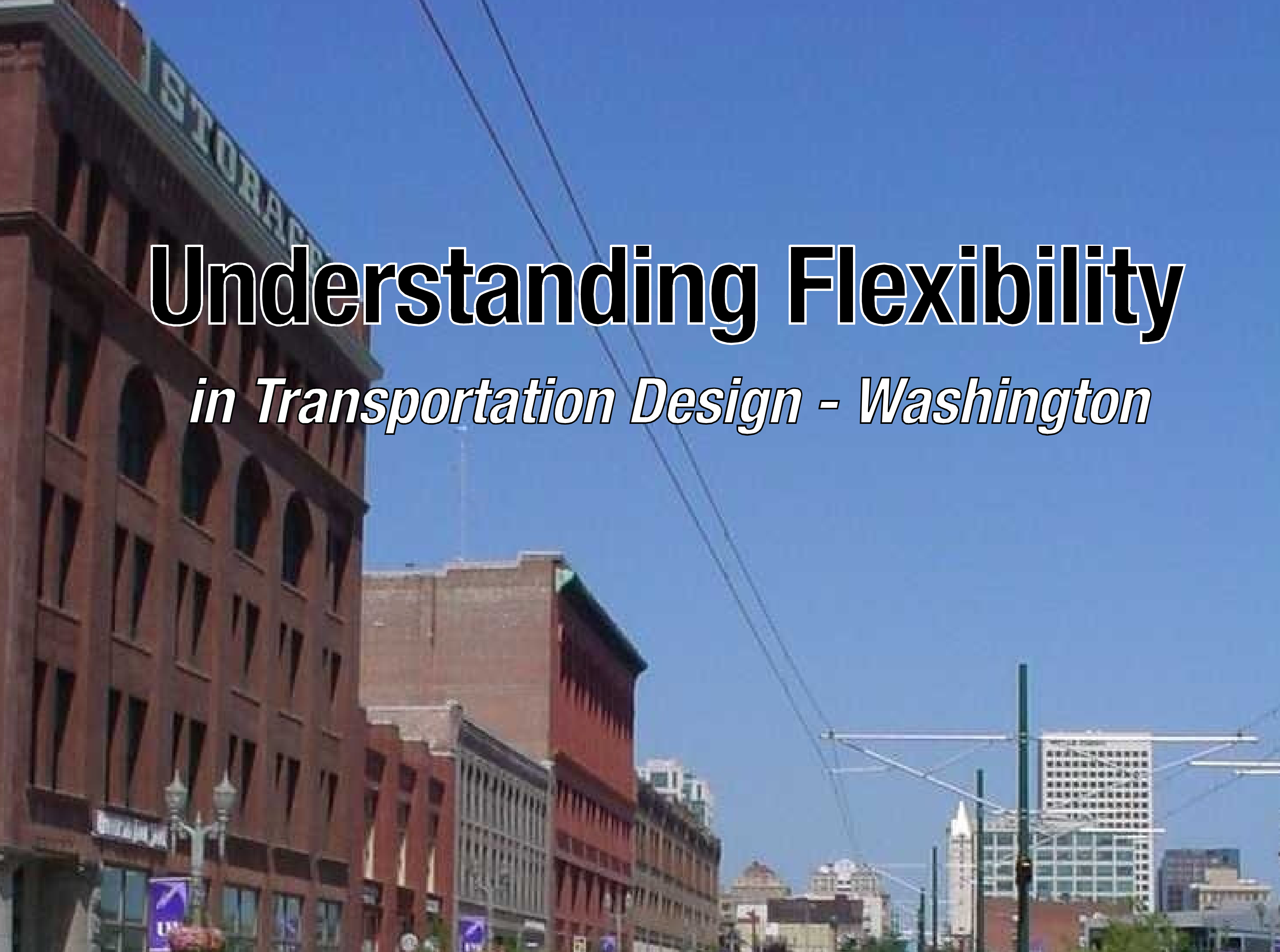
Understanding Flexibility

in Transportation Design - Washington



Washington State
Department of Transportation

For more information
Contact: Samih Shilbayeh, WSDOT HQ Design office at
(360) 705-7264 or
Visit our web site at:
http://www.wsdot.wa.gov/eesc/design/Urban/Default.htm

Cover photo of downtown Tacoma, Washington
by Anna St. Martin

Washington State
Department of Transportation
Douglas B. MacDonald
Secretary of Transportation

Transportation Building
310 Maple Park Avenue S.E.
P.O. Box 47300
Olympia, WA 98504-7300

360-705-7000
TTY: 1-800-833-6388
www.wsdot.wa.gov

April 26, 2005

Dear Reader:

The Washington State Department of Transportation (WSDOT) is pleased to provide you "*Understanding Flexibility in Transportation Design – Washington,*" a new publication intended to help those involved with transportation project development understand the concepts related to Context Sensitive Design (CSD) and community-based project development approaches.

The CSD approach broadens the focus of the project development process to look beyond the basic transportation issues, and develop projects that are integrated with the unique context(s) within the project setting. The CSD concept is a collaborative project development process that obligates participants to understand the impacts and trade-offs associated with project decisions. *Understanding Flexibility in Transportation Design – Washington* is intended to facilitate informed decision-making as decision points occur during the process. It attempts to present the issues associated with the most common considerations presented in the project development process.

This publication is the result of contributions made by an Interdisciplinary Group (IDG), who gave freely of their time, energy, and expertise. The group was comprised of members representing WSDOT; cities and counties; regional councils; and federal transportation agencies. We thank the IDG members and offer congratulations on the quality of the finished product.

We hope you find that *Understanding Flexibility in Transportation Design – Washington* is helpful and contributes in a meaningful way to future successes in developing transportation projects in our communities.

John Conrad
Assistant Secretary-
Engineering and Regional
Operations Division

Understanding Flexibility

in Transportation Design - Washington

By

Washington State Department of Transportation (WSDOT)

and the
Safety and Aesthetics Interdisciplinary Group (IDG)

First Edition
April 2005

Washington State
Department of Transportation

Safety and Aesthetics IDG Lead Organizations and Participants

Association of Washington Cities (AWC)
City of Bremerton
City of Des Moines
City of Federal Way
City of Seattle
City of Shoreline
City of Spokane
City of Tukwila
County Road Administration Board (CRAB)
Federal Highway Administration (FHWA)
Department of Community, Trade and Economic Development (CTED)
Pierce County
Puget Sound Regional Council (PSRC)
Thurston Regional Planning Council (TRPC)
University of Washington (UW)
Washington State Department of Transportation (WSDOT)

Editors

John Milton
Anna St. Martin
Rebecca Nichols (Copy Editor)

Program Managers

Dave Olson (2001-2005)
Samih Shilbayeh (2004-2005)
Brian Hasselbach (2002-2003)
Nancy Boyd (2001-2002)

Contributing Authors

PSRC: Rocky Piro
TRPC: Thera Black
FHWA: Paul Harker
University of Arizona: Ida van Schalkwyk
WSDOT:
Richard (Dick) Albin
Linda Anderson
Megan Beeby
Nancy Boyd
Craig Broadhead
Charlotte Claybrooke
Theodore (Ted) Focke
Paul Gamble
Brian Hasselbach
Larry Hinson
Colleen Jollie
John Maas
Mark Maurer
Doug McClanahan
Larry Messmer
John Milton
Dave Olson
Sandra Salisbury
Darlene Sharar
Samih Shilbayeh
Bruce Smith
Anna St. Martin
Cindy Tremblay
Sandie Turner
Brian Walsh
Tony Warfield
Mia Waters

IDG Members and Participants

Local, State, Federal Agencies
Maiya Andrews (Des Moines)
Tom Ballard (Pierce County)
Thera Black (TRPC)
Ken Brown (City of Spokane)
Ned Conroy (PSRC)
King Cushman (PSRC)
Shane DeWald (Seattle)
Jim Ellison (Pierce County)
Paul Harker (FHWA)
Mike Johnson (Seattle)
Susan Kempf (CTED)
Al King (CRAB)
Richard Meredith (Shoreline)
Ken Miller (Federal Way)
Jim Morrow (Tukwila)
Chris Mudgett (CRAB)
Walt Olsen (CRAB)
Don Petersen (FHWA)
Rocky Piro (PSRC)
Lynn Price (City of Bremerton)
Ashley Probart (AWC)
Janet Rogerson (OTED)
Jim Seitz (AWC)
Shari Schaftlein (FHWA)
Kathy Wolf (University of Washington)

WSDOT
Richard (Dick) Albin
Sally Anderson
Jennifer Brown
Neal Campbell
Troy Cowan
Mike Dornfeld
Jim Eastman
David Fennell
Ted Focke
Roger Horton
Brian Hasselbach
Mark Leth
Mark Maurer
Dave McCormick
John Milton
Dave Olson
Paula Reeves
Elizabeth Robbins
Sandra Salisbury
Darlene Sharar
Samih Shilbayeh
Bruce Smith
Anna St. Martin
William (Bill) Stoll
Shuming Yan
Scott Zeller

Photo Sources

The photographs used throughout this document were taken from many individuals and for different purposes. Effort has been made to give credit to the individual photographers when possible, as listed below. In the instance that credit has not been given as appropriate or is lacking, please contact Samih Shilbayeh, and the updated information will be included in subsequent editions of this document.

CTED
Rick Glidden
Mark Maurer
John Milton
PSRC
Ida van Schalkwyk
Samih Shilbayeh
Anna St. Martin
Brian Walsh

Table of Contents page

Appendix A Case Studies

Appendix B

Division I Introduction
Chapter I-1 Background and Intent of Document

Introduction

Washington State's population is growing at a rate that is placing ever-increasing demands upon its transportation system. Urban roadways, in particular, are suffering from significant additional burdens. While having the responsibility to provide for these demands, engineers and planners from state and local agencies are tasked with reconciling multiple, sometimes conflicting, expectations for roadway users.

Exhibit I-1.1 – Urban State Highway (Location: Stevenson, WA)

Much of the apparent conflict involves optimizing the competing needs of safety, aesthetics, environment, mobility, and access. The trade-offs between quantitative and qualitative factors are not always clear, and biases have often led to unwillingness to hear both sides of the issues at hand.

Within Washington State, key issues include:

- Access management
- Urban median design
- Bike and pedestrian access and safety
- Streetscaping
- Transit and freight
- Traffic calming devices
- Business access
- Operational intent of the facility
- Urban forestry

Exhibit I-1.2 – Street Amenities (Location: Olympia, WA)

To best address the challenges of these issues, and to ensure that complicated or problematic issues are discussed early in the process, Washington State Department of Transportation (WSDOT) and its local partners have initiated a number of efforts to integrate community involvement and collaborative decision-making into the project development process. These efforts have been guided by an interdisciplinary group (IDG), comprised of members representing cities and counties; regional councils; and local, state, and federal transportation agencies.

The design concepts and processes discussed in this document provide the opportunity for flexibility in transportation design, along with community involvement and collaborative decision-making, to facilitate the development of projects that will meet the demands, while also being sensitive to the surrounding context of the project.

Purpose and Need

Understanding flexibility in design is a challenging, often time-consuming process, but one that is well worth the effort. This document is intended to assist those involved with the project development and design processes in understanding concepts related to context sensitive design (CSD). Each division

Exhibit I-1.3 – Multi-Modal Facility (Location: Maple Valley, WA)

addresses different aspects of design and provides the tools and concepts necessary to understand the complexity of each design element.

The divisions were developed by professionals with expertise in their particular fields. Each concept presented will help lead those responsible for planning and project delivery to a balanced design. This flexibility in transportation design document is not intended to be inclusive of all the elements at hand; rather, it is guidance to assist in the decision-making process.

It is the intent of this document to prompt the user to consider the opportunities associated with the context sensitive design process in order to optimize the use of the surrounding conditions and resources.

Using Flexibility in Design

Exhibit I-1.4 – Street Art (Location: Colville, WA)

The IDG believes that a good process should result in the following outcomes, which are similar to those discussed in the "Thinking Beyond the Pavement" National Conference:

- A project satisfying the purpose and need, as agreed to by a full range of stakeholders. This agreement is forged in the earliest phase of the project and is amended as necessary.
- Projects optimizing the safety of the facility for both the users and the community.
- Projects developed in harmony with the surrounding community, which preserve the environmental, scenic, aesthetic, historic, and natural resource values of the area.
- Projects designed and built with the least possible disruption to the adjacent community.
- Projects involving the efficient and effective use of all the resources of the involved parties.[1]

Ongoing Efforts

The principle of flexibility in design is similar to the processes local agencies and WSDOT currently employ, such as the National Environmental Policy Act (NEPA), Community Impact Assessment (CIA), and public involvement. In general, all call for an earnest attempt to bring stakeholders to the table and engage in meaningful discussion that will lead to community-based decision-making.

Exhibit I-1.5 – Urban Streetscape (Location: Lacey, WA)

A number of efforts are underway that embody the fundamental principles of the context sensitive design and community-based project development approaches. Commitments to these approaches are reflected in the WSDOT Context Sensitive Solutions Executive Order (E 1028.00) and the 2003-2022 *Washington Transportation Plan* (WTP). The WTP calls for effective community-based design and collaborative decision-making in Goals 9 and 10, which are detailed below.

Goal #9 Effective Community-Based Design
Integrated community design, land use, and transportation investments improve quality of life.

[1] "Thinking Beyond the Pavement," National Conference, 1998.

Goal #10 Collaborative Decision-Making
Collaboration occurs between federal, tribal, state, regional, local, and private sector parties.

Other on-going efforts also illustrate a commitment to community-based design. These efforts are described in greater detail in the following sections.

Safety and Aesthetics in Urban Roadway Design

The March 2001 *Value Engineering Study on Urban Roadside Treatments* recommended the development of comprehensive policy guidance for aesthetic urban roadway design. As a result, in June 2001, the WSDOT Headquarters Design Office launched a new effort, "*Safety and Aesthetics in Urban Roadway Design*."

This effort created the interdisciplinary group (IDG), mentioned previously. The IDG is comprised of representatives from cities, the Association of Washington Cities (AWC), the County Road Administration Board (CRAB), the Federal Highway Administration (FHWA), Metropolitan Planning Organizations (MPOs), and various disciplines within WSDOT, including Design, Planning, Traffic, Project Development, Local Programs, Environmental Services, and Landscape Architecture.

The group meets on a quarterly basis and assists in the identification of priorities, potential issues, and work elements; allows for two-way communication; and assists in the identification of task-specific subcommittees.

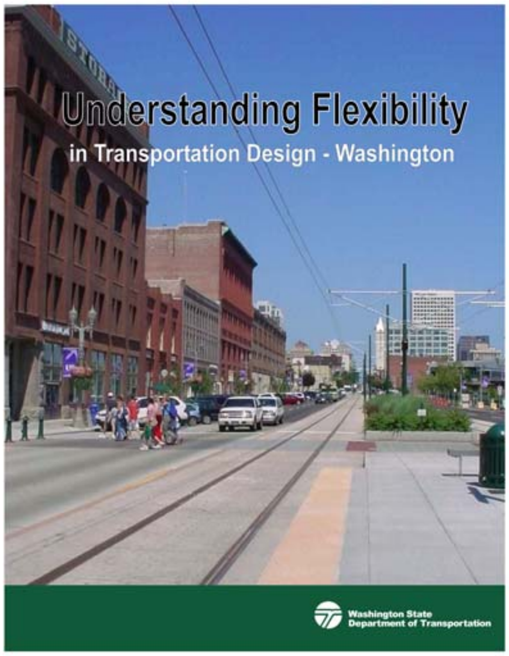
The work from this group and its subcommittees has resulted in, and is expected to continue to result in, the development of a number of tools. These tools include:

- This document on flexibility in transportation design
- The development of revised or new design policy:
  - An In-Service Evaluation Process for new design concepts on state highway systems, as proposed by local agencies
  - Urban Design supplement
- New communication tools:
  - The interdisciplinary group itself
  - The Urban Design Alternatives Treatment Brochure
  - Training efforts commencing Fall 2004
- State research on crash testing of new aesthetic roadside barriers and designs
- National research on aesthetic designs

Community Partnerships Forum

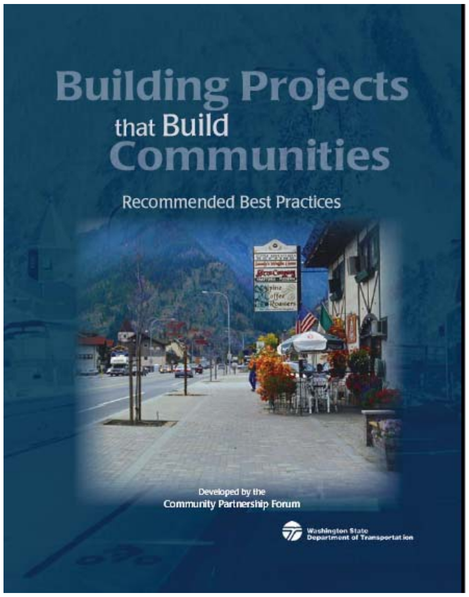
The Community Partnerships Forum was formed to improve relationships and communication between local agencies and WSDOT, particularly on projects planned, scoped, and constructed in urban areas. The Community Partnerships Forum is also a multi-jurisdictional group, responsible for the development of the *Building Projects that Build Communities* guidebook, Exhibit I-1.7, which can be found on the web at: http://www.wsdot.wa.gov/biz/csd/BPBC_Final/building_projects.pdf

Exhibit I-1.6 – Understanding Flexibility in Transportation Design – Washington



Community-Based Project Development

Exhibit I-1.7 – Community Partnerships Forum Document, 2003



One of the most difficult challenges facing the community is the provision of safe, efficient transportation service that also conserves and enhances the environmental, scenic, historic, community, and business resources. Construction activity on facilities often requires local, state, and federal agency input and consideration. These projects, as well as local agency transportation projects, may also impact businesses, neighborhoods, and other interest groups depending on location and improvement efforts.

As such, it is vitally important for project staff to provide meaningful opportunities for involvement by other agencies and interest groups in the project development process. This requires the use of a collaborative, interactive partnership that involves good communication and relationship building.

Meaningful involvement by the localities and other interest groups will likely result in a project that incorporates the needs of a variety of user groups; is readily accepted by the local community; and presents a possible savings in project costs by avoiding potential delays and the revisiting of design decisions later in the development process.

The *Building Projects that Build Communities* guidebook is intended to assist practitioners in implementing the community-based approach. The guidebook features effective processes for building important partnerships, as projects are planned and developed.

Managing Project Delivery (MPD) Process

The *Managing Project Delivery Process* is an approach the WSDOT utilizes to deliver projects. The process calls for collaborative interaction with a variety of user groups, in order to develop and deliver projects on time and within budget. The following key features define this approach:

- Building an interdisciplinary team, whose members have the necessary skills for the project
- Including customers in the project delivery process
- Communicating
- Managing customer expectations
- Managing change[2]

A Roadside Funding Matrix has been included in Appendix B for those projects in which WSDOT is the lead agency when working with local agencies. The Matrix lists the design elements of various projects and whether or not they are eligible for funding through WSDOT.

Using This Document

This document provides a compilation of the issues that are associated with transportation facility design; discusses the trade-off considerations related to each issue; and prompts the user to think about how a particular consideration impacts other factors related to highway design. The document is therefore a

[2] *Design Manual*, Chapter 140, WSDOT.

repository for the ideas and considerations that can be included in the project development and design process. The content of this document is not intended to constitute a design standard; rather, it is simply a learning tool to assist in the development of projects that are sensitive to their surrounding contexts.

This document is organized into the following:

- **Division I** provides introductory information on the topic of Context Sensitive Design, historical development of transportation safety policy, and the issues of liability surrounding flexibility in design.
- **Division II** discusses the significant and distinguishing features of a variety of contexts in which projects may be located and addresses the elements involved in developing communities within their unique contexts.
- **Division III** details the needs and specific considerations of the variety of users of transportation facilities.
- **Divisions IV** and **V** provide specific detail on considerations and the subsequent trade-off issues relating to the natural environment and the facility design.
- **Division VI** covers the major elements in the project development process.
- **Appendices:**
  - **Appendix A** presents case studies from Washington State to illustrate how facilities may be designed with sensitivity to the context.
  - **Appendix B** provides a Roadside Funding Matrix for projects in which WSDOT is the lead agency when working with local agencies.

Consider this document a tool to augment existing processes – it provides an additional aid to ensure projects are developed in a manner that considers all users and their respective needs. It is not intended to present standards for design. As noted above, WSDOT and many local transportation agencies are already engaged in community-based decision-making. The intent of this document is to assist those efforts and provide users additional information with which to make decisions.

Governing Regulations and Directional Documents

Context Sensitive Solutions Executive Order, WSDOT, E 1028.00.

Design Manual, WSDOT, M 22-01.

A Policy on Geometric Design of Highways and Streets, 4th ed. (Green Book), American Association of State Highway and Transportation Officials (AASHTO), Washington D.C., 2001.

Roadside Classification Plan (RCP), WSDOT, M 25-31.

Washington State Highway Systems Plan: 2003-2022, WSDOT Transportation Planning Office, Olympia, WA, 2002, http://www.wsdot.wa.gov/ppsc/hsp/pdf/HSP-2003-2022.pdf

Washington's Transportation Plan: 2003-2022, Washington State Transportation Commission and WSDOT, Olympia, WA, 2002, http://www.wsdot.wa.gov/ppsc/planning/

Additional Resources

Community Partnerships Forum, Building Projects that Build Communities – Recommended Best Practices, WSDOT, Olympia, WA, 2003, http://www.wsdot.wa.gov/biz/csd/BPBC_Final/

Context Sensitive Design/Thinking Beyond the Pavement, Federal Highway Administration (FHWA), http://www.fhwa.dot.gov/csd/index.htm

Context Sensitive Solutions, WSDOT, http://www.wsdot.wa.gov/biz/csd/

Gee, King W., FHWA Associate Administrator for Infrastructure, October 29, 2002 Memo, http://www.fhwa.dot.gov/csd/102902.htm

Highways & Local Programs, WSDOT, http://www.wsdot.wa.gov/TA/Operations/Operations.html

Main Street…When a Highway Runs Through It: A Handbook for Oregon Communities, Transportation and Growth Management Program, Oregon Department of Transportation and the Oregon Department of Land Conservation and Development, Salem, OR, 1999.

Milton, John C., P.E., Assistant State Design Engineer – Urban Corridors, miltonj@wsdot.wa.gov, WSDOT Design Office, MS 47330, Olympia, WA 98504, 2004.

Neuman, Schwartz, Clark and Bednar, *A Guide to Best Practices for Achieving Context Sensitive Solutions*, NCHRP Report #480, Transportation Research Board, Washington, D.C., 2002.

Safety, Aesthetics and Context Sensitive Design, Design Office, WSDOT, http://www.wsdot.wa.gov/eesc/design/Urban/Default.htm

Vital Few Environmental Streamlining and Stewardship Goals, FHWA, http://environment.fhwa.dot.gov/strmlng/es4vitalfew.htm

When Main Street is a State Highway, Maryland State Highway Administration, Baltimore, MD, 2001, http://www.sha.state.md.us/businessWithSHA/projects/ohd/Mainstreet/MainStreet.pdf

Introduction

The influence of societal needs on transportation decision-making has changed throughout the years. These changing times could adequately be described as "eras of transportation." Predominate in influence during these eras was the expansion of the interstate system, mass transit, and environmental stewardship, with safety being a primary concern. Transportation safety has become the comprehensive pursuit of often-competing needs between the facility, the environment, and the users.

Engineers and policy makers often focus on safety as one of their principal concerns. As the goals of Context Sensitive Design/ Context Sensitive Solutions come to the forefront of transportation design and planning efforts, there have been many questions about how these goals will be implemented and what impacts the new designs will have on safety. Questions are also raised concerning how to deal with the potential legal consequences and increases in liability.

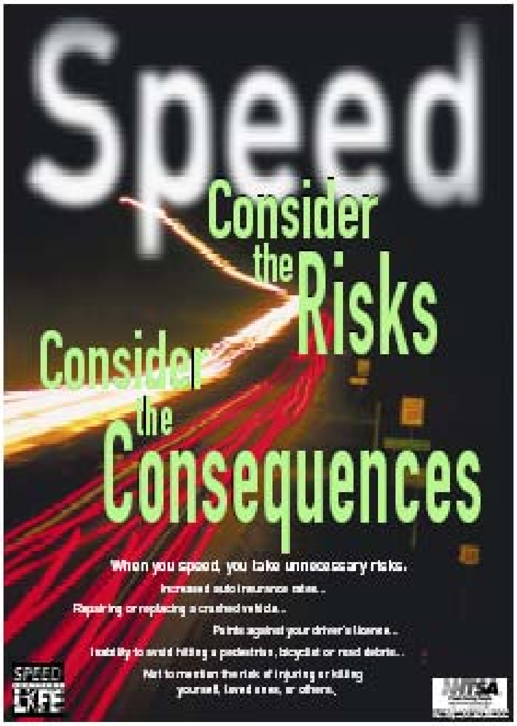
Exhibit I-2.1 – Glennon's Transportation Safety Eras

I. Campaign Era
II. Action Era
III. Priority Era

Through all eras, safety has competed for the scarce resources of the transportation dollar, with one common component – that trade-offs based on competing elements and policies were inevitable – and that safety, although a top concern, must be balanced with other concerns to meet the needs of the public and the transportation system.

Further, designers, operators, planners, and advocates of safety view the ultimate solution from very different points of view. A solution that is safe for one mode of transportation may not translate into increased safety for another, or a safety solution may be viewed by some as having excessive environmental or contextual impacts with little gain in safety. It is important to recognize the complexity of these issues and how highway design has changed to meet these needs.

Exhibit I-2.2 – Speed Reduction Campaign Poster (Source: The National Highway Traffic Safety Administration (NHTSA))



It has been suggested that motor vehicle safety efforts can be characterized into three distinct historic periods (Glennon, 1996). These periods are the Campaign Era, the Action Era, and the Priority Era. In addition to these eras, author John Milton suggests the Public Involvement Era, the Environmental Era, the Modal Era, and the current Context Sensitive Era as eras that also had great impacts on safety decision-making. Each of these eras recognized the need to optimize safety against the competing needs of the transportation system.

Campaign Era

Glennon suggests that the *Campaign Era*, prior to the 1960s, was characterized by public information efforts that focused on particular aspects of safety often aimed at improving driver behavior in order to improve safety. Some of the campaigns included, "Stop, Look, and Listen," "The Life You Save May Be Your Own," and "Speed Kills." Today, safety campaigns continue with varying levels of success.

This time frame also saw a great increase in the amount of new transportation facilities being built. These new facilities were designed and installed with the safe and efficient movement of the automobile as the priority. In order to achieve these high levels, designers began to adopt "standards" for use in facility design. Engineering judgment was deemed less important, as the need to construct facilities efficiently and in a consistent manner became paramount.

Since the 1960s, a great deal of emphasis has been placed on providing a clear roadside to lessen the frequency and severity of impacts between road users and fixed objects on the nation's highways. This is a dramatic shift from the 1950s, when the prevailing attitude was that any driver who left the road and ran into a tree or sign deserved the consequences of their actions.

Action Era

As the growth of freeway construction increased in the 1960s, new opportunities for improved highway design became evident to the public agencies and road users. In response, the 1966 National Highway Safety Act was passed by Congress. This act adopted 16 highway safety standards. The Highway Safety Act marked the beginning of the *Action Era.* Money was allocated not only to standards, but also to enforcement, education, and emergency medical services. In addition, data systems and research also increased in importance in the effort to improve safety. It quickly became clear that not enough money was available to pursue all elements of safety.

Priority Era

According to Glennon, the revenue shortage ushered in the *Priority Era*. The *Priority Era* required transportation officials to target money to areas with the highest return on the safety dollars spent. The simple application of standards came first and foremost in a transportation agency's attack on the "safety problem." This was because standards were often developed with an underlying "return on investment" concept.

Public Involvement Era

As Milton suggests, the *Public Involvement Era* came next. The push for growth and the strength of the transportation system in the 1950s and 1960s allowed designs that had limited public involvement. Increasingly, because of the limited planning efforts and public participation, designs that had significant impacts on social, environmental, and historical sites became more prevalent. The construction of these designs in the 1970s led to public demands for increased participation in the decision-making process. This was particularly true in the placing of transportation facilities. The public desired that these facilities be developed in a manner that would limit the impacts created by the facilities' construction and operation. Laws were developed to ensure the public had an opportunity to speak and that specific elements were addressed.

Exhibit I-2.3 – Transportation Eras Continued

IV. Public Involvement Era
V. Environmental Era
VI. Modal Era
VII. Context Sensitive Era

Environmental Era

These actions led to the *Environmental Era*. This era saw the National Environmental Policy Act, the State Environmental Policy Act, and laws for clean air and water become institutionalized as part of the process of transportation design. Designs were developed that optimized safety and mobility, while taking into account the social and environmental impacts that could result from them. Trade-offs between the competing needs and alternatives for travel were becoming much more apparent in the designs of the 1980s.

Modal Era

Finding solutions to projects with limited transportation budgets, and the need for safe, efficient, and environmentally friendly projects led to designs that focused on more than the single-occupant vehicle. The *Modal Era* presented designs that focused on increasing vehicle occupancies; providing higher levels of mass transit and rail service; and expanding the opportunities for the different modes of transportation to integrate. It was in the *Modal Era* that an increased emphasis on the pedestrian and bicycle travel modes emerged. With this new emphasis, non-motorized facility improvement and consideration for the needs of the travelers became increasingly important. Sidewalks, travel ways and trails, and the interactions between vehicles and other modal users became an important part of most projects. The *Modal Era* also saw changes in access considerations for the disabled.

Context Sensitive Era

The newest era is arguably a combination of all the preceding eras. This new era, called the *Context Sensitive Era*, is an attempt to combine safety, mobility, public outreach, social, environmental, and modal considerations in highway and roadway designs. The *Context Sensitive Era* is based on the realization that different facilities have different needs. This Era also recognizes that trade-offs in decision-making must be weighed in every project. To do so, it is felt, results in a project of greater overall value to the public. The benefits of safety design elements, which focus on individual improvements, must be weighed against alternative solutions that optimize the benefits of competing factors, even when those factors are not directly related to safety.

Safety in the *Context Sensitive Era* is based on the understanding that safety is the product of the complex interaction among many variables. Consequently, what is commonly a safety-related issue in the urban environment is not always an issue in the rural environment, and vice versa. For example, statistics show that three severe-injury collision types are prominent in the urban environment: rearend, fixed object, and entering-at-angle collisions. In the rural highway environment, fixed object, overturn, and rearend accidents dominate. Traffic mix is also an important part of the safety equation – as trucks, cars, buses, bicycles, and pedestrians must all exist in the same facility prism.

Conclusions

Clearly, the historical changes in policy direction mandated by changes in federal, state, and local laws, regulations, and policies recognize that safety is a competing element in the highway system. Trade-offs are frequently made to address these competing needs, while considering the philosophies of previous eras. The ability to understand this historical perspective also allows for a better understanding of how projects were and are developed and how they continue to grow in the changing environment and societal landscape.

Unfortunately, during all these eras, one thing has remained constant in the state of Washington: the growth of claims against transportation agencies for tortious acts. This has restrained the ability to make trade-offs that allow for full optimization of the components because of the fear of lawsuits and tort liability.

It is a major concern for the *Context Sensitive Era*, since designs must be increasingly flexible and allow for greater engineering and scientific judgment in the consideration of issues that may be well beyond that of safety.

Basic knowledge of the legal issues and ramifications involved in transportation decisions could be very beneficial to the reader (see Chapter I-3). Many problems might be avoided by consulting with counsel assigned to specific jurisdictions, which could allow areas of concern to be addressed and mitigated prior to implementation of projects and programs.

Governing Regulations and Directional Documents

Design Manual, WSDOT, M 22-01.

Local Agency Guidelines, WSDOT, M 36-63.

State Environmental Policy Act (SEPA), *Revised Code of Washington* (RCW) 43.21C, *Washington Administrative Code* (WAC) 197-11, WAC 468-12.

State Government – Executive, Title 43 RCW.

Additional Resources

Black's Law Dictionary, West Publishing CO., St. Paul, MN, 7th ed., 1999.

Consider the Risks, Consider the Consequences, Speed Shatters Life Poster, National Highway Traffic Safety Administration (NHTSA), http://www.nhtsa.dot.gov/people/outreach/safesobr/12qp/pdf/speed.pdf

Glennon, John C., *Roadway Defects and Tort Liability*, Lawyers & Judges Publishing Company, Inc., Tucson, AZ, 1996.

Milton, John, "Context Sensitive Design Experience in Washington State," Session 292, TRB Annual Meeting, Washington, D.C., January 2005.

Neuman, Schwartz, Clark and Bednar, *A Guide to Best Practices for Achieving Context Sensitive Solutions*, NCHRP Report #480, Transportation Research Board, Washington, D.C., 2002, p. 50.

Neuman, Timothy R., and James B. Saag, *A Guide to Applying AASHTO Policies to Achieve Flexibility in Highway Design*, NCHRP Report 480, Washington, D.C., 2003.

Introduction

The concepts of legal responsibility and liability deserve a better understanding as they relate to highway and roadway design. The precepts behind the laws and regulations that exist are complex and are best interpreted through the assistance of an agency's legal counsel. Notwithstanding this, designers too must face and deal with the realities and the constraints of the highway and roadway environments, political requirements, and environmental and right of way consequences placed before them.

Designers should understand that not all liability can be avoided and, at times, risks are appropriate and reasonable given the trade-offs that must be made in design. The concept of trade-offs, often referred to as flexibility, is a new and evolving concept as it relates to Context Sensitive Designs (CSDs). Though flexibility in design might result in additional risk to an agency, its benefits can be well worth the effort.

Steps can be taken to reduce the overall risk that might be incurred. This concept is called risk management, where actions are taken by agencies in an attempt to avoid or mitigate losses to the agency. One of the first steps in risk management is to understand the elements related to the legal process; and how, through good documentation and decision-making, liability can be reduced. Though the concepts and risks of legal liability may seem harsh and unyielding at times, taking appropriate steps can help alleviate any consequences that might be incurred. It is most important to work with partners early, to identify concerns and trade-offs, and to document those decisions well. Further, it is of significant benefit to use the advice of legal counsel to identify steps to help avoid legal risk now and in the future.

Legal Liability

Throughout the transportation eras (discussed in Chapter I-2), one thing has remained constant in the state of Washington: the growth of claims against transportation agencies for tortious acts. It is a major concern for the *Context Sensitive Era*, since designs must be increasingly flexible and allow for greater engineering and scientific judgment in the consideration of issues that are sometimes beyond that of safety.

While many claims can be avoided, some cannot. A better understanding of the legal issues will benefit the reader by providing basic knowledge of these issues and their ramifications. The reader is also encouraged to consult with counsel assigned to specific jurisdictions. Many problems could potentially be avoided by this simple interaction. Areas of concern could also be addressed and mitigated prior to implementation of projects and programs.

Legal liability has become an increasingly important aspect for many transportation agencies to consider. A number of factors have contributed to this phenomenon. Laws enacted by the Washington State Legislature (RCW 4.92.090) in the early 1960s ended the concept of sovereign immunity. Under sovereign immunity, the state was immune from tort suit and liability. With the loss of this immunity, transportation agencies have become increasingly sensitive to reducing the risk of liability exposure whenever possible, since significant expenditures and resources are required to defend and settle disputes. The burden of tort liability has eroded the ability of the engineer to make reasonable engineering judgments for fear of being challenged in a court of law. This heightened awareness to liability exposure by engineers has led to training and manuals that leave little flexibility within (or when deviating from) the standards.

Exhibit I-3.1 – Key Issues

- Erosion of sovereign immunity in the 1960s
- Flexibility is achieved through the optimization of trade-offs
- Consult counsel for interpretation of laws and liability

The concept of flexibility in facility design, as it relates to tort liability, is therefore met with an understandably cautious mindset. Placed before many agencies is unsubstantiated research or anecdotal evidence of the benefits of one design treatment over another. On the other hand, evidence in the form of accepted design manual standards and guidelines, with supporting research, is available to dissuade the design professional from varying from commonly accepted policies or procedures. Thus, the designer is often placed in the role of the obstructionist, or at times the advocate, of a standard or mode of travel. Unfortunately, these stances are commonly not looked upon with great admiration by agencies, the public, or parties who are in disagreement.

In reality, the common bond between parties in disagreement is the issue of trade-offs and the optimization of those trade-offs. The parties must work together to understand issues at hand, existing research, and competing needs. In the debate and discussion aimed at optimizing alternatives, an underlying fear of tort liability often arises, much of which would be better left to discussions with counsel, rather than the parties' attempts at interpretation. Most practitioners understand little as it relates to the basic principle of tort liability and how this knowledge can and does impact design flexibility. This chapter is intended to provide additional information regarding torts, and to present items that should be considered in any design, including its impact on tort liability.

Tort Liability

The term "tort law" is based on the concept that when a person suffers personal injury or property damages, they may shift some of the responsibility for that damage to another entity. Compensation for that responsibility is often addressed through monetary damages being placed on those who breach the duty imposed by law. Thus, in the case of a roadway agency, the duty exists to design, construct, maintain, and operate roadways in a manner that does not expose users to undue hazards. In cases where hazards cannot be removed, the agency may warn users of the hazards.

If an agency fails to exercise reasonable care in the design, construction, maintenance, or operation of a roadway, the opportunity for legal action against the agency increases. Risk to the department is reduced when design is consistently governed by nationally accepted standards or guidelines, or by references developed to interpret national standards for compatibility with state, regional, or local conditions. The *Manual on Uniform Traffic Control Devices* (MUTCD), the American Association of State Highway and Transportation Officials (AASHTO) *Policy on Geometric Design of Highways and Streets*, the Washington State Department of Transportation (WSDOT) manuals, and *Local Agency Guidelines* (LAG) are common examples. A plaintiff's expert often interprets these policies in a way that can vary greatly from what is customarily accepted within the department or agency. These interpretations, should a judge accept them as an issue of fact, are often enough to bring a case to trial or settlement.

Civil Court Process

The civil court process is initiated when the plaintiff files a claim alleging that the agency failed in its duty to exercise reasonable care. Once a claim is filed, a suit may follow, in which the case will receive judgment in front of a judge or jury. Often, prior to trial, summary judgment motions are filed. Summary judgment motions are procedural devices used to resolve claims quickly and without trial. These motions are often filed when either material fact or conclusions drawn from fact are undisputed, or where only a question of law exists. Summary judgments may be made to all or part of the claim. Issues of law arise when only one conclusion can be drawn and where the evidence is not disputed. When evidence is disputed, an issue of fact may exist. In essence, an issue of fact arises when a fact is maintained by one party and disputed by the others in pleadings. Judges in these cases are generally reluctant to issue summary judgment as an issue of law, particularly when a plaintiff's expert either rightly or wrongly suggested there was an issue of fact to be decided. This is clearly the case when a plaintiff's expert alleges a hazardous condition existed and can show either documentation or research that may allude to the issue, even though common practice shows otherwise. The elements of a tort are:

a) Was there a duty of care?
b) Was there a breach of that duty that fell below the standard of care expected from a reasonable person in a similar circumstance?
c) Was the failure to meet the standard of care the proximate cause of the injuries?
d) What damages will be awarded for failure to meet that standard of care?

Once a judge determines that a transportation agency owes a duty of care to protect a plaintiff, a jury decides whether the agency satisfied that duty. Generally, the duty is defined as: the exercise of reasonable care in design, maintenance, and operation of highways. Evidence usually used to determine whether reasonable care was exercised is compliance with accepted standards, such as MUTCD or AASHTO, and state design and maintenance manuals. This evidence is typically introduced through the testimony of engineers and other experts,

Exhibit I-3.2 – Civil Court Process

- Claim of negligence
- Filing of lawsuit
- Motions for summary judgment
- Mediation
- Settlement or Hearing

who give opinions on the interpretation and application of the standards.

Negligence

Exhibit I-3.3 – Negligence
The failure to use care that would be expected of a reasonable, prudent, and careful individual under similar circumstances

In most circumstances, alleged negligence against a transportation agency is unintentional negligence or tort. Liability arises from this type of negligent conduct, since it is assumed there is a duty owed by a transportation agency to design, construct, maintain, and operate a road in a way that is reasonable and expected, and that this duty was breached. As defined, negligence is the failure to use care that would be expected of a reasonable, prudent, and careful individual under similar circumstances. The plaintiff in a tort claim often seeks to be compensated for injuries that arise from the negligent act, within the current economic and social climate. In Washington, negligence or fault is defined by RCW 4.22.015.

The standard required of the defendant is also required of the plaintiff. In some cases, it can be concluded that the plaintiff failed to meet the standard of care required for an individual in the same circumstances. For example, consider the motorist who speeds in icy conditions. In this instance, the jury or judge may find that the excessive speed contributed to the accident. Therefore, the failure to follow the legal standard of care required for one's own safety might be determined "contributory negligence." RCW 4.22.005 addresses this issue, and states that the contributory fault of the claimant proportionately diminishes the amount of compensation awarded, but does not bar recovery.

Exhibit I-3.4 – Example of Joint and Several Liability

- Assume that Defendant One, the driver of a vehicle, is speeding recklessly and is found to be 99% at fault in an accident that injures a faultless passenger, and that Defendant Two is 1% at fault because of a minor design deviation or variance.
- Assume the jury issues a finding of $1,000,000 dollars to the plaintiff. Now, Defendant One would be liable for $990,000 and Defendant Two for $10,000. However, in this particular case, Defendant One has no insurance or ability to pay for the judgment. As such, Defendant Two would be jointly and severally responsible for the judgment. In other words, Defendant Two would be responsible for the entire $1,000,000 settlement.

In another example, consider a case where the jury awards a plaintiff $100,000 for injuries suffered. The jury also renders the opinion that the plaintiff is 60% at fault and the defendant is 40% at fault. In this instance, the plaintiff would be awarded $40,000 from the defendant.

Joint and Several Liability

In many cases, there is more than one defendant. In these cases, a defendant who is found liable for any portion of a plaintiff's injury is jointly and severally liable for all damages with the other defendants in the case who are held liable (as defined by RCW 4.22.030). This means that, if a co-defendant cannot pay their share of liability, then the other defendant must pay that share of the settlement – even if their liability is minimal. This is the reason plaintiffs will often join defendants in a case, even though it is clear that little or no liability exists for one or more of the defendants. This is also known as suing the "deep pockets." In addition, this is often why agencies will settle for large sums, even though little fault may be apparent. The risk of a minor amount of liability being found is high when the plaintiff's expert is free to find even the slightest amount of fault as the reason for the accident to have occurred. A discussion of joint and several liability is found in RCW 4.22.070, including a discussion of the percentage of fault, the determination of fault, exceptions, and limitations.

Discretionary Immunity

As the concept of sovereign immunity ended, state legislatures began restoring parts of immunity.

The philosophy behind the determination of a discretionary act begins with the “separation of powers” doctrine, which suggests that certain government policy-making should not be subject to judicial review. However, both the state and federal legislative branches have been reluctant to define the term “discretionary function.”

In part, tort opinions attempt to find a balance between the rights of the parties and the interests of the public. Executive branches of government for the federal, state, and local systems, federal and state agencies, and the courts influence this balance.

It is not uncommon for a court to search for sources of the policy as it begins to contemplate its decisions. Given the desire of cities, states, and the federal government to incorporate policies that allow for flexibility in design (within the principles of CSD), it is expected that courts will strike a balance which will account for safety, mobility, aesthetics, and the environment, while weighing the impacts of one element over another when determining the weight of a questioned tortious action.

It would be critical, then, that any such flexibility in highway design policy decisions be crafted to meet the four-part test established by the Washington State Supreme Court in *Evangelical United Brethren Church of Adna v. State:*

1) Does the challenged act, omission, or decision necessarily involve a basic governmental policy, program, or objective?
2) Is the questioned act, omission, or decision essential to the realization or accomplishment of that policy, program, or objective as opposed to one that would not change the course or direction of the policy, program, or objective?
3) Does the act, omission, or decision require the exercise of basic policy evaluation, judgment, and expertise on the part of the governmental agency involved?
4) Does the governmental agency involved possess the requisite constitutional, statutory, or lawful authority and duty to do or make the challenged act, omission, or decision?

Level of Decision-Making in Discretionary Immunity

Washington courts have limited the doctrine of discretionary immunity to high-level policy decisions that consciously weigh one policy alternative against another. The doctrine is not applied to lower-level decisions, which are often considered operational, such as engineering decisions that relate to the specifics of the construction of a facility.

Agencies should be cautioned, therefore, that Washington courts would likely find that the adoption of an overall design policy would be discretionary, but that individual decisions applying such a policy, if they resulted in less safety than an alternative design, could be viewed by a jury as an "operational" decision.

An example is the case of Stewart v. State, concerning the lighting on the freeway bridge north of Everett (see Additional Resources). This case is typical of Washington court decisions that refuse to apply discretionary immunity to engineering decisions regarding the design of a facility. Another case is Miotke v. Spokane, a 1983 case concerning engineering decisions made in the improvement of Spokane sewage treatment (see Additional Resources).

It could also be argued that decisions are not necessarily based on the level of decision-maker, but rather the type of decision being made and whether the decision resulted from a balancing of policy considerations. Design engineers, for instance, when deciding on the overall design of a project, will be urged to balance and optimize the trade-offs between the societal, economic, environmental, historic, safety, and mobility impacts of many of their decisions. They will also be strongly urged to document the decision process (including discussion and debate) and to retain this information for any future civil and design-related actions.

Ministerial Decisions

Ministerial functions are generally defined tasks, which offer little decision-making opportunity and do not require a decision among alternatives prior to completing the task or action.

In Washington State, engineering decisions are considered to be ministerial decisions, unless it can be shown that there was a considered debate about things such as costs, benefits, and safety and that this debate occurred above the lower levels of the agency. If there is a deviation from well-accepted safety standards (such as clear zone) and there is no showing of any debate about pros and cons at a higher policy-making level of the agency, courts usually consider a decision about the safety measure to be "ministerial" rather than discretionary, and subject to possible liability. The mere fact that standards are varied from constitutes a deviation from adopted policy and is considered an issue of fact.

Documentation

Many design engineers are reluctant to vary from standards, in part because the mere fact of doing so often incurs liability to an agency. Design manuals have the effect of policy for the agencies that use them and, in many cases, the following of standards allows the engineer the cover of “discretionary immunity.” It is recognized that design engineers rely on standards as a foundation for decision-making that promotes consistency, efficiency, and predictability for the agency and stakeholders, both internal and external. Standards are valued greatly for their utility, but at times are applied strictly, without consideration for the unique constraints or opportunities that a project or site might offer. These cases require professional interpretation and, in many cases, variation from the standards or guidelines, to achieve optimum outcomes. These are considerations that the courts might find to be beneficial in decision-making. In the aforementioned Stewart v. State case, which was heard by the Washington State Supreme Court, it was argued by the state that the design should fall under the discretionary immunity doctrine. The court ruled:

> There was no showing by the State that it considered the risks and advantages of these particular designs, that they were consciously balanced against alternatives, taking into account safety, economics, adopted standards, recognized engineering, and whatever else was appropriate.

Clearly then, documentation of design is important (see Chapter VI-1), particularly in deviating from adopted standards. In states other than Washington, courts have found that documentation in which trade-offs were discussed in the deviation reports qualified as a discretionary function. Hence "discretionary immunity" could be argued, provided that these deviations offer the necessary discussion of trade-offs between multiple policy issues, different options and considerations, and the benefits and costs associated with each of those alternatives. Most notably would be the discussion of safety. When presented to a council or commission for further policy-making discussion, these debates and documentation could also strengthen the "discretionary defense" argument. Deviations that result in a measurable degradation of overall safety, when compared to existing conditions, should not be considered. To increase the usefulness of the documents describing the deviations, it is wise to show what mitigation measures have been considered and implemented where appropriate.

Clearly the best defense in supporting oneself in court is the presentation of written evidence. The documentation is best prepared as part of the design and provides a rationale for decision-making. It explains why certain criteria were not met, given the circumstances and environment of the project. NCHRP 480, the Washington State *Local Agency Guidelines* (LAG) manual, and the WSDOT *Design Manual* all provide examples for documentation of such decisions and considerations.

Conclusions

The final decision for transportation facility design is left to the professional engineer whose stamp is required for the project. The engineer is required to approve designs consistent with sound engineering practice. Political and public pressure to adopt flexible designs will undoubtedly occur and must be dealt with according to the engineer's best judgment and training.

Engineers must take the time to clearly articulate safety issues and liability concerns to the public, planners, and advocates unfamiliar with engineering design principles and the court systems. Safety discussions are important responsibilities of the designer, and are best discussed at the earliest stage of project development.

When the principles of flexibility in design are incorporated into a project, there must be an explicit discussion of any safety consequences, and documentation of both that discussion and the reasons for the ultimate decisions on the safety issue. Decisions based on well-recognized and documented engineering principles and practices are the best way to reduce risk.

Context sensitive designs may increase liability. The risk corresponding to this increase depends on the investment made by the agency in the development, interpretation, and application of standards, guidelines, and policies upon which design decisions are based. Standards that allow for flexibility and are consistent with common national and local practice will help mitigate any increases in liability.

Clearly, the higher the level of decision-making, the more probable it is that the policy will meet the test set forth in Evangelical United Brethren Church of Adna v. State. When lower-level operational decisions are required, they should be documented and retained. The documentation should discuss the decisions and the alternatives considered and should always be retained for future reference.

Governing Regulations and Directional Documents

Actions and Claims Against State, *Revised Code of Washington* (RCW) 4.92.

Civil Procedure, Title 4 RCW.

Contributory Fault – Settlement Agreements, RCW 4.22.

Design Manual, WSDOT, M 22-01.

Local Agency Guidelines, WSDOT, M 36-63.

State Environmental Policy Act (SEPA), RCW 43.21C, *Washington Administrative Code* (WAC) 197-11, WAC 468-12.

State Government – Executive, Title 43 RCW.

Additional Resources

Black's Law Dictionary, West Publishing Co., St. Paul, MN, 7th ed., 1999.

Evangelical United Brethren Church of Adna v. State - 67 Wn.2d 246, 407 P.2d 440, 445 (1965).

Glennon, John C., *Roadway Defects and Tort Liability*, Lawyers & Judges Publishing Company, Inc., Tucson, AZ, 1996.

Miotke v. Spokane – 101 Wn.2d 307, 678 P.2d 803 (1984).

Neuman, Schwartz, Clark and Bednar, *A Guide to Best Practices for Achieving Context Sensitive Solutions*, NCHRP Report #480, Transportation Research Board, Washington, D.C., 2002, p. 50.

Neuman, Timothy R., and James B. Saag, *A Guide to Applying AASHTO Policies to Achieve Flexibility in Highway Design*, NCHRP Report 480, Washington, D.C., 2003.

Stewart v. State - 92 Wn.2d 285, 597 P.2d 101 (1979).

Introduction

This chapter describes the various contexts in which transportation facilities may exist and the importance of the context and of project locations, and it prompts consideration of the elements within a particular project's setting that can influence design decisions.

The sections in this chapter describe both urban and rural settings. Projects may span a number of different contexts, depending on the location and length of the project. It is important to recognize the unique needs of each particular context and craft solutions that address those needs, as well as the needs within the transitional areas, as discussed in Chapter V-2.

A primary goal of project development is the recognition and balancing of needs associated with multiple modes of transportation. In a multi-modal context, design involves trade-offs and decisions in increasing number and complexity, as the number of travel modes increase. This chapter covers the subject of project context – urban, suburban or rural – and the influence these environments have on decisions made during the project development process.

The intent of this chapter is to describe the various contexts that might be encountered and, using the tools described in the following divisions, determine the appropriate application of design criteria, in order to accommodate the various travel modes as efficiently and effectively as possible.

Urban and Rural Settings

The contexts described in the following sections represent two distinct categories – urban and rural environments.

Urban Environments

The Washington State Growth Management Act (GMA) defines "urban growth" as built-up areas that make "intensive use of land for the location of buildings, structures, and impermeable surfaces…"[1]

The GMA encourages the development of formally designated urban areas "where adequate public facilities and services exist or can be provided in an efficient manner."[2] Under the GMA, transportation facilities are to be "efficient, multi-modal transportation systems that are based on regional priorities and coordinated with county and city comprehensive plans."[3]

The complexity of urban facilities requires a more flexible approach to address the design considerations of transportation

[1] Revised Code of Washington (RCW) 36.70A.030-17.
[2] RCW 36.70A.020-1.
[3] RCW 36.70A.020-3.

facilities. Such an approach is particularly appropriate for the state of Washington, given GMA's presuppositions that urban areas will be treated distinctly from rural areas, as well as resource lands and critical areas.

Within the urban growth areas that have been formally designated throughout the state of Washington, there are very distinct sub-areas, districts, and communities, as defined by their unique characteristics and attributes. The development of projects within these locations needs to recognize these unique features and take them into consideration during the design process.

Rural Environments

Rural towns and communities are considered "cities within rural areas" for the purposes of this chapter. The GMA calls for all incorporated communities to be located within a formally designated urban growth area. However, for cities within rural areas, these urban growth areas can be "stand-alone" locations that are physically separated from the other urban areas by rural areas or resource lands.

Development patterns and facilities for these towns are not to contribute to sprawl or low-density, urban-type development in adjacent rural lands. However, while towns in the rural areas are considered to be "urban" locales under the GMA, they are also recognized as distinct locations, where more moderate densities might be appropriate and where commercial activities appropriately support rural-type industries, including farming and forestry.

Contexts within Urban and Rural Settings and Associated Considerations

The following sections describe eight primary contexts associated with the urban and rural environment settings:

- Urban Centers
- Urban Corridors and Nodes
- Suburban Corridors and Nodes
- Industrial Corridors
- Rural Town Centers
- Transitional Areas (Within the Designated Urban Growth Area)
- Rural Connecting Corridors
- Residential Areas

Each section describes the context and provides some description of the factors that need to be considered with regard to the development of a transportation facility.

Urban Centers

Urban centers are focal points within the urban growth areas that are primarily located within incorporated cities. They are relatively small areas geographically, where a significant share of commercial and residential development is targeted, along with a variety of support services and facilities. These locations provide a diverse environment with a mix of housing, employment, shopping, parks, and recreation opportunities.

Urban centers generally offer access to frequent rapid transit, which connects passengers to other centers and surrounding neighborhoods.

Urban centers are traditionally walkable communities, with broad sidewalks and structures typically built out to the curb line. Parking is frequently provided within structures, ideally accessed from side streets. On-street parking is normally provided, but primarily intended for short-term users.

Transportation facilities within urban centers need to account for multi-modal travel and provide the associated facilities. The needs may include easy walking access for pedestrians; racks, lanes, and lockers for bicyclists; and facilities to support a large number of transit users. In urban centers, more intersections might be equipped with traffic signals than in the suburban, industrial, or rural contexts. In general, vehicle speeds are lower in this setting than in other contexts.

Examples of urban centers include the downtown areas of the cities of Bellevue, Everett, Kent, Olympia, Renton, Spokane, Tacoma, Vancouver, Wenatchee, and Yakima.

Exhibit II-1.1 notes the relative volumes of modal users within an urban center.

Exhibit II-1.1 – Relative Volumes of Users in Urban Centers (by mode)

High Volume	Medium Volume	Low Volume
• Pedestrians • Bicycles • Transit • Automobiles	• Trucks	

In urban centers, trucks can vary by type and size depending on the needs and road network of the particular location. It can be expected that delivery trucks (single unit vehicles) would be the primary truck type.

Urban Corridors and Nodes

An urban corridor is generally a multi-modal arterial that is well integrated into the built environment. These corridors are usually located within commercial areas with buildings located up to the curb line, and ground floor space primarily dedicated to retail and office space. Loading areas are frequently located behind buildings or to one side, and are generally accessed by alleys or side streets. There might be instances where this context includes primarily the residential districts of a community, where front yards face the street and alleyways are located to the rear of the residences.

Within these corridors, there might be specific “nodes” or smaller centers that serve as focal points for neighborhoods or areas of particular local community activity. These nodes can provide a moderately dense mix of housing and services, including stores, community centers, and libraries. These represent areas in which easy access for pedestrians, bicyclists, and transit users would be desirable.

Adjacent neighborhoods and districts are typically connected to urban corridors by a network of sidewalks. Within this context, transit routes normally include stops at least every half-mile. Along the corridor itself, a variety of travel modes need to be considered: pedestrians, bicyclists, transit users, motorists, and freight. These roadways frequently have medians, and on-street parking is sometimes provided (where speeds and pedestrian considerations allow). Traffic lights are commonly provided at regular intervals (based on identified needs), as well as pedestrian crossing signals. The speeds on these facilities are generally below 45 mph.

In many cases, placement of buildings, and access to businesses, limit the right of way and available space for placement of utilities and roadside amenities. Pedestrian generators are often transit facilities and high-density residential, combined with mixed-use commercial. Limited walking distances at these locations create high cross-street pedestrian traffic potential. The highest pedestrian levels are at intersections; however, at times, mid-block crossing issues are encountered.

Exhibit II-1.2 – Relative Volumes of Users in Urban Corridors and Nodes (by mode)

High Volume	Medium Volume	Low Volume
• Automobiles • Transit • Trucks	• Bicycles • Pedestrians	

Examples of urban corridors and nodes would be:

- Aurora Avenue (Seattle)
- Division Street (Spokane)
- Pacific Avenue (Tacoma)

Exhibit II-1.2 notes the relative volumes of modal users within urban corridors and nodes.

Pedestrian levels at intersections can be high volume. This is generally dependent on the proximity of pedestrian generators and destinations in relation to the nearest crossing location. With some urban corridors, shoulders and bicycle lanes are limited and bicyclists may be advised to use alternate routes.

Suburban Corridors and Nodes

Suburban corridors are distinguished from urban corridors by the existence of more automobile-oriented uses along the corridor. Buildings may, in contrast to the urban corridors, be set back from the street, with parking accessed directly from the arterial. Typically, each business has its own parking lot, where areas are provided for parking in front, on the side, and even at the rear of the building. Transit routes might be included along these corridors, but stops are less frequent – generally with a spacing of ½ mile or greater. Speeds are typically below 45 mph. Right of way is greater than most urban corridors, which allows for greater offsets of utilities and roadside amenities from the traveled way. Pedestrian traffic is more often related to nearby residential land use of both single unit and high density, intermixed with businesses.

The roadway itself may include a median along the center line of the roadway or a two-way left-turn lane. Traffic signals are typically located only at major intersections or access points along the route.

Transportation facilities along suburban corridors need to be developed to accommodate multi-modal travel options. Future roadway reconstruction projects need to consider the inclusion of pedestrian and bicycle facilities in areas where they are deficient. Project stakeholders also need to evaluate opportunities to provide regular pedestrian crossings across the roadway, and to enhance transit facilities through the incorporation of covered structures at stops and easy pedestrian connections between nearby businesses and adjacent neighborhoods. These pedestrian and bicycle facilities should be designed so that they are integrated into the existing road network, and in a manner that optimizes the safety of these users.

Examples of suburban corridors include:

- Pacific Highway (SR 99) in the cities of SeaTac, Federal Way, and Des Moines
- Evergreen Way in Everett
- SR 527 – 164th St. SE to 132nd St. SE in Mill Creek

Exhibit II-1.3 notes the relative volumes of modal users within suburban corridors and nodes.

Exhibit II-1.3 – Relative Volumes of Users in Suburban Corridors and Nodes (by mode)

High Volume	Medium Volume	Low Volume
• Automobiles • Trucks	• Transit • Bicycles • Pedestrians	

Industrial Corridors

This particular context is characterized by multi-modal arterials that traverse areas where intensive manufacturing or industrial activity is concentrated. Transit routes might be included in these districts, with stops located near the entrances to major industrial complexes, or along roadways adjacent to these complexes. Speeds vary in the corridor depending on the type of facility serving the area. In some cases, facilities are freeway-oriented and in other cases are served by arterials with signalized crossings. Right of way may also vary depending on location.

Transportation facility design along these corridors should consider potential safety issues for each of the users of this facility type, in particular freight traffic, passenger vehicle traffic, and pedestrians. Industrial corridors are typically truck routes and should be designed to accommodate the efficient movement of freight and goods.

An example of this context is Marginal Way in the city of Seattle.

Exhibit II-1.4 notes the relative volumes of users within industrial corridors.

Exhibit II-1.4 – Relative Volumes of Modal Users in Industrial Corridors (by mode)

High Volume	Medium Volume	Low Volume
• Trucks • Automobiles	• Transit	• Bicycles • Pedestrians

Rural Town Centers

Town centers of cities located in a rural environmental context are typically focal points where citizens gather for a variety of activities, including business, shopping, and recreation. This context is often characterized by a strong public presence, because it typically includes the city hall, “Main Street,” and other significant public spaces.

Transportation facilities within town centers need to consider users of multiple transportation modes. Intersections located within these contexts typically consist of a mix of signalized intersections with pedestrian crosswalk signals and four-way stop intersections. Travel speeds for vehicles are usually reduced through the use of speed limits or physical features, such as narrowing the roadway itself.

Speed is often reduced at the entrance of rural town centers. Pedestrians may consist of both local and non-local individuals. In some locations, additional information may be provided for the unfamiliar visitor. Right of way varies, but is often limited. Many rural town centers are considered historical in nature and special design consideration may be warranted.

Examples of this context include:

- SR 203 in the cities of Duvall and Carnation
- US 2 in Leavenworth

Exhibit II-1.5 – Relative Volumes of Users in Rural Town Centers (by mode)

High Volume	Medium Volume	Low Volume
• Pedestrians	• Trucks • Automobiles • Bicycles	• Transit

- SR 14 in Bingen
- US 395 in Colville

Exhibit II-1.5 notes the relative volumes of modal users within rural town centers.

Transitional Areas (Within the Designated Urban Growth Area)

Along the outskirts of rural towns, there may be transitional areas that are located within the urban growth area. These corridors include multi-modal arterials, where various types of land use occur along the corridor. The context can vary from corridors that are more commercial in nature to corridors that are primarily residential in nature.

The transitional areas that are commercially-oriented can be characterized by buildings that are constructed either up to the curb line, with parking located to the side of the building, or by buildings that are set back from the street, with surface parking provided at the front of the building.

The transitional areas that are residential in nature are characterized by homes on larger lots, with driveway access directly from the arterial.

Transit facilities will be infrequent in this context, likely consisting of regional service that connects the rural town to adjacent towns and cities. However, a local circular service might be appropriate.

It is necessary to consider the accommodation of both business and residential access, as well as to provide sidewalks or pathways for pedestrians and bicyclists in the design of transportation facilities in the transitional areas. Corridors through such areas are also likely to serve as truck routes and, as such, safety features need to be considered for motorists, trucks, bicyclists, and pedestrians, and for how these users might interact. Speeds on these facilities are high; typically 45 mph or greater. Right of way is generally available, but environmental considerations often play a role in the placement of utilities and roadside amenities.

Exhibit II-1.6 – Relative Volumes of Users in Rural Town Transitional Areas (by mode)

High Volume	Medium Volume	Low Volume
• Automobiles	• Trucks • Bicycles	• Pedestrians • Transit

When the facility is entering the rural setting from a more urbanized area, the focus will be on transitioning into a higher-speed context. The focus when entering an urbanized area is on highlighting the change in context for the users, to typically induce a reduction in speed.

US 101 in Raymond and SR 240 in Richland are examples of this environmental context.

Exhibit II-1.6 notes the relative volumes of modal users within rural town transitional areas.

Rural Connecting Corridors

The next context, rural connecting corridors, is characterized by arterials that link rural towns together or rural towns with other urbanized areas. Facilities within this context need to be designed in a manner that preserves the rural land-use patterns. Access points are typically limited, and special consideration must be given to ensure that the development of the project does not attract undesired development or create urban sprawl. Walkways or bicycle paths can be developed along these corridors to provide access both for recreational activities and commuting. Speeds are generally 50 mph or greater. Right of way is often available to provide for utilities and roadside amenities. Pedestrian generators are limited.

Examples of this context include:

- SR 20 at Ducken Road to Rosario
- I-90 over Snoqualmie Pass
- US 12 in east Lewis County

Exhibit II-1.7 notes the relative volumes of modal users within rural connecting corridors.

Exhibit II-1.7 – Relative Volumes of Users in Rural Connecting Corridors (by mode)

High Volume	Medium Volume	Low Volume
• Automobiles	• Trucks	• Transit • Pedestrians • Bicycles

Residential Areas

Collector and local access streets characterize the final context, residential areas. Residential areas may be located in urban, suburban, or rural areas. Land usage is typically single-family and high-density housing. Although limited, small businesses and shopping marts might also be found.

Residential areas can be characterized by homes, condominiums, and apartments that are set back a minimal distance from the street. Parking is located on the street or by a driveway to the side of the housing. Where buildings are set back from the street, parking may be located in front of the housing or to the side, depending on local codes and regulations.

Transit facilities will be mixed at a higher rate in urban areas, than in most rural locations that have transit service mainly to employment, shopping, and adjacent towns and cities.

The provision of sidewalks and pathways for pedestrians and bicyclists in the design of transportation facilities in residential areas is beneficial, particularly in higher-density urban locations. Corridors through such areas are also likely to serve passenger vehicles, small trucks, pedestrians, and bicycles. Speeds in these areas are typically low and often controlled by calming devices. Local ordinances may control the placement of utilities and roadside amenities. The provision for pedestrian and bicycle needs is desirable given the high-volume nature of each.

Exhibit II-1.8 – Relative Volumes of Users in Residential Areas (by mode)

High Volume	Medium Volume	Low Volume
• Pedestrians • Bicycles	• Automobiles	• Transit • Trucks

Case Studies

Appendix A presents a collection of case studies that illustrate some of the principles, processes, and concepts of flexibility in transportation design. Within each case study, issues were identified and resolved by considering alternatives and weighing the trade-offs. The challenges and solutions encountered in each project are discussed in the case studies.

Balancing the Considerations

Identifying the mix of users is a crucial first step in evaluating the trade-offs for any project. Local land use sets the tone for facility improvements. Certainly, the higher the presence of any particular user group (personal motorized transportation, pedestrian, freight, bicyclist, wildlife, etc.), the greater the complexity in accommodating each during design. Generally, the urban areas have a higher mix of user types, and operate at lower speeds than the rural areas. There are more trip ends in urban areas. The urban environment is also more limited in opportunities to expand the footprint, due to the built-up nature of urban areas.

- Trip origins and destinations should be considered to establish travel patterns. With the level of use factored in for each user group, the necessary accommodations begin to emerge.
- Conflict points should be identified, and proposals developed to minimize them. They may be separated physically or by time periods. The different contexts encompassed by transportation projects necessitate a case-by-case, mode-by-mode evaluation of all these issues.

Governing Regulations and Directional Documents

Growth Management – Planning by Selected Counties and Cities, Washington State Growth Management Act (GMA), *Revised Code of Washington* (RCW) 36.70A.

Division II Applying the Considerations
Chapter II-2 Defining and Creating a Sense of Place

Introduction

Many communities are currently engaged in defining a "sense of place" within their community. A sense of place is closely related to how people perceive their environment. It involves the actual safety and comfort of the area, the general appeal, and the feelings of connection between the people and the place. The efforts of these communities focus on implementing the design of efficient transportation facilities to fulfill their desires and needs; maintaining and enhancing a healthy local economy; and developing the downtown with sensitivity to the environment and the users. Their efforts attempt to embody the values and goals defined by the community. A variety of considerations can influence a community's efforts to develop this quality, including the design of the road and roadside and the characteristics of buildings and public spaces. This chapter describes the main considerations a community might weigh when developing its downtown area, and can be useful in guiding facility planners, scientists, and engineers when entering into a downtown revitalization or enhancement project.

Exhibit II-2.1 – Key Outcomes

- Provides safety to all users
- Maintains the natural environment
- Supports a healthy economy
- Incorporates a community's desires and needs

The topics discussed in this chapter are most applicable to the urban center, town center, and urban corridor contexts. The common characteristics of higher densities of people, multiple modes of transportation, and mixed land uses within these contexts call for unique transportation facilities that will serve the widely varied needs of a community.

Purpose and Need

As designers of urban transportation systems, it is critically important to understand the role that a transportation facility serves within a community and corridor in the local, regional, and statewide context. Considering the facility within its specific context can assist with the identification of design attributes that are important to the larger local and regional community. It is important that the transportation project development process includes a wide variety of interest groups and incorporates community-based decision-making to ensure the facility will meet the needs of both the community and the corridor. Understanding a community's desires and needs helps the design team contribute to the community's economic success, and can aid in establishing a collaborative, interdisciplinary approach that involves local governments, businesses, and citizens.

Often the state route serves multiple purposes. When a highway is located within a city, it can be the city's "Main Street." At the same time, it is a route that is intended to support regional mobility, freight needs, and transit. Taking the time to understand who uses, crosses, and depends on the facility will help ensure the appropriate design elements are balanced and incorporated into the project.

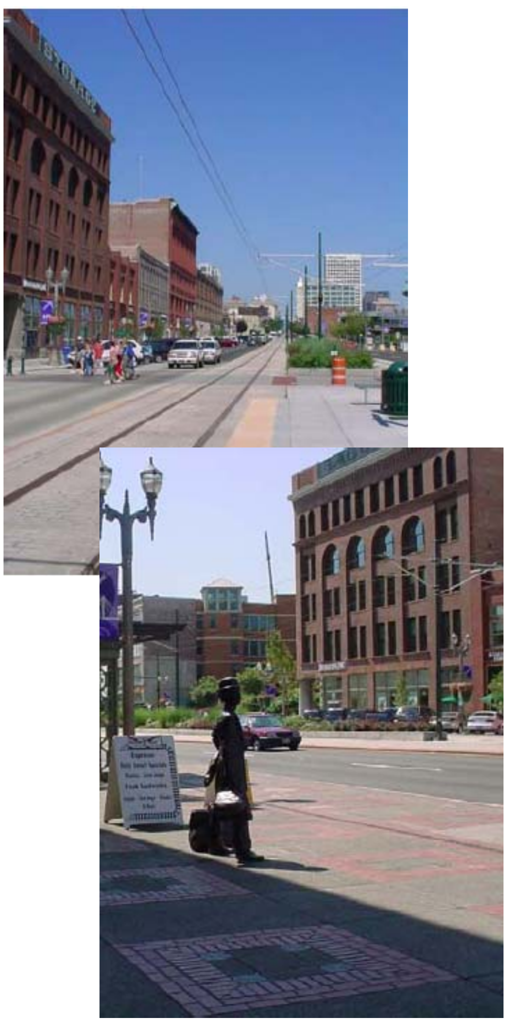
On state facilities that serve as the main street through towns and cities, the issues involved in creating a desired downtown environment must be balanced with the safety, mobility, and accessibility requirements that exist on the highway. With this consideration in mind, some features desired in projects that involve main street and community development might not be feasible, either because of the context of the development, or the design guidelines of the facility. In the project development process, it may be beneficial to address the possibility of developing the primary community-centered area along a city street that is parallel or perpendicular to the state highway. In this way, the desires of the community members and the needs of the route may be addressed with limited conflict.

The design features discussed in this chapter are intended for general consideration, and require an impact analysis prior to inclusion in a Route Development Plan.

The following section discusses important considerations in creating a sense of place that is acceptable to all stakeholders. It provides a discussion on the human scale, multi-modal transportation services, the built environment, and permanence.

Determining and Considering the Needs of All Users and Stakeholders

Exhibit II-2.2 – Views To & From Roadway (Location: Tacoma, WA)



A community considers a number of factors when developing its downtown area. These considerations are categorized into the following distinct areas:

- **Human Scale**
  - Perspective of features
  - Create spatial definition
  - Maintain safety while developing aesthetics
- **Multi-Modal Transportation Services**
  - Ensure street design supports adjacent land use
  - Truck usage considerations
- **Built Environment**
  - Encourage community involvement and activities
  - Create a qualitative sense of safety
  - Provide amenities for physical comfort
  - Maintain the quality of the environment created
- **Permanence**
  - Use connections to local identity
  - Ensure the created environment is sustainable
  - Develop infrastructure with a high quality of design and construction

The following sections describe some of the factors involved with each.

Human Scale

In many downtown environments, the focus is on multi-modal transportation and, in particular, pedestrian accessibility and use. To support this objective, the features within the downtown region are often scaled in a manner that will relate to those who see and use them most frequently.

Perspective of Features

This consideration usually entails the development of features that are visually oriented to pedestrians and motorists traveling at slower speeds. This can be accomplished in a number of ways:

Consider views to and from the roadway – The views involved with the roadway structure play an important role in developing and communicating the atmosphere of the downtown region.

As illustrated in Exhibit II-2.2, the appearance of the road from the pedestrian point of view influences how pedestrians feel about the downtown environment, and what people see as they pass through influences whether they will decide to return.

Create public spaces – The creation of public places affords the public the opportunity to gather in the downtown area. Public places create a number of benefits, such as bringing pedestrians into an area; fostering a sense of interest and enthusiasm for an area; and creating opportunities for public social contact between community members.

Use pedestrian-scale street features – Incorporating street furniture, bike racks, and other features into a downtown area can create a more comfortable, inviting atmosphere that attracts pedestrians.

Limit main street parking lots – In the visual sense, main street parking lots are typically unattractive. Allowing them along the main street may create a discontinuity in the environment. The city or town can develop a parking management plan, which can be used to designate how the community will meet the need for vehicle storage in the downtown area. Parking lots can be encouraged on the side streets, where their visual impacts will not be as significant.

Create Spatial Definition

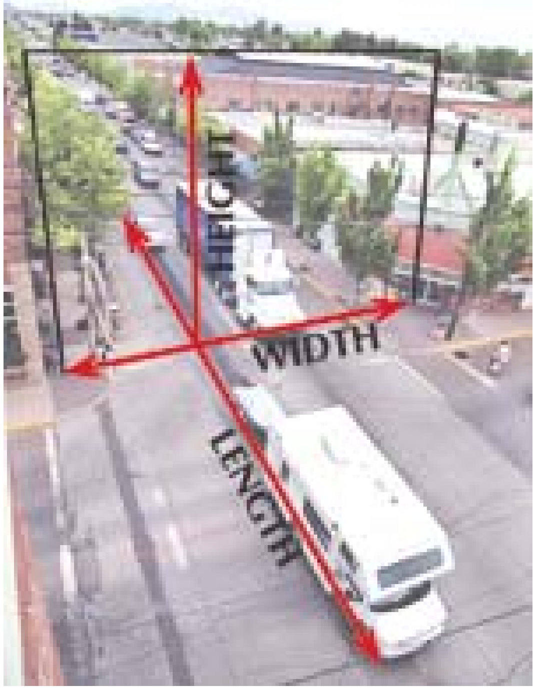
Spatial definition is the use of three-dimensional space to create the desired environment. The management of spatial definition can play a major role in creating an inviting and comfortable atmosphere within a downtown area (see Exhibit II-2.3).

The urban and town center environment is often designed to encourage motorists to slow their speeds through downtown, while still serving to appropriately inform drivers of the upcoming conditions and options; not distract drivers' attention; and preserve and enhance the safety of all travelers.

Orient buildings to face the street – Locating the front entrance of downtown buildings to the street enhances pedestrian accessibility and activity along the street, while encouraging a "downtown " feeling by promoting ground-floor uses that can provide window-shopping opportunities.

