The preferred treatment is to provide a new, single structure that spans the area between the roadways. When this is impractical, consider widening the two bridges on the median sides to reduce the open area to 6 in. When neither option is practical, consider installing netting or other elements to enclose the area between the bridges. Consideration and analysis of all site factors are necessary if installation of netting or other elements is proposed. Document this evaluation in the design documentation file and obtain the approval of the State Design Engineer.

(5) Vertical Clearance

Vertical clearance is the critical height under a structure that will safely accommodate vehicular and rail traffic based on its design characteristics. This height is the least height available from the lower roadway surface (including usable shoulders), or the plane of the top of the rails, to the bottom of the bridge. Usable shoulders are the design shoulders for the roadway and do not include paved widened areas that may exist under the structure.

(a) **Minimum Clearance for New Structures.** For new structures, the minimum vertical clearances are as follows:

1. A bridge over a roadway. The minimum vertical clearance is 16.5 ft.

2. A bridge over a railroad track. The minimum vertical clearance is 23.5 ft. Vertical clearance is provided for the width of the railroad freight car. (See Figure 1120-2a.) Coordinate railroad clearance issues with the WSDOT Railroad Liaison Engineer.

3. A pedestrian bridge over a roadway. The minimum vertical clearance is 17.5 ft.

(b) **Minimum Clearance for Existing Structures.** The criteria used to evaluate the vertical clearance of existing structures depends on the work that is being done on or under that structure. When evaluating an existing structure on the Interstate system, see 1120.04(5)(d) "Coordination." This guidance applies to bridge clearances over state highways and under state highways at interchanges. For state highways over local roads and streets, city or county vertical clearance requirements may be used as minimum design criteria. See Figure 1120-1 for a table of bridge vertical clearances.

1. For a project that will widen an existing structure over a highway or where the highway will be widened under an existing structure, the vertical clearance can be as little as 16.0 ft on the Interstate System or other freeways, or 15.5 ft on nonfreeway routes. An approved deviation is required for clearance less than 16.0 ft on Interstate routes or other freeways, and 15.5 ft on nonfreeway routes.

2. For a planned resurfacing of the highway under an existing bridge, if the clearance will be less than 16.0 ft on the Interstate System or other freeways and 15.5 ft on nonfreeway routes, evaluate the following options and include in a deviation request:

- Pavement removal and replacement.
- Roadway excavation and reconstruction to lower the profile of the roadway.
- Providing a new bridge with the required vertical clearance.

Reducing roadway paving and surfacing thickness under the bridge to achieve the minimum vertical clearance can cause accelerated deterioration of the highway and is not recommended. Elimination of the planned resurfacing in the immediate area of the bridge might be a short term solution if recommended by the region's Materials Engineer. Solutions that include milling the existing surface followed by overlay or inlay must be approved by the region's Materials Engineer to ensure that adequate pavement structure is provided.

3. For other projects that include an existing bridge where no widening is proposed on or under the bridge, and the project does not affect vertical clearance, the clearance can be as little as 14.5 ft. For these projects, document the clearance to the design documentation file.

4. For an existing structure over a railroad track, the vertical clearance can be as little as 22.5 ft. (See Figure 1120-2b.) A lesser clearance can be used with the agreement of the railroad company and the Washington State Utilities and Transportation Commission. Coordinate railroad clearance issues with the WSDOT Railroad Liaison Engineer.

(c) **Signing.** Low clearance warning signs are necessary when the vertical clearance of an existing bridge is less than 15 ft 3 in. Other requirements for low clearance signing are contained in the Manual on Uniform Traffic Control Devices and the Traffic Manual.

(d) **Coordination.** The Interstate system is used by the Department of Defense (DOD) for the conveyance of military traffic. The Military Traffic Management Command Transportation Engineering Agency (MTMCTEA) represents the DOD in public highway matters. The MTMCTEA has an inventory of vertical clearance deficiencies over the Interstate system in Washington State. Contact the MTMCTEA, through FHWA, if any of the following changes are proposed to these bridges:

- A project would create a new deficiency of less than 16.0 ft vertical clearance over an Interstate highway.
- The vertical clearance over the Interstate is already deficient (less than 16.0 ft) and a change (increase or decrease) to vertical clearance is proposed.

