



**Washington State  
Department of Transportation**

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# Roadside Manual

M 25-30.06

December 2023

**Engineering and Regional Operations**

Development Division, Design Office

## **Americans with Disabilities Act (ADA) Information**

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## Foreword

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The *Roadside Manual* has been prepared to coordinate and guide the management of Washington State highway roadsides including planning, design, construction, and maintenance activities.

The intent of this manual is to provide a consistent, coordinated, proactive approach to the treatment of roadsides statewide and to facilitate cost-effective restoration of state roadsides. The policies and guidelines provided here allow room for regional variations within the statewide parameters.

This manual implements the policies found in the *Design Manual* and the *Roadside Policy Manual*.

For further information, to offer comments on the *Roadside Manual*, call the Roadside and Site Development Unit of the Headquarters Design Office at 360-705-7242 or [HartwiJ@wsdot.wa.gov](mailto:HartwiJ@wsdot.wa.gov).

To order additional copies of the *Roadside Manual* contact Engineering Publications at 360-705-7428.

/s/ Jeff Carpenter

**Jeff Carpenter, P.E.**

Director & State Design Engineer,  
Development Division



## Comment Form

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From: \_\_\_\_\_ Date: \_\_\_\_\_  
\_\_\_\_\_  
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\_\_\_\_\_

To: WSDOT Headquarters  
Development Division, Design Office  
Attn: Roadside and Site Development  
PO Box 47329  
Olympia, WA 98504-7329

Subject: *Roadside Manual*

Comment (marked copies attached):



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### 100.01 Purpose

The Washington State Department of Transportation (WSDOT) has developed the *Roadside Manual* to provide coordination between all WSDOT partners responsible for roadside activities, and to establish a common basis for consistent roadside management decisions statewide. It also establishes a convenient and accessible reference for new and previously unpublished material related to roadside management including planning, design, construction, and maintenance. In addition, the manual supplements statewide roadside guidelines established in the [Roadside Policy Manual](#).

### 100.02 General

Roadsides are an important component of highway design, operation, and maintenance because of the operational, environmental, visual and auxiliary functions they provide. Properly designed and maintained, roadsides complement the functions of the roadway, integrate the roadway facility into the surrounding landscape and provide a positive psychological effect on vehicle occupants.

Almost one-third of fatal accidents are single vehicle run-off-the-road accidents. Recognition of this fact has led to roadway, traffic barrier, sign, and lighting standard designs that can reduce the seriousness of roadside encroachments. Roadsides can have a significant effect on errant-vehicle occupant safety. Refer to the [Design Manual](#) for guidance on roadway and roadside safety design.

Roadsides include virtually every habitat type that occurs in Washington State. They provide for native plant preservation and revegetation, habitat for animal species, and opportunities for stormwater storage and aquifer recharge.

In addition, there is increasing scientific evidence that roadsides can have a psychological effect on vehicle occupants. Nature-dominated roadsides may relieve drive-related stress and may have an immunizing effect on reaction to future drive-related stresses. The inverse has also been shown to be true: drives dominated by human development can increase drive-related stress. These research findings have important implications for management of roadsides. Roadsides are important for both physical safety of, and psychological impact on vehicle occupants.

### **100.03 Definitions**

The roadside is the area outside the traveled way. This applies to all lands managed by WSDOT and may extend to elements outside the right of way boundaries. This includes unpaved median strips and auxiliary facilities such as rest areas, roadside parks, viewpoints, heritage markers, pedestrian and bicycle facilities, wetlands and their associated buffer areas, stormwater treatment facilities, park and ride lots, and quarries and pit sites.

### **100.04 Format**

This manual is organized around a framework of roadside functions: operational, environmental, visual and auxiliary. Each of these functional areas has relevance to planning, design, construction, and maintenance personnel.

To avoid unnecessary duplication, existing WSDOT roadside publications have been outlined, referenced, or transferred to this manual.

Each division in this manual includes the following:

- Resources, including related published material and who to contact for more information.
- Definitions of technical terms specific to the division's subject matter. These and other definitions are also found in the glossary.
- Procedures for accomplishing roadside projects, including coordination and communication procedures, schedules, and required actions. Most chapters include a list of recommended procedures for each subject area.

### **100.05 Revisions**

This manual will continue to present the best and most up-to-date information available. It is vital that you, the user, participate in the revision process by using the form provided at the front of the manual to report flaws and to contribute new material.

## 110.01 General

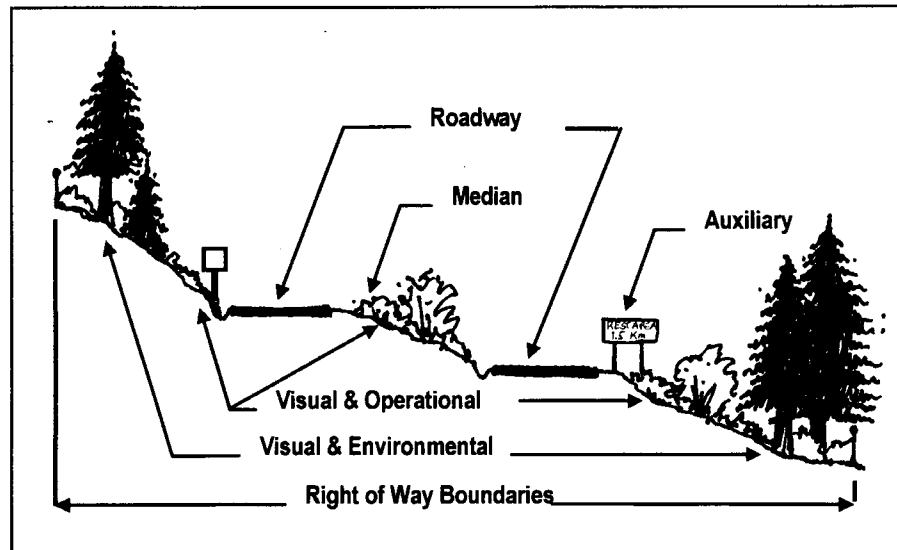
## 110.02 Roadside Management

### 110.01 General

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

Exhibit 110-1 shows the extent of a typical forested roadside and an example of the possible locations of roadside functional features.

**Exhibit 110-1 Roadside functional area examples**



The Washington State Department of Transportation (WSDOT) is responsible for the stewardship of approximately 97,500 acres of roadsides along 7,061 miles (in 2001) of state roadway, including hundreds of auxiliary facilities.

Roadside management encompasses planning, design, construction, and maintenance of the roadside environment. The roadside is managed to fulfill four functional categories: operational, environmental, visual, and auxiliary functions. In reality, these functions are interrelated and inseparable, but the four functions help communicate the range of roadside management issues.

The roadside provides the essential area for these functions and contributes to WSDOT's delivery of transportation services. [Exhibit 110-2](#) shows the functions and some examples of those functions.

These examples and their applications are discussed in greater detail in the next several chapters.

Exhibit 110-2 Roadside functions

Function	Examples
operational functions	Those functions that provide safe and multiuse roadsides. Operational functions include access control, and providing recovery areas and sight distances with accommodations for signs and utilities, and snow storage. The <a href="#">Design Manual</a> remains the primary guidance for operational design guidance.
environmental functions	Those functions that protect and enhance our natural and built surroundings. Environmental functions include water quality preservation, protection and improvement, stormwater detention and retention, wetland and sensitive area protection, noxious weed control, noise control, habitat protection, habitat connectivity, air quality improvement, and erosion control.
visual functions	<p>Those functions that are designed and experienced primarily from a visual perspective. Visual functions promote a positive quality of life and are integral to operational, environmental, and auxiliary functions. They include positive guidance and navigation, distraction screening, corridor continuity, roadway and adjacent property buffering, and scenic view preservation.</p> <p>There are two primary roadside views: those from the roadway and those toward the roadway. In addition, many environmental functions, such as noxious weed control, wetland and sensitive area preservation, and habitat preservation are readily perceived and evaluated through sight.</p>
auxiliary functions	Those functions that provide additional operational, environmental, and visual functions for a complete transportation system. Examples of auxiliary facilities are community enhancement areas, safety rest areas, roadside parks, viewpoints, agricultural uses, heritage markers, bicycle and pedestrian facilities, park and ride lots, and quarries and pits.

## 110.02 Roadside Management

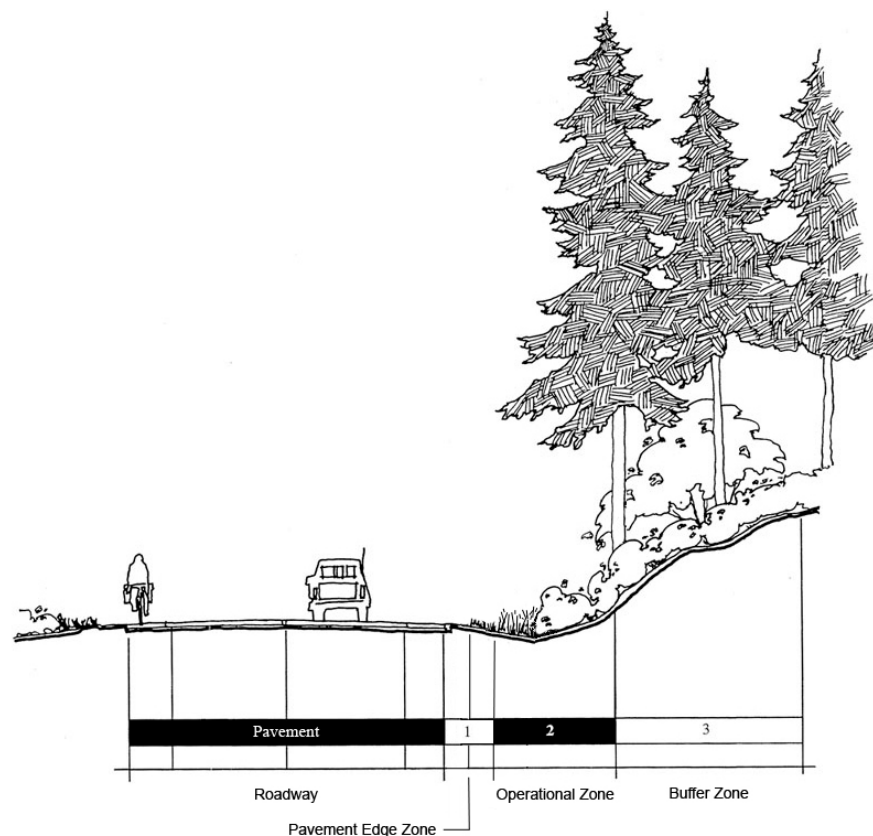
The roadside is managed to fulfill the operational, environmental, visual, and auxiliary functions. Decisions concerning roadside management must be balanced to coordinate and integrate these functions without compromising safety.

Roadside functions vary at different locations according to specific highway and site conditions. Although every area of roadside simultaneously provides many functions, some roadside sections are used primarily to serve very specific functions that are dictated by highway traffic and safety needs, the physical environment, legislated requirements, commitments, and WSDOT policies and programs.

Roadsides are managed in three zones. Zone 1, when present, is a vegetation-free zone immediately adjacent to the roadway. Zone 2 typically contains the clear zone (although in some locations, the Design Clear Zone may extend beyond the right of way line).

Zone 3 extends from Zone 2 to the right of way line, as seen in Exhibit 110-3. Please see the [Maintenance Manual](#) or the [Roadside Policy Manual](#) for more information.

### Exhibit 110-3 Roadside management zones



#### Pavement Edge Zone

*Low Growing or Routinely Mowed Vegetation and/or Vegetation-Free Strip*  
Maintained using mechanical and/or chemical methods for sight distance, stormwater drainage and filtration, noxious weed control, pavement preservation and roadside hardware maintenance.

#### Operational Zone

*No Vegetation with Stem Diameter Greater than 4"*  
Maintained using IVM techniques for sign visibility, sight distance, errant vehicle recovery and weed control.

#### Buffer Zone

*Native or Naturally Occurring Vegetation*  
Where adequate right of way exists, maintained using IVM techniques to encourage desirable, self-sustaining plant communities.



- 120.01 General
- 120.02 Reference
- 120.03 Resources
- 120.04 Definition
- 120.05 Managing for Sustainable Roadsides

## 120.01 General

Roadside management encompasses roadside planning, design, construction, and maintenance. The primary challenge in roadside management is to preserve and restore roadside character and fulfill roadside functions, regardless of fluctuations in funding and personnel. By setting feasible standards and working consistently within long-term goals, roadside management can promote sustainable roadsides.

## 120.02 Reference

Roadside Vegetation Management Plans

 [www.wsdot.wa.gov/maintenance/roadside/mgmt\\_plans.htm](http://www.wsdot.wa.gov/maintenance/roadside/mgmt_plans.htm)

## 120.03 Resources

- Region Landscape Architects
- Headquarters (HQ) Design Office, Roadside and Site Development Section

## 120.04 Definition

**sustainable roadsides** Roadsides that are designed and maintained with the intent of integrating successful operational, environmental, and visual functions with low life cycle costs.

## 120.05 Managing for Sustainable Roadsides

Sustainable roadsides fulfill roadside design intent and roadside functions over the long term, within present and future available funding, personnel, and equipment allocations and methodologies. To achieve sustainable roadsides, roadside partners must strive to utilize, protect, and support the physical and ecological resources necessary for a fully functioning roadside.

The primary management considerations for sustainable roadsides are:

- **Design intent:** Roadside functions (operational, environmental, visual, and auxiliary) and maintenance standards, criteria, and actions are coordinated and balanced to the greatest degree possible to achieve the design intent on all levels. Design to achieve the long-term goals of Integrated Vegetation Management (IVM). Refer to the [Roadside Vegetation Management Plans](#) website.

- **20-year planning horizon:** All roadside management decisions are weighed in their long-term context, including projected land use and public health, safety, and welfare considerations. Address future adjacent land uses and roadside functions when designing present-day projects.
- **Projected life cycle costs:** All roadside management decisions are in keeping with present and future available funding, personnel, equipment, and methodologies. What are the costs of the project over its “lifetime?”
- **Utilize, protect, and support the roadway and roadside infrastructure:** All roadside management decisions are balanced with the need to sustain, and to preserve, restore, and enhance the roadside character and natural environment. The emphasis is on careful management of existing and volunteer native vegetation.
- **Continued cooperative involvement:** Roadside management decisions are based on continued active involvement between all roadside partners within WSDOT. This begins at the earliest planning stages with communication between all affected parties through an open, collaborative management process and designated lines of communication between roadside partners.

This manual presents criteria and details for implementation of the sustainable roadside concept. All documents pertaining to roadside management such as design documents, construction plans, and area maintenance plans shall be created and implemented using the considerations for managing sustainable roadsides.



### 200.01 General

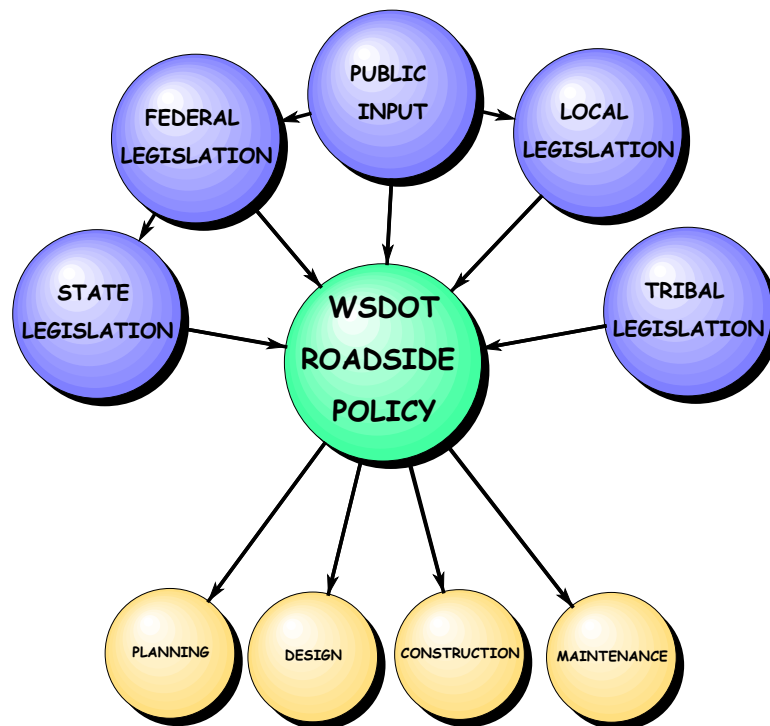
### 200.02 Procedures

#### 200.01 General

Washington State Department of Transportation (WSDOT) roadside policy is governed by a web of jurisdictional entities, and affects planning, design, construction, and maintenance.

An activity is directed by department policy and guidelines that are influenced by federal, state, and local legislation and regulations. Roadside policy is also influenced by public input and tribal legislation (see Exhibit 200-1).

**Exhibit 200-1 Jurisdictional entities governing roadside policy**



#### 200.02 Procedures

##### 200.02(1) Public Involvement

Public involvement in WSDOT roadside activities is conducted in a manner that is consistent with the process established for roadways in general. (See the WSDOT [Design Manual](#), Chapter 210, Public Involvement and Hearings.) It is the department's goal that decisions be made in the best overall public interest, and that other agencies and the public be involved early enough to influence project decisions.



- 210.01 General
- 210.02 Environmental Preservation and Protection
- 210.03 Visual Quality and Scenic Enhancement
- 210.04 Accessibility
- 210.05 Funding and Planning

### 210.01 General

Federal legislative acts and policies govern many roadside activities. (See the [Design Manual](#), Chapter 220, for documentation requirements.) The [Environmental Manual](#) contains extensive references to laws and directives applicable to the environment. FHWA's website also contains references to environmental regulations: [www.fhwa.dot.gov/environment/env\\_sum.cfm](http://www.fhwa.dot.gov/environment/env_sum.cfm)

Following is a brief summary of the major acts and policies affecting roadsides.

### 210.02 Environmental Preservation and Protection

#### 210.02(1) *National Environmental Policy Act (NEPA), 42 USC 4321 (1969)*

Established to ensure consideration of environmental factors through a systematic interdisciplinary approach before committing the department and FHWA to a course of action.

Declares that it is the “continuous responsibility” of the federal government to “use all practicable means” to “assure for all Americans safe, healthful, productive, and esthetically and culturally pleasing surroundings.”

#### 210.02(2) *Clean Water Act, 33 USC 1251 et seq.*

The Water Pollution Control Act, better known as the Clean Water Act (CWA), was established to restore and maintain the chemical, physical, and biological integrity of the nation's water through the prevention, reduction, and elimination of pollution. [Section 404](#) addresses discharge of dredge and fill in all waters of the United States, including wetlands, and is enforced by the U.S. Army Corps of Engineers and the U.S. Environmental Protection Agency (EPA).

The CWA provides for comprehensive federal regulation of all sources of water pollution. It prohibits the discharge of pollutants from non-permitted sources. The CWA authorizes the EPA to administer or delegate water quality regulations covered under the act. In Washington, the EPA has delegated administrative authority of the CWA to the Washington State Department of Ecology (Ecology) except on tribal and federal lands.

To promote compliance with state surface water quality standards, Ecology issues:

- CWA Section 401 certificates of water quality compliance for each project requiring a CWA Section 404 permit.
- Administrative orders for projects not requiring Section 404 permits.

- National Pollutant Discharge Elimination System (NPDES) Construction individual and general permits.
- NPDES Municipal Permits.

**210.02(3) Clean Air Act, 42 USC 7401 et seq.**

Established to protect and enhance air quality and to assist state and local governments with air pollution prevention programs.

**210.02(4) Endangered Species Act of 1973 as amended, 16 USC 1531-1541**

Established to conserve species of fish, wildlife, and plants facing extinction.

**210.02(5) Rivers and Harbors Act of 1899, 33 USC 410 et seq.**

Protects navigable waters of the United States. It is enforced by the U.S. Army Corps of Engineers.

**210.02(6) Noise Control Act of 1972, 42 USC 4901 et seq.**

Established to promote an environment free from detrimental noise that jeopardizes the public's health and welfare.

**210.02(7) National Forest Management Act (NFMA), 16 USC 1604 (g)(3)(B)**

Requires the Secretary of Agriculture to assess forest lands, develop a management program based on multiple-use, sustained-yield principles, and implement a resource management plan for each unit of the National Forest System. The NFMA applies directly to lands administered by the United States Forest Service (USFS), but also provides direction for Bureau of Land Management (BLM) land management plans. The BLM and USFS have integrated National Environmental Policy Act requirements with their land management regulations.

The USFS has developed forest-specific "forest plans" that identify "species of concern" found within each forest.

WSDOT projects that involve federal forest lands must comply with regulations under the NFMA and the Northwest Forest Plan (*Environmental Manual*, Chapter 436).

**210.02(8) Preservation of the Nation's Wetlands, EO 11990**

Provides policy and implementing procedures that require all agencies to plan, construct, and operate to ensure protection, preservation, and enhancement of the nation's wetlands to the fullest extent practicable.

**210.02(9) Prevention of Invasive Species, EO 13112, February 1999**

Directs federal agencies to expand and coordinate their efforts to combat the introduction and spread of plants and animals not native to the United States. FHWA has developed guidelines that provide a framework for preventing the introduction of and controlling the spread of invasive plant species on highway rights of way.

**210.02(10) Executive Order (EO) 13423 – Strengthening Federal Environmental, Energy, and Transportation Management**

Signed by President Bush on January 24, 2007, [EO 13423](#) instructs federal agencies to conduct their environmental, transportation, and energy-related activities under the law in support of their respective missions in an environmentally, economically, and fiscally sound, integrated, continuously improving, efficient, and sustainable manner.

**210.02(11) Executive Order 13514 – Federal Leadership in Environmental, Energy, and Economic Performance**

Signed by President Obama on October 5, 2009, [EO 13514](#) expands on the energy reduction and environmental performance requirements for federal agencies identified in [EO 13423](#). The goal of this EO is to establish an integrated strategy toward sustainability in the federal government and to make reduction of greenhouse gas emissions a priority for federal agencies.

**210.02(12) Presidential Memorandum on Environmentally Beneficial Landscaping, FRL-5054-1 (1994)**

Directs federal agencies to lead the country toward more environmentally and economically beneficial landscape practices, including:

- Use of regionally native plants.
- Construction with minimal impact to habitat.
- Reduced use of fertilizers, pesticides, and other chemicals.
- Use of water-efficient and runoff-reduction practices.
- Use of demonstration projects employing these practices.

Pertains to all highway programs using federal funds and provides for the development of implementation guidance.

**210.02(13) US DOT Policy Statement on Climate Change Adaptation, June 2011**

Based on [EO 13514](#), this policy statement directs that USDOT “shall integrate consideration of climate change impacts and adaptation into the planning, operations, policies, and programs of DOT in order to ensure that taxpayer resources are invested wisely and that transportation infrastructure, services and operations remain effective in current and future climate conditions.”

The policy notes that all modal administrations within the agency have the responsibility to consider the impacts of climate change on their current systems and future investments:

🔗 [www.fhwa.dot.gov/environment/climate\\_change/adaptation/policy\\_and\\_guidance/usdot.cfm](http://www.fhwa.dot.gov/environment/climate_change/adaptation/policy_and_guidance/usdot.cfm)

**210.02(14) Sustainable Highways Program, FHWA**

Supports programs and activities conducted across the country to facilitate balanced decision making among “environmental, economic, and social values—the triple bottom line of sustainability.” To read more about the Sustainable Highways Program, visit:

🔗 [www.sustainablehighways.dot.gov/](http://www.sustainablehighways.dot.gov/)

## 210.03 Visual Quality and Scenic Enhancement

### 210.03(1) *Highway Beautification Act (HBA) of 1965, 23 CFR 750*

Establishes provisions and controls to protect the public investment, promote safety and recreation, and preserve natural beauty along federal and primary highway system roadsides, including:

- Control of outdoor advertising signs.
- Authorization for information centers at safety rest areas.
- Control of junkyards.

Allocated of 3% of federal-aid funds that were apportioned to states for landscape and roadside development and for acquisition of interest in, and improvement of, strips of land necessary for the restoration, preservation, and enhancement of scenic beauty adjacent to the highways.

### 210.03(2) *Control of Outdoor Advertising, 23 USC 131*

Congress finds outdoor advertising signs should be controlled in order to promote the safety and recreational value of public travel and preservation of natural beauty.

### 210.03(3) *Junkyard Control and Acquisition, 23 CFR 751 and 23 USC 136*

Congress finds junkyards should be controlled to promote the safety and recreational value of public travel and preservation of natural beauty.

### 210.03(4) *Landscaping and Scenic Enhancement, 23 USC 319*

Provides for the acquisition and improvement of strips of land necessary for the restoration, preservation, and enhancement of scenic beauty to federal-aid highways.

Requires the planting of native wildflower seeds or seedlings as part of any Federal-aid Highway landscaping project. At least ¼ of one percent of the funds expended for landscaping projects shall be used for these plantings. WSDOT uses native woody flowering species and flowering forbs to help meet this goal.

### 210.03(5) *Landscape and Roadside Development, 23 CFR 752*

“Highway esthetics is a most important consideration in the Federal-aid highway program. Highways must not only blend with our natural, social, and cultural environment, but also provide pleasure and satisfaction in their use.... The development of the roadside to include landscape development, safety rest areas, and the preservation of valuable adjacent scenic lands is a necessary component of highway development. Planning and development of the roadside should be concurrent with or closely follow that of the highway.”

### 210.03(6) *FHWA Scenic Enhancement Initiatives Memorandum, HRW-12 (1990)*

Rescinds a 1977 memorandum permitting selective clearing of right of way vegetation to improve visibility of outdoor advertising structures.

Encourages states to retain excess lands that could be used to restore, preserve, or enhance the scenic beauty and quality of the highway environment, including scenic vistas, wetlands, and preservation of wildlife habitat.