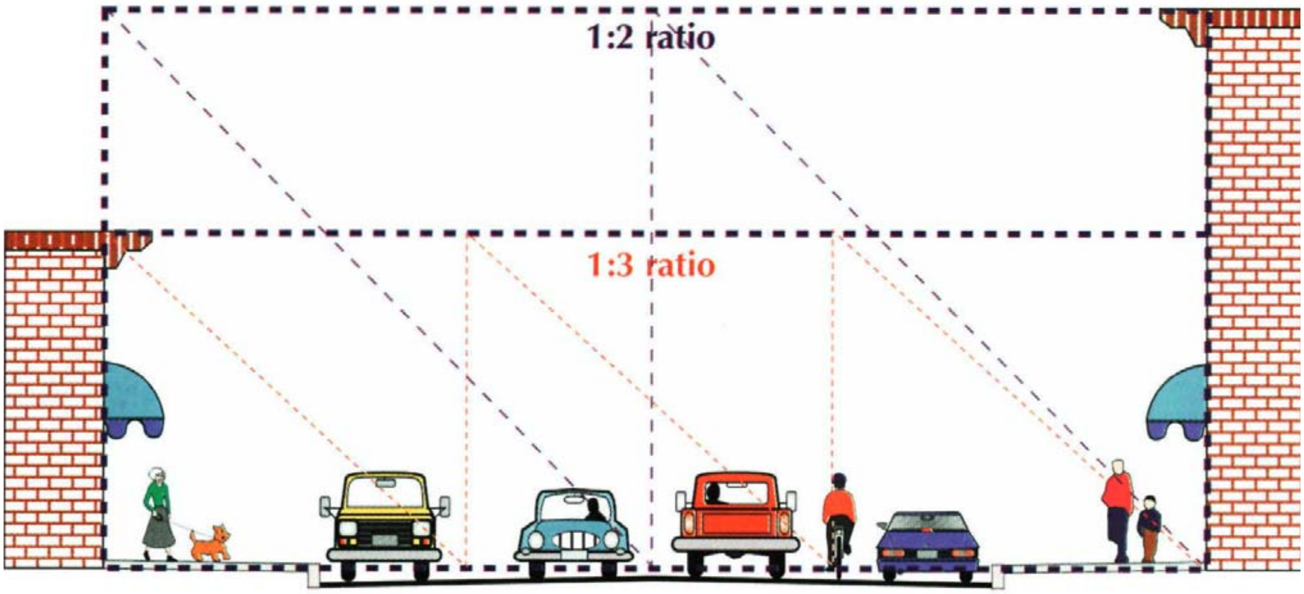
Exhibit II-2.3 – Spatial Definition (Location: Olympia, WA)

Exhibit II-2.4 – Streetscape Definition (Source: Main Street…, p. 14)



Consider the "height-to-width ratio" [1,2] – The ratio between the heights of the buildings or other street frontages to the width of the traveled way affects the downtown environment. Limiting this ratio to 1:5, and more ideally to between 1:2 and 1:3, helps create a human scale environment and can encourage greater use of the area (see Exhibits II-2.4 and II-2.5).

Exhibit II-2.5 – "Human scale height-to-width ratios fall between 1:3 and 1:2 as measured from the building fronts or large trees if present." (Source: Main Street…, p. 17.)



In many areas this might not be an achievable element, due primarily to the locations of existing buildings. In such cases, alternatives, including protected street-side and median plantings, can be used to visually redefine a streetscape that is wider than desired. The impacts of these elements on the safety of all users must be evaluated. For further information on roadway and safety guidelines, see Chapter V-3 and the Washington State Department of Transportation (WSDOT) *Design Manual*.

Maintain Safety While Developing Aesthetics

The development of aesthetic treatments is often an important component in a community development project. It is important to maintain an appropriate balance between the desire for aesthetic treatments and the safety needs of a roadway.

Fixed objects – The placement of vegetation or other fixed objects along a street may introduce hazards into the roadside environment (see Exhibit II-2.6). The vehicle risks associated with fixed objects are correlated with the speeds of the facility users, average daily traffic (ADT), offset, and object size and form. For example, on a low-speed facility with low ADT and large offset, there may be limited additional risk associated with street trees. However, on facilities with higher speeds and ADT, and a smaller offset, there is the risk of potential increases in accident frequency and severity. These features might pose a risk to pedestrians as well; pedestrians' perceived sense of safety may increase, while their visibility to vehicular traffic may decrease. The risk associated with fixed objects may be reduced

Exhibit II-2.6 – Street Tree Struck by Vehicle (Location: Olympia, WA)

[1] *Creating Livable Streets,* p. 45.
[2] *Main Street…When a Highway Runs Through It,* p. 17.

by placing the features farther from the roadway, or shielding them from vehicular traffic.

Multi-Modal Transportation Services

Supporting multiple modes of transportation can decrease traffic congestion, thus improving air quality; encouraging pedestrian activity; and improving mobility and accessibility. Below are some of the considerations and additional benefits involved in developing multi-modal transportation facilities.

Ensure Street Design Supports Adjacent Land Use

It is vitally important that the design of the transportation facility supports the existing and projected needs of the community, based on the adjacent land uses.

Support multi-modal travel throughout the downtown area – By having multiple modes of travel throughout the downtown area, the accessibility of downtown features can be increased.

Exhibit II-2.7 – Multi-Modal Facility (Location: Tacoma, WA)

Issues that may play into what types of transportation and levels of service to provide in the downtown environment include the existing and desired, or expected, use of the different modes of transportation (mass transit, vehicular, walking, bicycling); the origins and destinations of the facility users; and the types of land use along the facility (see Exhibit II-2.7).

Provide travel mode choice – Incorporating frequent interchange points between modes throughout the downtown area allows people to decide how to travel to and through the area. They are not limited by the constraints of having to make their entire trip by one mode of transportation. This might encourage people to use alternatives to private vehicles more frequently.

Conversely, more frequent interchange points between travel modes result in more frequent opportunities for conflicting needs between the different modes and users. The issue of safety must be carefully considered when seeking to develop accessibility.

Minimize travel mode interference – Several modes of transportation use the same facilities, so conflicting needs have to be balanced. The ease of transition between travel modes should be prioritized, while establishing modal connectivity and serving all users.

Establishing multiple modes of transportation that are interconnected throughout the region is a critical issue. Trade-off discussions must weigh the alternatives and strike a balance between the competing needs of the facilities. For example, optimizing the usefulness of mass transit includes frequent bus stops. While this has definite benefits for pedestrians, bicyclists, and other transit riders, this situation can cause delays and frustration for the vehicle-driving population, increased emissions harmful to the environment, and increased potential for traffic conflicts. Features such as bus pullouts may be part of an appropriate solution in such situations. Trade-off discussions must weigh the options and conflicting needs to reach a solution optimizing the use of the downtown area based on the desires of community members and the needs of the facility within its context.

Consider the needs and comfort of all travelers – Urban facilities must serve a wide variety of users, and one of the goals is to make traveling in the downtown area a comfortable and safe experience for all users.

Truck Usage Considerations

Trucks provide most of the delivery services to businesses in the downtown area (see Exhibit II-2.8). Ensuring that this crucial link between the movement of goods and the community is not significantly hindered is essential in developing the downtown economy.

Exhibit II-2.8 – Delivery Vehicle Access (Location: Tacoma, WA)

Define and meet delivery vehicle access needs – Trucks have wider turning radii and offtracking than passenger vehicles. The urban and town center contexts must provide the means for these vehicles to reach their destinations. Possible alternative solutions for truck access in downtown areas include locating loading facilities that accommodate delivery vehicle needs, and designing intersections located periodically along main routes that accommodate the turning movements of larger vehicles. (See Chapter III-4 for more information on considering delivery vehicle needs.)

Consider developing alternate truck routes – When parallel side streets exist, it might be possible to develop alternate routes. Delivery trucks, for example, could then be directed to the side streets for alley deliveries. These routes can be designed to accommodate the turning and loading needs of delivery vehicles, and can also be used to decrease through truck traffic on the main route.

Built Environment

The environment encompasses a wide variety of considerations, including but not limited to the built, social, economic, natural, cultural, and human factors. Developing a sense of place within a community involves balancing proposed projects, growth, and development with the preservation and enhancement of environmental resources. These are but some aspects to be considered in achieving this balance:

Encourage Community Involvement and Activities

A thriving downtown environment hosts a wide variety of activities. Listed below are some techniques used to develop or enhance the downtown infrastructure to encourage and support the activities valued by the members of a community.

Exhibit II-2.9 – Shopping Center Near Transit Station (Location: Lakewood, WA)

Incorporate public involvement in projects – Proposed projects can ensure consistency with a community's vision by including meaningful, frequent opportunities for public involvement and input in the project development stage. Incorporating public comment into the project can ensure that the project is true to a community's goals, and help foster a sense of investment in and support for the project.

Provide for accessible transit stations and stops, and sidewalks – By ensuring that the transit and pedestrian facilities are inviting and accessible (see Exhibit II-2.9, as well as Chapter III-1), the public can feel safe and confident about using these methods of transportation. Ensuring that pedestrian facilities are appropriately visible is also vitally important in establishing a safe environment for the users.

Create a Qualitative Sense of Safety

A sense of personal safety is a principal concern when designing effective transportation facilities, whether it is for the driver, transit/rail user, or the non-motorized modes. There are many factors that influence the actual and perceived safety of an area, and a few of these considerations are discussed below.

Transportation user sense of place – Within the downtown core, as well as the urban, suburban, and rural environment, a variety of contexts, modes, and facilities are considered. The willingness of individuals to use a facility, whether it is a bus stop, crosswalk, or roadway, is influenced by their perception of safety and convenience. For each of the user groups, it is necessary to establish a sense that they belong in the environment, that they are safe along the entire route (see Exhibit II-2.10), and that the facilities are usable.

Exhibit II-2.10 – Sidewalk Buffered from Vehicular Traffic (Location: Tumwater, WA)

For instance, on a low-volume higher-speed rural route, a shoulder can provide an ample degree of perceived and actual safety for a pedestrian, because exposure to vehicles is low. Along a high-volume downtown business core, lower speed, greater buffers, wider sidewalks, and lighting might all be necessary to achieve the same desired effect and usability.

Ensure public spaces are visually accessible – By ensuring that public spaces are visually accessible, people can become familiar with the environment and feel comfortable using the space. The openness might also discourage loitering and vandalism, which detract from the sense of safety in an area. (See Exhibit II-2.11.)

Exhibit II-2.11 – Visibility into Public Space (Location: Kent, WA)

Include adequate lighting in downtown area and public spaces – Adequate lighting extends the time in which the areas can be comfortably enjoyed, and it might discourage loitering and criminal activity. Lighting also increases nighttime visibility and can make pedestrians more distinguishable along the roadside.

Lighting fixtures should be placed to avoid: unnecessary fixed objects within the Design Clear Zone; the introduction of light trespass; or the disturbance of wildlife in its natural habitat. Refer to Chapters IV-8 and V-10 for further considerations.

Lighting need not be overhead alone. Uplighting pedestrians at crosswalks and along roadsides may provide significant benefits.

Provide Amenities for Physical Comfort

As the downtown area develops into a distinct district, it needs to be able to accommodate the requirements of its users. Amenities for the comfort of the downtown community can enhance the appeal of the environment.

Street furniture – Seating, lighting, trash-receptacles, public telephones, and water fountains are just a few of the features that can be included in the design of transportation facilities and public spaces (see Exhibit II-2.12). Providing these amenities might encourage people to relax and enjoy the experience of being downtown. They do, however, require maintenance, which

Exhibit II-2.12 – Street Furniture (Location: Newport, WA)

must be considered when the downtown maintenance program is being established. (See Chapter V-12 on streetscape amenities for additional information.)

Transit/pedestrian shelters – These need to be designed to accommodate passengers in the worst typical weather of the region. For example, in areas with frequent snow or rain, eaves and overhangs are desirable. In hot regions, large areas of roof that provide shade but allow the air to move freely are more suitable.

Maintain the Quality of the Environment Created

Exhibit II-2.13 – Maintenance Needs (Location: Covington, WA)

The newness of a reconstructed and refurbished downtown might be an initial draw, but as the community continues to evolve, the downtown atmosphere will require ongoing maintenance. Keeping the area clean, in good repair, and up-to-date is vital to establishing a downtown environment that will endure.

Establish a physical maintenance program – Without a maintenance program, the environment and features constructed can deteriorate. Maintaining the environment is vitally important to sustaining the “sense of place” created (see Exhibit II-2.13).

Ensure facilities meet defined needs – After the initial projects have been implemented, it is advisable to do a follow-up study to determine if the facilities are being used, and if they fill the intended needs.

Adapt facilities to meet changing needs – As a community develops, its needs and desires develop also. As one need for a facility fades, the community can reconsider its objectives and the current needs of the downtown environment.

Permanence

Exhibit II-2.14 – Local Identity (Location: Raymond, WA)

Incorporating features that convey the community’s ability to thrive communicates a sense of permanence in the downtown environment. Some features useful in achieving this goal include the use of features specifically important to the community; structures that are built to endure; and enhancing the economic potential of the region.

Use Connections to Local Identity

Every community has some feature that makes it unique (see Exhibit II-2.14). Whether it is the ethnic community group that influenced its development, the river that runs through town, or the local industry, unique characteristics help define and convey the history of a community. The members of the community can feel a special connection to their downtown as a result, taking pride in what it has to offer.

Exhibit II-2.15 – Maintenance (Location: Kent, WA)

Ensure the Created Environment is Sustainable

It is important to consider the sustainability of the elements that are incorporated into a facility development or enhancement plan. The long-term costs should be looked at, as well as the benefits of each element.

Develop a maintenance program – It is critically important during the planning process that the maintenance of any proposed features be considered (see Exhibit II-2.15). The maintenance costs required by the entire system must be discussed, and the responsibility to cover those costs determined and agreed upon prior to the implementation of the project.

Use materials appropriate for the natural environment – The features natural to the area should be utilized. This includes using plants that are indigenous or easily sustained in the environment, and using building materials that will not deteriorate quickly.

Develop Infrastructure with a High Quality of Design and Construction

Some of the benefits of using high-quality materials at the outset are that they are durable and will be worth repairing when the time comes; high quality might encourage respect for the property; and visually pleasing environments promote frequent usage.

Balancing Considerations

More and more communities are seeking to develop the unique qualities of their cities, and to establish a sense of community within their downtown areas. The specific guidelines and criteria the community defines through this development process can be used to balance future proposed projects with the goals and values of the community. As WSDOT, local agencies, and community members work together, the development of safe and appropriate transportation facilities must remain the primary goal. Balancing the needs for safety and the desires of the community can be accomplished through a conscientious effort to include, negotiate with, and inform the wide range of stakeholders involved with the project. These efforts can result in facilities that provide the downtown environment desired by a community, while serving the functional needs of the route within the facility's context.

Resources

Beaumont, Constance, and Richard Moe (preface), *Smart States, Better Communities: How State Governments Can Help Citizens Preserve Their Communities*, National Trust for Historic Preservation, Washington, D.C., 1996.

Creating Livable Streets: Street Design Guidelines for 2040, Street Design Work Team, Oregon Department of Transportation, Salem, OR, 1997.

Hirschhorn, Joel S. and Paul Souza, *New Community Design to the Rescue: Fulfilling Another American Dream*, National Governors Association Center of Best Practices, Washington, D.C., 2001.

Main Street…When a Highway Runs Through It: A Handbook for Oregon Communities, Transportation and Growth Management Program, Oregon Department of Transportation and the Oregon Department of Land Conservation and Development, Salem, OR, 1999.

Myerhoff, W. Arthur, Community Design – A Team Approach to Dynamic Community Systems, Sage Publications, Thousand Oaks, CA, 1999.

Principles of Context Sensitive Design, FHWA, http://www.fhwa.dot.gov/csd/qualities.htm

Robertson, Kent, "Can Small-City Downtowns Remain Viable? A National Study of Development Issues and Strategies," Journal of the American Planning Association, Vol. 65, Issue 3, 1999.

Robertson, Kent, "Enhancing Downtown's Sense of Place," Main Street News, September 1999.

The Role of Transit in Creating Livable Metropolitan Communities, Transit Cooperative Research Program Report 22, Projects for Public Spaces, Inc., National Academy Press, New York, 1997.

Safety and Aesthetics in Urban Roadway Design, Design Office, WSDOT, http://www.wsdot.wa.gov/eesc/design/Urban/

Schwartz, Andrew (editor), *How to Turn a Place Around: A Handbook for Creating Successful Public Spaces*, Projects for Public Spaces, Inc, New York, 2000.

Division III Facility Users
Chapter III-1 Pedestrians

Introduction

Pedestrians will very likely be part of a project, either as primary users of the facility or subsequent users, as they transition from other modes to reach their final destinations. All users are pedestrians at some time.

Pedestrian facilities, such as sidewalks, trails, and crosswalks, serve as critical links in the transportation network. These facilities are necessary for safe travel, encourage pedestrian activities, and form part of the comprehensive transportation planning and development programs for urban and rural communities. The challenge is to provide safe and efficient facilities, whether in a congested and cluttered urban, sprawling suburban, or high-speed rural context.

The type of pedestrian facility provided should depend on pedestrian needs, local transportation plans, the roadside environment, pedestrian volumes, user age groups, safety/economic analysis, the context, and continuity of local walkways along or across the roadway. The Washington State Department of Transportation (WSDOT) has chartered a Bicycle and Pedestrian Advisory Committee (BPAC). The BPAC provides collaboration on projects impacting pedestrians and bicyclists, and includes the participation of citizens and pedestrian and bicycle advocates.

This chapter will discuss the design purpose and need; the needs and characteristics of pedestrians; balancing considerations, treatments, and methods; and accessibility. It also provides references to governing regulations, directional documents, and other resources.

The goal of WSDOT and the Federal Highway Administration, in coordination with local agencies, is to increase biking and walking to at least 15 percent of all trips, and simultaneously reduce the number of bicyclists and pedestrians killed or injured in traffic crashes by at least 10 percent.

Exhibit III-1.1 – Pedestrians Crossing at an Intersection (Location: Tumwater, WA)

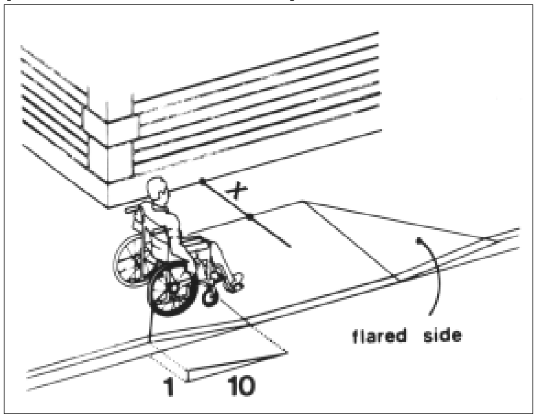
Exhibit III-1.2 – Pedestrian Facilities Provided Along a Roadway - Note the Buffer Zone and Speed Limit Sign (Location: Lacey, WA)

Definitions

Americans with Disabilities Act (ADA) of 1990 An act passed by Congress that recognizes the civil rights of people with disabilities. Titles II and III are particularly important for the design of accessible facilities.

Accessible public rights of way (PROW or R/W) Facilities within the public rights of way where persons with disabilities have the same degree of convenience, connection, and safety afforded to the public in general. They include, among others, access to sidewalks and streets (including crosswalks), curb ramps, street furnishings, parking, and other components of public rights of way. Refer to "Designing for Accessibility" in the Design and Planning Approach section for a discussion of accessible facilities.

Exhibit III-1.3 – A Curb Ramp with Flared Sides and a Landing on the Approach (Source: ADAAG, 1992)



Alteration (ADA) "A change to a building or facility that affects or could affect the usability of the… facility or portion thereof. Alterations include, but are not limited to, remodeling, renovation, rehabilitation, reconstruction, historic restoration, resurfacing of circulation paths or vehicular ways, changes or rearrangement of the structural parts or elements… Normal maintenance… are not alterations unless they affect the usability of the…facility" (U.S. Access Board, 2004).

Crosswalks Locations where it is optimal or preferred that pedestrians cross. They also designate the right of way that vehicular traffic has to yield to pedestrians.

Curb extensions Also known as bulbouts or neckdowns, curb extensions reduce the effective street width by extending the sidewalk or the curb line out into the parking lane.

Curb ramp (ADA) A short ramp that cuts through a curb or is built up to a curb (U.S. Access Board, 2004). It provides access between the sidewalk and the roadway to people with mobility impairments and those using wheelchairs, strollers, walkers, crutches, etc. (see Exhibit III-1.3). Curb ramps are designed according to ADA guidelines.

Detectable warning (ADA) A surface that is detectable by a person using a cane or by the underside of the foot. It indicates approaches to streets and also warns where hazardous drop-offs exist (U.S. Access Board, 2004).

People with disabilities Individuals with disabilities "ranging from physical conditions affecting mobility, stamina, sight, hearing, and speech to conditions such as emotional illness and learning disorders" (U.S. Access Board, 2004).

Ramp (ADA) "A walking surface that has a running slope steeper than 1:20" (U.S. Access Board, 2004).

Sidewalk A pedestrian lane separated from the roadway and located within the public right of way (PROW or R/W).

Street furniture Elements such as benches, bus shelters, trash receptacles, water fountains, or bicycle racks.

U.S. Access Board A federal agency that: develops and maintains accessibility requirements for facilities, including PROW, transit vehicles, buildings, etc.; provides technical assistance and training on guidelines and standards; and enforces accessibility standards for federally-funded facilities.

Purpose and Need

The provision of pedestrian facilities and the accommodation of pedestrians within a project have various elements, which include:

- Creating interconnectivity between different land uses
- Providing for the transfer between modes
- Separating pedestrians from vehicular traffic through either space or time
- Supporting walking as a transportation mode

The design and planning of pedestrian facilities requires a good understanding of pedestrian behaviors, safety, traffic generators, pedestrian motivators, and conflicts with motor vehicles.

This section will discuss planning and design approaches for the incorporation of features and facilities that meet the needs of pedestrians and contribute toward the creation of a seamless and integrated transportation system.

Exhibit III-1.4 – Relative Pedestrian Volumes in the Different Design Contexts (local conditions must be verified)

Design Context	Relative Pedestrian Activity		
	High	Medium	Low
Urban Centers	X		
Urban Corridors and Nodes		X	
Suburban Corridors and Nodes		X	
Industrial Corridors			X
Rural Town Centers	X		
Residential Areas	X		
Rural Town Transitional Areas			X
Rural Connecting Corridors			X

Design and Planning Approach

When providing for the needs of pedestrians, there are several aspects to consider:

Design context – The level and type of pedestrian features and facilities provided varies between the urban and rural environment. Even within each of these environments, the types of features that one considers will differ. The relative pedestrian volumes also differ between these contexts, requiring different measures and levels of provision for pedestrians (refer to Exhibit III-1.4).

Designing for accessibility – The Americans with Disabilities Act of 1990 requires that facilities and services do not exclude persons with disabilities. It is therefore necessary to evaluate accessibility throughout the project development process. Refer to the section “Designing Accessible Facilities” for a discussion on accessibility.

Participation and consultation – Metropolitan Planning Organizations (MPOs) and Regional Transportation Planning Organizations (RTPOs) are required by state and federal law to have motorized and multi-modal plans. The non-motorized part of the project may require a much higher level of advocate participation since pedestrian patterns and motivations are not as readily or frequently measured as motorized traffic capacity and demand. MPOs, RTPOs, and pedestrian advocates play key roles in helping the project team understand how the project fits into the overall local or regional plan and where pedestrian needs require special attention.

Consideration of potential or existing conflicts with other road users – Conflicts between pedestrians and other road users are inevitable. It is, however, important to identify these potential conflicts and to consider whether the conflict can be avoided by a separation of time or space. (An example of separation in time would be the provision of pedestrian signals, and examples of separation in space would be the provision of sidewalks or pedestrian overpasses).

When considering potential pedestrian/vehicular conflicts, vehicle speeds are included in the problem or needs-identification process. Speed affects pedestrian injury severity and reduces the ability of the driver to perceive the pedestrian’s actions and react in time to avoid an accident. Research in the UK has shown that the probability of death during a pedestrian-vehicle accident increases from 10% at 20 km/h to 90% at 60

Exhibit III-1.5 – Probability of Pedestrian Fatality and Vehicle Impact Speed, and Vehicle Impact Speed versus Pedestrian Injury Severity (Source: ETSC 1995, 1 UK DOT 1993)

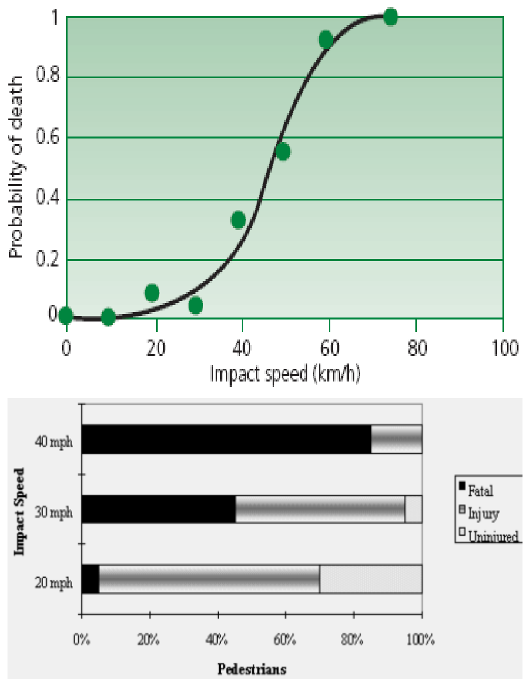


Exhibit III-1.6 – Sidewalk Used by a Child Bicycling to School (Location: Lacey, WA)

km/h, as shown in Exhibit III-1.5[1,2] The figure also shows the expected pedestrian severity for vehicle impact speeds of 20, 30, and 40 mph.

This is also part of the reasoning behind prohibiting pedestrians on highway facilities, and why providing crosswalks on high-speed facilities is not routinely advised. The provision of pedestrian facilities can give the impression that it is safe at that location. Care is needed not to create a false sense of security. When pedestrian need is high and alternative routes are not available, the need to provide sufficient pedestrian facilities to prevent pedestrian/vehicular accidents is increasingly critical.

Balancing the needs of all users – The provision of exclusive pedestrian facilities may not be warranted in all locations. While it is understood that walking is the cheapest form of transportation and therefore available to almost everyone, it is necessary that every effort be made to balance the needs of all users of the project. Pedestrian facilities are typical for urban environments and are most appropriate where high volumes of transit users exist, and near or at school zones and other pedestrian generators.

Integration with other features of the project and surrounding area – Every project is different and the goals for improvement vary. The context of the project can provide an indication of what kind and level of pedestrian facility would be appropriate.

A transit facility, for example, will require the provision of sidewalks that tie the transit facility with adjacent land use and destinations. A project in an urban center can be dependent on pedestrian volumes for economic growth. Therefore, planning for pedestrians in this environment would be more extensive (discussed in Chapter II-2, Defining and Creating a Sense of Place).

It is also necessary to investigate areas adjacent to the project to ensure that the continuity of existing pedestrian routes is maintained or developed. Whether or not pedestrian routes are improved to create continuity is related to public need, available budget, and agency-specific goals and objectives for the project. Information gathered during the participation and consultation period related to pedestrian needs is particularly useful in determining project elements.

Integration with the existing and planned road network – The road network consists of various types of facilities. These facilities are categorized using federal functional classification. Certain functional classes and contexts provide fewer opportunities regarding the provision of pedestrian infrastructure and accommodations. The functional classification is derived from the type of access management or control, and the mobility levels associated with the road. This is because the classification and context of the road are indications of the associated

[1]"Reducing Traffic Injuries Resulting From Excess and Inappropriate Speed," 1995.
[2]Traffic Advisory Leaflet, July 1993, and Traffic Calming Regulations, August 1993.

vehicular speed of the road. The application of features that are inconsistent with the design context can reduce driver acceptance and understanding, as well as pedestrian safety.

Key pedestrian facility considerations to include in the decision process – Key considerations include speed, roadway widths, visibility, mid-block crossing locations, curb radii, intersections, sidewalks, buffers, access management, ambience, vehicle turning movements, traffic calming, and continuity. These issues are covered in Division V of this document.

Exhibit III-1.7 – Key Considerations

- Speed
- Roadway widths
- Mid-block crossings
- Curb radii
- Intersections
- Crosswalks
- Buffers
- Access management
- Ambience
- Vehicle turning movements
- Traffic calming
- Continuity

Pedestrian Activity Generators

The types of land use that indicate high pedestrian activity are urban centers, retail/commercial districts, high density residential areas, transit stops, and residential developments with four or more housing units per acre, interspersed with multifamily dwellings or hotels, located within 0.5 mile of other attractions. These attractions might be retail stores, schools, recreation areas, or senior citizen centers. Certain types of businesses, such as “deli-mart” type stores, fast food restaurants, and skateboard parks, can cater to a specific pedestrian age group and generate high activity levels.

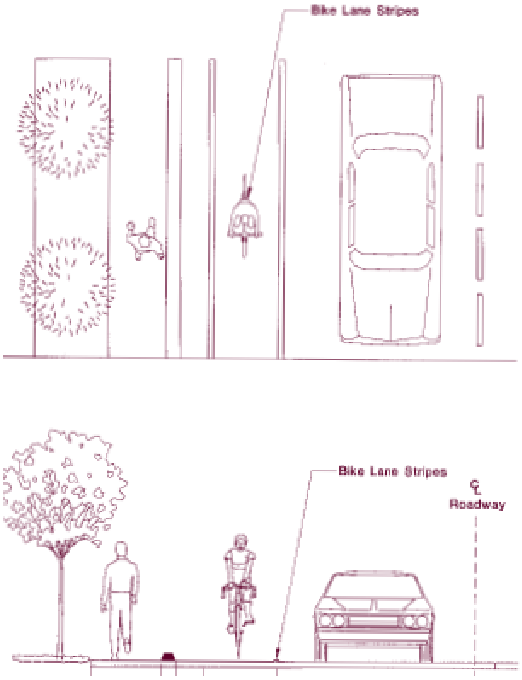
Information on land use, development, and estimated pedestrian densities is available from metropolitan planning organizations, region planning offices, and city and county planning department comprehensive plans.

School districts designate walking routes for every elementary school, and by law should have a current “school walk-route plan.” In general, children within one mile of the school are not provided bus service unless there are hazardous walking conditions. The school district’s safety manager can provide information about the walking routes, average student age, transit stops, and the distance from the school to attractions. There might be particular safety concerns that can potentially be addressed as part of the project. The safety manager can be particularly useful in providing the project team with this kind of information.

Sports, school plays, and other special events occurring after normal school hours can also generate exceptionally high levels of pedestrian activity. The impact of these events should be considered when providing pedestrian facilities.

An important element of planning and design for pedestrians is incorporating the needs and characteristics of pedestrians into the project. In the next section, this topic is discussed in more detail.

Exhibit III-1.8 – Bike Lane as Buffer Between Pedestrians and Motor Vehicles (Source: WSDOT ADA manual)



Pedestrian Needs and Characteristics

The pedestrian experiences the environment on a physical, psychological, and social level. The physical level refers to the physical road and roadway features, along with the traffic using the facility. The social aspect refers to the purpose of the journey. The purpose of this section is to discuss the limitations and characteristics of pedestrians.

Characteristics and Considerations

Exhibit III-1.9 – An Older Pedestrian in a Crosswalk (Location: Newport, WA)

Walking Speed

The average walking speed of a healthy adult pedestrian is 4 feet per second (fps). It is much lower for an older pedestrian: 2.2 fps (see Exhibit III-1.9). A person in a wheelchair travels at an average rate of 3.55 fps. The walking speed of children is also lower and varies depending on the size and age of the child.

Desire Lines

Desire lines refer to routes that pedestrians would prefer based on convenience (e.g., the route selected in order to minimize walking distance). These lines are normally straight and natural, and are used to identify locations to consider for facility crossings and route continuity.

In planned developments where the location of building entrances are not yet determined, entrances can be located in such a manner that they focus pedestrian flows to locations where it is safe to cross. When projects involve existing developments, the location of crossing facilities can be problematic and may include consideration of physical features and landscaping to discourage pedestrians from crossing at less favorable locations. This is typically the case for the urban center design context.

Integration with Different Modes

It is likely that pedestrians will be present at urban transportation projects in some form or another. For example, it may be as a driver who parks a car and walks to a development, or as a pedestrian transferring between buses or trains.

It is therefore necessary to provide pedestrian links between the different transportation modes, and between parking areas and nearby developments. Discontinuities in pedestrian routes can present particular difficulties to persons with disabilities.

Performing the Crossing Task

To safely cross a street, a pedestrian has to scan the road environment, perceive traffic, perform judgments regarding the movement, speed, and distance of vehicles in their path, and cross the street before a vehicle crosses their path. Some of these tasks are particularly difficult for younger and older pedestrians because they experience difficulty when judging the speed of vehicles and the available gaps in the traffic stream.

Exhibit III-1.10 – Children Crossing at an Unmarked Intersection (Location: Newport, WA)

Young Pedestrians and Motor Vehicles

Young pedestrians present particular challenges to the road environment because they are small and can easily be hidden by vehicles or physical features along the roadside. Certain abilities (such as peripheral vision) do not develop until 11 or 12 years of age. Children also tend to believe it is safer to run across a street (see Exhibit III-1.10). However, they are easily distracted because of difficulties with multi-tasking and may also have difficulty judging vehicle speeds. School zones, for example, account for this limited decision-making capability by reducing vehicle speeds. Coincidently, school zone signing and marking improves driver behavior and expectancy by indicating the presence of children.

Sight Lines and Sight Distances

Features along the roadway can obscure pedestrians and reduce the ability of the driver to react in time to avoid a collision with a pedestrian. For this reason, landscaping with low height vegetation is recommended to maintain sight lines to pedestrian movement (see Exhibit III-1.11). Nighttime conditions present additional issues, as sight distances are reduced even further. The lack of night vision may be aggravated by pedestrians who wear dark clothes or by drivers who are under the influence of drugs or alcohol.

Exhibit III-1.11 –Landscaping at an Intersection that Facilitates Pedestrian Visibility (Location: Sequim, WA)

Balancing Considerations

Pedestrian designs that serve all users of the road, and are integrated into other aspects of the project and the natural environment, require reconciliation of multiple and often conflicting expectations and needs. This includes the optimization of safety and aesthetics, and environmental, mobility, access, and budgetary issues, with safety being the highest priority. During project design, efforts should be made to consider the trade-offs of a design and to manage the needs of different mode users.

The provision of pedestrian facilities requires balancing the following:

- Minimizing the potential for pedestrian/vehicular accidents
- The space available – provision of features and facilities in the public right of way
- The need for pedestrian movement – interconnectivity between modes and destinations
- Impact on other transportation modes

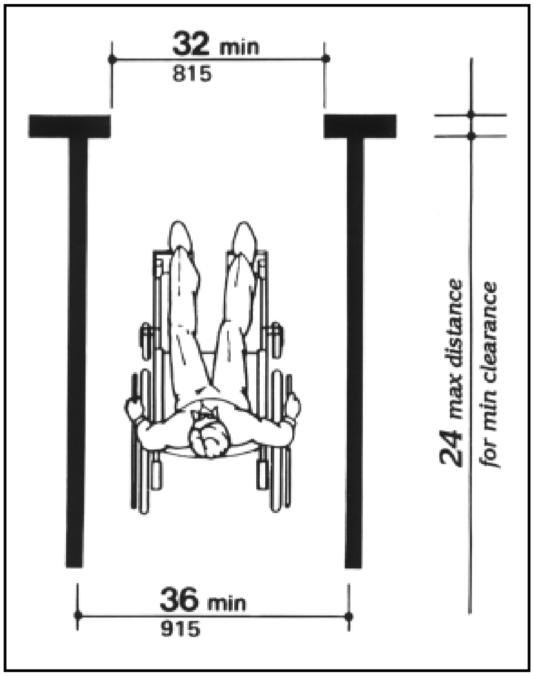
Exposure to high-speed vehicular traffic – An environment or space for pedestrians should be provided where their exposure to traffic (especially high-speed vehicular traffic) is limited, the visibility between pedestrians and drivers is enhanced, and signage is provided to direct and alert users to the expected movement patterns of other users.

Space availability is the provision of features and facilities within the available public right of way. This includes the provision of sidewalks and other features in an environment that may already be cluttered by utilities or limited by the available width between the street and storefronts.

Need for pedestrian movement includes providing connectivity for pedestrians between parking areas, pedestrian generators, residential developments, and other modes of transportation, as well as prioritizing locations frequented by users that do not or cannot drive.

Impact on other transportation modes includes a concern for the mobility of motorized and other non-motorized users.

Exhibit III-1.12 –The minimum clear width of 32 inches for a single wheelchair is used to define the dimensions of an accessible public right of way (Source: ADAAG, 1992)



Designing Accessible Facilities

About 54 million Americans have some type of disability at some time during their lifetime.[3] The Americans with Disabilities Act (ADA) of 1990 requires that the same level of accessibility provided to the general public be provided to persons with disabilities.

Legal Context

Accessible facilities are required by regulations issued by federal agencies, such as the Department of Justice (DOJ) and the U.S. Department of Transportation (DOT), under the ADA of 1990. The U.S. Access Board is responsible for the development of accessibility guidelines under the ADA. When these guidelines are adopted by federal agencies, they become the design standard used in the provision of accessible facilities. The current standard, adopted by DOJ and DOT, is the ADA Accessibility Guidelines for Buildings and Facilities (ADAAG), as amended through September 2002, and the technical provisions for detectable warnings (refer to FHWA Memorandum dated May 6, 2002).

Although new accessibility standards were published by the U.S. Access Board in July 2004 (ADA/ABA-AG), FHWA confirmed in a memorandum that the existing 2002 guidelines should be used until the new guidelines are adopted (FHWA Memorandum dated July 30, 2004). The adoption process can take up to two years.

What is included in the term accessibility?

Accessible facilities refer to any feature of a facility where accommodation is made to ensure that persons with disabilities enjoy the same level of accessibility as all other road users.

In terms of the transportation environment, typical elements requiring consideration of accessibility include: accessible routes (sidewalks and walkways), curb ramps, detectable warnings, parking spaces, amenities in the pedestrian environment (such as drinking fountains and benches), parking areas, transit facilities (boarding and shelters), and accessible pedestrian signals. For ADA-related design guidelines, refer to the documents, *Designing Sidewalks and Trails for Access*, Part 1: Review of Existing Guidelines and Practices, http://www.fhwa.dot.gov/environment/sidewalks/index.htm and *Designing Sidewalks and Trails for Access*, Part 2: Best Practice Design Guide, FHWA, http://www.fhwa.dot.gov/environment/sidewalk2/index.htm.

Exhibit III-1.13 – Detectable Warning Template (Source: WSDOT)

Providing detectable warnings – The ADA requires the provision of detectable warnings at curb ramps and blended transitions (see Exhibit III-1.13). This requirement is applicable to both new construction and alterations (including resurfacing projects).

Specific needs of persons with visual disabilities – Key to the safe negotiation of persons with visual disabilities is "way finding." Way finding can be improved by providing well-

[3] http://www.access-board.gov/ada-aba.htm

defined walkway edges, detectable warnings, and physical features such as high contrast markings, pedestrian lighting, and bollards to indicate crossing locations. Accessible pedestrian signals can significantly improve the safe negotiation of signalized intersections.

Treatments and Methods

A variety of different users are found in the walking environment, including young children, workers, families, athletes, and the elderly. Each of these users has three basic needs in common: convenience, safety, and the ability to use the walking environment to move between origins and destinations. The chapters in Division V of this document provide information about pedestrian facilities as they fit within the framework of the chapter. The document *Guide for the Planning, Design, and Operation of Pedestrian Facilities* by AASHTO, 2004, provides comprehensive design recommendations for pedestrian facilities.

Research Findings

In 2004, the U.S. Department of Transportation, Federal Highway Administration released *A Review of Pedestrian Safety Research in the United States and Abroad*. The document summarizes research on pedestrian safety in the United States with a focus on the safety effects of various roadway features and traffic-control devices. A summary of the main findings from that review document can be found below. The complete report is available online: http://www.walkinginfo.org/pdf/PedSynth/Ped_Synthesis_Report.pdf.

Marked crosswalks on multilane roads with traffic volumes above 12,000 vehicles per day require additional improvements, such as raised medians, installing speed-reducing measures, and/or other traffic control measures to provide for safer pedestrian crossings.

Raised medians on multilane roads can substantially reduce pedestrian crash risks and can also make it easier to cross the street.

Nighttime lighting at adequate levels can enhance pedestrian safety.

WALK/DON'T WALK signals at intersections with an exclusive pedestrian interval (i.e., motorists are stopped in all directions during the same interval each cycle while pedestrians cross in any direction) reduce pedestrian collisions by 50 percent. Exclusive timing schemes are most appropriate at downtown intersections with a combination of heavy pedestrian volumes, good pedestrian compliance, and low vehicle volumes.

Restricted right-turn-on-red (RTOR) measures that have been effective in reducing pedestrian risks include illuminated NO-TURN-ON-RED signs, and offset stop bars at intersections where RTOR is allowed.

Warning signs that have been found to reduce vehicle speeds or conflicts between pedestrians and motorists include the "strong yellow-green" pedestrian warning sign, YIELD TO

Exhibit III-1.14 – An Audible and Visible Pedestrian Signal (Location: Bellevue, WA)

Exhibit III-1.15 – Pedestrian Signal with a "Scramble" or All Pedestrian Phase (Location: Bellevue, WA)

PEDESTRIANS WHEN TURNING sign, PEDESTRIANS WATCH FOR TURNING VEHICLES sign, the three-section WALK WITH CARE signal head, and a DON'T START display to replace the flashing DON'T WALK display.

Exhibit III-1.16 – Marked Crosswalk with Median Refuge (Location: Lacey, WA)

Curb medians provide a safer environment for pedestrians compared with two-way left-turn lanes (TWLTLs). Undivided highways have the highest crash risk for pedestrians in TWLTL settings.

Treatments that address pedestrians with disabilities include textured pavements, audible and vibrating pedestrian signals, larger signs and pedestrian signals, and wheelchair ramps.

Bus stop placement on the far side of an intersection and at locations with good sight distance and alignment (e.g., not on steep grades or on horizontal curves) is important.

Facilities for safer school trips include sidewalks and proper signalization with well-trained adult crossing guards and selective police enforcement. Certain warning signs (e.g., flashing school speed limit signs) and markings (e.g., school crosswalks) are also appropriate and beneficial to pedestrians in school zones.

Sidewalks and walkways are critical components of a pedestrian transportation network in urban and suburban areas. Rural roads should also provide shoulders for pedestrian travel.

Overpasses and underpasses that are carefully planned and designed to encourage pedestrian use can substantially improve crossing safety at freeways or busy arterial streets.

Converting from two-way to one-way streets can substantially reduce pedestrian collisions, particularly if the one-way street conversion does not result in increased vehicle speeds.

Traffic-calming measures such as street closures, speed humps, chicanes (a series of alternating curb extensions), traffic curbs, and diverters have been found to effectively improve safety for pedestrians and traffic as a whole based on reductions in crashes, vehicle speeds, or reductions in cut-through traffic on neighborhood streets.

Walking Environment

Exhibit III-1.17 – Accessible Pedestrian Signal (APS) on a Transit Route (Location: Bellevue, WA)

In this section, design elements within the walking environment and applications that require particular consideration for pedestrians are discussed (school zones, landscaping, parking, transit, roadway illumination, and pedestrian underpasses and overpasses). Refer to Division V for a detailed discussion of streetscape amenities. It should be noted that the planning and design of pedestrian facilities always take place within the design context of the project. Sidewalks, walkways, and buffer zones are typical elements in the walking environment that warrant particular attention.

Sidewalks, Walkways, and Trails provide spaces for pedestrians to travel (among others): to and from work; to and from transit facilities; within residential neighborhoods to visit with friends; to and from commercial developments; and to places of worship.

Sidewalks can reduce the number of pedestrian-related accidents by separating pedestrian and vehicular traffic. Sidewalks are particularly important near transit stops, schools, and other major pedestrian generators. The potential for use will determine whether a continuous sidewalk on one or both sides of the road is appropriate or not. Exhibit III-1.17 illustrates a pedestrian signal. The median provides refuge to pedestrians and an Accessible Pedestrian Signal (APS) is also provided at the median itself.

Buffer zones are strips that can be provided to separate sidewalks from vehicular traffic in the roadway. In urban centers, buffer zones with street furniture may improve the walking experience and be effective in preventing crossing at less desirable locations. In suburban and rural areas, a landscape strip may also be provided. The use of landscaping is discussed in more detail below. Refer to Chapter V-12, Streetscape Amenities, for a detailed discussion of this topic.

Exhibit III-1.18 – Buffer Zone Provided Between the Roadway and a Sidewalk (Location: Sammamish, WA)

Curb Ramps

Curb ramps are essential in the provision of accessible pedestrian facilities and are required by the ADA. ADAAG guidelines are used to design curb ramps. A curb ramp not only provides accessibility to people with disabilities, but also for loading and off-loading, accommodating strollers and pushcarts, and for bicyclists using the sidewalk. Detectable warnings should be provided at all new curb ramps and on existing curb ramps within pavement surface improvement projects.

Street Crossings

Marked crosswalks – Crosswalks that are marked indicate to pedestrians a preferred crossing location. Marked crosswalks are typically used at intersections, at signalized mid-block pedestrian crossings, and other appropriate locations.

The horizontal signing indicating marked crosswalks provides visual clues to the driver of possible pedestrians. It directs pedestrian movements along a path, where high pedestrian volumes are normal. Driver expectancy may be improved by providing additional warning signs. This is valuable in the urban environment where significant visual clutter exists or in the rural environment where the driver does not expect pedestrians to cross. In the rural context, speed limits and warning signs on the approach to and at the crossing are needed to allow drivers to slow down sufficiently so that they may stop safely when pedestrians are present. Unmarked crossings, as in Exhibit III-1.19, may not provide adequate visibility for pedestrians.

Exhibit III-1.19 – Unmarked Mid-block Pedestrian Crossing with Median Refuge (Location: Tukwila, WA)

Median refuges – A median refuge can be beneficial to pedestrians, because it enables pedestrians to cross in stages, making each phase of crossing distance shorter. It also simplifies the crossing task, as pedestrians only need to be on the lookout for traffic from one direction at a time. (See Exhibit III-1.16.)

Exhibit III-1.20 – Pedestrian Crossing at a Roundabout (Location: Lacey, WA)

Intersections

Intersections require particular consideration for pedestrians, as they not only accommodate conflicting vehicular movements, but also provide the opportunity for pedestrians to cross.

Exhibit III-1.21 – Essential elements to consider when providing pedestrian facilities at intersections

- Consider safety by evaluating the separation of potential conflicts in space and/or time
- Optimize pedestrian visibility
- Evaluate pedestrian route continuity
- Consider the mobility, comfort, and convenience of all users
- Consider appropriate pedestrian features consistent with the design context
- Identify the time and distance required for a pedestrian to cross at the intersection
- Reduce vehicular speed at the intersection
- Accessibility

Exhibit III-1.22 – Pedestrian Facilities Approaching and at a Roundabout, Including Sidewalks and Crosswalks. (Note the pedestrian barrier provided to prevent undesirable pedestrian crossing and how route continuity was maintained through the intersection.) (Location: Port Orchard, WA)

Balancing the needs of vehicles and pedestrians can be particularly challenging where limited space exists (often found in urban environments). Typical features to consider when planning for pedestrian needs include: curb extensions, curb radius reductions, and traffic control features.

Separate conflicts – At signalized intersections, pedestrian conflicts can be separated in time by providing a pedestrian phase or an exclusive pedestrian phase.

Pedestrian visibility – Features at an intersection and limited sight distance can obscure pedestrians and reduce driver expectancy. Pedestrian visibility can be improved by restricting parking within the influence area of the intersection and moving or removing features that restrict sight distance (vegetation, newspaper stands, utilities, etc.). The visibility of the pedestrian crossing at the intersection in Exhibit III-1.20 is improved by using a fluorescent pedestrian crossing sign and the pavement treatment, as shown.

Pedestrian route continuity – If sidewalks exist on the approaches to the intersection, tie them into the intersection features. This will facilitate route continuity and minimize barriers to mobility and accessibility.

Mobility, comfort, and convenience of all users – The road environment is shared by a multitude of different users. In the design of an intersection, the goal is to balance the needs of all users, rather than giving any one mode or movement preference or excluding certain users.

Appropriate pedestrian features – The type of pedestrian features provided will depend on the design context, pedestrian volumes, the volumes and types of vehicles using the intersection, existing intersection design, and site-specific features.

Time and distance needed to cross – Wide roads increase the pedestrian exposure times to vehicles. If feasible, the use of curb extensions and the reduction of curb radii can shorten the crossing distance and exposure time. Median refuges are also effective in shortening crossing distance. Crossing time and distance also affect decisions about pedestrian phases at traffic signals.

Accessibility – The ADA requires that all new or altered intersections be accessible.

Roadway Design

The design features of the roadway are primarily determined by the design context of the project. In urban environments with high pedestrian volumes, it is particularly important to slow vehicular traffic, provide sight distance to pedestrians, and channelize pedestrian flows to desirable crossing locations. On urban collectors and arterials, raised medians can be beneficial, as they provide refuge for pedestrians. However, they might also increase speeds due to reduced vehicle conflict. Where marked crossings are provided, warning signs are often used. In suburban and residential areas, traffic calming might be appropriate to slow traffic because of the increased presence of children or pedestrian volumes.

Signing

Vertical and horizontal signing play three major roles: (1) they indicate to pedestrians where it is desirable to cross (e.g., at marked crosswalks), (2) they indicate right of way to drivers (e.g., they need to yield right of way to pedestrians at legal crossings), and (3) they prepare the driver to react appropriately (e.g., slow down through speed limits and roadway design, so that the driver is able to stop for pedestrians using a marked crosswalk).

Exhibit III-1.23 – Vegetation Reducing Sign Visibility (Location: SeaTac, WA)

Landscaping and signing – Where landscaping is planned next to signage, it is desirable that the mature height of the vegetation not obstruct sight lines to vertical signing. Regular maintenance is needed where landscaping obscures signing.

Signing and aesthetics – Within the context of an urban center, designers might be tempted to use alternative forms of signing or leave out certain signing to improve aesthetics. It should be noted that this practice might not be consistent with requirements set for by the WSDOT *Design Manual*, *Local Agency Guidelines* (LAG), or the *Manual for Uniform Traffic Control Devices* (MUTCD). In most cases, variances (as they relate to signing) are limited and consultation should be made with the local traffic engineer. Refer to Chapter II-2, Defining and Creating a Sense of Place, and Division V-11, Visual Functions, for detailed discussions of aesthetics and related aspects.

Advance stop lines at marked crosswalks improve sight lines between vehicles and pedestrians. The success of this application depends on driver compliance.

Advance pedestrian warning signs are beneficial at locations where drivers would not normally expect pedestrians and for drivers unfamiliar with the area. The use of fluorescent sign backgrounds can improve sign visibility.

Speed limit signs indicate the appropriate speed for the particular facility. Note that the existence or mere placement of a speed limit sign along a road does not ensure compliance, and that compliance is unlikely if it is inconsistent with the design context. Enforcement can improve compliance, but is generally not sustainable in the long term.

Signals

The length of pedestrian phases at signalized intersections is determined by pedestrian crossing and clearance times. Refer to the applicable guidelines and standards of the agency for details regarding the provision of signalized pedestrian crossings.

Accessible pedestrian signals are particularly beneficial at intersections where exclusive left-turn phases are used and where the signal phasing can make the facility inaccessible to persons with visual disabilities.

Pedestrian push buttons – The use of pedestrian-actuated phases is generally limited to locations where pedestrian crossings are sporadic. It is not recommended at locations where a pedestrian with visual disabilities cannot complete the full crossing during one pedestrian phase.

Figure III-1.24 – A Flashing Beacon to Improve Visibility of the School Zone Pedestrian Crossing (Location: Bainbridge Island, WA)

School Zones

School zones provide for the limitations of the young pedestrian (discussed earlier). Enforcement and the use of crossing guards are particularly beneficial to enforce driver compliance to the lower speed limit and to allow students to cross safely. Refer to the applicable standards and guidelines for the signing requirements at school zones. At locations where unusual conditions reduce the ability of the driver to react prior to the school zone, advance warning signs and flashing beacons can be particularly beneficial. (See Exhibit III-1.24.)

Landscaping

Landscape treatments such as grading and planting are important treatments provided in conjunction with the design of a transportation facility to meet both pedestrian and driver needs. Landscape grading to create berms is a common practice in the creation of buffer zones, while grading to create swales is often useful for drainage conveyance or detention requirements. For further information, see Divisions IV and V.

Strategic plant selection and layout contribute to projects in the following areas:

Exhibit III-1.25 –Streetscape Amenities and Trees Along a Roadway (Location: Bellevue, WA)

Transportation Safety

- Separating pedestrians from vehicles
- Creating a more predictable roadway environment
- Reducing visual clutter likely to distract drivers
- Reducing headlight glare from opposing lanes or adjacent parking facilities
- Calming traffic speeds via visual reduction of available roadway width
- Directing pedestrians to safe crossing areas

Environmental Quality

- Improving air quality – directly via photosynthesis, and indirectly via walking as an alternative to driving
- Reducing runoff
- Improving water quality
- Providing habitat for birds and other urban wildlife

Economic Vitality

- Increasing property values
- Increasing pedestrian activity in shopping districts

Typical factors to consider in the design of landscape treatments and when assessing landscape alternatives include:

Importance of vegetation – Existing healthy, established, or mature trees and other natural or architectural features of historical significance or otherwise important to the agency or community should be integrated.

Maintenance needs – During project development, the level of vegetation maintenance required and the agency responsible for it need to be identified. In most cases, the local agency will be responsible for landscaping maintenance.

Mature height of the vegetation – Vegetation can easily obstruct sight lines to pedestrians and reduce the ability of the driver to react to a pedestrian crossing the street. Mature height and spread of plant selections should be considered for compatibility with lines of sight, adjacent infrastructure, adjacent land uses, and available space for growth.

Safety needs – The location, type, and placement of vegetation selected vary depending on the context and speeds of a location. Refer to Division V for further guidance on roadside safety, as well as guidance in terms of the roadside, visual function, and streetscape amenities, and to Division IV for a discussion of urban forestry.

Parking Facilities

Pedestrian facilities that link parking areas with developments are essential in terms of safety, convenience, and accessibility. Refer to Chapter V-8 for a detailed discussion on parking. ADAAG provides accessibility guidelines for parking areas, and for linking parking areas with existing pedestrian facilities and building entrances.

Exhibit III-1-26 – A Transit Facility (Location: Bellevue, WA)

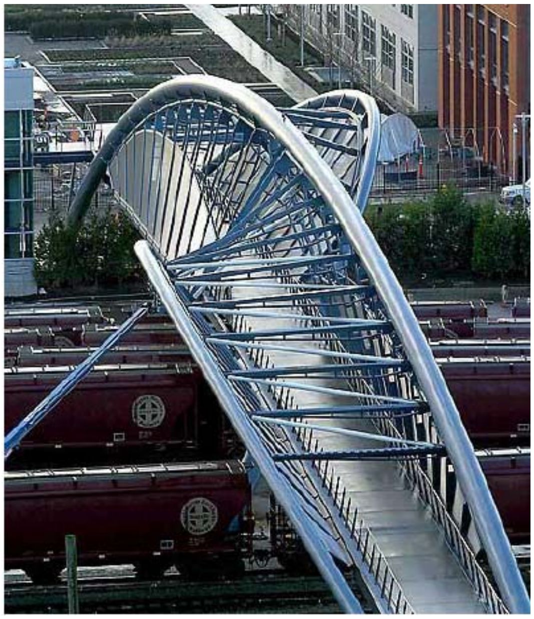
Transit Facilities

Sidewalks to and from transit facilities are recommended because of the nature of the facility. Particular attention should be paid to route continuity for other pedestrian generators in the area. The ADA requires accessible features at transit facilities. Refer to Chapter III-3, Transit, for a detailed discussion of the design of transit facilities.

Roadway Lighting

Illumination is generally provided along sidewalks and other pedestrian facilities. Uplighting is particularly beneficial to create contrast between the pedestrian and the surrounding environment at night. Refer to Division V-10, Illumination.

Exhibit III-1.27 – An Artistic Pedestrian Bridge (Location: Seattle, WA)



Grade-Separated Pedestrian Facilities

Grade-separated facilities provide separation in space from vehicular traffic. The likelihood that pedestrians will use the facility will determine its success. These facilities include pedestrian overpasses, underpasses, tunnels, and bridges.

Because pedestrians find level crossings easier to use, it is necessary to integrate grade-separated facilities with the surrounding area and the rest of the project in such a manner that flow to and from the facility is natural and the most convenient. This will encourage pedestrian use. Physical features that discourage pedestrians from crossing at level are beneficial if they can be integrated into the project.

Items to consider when designing and planning this type of facility include pedestrian safety, convenience, comfort, budget constraints, aesthetics, maintenance, and the physical constraints of the site.

Pedestrian overpasses and bridges are generally more acceptable to pedestrians than tunnels and underpasses.

Pedestrian overpasses and bridges can contribute to the sense of place and the aesthetics of a project. They can also provide the opportunity to incorporate community-related features or characteristics of the area into the design. Pedestrians are sensitive to bridge movements and protective screening can potentially improve the safety of the facility. As shown in Exhibit III-1.27, these facilities can also present opportunities to improve the aesthetics of the area, and to demonstrate the community character.

A pedestrian underpass or tunnel provides a walkway for pedestrians under the roadway. The project team needs to consider the associated cost, the need for drainage and possible drainage-related problems, and determine the likelihood that pedestrians will use the underpass. The provision of natural light in an underpass, along with providing easy access to and from the tunnel without increasing the walking distance, can encourage pedestrians to use the underpass.

Governing Regulations and Directional Documents

ADA Accessibility Guidelines for Buildings and Facilities (ADAAG), as amended through September 2002, U.S. Access Board, http://www.access-board.gov/adaag/html/adaag.htm

Addressing ADA Accessible Facilities on Road, Street, and Highway Projects, WSDOT *Design Manual* Supplement: Effective Date: 6/29/2004, http://www.wsdot.wa.gov/eesc/design/policy/Documents/ADASupplementFinalJune21-2004.pdf

Americans with Disabilities Act, Public Law 336 of the 101st Congress, enacted July 26, 1990, http://www.usdoj.gov/crt/ada/pubs/ada.txt.

Bicycle, equestrian, pedestrian paths as public highways, *Revised Code of Washington* (RCW) 47.30.070.

Design Manual, WSDOT, M 22-01.

Establishing paths and trails, RCW 47.30.040.

Expenditure of available funds for non-motorized traffic facilities, RCW 47.30.030.

Expenditures deemed to be for highway purposes – Powers and duties of department – Restrictions on use of paths and trails, RCW 47.30.060.

Memorandum: Information: Americans with Disabilities Act (ADA) Accessible Guidelines and Detectable Warnings, Federal Highway Administration (FHWA) to Resource Center Managers, Division Administrators, and Federal Lands Highway Division Engineers, Dated July 30th, 2004, Ref. HIPA-20, http://www.fhwa.dot.gov/environment/bikeped/dwm04.htm.

Memorandum: Information: Americans with Disabilities Act (ADA) ADAAG Detectable Warnings (Truncated Domes), FHWA to Resource Center Managers, Division Administrators, and Federal Lands Highway Division Engineers, Dated May 6th 2002, Ref. HIPA-20, http://www.fhwa.dot.gov/environment/bikeped/dwm.htm.

Minimum expenditures for paths and trails, RCW 47.30.050.

Right of Way Manual, WSDOT, M 26-01.

Additional Resources

AASHTO Guide for the Planning, Design, and Operation of Pedestrian Facilities, American Association of State Highway and Transportation Officials (AASHTO), Washington, D.C., 2004.

*Accessibl*e Pedestrian Signals, U.S. Access Board, Washington, D.C., 1998, http://www.access-board.gov/research&training/pedsignals/pedestrian.htm

Accessible Rights of Way: A Design Manual, HEP 10, FHWA, Washington, D.C., 1999, http://www.access-board.gov/publications/PROW Guide/PROWGuide.htm

Design and Safety of Pedestrian Facilities, A Recommended Practice, Institute of Transportation Engineers (ITE), Washington, D.C., 1998, http://safety.fhwa.dot.gov/fourthlevel/pdf/DesignSafety.pdf

European Transport Safety Council, "Reducing Traffic Injuries Resulting From Excess and Inappropriate Speed," Brussels, 1995 in *Synthesis of Safety Research Related to Speed Management*, FHWA-RD-98-154, July 1998.

Fatality Facts Insurance, Institute for Highway Safety, Arlington, VA, 2003.

FHWA Office of Safety: Pedestrian and Bicycle Safety Program, http://safety.fhwa.dot.gov/programs/ped_bike.htm

Greenways: A Guide to Planning, Design, and Development, The Conservation Fund, Island Press, Washington, D.C., 1993.

Implementing Pedestrian Improvements at the Local Level, HSR 20, FHWA, McLean, VA, 1999.

Improving Conditions for Bicyclists and Pedestrians, A Best Practices Report, HEP 10, FHWA, Washington, D.C., 1998, http://www.fhwa.dot.gov/safety/fourthlevel/pdf/INTRO-sept.pdf

Improving Pedestrian Access to Transit: An Advocacy Handbook, WalkBoston. NTIS, Federal Transit Administration, Springfield, VA, 1998, http://safety.fhwa.dot.gov/fourthlevel/pdf/fta.pdf

Killing Speed and Saving Lives, UK Department of Transportation, London, England, 2000.

Kirschbaum, Julie B. et al., *Designing Sidewalks and Trails for Access, Part 1: Review of Existing Guidelines and Practices*, FHWA-HEP-99-006, FHWA, Washington, D.C., 1999, http://www.fhwa.dot.gov/environment/sidewalks/index.htm

Kirschbaum, Julie B. et al., *Designing Sidewalks and Trails for Access, Part 2: Best Practice Design Guide*, FHWA-HEP-01-027, FHWA, Washington, D.C., 2001, http://www.fhwa.dot.gov/environment/sidewalk2/index.htm

Litman, Todd, et al., *Pedestrian and Bicycle Planning: A Guide to Best Practices*, 2002, http://www.vtpi.org/nmtguide.doc

Moore, R. L., *Conflicts on Multiple-Use Trails: Synthesis of the Literature and State of the Practice*, FHWA-PD-94-031, FHWA, 1994, http://www.fhwa.dot.gov/environment/conflicts/index.htm

Office of Safety: Pedestrian and Bicycle Safety Program, FHWA, http://safety.fhwa.dot.gov/programs/ped_bike.htm

Oregon Bicycle and Pedestrian Plan, Bicycle and Pedestrian Program, Oregon Department of Transportation, Salem, OR, 1995.

Pedestrian and Bicycle Information Center – an information clearinghouse managed by University of North Carolina Highway Safety Research Center, http://www.pedbikeinfo.org/index.htm

Pedestrian Compatible Roadways – Planning and Design Guidelines, Bicycle and Pedestrian Advocate, New Jersey Department of Transportation, Trenton, NJ, 1995, http://www.state.nj.us/transportation/publicat/pedest_guide.htm

Pedestrian Facilities Guidebook, Bicycle and Pedestrian Program, Washington State Department of Transportation, Olympia, WA, 1997, http://www.state.nj.us/transportation/publicat/pedest_guide.htm

Pedestrian Facilities Users Guide: Providing Safety and Mobility, Publication No. FHWA-RD-01-102, FHWA, Washington, D.C., 2002, http://www.walkinginfo.org/pdf/peduserguide/peduserguide.pdf

PedSafe, Pedestrian Safety Guide and Countermeasure Selection System, USDOT, http://www.walkinginfo.org/pedsafe/index.cfm

Planning and Implementing *Pedestrian Facilities in Suburban and Developing Rural Areas*, Report No. 294A, Transportation Research Board, Washington, D.C., 1987.

Planning Design and Maintenance of Pedestrian Facilities, Federal Highway Administration, Washington, D.C., 1989. Available from National Technical Information Service, Springfield, VA.

Portland Pedestrian Design Guide, Portland Pedestrian Program, Portland, OR, 1998.

Prevention's Practical Encyclopedia of Walking for Health, Rodale Press, Emmaus, PA, 1999.

Priorities and Guidelines for Providing Places for Pedestrians to Walk Along Streets and Highways, Federal Highway Administration, Washington, D.C., 2000.

Pucher, John and Lewis Dijkstra, "Making Walking and Cycling Safe: Lessons from Europe," *Transportation Quarterly*, Vol. 54 (3), 25-50. February 2000, http://www.apbp.org/pdfs/pucher.pdf

Traffic Advisory Leaflet, UK Department of Transport, Traffic Advisory Unit (TAU), July 1993.

Traffic Calming Regulations, UK Department of Transport, Traffic Advisory Unit (TAU), August 1993.

Traffic Safety Facts: Pedestrians, National Highway Traffic Safety Administration, National Center for Statistics & Analysis, Washington, D.C., 2001, http://www-nrd.nhtsa.dot.gov/pdf/nrd-30/NCSA/TSF2001/2001pedestrian.pdf

Trail Intersection Design Guidelines, Florida Department of Transportation, Tallahassee, FL, 1996.

Universal Access to Outdoor Recreation: A Design Guide, PLAE, Inc, MIG Communications, Berkeley, CA, 1993.

Walking in Washington – WSDOT's website for pedestrian related issues, http://www.wsdot.wa.gov/walk/design/info.htm

Walking: The Pleasure Exercise: A 60-Day Walking Program for Fitness and Health, Rodale Press, Emmaus, PA, 1986.

Zegeer, Charles V. et al., *Design and Safety of Pedestrian Facilities*, RP-026A, Institute of Transportation Engineers (ITE), Washington, D.C., 1998, http://safety.fhwa.dot.gov/fourthlevel/pdf/DesignSafety.pdf

Division III Facility Users
Chapter III-2 Bicyclists

Introduction

An integrated transportation system considers the needs of non-motorized users, including bicyclists. The needs of bicyclists are considered in conjunction with those of motorists on what is a shared use facility. Bicyclists often share the roadway with motorists, but at times are provided with separated facilities away from the roadway. Bicycle usage issues should be considered as part of the project development process.

The skill and experience levels of riders vary. Facilities and conditions that are comfortable for one rider may be less comfortable for a rider with limited experience.

Appropriately accommodating bicyclists in transportation projects requires an understanding of user mix; the travel patterns of bicyclists and other road users; and the conflicts between the different users and modes. Local bicycle clubs can provide input during the consideration of these issues. The Washington State Department of Transportation (WSDOT) also has a chartered Bicycle and Pedestrian Advisory Committee (BPAC) that provides collaboration on projects impacting bicyclists. Exhibit III-2.1 lists some of the factors that influence the selection of bicycle facilities. [1]

The goal of WSDOT and the Federal Highway Administration, in coordination with local agencies, is to increase biking and walking to at least 15 percent of all trips, and simultaneously reduce the number of bicyclists and pedestrians killed or injured in traffic crashes by at least 10 percent.

Exhibit III-2.1 – Key Issues[1]

- Motor vehicle speeds and volumes
- Skill level of cyclists
- Parking for motor vehicles and bicycles
- Physical barriers and obstructions
- Directness and connectivity with traffic generators
- Aesthetics
- Personal safety/security
- Conflicts with other users, such as heavy vehicles and buses
- Roadway surface maintenance and pavement surface quality
- Specific locations: bridges; traffic signal control; and intersection design and conditions
- Available right-of-way
- Available budget
- State and local regulations

Definitions

Bicycle route A system of bikeways, designated by the jurisdiction having authority, featuring appropriate directional and informational route markers. A series of bikeways may be combined to establish a continuous route and may consist of any or all types of bicycle facilities.

Bike lane A portion of a highway or street identified by signs and/or pavement markings reserved for bicycle use.

Rural bicycle touring routes State highways or sections of state highways that are used, or have a high potential for use, by experienced bicyclists riding long distance on single- or multiple-day trips.

Shared roadway A roadway that is open to both bicycle and motor vehicle travel. Shared roadways do not have dedicated facilities for bicycle travel. Exhibit III-2.2 shows a shoulder for use by bike traffic.

Exhibit III-2.2 – Shared Use Roadway (Location: Maple Valley, WA)

[1] AASHTO, *Guide for the Development of Bicycle Facilities*, 1999.

Signed shared roadway (designated as a bike route) A shared roadway that has been designated through signing as a preferred route for bicycle use. Appropriate bike route signs are installed to assure bicyclists that improvements (such as widening shoulders) have been made to improve safety.

Shared use path A facility on exclusive right of way with minimal cross flow by motor vehicles. It is designed and built primarily for use by bicycles, but is also used by pedestrians, joggers, skaters, wheelchair users (both non-motorized and motorized), and others.

Purpose and Need

Exhibit III-2.3 – Bike Tunnel (Location: Lacey, WA)

Bicycle traffic exists on most highways and streets. More concentrated use of bicycles typically occurs in residential areas that are close to accessible destinations, such as employers, shopping centers, recreational facilities, or schools. The majority of bicycle travel occurs on highways and streets without bicycle facility designations. Situations that present significant speed differentials between bicyclists and motorists, or conflicting travel paths, may lead to separation of motorists and bicyclists. Exhibit III-2.3 shows a bike tunnel in Lacey. This tunnel removed the need for bicyclists and pedestrians to cross a busy arterial.

Characteristics and Needs of Bicyclists

Bicyclists select their routes based on weighing acceptable travel distance and time with routes with the least stress.[2] There are a number of elements affecting the “bicycle stress level” and these elements are useful in determining the needs of bicycle facilities.[3] The primary and secondary variables affecting cyclist stress are:

- Primary elements: motor vehicle volumes and speeds in the curb lane, and curb lane width;
- Secondary elements: parking turnover, the number of commercial driveways, and the percentage of heavy vehicles using the roadway; and
- Steep grades.

There are two typical bicycle-motor vehicle conflicts that lead to accidents: a cyclist turning left in front of an oncoming vehicle and cyclists riding straight through an intersection. Studies have shown that bicyclists are particularly vulnerable because they have a greater tendency to disobey traffic laws and ordinances, are less conspicuous than other vehicles, cannot accelerate or act in time to avoid collisions that could have been avoided otherwise, and do not have the protection that a motor vehicle offers to its occupants.[2]

---

[2] Dewar, P.E., and Olson P.L., *Human Factors in Traffic Safety*, 2002.
[3] Sorton, A., and T. Walsh, *Bicycle Stress Level as a Tool to Evaluate Urban and Suburban Bicycle Compatibility*, 1994.

Planning and Design of Bicycle Facilities

Planning Bicycle Facilities

Before any decisions can be made about bicycle facilities and provision, it is necessary to determine existing conditions, and existing and future needs for bicycle travel. It is during this investigation that user groups are identified to ensure that bicycle facilities are needed, and that the design appropriately matches the speed and volume of both bicycle and vehicular traffic. It is desirable to include consideration of the routes used by buses, service vehicles, and emergency vehicles to enable the design team to consider potential conflicts with cyclists.

Types of Bicycle Facilities

There are three basic types of bicyclists that determine which type of facility is needed: advanced riders (Category A), basic riders (Category B), and children (Category C). The advanced rider is typically more comfortable sharing the road with motor vehicles, but still needs sufficient space to maneuver safely through traffic. The basic rider is less confident, generally avoids roads with higher vehicular speeds and volumes, and prefers to use designated bike lanes or wide shoulder lanes when traveling on higher-order roads. In the case of children, it is sometimes necessary to provide them with access to specific destinations, such as recreational facilities, schools, and convenience stores.

Where speed differentials between cars and bikes are insignificant, bicyclists are often intermixed in the traffic lanes with motorized vehicles. As the bicycle volumes increase, safety and traffic operation may be improved by providing an exclusive bike lane.

Barriers and Obstructions

There are various barriers that can impede bicycle travel: poor sight distance; railroad tracks; actuated traffic signals that do not respond to bicycles; pavement surface impediments; narrow lanes; driveways; steep grades; and many others. Pavement impediments include debris, incompatible drainage grates, rough pavement, and bridge expansion joints. Periodic sweeping and pavement patching can efficiently resolve a number of issues related to the pavement surface.

Exhibit III-2.4 – Bike Rack (Location: Maple Valley, WA)

Vehicular On-Street Parking

The rate of vehicle parking turnover can affect the safety of bicycles. The type of on-street parking can also affect cyclists. Diagonal and perpendicular parking is not recommended, as it increases the potential for conflicts with cyclists and reduces sight distance.

Bicycle Parking

Bicycle parking is an important element of provision for cyclists at traffic generators. Long-term or short-term parking can be provided. Long-term parking is typical for places of employment, schools, and high density housing where bicycles are left unattended for long periods of time. It is usually in the form of cages, lockers, or rooms, and can be combined with showers and changing facilities. Short-term parking provides a fixed component that allows for the locking of the bicycle frame and wheels, but does not offer protection against the weather. This parking should be placed in an area that is conveniently located near entrances of buildings. Exhibit III-2.4 shows a bike rack at the Maple Valley Library.

Heavy Vehicle and Bus Traffic

Heavy vehicles and buses can present special problems to bicycles. The width of these vehicles reduces the available space in which the cyclist can maneuver. Bus stops along a bicycle path can cause conflicts, and these roads are more likely to experience higher levels of pavement deterioration that also affects cyclists. On higher-speed facilities, narrow shoulders can be problematic because the mirrors of passing vehicles can strike the bicyclist, and winds created by large vehicles can affect bike stability.

Bicycle Route Continuity

A key part of bicycle facility design includes the evaluation of route continuity. This refers to the evaluation of the way in which bicycle traffic along the bicycle corridor interacts with motor vehicle facilities, particularly at crossing points, and how the bicycle facility ties in with other bicycle paths and routes in the region. It is also necessary to consider the collection and distribution points along the facility. Poor planning can result in disjointed facilities that abruptly change the cycling environment, creating undesirable conditions.

Exhibit III-2.5 – Vertical Signing (Location: Lacey, WA)

Personal Safety/Security

Consideration of safety and security is particularly important along isolated shared use paths and at bicycle parking facilities.

Signing and Markings

Vertical signing and horizontal markings are important features of designated bicycle facilities. While vertical signing provides information to the cyclist and the other vehicular traffic regarding the type of bicycle facility and aspects such as right of way, horizontal lane markings provide division between bicycles and other vehicular traffic. The *Manual on Uniform Traffic Control Devices (*MUTCD) and agency guidelines provide guidance in this respect. Exhibit III-2.5 shows a bike route sign on the approach to a roundabout in Lacey.

Key Bicycle Facility Considerations Included in the Decision-Making Process

Key considerations include: paved shoulders, adequate lane widths, on-street parking, pavement surface quality, drainage inlet grates, signage, intersections, turning lanes, separations or barriers strips, grade, sight distance, lighting, railroad crossings, and roundabouts. These issues are covered in Division V of this document.

Detailed Design Issues

More background information is available in AASHTO's *Guide for the Development of Bicycle Facilities*, 1999 (an updated version of which should be available in 2005). The FWHA Pedestrian and Bicycle Information Center provides additional resources online: www.pedbikeinfo.org. It is also recommended that the designer refer to agency-specific design guidelines.

Treatments and Methods

All bicyclists have three basic needs in common: safety, convenience, and the ability to use the biking environment to move between origins and destinations. This section addresses four bicycle facility issues of particular concern and provides a summary of bicycle research findings.

Intersections

Signing and striping can decrease the chance of bicycle/motorist conflicts at intersections. Cyclists turning left have the option to make either a “motor vehicle style” or “pedestrian style” turn. Where there will be numerous left-turning bicyclists, a separate left-turning lane may be needed. A shoulder or bike lane should be provided for cyclists who want to turn right or use the crosswalk to move through the intersection. For cyclists traveling straight through an intersection that has a right-turning lane, a striped bicycle lane should be provided to the left of the right-turning lane, with a broken line in advance of the intersection to indicate where motorists should lane over. (See the MUTCD2 for guidance regarding pavement marking on bike lanes.)

SPUI – Single Point Urban Interchange

Single Point Urban Interchanges are difficult for bicyclists to negotiate. If they must be used, the following should be considered: the signal timing should be adjusted to accommodate the speed of bicyclists; signage should be used to clarify non-standard directions for travel; and the design for lower motorist speeds should tighten turning radii and narrow travel lanes, when possible.

Exhibit III-2.6 – Lake Wilderness Trail Underpass (Location: Maple Valley, WA)

Paths and Trails

From 1993 to 2003, there were zero bicycle fatalities on shared use paths. However, there are issues of conflicts at path/roadway intersections. Appropriate solutions for these crossings should address right of way assignment; sight distance for both bicyclists and motorists; pavement marking; signage; traffic control devices; access control; and the need for refuge islands. Mid-block crossings should be clearly separated from roadway intersections. Path crossings at an existing intersection should be closely integrated to the intersection. Complex crossings should be treated as unique situations that may require a special design. All crossings require a regulatory traffic control device and sound engineering judgment. On paths and trails, there are sometimes conflict issues between cyclists and other path users. Signage, the use of appropriate sight distance, and pavement markings can be used to help minimize this concern.

Research Findings

A review of the limited research findings associated with bicycle safety and facilities indicated a need for further research in this field. The following information is a summary of three bicycle-related studies. It provides an update on the subject of railing heights, the effect of differing curb lane widths, and the results of a bicycle attitude survey.

Railing Heights

In May of 2004, a study by National Cooperative Highway Research Program (NCHRP) was released addressing the issue of railing heights. Based on the findings of Orr, a standard bicycle railing height of 48 inches (1.2 m) is recommended in locations where bicyclists need to be protected from a severe hazard. The study found that the center of gravity of the 95th percentile person on a bike is 45.9 inches. For adult males, the 95th percentage height is 72.8 inches. Bicycle railing heights should be based on the following safety concerns: the potential that the bicyclist will vault over the railing, and how the railing is used as a physical barrier.