Coordination with MTMCTEA is required for these changes on all rural Interstate highways and for one Interstate route through each urban area.

Project Type	Vertical Clearance	Documentation Requirement (see notes)
Interstate and Other Freeways [1]		
New Bridge	> 16.5 ft	2
Widening Over or Under Existing Bridge	> 16 ft	2
	< 16 ft	4
Resurfacing Under Existing Bridge	> 16 ft	2
	< 16 ft	4
Other with No Change to Vertical Clearance	>14.5	3
	<14.5	4
Nonfreeway Routes		
New Bridge	>16.5 ft	2
Widening Over or Under Existing Bridge	>15.5 ft	2
	<15.5 ft	4
Resurfacing Under Existing Bridge	>15.5 ft	2
	<15.5 ft	4
Other with No Change to Vertical Clearance	> 14.5 ft	3
	< 14.5 ft	4
Bridge Over Railroad Tracks[7]		
New Bridge	> 23.5 ft	2
Existing Bridge	> 22.5 ft < 22.5 ft	2 4, 5
Pedestrian Bridge Over Roadway		
New Bridge	> 17.5 ft	2
Existing Bridge		6

Notes:
1. Applies to all bridge vertical clearances over highways and under highways at interchanges
2. No documentation required
3. Document to design documentation file
4. Approved deviation required
5. Requires written agreement between railroad company and Washington State Utilities and Transportation Commission
6. Use the same criteria as other existing bridges previously listed in the figure
7. See Figure 1120-2a and 2b

Bridge Vertical Clearances
Figure 1120-1

(6) Bridge Approach Slab

Bridge approach slabs are reinforced concrete pavement installed across the full width of the bridge ends. They provide a stable transition from normal roadway cross section to the bridge ends and compensate for differential expansion and contraction of the bridge and the roadway. Bridge approach slabs are provided on all new bridges. If an existing bridge is being widened and it has an approach slab, slabs are required on the widenings. The region, with the concurrence of the State Geotechnical Engineer and the State Bridge Engineer, may decide to omit bridge approach slabs.

(7) Pedestrian and Bicycle Facilities

When pedestrians or bicyclists are anticipated on bridges, provide facilities consistent with guidance in Chapters 1020 and 1025.

(8) Bridge Rail End Treatment

Plans for new bridge construction and bridge rail modifications include provisions for the connection of traffic barriers to the bridge rail. Indicate the preferred traffic barrier type and connection during the review of the bridge preliminary plan.

(9) Bridge Slope Protection

Slope protection provides a protective and aesthetic surface for exposed slopes under bridges. Slope protection is normally provided under:

- Structures over state highways
- Structures within an interchange
- Structures over other public roads unless requested otherwise by the public agency
- Railroad overcrossings, if requested by the railroad

Slope protection is usually not provided under pedestrian structures. The type of slope protection is selected at the bridge preliminary plan stage. Typical slope protection types are concrete slope protection, semi-open concrete masonry, and rubble stone.

(10) Slope Protection at Watercrossings

The WSDOT Headquarters (HQ) Hydraulics Branch determines the slope protection requirements for structures that cross waterways. The type, limits, and quantity of the slope protection are shown on the bridge preliminary plan.

(11) Protective Screening for Highway Structures

The Washington State Patrol classifies the throwing of an object from a highway structure as an assault, not an accident. Therefore, records of these assaults are not contained in the Patrol's accident databases. Contact the region's Maintenance Engineer's office and the Washington State Patrol for the history of reported incidents.

Protective screening might reduce the number of incidents but will not stop a determined individual. Enforcement provides the most effective deterrent.