## 210.04 Accessibility

### 210.04(1) *Americans with Disabilities Act of 1990*

Requires all services, programs, and activities, when viewed in their entirety, to be readily accessible to, and usable by, people with disabilities: ♿ [www.ada.gov](http://www.ada.gov)

## 210.05 Funding and Planning

### 210.05(1) [Fixing American's Surface Transportation Act \(FAST Act\)](#)

On December 4, 2015, President Obama signed into law the Fixing America's Surface Transportation Act, or "FAST Act." It is the first law enacted in over ten years that provides long-term funding certainty for surface transportation, meaning States and local governments can move forward with critical transportation projects, like new highways and transit lines, with the confidence that they will have a Federal partner over the long term.

### 210.05(2) *Federal Highway Administration Strategic Plan*

The vision for this strategic plan is to create the best transportation system in the world by creating the safest, most efficient, and most effective highway and intermodal transportation system for the American people. FHWA's strategic goal for system performance is that the nation's highway system provides safe, reliable, effective, and sustainable mobility for all users: ♿ [www.fhwa.dot.gov/policy/fhplan.htm](http://www.fhwa.dot.gov/policy/fhplan.htm)





220.01	General
220.02	Planning
220.03	Environmental
220.04	Maintenance
220.05	Materials
220.06	Partnerships
220.07	Safety Rest Areas

### 220.01 General

Refer to the [Design Manual](#) for safety and documentation requirements. The [Environmental Manual](#) contains references to laws and directives applicable to the environment.

Roadside restoration and the correction of unsightly conditions is a highway purpose:

#### **220.02(1) RCW 47.40.010, Improvement and beautification a highway purpose**

The planting and cultivating of any shrubs, trees, hedges or other domestic or native ornamental growth, the improvement of roadside facilities and view points, and the correction of unsightly conditions, upon the right-of-way of any state highway is hereby declared to be a proper state highway purpose.

The following is a brief summary of other major state acts and directives affecting roadsides.

### 220.02 Planning

WSDOT must comply with primary planning statutes and regulations to receive state and federal funds. A complete listing of all planning relevant RCWs and CFRs can be found on the [WSDOT Transportation Planning](#) web page. The following list is specific to Roadside Development.

#### **220.02(1) RCW 47.06, Amended in 1993 by Engrossed House Bill 1007**

Directs the Transportation Commission to develop the Transportation Policy Plan for Washington State, and directs WSDOT to develop the Statewide Multimodal Transportation Plan.

#### **220.02(2) Washington State Growth Management Act of 1990 and Amendments**

Sets goals to guide planning for growth in all communities exceeding a set threshold. Requires designations of natural resource lands and critical areas. Provides for regional transportation planning program.

Requires state agencies to comply with local comprehensive plans and development regulations. Requires local governments to develop a process for siting “essential public facilities.”

Requires certain cities and counties to designate environmentally sensitive areas, including wetlands, flood plains, and habitat.

## 220.03 Environmental

The following list includes legislation, regulations, and guidelines most commonly encountered in roadside activities. For more complete information on state environmental legislation, regulations, and guidelines directly affecting WSDOT actions, see the WSDOT [Environmental Manual](#) or contact the Headquarters Environmental Services Office.

### 220.03(1) General

#### 220.03(1)(a) State Environmental Policy Act (SEPA) and [RCW 43.21C](#)

Declares a state environmental policy and promotes efforts to prevent or eliminate damage to the environment, including visual impacts.

#### 220.03(1)(b) State Environmental Policy Act Rules: [WAC 197-11](#)

Establishes uniform requirements for agencies and developers to comply with SEPA regulations.

#### 220.03(1)(c) Transportation Commission and Transportation Department Environmental Policy Act Rules: [WAC 468-12](#)

Integrates the policies and procedures of SEPA into the programs, activities, and actions of the department.

### 220.03(2) Water Quality

#### 220.03(2)(a) Puget Sound Water Quality Authority Act: [RCW 90.70](#)

Established the Puget Sound Water Quality Authority and directed the Authority to develop a Puget Sound Water Quality Management Plan.

#### 220.03(2)(b) Puget Sound Runoff Program: [WAC 173-270](#)

Provides guidelines and criteria for implementation of the program.

#### 220.03(2)(c) Shoreline Management Act of 1971: [RCW 90.58](#)

Manages Washington State's shorelines by planning for and supporting all reasonable and appropriate uses.

#### 220.03(2)(d) State Water Pollution control Act: [RCW 90.48](#)

Protects all surface and underground waters.

#### 220.03(2)(e) Water Resources Act of 1971; [RCW 90.54](#)

Provides for utilization and management of waters in Washington State.

### 220.03(3) Biology/Wetlands

#### 220.03(3)(a) Hydraulic Code of Washington, [RCW 77.55](#)

Establishes program for regulating activities within the waters of the state for fish protection. Requires hydraulic project approval for actions within the ordinary high

water mark. Administered by the Washington State Department of Fish and Wildlife and the tribes.

**220.03(3)(b) Fish Passage** – See the [Environmental Manual, Chapter 436](#)

**220.03(3)(c) Protection of Wetlands** – See the [Environmental Manual, Chapter 431](#)

#### **220.03(4) Noise**

**220.03(4)(a) Noise Control Act of 1974:** [RCW 70-107](#)

Expands efforts to abate and control noise while considering the social and economic impact upon the community and the state.

**220.03(4)(b) Sound Level Measurement Procedures:** [WAC 173-58](#)

Establishes standardized procedures to measure sound levels from sources including environmental and construction noise.

**220.03(4)(c) Maximum Environmental Noise Levels:** [WAC 173-60](#)

Establishes maximum noise levels for identified environments.

#### **220.03(5) Visual Quality**

**220.03(5)(a) Scenic and Recreational Highway Act of 1967:** [RCW 47.39](#)

Establishes the Scenic and Recreational (S&R) Highways Program and designates more than 1900 miles of scenic highways.

**220.03(5)(b) Roadside Improvement and Beautification:** [RCW 47.40](#)

Outlines permit process for persons wishing to use highway right of way for improvement and beautification. Establishes penalty for destroying native flora on state lands. Mandates litter removal and authorizes state and local Adopt-a-Highway programs.

**220.03(5)(c) Junkyards Adjacent to Interstate and Primary Highways:** [RCW 47.41](#)

Establishes controls for junkyards adjacent to highways.

**220.03(5)(d) Highway Advertising Control Act-Scenic Vistas Act of 1971:** [RCW 47.42](#)

Amends the Highway Advertising Control Act to include the designated Scenic and Recreational Highways. Controls advertising signs along state highways and their interference with views.

**220.03(5)(e) Amended Scenic and Recreational Highway Act of 1967:** [RCW 47.39 \(1990\)](#)

Directs WSDOT to develop criteria and a threshold methodology to evaluate highways for possible inclusion in the S&R system. States that scenic and recreational highways are designated because of a need to develop management plans that will protect and preserve the scenic and recreational resources from loss through inappropriate development. States that protection of these resources includes managing land use outside normal highway rights of way, and adds additional routes to the S&R System.

**220.03(5)(f) Amended Scenic and Recreational Highway Act of 1967: [RCW 47.39](#) (1993)**

Includes 45% of state highways in the Scenic and Recreational Highway (S&R) system. Directs the department to consider the use of the designated system by bicycles and pedestrians. Delegates authority for establishment of planning and design standards for S&R highways.

**220.03(5)(g) Scenic Enhancement for Utilities Accommodation on State Highway Rights of Way: [WAC 468-34-330](#)**

Describes a scenic classification system for utilities accommodation on state highway rights of way as developed through cooperation of WSDOT and the Aerial Utility Industry.

**220.04 Maintenance**

The following list includes legislation, regulations, and guidelines most commonly encountered in roadside activities. For more information on processes and guidelines directly affecting WSDOT maintenance actions, see the WSDOT [Maintenance Manual](#) or contact the Headquarters Maintenance Office.

**220.04(1) General****220.04(1)(a) Roadway Safety, [RCW 47.32.130](#)**

Provides for the removal of elements, such as vegetation, outside WSDOT right of way to increase roadway safety.

**220.04(1)(b) Noxious Weed Control, [RCW 17.10.145](#)**

Directs state agencies to control noxious weeds on their lands.

**220.04(1)(c) Preservation, restoration and cleanup of areas disturbed through utility installation, maintenance and repairs: [WAC 468-34-340](#)**

Outlines criteria for utility use of highway right of way, requires utilities to repair or replace unnecessarily removed or disfigured trees and shrub, and specifies vegetation management practices.

**220.04(1)(d) Vegetation Management Program, [WAC 173-270-040](#)**

States that the purposes of vegetation management in highway rights of way are to establish and maintain stable plant communities that resist encroachment by undesirable plants, noxious weeds, and other pests; meet WSDOT operational, health, natural resources and environmental standards; be cost effective; and protect the public investment with minimal negative impacts on the environment. Requires a vegetation management program for all state highways with the Puget Sound basin.

## 220.05 Materials

### 220.05(1) Compost Products

**RCW 43.19A.050** Instructs the department to prepare a strategy to increase purchases of recycled-content products.

- Compost products as a percentage of the total dollar amount (spent on soil cover or soil amendments) on an annual basis:
  - At least eighty percent by 1998

**RCW 70.95.030** Defines “compost” and “soil amendment”

### 220.05(2) Fertilizers **RCW 15.54**

- Requires license for distribution of bulk fertilizers.
- Requires identification of those products that are (i) waste derived fertilizers, (ii) micronutrient fertilizers, or (iii) fertilizer materials containing phosphate.
- Requires a minimum labeling statement that it meet Washington standards for arsenic, cadmium, cobalt, mercury, molybdenum, lead, nickel, selenium, and zinc.

## 220.06 Partnerships

Partnership opportunities for roadside activities generally occur through the Adopt-a-Highway program. For more information on this program, see the WSDOT [Adopt-a-Highway](#) page or contact the Headquarters Maintenance Office.

### 220.06(1) *General*

#### 220.06(1)(a) Adopt a Highway, **RCW 47.40.100** and **WAC 468-72**

Establishes and provides guidelines for state Adopt-a-Highway program. The purpose of the program is to provide volunteers and businesses an opportunity to contribute to a cleaner environment, enhanced roadsides, and protection of wildlife habitats.

## 220.07 Safety Rest Areas

The following list includes legislation, regulations, and guidelines most commonly encountered in roadside activities. For more information on Safety Rest Areas, see the WSDOT [Safety Rest Areas](#) web page.

### **220.07(1) General**

#### **220.07(1)(a) Acquisition of Property for Preservation of Beauty, Historic Sites, Viewpoints, Safety Rest Areas, Buffer Zones: [RCW 47.12.250](#)**

Authorizes acquisition of property, or interests, or rights to property adjacent to state highways for the stated purposes.

#### **220.07(1)(b) Roadside Areas-Safety Rest Areas: [RCW 47.38](#)**

Directs the development of rules and establishes limitations on use of rest areas and other roadside areas. Authorizes development of information centers. Establishes recreational vehicle sanitary disposal systems.

#### **220.07(1)(c) Uniform Building Code Requirements for Barrier-Free Accessibility: [RCW 19.27](#) and [70.92](#)**

Requires all new structures, and those being substantially renovated, be approachable and usable by persons with disabilities.

**Transportation Commission**

The Transportation Commission provides policies to shape and direct decisions about the future of Washington's transportation systems. The state transportation policy summary can be found on the Internet at:

<http://www.wsdot.wa.gov/commission/ReportsPlans/StateTranspPolicy.htm>

The policy addresses several issue areas, one of which is environmental protection and energy conservation. The environmental section of the policy states the following three principles:

- Minimize, and avoid when practical, air, water, and noise pollution; energy usage; use of hazardous materials; flood impacts; and impacts on wetlands and heritage resources from transportation activities.
- When practical, and consistent with other priorities, protect, restore and enhance fish and wildlife habitats and wetlands impacted by transportation facilities.
- Coordinate and take the lead in partnering with other agencies in environmental issues affecting transportation to reduce costs and increase effectiveness.

**Executive Order Number E 1018.00**

In this order, dated September 26, 2001, the Secretary of Transportation committed the department:

- To implement and maintain an environmental management system that embraces all the department's program functions.
- To establish, maintain and make available to the public appropriate performance indicators of the department's exercise of its environmental stewardship, and to consistently review these indicators as a basis to improve the department's performance.
- To comply with all environmental laws and regulations applicable to our business and activities.
- To assure that employees of the department receive training appropriate to their functions concerning the department's environmental responsibilities.

- To communicate to contractors, designers, consultants, and other participants in the department's work the management practices and compliance requirements established to further the aims of this Policy Statement {[Executive Order # E1018.00](#)}.
- To encourage employees and all other citizens to communicate with the department about ways to increase the effectiveness of departmental practices supporting its mission of environmental stewardship.
- To make every reasonable effort to also protect the cultural and historic resources of the state.

## Planning

### ***State Highway System Plan***

The State Highway System Plan is the state highway portion of the Washington Transportation Plan (WTP). The WTP was developed, and is updated, by the Washington State Transportation Commission in response to [RCW 47.06](#), as well as to state law and federal laws, such as the Transportation Equity Act for the 21st Century (TEA 21), and the Clean Air Act.

The WTP specifically defines service objectives and proposes strategies for maintaining, preserving, and improving state highways. This plan forms the basis for development of future state transportation programs, projects, and budgets.

### ***Statewide Roadside Plans***

#### ***Roadside Classification Plan M-25-31, (1996)***

Provides a statewide roadside classification process and guides roadside treatment for the management of safe, environmentally beneficial, and sustainable roadsides. The text of the [Roadside Classification Plan](#) can be found at the following website:

<http://www.wsdot.wa.gov/eesc/cae/design/roadside/rcp.htm>

#### ***Vegetation Management, Environmental Impact Statement (EIS), 1993***

Produced in response to proposed anti-pesticide legislation, this document incited a large response from the public with regard to the use of chemical herbicides. As a result, the Department has shifted its roadside management emphasis toward locally based, long-term planning Integrated Vegetation Management (IVM). In addition, the EIS recommended development and use of Roadside Management Plans for each of the area maintenance offices. The plans provide the



means for documenting site-specific long term goals and determining the planning and evaluation necessary to achieve those goals.

### ***Region and Route-Specific Roadside Plans***

The following planning tools are available in some, but not all, areas.

#### **Corridor Management Plans**

WSDOT defines transportation corridors as “accessible, passable routes between points encompassing a traveler’s perspective and experience of the available resources while using a transportation mode (roadway/railway, trail/path, or water route).

A ***corridor management plan*** is a document composed of maps and written material stating a community’s vision and goals for a scenic byway corridor. This document inventories and assesses the resources of the corridor, and outlines specific strategies and actions to preserve and enhance them.

#### **Roadside Master Plans**

Guides roadside related, long-term design and management activities on Washington State highway roadsides. Based on the [\*Roadside Classification Plan\*](#), Roadside Master Plans are route-specific conceptual plans prepared for a route, or portion of a route, where conditions require coordination beyond that provided under the [\*Roadside Classification Plan\*](#).

#### **Route Development Plans (RDP)**

A long-range plan for a specific highway corridor that describes existing highway conditions and local land use plans. Recommends improvements and goals for future improvements and transportation services. The plan is developed through cooperative efforts with affected city, county and regional agencies.

Route Development Plans are route-specific and may include a Roadside Master Plan where roadside planning concerns are identified.

## **Policies**

### ***Environmental***

#### **Water Quality Policy**

Minimize and control levels of harmful pollutants generated by transportation activities. Mandates preventing them from entering surface and groundwater resources.

### **Fish and Wildlife Habitat Protection Policy**

Protect, restore, and enhance, where feasible, fish and wildlife habitat and populations within transportation corridors.

### **Noise Abatement Policy**

Minimize noise impacts from transportation systems and facilities.

### **Wetlands Conservation Policy**

Support federal and state “no net loss” policies by protecting, restoring, and enhancing natural wetlands adversely impacted by transportation related construction, maintenance, and operations activities. (Department Directive 31-12)

### **Use of Hazardous Substances Policy**

- Reduce and eliminate, where practical, the reliance of the state’s transportation system on environmentally hazardous substance utilized in the construction and maintenance of transportation facilities.
- Ensure the adoption of best management practices in handling hazardous substances for transportation purposes.

## **Visual Quality**

### **Visual Quality Policy**

Protect and enhance the visual quality of Washington State’s transportation corridors and facilities.

For more information on visual impact assessment on Interstate highways see this website:

<http://www.wsdot.wa.gov/EESC/design/Roadside/#Viu>

### **Utilities Accommodation Policy**

The objective of this policy is to prescribe the means by which utility installations, when located in a manner not interfering with the free and safe flow of traffic or otherwise impairing the highway of its visual quality, may be accommodated within state highway rights of way.

## **Heritage Resources**

### **State Transportation Policy on Heritage Resources**

WSDOT has an interest in preserving, enhancing, and interpreting heritage resources to:

- Provide appropriate access to those resources that have been identified by national, tribal, state, and local resource management entities.

- Provide directional and interpretive signing along the transportation system. Consider directional signing on the transportation system to access cultural, natural, and historical resources only when resources are identified as significant in regional transportation plans or where there are clear economic benefits.
- Assist, where appropriate, with preserving and enhancing heritage resources that are within transportation corridors or are an integral part of the traveling experience along a corridor. Identify significant proposed transportation projects relating to the preservation, enhancement, or interpretation of resources on the transportation system in regional transportation plans.
- Avoid, minimize, or mitigate impacts of transportation projects on heritage resources.
- Cooperate in promoting heritage resources to aid tourism and achieve economic benefits.
- Commit state funding to leverage funding opportunities from other sources for transportation projects that preserve, enhance, and interpret heritage resources within transportation corridors.

### ***Directives***

- Adopt a Highway Litter Control Program (D 51-50)
- Safety Rest Areas and Roadside Parks (D 55-96)
- Protection of Wetlands (D 31-12)

### ***References***

- *Construction Manual* (M 41-01)
- *Design Manual* (M 22-01)
- *Environmental Manual* (M 31-11)
- *Highway Runoff Manual* (M 31-16)
- *Hydraulics Manual* (M 23-03)
- *Maintenance Manual* (M 51-01)
- *Plans Preparation Manual* (M 22-31)
- *Roadside Classification Plan* (M 25-31)
- *Safety Manual* (M 75-01)
- *Scenic Byway Logo Signing Guidelines* (M 3003.00)
- *Standard Specifications for Road, Bridge and Municipal Work* (M 41-10)

- *Transportation Commission Policy Catalog* found on the web at:  
<http://www.wsdot.wa.gov/commission/ReportsPlans/Catalog.pdf>
- *Utilities Manual* (M 22-87)
- *Water Quality Manual* (M 22-15)
- *Defining Washington's Heritage Corridors Program*, WSDOT, 1995

[300.01 Operational Functions](#)

[300.02 References](#)

[300.03 Design Objectives](#)

### 300.01 Operational Functions

Roadside operational functions are those that provide for safe, multi-use roadsides. Operational functions include access control, and providing recovery areas and sight distances with accommodations for signs and utilities. They complement roadway operational functions.

The most critical of roadside operational functions are those that affect vehicle occupant safety. These will be covered in the Roadside Safety chapter of this manual. The roadside operational features most seen and used by travelers are informational and instructional signs within the roadside right of way limits. In addition, critical features of roadside design include provisions for bicycle and pedestrian safety, maintenance access, and worker safety.

Although operational functions receive priority consideration in all phases of roadside management, sustainable roadsides require integration of operational features with environmental, visual, and auxiliary functions.

### 300.02 References

#### 300.02(1) Design Guidance

[Design Manual](#), M 22-01, WSDOT

[Highway Runoff Manual](#), M 31-16, WSDOT

[Hydraulics Manual](#), M 23-03, WSDOT

[Roadside Policy Manual](#), M 3110, WSDOT

[Roadside Design Guide](#), AASHTO

[Traffic Manual](#), M 51-01, WSDOT

[Utilities Accommodation Policy](#), M 22-86, WSDOT

[Utilities Manual](#), M 22-87, WSDOT

#### 300.02(2) Supporting Information

[Landscape Aesthetics: A Handbook for Scenery Management](#), United States Forest Service, Agriculture Handbook Number 701, 1995

[Manual of Aesthetic Design Practice](#), Province of British Columbia, Ministry of Transportation and Highways, Highway Engineering Branch, 1991

### 300.03 Design Objectives

The [Design Manual](#) is the authority for roadside safety. Chapter 310 of this manual discusses aspects of, and possible enhancements to, roadside safety. Chapter 320 discusses signs in the roadside corridor. Following are other operational design objectives.

#### 300.03(1) *Delineation*

##### 300.03(1)(a) Primary Considerations

Design vegetation and grading to help guide traffic through the highway corridor. For example, plantings in median strips, and the use of directional berms help guide the driver along the roadway.

#### 300.03(2) *Hydraulics*

##### 300.03(2)(a) Primary Considerations

Integrate hydraulic elements such as swales, ditches, redirectional berms, and detention/retention basins into roadside designs. Refer to the Design Manual, the [Highway Runoff Manual](#), and the [Hydraulics Manual](#) for hydraulic design objectives.

#### 300.03(3) *Snowdrift control*

##### 300.03(3)(a) Primary Considerations

Encourage features that act as a reservoir for snow (such as forest growth) where drifting snow is a problem. Gentle slopes can also be used to reduce the accumulation of drifting snow.

#### 300.03(4) *Snow storage*

##### 300.03(4)(a) Primary Considerations

In snowbelt areas, consider:

- Storage of plowed snow and the direction of snow blown by snow blowing equipment.
- Allowance for snow storage areas in safety rest areas, for example.
- Effect of deicing chemicals on vegetation selected for roadsides in snowbelt areas.

Drainage designs need to consider runoff and snowmelt while snow is in the storage area. If snow is piled over the top of drainage inlets, the inlets will not function. Rain or melting snow runs down the outside of the snow pile to low areas, forming ponds or flowing across the road. This causes a safety problem on the roadway. Consult the [Hydraulics Manual](#) for drainage design.

### **300.03(5) Utilities**

In most cases, utilities will already be along the corridor. However, in recent years utility companies have been upgrading lines by putting them on larger poles. Refer to the [Roadside Policy Manual](#) for WSDOT policy when there are requests to alter vegetation. We are required by law to accommodate utilities within our right of way. See the [Utilities Accommodation Policy](#) for more information. Under current law, wireless companies are not considered utilities. They operate within our right of way through air space leases. Real Estate Services works with those companies.

WSDOT's goal is to retain the native corridor character while accommodating utilities and air space leases. Use low stature trees and large shrubs under powerlines; and larger trees, where feasible, to screen utility lines and wireless structures.

#### **300.03(5)(a) Primary Considerations**

Consider the following for new utility structures within the roadside or that can be viewed from the roadway:

- Preserve existing desirable vegetation to the greatest extent feasible. Follow the policies within the [Roadside Policy Manual](#) when vegetation is impacted.
- Integrate utility structures with adjacent vegetation. Use existing and planted trees as backdrops to, and screening for, utility structures.
- Select colors of utility structures to blend into the background. Refer to [Landscape Aesthetics: A Handbook for Scenery Management](#) (USFS) for examples.
- Minimize disruption of views from the highway by placing utility structures away from significant views.
- Place utilities underground where practical.
- Scale the utility structure to complement the roadway design speed and the scale of the highway.
- Consider vehicle speeds in utility design. A structure becomes more prominent as design speeds decrease.
- WSDOT lighting is compliant with [International Dark Sky Association](#) guidelines. (See the [Design Manual](#) and the [Traffic Manual](#), for lighting information.)





310.01	<a href="#">General</a>
310.02	<a href="#">References</a>
310.03	<a href="#">Resources</a>
310.04	<a href="#">Definitions</a>
310.05	<a href="#">Safety of Vehicle Occupants</a>
310.06	<a href="#">Worker and Pedestrian Safety</a>

## 310.01 General

Safety is the top priority of the Washington State Department of Transportation (WSDOT).

Roadside safety addresses the area outside of the roadway. It is an important component of total highway design. Since run-off-road accidents comprise almost one third of all motor vehicle accidents, the physical characteristics of the roadside can either reduce, or increase the seriousness of the consequences of vehicles leaving the roadway.

While safety of vehicle occupants is a major consideration in roadside design, the safety of personnel working along the roadside is also a critical consideration. Some of the same mitigation measures that protect vehicle occupants can allow personnel working in roadside areas escape routes, or shields. Those mitigation measures include making the slope traversable, or installing traffic barriers or earth berms.

WSDOT personnel are trained, and are familiar with the dangers inherent in working in roadside areas. Volunteers, such as Adopt-a-Highway groups, and contractors must also be aware of roadside hazards. Anyone working in roadside areas must wear highly visible vests and protective headgear, and use traffic control measures. In addition, make every effort to have workers face oncoming traffic. Check the [Safety Procedures and Guidelines Manual](#) and the [Construction Manual](#) for more detail.

## 310.02 References

### 310.02(1) Design Guidance

[Construction Manual](#), M 41-01, WSDOT – Safety issues

[Design Manual](#), M 22-01, WSDOT – Sight distance along the roadway; roadside safety; traffic safety elements; sight distance at intersections; sight distance at road approaches; and sight distance for paths and trails

[Roadside Policy Manual](#), M 3110, WSDOT

*Roadside Design Guide*, AASHTO

[Safety Procedures and Guidelines Manual](#), M 75-01, WSDOT

[Traffic Manual](#), M 51-02, WSDOT

### 310.03 Resources

WSDOT Maintenance & Operations Programs (M&OP) Safety Office

WSDOT Headquarters (HQ) Design Office

Regional field offices

WSDOT Adopt-a-Highway coordinator

Landscape Architecture offices

Maintenance offices

Construction offices

### 310.04 Definitions

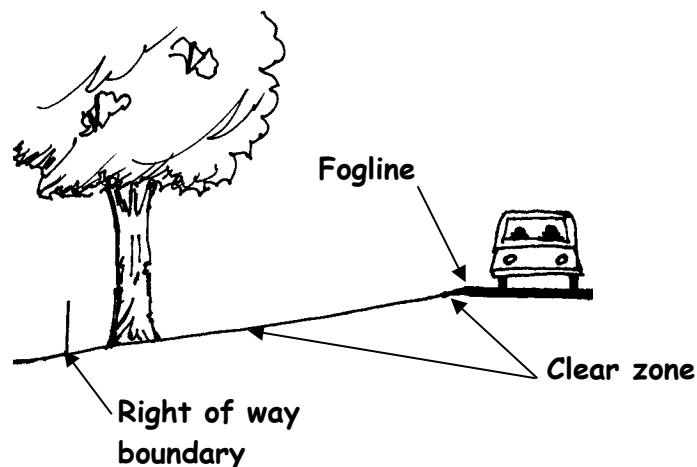
**fixed service item** A stationary facility or structure such as a utility box or light standard.