Curb Lane Width

In 2004, Hunter and Feaganes examined the effects of converting a 14-foot wide curb lane into an 11-foot travel lane and a striped 3-foot undesignated lane. Both mid-block (4 or 6 lanes) and four intersection approaches on relatively high speed/volume roads were included in the study. Where striping changes were made, lateral spacing of bicyclists and motor vehicles from the gutter pan seam was found to be greater. On average, bicyclists were 7 to 9 inches away from the gutter pan seam. The striped lane reduced motor vehicle encroachment into the multi-lane roadway. A copy of the full report can be found at: http://www.dot.state.fl.us/research-center/Completed_Proj/Summary_SF/FDOT_0510809_BA784_rpt.pdf.

Bicycle Attitude Survey

The Florida Department of Transportation conducted a bicycling and walking attitudes survey in August 2003. The study, which was lead by Professor Evan M. Berman, indicates that bicyclists are represented in all demographic groups. Most cyclists are under 66, and have an annual household income of $60,000 or more. A majority of respondents (bicyclists and non-bicyclists) agree or strongly agree that they would like to live in a place where they can meet more of their daily needs through walking and bicycling. Most believe that lower motor vehicle speeds and wider bike lanes are safer for bicyclists. A copy of the full report can be found at: http://www.dot.state.fl.us/safety/ped_bike/brochures/pdf/Bike & Ped Survey - Final Report, w. Appendices 1-8.pdf.

Balancing Considerations

The type of facility appropriate for bicycling is dependent on the type of riders, the context in which the facility exists or will exist, and the volume of riders present or anticipated.

Design Contexts

Rural Connecting Corridors

On rural connecting corridors, riders are usually traveling longer distances and are present in small numbers. The riders on these facilities also tend to have considerable experience. In this environment, bicycle facilities are most commonly shared-roadway facilities with motor vehicles. The routes may or may not be signed as bicycle facilities. Cyclists typically ride on the shoulder when vehicles are present at higher speeds. Cycling facilities in this context focus on the provision of adequate shoulder width and smooth, clear shoulder surfaces. The presence of rumble strips, barriers, or guardrails along the shoulders of these facilities may warrant additional shoulder width. Debris accumulating along the shoulder is also a concern to cyclists in this environment. Some rural routes are regularly used for bicycle touring activities. Those routes should undergo increased scrutiny for their compatibility with bicycle travel. In some cases these events are directional rides, which may necessitate more emphasis on a particular travel direction.

Transition of Rural Corridors into Rural Towns

As bicycle facilities transition from rural corridors into rural towns, motor vehicle speeds tend to be lower, while bicycle and motorized traffic volumes increase. This creates an environment that is more favorable toward allowing bicycles and vehicles to share lanes. In some situations, bike travel may be directed onto a shared use path for bikes and pedestrians. In either case, the considerations are similar to rural connecting roadways. Bicycle trips tend to be shorter and the experience of riders will vary greatly. At these locations, the conflict points at vehicle crossings and locations where turning movements are made require particular consideration.

Rural Town Centers

In rural town centers, it is less likely that the rider will encounter shoulder rumble strips, barriers, or guardrails. Considerations in this design context include:

- Street-side parking and its influence on bicycle travel;
- Traffic signals that incorporate the needs of riders;
- Evaluating bicycle compatibility of design elements, such as curbing, gutters, driveways, and sidewalks; and
- Connectivity with the local street system to allow for accessible bike linkages to local services and neighborhoods.

Suburban Corridors and Nodes

Suburban corridors and nodes present many of the same issues as rural transitional areas, but usually have increased vehicular traffic volumes that operate at higher speeds. Bicycle volumes can be moderate to high in this context, and the mixture or rider experience will cover the entire range. The presence of traffic signals, curbs, gutters, driveways, and sidewalks is significantly higher than in rural areas. These facilities may traverse neighborhoods and business districts. Bicycle facilities in this context may include shared roadways or shared use paths. The presence of bike lanes on the roadway becomes a reasonable consideration in this environment. Other aspects that may require consideration include conflict points with the higher expected volumes of vehicular traffic, and street illumination because of the greater probability for usage on these facilities during the hours of darkness.

Industrial Corridors

Along industrial corridors, the use of bicycles can be expected. The level of use may be low to moderate. Usage is heavily dependent on the context of the adjoining sections of the corridor. The more remote and isolated the corridor, the lower the likelihood of bicycle users. Trip purposes may include commuters, recreational cyclists, or bicycle transportation as an integral part of the transportation system within an industrial complex. The context may be similar to a rural corridor or transition area, or a suburban corridor, but with much higher truck volumes. Heavy vehicles affect bicycle traffic in the following ways:

- Trucks at higher speeds create significant wind turbulence that tends to push or pull bicycles along the roadside,
- Occasional oversized loads may infringe upon the area available for cycling; and
- Truck-turning movements may also infringe on shoulders or bike lanes within the corridor.

Urban Corridors and Urban Centers

Exhibit III-2.7 – Bike and Pedestrian Facility (Location: Seattle, WA)

Urban corridors and urban centers present the largest mix of users. Vehicle speeds are generally 25 to 35 mph in this environment, with high traffic volumes. Signal-controlled intersections are common throughout urban corridors.

Bicyclists are part of this traffic mix, and commuting is a significant portion of bicycle trips. With the variety of other users present, urban corridors and urban centers often provide full pedestrian and transit facilities, and on-street parking may exist. The built-up roadside environment usually offers very limited opportunities to expand the footprint of the transportation facilities. In this context, bicycles are most frequently accommodated on shared use lanes or bike lanes. Bicyclists will experience frequent conflicts when crossing vehicle turning paths, when vehicles overtake them, and with pedestrian traffic. In this context, bicycle traffic may be encouraged on one street and discouraged on the parallel street, to minimize the conflicts with vehicles. Exhibit III-2.7 shows a roadway with a shoulder for use by bikes and pedestrians. Note the rider usage of the bike lane.

Governing Regulations and Directional Documents

AASHTO, *Guide for the Development of Bicycle Facilities*, 3rd Edition, Washington, D.C., 1999.

Bicycle Facility Design Standards. City of Philadelphia Streets Department, Philadelphia, PA, 1998.

Bicycle Facility Planning, Pinsof & Musser, Planning Advisory Service Report # 459, American Planning Association, Chicago, IL, 1995.

Bicycle paths, lanes, routes, etc., may be constructed, maintained or improved from county road fund, *Revised Code of Washington* (RCW) 36.82.145.

Bicycle road fund – Sources – Use, RCW 35.75.050.

Bicycle, equestrian, pedestrian paths as public highways, RCW 47.30.070.

Bicycles as Motor Vehicles, RCW 46.04.071.

Establishing paths and trails – Factors to be considered, RCW 47.30.040.

Expenditures deemed to be for highway purposes – Powers and duties of department – Restrictions on use of paths and trails, RCW 47.30.060.

Expenditures for paths and trails – Minimum amount, RCW 47.30.050.

Facilities for nonmotorized traffic – Expenditure of available funds, RCW 47.30.030.

Manual on Uniform Traffic Control Devices for Streets and Highways (MUTCD), USDOT and Federal Highway Administration (FHWA), Washington, D.C., 2003.

Mopeds, Electric-Assisted Bicycles – General Requirements and Operation, RCW 46.61.710.

Pavement Edge and Raised Pavement Markers Supplementing Other Markings, Washington Administrative Code (WAC) 468-95-035.

A Policy on Geometric Design of Highways and Streets, 4th ed. (Green Book), American Association of State Highway and Transportation Officials, (AASHTO), Washington, D.C., 2001.

Provisions for bicycle paths, lanes, routes, roadways and improvements to be included in annual revision or extension of comprehensive street programs -- Exception, RCW 35.77.015.

Rules of the Road, RCW 46.61.

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

Use of street and road funds for bicycle paths, lanes, routes and improvements authorized, RCW 35.75.060.

Washington State Highway Systems Plan: 2003-2022, WSDOT Transportation Planning Office, Olympia, WA, 2002, http://www.wsdot.wa.gov/ppsc/hsp/pdf/HSP-2003-2022.pdf

Washington State Modifications to the MUTCD, WSDOT, M 24-01.

Additional Resources

Biking in Washington – WSDOT’s website for bicycle related issues, http://www.wsdot.wa.gov/bike/

Dewar, P.E., and P.L. Olson, *Human Factors in Traffic Safety*, Lawyers & Judges Publishing Company, Inc., Tucson, AZ, 2002.

FHWA Pedestrian and Bicycle Information Center, http://www.pedbikeinfo.org/

Florida DOT, Pedestrian and Bicycle Safety Office, 605 Suwannee Street, Tallahassee, FL 32399.

Implementing Bicycle Improvements at the Local Level, FHWA, HSR 20, McLean, VA, 1998, http://www.fhwa.dot.gov/safety/fourthlevel/pdf/LocalBike.pdf

Evaluation of Shared-use Facilities for Bicycles and Motor Vehicles, FHWA, HSR 20, McLean, VA, 1996, http://www.fhwa.dot.gov/safety/fourthlevel/pdf/UnivNCMar96.PDF

Hunter, William W. and John R. Feaganes, *Effect of Wide Curb Lane Conversions on Bicycle and Motor Vehicle Interactions*, Highway Safety Research Center, University of North Carolina, Florida Department of Transportation, Tallahassee, FL, 2004, http://www.dot.state.fl.us/research-center/Completed_Proj/Summary_SF/FDOT_0510809_BA784_rpt.pdf

Improving Conditions for Bicyclists and Pedestrians: A Best Practices Report, FHWA, HEP 10, Washington, D.C., 1998, http://www.fhwa.dot.gov/safety/fourthlevel/pdf/INTRO-sept.pdf

Kansas Bicycle Transportation Facilities Guide, Kansas DOT, Bureau of Transportation Planning, Topeka, KS, 1997.

North Carolina Bicycle Facilities Planning and Design Guidelines, North Carolina DOT, Raleigh, NC, 1994.

Oregon Bicycle and Pedestrian Plan, Oregon Department of Transportation, Bicycle and Pedestrian Program, Salem, OR, 1995.

Selecting Roadway Design Treatments to Accommodate Bicyclists, FHWA, HEP 10, Washington, D.C., 1993.

Sorton A, and T. Walsh, *Bicycle Stress Level as a Tool to Evaluate Urban and Suburban Bicycle Compatibility*, Transportation Research Record #1438, 1994. pp. 17-24.

Division III Facility Users
Chapter III-3 Transit

Introduction

Transit is a general term applied to regularly provided public transportation in the form of: bus service, passenger rail, and other conveyance. Transit can be publicly or privately owned. This chapter focuses on those services that use the roadway (primarily buses), but also refers to other services such as rail.

An increasing number of local governments in Washington State are providing transit services. Consequently, the increasing transit ridership and service requirements have had an impact on urban traffic conditions and influenced roadway considerations. Transit service is part of the multi-modal solution in many locations and for many cities. By their nature, transit stops are multi-modal transfer points.

There are three types of roadway transit operations: fixed route, route deviation, and demand response. In addition to these three main types of operations, transit operations vary further by employing a variety of vehicles within each operation. Exhibit III-3.1 shows an example of different sizes of buses available to transit providers. Fixed route services may use small buses with wheelchair lifts, as well as the typical 30- to 40-foot buses. Some transit operators in larger urban areas also operate 60-foot articulated buses – vehicles with two sections that are permanently connected by a flexible material. Rail-based transit systems that are popular in other states are now being developed in Washington. These systems may be efficiently and effectively employed within the urban center and corridor contexts, and as connecting links between two or more centers with high population densities.

There are no specific federal or state requirements that dictate the development of transit systems. Each transit agency works cooperatively with federal, state, and local agencies, and private developers to initiate projects and is bound by its partners' and its own guidance and criteria.

The following sections present a variety of considerations for the development of transit service within a community as an element of a transportation or community development project.

Exhibit III-3.2 shows a multi-modal example of an urban transit center.

Exhibit III-3.1 – Transit Fleet Vehicles (Source: Metro Transit, Seattle, WA)

Exhibit III-3.2 – Transit Center (Location: Olympia, WA)

Definitions

Demand response; dial-a-ride and paratransit The common names associated with vehicles that operate on a non-fixed route or schedule and can stop to pick up or drop off passengers on any street or driveway. Often, demand response is restricted to use by persons with disabilities. However, the transit operator might provide demand response in less developed areas for the general public.

Dwell time The time spent at a bus stop to let passengers get on or off.

Fixed route A transit system in which vehicles operate along a determined route and schedule. Fixed routes in some larger urban areas may be express or commute – meaning that the transit operator might skip stops and/or only provide service during peak hours.

Headway A term used to describe the distance between vehicles or buses.

High-capacity transit Rail-based modes of transportation with the express purpose of moving passengers on regular and frequent trips between convenient locations, such as for daily commute trips.

Layover The time a transit vehicle remains at a transit stop or center in order to permit passengers an opportunity to transfer between routes, and to permit the transit driver time for a break between the end of one run and the beginning of the next.

Route deviation Transit operation in which vehicles operate in the same manner as a fixed route, except that the transit vehicle may deviate to other streets in order to pick up or drop off passengers and then return to the fixed route.

Purpose and Need

Exhibit III-3.3 – Transit Users at a Station (Location: Lakewood, WA)

The provision of transit facilities as part of a project has mobility and access impacts on a community and the surrounding road network. Where a project is proposed, community sentiment may be high regarding the provision of transit services. This input is likely to be in the form of the amount, location, and type of service desired. Many communities are also concerned about proposed stations being built in a manner that keeps with local character; provides shelter from the weather; and/or provides lighting for improved visibility and security.

A transit facility's use may be impacted by the willingness of a community to use mass transit; the origins and destinations of the potential transit users; connectivity; and the other proposed and existing features that may encourage transit use. A system designed with the user in mind is likely to be associated with higher levels of ridership. Exhibit III-3.3 shows an example of a bus station near the Lakewood Mall. The station has large covered stops with wide pedestrian areas.

During the design process, it is beneficial to determine whether or not to sustain, improve, or provide fixed routes or route deviation services. Communication between transit operators, city planners, and roadway design engineers is important, and aids in improved estimates of transit facility capacity. It is important to consider the size of the transit vehicles, and both current and future operations. For rail-based systems, the access points to the facility need to be well coordinated with the other transportation modes to ensure optimization for the users of both systems. This includes consideration of vehicle storage and pedestrian movement.

Analysis Method

Once project stakeholders identify a need or desire to include transit treatments in the project, they need to assess some of the following aspects to accommodate transit system service:

- Bus Stop Locations
- Bus Signs and Markings
- Passenger Shelters and Transit Centers
- Bus Pullouts
- Exclusive Bus Lanes
- Pedestrian and Bicyclist Facilities
- Modal Connections

It should be noted that transit facilities have to conform to accessibility requirements as per the ADA of 1990.

Bus Stop Locations

The fewer stops a transit system provides, the greater the number of passengers that need to board at any given location, the longer the distance passengers have to walk in order to access transit service, and the longer the time an individual bus occupies a stop. Longer walking distances are associated with reductions in transit system use. Conversely, too many stops increase the overall travel times for transit due to time lost in accelerating, decelerating, and the dwell time associated with each stop.

Bus stop locations can reduce the vehicle capacity on the road on which they are located. Conversely, this reduction in capacity can be offset by an increase in people traveling. Care should be taken in the locating of stops. Some stop locations, particularly on the near side of an intersection, can have a significant affect on operations and safety. Research indicates that the best location for bus stops is at the far side of an intersection. These stop locations have the smallest impact on capacity because buses are able to use an adjacent lane to avoid right-turn queues.

Mid-block stop locations are the least desirable option for the driving public and transit passengers. Mid-block stops lead to an increase in the likelihood of traffic conflicts. At these locations, transit passengers tend to cross to and from their origins and destinations along the route and in close proximity to the bus stop. This makes the crossing unpredictable to drivers because the crossing task is not performed in a controlled manner. Multiple threats to pedestrians are common at these locations.

To compare the advantages and disadvantages of the three types of bus stop locations – far side, near side, and mid-block – refer to the *Transit Capacity and Quality of Service Manual*, Part 2 Bus Transit Capacity, Chapter 2, Exhibit 2-10. The Transit Cooperative Research Program's (TCRP) Report 19, *Guidelines for the Location and Design of Bus Stops*, is an excellent reference for the geometric design issues associated with bus stops.

Transit facilities should be designed to allow enough room for the bus to accelerate and pull away from the curb, shoulder, or pullout. Since bus facilities are multi-modal in nature, it is also important to provide adequate space for bicyclists to load or unload bicycles from the front of the bus and adequate space for users with disabilities. Bus stops are often designated as "no parking" or with restricted hours of parking. In these areas, using signs as well as pavement and curb markings would be beneficial. *Guidelines for the Location and Design of Bus Stops*, Chapter 3, addresses this need, as an element of street-side factors.

Bus Signs and Markings

Exhibit III-3.4 – Bus Stop Signage (Location: Oak Harbor, WA)

A key element of all bus stops is the bus stop sign. It notifies the pedestrian, bicyclist, driving public, and transit operators where buses can be expected. Often, the sign identifies the bus routes associated with that specific location. Both bus drivers and passengers use signs to identify the destination of a bus route. Signs need to be set away from the corner or the nearest crosswalk striping to accommodate the probable bus lengths. Standardized signs allow passengers to quickly identify routes. Curbing and curb markings can be used to guide passengers and to identify the location of a bus stop. A uniform color of paint can be used throughout a transit system to inform transit users, and to indicate to drivers that curbside parking is not allowed at bus stop locations. Exhibit III-3.4 shows an example of transit signing, which was designed in keeping with a naval theme. (The provision of bike racks is shown in the lower left-hand corner of the photo.)

Passenger Shelters and Transit Centers

Most transit agencies have criteria to determine the need for passenger shelters. While there might be common elements among the various transit agencies' criteria, each agency has the opportunity to develop its own set of guiding criteria to use when determining shelter needs and placement.

In general, bus shelters need to be set back from the street to avoid damage from passing vehicles. The Americans with Disabilities Act (ADA) specifies minimum criteria for accommodating persons with disabilities, including a requirement that shelters be placed on paved pads to provide traction for wheelchairs. Although their value in shielding the pedestrian is limited, bus shelters do have a safety function in that they add to drivers' awareness that pedestrians may be present. Local weather conditions also affect the design of passenger shelters, as they must protect passengers from wind, sun, rain, or snow. The aforementioned *Guidelines for the Location and Design of Bus Stops*, Chapter 4, addresses this subject as an element of curbside factors. Exhibit III-3.5 shows an example of a shelter that blends into the context of downtown Tacoma.

Exhibit III-3.5 – Bus Shelter at Bus Stop (Location: Tacoma, WA)

Transit centers differ from bus stops in that they serve many different routes. These routes may have extended layover times between connecting routes. Because transit centers serve as transfer points, adequate space on the sidewalk or waiting area allows passengers to wait comfortably. This need has resulted in the creation of transit centers with more passenger shelters that are enclosed and connected. Convenience facilities such as public restrooms, telephones, vending machines, bike racks, and lockers are also frequently made available. To aid passengers in the effective use of a transit system, route schedule information needs to be posted in convenient locations within the transit center. For transit centers that operate near or during hours of darkness, street lighting is common. This can increase the sense of safety among the users of the facility and can affect the likelihood of ridership after sunset. The provision of lighting might also reduce incidences of vandalism.

Exhibit III-3.6 – On-Street Transit Center (Location: Spokane Transit Authority Plaza)

Transit centers might place waiting buses either on street or off-street with restricted vehicle access. Each scenario has its own implications for other vehicular traffic. The amenities mentioned above are common to both types, though not included at all transit centers.

Exhibit III-3.6 illustrates a typical on-street transit center, which is located in the Spokane Transit Authority's Plaza, in downtown Spokane. In this example, buses angle into the curb, and pull out and into vehicular traffic.

A typical example of an off-street transit center is C-TRAN Fisher's Landing in Vancouver, as shown in Exhibit III-3.7. In this case, the buses have restricted right of way located off the street. This particular facility includes a park-and-ride lot located along one side of the restricted right of way, with the transit center structure located along the other side of the restricted right of way. Providing park-and-ride lots can improve the ridership of transit facilities.

Exhibit III-3.7 – Off-Street Transit Center (Location: Vancouver, WA)

Another common consideration for transit centers is pedestrian traffic. Appropriately designed crosswalks, lighting, and associated signs are important in promoting a safe traveling environment around transit centers.

Bus Pullouts

A bus pullout is an important feature to consider, given the potential impact on traffic operations for all modes of travel and the loss of sidewalk space required to accommodate the pullout lane. Though the pullout removes the bus from the curb lane so that traffic can efficiently pass while the bus is stopped, the impact of bus re-entry on traffic operations and safety must be considered. The TCRP's *Transit Capacity and Quality of Service Manual* addresses factors influencing bus capacity. These factors include calculating vehicle capacity at loading areas, dwell time, clearance time, and on-street stops. Exhibit III-3.8 shows a bus pullout in Tumwater. In this example, the curb and sidewalk are skewed to allow for the pullout. A shelter and amenities are provided at this location, and street trees are placed to the back of the sidewalk.

Exhibit III-3.8 – Bus Pullout (Location: Tumwater, WA)

Exclusive Bus Lanes

The use of exclusive bus lanes can make a significant contribution to safer operation for all road users. In principle, exclusive bus lanes remove most of the conflict between transit vehicles and other vehicular traffic. They are particularly valuable in peak-hour situations where these exclusive lanes provide priority to bus traffic to reduce the travel time when compared to other vehicular traffic. This reduction in travel time makes transit more desirable and can increase ridership. Exclusive bus lanes are typically used in larger, urbanized areas.

Exhibit III-3.9 – Exclusive Bus Lane (Location: Vancouver, WA)

Exhibit III-3.9 shows an on-ramp to SR 14 in the Vancouver area. The use of this lane allows transit to bypass vehicles waiting to enter the Interstate.

TCRP's *Transit Capacity and Quality of Service Manual*, Part 2, Bus Transit Capacity, Chapter 4, addresses exclusive arterial street bus lanes. It identifies three exclusive bus lane types: lanes that allow no use of the adjacent lane; lanes that allow partial use of the adjacent lane; and lanes that allow full use of the adjacent lane. The latter design permits vehicles unimpeded opportunities to pass stopped buses. In addition, Chapter 5 of the manual considers bus operations in mixed traffic – an essential element in the consideration of either of the first two lane types.

A special type of bus lane is the "Business Access Transit" (BAT) lane. These lanes are transit lanes that allow use by other vehicles to access abutting businesses.

Pedestrian and Bicyclist Facilities

Improving pedestrian and bicycle connections to transit facilities significantly improves safety and expands the ranges of possible destinations for those walking and biking. Pedestrian activity generators are a primary consideration in laying out bus routes. Common distribution points for pedestrians include neighborhood bus stops, shopping areas, malls, and office complexes.

In a similar fashion, attracting bicyclists to transit requires attention to bicycle parking and major bicycle travel paths within an overall transportation network. There may be intercity bicycle trail systems, or streets identified as preferred bicycle routes. Accommodating bicyclists also requires attention to storage or transport of the bicycle on the bus. This usually means a bicycle rack or storage space on the bus.

Refer to Chapter III-1 for additional information on pedestrian facilities, and Chapter III-2 for details on bicycle facilities.

Modal Connections

While much of the previous discussion about transit has presented this topic as an exclusive mode of transportation, modal connections are an important consideration. A totally integrated transportation system provides the highest levels of connectivity with all modes. Transit trips are normally a single link in a chain of trip segments, connecting origin points with destinations. The transit facility itself is rarely the beginning or the ending point for travelers. A bus transit rider could potentially start their trip in a personal vehicle, get on a bus at a park-and-ride lot, ride to the ferry terminal and catch the ferry, catch a bus at the arrival end of the ferry trip, and walk or bike from a bus stop to their final destination. While the previous example probably exceeds the modal linkages for most users, some level of reliance on multiple transportation modes is quite common.

Through careful planning, bus transit facilities can link a wide variety of alternate travel modes, such as: personal vehicles, passenger rail, airports, and ferry terminals. Integrating these modes in an efficient transportation system requires attention to physical connection points as well as departure and arrival schedules. Connection points may be park-and-ride lots, train stations, airport terminals, or ferry terminals. For modes such as train, airplane, or ferry, coordination of the arrival and departure times is a concern. Wait times between modal transfers can be linked to levels of use. Regular and reliable schedules at the major connection points provide great flexibility in trip choices.

Balancing Considerations

The provision of carefully considered transit treatments can contribute significantly to the improvement of pedestrian and traffic safety on highways or city streets. Furthermore, considering transit service options during the design process can improve the predictability of transit movements and routes.

Transit treatments influence the community and a number of elements of the design process. These elements and their associated effects include:

Mobility

Transit provides a travel choice, as well as mobility, to those without access to vehicles, such as children under the age of 16, senior citizens, individuals with disabilities, people who choose not to use a car, and households of modest incomes.

Disabilities

Transit customers include a disproportionate number of persons with disabilities. These users' requirements should be considered and accommodations for them incorporated into the design of the transit stops, signs, and pedestrian facilities.

User Age

Transit systems are often a mode of choice for people too young to drive, or those who no longer drive. Elderly users, or those with health problems in particular, may have diminished physical capabilities affecting sight, balance, and stamina. Minimizing these physical limitations requires consideration of illumination, color contrast, traction of walking/stepping surfaces, number and height of steps, and distance to the transit stop from pedestrian origin/destination points.

Origins/Destinations

Transit riders tend to be regular customers, so the consideration of where riders originate and go is necessary to allow provision of more efficient bus stops and routes.

Safety and Aesthetics

Transit treatments may improve the continuity throughout the transit system. They also may improve the flow of traffic, thereby reducing the associated traffic conflicts and automotive emissions.

Route Identification

Route efficiency and subsequent communication of those routes through signs to other motorized and non-motorized roadway users, will allow them to better predict bus and passenger movements and respond accordingly.

Exhibit III-3.10 – Shopping Center Access (Location: Lakewood, WA)

Transit Stop Use

Although rare, re-routing of transit can lead to abandoned transit stops, increased impervious surface, and pavement maintenance. The project team can work with transit providers on optimizing stop placements.

Stop Placement

Stop placement will affect the ability of transit to re-enter traffic. In-lane transit stops may be used where bus lanes are not available. Though they may increase conflicts with and decrease the mobility of non-transit vehicles, they may provide important linkages between transit and the highway system. Transit vehicles have an easier time re-entering traffic from in-lane stops.

Exhibit III-3.11 – Modal Interchange – Motorized Vehicle, Bus, Bike, and Light Rail (Location: Tacoma, WA)

Connectivity

The different modes of transportation, including transit, need to interconnect. Transit is one component of a wider transportation network. Primary travel corridors for aviation, rail, motorized vehicles, bicyclists and pedestrians should be considered when determining the location of connection and transfer points. For bicyclists, there is also a need to provide facilities for transporting bicycles on or in the transit vehicle. Connection and transfer points, along with facility design, are addressed during the route development process.

Transit is an increasingly important mode of travel for numerous reasons. The consideration of the multi-modal context of transit and its interactions with the environment in which it is provided are important to the overall success of the roadway system. Roadway design that allows for safe, secure, easy, and comfortable access to the facility requires early consideration in the project development process. In many contexts, the limited right of way requires choices to be made which weigh the needs of each mode in the decision process. This discussion requires input from many stakeholders and should be considered when planning and scoping the project to get the best results. Exhibits III-3.10 and 3.11 show transit facilities at shopping and modal interchange destinations.

Governing Regulations and Directional Documents

Staplin, L., K. Lococo, S. Byington, and D. Harkey, *Guidelines and Recommendations for Accommodating Older Drivers and Pedestrians*, Publication No. FHWA-RD-01-051, Turner-Fairbank Highway Research Center, McLean, VA, 2001, http://www.tfhrc.gov/humanfac/01105/cover.htm

Traffic Operations Control for Older Drivers and Pedestrians, Publication No. FHWA-RD-95-169, Turner-Fairbank Highway Research Center, McLean, VA, July 1996, http://www.fhwa.dot.gov/tfhrc/safety/pubs/95169/95169.html

Additional Resources

Furth, Peter G. and Adam B. Rahbee, *Optimal Bus Stop Spacing Through Dynamic Programming and Geographic Modeling*, Transportation Research Council (TRC) Report No. 1731, 2000.

Guidelines for the Location and Design of Bus Stops, Transit Cooperative Research Program (TCRP) Report 19, National Academy Press, Washington, D.C., 1996.

Guttenplan, Martin, et al., *Multi-Modal Level-of-Service Analysis at Planning Level*, Transportation Research Council (TRC) Report No. 1776, 2001.

Improvements in Symbol Sign Design to Aid Older Drivers, Publication No. FHWA-RD-95-129, Turner-Fairbank Highway Research Center, McLean, VA, August 1995, http://www.fhwa.dot.gov/tfhrc/safety/pubs/95129/95129.html

Kirschbaum, Julie B., et al., *Designing Sidewalks and Trails for Access*, FHWA, Washington, D.C., 1999.

Safety Mobility for Older People, http://ntl.bts.gov/DOCS/Safe_Ntbk/index.htm

Smith, Emily, *Making Streets Safer for Seniors on Foot*, University of North Carolina Highway Safety Research Center, The Partnership for a Walkable America, http://www.hsrc.unc.edu/pdf/pedbike/strsaf.pdf

Traffic Safety Facts: Older Population, DOT HS 809 611, National Center for Statistics and Analysis, National Highway Traffic Safety Administration, Washington, D.C., 2002, http://www-nrd.nhtsa.dot.gov/pdf/nrd-30/NCSA/TSF2002/2002oldfacts.pdf

Transit Capacity and Quality of Service Manual, TCRP-CD-02, Transportation Research Board, Washington, D.C., January 1999, http://www.tcrponline.org/index.cgi

This page intentionally left blank

Introduction

The design of the state highway system requires incorporating the needs of all expected users. The selection of the appropriate design vehicle(s) is an important consideration in developing the geometric design of intersections and roadways. In particular, the design vehicle is used in the design of curb radii at intersections. This chapter is specific to motorized vehicles and focuses on the characteristics of the vehicles, not the drivers. Chapters III-1 through III-3 include information on other transportation modes.

Exhibit III-4.1 – Key Issues

- Facility context
- Delivery vehicle access
- Pedestrian crossing considerations
- Traffic volumes
- Design speed

In the urban context, in particular, the need to design for the use of the largest possible vehicle can result in a conflict of design objectives. For example, designing to accommodate a larger vehicle will result in larger turning radii, which in turn increases the impervious surface area and pedestrian crossing distances. The following sections provide a brief discussion on design vehicle considerations.

Purpose and Need

Many businesses use the largest trucks allowed by state law to deliver their products directly from the manufacturer to the retail outlet. This method of shipping eliminates both the handling costs associated with off-loading and reloading at centralized distribution points, and the fuel costs incurred by using several smaller trucks to complete the delivery.

Exhibit III-4.2 – Urban Road with Large Truck (Location: Snohomish, WA)

Many streets and highways are not designed to accommodate these large vehicles. In older central business districts, for example, the surface streets might have been designed for a much smaller vehicle. This situation can lead to larger vehicles encroaching onto adjacent lanes or sidewalks. Highway designs developed to accommodate large trucks on the state highway system often favor a multilane, high-speed route. The goal, then, is to integrate this need for freight mobility with a community’s need for an attractive, livable environment. This can best be accomplished by providing design options for highway development within cities and communities that are reasonably compatible with the needs of both priorities.

The primary elements that drive the design of the facility are design speed, traffic volumes, and facility context. Consideration is also given to peak period volumes and traffic mix.

Design Vehicle

The design of a roadway or intersection should take into consideration two vehicles: (1) the design vehicle, which is normally the largest vehicle to use the facility on a regular basis, and (2) the largest vehicle expected to use the facility on a less frequent basis, which is the largest legal vehicle. (This does not necessarily mean that all intersections must accommodate turning movements for the largest vehicles.) Accommodating the largest vehicle to occasionally use the facility, means allowing for turning movements without leaving the paved shoulders or encroaching on sidewalks.

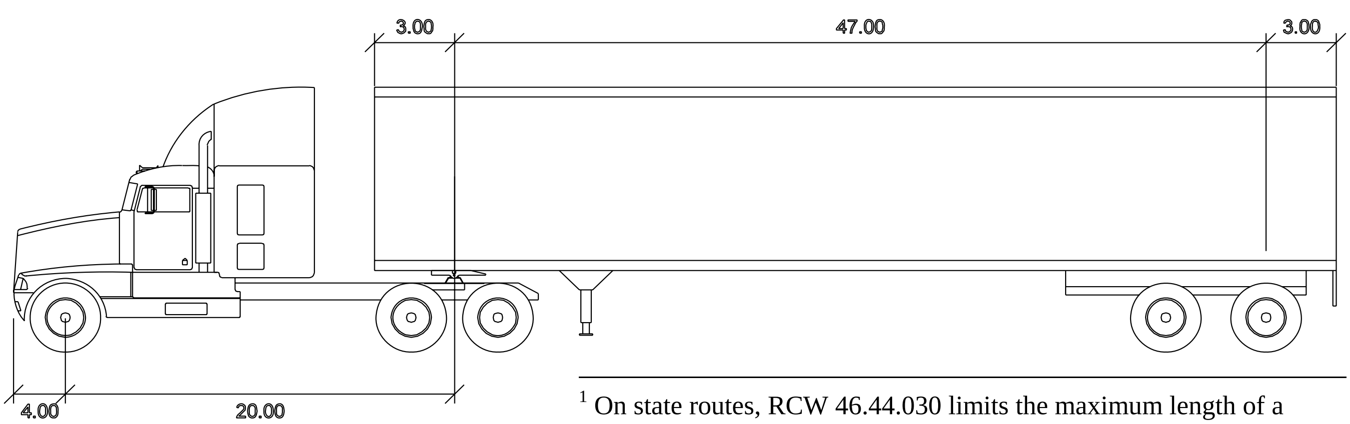
When selecting design vehicles for intersections, independent decisions should be made for each leg of the intersection. This frequently results in different design vehicles for different legs of the intersection. Design vehicle decisions for intersections influence elements such as roadway width, throat width, turning roadway design, and corner radii. Vehicle routing and the size of vehicles necessary to serve businesses along the corridor should be considered when selecting a design vehicle for intersections. Alternative routes that might be available for larger vehicles (as well as local pedestrian activity, bicycle usage, traffic volume, the percentage of trucks, and the speed of the facility) should also be considered.

Exhibit III-4.3 – Truck at a Suburban Roundabout (Location: SR 510, Lacey, WA)

Proper design vehicle consideration results in efficient traffic flow with the typical traffic mix of vehicles and non-motorized traffic. If too small a design vehicle is used in the design parameters, traffic disruptions can result when larger vehicles pass through. If too large a design vehicle is used, the pedestrian crossing distances and impervious surface area are needlessly increased, with no overall benefit.

The WB-67 is the largest legal vehicle on state routes, and it has frequently been used as the largest vehicle expected on a facility. The WB-67 is not the most prevalent large truck on our highway system and designs to accommodate these vehicles in the urban setting are frequently used, though the use of the WB-67 is often considered excessive. The somewhat smaller WB-50 truck is the most common vehicle used to transport products and goods. Because of its shorter wheelbase, it does not exhibit the extreme trailer off-tracking as the WB-67, though the off-tracking is still pronounced. There is also a smaller tractor and trailer truck, the WB-40, which can impact facility design. This older vehicle (WB-40), with its smaller enclosed trailer, is losing favor with the trucking industry because of its limited hauling capacity.[1]

Exhibit III-4.4 – Illustration of the WB-67 (Source: WSDOT)



[1] On state routes, RCW 46.44.030 limits the maximum length of a "truck" to be "any combination consisting of a tractor and semi-trailer that has a semi-trailer length (not) in excess of fifty-three feet." The WB-67 has a semi-trailer length of 53 feet. The "WB" refers to the wheelbase, and the "67" is the distance, in feet, of that wheelbase. The overall length of this vehicle is 74 feet, including the chassis and body extensions beyond the wheels. By comparison, the passenger car design vehicle is only 19 feet long.

The most common truck in the urban and town center contexts is the single-unit truck (SUT) or the single-unit vehicle (SUV). It is a “single unit” because it does not have a trailer. Delivery trucks, garbage collection trucks, fire trucks, and dump trucks all have basically the same wheelbase and turning capabilities. These vehicles can negotiate much sharper turns and usually have little trouble using the same streets as passenger vehicles. Delivery trucks have a very limited hauling capacity and are not normally used to service large retail outlets with extensive inventories.

Exhibit III-4.5 – SR 161 with Multiple Large Vehicles (Location: Graham, WA)

Buses are another type of large vehicle that influence roadway design. There are three basic bus types. The most common is the school bus, which has a short wheelbase and long rear overhang. This wheelbase is similar to an SU truck and is favored for service to residential areas where roadways are narrow and intersections require sharp turns. Transit companies also use this vehicle to provide passenger service to these same areas. A bus with a longer wheelbase is used in cities and business districts because of its greater passenger-carrying capabilities. These buses are, however, quite long and require large areas to execute a turn. The turning characteristics of these buses are similar to the WB-40 vehicle. In the built-up area at the core of a city, most intersections do not have the wide areas required for bus and truck turns. To compensate for this, transit companies use bus routes on a straight-line grid system to minimize turning maneuvers. The third type of bus is the articulated bus, which can reduce the turning problem. Articulated buses are hinged in the middle to behave similarly to a moderately long truck with a trailer, and can carry more passengers without increased off-tracking.

Simulation Software

To aid in the design of intersections, there are several versions of turning simulation software available. These software packages use the specified design vehicles to help designers in the design process, by allowing designers to input the vehicle’s characteristics to generate output relating to the roadway characteristics required to accommodate the vehicle.

Balancing Considerations

Challenges arise when large trucks leave the freeway and enter the adjoining surface streets and highways to make deliveries. At intersections, these trucks require a large area to turn onto another roadway. The tractor at the front of the vehicle is capable of fairly tight turns. However, the long trailer tends to sweep across a much larger area. Exhibit III-4.6 illustrates this turning maneuver. The right turn is particularly difficult for large tractor and trailer trucks and it is common for the trailer to ride up on the curb and sidewalk in the apex of the intersection corner or encroach into lanes of traffic going in the opposite direction. Because the WB-67 is legal on all state routes, it is typically used in the design of the roadway width on state routes and considered in the design of the intersections along a state route.

Exhibit III-4.6 – Large Truck Turning (Location: Olympia, WA)

Designing intersections to accommodate the turning movements of the design vehicle on the facility ensures that the vehicle can complete the turn, without leaving the paved shoulders or encroaching upon sidewalks. It may not be necessary to design every intersection or intersection leg to accommodate these turns. The needs of pedestrians and land uses are areas to consider when making design vehicle selections. Delivery vehicle access may be met by designing a portion of the intersections along a route to allow truck-turning movements. This can be done at specified locations or at regular intervals. Also, providing delivery areas adjacent to the roadway may improve accessibility without requiring that all the intersections accommodate the turning movements of delivery vehicles.

Exhibit III-4.7 – Large Truck Turning from a One-Way Street (Location: Seattle, WA)

Designing intersections to accommodate the turning movements of a large design vehicle will increase pedestrian crossing distances, pavement area, and right-turning speeds, and will require signal-timing adjustments. Intersection designs that do not accommodate the appropriate design vehicle may increase the potential for encroachment onto sidewalk corners.

In some instances, it might be appropriate to consider developing alternate truck routes within the urban and town center contexts. These routes can be designed to accommodate the specific needs of through truck traffic, and provide alternate routes for some local delivery trips. At intersections on a main street, the size of the curb radius may be reduced to discourage use by vehicles that are too large for the facilities accessed by the intersection. When access along the facility is limited in any way, means for the delivery of goods must be provided. Alternately, the state route may be developed to bypass the downtown area.

In addition to the size and characteristics of the vehicles that will use the facilities, it is also important to consider the speeds at which the vehicles will be traveling.

Governing Regulations and Directional Documents

Design Manual, WSDOT, M 22-01.

Motor Vehicles – Size, Weight, Load – Maximum Lengths, *Revised Code of Washington* (RCW) 46.44.030.

A Policy On Geometric Design of Highways and Streets, 4th ed. (Green Book), American Association of State Highway Transportation Officials, (AASHTO), Washington, D.C., 2001.

Division IV Environmental Considerations
Chapter IV-1 Urban Forestry

Introduction

In the urban context, most people think of vegetation as street trees. While street trees make the most substantial visual impact and often provide the best environmental return on the dollar invested, there are many additional types of vegetation to consider in the development of a transportation facility in the urban environment. Depending on the context, planting strips may contain a combination of grasses, ground covers, shrubs, and trees. Some communities are exploring the option of employing planting strips and medians as stormwater treatment facilities. In this case, vegetation plays an important role in filtering, holding, and transpiring water.

Exhibit IV-1.1 – Roadside Vegetation in the Urban Downtown Environment (Location: Kent, WA)

The need for handling stormwater, both for water quality treatment and for storage and infiltration has become increasingly important. In addition, communities view roadsides as existing or potential locations for urban forests, and as places that convey information about their community. There are many competing uses for our roadsides, and the land available for these uses is often very expensive and in limited supply. There is increasing emphasis to consider the roadside a resource in which multiple functions can be accommodated. In many cases, the roadside can perform many visual, operational, and environmental functions. In other cases, needs must be analyzed and prioritized. What functions can be accomplished within the median? Where can existing roadsides be retrofitted for new uses? An example is stormwater treatment. In the past, large ponds were constructed to retain and detain water from a large catchment area. Current trends are for treatment facilities to be located as close to the source of runoff as possible, using multiple and smaller treatment facilities, often referred to as Low Impact Development.

Definitions

***Best Management Practices* (BMPs)** The structural devices, maintenance procedures, managerial practices, prohibitions of practices, and schedules of activities that are used singly or in combination to prevent or reduce the detrimental impacts of stormwater, such as pollution of water, degradation of channels, damage to structures, and flooding.

Green streets The concept that integrates the ideas of urban forestry and Low Impact Development (LID) into the urban and semi-urban environments.

***Low Impact Development* (LID)** The ecosystem-based approach to land development and stormwater management that can supplement conventional stormwater treatment techniques and reduce site runoff.

Urban forest The aggregate of all vegetation within an urban area, the management of populations of trees, and the interaction of people with the biology of urban flora and fauna.

Purpose and Need

Environmental regulation and BMPs require treating and slowing the flow of stormwater after it runs off impervious road surfaces and before it reaches larger water bodies. The construction of large stormwater ponds requires large areas and is costly. Smaller, more evenly distributed and linked bioretention depressions and swales can often handle the same quantity of runoff more efficiently at a lower cost than large-scale systems. Natural dispersion areas can provide stormwater storage. The urban forest can play a role in stormwater storage, and also has other important functions.

Exhibit IV-1.2 – Bioretention (Location: Seattle, WA)

Trees provide shade, impede erosion, reduce runoff, improve water quality, and act specifically along transportation corridors to both visually and functionally reduce the impacts of large paved areas and the vehicular operations they support. They provide oxygen and trap airborne particulates, providing air quality improvements. In addition, they store water, providing stormwater storage capacity. These all have quantifiable benefits for the environment. Many cities and towns have permit requirements for street trees and planting islands. Vegetation performs many functions in and adjacent to transportation facilities. In addition to the stormwater benefits listed above, roadside vegetation traps airborne particulate pollutants, absorbs CO_2, produces oxygen, screens headlight glare from on-coming traffic, softens the urban landscape, adds human scale, and is aesthetically pleasing.

Recent studies indicate there may be significant economic and social benefits from the urban forest. For example, in shopping districts with street trees, shoppers spend 11% more on the same products, stay longer, and return more frequently compared to shopping districts without street trees and other planting areas.[1] Of particular concern in downtown, residential, and recreational contexts, another study shows that people who live in areas with trees have significantly better relationships with their neighbors, are significantly less violent, know more people, and have more visitors than people who live in buildings without trees.[2]

Further information on the functions and benefits of vegetation can be found in Chapter 800 of the *Roadside Manual.* More information on planting design and establishment can be found in Chapters 800 and 810 of the *Roadside Manual.*

Balancing Considerations

There are numerous factors to consider when including vegetation in a transportation plan. To be safe, effective, and beneficial to the community and the environment in the long run, there must be careful consideration of the factors, and weighing of the benefits and drawbacks to arrive at a desirable solution.

---

[1] Kathy Wolf, Ph.D., Nature and Consumer Environments.
[2] Edward C. Sullivan, Do Trees Strengthen Urban Communities? 1996.

The many benefits attributed to vegetation in urban areas come at a cost for both installation and ongoing maintenance during the life of the facility. Planting in urban areas commonly requires engineered soil mixes, provisions for proper drainage, and supplemental water during establishment via irrigation or a hand-watering program. Dependence on community volunteers for routine maintenance, such as mowing, weeding, and or hand watering, is advisable only in conjunction with agency support to actively operate a volunteer coordination program. In the absence of such a program, project investments are at risk, as are the safety, environmental, and economic benefits they were designed to provide.

Vegetation management, in such areas as medians and traffic islands associated with urban transportation corridors, is the work of trained professionals, specialized in the areas of traffic control, hazard mitigation, landscape maintenance, and integrated pest management. This guarantees the investment in the improvement of the transportation facility and the safety of both the workers and the users of the facility. Proper care to safeguard the public is ongoing for the life of the facility, so the cost in materials and labor must be budgeted accordingly. The following is a list of vegetation considerations:

- Street trees provide shade, impede erosion, reduce runoff, improve water quality, and provide a "sense of place."
- Supplemental water is always required and irrigation is often the practical means to provide it.
- Routine maintenance (pruning, weeding, mulching, litter pick-up) is required for the life of the facility.
- Plant species, layout, and maintenance are necessary considerations in traffic operations; sight distance calculations; and pedestrian, bicycle, transit, and vehicle safety.
- It commonly impacts the useful life of paved surfaces in constrained areas. Use of engineered or structural soil is worthy of consideration for some conditions.

Although street trees have significant benefit, care needs to be taken in their placement in proximity to the traveled way. A California study on median tree placements showed large trees in curbed medians along conventional urban and suburban state highways are associated with more collisions and with increased collision severity and the effects on speeds are inconclusive.[3]

Urban Forests

The images in Exhibit IV-1.3 show the same street. The first photograph shows the existing condition, and below is a digitally altered image to show how the addition of street trees will change the environment along the facility.

As stated by the Center for Urban Forest Research at the University of California - Davis on their website,[4] "Urban forests improve air quality by reducing atmospheric carbon dioxide levels and absorbing air pollutants. Trees can directly

Exhibit IV-1.3 – Existing Street and Digitally Enhanced Photo 25 Years Later (Location: Beaverton, Oregon)

[3] Edward C. Sullivan, *Safety of Median Trees*, 2004.
[4] Air Quality, http://cufr.ucdavis.edu/research/air.asp

sequester carbon dioxide as woody and foliar biomass while they grow. Properly planted and managed trees can also reduce the need for heating and air conditioning. A study of six million trees reveals that the trees removed and stored approximately 304,000 tons of atmospheric carbon dioxide, 12,000 tons of ozone, and 9,000 tons of particulates."

Another study shows that trees provide important benefits in parking lots by moderating the heat absorbed by asphalt. Cooler air temperatures reduce ozone concentrations by lowering hydrocarbon emissions. The cooler the car, the lower the rates of evaporation from gas tanks, hoses, and vehicle fabrics. Trees in Davis, California parking lots reduced surface asphalt temperatures by as much as 36°F, vehicle cabin temperatures by over 47°F, and fuel-tank temperatures by nearly 7°F.

Street trees play an important role in stormwater management and air quality. A study by Xiao, et al,[5] found that a 9-year-old broadleaf deciduous pear tree intercepted 15% of gross precipitation over the canopy surface area and an 8-year-old broadleaf evergreen tree (cork oak) captured 27%. The maximum amount of interception occurred at the beginning of each event. (Interception is defined as the sum of canopy surface water storage and evaporation). Additionally, the shade that tree canopy cover provides effectively moderates the temperature of runoff, which reduces the pollutant effect of temperature on natural streams and native fish species.

One study found that a medium-sized tree could intercept as much as 2,380 gallons of rainfall per year. A mature evergreen tree (75 feet or more) in coastal regions is estimated to intercept 4,000 gallons of rainfall per year.[6] The Center for Urban Forest Research reports that computer simulations of deciduous trees in California's Central Valley estimate that for every 1,000 trees, stormwater runoff is reduced nearly 1 million gallons. These values show the role trees play in reducing runoff of polluted stormwater and in reducing the need for engineered controls.[7]

A study of urban forests in Modesto, California (reported on the UC Davis Center for Urban Forest Research website[8]) shows that for each $1 invested in urban forest management, $1.89 in benefits is returned to residents. The study found that city trees removed 154 tons of air pollutants, increased property values by over $1.5 million, and provided shade that saved over $1 million in energy costs.

Studies also show there are significant human benefits from urban forests and the experience of nature: physiological responses to stress are mitigated; blood pressure lowers; breathing and heart rates reduce; medical recovery rates and convalescence shorten with views of nature; and productivity increases.[9]

---

[5] Quigfu Xiao et al, "Rainfall Interception by Trees," 2000.
[6] Is All Your Rain Going Down the Drain? 2003.
[7] Water, http://cufr.ucdavis.edu/research/water.asp
[8] Benefits and Costs, http://cufr.ucdavis.edu/research/benefit.asp
[9] Roger Ulrich, "Human Responses to Vegetation and Landscapes," 1986. pp. 29-44.

Street Tree Considerations

- "Structural" soils are worth considering to provide for root growth under pavement. (The region's Landscape Architect can be contacted for information.)
- Supplemental water is necessary; irrigation is often the practical choice.
- Enhanced sense of community.
- Increased property values.
- Shoppers prefer to shop at stores along tree-lined streets.
- Stormwater uptake.
- Oxygen released and carbon dioxide removed.
- Shade & cooling in summer – energy use down.
- Air quality improvements.
- Annual maintenance required to sweep and dispose of leaves. Pruning required occasionally to keep the tree in a healthy condition.
- Tree offsets and varying curb heights may be needed and are dependent upon design speed. (See brochure at http://www.wsdot.wa.gov/eesc/design/Urban/PDF/NewBrochure.pdf, Chapter 700 of the Washington State Department of Transportation (WSDOT) *Design Manual*, and the *Local Agency Guidelines*.)
- Location of tree and placement of root control devices to reduce pavement and sidewalk heaving and cracking.

Low Impact Development

Low Impact Development (LID) is an innovative ecosystem-based approach to land development and stormwater management that can supplement conventional stormwater treatment techniques and reduce site runoff. "Green Streets," an alternative term used for the same philosophy and set of techniques, seeks to manage stormwater and to make the best use of a street tree canopy, in order to intercept stormwater, mitigate for increased temperatures, and improve air quality.

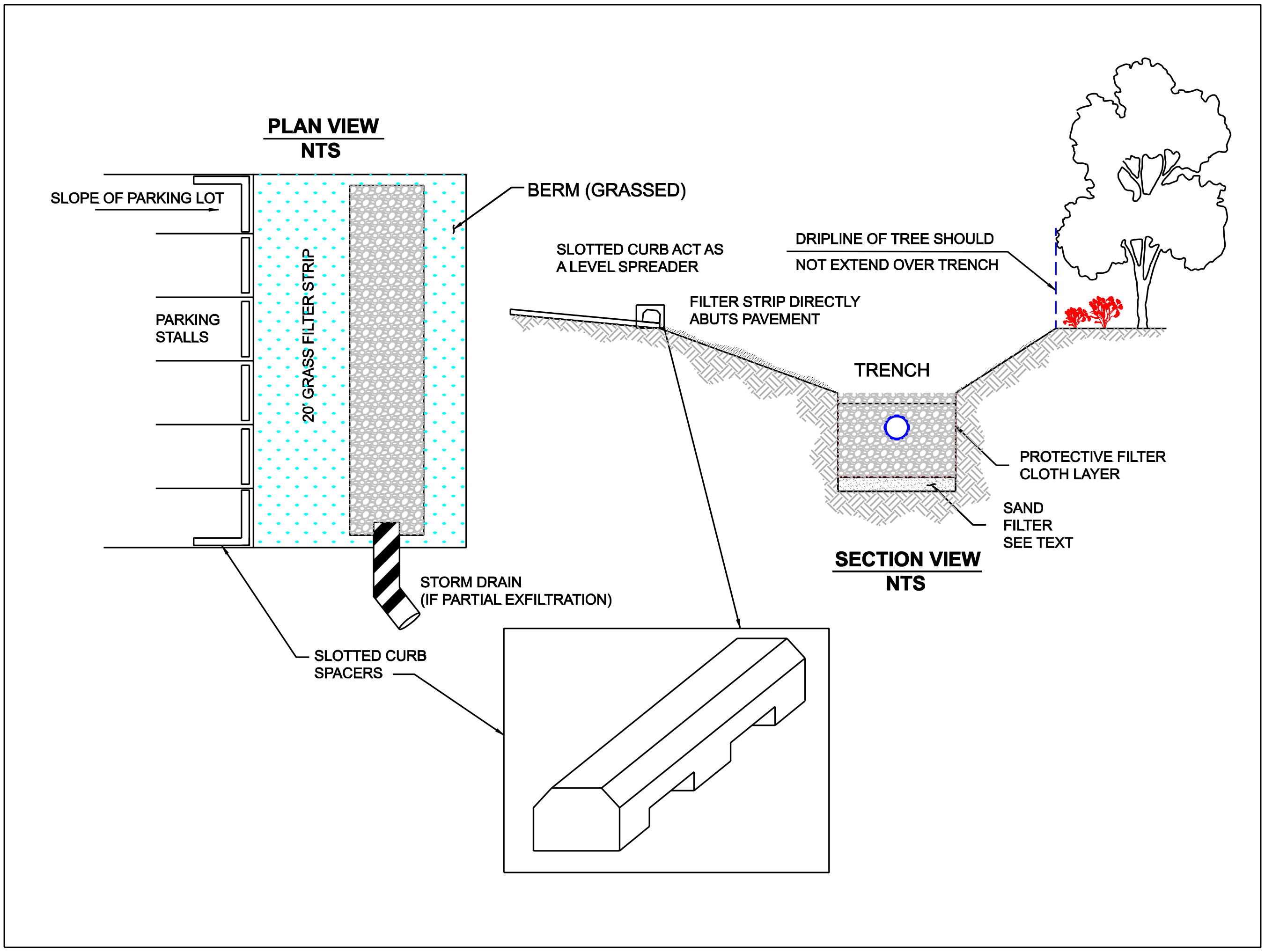
LID uses BMPs to handle the impacts of a roadway, as near to the source of the impact as practical. LID BMPs use small-scale stormwater treatment techniques that are distributed evenly through a project area, in order to maintain or return the site runoff rate to pre-disturbance conditions. An example in a semi-urban area is the use of permeable concrete pavement systems for sidewalks, in conjunction with smaller, linear stormwater detention facilities.

The following BMPs are examples of LID techniques that can be incorporated into a highway system.

- Engineered subsurface materials and underdrain systems allow swales to store and infiltrate water at a greater rate than conventional drainage ditches.
- On new projects, the retention of existing desirable vegetation (where feasible) allows plant material to continue to intercept rainfall, provide air quality improvements, and mitigate surface temperatures.

- Linear compost filter strips and compost blankets adjacent to the roadway shoulder require little room, but are able to store and clean large amounts of stormwater runoff.
- Porous concrete pavements can be used for pedestrian surfaces, outlying parking areas and, in some cases, road shoulders. When properly constructed over an engineered subgrade, these systems can infiltrate 3 to 5 gallons per minute per square foot. Many municipalities do not require any further stormwater mitigation measures when porous pavements are used.[10]

Exhibit IV-1.4 – Bioretention Area Cross Section (Source: WSDOT Roadside Manual)



[10] Stormwater Management Fact Sheet: Bioretention.

Points to Consider for Low Impact Development Techniques	
Retain existing vegetation	• Stormwater credit possible • May be used for natural dispersion area • Design around significant vegetation • Retaining walls may be needed • Retains character or "Sense of Place" • Commonly a community priority • May be a local land use requirement • TESC / Stormwater Management BMP • Reduces mitigation requirements
Remove existing vegetation	• Increased erosion • Restoration necessary • Stormwater runoff increases by quantity of water previously held in vegetation • Mitigation for stormwater impacts increases • Requires coordination early in project design • May result in fewer constraints on design
Large, regional stormwater ponds	• Purchase large site for pond • Excavate and haul material • Revegetation necessary • Fencing may be necessary if greater than 3H:1V side slopes
Large stormwater vaults	• Excavate and haul material • Expensive, engineered system • Fit under roadway • Expensive, on-going hazardous maintenance required
Multiple, small treatment sites close to source	• Fit into existing right of way • Simple techniques • Linked sites (string of pearls concept), each holding water • Shallow slopes – no fencing
Compost filter strips or blankets	• Clean and detain water • Can be blown on • Enhance plant growth (which holds water) • Cost for compost blown in place • Erosion control BMP
Permeable pavements	• Soils must drain, but not too quickly • Engineered subgrade to hold water before it infiltrates • Infiltrates 3 to 5 gallons per minute per square foot • No stormwater mitigation needed for these surfaces – decreased cost • Life cycle same as conventional concrete • Cost 25% more than conventional pavements • Requires semi-annual sweeping or power washing

Large initial investments in these techniques have to be evaluated in the context of savings realized by not having to construct large regional ponds or vault systems for stormwater mitigation.

The Washington State Department of Ecology's *Stormwater Manual* allows stormwater credits for the retention of trees on a site. A large, mature tree can store up to 500 gallons of water in its infrastructure at any one time. Cutting that tree down necessitates allowing for the storage of that water in a pond. Therefore, it might cost more to cut a large group of trees down than to preserve them.

Analysis Method

Urban Forests

Street tree design requires early consideration in the design development process to maximize opportunities for retention of existing healthy trees and/or to optimize conditions to most effectively support the health and longevity of newly planted trees.

Tree grates, though commonly used in urban environments to temporarily protect against compaction of small areas immediately adjacent to the trunks of newly planted trees, are typically costly. Cost for installation of tree grates is an important factor, particularly since they are temporary and likely to be removed early in the life of the project. More important from a safety standpoint is the cost for ongoing maintenance: to expand the open area at the base of a tree to accommodate growth and prevent girdling (which results in hazardous trees); reset grates pushed out of alignment with sidewalks; mitigate the tripping hazards; replace grates that are broken; and remove grates once trees outgrow them.

A design that provides increased space for root growth for trees is always a desirable goal, given the return benefits of reduced pavement damage and increased tree health and stability. Increasing space range includes alternatives from simple to complex. Simple solutions would include provisions for optimum open surface area at the base of the tree (8'x 8' tree pits, as an alternative to the often-used standard of 5'x 5') and/or wider planting strips (8' wide, as an alternative to the often-used standard of 5'). Complex solutions often involve use of engineered or structural soil mixes, which involves excavation of existing material and backfill with an imported aggregate/soil/binder mix, with the area of treatment commonly involving entire planting strips (i.e., areas 5' or greater in width and 3' or greater in depth over the length of the planting strip). Cost for use of engineered or structural soil is moderate, when compared with the value of an increased useful life for paved surfaces (the extent of which is not yet known, due to the relatively recent movement toward use of these materials and lack of historical data preceding the 1970s-1980s).

Additionally, proper planting and construction techniques utilizing root barrier, and/or use of fully prepared elongated tree pits (10-15' in length), continuous planting strips, or "root-ways" (channels under pavement to connect trees in tree pits or allow tree roots access to open areas behind the sidewalk) encourage lateral rooting and/or the development of interconnected root systems.

Supplemental water is always necessary to establish newly installed plantings in the urban environment. Irrigation is commonly the most cost-effective means to provide supplemental water, given the high cost for labor and safety, and the traffic operation conflicts associated with hand watering. Plant selection must be made to provide the functions required by the project in a manner that is compatible with the context of the project and the project budget, with particular emphasis on the cost for long-term maintenance.

The role of the Landscape Architect as a project team member, responsible for ensuring a safe, maintainable, context sensitive, and aesthetically pleasing landscape treatment, is of value for a time period that far exceeds the project development and construction process. The Landscape Architect can oversee proper planting and construction techniques to safeguard the structural stability of sidewalks, curbing and pavement, and the sight distances and clear zone that a mature tree may impact due to its placement.

Irrigation is usually required in urban planting situations because of the increased impervious surfaces and lack of ground water. Plant species should be chosen to match the context, design intention, and existing or proposed resources.

Low Impact Development

LID techniques can be used effectively in semi-urban and urban areas, as well as in rural, open, or forested areas. Parking lots and sidewalks can be effectively retrofitted to use LID techniques to store and treat stormwater before releasing it to a sewer system. (See the *Highway Runoff Manual* and the Parking Area Design chapter in the *Roadside Manual* for more detailed information.)

While LID techniques might not handle all stormwater runoff on sites with high percentages of impervious surfaces, they can be used in combination with more conventional treatments to clean and detain stormwater runoff.

Governing Regulations and Directional Documents

Clean Air Act, 42 *United States Code* (U.S.C.) §§ 7401-7642.

Clean Water Act, 33 U.S.C. § 1251.

Design Manual, WSDOT, M 22-01.

Highway Runoff Manual, WSDOT, M 31-16.

Puget Sound Runoff Program, *Washington Administrative Code* (WAC) 173-270.

Puget Sound Water Quality Authority Act, *Revised Code of Washington* (RCW) 90.70.

Roadside Classification Plan, WSDOT, M 25-31.

Roadside Funding Matrix, WSDOT, Appendix B.

Roadside Manual, WSDOT, M 25-30.

State Water Pollution Control Act, RCW 90.48.

Stormwater Management Manual for Western Washington, Washington Water Quality Program, Washington State Department of Ecology, Olympia, WA, 2001, http://www.ecy.wa.gov/pubs/9915.pdf

Water Resources Act of 1971, RCW 90.54.

Additional Resources

Bassuk, Nina, Jason Grabosky, Peter Trowbridge, and James Urban, "Structural Soil: An Innovative Medium Under Pavement that Improves Street Tree Vigor," Urban Horticulture Institute, ASLA (American Society of Landscape Architects) Annual Meeting Proceedings, 183-185, 1998, http://www.hort.cornell.edu/department/faculty/bassuk/uhi/outreach/csc/article.html

Center for Urban Forest Research, University of California, Davis, http://wcufre.ucdavis.edu/
Air Quality, http://cufr.ucdavis.edu/research/air.asp
Benefits and Costs, http://cufr.ucdavis.edu/research/benefit.asp
Urban Forest and Urban Infrastructure Conflicts, http://cufr.ucdavis.edu/research/studies.asp?TopicID=7
Water, http://cufr.ucdavis.edu/research/water.asp

Environmental Services Office (ESO), Region Environmental Manager, WSDOT.

Green Streets: Innovative Solutions for Stormwater and Stream Crossings Handbook, City of Portland, http://www.metro-region.org/article.cfm?ArticleID=262

Hydraulics Office, Headquarters Hydraulics Engineer, WSDOT.

Is All Your Rain Going Down the Drain? Look to Bioretainment – Trees are a Solution, Center for Urban Forest Research, Davis, CA, 2003, http://cufr.ucdavis.edu/products/cufr_392_rain_down_the_drain.pdf

Landscape Architecture Office, Region or Headquarters Landscape Architect, WSDOT.

Low Impact Development, Puget Sound Water Quality Action Team, http://www.psat.wa.gov/Programs/LID.htm

Stormwater Management Fact Sheet: Bioretention, The Stormwater Manager's Resource Center, http://www.stormwatercenter.net/Assorted%20Fact%20Sheets/Tool6_Stormwater_Practices/Filtering%20Practice/Bioretention.htm

Sullivan, Edward C., and F.E. Kuo, *Do Trees Strengthen Urban Communities, Reduce Domestic Violence?* Forestry Report R8-FR 56, Department of Natural Resources and Environmental Sciences, University of Illinois at Urbana, January 1996, http://www.urbanforestrysouth.usda.gov/pubs/Tech_bulletin/tb4.htm

Sullivan, Edward C., *Safety of Median Trees with Narrow Clearances on Urban Conventional Highways: Phase III Final Report*, Cal Poly State University, 2004, http://ceenve.calpoly.edu/sullivan/trees

Taylor, Faber, F.E. Kuo, and E.C. Sullivan, "Coping With ADD: The Surprising Connection to Green Play Settings," Environment and Behavior, Volume 33, Number 1, pp. 54-77, January 2001. http://www.herl.uiuc.edu/trees/ADDandNature/TechBull_ADD_Nature.pdf

TreeLink, Urban Forestry, http://www.treelink.org/

Ulrich, Roger S., "Human Responses to Vegetation and Landscapes," Landscape and Urban Planning, Elsevier, Vol. 13, pp. 29-44, 1986.

Wolf, Kathleen, PhD, *Nature and Consumer Environments, Human Dimensions of Urban Forestry and Urban Greening*, http://www.cfr.washington.edu/research.envmind/consumer.html

Xiao, Quigfu et al, "Winter Rainfall Interception by Two Mature Open-Growth Trees in Davis, California," Hydrological Processes, Volume 14, pp. 763-784, 2000, http://cufr.ucdavis.edu/products/4/cufr_87.pdf

Introduction

Historically, cities were commonly developed along waterways. Consequently, many of our urban areas have streams or rivers running through them. For many years, the value of streams was not recognized and, as a result, streams were routed through culverts, straightened, lined with rock, or filled with debris. With increased recognition of their environmental, psychological, and social benefits, many cities are daylighting and restoring their local waterways. Streams may either cross under a roadway or run parallel to it and, for this reason, transportation agencies have the opportunity to restore or enhance streams and their associated riparian buffers.

Exhibit IV-2.1 – First Creek Fish Passage (Location: near Lake Chelan, WA)

The listing of several salmonid species under the Endangered Species Act in recent years has added more complexity to the already ecologically and philosophically complex issue of stream restoration and relocation. Stream relocation is necessary for some projects due to unavoidable impacts, or to improve fish habitat and movement. Habitat improvements can also be undertaken as a component of environmental mitigation.

Some of the benefits and possible outcomes of stream restoration, particularly within the urban contexts are:

- Community acceptance of projects can grow with success
- Habitat improvement
- Desirable place for people to walk or view wildlife
- Increased stormwater treatment possibilities
- Educational opportunities
- Unlimited human access will discourage wildlife use and degrade the riparian buffer
- In urban areas, planting might need to be larger and denser to provide for faster plant establishment, so people can see quick results and to prevent trampling of small plants
- Urban hydrology is more variable than natural stream systems
- Alternative stormwater treatment requires doing something different than a standard rectangular pond
- Trees moderate temperatures

Definitions

***Large Woody Debris* (LWD)** Sometimes referred to as Coarse Woody Debris (CWD), LWD are large pieces of wood in a stream or river that will not wash away easily.

Riparian areas A complex, interdependent system of plants and biota in an environment adjacent to water. Riparian areas intercept stormwater, remove pollutants, stabilize banks, offer a future supply of LWD, provide wildlife habitat, and moderate water temperatures.

Riparian buffers A management tool or practice for protecting riparian areas and their associated water bodies.

Salmonid Any species of fish that is ocean-going and fresh-water spawning, most notably salmon.

Purpose and Need

Stormwater regulations require public agencies to treat stormwater for quantity and quality to a higher degree than was required in the past. This creates opportunities for innovative projects that treat stormwater before it enters streams and water bodies adjacent to the highways. When agencies partner in projects, the results can benefit all participants.

Innovative Stormwater Treatment Facilities & Stream Restoration

Exhibit IV-2.2 – Stormwater Facility (Location: Indian Creek, Olympia, WA)

Exhibit IV-2.3 – Stormwater Facility (Location: Indian Creek, Olympia, WA)

When streams cross under a new section of roadway, or a fish passage is improved, there is the opportunity to add complexity and restore the stream buffer. In-stream complexity can be accomplished by adding LWD or rock of varying sizes. The size and type of rock or LWD depends on gradient, stream flow, contributing watershed, substrate, and habitat needs. Stream buffers are enhanced with native woody vegetation. A multidisciplinary team consisting of a hydrologist or fluvial geomorphologist, habitat biologist, landscape architect, and hydraulic engineer develops the stream restoration plan.

As an example, prior to construction of the Indian Creek Stormwater Treatment Facility in Olympia, untreated stormwater from I-5 flowed into a natural tributary on this site, degrading both the tributary and Indian Creek. The site, considered to be of little value, was overgrown with invasive plant species and was used as a dumping ground.

Through a cooperative effort between WSDOT, the city of Olympia, the Olympia Arts Commission, and the Squaxin Island and Nisqually Tribes, this new facility serves as a tranquil escape in the midst of an urban environment, while providing an effective regional stormwater treatment facility. Indian Creek's unique bioengineered design integrates public art with functional aspects of stormwater treatment and slope stabilization. Berms were used to reduce noise pollution and to provide a gentle separation between the trails, highway, and surrounding neighborhood. The berms were planted with native plant species.

Exhibits IV-2.2 and 2.3 show the restored Indian Creek and tributary areas near I-5 that are used for stormwater treatment.

Balancing Considerations

A restored urban stream and its associated riparian system can provide multiple benefits to a watershed, its wildlife, and its people. A successful project provides a stable channel within a dynamic equilibrium, provides habitat for a target species, and provides a riparian ecosystem as a buffer and a source of future LWD recruitment. This can be achieved and still allow people to view the site at specific points, so that wildlife use is not impaired.

Many urban streams are highly degraded systems that do not function for wildlife, desired stream dynamics, ground water recharge, or for people. An urban stream restoration is an opportunity for public education. The multiple functions of a healthy riparian system can be taught to citizens during the planning and permitting process, as well as through signs at the site after the project is completed.

Analysis Method

The latest version of WSDOT's *Highway Runoff Manual* provides information on alternative stormwater treatment opportunities using Low Impact Development (LID) techniques.

WSDOT's *Environmental Procedures Manual* provides guidance on permitting requirements for stream restoration and stormwater treatment requirements.

WSDOT's *Roadside Classification Plan* and the *Roadside Manual* provide information on stream restoration and requirements for roadside restoration in urban and semi-urban environments.

Governing Regulations and Directional Documents

Clean Water Act, Title 33 *United States Code* (USC) § 1251.

Construction Projects in State Waters, *Revised Code of Washington* (RCW) 77.55.

Endangered Species Act, as amended, 16 USC §§ 1531-1543.

Environmental Procedures Manual, WSDOT, M 31-11.

Highway Runoff Manual, WSDOT, M 31-16.

Highway-Related Stormwater Management, RCW 90.78.

Hydraulics Manual, WSDOT, M 23-03.

National Environmental Policy Act (NEPA), 42 U.S.C. §§ 4321-4370(f).

Roadside Manual – Soil Bioengineering Chapter, WSDOT, M 25-30.

Salmon Recovery, RCW 77.85.

Shoreline Management Act, RCW 90.58.

State Environmental Policy Act (SEPA), RCW 43.21C, *Washington Administrative Code* (WAC) 197-11, WAC 468-12.

Water Pollution Control, RCW 90.48.

Additional Resources

Harrelson, Cheryl C., C. L. Rawlins, and John P. Potyondy, *Stream Channel Reference Sites: An Illustrated Guide to Field Techniques*, USDA Forest Service, Fort Collins, CO, 1994, http://www.stream.fs.fed.us/publications/PDFs/RM245E.PDF

Abbe, T.B., "There Are About One Hundred and Twenty Trees and Several Thousand Tons of Wood in the ELJ; Will It Do What We Expect?" Wildlife Conservation, Vol. 4, 1999, pp. 46-51.

Abbe, T.B. and D.R.. Montgomery, "Large Woody Debris Jams, Channel Hydraulics and Habitat Formation in Large Rivers," Regulated Rivers: Research & Management, Vol. 12, no. 2-3, 1996, pp. 201-221.

Abbe, T.B., D.R. Montgomery, K. Fetherston, and E.M. McClure, "A Process-Based Classification of Woody Debris in a Fluvial Network: Preliminary Analysis of the Queets River, WA," EOS Transactions, American Geophysical Union, Vol. 74, 1993, p. 296.

A Guide to Placing Large Wood in Streams, Oregon Department of Forestry, and Oregon Department of Fish And Wildlife, 1995.

Leopold, Luna B., *Fluvial Processes in Geomorphology*. W.H. Freeman, San Francisco, 1964.

Leopold, Luna B., *A View of the River*, Harvard University Press, Cambridge, MA, 1994.

Maser, C. and J.R. Sedell, *From the Forest to the Sea: The Ecology of Wood in Streams, Rivers, Estuaries and Oceans*, St. Lucie Press, Delray Beach, Florida, 1994.

Montgomery, D.R., J.M. Buffington, R.D. Smith, K.M. Schmidt, and G. Pess, "Pool Spacing in Forest Channels," Water Resources Research, Vol. 31, no. 4, 1995, pp. 1097-1105.

Montgomery, D.R., et al, "Distribution of Bedrock and Alluvial Channels in Forested Mountain Drainage Basins." Nature, Vol. 381, no. 6583, 1996, pp. 587-589.

Rosgen, David L., “Applied River Morphology,” Wildland Hydrology, Pagosa Springs, Co., 1996.

Rosgen, David L., “A Classification of Natural Rivers,” Catena, Vol. 22, No. 3, 1994, pp. 169-199.

Sedell, J.R., et al, "Role of Refugia in Recovery From Disturbances: Modern Fragmented and Disconnected River Systems," Environmental Management, Vol. 14, 1990, pp. 711-724.

Stream Corridor Restoration, Federal Interagency Stream Corridor Restoration Working Group, Springfield, VA, revised 2001, http://www.nrcs.usda.gov/technical/stream_restoration/newgra.html

Stream Habitat Restoration Guidelines, Washington Department of Fish and Wildlife (WDFW), 2002, http://wdfw.wa.gov/hab/ahg/shrg/index.htm

Wood in World Rivers International Conference, searchable database, http://riverwood.oregonstate.edu/html/intro.html

Introduction

Wildlife, fish, and sensitive plants require special consideration during project planning and development. In addition to Endangered Species Act (ESA) compliance, areas of particular concern include: direct effects from construction, such as noise disturbance or other disruption of habitat areas; interference to critical life functions, such as wintering, foraging, migration, breeding and rearing; degradation or loss of habitat; habitat fragmentation; and edge effects. Other important concerns are the effects related to collisions between vehicles and animals, the loss of animal or plant populations or viability, and impacts to food resources.

This section provides a basic overview of a few of the environmental considerations relating to fish, wildlife, and plants. While these issues might seem to be a greater concern in the rural settings, that is not always the case. These considerations may have important implications for the design of facilities in all contexts. Guidance on addressing the preservation and enhancement of natural resources is constantly being updated to reflect the best available science.

Exhibit IV-3.1 – Ocean Phase Chum Salmon (Source: http://wdfw.wa.gov/fish/)

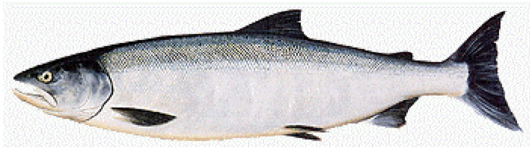
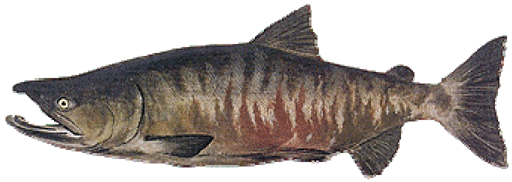


Exhibit IV-3.2 – Male Chum Salmon with Spawning Colors (Source: http://wdfw.wa.gov/fish/)



Definitions

Endangered species Any species in danger of extinction throughout all or a significant portion of its range.

Federal nexus Any involvement by federal agencies: federal permits, federal lands, or federal funding.

Habitat Place where a plant or animal naturally or normally exists during its life cycle.

Indirect effects Effects caused by or resulting from the proposed action (but that occur later in time), including effects resulting from associated development and other activities that occur following improvements in transportation.

Listed species Any species of fish, wildlife, or plant, which has been determined to be endangered or threatened under Section 4 of the ESA.

Programmatic biological assessment A biological assessment designed to cover programs, not specific projects.

Threatened species Any species likely to become endangered within the foreseeable future throughout all or a significant portion of its range.

Viability Ability of a population to maintain sufficient size so it persists over time, in spite of normal fluctuations in numbers; usually expressed as a probability of maintaining a specific population for a defined period.

Exhibit IV-3.3 – Before and After Photos of a Completed Fish Passage Project (Location: SR 112 at Rasmussen Creek, Olympic Peninsula)

Purpose and Need

Environmental biologists are involved at all stages of project development, design, and construction, but coordination early in the process allows the identification of potential adverse impacts and the opportunity to establish avoidance or minimization measures.