Installation of protective screening is analyzed on a case-by-case basis at the following locations:

- On existing structures where there is a history of multiple incidents of objects being dropped or thrown and enforcement has not changed the situation.
- On a new structure near a school, a playground, or where frequently used by children not accompanied by adults.
- In urban areas, on a new structure used by pedestrians where surveillance by local law enforcement personnel is not likely.
- On new structures with walkways where experience on similar structures within a 1 mile radius indicates a need.
- On structures over private property that is subject to damage, such as buildings or power stations.

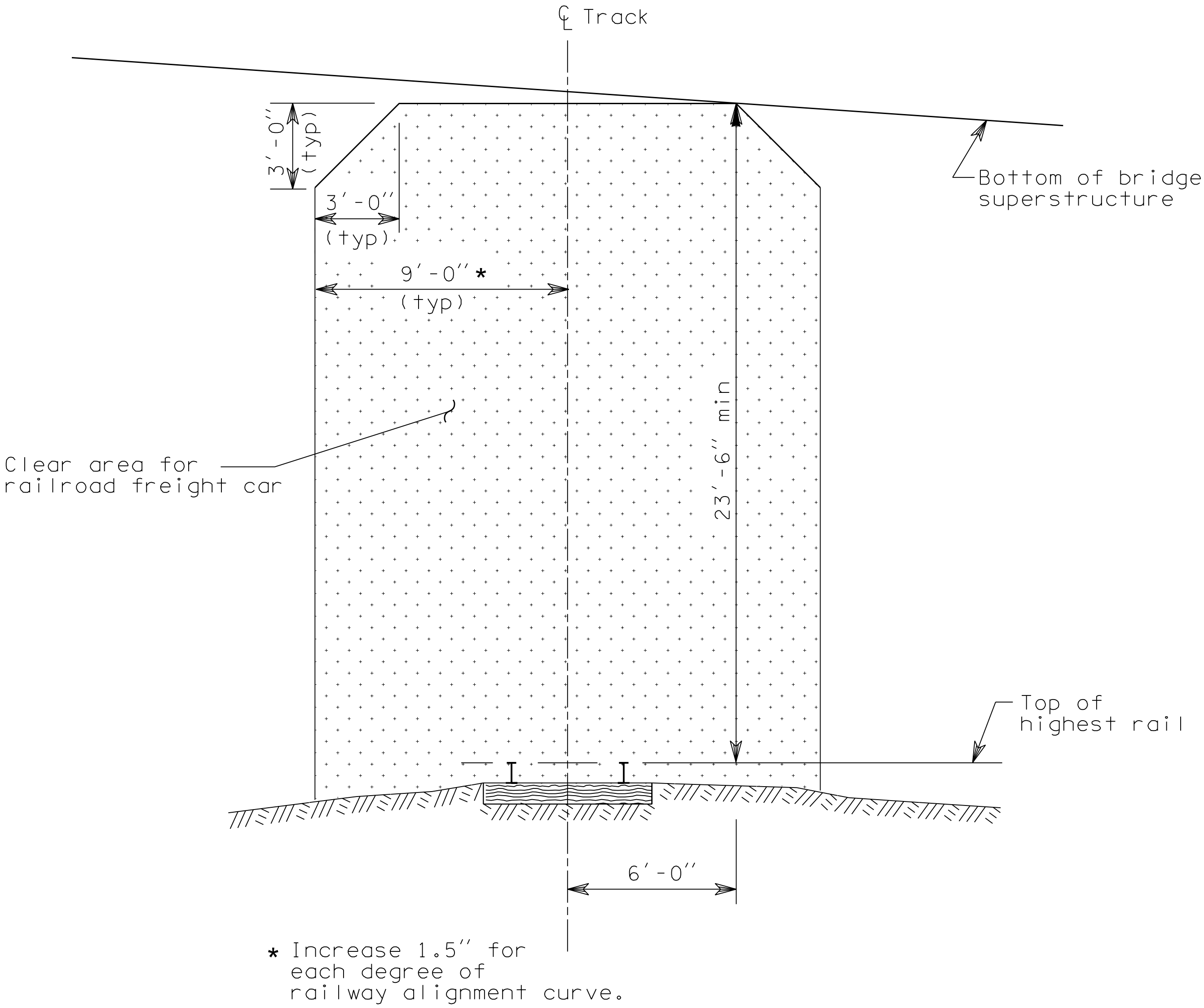
In most cases, the installation of a protective screen on a new structure can be postponed until there are indications of need.