**maintenance pull-off** A widened shoulder area near fixed service items. Suggested width: 12 feet minimum. Suggested length: 100 feet maximum.

**solar exposure** Refers to the exposure of the road surface to the rays of the sun. Solar exposure can be blocked by landforms, structures, and vegetation adjacent to the roadway.

### 310.05 Safety of Vehicle Occupants

Exhibit 310-1 Clear zone example



#### 310.05(1) Clear Zone

The clear zone (see Exhibit 310-1) is the total roadside border area, starting at the edge of the traveled way, available for use by errant vehicles. This area may consist of a shoulder, a recoverable slope, a nonrecoverable slope, and/or a clear run-out area. The clear zone cannot contain a critical slope (slopes steeper than 3(H):1(V) are considered critical slopes). The Design Clear Zone is the minimum target value used in highway design. In areas with an open character, the clear zone may extend beyond the right of way boundary.

**310.05(1)(a) Primary Considerations**

Provide a clear zone, as discussed in the [Design Manual](#).

On new and major reconstruction projects, grade roadsides to mitigate impacts on errant vehicles whenever reasonable.

- Smooth and flatten slopes so there are no significant discontinuities and the fewest practical protruding fixed objects.
- Round toe of slope to make it traversable, and to assist an encroaching vehicle's contact with the surface.

These actions will have the added visual benefit of a more natural-appearing topography in most regions.

In some instances, removal of all trees within the Design Clear Zone may not be desirable (such as within a forest or park). If the impacts are minimal, a barrier or a deviation may be appropriate. In other cases, removal of trees may be necessary to increase driver safety. In these cases, analyze roadside-encroachment-accident reports to determine if roadside vegetation is contributing to accident rates. If a tree is removed, replace with shrubs or groundcovers according to the ratios found in the [Roadside Policy Manual](#).

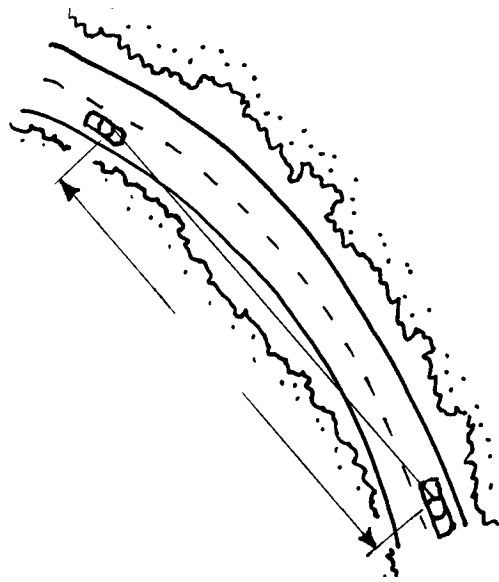
A deviation is required anywhere that a Design Clear Zone is not provided, or the driver is not protected from hazards.

**310.05(2) Sight Distance**

The sight distance is the length of highway visible to the driver (see [Exhibit 310-2](#)).

The decision sight distance is the sight distance required for a driver to (1) detect an unexpected or difficult-to-perceive information source or hazard, (2) interpret the information, (3) recognize the hazard, (4) select an appropriate maneuver, and (5) complete the maneuver safely and efficiently.

It is essential that the driver of a vehicle be able to see far enough to assess developing situations and take appropriate action. Roadside landforms, signs, structures, and vegetation must be designed, installed, and maintained to facilitate safe driving.

**Exhibit 310-2 Sight distance primary considerations****310.05(2)(a) Primary Considerations**

- Allow for adequate sight distance at intersections and at vertical and horizontal curves when designing landforms, and locating signs, vegetation, and other roadside objects. (See the [Design Manual](#) for details.)
- Within sight distance on the inside of horizontal curves or at intersection approaches, select low-growing vegetation that, at maturity, will not obstruct signs or hazards from the view of the driver.
- Maintain vegetation growth in a desirable condition so that signs are not obscured.
- [RCW 47.32.130](#) provides for the removal of vegetation outside WSDOT right of way to increase roadway safety.

**310.05(3) Traffic Barriers**

A traffic barrier is any type of longitudinal barrier, including bridge rails, guardrails, earthen berms, or impact attenuators used to redirect vehicles from hazards located within the Design Clear Zone; to prevent median crossovers; to prevent errant vehicles from going over the side of a bridge structure; or to protect workers, pedestrians, or bicyclists from vehicular traffic. (See the [Design Manual](#) for details on their use and placement.)

**310.05(3)(a) Considerations**

There are barrier designs that visually fit into their surroundings. They can be used in sensitive areas, examples are: steel-backed timber rail, weathering steel or coated w-beam, simulated stone concrete barrier, etc. Contact the HQ Design Roadside Safety office for details.

Use these barriers to maintain corridor continuity or where they enhance the existing roadside character, as determined in the [Roadside Policy Manual](#), and where they are evident in, and similar to the adjacent surroundings.

**310.05(4) Fire Control**

The goal of roadside fire control is to reduce potential fire hazards. One of the objectives of Roadside Management Zone 1 is fire prevention. Grasses native to Eastern Washington with a blue-grey color are generally fire-resistant. Species include: Bluebunch wheatgrass, Sandberg bluegrass, Bottlebrush squirreltail, Common yarrow, Lewis blue flax, Prairie junegrass, and Sand dropseed.

**310.05(5) Primary Consideration**

Do not block access to fire hydrants when the hydrant is located in the right of way. This is a consideration when locating noise walls or thick hedges.

**310.05(6) Roadway Shading**

Forested areas are cooler in summer and warmer in winter due to the insulating effect of masses of trees. Removal of vegetation can result in problems with sunlight and headlight glare. Analyze the cause of shading to avoid removing trees unnecessarily. Appendix C shows the relationship of sun angle and vegetation to roadway shading.

- Too much shading might result in frost, snow, and ice remaining on the roadways, prolonging hazardous driving conditions. However, removing too much vegetation from the roadsides can create a sterile and barren appearance and increase solar glare. If it is determined that removing trees will increase solar exposure, re-vegetate the affected area with lower growing vegetation in conformance with the [Roadside Policy Manual](#). Wherever practical, locate structures and trees to limit shading on the road surface during early morning and late evening hours.

**310.06(a) Primary Considerations**

Consider the following:

- Analyze shading elements before the removal of trees and vegetation to determine if that action is warranted. Removal of vegetation will not increase solar exposure if a land form or structure will still be blocking sunlight.
- Accident history is available for any given location.
  - Use accident history to evaluate whether icing has contributed to accidents in a particular location.
  - Use accident history information to evaluate if shading by the vegetation is contributing to accident rates.
- Talk to maintenance personnel to determine where icing historically occurs.
- Deciduous trees that lose their leaves in winter can be used where solar exposure is desired. Planting evergreens to the north of the roadway will generally block wind without obstructing sunlight.

**310.05(7) Sunlight and headlight glare**

Glare caused by the low angle of the sun in winter, or during the early or late hours of the day can be a serious problem to the motorist. Glare from oncoming headlights can also be a problem.

**310.05(7)(a) Primary Considerations**

Locate roadside features to screen reflective objects where practical.

- Glare can be blocked with vegetation, glare screens, berms, walls, etc.
- Vegetation in medians can reduce headlight glare.
- Bright lights from land uses, such as adjacent industrial complexes, can be screened by walls or evergreen trees and shrubs.

Tunnel entrances present a particularly difficult situation where the driver's eye must adjust from the bright glare outside the tunnel to lower light levels inside the tunnel. Upon leaving the tunnel, the driver's eye must readjust from the lower light levels inside the tunnel to the bright glare outside. Each of these situations can present hazardous driving conditions for the driver.

Glare at a tunnel entrance can be mitigated with dark evergreen vegetation that helps the driver's eye transition to the lower light levels in the tunnel.

**310.06 Worker and Pedestrian Safety****310.06(1) Maintenance Crew Safety**

Maintenance access is especially critical in high traffic volume areas.

**310.06(1)(a) Primary Considerations**

- Follow the [Safety Procedures and Guidelines Manual](#) for traffic control. (See possible traffic control plans under the [Standard Plans](#).)
- During the planning and design phases of roadway construction, allow for the widest practical shoulder width near fixed service points. (See the [Design Manual](#), Division 12, for shoulder width requirements.)
- Provide for maintenance vehicle access where shoulder area is limited by providing maintenance pull-offs in a nearby location.
- When other options do not exist, design fall-protection fencing or harness tie off points where crews are able to secure themselves while working in areas with vertical elevation changes of 4 feet or more. [WAC 296-880](#) provides requirements for "Fall Restraint and Fall Arrest." The Washington State Department of Labor and Industries enforces this WAC.

**310.06(1)(b) Recommendations**

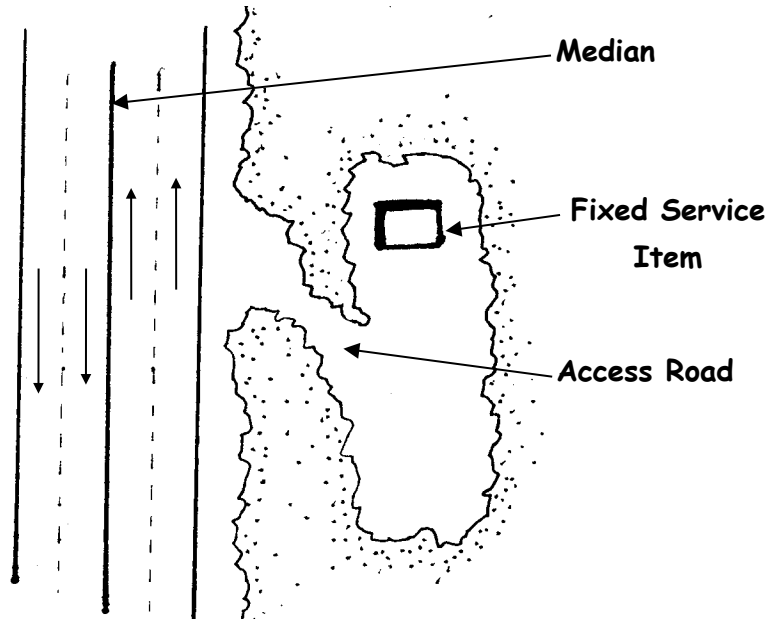
Coordinate with the regional Traffic Engineer.

When incorporated into designs, where practical, the following recommendations will enhance worker safety:

- Provide Maintenance pull-off areas or wide shoulders (minimum 12 feet) adjacent to a device or item requiring regular service. Near utility poles, sign bridges, pull-boxes, and junction boxes (fixed service points), the ideal shoulder width is 20 feet.

- o **Note:** Design these maintenance pull-off areas to support vehicles with a wide-stance and outriggers (Sign Trucks, aerial manlifts, portable VMS trailers). Balance this cost against the future cost of extensive lane and traffic control, the hazard of road crew exposure to traffic, and restriction of traffic flow.
- o Fill material for these shoulders must be flat, located above the Ordinary High Water Level of nearby surface waters, and be firm enough to support the weight of a 41,000 GVW maintenance vehicle. The footprint of these vehicles is 35 feet long by 12 feet wide.
- Place junction boxes, vaults, and other fixed service points on the right side of the roadway (rather than in median strips) as much as practical, with as much parking and re-entry area as practical.
- When fixed service points such as transmitters, cabinets, camera poles and sediment ponds are more than 24 feet from the roadway edge, provide an access support road capable of supporting large (17.5 ton) service vehicles. The configuration in Exhibit 310-3 is not as noticeable to passing motorists.
- When long stretches, 2,500 feet or more, of guardrail are used in areas with limited shoulder, provide a maintenance parking area adjacent to either end, where practical.

**Exhibit 310-3 Possible maintenance access road configuration**



### 310.06(2) Security

To minimize security problems at pedestrian areas (trails, safety rest areas, and viewpoints), it is essential to provide clear visibility into the facility from adjacent areas, and within the facility itself.

**310.06(2)(a) Primary Considerations**

- Locate buildings and other structures to provide the maximum practical visibility from other areas.
- At Safety Rest Areas, locate “Free Coffee” shelters to provide visibility to the largest area possible.
- Locate auxiliary structures (local information boards, panels, etc.) to allow maximum visibility of site.
- Where practical, install lighting and Emergency (911) cellular phone linkages to discourage vandalism, theft, and person-to-person crimes.

The following are general recommendations for areas where security concerns regarding vegetation are present. These actions have been used successfully in a number of areas to alleviate security concerns while minimizing impacts on existing vegetation. These actions are only applicable to an existing security concern, and are not intended as a standard treatment for every roadside or pedestrian area!

- Analyze the area to determine the security concern source and extent. Tailor all actions to preserve as much vegetation as possible while alleviating the security concern.
- Complete removal of all vegetation (clearing) is not an acceptable method of alleviating every security concern.

Where vegetation is reducing desired visibility, consider the following actions:

- Limb branches of large evergreen trees (Western Red Cedar, Douglas fir, etc.) to approximately 10 feet above ground level. Since branches of these trees tend to droop down, prune off the ends of branches that hang lower than 6 feet above ground level.
- Prune smaller deciduous trees to encourage an open habit with leaves above a 6-foot elevation (Hazelnut, Serviceberry, Vine Maple, etc.). Remove only branches that are within the direct line of vision.
- Trim shrubs and groundcover to 2 feet in height and do not allow them to grow higher than 3 feet in height (Salal, Snowberry, Nootka Rose, etc.).
- Limit the use of shrubs in areas directly adjacent to paths, parking areas, and remote picnic sites. Use groundcover plants instead.

Consult with the region’s Landscape Architecture Office or the HQ Roadside and Site Development Section for site and species specific pruning methods.



- 320.01 General
- 320.02 References
- 320.03 Resources
- 320.04 Primary Considerations

## 320.01 General

It is essential that the driver of a vehicle be able to gather information in time to make careful decisions. Roadside signs and adjacent vegetation must be designed, located and maintained to facilitate safe driving. WSDOT does not remove or trim vegetation to increase visibility of signs that are physically located outside of the right of way.

Signs both on and off the right of way are strictly regulated by an array of statutes and regulations to assure that motorists receive proper warning, guidance, and services information while maintaining the integrity of the roadside environment.

## 320.02 References

### 320.02(1) Design Guidance

[\*Design Manual\*](#), M 22-01, WSDOT

[\*Motorist Information Sign Program\*](#), WSDOT

[\*Highway Advertising Control Program\*](#), WSDOT

[\*Roadside Policy Manual\*](#), M 3110, WSDOT

*Scenic Byway Logo Signing Guidelines*, M 3001, WSDOT

[\*Traffic Manual\*](#), M 51-02, WSDOT

## 320.03 Resources

Regions' and HQ Traffic Office

Headquarters (HQ) Design Office

Regional and HQ Real Estate Services Offices

Maintenance Offices

For gateway signing, refer to the Roadside Policy Manual, and Design Manual, Chapter 950, for signs that exceed the allowable limit found in the Traffic Manual.

### 320.04 Primary Considerations

- Consult signing specialists and outdoor advertising representatives in the region's and HQ Traffic Office about signing related procedures and issues.
- Establishing access control can affect legally permitted outdoor advertising signs located on adjacent private property. The region's and HQ Real Estate Services offices are responsible for compensation procedures.
- Integrate sign locations with existing and proposed conditions.
  - Consider existing vegetation when placing signs.
  - Coordinate sign location with the region's Traffic Engineer.
- Coordinate new plantings with the region's Landscape Architect.

To decide whether a sign is needed, given a certain set of roadway and traffic conditions, the engineer must rely on judgment and consistent criteria that is based on:

- An understanding of the road user's information needs and how road users acquire information.
- A vision of traffic control, wherein individual traffic signs are viewed as part of a larger system of signs, signals and markings that provide clear and timely information to the road user.
- Accepted procedures and devices resulting from traffic control engineering studies.

### 400.01 General

#### 400.01 General

Environmental functions include water quality preservation, protection and improvement; stormwater detention and retention; wetland and sensitive area protection; noxious weed control; noise control; habitat protection; habitat connectivity; air quality improvement; and erosion control.

Environmental functions are inseparable from operational, visual and auxiliary functions. For example, a central median can provide visual screening from oncoming traffic, reduce headlight glare to improve safety, provide habitat for certain wildlife, and provide a location for stormwater collection.

Information previously found in the Roadside Manual chapters 410 through 460 is now found through the [Environmental Services Office](#) webpages and the [Environmental Manual](#). Those chapters have been removed from this manual.

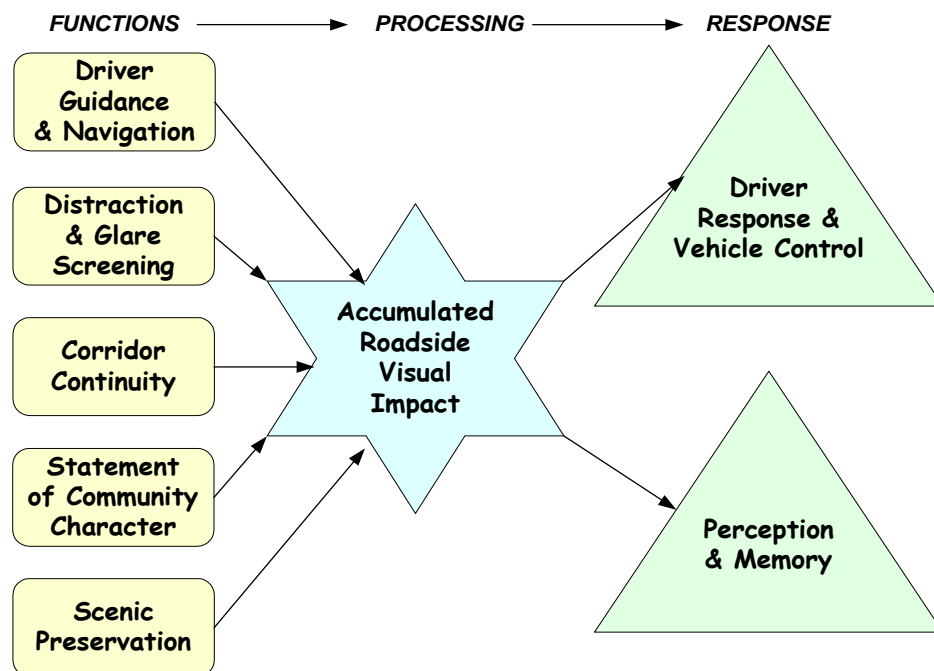


## General

Roadside visual functions are those roadside features that are primarily perceived or experienced through sight. Primary visual functions include:

- Driver guidance and navigation
- Distraction and glare screening
- Corridor continuity
- Reinforcing community character
- Scenic preservation

The driver uses visual information from the roadside environment to assist in controlling, guiding, and navigating the vehicle as shown in [Figure 500.1](#). The driver and passengers also form impressions and memories from what is seen along the roadside, thus roadsides are important in establishing community and state identity.



**Figure 500.1 Input & Output Model for Roadside Visual Functions**

The driver can only absorb and process a limited amount of visual information at a time. Excessive visual stimulation and complexity

can distract the driver and decrease driver control. Conversely, monotony from lack of visual interest can decrease driver attention and thus diminish control.<sup>1</sup> Difficulties with perception, attention, and distraction are a primary cause in over forty percent of traffic accidents.<sup>2</sup>

Visual stimuli are translated into driver responses. The sequence of visual events leading to an appropriate decision must be organized to meet this objective. Highway alignment, roadway geometrics, landform configurations, vegetation, and structures all contribute to driver guidance.

Visual functions are inseparable from other roadside functions. Operational functions such as sight distance, headlight screening, signing, and sunlight glare mitigation can also be considered visual functions. The retention of native vegetation and habitat, an environmental function, also has a visual impact on motorists.

## Resources

The region's Landscape Architects

Maintenance & Operations Programs Landscape Architect

HQ Scenic Byway Coordinator within Highways & Local Programs

HQ Design Office Roadside and Site Development Unit

## References

*Roadside Classification Plan* (M 25-31), WSDOT

G. J. Alexander and H. Lunenfeld, *Positive Guidance In Traffic Control*, FHWA, Washington, D. C., April 1975.

G. J. Alexander and H. Lunenfeld, *Driver Expectancy In Highway Design and Traffic Operations*, USDOT Final Report FHWA-TO-86-1, FHWA, Washington, D. C., 1986.

Peter L. Hornbeck and Garland A. Okerlund, Jr., *Visual Values for the Highway User*, FHWA, Washington, D. C. (undated).

T. J. Post, G. J. Alexander, and H. Lunenfeld, *A User's Guide To Positive Guidance* (2<sup>nd</sup> edition), Report FHWA-TO-81, FHWA, Washington, D. C., 1981.

Sally Schauman, et al., *Visual Perception of the Roadway and Roadside Elements by the Observer in Motion*, Washington State

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<sup>1</sup> A. Wertheim, 1978, "Explaining Highway Hypnosis." *Accident Analysis and Prevention*, 10:111-129.  
G.W. Williams, 1963, "Highway Hypnosis," *International Journal of Clinical and Experimental Hypnosis*, 103: 143-151.

<sup>2</sup> Transportation Research Board, 1993

Transportation Center, WA-RD 283-1, TRAC/WSDOT, Seattle, Washington, December 1992.

Transportation Research Board (TRB), *Human Factors Research In Highway Safety*, National Research Council, Circular 414, Washington, D. C., September 1993.

## Definitions

**aesthetics** Evaluations and considerations with the sensory quality of resources (sight, sound, smell, taste, and touch) and especially with respect to judgment about their pleasurable qualities.<sup>3</sup>

**cognition** The mental process or function by which knowledge is acquired.

**coherence** Quality of state of being united in principles and relationships or to be logically and aesthetically connected.

**complexity** The multiple qualities in a landscape that provide visual interest such as the combination of form, color, and texture.

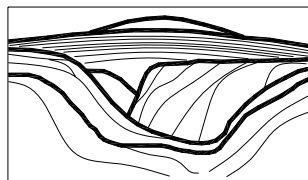
**control** The driver's ability to safely drive the vehicle.

**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.

**feature** A visually distinct or outstanding part, quality, or characteristic of a landscape.

**form** The mass or shape of an object. Usually considered to be three dimensional. In the figure below, the forms of the mountain, hills and valley are shown.



**Figure 500.2 Forms in the Landscape**

**landscape** An area composed of interacting ecosystems that are repeated because of geology, land form, soils, climate, biota, and

<sup>3</sup> U. S. Department of the Interior, Bureau of Land Management. BLM Manual: visual resource management, Washington D. C. 1977.

human influences throughout the area. Landscapes are generally of a size, shape, and pattern that is determined by interacting ecosystems.<sup>4</sup>

**navigation** Trip planning and execution.

**view** Something that is looked toward or kept in sight, especially a broad landscape or panorama. Act of looking toward an object or scene. The figure below shows views from the roadway toward the forest along the roadside.

**vista** A confined view, especially one seen through a long passage, as between rows of trees or down a canyon. A vista often focuses upon a specific feature in the landscape.

## Policy

### **23 USC 1310A** “Control of Outdoor Advertising”

The Congress hereby finds and declares that the erection and maintenance of outdoor advertising signs, displays, and devices in areas adjacent to the Interstate System and the primary system should be controlled in order to protect the public investment in such highways, to promote the safety and recreational value of public travel, and to preserve natural beauty

**23 CFR 750** “Highway Beautification Act” of 1965 and all amendments.

This federal policy prohibits the clearing of vegetation along Interstate highways for viewing of commercial establishments.

**RCW 47.32.130** Gives WSDOT the authority to remove objects and structures on, or in proximity to the right of way that pose an immediate threat to roadway safety.

**RCW 47.38** Roadside Areas -- Safety Rest Areas

**RCW 47.39 and amendments.** Scenic and Recreational Highway Act of 1967.

**RCW 47.42** “Highway Advertising Control and Scenic Vistas Act” Controls advertising signs along state highways.

*Roadside Classification Plan* M 25-31, WSDOT

## Planning

Fulfill the visual functions in accordance with the *Roadside Classification Plan* for achieving corridor continuity, blending, and buffering with adjacent land uses. The following measures will aid in achieving this goal.

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<sup>4</sup> U. S. F. S., December 1995.



- Provide adequate right of way to meet the requirements of the *Roadside Classification Plan* including acquisition of additional land for the following purposes:
  - Blending
  - Buffering
  - Screening
  - Environmental obligations
- Allow for generous medians and wide right of way buffer widths when acquiring land for state highways and state highway projects.
- Increase normal right of way widths to protect desirable views and vistas or to provide for visual screening.
- Consult the Corridor Plans along Scenic Byways or Heritage Tour Routes that reflect community preferences for treatment of the roadside and provide guidance for visual quality along roadway segments.
- Coordinate with the Heritage Corridors Program Office and the regional Planning Office to obtain current Corridor Plans on designated routes.
- Work with local communities to enhance community character.
- Consider partnership agreements with adjacent property owners to reduce maintenance impacts while ensuring adherence with the *Roadside Classification Plan*.