Exhibit IV-3.4 – Impact Minimization

- Integrate conservation planning into transportation planning.
- Use conservation banking in concert with large-scale conservation plans to mitigate for unavoidable impacts of transportation.
- Coordinate with resource agencies early, substantively, and continuously throughout transportation planning and project development.
- Build wildlife crossings where necessary to repair ecological damage and restore habitat connectivity.
- Provide alternative transportation and maintain roads in public lands in a manner consistent with surrounding natural resources.
- Use only native species in roadside vegetation management.

The treatment of stormwater flows from new and existing impervious surfaces is necessary to prevent potential impacts to fish and wildlife. Design elements that treat both stormwater quality and quantity before it reaches aquatic environments provide the greatest amount of protection.

Natural areas within the urban contexts are increasingly important for many species, including songbirds and small mammals. It is important to consider the preservation or replacement of these urban natural areas when projects are implemented.

Wildlife mobility is often overlooked when designing projects in urban environments. The ability of wildlife to move safely between different environments is important for both species preservation and public safety. Project design can influence both of these factors. Traffic-related wildlife mortality can play a role in the decline of some species listed under the ESA. Measures to facilitate wildlife crossing the facility safely may be appropriate at specific locations where incidents with animals are frequent. These measures may include devices that alert the drivers to the approach of tagged animals (generally large mammals such as elk); structures that discourage animals from crossing at specific locations; or naturalized wildlife under- or over-passes to provide safe passage.[1]

When projects occur in rural contexts, the potential indirect effects from induced growth must be addressed. If the design includes a new transportation system, an increase in capacity to an existing system, or allows access to areas that were previously not accessible, changes in land use can occur. In addition to the project itself, subsequent growth or changes in land use can render habitats unsuitable for sensitive species.

Balancing Considerations

Exhibit IV-3.5 – Native Plant Material Installation (Source: WSDOT)

The ESA requires projects with a federal nexus to address impacts to listed species. However, all projects that potentially impact any fish, wildlife, or plant resource, regardless of federal nexus or listing status, are benefited by an evaluation of the project design in order to reduce or eliminate impacts. Several design challenges can arise when the commitment to protect fish, wildlife, and plant resources is made. Involving the Washington State Department of Transportation's (WSDOT's) Environmental Services' Biology Branch early in the design process can ensure that minimization or avoidance measures can be implemented.

Retention of mature trees is an important consideration in many designs, and in some cities this retention of trees is backed by

[1] Patricia White, *Second Nature*, 2003, pp. 41-46.

ordinance. In the protection of these mature trees, it is necessary to coordinate with the designer and landscape architects early in the project development process. This will ensure that the protection of trees is done in a manner that will create the least harm to trees and will not negatively impact the project. A common example of tree protection deals with care of the root zone (dripline) and soil structure within the root zone. The means of tree protection may be part of the consideration for the location and construction methods associated with other design elements, such as drainage structures or safety hardware. Lack of consideration for these conditions often results in redesign and change orders during construction. The loss of trees may also have a negative impact on citizen support, particularly in cases where good planning could have saved the tree.

Exhibit IV-3.6 – Native Plant Material in Median (Location: SR 99, SeaTac, WA)

Processes that can assist in the development of projects that will have the least harmful impacts on native fish, wildlife, and plants are listed in Exhibit IV-3.4, as recommended in *Second Nature.*[2]

For additional information on vegetation, waterways, and fish, refer to Chapters IV-1, IV-2, and V-13. These chapters include some details about mitigative measures, and LID practices and techniques.

Governing Regulations and Directional Documents

Bald and Golden Eagle Protection Act, Title 16 *United States Code* (U.S.C.) § 668.

Endangered Species Act, 16 U.S.C §§ 1531-1544.

Fish and Wildlife Coordination Act, 16 U.S.C. §§ 661-667(e).

Local and Critical Areas Ordinances.

Magnuson-Stevens Act – to Address the Preservation of Essential Fish Habitat (EFH), 16 U.S.C. § 1801.

Marine Mammal Protection Act, 16 U.S.C. § 1361.

Migratory Bird Treaty Act, 16 U.S.C. § 703.

National Environmental Policy Act (NEPA), 42 U.S.C. §§ 4321-4370(f).

Shoreline Management Act, *Revised Code of Washington* (RCW) 90.58.

State Environmental Policy Act (SEPA), RCW 43.21C, *Washington Administrative Code* (WAC) 197-11, WAC 468-12.

Additional Resources

Biology Program, Environmental Services, WSDOT, http://www.wsdot.wa.gov/environment/biology/default.htm

Clay, Charles H., *Design of Fishways and Other Fish Facilities,* Lewis Publishers, Boca Raton, FL, 1995.

Critter Crossings: Linking Habitats and Reducing Roadkill, Federal Highways Administration (FHWA), http://www.fhwa.dot.gov/environment/wildlifecrossings/index.htm

Ecosystem Conservation, U.S. Fish and Wildlife Service, http://ecosystems.fws.gov/

Environmental Guidebook, FHWA, http://environment.fhwa.dot.gov/guidebook/index.htm

Environmental Services Office (ESO), Region Environmental Manager, WSDOT.

Keeping It Simple: Easy Ways to Help Wildlife Along Roads, FHWA, http://www.fhwa.dot.gov/environment/wildlifeprotection/index.cfm

---

[2] Ibid. pp. 62-63.

National Marine Fisheries Service (NOAA Fisheries), Northwest Region, http://www.nwr.noaa.gov/

Odeh, Mufeed, *Innovations in Fish Passage Technology***,** American Fisheries Society, Bethesda, MD, 1999.

United States Fish and Wildlife Service, Pacific Region, http://pacific.fws.gov/

White, Patricia A., and Michelle Ernst, *Second Nature: Improving Transportation Without Putting Nature Second*, Defenders of Wildlife and Surface Transportation Policy Project, Washington, D.C., 2003.

Washington Department of Fish and Wildlife, http://wdfw.wa.gov

Wildlife Crossings Toolkit, USDA Forest Service, http://ecosystems.fws.gov/

Introduction

The development of any transportation project must consider cultural resources throughout the planning, design, and construction phases. Cultural resources are important reflections of human and environmental influences. Cultural resources include the remains of or existing sites, structures, or objects used by humans for over 50 years. These resources can be historic, prehistoric, archaeological, or architectural in nature. Cultural resources vary and can assume many different forms, ranging from artifacts to structures, open areas, or groupings of resources that are similar in characteristics (such as historic districts). Cultural and historic resources provide an invaluable glimpse into the past and might be of significant importance to a community's history and contemporary culture.

Exhibit IV-4.1 – Historic Downtown Revitalization (Location: Wenatchee, WA)

Appropriate consideration will ensure that these non-renewable, environmentally sensitive resources are protected, conserved, and interpreted. Cultural resources are afforded the greatest potential for preservation when project proponents actively engage consulting parties in the proposed activity; collaboratively identify resources; and cooperatively seek ways to avoid, minimize, or, if no other recourse is available, mitigate impacts to resources.

Adequate consideration given to cultural resources and their intrinsic value can ensure that the integrity of these resources is retained for future generations.

Definitions

***Advisory Council on Historic Preservation* (ACHP)** An independent federal agency, established under the National Historic Preservation Act (NHPA), that: (1) advises the President and Congress on matters of historic preservation, (2) conducts Section 106 reviews, and (3) provides technical assistance in historic preservation actions.

Consultation The Washington State Department of Transportation (WSDOT) Executive Order on Tribal Consultation defines it as "respectful, effective communication in a cooperative process that works toward a consensus, before a decision is made or an action is taken."

Cultural landscape A geographic area that has historically been used by people; shaped or modified by human activity, occupancy, or intervention; and/or possesses a significant concentration, linkage or continuity of areas of land use, vegetation, buildings and structures, roads and waterways, and natural features.

Cultural resources Visible evidence of human interaction with the environment. The term "cultural resources" refers to actual physical things, places, structures, or artifacts that are material evidence of a past way of life, as well as referring to traditional cultural properties. They can be historic, prehistoric, archaeological, or architectural in nature and may be grouped in districts.

Effect Alteration to the characteristics of a historic property, qualifying it for inclusion in or eligibility for the National Register of Historic Places.

Exhibit IV-4.2 – Historic Harpole Bridge (Location: SR 133 Palouse River, Colfax vicinity, Whitman County, WA)

Historical properties Cultural resources eligible for or listed in the National Register of Historic Places.

National Register of Historic Places The nation's official listing of properties significant in national, state, and/or local history, meeting one or more criteria for evaluation, as outlined in 36 CFR 60.4.

Section 106 review The Advisory Council's regulations (36 CFR 800), which implement Section 106 of the National Historic Preservation Act of 1966, as amended. This is the federal review process that ensures historic properties are considered during federal aid project planning and execution.

State Office of Archaeology and Historic Preservation (OAHP) Administers the national historic preservation program at the state level; reviews National Register of Historic Places nominations; maintains data on historic properties that have been identified, but not yet nominated; and consults with federal agencies during Section 106 reviews.

Traditional cultural property Association with cultural beliefs or practices of a living community that (1) are rooted in that community's history, and (2) are important in maintaining the continuing cultural identity of the community.

Tribal Historic Preservation Officer Tribes can assume any or all of the functions of a State Historic Preservation Officer (SHPO) with respect to tribal land.

Undertaking Any activity that can result in changes to the character or the use of historic or cultural properties. The activity is required to be under the direct or indirect jurisdiction of a federal agency.

A more extensive list of terms and definitions related to cultural resources can be found in WSDOT's *Environmental Procedures Manual,* Exhibit 456-1.

Purpose and Need

There are a number of federal, state, and local requirements that dictate cultural resource preservation. The processes that are required depend on the project's purpose and needs, the available funding sources, and the requirements specified on the permits. Appropriate time and resources need to be devoted to the consideration of cultural resources during the project development process.

The first priority when developing a project within an area that affects locations of known historic and cultural significance needs to be avoidance. In situations where avoidance is not feasible, the project development staff needs to minimize the impacts and, if minimization efforts fail, they must mitigate the impacts. Development of mitigation requires active dialogue with the Washington State Office of Archaeology and Historic Preservation/Tribal Historic Preservation Office, Tribes, community members, and other interested parties.

It is important to recognize that cultural resources can be of the utmost importance and significance to a community. The disregard of resources or the introduction of visual, audible, or atmospheric elements that are out of character with historic properties or settings can result in adverse effects to historic properties and communities.

Consideration of cultural resources is an important step in the overall project development process, in order to ensure that resources are adequately protected.

Balancing Considerations

The intent of considering cultural resources during the project development process is to ensure protection of those resources and afford adequate opportunity for meaningful consultation with interested parties. Consultation on cultural resources is required under Section 106 of the National Historic Preservation Act, as amended (36 CFR 800), and the WSDOT Executive Order on Tribal Consultation (E 1025.00).

As defined earlier, consultation means respectful, effective communication in a cooperative process that works toward a consensus, before a decision is made or an action is taken. Consultation can result in the avoidance of impacts to cultural resources; the minimization of effects; or mitigation measures. The resulting course of action needs to be a product of meaningful dialogue with all stakeholders.

Exhibit IV-4.3 –Road Washout and Archaeological Site (Location: Vashon Island, WA)

King County Roads Services

Meaningful dialogue can result in the opportunity for preservation of cultural resources and the development of a project in a manner that is consistent with an area's cultural and historic characteristics. It also has the potential to foster strong relationships with consulting parties. The dialogue can help to avoid the introduction of new elements that are out of character with existing resources or the surrounding area, which can result in depreciation of the characteristics that define a resource's cultural or historic significance.

A common misperception is that urban areas do not have any cultural resources, due to the extensive level of disturbance. This is not the case, as many large metropolitan areas are rich with cultural resources in the form of historic districts and structures, and prehistoric remains buried beneath modern developments.

Another common misperception is to regard the potential historical significance of a bridge or structure as negligible. Regardless of the extent of dilapidation or the need for replacement, a bridge or structure might be eligible for the National Register of Historic Places and needs to be appropriately handled, prior to demolition or rehabilitation.

Lack of meaningful consultation with interested consulting parties has the potential to delay the project indefinitely; increase the costs of the project; and create mistrust between parties.

Analysis Method

There are numerous federal, state and local laws that require an agency to consider its proposed project's impacts to cultural resources. Careful consideration of cultural resources and active, meaningful coordination with interested parties is essential for compliance with these requirements.

Federal Requirements

Section 106 of the National Historic Preservation Act requires federal agencies, and their delegates, to take into account the effects of their undertakings on historic properties and afford the Advisory Council on Historic Preservation a reasonable opportunity to comment on such undertakings. The Section 106 process seeks to balance historic preservation concerns with the need for a federal undertaking, through consultation among agency officials and other parties with an interest in the effects of the undertaking on historic properties. This consultation process needs to commence at the earliest planning stages of the project.

Exhibit IV-4.4 – Historic Civilian Conservation Corps Rail (does not meet current day design requirements) (Location: Deception Pass, WA)

In addition to identifying interested consulting parties for the project, identification of cultural and historic resources is an important step in the Section 106 process. The National Historic Register criteria for eligibility are the defining guidelines for determining the presence of cultural and historic resources. The criteria evaluate the resource's value with respect to its significance in American history, architecture, archaeology, engineering, and culture. To be eligible for or listed on the National Register of Historic Places, the historic property must meet one of four criteria:

1) The resource is associated with significant events from the past.
2) The resource is associated with a significant person from the past.
3) The resource embodies distinctive characteristics of a type, period, or method of construction.
4) The resource has or can yield information that is significant to history.

Exhibit IV-4.5 – Retrofitted Rail Using Historic Features (meets current day design requirements) (Location: Deception Pass, WA)

The goal of consultation is to identify interested parties; identify historic properties potentially affected by the undertaking; and seek ways to avoid, minimize, or, if need be, mitigate any adverse effects to cultural resources.

Chapter 456 in WSDOT's *Environmental Procedures Manual* provides a more detailed explanation of the Section 106 review process and its individual steps and requirements.

State Requirements

The State Environmental Policy Act (SEPA) requires that an agency consider the impacts of a proposed project to cultural resources during the public environmental review process.

Agencies proposing projects that lack a federal nexus consult with the Washington State Office of Archaeology and Historic Preservation (OAHP) through the SEPA process. OAHP provides agencies with formal opinions on a project site or a resource's significance, and the potential impacts to cultural and historic resources.

The web pages of the Washington State Department of Ecology, SEPA, and OAHP provide additional detail on the process non-federal nexus projects must undergo.

In 1989, the Governor and Tribes across the state signed the Centennial Accord. The Accord is based on the mutual respect of one another's sovereignty and the commitment to work on a government-to-government basis.

Local Requirements

City and county comprehensive plans can contain a historic preservation element – a goal stated in the Growth Management Act (GMA). Consideration needs to be given to city and county comprehensive plans, as well as parks and recreation plans, that might contain policy and plan guidance on historic resources, sites, and/or structures of local importance.

In addition, local agencies might maintain their own inventories of historic sites that are of local significance.

Washington State's Certified Local Government (CLG) Program helps local governments to actively participate in preserving Washington's irreplaceable historic cultural resources as assets for the future. This nationwide program of financial and technical assistance was established by the National Historic Preservation Act. In Washington, it is implemented and administered by the OAHP. Washington currently has 34 CLG programs statewide.

Local governments that establish a historic preservation program meeting federal and state standards are eligible to apply to the State Historic Preservation Office (SHPO) and the National Park Service for certification. A local government that receives such certification is known as a CLG. A listing of program participants can be found at the following link: http://www.oahp.wa.gov/pages/LocalGovernment/Participants.htm

Agency Requirements

In February 2003, Secretary MacDonald issued an Executive Order on Tribal Consultation, affirming WSDOT's commitment to consult with Tribes on a government-to-government basis. The Centennial Accord Plan outlines how each WSDOT division and office consults with Tribes, including cultural resources.

Governing Regulations and Directional Documents

Abandoned and Historic Cemeteries Act, *Revised Code of Washington* (RCW) 68.04-05.

Archaeological Resources Protection Act of 1979, 16 *United States Code* (U.S.C.) § 470.

Department of Transportation Act of 1966 (Section 4f), 49 U.S.C. § 303.

Environmental Procedures Manual, WSDOT, M 31-11.

Growth Management Act (GMA) RCW 36.70A.

Indian Graves and Records Act, RCW 27.44.

National Environmental Policy Act (NEPA), 42 U.S.C. §§ 4321-4370(f).

National Historic Preservation Act of 1966, as amended, 16 U.S.C. §§ 470(f), 106.

National Register of Historic Places - Criteria for Evaluation, 36 CFR 60.4.

National Register of Historic Places - Protection of Historic Properties, 36 CFR 800.

Native American Graves Protection and Repatriation Act (NAGPRA), 25 U.S.C. § 3001.

Protection of Archaeological Resources, 43 *Code of Federal Regulations* (CFR) Part 7.

State Environmental Policy Act (SEPA), RCW 43.21C, *Washington Administrative Code* §§ 197-11, 468-12.

Surface Transportation and Uniform Relocation Assistance Act, (STURAA) of 1987, Public Law 100-17.

Tribal Consultation Executive Order, WSDOT, E 1025.00.

Additional Resources

Advisory Council on Historic Preservation, http://www.achp.gov/

Archaeology and Historic Preservation Office, Washington State Department of Community, Trade, and Economic Development, http://www.oahp.wa.gov/

Environmental Review, Washington State Department of Archeology and Historic Preservation, http://www.oahp.wa.gov/pages/EnvironmentalReview/EnvironmentalReviewOverview.htm

Environmental Services Office (ESO), Region Environmental Manager, WSDOT, http://www.wsdot.wa.gov/environment/culres/default.htm

National Register of Historic Places, http://www.cr.nps.gov/nr/index.htm

State Environmental Policy Act (SEPA) Washington State Department of Ecology, http://www.ecy.wa.gov/programs/sea/sepa/e-review.html

Washington State Department of Community, Trade, and Economic Development, http://www.cted.wa.gov/

Washington State Office of Archaeology & Historic Preservation (OAHP), “Strengthening Communities Through Historic Preservation – Washington State Historic Preservation Plan 2004,” http://www.oahp.wa.gov/pages/AboutUs/documents/PreservationPlan04.pdf

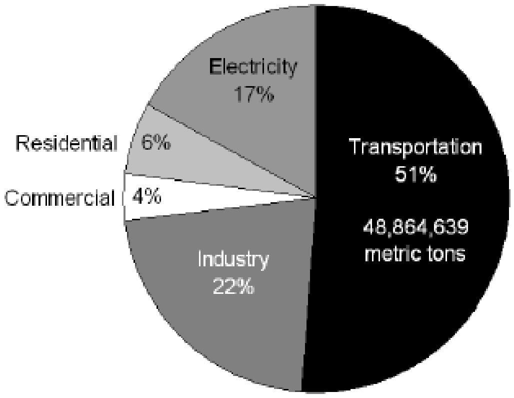
Washington State Office of Archaeology & Historic Preservation (OAHP), National Register of Historic Places / Washington Heritage Register, http://www.oahp.wa.gov/pages/HistoricSites/Register.htm

Division IV Environmental Considerations
Chapter IV-5 Air Quality

Introduction

Air pollution originates from many different sources. In Washington State, the primary sources of air pollution include: motor vehicles, industry, outdoor burning, and woodstoves/fireplaces. Air pollution can create human health issues, such as burning sensations in the eyes and nose, an itchy throat, and difficulty with breathing; and it has a greater affect on the young and the elderly. Some contaminants permanently damage the lungs and may cause cancer. In addition to the effects on humans, air pollution can impact plants, animals, property, and the atmosphere. To this extent, carbon dioxide (CO_2), among a number of other gases, is indicated as contributing to greenhouse gas buildup in most corroborating research. Highest among the contributing factors in carbon dioxide production is the burning of fossil fuels by industry and transportation. In Washington, transportation is the largest producer of carbon dioxide (51% or 48,864,639 metric tons). Refer to Exhibit IV-5.1 for other sources.

Exhibit IV-5.1 – Carbon Dioxide Emissions in Washington State (Source: Washington State University Energy Program)



The U.S. Environmental Protection Agency (USEPA) states that:

"Figuring out to what extent the human-induced accumulation of greenhouse gases since pre-industrial times is responsible for the global warming trend is not easy. This is because other factors, both natural and human, affect our planet's temperature. Scientific understanding of these other factors – most notably natural climatic variations, changes in the sun's energy, and the cooling effects of pollutant aerosols – remains incomplete.

Nevertheless, the Intergovernmental Panel on Climate Change <../content/aboutthesite.html/> (IPCC) stated there was a "discernible" human influence on climate; and that the observed warming trend is "unlikely to be entirely natural in origin." In the most recent Third Assessment Report (2001), IPCC wrote "There is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities.

In short, scientists think rising levels of greenhouse gases in the atmosphere are contributing to global warming, as would be expected; but to what extent is difficult to determine at the present time.

As atmospheric levels of greenhouse gases continue to rise, scientists estimate average global temperatures will continue to rise as a result. By how much and how fast remain uncertain. IPCC projects further global warming of 2.2-10℉ (1.4-5.8℃) by the year 2100. This range results from uncertainties in greenhouse gas emissions, the possible cooling effects of atmospheric particles such as sulphates, and the climate's response to changes in the atmosphere."

Exhibit IV-5.2 – Congestion (Source: Seattle Times Newspaper, Seattle, WA)

Regardless of the contributing extent, it is wise to stabilize CO_2 in the atmosphere. To do this, it will be necessary to employ a number of strategies, including transportation strategies. The following section discusses some of these concepts.

Definitions

Carbon dioxide CO_2 is made up of one carbon atom and two oxygen atoms. It is a naturally-occurring gas that is the product of human and aerobic respiration. It is also a by-product of burning fossil fuels and biomass, as well as land use changes and other industrial processes. It is the principal anthropogenic (human caused) greenhouse gas that affects the earth's radiative balance. CO_2 is the reference gas against which other greenhouse gases are measured and therefore has a Global Warming Potential of 1. Plant life uses CO_2 in its processing and converts it back into oxygen and other molecules.

Carbon monoxide A by-product of the burning of fuels in motor vehicle engines. Motor vehicles are the main source of carbon monoxide, the excess of which is generally a problem during still, cold conditions.

Conformity Projects are in conformity when they do not (1) cause or contribute to any new violation of any standard in any area, (2) increase the frequency or severity of any existing violation of any standard in any area, or (3) delay timely attainment of any standard or any required interim emission reductions or other milestones in any area (EPA's Conformity Rule).

Maintenance area An area that previously was considered a "non-attainment area," but has since achieved compliance with the National Ambient Air Quality Standards (NAAQS).

Non-attainment area An area that exceeds health-based NAAQS for certain air pollutants designated by the EPA.

***State Implementation Plan* (SIP)** An SIP is a collection of the plans a state will use to clean up polluted areas. Each state must develop an SIP to explain how it will do its job under the Clean Air Act. The EPA approves the SIP.[1] Regional air emissions caps (budgets) are set as part of the SIP, and transportation projects must be at or below the cap.

Balancing Considerations

Air quality laws and regulations require that many types of projects be reviewed for potential impacts to air quality as part of the National Environmental Policy Act (NEPA) and State Environmental Policy Act (SEPA) evaluations. There are specific federal and state requirements within non-attainment and maintenance areas that require project designs to account for impacts to air quality. These regulations require air quality analysis, called "hot-spot" analysis, for projects that change the flow of traffic within the area or affect existing air quality problem areas by carbon monoxide. A hot-spot analysis predicts

[1] *Environmental Procedures Manual*, WSDOT.

emission levels around the proposed project location, through the use of special modeling software.

Design elements that affect air pollution emissions and that subsequently need identification for modeling include: roadway alignment, travel lane widths, traffic volumes, traffic speeds, turn lanes, traffic signals, signal cycle length, signal red time, signal green time, arrival times, and saturated flow rate. Locations near the projects that are accessible to the general public, such as sidewalks, residences, parks, playgrounds, and vacant lots, also need to be identified.

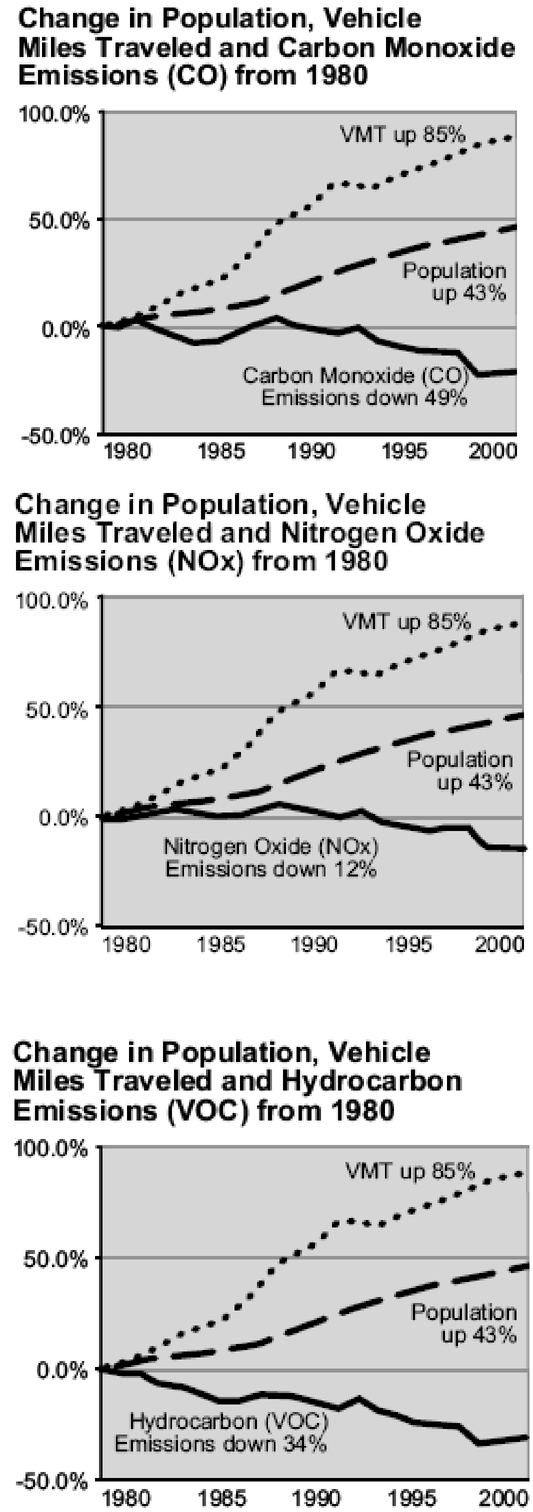
Modeled projects that indicate an impact to air quality need to evaluate design modifications, in order to reduce the potential impacts. Project modifications need to change the project in a manner that improves air quality, in order to meet the NAAQS. Typical project modifications might be adjustments to the roadway design to improve traffic flow; signal timing or placement; signal synchronization; addition of turn pockets; and/or consideration of roundabouts. The objective is to reduce the air quality impact to a level at or below the no-build scenario.

Project stakeholders might wish to consider opportunities for reducing the overall pollutants in the area. These considerations might not affect the level of pollutants that are modeled in a hot-spot analysis, but they can improve regional air quality. Project stakeholders can attempt to decrease regional air emissions by encouraging multi-modal transportation options, such as pedestrian, bicycle, and transit use. Project modifications to encourage multi-modal transportation options might include wider sidewalks; adequate pedestrian crossings; slowing vehicle speeds; the addition of bicycle lanes; pedestrian rest areas; and transit pullouts. Incorporation of vegetation into the project, particularly by retention of mature or near-mature trees and shrubs, but also via installation of new plantings with emphasis on tree canopy, is an important project objective to mitigate air quality impacts (see Chapter IV-1, Urban Forestry).

Particularly in the urban environment, the incorporation of the above elements can result in the loss of on-street parking, increased costs of right of way acquisition, and can potentially displace existing businesses. A balance needs to be achieved between air quality-friendly design changes and the costs that are associated with them.

Current laws require air quality analysis for all projects that change the flow of traffic[2] within or affecting air quality problem[3] areas for carbon monoxide. Projects that affect a problem area require the completion of a hot-spot analysis to predict future air quality. Special modeling software is used to quantify future pollutant emissions. In order for transportation projects to obtain federal funding, they are required to conform to the SIP. Project conformity to the SIP is completed within the Transportation Improvement Program (TIP), which in turn, is

Exhibit IV-5.3– Changes in Emissions (Source: WSDOT Environmental Office)



[2] Changing flow of traffic includes such activities as signalization, intersection channelization, and added lanes.
[3] Air Quality problem areas are federally designated as non-attainment or maintenance areas by the Environmental Protection Agency. These areas include the Puget Sound area, Vancouver, and Spokane.

prepared by the Metropolitan Planning Organization (MPO). Only those projects and alternatives included within the TIP can proceed to the construction phase.

Under the Clean Air Act, the USEPA sets limits on how much pollutant is allowed in the air throughout the United States. Currently, there are six criteria pollutants established as National Ambient Air Quality Standards intended to protect public health: carbon monoxide (CO), lead (Pb), nitrogen dioxide (NO_2), ozone (O_3), sulfur dioxide (SO_2), and particulate matter (PM). The standard most likely to be exceeded in transportation is carbon monoxide.

Governing Regulations and Directional Documents

Clean Air Act, 42 *United States Code* (U.S.C.) § 85.

Environmental Impact and Related Procedures - Section 4(f) (49 U.S.C. 303), 23 *Code of Federal Regulations* (CFR) 771.135.

Environmental Policy Statement, WSDOT, E 1018.00.

Environmental Procedures Manual, WSDOT, M 31-11.

Environmental Protection Agency Conformity Regulations, 40 CFR Part 51 and 93.

Federal Highway Administration Standards, 23 U.S.C. § 109(j).

National Environmental Policy Act (NEPA), 42 U.S.C. §§ 4321-4370(f).

State Environmental Policy Act (SEPA), *Revised Code of Washington* (RCW) 43.21C, *Washington Administrative Code* (WAC) 197-11, WAC 468-12.

Additional Resources

Air Quality, Acoustics and Energy, Environmental Services Office (ESO), Northwest Region, WSDOT, http://www.wsdot.wa.gov/regions/Northwest/rp&s/environmental/aae/default.htm

Air Quality Program, Washington State Department of Ecology, http://www.ecy.wa.gov/programs/air/airhome.html

Environmental Services Office (ESO), Region Environmental Manager, WSDOT.

Washington State Department of Transportation, *What About Air Quality – Thoughts from WSDOT on Air Quality Concerns and Transportation*, May 2004. http://www.wsdot.wa.gov/publications/folio/AirQuality.pdf

Introduction

Traffic noise is the sound generated on streets and highways. Noise, in general, has been of increasing concern to the public and to local, state, and federal officials. At the same time, modern acoustical technology has been providing better ways to lessen the adverse impacts of traffic noise, and state and local regulations have been established to restrict roadway construction noise during the evening and nighttime hours.

Purpose and Need

According to state policy and procedures, noise barriers are considered when noise impacts are identified on projects with state or federal transportation funding, or when the project is located on or influences a state highway or federal aid highway. Case Study 2 in Appendix A discusses a noise abatement project along SR 527 through Mill Creek. Exhibit IV-6.2 is from this project.

Exhibit IV-6.1 – Traffic Noise Variables

- Speed of traffic
- Volume of traffic
- Number of trucks in the traffic flow

Transportation projects on local or private streets with only local or private funding are not required to follow state noise procedures and federal requirements. For those local projects, the following description of noise evaluation and considerations may be considered a guide to identify possible noise abatement measures.

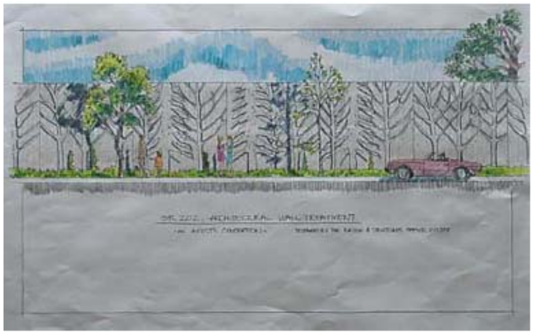
Title 23 CFR 772 defines noise impacts as "impacts which occur when the predicted traffic noise levels approach or exceed the Noise Abatement Criteria (NAC), or when the predicted traffic noise levels (in the design year) substantially exceed the existing noise levels." The Washington State Department of Transportation (WSDOT) considers a predicted noise level of 1 decibel below a noise abatement criterion as sufficient to satisfy the condition of approach. Locations impacted by traffic noise are to be considered for traffic noise abatement. Where abatement is warranted, at a minimum, the following types of abatement are to be considered:

- Traffic management measures (e.g., traffic control devices and signing to prohibit certain vehicle types, time-use restrictions, and modified speed limits)
- Change of either vertical or horizontal alignment
- Construction of noise barriers
- Acquisition of property

Exhibit IV-6.2 – Patterned Noise Wall (Location: Mill Creek, WA)

The relevant criteria to consider when identifying and evaluating noise abatement measures are whether they are feasible and reasonable. Feasibility deals primarily with engineering considerations, such as: can a substantial reduction be made, and will abatement measures affect property access? Reasonableness assesses the practicality of the abatement measure, given a number of factors, including cost, amount of noise reduction, and future absolute traffic noise levels.

Exhibit IV-6.3 – Architectural Wall Treatment (Location: SR 202, WA)



There are modified methods for dealing with transit-oriented noise for projects outside of the highway system (such as park-and-ride lots). The Federal Transit Administration (FTA) determines these methods and WSDOT evaluates the applicability of the methods on a case-by-case basis. For a practitioner wishing to follow FTA criteria, its guidebook provides a step-by-step approach to screening and appropriate levels of evaluation. Other modes, such as rail and aviation, have different criteria for impact and mitigation, as determined by the Federal Railroad Administration (FRA) and Federal Aviation Administration (FAA), respectively. The majority of community noise concerns for rail are whistle/signal blowing at at-grade crossings and the vibration generated by the trains as they pass.

Balancing Considerations

Urban areas can pose design challenges when considering noise abatement. These areas possess more access points for vehicles to enter and exit the roadway – access that can either be restricted by an abatement measure or might require the incorporation of breaks in the abatement measure. Breaks in the abatement measure, such as a noise wall, might reduce the effectiveness and cause the abatement to be unfeasible. Adjoining roadways also contribute to the sound level of the area and might make a reduction in sound unfeasible. Noise walls or other abatement measures can create shadows on adjacent homes or even on the roadways, resulting in potential safety considerations. Abatement can also impact views from the roadway to commercial businesses or from adjacent properties to scenic views.

In a noise barrier project, project development staff might encounter a number of trade-offs among stakeholders. Concessions might be necessary in order to determine and agree upon an appropriate noise barrier location, and its impacts to pedestrian access, parking, drainage, aesthetics, vehicle access, and other environmental considerations.

Exhibit IV-6.4 – Broad Leaf Pattern on Noise Wall (Location: Sunset Interchange on I-90, Issaquah, WA)

Noise barriers prevent and restrict access. Barriers can discourage pedestrian use, such as when a sidewalk is moved closer to traffic or is reduced in width in order to accommodate the installation of a noise barrier. On the other hand, noise barriers have the potential to improve safety by separating pedestrians and traffic (although this can also reduce feelings of public security, with the loss of visibility). A barrier might prevent parking along the roadway and prevent access to businesses or homes. A barrier might also encroach into a sensitive area, creating additional environmental impacts.

One area that should not be underestimated is the power of vegetative screening to reduce the concerns of wayside residents about the transportation facility. During project implementation, it is advisable that designers maintain as much screening vegetation as possible (especially large trees and shrubby underbrush) between the roadway and the wayside residents. Although the vegetation does little to reduce noise, the natural screen does provide a substantial visual benefit that may reduce many citizen inquiries and complaints.

Once abatement has been determined necessary, reasonable, and feasible, project stakeholders need to consider abatement aesthetics. Consideration of opportunities for facial treatments and aesthetic appearance alterations can be included in the decision-making process.

Governing Regulations and Directional Documents

Environmental Impact and Related Procedures - Section 4(f) (49 *United States Code* (U.S.C.) 303), 23 *Code of Federal Regulations* (CFR) 771.135.

High-Speed Ground Transportation Noise and Vibration Impact Assessment, Federal Railroad Administration, Washington, D.C., 1998, http://www.fra.dot.gov/us/home

National Highway System Designation Act of 1995, 23 U.S.C.

Noise Barriers, Standard Plans, WSDOT, M 21-01, http://www.wsdot.wa.gov/eesc/design/designstandards

Noise Evaluation Procedures for Existing State Highways, WSDOT, D 22-22.

Procedures for Abatement of Highway Traffic Noise and Construction Noise, 23 CFR 772.

Transit Noise and Vibration Impact Assessment, DOT-T-95-16, Federal Transit Administration, Washington, D.C., 1995, http://www.fta.dot.gov/transit_data_info/reports_publications/publications/environment/4805_5144_ENG_HTML.htm

Traffic Noise Analysis and Abatement Policy and Procedures, WSDOT, June 18, 2004, http://www.wsdot.wa.gov/regions/Northwest/rp&s/environmental/aae/policies.htm

Additional Resources

Air Quality, Acoustics and Energy Section, Environmental Services Office (ESO), Northwest Region, WSDOT, http://www.wsdot.wa.gov/regions/Northwest/rp&s/environmental/aae/default.htm

Analysis of Highway Construction Noise, Federal Highway Administration (FHWA), Technical Advisory T6160.2, Washington, D.C., March 13, 1984.

Barry, T.M., and J.A. Reagan, *Highway Traffic Noise Prediction Model*, Report Number FHWA-RD-77-108, FHWA, Washington, D.C., December 1978.

Environmental Procedures Manual, WSDOT, M 31-11, http://www.wsdot.wa.gov/fasc/EngineeringPublications/Manuals/EPM/EPM.htm

Environmental Services Office (ESO), Region Environmental Manager, WSDOT.

Traffic Noise Model® (TNM), FHWA, Washington, D.C., 2004, http://www.trafficnoisemodel.org/main.html

Fundamentals and Abatement of Highway Traffic Noise, FHWA, Washington, D.C., September 1980.

Highway Construction Noise: Measurement, Prediction and Mitigation, Special Report, FHWA, Washington, D.C., May 2, 1977.

Highway Noise Barrier Design Handbook, FHWA, Report Number FHWA-EP-00-005, DOT-VNTSC-FHWA-00-01, Washington, D.C., February 2000, http://www.fhwa.dot.gov/environment/noise/manual.htm

Highway Traffic Noise Analysis and Abatement Policy and Guidance, FHWA, Washington, D.C., June 1995.

Highway Traffic Noise in the United States: Problem and Response, FHWA, Washington, D.C., April 2000, http://www.fhwa.dot.gov/environment/USprbrsp.pdf

Highway Traffic Noise Type 1 Projects, FHWA, memorandum HEP-40, October 20, 1998, http://www.fhwa.dot.gov/environment/noise/type1mem.htm

Lee, Cynthia S.Y., and Gregg G. Fleming, *Measurement of Highway-Related Noise*, Report Number FHWA-PD-96-046, FHWA, Washington, D.C., May 1996.

This page intentionally left blank

Introduction

Vibration in urban areas from vehicle traffic, rail transportation, and project construction has the potential to annoy and disturb people and animals. Vibration can even cause property damage. Effects from vibration vary according to the displacement, velocity, and acceleration that is generated from the source. Heavy trucks, buses, and construction activities generate the highest levels of vibration on roadways.

Purpose and Need

Within the *Code of Federal Regulations* (CFR), specifically 23 CFR 771.135, there are regulations pertaining to vibration on Section 4(f) facilities (see Exhibit IV-7.1). Elements that produce substantial vibration, like railroads, will need to focus concerns on long-term effects, while temporary vibrations from construction activities to Section 4(f) facilities also need to be considered.

Balancing Considerations

Project development staff needs to consider impacts caused by vibration. A project team needs to work with local jurisdictions to identify locations where potential impacts might occur. Vibratory rollers, pile driving, and pavement or structure demolition are some construction activities that have the potential to cause property damage and interfere with local businesses. Vibration has the potential to structurally damage historic buildings and disrupt wildlife.

Project development staff also needs to look for electronic laboratories, television stations, radio stations, and other calibration-type businesses near a proposed project. These types of businesses use sensitive equipment that can be harmed by vibration. Large-scale vibratory work near cemeteries might also cause a general concern among the public. Mitigation might be necessary to prevent or reduce impacts. Mitigation efforts might include a scheduling of the work outside of typical office hours, down-sizing the type of equipment used, or the use of different types of construction methods.

Exhibit IV-7.1 – Section 4(f) facilities include, but may not be limited to:

- Public parks
- Recreation areas
- Wildlife/waterfowl refuges
- Historic sites
- Historic bridges and highways
- Archaeological resources
- Fairgrounds
- School playgrounds
- Trails
- Wild & scenic rivers
- Public multi-use land holdings
- Bikeways
- Scenic byways

Governing Regulations and Directional Documents

Environmental Impact and Related Procedures – Section 4(f) (49 U.S.C. 303), 23 CFR 771.135.

Additional Resources

Air Quality, Acoustics and Energy, Environmental Services Office (ESO), Northwest Region, WSDOT, http://www.wsdot.wa.gov/regions/Northwest/rp&s/environmental/aae/default.htm

Environmental Procedures Manual, WSDOT, M 31-11, http://www.wsdot.wa.gov/fasc/EngineeringPublications/Manuals/EPM/EPM.htm

Environmental Services Office (ESO), Region Environmental Manager, WSDOT.

This page intentionally left blank

Introduction

The illumination systems associated with transportation facilities have the potential to affect the surrounding environment – particularly in urban areas. Street lighting and other lighting, such as pedestrian crossing lights, may disturb the nocturnal environment. Night lighting can cause visual discomfort from direct glare; increased urban sky glow; light trespass into property where darkness is preferred; and may interfere with wildlife, impact vegetation, and waste energy if inefficient.

Definitions

Light trespass Light from another source introduced to an area where light is unwanted – for example, when a neighbor's backyard floodlight illuminates a neighboring house.

Light pollution The uneconomical use of light that sends light wastefully toward the sky, or light that provides so much glare that visibility is impaired.

Balancing Considerations

When illumination is called for in a project, there is an opportunity to ensure that environmental impacts are minimized or avoided altogether. Illumination is used for both safety and security purposes and has benefit for all road users when properly installed. A well-designed illumination system reduces impacts by directing light to the intended area and preventing direct glare. Fixtures are available that can direct lighting in different illumination patterns and intensities. On road systems, lighting is installed so that luminance is uniform across the light area. Examples of lighting systems that result in greater impacts to the environment are poorly aimed lights; ball lights or globe lights with no shielding; non-directional lights; and lights pointed toward the sky. To avoid or reduce potential impacts, reflecting or shielding light away from adjacent properties and wildlife areas should be considered.

Exhibit IV-8.1 – Street Illumination (Location: Seattle, WA)

Governing Regulations and Directional Documents

There are currently few regulations on lighting and light pollution. However, a number of local jurisdictions, including the cities of Seattle, Bothell, Redmond, Kent, Enumclaw, Pullman, Goldendale, and Kelso, as well as Bainbridge Island, and Douglas and Island Counties, have approved ordinances and codes regarding lighting within their jurisdictions. Most of the ordinances focus on shielding light from the unintended target and preventing glare from occurring.

During the design of urban projects, local regulations should be reviewed to determine rules and ordinances related to light pollution and light trespass. Project elements should be designed to be consistent with local ordinances and codes.

Exhibit IV-8.2 – Urban Sky Glow (Location: Seattle, WA)

Roadside Classification Plan, WSDOT, M 25-30, http://www.wsdot.wa.gov/eesc/design/roadside/pdf/RCP_2.pdf

Roadside Manual, WSDOT, M 25-30, http://www.wsdot.wa.gov/fasc/engineeringpublications/Manuals/RoadsideManual.pdf

Additional Resources

Archaeology and Historic Preservation, Office of, Washington State Department of Community, Trade and Economic Development, http://www.oahp.wa.gov/

Environmental Procedures Manual, WSDOT, M 31-11, http://www.wsdot.wa.gov/fasc/EngineeringPublications/Manuals/EPM/EPM.htm

Environmental Services Office (ESO), Region Environmental Manager, WSDOT.

*Lighting For Exterior Enviro*nments, RP-33-99, An IESNA Recommended Practice, www.iesna.org

Introduction

Many recycled products have uses in roadway construction and maintenance (see Exhibit IV-9.1). Examples include recycled asphalt pavement (RAP), concrete fly ash (primarily from coal-fired operations), and plastics. In many cases, the use of recycled material is cost-competitive with the use of virgin material. Use of such material may save energy, reduce air and water pollution, and save valuable landfill space. The table below lists examples of recycled products, their sources, and some applications of the products (this list is not exhaustive).

Exhibit IV-9.1 – Hand Distribution of Mulch (Recycled Woody Material) (Source: WSDOT Roadside Manual)

Recycled Material	Sources	Uses
RAP	• Parking lots • Roads	– Mixed with new asphalt for road and other pavement courses – Road ballast – Aggregate
Concrete	• Concrete demolition	– Aggregate – Road ballast – Asphalt aggregate
Fly Ash	• Coal combustion by-product	– Concrete additive – Controlled density fill
Used Tires	• Municipal Solid Waste (MSW)	– Crumb rubber (chip and crack seal, some safety devices) – Embankment
Glass	• MSW	– Ballast – Base – Backfill – Foundation material
Plastics	• MSW	– Posts – Block outs – Noise wall
Wood Wastes/ Compost	• MSW • Roadside maintenance	– Mulch for landscaping – Amended loam

There are many innovative uses for recycled materials in road construction and maintenance. However, the listed materials and uses have been well studied.

The use of recycled materials may have environmental and cost advantages, but at the same time, these materials must meet minimum performance criteria. A significant body of research exists concerning the use of recycled materials in highway construction and maintenance. Some of this research is listed in the Additional Resources section.

Definitions

Recycled Asphalt Pavement (RAP) Asphalt pavement either removed from the job site or stockpiled for use as a new asphalt pavement course or aggregate.

Fly ash A very fine ash created by coal-fired combustion units, carried in flu gas, and removed by air pollution control equipment.

Municipal solid waste Includes household, commercial, and industrial waste.

Crumb rubber The small rubber pellets generated from grinding and processing used tires.

Purpose and Need

The inclusion of recycled materials in a highway construction project is intended to have three major outcomes. First, use of recycled materials will lessen the impacts of the project on natural resources by substituting recycled materials for virgin materials. Second, the use of recycled materials lessens impacts to air, water, and landfill space by avoiding the use, processing, and transportation of virgin materials and the subsequent pollution those processes cause. Third, the use of recycled materials can reduce the cost of the project in situations where the use of recycled materials is cheaper than virgin materials. The use of recycled materials should be considered when a supply is readily available, the materials' costs are competitive with virgin materials, or when shipping of virgin materials can be reduced by substitution with recycled materials.

Balancing Considerations

Under the right circumstances, the use of recycled materials in transportation facility construction and maintenance reduces the overall environmental impact of the activity, provides a market for those materials, reduces costs, and has the potential to increase a community's pride in the final product.

Cost

Exhibit IV-9.2 – Lightweight Tire Fill (Location: SR 101 South of Cosmopolis, WA)

Cost and performance of any construction material, whether virgin or recycled, are critical considerations.

The cost of a material is a reflection of the market for the material and its constituents. For example, in times of high crude oil prices, RAP may enjoy a price advantage over virgin asphalt. The opposite may be true in times of low crude oil prices. Further, not all contractors are going to maintain large stockpiles of RAP or have access to other recycled materials at any given time. Therefore, great care needs to be taken when requiring the use of recycled materials in any given design or contract.

Under certain circumstances, significant environmental and cost benefits can be realized from the use of recycled materials. For example, circumstances advantageous to the use of recycled material include periods and locations where virgin materials are expensive or scarce, and when the source of recycled material is particularly plentiful (such as when the project, or a nearby project, calls for significant asphalt or concrete demolition, or when the project is located near an area with an aggressive glass recycling program).

Performance

All building materials must meet basic performance requirements. Premature failure is not only unacceptable from a cost perspective, it is also environmentally damaging, particularly if a project must be fixed or completely re-done with new materials. Consequently, it is vitally important that all materials meet the requirements outlined in the WSDOT Standard Specifications.

Test methods are both material-specific and application-specific. Required test methods can be found both in the Standard Specifications and the WSDOT *Materials Manual*.

Governing Regulations and Directional Documents

Environmental Policy Statement, WSDOT, E 1018.00.

Materials Manual, WSDOT, M 46-01.

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

Washington's Transportation Plan: 2003-2022, Goal 17, Washington State Transportation Commission and WSDOT, Olympia, WA, 2002, http://www.wsdot.wa.gov/ppsc/planning/

Additional Resources

Construction Office, Region Construction Engineer, WSDOT.

Environmental Services Office (ESO), Region Environmental Manager, WSDOT.

Investigation Into Organic Scrap Material Substitutions in Portland Cement Concrete, Research Report #1349-1F, University of Texas at Austin, Dept. of Civil Engineering, Center for Transportation Research, http://www.utexas.edu/depts/ctr/recycle/concrete.htm

Location and Availability of Waste and Recycled Materials in Texas and Evaluation of Their Utilization Potential in Roadbase, TxDOT Research Study 0-1348, Center for Transportation Research, http://www.utexas.edu/research/ctr/recycle/roadbase

Materials Laboratory, Region Materials Engineer, WSDOT.

Production Variability Analysis of Hot-Mixed Asphalt Concrete Containing Reclaimed Asphalt Pavement, Research Report #2918-1F, University of Texas at Austin, Dept. of Civil Engineering, Center for Transportation Research, http://www.utexas.edu/research/ctr/recycle/hmac.html

Recycled Materials In Embankments Except Glass, Study 0-1351, Center for Innovative Grouting Materials and Technology, University of Houston, http://www.utexas.edu/research/ctr/recycle/embank

Recycled Materials in Roadway Safety Devices, Research Report #1458-1, Texas A&M University System, College of Engineering, Texas Transportation Institute, http://www.utexas.edu/research/ctr/recycle/safety

Recycled Materials in Vertical Moisture Barriers, Research Report #1354, Texas Tech University, Dept. of Civil Engineering & Dept. of Chemical Engineering and University of Texas at El Paso, Dept. of Civil Engineering, http://www.utexas.edu/research/ctr/recycle/vertical.html

Use of Glass Cullet in Roadway Construction, Research Report #1331-1 Texas Tech University, College of Engineering, http://www.utexas.edu/research/ctr/recycle/cullet

Use of Recycled Materials in Highway Construction, Federal Highways Administration (FHWA), http://iti.acns.nwu.edu/clear/infr/pr_au94.html

Using Hydrated Fly Ash as a Flexible Base, Research Report #1365-1F, Texas Tech University, Dept. of Civil Engineering, http://www.utexas.edu/research/ctr/recycle/flyash/html

This page intentionally left blank

Purpose of State Highways and Other Roads

Traditionally, the primary objective of the highway and local street system is the movement of people, products, and services. This objective is accomplished by providing safe, efficient, dependable, and environmentally responsible transportation facilities to:

- Promote a positive quality of life.
- Enhance the economic vitality of all areas of the state.
- Protect the natural environment and improve the built environment.

Project stakeholders benefit from the evaluation of facility elements from different perspectives, whether the perspective is mobility versus access; the differing needs of the rural and urban settings; or the treatment of non-motorized and motorized vehicles and users. Understanding the specific context of a project will help ensure that characteristics are not simply applied as a result of a "one size fits all" approach. This understanding leads to recognition of the fundamental issues and requirements of the surrounding environment, and the application of solutions that best fit those needs.

Exhibit V-1.1 – Multifunction Improvement (Location: Stevenson, WA)

Projects are often developed in a manner that maximizes the objectives of the project and the capacity of the facility, providing for the highest appropriate speeds without compromising the optimal safety of the facility. State highways, particularly in the urban environments, also serve to provide access. Generally, access control is established to preserve the safety and efficiency of highways, and to protect public investment. Within the urban environment, the need for access to adjacent businesses and residential areas significantly increases. This dual function, however, results in inherently contradictory purposes. Free-flowing mobility becomes difficult to achieve and sustain when increased access is provided. Conversely, frequent access cannot be provided when optimal mobility is the primary need identified. As with all considerations outlined within this document, an important starting point is to determine the primary need and function for a specific facility.

While functional classifications are important for design considerations (and add an element of uniformity), it is important to recognize that each roadway has a specific context along with its functional role within the road network. The most successful projects are characterized by an understanding and conceptual buy-in by stakeholders, both internal and external to the project, as to the function and use of the facilities.

Exhibit V-1.1 shows a picture of a project in the city of Stevenson. The project focused on improvements to safety, stormwater elements, and the economy through a rural minor arterial environment.

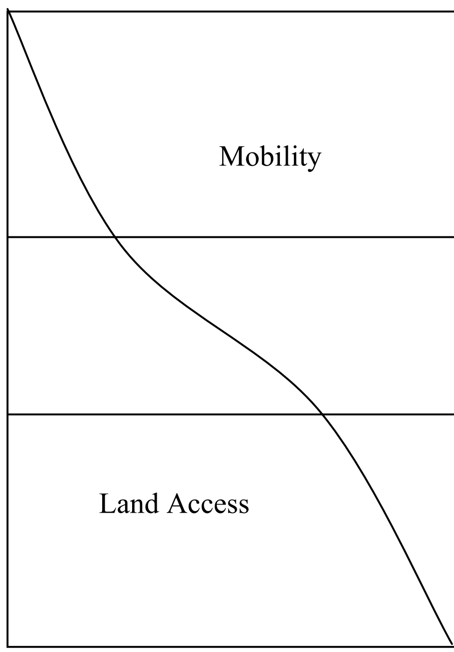
This chapter provides some detailed discussion on the characteristics and components of roadways – particularly with respect to mobility and access functions.

Classification of Roadways

The highway and local road systems are divided and classified according to the character and volume of traffic carried by the routes, and distinguished by specific geometric design criteria. The functional classifications, from highest to lowest, are: interstate, principal arterial, minor arterial, collector, and local access road and street. These differing road systems exist in both the urban and rural environments. Each facility has a particular focus and service intent.

Exhibit V-1.2 provides the general differentiation between the classifications and the services they provide.

Exhibit V-1.2 – Priorities of Roadway Services
(Source:* **Safety Effectiveness of Highway Design Features,** *Volume 1, Access Control, FHWA, 1992 – modified by WSDOT)



Arterials
- Higher mobility
- Low degree of access
- Lower degree of pedestrian safety

Collectors
- Balance between mobility and access

Locals
- Lower mobility
- High degree of access
- Higher degree of pedestrian safety

As is demonstrated in Exhibit V-1.2, road systems provide different levels of mobility and access, and trade-offs are made between mobility and accessibility as the functional class changes. Although facilities exist that provide high levels of both access and mobility, these locations are often associated with lower levels of safety when compared to similar locations in which the mobility and access is provided, as shown in the exhibit above.

For non-motorized users, the focus will be in the areas of collector and local road classification. Within these facilities, pedestrian safety is a major concern on local roads. The concept of functional class is focused on vehicles.

The following table provides the general differentiation between the classifications and the services they provide:

Functional System	Services Provided
Urban Principal Arterial System	Serves the major centers of activity in a metropolitan area, the highest traffic volume corridors, the majority of trips both entering and leaving an urban area, and the through movement to bypass the central city; carries intra-urban and intercity bus travel, travel between major intercity communities, between central business districts, etc; includes almost all fully- and partially-controlled access facilities; and is stratified into three subsystems: • *Interstate/multilane routes* with access fully controlled, which serve the national defense and connect the nation's principal metropolitan areas. • *Other Freeways and Expressways* – non-Interstate principal arterials with access fully controlled. • *Other Principal Arterials* – arterial routes with limited control of access.
Urban Minor Arterial System	Interconnects with and augments the urban principal arterial system; provides service to trips of moderate length; distributes travel to geographic areas smaller than those identified with the higher level of functional class; contains facilities that place more emphasis on land access than the higher level functional class system; and offers a lower level of traffic mobility.
Urban Collector System	Provides land access service and traffic circulation within residential neighborhoods, and commercial and industrial areas.
Urban Local Access System	Provides direct access to abutting land, and access to the higher order systems; offers lowest level of mobility and usually contains no bus routes; and service to through traffic movement usually is deliberately discouraged.
Rural Principal Arterial System	Connected network of continuous routes that serve corridor movement having trip length and travel density characteristics indicative of substantial intrastate or interstate travel, stratified into two subsystems: • *Interstate* – all designated routes of the Interstate System. • *Other Principal Arterials* – all non-Interstate principal arterials.
Rural Minor Arterial System	Links cities, larger towns, and other travel generators (e.g., resort areas that are capable of attracting travel over similarly long distances), and forms an integrated network providing interstate and intercounty service.
Rural Collector System	Primarily serves intra-county travel and constitutes those routes on which predominant travel distances are shorter than on arterial routes, and is subclassified into two subsystems: • *Major Collector* – provides service to any county seat or larger town not on an arterial route and to other traffic generators of equivalent intra-county importance (e.g., schools, county parks). • *Minor Collector* – provides service to smaller communities not on an arterial route, collects traffic from local roads, and brings all developed areas within a reasonable distance of a collector road.
Rural Local System	Provides access to adjacent or abutting lands and provides service to travel over relatively short distances.

It is important to understand that when the classification of the roadway is inconsistent with the project purpose and need (or vice versa), situations are created where design elements are selected that are not appropriate for the roadway function (for instance, when high-speed, high-volume designs are used in residential areas).

There is work in progress to stratify the transportation facilities within specific functional classifications to better align with the various contexts. When complete, it is expected that this work will provide clarity on the desirable functions and characteristics for expressways, boulevards, avenues, streets, rural roads, and highways, etc. If adopted, this guidance should provide clarity on design characteristics for these facilities.

Exhibit V-1.3 – Pedestrian Overpass (Location: Clark County, WA)

In transition areas, consideration of the functional requirements and needs are location-specific. The designs and solutions are typically based on the current and future use of the facility; the area and context it serves; and the speed and mix of traffic. It is also important to consider whether traffic is entering or exiting the transition area.

Pedestrian and bicycle facilities will be included as part of urban minor arterial systems, urban collector systems, and urban local access areas. In some rural areas, there are a limited number of services for bicyclists based on bicycle corridor locations.

Exhibit V-1.3 shows Padden Parkway in Clark County. This project improved a limited access facility within the county and focused on freight, transit, and pedestrian improvements — all within the high-speed context of the principal arterial facility.

Purpose of Roadway Components

The roadway can be divided into several physical components, which are briefly discussed in this section. (See Chapters V-2 and V-3, which cover roadway and roadside considerations in more detail.)

Traveled Way (or Lanes)

The traveled way is the portion of the roadway intended for the movement of through motorized and non-motorized vehicles. It includes through lanes, HOV lanes, and auxiliary lanes for through traffic. It does not include lanes for other purposes, such as turn lanes, acceleration lanes, deceleration lanes, or parking lanes. The width of the traveled way is contingent on the number and the width of those lanes.

Shoulder

The shoulder is the portion of the roadway designated primarily for the accommodation of stopped vehicles, emergency use, support of the traveled way, and for use by pedestrians and bicyclists (where bicycle lanes and sidewalks are not provided). The width of the shoulder is dependent on the functions that will be provided.

Auxiliary Facilities

Auxiliary facilities are portions of the roadway adjoining the through lanes for parking; acceleration/deceleration; turning; storage for turning; weaving; truck climbing; passing; and other purposes supplementary to through-traffic movement. They might be a part of the traveled way, such as lanes for passing, truck climbing, and weaving. Lanes for turning, storage for turning, and acceleration/deceleration are not part of the traveled way, but require a shoulder. Facilities for parking lanes, bike lanes, bus pullouts, etc., may replace the shoulder.

Median

A median is the portion of a divided highway separating the traveled ways for traffic in opposite directions. The primary functions of a median are to improve safety by reducing opposite-direction crashes, and to manage access by controlling left turns. Medians also provide space for drainage facilities; bridge piers; vehicle storage; space for crossing and left-turn movements; visual buffer of opposing traffic; safety refuge areas for errant or disabled vehicles; storage for snow and water; aesthetic opportunities; pedestrian refuges; and increased comfort and ease of operations.

Exhibit V-1.4 – Urban Arterial with Median, Trees, and Low Profile Barrier (Location: SR 99, Des Moines, WA)

Curbs

Curbs are raised barriers within or along the edge of the roadway. Curbs are used for drainage control, to delineate the roadway edge, on pedestrian walkways and islands, and to provide access control by preventing mid-block left turns. Typically, curbs do not have any significant redirectional capabilities.

Parking Lanes

When present, on-street parking is located adjacent to the traveled way and may replace the shoulder. Parking lanes provide temporary storage for vehicles with local trip destinations. The width of the parking lane will depend on the angle of the parking stalls. (See Chapter V-8, Parking, for more details.)

Exhibit V-1.5 – Bicycle Lane and On-Street Parking (Location: Seattle, WA)

Bicycle Lanes

Bicycle lanes are portions of a highway or street that have been identified for bicycle travel by signs, pavement markings, or both. Bicycle lanes are frequently a feature of urban street designs. (See Chapter III-2, Bicyclists, for more details.)

Pedestrian Facilities

Pedestrians are present on many transportation facilities. Their needs may conflict with the requirements of vehicular travel, particularly when crossing. Facilities such as sidewalks; highway shoulders; walking and hiking trails; shared use paths; pedestrian grade separations; crosswalks; and pedestrian refuge areas provide safe and efficient facilities. (See Chapter III-1, Pedestrians, for a more detailed discussion.)

Vegetation

The inclusion or retention of vegetation provides a number of different functions that result in operational, environmental, and visual benefits. Vegetation can prevent soil erosion; enhance water quality; provide runoff storage; provide slope stabilization; preserve and provide wildlife habitat; preserve scenic views; and serve as a buffer and glare screen.

Landscaping can be used to affect driver behavior by creating the perception that the roadway is narrower than it actually is, which may result in reduced vehicle speeds. This might be of particular interest in the urban environment. The different types of vegetation will have varying effects on the traffic. The growth of vegetation can create sight distance conflicts affecting the visibility and thus the safety of facility users. Vegetation can also create other roadside-related difficulties. It is therefore beneficial to create a management plan and program to address roadside vegetation. The selection of species and the placement of plant materials require consideration of not only the safety of all facility users, but also the maintenance necessary to protect the public and the investment, and to manage risk to the agency for the useful life of the facility. (See Chapters IV-1 and IV-3 for further discussions on this topic.)

Roadsides

The roadside is the area between the shoulder and the right of way line. The primary uses of the roadside are to provide room for cut and fill slopes, for recovery of out-of-control vehicles, and for sidewalks. Roadsides are also used for landscaping, and for the control, storage, and filtration of runoff water. Providing these functions while maintaining safety also requires attention to the Design Clear Zone and speed, to ensure that the consequences of vehicles running off the road are minimized.

Balancing Considerations

Designers are challenged with balancing a multitude of needs and expectations for transportation facilities, particularly within the urban context.

Urban contexts demand multi-modal options, presenting the need to balance the provision of facilities for private automobiles, truck use, transit, bicyclists, and pedestrians. Land use decision-making and subsequent development within built-up urban areas can present challenges for uniform standards, due to the wide variety of needs placed on the facility. The limited space available in the built-up urban contexts complicates the decision-making process. Careful consideration of the desired features is necessary to weigh the alternatives and develop the optimal use of the available right of way and other resources.

Exhibit V-1.6 – Principal Arterial (Location: SR 516, Covington, WA)

Each of the characteristics previously discussed makes an important contribution to the function of the facility. The importance of each element is related to the context and the environment in which the road operates. What is important to understand is that driver behavior and vehicle operation are best when the context and facility are consistent with driver expectations. Although it is understood that no design can account for all driver errors and actions, features in the road environment, such as those shown in Exhibit V-1.6, can affect driver behavior and vehicle operation. Exhibit V-1.6 shows a facility in Covington, where vegetated medians and sidewalks are used to restrict and delineate access in the urban environment.

As with any consideration outlined within this document, the project staff first has to determine the full nature of the issue to be addressed, within the specific context of the project setting. From the state highway and local community perspective, improvements to the safety, mobility, capacity, and environment are all important parts of a project. But other considerations, such as a system that provides transportation options – which include features that modify drivers' behavior, improve livability, benefit the economy, and improve accessibility along the route – are also very important and may predominate in some circumstances.

Once the nature of the issues is identified, project staff continues the process by conducting an evaluation of the needs of the community, the function of the facility within its context, and how the facility design can merge them together into a successful project. It may also be beneficial for project stakeholders to consider the long-range land use plans for the facility.

Once these fundamental issues are defined through a collaborative interaction with a variety of users, a substantial evaluation of the options can be carried out.

Governing Regulations and Directional Documents

Design Manual, WSDOT, M 22-01.

Functional Classification of Highways, *Revised Code of Washington* (RCW) 47.05.021.

A Policy on Geometric Design of Highways and Streets, 4th ed. (Green Book), American Association of State Highway and Transportation Officials (AASHTO), Washington, D.C., 2001.

Additional Resources

"Access Control," *Safety Effectiveness of Highway Design Features*, Volume 1, Federal Highway Administration (FHWA), Washington, D.C., 1992.

Flexibility in Highway Design, FHWA, Washington, D.C., 1997, http://www.fhwa.dot.gov/environment/flex/index.htm

This page intentionally left blank

Introduction

Specific types of land use exist within the context and location of each project. In some cases, projects will serve as a transition between the contexts. In this sense, land use transitions play multiple roles.

As defined in Chapter II-1, the context of a location takes on a number of different forms. These forms are clearly related to land use within the urban and rural contexts.

In essence, transition areas will play a particular role in alerting the road user to changes in the road environment. This improves driver expectation and will assist in changing driver behavior and response. Changes of particular concern are as follows:

- Context
- New or changing road users
- Land use
- Speed
- Access control and management
- Functional classification
- Alignment
- Clear zone and other changes to roadside features

The following sections present the effects of these changes and treatments within transitional areas.

Purpose and Need

The transition between a rural high-speed environment and a lower-speed urban environment often provides unique challenges.

Urban and rural contexts are fundamentally different in their design and use. In transitional areas, opportunities exist to alert road users to upcoming changes, either visually or through changes in the road characteristics. Further, transitional areas will often serve future land uses and changes in residential, business, or industrial activities. Locations once suburban become more urbanized, and locations once rural become suburban and urban.

Design Considerations

The elements that may affect the transitional areas include the physical characteristics of the roadway and roadside, and the classification of the roadway. These influences are listed in more specific detail in Exhibit V-2.1, and in the following discussion.

Cross Section

The cross section of the roadway is determined by the width of the facility, and its lanes, median, sidewalks, and shoulders.

Exhibit V-2.1 – Key Transition Area Considerations:

- Cross Section
- Posted Speed
- Access Control and Management
- Functional Classification
- Horizontal Alignment
- Vegetation
- Clear Zone and Other Roadside Features
- Traffic Calming

Varying widths of the cross section can be indicators of change to the road environment or context. Lanes, shoulders, medians, and pedestrian facilities may all change in width. Medians may be designed and placed at the entrance and exit of particular contexts. Some roadways may use lanes for parking at different parts of the day, or may preclude parking altogether.

Posted Speed

The speed of the facility determines some of the characteristics of the roadway environment. At or prior to locations where there are changes in speed can be excellent points to consider applying transitional elements in the facility environment.

Access Control and Management

The elements of access management are important in specifying the changes in land uses, and ensuring the safety of the users.

Functional Classification

Exhibit V-2.2 – Northern Gateway into Colfax (Location: Colfax, WA)

The functional classification of highways and streets accounts for the different land uses, while preserving the different objectives of the system users. The system users have a variety of needs, ranging from minimized travel times, to distribution to or from the origin and destination points. Collection facilities provide the greatest level of accessibility to individual origins and destinations, and consequently operate at lower speeds. Distribution facilities operate at moderate speeds and have more regulated access controls. Distribution facilities link the collection facilities with high-speed travel facilities. Minimizing travel times, particularly over longer distances, necessitates higher travel speeds, which in turn means that access to the system must be carefully controlled to minimize turbulence in traffic flow and conflict points with vehicles entering or leaving the facility.

Horizontal Alignment

The alignment can be designed to introduce the users to the new context. For instance, when entering a downtown area, there might be additional curvature added to the roadway to encourage drivers to slow down and pay attention to their environment. On the other hand, the roadway leading out of the downtown and into a rural setting might be designed to encourage an appropriate increase in speeds by having a straight alignment and roadsides that are gradually more open.

Vegetation

The type, design, and location of landscaping can be changed to visually indicate changes in the roadway and context. The height of plantings may be varied or spacing may be changed in an attempt to influence driver behavior, action, or awareness.

Clear Zone and Other Roadside Features

The placement of objects can vary depending on environment. Roadside objects may change from large fixed objects, to smaller elements that are more flexible. Parking may be added or reduced to influence shopping or other activities.

Traffic Calming

Traffic calming may be used to indicate the increased presence of certain types of activities or users. Residential areas may use traffic claming to slow speeds and discourage pass-through trips. Refer to Chapter V-9 for further information about this topic.

Land Use Transition Treatments

Gateways

One specific transitional area that presents ample opportunity for aesthetic treatments is the transition into a town or urban center context. In these locations, the highway might serve as the town's main street, necessitating visual cues to the users as to the changes in land use. These indicators are necessary to slow vehicles and heighten the users' awareness of the more urban conditions. Typically, signs are used to indicate a change in speed limit, but other subtle and effective techniques can be employed to encourage drivers to slow down. The use of community gateways might slow vehicle speeds, while providing an enhanced "sense of place" to community residents and visitors. Exhibit V-2.3 shows an example of such a gateway.

Exhibit V-2.3 – Residential Gateway (Location: Tumwater, WA)

As entryways to towns, cities, regions, or the state, gateways provide unique opportunities to highlight an area through landscape design. Community gateway treatments typically address areas located beyond the curb line or paved shoulder of the roadway and are designed in partnership with the local community to convey a positive first impression to visitors and to express community identity.

Gateway areas can be used to blend design elements from two adjacent areas by transitioning vegetation species and layout, and incorporating lighting fixtures or street furnishings. These elements visually signal an oncoming driver to reduce vehicle speed for that particular area. Exhibit V-2.2 shows a transition area in Colfax, Washington. This location function helps to reduce highway speeds through town.

Exhibit V-2.4 – Southern Gateway into Oroville (Location: Oroville, WA)

The desired outcomes from the installation of gateways are increased safety and an enhanced sense of place and community identity. Below are some of the gateway considerations:

- Placement of transition elements in the right of way
- Context of the facility
- Reflection of community values
- Clear zone requirements
- Agreement for maintenance and operation (state projects have Government Contract Agreements for turn back and maintenance)
- Defined land use change
- Provision of visual cues to reduce speed

As with any design element, coordination with maintenance personnel is important to ensure the feature is maintainable. Placement of gateway elements requiring maintenance also requires the consideration of the safety of maintenance personnel or volunteers.

The maintenance of gateway areas is usually turned back to the local community following construction. Exhibit V-2.4 shows a gateway into Oroville, Washington. Elements are placed outside of the right of way and indicate and mark the city's entrance.

Other Transition Treatments

Whereas gateways mark distinct change in context, other treatments can be used to smooth the transition between the contexts. For example, landscaping themes used in the upcoming center or corridor might be gradually introduced. Or, roadside characteristics might be changed, such as the introduction of sidewalk or on-street parking. Increasing the number of access control treatments can also help to transition between contexts.

Balancing Considerations

The role of planners and designers is to balance and preserve the existing and planned land use with the different functions of highways and streets. Success requires understanding of the land use context, the intended function of the transportation facilities, the goals of the community, the objectives of the local comprehensive plan, and how the local community has applied the requirements of the Growth Management Act.

Governing Regulations and Directional Documents

Design Manual, WSDOT, M 22-01.

Growth Management Act (GMA), *Revised Code of Washington* (RCW) 36.70A.

Highway Advertising Control Act-Scenic Vistas Act of 1971, RCW 47.42.

Roadside Classification Plan, WSDOT, M 25-31.

Roadside Improvement and Beautification, RCW 47.40.

Roadside Manual, WSDOT, M 25-30.

Additional Resources

Landscape Architecture Office, Region or Headquarters Landscape Architect, WSDOT.

Maintenance Office, Area Maintenance Engineer, WSDOT.

MAKERS Architecture and Urban Design and The Transpo Group, *Inc.*, Options and *Innovations* Toolkit: "Context Sensitive Solutions for Rural Town Centers and Corridors," Puget Sound Regional Council, 2004.

Traffic Office, Region Traffic Engineer, WSDOT.

When Main Street is a State Highway, Maryland State Highway Administration, Baltimore, MD, 2001, http://www.sha.state.md.us/businessWithSHA/projects/ohd/Mainstreet/MainStreet.pdf

Division V Design Considerations
Chapter V-3 Roadway

Introduction

The roadway consists of a number of different elements that, when combined together, provide for a safe and efficient facility. The designer often thinks of these elements individually, but it is necessary to also see them as a part of the whole road system. This chapter focuses on the roadway, while Chapter V-4 discusses the roadside, and Chapter V-5, intersections.

Exhibit V-3.1 – Roadway Cross Section (Location: Lacey, WA)

With roadway design, a fundamental consideration is the geometrics of the facility. Some roads favor high speed by limiting access; others, low speed, with high levels of access. The provision for non-motorized transportation is an important part of the design equation.

Roadway geometric design includes consideration of cross section (lanes, shoulders, median, slopes and ditches, curbs, and sidewalks), horizontal alignment, and vertical alignment. The geometrics listed above relate to the speed and function of the road, the mix and type of vehicles, and the non-motorized transportation needs. Geometric design must weigh the needs of the facility from a mobility, safety, and access point of view, along with land use, environment, community needs, values, aesthetics, and likely users.

Ultimately, good geometric design results in a roadway that is safe and efficient; built within the schedule and budget of the project; and done in a manner that provides for the environment and context in which it is built.

Exhibit V-3.1 shows a cross section that includes a median, bicycle lane, sidewalk, and changes in vertical and horizontal alignment in Lacey, Washington.

Definitions

Access A means of entering or leaving a public road, street, or highway with respect to abutting property or another public road, street, or highway.

Access control The limiting and regulating of public and private access to Washington State's highways, as required by state law.

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

Bicyclist A person riding or maneuvering a vehicle having two tandem wheels, a minimum of 14" (35 cm) in diameter, propelled solely by human power. A three-wheeled adult tricycle is considered a bicycle.

Motorist A person riding or maneuvering a motorized vehicle.

Pedestrian A person on foot, in a wheelchair, or walking a bicycle.

Rumble strips Grooves or rows of raised pavement markers placed perpendicular to the direction of travel to alert inattentive drivers.

Traffic barrier A longitudinal barrier, including bridge rail, or an impact attenuator that is used to redirect vehicles from hazards located within an established Design Clear Zone. Traffic barriers are used to prevent median crossovers, errant vehicles from going over the side of a bridge structure, or (occasionally) to protect workers, pedestrians, or bicyclists from vehicular traffic. Barrier heights vary depending on vehicle speed.

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.

Purpose and Need

Facility Function

Exhibit V-3.2 – Multifunction Roadway (Location: SR 169, Maple Valley, WA)

A transportation facility is intended to provide safe and efficient service to bicyclists, pedestrians, and motorists. The level of service may vary depending on the type of facility and its context (whether it exists in an urban or rural environment.) Generally, the function of the facility consists of providing a route for the road user from origin to destination, and providing access to businesses, industries, community and governmental resources, and residences. Roads are made up of many different components. Some of the components are discussed below in terms of how they affect the functionality of the transportation facility.

Access Control

Access management is a significant factor in providing a safe and efficient roadway for all modes. The design features and operating characteristics of roadways require careful planning, so that they reduce traffic conflict points and minimize interference among different modes of travel.

Geometry

Providing adequate width for roadways, bikeways, and walkways; adequate sight distance; accessible grades; and appropriate alignment (in order to avoid blind corners) is critical to designing a facility that serves its users well. The traffic mix and the characteristics of the users will directly affect what roadway elements are needed for the specific project.

Operating/Posted Speeds

On urban and suburban roads, operating speeds have greater variation from average speeds (depending on the time of day), than on rural roads. This speed variance is often related to slower speeds during congested peak hour conditions and higher speed conditions with free flow. While speed is related to accident severity, speed variance between vehicles is related to accident frequency. Because of this condition, it is common to set posted speeds consistent with the 85^{th} percentile speed. Design features that reduce the variance in motor vehicle speeds (e.g., signing, pavement markings, consistent design features, and appropriate speed settings) reduce the potential for collisions.