Submit all proposals to install protective screening on structures to the State Design Engineer for approval. Contact the Bridge and Structures Office for approval to attach screening to structures and for specific design and mounting details.

1120.05 Documentation

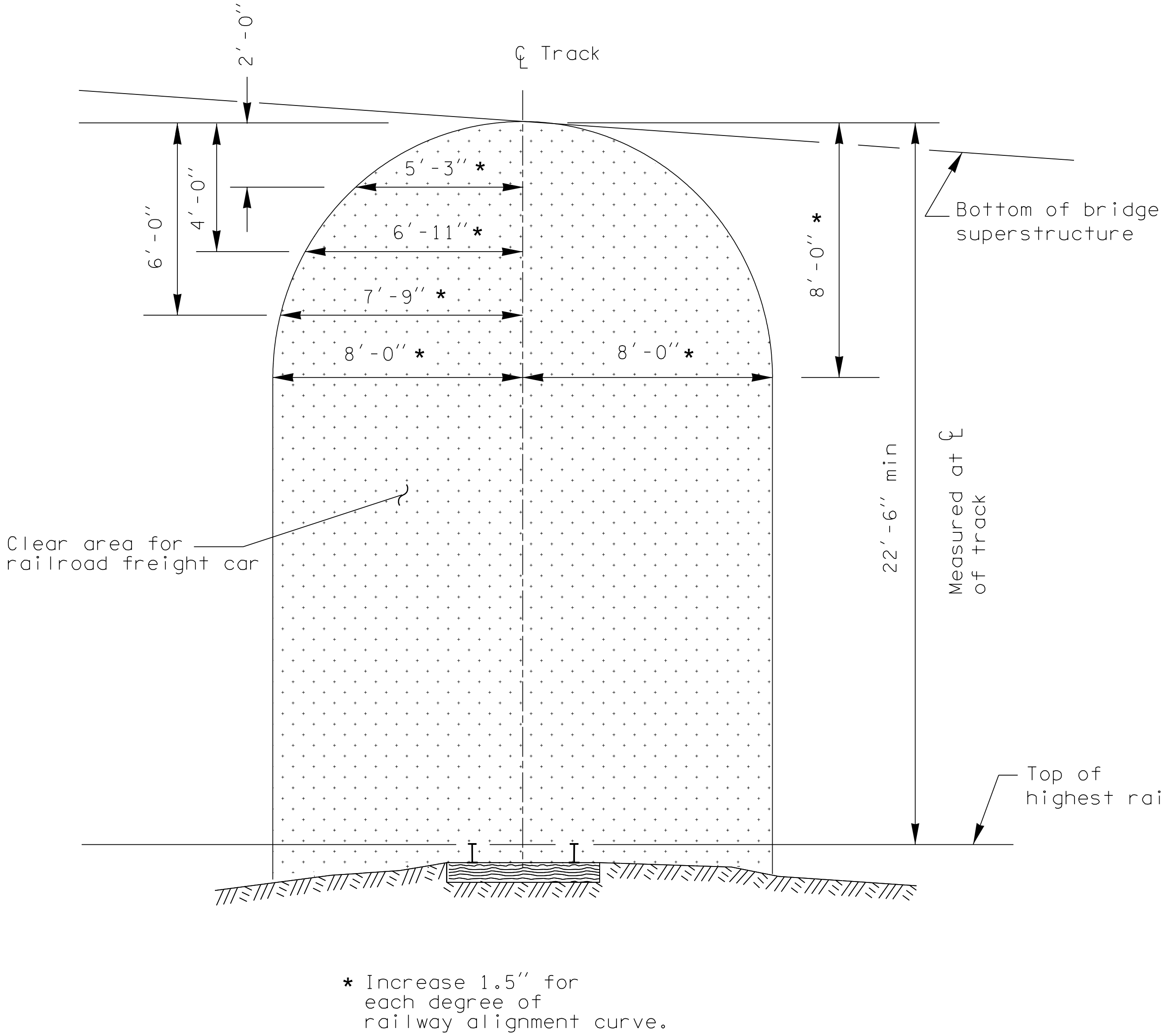
Include the following items in the design documentation file. See Chapter 330.