### ***Public Involvement***

Public involvement in WSDOT roadside activities is conducted in a manner that is consistent with the process established for roadways in general. (See WSDOT *Design Manual* chapter on “Public Involvement and Hearings.”) It is the department’s goal that decisions be made in the best overall public interest and that other agencies and the public be involved early enough to influence project decisions.

WSDOT also conducts public meetings to get public responses to proposed transportation projects using visual simulations. In addition, WSDOT (partnering with universities) conducts visual preference research to assess drivers’ and community’s values and perceptions for roadside view alternatives.<sup>5</sup>

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<sup>5</sup> Schauman, et al., 1992, 1996

# Design

## *Physical Features*

### **Expectancy and Driver Response**

Driver expectations are an important basis for the design of safe roadways. Roadside features can create patterns that can provide the driver with clues to what lies ahead. The visual environment can be enhanced to reinforce accurate expectations about what driving responses are necessary.

An effective highway design is based on predictability and coherence in the visual environment (corridor continuity). It anticipates driver expectations and surprise factors, and gives the driver sufficient visual information to accurately predict upcoming roadway conditions. This information forewarns drivers and helps them avoid accidents. Land use, sight distance, terrain, corridor continuity, screening distractions, and reinforcing visual features give the driver clues about the road ahead.

“Positive Guidance” is a process that uses engineering tools to optimize the highway system in order to improve traffic operations and safety at hazardous locations. When this procedure is applied, the roadside features are an integral part of a Positive Guidance design of a highway information system.

### **Distraction**

Drivers might have difficulty seeing and selecting relevant visual information within complex visual scenes. When there is too much visual information (“clutter”), drivers can be distracted and safety can be impaired.

Drivers can make poor decisions when they are distracted. All aspects of the visible environment contribute to information overload and distraction. Special attention is required to keep highway directional signs to a minimum, and to locate them in such a way as to avoid distracting the driver.

Research on advertising signs within view of the roadway suggests that novel, sensuous, or moving displays are likely to distract the driver’s attention. Minimize these distractions through roadside screening or negotiations with responsible parties. When this fails, WSDOT has the authority to remove object and structures outside the right of way that pose an immediate threat to motorists and roadway safety ([RCW 47.32.130](#)). Such action may especially be warranted where accident data verifies that such object or structure does indeed pose a safety hazard.

## Recommendations

Design in such a way as to:

- Send a clear message.
- Minimize visual distractions.
- Design roadsides so they are sustainable, given expected service level and funding.
- Define the roadway through appropriate roadside treatments (landform, vegetation, wall treatment, and so forth) to enhance guidance characteristics.
- Provide for screening of distractions with berms and vegetation.
- Avoid unnecessary tree removal next to commercial and industrially zoned areas.
- When designing for roadside treatment, consider the existing treatment or character of the adjacent road segment to provide for corridor continuity.

### ***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 associate and derive impressions about communities by what they see along the roadside. The roadside *can* be a community amenity. The preservation of visual quality strongly supports the economic interests of the state through the tourism industry. WSDOT will endeavor to support a community's effort to enhance their entrance as outlined in the [\*Roadside Classification Plan\*](#).

The presence of natural features and the perception of a clean, healthy natural environment have often been linked with positive visual preference.<sup>6</sup> Among scenic roadway users, natural features (lakes, rivers, mountains, hills, natural vegetation, long distance views) are most highly valued.<sup>7</sup> Structures and activities having a negative impact on the natural quality of the landscape are regarded with suspicion, and commercial establishments, signs, and multifamily housing are generally viewed as detractors to visual quality. Research on the extent of agreement among observers of

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<sup>6</sup> Kaplan and Kaplan, 1982, 1989 and Kaplan, 1995.

<sup>7</sup> Kent, 1993.

environmental attractiveness found that natural and rural environments are preferred over urban and semiurban environments.<sup>8</sup> However, the public, generally values visual features that fit the locality and contribute to a sense of place. Cultural landscapes are generally most valued by the people who live nearby.<sup>9</sup>

## Directed Attention Fatigue

People use directed attention to work in distracting surroundings and make decisions in complex situations, such as driving on heavily traveled roads. The visual environment can aggravate or alleviate directed attention fatigue. Extended, unrelieved periods of directed attention can diminish the capacity to analyze, plan, and make decisions resulting in irritability and taking unnecessary risks. Visual access to natural environments is one of the key elements in counteracting directed attention fatigue through restorative experiences.<sup>10</sup> There is increasing evidence<sup>11</sup> to suggest that natural and naturalized roadsides might diminish or alleviate directed attention fatigue in the roadway user. Therefore, careful planning and design of corridor views for scenic vistas and aesthetically pleasing roadside treatment can be important for improving roadway safety.

## Recommendations

- Consider viewer perceptions when designing and maintaining roadside areas.
- Provide for opening up desirable views by planting or encouraging low growing vegetation.
- Consider berms and vegetation to screen undesirable views where right of way widths and corridor continuity allow.
- Consider working with community partners to provide community gateways that enhance roadside character in keeping with the [\*Roadside Classification Plan\*](#).

## Maintenance

Maintenance activities affect roadside visual quality. When there are extensive visual impacts from a maintenance activity, such as removal of significant vegetation, public involvement is recommended. The Corridor Plan can be used for guidance.

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<sup>8</sup> Coughlin and Goldstein, 1970. and Ulrich, 1981, 1986.

<sup>9</sup> Melnick, 1983.

<sup>10</sup> Kaplan, 1995.

<sup>11</sup> Parsons, et al., 1998.

- Identify opportunities to partner with adjacent land owners to preserve or reveal desirable views and roadside segments that enhance or maintain corridor continuity. (It is not WSDOT policy to remove vegetation to open up views toward commercial properties.) Balance desirable visual functions with the needs of roadway users and adjacent landowners.
  - Coordinate with the regional Landscape Architect, or the HQ Design Office Landscape Architect in regions without a Landscape Architect.
  - On Scenic Byways coordinate with the Heritage Corridors Program Office.
- Enhance or retain vegetation to screen undesirable views and to meet the requirements of the *Roadside Classification Plan* (corridor continuity, blending with, and buffering adjacent land uses).
- Maintain low growing vegetation or limb up trees to retain desirable views.
- Carefully consider actions before removing vegetation to open up views. Consider whether development adjacent to the highway is likely to eliminate the view after removing vegetation. Analyze the angle of view from the driver's perspective and minimize removal of vegetation to meet the view objective. Consider selective removal of tree limbs or removal of only the limbs on the lower one third of the tree to reveal desirable views.
- Consider the Corridor Plan as a basis for determining the Maintenance Plan and funding service levels for a given highway corridor.

## Additional Sources of Information

Robert E. Coughlin and Karen A. Goldstein, *The Extent Of Agreement Among Observers On Environmental Attractiveness*, Regional Science Research Institute discussion paper #37, Philadelphia, PA, February 1970.

C.W. Hamilton, R. Bell, D. Giblin, K. Wolf, and K. Ewing, *Planting for Sustainable Roadsides: Empirical and Experimental Studies and Recommendations for Western Washington*. Technical Research Report WA-RD 439.1. Olympia, Washington: Washington State Department of Transportation, 1998. Chapter Four: Landscape Perception and Roadside Design Guidelines.

R. Kaplan and S. Kaplan, *The Experience Of Nature: A Psychological Perspective*, Cambridge University Press, Cambridge and New York, 1989.

R. Kaplan and S. Kaplan, *Cognition And Environment: Functioning In An Uncertain World*, Praeger Publishers, New York, 1982.

Stephen Kaplan, "The Urban Forest As A Source Of Psychological Well-Being," *Urban Forest Landscape*, Gordon A. Bradley, ed., University of Washington Press, Seattle and London, 1995, pp. 100-108.

Richard L. Kent, "Attributes, Features, And Reasons For Enjoyment Of Scenic Routes: A Comparison Of Experts, Residents, And Citizens," *Landscape Research* 18(2) 1993 92-102, 1993.

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[http://www.herl.uiuc.edu/IMAGES/scientific\\_article\\_VV.pdf](http://www.herl.uiuc.edu/IMAGES/scientific_article_VV.pdf)

R. Z. Melnick, "Protecting Rural Cultural Landscapes: Finding Value In The Countryside," *Landscape Journal* 2:85-96, 1983.

P. A. Miller, "Scenic Value In The Urbanizing Landscape," *Urban Forest Landscape*, Gordon A. Bradley, ed., University of Washington Press, Seattle and London, 1995, pp. 111-127.

R. Parsons, Tassinary, L. G., Ulrich, R. S., Hebl, M. R., and M. M. Grossman, "The View From The Road: Implications For Stress Recovery And Immunization," *Journal of Environmental Psychology*, November 1998.

Carla B. Rabinowitz and Robert E. Coughlin, "Analysis Of Landscape Characteristics Relevant To Preference," Regional Science Research Institute discussion paper # 38, Philadelphia, PA, March 1970.

Andrea Faber Taylor, Frances E. Kuo, and William C. Sullivan. "Views of Nature and Self-Discipline: Evidence From Inner City Children." *Journal of Environmental Psychology*. 2001 21.  
[http://www.herl.uiuc.edu/IMAGES/scientific\\_article\\_GG.pdf](http://www.herl.uiuc.edu/IMAGES/scientific_article_GG.pdf) Robert Ulrich, "Human Responses to Vegetation and Landscapes," *Landscape and Urban Planning* 13, 1986 pp. 29-44.

--- "Natural Versus Urban Scenes: Some Psychophysiological Effects," *Environment and Behavior*, 13.5, 1981, pp. 523-56.

--- "Scenery in the Travel Route," in *Experience of Nature*, Rachel and Steven Kaplan, eds., 1974.

K. Wolf, *The View From the Road*, Seattle, WA, 1998.  
<http://www.cfr.washington.edu/research.envmind/>

**General**

Auxiliary functions are those functions that serve additional operational, environmental, and visual functions for a complete transportation system. Examples of auxiliary functions are community enhancement areas, safety rest areas, farming of roadsides, and quarries and pit sites.

Auxiliary functions enhance driver and passenger safety, comfort, and mobility, or are related to roadway maintenance.





## **Chapter 610      Safety Rest Areas & Traveler Services**

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The safety rest area and traveler services information is now located in the *Design Manual*, Chapter 1710:

🔗 [www.wsdot.wa.gov/publications/manuals/fulltext/M22-01/1710.pdf](http://www.wsdot.wa.gov/publications/manuals/fulltext/M22-01/1710.pdf)



The universal access information is now located in the *Design Manual*, Chapter 1510:

 [www.wsdot.wa.gov/publications/manuals/fulltext/M22-01/1510.pdf](http://www.wsdot.wa.gov/publications/manuals/fulltext/M22-01/1510.pdf)



## General

Parking areas are an important component of many transportation facilities such as safety rest areas, park and ride lots, and viewpoints. The parking area is often the first thing users see upon entering the facility, creating an important first impression.

The optimum design for a parking area is not necessarily one that provides the maximum number of parking spaces. It is one that provides safe pedestrian and vehicular circulation, with ample stall and aisle widths, adequate turning radii, reasonable gradients, a pleasing appearance, visual access for law enforcement surveillance, provisions for handling and treating stormwater runoff, fits the site, is easy to maintain, and is in close proximity to the facility it serves. These elements illustrate the complexity of issues that must be addressed in parking area design.

Studies show that the use of shaded parking in hot weather can reduce noxious emissions by up to a ton a day for a municipality. The use of porous pavements for overflow parking areas can decrease the size of stormwater facilities needed.

Parking facilities must conform to local (city or county) regulations and zoning codes in addition to the guidelines outlined in this chapter.

## References

*Design Manual*, WSDOT, M 22-01

*Roadside Manual*, WSDOT, M 25-30, Chapter 620 “Universal Access.”

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

*Accessibility Design for All: An Illustrated Handbook*, Washington State Regulations ([WAC 51-40](#)), by Barbara L. Allan and Frank C. Moffett, Olympia, Washington: A.I.A. Washington Council, 1998. Provides dimensions and slopes for accessibility in the state of Washington.

*Guide for the Design of High Occupancy Vehicle and Public Transfer Facilities*. AASHTO, 1983

*Manual of Uniform Traffic Control Devices (MUTCD)* for pavement markings and signing at <http://mutcd.fhwa.dot.gov/>

## Resources

The region's Landscape Architect

Headquarters Roadside and Site Development Unit

Region or Environmental Affairs Office Water Quality Unit

The region's Hydraulics Engineer or the HQ Hydraulics Office

The region's Traffic Engineer, for signage, illumination, and traffic data.

## Definitions

***context sensitive design*** A collaborative, interdisciplinary approach that involves all stakeholders to develop a transportation facility that fits its physical setting and preserves scenic, aesthetic, historic, and environmental resources, while maintaining safety and mobility. Context Sensitive Design is an approach that considers the total context within which a transportation improvement project will exist.<sup>1</sup>

***facility*** All or any portion of buildings, structures, vehicles, equipment, roads, walks, parking lots, or other real or personal property or interest in such property.<sup>2</sup>

## Planning

- When choosing locations for parking facilities consider impacts the facility will have on existing desirable vegetation, topography, and adjacent neighbors. For example if there are large trees, how can parking be sited to preserve these trees? How can the site design minimize grading?
- Encourage design and placement of facilities to provide for safety and access to services by many different types of transportation, such as car, bicycle, or pedestrian travel.
- Use context sensitive design principles in planning and funding of projects. See <http://www.fhwa.dot.gov/csd/index.htm> for more information on context sensitive design.
- Location of the parking facility in relation to the facility it serves should be carefully considered. Parking areas should not be the dominant visual element of the facility. Rather, the parking area design should direct the viewer to the main point of entry or attention.

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<sup>1</sup> U.S. Department of Transportation, Federal Highway Administration. <http://www.fhwa.dot.gov/csd/>

<sup>2</sup> Subpart A, 49 CFR Part 27.

## Design

- Adjust design to comply with local regulations and requirements.
- Design aisles and breaks in planting strips to provide for easy maintenance. Aisles should be wide enough to allow access by street sweepers. High points in corner areas will allow water to drain away from these locations so they do not collect water and leaves. Refer to planting area design later in this chapter for additional design considerations.
- Ensure environmental quality by addressing air, drinking water and noise concerns, watershed restoration, and preservation of habitats and public green spaces.
- Use transportation facilities to enhance community aesthetics by incorporating unique local features (scenic views, community neighborhoods, historic districts, cultural and natural resources, etc.) and providing focal points for communities through those facilities such as multimodal stations, pedestrian plazas, and parkways.

### ***Pedestrian Safety***

#### ***Security***

Users of a facility should feel safe and not feel imprisoned or threatened. For example lighting, security cameras, emergency telephones, and appropriate vendors are preferable to fences and on-site security. Frequent removal of graffiti, broken glass, and trash is important when providing an environment that feels safe and secure to the user.<sup>3</sup> The perception of safety is as important as its reality.

In planting areas near conflicting traffic movement, such as backing vehicles or opposing traffic, select shrubs and groundcovers that grow no higher than 2 feet and keep trees limbed up to 8 feet above ground level to provide clear sight lines for safe traffic movement.<sup>4</sup>

Clear lines of vision are important so that police can provide surveillance within the site and surveillance from the street. Lighting is an important component in pedestrian and vehicle security and safety.

#### ***Sidewalks***

Provide sidewalks near bus transfer areas or a scenic viewpoint with a minimum width of 10 feet. Provide 10 square feet per person for each user expected to be at the focal point at any one time:

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<sup>3</sup> Robert J. Spillar, P.E., *Park-and-Ride Planning and Design Guidelines*. New York: Parsons Brinckerhoff Inc. 1997.

<sup>4</sup> *Design Manual*, Chapter 1025.07(2d).

Compare the density above with the following: Disneyland on a crowded summer day has a density of approximately 15 square feet per person. A crowded theater lobby has a density of approximately 5 square feet per person.<sup>5</sup>

Design slopes across access driveways so that cross slopes do not exceed 2 percent. This will allow safe crossing for people in wheelchairs or using strollers or walkers.

### **Accessibility**

All pedestrian facilities must be designed to meet standards set by the Americans with Disabilities Act. See [Chapter 620](#) of this manual for these guidelines. Accessible parking spaces must be located nearest to the destination point, such as a rest room or bus stop. The number of accessible parking spaces shall be provided according to [Figure 630.1](#)<sup>6</sup>:

<b>Total Number of Spaces in Lot or Garage</b>	<b>Minimum Number of Accessible Spaces</b>
1-25	1
26-50	2
51-75	3
76-100	4
101-150	5
150-200	6
201-300	7
301-400	8
401-500	9
501-999	2% of total spaces
Over 1000	20 spaces, plus 1 space for every 100 spaces, or fraction thereof, over 1000 <sup>7</sup>

**Figure 630.1 Ratio of handicap parking stalls to total stall numbers.**

<sup>5</sup> Abbaté, Mike. "Pedestrian Density:" GreenWorks, PC \* Landscape Architecture \* Environmental Design.

<sup>6</sup> Accessible Design For All, Appendix A, p. 23. [WAC 51-40-1103](#).

<sup>7</sup> Accessibility Design for All. Appendix A, p. 33.



Accessible Parking Space Dimensions					
Cars			Vans		
Stall Width	Access Ramp	Slope	Stall Width	Access Ramp	Slope
8 feet	5 feet	2%	11 feet	5 feet	2%

**Figure 630.2 Dimensions for Accessible Parking Spaces**

Two parking stalls can share the same access aisle. These wider spaces allow people to move from the car into a wheelchair or to use van lifts. Because of the need for stability for these maneuvers, slopes in accessible parking areas may not slope more than 1V: 48H (approximately 2%) in any direction.<sup>8</sup> See [Chapter 620](#) of this manual for more information on Universal Access issues.

Detectable warning strips on walking surfaces help to warn visually impaired pedestrians of a hazard. Truncated domes are specified by the Access Board's ADA Accessibility Guidelines. Examples are seen in [Figure 630.3](#) and [630.4](#).

### **Lighting**

- Provide illumination as per the [Design Manual](#) Chapter 840 on Illumination.
- Consider adjacent land uses when designing the illumination plan. Using trees and tall shrubs to screen the parking facility's vehicle activity and lighting from adjoining residential land use can be effective and may be required by county or local code in many locations.
- Pay particular attention to the scale of lighting fixtures in pedestrian areas. Standard heights for roadway lighting are not appropriate for pedestrians.
- Ensure that lighting illuminates pedestrian pathways, not just the roadway.
- Lighting maintenance requires set-up room for the man-lift truck to change lights. Replacement of lights can occur during midday or off peak hours, but must be taken into consideration during the design of the facility.
- Junction boxes and hand-hole access at the poles must be accessible for servicing and not covered with vegetation.

<sup>8</sup> Accessibility Design for All. P 22.

## ***Pedestrian Circulation***

See the *Design Manual*, Chapter 1025 on Pedestrian Design Considerations and the *MUTCD* (<http://mutcd.fhwa.dot.gov>) for pavement markings and signing.

Clear separation of pedestrian and vehicle circulation will increase safety in parking facilities. Once people leave their vehicles, lines of approach to the bus stop or toilets should be obvious. People will take the shortest, most direct route to their destination.

For park and ride lots, aisle lengths should not exceed 400 feet if possible.<sup>9</sup>

Minimize pedestrian crossings in front of moving vehicles. When this is necessary, especially in safety rest areas, provide cues to the drivers before pedestrian crossings. Cues can include items such as:

- signing
- painted crosswalks
- rumble strips in advance of a stopping or slowing condition
- speed bumps
- raised crosswalks
- embedded lights in pavement

Parking areas may require more aggressive delineation than typical roadway applications to indicate pedestrian paths and vehicular channelization. Using planting islands to direct pedestrian and vehicular traffic can be effective.

## ***Vehicular Circulation***

Separate vehicle circulation from pedestrian circulation as much as possible.

In two-way vehicular circulation patterns, minimize left hand turns when entering the lot to minimize traffic delays.

The most desirable direction for internal circulation within the parking area is clockwise. This is because it follows the normal pattern of driving to the right.

Locate the vehicle entrance and exit far from the major pedestrian circulation area. For example, locate the entrances as far from the bus stop as possible.

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<sup>9</sup> AASHTO. *Guide for the Design of High Occupancy Vehicle and Public Transfer Facilities*. 1983. p. 24.

In large multi-aisle parking lots, consider two-lane vehicular cross aisles to facilitate circulation. These cross aisles can be located when each row exceeds 25 stalls.

Allow enough length and slope on driveways to provide access for large vehicles (such as trucks, busses, and motor homes) so that the back bumpers do not drag on curb cuts. See the Road Approaches chapter in the [Design Manual](#).

Circulation within the parking lot should be clearly indicated by planting beds or islands and differences in paving patterns. Excessive use of pavement markings is difficult to maintain.

For small parking lots with uncontrolled or stop-controlled driveway intersections on one-way streets, it is desirable to utilize separate entry and exit points to avoid left-turn conflicts with outbound traffic. The inbound lane can be on one side of the lot and the outbound on the other, or the lanes can be separated by a wide divider.

### ***Transit Movement***

Separate bus loading and unloading areas from auto and pedestrian travel ways.

Provide covered, enclosed areas for pedestrians to wait for buses.

At transit stops truncated domes are required<sup>10</sup> at loading areas. [Figures 630.3](#) and [630.4](#) show views of truncated domes.



**Figure 630.3** Truncated Domes under construction at transit stop

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<sup>10</sup> [Design Manual](#), Chapter 1025 and [Standard Plans](#).



**Figure 630.4** Close-up of truncated domes with pen for scale

The truncated domes are available in several different materials: metal plates, concrete paving tiles, polymer concrete appliqués, or stamped concrete.

## ***Stormwater Treatment and Detention***

### ***Biofiltration Swales***

Integrate vegetated swales into the facility to collect and detain stormwater. These can be designed within planting islands and around the perimeter. These swales also serve as water quality filtration strips and can be an amenity on the site.

Long, linear swales break up the large expanse of pavement, collect stormwater, and allow for tree planting. A minimum width is 10 feet for these planted swales.

Use on-site stormwater drainage to provide water for plants. For example, plant trees on the edges of swales in parking islands. Trees should be spaced a minimum of every 75 feet on center within the parking lot, and aligned with stall lines.



**Figure 630.5 Vegetated bioswale in parking lot**

If curbing is used around swales, regular gaps in the curbing must be provided to allow stormwater runoff to drain into the swale. The elevation of the swale in relation to the pavement should be low enough for water and debris to drain into the swale without continuous maintenance. However, these locations will require periodic maintenance to clear debris build-up.



**Figure 630.6 Curb interruption to facilitate drainage into bioswale**



If curbing is not placed around the swale, stop blocks must be used for each parking space surrounding the swale to prevent vehicles from entering the swale.

Compacted soils resist infiltration of water. Rip soils in planting islands before adding soil amendments and plant materials. These planting islands can require subsurface drainage.



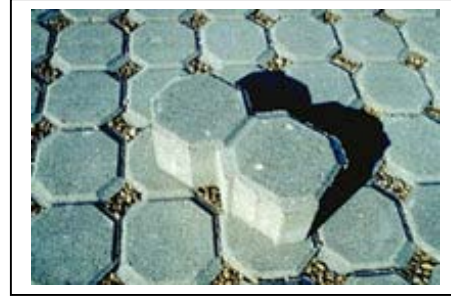
**Figure 630.7 Inlet for subsurface drainage**

### ***Permeable Pavements***



Consider vegetated pervious open grid-type parking stalls to allow infiltration of stormwater. These are most effective for peripheral or overflow parking. Consult with the region, or state Materials, or Hydraulics office to select an appropriate pavement type.

An alternative modular paving system that can support long-term parking is available.



These interlocking paving systems can support truck or bus traffic and full-time use. Consider users of the facility since these surfaces can cause problems for some pedestrians, especially when wearing high-heels.

**Figure 630.8 Permeable Paving Systems**

### **Porous Concrete Pavement**

No-fines porous concrete pavement is an emerging technology in our area that has been used in the eastern United States and in Europe for years. Costs are slightly higher (approximately 25% more) than that of conventional Portland cement concrete pavement. However, because porous concrete pavement infiltrates water at 270 to 450 inches per hour per square foot (3-5 gallons per minute per square foot), stormwater detention facilities are usually not needed to mitigate those surfaces, thereby reducing costs for stormwater mitigation.



**Figure 630.9 Porous concrete sidewalk cross-section, in Olympia**

Porous concrete pavement uses large aggregate and Portland cement with an additive to slow the rate of evaporation of the mix during placement. The thickness of the pavement is greater than conventional concrete to provide structural stability and is laid over an aggregate subbase. Because of the large pore spaces (15 to 25% of the total volume), porous concrete pavement is more resistant to frost heave than conventional concrete pavement. With regular (4 times per year) vacuuming or blowing to remove fine materials that can clog the pore spaces, these systems can continue to infiltrate stormwater and last as long as conventional concrete pavement systems. Higher installation and maintenance costs might be balanced by savings in stormwater storage and treatment costs.

The large pore spaces may cause problems with people in spiked heels, or people with pointed-tip canes. For this reason the use of this system may be more appropriate on outlying areas.

Regional water quality engineers can provide assistance in calculating water storage and infiltration needs with porous concrete systems.

Because these systems infiltrate water at high rates, they are not appropriate where pollutants, such as fluid drips are likely to occur and where ground water tables are close to the surface. See the region water quality engineer for appropriate locations.

Information on pavements can be found at:

<http://www.wsdot.wa.gov/fasc/engineeringpublications/Manuals/Volume1.pdf>

## ***Planting Area Design***

### ***Tree shading for emissions reduction***

While cars sit in the sun, gasoline evaporates from fuel tanks and worn hoses. These evaporated materials are principle components of smog. In 1999, the United States Forest Service and the University of California at Davis completed a pilot study to measure the difference in parking lot microclimate and parked vehicle emissions resulting from the presence or absence of shade tree cover. Results indicate that shade tree cover in parking lots reduces motor-vehicle hydrocarbon and nitrogen oxide emissions from cars parked in those lots.