Contexts

Within the various contexts, the considerations and trade-offs associated with different features vary. The speed of the facility will have a high impact on the elements that are appropriate along the facility and the measures needed to ensure the safe use by all the facility users. For example, within the low-speed urban center context, utility poles placed 18 inches from the curb may be acceptable. This is due in part to the frequent provision of on-street parking, which serves to increase the distance between the vehicular traffic and the utility poles. On the other hand, in a high-speed rural corridor, an 18-inch offset may not provide the needed level of safety, due to the excessive deceleration of a vehicle in the event it collides with a utility pole. The mix and types of users are other elements that will directly affect the needed and appropriate elements of the transportation facility through the project area.

Users

Within urban centers, there are higher levels of non-motorized users than in the more rural or industrial contexts. It is appropriate to treat all of the modes equally in these locations. In addition to considering the individual needs of the different user groups, it is imperative to recognize the ways in which the users interact, and thus how the provision of safe facilities for one group may enhance the safety of the other groups. Refer to Division III for a detailed discussion on the different user groups.

Design Levels

State and local transportation agencies define and use differing design levels for facilities that serve the variety of transportation needs. WSDOT defines its design levels as follows:

Basic Design Level

With its focus on maintaining the safe operation of highways, the basic design level preserves pavement structures and extends pavement service life.

Modified Design Level

The emphasis of the modified design level is on preserving and improving existing roadway geometrics, safety, and operational elements.

Full Design Level

The full design level aims to provide the optimum mobility, safety, and efficiency of traffic movements. The overall objective is to move the greatest number of users, based on facility type and speed.

Not all facilities have the same level of significance, so it is appropriate that not all of them are designed to the full design level. The factors that significantly impact the level at which a facility is designed include: the functional classification, context, traffic volume, character, composition, and terrain classification.

Facility Design

Exhibit V-3.3 – Roadway Design Considerations

- Design Speed
- Facility Alignment
- Sight Distance
- Cross Section

Roadway width and corner radii are critical elements to consider when designing roadways to accommodate all users. The roadway is designed to allow all elements of the traffic mix to travel safely and at reasonable speeds throughout the corridor. To achieve this goal, the desired design speed must be selected. That, in turn, affects the vertical and horizontal alignment design that facilitates the comfortable, safe, and efficient flow of users of the facility. The following sections detail some of the considerations associated with roadway design.

Design Speed

Design speed is the speed used to select various geometric design criteria and requirements for features of the roadway, such as vertical and horizontal alignment, clear zones, and sight distances. The design speed is established through consideration of the roadway classification, terrain type, roadway function, roadside development, and (sometimes) public input. It is increased for higher-class facilities in rural areas and reduced for lower classes in urban areas and mountainous terrain.

Care should be taken in the selection of a design speed that is consistent with drivers' expectations and operating speeds. Lower design speeds are most appropriate in urban and residential areas with high pedestrian traffic. The design speed should not be less than the posted speed or the speed of traffic. While design speeds are often set based on functional classification and traffic mix, options for modification of these design speeds do exist. In these cases, studies are done to evaluate the safety needs, character, context, and function of the road at the given location.

In general, consideration of the needs and usage of pedestrians and bicyclists is not a major factor in determining vehicle speed limits on roadways. However, it is a pivotal factor in some cases, such as corridor safety analysis studies.

Facility Alignment

Exhibit V-3.4 – Alignment Elements

- Topography
- Class of highway
- Safety
- Sight distance
- Construction costs
- Drainage
- Adjacent land use
- User characteristics
- Aesthetics
- Number and type of lanes

The alignment of a transportation facility consists of horizontal and vertical components. These components are often considered the primary controlling elements for geometric design. The horizontal and vertical alignments should be designed concurrently, with consideration given to how they affect one another. Close coordination will help ensure a safe facility is designed that encourages uniform speed; has a pleasing appearance; fits well within its context; and operates efficiently. It is also important to coordinate these two elements with design speed, drainage, intersection design, and aesthetic principles in the early stages of design.

The alignment plan includes all horizontal elements of the facility, including curves and their superelevation. The roadway profile consists of the vertical features, predominantly crest and sag curves. Some of the controlling factors affecting the alignment of the facility are the topography, context, and user characteristics.

For example, in a residential area the alignment is designed to introduce the least disturbance to residents, while safely guiding the users along the route.

Visual characteristics are considered in addition to the functional considerations of the alignment. The facility alignment may be designed to enhance and increase the accessibility to scenic views, such as parks, bodies of water, geologic and geographic formations, and noteworthy structures.

The curvature of the road affects the vehicle path. As a vehicle travels around a curve, the rear wheels track to the inside of the path the front wheels travel. The amount of this offset depends on the size of the vehicle and the radius of the turn. For example, a passenger car turning on a 100-foot radius will have an offset of less than 1 foot, while a large semi truck will have an offset of about 15 feet. The same truck turning on a 300-foot radius will have an offset of only 4 feet. Refer to Chapter III-4 for more detail regarding design vehicles.

Whether the roadway is designed to be straight or with many curves, it is important to consider how vehicles travel in lanes. Wider lanes in straight sections allow for increased maneuverability and, in curved sections, for the off tracking of large vehicles. While necessary in many cases, large cross sections require additional crossing distance for pedestrians. This increases the pedestrian’s exposure time to vehicles.

The cross slope, or crown, strikes a balance between vehicle steering and surface runoff needs. If the slope is too steep, vehicles will have the tendency to drift to the low side of the roadway; if it is flat, rainwater will not run off and will pool in the roadway.

In the high-speed, rural context and on major arterials, it might be necessary to increase, or superelevate, the roadway cross slope. Superelevation is set at a level to overcome part of the centrifugal force that acts on a vehicle in order to maintain the desired speed and steering of the vehicle. Superelevation overcomes only part of the centrifugal force, so that the driver can still feel the effects of the curve.

Sight Distance

For safe and efficient travel on a roadway, all users need to have adequate sight distance to see the road ahead, as well as to see other users. The required sight distance is controlled by the design speed of the roadway and the specific needs at the location being considered. Sight distance needs can be divided into four groups: stopping sight distance, passing sight distance, decision sight distance, and intersection sight distance.

Exhibit V-3.5 – Sight Distances

- Stopping sight distance
- Passing sight distance
- Decision sight distance
- Intersection sight distance

Stopping Sight Distance

Stopping sight distance is the distance needed for a driver to see a hazard, recognize it as a hazard, and safely stop the vehicle. It is required at all locations, on all roadways. It influences the vertical alignment and the placement of objects on the inside of horizontal curves, and depends on the speed of the vehicle. Sight distance is calculated for a motorist in a passenger car viewing and recognizing an 18-inch object. Cities and counties typically use a 2-foot object height in sight distance calculations. WSDOT uses an object height of 6 inches, but may allow 2 feet based on the needs of the location. The larger the object, the less sight distance is required to see the object.

Passing Sight Distance

Passing sight distance is the distance that a driver needs to be able to see on a two-lane highway to pass other users, including cars, buses, and cyclists. It is generally not a consideration on urban roadways. Passing sight distance is determined using the passenger car as the design vehicle.

Decision Sight Distance

Decision sight distance is the distance needed for users to make decisions and execute appropriate maneuvers at complex locations in a safe manner. Decision sight distance is used where there are roadside uses and activities, or design elements that require time for the driver to make a correct decision and carry out a maneuver (such as when faced with a lane reduction requiring merging with the adjacent lane).

Intersection Sight Distance

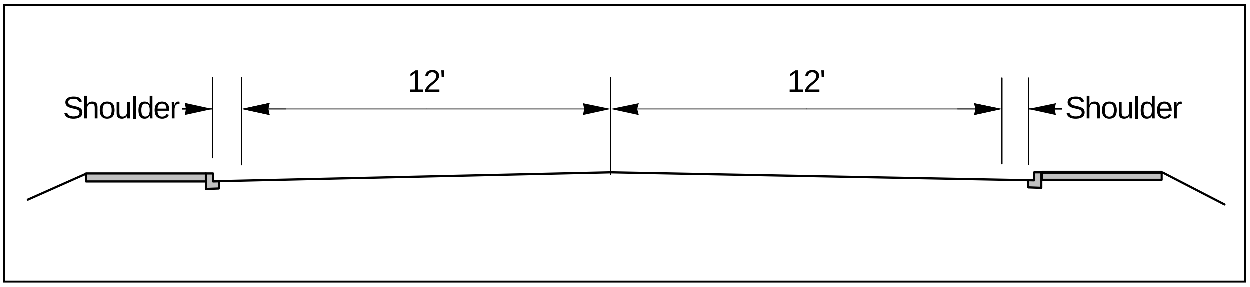
Intersection sight distance is the distance provided to allow the drivers of a stopped vehicle to see along the intersecting highway when deciding to enter or cross the highway. Intersection sight distance is generally greater than stopping sight distance for the major road.

The urban environment may present a larger challenge in terms of providing intersection sight distance when compared to more rural areas, because of the proximity of buildings, trees, and other features to the roadway. Refer to Chapter V-5 for a detailed discussion of intersection sight distance and intersection design.

Cross Section

The elements of the roadway cross section include the number of lanes, widths of lanes, shoulders, roadsides, slopes, the type of auxiliary facility and median, the presence of curbs, and any added features on the roadside (for example, pedestrian facilities or drainage). The cross section relates to the width of the road, shoulders, and sidewalks. Widths of the lanes are typically related to functional class, speed, volume, and traffic mix. Shoulders are provided based on the same requirements, as well as the need for non-motorized use. Sidewalk width is also based on likely use and may include provisions for buffer areas, furniture, and transit stops. Exhibit V-3.6 shows a basic cross section that could be used on a low-volume facility.

Exhibit V-3.6 – Typical Cross Section (Source: WSDOT)



Roadway Elements

A roadway consists of several elements that are incorporated to meet the unique needs of the facility within its context. The elements include:

- Lanes
- Medians
- Shoulders
- Auxiliary Facilities
- Pedestrian Facilities

The number of lanes, the widths of the median and shoulders, and the inclusion of sidewalks and/or other auxiliary facilities all depend on the needs of the facility users.

In Chapter V-1, which deals with the purpose and characteristics of transportation facilities, the various elements of the roadway and roadside are briefly discussed. The sections below present further discussion on the purpose, use, safety benefits, and considerations of each of these elements.

Lanes[1]

The primary functions of lanes are to:

- Move the facility users from point A to point B in a safe and efficient manner.
- Provide the needed level of access to commercial, residential, and industrial areas, and to other transportation facilities.

Traffic volume is the main determining factor for the number of lanes required on a facility. Other factors that can affect the number of lanes include maintaining continuity throughout a corridor, and the flexibility of operation.

Lanes should be wide enough to allow the design vehicle to use them without crowding vehicles in adjacent lanes. Lane width depends on the size of the vehicles that use the facility, clearance between vehicles, and horizontal alignment.

Lane width and pavement structure condition influence safety and comfort. The added cost for wider lanes may be offset by the reduction in shoulder maintenance cost due to the lessening of wheel load concentrations at the edge of the lane. Lanes 12 feet wide provide desirable clearance between large vehicles where traffic volumes are high and where a high number of large vehicles are expected. With narrow lanes, drivers must operate their vehicles closer (laterally) to each other than they normally desire. To compensate for this, drivers reduce their speed and increase the headway, resulting in reduced capacity on the facility. This action may be appropriate in some urban cities and other select locations. Careful consideration should be made for changes in lane width using the speed, context, volumes, and mix of users. Right of way and environmental concerns can also be determining factors.

[1] Lanes may also be referred to as traveled way (see Chapter V-1).

Lane Safety Elements

There are various lane-safety elements that can be used, including roadway rumble strips, centerline rumble strips, and pavement markings. These three elements are discussed in more detail below.

Roadway rumble strips (RRSs) are placed across the traveled way to alert drivers to an approaching change of roadway condition or a hazard that requires substantial speed reduction or other maneuvering. Locations where roadway rumble strips may be used include:

- At the end of a freeway
- Before stop-controlled intersections
- Near port of entry/customs stations
- At lane reductions where accident history shows a pattern of driver inattention

RRSs may also be placed at other locations where the character of the roadway changes, or on rural facilities associated with run-off-the-road accidents.

Roadway rumble strips are not used within the urban contexts, but are predominantly on rural arterials and interstates.

Centerline rumble strips (CRSs) are placed on the centerline of undivided highways to alert drivers that they are entering the opposing lane. CRSs are a countermeasure for locations with crossover accidents.

Pavement markings are the lane striping along the centerline, between the single-direction traveled lanes, and along the outside edge of the traveled way. They all serve as guidance to the facility users. For example, different markings indicate: when it is not safe to pass another vehicle by using the lane for the opposing direction of traffic; when a highway lane becomes an exit-only lane; to indicate the appropriate lanes from which to turn at the approaching intersection; to indicate the presence of a pedestrian crosswalk or school zone; and restrictions on user types in specified lanes such as HOV and bicycle lanes. By providing information to the users, pavement markings allow the users to make better informed, and thus safer, decisions.

Medians

Medians may be depressed, raised, or flush with the through lanes. When selecting a median width, future needs should be considered, such as wider left shoulders when widening from four to six lanes. At locations where the median will be used to allow vehicles to make U-turns, increasing the median width to meet the needs of vehicles making the U-turns also requires consideration.

The primary functions of a median are to:

- Separate opposing traffic and reduce head-on accidents
- Provide an area for emergency parking and for recovery of out-of-control vehicles
- Allow space for left-turn lanes
- Minimize headlight glare
- Allow for future widening
- Allow for access management
- Promote an urban experience
- Calm traffic
- Provide a pedestrian refuge

Pedestrians may use medians as refuges during a crossing maneuver. Specified breaks in the median can be provided to provide pedestrians with a safe halfway point at crossing locations, so that they can cross one direction of traffic at a time. In cases where there is substantial vegetation within the median, there might be concerns about the visibility of pedestrians waiting in the refuge to cross the traffic stream. In low-light conditions this concern can be heightened, as pedestrians are able to see vehicles more clearly than motorists can see pedestrians. For additional information on this topic, see Chapter V-10, Illumination.

Exhibit V-3.7 – Median at Intersection (Location: SeaTac, WA)

Median Safety Elements

Median barrier – Medians are analyzed to determine the potential of an errant vehicle to cross the median and encounter oncoming traffic. Median barriers are normally used on limited access, multilane, high-speed, high traffic volume highways. These highways generally have posted speeds of 45 mph or greater. Median islands and treatments are increasingly being used on arterial routes in the urban and suburban environments. The routes generally have speeds below 45 mph. Jersey-shaped or single-slope concrete median barriers are not normally installed on collectors or other state highways that do not have limited access control, except for low-profile barriers (18–20 inches). Low-profile barriers are used on arterials with median landscaping to prevent encroachment into the planting area. Providing access through either type of median barrier requires openings and, therefore, end-treatments.

Headlight glare screen – Headlight glare from opposing traffic can cause safety problems. Glare can be reduced through the use of wide medians, separate alignments, earth mounds, plants, concrete barriers, and by devices known as glare screens (specifically designed to reduce glare). In addition to reducing glare, taller concrete barriers also provide improved crash performance for larger vehicles, such as trucks. The following factors should be considered when assessing the need for glare screens:

- High rate of night, or ratio of night/day accidents, or unusual distribution/concentration of night accidents
- Over-representation of older drivers in night accidents
- Combination of horizontal and vertical alignment.
- Direct observation of glare
- Public complaints concerning glare

Centerline rumble strips (CRSs) are frequently placed on both sides of a median along a divided highway. They alert drivers to the fact that they are too close to the median. Raised profile lane markings are also used.

Shoulders

Shoulder functions control the determination of shoulder width. Higher speeds and higher traffic volumes are generally associated with the use of wider shoulders. A minimum width of shoulder is needed to provide clearance and lateral structural support to the roadway. Without the minimum clearance, traffic will move over to get away from roadside objects, such as curbs, effectively narrowing the lane. Wider shoulders are needed to allow disabled vehicles to pull out of the through lanes. However, if shoulders are too wide for extended lengths, users might begin to use them as lanes, which would degrade safety. The shoulder slope is normally the same as that used for the through lanes. In many urban locations, the provision of a shoulder is limited because the provision of non-motorized amenities, vehicle needs, environmental treatments, and right of way restrictions compete.

The primary functions of a shoulder are to provide space for:

- Stopping out of the traffic lanes.
- Escaping potential accidents or reducing their severity.
- Lateral clearance to roadside objects, such as guardrail.
- Pedestrian and bicycle use.
- Slow vehicle turnouts and shoulder driving.
- Improving sight distance in cut sections.

Exhibit V-3.8 – Shoulder Rumble Strip (Location: I-5, WA)

Shoulders have a dual purpose, which is to provide for travel of non-motorized transportation and to serve as vehicle refuge in emergency and breakdown conditions. Wide shoulders can also provide a buffer area between pedestrians and vehicles.

While lane width and the design vehicle being employed are important design considerations, it is common in curbed urban environments not to include shy distance from the curb.

Shoulder Safety Elements

Shoulder safety elements include features such as shoulder rumble strips and roadside barriers.

Shoulder rumble strips are placed on the shoulders just beyond the traveled way to warn drivers when they are entering a part of the roadway not intended for routine traffic use. Shoulder rumble strips may be used when an analysis indicates a problem with run-off-the road accidents due to inattentive or fatigued drivers.

Rumble strips affect the comfort and control of bicycle riders; consequently, their use is to be limited to highway corridors that experience high levels of run-off-the-road accidents. Shoulder rumble strips are used sparingly in urban situations. Exhibit V-3.8 shows an example of ground-in rumble strips along a rural section of I-5. (See WSDOT policy on rumble strips in the *Design Manual*, Chapter 700.)

Exhibit V-3.9 – Rumble Strips

- Mostly used on rural roads
- Ensure shoulder pavement is structurally adequate to support milled rumble strips
- Posted speed is 45 mph or greater
- Ensure that at least 4 feet of usable shoulder remains between the rumble strip and the outside edge of shoulder. If guardrail or barrier is present, increase to 5 feet of usable shoulder
- An engineering analysis indicates a run-off-the-road accident experience considered correctable by shoulder rumble strips

Roadside barriers – In locations without sufficient shoulder width, and where the consequences of leaving the roadway are severe (such as near non-recoverable slopes), barriers may be installed to redirect errant vehicles. Roadside barriers are less common in the urban environment where restricted right of way limits potential uses.

Barriers placed in locations where wildlife frequently cross the facility can influence traffic safety and wildlife mortality. When faced with a traffic barrier that is difficult for them to cross, wildlife will often travel parallel to the barrier, remaining on the highway for a longer period. This increases the risk of collisions with the wildlife or with other vehicles when motorists attempt to avoid the animal. Design engineers and biologists have worked together to develop guidance for appropriate barrier placement. (See WSDOT *Design Manual*, Chapter 710.)

Auxiliary Facilities

Auxiliary facilities, as described in Chapter V-1, include:

- Acceleration/deceleration lanes
- Turning lanes, and turn storage lanes
- On-street parking
- Truck climbing
- Bicycle lanes
- Passing lanes
- Bus pullouts

The primary functions of auxiliary facilities are to:

- Increase the efficiency of the facility.
- Provide for the specific needs of the users within a localized area (such as a turning lane at an intersection).

These facilities may be within the traveled way, the shoulder, or they may replace the shoulder.

Turn lanes are not the only auxiliary facilities. For example, passing and truck climbing lanes occur within the traveled way; right-turn lanes are within the shoulder area; and bicycle lanes, bus pullouts, and parking replace the shoulder. Exhibit V-3.10 shows turn lanes on International Boulevard in SeaTac. The turn lanes provide access, and locations for acceleration and deceleration outside of the through lanes.

Exhibit V-3.10 – Turn Pockets (Location: SeaTac, WA)

Auxiliary Facility Safety Elements

By providing for the localized user needs, users may not have to contend with as many conflicting movements. This reduces the irritation of the facility users, which generally results in higher levels of responsibility among the users (not as willing to take risky actions), and higher levels of safety.

Pedestrian Facilities

The primary purpose of providing pedestrian facilities is to provide a system to move people and to ensure the safety of the users by reducing the opportunities for conflicts between the different travel modes.

- Sidewalks provide greater access for pedestrians to the amenities along the transportation facility.
- Sidewalks increase the safety of pedestrians along the route.
- Pedestrian crossings can funnel pedestrians to specific locations to cross, allowing for safety measures to be applied at the locations.

Pedestrian Safety Elements

A variety of elements can be provided in the roadway to improve the safety of pedestrians. These include: mid-block crossings; median refuges; accessible pedestrian signals on medians; improvements at school zones; prohibition of parking near crosswalks and intersections; improved design of right turn slip lanes, etc. Pedestrian facilities are discussed in detail in Chapter III-1.

Mid-Block Crossings

Mid-block crossings at pedestrian generators can potentially improve the safety of pedestrians, particularly where the nearest intersection will require long walking distances.

Median Treatments

Median refuge islands at mid-block crossings allow pedestrians to cross a wide road in two stages, and at traffic signals, they allow slower moving pedestrians to cross the facility over two cycles. Placement of medians should consider the speed and offset of traffic. Accessibility-related issues are a consideration for pedestrians at median crossings.

Signs and Signals

Signs and signals play an important role in pedestrian safety. Signs can be provided to alert drivers to the presence of pedestrians, slow vehicular speeds, and provide advance warning for pedestrian crossings. The application of advance stopping bars at mid-block crossings can potentially reduce multiple-threat accidents.

Parking Restrictions

The prohibition of parking near mid-block crossings and intersections prevents parked vehicles from restricting sight lines.

Facility Types

Transportation facilities are grouped into two general categories: divided and undivided. The facilities are further categorized by the number of lanes; namely two-lane and multilane facilities.

In general, there are two-lane undivided; multi-lane undivided; and multi-lane divided facilities. On occasion, there can be two-lane divided and one-way couplet facilities, as well.

Balancing Considerations

Identifying opportunities to maximize the mobility and safety for all users is a primary challenge in the project development process. For example, widening a roadway through an urban area can result in higher vehicle speeds. The roadway alteration that is positive for the vehicular traveler might result in difficulties or potential hazards for pedestrians. The increased width might present challenges for some pedestrians because of lengthier crossing times, with higher vehicle speeds resulting in collisions with pedestrians that have more severe injuries.

A roadway developed for multi-modal use has many outcomes, including increased safety and comfort for all users. The well-designed roadway encourages people to bicycle and walk to their destinations. The facility may be designed to maximize capacity and not be designed to lower motor vehicle speeds; it may limit access by reducing driveways and access points to reduce the conflicts between the modes. The roadway may incorporate new or more architectural and aesthetic elements to blend these facilities together within the context of the local setting.

The potential impacts shown in the table below can result when the feature listed is changed in the manner indicated, and all other features are held constant.

Feature	Change	Potential Impacts
Design Speed	Increase	• Shorter travel times (depends on LOS) • Reduced opportunity to view features and services adjacent to roadway • Decrease in safety
	Decrease	• Increased opportunity to view features and services adjacent to roadway safety • Improved pedestrian/bicyclist environment • Increase in safety
Lane Width	Increase	• Additional room for vehicles to maneuver • Higher operating speeds • Increased impervious surface • Increased capacity • Longer pedestrian crossing distances – greater risk • Can provide room for turning movements at intersections • Can provide room for additional lanes • More room for bicyclists

(continued)

Feature	Change	Potential Impacts
Lane Width	Decrease	• Reduced room for vehicles to maneuver • Reduced capacity • Reduced vehicle speeds • Shorter pedestrian crossing distances • Decrease in safety for pedestrians
Shoulder Width	Increase	• Increased space for errant and disabled vehicles • Increased space for bicycles • Increased impervious surface • Increased impervious area to be mitigated • Longer pedestrian crossing distances
	Decrease	• Reduced area for errant or disabled vehicles • Reduced area for bicycles and pedestrians • Reduced impervious area to be mitigated • Shorter pedestrian crossing distances

The following table lists additional features that might be included in a project, and the impacts that they may have on the roadway and surrounding area. The potential impacts are not absolutes, but are typical of the change indicated. In cases where two or more changes impact the same element, the impacts might counter each other, or introduce other impacts.

Feature	Potential Impacts
On-Street Parking	• Provides better access to businesses • Buffer between traffic and sidewalk • Increases crossing distances • Can enhance economic vitality • Improves pedestrian environment • May decrease pedestrian/motorist visibility • Can reduce operating speeds • Increases impervious surface
Median	• Might provide refuge area for pedestrians • Increases safety for all users • Can be incorporated as a mid-block access control feature
Roadside Aesthetic Features (e.g., architectural treatments, colored pavements, decorative fixtures, and landscaping)	• Might provide visual continuity across the corridor • Can enhance economic vitality • Might convey local character or sense of place • Might obscure users' views • Might present a fixed object hazard within the clear zone • Introduces additional maintenance responsibilities and costs • Improves perception of business and locality • Reduces pedestrian visibility by shading and blocking overhead lighting • Might shade portions of the roadway and thereby increase icing • Light/shade contrast will reduce vehicle and pedestrian visibility

The design of the roadway is therefore a complex process, requiring the consideration of multiple users, elements, and consequences. Where deviations are made, they should be carefully documented.

Governing Regulations and Directional Documents

Bridge Design Manual, WSDOT, M 23-50.

Dangerous Objects and Structures as Nuisances, *Revised Code of Washington* (RCW) 47.32.130.

Design Manual, WSDOT, M 22-01.

Draft Pedestrian Guide, American Association of State Highway and Transportation Officials (AASHTO), Washington, D.C., 2003.

Highway Safety Design and Operations Guide, AASHTO, Washington, D.C., 1997.

Jurisdiction, Control, RCW 47.24.020.

Limited Access Facility, RCW 47.52.010.

Local Agency Guidelines, WSDOT, M 36-63.

A Policy on Geometric Design of Highways and Streets, 4th ed. (Green Book), AASHTO, Washington, D.C., 2001.

Roadside Manual, WSDOT, M 25-30.

Rules of the Road, RCW 46.61.

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

Task Force for Roadside Safety, *Roadside Design Guide*, AASHTO, Washington, D.C., 2002.

Task Force on Geometric Design, *Guide for the Development of Bicycle Facilities*, AASHTO, Washington, D.C., 1999, http://www.bikeplan.com/aashto.htm

Traffic Manual, WSDOT, M 51-02.

Additional Resources

Lalani, Nazir, and the ITE Pedestrian and Bicycle Task Force, *Alternative Treatments for At-Grade Pedestrian* Crossings, Institute of Transportation Engineers, Washington, D.C., 2001.

Pedestrian Facilities Guidebook: Incorporating Pedestrians into Washington's Transportation System, OTAK, Incorporated, Kirkland, WA, 1997.

Recommendations to Reduce Pedestrian Collisions, Washington Quality Initiative's Pedestrian Safety Improvement Team and WSDOT, Olympia, WA, 1999.

Staplin, L.K., *Highway Design Handbook for Older Drivers and Pedestrians*, Federal Highway Administration (FHWA), McLean, VA, 2001.

This page intentionally left blank

Introduction

Roadside safety addresses the area outside of the roadway and is an important component of total facility design. Though there are numerous reasons why a vehicle may leave the roadway, a forgiving roadside can reduce the seriousness of the consequences of a roadside encroachment. Elements such as side slopes, fixed objects, and water are potential objects that a vehicle might encounter when it leaves the roadway. These elements present varying degrees of danger to the vehicle and its occupants.

From a safety perspective, the ideal highway has roadsides and median areas that are flat and unobstructed by these elements. Unfortunately, geography, environmental concerns, aesthetic desires, economics, and right of way do not always allow ideal roadside conditions. In a rural environment, where speeds are higher and right of way is less of a constraint, it is easier to achieve an unobstructed roadside. However, in the urban environment, right of way is often extremely limited, and trade-offs between the differing modes of traffic are warranted. While there is greater traffic concentration in the urban "downtown core" area, speeds are typically lower and, in many instances, on-street parking is provided, thus making a clear roadside a lesser concern. In suburban areas, the right of way may still be constrained, but speeds are higher, resulting in an increased concern for roadside safety.

Exhibits V-4.1 to V-4.3 show the three typical conditions described above:

- **Exhibit V-4.1** illustrates an urban low-speed roadside where trees are located behind curb. There is a shoulder provided, and an operational offset (see definitions) of approximately two feet.
- **Exhibit V-4.2** shows a suburban moderate-speed location. Roadside curb, a sidewalk with fixed objects behind the sidewalk, and a shoulder for bicycling are provided.
- **Exhibit V-4.3** is an example of a rural roadway with high operating speeds. A wide shoulder and a side slope are provided on the roadside.

Exhibit V-4.1 – Urban Core (Location: Bellevue, WA)

Exhibit V-4.2 – Suburban Roadside (Location: Maple Valley, WA)

Exhibit V-4.3 – Rural Roadside (Location: US 12, WA)

Definitions

Clear zone The total roadside border area, beginning at the edge of the traveled way, available for use by errant vehicles. This area may consist of a shoulder, a recoverable slope, a non-recoverable slope, or a clear run-out area. The clear zone cannot contain a critical fill slope.

Design Clear Zone (DCZ) The minimum target value used in highway design, based on safety criteria, affected or determined by traffic volume, design speed, and slope.

Hazard A side slope, a fixed object, or water that, when struck, can result in unacceptable impact forces on the vehicle occupants or place the occupants in a dangerous position. A hazard can be either natural or manmade.

Operational offset A distance provided for urban arterials, collectors, and local streets where curbs are used and space for clear zone is restricted. The operational offset provides room for opening of vehicle doors and does not restrict traffic flow. The minimum 18-inch offset is provided beyond the face of curb and, where practical, wider offset is provided.

Traffic barrier A longitudinal barrier, including bridge rail, or an impact attenuator used to redirect vehicles from hazards located within an established Design Clear Zone. Traffic barriers are used to prevent median crossovers, to stop errant vehicles from going over the side of a bridge structure, or (occasionally) to protect workers, pedestrians, or bicyclists from vehicular traffic. Barrier heights may vary depending on vehicle speeds and facility needs.

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.

Purpose and Need

Exhibit V-4.4 – Reasons Vehicles Leave the Roadway

- Driver fatigue or inattention
- Excessive speed
- Driving under the influence of drugs or alcohol
- Crash avoidance
- Roadway conditions such as ice, snow, or rain
- Vehicle component failure
- Poor visibility

Exhibit V-4.5 – Urban On-Street Parking (Location: Kent, WA)

As stated earlier, vehicles leave the roadway for a number of reasons[1] (see Exhibit V-4.4). While the reasons for leaving the roadway vary, the importance of leaving the roadside as clear of objects as possible remains the same. A roadside with flat slopes and free of fixed objects reduces the chances of severe accidents. A clear area away from the roadway allows for recovery of errant vehicles and reduces the probability of collisions with objects located alongside the roadway.

The provision of clear areas is often easier said than done in many locations. This is particularly true in the urban environment, where competing modes of transportation, right of way, access, and economic realities force solutions of compromise.

The type and volume of the facility play an important part in deciding the clear zone requirements; higher speeds and volumes often correlate to higher run-off-the-road accident probabilities. Lower speeds and lower volumes reduce this probability. In general, however, the relationship between speed and volume for urban and rural environments is inversely related. Downtown core facilities are generally associated with low traffic speeds, while rural highways typically have higher traffic speeds. In the transition between these two areas, such as the suburban area, speeds reduce from the rural to the downtown environment. The concern for the roadside increases with the transition from downtown core to rural environments.

[1] *Roadside Design Guide*, AASHTO, 2002.

In the urban downtown core area, it can be particularly difficult to provide clear roadside areas. In many of these core areas, on-street parking (as shown in Exhibit V-4.5) is a vital economic consideration, and clear zones have limited benefits in terms of safety. In areas without on-street parking, the appropriateness of object placement, concerns for pedestrians, access management, business needs, aesthetic concerns, and the environment are weighed against the need for a clear zone. During this process, trade-offs are made in an effort to optimize the benefits of the facility for all users.

In the suburban environment, there is an increased level of opportunity and benefit when providing a clear zone. However, right of way constraints might still exist, and the ability to provide a wider clear zone can be reduced by concerns for business, pedestrian, and aesthetic issues.

Roadside Elements

The potential for collisions with roadside objects and slopes is real and increases as speed, volumes, and proximity to the roadway increase. The treatment of clear roadside areas is unique to the environment in which they exist. Urban contexts, with high pedestrian volumes, differ significantly from rural contexts, where rights of way are generally more readily available and where pedestrian volumes are low. Low-speed roadways also have significant differences in the need for provision of clear roadside areas, when compared to high-speed locations. In locations where the competing needs predominate, clear zones will not be met, and in these cases the reasoning behind selection and location of objects within the roadside environment should be documented. Exhibits V-4.6 and V-4.7 show examples of fixed objects that are located within the clear zone.

The following sections discuss the general concepts and elements often found within the roadside environment. The information included is not intended to be an exhaustive list, but serves as an introductory discussion.

Exhibit V-4.6 – Fixed Object in Design Clear Zone (Location: Lakewood, WA)

Clear Zone

A clear roadside border area is a primary consideration when analyzing potential roadside and median hazards. The intent is to provide as much clear, traversable area as practical for a vehicle to recover. The Design Clear Zone is used to evaluate the adequacy of the existing clear area and proposed modifications of the roadside. When considering the placement of new objects along the roadside or median, evaluate the potential for impacts and try to select locations with the least likelihood of an impact by an errant vehicle.

Exhibit V-4.7 – Additional Fixed Objects in DCZ (Location: Stevenson, WA)

Side Slopes

Transportation facilities cross nearly every type of terrain, and therefore create locations with cut and fill slopes along the roadside. These types of slopes are less frequently encountered in the more urban contexts, and more often found in the rural corridor contexts. Because fill slopes that are steeper than 4H:1V can present significant difficulties to vehicles that run off the roadway and attempt to regain control, these slopes may require removal or mitigation. If flattening the slope is not feasible or cost effective, the installation of a barrier might be appropriate. Cut slopes may provide relatively smooth redirection to errant vehicles, and are usually less of a hazard than the traffic barrier that might be used to shield the slope. The exception is a rock cut with a rough face that might cause vehicle snagging.

Exhibit V-4.8 – Examples of Fixed Objects

- Wooden poles or posts with a cross sectional area greater than 16 square inches and no breakaway features
- Non-breakaway steel signposts.
- Non-breakaway light standards
- Trees that have a diameter of 4 inches or more, measured at 6 inches above the ground surface
- Fixed objects extending above the ground surface by more than 4 inches (for example, boulders, concrete bridge rails, piers, and retaining walls)
- Existing guardrail that does not meet the current design level
- Drainage items, such as culvert and pipe ends (road approach)
- Mailboxes located within the Design Clear Zone, which do not have the appropriate supports and connections
- Open culvert ends located on a roadway side slope (cross culvert) within the Design Clear Zone

Water

Water can be a valuable visual resource for a community, and featuring a natural waterway or a naturalized stormwater facility along a transportation facility may enhance the visual and environmental qualities of the project area. When water has a depth of 2 feet or more and is located within the designated clear area, there are safety concerns associated with the potential for drowning, particularly for the motorized users who may become trapped inside submerged vehicles. Design considerations for these conditions will depend on the context of the project, as well as the roadway and user characteristics, and should be evaluated on a project-by-project basis. Consideration should be given to the speed of the facility; the length of the roadway in proximity to the water body; the depth and swiftness of the water; and the distance and orientation to other features, such as roadway curves.

Fixed Objects

Within the various contexts that transportation projects develop, there are likely to be many objects that are classified as fixed objects, according to the WSDOT *Design Manual*. Exhibits V-4.6 and V-4.7 show fixed objects in the right of way and Exhibit V-4.8 lists examples of fixed objects.

The reason why fixed objects are considered for mitigation when in close proximity to transportation facilities is that, when struck by moving objects such as vehicles, they induce deceleration that may cause significant damage to the vehicles and injury to the vehicle occupants involved. The manner in which these elements are treated depends on the specifics of the context in which they exist or are planned.

For example, in the high-speed rural corridor context, elements such as non-breakaway poles, culvert ends, and mature trees may be inappropriate along the roadside without some measures taken to mitigate their impact, given the occurrence of a collision. However, in the more urban contexts with different driver/user characteristics, and lower associated vehicular speeds, these same elements may not require the same type of mitigation.

Hazard Mitigation Methods

Once the appropriate Design Clear Zone has been selected and all obstacles that are potential hazards have been identified, project development staff needs to consider mitigation measures from the following menu (in order of preference, while considering the speed, function, and context of the facility.)

1) Removing obstacles
2) Relocating obstacles
3) Making obstacles crashworthy
4) Shielding obstacles
5) Delineating obstacles

The selection of appropriate mitigation measures depends on the probability of an accident occurring, the likely severity, and the available resources that affect roadside issues. As suggested in the previous discussion, it is evident that the type of mitigation feasible within a specific project will depend on the context in which it is being developed. Thus, the mitigation measures taken in an urban center may be significantly different from those used in a rural connecting corridor. In many low-speed environments in the urban context, mitigation will be limited, since alternatives may not be available. However, the goals remain the same: to lower the probability of accidents occurring, and reduce the severity of the accidents that do occur, wherever possible. The potential solutions for any given location may be numerous, and benefit/cost and other trade-off analysis methods can be helpful in selecting an appropriate measure.

Exhibit V-4.9 – Guardrail System (Location: SR 410, Mather Memorial Highway, WA)

If the obstacle cannot be removed, relocated, or made crashworthy, or if there is some desire to maintain the object (for physical or economic reasons), the obstacle should be shielded whenever possible. There are numerous options for shielding; however, two main types are generally used – longitudinal barriers and attenuators.

Longitudinal Barriers

It is important to recognize that barriers themselves are a hazard (this is why “Shielding” is ranked 4th in priority for hazard mitigation the list above). Use of a barrier is intended to shield the hazard(s) while: (1) using the most forgiving barrier possible, and (2) keeping it as far away from the traveled way as possible. These two goals address both the probability of hitting the barrier and the severity of the accident. In the urban environment with limited space, the use of a longitudinal barrier might not be feasible. This is because of the space required for the device itself and the deflection characteristics of the barrier.

Exhibit V-4.10 –Cable Median Barrier (Location: I-5, Tacoma, WA)

Common types of longitudinal barriers are concrete barriers, guardrails, and cable barriers. These systems are shown in Exhibits V-4.9 to 11. Each of these barriers has different maintenance and operational requirements. In general, concrete barriers are used in situations where the roadway requires a barrier with lower maintenance requirements. Where maintenance requirements are less of a concern, W-beam guardrail or cable barriers are options. Cable barriers may deflect a significant distance when struck (up to 12 feet). This requires clear width to be provided behind the barrier system. Although the deflection characteristics may limit its use, cable barriers often result in lower accident severity because of the cable flexibility.

The typical barriers described above are commonly used on high-speed highways at the full design level, and on lower-speed

Exhibit V-4.11 – Low Profile Concrete Barrier (Location: SR 99, Des Moines, WA)

Exhibit V-4.12 –Impact Attenuator Protecting the End of a Low Profile Barrier (Location: SR 303, Bremerton, WA)

and lower design-level facilities along rural corridors. Within the urban, suburban, and town center contexts, it may be desirable to use more aesthetic barriers than the ones listed above. A low-profile barrier may not create as significant a visual impact, but will still provide the safety benefits needed in many urban and suburban locations. Exhibit V-4.11 shows an example of such a barrier system in Des Moines, Washington.

In some instances, it may be worthwhile to investigate the development of aesthetic barriers unique to the specific context. The use of roadside barriers and guardrails may not be practical in many urban locations where access is common and right of way is limited.

For more information on barriers, see the WSDOT *Design Manual*, Chapter 710.

Attenuators

Attenuators are generally used to shield obstacles that are located between traveled ways or very near to the traveled way. Typically, attenuators are used in both rural and urban corridors where there is not room for other types of barrier or terminals. Attenuators are not common in downtown core areas where speeds are lower. Like longitudinal barriers, there are a number of different types of attenuators (also known as crash cushions). Attenuators vary in size to accommodate different design speeds. Attenuators are also used to shield the ends of longitudinal barriers. Exhibit V-4.12 shows an impact attenuator that protects the end of a low profile barrier. For more information on impact attenuator systems, see the WSDOT *Design Manual*, Chapter 720.

Balancing Considerations

All jurisdictions require the provision of safe facilities for motorists, pedestrians, and bicyclists. The intended result of providing safety on the roadway and roadside is to minimize the probability and reduce the severity of a collision involving any of these road users.

Over the course of time, most roadways change in terms of purpose, associated speed, traffic characteristics, and many other variables along the length of the facility. In addition, roadside conditions also change. Given these variations, accident likelihood and severity will also vary. It is, therefore, appropriate to expect that the level of roadside safety expenditure and design effort will vary, given the unique characteristics of a facility.

From a roadside safety perspective, the ideal highway has roadsides and median areas that are flat and unobstructed by hazards. Although many roadways have some available clear area along the roadside for errant vehicles to recover, roadways often can benefit from more. The constraints of an urban setting frequently do not allow for this ideal scenario to exist or to be provided. The urban environment is likely to exhibit different characteristics along the way – businesses to the curb line, main street beautification treatments, transit facilities, street furniture, sidewalk cafes, and other similar treatments. These treatments may assume the form of fixed objects, but when weighed against the benefits they provide, may still be acceptable. This presents a difficult challenge between balancing the safety needs of motorized and non-motorized users and the cultural, business, and aesthetic desires of a community.

Project staff should explore opportunities to balance or communicate the need to pursue one direction over the other to users and other stakeholders, and understand the impacts of the solution. The solution in these cases is to optimize benefits to the greatest extent possible. It will be necessary to make trade-off decisions in these efforts.

Governing Regulations and Directional Documents

Bridge Design Manual, WSDOT, M 23-50.

Dangerous Objects and Structures as Nuisances, *Revised Code of Washington* (RCW) 47.32.130.

Design Manual, WSDOT, M 22-01.

The Guide for Planning, Design and Operation of Pedestrian Facilities, American Association of State Highway and Transportation Officials (AASHTO), Washington, D.C., 2004.

Highway Safety Design and Operations Guide, AASHTO, Washington, D.C., 1997.

Jurisdiction, Control, RCW 47.24.020.

Limited Access Facility, RCW 47.52.010.

Local Agency Guidelines, WSDOT, M 36-63.

A Policy on Geometric Design of Highways and Streets, 4^{th} ed. (Green Book), AASHTO, Washington, D.C., 2001.

Roadside Manual, WSDOT, M 25-30.

Rules of the Road, RCW 46.61.

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

Task Force for Roadside Safety, *Roadside Design Guide,* AASHTO, Washington, D.C., 2002.

This page intentionally left blank

Introduction

The design of intersections requires an understanding of traffic operations and design. Intersections are designed to be as simple and predictable as conditions allow, facilitating appropriate expectations from drivers and non-motorized users of the roadway. The designer applies both experience and creativity to meet this need. The users of the intersection are often a diverse mix of groups, including passenger vehicles, heavy vehicles of varying classifications, bicyclists, and pedestrians. The designer is also faced with environmental and right of way considerations on many projects. The ultimate task is to balance the needs of the users; provide for a safe and efficient system; be a steward of the environment; and take as little right of way as possible. This chapter describes specific considerations for intersection design, control, and operations. Interchanges are not included as part of the discussion; the reader is referred to the WSDOT *Design Manual* for design considerations for interchanges.

Purpose and Need

The purpose of intersections is to provide the safe and efficient movement of all users of the intersection, including pedestrians, bicyclists, persons with disabilities, trucks, passenger cars, and other expected users. To do so, intersection design incorporates the following basic elements:

- Providing adequate capacity during peak-hour conditions
- Providing for the safe negotiation of all users through the intersection, which includes adequate space, minimizing conflict points, etc.
- Providing adequate lighting
- Providing appropriate access to the rest of the road network and facilitating safe access to adjacent properties
- Providing adequate control and signing for all users of the intersection
- Providing adequate warning about special features or conditions that require higher levels of attention than what is normally expected
- Minimizing delays, pollution, emissions, and adverse effects on the environment, adjacent properties, and the connecting road network
- Providing adequate drainage

Design Considerations

At an intersection, two or more roadways cross or join. These points of intersection provide access to the surrounding road network, and are designed to safely and efficiently accommodate a variety of conflicting movements. Intersections are an important part of roadway design for vehicles and non-motorized users alike. These controlling locations assign right of way to road users through individual or concurrent phases or, in the case of roundabouts, through yield control. Traffic characteristics, the needs of various users, physical features, and economics are considered during intersection design. Intersections are designed so that the physical features will minimize possible conflict between users, enhance safety, and provide efficient mobility and accessibility. Trade-offs that may be considered when working to minimize conflicts between users include: sidewalk, lane, and shoulder width; pedestrian crossing distances vs. lane/shoulder; and auxiliary elements (e.g., turn lanes, bike lane, HOV lanes). Refer to Division III for a discussion of the different road users that can be expected at intersections. There are various considerations when designing an intersection, which are summarized by AASHTO[1] as follows:

Elements to Consider During Intersection Design	
Human Factors (driver, pedestrian, or bicyclist)	• Movement habits • Ability of users to make decisions • User expectancy • Decision and reaction time • Conformance to natural paths of movement
Traffic Considerations	• Design and actual capacities • Design-hour turning movements • Size and operating characteristics of vehicle • Variety of movements of all users (diverging, merging, weaving, and crossing) • Vehicle and pedestrian speeds • Transit involvement • Crash experience • Bicycle movements • Pedestrian movements
Economic Factors	• Cost of improvements • Effects of controlling or limiting rights of way on abutting residential or commercial properties where channelization restricts or prohibits vehicular movements • Energy consumption

[1] AASHTO, *A Policy on Geometric Design of Highways and Streets*, 2001.

Physical Elements	• Character and use of abutting property • Vertical alignments at the intersection • Sight distance • Angle of the intersection • Conflict area • Speed-change lanes • Geometric design features • Traffic control devices • Lighting equipment • Safety features • Bicycle traffic • Environmental factors • Crosswalks
Functional Intersection Area	• Distance that the intersection influences the traffic • Storage for queue generated for each movement at the intersection • Traffic progression

In the sections that follow, traffic considerations, functional area of intersections, and physical elements will be discussed in further detail.

Considerations for Intersections

In this section, three elements for consideration are discussed: traffic management, access control, and intersection spacing. Traffic control is discussed in a separate section of this chapter.

Traffic Management

Intersection traffic management is the process of moving traffic safely through intersection areas of potential conflict. Traffic control devices, channelization, and physical layout are the primary tools used to establish intersection traffic management. Exhibit V-5.1 lists the four objectives to intersection traffic management that can greatly improve intersection operations.

Exhibit V-5.1 – Traffic Management

- Maximize intersection capacity
- Reduce conflict points
- Assign right of way
- Consider non-motorized users

Maximize Intersection Capacity

Since two or more user paths cross, converge, or diverge at intersections, the capacity of an intersection is normally less than the roadway between intersections. Solutions such as: prohibiting some movements; adding lanes and queuing space for heavier movements (and to separate movements); adding transit facilities; and proper right of way assignment can increase intersection capacity.

Reduce Conflict Points

Conflict points are created when traffic paths cross, converge, or diverge. The potential for accidents increases at conflict points. Establishing appropriate controls can reduce the probability of accidents occurring because they separate conflicting movements by time. Applying appropriate controls that allow for protected pedestrian movements can also reduce pedestrian accident

Exhibit V-5.2 –Intersection with Limited Pedestrian Accessibility (Location: Pierce County, WA)

Exhibit V-5.3 – An Elderly Pedestrian at an Uncontrolled Intersection (Location: Newport, WA)

potential. Reducing pedestrian exposure time and crossing distance also reduces conflicts.

Assign Right of Way

It is usually necessary to assign right of way through the use of traffic control devices to reduce the possibility of two users attempting to occupy the same space at the same time, and to maximize capacity for all users of the intersection. Traffic on major routes is given the right of way over traffic on minor roadways, to increase intersection operational efficiency.

Consider Non-motorized Users

The travel paths for non-motorized users are typically parallel to the roadway, and perpendicular at crossing locations. Designing facilities with non-motorized users in mind will help ensure that the needs of non-motorized users are taken into consideration, the result of which is an improved facility for all users. It is desirable to consider the special needs associated with communities that have higher populations of elderly people, people with disabilities, or small, unsupervised children. The slower movement of some elderly and disabled persons often results in longer pedestrian crossing signal phases. A high density of children may create a desire for signalized mid-block pedestrian crossings.

Adjacent land use and future land use can provide valuable information regarding the expected non-motorized users. This information can be obtained from city, county, and regional planning organizations.

Exhibit V-5.2 illustrates an impeded pedestrian path. The crosswalk terminates near objects that might restrict pedestrian movement, particularly for pedestrians with disabilities.

Access Control

An intersection is an access on a corridor and, as such, forms part of the access management of the corridor. For example, access management strategies, such as fixed medians in sections adjacent to the intersection, can require provision for U-turn movements.

Intersection Spacing

The spacing of intersections is critical for the safety and operations of a corridor. Adequately spaced intersections provide for coordination of traffic signals that result in a reduction in delays, emissions, and conflict points along the corridor.

Functional Intersection Area

The functional intersection area differs from the physical areas of the intersection in that it extends downstream and upstream of the physical intersection area, and it includes auxiliary lanes and the associated channelization. It is calculated by incorporating the perception reaction distance, the queue storage area, and the maneuvering distance. The influence area of the intersection represents the area where the driver and other road users are primarily busy with the tasks associated with the intersection itself, and where additional demand is likely to lead to driver overload, and possibly result in errors. It is for this reason that access points are not desirable within the functional area of intersections.

Traffic Control and Signing

Traffic control devices are signs and signals used to assign right of way. The type of intersection control selected will depend on the peak-period traffic volumes of the main line and side streets. The options for traffic control at intersections are as follows:

Intersection Control

- No control
- Yield control or stop control on the minor roadway
- All-way stop control
- Signal control
- Alternative control devices

Exhibit V-5.4 – Uncontrolled Intersection (Location: Lacey, WA)

No Control

Intersections are conflict points, and uncontrolled intersections are appropriate only at low user volumes, as on residential streets (like the one shown in Exhibit V-5.4). A user approaching the intersection must be able to see enough of the other legs to determine if it is safe to cross or turn; slow down; or stop to yield to another user that reached the intersection approach first.

Exhibit V-5.5 – Yield Control (Location: Lacey, WA)

Yield and Stop Control on Minor Roadway

Yield signs assign right of way without requiring the other user to stop. Users on the minor roadway approaching a yield sign must be able to see enough of the other legs to determine if it is safe to enter the intersection. If it is safe, the users on the minor roadway may proceed without stopping; otherwise, they must wait until it is safe to proceed. Users on the main roadway may pass through the intersection uninterrupted. Yield signs are most common at the merge of turning roadways at intersections. Exhibit V-5.5 shows yield control at the roundabout on Marvin Road in Lacey.

Stop control on the minor roadway is the most common intersection control on state routes.

All-Way Stop Control

All-way stops are used at intersections with approximately equal traffic volumes on the intersecting roadways. Other considerations include the need to control left-turn conflicts, the need to control vehicle-pedestrian conflicts, and the inability of a user to see conflicting traffic. All-way stops may also be used as interim measures when traffic signals are justified.

Signal Control

Traffic signals are used to alternate the assignment of right of way to the various movements at an intersection, including pedestrians. When properly designed, located, operated, and maintained, they provide an orderly flow of traffic and movement, increase the capacity of the intersection for all modes, reduce the severity of accidents at the intersection, and interrupt heavy traffic to allow cross traffic to use the intersection. Also, when coordinated with adjacent signals, they can provide nearly continuous movement of traffic along a route. Exhibit V-5.6 illustrates a signalized intersection with six signal heads and pedestrian crossing signals in SeaTac, Washington. When improperly designed, located, operated, or maintained, traffic signals can cause excessive delay, increased violation of the signal indications, increased use of other routes to avoid the signal, and increased frequency and severity of traffic accidents.

Exhibit V-5.6 – Signal Control (Location: SeaTac, WA)

In the urban environment there can be concerns with the allowed spacing of intersections along state routes. The standard requires a minimum distance of 0.5 mile between consecutive signalized intersections.

This minimum spacing (or more) allows for the coordination of traffic signals on a corridor, resulting in a significant reduction in delays, stops, and emissions. It also improves the safety of the corridor and driver expectancy. A signal spacing that is substandard (i.e., closer than 0.5 mile) is very likely to be missed by a driver and the driver will fail to negotiate the intersection safely.

The benefits of closer signal spacing (while meeting the 0.5 mile minimum spacing) include:

- More controlled crossing opportunities for both pedestrians and vehicles.
- Better grouping (platooning) of vehicles through intersections to improve progression along corridors.
- Improved cross-traffic flow along a corridor.

The disadvantages of closer signal spacing (while meeting the 0.5 mile minimum spacing) may include:

- Increased travel time and congestion along a corridor.
- Induces road users to less appropriate routes.
- Increased rear end accident potential from stopping and starting vehicles.

Within urban areas and business districts, which have a heavy mix of vehicle and pedestrian traffic, designs become increasingly difficult. This difficulty is caused by the limited crossing opportunities and the fact that most crossings are at-grade. In some areas of heavy pedestrian and bicycle use, there is a need to consider using pedestrian-demand signal control and bike-actuated signals.

Exhibit V-5.7 – Five-Lane Urban Highway Inhibiting Safe Pedestrian Movements (Location: SR 99, Shoreline, WA)

Busy arterials in dense urban zones may become barriers separating neighborhoods and business districts. Neighborhood facilities, such as parks, schools, libraries, markets, and bus stops, can become difficult to access. This is particularly true on high-volume, multiple-lane facilities (as illustrated in Exhibit V-5.7, along SR 99 in Shoreline).

In addition, roadways with two or more lanes in each direction might find the multiple-threat scenario for pedestrians (closest lane of traffic stops, while second or third lane continues without sight of the pedestrian) to be of great concern. While some might suggest that the worst pedestrian crossing locations should be closed, this issue is usually controversial and oftentimes ineffective, since pedestrians will continue to cross at these locations. Signalized crossings are a possible compromise, if they maintain reasonably safe crossing conditions for both vehicles and pedestrians.

Current WSDOT policies and access management administrative code require a minimum of 0.5 mile between signals. Many pedestrians are reluctant to walk a great distance to use a marked and signalized location. Short distances, such as 0.25 mile spacing, are considered too far for some pedestrians. For those pedestrians, the choice of crossing is generally related to the shortest path between the origin and destination, and mid-block crossings will often occur. This element should be considered when designing roadways and pedestrian facilities. While closer signal spacing may be appropriate in the urban downtown context, on high-speed facilities, close spacing increases stopping of main line traffic, and can increase rear end accidents and difficulties in coordination of signals.

Alternative Control Devices

Additional methods of intersection control have been used in the United States, including roundabouts and median U-turns. These intersection types may present their own challenges or unique solutions to handling the variety of users present.

Exhibit V-5.8 – Two-Lane Roundabout (Location: Lacey, WA)

Roundabouts

Modern roundabouts are typically at-grade, circular intersections, as illustrated in Exhibit V-5.8, though the exact configuration may vary. Yield control is used on all the approaches. They can be an effective intersection design that could result in fewer conflict points, lower speeds, and easier decision-making than conventional intersections. Roundabouts generally require less maintenance than traffic signals and have been found to reduce fatal and severe injury accidents, traffic delays, fuel consumption, and air pollution. A roundabout is designed to force traffic passing through it to slow. This slowing adds to the reduction in fatal and severe injury accidents. Traffic passes through a roundabout by merging with and diverging from the traffic in the roundabout. This does not form the platoons associated with a traffic signal and traffic will be more evenly distributed. However, the gaps used by traffic to enter or cross the major street at minor intersections downstream, are also eliminated.

Exhibit V-5.9 –Directional Sign (Location: SR 510, Lacey, WA)

Lanes can be added in a roundabout to increase the capacity. However, added lanes are not necessarily needed between the intersections, because the intersection area required for a roundabout is larger than that for a signal, and platoons are not formed by traffic passing through. (To add capacity to a *signalized location*, lanes are added to the roadway, normally requiring the roadway distance between the intersections to be increased to allow for the platoons formed by the signal.)

Modern roundabout design includes a diameter that constrains circulating speeds; raised splitter islands that slow down entering vehicles; and a yield-at-entry point, which requires entering vehicles to yield and allow circulating traffic to flow freely.

Overall, accident rates and severity are lower at roundabouts than other intersection types. Injury accident rates are generally lower, although the proportion of single-vehicle accidents is typically higher. Bicyclists and pedestrians are also involved in a relatively higher proportion of injury accidents at roundabouts than they are at other intersections.[2]

When operating within their design traffic volume, roundabouts normally operate with fewer vehicle delays than other intersections. With a roundabout, it is unnecessary for traffic to completely stop when no other vehicles are approaching, or when deceleration prevents a conflict. When there are queues, traffic within the queues usually continues to move, and this is typically more tolerable to drivers than a stopped queue. The performance of roundabouts during off-peak periods is particularly good, in contrast to other intersection forms, typically with very low average delays.

Roundabouts tend to treat all movements at an intersection equally. Each approach is required to yield to circulating traffic, regardless of whether the approach is a local street or major arterial – all movements are given equal priority. This might result in more delay to the major movements than is desirable.

Roundabouts can provide environmental benefits if they reduce vehicle delays and the number and duration of stops, in comparison to a traditional intersection design. Even when heavy volumes exist, users within a roundabout continue to advance slowly in moving queues rather than coming to a complete stop. This reduces noise, air quality impacts, and fuel consumption by reducing the number of acceleration/deceleration cycles and the time spent idling.

Exhibit V-5.10 – Center Islands With and Without Landscaping (Locations: Bethel Ave/SR 166/Mile Hill Drive and SR 203/ Novelty Hill Road, Duvall, WA)

Roundabouts usually require more space within the intersection for the circular roadway and central island than traditional intersections, and often have a significant right of way impact at the intersection. If a signalized location requires long or multiple turn lanes to provide sufficient capacity or storage, a roundabout with similar capacity might require less space on the approaches. As a result, roundabouts might reduce the need for additional right of way on the roadways between intersections.

At interchanges in urban areas, intersections are typically signalized at both ramp terminals. This generally requires additional lanes between the intersections to provide capacity and storage. At ramp terminals, roundabouts have been used to reduce the number of lanes crossing the freeway. This benefit has been achieved because of the increased capacity of the roundabout.

Landscaping and other objects placed in the center of the roundabout can reduce visibility and be considered fixed objects. Care should be taken in the placement of these objects to provide appropriate sight distances and clear zone. Exhibit V-5.10 illustrates two conditions: the upper photograph shows a roundabout with landscaping in the center island, and in the

[2] Persaud et al., *Safety Effects of Roundabout Conversions in the US*, 2001.

lower photograph, there is no landscaping in the center island of the intersection.

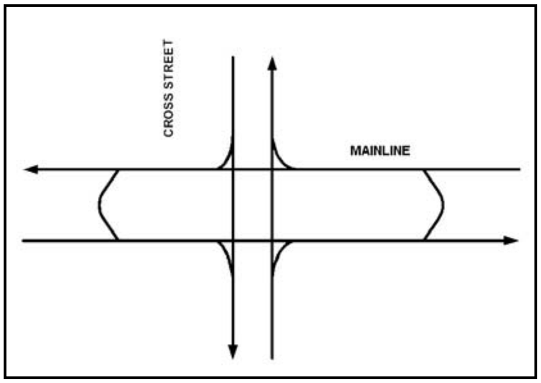
A roundabout does not have signal equipment that requires power, periodic light bulb and detection maintenance, or signal timing updates. However, depending on the landscaping provided on the central island, splitter islands, and perimeter, roundabouts can have higher landscape maintenance costs.

In addition to roundabouts, there are a number of unique intersection designs that can improve the operation and safety of an intersection. These designs use U-turns, connecting roadways, and grade separations to remove or separate some of the movements; however, these applications are not appropriate in all situations. As with all considerations within this document, each design characteristic should be evaluated in the context of its specific setting and unique needs.

Median U-Turn

Exhibit V-5.11 shows median U-turn facilities on a corridor. U-turn roadways are provided at some distance from the intersection as part of an access management strategy to limit left turns at a particular location. U-turns therefore provide the opportunity to carry out the turning movement at alternative locations that will be closer than the nearest intersection or where U-turns at the nearest intersection are prohibited due to safety considerations such as sight distance. The influence area of the intersection should be considered when determining U-turn location(s).

Exhibit V-5.11 – Median U-Turn (Source: WSDOT)



With this type of median U-turn configuration, left turns may not be allowed from either roadway. Instead, to turn left from the main line, a user must go through the intersection, make a U-turn at the U-turn roadway, return to the intersection, and turn right. Likewise, left-turning traffic from the cross street must turn right onto the main line, proceed to the U-turn roadway, and execute a U-turn. Both of these movements require weaving between the intersection and the U-turn roadway. This intersection configuration may be used in combination with a traffic signal.

Median U-turns can present difficulties for bicyclists because they require bicyclists to cross the lanes of through traffic to maneuver from the bike lane toward the U-turn road. Also, if the intersection is not signalized, pedestrians can face difficulties crossing the traffic stream.

When a raised median divides a facility, it may be appropriate to provide opportunities for vehicles to execute U-turns to increase access. U-turn roadways or lanes may be used at mid-block locations along divided corridors. Generally, a mid-block U-turn lane consists of a lane introduced within the existing median that allows for U-turns from one or both directions of traffic. To accommodate the wider turning path of larger vehicles, it is appropriate at times to provide additional room along the outside shoulder of the lane into which traffic is being turned. Consideration must be given to the ability of the turning vehicle to see and be seen by approaching vehicles.

Physical Intersection Features

In this section, the following intersection design elements are discussed in further detail:

- Sight Distance
- Approach Angle
- Alignment
- Corner Clearance
- Roadside Features
- Drainage Features
- Channelization

Sight Distance

For safe and efficient travel on a roadway, all users need to have adequate sight distance to see the road ahead, as well as to see other users. The required sight distance is controlled by the design speed of the roadway and the specific needs at the location being considered. Sight distance needs can be divided into three groups: stopping sight distance, decision sight distance, and intersection sight distance.

Exhibit V-5.12 – Sight distances
- Stopping sight distance
- Decision sight distance
- Intersection sight distance

Stopping Sight Distance

The distance needed for a driver to see a hazard, recognize it as a hazard, and safely stop the vehicle. Stopping sight distance is required at all locations, on all roadways. It influences the vertical alignment and the placement of objects on the inside of horizontal curves and depends on the speed of the vehicle. Sight distance is calculated for a motorist in a passenger car viewing and recognizing an 18-inch object. Cities and counties typically use a 2-foot object height in sight distance calculations. WSDOT uses a 6-inch height, but may allow 2 feet based on the needs of the location. The larger the object, the less sight distance is required to see the object.

Decision Sight Distance

The distance needed for users to make decisions and execute appropriate maneuvers at complex locations in a safe manner. Decision sight distance is used where there are roadside uses and activities, or design elements that require time for the driver to make a correct decision and carry out a maneuver (such as when faced with a lane reduction requiring a merge).

Intersection Sight Distance

The distance a user needs to safely enter or cross another roadway. The type of traffic control at the intersection determines the intersection sight distance:

- At uncontrolled intersections, users on all legs must be able to see a potential conflict approaching on one of the other legs in time to stop before the intersection.
- Intersections with yield control have similar requirements, except intersection sight distance, which is only required for the legs with the yield.

- At two-way stop-controlled intersections, users at the stopping point need to be able to see an approaching user at the gap-acceptance distance from the intersection. The gap-acceptance distance (expressed in seconds) is the distance an approaching vehicle must be away, for a driver to be comfortable entering the intersection from a stop. The gap-acceptance times vary with movement (turning or crossing), number of lanes, width of median, and grade.
- At a four-way stop, drivers only need to be able to see the first user stopped at each of the other legs.
- Where traffic is controlled by a traffic signal, the first user waiting at the light should be able to see users that stopped at the other approaches. This is the same for the left-turn lane, when there is a left-turn signal; when there is not a left-turn signal, left turns are treated the same as left turns from a major roadway. When right turn on red is permitted, it is treated the same as right turns at two-way stops.
- For left turns and U-turns from a major roadway (where traffic control is non-existent in the opposite direction), the sight distance is controlled by the gap-acceptance distance, similar to the two-way stop.
- In urban areas, drivers are more attentive than in rural areas, so shorter perception/reaction times can be used in sight-distance calculations.

Exhibit V-5.13 – Lack of Intersection Sight Distance (Location: Pierce County, WA)

The distance that a user can see is influenced by the position of the user on the roadway, the vertical and horizontal distances, the height of the object that needs to be seen, and the size and location of sight obstructions. At intersections, the stopping distance is determined by the distance a driver needs to see to stop at the intersection, and by the distance from which a driver must make the decision to stop or enter the intersection. Exhibit V-5.13 shows limited intersection sight distance in Pierce County.

The urban environment may present a larger challenge in terms of providing sight distance when compared to more rural areas, because of the proximity of buildings, trees, parking needs, and other features of the roadway.

Approach Angle

The use of 90-degree approach angles is desirable. Skew intersections reduce sight distance for drivers; present difficulties to older drivers due to a reduced ability to look over the shoulder for approaching traffic; and increase the distance for a pedestrian to cross (increasing exposure and therefore reducing the safety of the pedestrian).

Alignment

An alignment as flat as practical is preferred for intersections. This allows users to see the intersection and other road users and act appropriately. Where site conditions allow, it is desirable to have intersection and queuing areas that are as level as possible.

The combination of horizontal and vertical curves at or near intersections is not recommended as these elements greatly reduce the ability of the driver to react appropriately. Proper sight distance is also important at these intersections.

Corner Clearance

The design of an intersection requires that the needs of all users be identified and addressed, whenever possible. With right-turn corners, there can be competing design objectives when providing for the design vehicle and the crossing requirements of the pedestrian. When a large radius is allowed, large trucks are better able to make turns. However, vehicle speeds increase and the pedestrian crossing distance is extended. Where pedestrian issues are a primary concern, the design objective becomes one of reducing the potential for vehicle-pedestrian conflicts. This normally means designing with smaller right-turn radii.

Roadside Features

Refer to Chapters IV-1 and V-10 for more information on landscaping, Chapter III-3 for transit facilities, and Chapters V-4, V-7, and V-12 for roadside amenities.

Drainage Features

Drainage is critical for the safe negotiation of an intersection. Lack of appropriate drainage can increase the likelihood of reduced braking ability of vehicles and usability by pedestrians and bicyclists.

Channelization

Channelization is the separation of traffic movements into delineated travel paths through the use of pavement markings, curbs, or other suitable means. The main objectives of channelization are to facilitate the orderly movement of vehicles, bicyclists, and pedestrians; improve safety; increase capacity; and maximize convenience. Channelization achieves these objectives with one or more of the following:

- Separating traffic paths can eliminate unnecessary path overlapping and can segregate movements with different requirements. Exhibits V-5.14 and V-5.15 illustrate this concept.
- Separating conflict points can reduce the probability that a driver will be required to make more than one decision at a time.
- Reducing the angle between traffic paths at conflict points for merging and diverging can lessen the severity of the conflict.
- Providing pedestrians mid-block refuge between traffic paths can allow crossing of each traffic movement independently.
- Protecting and storing turning and crossing vehicles by allowing them to slow or stop clear of other traffic paths can reduce the number and severity of conflicts.
- Prohibiting some movements will eliminate conflict points. Only movements that have a minor demand and have an alternate route should be prohibited.
- Controlling speeds by building curves or reducing the roadway width will reduce the speeds of vehicles approaching a stop sign or crossing point, and will also

Exhibit V-5.14 – Unchannelized Left Turns with Path Overlap (Source: WSDOT)

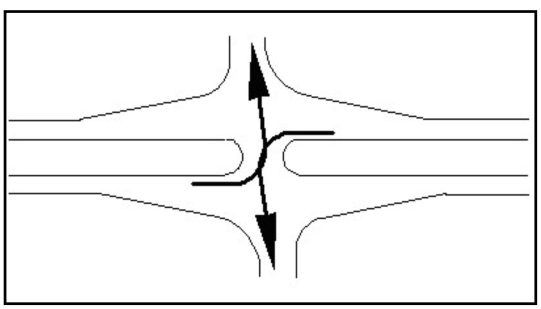
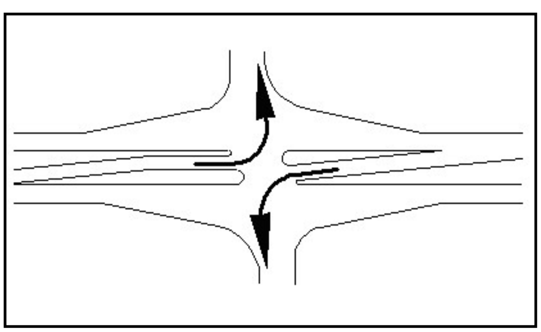


Exhibit V-5.15 – Channelized Left Turns without Path Overlap (Source: WSDOT)



decrease the speed difference between traffic streams that merge (thus reducing accident likelihood and severity).

- Reducing the pavement area caused by excessive skew and large corner radii might lessen the probability of confusion and erratic maneuvers, reducing driver error and therefore producing a likely reduction in the probability of accidents.
- Installing traffic control devices, such as stop signs and traffic signals in the optimum positions, can improve driver expectancy and therefore reduce driver error.
- Left-turn and right-turn lanes are forms of channelization that can be added to improve the efficiency and safety of intersection vehicles, by removing the turning vehicles from the through lanes. (However, they can have a negative impact on the safety and efficiency of pedestrians and bicyclists using the intersection.) Vehicles making left turns frequently have to wait for a gap in opposing traffic before completing their turn. A left-turn lane allows the wait to occur outside of the through traffic stream, reducing delays to through traffic and lessening the probability of a rear end accident. Right turns are less likely to require a stop before completing the turn; however, they can still influence the operation of the intersection. Right-turn lanes allow turning vehicles to complete some or all of their deceleration outside of the through lanes. Turn lanes without adequate storage will impact and reduce through traffic movement capacity.

Accessibility

Intersections provide pedestrians with crossing opportunities and, therefore, necessitate consideration of accessibility, as required by the ADA of 1990. These considerations allow people with disabilities to enjoy the same level of access as that provided to others using the facility, and also assist in the movement of pedestrians using strollers, etc.

Any intersection that provides access to pedestrians has to be made accessible. This entails inclusion of a properly designed curb ramp that includes a level landing area, cross slopes no more than 2%, and ramp slopes no more than 8.3%. Detectable warnings at the bottom of the curb ramp allow for persons with visual disabilities to distinguish between the pedestrian area and the roadway itself, and are legally required for all new construction and alteration projects. Where possible, the provision of accessible pedestrian signals with auditory and tactile information allows persons with disabilities to safely negotiate a signalized intersection. This is also recommended for marked mid-block crossings.

Complex intersections can create particular accessibility problems and it is therefore desirable that designs be kept as simple as possible.

Refer to Chapter III-1 and the ADA Accessibility Guidelines (ADAAG) for the legal minimum standards for accessibility. Although the U.S. Access Board published new accessibility standards in July 2004 (ADA/ABA-AG), FHWA stated in a memorandum dated July 30, 2004, that the existing 2002 guidelines should be used until the new guidelines are adopted by the Department of Justice and the U.S. Department of Transportation.

Balancing Considerations

Exhibit V-5.16 – Downtown Intersection with Aesthetic and Pedestrian Treatments (Location: Bellevue, WA)

There are a number of trade-offs to consider when selecting the intersection configuration that will best suit the needs of the project. Elements that affect what design will function best within the context include the traffic mix, user needs, corridor speeds, available right of way, significant differences in traffic volumes on intersecting facilities, and traffic flow. In addition to the functional considerations, there are aesthetic considerations, including what types of facilities are acceptable to the community, and desires for corridor continuity. In order to design a facility that functions efficiently for all the users within the context, it is imperative to consider all of these elements. Roundabouts are sometimes chosen to provide intersections that have high safety potential, aesthetic and environmental benefits, and high capacity. Aesthetic treatments within intersections are becoming more common, as well as the use of alternative timing schemes that provide for a greater emphasis on pedestrian needs. Exhibit V-5.16 shows a downtown Bellevue intersection with aesthetic treatments, audible pedestrian signals, and a pedestrian-only phase at a transit center.

Governing Regulations and Directional Documents

ADA Accessibility Guidelines for Buildings and Facilities (ADAAG), as amended through September 2002, U.S. Access Board, http://www.access-board.gov/adaag/html/adaag.htm

Americans with Disabilities Act, Public Law 336 of the 101st Congress, enacted July 26, 1990, http://www.usdoj.gov/crt/ada/pubs/ada.txt

Design Manual, WSDOT, M 22-01.

Memorandum: Information: Americans with Disabilities Act (ADA) Accessible Guidelines and Detectable Warnings, FHWA to Resource Center Managers, Division Administrators, and Federal Lands Highway Division Engineers, Dated July 30th, 2004, Ref. HIPA-20, http://www.fhwa.dot.gov/environment/bikeped/dwm04.htm

A Policy On Geometric Design of Highways and Streets, 4th ed. (Green Book), American Association of State Highway Transportation Officials, (AASHTO), Washington, D.C., 2001.

Division V Design Considerations
Chapter V-6 Access

Introduction

Access management programs are intended to support safe and efficient traffic operation of the road facilities. Although generally considered as a solution to issues created by vehicle access, this type of control can help all modes.

Because highways and roads are less likely to be reconstructed in the future to meet the increased vehicle demand, access management plays a critical part in the operation of a facility. Closely spaced driveways, intersections, and signals can cause an increase in collision potential for certain accident types and congestion. Access management, if done properly, can help maintain property values as well.

Requirements of Revised Code of Washington (RCW) 47.50 and RCW 47.52 dictate that access to all state highways be regulated. The Washington State Department of Transportation (WSDOT) regulates access to all state highways in order to: protect WSDOT's interest in the health, safety, and welfare of the public; preserve the functional integrity of the state highway system; and promote the safe and efficient movement of people and goods. The exception to this regulation is city streets that are also state highways, in which case cities have permitting responsibilities.

Exhibit V-6.1 – U-Turn at Intersection (Location: SR 516, Covington, WA)

Access management benefits both motorized and non-motorized travelers. Fewer access points equates to fewer conflict points and less stopping on the facilities. This reduction typically means less potential for accidents. Pedestrians can also benefit from medians that provide refuge from crossing maneuvers and reduced exposure to traffic by limiting the number of access points they must negotiate. Access control also provides for a clearer delineation of where vehicles and non-motorized users are expected. This increases driver awareness and allows for better mixing of the modes.

Access to community and business parking is not discussed in this chapter.

Definitions

Access A means of entering or leaving a public road, street or highway with respect to abutting property or another public road, street, or highway.

Access control The limiting and regulating of public and private access to Washington State's highways, as required by state law.

Backage road A street or roadway that functions similarly to a frontage street or road, but provides access to abutting properties along the sides of the street or roadway.

Conflict point An intersection point of two or more travel paths. These locations present opportunities for multiple users (motorists, cyclists, and pedestrians) to occupy the same physical location. Conflict points are usually managed by separations in time, where one user is required to wait for another. Time gaps may be controlled by rules of the road, signs, or signals.

Frontage road A local street or roadway that parallels an expressway, highway, freeway, or through street or roadway, and provides access to property near the expressway, highway, or freeway. A frontage road provides access to abutting properties along only one side.

Limited access highways All highways listed as "Established Limited Access or Planned Limited Access" on the Master Plan for Limited Access Highways, where the rights of direct access to or from abutting lands have been acquired from the abutting landowners.

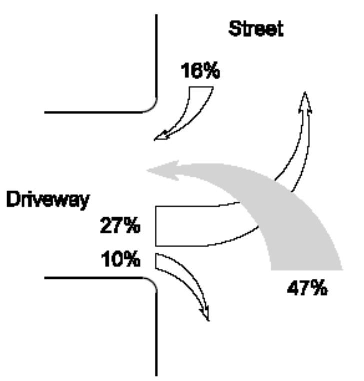
Managed access highway Any highway not listed as "Established Limited Access" on the Master Plan for Limited Access Highways, and any highway, or portion of a highway, designated on the Master Plan as "Planned Limited Access," (or, if listed as "Established Limited Access," until such time as the limited access rights are acquired) are termed managed access highways. Under managed access legislation, the property owner's access rights are regulated through an access connection permitting process.

Exhibit V-6.2 – Planted Median (Location: Kent, WA)

Purpose and Need

Numerous studies have shown that regulating and limiting access to highways and roadways is a cost-effective way to help maintain the safety, capacity, and functional integrity of the facility in many cases. Unrestricted access to and from public highways results in congestion and an increased number of conflict points for the traveler. It causes undue slowing of traffic in many areas. Adding more lanes to an existing highway or having to relocate and reconstruct a deficient highway is expensive and oftentimes not possible. Regulating access to state highways by promoting the use of frontage roads, backage roads, existing county roads or city streets, and advocating the internal shared circulation of adjacent developments, is a proactive and cost-effective way of preserving the public investment in the state highways.