- ☐ Structural Capacity Report
- ☐ Evaluation of need and approval for enclosing the area between bridges
- ☐ Correspondence involving the MTMCTEA
- ☐ Justification for eliminating an overlay in the vicinity of a bridge
- ☐ Final Foundation Report
- ☐ Justification and HQ concurrence for omitting approach slabs
- ☐ Analysis of need and approval for protective screening on highway structures
- ☐ Railroad agreement allowing less than 22.5 ft vertical clearance
- ☐ Approval of proposal to mill and existing service



Railroad Vertical Clearance for New Bridge Construction

Figure 1120-2a



Railroad Vertical Clearance for Existing Bridge Modifications
Figure 1120-2b

1210 Hydraulic Design

1210.01 General

Hydraulic design factors can significantly influence the corridor, horizontal alignment, grade, location of interchanges, and the necessary appurtenances required to convey water across, along, away from, or to a highway or highway facility. An effective hydraulic design conveys water in the most economical, efficient, and practical manner to ensure the public safety without incurring excessive maintenance costs or appreciably damaging the highway or highway facility, adjacent property, or the total environment.

This chapter is intended to serve as a guide to highway designers so they can identify and consider hydraulic related factors that impact the design. Detailed criteria and methods that govern highway hydraulic design are in WSDOT's *Hydraulics Manual* and *Highway Runoff Manual*.

Some drainage, flood, and water quality problems can be easily recognized and resolved; others might require extensive investigation before a solution can be developed. Specialists experienced in hydrology and hydraulics can contribute substantially to the planning and project definition phases of a highway project by recognizing potentially troublesome locations, making investigations and recommending practical solutions. Regions may request that the HQ Hydraulics Branch provide assistance regarding hydraulic problems.

Since hydraulic factors can affect the design of a proposed highway or highway facility from its inception, consider these factors at the earliest possible time during the planning phase. In the project definition phase, begin coordination with all state and local governments and Indian tribes that issue or approve permits for the project.

1210.02 References

(1) Existing Criteria and References

Existing criteria and additional information for hydraulic design requirements, analyses, and procedures are contained in the following references:

Hydraulics Manual, M 23-03, WSDOT

Highway Runoff Manual, M 31-16, WSDOT

Standard Plans for Road, Bridge and Municipal Construction, (Standard Plans) M 21-01, WSDOT

Standard Specifications for Road, Bridge and Municipal Construction, (Standard Specifications) M 41-10, Amendments, and General Special Provisions, WSDOT

Utilities Manual, M 22-87, Section 1-19, "Storm Drainage," WSDOT

(2) Special Criteria

Special criteria for unique projects are available on request from the HQ Hydraulics Branch.

1210.03 Hydraulic Considerations

(1) The Flood Plain

Encroachment of a highway or highway facility into a flood plain might present significant problems. A thorough investigation considers the following:

(a) The effect of the design flood on the highway or highway facility and the required protective measures.

(b) The effect of the highway or highway facility on the upstream and downstream reaches of the stream and the adjacent property.

(c) Compliance with hydraulic related environmental concerns and hydraulic aspects of permits from other governmental agencies per Chapters 220 and 240.

Studies and reports published by the Federal Emergency Management Agency (FEMA) and the Corps of Engineers are very useful for flood plain analysis. The HQ Hydraulics Branch has access to all available reports and can provide any necessary information to the region.