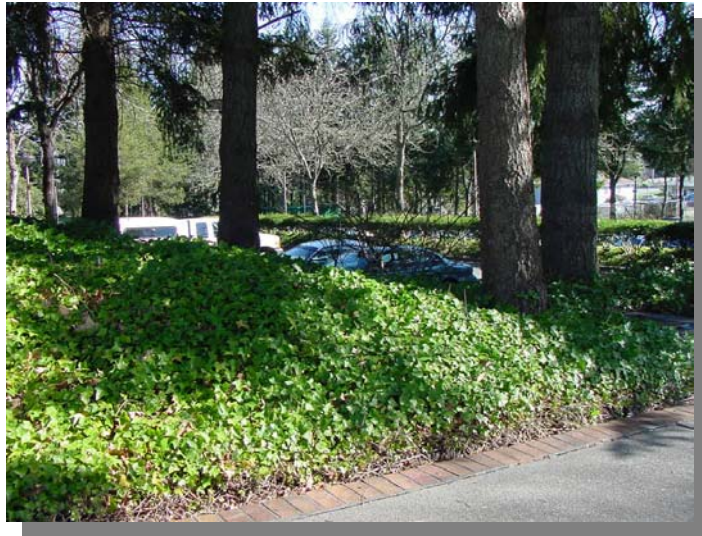
In this study, conducted in Sacramento California, interior vehicle temperatures averaged 45°F cooler in the tree-shaded vehicle when compared with temperatures inside unshaded vehicles. Increasing parking lot canopy cover from 8% to 50% would reduce total vehicle-generated hydrocarbon emissions by two percent and nitrogen oxide emissions by just under 1% in similar climates. In addition, this study noted that there



was a user preference for shaded parking spaces.<sup>11</sup> (Shade also extends the life of asphalt pavement.)

Trees in parking areas provide shade, visually reduce the impact of large pavement areas, and reduce heat gain.

- Use perimeter trees and shrubs to screen the parking area from nearby residential uses, while allowing for visibility by security personnel.



**Figure 630.10 Use of berms and vegetation to screen parking from residential area**

- Design for a minimum of 50% canopy cover over parking areas.
- Select tree species that do not drip pitch or attract aphids.
- Where trees are planted near a bus route, or bus parking, limb up trees to eight (8) feet above the ground.
- Use planting areas to divide paved surfaces into smaller, more defined parking areas.
- Consider end islands to delineate aisles and intersections and to protect the end vehicles. End islands should have raised curbs.

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<sup>11</sup> Klaus I. Scott, James R. Simpson, and E. Gregory McPherson. "Effects of Tree Cover on Parking Lot Microclimate and Vehicle Emissions. *Journal of Arboriculture* 25(3): May 1999, pp. 129-142.  
<http://wcufre.ucdavis.edu/research/air.html>



**Figure 630.11 Raised curbs around end island**

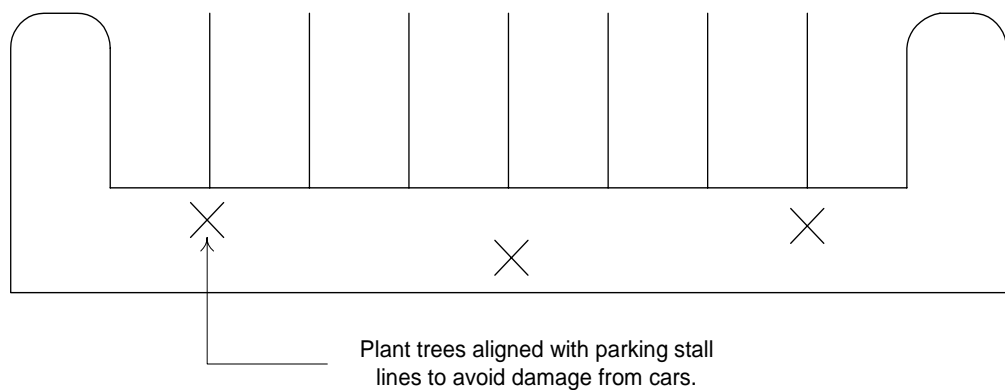
- An alternative to planting in linear parking islands is the design of large concentrated planting islands within parking lots. This can allow plant communities to establish in these islands. They can also be stormwater infiltration areas.
- Keep landscaping as low-maintenance as reasonably possible.



**Figure 630.12 Large, concentrated planting island**

- In high snow load areas, end islands may cause difficulties with snow removal. In these areas, large central planting islands may be more appropriate. Consider snow storage needs and adjacent vegetation in high snow load areas.

- In arid climates, irrigation may be necessary for plant survival. These areas benefit most from tree shading of parking stalls in the summer due to higher temperatures.
- Consider the use of structural soils<sup>12</sup> under paved surfaces to allow root penetration without damage to the pavement and to retain parking spaces while increasing soil volume for trees in parking islands. This will benefit both the tree and long-term maintenance of the parking lot. Additional information can be found at: <http://www.hort.cornell.edu/departments/faculty/bassuk/uhi/pubs.html>
- Interior planting islands should have drainage provided and depth to allow tree root growth at least 3 feet deeper than paving grade.
- Plant trees to align with the parking stall lines to prevent their damage by car bumpers, as shown in Figure 630.13 and 630.14.



**Figure 630.13 Locating trees in line with stall lines**

<sup>12</sup> See chapter 700 in this manual for a description of this mix.



**Figure 630.14** Align trees with parking stall lines to minimize bumper damage to trees

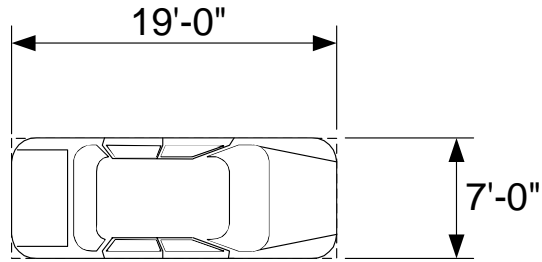
### ***Stall Layout and Size***

Good parking area design is easy to understand and convenient for the user and it uses the site efficiently.

- Provide wider stalls for short-term users (turnover of five or more cars per day), and narrower stalls for long-term users (turnover of one or two cars per day).
- Provide 10 feet wide stall widths in safety rest areas. Stall widths of 9 ft may be justified if 60 degree angle parking is used.
- Provide a minimum of 8.5 feet wide stalls in park and ride lots. Wider stalls are easier to park in and exit from.
- Efficient layouts provide parking around the periphery of the site and orient the stalls to the longest dimension of the site.

The large AASHTO design passenger car has the following dimensions:





## AASHTO Passenger Car

A large number of sport utility vehicles (SUVs) and trucks on the road have these dimensions.

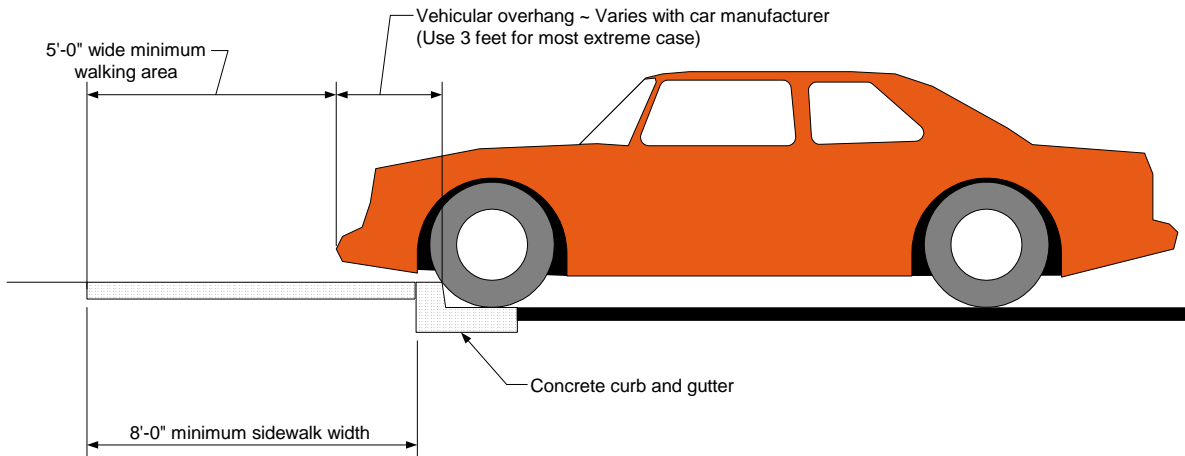
### ***Orientation of Aisles to Destination***

Aligning the parking stalls perpendicular to the focus of a facility allows pedestrians to reach their goal without having to cut between parked cars, cross vehicular traffic, or cut across stormwater swales. This is shown in [Figure 630.15](#).



**Figure 630.15** Aisles oriented perpendicular to destination – note bumper overhang

Car bumpers overhang tire stops and curbs. Consideration must be made in the design of sidewalks and planting areas for this overhang.



**Figure 16 Car bumper overhang**

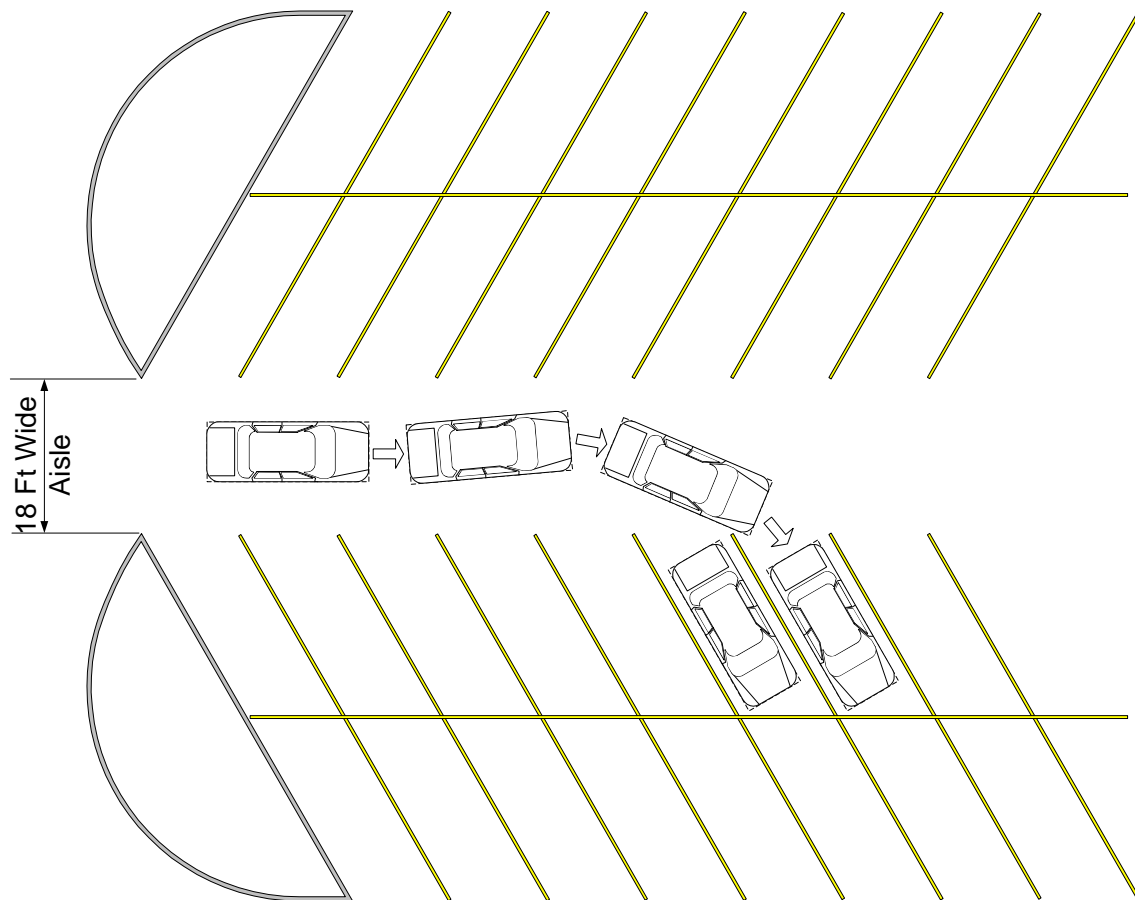
### ***Parking Angle***

The decision to use angle or perpendicular parking should consider all factors. Some considerations are listed below:

#### **Angle Parking (most often 60 degrees)**

- One-way aisles are used.
- Most drivers find angled-in parking easier to use.
- It is appropriate for short stays with high turnover, such as those in safety rest areas.
- Angled parking generally takes more space than perpendicular parking.
- Angled parking has been used successfully in oddly dimensioned sites to achieve layout efficiency.
- Planting areas are easier to provide.

Figure 630.17 shows the minimum aisle width and turning radius needed for angled parking.

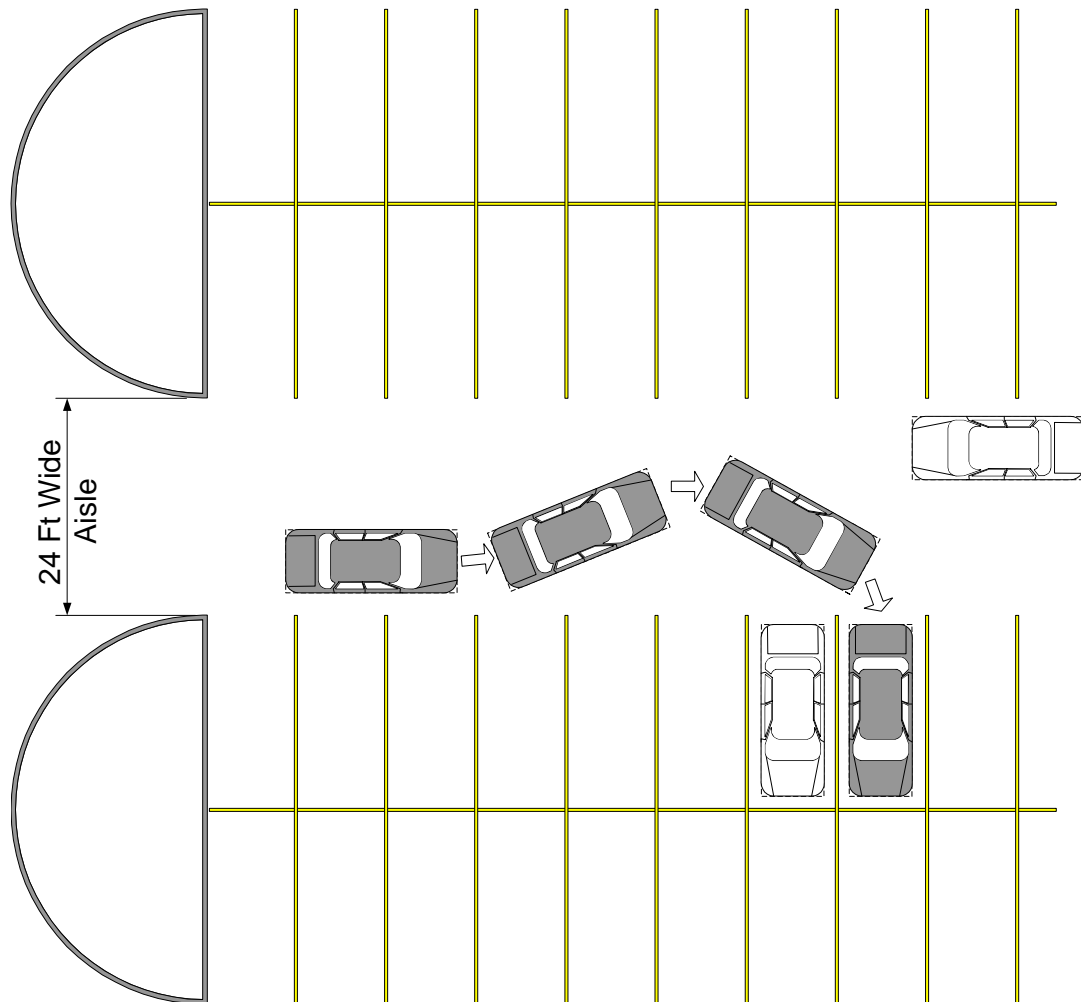


**Figure 630.17 Angled Parking**

### **Perpendicular Parking (90 degree)**

- Perpendicular parking requires less knowledge of the circulation pattern because two-way aisles are used.
- Wider aisle widths are necessary to allow for two-way traffic and to allow drivers to pass a waiting vehicle.
- A slightly higher number of stalls can be accommodated in a rectangular lot when compared to angle parking layouts.

Figure 630.18 shows the wider aisles and necessary turning radius needed when parking and perpendicular stalls and the minimum aisle width.



**Figure 630.18 Perpendicular parking**

[Figure 630.19](#) shows a comparison between angle and perpendicular parking stalls.



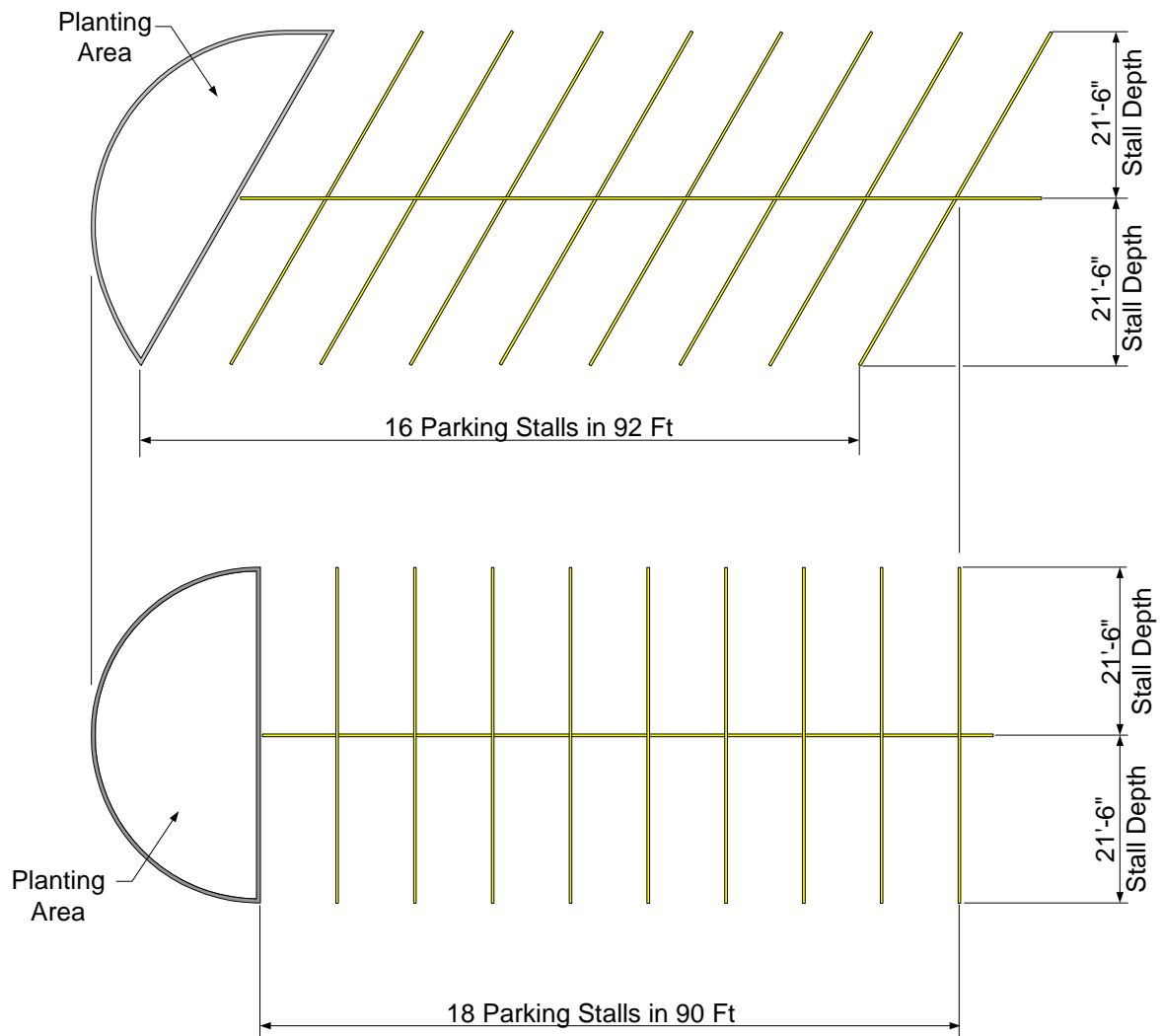


Figure 630.19 Comparison between dimensions in angle and perpendicular parking layout

Note that as stall width decreases, aisle width increases. Perpendicular parking is more difficult when aisle widths are not wide enough.

Driver and pedestrian safety and the flow of traffic must be considered when determining the number of spaces in a parking lot. Efficiency and convenience must be in balance.

Other stall angles are used less commonly. For example, a 45-degree angle can provide stall space in a narrow lot because stall-to-curb dimensions and aisle widths decrease with angle of stall.

## ***Motorcycle and Bicycle Parking***

### ***Motorcycle Parking***

Provide for motorcycle parking. A good place for this is at the end of rows where insufficient room remains for a full car width. Mark motorcycle stalls individually, as with car stalls, and mark clearly for “Motorcycle Parking Only” to prevent cars from occupying an area that may be big enough for several motorcycles. Generally, it is appropriate to include one motorcycle stall for every 100 car stalls. Motorcycle stalls should be at least 4’-9” wide and 9’-0” long at a 60 degree angle.

Consider providing racks to secure motorcycles for long-term parking areas. Embed these racks in concrete and use steel tubing or reinforced concrete. Placing high-tensile strength wire cable (1/3” diameter) loosely inside the steel tubing and securing each end can provide additional security since, as it moves within the tube, it is difficult to cut with a hacksaw. A preservative wax or grease can also be used to coat the wire cable to allow it to move more freely within the tube. Place the attachment area a minimum of 1 foot above the ground. To address theft and safety concerns due to the higher exposure of motorcycles and their users, it is desirable to provide adequate lighting at the location of the racks.

### ***Bicycle Parking***

Provide bicycle racks and/or storage units near the pedestrian waiting areas in park and ride lots. Storage units are preferable to racks to keep bicycles out of the weather and provide extra security. Some municipalities rent the storage units for a nominal fee to help pay for the extra cost. Maintenance of these units must be included in budget provisions. The designer should coordinate with the agency that will maintain the park and ride facility.

Locate the bicycle racks so they are accessible to bicyclists without conflicting with major pedestrian or vehicular paths of travel. For areas with high bicycle use, some separation between bicycle racks is desirable to prevent concentration of all users at one point.

Consider bicycle use at safety rest areas and viewpoints where bicycles are permitted, and provide racks as appropriate.

Bicycle racks should support the frame of the bike, allow at least one wheel to be locked to the frame, allow the use of different kinds of bicycle locks, and be durable and easy to use. To address theft and safety concerns due to the higher exposure of bicycles and their users, it is desirable to provide adequate lighting at the location of the racks.

See the Bicycle Facilities chapter of the *Design Manual* for further information.

## Construction

When constructing parking facilities, avoid compaction of soil within planting strips. This can alleviate the need to rip the soil before planting. Avoid impacts to plants that will remain after construction. See [Chapter 800](#) of this manual for more information on mitigating impacts to vegetation.

## Maintenance

Adequate funding for maintenance must be provided to maintain public safety. Clean facilities provide the perception of safety and discourage vandalism. Immediate removal of graffiti and litter removal are necessary.

Consult Maintenance personnel during the design phase of any parking facility to determine their concerns and respond to their suggestions.

## Additional Sources of Information

Linda S. Glisson, ed. *The Parking Handbook for Small Communities*. National Mainstreet Center: Washington D.C. 1994.

<http://www.epa.gov/owow/nps/bioretention.pdf> Information on design of planting islands within parking areas.



**General**

With increased focus on stormwater in Washington and new understanding of the role of soils in the mitigation of water quality and quantity, engineered soil and soil amendments have become an important stormwater Best Management Practice (BMP). Topsoil is a biologically active system of minerals, organic matter, air, water, and microorganisms that can take thousands of years to develop. Topsoil nourishes and provides structural support for plant roots and absorbs and cleans water. This chapter focuses on for the use of soil and compost for roadside projects.

Much of the roadside environment is reduced to subsoil at the surface following a typical roadway construction project. Subsoil has little or no organic matter, few pore spaces, and few microorganisms. While the mineral component of soil provides structural support for roads and bridges, climax vegetation cannot grow in this environment, thus we see nitrogen fixing pioneer species like red alder, and exotic plants including Scotch broom and Himalaya blackberry, colonizing construction sites. The resulting community of native and exotic, invasive plants can require costly maintenance and time consuming management. The job of reconstructing a functioning soil community is difficult and costly, and might not be achievable in some areas.

It is necessary to have healthy soil to revegetate a site. Revegetation is necessary to provide slope stabilization, erosion control, biofiltration and infiltration for water quality, screening, local climate modification, habitat, and so forth. Revegetation might also be necessary to meet permit or environmental requirements. As a result, healthy topsoil is an important component of a construction project.

Plant life and water absorption capability require similar soil conditions: loose, friable soil with the right balance of organic matter, microorganisms, and minerals. In contrast, roadway construction requires highly compacted soils with low organic matter content for stability. WSDOT requires that soils for road foundations are compacted to 95% density. Plants require that soils have a density of less than 80%. This density complication poses a challenge in all phases of roadside revegetation management.