Exhibit V-6.3 – Percentage of Driveway Crashes by Movement (Source: TRB Access Management Manual)



A city may also manage access to facilities that are not state highways. Developing the infrastructure to be efficient along a limited or managed access facility will not only provide the benefits previously discussed, but can also help in creating a community capable of supporting growth.

Nationally, it has been shown that elements of access management, such as raised medians (see Exhibit V-6.2) and exclusive left-turn lanes, reduce collisions relating to the movements. The reductions in collisions range from 18 to 88%.[1] Exhibit V-6.3 provides an illustration of the percentage of driveway crashes by movement.

[1] *Benefits of Access Management*, FHWA.

Limited and Managed Access Control Programs

All Washington State highways are designated as being either *limited access* highways or *managed access* highways. All towns, cities, and communities that abut or rely on the state transportation system are affected by either the limited or managed access program. Control of access is accomplished by either acquiring the right of access from abutting property owners (limited access control), or by limiting the number of connections to the highway (managed access control). Until the access rights have been acquired from abutting property owners, a route is regulated through the managed access program and is termed a managed access highway.

The use of access control will enhance the development of an effective transportation system and increase the traffic-carrying capacity of the state highway system. Access control reduces the incidences of traffic collisions, personal injury, and property damage or loss. It mitigates environmental degradation and promotes sound economic growth and the growth management goals of the state. It also reduces highway maintenance costs and the necessity for costly traffic operations measures, and lengthens the effective life of transportation systems in the state, thus preserving the public investment in such transportation systems.

Exhibit V-6.4 – Access Before and After Streetscape Redevelopment (Location: SR 99, SeaTac, WA)

Limited Access Program

The Limited Access program regulates access of abutting lands by acquiring the abutter's property right-of-access. Abutting lands either have no right or limited right of ingress or egress to a limited access highway, which is documented on the abutters property deed.

WSDOT has full jurisdiction on non-Interstate limited access highways, whether they are inside or outside incorporated town or city limits. The Federal Highway Administration (FHWA) has full jurisdiction on all Interstate highways.

Managed Access Program

WSDOT has access-permitting jurisdiction over all managed access state highways outside incorporated towns and cities. Incorporated towns and cities have access-permitting jurisdiction for the managed access state highways within their boundaries. Where an access is allowed, access connection permits are issued on managed access highways.

RCW 47.50.030(3) states:

Cities and towns shall, no later than July 1, 1993, adopt standards for access permitting on streets designated as state highways which meet or exceed the department's standards, provided that such standards may not be inconsistent with the standards adopted by the department.

The department's standards referenced here are WSDOT's Managed Access program standards.

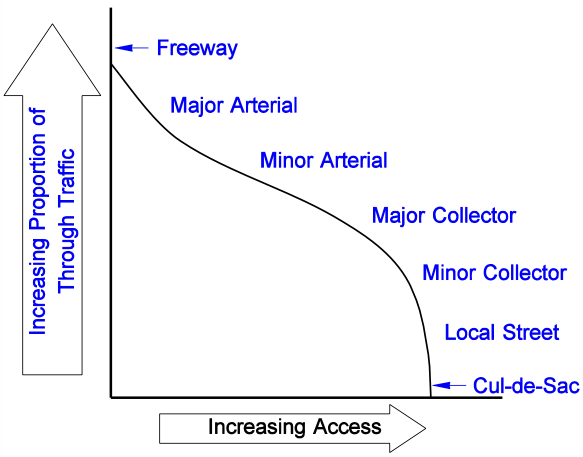
Planning Role

Access regulation coordinates land use planning decisions by local governments and investments in the state highway system. This coordination controls the proliferation of approaches and access connections to and from the state highway. Uncontrolled access to the state highway system is a contributing factor to the congestion and functional deterioration of Washington State's transportation system.

Access management programs assist in determining the appropriate vehicular access to land development. They help maintain the functional capability of the facility through the reduction of conflict points and stopping and starting on the road. This preservation is accomplished through the systematic control of the location, spacing, design, and operation of driveways, median openings, interchanges, and street and roadway connections.

Principles of Access Management

Exhibit V-6.5 – Access Functional Classes (Source: TRB Access Management Manual)



Access management programs attempt to limit and consolidate access while supporting street system purpose and need. Access management uses the following principles (based on the principles in TRB's *Access Management Manual*):

Provide a specialized roadway system – Different functional classes of roads are intended to serve a particular function. The access management on the facility should be consistent with the function of the road. Exhibit V-6.5 illustrates the different functional classes and the associated functions.

Limit direct access to major roadways – The higher the volume on the road (particularly regional traffic), the greater the potential benefit from access control. Lower levels of access control are typical on local and collector routes.

Promote intersection hierarchy – Transitions from one functional class facility to another is common and should be done to achieve the necessary change in driver behavior and actions. For instance, freeways intersect with arterials, and arterials with collectors and local streets. When the difference between the functional classes of the intersecting roadways is more than one class, operational and safety concerns are more likely.

Locate signals to favor through movements – Providing sufficient intersection spacing allows for good coordination of signal systems (thereby increasing operational efficiency) and the creation of sufficient gaps for exit movements from unsignalized driveways. Appropriate spacing allows the highest volume of vehicles to proceed and encourages pedestrians to cross at appropriate locations. Spacing of intersections should be consistent with future needs of the corridor.

Preserve the functional area of intersections and interchanges – Intersections and interchanges have areas where access to the facility is not optimal. These areas are important to the operation of interchanges or intersections. It is in these areas that critical decision-making takes place, and activities such as accelerating, decelerating, maneuvering, and stopping occur.

Provision of access points in these areas increases workload for the driver. This additional workload increases the likelihood of driver errors caused by exceeding driver workload limitations.

Limit the number of conflict points – As workload increases for the driver so does the potential for collisions. Conflict points, created by access points, lead to increased decision-making and workload. The number of conflict points increases substantially when bicyclists and pedestrians are added, unless access management features can separate road users in time or space.

Separate conflict areas – Drivers benefit from increased time for decision-making. Locating access points with sufficient distance between conflicts allows for increased perception and reaction time to potential decisions. As speed increases, so does the desire for larger spacing between access points.

Remove turning vehicles from through traffic lanes – Turn lanes allow vehicles to decelerate, stop, and wait outside of the through lane, thereby reducing potential conflict with through traffic traveling at higher speeds.

Use non-traversable medians to manage left-turn movements – Medians channel turning movement on major roadways to designated locations. Intersections provide excellent locations for turning; other potential turning locations should be selected based on their project benefits.

Provide a supporting street and circulation system – With the application of the first two principles, access points are limited on the higher-order roads that are associated with high speed and volume traffic. It is, however, necessary to provide adequate access to properties through the side road network and to consider the flow of traffic through the lower-order roads to these access points. It is therefore desirable that the supporting road network (road network around the property) supports access to the property. Such a network provides for circulation traffic through interconnect systems and, in some cases, provides alternative routes for bicyclists, pedestrians, and short trip drivers without increasing through traffic through residential neighborhoods.

Exhibit V-6.6 – Streetscape Before and After Turning Movement Definition (Location: SR 99, SeaTac, WA)

Determining and Considering the Needs of and Benefits to All Users

Transportation system users in Washington State rely on the efficient and safe operation of the transportation systems for many reasons. Communities, motorists, cyclists, pedestrians, transit riders, businesses, freight industry, tribal governments, and local, state, and federal government agencies have varying uses for and needs of streets, roadways, and highways. For some, the access points are a trip origin or destination point. For through travelers, those same origin and destination points may represent potential conflicts.

The goal of limited and managed access is to balance the apparent conflicting needs of mobility and access across the state. Without balancing these often-competing needs, our state's transportation system will be unable to function at the levels of mobility and safety necessary for our state to prosper.

Access Management Benefits to System

Access management tools help to define:

Intersections – Having appropriately spaced intersections helps to improve a transportation system's mobility and safety by allowing for better vehicular, bicycle, and pedestrian movement.

Driveways – When there is no defined location for vehicular traffic to enter and exit, the potential for collisions with other facility users increases. With appropriately spaced and clearly defined driveways, motorists have an enhanced understanding of where to access and leave the abutting property. This presents pedestrians and bicyclists with specific and defined areas where they will be competing with vehicular activity.

Sidewalks – Areas that do not have sidewalks are more difficult to negotiate for all users. Pedestrians have no area defined for their use and they are forced to walk along the shoulder, if a shoulder exists. Motorists are less likely to expect pedestrian movements if they are on a shoulder than if pedestrians are on a sidewalk. Sidewalks define areas for pedestrian activity to the other users of the transportation system.

Bicycle lanes – Providing defined bicycle lanes keeps bicycle, pedestrian, and motorist traffic from mixing. Each mode of transportation travels at different speeds, and providing each their own specified area enhances the use, safety, and attractiveness of all components of a transportation system.

Crosswalks – Defined crosswalks help highway users know where pedestrians are to be encountered. Also, allowing for mid-block crosswalks in areas where intersections are limited, aids in defining where pedestrian traffic may be crossing.

Transit pullouts – Having transit pullouts removes the transit loading and unloading operation from the through movement of traffic.

Left and U-turn locations – Defining left turn and U-turn locations, in lieu of utilizing two-way center turn lanes and left out/in movements, aids in reducing collisions.

Access Management Benefits to Users

Access management can also provide benefits to the wide range of transportation system users in the following ways:

Motorists – By creating fewer decision points, fewer traffic conflicts, and fewer traffic delays, the driving task is simplified for the motorist, resulting in increased driver safety and mobility.

Cyclists – Creating fewer decision points and fewer traffic conflicts, and by encouraging/enforcing more predictable motorist travel patterns, the cycling task is simplified, increasing the cyclists' safety.

Pedestrians – By limiting the access points where motorists enter and exit the roadway, and providing medians (which may be used as refuges by pedestrians when crossing several lanes of traffic), walking along and crossing the roadways can be safer for pedestrians.

Transit riders – By reducing travel times and delays, and providing a safer walking environment (as mentioned above), transit service can be provided to the riders more efficiently.

Freight industry – By reducing delays, increasing safety, and thus allowing shorter delivery times, transportation costs are reduced.

Businesses – With a more efficient transportation system serving them, businesses can benefit from a broader market area; stabilized property values due to well-managed corridors; and more predictable and consistent freight delivery.

Government agencies – The cost of delivering an efficient and safe transportation system is lower, resulting in a more effective method of accomplishing the agencies' transportation objectives.

Communities – By creating a safer transportation system and reducing the need for construction (which causes disruption and displacement of businesses and homes), communities benefit from a more attractive transportation corridor, while preserving their investment in the transportation system.

Balancing Considerations

The balance between the competing needs of mobility and access is not easily accomplished. The desires of local landowners and businesses are not always consistent with the desires to consolidate or remove access for safety and mobility reasons. Rules that regulate and limit access are mechanisms to consider with any access management program. It is also beneficial to set performance levels related to access, so that designers can determine properly performing locations. Consideration of access often relates to the convenience and business desires of landowners. These are intangible elements because they are developed by individual perception, but still remain very important issues to consider when weighing the provision of access against all other competing factors.

While the needs of each stakeholder should be accommodated to the fullest extent possible, it is not possible to satisfy all when developing access management strategies. Good access management is achieved when optimum balance is maintained between mobility, safety, and individual access needs, while maintaining the function and context of the route.

Governing Regulations and Directional Documents

Agreements Manual, WSDOT, M 22-99.

Design Manual, Chapter 1420: Access Control, Chapter 1430: Limited Access, Chapter 1435: Managed Access, WSDOT, M 22-01.

Highway Access Management - Access Control Classification System and Standards, *Washington Administrative Code* (WAC) 468-52.

Highway Access Management Access Permits - Administrative Process, WAC 468-51.

Highway Access Management, *Revised Code of Washington* (RCW) 47.02.

Limited Access Facilities, RCW 47.02.

Limited Access Hearings, WAC 468-54.

Limited Access Highways, WAC 468-58.

Plans Preparation Manual, WSDOT, M 22-31.

*Right of Way Manu*al, WSDOT, M 26-01.

Rules of the Road, RCW 46.61.

Utilities Accommodation Policy, WSDOT, M 22-86.

Additional Resources

Access and Hearings Engineer, WSDOT Headquarters, http://www.wsdot.wa.gov/eesc/design/access

Access Management, Transportation Research Board (TRB) Committee ADA70, http://www.accessmanagement.gov/

Benefits of Access Management, FHWA-OP-03-066, Federal Highway Administration (FHWA), Washington, D.C, (N.D.), http://www.accessmanagement.gov/pdf/BenefitsAccessMgmt.pdf

Design Office, Region Project Development Engineer, WSDOT.

Gluck, Jerome, Herbert S. Levinson, and Vergil Stover, *Impacts of Access Management Techniques*, National Highway Cooperative Highway Research Program (NCHRP) Report 420, TRB, Washington, D.C., 1999.

Committee on Access Management, *Access Management Manual*, TRB, Washington, D.C., 2003, http://www.trb.org/

Introduction

The boundaries of publicly owned property amount to physical width limits for transportation corridors. Historically, our transportation corridors have also been utilized for placement of utilities, such as electrical power, natural gas, storm sewer, sanitary sewer, or communication cables. Those utilities may be located above, below, or alongside the transportation facilities. As growth necessitates expansion of the transportation facility, it can create conflicts with right of way boundaries and utility placement.

In built-up urban environments, these conflicts are often difficult and time consuming to resolve. In the more rural environments or lesser-developed urban areas, there might be more physical space available and fewer utilities to contend with. These various contexts will no doubt lead to different solution sets. Dealing with these elements of a project will impact schedules and budgets as those solution sets are developed.

Right of Way Management

Proper management of the acquisition of additional right of way and the relocation of occupants is critical to the success of a project. A construction project cannot be advertised without a certification that the WSDOT or local agency has possession of all necessary rights of way and all occupants have been appropriately relocated.

Exhibit V-7.1 – Right of Way Availability (Location: Olympia, WA)

For a local agency to acquire property for a project, it must have procedures in place that are approved by Washington State Department of Transportation (WSDOT). The *Local Agency Guidelines* (LAG) manual provides further guidance in right of way procedures.

It is preferred that right of way personnel be involved early in the project planning stages to allow them to attend public meetings; provide scoping estimates; assist in writing portions of the Environmental Impact Statement (EIS); and to provide information on the right of way process to both project developers and the public. Right of way personnel have need for the necessary mapping and funding, as well as adequate lead-time, in order to acquire the property, without pressure to the property owners or delaying projects. If a small project requires additional right of way, a minimum of one year is necessary from receiving the approved right of way plans and project funding for the acquisition of the property. Additional time is generally desired for larger projects, because of the increased need for acquisitions and higher probability of reluctant sellers.

Right of way is required for the safety and mobility of a project, in addition to environmental and other concerns. The management of right of way is therefore critical to the success of a project. Planning for possible right of way uses, and managing that need in a proactive manner through the consideration of future land use, and short, medium, and long term transportation plans will allow for the timely detection of locations where the availability of rights of way exist and where current property is maintained, rather than surplused. This systematic acquisition of property can greatly improve the safety, mobility, and environmental concerns of the facility. This includes issues such as stormwater treatment, clear zones, and having adequate width available to implement access management measures. As such, timely acquisition of this right of way can allow for measures that would have been impossible otherwise. It will also facilitate timely decision-making regarding right of way and potentially reduce the associated cost and possible delays to the project.

If highway rights of way are to be used for a non-highway purpose, Real Estate Services (RES) researches the impacts of the proposed use on the maintenance and operation of the facility. If the department can allow the use in the right of way, RES determines the value of the land or the rental amount, and processes all of the necessary deeds or leases. Any agreement that allows a non-highway use on WSDOT property requires the signature of the Director of Real Estate Services. Exhibit V-7.1 shows an arterial street with significant right of way for all modes. Medians are provided to enhance the aesthetic value of the facility. Light fixtures are placed behind the sidewalks, improving the sidewalk width available to pedestrians.

Utilities Considerations

It is generally recognized that it is in the public's best interests for utilities to jointly use the right of way of public roads and streets, when such use and occupancy does not conflict with the provisions of any federal, state, or local law or regulation, and when it does not adversely affect the highway or traffic safety, or otherwise impair the roadway or its aesthetic qualities. As a result, the right of way of highways is often used to both serve conventional highway needs and to accommodate utilities.

Exhibit V-7.2 – Utility Impacts to Pedestrians (Location: Lakewood, WA)

Project developers need to consider to what extent and under what conditions a joint use is allowed. While the transportation agency may own drainage or other utilities, many of the most common utilities (such as telephone and power services) are not owned, nor are their operations directly controlled, by the transportation agency. Some joint uses of the right of way may have an effect on the transportation facility. For example, when aboveground utilities are suspended from poles, the poles may reduce the clear zone. Because of this, highway authorities have developed policies and practices that govern when and how utilities may use public highway rights of way. Those conditions are documented in WSDOT's FHWA-approved *Utilities Accommodation Policy*.

Utilities can be a crucial issue in the project development phase, and they are certainly a critical component to the construction phase of a project. Utility relocation is one of the main causes of project delays and additional project expenses. Lack of coordination, cooperation, and communication between transportation agencies and utility companies is generally cited as the root of the problem.

Utility staff involved at an early stage can:

- Identify utility facilities that the project might impact – both utilities within existing WSDOT right of way and utilities located on properties that might be acquired for the project.
- Notify utility companies of potential conflicts requiring facility relocation.
- Work with design staff to explore design alternatives, which can reduce or eliminate the conflict with a utility.
- Work with affected utility companies to ensure that facility relocation occurs in a timely manner.
- Prepare appropriate agreements to determine roles and responsibilities of WSDOT and the utility company.
- Coordinate issues with the utility company and various WSDOT disciplines.

Project staff needs to encourage coordination, cooperation, and communication between the transportation agency, utility companies, local agencies, contractors, consultants, and other stakeholders.

The special needs of some locations and contexts, particularly in the urban and suburban environments, can require additional time in a project. Activities, such as the undergrounding of utilities, might require additional lead time for utilities to meet the preferences of the project, since new materials and supplies must be purchased and often right of way must be acquired.

Project staff needs to:

- Develop construction schedules consistent with the needs of the project.
- Formalize communication and coordination efforts with utilities and sub-contractors as stakeholders in the context sensitive design process.
- Avoid conflicts by designing around known utilities, and by investigating sub-surface utilities.
- Encourage and facilitate cooperative working relationships.
- Hold regular meetings with utility companies in the planning, design, and construction phases.
- Encourage utility companies to make and keep commitments in work plans.

Advances in technology might provide opportunities to minimize project or site impacts. Exhibit V-7.3 shows how the visual impact of utilities can be reduced by relocation of overhead utilities.

Exhibit V-7.3 – Utility Undergrounding (Location: SR 99, SeaTac, WA)

Balancing Considerations

Right of way is a primary consideration in the location of a highway or road. The cost, in terms of the balance between the dollars and impacts to the environment, must be weighed against the provision of mobility and safety for all modes of travel. The competing needs must be carefully assessed to optimize and provide the appropriate right of way.

Further, by addressing the impacts of project right of way needs and the concerns of utility companies in the early phases of a project, many delays and conflicts can be avoided or minimized.

In evaluating the trade-offs associated with right of way management and utility considerations, several factors have to be considered. A key factor is future land use. The potential for growth along the corridor can provide some predictive measures for future expansion needs. In the more rural settings on the fringes of developing urban areas, early acquisition of adjacent properties is a means to preserve future capacity. In built-up urban areas, that possibility does not generally exist. In those environments, the typical process is very iterative and involves evaluation of a number of alternatives, weighed against the investment in additional property.

Governing Regulations and Directional Documents

Agreements Manual, WSDOT, M 22-99.

Franchises on State Highways, *Revised Code of Washington* (RCW) 47.44.

General Provisions and Project Procedures, *Code of Federal Regulations* (CFR) 23.712B.

Local Agency Guidelines (LAG), WSDOT, M 36-63.

Plans Preparation Manual, WSDOT, M 22-31.

Relocation Assistance – Real Property Acquisition Policy, RCW 8.26.

Right of Way Manual, WSDOT, M 26-01.

Uniform Relocation Assistance and Real Property Acquisition, *Washington Administrative Code* 468-100.

Utilities Accommodation Policy, WSDOT, M 22-86.

Utilities Manual, WSDOT, M 22-87.

Additional Resources

Real Estate Services, Region Real Estate Services Manager, WSDOT, http://www.wsdot.wa.gov/TA/Operations/LAG/REA/REAContacts.htm

Division V Design Considerations
Chapter V-8 Parking

Introduction

The majority of Americans prefer the private vehicle to other modes of transportation because it provides the freedom to choose when, where, and for how long they will engage in activities. The popularity of the private automobile in the United States, along with urban sprawl, establishes a need for vehicle storage in the form of parking facilities at destination points.

During the project development process, the issue of parking and the various ways of providing for it need to be considered. Within the urban and town center contexts, the provision of sufficient parking that is conveniently located may require significant attention from the project development staff. On the other hand, parking in the industrial corridor and rural connecting corridor contexts is frequently addressed by private businesses according to jurisdictional guidelines. The focus of this chapter is on the trade-offs associated with the development of on-street parking.

Exhibit V-8.1 – On-Street Parking (Location: Kent, WA)

Purpose and Need

Most downtown enhancement projects that affect parking facilities can be controversial. Customer access to retail stores is vital to the health of the downtown commercial district. As such, it is necessary to address retail stores' need for adequate customer access, including parking, in the development of a downtown project.

Enhancement projects do not have the luxury of unlimited funding for parking structures or lots. Given the many demands placed on funds and other resources, project development staff and stakeholders must balance the demand for parking with the need for other project elements. For example, Exhibit V-8.1 shows a typical curb bulb out that provides a more desirable pedestrian crossing, and also allows room for roadside amenities, such as planting areas and benches in the low-speed downtown environment. In all cases, the trade-offs should be considered to arrive at a solution that is beneficial to the facility users and the community.

ADA Provisions

The primary concern of ADA compliance and on-street parking facilities is the difficulty of providing ADA stalls at the curb. When stalls are positioned perpendicular to the roadway, ADA accessible stalls are incorporated without issue. (Due to the width of turning movement, a greater roadway width is required.) Exhibit V-8.2 illustrates ADA accessible parking within the park-and-ride lot of a transit center. The pathway from the parking area to the development and/or adjacent sidewalks also needs to be accessible.

Exhibit V-8.2 –ADA Accessible Parking Lot (Location: Vancouver, WA)

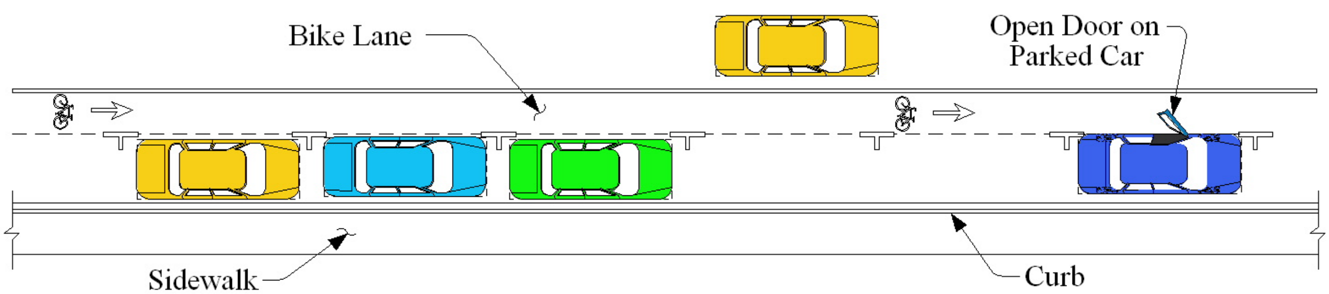
On-Street Parking

There are several on-street parking stall arrangements. The arrangements include stalls parallel to the roadway; at some diverging angle from the curb; perpendicular to the curb; and angled away from the curb to accommodate a backing-in maneuver. There may be sight distance considerations, particularly near intersections and driveways.

Parallel Parking

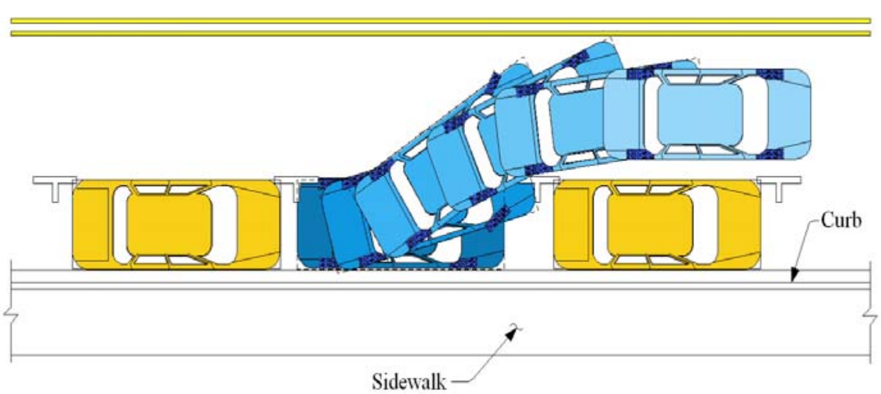
This type of parking provides the driver with a clear view of approaching traffic when leaving the parking stall. Parallel parking stalls require the least amount of roadway width. However, the length of the stall directly limits the number of stalls that can be placed in a city block. Ten stalls is a good approximation of what can be expected for most 300-foot long blocks taking into account the need for extra space between the last parked car and the intersection to prevent obscured views of pedestrians and other intersection traffic. Exhibit V-8.3 shows a typical layout for parallel parking along a street.

Exhibit V-8.3 – Layout of Parallel Parking Stalls (Source: WSDOT)



Parallel parking stalls may cause a disruption to traffic and a greater risk for bicyclists because the driver must stop first and then back into the stall. This maneuver, shown in Exhibit V-8.4, presents a safety risk for bicyclists because the backing vehicle will enter the most common on-road bicycle riding location, with limited visibility of oncoming cyclists. Parallel parking also presents the danger of extended mirrors, vehicles leaving the parking spaces, and car doors opening in the bicycle travel way (see exhibit V-8.3). This parking option may also limit the visibility of pedestrians, bicyclists, and motor vehicles at the intersection, and thereby increase the risk of accidents.

Exhibit V-8.4 – Parallel Parking Maneuver (Source: WSDOT)



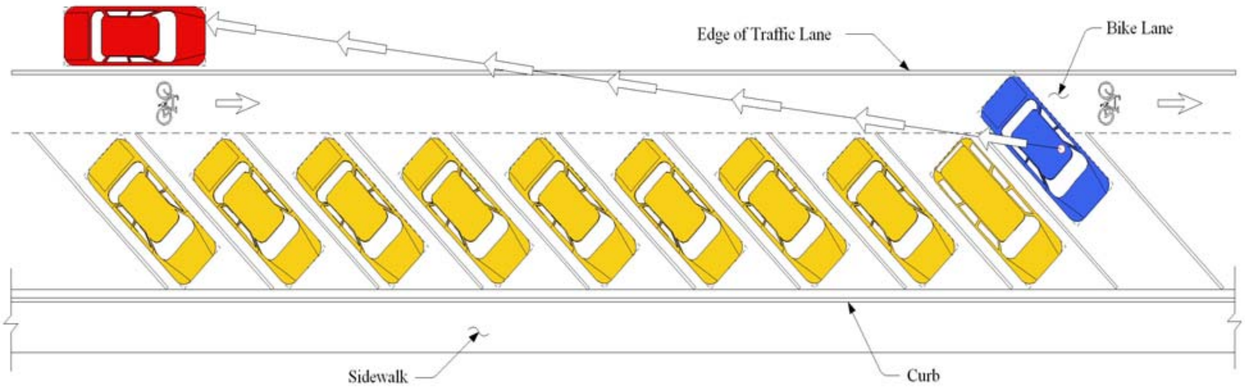
Angled Parking

In general, more angled parking stalls can be accommodated along one side of a street than parallel stalls within the same longitudinal area. This may be an attractive option to the abutting retail stores. The roadway width required for angled parking is greater than for parallel stalls, and it increases with the increasing angle of inclination. Without curb bulbs, this can cause increased pedestrian crossing times. The disruption to traffic flow is minimized during entry into the stall for the head-in angle parking stall arrangements. Exhibit V-8.5 shows head-in angle parking in Kent.

Exhibit V-8.5 – Angled Parking Stall (Location: Kent, WA)

The position of the driver in the vehicle that is reentering traffic, combined with the placement of adjacent vehicles, can limit the driver's view of traffic. State law allows angle parking off state highways when an engineering study demonstrates that the motorist has sufficient room in which to back up to obtain a clearer view of approaching traffic. The distance that the driver can see prior to re-entering the traffic flow must be considered to ensure that the parking arrangement is safe for the desired location. Exhibit V-8.6 shows typical sight distance to oncoming vehicles.

Exhibit V-8.6 – Sight Distance for Re-entry into Traffic (Source: WSDOT)



Exhibits V-8.7 and 8.8 show on-street parking stalls and parking maneuvers.

Exhibit V-8.7 – Head-In Parking Maneuver and Stall (Source: WSDOT)

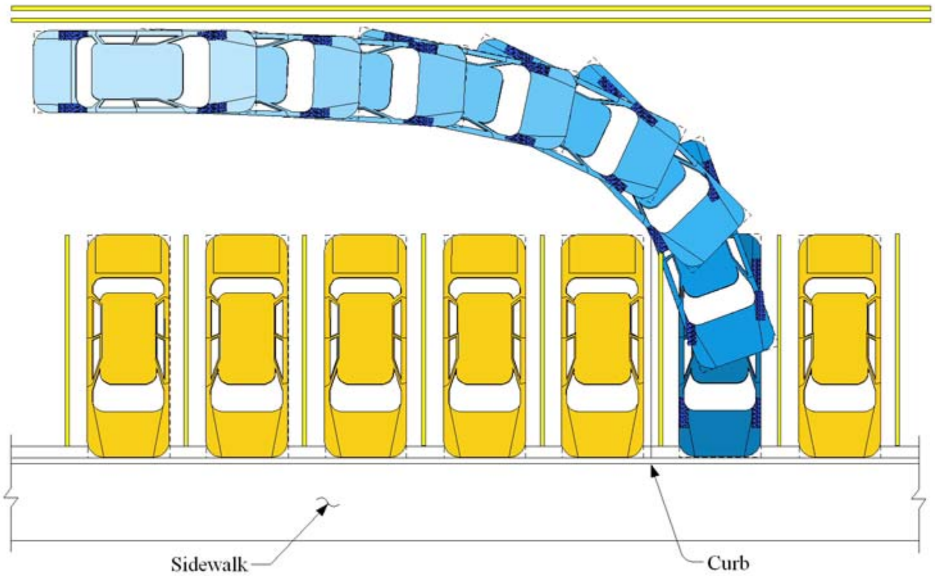


Exhibit V-8.8 – Angle Parking Maneuver and Stall (Source: WSDOT)

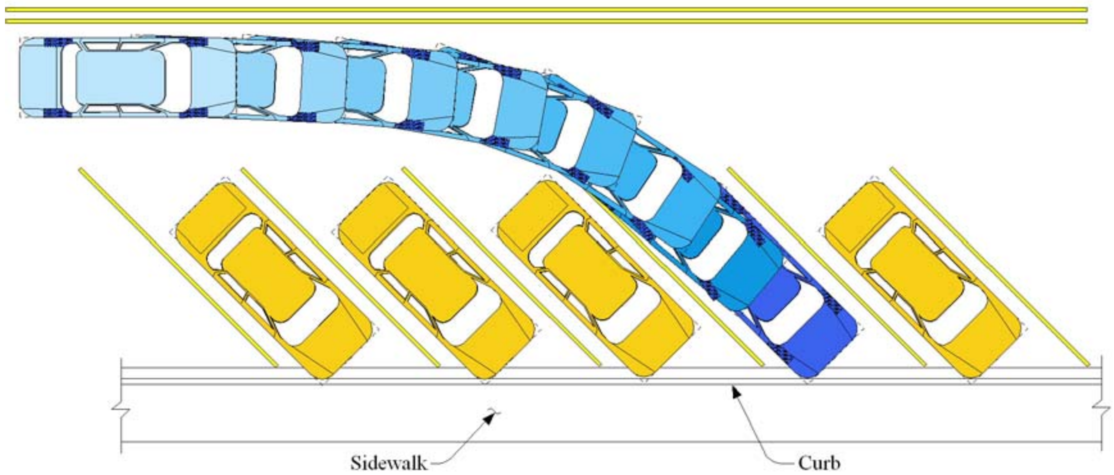
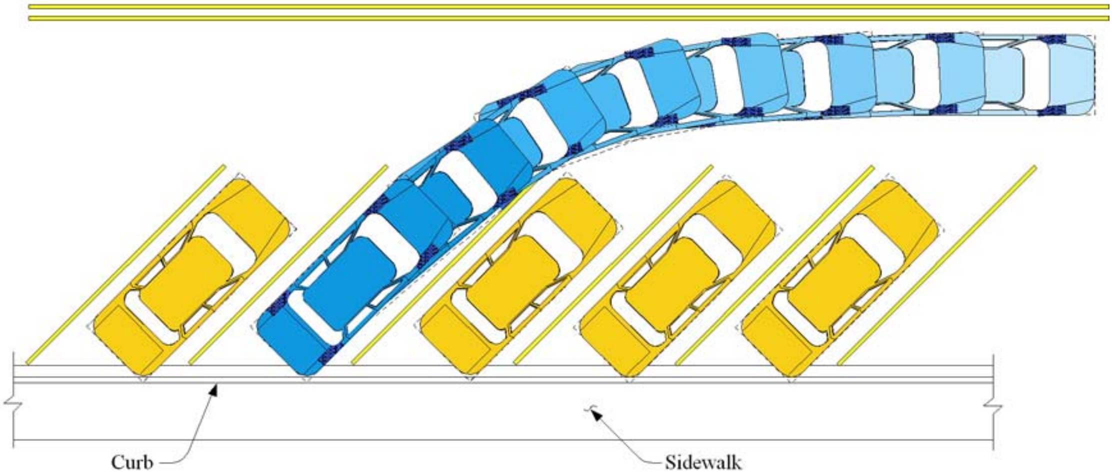


Exhibit V-8.9 – Back-in Angle Parking (Location: Olympia, WA)

An additional type of angled parking is back-in parking. This configuration for the parking stalls may have improved visibility for the drivers as they re-enter traffic. This improvement may be particularly significant for uphill parking. Consideration must be given to the factors that can influence the safety of this parking arrangement. Also, as motorists back into the parking stall, they must be given some clue that they have backed in sufficiently without the danger of hitting an object on the side of the road, or encroaching on the pedestrian sidewalk space. Extending the curb to allow for this overhang might be sufficient, while avoiding the tripping hazard presented by wheel stops. Exhibit V-8.9 shows back-in angle parking in Olympia. This is diagrammed in Exhibit V-8.10.

Exhibit V-8.10 – Back-in Parking Maneuver and Stall (Source: WSDOT)



Balancing Considerations

The trade-offs associated with the various parking options may include the presence of bicycle and pedestrian traffic; the value and availability of land on which to develop the parking facilities; parking fees; and the effects of the parking facility on traffic flow.

Concerns about uncontrolled urban expansion have driven many communities to enact stringent growth management rules and ordinances as tools to concentrate development within a limited area. Within these more densely populated contexts, the land value increases the competition for space. In such cases, the option of developing sufficient parking lots that are conveniently located may not be the optimum solution for vehicle storage needs, from an economic standpoint. Finding opportunities to accommodate parking in these areas can require creative and unconventional solutions.

Due to the value of the land and the cost of ongoing maintenance, it is often necessary to charge a fee for both on-street and lot parking. The development of parking facilities provided exclusively for business employees and patrons is not addressed by transportation agencies, though it will affect transportation planning because of access needs. A city or town can develop a parking management plan to coordinate the supply of parking within the project area with the needs for parking.

One of the issues associated with on-street parking is the disruption of traffic flow due to vehicles parking and re-entering traffic. The impacts to traffic flow must be considered when deciding what parking options to pursue.

Some of the factors that might play into what type of parking will work best within a specific community and context are: the desires of the community; the traffic mix; the available right of way (with the other needs for that property); the environment's appeal to walkers and bicyclists; and the speed of traffic. The list below details some of the more specific trade-offs associated with the varied arrangements of on-street parking.

Parking Stall Configuration	Trade-offs
Parallel	• Optimum sight distance for re-entry into traffic • Fewest stalls per block • Most difficult parking maneuver • Not appropriate for ADA access • Highest risk for conflicts between bicyclists and motor vehicles • Requires the least amount of roadway width
Angled Head-In	• Easy parking maneuver • Limited use for ADA accessibility • Number of stalls per block depends on angle
Head-In 90^o	• Provides the most stalls per block • Most difficult re-entry into traffic/worst sight distance • Requires the greatest amount of roadway width • Optimum for ADA access
Angled Back-In	• Beneficial sight distance for re-entry into traffic • Less risk of bicycle/motor vehicle conflict • Limited use for ADA accessibility • Number of parking stalls per block depends on the angle • Potential for impinging on pedestrian sidewalk

Governing Regulations and Directional Documents

Design Manual, WSDOT, M 22-01.

Design Manual Supplement "Addressing ADA Accessible Facilities on Road, Street, and Highway Projects," http://www.wsdot.wa.gov/eesc/design/policy/Documents/ADASupplementFinalJune21-2004.pdf

Americans with Disabilities Act (ADA) Accessible Guidelines and Detectable Warnings, Memorandum, FHWA to Resource Center Managers, Division Administrators, and Federal Lands Highway Division Engineers, Dated July 30th, 2004, Ref. HIPA-20, http://www.fhwa.dot.gov/environment/bikeped/dwm04.htm

Americans with Disabilities Act, Public Law 336 of the 101st Congress, enacted July 26, 1990, http://www.usdoj.gov/crt/ada/pubs/ada.txt

ADA Accessibility Guidelines for Buildings and Facilities (ADAAG), as amended through September 2002, US Access Board, http://www.access-board.gov/adaag/html/adaag.htm.

Nondiscrimination on the Basis of Disability in State and Local Government Services, 28 *Code of Federal Regulations* (CFR) Part 35.

Parking Generation, 3rd ed., Institute of Transportation Engineers, IR-034B, Washington, D.C., 2004.

A Policy on Geometric Design of Highways and Streets, 4th ed. (Green Book), American Association of State Highway and Transportation Officials (AASHTO), Washington, D.C., 2001.

Roadside Manual, WSDOT, M 25-30.

Additional Resources

Accessible Rights-of-Way: A Design Guide, US Access Board, Washington, D.C., 1999, http://www.access-board.gov/publications/PROW%20Guide/PROWGuide.htm

ADA and ABA Accessibility Guidelines for Buildings and Facilities, U.S. Access Board, Washington, D.C., June 23, 2004, http://www.access-board.gov/ada-aba/status.htm

Bentzen, Billie Louise, Ph.D., Janet M. Barlow, and Lee S. Tabor, *Detectable Warnings: Synthesis of U.S. and International Practice*, U.S. Access Board, Washington, D.C., 2000, http://www.access-board.gov/publications/DW%20Synthesis/report.htm

Design Guidelines Manual – Destination 2030: Physical Design Guidelines, Puget Sound Regional Council, Seattle, WA, 2003.

Draft Guidelines for Accessible Public Rights-of-Way, US Access Board, June 17, 2002, http://www.access-board.gov/rowdraft.htm

Kirschbaum, Julie B., et al., *Designing Sidewalks and Trails for Access*: Part II of II: Best Practices Design Guide, FHWA, Washington, D.C., 2001, http://www.fhwa.dot.gov/environment/sidewalk2/index.htm

Introduction

As noted throughout this document, transportation planning and design staff are tasked with weighing safety, mobility, and capacity considerations with the desire for multi-modal facilities, a sensitivity to community values, and desires for aesthetic treatments. Traffic calming is an example of the shift in thinking on both the national and local levels regarding how planning and engineering are currently approached.

Exhibit V-9.1 – Urban Traffic Calming (Location: US 395, Colville, WA)

Traffic calming is a process of modifying driver behavior, primarily through physical features and effective street design, that allows for self-enforcement of desired driving patterns with the purpose of reducing vehicular speed and volume. Traffic calming helps address local concerns about speeding and cut-through traffic, and improves safety and mobility for both motorized and nonmotorized traffic by altering aggressive driving behaviors, mostly through residential streets.

Traffic calming is most effective when developed in cooperation with all users of an impacted roadway, including both the motorized and nonmotorized users. Active dialogue with roadway users and other interested stakeholders aids in defining the problem to be addressed and helps determine whether the implementation of a traffic-calming measure is the most appropriate solution.

The use of traffic-calming measures can result in a number of desired outcomes, including: improved roadway safety for all users; increased comfort and mobility for nonmotorized travel; and increased community livability.

Traffic calming is considered a management technique for roadways, traffic volume, and land use, which is intended to create a more livable environment. Traffic calming is an overall strategy that results from the implementation of individual activities. The Institute of Traffic Engineers describes three levels of traffic calming:[1]

- ***Level I traffic calming:*** results of actions to restrain traffic speed and lessen traffic impacts at the local level, where traffic volumes, levels of service, and network capacity are not an issue.
- ***Level II traffic calming:*** results of actions to restrain traffic speed and lessen traffic impacts on corridors and traffic routes (district or subarterial roads), where traffic volumes, levels of service, and network capacity are or might become an issue.
- ***Level III traffic calming:*** results of actions on a broader scale, to lessen traffic level and impacts citywide.

[1] Institute of Transportation Engineers, *Traffic Engineering Handbook*, 5th Edition, 1999.

Level I traffic calming is most often related to neighborhood traffic management. Level II traffic calming is typical in activity centers, such as retail locations, main streets, and slow-speed mixed-traffic areas. Level II traffic calming may extend its reach to reducing traffic demand and impacts. Level III traffic calming is most often intended to have a citywide or area-wide impact. The intent of this level of traffic calming may be to suppress traffic flow or types, to influence travel behavior and patterns.

Traffic-calming techniques are intended to reduce vehicle speeds, mainly through the implementation of physical design features. For the effective use of traffic-calming techniques, designers must consider the functional classification of the roadway, the composition of the surrounding land use, and the desires of roadway users.[2]

Level I traffic calming is done with the understanding of the context and function of the road. Its application requires the understanding that the road serves purposes other than those of high mobility and efficiency. With this presupposition, Level I traffic calming is not typically appropriate for arterial roads and where higher mobility and efficiency is paramount. It is generally appropriate for local roads, streets, and neighborhoods.

This is not meant to suggest that traffic calming is only appropriate on local streets. Selectively, traffic calming may be used to lower speed conditions where local activities predominate. This is considered to be Level II traffic calming. Level II traffic calming weighs the need of mobility with that of local concerns. It allows for flexibility within the context of functional classification and provides for a sub-classification of the common levels. It allows for the physical form of arterials to be modified, so they are consistent with local land uses, conflicts, and access control. The typical land use may include rural town business centers or busy strip retail and business areas in older urban locations.

These routes typically serve a sub-regional need, except during peak conditions where they also serve as overflow routes to major facilities. They generally serve two lanes in each direction with traffic up to 12,000 vehicles per day.

Level III traffic calming generally relates to efforts that are implemented through policy change, and are not typically implemented road modifications.

In any application of traffic calming, the impacts and consequences of the selected treatment must be understood. Improper use may lead to adverse consequences.

Exhibit V-9.1 shows Level II traffic calming in Colville. This application uses a modified roundabout in the middle of an urban town to accommodate slowing of traffic and local accesses.

In addition to the primary purposes, traffic-calming measures might also have a number of secondary benefits. For example, traffic calming may improve neighborhood livability through the perceived feeling of increased security and comfort resulting from reduced speeds, volumes, noise pollution, and accidents.

[2] Reid Ewing, *Traffic Calming: State of the Practice*, 1999, p. 3.

Many of the features described in this chapter are typically used in residential areas, and may not be appropriate on state highways or high-speed facilities. However, the general concept of modifying the behavior of the facility users by including specific design elements is applicable on all transportation facilities.

These design elements support traffic calming by providing visual interest, which might provide cues to drivers to proceed at slower travel speeds. Features can also be used to effectively shift horizontal alignment, reducing the visual perception of a “speedway” and encouraging driver behavior appropriate for the adjacent land uses. The presence of these elements creates a roadside environment that is vastly different from the barren roadsides typical in a higher-speed environment. It is precisely this change in the environment that causes the driver/user to perceive the location as more a destination, than a roadside.

Purpose and Need

The term “traffic calming” may apply to a variety of techniques employed to slow the speeds of motor vehicles through an area. These techniques include physical design features, education campaigns, local law enforcement efforts, and features that rely on human psychology to compel drivers to slow down.

In general, with respect to the physical design features, traffic-calming measures are effective in “calming” by physically narrowing lanes or adding design elements that reduce the comfortable driving speed or the attractiveness of a roadway as a cut-through option. Street design can be a useful tool to ensure that driver behavior is more compatible with other system users and surrounding land uses.

Traffic calming can also employ a number of other elements to alter driver behavior. These elements do not directly induce drivers to reduce speeds, but rely on the provision of visual cues to compel drivers to slow down.

For example, the use of pavement treatments (brick or colored pavement) provides a distinctive visual signal to drivers that an area is designated for a specific use, such as a lane for bicycle use or a pedestrian crossing, although they may not be as visible as standard painted or applied marking crosswalk patterns.

The use of textured or colored pavement can also serve other purposes. The use of pavement treatments along shoulders, for example, might give drivers a visual perception that the travel lane is narrower than it really is, which might result in lower vehicle speeds. This is a simple example of how a relatively inexpensive design feature can promote a self-enforcing behavioral change.

Streetscape elements, including landscaping and lighting, are features that might also create a desired traffic-calming effect. These elements provide a vertical balance to the horizontal length of travel lanes, creating visual signals to reduce speed. Shifts in horizontal alignment reduce the perception of a “speedway” and might discourage drivers from speeding or using a roadway as a cut-through option.

Methods and Treatments

Planners and engineers are constantly challenged to meet the numerous, sometimes conflicting, expectations for transportation facilities. Drivers desire to move freely, safely, quickly, and unimpeded. Pedestrians need a safe and comfortable walking environment with adequate opportunities to cross the street. Cyclists are entitled to safe roadways in environments shared with motor vehicles. Residents desire neighborhoods that are secure and livable – devoid of excessive vehicle speeds, volumes, noise, and accidents. Street-front commercial districts require safe and adequate business access. These various expectations do not always integrate well with each other. Traffic calming is a tool to help mitigate the intended and unintended impacts of a transportation system on its various users and create balance between the various expectations for the roadway.

There are a variety of different traffic-calming measures, and they vary in effectiveness depending on the particular issue to be addressed. As with all aspects of system design, the key to successful traffic calming is to clearly understand the nature of the problem to be resolved and then to select the appropriate measure(s) to address that problem.

This section describes some of the more common traffic-calming techniques and the considerations to explore when evaluating their use. The features are organized into three categories (based on the principle manner in which they work) and they include:

- Physical Modifications
- Visual Cues
- Social Measures

Physical Modifications

By incorporating appropriate design elements into the street cross section, various aspects of driver behavior can be physically modified (examples are listed below). Some of these features are not appropriate on state highways. Similar to any context sensitive design element, it should be noted that the treatments must be matched with the facility. Curb bulbouts, when used, must be carefully designed to accommodate turning vehicles and include consideration of the functional area of the intersection.

Exhibit V-9.2 – Neighborhood Traffic Circle (Location: Olympia, WA)

Traffic Circles

Traffic circles are small, raised circular islands located in the center of intersections. Their placement requires vehicles to travel around the circle instead of proceeding straight through. Effective design of a traffic circle results in slower driving speeds through the intersection and a reduction in right-angle collisions. Located inappropriately, they may cause a hazard to vehicles or pedestrians. These devices are typically located on non-arterial streets or on streets with speed limits of 25 mph or less. Traffic circles are not to be confused with roundabouts or rotaries. Exhibit V-9.2 shows a traffic circle in an Olympia neighborhood.

Speed Humps

Speed humps are raised areas of the roadway pavement, of varying heights and lengths, depending on the roadway and traffic volumes. This feature supports traffic calming by reducing vehicle speed and discouraging unnecessary cut-through traffic. Speed humps are only appropriate on lower-speed facilities. They are commonly used near schools and parks, where the presence of children is likely and self-enforcement of speed reductions is important. The feature generally requires the use of at least two humps, in a series, for effective speed control.

Curb Extensions

Curb extensions narrow the overall width of the roadway by extending the curb to the edge of the travel lane, on one or both sides of the road. The most common type of curb extensions are bulbouts, which are usually located at the corners of an intersection, but can also be used as mid-block treatments to shorten pedestrian crossing distances and slow traffic speeds. Bulbouts at intersections may also reduce the speed of right-turning vehicles. Other curb extensions can be used as deterrents to cut-through traffic by extending to the full width of travel lanes. These features are often referred to as “directional closures,” as they preclude a lane of travel.

Chicanes

A chicane is a series of two or three curb extensions on alternating sides of a roadway – typically located mid-block – that narrows the available travel width and encourages vehicles to slow, in order to navigate through the feature. It also requires vehicles to yield to oncoming traffic, further encouraging a reduction in speed. Exhibit V-9.3 shows a mid-block chicane.

Exhibit V-9.3** – **Neighborhood Chicane (Location: Olympia, WA)

Diagonal Diverters

Diagonal diverters are barriers placed diagonally across an intersection, which force vehicles to turn instead of proceeding straight through an intersection. Depending upon their use, diagonal diverters can restrict vehicle access on all legs of an intersection. Effective use can help to minimize the unwanted impacts of excessive cut-through traffic in neighborhoods or other districts.

Median Barriers and Median Islands

A median barrier is a concrete barrier located along the roadway center line. For high speeds, a 32-inch barrier is appropriate. For speeds 45 mph and below, an 18-inch barrier can be used. Median islands are also used in locations to prevent left-turn movements or restrict other movements, which may be warranted as an access management measure. This type of system generally uses 6-inch and 9-inch vertical curb. It should be noted that barriers and curbs at these heights have limited redirectional capability, particularly at speeds above 25 mph. The wider and higher median barriers provide an opportunity for aesthetic treatments, often including landscaping measures, and may terminate to allow for left-turn lanes. Exhibit V-9.4 shows the use of a vegetated median island in Maple Valley.

Exhibit V-9.4** – **Planted Median Barrier (Location: Maple Valley, WA)

Exhibit V-9.5** – **Pedestrian Refuge (Location: Tumwater, WA)

Exhibit V-9.6** – **Pedestrian Crossing Sign (Source: WSDOT)

Exhibit V-9.7** – **Traffic Calming Sign (Source: WSDOT)

Pedestrian Refuges

A pedestrian refuge is a type of median designed to provide pedestrians the opportunity to cross one travel direction of the roadway at a time. Refuges provide more secure places for pedestrians to stop when crossing the street, and are particularly beneficial on roadways with high volumes or high travel speeds.

Exhibit V-9.5 shows a pedestrian refuge in Tumwater.

The list below provides some factors to consider. These considerations are not exhaustive or all-inclusive, but they can help project stakeholders identify appropriate alternatives.

- Effective designs modify driver behavior without restricting access by emergency vehicles.
- Potential to shift travel onto adjacent streets ill equipped to handle the traffic.
- The impacts to on-street parking.
- The impacts of the design on transit routes.
- The incorporation of landscaping or other aesthetic treatments requires appropriate design and maintenance.
- The anticipation of the shared needs of motorized and nonmotorized travelers and the minimization of conflicts where possible.[3]
- Adequate visual and response times for users.
- The potential to create undue increases in noise levels for adjacent neighborhoods.
- Safe accommodation of designated bicycle lanes.
- Long-term roadway maintenance.
- The turning movement demands of large vehicles.
- The demand for pedestrian use and the incorporation of appropriate landscaping and features that enhance pedestrian safety and provide for accessibility according to the Americans with Disabilities Act (ADA) of 1990.
- Evaluation of the short-term and long-term access needs of affected properties
- Vehicular travel speeds, volumes, and other factors when evaluating applicability.

Visual Cues

Visual cues provide a message to users that conditions have changed, and a change in behavior might be needed for the safety of all users.

Signs and Pavement Markings

Speed limit signs and pavement markings govern travel behavior and are likely the most common traffic-calming devices employed. Appropriate speed limits are determined by a variety of factors, including road design, adjacent land uses, and typical weather conditions. Signs and pavement markings are the tools used to encourage the user behavior determined to be appropriate for the roadway and to accommodate other conditions, such as pedestrian crossing zones or designated bicycle lanes.

---

[3] Reid Ewing, *Traffic Calming: State of the Practice*, 1999, p. 42.

Alone, speed limit signs and markings can be effective tools to inform drivers of speed limits, but they are often augmented with law enforcement, to make them more effective.

Exhibits V-9.6 and V-9.7 show two different signs used in conjunction with traffic-calming measures. The use of fluorescent signing material improves sign visibility. Exhibit V-9.7 shows upcoming conditions to drivers. This type of signing can help reduce neighborhood pass-through traffic.

Exhibit V-9.8 – Neighborhood Entry Treatment (Location: Tumwater, WA)

Entry Treatments

Entry treatments define the entryway into a neighborhood, as a Gateway defines the entry into a town. Treatments may assume the form of a raised island along the center line of the roadway or the use of different colored or textured pavement, as well as streetscape elements like statuary features or signage. Entry treatments support traffic calming by providing visual cues to drivers that a neighborhood area is ahead and they should moderate their vehicle speed, as appropriate. Refer to design considerations for medians and pedestrian refuges, when considering the incorporation of those features into entry treatments. Exhibit V-9.8 shows an example of a neighborhood entry. The placement of the entry is done in a manner that does not block sight distance to traffic in either direction of the road.

Exhibit V-9.9 – Crosswalk Treatment (Location: Olympia, WA)

Crosswalk Treatments

Various crosswalk treatments can be employed to increase driver awareness of pedestrians at busy intersections or mid-block crossings. Raised crosswalks are constructed at a slightly higher elevation than the adjacent street surface and can incorporate bricks or other textured pavement into the design. The use of textured or colored pavement can also be an effective treatment for at grade crosswalks, providing visual cues to the driver that pedestrian crossings are encouraged at this location, although painted or applied crosswalk patterns might be more visible. Exhibit V-9.9 shows a crosswalk treatment near the State Capitol. The use of textured sidewalks also requires pavement markings to delineate the crossing area, as shown in this example.

Streetscape Elements

Streetscape elements include roadside features like ornamental lighting, benches, landscaping, artwork, and other features. Chapter V-12 has additional discussion on streetscape amenities. The list below provides some factors to consider:

- Effective design can affect user behavior, without restricting access by emergency vehicles
- The impacts to on-street parking
- Vehicular travel speeds, volumes, and other factors when evaluating application of treatment
- The incorporation of landscaping or other aesthetic treatments requires appropriate design and maintenance
- Safe accommodation of designated bicycle lanes

Continued

- The demand for pedestrian use and the incorporation of appropriate landscaping and features that enhance safety and visibility
- Provision of adequate visual cues and response times for drivers
- Long-term maintenance activities

Social Measures

Social measures increase awareness through education, information, and through the enforcement of established rules. The use of social measures 1) heightens awareness, but requires a conscious effort on the part of the driver to actually modify behavior, and 2) requires a sustained commitment of implementation resources.

Exhibit V-9.10 – Local Newsletter (Source: Lacey, WA)

Newsletters

Publication of a local newsletter can promote an understanding of the rights and responsibilities for all travel modes, as well as appropriate travel courtesy and safety guidelines. Although a newsletter might be an effective tool for framing concerns and opportunities, it is usually a complementary effort to design-based traffic-calming measures. As a stand-alone measure, it is only effective if read and subsequently incorporated into a user's travel behavior. (See Exhibit V-9.10 for an issue of the Lacey Life newsletter, which shows an article about maneuvering through a new roundabout and one-way couplet.)

Volunteer Speed Watch

These programs generally provide concerned citizens an opportunity for proactive problem-solving in their neighborhoods by allowing them to monitor the speed of vehicles traveling on a roadway. Citizens normally partner with the local police department to use monitoring equipment.

Volunteer speed watches or similar programs, such as portable radar trailers that notify speeding drivers with a message, are generally intended to heighten awareness only. They typically do not include a legal violation or fine component. As such, a change in behavior is strictly a conscious decision by the driver.

Enforcement

Enforcement promotes traffic calming by the issuance of violations and fines to noncompliant drivers. Enforcement relies on a police department's ability to monitor a roadway during infractions and might not be effective in discouraging or abolishing elevated speeds or volumes in the long run, when no police are present.

Balancing Considerations

Given the various factors related to traffic calming, the selection and design of any one feature can include a number of considerations.

A successful solution begins with a comprehensive understanding of the conditions and location. Depending on the issue, the identification of causal factors and the subsequent development of a solution might include motorized and nonmotorized transportation users; adjacent residents and businesses; law enforcement agencies; emergency services; transit providers; and the responsible transportation agencies. The solution chosen may also require a consideration of future maintenance and operations to keep the treatment in working order; which may include signing, channelization, or maintenance of the feature itself. In cases where landscaping is used, maintenance considerations include vegetation control and upkeep. A variety of traffic-calming features can be evaluated for how well they might address the specific concerns and how effective the feature might be in balancing the various expectations and requirements of the facility.

As with any design element under consideration, an evaluation of all the associated impacts is a crucial part of developing a solution. One must look beyond the desired effects of a solution and also consider the other effects that are involved. In some instances, those other effects can materialize on other corridors, if the solution alters traffic patterns.

Exhibit V-9.11 – Traffic Calming Considerations

- Shift of travel onto adjacent street
- Emergency vehicle access
- On-street parking
- Transit routes
- Unintended impacts to vehicles, bicycles, and pedestrians
- Turning movements of vehicles
- Access management impacts

A variety of traffic-calming treatments can be applied to create a lower speed and volume environment. To be successful, the traffic control should consider more than just local impacts, as described in Exhibit V-9.11. During the identification and planning of possible traffic-calming measures, the needs of both the adjacent residents and other users of the facility, along with an evaluation of the expected outcome of these measures, are to be considered to ensure that unintended negative impacts are included in the evaluation and selection process.

Traffic-calming measures should be carefully weighed to ensure they meet the engineering constraints and uses of a facility. The sections above provide some guidelines for evaluating whether a particular technique will be appropriate, given certain types of roadways or conditions. The references included in this chapter provide additional detail on specific design considerations for selecting suitable traffic-calming measures.

The desire to modify driver behavior does not suggest that basic engineering standards can be ignored. Rather, project designers have to seek opportunities to develop solutions that successfully identify issues and propose appropriate measures that meet the requirements of the system users and comply with responsible engineering guidelines.

Governing Regulations and Directional Documents

Traffic calming is not mandated by any federal or state regulations, but it is consistent with how transportation planning and engineering are currently implemented by local governments. Traffic-calming techniques serve as important tools in addressing concerns regarding excessive speeding and the inappropriate use of neighborhood streets for cut-through traffic. Any of the measures should meet the accessibility requirements set by the ADA of 1990.

Additional Resources

Canadian Guide to Neighborhood Traffic Calming, Transportation Association of Canada, Ottawa, 1998.

Design Office, Region Project Development Engineer, WSDOT.

Ewing, Reid, *Traffic Calming: State of the Practice*, FHWA and Institute of Transportation Engineering, Washington, D.C., 1999, www.ite.org/traffic/tcstate.htm#tcsop

Hartnett, Susan and Mike Coleman, *Traffic Calming: Techniques and Management*, 1999, http://www.engr.washington.edu/epp/Transpeed/trc.html

Institute of Transportation Engineers, *Traffic Engineering Handbook*, 5th Edition, Chapter 9, Washington, D.C., 1999, http://www.ite.org/

An Improved Traffic Environment – A Catalogue of Ideas, Road Directorate, Ministry of Transport, Denmark, 1993.

Litman, Todd, *Traffic Calming Costs, Benefits and Equity Impacts*, Victoria Transport Policy Institute (VTPI), Victoria, B.C., 2002, http://www.vtpi.org/tca/

Maintenance Office, Area Maintenance Engineer, WSDOT.

Neighborhood Traffic Calming Program, City of Bellevue, http://www.ci.bellevue.wa.us/page.asp?view=1593

Neighborhood Traffic Calming Program, City of Portland, http://www.trans.ci.portland.or.us/trafficcalming/default.htm

Traffic Office, Region Traffic Engineer, WSDOT.

Transportation Department, City of Seattle, http://www.cityofseattle.net/transportation/

Introduction

Illumination is lighting hardware placed along the roadway, intended to improve visibility during the hours of darkness. Illumination is generally provided at select locations along highways and sidewalks, in parking lots, and at other facilities to enhance visual perceptions of conditions or features that require additional driver, cyclist, or pedestrian alertness during the hours of darkness.

Exhibit V-10.1 – Illumination Fixtures (Location: Tacoma, WA)

In addition to providing improved visual perception, illumination can be used to improve the aesthetic characteristics of a transportation facility by considering the character of luminaires and poles, spacing, and color of light. Exhibits V-10.1 and V-10.2 provide examples of illumination fixtures that some individuals consider more aesthetically pleasing than standard fixtures. The context or contexts through which a facility passes should influence what types of illumination fixtures are used. The choice of fixtures may present an excellent opportunity to involve local stakeholders in the project development process.

Design of a lighting system considers the total area that the designer intends to illuminate; the area used by pedestrians; and the adjacent land use. Lighting system design also considers established criteria for light standards, heights, and luminaires, as well as the development of an electrical design that considers circuit layout and spacing of the light standards.

The Washington State Department of Transportation (WSDOT) is responsible for illumination on state highways with limited access control, and on state highways located outside the corporate limits of cities. Within incorporated cities, the illumination maintenance and photometric of city streets that are also state highways (under WSDOT managed access control) is the responsibility of the city.

Balancing Considerations

The provision of illumination on a highway or street is intended to improve impaired visibility during the hours of darkness. Adequate visibility during day or night conditions is a fundamental requirement that enables users to move on the facilities in a safe and coordinated manner. Street lighting, when appropriately designed and maintained, produces comfortable, accurate, and improved night visibility and visibility of objects, which facilitates desired user traffic flows.

In locations with higher vehicular volumes and speeds, it is even more important for the user to be able to make informed decisions and have adequate time to make necessary maneuvers, without creating undue conflict in the traffic lanes. Illumination may reduce the probability of sudden braking and swerving as the driver reacts to objects on a darkened roadway. The visibility of signing and pavement markings also helps ensure improved mobility and accessibility.

Certain types of accidents can be correlated to nighttime and severe weather, both of which can reduce visibility. The provision of illumination can improve visibility in some cases, and might also increase the sense of ease and comfort of a user during the hours of limited visibility.

Exhibit V-10.2 – Additional Illumination Fixtures (Location: Kent, WA)

Illumination can be used by communities as a means of illustrating civic pride through the design of the illumination fixtures. In addition, illumination is often an excellent crime deterrent.

The following sections describe some of the effects of illumination to consider during the design process.

Aesthetic elements – Illumination can be used to improve the aesthetic appearance of a transportation facility by considering the fit of the lighting into the existing surroundings. Including the character of the equipment, spacing, color of light, and plant materials into the highway design considerations helps ensure that the provision of illumination complements the existing surroundings.

Historic connections – The provision of illumination within or adjacent to historic districts prompts designers to consider a design that uses equipment consistent with the characteristics of the historic district, so as not to diminish the integrity of the traits that make the district a historic resource.

Illumination fixture placement – The placement of street lighting fixtures must be considered, as well. When located near a facility with relatively high speeds and volumes, the fixtures can present safety risks to errant motorists. Those risks need to be evaluated during the design process. One option is to include breakaway features to reduce the severity of potential impacts. However, breakaway fixtures can be a danger to pedestrians and non-involved vehicles, and might not be appropriate in areas with concentrations of pedestrians.

User visibility and safety – Lighting might have the unintended effect of providing pedestrians and bicyclists a false sense of security within the roadway environment. Studies have indicated that where a pedestrian can see a vehicle, the converse is not necessarily true.[1] An incorrect assumption that a driver can see them might prompt a pedestrian to take an undesired risk. Ground-level lighting fixtures, or uplighting to provide contrast between pedestrians and the surrounding environment, can result in improved safety.[2]

Lighting quality – Illumination has the potential to create discomfort from direct glare and increased urban sky glow. To provide illumination in areas where pedestrian use is expected, smaller, low-angle street lamps can be considered. These types of lamps emit a full-spectrum light, which results in reduced glare and an assurance of realistic night sky colors.

---

[1] Paul L. Olson, *Forensic Aspects of Driver Perception and Response*, 1996.
[2] Ibid.

Light trespass – The provision of illumination near residences and neighborhoods has the potential to result in light trespass onto properties where natural darkness is preferred. Consideration of placement or the provision of a screen might be necessary to reduce the potential for light trespass. For further information, see Chapter IV-8, Night Sky Darkness.

Illumination and wildlife – Lighting located near wildlife has the potential to influence the nocturnal habits of certain species of wildlife. Wildlife's migratory and feeding patterns, for example, can be influenced if confusion occurs regarding the time of day, as a result of illumination.

Vegetative growth and lighting patterns – In areas where vegetation is an element of the project, consideration must be given to species selection and placement of illumination, to minimize conflict with lighting. This consideration should include current and future roadside management activities for maintaining appropriate lighting levels.

Analysis Method

The design of a lighting system requires consideration of a number of factors, including the classification of the roadway, the extent of development in the adjacent area (as well as the type of development), and the level of anticipated nighttime activity.

Light level requirements vary depending on the magnitude of pedestrian activity and the adjacent land use. Pedestrian activity is measured by the number of pedestrian crossings (either at a single crosswalk or at several locations along the roadway) during the nighttime peak pedestrian hour usage. Activity is defined as high (downtown retail areas, concert halls, stage theaters), medium (libraries, movie theaters, apartments), or low (residential).

Lighting system design considers the design area that is subject to the minimum light-level requirement. This encompasses the area between the edges of the traveled way along the roadway and the outer edges of the stopping points at intersections. The design area also includes bike lanes and sidewalks, in locations where those facilities are present.

The WSDOT *Design Manual* provides detail on the criteria the department uses for determining light standards (supports), height, and types of luminaires to be used. Placement of a light standard within a median vs. the shoulder, within the Design Clear Zone, or when a sidewalk is present, for example, are all considerations to be included in the design process.

Chapter 840 of WSDOT's *Design Manual* provides a detailed description of the process for determining appropriate design criteria for a lighting system, as well as the standard the WSDOT uses, given the preceding considerations.

Governing Regulations and Directional Documents

Design Manual, WSDOT, M 22-01.

Design Standards for Rearranged County Roads, Frontage Roads, Access Roads, Intersections, Ramps and Crossings, *Washington Administrative Code* (WAC) 468-18-040.

Jurisdiction, Control, *Revised Code of Washington* (RCW) 47.24.020(6).

National Electric Code 2002, National Fire Protection Agency (NFPA), Quincy, MA, 2001.

A Policy on Geometric Design of Highways and Streets, 4th ed. (Green Book), American Association of State Highway and Transportation Officials (AASHTO), Washington, D.C., 2001.

Additional Resources

American National Standard Practice for Roadway Lighting, IES RP-8-1983, Illuminating Engineering Society, New York, 1983.

American National Standard Practice for Roadway Lighting, IES RP-8-2000, Illuminating Engineering Society, New York, 2000.

"City Streets as a Part of the State Highway" – Final Report, WSDOT, Olympia, WA, 1997.

FHWA, *Roadway Lighting Handbook*, Criterion Press, Overlake, KS, 1978.

Joint Task Force for Highway Lighting, *An Informational Guide for Roadway Lighting*, American Association of State Highway and Transportation Officials (AASHTO), Washington, D.C., 1984.

Maintenance Office, Area Maintenance Engineer, WSDOT.

Olson, Paul L., *Forensic Aspects of Driver Perception and Response*, Lawyers & Judges Publishing Company, Inc., Tucson, AZ, 1996.

Recommended Practice for Tunnel Lighting, IESNA RP-22-96, Illuminating Engineering Society of North America, New York, 1996.

Roadway Lighting Handbook Addendum to Chapter Six, FHWA, Washington, D.C., 1983.

Traffic Office, Region Traffic Engineer, WSDOT.

Introduction

Visual functions include user guidance and navigation; the enhancement of community character; blending of the roadway into its surroundings; corridor continuity; roadway and adjacent property buffering; and scenic view preservation. The enhancement of visual quality often relies on vegetation for buffering, blending, and screening. Visual enhancement can also be accomplished through patterns or textures on walls, bridge rails, and tunnel portals, or through a comprehensive theme along a corridor, using colors or patterns.

There are two primary roadside views: (1) those from the facility, and (2) those toward the facility. In addition to safety and aesthetic considerations, many Integrated Vegetation Management (IVM) practices, such as noxious weed control, and environmental functions, such as habitat preservation, are readily perceived and evaluated through sight.

Definitions

Aesthetics Evaluations and considerations concerning the sensory quality of resources (sight, sound, smell, taste, and touch) and especially with respect to judgment about their pleasurable qualities.[1]

Complexity The multiple qualities in a landscape that provide visual interest, such as the combination of form, color, and texture.

Corridor continuity The overall coordination and sequence of visual features, as experienced by the roadway user.

Expectancy The driver's readiness to respond to events, situations, or the presentation of information. It is primarily a function of the driver's experience.

Intactness The integrity of visual order in the natural and man-built landscape, and the extent to which the landscape is free from visual eyesores.

Landscape An area composed of interacting ecosystems that are repeated because of geology, landform, soils, climate, biota, and human influences throughout the area.

Unity The degree to which the visual resources of the landscape join to form a coherent, harmonious visual pattern. Unity refers to the compositional harmony or inter-compatibility between landscape elements.

Vividness The memorability of the visual impression received from contrasting landscape elements as they combine to form a striking and distinctive visual pattern.

[1] Bureau of Land Management Manual, "Visual Resource Management," 1977.

Purpose and Need

Roadside vegetation strategically preserved (or placed in combination with related design elements) unifies the roadway with its surroundings. Whether included to provide visual relief within the highly urbanized environment, or preserved as a means to blend the manmade roadway with its surroundings in the rural setting, vegetation is the most commonly used tool in the expanding realm of Context Sensitive Design (CSD). Related elements such as luminaires, signs, street furniture, or wall textures are also used to enhance and build community acceptance for the roadway project.

Considering the view of the constructed roadway from adjacent properties, vegetation is often used along with noise walls and berms to reduce impacts. With regard to the view of the roadside from the newly constructed facility, vegetation and landforms screen distracting roadside clutter from the view of drivers and block unsightly views such as junkyards from both drivers and passengers.

Balancing Considerations

Exhibit V-11.1 – Signage & Trees Used to Direct Users (Location: Lacey, WA)

By understanding how people relate visually to their environment, it is possible to design and maintain safer roadways and to integrate highway functions into a community.

Driver workload relates to the effort and attention required to complete a task in the roadway environment. As demands on the driver increase, so does performance to a certain level. After this optimal level is reached, driver performance begins to deteriorate.

During the driving task, drivers will try to maintain a comfortable workload. If the workload is overly demanding, the driver will increase attention and preferably take action to increase comfort. This might include reducing speed in areas of congestion or decision-making. Too little workload and the driver may become inattentive and engage in non-driving activities, such as using a cell phone or talking to a passenger.

The extent of driver workload changes with the factors that exist on and alongside the road. These factors include traffic congestion, geometrics, sight distance, curves, intersections, and roadside features. Locations with large changes in workload have been shown to be associated with increased collisions. The following section discusses some of these issues.

Expectancy and Driver Response

Roadside features can create patterns that provide the user with clues to what lies ahead. The visual environment can be enhanced to reinforce accurate expectations about what driving responses are necessary. For example, clear, uncluttered signage can provide adequate information that allows for timely decisions. Maintenance plans are often developed to meet this need.

An effective facility design is based on predictability and coherence in the visual environment (corridor continuity). It improves user expectancy and reduces surprise factors by giving sufficient visual information to accurately predict upcoming conditions. This information forewarns the users, allowing them to make appropriate speed and lane selection, and improves decision-making, therefore helping them avoid accidents. For example, the use of a particular tree line along a corridor can provide clues, from a distance, about the curvature of the road, or clear signing can provide adequate information that allows for timely lane changes.

Exhibit V-11.1 shows vegetation and signage used to indicate changes in the road environment.

Distraction

Within complex visual scenes, individuals might have difficulty seeing and selecting the relevant visual information necessary to safely and effectively negotiate the road environment. Too much visual information can distract transportation facility users, resulting in them missing critical information and therefore impairing safety. Without changes in speed or attention, drivers can make poor decisions when they are distracted. While it may be desirable to place roadside amenities at certain locations, placement should be assessed with the goal to maintain a road environment in which too much information is not presented at once (or over a short distance).

Unity and simplification of the visual environment can reduce the likelihood of distractions caused by the surroundings. For example, in the rural or suburban contexts, massed vegetation or vegetative screening can be used to create a more integrated and less distracting environment. In urban centers, on the other hand, the efforts to eliminate distractions might include the use of consistent signing, pavement markings, and roadside treatments throughout the project area. Visual clutter can also be reduced by minimizing the number of signs.

Roadsides and Memory

Perceptual or cognitive factors influence the memories or impressions of a place. It is the roadside and the view from the road that the driver or visitor remembers, long after having driven along the road. Roadsides are more than a buffer for the roadway; they are often the transition into a community. Drivers develop impressions about communities by what they see along the roadside. Research has shown that the public values visual features that fit the locality and contribute to a sense of place.[2] In this sense, it is beneficial to treat the roadside as a community amenity, when the context allows. It is also believed that development, preservation, or enhancement of visual quality (such as scenic routes) also supports the economic interests of the state through increased tourism.

Directed Attention Fatigue

People use directed attention to work in distracting surroundings and make decisions in complex situations, such as working in the office, or driving on heavily traveled roads. Extended, unrelieved periods of directed attention can diminish the capacity to

---

[2] Melnick, "Protecting Rural Cultural Landscapes," 1983.

analyze, plan, and make decisions, resulting in irritability and the taking of unnecessary risks.

The visual environment can either aggravate or alleviate directed attention fatigue. Visual access to natural elements is key in counteracting directed attention fatigue through the provision of restorative experiences.[3] Often, the most natural elements in urban areas are street trees or planting areas. There is increasing evidence[4] to suggest that natural and naturalized roadsides might diminish or alleviate directed attention fatigue in the roadway user. Careful planning and design of corridor views for scenic vistas and aesthetically pleasing roadside treatments can be important for improving roadway safety, by providing breaks from the concentrated attention demanded of the drivers by more complicated roadsides. Inclusion of street trees and planting areas within the city can be important for improving physical health and the quality of life. (See Chapter IV-1, Urban Forestry, for more information on the outcomes of vegetative material.)

Other Considerations

Experience has shown that communities are likely to be more accepting of a project with good visual character, particularly one that is in keeping with the culture and context of the locality. The roadway is often thought of as an integrated environment, in which the roadside treatment can be used to enhance guidance; visually minimize the complexity and size of the surrounding environment; and create a sense of place.

Exhibit V-11.2 – Scenic View Preservation Top: View From Road, Bottom: View From Sidewalk (Location: Tacoma, WA)

To achieve this goal, it is important to work with communities and businesses to provide roadsides (and roadside restoration) that enhance the community and provide the necessary visual function for the roadway, while not obscuring desirable views, such as those to access points or businesses.

Highways and roadways are intended to take the traveler safely from the origin of a trip to a destination. Information in the form of signage and markings is provided to accomplish that need. As suggested previously, driver distraction and information are critical factors in the placement of any roadway or roadside element. In meeting the need to minimize visual distraction, it is important to use objects on the roadside with a specific intent. Signs, for instance, are placed to minimize visual distraction, while still providing adequate information to allow the driver to move safely between origins and destinations. Signage is also done in a manner that is consistent and predictable, to reduce distraction and improve sign comprehension.

In some cases, vegetation and features have been used along the roadside to create the effect of a narrowing environment. This effect provides the driver with information about a change, but also increases the distraction level with the intent of reducing speed. With any placement of roadside objects, care should be taken in selecting and locating the objects in a manner that does not create a hazard.

As the previous paragraphs suggest, visual functions are an important part of highway and roadway design because of driver

---

[3] Kaplan, “Urban Forest as a Source of Psychological Well-Being,” 1995.
[4] Parsons et al., “The View from the Road,” 1998.

workload. A well-designed roadside can help reduce attention fatigue by helping the driver stay alert to the surroundings. This is achieved by providing vegetation and elements that create visual balance.