(2) Stream Crossings

When rivers, streams, or surface waters (wetland) are crossed with bridges or culverts (including open bottom arches and three-sided box culverts), consider the following:

- Locating the crossing where the stream is most stable.
- Effectively conveying the design flow(s) at the crossing.
- Providing for passage of material transported by the stream.
- The effects of backwater on adjacent property.
- Avoiding large skews at the crossing.
- The effects on the channel and embankment stability upstream and downstream from the crossing.
- Location of confluences with other streams or rivers.
- Fish and wildlife migration.
- Minimizing disturbance to the original streambed.
- Minimizing wetland impact.

Also see the *Hydraulics Manual* Chapter 8 for further design details.

(3) Channel Changes

It is generally desirable to minimize the use of channel changes because ongoing liability and negative environmental impacts might result. Channel changes are permissible when the designer determines that a reasonable, practical alternative does not exist. When used, consider:

(a) Restoration of the original stream characteristics as nearly as practical. This includes:

- Meandering the channel change to retain its sinuosity.
- Maintaining existing stream slope and geometry (including meanders) so stream velocity and aesthetics do not change in undisturbed areas.
- Excavation, selection, and placement of bed material to promote formation of a natural pattern and prevent bed erosion.
- Retention of stream bank slopes.
- Retention or replacement of streamside vegetation.

(b) The ability to pass the design flood.

(c) The effects on adjacent property.

(d) The effects on the channel and embankment upstream and downstream from the channel change.

(e) Erosion protection for the channel change.

(f) Environmental requirements such as wetlands, fish migration, and vegetation re-establishment.

Do not redirect flow from one drainage basin to another. (Follow the historical drainage pattern.)

Consult the HQ Hydraulics Branch for the best guidance when channel changes are considered.

(4) Roadway Drainage

Effective collection and conveyance of storm water is critical. Incorporate the most efficient collection and conveyance system considering initial highway costs, maintenance costs, and legal and environmental considerations. Of particular concern are:

(a) Combinations of vertical grade and transverse roadway slopes that might inhibit drainage.

(b) Plugging of drains on bridges as the result of construction projects. This creates maintenance problems and might cause ponding on the structure. The use of drains on structures can be minimized by placing sag vertical curves and crossovers in superelevation outside the limits of the structure.

(c) See Chapter 630 for discussion of the relationship of roadway profiles to drainage profiles.

(5) Subsurface Drainage

Subsurface drainage installations control ground water encountered at highway locations. Ground water, as distinguished from capillary water, is free water occurring in a zone of saturation below the ground surface. The subsurface discharge depends on the effective hydraulic head and on the permeability, depth, slope, thickness, and extent of the aquifer.

The solution of subsurface drainage problems often calls for specialized knowledge of geology and the application of soil mechanics. The region Materials Engineer evaluates the subsurface conditions and includes findings and recommendations for design in the geotechnical report.

Typical subdrain installations control seepage in cuts or hillsides, control base and shallow subgrade drainage, or lower the ground water table (in swampy areas, for example).

Design a system that will keep the stormwater out of the subsurface system when stormwater and subsurface drainage systems are combined.

(6) Subsurface Discharge of Highway Drainage

Consider subsurface discharge of highway drainage when it is a requirement of the local government or when existing ground conditions are favorable for this type of discharge system. Criteria for the design of drywells or subsurface drainage pipe for this type of application are described in Chapter 6 of the *Hydraulics Manual*. The criteria for the design of infiltration ponds are described in the *Highway Runoff Manual.*

(7) Treatment of Runoff

On certain projects, effective quantity control of runoff rates and removal of pollutants from pavement are intended to address flooding and water quality impacts downstream. See the *Highway Runoff Manual* for specific criteria on quantity and quality control of runoff.

1210.04 Safety Considerations

Locate culvert ends outside the Design Clear Zone when practical. See Chapter 700 for culvert end treatments when this is impractical.

See Chapter 1460 regarding fencing for detention ponds and wetland mitigation sites.

1210.05 Design Responsibility

Chapter 1 of the *Hydraulics Manual* describes the responsibilities of the regions and the HQ Hydraulics Branch relative to hydraulic design issues.