## References

*Highway Runoff Manual* M 31-16

Revisions to Highway Runoff Manual:

<http://wwwi.wsdot.wa.gov/eesc/environmental/Stormwater/HRMRevisions.htm>

*Construction Manual* M 41-01

*Design Manual* M 22-01

*Roadside Classification Plan* M 25-31

*Standard Specifications for Road, Bridge and Municipal Construction*  
M 41-10

## Resources

The region's Landscape Architect

The region's Environmental Office

Headquarters Maintenance & Operations Program (HQ M&OP)  
Materials Lab

HQ Design Office Roadside and Site Development Unit

## Definitions

**biosolids** Treated wastewater residuals or solids used as a soil amendment.

**clay** Mineral soil particles with a diameter of less than 0.002 millimeter. A fine-grained soil that has a high plasticity index in relation to liquid limits.<sup>1</sup>

**climax vegetation** Relatively stable vegetation in equilibrium with its environment and with good reproduction of the dominant plants.<sup>2</sup>

**compost** Stable, mature, decomposed organic solid waste that is the result of the accelerated, aerobic biodegradation and stabilization under controlled conditions. The result has a uniform, dark, soil-like appearance.

**humus** Decomposed organic matter that remains once visible plant structure can no longer be determined.

**leaching** The removal of materials (CaCO<sub>3</sub>, MgCO<sub>3</sub>, and other more soluble materials) in solution from the soil.

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<sup>1</sup> Donahue, Roy L., John C. Shickluna, and Lynn S. Robertson, *Soils: An Introduction to Soils and Plant Growth*, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1971, p. 509.

<sup>2</sup> Ibid, p. 510.

**loam** A soil texture class that contains 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand.<sup>3</sup>

**microorganisms** Forms of life that are either too small to be seen with the unaided eye, or are barely discernible.<sup>4</sup>

**mottling** Soils irregularly marked with spots of color. The presence of orange mottling usually indicates soils that have been through periods of saturation interspersed with periods where the soil had dried out.

**pioneer species** Fast growing plants that are quick to establish on poor soils. Nodules on their roots fix nitrogen giving them a competitive edge in disturbed soil environments.

**pore space** Total space not occupied by soil particles in a bulk volume of soil, commonly expressed as a percentage.<sup>5</sup>

**ripping** Deep scarification using specialized equipment, usually done on compacted soils to increase pore space and improve soil structure for plant growth and infiltration of surface water.

**sand** A mineral soil particle between 0.05 and 2.0 mm in diameter. A soil textural class.<sup>6</sup>

**silt** A mineral soil separate consisting of particles of 0.002 and 0.05 mm in diameter. A soil textural class.<sup>7</sup>

**soil** The unconsolidated mineral and organic matter on the surface of the earth that has been subjected to and influenced by genetic and environmental factors of parent material, climate (including moisture and temperature effects), macro and microorganisms, and topography, all acting over a period of time and producing a product – soil – that differs from the material from which it is derived in many physical, chemical, biological, and morphological properties and characteristics.<sup>8</sup>

**soil horizons** Layers of soil approximately parallel to the land's surface and differing from underlying or overlying layers in physical, chemical, and biological properties or characteristics, such as color, structure, texture, consistency, amount of organic matter, and degree of acidity or alkalinity.<sup>9</sup> The "O Horizon" is the organic layer. The "A Horizon" is a mineral layer forming at or adjacent to the surface, in which humus is accumulated. The "B Horizon" is a mineral layer comprised of fine grained soils that have been leached.

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<sup>3</sup> Ibid, p. 536.

<sup>4</sup> Ibid, p. 538.

<sup>5</sup> Ibid, p. 546.

<sup>6</sup> Donahue, et al., p. 550.

<sup>7</sup> Ibid, p. 552.

<sup>8</sup> Ibid, p. 553.

<sup>9</sup> Ibid, p. 558.



**Figure 700.1 Soil Horizons**

**soil organic matter** The fraction of the soil that includes plant and animal residues at various stages of decomposition, cells and tissues of soil organisms, and substances synthesized by soil organisms.<sup>10</sup>

**soil structure** The combination or arrangement of primary soil particles into secondary particles or units. The secondary units are characterized and classified on the basis of size, shape, and degree of distinctness into classes, types, and grades respectively. Examples are: platy, prismatic, columnar, blocky, granular, and crumb.<sup>11</sup>

**subsoil** The soil layers below the A Horizon that contain little or no organic matter.

**tilth** The physical condition of soil as related to its ease of tillage, fitness as a seedbed, and ease of seedling emergence and root penetration.<sup>12</sup>

**topsoil** The original or present, dark-colored (A Horizon), upper soil that ranges from a few millimeters to a meter thick at different locations.<sup>13</sup>

**unsuitable soils** Generally organic soils that are not appropriate for engineering functions. These soils might be ideal for roadside restoration and revegetation functions.

<sup>10</sup> Ibid, p. 561.

<sup>11</sup> Ibid, p. 561.

<sup>12</sup> Ibid, p. 570.

<sup>13</sup> Ibid, p. 570.



## Structure and Disturbance

The ideal soil for most plants is approximately 50% solid and 50% pore space. The solid component contains minerals and organic matter. Ideally, pore space contains roughly equal parts of air and water. Microorganisms (such as fungi) or invertebrates (such as earthworms) are present in a healthy soil and function to process organic matter, recycle nutrients, and nurture plants.

Any disturbance to the soil alters and influences this complex system. Disturbances include construction, fertilizer and pesticide application, soil compaction from foot traffic and equipment use, and altering hydrological patterns through irrigation, grade changes, and stormwater retention. In other words, any management activity on the roadside is a potential disturbance to the soil system. In areas where plant cover is desirable, roadside management activities are selected and timed to minimize harmful disturbances to the soil, and are focused on long-term soil health.

Soil preservation and preparation are necessary to support goals of the [Roadside Classification Plan](#) (RCP).

The following table lists recommended practices for dealing with soils along the roadside.

During the project definition process, determine how and to what extent soils will be affected. Document in the Design File.
Minimize the extent of disturbance activities to minimize impacts to soil outside the project's construction limits.
Before beginning any earthwork that includes disruption of the soil, note whether the soils in this area are part of a fill slope comprising the roadway prism. If so, work with the Regional Materials Engineer.
Mitigate construction-related soil compaction in vegetation restoration areas.
Stockpile and reuse native soils where practical.
Minimize erosion potential and weed species invasion by establishing a healthy plant cover.
Maintain roadside management zones 2 and 3 to stabilize and improve soil tilth and fertility.

**Figure 700.2 Summary of Recommended Practices**

## Soil Amendments

The decision to use a soil amendment depends upon the existing soil and the desired outcome. Some soil amendments might encourage unwanted exotic vegetation, while the combination of other soil amendments with native soils might favor native vegetation. Check with the region Landscape Architecture Office or the HQ Design Office Roadside & Site Development Unit for recommendations.

### ***Topsoil***

*Topsoil* can be an amendment when only subsoil remains on a site. Commercial topsoil generally consists of mineral soils mechanically combined with organic matter. See the [Standard Specifications](#) Division 9 for working descriptions of topsoil.

Remove, stockpile, and replace existing topsoil when appropriate. Existing topsoil can have necessary nutrients, organic matter, and microorganisms. The use of existing topsoil onsite can reduce the costs of disposing of excess excavated material. An examination of the site with an inventory of existing vegetation is necessary prior to determining when to use existing topsoil. Stockpiling of topsoil might not be advisable when noxious weeds and their seeds are present. Consult the Landscape Architect for assistance.

Imported topsoil can be used to provide a medium for plant growth when native soil has been removed or is highly disturbed.

### ***Compost***

*Compost* is highly decomposed organic matter that is used to add nutrients and improve soil structure for plant growth. Acceptable compost products originate a minimum of 65 percent by volume from recycled plant waste. A maximum of 35 percent by volume of other approved organic waste and/or biosolids may be substituted for recycled plant waste. Compost should have a Carbon to Nitrogen ratio (C:N) of approximately 30:1.

### ***Bark or Wood Chip Mulch***

*Mulch* shall be bark or wood chip fiber as described in the [Standard Specifications](#) Division 9. Mulch is used on top of soil and around plants to moderate soil temperature, retain soil moisture, provide a base for desirable fungal colonization, and inhibit weed growth.

### ***Fertilizer***

Commercial fertilizers are labeled to document the content's ratio of Nitrogen (N), Phosphorus (P), and Potassium (K) (Usually listed in

order: N-P-K). These are the three main elements associated with plant growth and health. Generally, nitrogen encourages green top growth, while phosphorus and potassium encourage root growth. Fertilizer is applied in various combinations (for example, 20-20-20 or 10-15-5), as determined to be necessary by the results of a soil analysis.

### ***Mycorrhizae***

Mycorrhizae are a group of fibrous fungi existing naturally in topsoils that engulf soil particles and pore spaces to absorb water and nutrients in solution and transfer this solution to the roots of plants. In effect, they multiply the plants' root systems many times.

Additional benefits from mycorrhizae may include plant species diversity and improved soil structure. The mycorrhizae applied depend on the species of plant. Check with the Horticulturist or Landscape Architect for assistance.

## **Structural Soils**

The Urban Horticulture Institute at Cornell University has developed a cost effective structural soil mix that can improve the survivability of street trees in urban environments. This mix might be useful in selected WSDOT projects. The mix is:

- 80% angular stones  $\frac{3}{4}$  to 1  $\frac{1}{4}$  inch in diameter
- 20% topsoil with organic matter content of 10%
- Soil stabilizer per the manufacturer's specifications
- Potable water – enough to cause soil to coat the stones without having water run off

The angular stones form a skeleton that provides the weight-holding capability for the mix. Specialized compaction tests are not needed with this mix. The water storing polymers bind the stones together and stabilize the soil mix. In addition, this structural soil mix leaves a large volume of rooting space that allows the plants to get oxygen and water. See the Regional or HQ Design Office Landscape Architects for more information.

More information can be found at: <http://www.urban-forestry.com/citytrees/v36n3a12.html>

## Planning

During the planning process designers and engineers are to consider the following:

- Impacts the proposed construction will have on existing soils.
- Treatment needed to provide adequate soils for restoration of roadside character

### ***Procedures***

Determine the extent soils will be impacted. This analysis is performed at the earliest phase of the project. This knowledge will be used to complement design and construction. Consider:

- How the proposed project will affect the existing soil.
- Existing soil compaction and compaction ratios resulting from construction activities.
- Measures to mitigate overly compacted soils, such as ripping the soil.
- Expected treatment levels and soil preparation to accomplish those levels; for example, soil amendments and mulch.

## Design

Activities during the design phase include:

- Soil preservation — plan to stockpile and redistribute existing topsoil within the contract's order of work.
  - Site analysis. Prepare a plant inventory to document predevelopment conditions.
  - Consult with the Landscape Architect prior to considering stockpiling topsoil.
  - Cost savings can be realized by using soils unsuitable for engineering uses (those with high organic content) on roadside projects.
- Determine where to stockpile soil on site.
- Determination of the extent of cut and fill slopes and clearing and grubbing limits.
- Soil analysis (type, compaction, and fertility).
- Specifying topsoil and amendments.
- Matching proposed vegetation with the soil, climate, hydrology,

and anticipated maintenance levels.

The challenge to the roadside designer is to specify the appropriate soil preparation for planting, to prevent soil erosion, and to achieve desired soil structure. Appropriate soil preparation, including possible amendments, is crucial for the success of desirable roadside revegetation.

## **Procedures**

### **Site Analysis**

- Examine proposed planting areas for any apparent drainage problems. Note any underlying characteristics that might affect drainage (hardpan, compacted subsoil, clay layers, and so forth.). Plan to correct deficiencies or plant appropriate species.
- Analyze soil for susceptibility to erosion from stormwater runoff.
- Determine solar exposure of slopes (slope aspect) and its effect on soil and vegetation.
- Conduct a plant inventory or a germination test to determine seed bank to decide if topsoil stockpiling is practical.

### **Soil Testing**

Perform a soil test to determine nutrient content and pH of soil.

- Obtain a soil sample bag or a plastic bag capable of holding approximately one quart of soil
- Select a representative area for your sample. If the soil seems to vary in color and composition within the project area, sample those soils also.
- Dig a hole 300 to 460 mm (12 to 18 inches) deep and set the material to the side. Scrape off a small amount of material from the top to the bottom of the side of the hole and place into plastic bag. Do not include any material taken from the hole initially. Refill the hole with the set aside material.
- Locate the test pit on the site map. If more than one sample is taken from the site, number the test pits to correspond with the samples taken.

- Seal the bag tightly and place in a manila envelope and write all the information on the paper surface: your name, date of sampling, site location, and sample identification (such as test pit #1).
- Fill out Soil Test Form and include it with your sample.
- Box or wrap sample for mailing.
- Send the soil sample to a soil chemistry lab listed below.
- Consult with the Landscape Architect for specific amendment recommendations when you get test results, if necessary.

**Soil testing laboratories for soil chemical properties** (call laboratories for forms and pricing information):

**A & L Western Agricultural Laboratories**

10220 SW Nimbus Ave., Bldg K-9  
Portland, OR 97223  
Phone: 503-968-9225

**Black Laboratories**

503 N. Gardner Rd.  
Burlington WA 98233  
Phone: 360-757-6112

**Harris Laboratories, Inc.**

621 Rose Street, Box 80837  
Lincoln, NE 68501  
402-476-2811

**Northwest Agricultural Consultants**

2545 West Falls  
Kennewick, WA 99336  
Phone: 509-783-7450

**Soil and Plant Laboratory, Inc.**

PO Box 1648  
Bellevue, WA 98009-1648  
Phone: 425-746-6665

The WSDOT Materials Laboratory does soil testing for engineering properties such as soil strength and gradation. The Regional Materials Engineer can help with soils engineering and related testing.

## **Compaction**

Appropriate soil treatment is crucial for the success of roadside restoration (including erosion prevention seeding). Analyze the soil for compaction. Pay close attention to areas that have been, or will be, staging areas. These areas will have to be ripped to restore pore spaces between the soil particles. Rip compacted soils, ideally in two directions, to a minimum depth of 460 mm (18 inches) before planting. The roots of most plants are above this depth.

Specify in all contracts that the contractor has the responsibility to restore the soil to a less than 80% density in all staging areas. Higher compaction rates are allowed in areas that are critical for road or structure stability. Include the costs of these procedures as part of the contract. The contract cannot be closed until this step is completed.

Soil compaction can be tested using the bulk density test. Test the soil to a depth of 0.6 m (2 feet). If the density is greater than 80%, take steps to break up the compacted soil. Contact the regional Materials Engineer for assistance.

## ***Clearing and Grubbing***

Set clearing and grubbing limits to minimize soil disturbance.

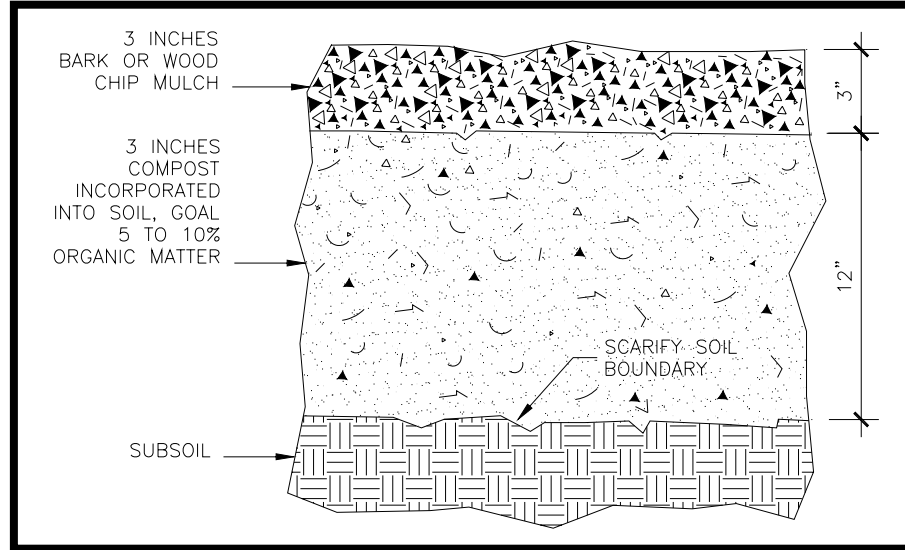
In some areas grubbing is unnecessary. Stumps and root systems may be left in the soil to provide stability. Decomposition of trees varies in time depending upon species and climate. Their decomposition, however, will provide nutrients, organic matter, and habitat for microorganisms.

## ***Plans, Specifications, and Estimate (PS&E)***

- Specify soil amendments to achieve revegetation and restoration requirements.
- Specify wide-track construction equipment in contract documents when it is necessary to work in wet soils.
- Where practical, strip topsoil and stockpile for redistribution after completion of rough grading. This is the best source of native seeds but it is also a source of exotic invasive vegetation and noxious weeds. (The plant inventory and germination test performed during the site analysis determine what plants are growing in the soil.)
- Assess the entire project for other places to use removed topsoil. Restoration sites are practical locations to place excess topsoil.

### **Soil Treatment to Enhance Native Plant Growth**

To encourage native woody plant species, the following technique can be employed. Incorporate 3 inches of Compost Type 2 into the top 12 inches of soil. Place 3 inches of bark or wood chip mulch on the surface. Plant through these layers. This is shown in [Figure 700.3](#).



**Figure 700.3 Amendments to encourage native woody plants**

## **Construction**

The challenge to the Project Manager and the Construction Office is to avoid or minimize damage to the soils resulting from construction activities. Mitigate unavoidable damage to the soil before planting.

### **Procedures**

The following procedures will minimize impacts to topsoil during construction:

- Set limits of work areas for vehicles and equipment to minimize and prevent excessive soil compaction. Use flagging and fencing in conjunction with signs to define work areas.
- Minimize compaction during construction. Avoid heavy machinery use on saturated soil.
- Use wide-track construction equipment.
- Cover staging areas with a 150 mm (6 inch) layer of wood chip mulch to reduce compaction.



- Before specifying or beginning earthwork that includes scarifying the soil, note and document the soils' structural function and performance. This is particularly critical on fill slopes where the soil is compacted to comprise the highway prism.
- Mitigate construction-related soil compaction in vegetation restoration areas by ripping the soil to loosen its structure.
- When stockpiling topsoil, mound soil no higher than 1.3 m (4 feet) high for less than 1 year. Cover to prevent soil erosion and contamination by weeds.
- Use only well composted soil amendments and incorporate them as specified.
- Avoid walking, operating equipment or driving vehicles on planting areas after soil preparation is complete.
- Minimize erosion potential by establishing a healthy plant cover.

## **Maintenance**

Maintenance activities can greatly affect soil structure in a positive or negative way. A solid plant cover is the best defense against erosion and invasive species. Routine maintenance activities can help build the soil to support vigorous plant growth.

### ***Procedures***

- Plants suffer from nutrient deficiencies in the soil. Contact the Landscape Architect for recommendations before amending soil. The Landscape Architect can provide information on appropriate fertilizers or soil amendments.
- Allow organic matter to remain on the ground where it will not jeopardize safety or visual quality. Logs and brushpiles enrich the soil and provide habitat while decomposing. Such decomposition can reduce the need for additional fertilization or soil amendments and reduce maintenance expenditures.
- Fresh wood chips can use up available nitrogen and affect plant growth. To avoid this problem, spread wood chips thinly over a large area or add nitrogen to aid in decomposition.
- Avoid driving vehicles or operating equipment on saturated soil and in vegetated areas.
- Reseed, cover, or mulch bare soils as soon as possible when they have been exposed by maintenance activities or errant vehicles.



## ***Erosion Prevention and Sediment Control***

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### **General**

Erosion is a natural process that can be greatly accelerated by human activities, especially those that change or remove vegetation or that disturb the soil. In addition to human activities, fire and animal activities can also accelerate erosion. Soil is composed of mineral and organic matter and takes thousands of years to develop. The U. S. is losing topsoil seventeen times faster than it develops<sup>1</sup>. All construction activities have the potential to cause soil erosion. Therefore, erosion prevention and sediment control are components of any project that disturbs vegetation or soil horizons. Erosion prevention will reduce both the need for costly sediment controls and the risk of environmental damage.

Federal, state, and local water quality regulations prohibit the discharge of turbid water from construction activities into adjacent water bodies and require WSDOT to use approved Best Management Practices (BMPs). The water quality and stormwater BMPs can be found in the [Highway Runoff Manual](#) and the [Standard Specifications for Road, Bridge and Municipal Construction 2002](#).

All highway construction projects and any activities involving earthwork require a Temporary Erosion and Sediment Control (TESC) Plan and may require a Stormwater Site Plan (SSP).

Adding any new impervious surface can require that an SSP be included in your project. Check with the regional environmental office and the [Highway Runoff Manual](#) for compliance with the applicable regulations. An SSP includes the permanent and temporary stormwater pollution prevention BMPs and includes the TESC Plan. When the project clears vegetation, a NPDES permit might be required. Check with the environmental office to determine area thresholds for permit requirements. The SSP will be used to satisfy the requirements of the NPDES permit. In addition, the SSP will be used to aid acquisition of HPA, Shoreline, and Army Corps of Engineer (ACOE) permits.

### **References**

[RCW 90.48.080](#) -- *Discharge of polluting matters in waters prohibited*

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<sup>1</sup> Pimentel, David, "Environment and Economic Costs of Soil Erosion and Conservation Benefits," *Science*, 24 February 1995.

*WAC 173-201A -- Water quality standards for surface waters of the state of Washington*

*Highway Runoff Manual* M 31-16, WSDOT

*Hydraulics Manual* M 23-03, WSDOT

*Standard Specifications for Road, Bridge, and Municipal Construction* M 41-10, WSDOT and APWA.

<http://www.wsdot.wa.gov/eesc/environmental/WQTESC.htm>

## **Resources**

The region's Erosion Control Specialist

The region's Water Quality Unit

The region's Environmental Staff

The region's Hydraulics

The region's Landscape Architect

HQ M&OP Geotechnical Engineers

HQ Environmental Affairs Office

Statewide Erosion Control Coordinator

HQ Design Office Landscape Architect

## **Definitions**

**Best Management Practices** (BMPs) Physical, structural, and managerial practices that, when used singly or in combination, improve the downstream quality of stormwater and reduce the downstream quantity impacts of stormwater.

**bioregion** A geographic region based on topography and biological similarities such as watersheds, plant/animal ecosystems, or relative elevations.

**check dam** A small barrier, such as quarry spalls, sand bags, or silt fencing, that slows water velocity and allows solids to settle out behind the barrier.

**wood chip berm** A berm with a minimum height of 2 feet constructed to trap sediments on a construction site. Berms must be constructed on contour to distribute treatment along entire berm and prevent blowouts by accumulating water. Once vegetation has been established, berms may be raked and leveled to provide a mulch layer around woody vegetation.

***detention facility*** An above or below ground facility, such as a pond or tank, that temporarily stores stormwater runoff and subsequently releases it at a slower rate than it is collected by the drainage facility.

***erosion*** The wearing away of the land surface by running water, wind, ice, or other geological agents, including such processes as gravitational creep; also detachment and movement of soil or rock fragments by human and animal activities.

***Erosion Control:*** Any temporary or permanent BMPs taken to prevent or reduce soil erosion, whether from wind or water.

***fascine*** A tied bundle of plant stems or branches, laid in a trench or a terrace on the contour and staked into position. Used to slow water velocities, trap sediment and establish vegetation. Used on basically stable slopes that have a shallow, unstable surface layer.

***hydraulic conveyance system*** Natural and man made drainage facilities that collect, contain, and provide for the flow of surface and stormwater from the highest elevations down to a receiving water body. The natural elements of the conveyance system include swales, and small drainage courses, streams, rivers, lakes, and wetlands. The man made elements of the conveyance system include gutters, ditches, pipes, channels, and most retention/detention facilities.<sup>2</sup>

***retention*** The process of collecting and holding surface and stormwater runoff with no surface outflow.

***retention/detention facility (R/D)*** A type of drainage facility designed either to hold water for a considerable length of time and then release it by evaporation, plant transpiration, and/or infiltration into the ground; or to hold surface and stormwater runoff for a short period of time and then release it to the surface and stormwater management system.

***Sediment control*** The trapping of soil particles moved by wind or water.

***settleable solids (SS)*** The materials which settle out of suspension within a defined period (typically one hour). It is reported on a volume basis (milliliter per liter, mL/L), but can also be reported on a weight basis (milligrams per liter, mg/L).

***steppe*** A grass covered semi-arid plain, such as those found in Washington east of the Cascade mountain range.

***Stormwater Site Plan (SSP)*** A plan and report that documents the BMPs that will be taken during and after project construction to provide temporary erosion and sediment control and permanent stormwater quality and quantity control. The SSP also includes the

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<sup>2</sup> [Highway Runoff Manual](#), WSDOT

Hydraulics Report, Vegetation Management Plan, Downstream Analysis Report, as well as other reports. The SSP is required by the Washington State Department of Ecology (Ecology) in order to get a NPDES baseline/general permit. In addition, the SSP will be used to aid acquisition of HPA, Shoreline, and ACOE Permits.

**tackifier** An amendment, resistant to water, which is added to organic material such as mulch to cause it to adhere to adjacent particles and to the soil.

**Temporary Erosion and Sediment Control (TESC) Plan** A “living” plan that provides for the prevention, interception, and treatment of all potential turbidity and silt-laden runoff that could occur during clearing, grading, construction, and site stabilization. The TESC Plan describes stabilization and structural practices, both of which are implemented to minimize erosion and the transport of sediments.

**Total Suspended Solids (TSS)** The entire weight of organic and inorganic particles dispersed in a volume of water, expressed in milligrams per liter (mg/L).

**turbidity** The visual clarity of the water as measured in Nephelometric Turbidity Units (NTUs). The turbidity, or clarity, of surface streams is an important determinant of its condition and productivity. Turbidity in water is caused by suspended and colloidal matter, such as clay, silt, organic and inorganic matter, and microorganisms. Turbidity does not settle out of water in a reasonable time period. The turbidity of drinking water is less than 1 NTU, while the turbidity of stream water can vary from fewer than 10 NTUs to greater than a few hundred NTUs.