When designing roadside treatments, it is also important to consider the character of the adjacent road segments to provide corridor continuity or a transition from one environment to the next (see Chapter V-2, Land Use Transition, for additional information).

The use of design elements that improve the visual function are not without their drawbacks, although many of these can be accommodated for if considered properly.

Vegetation is a key issue in Washington State. The environment we live in creates significant growth in roadside vegetation. Clearly, there will be instances where vegetation will grow at such a rate that signs, markings, and sight distances might be obscured. Although unfortunate, this will inevitably occur because of Washington's ability to sustain plant life and provide for rapid vegetation growth. It is for this reason that many transportation agencies have routine maintenance plans and activities to reduce this potential.

Roadside objects and vegetation can also create shading and a reduction in heating of the road surface during inclement weather. It is understood that drivers are responsible for operating their vehicles safely during poor weather and that if they fail to do so, accidents are much more likely. However, this element deserves further attention as part of the discussion of visual function.

Exhibit V-11.3 – Vegetation Reducing Sign Visibility (Location: SR 99, SeaTac, WA)

Other potential impacts include icing, and a reduction in contrast between the pedestrian and the background due to shading and distractions created from dappled shade effects (alternating light and shade) while driving.

As with most placements of objects in the road environment, care should be taken; first, in the visual function that the object provides, and second, in understanding the possible impacts from the object placement on the roadside and the safety of the traveling public.

Exhibit V-11.3 shows sign placement behind trees. At this location, the potential exists for vegetation to reduce the view to the signs in some parts of the year.

Analysis Method

The WSDOT *Roadside Classification Plan* and the *Roadside Manual* provide detail on the criteria the department uses for determining visual functions and roadside treatments.

Beyond the curb or the paved shoulder, cities are responsible for funding design enhancements and maintenance, even where WSDOT is responsible for the construction. In those instances, agreements that outline funding and the turn-back process have to be negotiated and put in place early in the planning process. (See the WSDOT *Design Manual* for further information.)

When selecting plants, consider their mature size and their habitat needs. Some trees are better suited to an urban environment than others (for example, small trees at maturity will be more suitable in areas with overhead power lines).

Maintenance

Maintenance responsibility for trees and all other vegetation provided by a project should be understood and documented via written agreement with the responsible agency. Maintenance responsibility for different elements needs to be clarified and understood at the earliest possible point in the design process. This will ensure that the appropriate stakeholders are involved. Consultation with maintenance personnel early and throughout the design process is an important step to reducing long-term costs and ensuring the maintainability of the design.

When installing trees in association with a proposed project, the following concerns need to be considered with regard to maintenance needs:

- Maintenance of plantings is conducted via an agreement with the Local Agency, where the Local Agency is responsible for any maintenance.
- Trees with large leaves can cause drains to clog.
- Evergreen trees on the south side of the road may reduce winter road warming, which would increase the length of time that ice stays on the road, but may shield the road from wind and snowdrifts.

Maintenance personnel should be consulted during the design process. They can highlight important considerations, within their respective maintenance areas.

Governing Regulations and Directional Documents

Design Manual, WSDOT, M 22-01.

Highway Advertising Control Act-Scenic Vistas Act of 1971, *Revised Code of Washington* (RCW) 47.436.

Highway Beautification Act of 1965 (and all subsequent amendments), *Code of Federal Regulations* (CFR) 23.752.

Junkyards Adjacent to Interstate and Primary Highways, RCW 47.41.

Roadside Classification Plan, WSDOT, M 25-31.

Roadside Development, *Design Manual* Chapter 1300, WSDOT, M 22-01.

Roadside Improvement and Beautification, RCW 47.40.

Roadside Manual, WSDOT, M 25-30.

Scenic and Recreational Highway Act of 1967, RCW 47.39.

Scenic Enhancement for Utilities Accommodation on State Highway Rights of Way, *Washington Administrative Code* (WAC) 468-34-330.

Utilities Accommodation Policy, WSDOT, M 22-86.

Additional Resources

Alexander, G.J. and H. Lunenfeld, *Driver Expectancy in Highway Design and Traffic Operations,* USDOT Final Report FHWA-TO-86-1, FHWA, Washington, D.C., 1986.

Bureau of Land Management Manual, "Visual Resource Management," U. S. Department of the Interior, Bureau of Land Management, Washington, D.C., 1977.

Center for Urban Forest Research, University of California, Davis, http://wcufre.ucdavis.edu/

Community Forest Management Plan, City of Davis, Davis, CA, September 2002.

Hamilton, C.W., et al, *Planting for Sustainable Roadsides: Empirical and Experimental Studies and Recommendations for Western Washington*, Technical Research Report WA-RD 439.1, WSDOT, Olympia, WA, 1998, Chap. 4, "Landscape Perception and Roadside Design Guidelines."

Heerwagen, Judith, *Visual Perception of the Roadway and Roadside Elements by the Observer In Motion: Final Report*, Research Project T 9233, Task 15, Washington State Transportation Center (TRAC), WA-RD 283-1, WSDOT, Olympia, WA, 1992.

Hornbeck, Peter L. and Garland A. Okerlund, Jr., *Visual Values for the Highway User*, FHWA, Washington, D.C., (N.D.).

Kaplan, Stephan, "Urban Forest as a Source of Psychological Well-Being," *Urban Forest Landscape*, University of Washington Press, Seattle, 1995, pp. 100-108.

Kent, Richard L., "Attributes, Features, and Reasons for Enjoyment of Scenic Routes: A Comparison of Experts, Residents, and Citizens," *Landscape Research*, 18(2), 1993, pp. 92-102.

Landscape Architecture Office, Region or Headquarters Landscape Architect, WSDOT.

McPherson, E. Gregory, et al., *Western Washington and Oregon Community Tree Guide: Benefits, Costs, and Strategic Planting*, Center for Urban Forest Research, USDA Forest Service, Pacific Southwest Research Station, March 2002, http://wcufre.ucdavis.edu/products/5/cufr_164.pdf

Melnick, R.Z., "Protecting Rural Cultural Landscapes: Finding Value in the Countryside," *Landscape Journal*, 1983, Vol. 2, pp. 85-96.

Parsons, R.L. et al, "The View from the Road: Implications for Stress Recovery and Immunization," *Journal of Environmental Psychology*, November 1998.

Post, T.J., G.J. Alexander, and H. Lunenfeld, *A User's Guide to Positive Guidance* (2^{nd} edition), Report FHWA-TO-81, FHWA, Washington, D.C., 1981.

State Bridge and Structures Architect, Headquarters, WSDOT.

Transportation Research Board (TRB), *Human Factors Research in Highway Safety*, National Research Council, Circular 414, Washington, D.C., September 1993.

Visual Impact Assessment for Highway Projects, FHWA, Washington, D.C., 1981.

Wolf, Kathleen L., "The View From the Road: The Urban Forest and Our Freeways," Washington Department of Natural Resources, Community Forestry Program, *TreeLink*, No. 18, Summer 2001, http://www.cfr.washington.edu/research.envmind/Roadside/TreeLinkRoad.pdf

This page intentionally left blank

Introduction

Streetscape amenities include street furniture, artwork, vegetation, and other elements. As more communities embrace the livable community concept, they are seeking to have these elements become a part of new projects.

Street furniture may include benches, bus shelters, lamps, bicycle racks, wall seats, and planters. Artwork may be sculptures, paintings or murals, pavements with imprints or embedded objects, etc. Vegetation ranges from turf and ground covers to street trees, and may include raised planters.

Streetscape amenities should reflect, be sponsored by, and offer value to the community. When considering roadside amenities, remember there are trade-offs that need to be addressed. These trade-offs include:

- Add to the economic vitality of the community.
- If the object is a fixed object, there may be safety concerns.
- Objects should be placed to minimize their impact on sight distance.
- Properly designed and placed street furniture can increase the pedestrian traffic and retention times. This can improve personal safety in the area.
- Street amenities will require maintenance, and the responsibility of maintaining them must be established.

Exhibit V-12.1 – Street Furniture – Clock, Bike Rack, Trash Can (Location: Palouse, WA)

Definitions

Street furniture Any type of appurtenance, such as kiosks, trash cans, transit shelters, and other civic necessities for pedestrian use.

Purpose and Need

Streetscape amenities can distinguish one community or neighborhood from another. Often neighborhoods or business districts have a theme or would like to develop a theme to distinguish them from others. Consulting citizen groups, business groups, and community planners can assist the designer in choosing appropriate amenities for the project, or different areas of the project if it runs through more than one neighborhood or business district.

Roadside amenities can enhance any project. Often the visual analysis will determine that mitigation needs to be done to alleviate the impacts of the project. The use of roadside amenities can visually unite a corridor, lessen visual distractions, and make the area aesthetically pleasing.

Exhibit V-12.2 – Street Furniture – Kiosk and Benches (Location: Olympia, WA)

Balancing Considerations

Exhibit V-12.3 – Street Furniture on Sidewalk (Location: Tacoma, WA)

The primary beneficiaries of roadside amenities are the pedestrians and the people who live or work adjacent to the highway. Roadside amenities may be designed and included in a local or WSDOT project; however, funding restrictions may dictate the party responsible for funding these items. Refer to the Roadside Funding Matrix (Appendix B of this document) for more information.

The following are some considerations associated with street furniture:

Element	Considerations
Street Furniture	• Adds places for pedestrians to stop and rest • Transit shelters give riders shelter from adverse weather • Bicycle racks encourage bicycle use • Can be a hazard according to the *Design Manual* if it is a fixed object in the clear zone • Can add to maintenance costs for the city or community • May present obstacles to people with disabilities
Public Art	• Adds interest and value for pedestrians and local users • Can be a distraction if not carefully sited • Can be an impact hazard if improperly placed on the roadside • Can help tell the story of a local community or event • Can be an element or an anchor in the overall community theme
Vegetation	• Catches and retains rainfall and lessens runoff; captures particulate pollutants; creates oxygen • Street trees add shade • Irrigation usually necessary for proper plant health • Maintenance required annually to pick up leaf litter • Occasional maintenance, such as pruning and fertilizing, required for long-term plant health • Increases value of adjacent real estate • Can be an impact hazard if improperly sited • Can block sight distance if not properly maintained • Can damage sidewalks and paving in the long term

Analysis Method

The stakeholders and WSDOT should determine the goals of enhanced design elements. The theme should be consistent with the character of the local area and the highway. The statement of goals and objectives will guide development and help keep the project focused.

Governing Regulations and Directional Documents

Design Manual, WSDOT, M 22-01.

Highway Runoff Manual, WSDOT, M 31-16.

Roadside Classification Plan, WSDOT, M 25-31.

Roadside Manual, WSDOT, M 25-30.

Roadside Funding Matrix, WSDOT, Appendix B.

In addition to the manuals listed above, there might be city and county ordinances that require landscaping and other streetscape elements.

Additional Resources

WSDOT Headquarters Landscape Architecture Office.

Region Landscape Architecture Offices.

This page intentionally left blank

Introduction

Stormwater management is a critical issue, especially in the urban environment, where significant portions of the land cover are impervious surfaces. Impervious surfaces reduce infiltration and increase stormwater runoff. This increases the peak rate and volume of runoff resulting from a storm event. The reduction of infiltration leads to a greater extent and severity of flooding, and it generally also leads to increased stream bank erosion and aquatic habitat destruction. In addition to heavier flows, the water flowing off of impervious surfaces often contains pollutants that reduce the water quality of streams and rivers. This reduction in water quality may harm fish and other organisms that live in the streams. In most cases, the stormwater must be treated for both quality and quantity (flow control). To comply with stormwater permit requirements, stormwater facilities usually require large amounts of land to site treatment and control facilities.

Exhibit V-13.1 – Indian Creek Stormwater Facility (Location: Olympia, WA)

Many cities and counties are beginning to use a concept known as Low Impact Development (LID) in new and re-development projects. LID is an evolving approach to land development and stormwater management that uses a site's natural features and specially designed facilities to manage stormwater. It is a decentralized system that distributes stormwater across the landscape to enhance infiltration into the ground rather than sending it to a centralized treatment facility. This means there may be many small stormwater facilities rather than one large centralized facility. It also means that the facilities may be incorporated into the existing right of way, which may reduce the need to purchase additional large pieces of land for stormwater facilities (see Chapter IV-1, Urban Forestry.)

Whenever possible, it is preferable to infiltrate stormwater as close to the source as possible. This achieves the following:

- It slows peak stream discharges and extends them over a longer period of time, thereby reducing stream incision.
- It replenishes ground water, which can increase base flow volumes of streams and wetlands during the summer months.
- It can clean the water through natural filtration processes.
- It can eliminate or reduce the need for collection systems and large retention and detention ponds.

Not all projects will be able to apply LID principles entirely and might have to use more traditional stormwater treatment facilities. However, even these facilities can be designed to fit within the community and become an amenity (see Exhibit V-13.1).

Definitions

Base flow The portion of streamflow that is not attributable to storm runoff and is supported by ground water seepage into a channel.

***Best Management Practices* (BMPs)** The structural devices, maintenance procedures, managerial practices, prohibitions of practices, and schedules of activities that are used singly or in combination to prevent or reduce the detrimental impacts of stormwater, such as pollution of water bodies, degradation of channels, damage to structures, and flooding.

Biofiltration The process of reducing pollutant concentrations in water by filtering the polluted water through biological materials, such as vegetation.

Bioretention The removal of stormwater runoff pollutants using the chemical, biological, and physical properties afforded by a natural terrestrial community of plants, microbes, and soil. The typical bioretention system is set in a depression area and consists of plantings, mulch, and an amended planting soil layer underlain with more freely draining granular material.

***National Pollutant Discharge Elimination System* (NPDES)** The part of the federal Clean Water Act that requires point source dischargers to obtain permits, called NPDES permits, which, in Washington State, are administered by the Department of Ecology (DOE).

***Stormwater Management Manual for Eastern Washington* (SMMEW)** A technical manual prepared in September 2004 by Ecology containing BMPs intended to prevent, control, and treat pollution in stormwater and to reduce other stormwater-related impacts on waters of the state east of the Cascades.

***Stormwater Management Manual for Western Washington* (SMMWW)** A technical manual prepared in September 2001 by Ecology containing BMPs intended to prevent, control, and treat pollution in stormwater and to reduce other stormwater-related impacts on waters of the state west of the Cascades.

Purpose and Need

Exhibit V-13.2 – Indian Creek Stormwater Facility (Location: Olympia, WA)

Stormwater is regulated under the Clean Water Act (CWA). Section 402 of the CWA governs the NPDES and is the U.S. Environmental Protection Agency's (EPA) primary enforcement mechanism to ensure compliance with the CWA's provisions. EPA developed rules to implement the stormwater requirements in two phases. EPA regulations require NPDES permits for discharges from three broad categories of stormwater discharges:

- Municipal separate storm sewer systems (MS4s)
- Stormwater discharges associated with industrial activity
- Stormwater discharges associated with construction activity

In 1995, Ecology issued the Phase I NPDES municipal separate storm sewer general permits for several municipalities with populations greater than 100,000 in the Puget Sound Basin.

These Phase I NPDES permittees included the cities of Seattle and Tacoma, the counties of Clark, King, Pierce, and Snohomish, and WSDOT. These Phase I permits require WSDOT to "reduce pollutants in discharges to the maximum extent practicable."

Beginning in 1995, WSDOT construction projects were also required to comply with the Ecology NPDES requirements specific to construction activities. The threshold for a site disturbance area that typically triggered an NPDES Construction Stormwater General Permit was five acres. Some large WSDOT projects with particularly sensitive environmental concerns are required to obtain individual NPDES construction stormwater permits from Ecology. Activities at sites such as the Washington State Ferries Eagle Harbor maintenance facility are covered under the NPDES Industrial Stormwater General Permit.

Beginning in 1999, several fish species in Washington State were listed as threatened or endangered. This expanded the necessity for stormwater management on WSDOT projects in many parts of the state.

In March 2003, Ecology initiated NPDES Phase II. This extends the requirements for stormwater management to most of the state's urbanized areas. Phase II also lowers the threshold for construction projects to one acre of ground disturbance. With development of the Phase II permit program underway, Ecology is also turning its attention to reissuing the Phase I NPDES municipal general permits. As part of that process, WSDOT is seeking statewide NPDES permit coverage for all of its municipal separate storm sewer discharges.

Balancing Considerations

Since most projects involving increases in impervious surfaces are required to address stormwater management issues, the design will need to be done in a context sensitive manner. The beneficiaries of stormwater treatment are the local water bodies, aquatic inhabitants, and the people who use these waters (both for business and pleasure). This also improves the visual environment.

Exhibit V-13.3 – Metro Sewage Treatment Plant, Stormwater Treatment Facility (Location: Renton, WA)

When designing stormwater facilities, the designer should explore first the option of using LID concepts. If these concepts cannot fully meet all the stormwater management needs, then the designer should design the facility to blend with the community and landscape as much as possible. Adding native vegetation, waterfalls, check dams, channels lined with vegetation and smooth rock to resemble streams, and grading the facility with curvilinear lines to resemble natural ponds and lakes makes the facility more aesthetically pleasing, while adding functional components.

Within the suburban, rural, and some industrial contexts, there might be readily available land to install stormwater facilities. In urban contexts where the development is much denser, these opportunities can arise less often. In any case, stormwater treatment facilities that blend with the environment and connect with the surrounding context will add to the value of the area, and can increase the acceptance of the transportation project.

Design Considerations

Below are some considerations associated with potential stormwater management elements:

Exhibit V-13.4 – Rain Garden (Location: 2nd Avenue NW, Seattle, WA)

Exhibit V-13.5 – Pierce County Public Works Building Stormwater Treatment Facility (Location: University Place, WA)

Design Element	Considerations
Use of medians or planting strips as bioinfiltration swales or "rain gardens"	• Medians and planting strips allow water to be infiltrated on- site and close to source. • Stormwater infiltrated using bioinfiltration techniques meets water quality treatment requirements (including enhanced treatment). • Bioinfiltration areas require the selection of water tolerant plants. • Bioinfiltration areas require engineered soil mixes with certain design characteristics. • Bioinfiltration areas can be fit into site as space and topography allow.
Retention/ Detention Ponds	• Ponds are easy to design. • Ponds have low to moderate maintenance requirements. • Ponds usually require large pieces of land. • There is a potential for safety problems due to steep slopes that may require fencing. • Ponds require a stormwater collection and transmission system. • Ponds can be designed to fit with topography and look "natural."
Constructed Stormwater Treatment Wetlands	• Constructed wetlands can be used to meet water quality treatment requirements. • Constructed wetlands may be used for flow control. • Once established, constructed wetlands form a natural, self-sustaining system. • Constructed wetlands require expertise to select plants and design the wetland. • Created wetlands create habitat.

Infiltration Ponds and Basins	• Infiltration ponds and basins can only be installed where soils and ground water tables permit. • Stormwater must be pre-treated to prevent sediment buildup and clogging of infiltrative soils before discharging into infiltration ponds or basins in most cases. • They require a stormwater collection and transmission system. • Infiltration ponds and basins can be designed to fit with topography and look "natural." • Infiltration ponds and basins usually require a large piece of land.
Natural and Engineered Dispersion	• Uses the site's natural features to treat and control stormwater runoff. • Avoid and minimize impacts to natural ecosystems with large native vegetation and undisturbed soils with large amounts of organic matter. • Mature trees can hold up to 300 gallons of water. Removal of these trees can cause a change in surrounding vegetation. • Forests and vegetated areas can be used as Dispersion Areas. • Dispersion Areas initially may cost as much as other techniques because right of way or easements often need to be purchased, but long-term maintenance costs are lower.
Vegetative Filter Strips; Compost-Amended Vegetative Filter Strips	• Compacted roadside embankment. • Increase surface roughness. • Improve plant sustainability.

Analysis Method

Stormwater treatment is required on all projects that trigger thresholds listed in the *Highway Runoff Manual*. Depending upon the location, site conditions, and the amount of projected runoff, there are several options for addressing water quality and quantity management requirements. The best solutions treat stormwater as close to the impact of the precipitation as possible. The best solutions mimic natural, pre-disturbance conditions, which include restoration of the soil biotic community, as well as revegetation.

Governing Regulations and Directional Documents

Clean Water Act (Federal Water Pollution Control Act), Title 33 *United States Code* (U.S.C.), **§** 1251 et seq.

Ecology, Department of - Puget Sound Runoff Program, *Washington Administrative Code* (WAC) 173-270.

Highway Runoff Manual, WSDOT, M 31-16.

National Pollution Discharge Elimination System, Washington State Department of Ecology, Olympia, WA, 2001, http://www.ecy.wa.gov/

Puget Sound Water Quality Authority Act, *Revised Code of Washington* (RCW) 90.70.

State Water Pollution Control Act, RCW 90.48.

Stormwater Management Manual for Eastern Washington (SMMEW), Washington State Department of Ecology, publication 03-10-038B, September 2004.

Stormwater Management Manual for Western Washington (SMMWW), Washington State Department of Ecology, publication 99-11, 2001.

Water Pollution Control, RCW 90.48.

Water Resources Act of 1971, RCW 90.54.

Additional Resources

Low Impact Development (LID) Center, http://www.lowimpactdevelopment.org/index.htm

Puget Sound Action Team - Low Impact Development, http://www.psat.wa.gov/Programs/LID.htm

Introduction

Many design decisions are made during the project development process. The earliest of these decisions relate to the scope of the project, funding, and, at times, the design process that will be followed during project development. Documenting and communicating these decisions are critical to ensuring that project stakeholders are aware of the status of the project and in agreement with that status. It also allows for agreements and input from permit agencies and approval authorities on specific issues, to ensure they have been discussed and addressed.

Incremental Design Approval

Projects benefit from good design documentation for a number of reasons. At times, differences in understanding regarding previous project decisions are encountered among the many offices responsible for a project's development. The reasons for differences in understanding are numerous. Some occur when the project is discussed without a clear understanding of the issues or the conditions upon which acceptance is based. Others occur when decision-makers and stakeholders are unclear about who is responsible for final approval of specific decisions. For example, some decisions can be made by achieving a consensus among the project stakeholders, but others must be made by an individual at a specific level within an organization or department. Changes in team membership and leadership, which frequently occur during projects, also lead to new members not being aware of previous agreements and conditions.

Exhibit VI-1.1 – Key Issues

- Documenting and communicating assumptions and decisions reduces misunderstandings and wasted work
- Approval of some design decisions is required by FHWA, and state and local laws and regulations
- Properly documented decisions dramatically reduce tort liability risk

An effective method to reduce misunderstanding is to document the decisions made by those involved with agreed-upon or required conditions, in a technical memorandum or white paper. Documenting the assumptions, design decisions, and conditions helps ensure that there is common understanding. Formal acceptance of these documents by the appropriate approval authorities helps ensure that the document was read and determined to be acceptable by the appropriate individual(s), which reduces the need to revisit the decision in the future.

Design Decisions

For many reasons, it is critical to document the decisions that are related to the specific design of a facility or elements, and how it meets accepted design guidelines, criteria, or standards applicable to the location. For projects on the state highway system, the primary source of the design criteria is contained in the Washington State Department of Transportation (WSDOT) *Design Manual*. The *Design Manual* is the basis for WSDOT's agreement with FHWA regarding highway design. It also provides a process for approval of proposed elements that do not meet the design criteria.

The City and County Design Standards section of the *Local Agency Guidelines* (LAG) manual is the primary source of design criteria for projects on arterials and collectors that are not on the state system. These standards are required by state law and include a process for approval of elements not meeting the design criteria.

In cases where a project meets most of the design criteria in the *Design Manual* or the City and County Design Standards section of the LAG manual, little additional documentation is needed. However, in some cases, meeting all the design requirements for a project is not practical due to a number of concerns, such as right of way, environment, mitigation commitments, or funding constraints. In cases where design criteria are not met, a "deviation" or design exception process is used to document the element that does not meet the design criteria. For projects on the State system, the deviation approval authority depends on the facility classification (Interstate, NHS, or non-NHS) and the type of work being performed (preservation, improvements, or reconstruction). The approval authority could be FHWA, WSDOT Headquarters (HQ) Design Office, or a WSDOT region office.

For projects not on the state system, under the guidance contained in the LAG manual and state law, the approval authority is the WSDOT HQ Highways and Local Programs Office.

When making important design decisions or considering a deviation, it is critical to discuss the proposal with the approval authority at the earliest possible time in the planning and scoping process, to determine the requirements for approval, the needed information and data, and to get an assessment of the likelihood of deviation approval.

Documentation and Tort Liability

As discussed in Chapter I-3, Legal Responsibility and Liability, properly documented decisions are critical to successful defense in tort claim litigation. If elements of a project do not meet the accepted design criteria and someone is injured on this facility, they may be able to claim negligence due to a failure of an agency to carry out its legal duty to the traveling public. The defense against claims for damages is at a significant disadvantage when there is no documentation to support the decision, even if it was the best option, as decided by a team or project engineer. This is because plaintiff's counsel will often present a position contrary to the decision made and the basis for that decision. When documentation exists which shows that a professional engineer evaluated the proposed deviation or design decision and selected a design that was, in their professional judgment, the best solution, it is great deal more difficult for a plaintiff to prove negligence or lack of analysis.

Legal claims often arise many years, or even decades, after the project is completed. Consequently, it is often difficult to identify and locate the project's designers. Even when the decisions can be discussed with the designer, the specific facts upon which the decision was based have often faded from memory. In those rare instances where the facts are recalled, it is still very difficult to "prove" what considerations were evaluated. Having properly documented decisions dramatically reduces these circumstances.

Storage of the design documentation is an important consideration. For state projects, the critical design decisions are assembled in a Design Documentation Package (DDP). The DDP is kept in the region for several years after the project is completed and then sent to the Washington State Records Center for long-term storage and retrieval. Local agencies would benefit from similar processes for long-term storage of design documentation.

Governing Regulations and Directional Documents

Design Manual, WSDOT, M 22-01.

Local Agency Guidelines (LAG) *Manual*, WSDOT, M 36-63.

Additional Resources

Mason, John M. Jr., and Mahoney Kevin M., *Design Exception Practices*, NCHRP Synthesis of Highway Practice, Washington, D.C., 2003.

Neuman, Timothy R., and James B. Saag, *A Guide to Applying AASHTO Policies to Achieve Flexibility in Highway Design*, NCHRP Report 480, Washington, D.C., 2003.

This page intentionally left blank

Introduction

The project development process is initiated in response to an identified need in the transportation system. The development process for transportation projects covers a range of activities extending from initial project concept to a finished set of contract plans. The process involves transportation planners, community leaders, environmental specialists, landscape architects, natural resource agencies, permitting agencies, design engineers, financial managers, and agency executives. The need might be an identified congestion problem, a safety concern, an economic improvement opportunity, an environmental enhancement, or a combination of multiple project types. In addition, projects might target a single mode of transportation or many different road users, including pedestrians, bicyclists, transit, passenger cars, and heavy trucks moving freight and goods. The sequence of decisions made throughout the planning and project development process progressively narrows the focus and, ultimately, leads to a project that addresses the identified needs.

There are many controlling factors that shape the decision-making process. These factors can include legislative mandates, financial limitations, agency program structure, partnering opportunities, and the design practices appropriate for the facility and the users it serves. Many of these controlling factors are intended to ensure that users of the various transportation systems will realize the greatest benefit from expenditures of their transportation dollars. It is important that participants in all phases of the planning and project development processes understand the limitations imposed upon other participants in the development of a project. There is also a need to understand the background behind previous decisions, as participants come and go during the life of a project. Unfulfilled commitments or proposed solutions that cannot be built do not contribute to the advancement of a project, and often tarnish the image of the individuals and agencies involved.

Definitions

Consultation The respectful, effective communication in a cooperative process that works toward an agreement or consensus before a decision is made or an action is taken. Consultation means more than simply informing. It is a process and not a guarantee of agreement on outcomes.

Purpose and Need

Transportation projects are initiated to address limitations in the existing transportation network. These limitations become the driving factors in developing appropriate solutions. Typically, at any given location, there are many years separating one capital improvement from the next. Consequently, it is vital that all of the stakeholders with an interest in the facility be made aware of these improvement opportunities and the driving factors behind the project. The stakeholders need to be involved in the process at its earliest planning and development stages, in order to determine if they have needs that can be dovetailed with the driving factors for the project. All participants involved with the development of a project have a responsibility to consider alternative viewpoints.

Participants must not lose sight of the primary function of the route, whether it is of local, regional, or statewide significance, and the driving factors behind the project. It is also necessary that the participants understand the context in which each project is developed. Attempts to apply inappropriate features and characteristics to routes or at inappropriate locations may lead to operational and safety issues for everyone. While participants may wish to recreate desirable characteristics observed at other locations, they need to carefully compare the facilities and the local environments, in order to ensure that what they observe at one location will indeed function in a similar and appropriate manner at a different location.

Exhibit VI-2.1 – Key Issues

- Purpose and need of project
- Stakeholder participation and understanding
- Function of route
- Context of route

The function of the transportation facility is not limited to providing for the functional needs of the roadway for vehicular travel. Characteristics of all users of the facility require consideration. Pedestrians, transit users and providers, bicyclists, and delivery vehicles might all have specific needs for the transportation facility that are to be addressed as significant components of the facility's purpose and need.

To fully understand the purpose and need for a transportation project, one needs to understand the basic purpose or function of individual routes within the overall transportation system. A Functional Classification System (see Chapter V-1) has been developed at a national level to categorize the functions of roadways. Within this system, routes are identified as principal arterials, minor arterials, collectors, and local roads.

Principal arterials typically connect distinct urban population centers with one another and may serve as primary routes through cities and towns. These arterials facilitate travel across the state and the nation, and are intended to maximize mobility at higher speeds. Principal arterials generally carry high traffic volumes and serve a multi-modal purpose.

Minor arterials are generally rural routes that link cities, larger towns, and other traffic generators together; and facilitate travel over long distances at relatively high travel speeds. They also serve to provide intracity and town functions in some locations. Minor arterials are part of the distribution system connecting principal arterials to collector routes.

Collectors are focused more on the movement of traffic within a county rather than across the state. They connect developed areas within a region to the higher functional classes, and primarily accommodate local trips. Collectors are developed to accommodate lower speeds than the arterials.

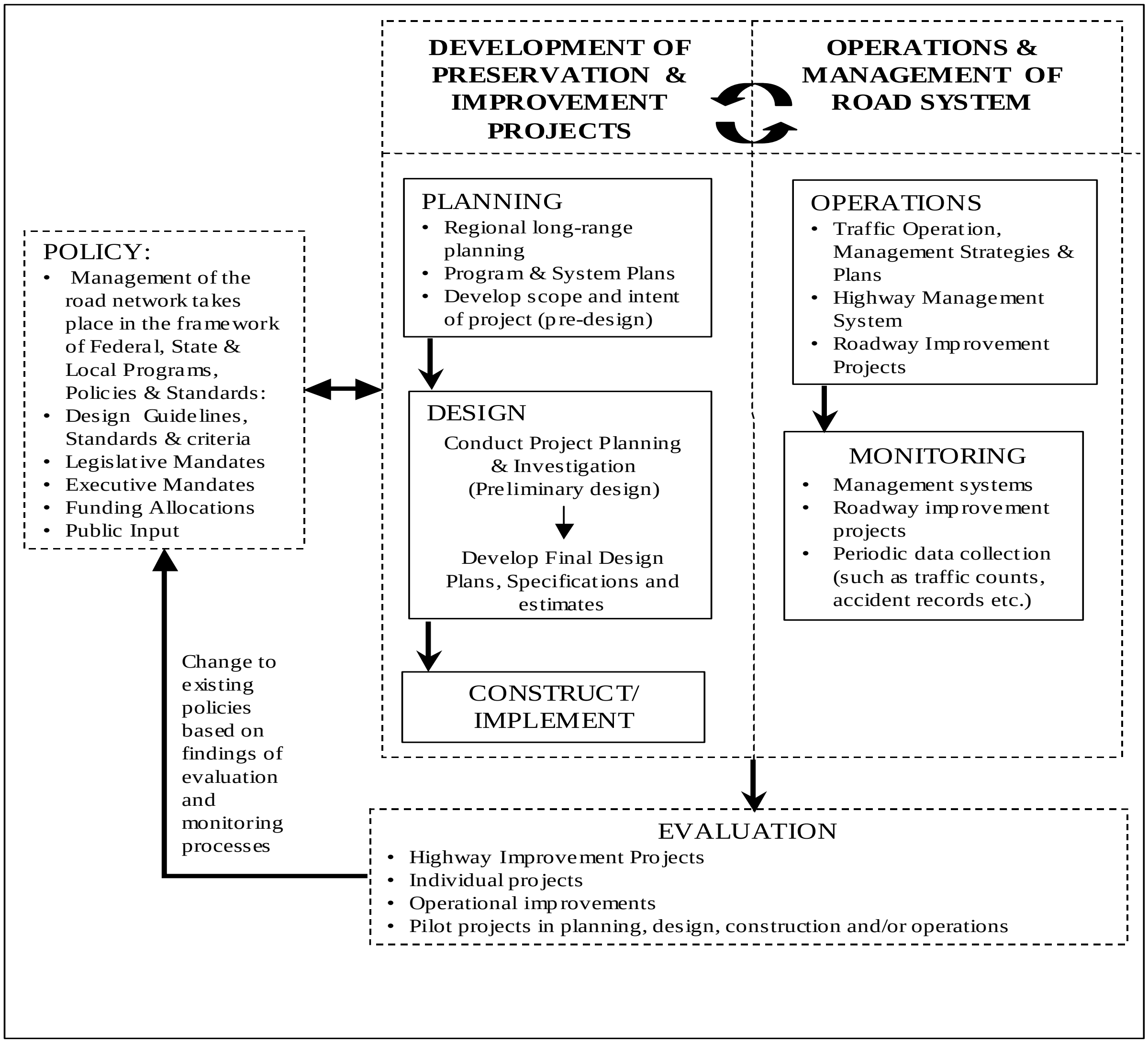
Local roads serve as access points to local destinations or points of origin. Their primary purpose is to provide access to land adjacent to the collector system. Local roads typically operate at the lowest speeds of all the different functional classes of roads. Traffic volumes on local roads are low in comparison to other route types and the trip lengths are short. Transportation projects should not be developed without consideration of these functional differences.

Project Development Role

To be effective, the project development process must link policymaking to planning, design, construction, maintenance, operations, and the evaluation of the road system, while incorporating the needs of road users into every step of the process. This process is shown in Exhibit VI-2.2 (taken from the draft *U.S. Highway Safety Manual*), which shows the linkages for the different processes in the road management process.

Policy forms the framework for any federal, state, and local program and often includes design guidelines, standards, and criteria used in planning, design, operations, monitoring, and the evaluation of programs and procedures.

Exhibit VI-2.2 – Road Management Process
(Source: TRB, draft* U.S. Highway Safety Manual*)



A successful project must allow for the seamless flow of information and processes between the planning and implementation phases of a project. In this respect, the examination at the systems, corridor, or project level, or by functional class and context, must be understood at the start of the project.

Planning is the first step in the project development process. Besides the typical transportation planning process, the concept of planning simply refers to any decision-making process used to solve complex, interrelated issues. Highway, roadway, and user needs are typically identified by various means. These needs are commonly related to removing or addressing some element of the system that has been identified as an area for improvement (e.g., improved mobility or safety).

The definition of needs and programs for the highway system is left to the policy of the respective agencies. Policy is often developed or influenced by legislative bodies, state governments, businesses, communities, and land use. Policy is also affected by local, state, and federal laws and requirements.

Early incorporation of preservation, environmental, aesthetic, mobility, or safety needs into the project development process ensures that the development of projects will be inclusive of the project goals and objectives, while still addressing the policy requirements of an agency. When this step is taken late in the process, little or no resources can be provided to accomplish the late-surfacing desires. Early consideration also provides the opportunity to achieve additional benefits from the project that were not foreseen when the project was first identified. For example, a rehabilitation project can provide the opportunity to improve pavement markings that can, in turn, improve the safety of a facility.

Early consideration of policy in planning is particularly useful in the scoping or pre-design process, where multiple solutions must be assessed for their possible trade-offs. Policy may reduce the number of solutions available or may add solutions based on the purpose and goals of the agencies involved.

Projects are developed for short, medium, and long-term improvement, or a combination thereof. Changes to traffic operations are not as long lasting as a major construction project, but are designed to address current issues. Intersection projects are often considered to be in the 10-year timeframe, although some might function well for a significantly longer period. Reconstruction projects are typically developed to last a minimum of 20 years because of the large associated costs.

These projects are developed with future conditions as the basis for design. This is, in part, where some of the reliance on standards by the engineers and architects begins. Standards are developed with the presumption that they will provide a “known safe performance” over a period of time. Standards are often univariate (one variable) in nature.

When standards are developed with specific intent, they often lack the consideration of competing needs. It is with this consideration that flexibility in design may be found. For instance, the provision of a large curb radius considers the benefit to the vehicle without consideration of the impacts to the environment or the pedestrian. While this is simplistic in its presentation, it is important to understand that the mere application of standards without the understanding of the potential impacts and trade-offs may not provide the maximum amount of benefit in terms of environmental, operational, or safety goals for all users.

Considerable practical knowledge in these areas is necessary when contemplating a change in agency methods, models, or policies. Both advocacy from select groups and design knowledge should be balanced to try to achieve the best outcome.

Many agencies develop programs and grants to assist with, or conduct research into, new and developing areas and standards. Research provides an opportunity to improve processes and understanding where knowledge is limited or not generally accepted. Research can be scaled to fit the needs of the particular issue and may have a practical or academic intent.

Having planned and scoped a project, a series of alternative design solutions are developed. These alternatives are assessed for their environmental impacts. From this assessment, a preferred alternative is developed. Once selected, the individual design and functional elements are identified and selected based on the purpose of the project, in an effort to optimize the solutions to the issues that exist in the field. A designer will often make trade-off decisions in which numerous competing impacts (e.g., safety, environmental, and right of way concerns) are weighed against each other.

After an alternative is selected, project elements are identified and each project element is evaluated. Based on the outcome of this process, project elements are selected, using not only safety, but also the criteria set by the project itself. Elements are then assessed in combination and by how they function in total. This assessment should include the combination of elements that meet the needs of the various road users and how they fit into the framework of the existing road network. This is done as part of the final design of a project. From this process, plans, specifications, and estimates are developed.

Implementation takes place through the process of advertisement, bidding, selection of a contractor and, finally, construction of the project.

After implementation, the project is evaluated for success and for any unintended effects by the agencies affected by the project, as well as those that provided funding for the project. The evaluative findings can be used to change or modify policy, procedures, and planning, where appropriate.

Issues to Consider

The effects of planning, design improvements, or operations projects vary depending on the classification of the road, context, location, traffic mix, and improvement chosen. Each project has a specific context, whether it is an urban, rural, or downtown environment, with both differing traffic volumes and different road users expected to make use of the project. The incorporation of safety into the decision-making process also includes consideration of these differences. The planner and design professional are encouraged to develop an understanding of the differing needs and contexts, whether they be two-lane rural, multilane rural, urban arterial, suburban arterial, or a downtown environment, and determine how they can influence the safety of the different users.

When the project design is not consistent with the classification of the road, safety might be reduced. Design speeds that are not consistent with the facility context, purpose, and use, lead to increases in the likelihood of speed violations and speed variances between vehicles. In addition, where little or no access control exists on routes, the speed variances are likely to increase, since vehicles are more likely to slow and stop along the roadway. Transition areas to lower speeds incrementally have proven to be beneficial in reducing speeds through cities, towns, and other areas. Consideration of the functional classification is beneficial when considering corridor segments where speed reduction is necessary.

Planners and designers must also weigh the overall benefit of safety with competing societal issues, including: the mobility of all users (such as transit, bicyclists, pedestrians, and individuals with disabilities); environmental, economic, and business impacts; construction and maintenance costs; and the aesthetics of the facility.

Planning Documents

The project development process begins with transportation planners at the city, county, and state levels. State law requires that transportation planning take place in coordination with all transportation providers, consistent with the objectives of the Growth Management Act (GMA). Planners are involved in assessing the needs and developing the initial project concepts to address those needs. Planners from multiple jurisdictions jointly develop project concepts for facilities with shared jurisdictional responsibilities.

In fulfilling their role, planners develop the project concepts through coordination with local comprehensive plans, corridor studies, route development plans, and other planning level documents. This approach helps ensure that the project concept is consistent with the functional class of the route, provides route continuity, meets the objectives of GMA, and dovetails with the local plans. The *Building Projects that Build Communities* document, as described in Division I, outlines the coordination process in greater detail.

In addition to system-wide planning, which addresses the entire transportation system, attention must be given to planning at a project level. This level of planning ensures efficient development and construction of projects that address purpose and need.

The level of effort in the initial planning phases needs to be commensurate with the projected project delivery period and the probability of funding. There is limited value in developing detailed solutions for projects that are not likely to materialize for 15 to 20 years, particularly if funding is unlikely. Conversely, for a current need that has a high probability of receiving funding, there is an implied responsibility to analyze solutions at a level of detail that ensures a high probability of success, with an accurate cost estimate. Coordination between planners and designers is critical to developing an appropriate project concept and an accurate estimate.

The preceding section lists a variety of documents and governing regulations that will serve as a good starting point in selecting design solutions. Many of the planning documents will have already identified long-term issues on a route or corridor-specific approach (potentially including trade-off discussions and alternative solutions). Failure to use any or all of these documents in the design of the project might result in the duplication of processes and a revisiting of decisions already made. It also means that previous commitments and potential funding partnerships might be overlooked. Good land-use planning efforts can result in reduced conflicts between modes and interests, and will yield a predetermined set of acceptable outcomes of some of the "local character" and "economic vitality" issues.

The process is completed by the following steps:

- Accumulate and review all studies and plans that address the corridor(s) impacted by the project.
- Compare the findings and recommendations with the stated goals of the project.
- Identify any gaps between the planning documents and the goals of the project.
- Identify all parties impacted by the project and arrange for their involvement in finalizing the project scope.
- Document all prior decisions/agreements.

Washington State's Transportation & Highway System Plans

Washington's Transportation Plan (WTP) is a statewide, multi-modal plan that outlines the existing conditions of Washington State's transportation system. The WTP also includes an assessment of the transportation system's needs for the next 20 years. The Washington State Transportation Commission and Washington State Department of Transportation (WSDOT) developed this plan in collaboration with Regional Transportation Planning Organizations (RTPOs), Tribes, and local governments. The WTP links transportation planning at the regional, tribal, and local levels with statewide transportation policy. The plan provides an inventory of potential investment opportunities in highway, ferry system, aviation, transit, freight rail, passenger rail, bicycle, and pedestrian facilities, as well as marine ports. The intent of the WTP is to achieve a safe, efficient, and reliable transportation system that benefits the economy, local communities, and the environment.

The WSDOT *Highway System Plan* (HSP) is an element of the WTP, which specifically addresses state highway routes.

State Route Development Plans

A *Route Development Plan* (RDP) is a planning study conducted for a specific highway corridor, typically in a 20-year planning horizon. The length of a corridor may vary from a few miles to an entire highway route. The RDP serves as a common vision among the partners involved with how the route may be developed over time. Typically, the RDP document includes an inventory of existing conditions, roadway classifications, transportation and land-use plans, decisions, and facilities, as well as a summary of proposed future conditions. Establishing the future direction for a corridor provides opportunities to develop agreements with potential project partners. Issues such as access management and development review policies can be addressed and developed to ensure continuity along the corridor. Multiple alternatives may be presented as solutions in the RDP.

Once an RDP is complete, it is treated as a comprehensive plan for that particular corridor, providing a framework for local agencies, WSDOT, and RTPOs to manage transportation needs along the corridor. Where design or traffic issues are considered, it is imperative to have input from both WSDOT Headquarters (HQ) and the specific region. Failure to include the proper stakeholders will lead to plans that are not implementable. RDPs are intended to be dynamic documents that are updated periodically to keep pace with ever-changing transportation needs. These documents provide an excellent project development baseline. From a corridor perspective, the RDP process addresses many of the trade-off discussions associated with project development.

Regional Plans

Washington’s statewide planning process includes regional organizations that are responsible for specific geographic areas. Urbanized areas with populations over 50,000 are required by federal law to be represented by Metropolitan Planning Organizations (MPOs). RTPOs are voluntary organizations enabled under state law to lead transportation planning efforts at a regional level. Where an MPO exists within the boundaries of an RTPO, the MPO is the lead agency for regional planning. MPO and RTPO membership may include representatives from cities, counties, ports, Tribes, transit agencies, WSDOT, major employers, and the general public. These organizations develop metropolitan and regional transportation plans that link land use with transportation.

The MPOs and RTPOs blend the individual city and county comprehensive plans into regional plans. These plans address land use and must include a transportation element. This approach ensures that the region’s transportation needs are consistent across jurisdictional boundaries, are backed by financial strategies, and are aggregated into a single document. This approach also makes it easier to identify how or when changes in individual plans affect other areas within the region. These regional plans are major building blocks in developing the *Washington Transportation Plan*.

Local Comprehensive Plans

The Growth Management Act (GMA), passed by the Legislature in 1990, is the driving force behind development of local comprehensive plans. The GMA requires counties and cities to develop comprehensive plans. Local comprehensive plans must comply with state and county planning regulations and policies.

A comprehensive plan is a coordinated land-use policy statement addressing land use, housing, capital facilities, utilities, rural issues, transportation, economic development, and parks and recreational facilities. As transportation projects are developed for local agencies, they must be aligned with land-use and transportation elements in the comprehensive plans. That alignment begins to shape transportation projects and unify the primary functions of a route with the long term plans of the local jurisdictions. Thus, a well-developed, comprehensive plan is a key step to ensuring that development of local transportation facilities is consistent with the planned land use and economic development of the surrounding area. The local comprehensive plan becomes an important guiding resource in the early development stages of transportation projects.

Corridor Studies

Corridor studies are conducted to determine the best way to serve existing and future travel demands. They typically address specific problems and often involve multiple issues (such as high accident locations, congestion levels, land-use changes, etc.) and different modes of travel. Corridor studies identify existing and future needs, recommend preferred alternatives, and contain facility descriptions. They also include information on environmental, operational, and other impacts (with proposed mitigation, when applicable). Corridor planning is conducted using at least a 20-year projection.

Normally, an existing facility, such as a highway or rail line, defines the corridor. Corridor studies, however, often extend well beyond the right of way associated with the highway or rail line. The length of the corridor is usually established by the connection between two major destinations, such as large cities. A corridor can also be defined as the entire length of a specific route.

Corridor studies provide information that accelerates the identification of major planning issues along a corridor. The development of corridor studies generally includes an initiation of the public involvement process, an economic analysis, and an identification of potential funding sources. Information included in corridor studies provides additional clarity in determining the appropriate transportation solutions for a corridor.

Roadside Classification Plan

The *Roadside Classification Plan* (RCP) provides statewide guidance for the development of roadside treatments. This document provides general guidance on planning, design, construction, and maintenance of the roadside environment. The RCP may serve as a guide for development of the route-specific *Roadside Master Plan* and *Roadside Management Plan*. In the absence of these plans, the concepts presented in this document can help guide the development of roadside elements on a project level.

Zoning and Mixed Use Development

City or county planning agencies establish and adopt zoning ordinances that govern appropriate land use. Because these ordinances address land-use issues, they can provide additional clarification on the elements that are appropriate for a local transportation facility.

Other Plans

Although they may not be as widely available as the previously described plans and guiding documents, a large assortment of additional plans with land-use and transportation linkages might also influence the scope of the project. While the following list is not all-inclusive, the additional plans and guiding documents that might be available include:

- Local Development Plans
- Transit Agency Plans
- Roadside Master Plans
- Roadside Management Plans
- Watershed Planning Documents
- Floodplain Plans
- Walkway Development Plans
- Path and Trail Development Plans
- Habitat Connectivity Plans
- Cultural Resource Plans
- Tribal Documents

As with the documents previously described, the existence of any of these plans or documents provides an additional starting point in the development of a project, which allows for the appropriate consideration of land-use and user-group needs. During project development, as many of these plans should be utilized as possible.

Determining and Considering the Needs of All Users and Stakeholders

The most successful projects consider the needs of all users and stakeholders early in the process of developing a project. Most often this begins at the planning level when stakeholders can assist in the development of the purpose and need of the project. This allows for communication and input early, so that issues can be addressed in the beginning rather than at the final stages of project development, where resources and time may not be available. The following section includes a brief discussion on stakeholders one might consider in the development of a project.

Community

It is generally recognized that projects within the urban environment have a greater variety of users and stakeholders than projects in more rural settings. Highways, streets, and roads that pass through communities impact everyone who uses those facilities, regardless of whether the user is traveling through the area or has an origin or destination point along or across the facility. Users include motorists, transit users, bicyclists, pedestrians, local residents, and businesses. The highway or street provides access to the community from distant locations, as well as the continuity of local street systems, and bicycle and pedestrian routes. The highways and streets themselves vary in their primary purposes. Some are intended to focus on the quick and efficient movement of through traffic, while others provide access and mobility for local businesses and residences.

The users of transportation facilities have a variety of needs and interests to be provided for by those facilities. For some of the users, efficient travel through the corridor is a primary goal. For others, the local community can be a destination. Consequently, these users might have a greater interest in the character or economic vitality of the local community. Local business districts, for example, might be interested in slowing vehicle speeds. Slower vehicle speeds might also create a more pedestrian-friendly roadside environment.

Tribes

There are numerous environmental, historic, cultural, jurisdictional, and financial reasons to include Tribes and tribal transportation planners in the project development process. Opportunities for partnerships and inspiration for designs abound. Though most of the Tribes are located in remote rural locations, there are a number of Tribes located within or near urban areas, including the Puyallup, Muckleshoot, Tulalip, and Suquamish Tribes; the Duwamish Tribe around Puget Sound; the S'Klallam Tribes near Port Angeles; the Umatilla Tribes near the Tri-Cities; the Yakama Nation near the city of Yakima; the Spokane, Kalispel, and Coeur d'Alene Tribes near the Spokane urban area; the newly recognized Cowlitz Tribe near the city of Vancouver; and the Lummi Nation and Nooksack Tribe, both near the city of Bellingham.

Presidential Executive Orders and Section 106 of the Historic Preservation Act, require consultation with Tribes on federally-funded projects. There are currently 37 tribal nations, with varying degrees of interest and jurisdiction over transportation projects. Washington State is home to 29 federally recognized Tribes, with whom WSDOT maintains government-to-government relations. Four Tribes are currently awaiting federal recognition and, though they do not currently have official government status, these Tribes are recognized as indigenous peoples and might gain recognition in the future. Another four tribal nations with reservations located outside of the state have traditional homelands and treaty rights within Washington State. Every square inch of the state is included in a "Usual and Accustomed Area" of one or multiple Tribes.

In addition to considering impacts on tribal interests during the development and construction of state and local projects, the Tribes and the Bureau of Indian Affairs (BIA) maintain their own road systems. There are 1,282 centerline miles of BIA roads within Washington State. Some state, county, and city roads are physically located on, or serve, reservation lands and are included in the Indian Reservation Roads inventories. These facilities are eligible for partnership funding.

Balancing Considerations

Designers need to identify the desires and interests of parties with a stake in the development of a transportation project. It is only after those desires and interests have been identified, that project staff can work with interested users to determine how to best serve those needs within the scope of the project. Many of the planning efforts presented in the preceding pages identified steps toward addressing the needs of communities. A thorough planning effort will identify those routes that are intended for the efficient movement of through traffic and those that are intended to reflect the character of the local community. Failing to address conflicting objectives along the same corridor leads to projects that fail to fully meet the needs of users.

Each agency or organization involved in developing a project is bound by regulations and policies that govern how that agency or organization may spend its funds. For an individual agency or organization, these regulations and policies may not support inclusion of stakeholder needs. However, a partnering approach to securing project funding and sharing resources can provide opportunities to circumvent some of these obstacles. Partnerships created in the project development process are likely to prompt the introduction of additional features within a project that might not be incorporated otherwise. These additional features may not even add to the cost of the project and may improve the cooperation and relationships with the involved agencies and communities.

Active communication and involvement with the public are the processes that identify and address these issues. The *Building Projects that Build Communities* document and the Managing Project Delivery (MPD) process provide resources to help local agencies and WSDOT staff understand the process for partnering by describing tools that can be used in the project development process.

Some issues might not be resolved easily and, if not, there is likely to be some conflict. The identification of conflict areas is a key step in advancing the project development discussions. For contentious issues within the project, the design feature should be identified, as well as how that feature might impact the users of the facility, and those who live or work in the immediate vicinity. The impacts should be presented without bias and the mitigation of adverse impacts discussed.

Discussing conflicts may or may not lead to an amenable solution. When solutions are not forthcoming, providing the desired function or feature at another nearby location, in an alternate form, or in a future project might be considered. In some instances, it might not be possible to reach a resolution that meets the needs of all stakeholders. In these instances, it should be determined if the original situation that created the proposed project is important enough to continue with, in spite of the unresolved issues. Project proponents need to ask themselves: what are the impacts of not pursuing the proposed project and do those impacts overshadow the ramifications of the unresolved issues? These questions will help lead to decisions as to whether or not to pursue the project, despite some unresolved issues.

Overview of Transportation Funding

Funding for transportation projects may be generated from a number of local, state, and federal sources. (See the Roadside Funding Matrix in Appendix B of this document.)

Local Funds

Local agency funds come from a variety of sources, including: gas tax; vehicle licensing fees; local sales tax; other local improvement fees; developer mitigation funds; and federal or state grant programs. When WSDOT performs work on state highways on behalf of local agencies, the local agencies typically reimburse the department for that work.

State Funds

State funding is generated from a number of sources, including: the state gas tax; vehicle licenses, permits and fees; ferry fares; aviation revenues; and bond proceeds.

The state gas tax is the largest contributor to the state funds available for transportation projects, and WSDOT retains approximately half of the state gas tax. The remainder of the revenue generated by the state gas tax is divided among the counties, cities, and state's highway accounts.

State funding is also generated through the collection of new and annual vehicle registration and licensing fees for trucks, based on weight.

Funding for the Washington State Ferries is augmented by revenue generated from ferry rates and concession sales.

Further transportation funding is generated from the taxing of aircraft fuel and revenue from aviation registration-related fees and excise taxes.

Finally, funding is also secured through the issuance of transportation bonds to generate funds for capital investment in transportation facilities.

Federal Funds

Transportation projects also receive funding from the current federal-aid highway act, The Transportation Equity Act for the 21st Century (TEA-21), and through the Federal Highway Administration. Federal funding for transportation projects assumes the form of a number of different funding programs, each complete with its own unique eligibility criteria.

Funding Constraints – 18th Amendment Restrictions

The intent of this section is to provide a general overview of the funds available for transportation-related projects and outline the most prevalent constraints for using state funds - the 18th Amendment of the State Constitution and the Revised Code of Washington (RCW) 46.68.070.

Within Washington State, transportation projects are funded through a combination of local, state, and federal transportation revenues and funds. The bulk of funding for transportation projects is generated through the authorization of federal-aid highway acts and state funds from the Motor Vehicle Fund. Many of these funding sources include specific eligibility criteria that must be adhered to. The eligibility criteria often impose limitations on the type of projects, or work within a project, eligible for those funds. Funds may be jeopardized when the project does not comply with the eligibility criteria.

Legislative actions have targeted specific projects with a portion of the WSDOT share of the gas tax. Projects on this list have specific objectives and funding amounts budgeted to accomplish those objectives. Further legislative action is required to alter the project objectives or funding amounts.

A key funding constraint in Washington State is the 18th Amendment to the state's Constitution, which was approved by voters in 1944. The passage of the amendment allowed the creation of a dedicated funding source for highway purposes, through the creation of the Motor Vehicle Fund. Money for the Motor Vehicle Fund is generated from federal grants; state motor fuel tax; motor vehicle licensing fees; and other transportation-related revenues, as described above.

The 18th Amendment to the state's Constitution restricts the expenditure of funds from the Motor Vehicle Fund to highway purposes only. The definition of "highway purposes" includes the support of state, city, and county highway maintenance and construction, and the highway-related activities of the Washington State Patrol and the Washington State Ferries. Expenditure of these funds may also be available for use by pedestrian, equestrian, and bicycle facilities, in situations where the facility is an existing trail on highway right of way; where an existing highway severs a trail system; or where the use of the trail will increase motor vehicle safety.[1] However, the funds may not necessarily be available for these systems if they are not deemed to have a highway purpose.

The restriction on the use of state funds, prompted by the 18th Amendment, can, at times, limit WSDOT's ability to participate in project activities more loosely tied to "highway purposes." Project activities, such as environmental enhancements and some aesthetic features, may not be eligible for state funds and are constraints that need to be considered in the project development process. If a project team determines that potentially non-eligible elements are important to the success of the overall project, then a strategy for securing other funding sources for those elements will be required.

Governing Regulations and Directional Documents

Centennial Accord Between the State of Washington and Federally Recognized Indian Tribes in the State of Washington, Office of the Governor, Olympia, WA, 1989.

Centennial Accord Plan, WSDOT, Olympia, WA, 2003.

Consultation and Coordination with Indian Tribal Governments, Exec. Order No. 13175, 65 Fed. Reg. 67,249 (2000).

Highway Funds, W.S. Const. amend. XVIII, § 40, [1943 House Joint Resolution No. 4, p. 938. Approved November 1944].

Highways, Title 23, Code of Federal Regulations (CFR).

[1] Legislative Transportation Committee, 2003.

Motor Vehicles - Disposition of Revenue – Motor Vehicle Fund Created – Use Limited, *Revised Code of Washington* (RCW) 46.68.070.

National Environmental Policy Act (NEPA), 42 *United States Code* (U.S.C.) §§ 4321-4370(f).

National Historic Preservation Act of 1966 (NHPA), 16 U.S.C. § 470.

Roadside Funding Matrix, WSDOT, Appendix B.

State and WSDOT Budget, Adopted by the Washington State Transportation Commission, http://leap.leg.wa.gov/leap/budget/default.asp

State Environmental Policy Act (SEPA), RCW 43.21C, *Washington Administrative Code* (WAC) 197-11, WAC 468-12.

State Transportation Policy, Washington State Transportation Commission, WSDOT. Transportation Planning Office, tpo@wsdot.wa.gov

Statewide Transportation Planning, RCW 47.06.

Transportation Equity Act for the 21st Century In Review, http://www.fhwa.dot.gov/tea21/sumcov.htm

Transportation Equity Act for the 21st Century of 1998, (TEA-21), Pub. L. 105-178 as amended by the TEA-21 Restoration Act, Pub. L. 105-206, 1998, http://www.fhwa.dot.gov/tea21/index.htm

Treaties of the 1850s between the United States and Tribes within Washington State, Governor's Office of Indian Affairs, http://www.goia.wa.gov/treaties/treaties.htm

Tribal Consultation Policy, WSDOT, E 1025.00, http://wwwi.wsdot.wa.gov/docs/OperatingRulesProcedures/1025.pdf

Washington State Growth Management Act, RCW 36.70A.010.

Washington State Highway System Plan: 2003-2022, WSDOT Transportation Planning Office, Olympia, WA, 2002, http://www.wsdot.wa.gov/ppsc/hsp/pdf/HSP-2003-2022.pdf

Washington State Transportation Plan, WSDOT, Olympia, WA, 1985-2000.

Additional Resources

Affiliated Tribes of Northwest Indians, www.atnitribes.org

Community Partnerships Forum, *Building Projects that Build Communities – Recommended Best Practices*, WSDOT, Olympia, WA, 2003, http://www.wsdot.wa.gov/biz/csd/BPBC_Final/

Governor's Office of Indian Affairs, Washington State, www.goia.wa.gov

National Congress of American Indians, http://www.ncai.org/

Tribal Usual and Accustomed Area Maps of Washington State, Army Corps of Engineers, available through the WSDOT Headquarters Tribal Liaison or Cartography/GIS Offices.

Washington State Transportation Resource Manual, Legislative Transportation Committee, Olympia, WA, 2003, http://ltc.leg.wa.gov/Manual03/default.htm

This page intentionally left blank

Introduction

The concept of flexibility in transportation design aligns very well with the processes of the National Environmental Policy Act (NEPA) and State Environmental Policy Act (SEPA). These processes are described in detail in the Washington State Department of Transportation (WSDOT) *Environmental Procedures Manual*. The three processes are integrated, rather than independent, and each recognize the significance and importance of the natural and human environments. Their intention is to select the alternative or solution that best addresses a defined purpose and need within the context of site-specific conditions. Gathering information about and addressing the environmental issues and needs of a community are key elements of these approaches. Because of the broad range of interests, a partnering approach to project development and funding is a logical method for dealing with these issues and needs within the scope of a project.

The transportation project development process involves defining a project's purpose and need; analyzing any potential environmental impacts and mitigation; and determining if other needs can be merged into the project to maximize its benefit for both the community and the environment. Within this process, the project sponsor or sponsors should strive to protect environmental resources (wetlands, cultural resources, etc.) and ensure that environmental conditions (air, water quality, etc.) are better than they were before the project was initiated. As stated in the *Environmental Procedures Manual*, project sponsors are obliged to first avoid (if possible), then minimize (to the extent practicable), and finally compensate for any remaining environmental impacts of a project. They do so by completing appropriate environmental restoration or enhancement projects in the vicinity of the project, or at an agreed upon off-site location (typically within the same watershed), to replace lost environmental functions and values. They need to do so in a context sensitive manner (as stated in the Environmental Considerations section, Division IV). However, in the process of identifying and analyzing any potential compensatory mitigation opportunities, the project sponsors should also seek to determine if any other environmental needs can be addressed through the project, in order to maximize its benefit for both the community and the environment. This can lead to environmental partnering to pool resources and maximize the overall benefits of the project.

As suggested above, most environmental funding is related to project mitigation or stand-alone environmental improvement projects. Funding can come from grants, or state or federal dollars.

In some scenarios, agencies enter into environmental partnerships. In environmental partnerships, the project sponsors work with another agency to satisfy an environmental need that is unrelated to the environmental impacts of a project. For instance, if a fish passage barrier exists within or adjacent to the right of way of a highway, which is a concern for the community or a natural resource agency, they may choose to retrofit the facility to improve fish passage (even if it is not part of a transportation improvement project, or related to a transportation improvement project that will degrade fish habitat). If the project sponsors partner with a particular interest group or groups to fund or implement portions of such an improvement, they are pursuing an environmental partnership.

Definitions

Advance mitigation Mitigation of adverse impacts upon the environment from transportation projects before design and construction.

Mitigation Sequentially avoiding impacts, minimizing impacts, and compensating for remaining unavoidable impacts.

Mitigation bank A wetland to be drawn upon to offset several small wetland losses from several off-site sites or projects, expressly for the purpose of providing compensatory mitigation in advance of authorized impacts. The compensatory mitigation may be through restoration, creation, or enhancement of wetlands, and the preservation of adjacent wetland or stream buffers and other habitats.

Mitigation credit A unit of wetlands or habitat mitigation, or other agreed upon unit of currency available at a mitigation bank site for use as compensation. A unit of trade representing the increase in the ecological value of the site defined either by area or by a measure of functional capacity through application of scientific functional assessment.

Mitigation plan The document(s) that contains all information and specifications necessary to fully implement and construct a compensatory mitigation project.

Mitigation site A site where wetlands or other aquatic resources or natural habitats are restored, created, enhanced, or preserved, expressly for the purpose of providing compensatory mitigation for impacts to similar resources.

Identifying the Environmental Issues and Needs in the Project Area

In order to develop a transportation project that

- Fits into its physical setting,
- Protects existing environmental resources, or
- Improves the overall condition of the environment.

It is necessary to understand the condition of the environment before and after the project; the issues of concern; and the environmental needs in the project area. Various stakeholders with knowledge of the area identify the needs. In some cases, these can be determined through the project environmental review process, but on large or more complex projects, it will also be necessary to consult with stakeholders to improve an understanding of the environmental issues in an area. Exhibit VI-3.1 presents a list of potential project stakeholders.

When project sponsors consult with stakeholders, it is helpful to provide a brief introduction to the project, describe the purpose and need for the project, summarize any environmental issues, and solicit feedback on those issues (and any other issues identified by the stakeholders). It is also desirable for the sponsors to request feedback on any environmental needs in the area, including any environmental restoration or enhancement projects that could serve as potential mitigation for project impacts.

In some cases, especially in areas with multiple projects, the sponsoring agencies might also hold "Partnering Workshops." In these workshops various stakeholders are invited to discuss any environmental issues, needs, and mitigation opportunities. Prior to the workshops, participants might be asked to provide environmental documents and maps that describe and locate any valued environmental resources and any restoration or enhancement projects that might address environmental needs. During the workshops, stakeholders might be asked to identify any environmental issues, needs, and mitigation opportunities on the maps.

Watershed or salmon recovery projects, or restoration needs and priorities identified in watershed or salmon recovery plans, as well as limiting factors analyses, are often of interest as potential mitigation opportunities. It is also important to know about any immediate and long-term plans for the area around potential mitigation sites. For instance, if the area around a potential mitigation site is slated for a substantial amount of growth (and growth-induced impacts), then a mitigation project at the site may provide a lower level of benefit for the community and environment in the long run, when compared to a project located where less growth is expected. This is particularly true where a restoration or enhancement project will have more lasting value.

Exhibit VI-3.1 – Potential Project Stakeholders

- Staff and local government officials
- Staff and officials of state and federal resource agencies
- Tribal government staff and officials
- Adjacent property owners and tenants
- Community groups (clubs, civic groups, churches)
- Local watershed planning groups
- Salmon recovery planning groups
- Environmental/conservation groups, including land trusts
- Recreation, hunting, fishing enthusiasts
- Utility providers
- The general public
- Bicycle clubs

Exhibit VI-3.2 – Project Discussion

- Provide a brief introduction to the project
- Describe the purpose and need for the project
- Summarize any environmental issues of the project
- Solicit feedback on the issues
- Identify and discuss any other environmental needs in the area

Identifying and Forming Environmental Partnerships

Once the environmental elements of a project have been identified, along with the mitigation needs for one or more projects in the area, it is then possible to identify alternatives for improvement – possibly through a common solution with potential partners. This is beneficial for each partner and creates a positive situation for the environment and each participating property.

In some cases, the stakeholders will partner with a transportation project sponsor on an environmental mitigation or enhancement project. However, more often than not, the project sponsor will discover a partnering opportunity by working cooperatively with various interest groups in the analysis of various mitigation site options and preferred site selection. (The preferred site is one that meets multiple needs, is cost effective, and provides the greatest net environmental benefit. These mitigation sites have an implementation plan that addresses the mitigation elements and designs.) The project sponsor should then seek feedback on, and refine, the plan for approval by any agencies with jurisdiction over the planned activities. On some WSDOT projects, the agency has also used a more rigorous "Watershed Characterization" process for this purpose. In this process, various environmental stakeholders are engaged in a detailed watershed needs and mitigation pairing analysis.[1] In developing a mitigation plan, any logical partners are identified and asked if they would like to participate, in an effort to satisfy similar interests.

Project sponsors may also seek to satisfy the mitigation needs of their project (or multiple projects) in advance of project construction by partnering on "advance mitigation." Advance mitigation is early mitigation for the anticipated unavoidable impacts of a single project or on a "mitigation banking effort." In these partnering efforts, "mitigation credits" are produced over time through environmental restoration or enhancement activities on a mitigation site. These credits become available for use by the project sponsors (and possibly their partners) as compensation for unavoidable project impacts as the environmental restoration or enhancement activities are completed and prove successful. The success is measured by the restoration, creation, enhancement, or preservation of certain environmental processes and habitats. It is also measured by the provision of the functions and values proposed in a mitigation plan.

Examples of Environmental Partnership

Exhibit VI-3.3 – First Creek Fish Passage (Location: Lake Chelan, WA)

Some examples of Environmental Partnerships that have resulted in multiple benefits for WSDOT, its partners, the public, and the environment, are discussed below:

1) ***First Creek Fish Passage,*** where WSDOT partnered on an impact mitigation project near its highway right of way;
2) ***Indian Creek Stormwater Facility,*** where WSDOT partnered on an impact mitigation project outside the immediate project area;
3) ***Schel-Chelb Estuary Restoration Project,*** where WSDOT partnered on a mitigation bank to earn mitigation credits for multiple projects; and
4) ***Moses Lake Mitigation Bank,*** where WSDOT partnered on an environmental enhancement project that was unrelated to any transportation improvement project.

First Creek Fish Passage

On this project (shown in Exhibit VI-3.3), WSDOT partnered with the Washington State Department of Fish and Wildlife (WDFW), State Parks, the Chelan Sportsman's Club, and the U.S. Fish and Wildlife Service to replace two culvert fish passage barriers under State Route 971 (South Lake Shore Drive). A culvert located at the Chelan State Park entrance and another located 100 yards upstream were replaced with "fish friendly" bridges. The project rebuilt a naturally "terraced" creek bed under the roadway and, for the first time in 50 years, Chinook salmon, and Kokanee, Cutthroat, and Rainbow Trout

[1] R. Gersib, *Enhancing Transportation Project Delivery Through Watershed Characterization*, 2003.

are now able to access the upper reaches of First Creek. The partners helped with project planning and funding.

Indian Creek Stormwater Facility

On this award-winning project (shown in Exhibit VI-3.4), WSDOT partnered with the city of Olympia, its Arts Commission, the Nisqually Tribe, and the Squaxin Island Tribe to address a stormwater and slope stability problem adjacent to Interstate 5. The result of the partnership was the creation of a park and stormwater facility by the partners. The site is now maintained by Olympia's Parks Department. The facility uses sedimentation ponds, bioswales, and an aerating waterfall, to treat 10 acres of runoff from Interstate 5 and local roads. The project incorporated public art, walking/jogging trails, and native landscape plants that are edible, and have medicinal or basket weaving uses in traditional Native American cultures. The project also incorporated a basket-shaped landscaped depression to honor the Nisqually and Squaxin Island Tribes, who used the area as a gathering place for basket-making materials.

Exhibit VI-3.4 – Indian Creek Stormwater Facility (Location: Olympia, WA)

Schel-Chelb Estuary Restoration Project

On this project, Washington State Ferries partnered with the Suquamish Tribe, Trout Unlimited, the U.S. Fish and Wildlife Service, and private landowners. Together, the partners restored a two-acre intertidal mudflat/salt marsh estuary as partial compensation for a 0.9-acre near-shore confined disposal facility sediment cleanup at a ferry maintenance facility in nearby Eagle Harbor on Bainbridge Island. This effort was needed to expand the ferry maintenance facility and maintain other community uses.

The combined Schel-Chelb Estuary (Exhibit VI-3.5) and Eagle Harbor cleanup projects increased the amount of high-quality aquatic habitat on Bainbridge Island. This comparison was relative to existing conditions and other multi-project alternatives. The Schel-Chelb partnership offered:

- An unequivocal net gain in overall habitat acreage and function;
- A design that was integrated with local development plans so riparian buffers adjacent to the estuary would not be compromised by future residential development in the area;
- A net increase in the value of the adjacent uplands, a condition which further enhanced the overall partnership;
- The removal of fish passage barriers; and
- The re-establishment of upstream connections by linking the system to a high-quality forested wetland.

Exhibit VI-3.5 – Schel-Chelb Estuary Restoration (Location: Bainbridge Island)

Moses Lake Mitigation Bank

On this project (see Exhibit VI-3.6), WSDOT partnered with the city of Moses Lake to create a mitigation bank by restoring and enhancing 11.3 acres of wetlands on a 12.2-acre site owned by the city, and preserving the site in perpetuity for wetland habitat and public access through a conservation easement. Various entities were involved in completing the restoration and

Exhibit VI-3.6 – Moses Lake Mitigation Bank (Location: Moses Lake, WA)

enhancement work, which included removing fill and other materials, increasing the amount of open water habitat, and planting native plant materials. The project also included installation of a viewing and interpretive platform and sign (the latter of which was provided by the Central Basin Audubon Society). The site provides WSDOT with off-site wetland mitigation credits for use on future highway projects located within the service area designated for the bank.

Environmental Partnership Options

Exhibit VI-3.7 – Partnership Opportunities

- Mitigation option analysis & selection
- Mitigation plan development
- Application for permits
- Initial property acquisition
- Restoration, enhancement, and retrofit work
- Mitigation credit use
- Long-term ownership
- Maintenance and operation

Project sponsors have a variety of options when it comes to partnering on an environmental enhancement project. These options also exist on the planning and implementation of environmental impact mitigation for a project (or, in the case of a mitigation bank, for multiple projects).

For any of the potential environmental partnering activities listed in Exhibit VI-3.7, the project sponsor can choose to retain responsibility for that activity; find a partner that is willing to assume responsibility for (and fund) that activity; or find a partner (or partners) willing to share responsibility for that activity with the project sponsor.

Potential Results of Partnering to Address Environmental Issues and Needs

Environmental partnerships may provide the opportunity to:

- Address a variety of environmental issues or needs identified by multiple stakeholders, including local entities;
- Find more ecologically sound solutions to environmental problems;
- Promote cost sharing, which can reduce overall project costs, and long-term maintenance and operation costs;
- Build trust between entities and between those entities and the public; and
- Engage interest groups that might otherwise address concerns through legal action.

If a project sponsor decides to partner with one or more entities on one or more of these activities for a project, the sponsor is engaging in an environmental partnership.

Governing Regulations and Directional Documents

Environmental Procedures Manual, WSDOT, M 31-11.

Highway Runoff Manual, WSDOT, M 31-26.

Highways – Federal Highway Administration, Department of Transportation – Mitigation of Impacts to Wetlands and Natural Habitat, 23 *Code of Federal Regulations* (CFR) **§** 777.

Local Agency Guidelines, WSDOT, M 36-63.

National Environmental Policy Act (NEPA), 42 *United States Code* (U.S.C.) **§§** 4321-4370(f).

State Environmental Policy Act (SEPA), *Revised Code of Washington* (RCW) 43.21C, *Washington Administrative Code* (WAC) 197-11, WAC 468-12,

Water Rights – Environment – Aquatic Resources Mitigation, RCW 90.74.010(1).

Additional Resources

Community Partnerships Forum, *Building Projects that Build Communities: Recommended Best Practices*, WSDOT, Olympia, WA, 2003, http://www.wsdot.wa.gov/biz/csd/BPBC_Final/

Gersib, R., et al., Enhancing Transportation Project Delivery Through Watershed Characterization, Methods and SR-522 Case Study, Washington State Department of Transportation, Olympia, WA, February 12, 2003.

Neuman, T.R., et al., *A Guide to Best Practices for Achieving Context Sensitive Solutions*, NCHRP Report 480, Transportation Research Board, Washington, D.C., 2002.

Statewide Environmental and Resource Agency Contacts, Environmental Services, WSDOT, http://www.wsdot.wa.gov/environment/statewideEnvironmentalContacts.htm

This page intentionally left blank

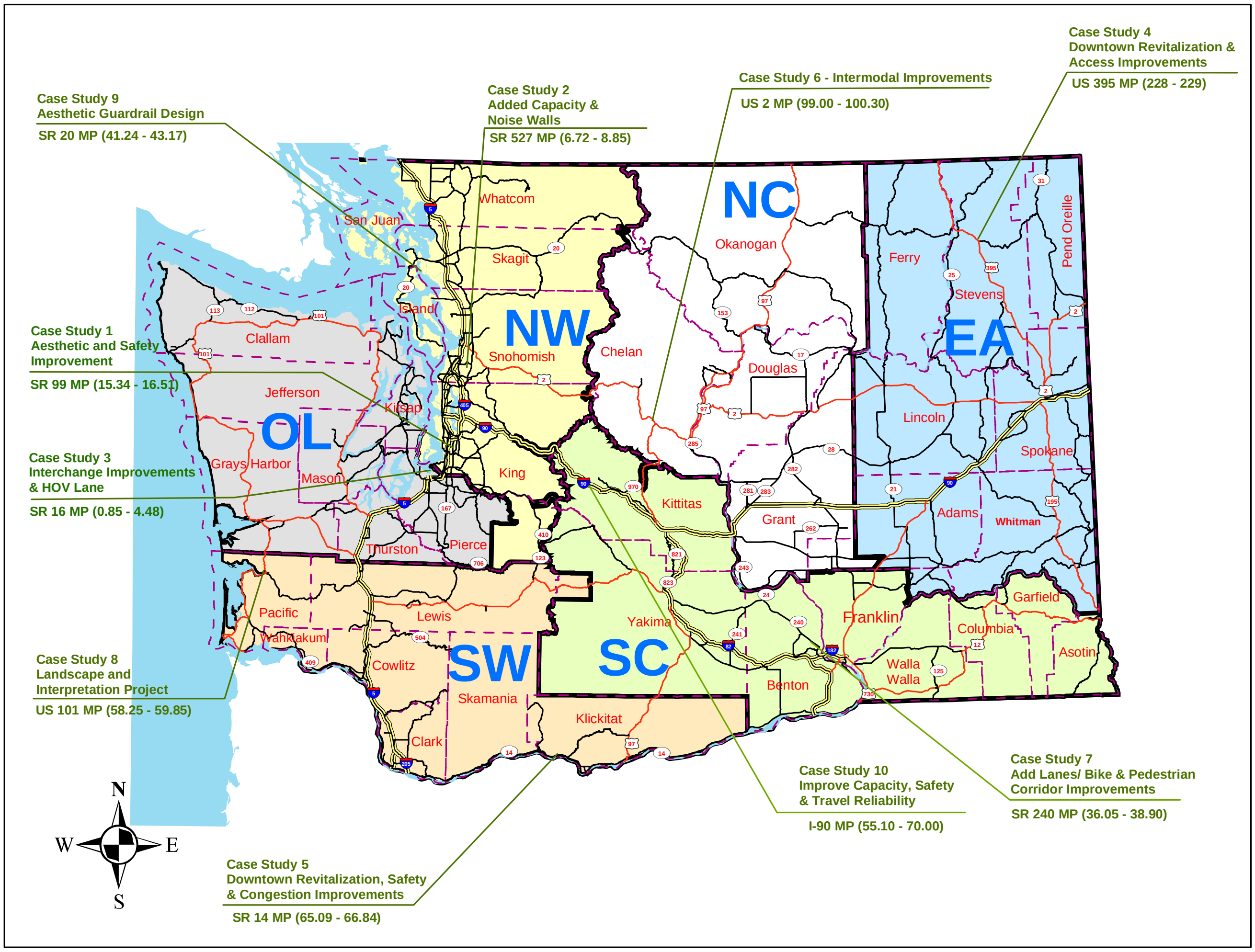
Case Study Locations

The case studies included in this appendix were selected from projects designed and constructed in a manner that illustrates the principles presented in this document. The specific case studies were selected in order to represent more of the variety of contexts, project scopes, and natural and social environments in which context-sensitive projects are designed. It was also deemed important to include examples from the entire state of Washington, so a determined effort was made to include at least one case study from each of the six regions, as defined by WSDOT.