1460.01 General

Fencing is provided primarily to discourage encroachment onto the Washington State Department of Transportation's (WSDOT's) highway right of way from adjacent property and to delineate the right of way. It is also used to replace fencing that has been disrupted by construction and to discourage encroachment onto adjacent property from the highway right of way.

The reason for discouraging encroachment onto the right of way is to limit the presence of people and animals that might disrupt the efficient flow of traffic on the facility. Although not the primary intent, fencing does provide some form of separation between people, animals, the traffic flow, or other special feature and, therefore, a small measure of protection for each.

1460.02 References

*Plans Preparation Manua*l, M 22-31, WSDOT

Roadside Manual, M 25-30, WSDOT

Standard Plans for Road, Bridge, and Municipal Construction (Standard Plans), M 21-01, WSDOT

Standard Specifications for Road, Bridge, and Municipal Construction (Standard Specifications), M 41-10, WSDOT

1460.03 Design Criteria

(1) General

Fencing on a continuous alignment usually has a pleasing appearance and is most economical to construct and maintain. The recommended practice is to locate fencing or, depending on terrain, 12 in. inside the right of way line.

Where the anticipated or existing right of way line has abrupt irregularities over short distances, coordinate with Maintenance and Real Estate Services personnel to dispose of the irregularities as excess property, where possible, and fence the final property line in a manner that is acceptable to Maintenance.

Where possible, preserve the natural assets of the surrounding area and minimize the number of fence types on any particular project.

(2) Limited Access Highways

On highways with limited access control, fencing is mandatory unless it has been established that such fencing may be deferred. Fencing is required between frontage roads and adjacent parking or pedestrian areas (such as at rest areas and flyer stops) and highway lanes or ramps unless other barriers are used to discourage access violations.

On new alignment in rural areas, fencing is not provided between the frontage road and abutting property unless the abutting property was enclosed prior to highway construction. Such fencing is normally part of the right of way negotiation.

Unless there is a possibility of access control violation, fencing installation may be deferred until needed at the following locations. (When in doubt, consult the HQ Access and Hearings Engineer.)

- Areas where rough topography or dense vegetation provides a natural barrier.
- Along rivers or other natural bodies of water.
- In sagebrush country that is sparsely settled.
- In areas with high snowfall levels and sparse population.
- On long sections of undeveloped public or private lands not previously fenced.

(3) Managed Access Highways

Fencing is not required for managed access highways. When highway construction will destroy the fence of an abutting property owner, originally constructed on private property, the cost of such replacement fencing may be included in the right of way payment. When the fences of several property owners will be impacted, it may be cost-effective to replace the fences as part of the project.

If fencing is essential to safe operation of the highway, it will be constructed and maintained by the state. Examples of this are the separation of traveled highway lanes and adjacent facilities with parking or pedestrian areas such as rest areas and flyer stops.

(4) Special Sites

Fencing is often needed at special sites such as pitsites, stockpiles, borrow areas, and storm water detention facilities.

It is recommended that storm water detention facilities and wetland mitigation sites be fenced if all of the following conditions exist:

- The storm water detention facility or wetland mitigation site is outside highway right of way fencing.
- The slopes into the storm water detention facility or wetland mitigation site are 3H:1V or steeper.
- The storm water detention facility or wetland mitigation site is located near a school, park, trail, or other facility frequented by children not accompanied by an adult.

Fencing proposed at sites that will be outside WSDOT right of way requires that local ordinances be followed if they are more stringent than WSDOT's.

Fencing is not installed around storm water detention ponds within right of way fencing.

Other special sites where fencing may be required are addressed in the following chapters:

- 1020 Bicycle Facilities
- 1025 Pedestrian Design Considerations
- 1120 Bridges

The type and configuration of the fence is determined by the requirements of each situation.