**water bars** Small logs, or concrete barriers, usually less than 15cm in diameter, placed along a trail or slope to intercept the downhill flow of precipitation and direct it to a desired location.

**water quality standards** The discharge of polluted waters to waters of the state is a violation of the Washington State Water Pollution Control Law ([RCW 90.48.080](#)). Ecology establishes surface water quality standards ([WAC 173-021A](#)) as required by the Environmental Protection Agency (EPA). These standards are intended to protect surface waters of the state for beneficial uses including: public health, enjoyment, and the propagation and protection of fish, shellfish, and wildlife. State water quality criteria are defined for classifications of waters and include turbidity, fecal coliforms, dissolved oxygen, temperature, and pH. All water discharged from construction sites shall meet the water quality standards for turbidity at the discharge point into the surface water resource. There is not a “dilution” or “mixing zone.”

**wattle** A length of straw contained in a sausage-shaped netting. These are biodegradable and are generally buried to half their depth along the contour to reduce slope length, slow water velocity, and trap sediment.

## **Process of Erosion (Water)**

**Raindrop** – The impact of raindrops on bare soil displaces soil particles. Over the duration of a storm, significant volumes of sediment are made available to be transported.

**Sheet** – As rain accumulates a non-concentrated, uniform layer of runoff is formed. This sheet flow transports detached soil from raindrop impacts, as well as plucks off additional soil particles caused by the shear stress of the runoff.

**Rill** – When sheet flows converge, increased volumes and velocities of water are concentrated. Small, intermittent watercourses with steep sides, known as rills, are formed. They are usually only a few inches deep.

**Gully** – When rills converge and/or impervious surfaces focus runoff in a single location, a large channel, known as a gully, is formed. Volumes and velocities of water, along with shear stress are increasing dramatically.

**Stream Bank** - Bank erosion of existing streams/channels is caused by increased peak flows.

## **Process of Erosion (Wind)**

As is the case with water erosion, the loss of soil by wind movement involves detachment and transportation processes. The lifting and abrasive action of the wind results in some detachment of tiny soil grains from the granules or clods of which they are a part. When the wind is laden with soil particles, however, its abrasive action is greatly increased. The impact of these rapidly moving grains dislodges other particles from soil clods and aggregates. These dislodged particles are now ready for movement.

**Saltation** – The most important of the mechanics of wind erosion is saltation, defined by soil particles bouncing short distances. They remain close to the ground, usually no higher than twelve inches. Depending on soil conditions, saltation may account for 50-70% of total erosion.

**Surface Creep** – Saltation encourages surface creep, which is the rolling and sliding along the surface of larger soil particles. Not only is surface creep initiated by saltation, it is actually prolonged by the ricocheting action of saltating particles. Surface creep may account

for 5-25% of total erosion.

**Suspension** – Dust particles of fine sand size or smaller are moved parallel and upward to the ground surface. Suspension can reach ten feet to many miles into the sky. Very fine particles are lifted from the surface by impact/saltation and carried high into the air, remaining suspended in air for long distances. Although it is a spectacular and visible method of transporting soil, it may account for only 15% of total erosion.

## Factors Affecting Severity of Erosion

- √ Gravity
- √ Soil Type and Texture
- √ Precipitation & Climate
- √ Storm intensity, storm duration,
- √ Vegetation
- √ Surface Area
- √ Slope Length & Gradient
- √ Surface Texture

Vegetation is the single most important element in the prevention and control of erosion from wind and water.

Maintaining or reestablishing vegetation is fundamental in preventing erosion. Eroding sites require stabilization through the use of measures such as:

- √ vegetation
- √ check dams to slow water
- √ impervious soil tackifiers
- √ soil particle binders to bind soil particles together
- √ erosion prevention blankets to reduce the force of water splash on soils
- √ In more extreme cases, walls to decrease slope angle or barriers to block wind may be needed.

## Site Analysis

An assessment of the factors affecting erodibility, whether before, during, or after construction, can provide critical information about erosion potential. Erosion and sediment control efforts are most effective when addressed during the planning or design phase.



Address the following elements in a comprehensive appraisal of the site:

- Topography.
- Water source, direction of flow, and local depressions.
- Prevailing wind direction.
- Average and extreme rainfall patterns.
- Vegetation present on site and at an appropriate reference site.
- Sensitive areas such as adjacent wetlands or streams.
- General soil type(s).
- Angle and length of slope.
- Type of erosion feature, when present: rills, gullies, bank undercutting, alluvial fans, etc..
- Pre-development stormwater runoff flow.
- Adjacent land use and associated impervious surfaces and runoff.

## **Erosion Prevention & Control BMPs**

Erosion control BMPs are used to prevent and/or minimize soil loss. Erosion control is more effective at preventing turbid runoff than sediment control. Project sites require erosion control when vegetation is removed, when the soil is disturbed, or when water flow has the potential to cause erosion. All erosion control BMPs require regular maintenance.

Principles for vegetative erosion control include, but are not limited to:

- Minimize the disturbance to desirable vegetation (The less disturbed, the less to stabilize).
- Limit or eliminate the following activities in the area:
  - Soil compaction.
  - Mechanical damage to roots and above-ground vegetation.
  - Alterations to desired hydrological patterns.
  - Deposition or addition of chemicals detrimental to plants or soil environment.
  - Clearing. (If grubbing is not necessary, cut off tops and leave roots.)

The following table gives an overview of recommended erosion prevention & control practices.

<b>Recommended Erosion Prevention &amp; Control Practices</b>
• Design the Temporary Erosion Control Plan (TESC) for the project.
• Avoid extensive grading and earthwork in erosion prone areas.
• Preserve desirable vegetation whenever reasonable.
• Consider clearing the site in small increments whenever vegetation must be removed. Limit the duration of exposure to erosional processes.
• Install erosion prevention BMPs prior to any grading activity.
• Install hydraulic conveyance system to handle increased runoff.
• Keep runoff velocities low.
• Divert runoff from steep slopes and bare areas by constructing interceptor drains and berms.
• Divert “clean” water away from disturbed areas.
• Protect cleared areas with mulches and temporary, fast growing herbaceous covers.
• Soils that create exceptionally highly turbid runoff, such as clay and silt, should receive further protection.
• Inspect and maintain BMPs.
• Understand that erosion control plans and SSPs must be modified to fit the site conditions at any point in time.

**Figure 710.1 Recommended Erosion Prevention Practices**

For more detailed information refer to the [\*Standard Specifications for Road, Bridge, and Municipal Construction\*](#).

## **Sediment Control BMPs**

Conventional sediment control BMPs are capable of removing a certain size soil particle, but in most cases it is not enough to bring the runoff in compliance with state water quality standards. Detention time and volume is critical in sediment control. Sand and gravel takes only seconds to trap, but silt and clay can take hours to weeks to settle. Providing such detention time is not always possible. Thus, preventing erosion in the first place makes sediment control more effective.

There are 13 minimum requirements in the [Highway Runoff Manual](#) and installing sediment control BMPs is one outlined as one of the first orders of work on a site.

## Methods

### *Vegetation*

Vegetation slows or prevents erosion by intercepting raindrop impacts, retaining soil with its roots, slowing runoff velocities, and decreasing runoff volumes by increasing infiltration and transpiring water to the atmosphere.

Erosion prevention & control BMPs are most likely to succeed when planned as part of the construction process. In much of the roadside environment there is no topsoil after construction. Mulches, water, lime, and/or fertilizers might be required in order to establish vegetation. Use a soil analysis to establish these additional requirements. A Horticulturist can interpret the soil analysis.

If outside the optimum planting seasons, a method of soil cover, other than vegetation, may be necessary. These include mulches and erosion control fabrics.

### **Seeding**

Establish grass to stabilize soils whenever possible, especially before winter rains (temporary irrigation may be necessary - see the region's Landscape Architect for assistance). See the region's Landscape Architect or region's Environmental Office for site-specific seed mixes. Seed within the following time frames:

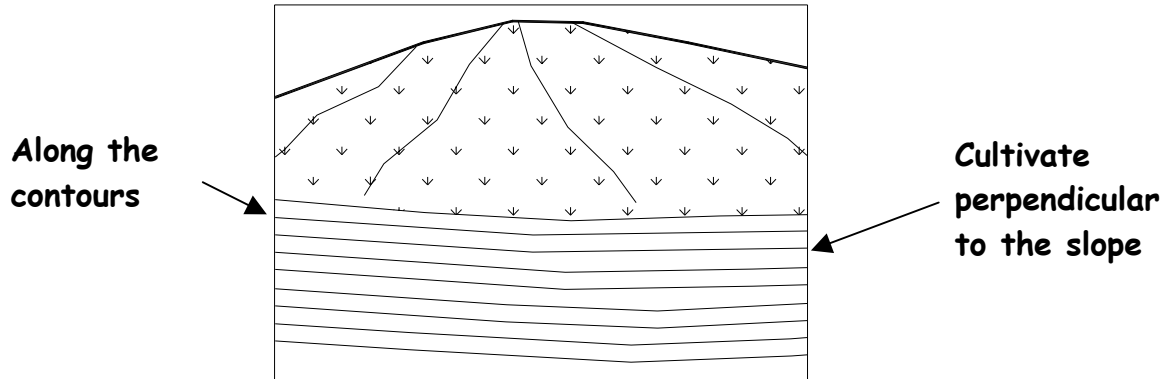
- In Western Washington: March 1 to May 15 and August 15 to October 1.
- In Eastern Washington: October 1 to November 15.

### **Long Term Erosion Control**

Native trees, shrubs, and groundcovers or emergent plants (as appropriate) are used to revegetate disturbed areas as a BMP for long-term erosion control and sediment control. To restore disturbed areas to continuous vegetative cover, consider the following points in conjunction with the [Highway Runoff Manual](#) Best Management Practices (BMPs):

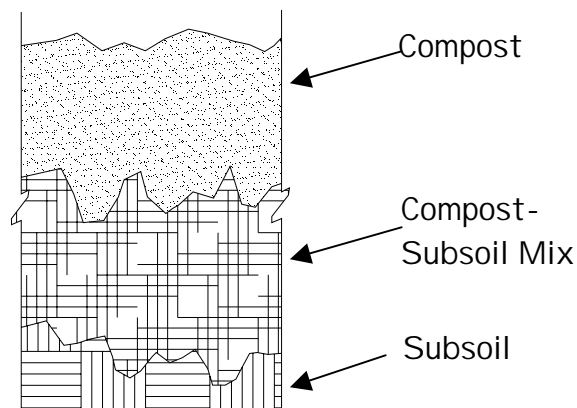
- Maintain continuous vegetative cover. This might not be possible in the steppe ecosystem, but maximum cover is desirable.

- Leave the soil surface rough and loose after soil preparation and final grading, with ridges and furrows perpendicular to the slope (on contour). This will slow the water's velocity, increase water detention and infiltration, decrease runoff, and promote vegetative growth. (This differs from soil treatment prior to installing a grass lawn.)
- Facilitate bonding of the topsoil with the subsoil. Consider ripping the subsoil prior to placing topsoil. Rough-grade, stair-step, or groove slopes along the contours.



**Figure 710.2 Groove Slopes Along Contours**

- When applying compost or topsoil, incorporate it several inches deeper than the topsoil layer. This is needed to minimize the formation of a slip plane, eliminates a perched water table, and provides roots a zone of penetration into the existing subsoil. The final surface of the topsoil will be rough in both cases.



**Figure 710.3 Soil Profile After Tilling to Mix Soil Layers**

Topsoil can be added on slopes of 2H:1V or flatter. In some sites, it is better to amend existing soil than to add topsoil. Check with the

region's Landscape Architecture Office for soil sampling and additional soil amendment information.

### ***Mulches***

Mulches can be used on the surface for temporary erosion prevention and control and incorporated into the soil to improve the soil environment for establishing vegetation. Organic mulches such as straw, wood fiber, chips, Compost Type 2, and bark are most effective for these purposes.

Both organic and synthetic tackifiers are available and can be added to bind the mulch, seed, and fertilizer to the disturbed soil surface until vegetation is established. These tackifiers can reduce the displacement of soil particles, seeds, and mulch caused by wind or rainfall.

### ***Silt Fence***

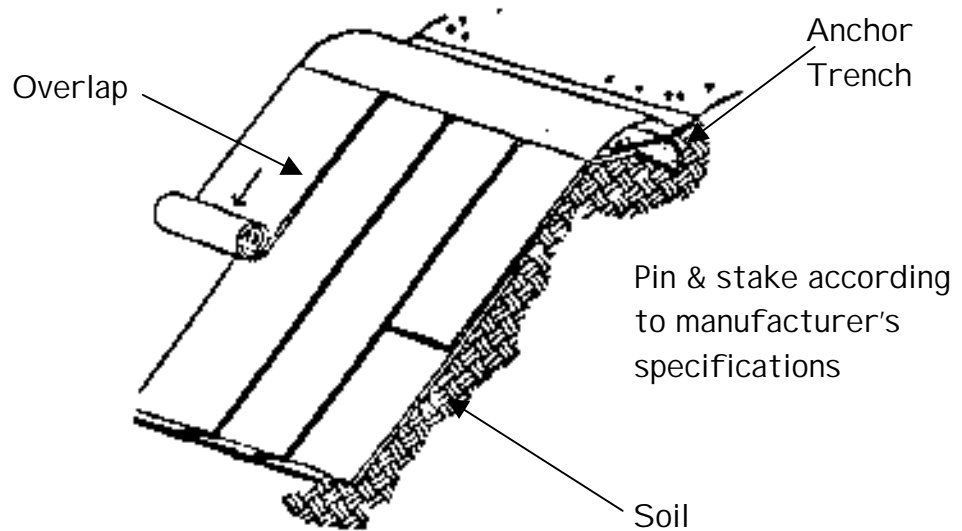
- Silt fencing is a temporary sediment control measure and must be installed per [\*Standard Specification\* 8-01.3\(9\)A](#). There are numerous types of silt fencing available. Check with the region's Environmental Office or the Statewide Erosion Control Coordinator for more information.
- Stronger, more positive controls are desirable for erosion control on projects that will overwinter, or where the BMPs may need to operate with little more than occasional inspection.
- Consider design elements in the project's earthwork and drainage that will allow good construction staging for erosion control methods and use silt fence only as a very short term (90 days) solution to erosion control.
- Flair ends to allow ponding of water and sediment. Be sure to check with the local jurisdictional agencies for specific local requirements for silt fence installation.
- Maintenance is crucial for proper silt fence performance. Redistribute the accumulated sediment in an appropriate location as directed by the Construction Inspector or the Environmental Coordinator.

### ***Rolled Erosion Control Products(RECPs)***

RECPs, also known as blankets and mats, are available in various materials and strengths depending upon the desired function. They can be used to cover soil during establishment of vegetation. Some may be left in place, if biodegradable, and will degrade over time when exposed to light. Contact the region's Environmental Office,

Hydraulics, the Statewide Erosion Control Coordinator, or the HQ Design Office Landscape Architect for aid in calculating the strength and type of material needed for each site.

RECPs must be installed properly to function well. An anchor trench is typically used and the fabric must be pinned and staked firmly in an overlapped position so that water does not lift the material from below.



**Figure 710.4 Typical RECP installation**

The following table lists types of erosion control fabrics. See manufacturers for details.

<b>ROLLED EROSION CONTROL PRODUCTS</b>		
<b><i>PRODUCT</i></b>	<b><i>ADVANTAGES</i></b>	<b><i>DISADVANTAGES</i></b>
Netting Not recommended		<ul style="list-style-type: none"> <li>• Temporary (&lt;1 yr.) and used with dry mulch</li> <li>• More costly than tackifier</li> <li>• Netting might interfere with maintenance if improperly anchored</li> <li>• Wildlife, such as birds, reptiles, and amphibians, might get tangled in the netting</li> </ul>
Open Weave Mats	<ul style="list-style-type: none"> <li>• Low to moderate cost</li> <li>• Moderate sediment yields</li> <li>• Allows moderate vegetative density</li> <li>• Moderate moisture absorption</li> </ul>	<ul style="list-style-type: none"> <li>• Temporary (1-2 years)</li> <li>• Low flows only</li> <li>• Incomplete ground cover (approximately 60% Open Space)</li> </ul>
Blankets	<ul style="list-style-type: none"> <li>• Low to moderate cost</li> <li>• Easy to install</li> <li>• Good moisture absorption</li> <li>• Very low sediment yield</li> <li>• Allows high vegetative density</li> </ul>	<ul style="list-style-type: none"> <li>• Temporary (1-3 years)</li> <li>• Low to moderate flows</li> <li>• Netting might interfere with maintenance if improperly anchored.</li> </ul>
Turf Reinforcing Mats	<ul style="list-style-type: none"> <li>• Moderate costs</li> <li>• Long-term (indefinite)</li> <li>• Moderate to high flows</li> <li>• Encourages infiltration</li> <li>• Allows moderate to high vegetative density</li> <li>• Extends performance limits of vegetation</li> <li>• Flexible - conforms to differential settlement</li> </ul>	<ul style="list-style-type: none"> <li>• Low to moderate sediment yields (unvegetated)</li> <li>• Requires vegetative establishment for effective long-term performance</li> </ul>

**Figure 710.5 Advantages and Disadvantages of Rolled Erosion Prevention Products by Type**

## ***Wattles, Water Bars and Fascines***

Wattles, water bars and fascines can be used to intercept runoff and to direct water across a slope to a selected location. They are common bioengineering techniques. Imbed and stake wattles, water bars, and fascines into the slope. They may be used in sets or in combination with other erosion control and sediment control methods.

## ***Straw Bales***

- As check dams, they are not an approved BMP.
- Other materials, such as quarry spalls, washed gravel, sand bags, and geotextile-encased silt dikes, are approved.
- Straw bale barriers are similar to silt fence in function and are an approved BMP.

## ***Sandbags***

Sandbags can be used as a temporary interceptor to slow water velocity. Sandbags placed across access or interior construction roads provide for a means to divert or slow erosive water flows on a construction site.

## ***Bonded Fiber Matrix***

A bonded fiber matrix is a continuous layer of wood fiber strands held together by a water-resistant bonding agent. When properly applied, it eliminates direct raindrop impact on soil, allows no gaps between the product and the soil, and it has a high water-holding capacity. A bonded fiber matrix will not form an impervious crust that can inhibit plant growth, and it will biodegrade completely into materials known beneficial to plant growth.

## ***PAM***

Polyacrylamide (PAM) is an inorganic polymer flocculant, with the ability to stabilize soils and remove fine suspended sediments from stormwater runoff. It is an approved BMP for soil binding and tacking mulch. The approved standard specification is as follows:

### **8-01.3(2)C Soil Binding Using Polyacrylamide (PAM)**

PAM shall be applied only to areas that drain to completed sedimentation control BMPs in accordance with the TESC plan. PAM shall not be applied to the same area more than once in a 48 hour period, or more than 7 times in a 30 day period.



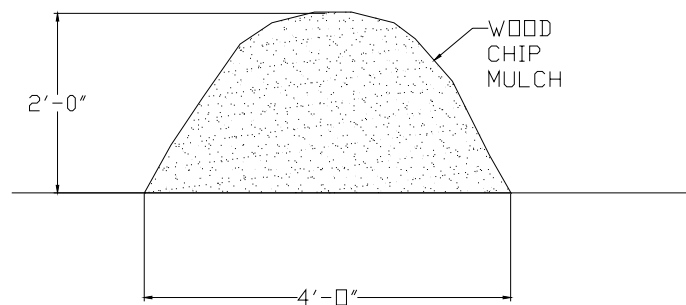
When applied with water, it shall be completely dissolved and mixed prior to application to the soil. PAM shall be applied at a rate of 0.5 pounds/1000 gallons water/1 acre. A minimum of 200 pounds of cellulose fiber mulch, treated with a non-toxic dye, shall be added and applied with the PAM.

When applied dry, the maximum rate is 5 pounds/1 acre. The PAM cannot be applied when it is raining. For small areas, a hand-held “organ grinder” fertilizer spreader, set to the smallest setting, will work. Tractor-mounted spreaders will work for larger areas.

Polyacrylamide (PAM) products shall meet ANSI/NSF Standard 60 for drinking water treatment. PAM shall be “anionic” (non-ionic) and linear (non-crosslinked). The minimum average molecular weight shall be 5 Mg/mole. See the latest [Standard Specifications for Road, Bridge and Municipal Construction](#) for full PAM specifications.

### Wood Chip Berms

Wood chip berms are an approved Standard Specification for erosion control. Studies have shown they are effective in slowing and treating stormwater runoff when installed and maintained properly. In addition to their immediate benefits, these berms can be either left in place or can be redistributed around adjacent plantings once vegetation has stabilized the upslope surfaces.



## WOOD CHIP BERM

NOT TO SCALE

**Figure 710.6 Wood chip berm detail**



## General

Contour grading directs water to a desired point, prevents erosion, provides noise deflection, provides visual fit of the facility into the landscape, and protects desirable vegetation. Examples of locations where contour grading is used are wetland mitigation sites and noise berms.

Contour grading plans detail the blending of the constructed landform with the surrounding earth forms. Blending the facility into adjacent landforms is Washington State Department of Transportation (WSDOT) policy, as stated in the *Roadside Classification Plan*.

## References

*Construction Manual* M 41-01, WSDOT

*Design Manual* M 22-01, WSDOT

*Highway Runoff Manual* M 31-16, WSDOT

*Hydraulics Manual* M 23-03, WSDOT

*Roadside Classification Plan* M 25-31, WSDOT

WSDOT Soil Bioengineering website:

<http://www.wsdot.wa.gov/eesc/cae/design/roadside/SBwebsite/mainpage/Index.html>

## Resources

The region's Landscape Architect Office

The region's Materials Engineer

HQ Hydraulics Office

HQ Roadside and Site Development Unit

HQ Geotechnical Branch

## Definitions

**angle of repose** The angle between the horizontal and the maximum slope that a soil assumes through natural processes.

**berm** The continuous artificial contouring of a slope or water-channel bank.<sup>1</sup>

**contour** An imaginary line on the surface of the earth connecting points of the same elevation.

**contour interval** The difference in elevation between two contours.<sup>2</sup>

**cross section** The representation of a landform as it would appear if cut by an intersecting plane.

**cut** That part of the ground surface that, when graded, is lower than the original ground.<sup>3</sup>

**datum** In surveying, a reference point, line, or surface for computing or correlating the results of surveys. In surveying, there are two principal types of datums: vertical and horizontal.

**elevation** Vertical distance of a point above or below a reference surface or datum.<sup>4</sup>

**fill** That part of the ground surface that, when graded, is higher than the original ground.<sup>5</sup>

**finish grading** Minor changes to finalize a prepared earth surface to its desired grade.

**grading** Modification of the ground surface by cuts and/or fills.

**interpolation** The determination of the elevation of a location between two known points. Done by calculating the slope between known points and using the horizontal distance from the known point to the intermediate point to calculate the elevation of the intermediate point.

**profile** The representation of a landform seen from the side.

**section** See *cross-section*.

## Contour Grading Plans

WSDOT grading for roadways is represented on plans using cross-sections. Landforms other than the roadway prism are usually represented using contours. Contour grading plans are required for landforms that have irregular variations between cross-sections. They

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<sup>1</sup> Hugo Schiechtl, *Bioengineering for Land Reclamation and Conservation*, University of Alberta Press, 1980.

<sup>2</sup> Morris M. Thompson, *Maps for America*, U.S. Department of Interior, Geological Survey National Center, Reston, Virginia, 1987.

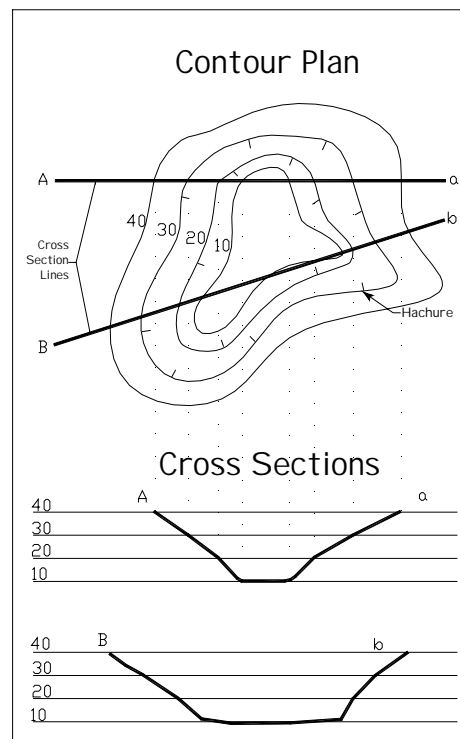
<sup>3</sup> Steven Strom and Kurt Nathan, *Site Engineering for Landscape Architects*, Van Nostrand Reinhold, New York, 1992.

<sup>4</sup> Thompson, 1987

<sup>5</sup> Strom and Nathan, 1992.

are also used to show fine grading where profiles or cross-sections do not show enough detail. Examples include wetland mitigation sites, retention and detention ponds, noise abatement berms, and interchanges. Cross-sections or grids for additional clarification often accompany contour grading plans. These elements, work together for an improved finished product that reduces the need for interpretation during construction. In addition, minor landform changes can affect sensitive plant and animal ecosystems. For example, providing for amphibian habitat requires grading plans to be accurate to within a few millimeters (inches) because these species need shallow water depths.

*Contour lines* graphically connect points of the same elevation in plan view. Contours are separated by a *contour interval*, which is the vertical separation between the contour lines. Each contour is separated from the next by that number of vertical units. In the figure below, the contour interval is 10 meters. Depending upon where the lines are drawn, the cross sections appear very different.



**Figure 720.1 Contours**

In [Figure 720.1](#), the contour line labeled “40” is exactly 40 units above a known point called a *datum*. Assume that every point on that line is exactly 40 meters above the datum. If this basin was filled with water to the 40 meter contour, the edge of the water would follow the contour line when viewed from above.