The locations are identified below in Exhibit A, including the case study number, title, route, and project mileposts.

Details about the project development process, environment, stakeholders, challenges, and solutions are given in each of the following case studies. Additional information may be available on the WSDOT website or from the project offices.

Exhibit A – Case Study Locations Map



This page intentionally left blank

Appendix A Case Studies
Case Study 1
Aesthetic and Safety Improvement, SR 99 – Pacific Highway South at Des Moines

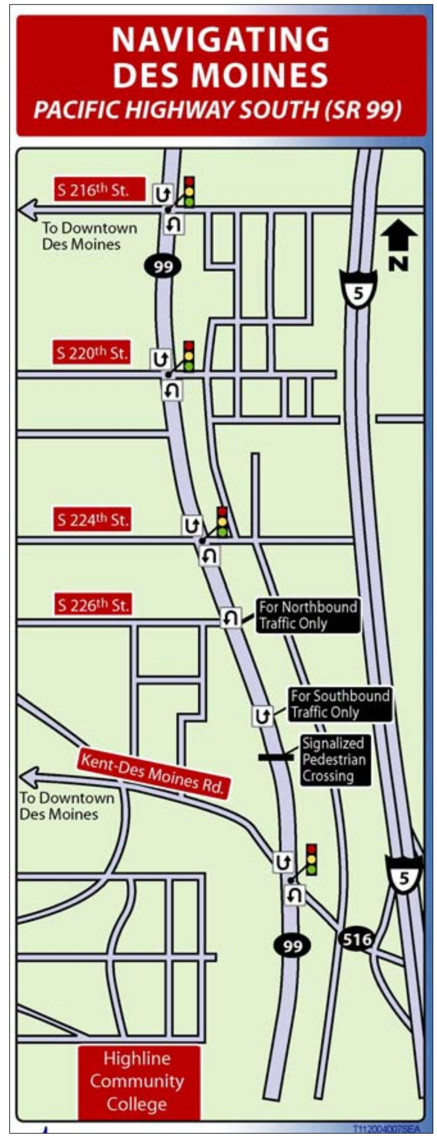
Project Description

Location

City of Des Moines

Pacific Highway South (SR 99)
South 216th Street to Kent-Des Moines Road (SR 516)
SR 99 MP 15.34 – MP 16.51

Exhibit A-1.1 – Project Area Map Showing U-turn & Signal Locations (Source: City of Des Moines)



Purpose & Need

The Pacific Highway South (SR 99) corridor suffers from severe traffic congestion and delay, and averages five accidents per million vehicle miles annually – including three fatal accidents and fourteen pedestrian accidents in a 3-year period. It also lacks the unified streetscape that provides a "sense of place." The city wanted to improve vehicle and pedestrian safety, traffic operations, HOV and transit facilities, and traffic capacity for the year 2020. The vision for the "Waterland City" also included a signature streetscape that was inviting to residents and visitors and encouraged economic redevelopment along the corridor. Another important objective was to improve the water quality in Barnes and Massey Creeks by detaining and treating the roadway runoff.

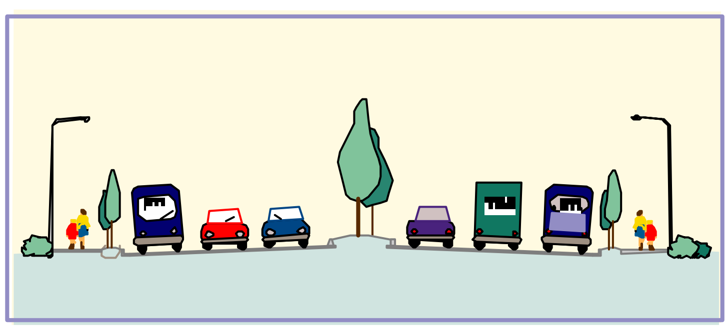
Context

This one-mile segment of Pacific Highway South extends the entire length of the city of Des Moines; the south limits at Kent-Des Moines Road (SR 516) abut the city of Kent and the north limits abut the city of SeaTac. The existing roadway is a 1950's era undivided five-lane facility with two-way left-turn lanes and paved shoulders. This high volume (32,000 ADT), multi-lane, non-NHS principal arterial, with a posted speed of 45 mph, serves as a major north-south corridor for the Puget Sound Region. The existing land use is semi-urban, commercial "strip" development with steep, narrow parcels fronting the highway.

Initial Design Concept

The city of Des Moines' work was preceded by a Washington State Department of Transportation (WSDOT) corridor study of the 14-mile segment from Tukwila through Federal Way, which established a basic concept of six lanes with outside HOV/transit lanes and a landscaped median. Des Moines' goal was to find solutions to traffic safety and operations problems that would promote and enhance redevelopment along the corridor. Initial design concepts included attractive gateways; street trees and landscaping; non-motorized facilities including sidewalks; access management; undergrounding of overhead utilities; and signalized pedestrian crossings. Developing these concepts into reality required a multi-disciplined approach to the following key challenges.

Exhibit A-1.2 – Initial Design Concept Rendering (Source: City of Des Moines)



Challenges

Exhibit A-1.3 – Challenges

- Establishing a safe clear zone
- Working with limited right of way
- Creating a streetscape for the community
- Improving pedestrian crossing safety
- Making the most of limited space for utilities
- Identifying sites for stormwater detention and treatment
- Minimizing construction impacts

The information-sharing and community feedback process undertaken by the project staff and the community and stakeholders impacted the project and required extensive effort from all parties to achieve the final product. There were several public meetings to ensure the project would meet the defined objectives while being completed on time and within budget.

Factors that affected the construction of this project included building the project while maintaining traffic flows, and achieving compliance with environmental requirements. Utility relocations played a pivotal role in the project, requiring coordination between the construction work schedule and utility relocation, and purchasing land for widening the roadway.

Funding

Funding partners for this $22.3 million project included the city of Des Moines, Washington State Transportation Improvement Board (TIB), Federal Highway Administration (FHWA), WSDOT, and King County Metro.

Schedule

This project began with preliminary engineering in 1997. The design phase and right of way acquisition began in 2000, and was completed in 2003. Construction began in fall of 2003 and was completed in early 2005.

Process

Public and Agency Participation

The project was completed in four phases: SR 99 Corridor Study, Predesign, Final Design, and Construction. Using a context sensitive design process, the team established a multi-disciplined approach to develop solutions to each of the key project challenges. This approach was based on a framework to ensure effective decision-making, reflect community values, achieve environmental sensitivity, and create safe and feasible solutions. The following table shows how solutions for challenges were developed using the framework below.

Exhibit A-1.4 – Key Challenges, Decisions, Values, and Solutions (continued)

Key Challenge	Effective Decision-Making	Community Values	Environmental Sensitivity	Safe & Feasible Solutions
Clear Zone	Early involvement of WSDOT/FHWA	Street trees in medians and roadside	Reduce impervious surface	Landscaped median with low height barrier
Streetscape	City Council, Streetscape Committee & community workshops	Sense of entry, a unified streetscape that enhances safety	Encourage economic development, create city identity	Improved lighting, sidewalks, planter strips
Improving pedestrian crossing safety	South King County Task Force: SCIPP	Provide safe place to cross, increase visibility between drivers and pedestrians	Reduce stranded pedestrians crossing mid-block	Create pedestrian refuges

Exhibit A-1.4 Continued – Key Challenges, Decisions, Values, and Solutions

Key Challenge	Effective Decision-Making	Community Values	Environmental Sensitivity	Safe & Feasible Solutions
Limited space for utilities	Partner with utilities to develop a shared trench	Reduce visual clutter of overhead utilities	Reduce clutter, compliance with Pacific Ridge Rezone	Underground utilities, improve reliability of utility systems
Limited right of way width	Right of way acquisition procedures plan, property owner meetings	Maintain functionality of the properties	Maintain highway functionality, promote economic vitality	Aerial photo maps to convey and minimize impact
Siting stormwater facilities	Partner with city of Kent; identify properties on the market	Blend ponds with surrounding environment	Minimize relocation needs, utilize wetland pond design	Joint facilities, avoid developable property, target parcels for-sale
Minimizing construction impacts	Council desire to minimize disruption	Maintain traffic & access to businesses	Minimize economic impact	Website, phone hotline, flagger use, signing

Clear Zone

With many cities along the corridor planning to transform SR 99 into a pedestrian-friendly, tree-lined boulevard, WSDOT became concerned about how its design standard for clear zone would apply to these high-speed corridors through urban environments. Introducing street trees into the landscaped median was a classic example of the conflict between community values for livable streets, and state highway safety standards. Since they shared in the safety and liability issues, the city and state worked together to develop solutions. The conflict was resolved by the city's choice to use a low profile 18" concrete barrier in the landscaped median areas, with an architectural treatment to minimize its height and soften its appearance. Crash tested to meet state and federal requirements for 45 mph, the barrier allowed the city to plant trees and install other streetscape treatments in the median.

Exhibit A-1.5 – Median with Trees and Median Barrier within Clear Zone

Exhibit A-1.6 – Streetscape Enhancements

Streetscape

The project team used workshops and committees to engage City Council members, property owners, and the public in establishing the vision and values for the project. These forums revealed that the community desired a strong sense of entry into Des Moines and wanted the project to encourage development while enhancing safety and reducing crime. The new streetscape design meets these needs by incorporating sidewalks with landscaped planters, increased pedestrian and roadway lighting, architectural elements with a marine theme, and a landscaped median. This streetscape plan also improves the environment by reducing runoff and pollution from impervious surfaces. These aesthetic improvements create a distinct sense of arrival and provide an attractive "front door" for the city of Des Moines.

Improving Pedestrian Crossing Safety

Through collaboration with the South County Improvements for Pedestrians Program (SCIPP), the city engaged experts to develop viable and affordable solutions to the pedestrian safety problems in the corridor. High-speed right-turning vehicles and long crosswalks contributed to pedestrian collisions at the intersection of Kent-Des Moines Road. A pedestrian island

Exhibit A-1.7 – Undergrounding Utilities

refuge was recommended as a means to slow the approaching right-turning vehicles and improve pedestrian visibility at this location. Another pedestrian safety location was at a mid-block location where pedestrians were being stranded in the two-way left-turn lane. A signalized pedestrian crossing was installed with a lighted refuge to increase pedestrian visibility at this location.

Limited Space for Utilities

Since utilities had to be moved for the widening of the roadway, the city had an opportunity to underground them. This provided another chance to improve the overall aesthetics of the corridor by removing the visual clutter of the existing lines and poles. The city worked with utility providers to gain acceptance for a shared utility trench that maximized the available space and reduced construction disruption. The utilities and the city established cost-sharing agreements for the trench, resulting in a cost-effective, low-impact, aesthetically pleasing solution.

Limited Right of Way

The corridor widening required frontage strip takes from 70 parcels along the corridor. The community wanted to maintain the functionality of these parcels and not preclude them from redevelopment. At the same time, it was important to maintain the functionality of the roadway. The city struck a balance through a formal right of way acquisition plan, using high-resolution aerial photos to identify encroachments and impacts in a way property owners could readily understand. This approach supported feasible solutions that balanced property function and highway function.

Exhibit A-1.8 – Stormwater Facility

Siting Stormwater Facilities

Off-site stormwater ponds were needed in each of the three sub-basins along the corridor. Because the potential sites were in residential areas, the community had concerns about impacts on property values and views. The city took a flexible approach to identifying suitable parcels by looking at properties that were already on the market or could not be used for other purposes. This minimized disruption and relocation impacts, as well as the loss of tax revenue. For one pond, the city partnered with the neighboring city of Kent to develop a shared facility on a site in Kent that was otherwise unusable. Landscaping around all of the ponds was designed to provide an attractive visual screen from adjacent residences.

Exhibit A-1.9 – Project Solutions

- Community acceptance
- Agency approvals
- Constructed project that provides the desired safety improvements
- Distinctive gateway to Des Moines with an aesthetic streetscape
- Improved water quality in Barnes and Barnes Creeks

Minimizing Construction Impacts

The community had concerns about reduced business access and traffic congestion during construction. Businesses were also concerned about possible loss of revenue. The City Council committed to minimizing these disruptions. To meet this goal, the project team developed a construction website that was updated weekly, and a telephone hotline that provided similar information. Early on in the project, the city received many compliments about the number of flaggers assisting in getting patrons in and out of businesses. This resulted in a decision to maintain a high number of flaggers for the life of the project – a solution that reduced frustration and improved access.

Results

Final Design/Project Construction

The completed project provides seven traffic lanes: two northbound and two southbound lanes for general purpose traffic; one northbound and one southbound lane for HOV/transit and business access, and one lane for left-turning vehicles at intersections. It includes continuous curb, sidewalks, and roadside planters, along with new roadway and pedestrian lighting that improves lighting levels by a factor of nearly 3. The number of driveways have been reduced and defined with concrete curb cuts and approaches, and a raised, landscaped median that includes an 18” tall barrier curb has replaced the two-way left-turn lane.

New traffic signals are provided at S. 220th and S. 224th Streets, along with a new signalized pedestrian crossing between S. 226th and Kent-Des Moines Road. The traffic signal bridge at Kent-Des Moines Road was replaced with a longer “monotube” structure that also improves signal head visibility. The long crosswalks at Kent-Des Moines Road have pedestrian signal heads with a “countdown” display to enhance safety. All traffic signals are interconnected to improve signal timing and allow future transit signal priority. A complete new storm drainage system conveys polluted runoff to one of three new off-site stormwater detention and treatment ponds, improving water quality and flooding in Barnes and Massey Creeks. Overhead power distribution and telecommunication lines have been replaced with a complete new underground system.

Building on the city’s nautical theme, the project gateways and bus zones incorporate unique architectural features that include a colorful array of wind-operated rotating sailboats. The sailboats range in size from 2 feet to 5 feet tall and were specially designed and fabricated for this project.

Exhibit A-1.10 – Existing Roadside

Exhibit A-1.11 – Pedestrian and Transit Improvements

Exhibit A-1.12 – New Gateway with Signature Sailboat Weather Vanes

Exhibit A-1.13 – Before Construction Southbound at 226th

Exhibit A-1.14 – After Construction Southbound at 226th

This page intentionally left blank

Case Study 2

Added Capacity & Noise Walls, SR 527 – 164th Street SE to 132nd Street SE

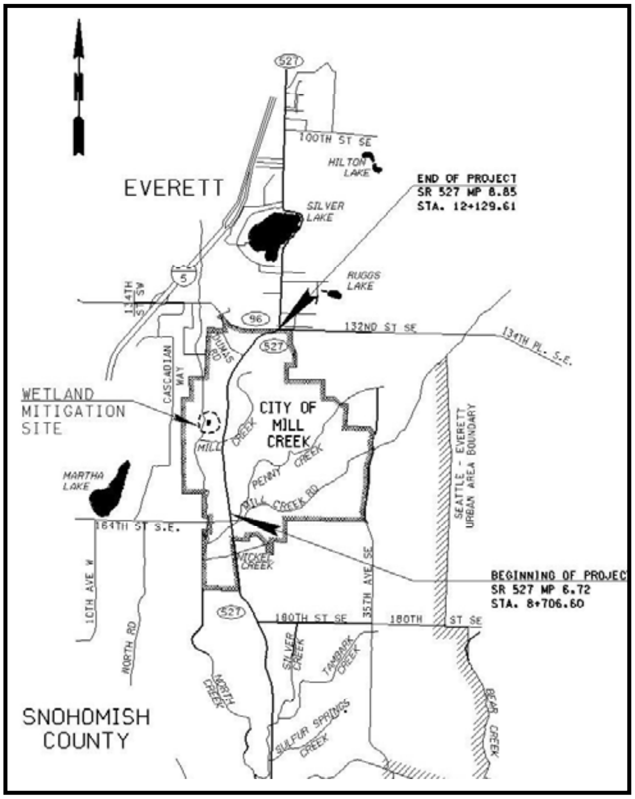
Project Description

Location

City of Mill Creek

SR 527 MP 6.72 – MP 8.85

Exhibit A-2.1 – Project Vicinity Map



Purpose & Need

This project was developed to address congestion on a section of SR 527 between 164th Street SE and 132nd Street SE. Highway SR 527 passes through downtown Mill Creek. This route serves as the main north-south gateway to the city. Rapid commercial and residential development in and around the city of Mill Creek has strained the existing highway's capacity. In the design of the project, the city requested that the Washington State Department of Transportation (WSDOT) meet the city's design standards, which are more stringent than WSDOT's own standards.

Context

This project is located in a suburban area north of the city of Everett. Rapid development is occurring in both commercial and residential land uses. The city is located near environmentally sensitive areas, with a number of creeks and wooded areas running through the city. Bicycle and pedestrian traffic is currently limited throughout the corridor, but growth in pedestrian and bicycle traffic is expected. The project is classified as urban, although the highway maintains a rural feel with tree-lined roadsides.

Initial Design Concept

To relieve congestion and increase capacity and mobility, SR 527 will be widened to five lanes, with a bicycle lane in each direction. Work items include walls, drainage, wetland mitigation, and traffic signal modifications.

Challenges

The original project concept was the basis for establishing the project budget and schedule. Design elements meeting the city's criteria were added later in the process. The city's changes introduced additional costs, and the potential to impact the delivery schedule. The placement and aesthetics of the noise walls were the focus of the city's modifications to the initial design concept. The project also impacted Mill Creek and Penny Creek, which introduced some environmental mitigation concerns.

Exhibit A-2.2 – Challenges

- Community collaboration
- Funding for the project
- Construction under traffic
- Meeting city standards
- Environmental impacts

Funding

The project has funding from WSDOT and the city of Mill Creek. WSDOT's budget for the original concept was about $26 million. As part of the mitigation for creek impacts, WSDOT contributed $150,000 to the city for the Penny Creek fish-passage culvert retrofit project.

The city of Mill Creek reflected its commitment to the project by contributing some construction costs.

Schedule

Scoping started in late 1990, and the design was completed in mid-2001. Construction is scheduled to occur in three phases. Phase 1 consisted of noise and retaining walls and was completed in mid-2002. Phase 2 will widen SR 527, and Phase 3 will have a roadside revegetation focus.

Process

Public and Agency Participation

Several open houses were held to hear the public's concerns, requests, and ideas. Large-scale plots of the highway were laid out for the public to write their comments on, allowing the citizens to place their comments right where they applied, making it easier for everyone to understand the comment. This turned out to be a very effective approach, which was well received by the public.

The city and WSDOT partnered on the design of all landscaping features for both the roadside and the planted medians. Plant types were selected to match the corridor "look," as defined by the city's streetscape plans. The "look" varied from the commercial areas to the residential areas of the highway corridor.

The project represents a partnership commitment with local agencies, neighbors, and the public.

Results

Design/Construction Issues

Exhibit A-2.3 – Solutions

- Public participation
- City contributed more money
- Work with contractor to lessen traffic impacts
- Work on design elements without affecting budget
- Communication with other agencies

The noise walls were an aspect of the design that the city was concerned could detract from the city's streetscape ideals. WSDOT's State Architect, Landscape Architect, and design team worked with the city to develop an artistic design that included a leaf pattern band along the top three feet of the noise wall panels with a "tree bark" finish below. The special "leaf relief" pattern did not add to the construction costs. WSDOT's Architect prepared the life-sized clay molds, and the contractor picked up the molds and sent them to a manufacturer to have the five different inverse rubber molds made.

Design commitments also included that the noise walls meander where possible (not just parallel to the highway), preserving a portion of existing trees and landscaping, as well as matching the city's meandering sidewalk concept. The city asked for specific designs with respect to the stepping affect at the top of the walls, and asked that each step be the same dimension consistent throughout the entire project, rather than random dimensions. The city also asked that the back of the noise walls have a "tree bark" finish to give the adjacent private property owners a respectable-looking barrier. An adjacent soldier pile retaining wall also utilized the "tree bark" finish for corridor continuity.

The walls were installed before the highway widening, at the request of the adjacent property owners and the city, to provide safety and noise abatement during the highway widening construction.

Traffic Impact

To minimize the initial impact to businesses, the contract required the contractor to provide a two-way left-turn lane in the commercial areas during the winter holiday period to assist shoppers accessing the businesses.

Financial Contribution

As a result of the public participation, the city of Mill Creek reflected its commitment to the project by participating in construction costs. In addition, many large developments located along the highway frontage contributed money to improvements in the project.

Exhibit A-2.4 – Leaf-Relief Top Banner with "Tree Bark" Finish

Exhibit A-2.5 – Meandering Noise Walls with Retaining Wall Below

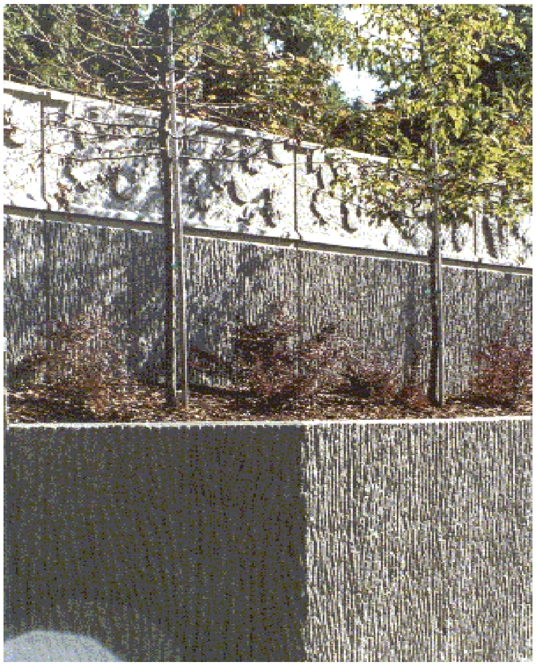


Exhibit A-2.6 – Top of Noise Wall Steps Mirrored with Retaining Wall

This page intentionally left blank

Case Study 3

Interchange Improvements & HOV Lane, SR 16 – Union Avenue to Jackson Avenue

Project Description

Location

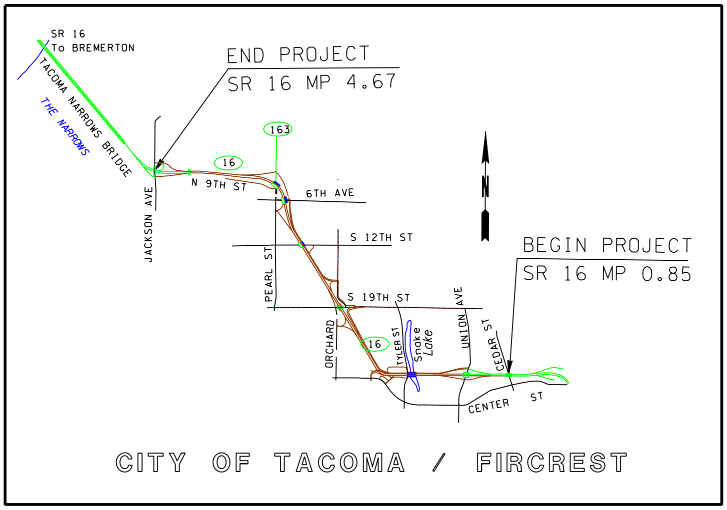
City of Tacoma

SR 16 MP 0.85 – MP 4.48

Purpose & Need

The purpose of this project is to increase capacity and provide High Occupancy Vehicle (HOV) lanes and other major improvements to SR 16 between I-5 and the Gig Harbor community. Traffic congestion is highest through this urban segment of SR 16 and therefore has priority to receive immediate improvement, with completion scheduled to coincide with the opening of the new Tacoma Narrows Bridge.

Exhibit A-3.1 – Project Vicinity Map



Context

This project is located in a highly urbanized area with mixed land use that includes commercial and residential components. The posted speed on SR 16 is 55 mph. A high school and a baseball stadium are located near Center Street. This location has relatively little room for additional new development and there are environmentally sensitive areas that need to be considered. Pedestrian and bicycle usage are relatively high, as this route provides access to local communities along the route.

Initial Design Concept

Improvements to this segment of SR 16 will provide greater multi-modal capacity that will result in faster and safer travel through the corridor and improved access to surrounding communities.

Pedestrians and bicyclists will benefit from a new shared-use trail designed to accommodate growing capacity needs and separation from high-speed, highly-congested freeway and city streets. The trail will provide access to important locations along the corridor.

This project will widen both bridges over Snake Lake, construct parallel bridges spanning 12th, 6th, and Pearl roadways, and construct a frontage road connecting 6th Avenue to Pearl Street. On-ramps will be widened to provide HOV bypass lanes and enforcement areas. The work described above will require multiple retaining structures to minimize environmental impacts. Environmental impacts will also be reduced with two noise barriers to protect existing residential neighborhoods and the treatment of stormwater runoff using state-of-the-art practices. The project will rebuild the Center Street Interchange and remove the non-standard slip ramps at Center Street and the loop ramp at Tyler Street. An important aspect of the project is to meet the historic requirement to extend the SR 16 trail farther west. The public will also benefit from the implementation of modern Intelligent Transportation Systems (ITS) technology to monitor and control traffic operations.

Challenges

Exhibit A-3.2 – Challenges

- Congestion
- Environmental permitting
- Center Street Interchange
- Interchanges closely spaced
- Project scheduling
- Modifications to Center and Mullen Streets

High traffic volumes and congestion caused many challenges for the design of this project, as did the requirements for environmental permitting.

The business community wanted to retain as much existing left-turning access on Center Street as possible. Competing with this desire was the required modification to the Center Street Interchange and Mullen Street at the freeway ramp's termini. These competing designs resulted in the need for cooperation and open discussion between the stakeholders.

The timing to complete the project is a critical element since the funding is secured and will need to be spent in an expedited manner to minimize funding impacts to other projects.

Funding

This project is state funded; the overall project budget is about $102 million.

Schedule

Construction started in early 2004 and will last for three years, coordinating with the opening of the new Tacoma Narrows Bridge in 2007.

Process

Exhibit A-3.3 – Existing Pearl Street

Exhibit A-3.4 – Proposed Pearl Street

Public Participation

The Center Street Interchange alternative was developed with the community in mind. This led to the need to produce access documents, conduct an access hearing, and design plans to alleviate congested conditions at the intersection of the Mullen and Center Street ramp connections.

The project team formed a committee whose intent was to optimize the SR 16 multi-use (bicycle/pedestrian) trail placement. This effort resulted in a design that improves the trail alignment, so that it follows more closely along SR 16, instead of meandering through Cheney Stadium and city streets. This effort reduced potentially costly elements in the trail system, such as a pedestrian bridge, by routing the trail spur underneath the Snake Lake/Tyler Street overcrossing.

Public participants also contributed to the design of the Union to Jackson Street section of the project. Many public meetings have been held, and this will continue. The project team believes that this public consultation will produce a better overall project and, more importantly, project acceptance. The project team also learned during this effort to provide graphics that help them and the public to visualize the completed project.

Results

Design/Construction Issues

While the SR 16 Final Environmental Impact Statement was developed primarily to cover the Tacoma Narrows Bridge crossing, some elements were not as well covered within this project. The design team worked to improve these areas as they related to public safety and interchange requirements.

The design team worked to achieve an approved design speed for the corridor that was practical for the highway; 60 mph. Recent modifications to design criteria and guidelines in the urban area have assisted in the development of this project. These modifications allow for additional flexibility in design criteria based on type and use of the facility.

Coordination between Washington State Department of Transportation (WSDOT) offices was the norm for the project team, since match points on either end of the project limits consisted of dynamic conditions.

Tracking tools and coordination processes that are defined by WSDOT as Managing Project Delivery methods were used to initiate and maintain design development among the multitude of project team members, from the inner design office to specialty teams, to external agencies and the public.

All of the project team members have learned many lessons they intend to share and apply on the next project to improve how they conduct design business.

A Value Engineering (VE) study led to several recommendations incorporated into the design of this project. At least one member of the local community and the city of Tacoma's Traffic Engineer were included in the study.

Prior to the VE study, the project team conducted a 30% Constructability Review. Resourcefully, the project team blended its experience of conducting round table reviews in general with the known available guidebooks on constructability (NCHRP #390 and #391, and the less-circulated WSDOT's *Manual of Instruction for the Implementation of the Constructability Review Process*.)

Exhibit A-3.5 – Solutions

- Construct HOV lanes and interchange improvements
- Mitigate environmental impacts
- Utilization of project management tools
- Develop alternative wherein two of the three ramp movements would be reconstructed
- Addition of an auxiliary lane
- Allocate a high number of design resources
- Coordination meetings
- Public meetings
- Work to overcome omissions to public safety and interchange standards
- Work to achieve an approved design speed for the corridor
- Coordination across WSDOT offices was the norm for the project team

Exhibit A-3.6 – Existing Center Street

Exhibit A-3.7 – Proposed Center Street

This page intentionally left blank

Case Study 4

Downtown Revitalization & Access Improvements, US 395 – Colville

Project Description

Location

City of Colville

US 395 MP 228 – MP 229

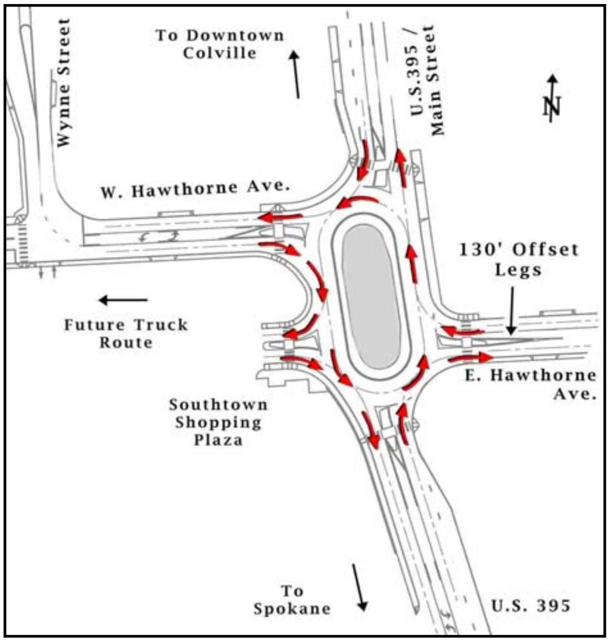
Purpose & Need

The mixture of significant freight and highway traffic on Main Street with its multiple traffic lights and slower speeds has created congestion, noise, and air quality concerns. Congestion also makes parallel parking maneuvers difficult for shoppers, which detracts from the shopper-friendly atmosphere desirable for downtown. Transportation of hazardous materials on Main Street is also a concern.

Context

This project is in a rural town-center context. The project is located in eastern Washington with a highway speed of 60 mph prior to the city and 25-35 mph through the city. The town center consists of small businesses throughout the core, and revitalization is desirable. Freight is a major component of the traffic, with the largest trucks present in high numbers. This route serves as a major artery to the town. There is substantial room for development in the area, although growth is predicted to be limited. Pedestrian safety is a concern and pedestrian volumes are moderate for a town of this nature.

Exhibit A-4.1 – Project Vicinity Map



Initial Design Concept

To relieve congestion and improve traffic flow, it was determined that the traffic signal at Main Street (US 395) and Hawthorne Road would be replaced with a unique oval-shaped roundabout. The Colville Roundabout would benefit users by decreasing motorist delay, increasing local traffic mobility, creating an attractive gateway into the city's south entrance, and improving pedestrian safety.

Challenges

The presence of large trucks (WB-67's) contributed to congestion and impacted the traffic flow in the project area. There were some concerns about providing access to businesses and side streets, and resolving conflicting vehicle movements across US 395 traffic lanes, without totally shutting down the traffic flow. Also, the impacts to adjacent properties necessitated negotiating with landowners on right of way purchase terms.

Exhibit A-4.2 – Challenges

- Understanding traffic flow
- Maneuvering trucks and emergency vehicles
- Improvement under traffic
- Corridor traffic flow
- Access
- Right of way acquisition

Funding

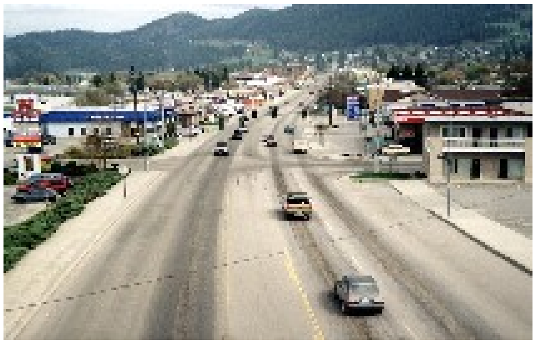
This project has local, state, and federal funds. The overall project budget is about $6 million. Washington State Department of Transportation's (WSDOT's) contribution to this project is about $1.5 million. The city of Colville's budget from local, federal, and Transportation Improvement Board (TIB) sources is about $4.5 million.

Schedule

This project is scheduled in three specific phases. Phase 1 included improvements to Wynne Street, and was completed in November 2000. Phase 2A consisted of improvements to the Main Street section of US 395, and was completed in November 2002. Phase 2B focused on enhancements to First Street and the roundabout on US 395, and was completed in 2003. The remaining Phase 3 will develop an alternate truck route, and its schedule is dependent on funding.

Process

Exhibit A-4.3 – Existing Intersection – Hawthorne Ave



Public and Agency Participation

The Mayor and City Council appointed an active and highly effective steering committee consisting of key business people, community activists, elected representatives, and public agency staff. Throughout the planning, design, and construction phases of the project, the Colville 2000 committee was instrumental in advising and directing the project.

The success of the downtown revitalization improvements to Main Street was a direct result of the active public/private partnership between the city of Colville, the WSDOT Local Programs office, TIB, and the Colville 2000 citizen's committee.

The city's project to revitalize Main Street was combined and coordinated with WSDOT's programmed signal, widening, and paving improvements on US 395.

Results

Design/Construction Issues

Designing the oval roundabout to accommodate the offset east/west approaches required a sensitive balance to minimize right of way needs and negative business impacts, while accommodating existing adjacent commercial access approaches.

Flexibility as Traffic Demands Change

Exhibit A-4.4 – Solutions

- Public involvement
- Accommodate large trucks
- Stage construction phases
- Build oval roundabout to accommodate business approaches and side streets
- Work with land owners to finalize property purchases

Although the Colville Roundabout presently operates with a single lane, it is designed to accommodate two lanes in the future (with minor modifications) as traffic volumes increase.

Colville's oval roundabout provides a high degree of flexibility for the traffic in the area, which is desirable given that the volumes and destinations of passenger and truck traffic may change with the addition of a future alternate truck route (which would route heavy truck traffic through an industrial corridor away from the downtown area).

Social and Economic Considerations

The Colville 2000 strategy combined economic development goals with major improvements to regional and local transportation systems. Transportation enhancements were woven into economic development so that the two objectives supported each other in a comprehensive partnership.

Secondary benefits of the proposed roundabout included an opportunity for an attractive city gateway enhanced with landscaping and architectural signage. The project also improved mobility for in-town traffic using minor legs of the US 395/Hawthorne intersection and the ability of drivers to make legal U-turns to better access businesses or parking. Pedestrian crossing safety was addressed by allowing pedestrians to cross one lane at a time through the use of center refuge islands provided at each entrance leg into the roundabout.

Traffic Impact

Construction of the roundabout required an innovative staging plan to maintain traffic flow and minimize traffic control costs. The detailed staging plan accommodated access to adjacent businesses during construction. In accordance with the staging plan, traffic flow on US 395 was continuously maintained throughout construction.

Exhibit A-4.5 – Finished Roundabout

This page intentionally left blank

Downtown Revitalization, Safety & Congestion Improvements, SR 14 – Bingen

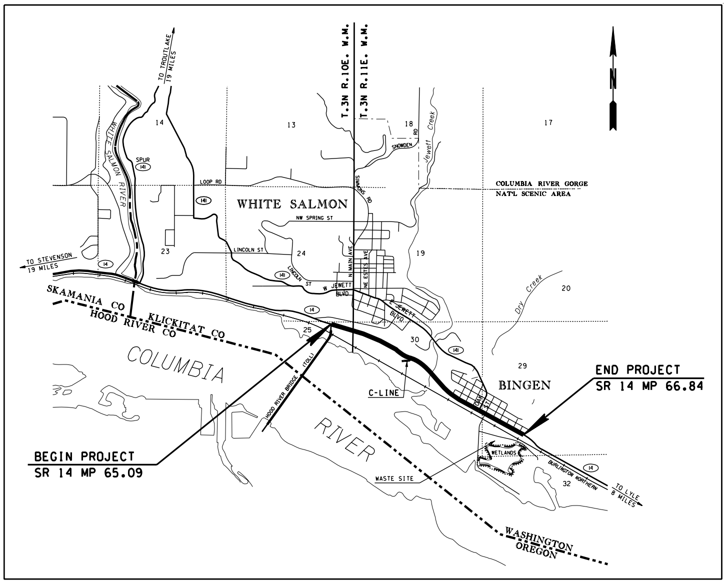
Project Description

Location

City of Bingen

SR 14 MP 65.09 – MP 66.84

Exhibit A-5.1 – Project Vicinity Map



Purpose & Need

The purpose of this project was to reduce traffic congestion through this section of SR 14, which improved safety and traffic flow (mobility). The city of Bingen needed economic revitalization of the downtown corridor, and anticipated that their efforts to improve the transportation system would result in improved economic vitality.

Context

This project is rural in nature with business and residential land use. On-street parking is present. The town has a posted speed of 40 mph just preceding the city, with speeds lowering to between 25-35 mph through the city. This location has the potential for additional new development. The project is also environmentally sensitive because of the Columbia River. There are sidewalks present in the central part of town and shoulders exist for use by bicyclists. The corridor experiences high levels of freight traffic.

Initial Design Concept

To relieve congestion and improve safety and mobility, it was envisioned that the westerly portion of this project would provide two through lanes, a two-way left-turn lane, and shoulders with curbs and a sidewalk on the south side from MP 65.12 to MP 66.17. The north side would be curbed to separate the off-site water from the roadway drainage, with a ditch section behind the curbing from MP 65.12 to MP 66.17. A new sidewalk would be installed on the north side from MP 65.93 to MP 66.17.

The easterly portion of this project is from Willow Street to Vine Street (MP 66.17 to MP 66.84). This portion of the project, which is within downtown Bingen, proposed to rebuild the roadway to meet the recommendations set forth in Bingen's "Downtown Revitalization Plan." The wide sidewalks would be rebuilt with bulbouts, new drainage would be installed, and the roadway would be overlayed with asphalt concrete pavement. New streetscapes would be installed along with decorative lighting to enhance the downtown corridor. A sidewalk would be constructed from MP 66.47 to 66.76 on the north side.

Exhibit A-5.2 – Challenges

- Designing the project to help revitalize the downtown
- Not enough room to widen roadway
- Location and number of diagonal parking on both sides of road in downtown section

Challenges

The scope of the project was modified to include the downtown revitalization project, which affected the project's delivery schedule. The city requested a downtown roadway cross section consisting of a two-lane roadway with narrow shoulders and diagonal parking on both sides of the road. This resulted in a need to acquire additional right of way.

Exhibit A-5.3 – Parking, Sidewalk, and Illumination Improvements

Funding

Funding for this project came from an assortment of federal and state grants, local agencies, and Klickitat County. The Washington Department of Transportation's (WSDOT's) contribution to the construction phase of this project was about $392,000. The city was able to obtain two revitalization grants for the project, in addition to other federal funding and state funding, for a total of about $7.8 million. The overall project budget is about $8.2 million.

Schedule

Construction was completed in August 2004.

Process

Public and Agency Participation

The city of Bingen developed a conceptual vision of the "Downtown Revitalization Plan." Open houses were then held to illustrate the proposed downtown corridor and to develop a comprehensive plan for the community.

Key stakeholders contributed to planning this project, including WSDOT, the cities of Bingen and White Salmon, local businesses, and residents.

Results

Design/Construction Issues

Exhibit A-5.4 – Solutions

- Shoulders widened to 6 feet
- Left-turn lanes and right-turn pockets added to facilitate traffic movement through town
- Street trees and planting strips added in the downtown area
- Pedestrian bulbouts and wider-than-standard sidewalks installed through the downtown corridor to encourage pedestrian activity
- Utilities placed underground through the town's core area
- Concrete pavers, street furniture, and special light standards added to improve the aesthetic qualities of the downtown corridor

The purpose of the WSDOT project was to improve mobility and safety within the SR 14 corridor from Dock Grade to Willow Street. The city of Bingen initiated discussions with WSDOT on how to include the downtown revitalization as a portion of the corridor project. The discussions and the results of subsequent efforts to secure funding led to the extension of the SR 14 project from Hood River Bridge to Vine Street.

As plans for SR 14 from Hood River Bridge to Vine Street were developed by WSDOT (the city of Bingen had WSDOT as contract administrator), the city provided for public review that included the Bingen City Council. During the design phase, the project team recommended that WSDOT be involved in the community visioning process. This enabled the design team to clearly understand and put forth the community vision, while maintaining WSDOT *Design Manual* guidelines.

One of the major issues during the construction phase was utility relocation. Utilities relocated were overhead power, telephone, cable, and gas and water lines. Undocumented underground utilities, such as fiber optic conduits and sanitary sewer and water lines were found. The roadway sections, drainage, and utilities were modified to accommodate changed conditions.

Case Study 6

Intermodal Improvements, US 2 – Leavenworth

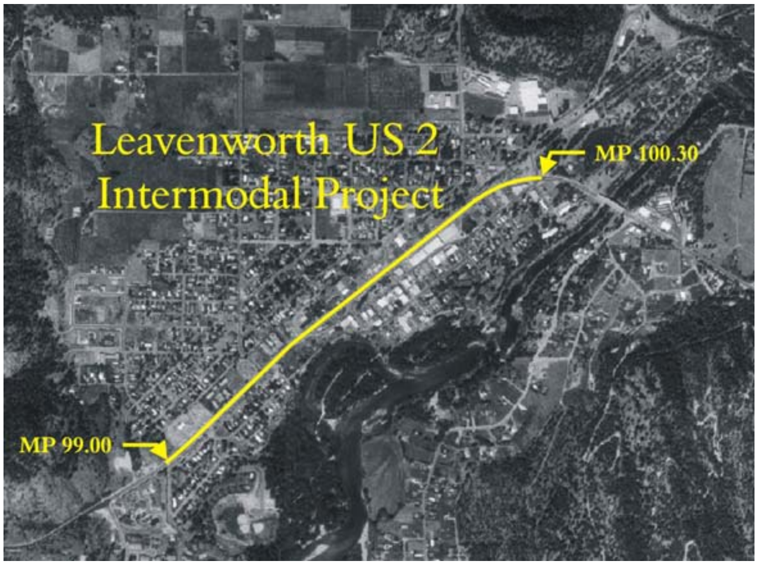
Project Description

Location

City of Leavenworth

US 2 MP 99.00 – MP 100.30

Exhibit A-6.1 – Project Vicinity Map



Purpose & Need

The purpose of this project was to improve multiple modes of transportation on US 2 through the community of Leavenworth. This city relies heavily on the tourist industry and regularly hosts events that draw large groups of people. The wintertime events, such as the Christmas lighting festival, required a large number of people to walk along the highway through melted snow puddles in areas where delineation from the adjacent highway was obscured and sidewalks were limited.

The highway had minimal illumination. Tourists walked from hotels to the business district and would benefit from additional lighting along the roadway.

Context

This project is rural in nature with adjacent recreational and business land use. Residential areas back the business land use on one side, and the Wenatchee River is located on the other. Hotels are present in this tourist destination in relatively high numbers. The town has a Bavarian theme, and structures and amenities adhere to this type of development. The speed limit at the entrance of the city is 50 mph and is lowered to 30 mph. The area is environmentally sensitive throughout, and surrounded by national forest, creeks, and the Wenatchee River. Pedestrian facilities are provided along the corridor in the town core, although limited elsewhere. Pedestrian volumes can be very high during the winter and summer tourist seasons.

Exhibit A-6.2 – Finished Patterned Sidewalk

Initial Design Concept

To relieve congestion and increase capacity and safety for pedestrian and vehicular traffic, this project would reconstruct the existing roadway to include concrete curbing, gutters, sidewalks, storm drainage, illumination, bike lanes, transit bus stops, turn pockets, and landscaping. A park-and-ride lot and bus pullouts would be included to enhance the ability of pedestrians to access the business center.

Challenges

The project was constructed under traffic. It was a challenge to provide access to customers during construction that included modification of the grade and elevation of the business approaches.

Exhibit A-6.3 – Challenges

- Business access during construction
- Approach grades
- Location of luminaires
- Unanticipated rocks and boulders in the excavation site

There were approximately 51 businesses adjacent to US 2 throughout this project. The placement of luminaires, electrical boxes, and other features relative to businesses was a challenge.

During the excavation of the storm sewer, large amounts of rocks and boulders were found that were not previously accounted for.

Funding

Washington State Department of Transportation’s (WSDOT’s) budget for this project was about $75,000. The city of Leavenworth’s budget from local, federal and the Transportation Improvement Board (TIB) was about $1.8 million. The overall project budget was about $1.9 million.

Schedule

Construction was completed in September 1995.

Process

Public and Agency Participation

Exhibit A-6.4 – Solutions

- Public participation
- Worked with contractor and business owners to lessen traffic impacts
- Placed luminaires based on negotiations with business owners
- Set up special provisions in the contract to address rock excavation

Several open houses were held in the city of Leavenworth throughout 1994 to answer questions on sidewalk design, curb cuts for businesses, signing, bus shelter design, traffic marking, and landscaping issues, among others.

The city of Leavenworth and WSDOT coordinated design meetings with multiple agencies on a regular basis throughout the design phase to make design decisions. The city established a Design Review Committee to facilitate communication between the design office and the community.

Results

Design/Construction Issues

During the design phase, several business owners were looking for alternatives for the placement of luminaires and bus shelters. As a result of open communication and negotiations, the design was completed and addressed most of the needs of the business owners.

WSDOT negotiated the resolution pertaining to the rocks and boulders in the excavation process by setting up special provisions in the contract.

Exhibit A-6.5** – **Finished Sidewalk and Bus Shelter

Traffic Impact

To minimize the initial impact to businesses, the contract required the contractor to provide the additional two-way left-turn lane in the commercial areas during the winter holiday period to assist shoppers accessing the businesses.

Add Lanes/Bike & Pedestrian Corridor Improvements, SR 240 & I-182 – Richland Wye

Project Description

Location

City of Richland

SR 240 MP 36.05 – MP 38.90

Purpose & Need

SR 240 is a vital commuter route for the Tri-Cities area that is experiencing increasingly heavy traffic volumes. There are currently four general-purpose lanes.

Context

This project is urban in nature with business and industrial land use. SR 240 has a posted speed limit of 55 mph and is a multilane facility. The Columbia River introduces environmentally sensitive issues to consider in the project development process. The corridor experiences high levels of freight traffic.

Exhibit A-7.1 – Project Vicinity Map

Initial Design Concept

To relieve congestion and increase capacity and mobility, this project will construct additional lanes on SR 240 between Richland and Kennewick, linking I-182 with the US Department of Energy's Hanford site, the Columbia Center commercial areas, and east Kennewick's industrial zones. The project will reduce travel time for auto and vanpool commuters, and will expand the bicycle corridor. There will be six lanes when the project is completed.

Challenges

Meeting current and future capacity needs required adding additional lanes to the design within an existing interchange area and bridge structures. The design of a dual-lane roundabout that incorporates the needs of pedestrians and bicyclists was a challenging part of the project. Maintaining four lanes of traffic during construction requires extra effort to make sure that traffic is flowing with minimal delays.

Exhibit A-7.2 – Challenges

- Meeting capacity needs
- Design of a dual-lane roundabout
- Traffic during construction
- Wetland mitigation
- Relocating 30 businesses and 238 storage unit tenants
- Utilities relocation

Funding

This project has mixed state and federal funding, with about $57 million from the state and about $3 million from federal sources. The total budget for this project is about $60 million.

Schedule

Scoping has been completed, and the design file approved by the end of April 2004. The construction duration is estimated at 36 months with activities starting in early spring of 2005.

Exhibit A-7.3 – Existing Four Lanes

Process

Public and Agency Participation

Exhibit A-7.4 – Existing Richland Wye

Numerous agencies were contacted and provided input. Two potential locations were identified where the Port of Benton (POB) railroad could potentially be impacted: the Richland Wye interchange, and in the vicinity of the Yakima River crossing. This necessitated acquiring a construction permit for right of way (ROW) purchase. It was also foreseen that the POB might have some concerns regarding ROW fence issues.

The Benton Franklin Transit also had a strong interest in the access in and out of its facility, as well as onto the westbound on-ramp for SR 240.

The preferred alternatives evaluated for the Richland Wye interchange did not impact the Columbia Irrigation District canal. Most of the land in the Yakima River Delta across what is locally called the Causeway is under the management of the United States Army Corps of Engineers (USACE). The interests of the USACE centered around environmental mitigations that might be used along the Causeway, the fact that the bicycle path would be located on the river side of the embankment, and the future lease of their land at Columbia Point, south to the city of Richland.

The city of Richland is affected by both these projects. WSDOT made a commitment to the city related to the George Washington Way interchange, where the minimum lane configuration would be two lanes outbound from the city and one lane inbound.

Results

Design/Construction Issues

Exhibit A-7.5 – Solutions

- Provide two additional main line lanes and two auxiliary lanes to meet future capacity needs
- Widen an existing structure
- Traffic staging plan
- Delay ad date for tenants to move
- Advertise relocation information
- Relocate utilities

When the corridor is completed, there will be three lanes in each direction on SR 240 from Stevens Drive to Columbia Center Boulevard. A new auxiliary lane will be constructed in each direction from I-182, across the new Yakima River Bridges, to the Richland Wye. Improvements at the I-182/SR 240 interchange and the Richland Wye interchange include ramp widening and construction of a roundabout.

The pedestrian/bicycle corridor will be lengthened, completing another link in the Columbia River Loop Trail system. This will encourage the use of alternate modes of transportation by improving pedestrian/bicycle connections.

Exhibit A-7.6 – Proposed Richland Wye

Mobility Benefits

The additional lanes and revised connections will provide mobility and maneuverability improvements. Interchange improvements will allow improved connections to I-182 and local roads.

Environment Impacts

The project will have several environmental benefits, including a compensatory mitigation plan to restore and enhance wetlands and provide flood plain and animal connectivity through this section of the Yakima River Delta***.***

Traffic Impacts

Two lanes of traffic will be maintained in each direction during peak traffic times. It is likely that there will be three total roadway closures, each three to four days, to allow for the reconstruction of connections to ramps and bridges. Closures will be scheduled over weekends to reduce impacts to traffic, and detour routes will be maintained during these closures.

Exhibit A-7.7 – Proposed Six Lanes

Exhibit A-7.8 – Proposed SR 240 Widening

Exhibit A-7.9 – Proposed Yakima River Bridge

This page intentionally left blank

Landscape and Interpretation Project, US 101 – Raymond

Project Description

Location

City of Raymond

US 101 MP 58.25 – MP 59.85

Purpose & Need

This project was part of Washington's scenic byways improvement program. It was a top priority for the city of Raymond to create a visually appealing community for travelers along US 101, and to introduce travelers to the unique Willapa basin, with its forested hills, natural rivers, tidal estuaries, salt marshes, and pristine bay.

Context

This project is rural in nature and is predominately within residential and small-business land use. The posted speed of US 101 is 55 mph, with speed lowering to 35 mph through the city. This location has potential for additional new development. The project raised environmentally sensitive issues throughout because of the Willapa River, which contains endangered salmon. There are pedestrian facilities in the corridor, and the route serves as a through route to other destinations.

Initial Design Concept

In order to create a visually appealing community for travelers along US 101, this project was designed with three major components, signage, landscaping, and interpretation, which provided:

- "Gateway to the Willapa" entrance signs at both the northerly and southerly city limits
- The landscaping of the corridor from north of the Willapa Bridge to the Port of Willapa Harbor.
- Interpretive displays and brochures with information on the local Willapa environment and heritage located at a new downtown waterfront park on a site immediately adjacent to US 101on the south fork of the Willapa River.
- Public restrooms available at the waterfront park.

Challenges

Some community members viewed this project as being forced on the community by governmental agencies, since there were limited opportunities for input from locals.

Although the project had appealing aspects and would often be perceived as beneficial, mixed opinions about the project remained because of the changing landscape and the proposed interpretive nature of the project.

Funding

Funds for the project were committed by several local agencies. The city's funding totaled $370,000 for design and construction.

Exhibit A-8.1 – Gateway to the Willapa

Exhibit A-8.2 – Logger Silhouettes

Exhibit A-8.3 – Challenges

- Overcoming perception of a "top down" project
- Maintenance and aesthetic issues
- Funding issues
- Selection of displays
- Changes during implementation
- Community participation

Schedule

The project duration was from June to November 1993.

Process

Public and Agency Participation

This project supported local objectives by improving the visual impression of the Raymond community. It had broad support from a range of public agencies. The city has agreed to undertake the necessary long-term maintenance of the facilities in this US 101 coastal corridor project, including landscaping, interpretation, and signage.

Results

Design/ Construction Issues

Exhibit A-8.4 – Native American Sculpture

Landscaping within the city of Raymond improves the scenic environment along the highway. The interpretive project is one component of a new waterfront park providing a number of recreational opportunities. The new park includes a 3,000 square foot pier for viewing, picnicking, and fishing, with a gangway to a floating dock for temporary displays and brochures. This site is also located on the Burlington Northern rail line, which will soon be abandoned and has been proposed for development into a regional recreational trail by the State Parks Commission.

The interpretive displays and brochures provide information on the unique Willapa environment as well as local history and culture. The entrance signs, landscaping, and interpretive project are focused on attracting the US 101 tourist into Raymond businesses and services as they pass through the city. The displays and brochures provide a range of information on the local ecosystems, including forests, riparian zones, tidal wetlands, and the river and bay systems. The displays also provide information on local history and culture: logging, river transportation, ethnic backgrounds, historic recreation, and entertainment.

Exhibit A-8.5 – Solutions

- Prepared a plan for public involvement
- City agreed to provide maintenance
- Scenic byway improvement
- Communication with all agencies
- Worked with various groups to keep project on schedule
- Selected displays based on community desires and needs

Regional Benefits

This project addresses four of the regional corridor objectives:

- Scenic/Recreational/Environment
- Cultural/Historical
- Economic/Tourism
- Educational/Interpretive

Environmental Enhancements

This project enhances the environment through the planting of over 800 trees and 2,000 shrubs. These plantings not only beautify the community, but also create noise and visual buffers between residential and industrial areas located along the corridor. Another primary component of this project is the education of the public on the very fragile and unique Willapa environment.

Project Description

Location

Deception Pass State Park
Olympic Peninsula

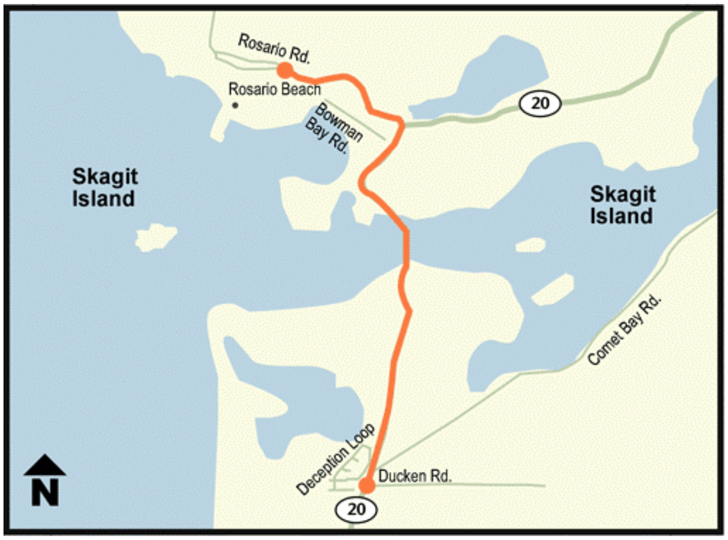
SR 20 MP 41.24 – 43.17

Purpose & Need

The purpose of this project is to improve safety and reduce accident frequency and severity. Within this section of SR 20, a primary issue is upgrading it to bike touring standards.

This project has both cultural and historic importance. This includes historic guardrail that does not meet current day design standards and is deteriorating from age. The Civilian Conservation Corps originally built the historic guardrail in 1935 with rock and mortar bollards and logs.

Exhibit A-9.1 – Project Vicinity Map



Context

This project is rural and scenic in nature and has high levels of recreational use. This includes the Deception Pass State Park and the nearby marina. There is relatively little development in the area, which has a small gas station and some local stores. A local tavern is also located nearby and safety issues related to this location were identified. Much of the area is environmentally sensitive with wetlands and endangered species elements to consider. The park (6f) classification requires little, if any, taking from the park be considered. This includes the historic nature of the guardrail.

Initial Design Concept

This project will replace historic, outdated guardrail along State Route 20 in Deception Pass State Park with new guardrail that is crashworthy and meets current day design requirements. The new guardrail will retain many of the character-defining features of the old guardrail, including the defining log, rock and mortar bollard appearance. The project will also make minor drainage improvements, upgrade illumination, do some minor paving near guardrail terminals, upgrade signing, and make improvements to the bicycle facilities.

Challenges

A high percentage of run-off-the road accidents occur in this corridor compared to other similar locations, and yet the existing historic guardrail is not a crashworthy roadside barrier.

Logs are pin-connected to the bollards and easily split free when struck, allowing vehicles to penetrate the rail system. Also, when a vehicle hits a bollard, it usually breaks apart on impact because the aged mortar that holds the rocks together cannot withstand the impact. The rock and mortar bollards protrude in front of the

Exhibit A-9.2 – Challenges

- Existing guardrail is not a crashworthy roadside feature
- Run-off-the road accidents
- Guardrail connection problems
- Foundation and bollards
- Match appearance of existing guardrail
- Maintenance and aesthetics

Exhibit A-9.3 – Existing Log Rail

face of the rail, potentially snagging vehicles. The foundation strength of the existing bollards is variable and inadequate.

It was requested that the system maintain as many of the character-defining features of the old rail as possible, and that the system be aesthetically pleasing. There was a strong desire by the Parks Department to maintain the older rail, even with its disadvantages. After significant discussion and consideration of the potential benefits and disadvantages of leaving the older rail, the Parks Department allowed for new rail placement, as long as most defining characteristics of the new system would mirror the old.

Funding

The design and construction is funded by Washington State Department of Transportation (WSDOT). The project budget is about $5 million.

Schedule

This project is currently in design. The scoping, project definition, and guardrail development was conducted between 2000 and 2004, including successfully completing three crash tests of a new guardrail design. Construction is scheduled to begin in October 2006 and will be complete in 2007.

Process

Public and Agency Participation

Washington State Parks and Recreation (WSPR) and the State Historical Preservation Office (SHPO) were the main participators in the project development process, along with members of the community who participated in open houses and outreach meetings.

WSDOT, WSPR, and SHPO are working together to develop a new guardrail design that will reduce the severity of accidents and still maintain the integrity of the park. The new guardrail system will incorporate visual elements of the existing guardrail.

Results

Design/Construction Issues

Exhibit A-9.4 – Solutions

- Record rail with HABR – Level 2 standards
- Preserve 250 foot section of original guardrail
- Remove existing guardrail system along the highway
- Restoration interpretive exhibits
- Install new aesthetic, crashworthy guardrail system with new bollards

The existing historic guardrail system will be recorded in accordance with the Historic American Building Record. Rock from some of the existing bollards will be used in the construction of the new bollards.

The new guardrail will improve safety and reduce the severity of accidents along SR 20. The existing guardrail will be removed and replaced with stone masonry bollards that are reinforced with a concrete core and a steel-backed Douglas fir guardrail between the bollards.

The existing guardrail, along with the original bollards, may be relocated to roads within Deception Pass State Park. Interpretive signs or an interpretive center will be created to showcase the historic guardrail.

Project Benefits

The new guardrail will improve motorists' safety by helping to reduce the severity of accidents. The new guardrail will look similar to the original guardrail and will maintain the visual integrity of the park.

Exhibit A-9.5 – Elevation Detail

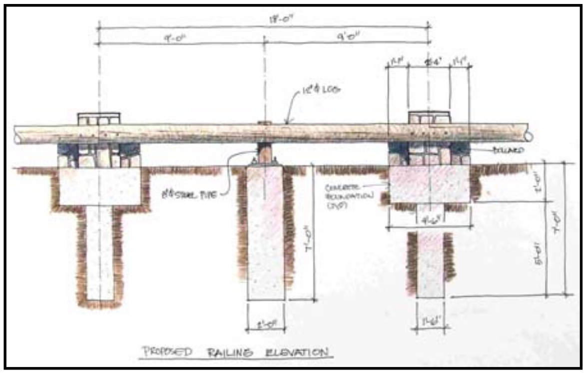


Exhibit A-9.6 – Proposed Log Rail

This page intentionally left blank

Case Study 10

Improve Capacity, Safety, & Travel Reliability, I-90 – Snoqualmie Pass East

Project Description

Location

Snoqualmie Pass
Cascade Mountains

I-90 MP 55.10 – MP 70.00

Exhibit A-10.1 – Project Vicinity Map

Purpose & Need

Since I-90 is the only east-west freeway in Washington over the Cascade Mountains, it serves as a major freight corridor for both interstate and local commerce. Some of the operational problems that occur on this route include: frequent weekend congestion with continuing traffic growth; multiple winter closures due to avalanche control work; rock falls from unstable slopes resulting in hazard to motorists; and added maintenance costs.

Context

This project is rural in nature with recreational and limited business land use. The project is located on an interstate highway. The posted speed on I-90 is 65 mph and is variable during inclement weather conditions. This location has limited new development potential because of its location in a national forest. There are environmentally sensitive issues to consider, including creeks, wetlands, and numerous species of wildlife. The corridor experiences high levels of freight traffic.

Initial Design Concept

This project will reconstruct the route to meet projected traffic demands, improve public safety, and other identified project needs, such as widening, sight distance improvement, crack sealing, slope stabilization, and reducing the need for avalanche control.

The project will also enhance environmental stewardship by improving wildlife connectivity, thereby improving the ability of wildlife to migrate safely across the highway.

Challenges

The scope of the project includes developing a design that reduces the potential for avalanche closures, straightens the freeway, and addresses the environmental needs in the area.

The environmentally sensitive area through which I-90 runs, introduces many environment-related challenges.

Washington State Department of Transportation (WSDOT) is challenged with determining the appropriate level of "ecological connectivity." The concept of ecological connectivity is relatively new in the transportation field, with little science or research available to use in defining acceptable levels or measures of connectivity. WSDOT engineers are working with

Exhibit A-10.2 – Challenges

- A design to reduce the potential for avalanche closures, straighten the freeway
- Ecological connectivity
- Environmentally sensitive areas
- Coordination work with stakeholders
- Make decisions without preferred alternatives chosen
- Budget

biologists and hydrologists to develop appropriate levels for this four-lane rural highway project. The ecological connectivity elements of this project have the potential to set a precedent on both the state and national levels.

The project team was challenged when they were required to make early project decisions without a preferred alternative chosen or knowledge of the actual project budget for the final design and construction.

Funding

The completion of the Environmental Impact Statement (EIS) and project scoping phases are the only portions of this project currently funded.

Schedule

In the fall of 2004, a series of hearings were held to gather comments on the alternatives presented in the Draft Environmental Impact Statement (DEIS). The preliminary time line for this project anticipates the construction phase starting in early 2006.

Process

Public Involvement Process

Exhibit A-10.3 – Traffic Backup on Existing Route

This project has had several public involvement activities to provide information to interested parties. Early in the planning stage, a series of public meetings were held to gather initial feedback on the various route alternatives. In addition, a website that provides information about the project was developed and is regularly updated. A newsletter with updates and changes is mailed out regularly to property owners, elected officials, and other interested individuals.

This project has utilized an Interdisciplinary Team (IDT) to assess alternatives and provide recommendations in preparing an Environmental Impact Statement. The IDT consists of WSDOT personnel from various disciplines, and representatives from the participating agencies. The IDT helped refine the project's purpose and need, and developed the alternatives to be presented within the DEIS. After reviewing public and agency comments on the DEIS, the IDT will make a recommendation for the preferred alternative to be included in the Final Environmental Impact Statement (FEIS).

Exhibit A-10.4 – Deteriorating Pavement on Existing Route

The Mitigation Development Team (MDT), a sub-group of biologists, was formed at the IDT's request. The objective of the MDT was to provide recommended solutions for impacts to the environmentally sensitive elements of the project. This team evaluated alternatives for the improvement of environmental conditions within the project. The IDT considered these alternatives for inclusion into the DEIS, and ultimately selected a preferred alternative.

Results

Design/Construction Issues

As a result of the ecological connectivity process, the project team developed an appropriate range of ecological connectivity options to present in the DEIS for the project. The expected benefits provided by these features had to be quantified in a manner that supports the costs necessary to construct them. Capturing the actual consequences of not providing ecological connectivity proved to be difficult.

Exhibit A-10.5 – Solutions

- Applying creativity and flexibility in the design standards
- Working with biologists and hydrologists
- Determining the appropriate level of "ecological connectivity"
- Utilizing Mitigation Development Team and Interdisciplinary Team
- Flexibility in decision-making

Exhibit A-10.6 – Proposed Alignment at Gold Creek

Exhibit A-10.7 – Proposed Overcrossing at Stampede Pass Interchange

This page intentionally left blank

Appendix B
Roadside Funding Matrix for WSDOT Capital Projects

Introduction

The purpose of this matrix is to provide guidance for WSDOT funding of various elements found within public works projects in which WSDOT is the lead agency. **It is not the purpose of this matrix to determine what elements should be included in each project.** This question is answered on a project-by-project basis based on the project needs, program, manuals, and context of the project.

Directions for Use

The left-hand column of the matrix is a list of design and operational **Elements** or **Functions** that occur on many projects. The top row is a list of improvement and preservation sub-programs within WSDOT. Use the matrix to determine if an element is eligible for funding under a particular program and location. For instance, there is an I2 – Safety Improvement project in a city with a population of less than 22,500 and it appears that transit pullouts will solve a problem that the project is intended to fix. Find the row with Transit Pullouts on the left and follow it to the column for I2. The cell at the intersection indicates that transit pullouts are eligible for funding.

Element Criteria and Policy Documents

Most of the elements listed in the matrix have policy and criteria defined by WSDOT. The second column (**WSDOT Design Standards**) indicates where this information can be found, i.e., *Design Manual* or *Roadside Classification Plan*. The **Notes** column identifies where the information is found in more detail. If the element is eligible for funding, then WSDOT will pay for the standard treatment. Any costs beyond the standard treatment will need to be contributed by the partnering agency. Example: the project location is in a city that has a standard for decorative luminaires. These luminaires cost 30% more than WSDOT's standard luminaire design. In this case, the city would be required to pay the extra 30% for the decorative luminaires.

Many communities would like to have additional elements or enhancements incorporated into projects. It is always possible for WSDOT to partner with communities to include these additional elements or enhancements. Communities are eligible to apply for grants or use other monies to cover these costs. The project office should work with the communities to incorporate these enhancements if they are beneficial or not detrimental to the project, and if the cost to WSDOT is minimal.

Many areas of the state within Urban Growth Boundaries are still under county jurisdiction, but are (or are becoming) urbanized. In many cases, they will be annexed by the adjacent city over time. The Project Office should meet with both the city and county to identify the community concerns as they plan and design the project. The Project Office should try to reach consensus with all parties, including identifying who will maintain the enhanced features. Establish a maintenance agreement with the local agency, if applicable.

There are always new techniques being developed for highway and public works projects. **The matrix is not intended to cover all situations or elements that could be encountered in such projects. When these situations or other unique features are proposed, they will be evaluated on a case-by-case basis.**

Restoration

It is WSDOT policy to restore elements impacted by our projects. If a project impacts an element, WSDOT is obligated to replace that element with project funds even if the element exceeds WSDOT standards. For instance, there is a crosswalk within the project limits that is made of stamped concrete. The project will reconstruct this intersection and impact the crosswalk. The stamped concrete treatment is beyond WSDOT standards, but since it is an existing feature, the WSDOT project will pay to replace the stamped concrete. The exception to this is if the element is at or near the end of its life cycle. In that case, the local agency may be required to cover some of the extra cost.

When restoring elements with WSDOT funds, it may be necessary to move those elements out of the clear zone if they are fixed objects. Refer to Chapter 700 of the *Design Manual* for clear zone requirements.

Limited Access Highways

As noted on the matrix (Exhibit B-1), limited access highways have the same design and funding parameters as cities with populations less than 22,500.

Please address your comments or questions to Mark Maurer, 360-705-7242 or maurerm@wsdot.wa.gov

Exhibit B-1 – Roadside Funding Matrix for WSDOT Capital Projects (Source: WSDOT)

Design Elements	WSDOT Design Standards	I1 - Mobility Improvements (Added Capacity)	I2 - Safety Improvements - Cities Less Than 22,500	I2 - Safety Improvements - Cities Greater Than 22,500*	I3 - Economic Initiatives (Freight, Tourism, Avalanche & Flood Control)	I4 - Environmental Retrofit	P1 - Roadway Preservation (Paving)	P2 - Structures Preservation	P3 - Other Facilities (Rest Areas, Unstable Slopes, Major	Notes
Pedestrian										
Pedestrian Refuge Areas (MEDIANS)	DM									DM 640.06, DM 910.07, DM 1025.07
Transit Pull Outs	DM									DM 1060.05
Transit Shelters	DM									DM 1060.03
Park and Ride Lots	DM									DM 1060.03
Safety Rest Areas	DM									DM 1030
Cross Walks	DM									DM 1025.07
Pedestrian Warning Devices	MUTCD & SP									DM 850.06
Curb Extensions (Bulbouts)	DM									DM 1025.07
Traffic Barrier - Protective	DM & SP									DM 700.01, DM 700.05, DM 710, SP Section "C"
Sidewalks -	DM & SP									DM 1025.07, SP "F-3" series
Meandering - Sidewalk	DM & SP									DM 1025.07
Vertical/Horizontal Separation - Sidewalk	DM & SP									DM 1025.07
Bike Path - Adjacent	DM & SP									DM 1020
Bike Path - Separate Alignment	DM & SP									DM 1020
Trails	DM & SP									DM 1025
Pedestrian Over/Under Crossings	DM & SP									DM 1025.07
Bollards	DM & SP									DM 1020.05, SP "H-13" series
Environmental Functions										
Noise Barriers	DM & EPM									DM 1140, DM 1300, SP "D-2" series
Storm Water Retention/Treatments	HRM									DM 530.05, DM 1210, SP Section "B"
Fish Barriers Removal and Habitat	DM									DM 240, DM 1210
Unstable slopes**	RCW & DM									**Depends on the cause, location and B/C of unstable slope. Refer to RCW 47-24, DM 510
Street Furnishings										
Art or Non-Functional Feature										For mitigation only
Street Furnishings - Benches, Bike Rack, Trash Cans										For mitigation only
Gateway Features										For mitigation only
Traffic Control Devices										
Pavement Textures and Coloring	DM & SP	***	***		***					***These elements are not eligible for funding unless adding them would fix a known deficiency such as a Pedestrian Accident Location. DM 1025.07
Lighting	RCW & DM									Refer to RCW 47-24, DM 840, DM 1020.04, DM 1025.07, SP Section "J"
Lighting Under Structures	DM									DM 840.06
Raised Median - Traffic Island	DM									DM 700.04, DM 1025.04, DM 1025.07
Signing	DM									DM 820, SP Section "G"
Traffic Signals	DM									DM 850, SP Section "J"
Pavement Markings	SP									DM 650.04, DM 810.09, DM 860, DM 910.07, DM 915.09, DM 1020.05, DM 1050.06, SP "H-3" series & "H-5" series
Landscaping										
Median - Landscaping	RCP				□			#		DM 1300
Outside Curb Landscaping	RCP							#		DM 620.05, DM 640.07, DM 915.04, DM 1020.04, DM 1060.03, DM 1300, DM 1310, DM 1350
Irrigation	RCP				□			#		DM 1330
Structural Soil Mix	RCP							#		Treatment Level 2
Roadside Restoration	RCP							#		DM Fig 330-3, DM 1300, DM 1350.05
Planters	RCP							#		Treatment Level 2
Planter Strips	RCP							#		Treatment Level 2
Structures										
Changes to Bridge Structure to Capture an Opportunity	DM							#		DM 1120
Bridge Railing	BM, DM &SP					+				DM 710.11, DM 1025.07
Throw Barriers - Protective Screening	BM, DM &SP									DM 1120.04
Wall & Structure Treatments/Textures	DM									DM 1130.05
Traffic Safety Barriers	DM & SP									DM 710, SP Section "C"
Traffic Safety Barriers Treatments and Textures	DM									DM 710.09
Other										
Fencing	RCP, DM & SP									Project specific need and intent. DM 1460, SP "L" series
Scenic Viewpoints	DM									DM 1300

Abbreviations:
BM - Bridge Manual
DM - Design Manual
EPM - Environmental Procedures Manual
HRM - Highway Runoff Manual
MUTCD - Manual of Uniform Traffic Control Devices
RCP - Roadside Classification Plan
RCW - Revised Code of Washington
SP - Standard Plans

Codes:
Eligible for WSDOT funding, as required
Not eligible for WSDOT funding, requires partnership
Negotiable, not required

*WSDOT retains full design control on limited access highways.
For bridge replacment only
□ For access management
\+ Culvert replacement project that installs a bridge.

Note: Definitions for the improvement categories are listed on the following page.

Definitions of Improvement Categories

I1 – Mobility Improvements Reduce traffic congestion and delays on state highways, complete the Puget Sound core freeway HOV lanes, improve existing travel options, and create links and remove barriers between transportation facilities and services. Does not apply to park–and–ride lots. (See Chapter 1060 of the *Design Manual*.)

I2 – Safety Improvements Prevent or reduce the number and severity of accidents on state highways.

I3 – Economic Initiatives Support efficient and reliable freight movement on state highways, support international trade and emergent economic development, and provide integrated traveler services and tourism support while encouraging partnerships.

I4 – Environmental Retrofits Remove identified fish passage barriers, reconstruct storm water discharge facilities as opportunities arise, and reduce the public's exposure to noise from state highway facilities.

P1 – Roadway Preservation Repave highways at the optimum time to minimize long-term costs and restore safety features. Note: there is a $25,000.00 limit per occurrence/location for spot improvements. (See Chapter 410 of the *Design Manual.)*

P2 – Structure Preservation Maintain existing structures that contribute to a safe transportation network, replace structures that become structurally or operationally deficient, and retrofit existing structures to reduce the risk of failure in the event of a natural catastrophe.

P3 – Other Facilities Stabilize known unstable slopes, refurbish safety rest areas, construct weigh facilities, rehabilitate or replace existing drainage structures, and rehabilitate or replace existing electrical, electronic, and mechanical systems.