1460.04 Fencing Types

(1) Chain Link

Installation of chain link fence is appropriate for maximum protection against right of way encroachment on sections of high volume highways under the following conditions:

- Along an existing business district adjacent to a freeway.
- Between a freeway and an adjacent parallel city street.
- At locations where existing streets have been cut off by freeway construction.
- At industrial areas.
- At large residential developments.
- At military reservations.
- At schools and colleges.
- At recreational and athletic areas.
- At developed areas at the intersection of two limited access highways.
- At any other location where a barrier is needed to protect against pedestrian, bicyclist, or livestock encroachment in limited access areas.
- See Chapter 640 for roadway sections in rock cuts.

The Standard Plans contains details for the four approved types of chain link fence. The recommended uses for each type of fence are as follows:

(a) **Type 1.** A high fence for areas of intensified use, such as industrial areas or school playgrounds. It is not to be used within the Design Clear Zone because the top rail of the fence is considered a hazard. (See Chapter 700.)

(b) **Type 3.** A high fence for use in suburban areas with limited existing development. It may be used within the Design Clear Zone.

(c) **Type 4.** A lower fence for special use, such as between the traveled highway lanes and a rest area or flyer stop, or as a rest area boundary fence if required by the development of the surrounding area. This fence may be used along a bike path or hiking trail to separate it from an adjacent roadway.

(d) **Type 6.** A lower fence used instead of Type 1 where it is deemed important not to obstruct the view toward or from areas adjacent to the highway. This fence is not to be used within the Design Clear Zone because the top rail of the fence is considered a hazard. (See Chapter 700.)

Coated galvanized chain link fence is available in various colors and may be considered in areas where aesthetic considerations are important. Coated ungalvanized chain link fence is not recommended.

(2) Wire Fencing

The Standard Plans and Specifications contain details for the two approved types of wire fence. The recommended uses for each type of fence are as follows:

(a) **Type 1.** This fence is used in urban and suburban areas where improvements along the right of way are infrequent and future development is not anticipated. It may also be used adjacent to livestock grazing areas. The lower portion of this fence is wire mesh and provides a barrier to children and small animals.

(b) **Type 2.** This fence is used in farming areas to limit highway crossings by farm vehicles to designated approaches: in irrigation districts to prevent ditch riders, maintenance personnel, and farmers from making unauthorized highway crossings; and where new alignment crosses parcels previously enclosed by barbed wire.

(3) Other Considerations

Extremely tall fences (7 to 10 ft high) may be used in areas where there are exceptional hazards such as large concentrations of deer or elk. See the region's Environmental Office and the *Roadside Manual* concerning wildlife management.

Metal fencing can interfere with airport traffic control radar. When locating fencing in the vicinity of an airport, contact the Federal Aviation Administration to determine if metal fence will create radar interference at the airport. If so, use nonmetallic fencing.

Do not straddle or obstruct surveying monuments.

1460.05 Gates

Keep the number of fence gates along limited access highways to a minimum. On limited access highways, all new gates must be approved as described Chapter 1425, "Access Point Decision Report."

Usually such gates are necessary only to allow highway maintenance personnel and operating equipment to reach the freeway border areas without using the through-traffic roadway. Gates may be needed to provide access to utility supports, manholes, and the like, located within the right of way.

Use gates of the same type as the particular fence, and provide locks to deter unauthorized use.

In highly developed and landscaped areas where maintenance equipment is parked outside the fence, provide the double gate indicated in the Standard Plans.

Where continuous fencing is not provided on limited access highways, Type C approaches are normally gated and locked, with a short section of fence on both sides of the gate.

1460.06 Procedure

Fencing is included in the access report, in accordance with Chapter 1430, and the PS&E, in accordance with the *Plans Preparation Manual*.

1460.07 Documentation

The following documents are to be preserved in the project's design documentation file. See Chapter 330.

- ☐ Reasons for providing fencing and for the type and configuration selected.
- ☐ Justification for using a nonstandard fence design.
- ☐ Justification for deferring or not providing fencing on a highway with limited access control or as otherwise recommended in this chapter.
- ☐ Access Point Decision Report for gates on limited access highways.

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