On any given plan sheet, contours that are spaced far apart have a gradual degree of slope. In contrast, contours that are spaced close together indicate steeper slopes. It is necessary to read the numbers along the contour lines to determine which direction the ground is sloped. Hachures are used on the down slope side of contours to depict enclosed concave forms.

### **The Rules of Contours:**

- Existing contours are drawn with dashed lines. Proposed contours are drawn with solid lines.
- Contours never cross.
- Contour lines depict connected points of equal vertical position.
- All contour lines close on themselves (this may be either on or off the plan sheet or map).
- The steepest slope is along a line perpendicular to the contour lines. Water will always flow downhill in a line perpendicular to contour lines.
- Contour lines never merge into one another. However, on a vertical face, such as a retaining wall, they may appear to merge on the plan sheet.
- The greater the detail of the plan, the smaller the contour interval.

Use interpolation to determine the approximate elevation of any point between contour lines. A point half way between the 30 m and 40 m contours, would have an elevation of 35 meters. A point four-tenths of the distance between the 27 m and 28 m contours would have an elevation of 27.4 meters.

A contour plan conveys grading information that would otherwise require many cross-sections to convey. For complex roadside grading, cross-sections used alone do not provide adequate information to ensure that the design intent is being met. It is for this reason that most roadside grading is depicted in a contour grading plan format. When cross-sections are used in conjunction with a contour grading plan they represent the condition only at the location of the cross-section line.

Cross-sections are used differently when they are intended to show a typical condition. For example, on a linear facility with a centerline (such as a roadway), cross-sections are often used to represent a typical condition between two stations. Make the intention clear on the plan sheet.

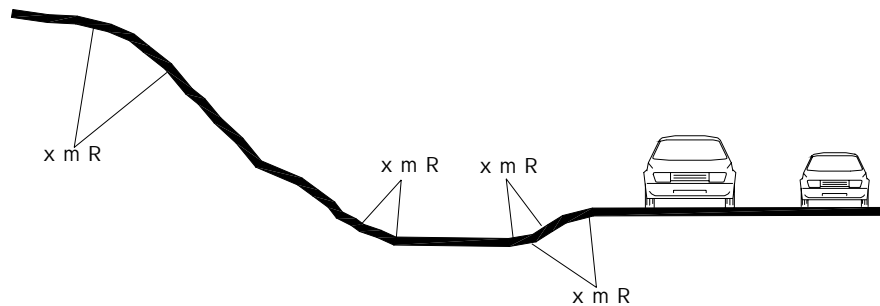
## Contour Design

There are many, often competing elements that require consideration in the design phase. Routes that are designated scenic highways might have a Corridor Management Plan. Review and consider the Corridor Management Plan to identify any considerations, such as visual appearance or buffers that might need to be factored in to the design.

Consider the following factors when developing a contour grading plan and associated cross-sections:

- The intent of the plan when choosing contour intervals.
- Drainage (including detention and retention functions).
- Balancing of cut and fill within project limits, if possible. It might be possible to create a berm to use excavated material from that project.
- Maximum allowable cut or fill next to a structure (minimum cover over a footing, maximum fill behind a wall or next to a pier).
- Vehicle recovery areas.
- Sight distance.
- Pedestrian safety and security.
- Impacts to groundwater and surface water both on and off the right of way, including wetlands.
- Preservation of existing desirable vegetation.
- Preservation of existing topsoil.
- Slope angle and potential soil erosion.
- Soil properties and angle of repose.
- Fence detention and retention ponds if banks are equal to, or steeper than 3H to 1V

Slope rounding. For design details on slope rounding, see [Standard Plans](#), number H8.



"x m R" represents the meter radius needed to meet the design intent and blend into surrounding landforms.

**Figure 720.2 Slope Rounding**

- Fit of the graded area into the surrounding landscape for corridor continuity.
- Visual factors (a form that blends with the adjacent landforms).
- Cost of grading.
- Slopes steeper than 2H to 1V may be difficult to stabilize and establish vegetation on.
- Maintenance access to drainage and traffic operational features.
- Access along fence line or noise walls, if necessary.
- For areas that are to be mowed, design slopes to be no steeper than 3H to 1V.

The region's Materials Engineer or HQ Geotechnical Branch can evaluate the stability of cut and fill slopes, help determine the groundwater regime, and determine the permeability of soils. Contact the region's Materials Engineer early in the design phase to allow for groundwater and soil engineering properties testing, as appropriate. See the [Design Manual](#) for guidelines.

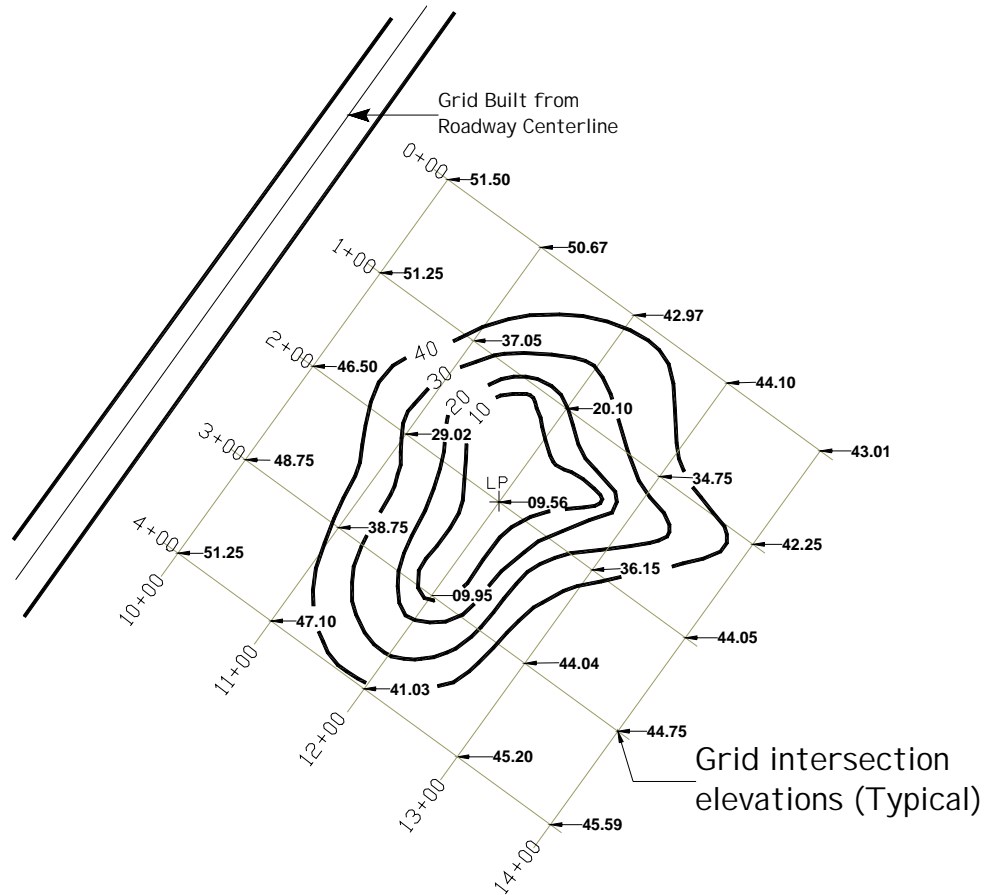
## Construction

The use of the grid method or station and offset method is useful in transferring grading information from the plans to locations in the field.



## Grids

To simplify staking during construction, a grid can be laid over the contour grading plan as seen in the simplified figure below.



**Figure 720.3 The Grid**

The grid size will be related to the size of the site and the complexity of the design contours. Make sure that enough grid points are used to reflect the contours as shown on the plan. Ensure that high and low spot elevations are located.

The grid is tied to a known base line and station point such as a roadway centerline, a fence, or a right of way line. Elevations at the grid intersections can then be determined by interpolation. Mark the elevation at all grid intersections. Contours and spot elevations can then be staked in the field using the elevations shown on the plans.

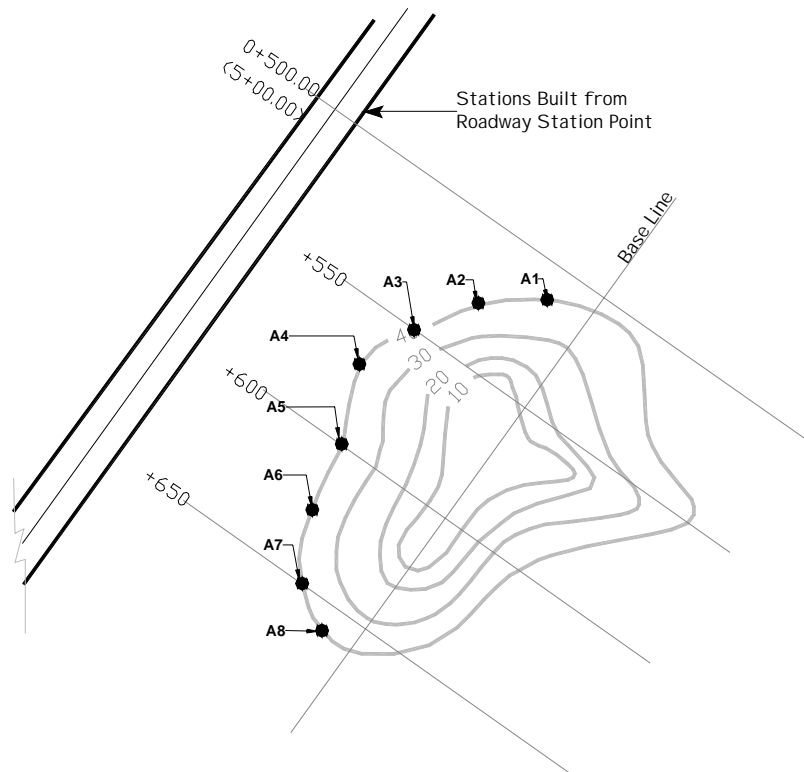
## Station & Offset Method

The station and offset method is an alternative to the grid method for locating contours in the field.

- Define the base line either by extending a known center line or by

drawing a line between two known survey points.

- Identify lines perpendicular to the base line at station points to measure the distance of control points from the base line.
- If available, use a data collector with a “Roading” module to set stakes in the field. With proper survey techniques, elevations will be determined at the location of the station and the offset. By comparing the elevation with the contour, a cut or fill can be marked on the stake.



**Figure 720.4 Baseline, Stations, and Offset Points**

A table showing the location of the control points, as in Tables 720.1 and 720.2, is an integral part of this method. Right or left direction of offset is determined by the direction of increasing stations.

Station	Station Point	Offset (m)
A1	0+511.80	15.70 Rt
A2	0+527.90	35.27 Rt
A3	0+550.00	49.35 Rt
A4	0+570.82	57.46 Rt
A5	0+600.00	45.23 Rt
A6	0+626.47	40.77 Rt
A7	0+700.00	29.00 Rt
A8	0+719.24	12.00 Rt

**Table 720.1 Metric Station & Offset Table**

Station	Station Point	Offset (ft)
A1	5+11.80	51.51 Rt
A2	5+27.90	115.72 Rt
A3	5+50.00	161.91 Rt
A4	5+70.82	188.52 Rt
A5	6+00.00	148.39 Rt
A6	6+26.47	133.76 Rt
A7	7+00.00	95.14 Rt
A8	7+19.24	39.37 Rt

**Table 720.2 English Station & Offset Table**

As with all contour grading plans, the plan sheet is accompanied by cross-sections. Include notes stating that grading between cross-sections will be as shown on the plan. Discuss this with the contractor at the preconstruction meeting. The slope can also be labeled on the cross-section.

### **Cross-Sections**

When cross-sections are included in a contract set, it is important to confirm whether they represent a typical condition or the condition only at a specific location. Generally, when cross-sections are used in conjunction with a contour grading plan they represent the condition only at the location of the cross-section line. Cross-sections that represent a typical condition are usually labeled as “Typical” or are labeled for “Sta \_\_\_\_ to Sta \_\_\_\_.”

## Compaction

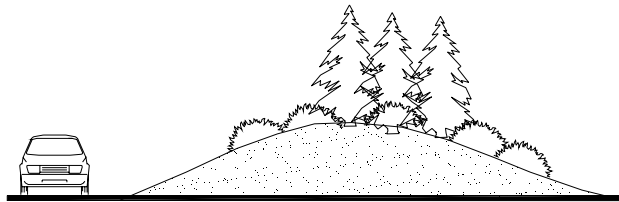
Soil compaction hinders plant growth and infiltration of water. The possibility of soil compaction exists when large equipment is grading a site. Soil compaction can be minimized by:

- Working when soils are not saturated.
- Ensuring vehicles have wide tracks or wide wheels (low ground pressure equipment [LGP]).
- Minimizing the passes a vehicle makes over any one area.

Refer to [Chapter 700](#) of this manual, “Soil and Soil Amendments” for more information.

In some cases, such as in detention pond berms, compaction is desirable. They will fail if not compacted. Slopes can be compacted to prevent surface sloughing. See the soil bioengineering chapter for information on using plants in combination with other materials, such as logs or rock, to stabilize slopes.

## Earth Berms



**Figure 720.5 Roadside berm example**

Berms are used to:

- Visually screen distracting views.
- Provide and enhance corridor continuity.
- Mitigate safety hazards.
- Provide noise abatement either alone or in conjunction with noise walls.
- Waste material from other sites.
- Retain or detain surface water flow.

## **Materials**

Berms can be used to balance cut and fill. However, materials used in the berm must facilitate plant establishment and continued growth. Materials used in berms must allow for the stability of the berm.

The materials used in the berm will determine the angle of the slope. Finer grained materials, such as clays and silts, require a flatter slope for stability.

The use of recycled materials, such as asphalt, has environmental and legal implications. Consult the HQ Construction Materials Engineer when recycled materials are considered.

For details on topsoil and compost see the Soil and Soil Amendments chapter in this manual, [Chapter 700](#).

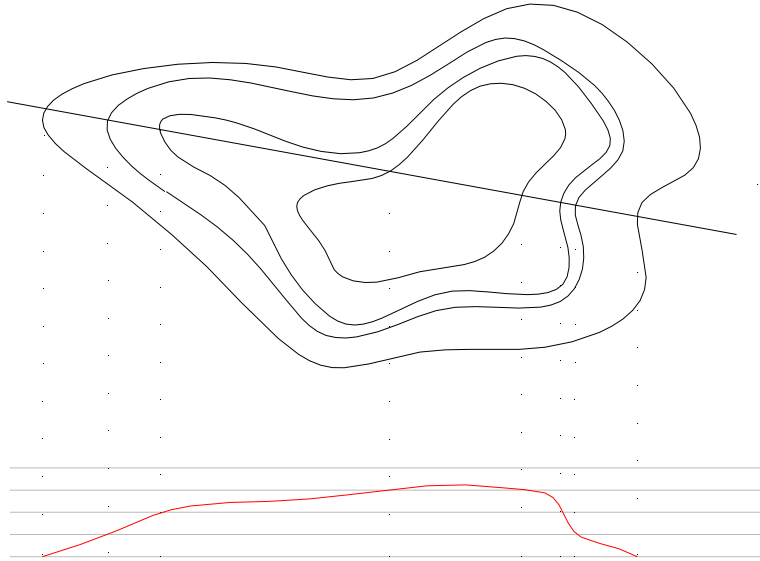
When noise walls are constructed on a berm, the materials must be able to support the weight of the noise wall. Consult the Technical Services Unit and the region's Materials Engineer for all berms that are used as a base for noise walls and when deciding whether material is suitable for a berm, as directed in the [Design Manual](#).

For any berm over 3 m (10 ft) high and any berm in conjunction with a detention/retention pond, consult the region's Materials Engineer. For detention/retention pond berms, consult with the Hydraulics engineer. These berms have specific engineering requirements and must meet dam design standards per the Washington State Department of Ecology.

For information on planting on berms within the highway right of way, see the vegetation chapter in this manual.

### ***Berm Design***

Berms can have variations in grades. When the slope, or grade, changes, the distance between contours on the plan changes as shown in the Figure below.



**Figure 720.6 Varying Distances Between Contours**

Variations in the distance between contours can make berms appear more natural and blend them into their surroundings.

**General**

Soil bioengineering is the use of plant material, living or dead, to alleviate environmental problems such as shallow rapid landslides, and eroding slopes and streambanks. In bioengineering systems, plants are an important structural component, not just an aesthetic component. This approach to slope stabilization requires a true partnership between engineering geologists, maintenance personnel, civil engineers, and landscape architects.

Soil bioengineering technology has been practiced for thousands of years. Chinese historians, for example, recorded the use of soil bioengineering techniques for dike repair as early as 28 BC. Construction of the German autobahn system during the 1930s involved extensive applications of soil bioengineering technologies.

Soil bioengineering most often mimics nature by using locally available materials and a minimum of heavy equipment, and can offer roadside managers an inexpensive way to resolve local environmental problems. These techniques can also be used in combination with “hard” engineering techniques such as rock or concrete structures.

Soil bioengineering project areas require periodic monitoring and maintenance until plants have become established.

Benefits of soil bioengineering include:

- Erosion areas often begin small and eventually expand to a size requiring costly traditional engineering solutions. Installation of soil bioengineered systems while problems are small will provide economic savings and minimize potential impacts to the road and adjoining areas.
- Soil bioengineering work is often the only practical alternative on sensitive or steep sites where heavy machinery is not feasible.
- Many designs can be implemented by hand crews.
- Native plant species are usually readily available and adapted to local climate and soil conditions. Costs might be limited to labor for harvesting, handling, and transport to the project site.
- Soil bioengineering projects may be installed during the dormant season of late fall, winter, and early spring. This is the best time to install plants and it often coincides with a time when other construction work is slow.

- Years of monitoring have demonstrated that soil bioengineering systems provide limited initial benefits, but grow stronger with time as vegetation becomes established. Even if plants die, roots and surface organic litter continue to play an important role during reestablishment of other plants.
- Once plants are established, root systems remove excess moisture from the soil profile. This often is the key to long-term soil stability.
- Soil bioengineering provides improved environmental functions, such as slope stabilization, stormwater retention, and habitat values.

## References

*Design Manual* (M 22-01), Soil Bioengineering Chapter.

USDA Natural Resource Conservation Service. Chapter 16, “Streambank and Shoreline Protection,” *Engineering Field Handbook*. United States Department of Agriculture, 1996.

USDA Natural Resource Conservation Service. Chapter 18, “Soil Bioengineering for Upland Slope Protection and Erosion Reduction,” *Engineering Field Handbook*. United States Department of Agriculture, 1992.

H.H. Allen and J.R. Leech. *Bioengineering for Streambank Erosion Control - Report 1, Guidelines*. Technical Report EL-97-8. U.S. Army Engineer Waterways Experimental Station, Vicksburg, MS. 1997. Can be found on the Internet through the following link:

<http://www.wes.army.mil/el/wetlands/wlpubs.html>

WSDOT Soil Bioengineering website:

<http://www.wsdot.wa.gov/eesc/cae/design/roadside/SBwebsite/mainpage/Index.html>

## Resources

The region’s Materials Engineer

Headquarters (HQ) Design Office Roadside and Site Development Unit

HQ Materials Lab, Geotechnical Branch, Engineering Geologists and Geotechnical Engineers

The region’s Landscape Architect

## Definitions

***angle of repose*** the angle between the horizontal and the maximum slope that a soil assumes through natural processes.<sup>1</sup>

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<sup>1</sup> Robert W. Zolomij. “Vehicular Circulation.” *Handbook of Landscape Architecture Construction*. 1975. p. 66.



Approximate Angle of Repose for Soil Texture	
Very wet clay and silt	1V:3H
Wet clay and silt	1V:2H
Dry sand and gravel	1V:1¾
Dry clay	1V:1½
Moist sand	1V:1¼

**slope gradient** the angle of the slope as expressed in a percentage.

**soil bioengineering** the use of live plant materials and engineering techniques to reinforce soil and stabilize slopes.

## Planning

Evaluate soil bioengineering methods as a possible tool for remediation and restoration of degraded slopes. Soil bioengineering has unique attributes, but is not appropriate for all sites. In some cases a conventional vegetative treatment works with less cost, or it may be best to use a geotechnically-engineered system alone or in combination with soil bioengineering.

- Evaluate projects that leave exposed slopes, and slopes requiring high maintenance for stabilization, for possible application of soil bioengineering technologies.
- Include bioengineering technologies as an alternative when evaluating costs.
- Include a slope stability analysis in plans for large erosional slopes.

## Design

### ***Landscape Setting and Uses***

Consider the natural history and evolution as well as cultural and social uses of the surrounding landscape. An awareness of these factors, and how they shape the present and potential future landscape, is critical for project success.

Knowledge of current and future roadside and land management goals is essential for project success. Consider the natural history, cultural, and social issues of the surrounding landscape as well. A proposed soil bioengineering project within a forested landscape, for example, requires knowledge and understanding of:

- Road construction methods and current maintenance practices.

- Objective of the bioengineering project - repair, remediation, prevention, habitat, etc.
- The area's geologic and glacial history.
- Its propensity for wild fires, wind storms, and floods.
- Occurrence and trends of natural and management related erosion.
- Sequence of vegetation removal and revegetation efforts.
- Fire management history.
- Soil Types and Properties
- Hydraulic and hydrological erosion and scour characteristics.

### ***Trends Within Erosion Sites***

Whether erosion occurs naturally or through human-induced activities, a site begins to heal itself immediately upon “failure” by trying to achieve an angle of repose. In mountainous terrain, for example, wood may become embedded in the slope thus terracing eroding soils. Once an angle of repose has been achieved between these natural terraces, vegetation begins to establish. Herbaceous plants usually provide initial vegetative cover on these sites. This initial cover also assists in establishment of soil microorganisms. Typical succession patterns evolve in stages from exposed ground, through herbaceous plant, shrub, pioneer tree, and finally mature tree stages. The first step is to examine and document these trends. Soil bioengineering designs are used to accelerate site recovery by mimicking what is happening naturally.

### ***Site Evaluation and Design Check List***

There are many soil bioengineering systems. Selection of the appropriate technique, or techniques, is critical to successful restoration. At a minimum, consider the following:

#### ***Climatic Conditions:***

Climates near the ground can vary considerably within short distances. South facing valley walls, for example, receive more direct sun rays, which cause higher soil temperatures, increased evaporation, more rapid snowmelt in the spring, and generally drier conditions than on the more shaded north facing walls. This difference will influence erosion rates and the composition and vigor of revegetation efforts.

- Consider precipitation types, amounts, seasonal variation, and duration.
- Consider temperatures, including seasonal averages and extremes.

### ***Topography and Aspect:***

- Slope gradient.
- Terrain shape (for example, gentle slope to valley or sharp peaks).
- Elevation of project area.
- Direction of sun exposure.

### ***Soils***

Identify conditions above, below, or within the project site that might have an effect on the project and incorporate these considerations into the design. Consult with the HQ Engineering Geologist to determine need for slope stability analysis. Some categories below will require soil testing to determine.

- Substrate - take soil probe sample from potential site.
- Soil types
- Soil permeability
- Moisture holding capacity
- Nutrient availability

### ***Water***

Detailed analysis or work in streams or rivers will require consultation with a hydraulics engineer. Work affecting streams or rivers will require consultation with the regional environmental office.

- Water velocity: Lateral stream stability
- Hydrologic regime: general and site specific.
- If applicable, stream and fish types affected by the erosion site.
- Location of natural drainage channels and areas of overland flow from road surfaces.
- Areas for safe water diversion.
- Condition of ditch line and culvert inlets and outlets.

### ***Erosion Process***

- Evidence of past sliding: deep or shallow failure surface in vicinity.
- Regional geomorphic trends or slope features (review aerial photos).
- Type of mass wasting or surface erosion feature.

- Source of eroding material: road fill slope, cut slope, landing, etc.
- Trend of site: improving naturally, remaining uniform, or worsening.

### ***Vegetation***

- Plant species and amount growing within and adjacent to project site. It is especially important to identify colonizing species.
- Locations for plant and seed collection.

### ***Plant Materials***

Living vegetation is the most critical component of a bioengineered system. Existing vegetation and knowledge of predisturbance plant communities can inform the designer of project limitations, opportunities, and long-term ecological goals.

Work with local native plant experts or the region's Landscape Architect, or the HQ Roadside & Site Development Unit to select the most appropriate plant species for the project area.

Deciding which plants to use is affected by the following factors:

- Site characteristics (topography, elevation, aspect, soil moisture, nutrient levels).
- Existing vegetation.
- Intended role of vegetation in the project.
- Growth characteristics and ecological relationships of the plants.
- Availability.
- Logistical and economic constraints.

Plants that can resist mechanical stresses of erosion, floods, and landslides, while developing a strong, stabilizing root system are best suited for soil bioengineering applications.



**Figure 740.1 Willow Rooting After 6 Week Immersion in Water.**

Examples of riparian plants suitable for soil bioengineering work include willow, dogwood, cottonwood, big leaf maple, spruce, cedar, aspen, and alder.

Plants better suited for drier and poorer soil conditions include bitter brush, basin big sage, rubber rabbit brush, snowberry, white pine, lodgepole pine, Douglas maple, oceanspray, and blue elderberry.

The best indicator of which plant materials to consider for the soil bioengineering project is the plants growing on or adjacent to the project site.

Plant materials are chosen from among those species available on the site or nearby. Alternatively, it might be possible to salvage like species from a similar area where vegetation is scheduled to be removed. Logistical concerns are important in the selection of plant material.

A single species may serve the primary structural requirement of the vegetation in a soil bioengineered system. However, it is preferable to use a mixture of species with varying, but complementary, characteristics. Benefits of using multiple species include:

- Lower susceptibility to devastation by disease or pests.
- Combinations of deep and shallow rooting species and vegetation of varying heights.
- The system is allowed to respond to changes in site conditions.

## **Construction**

### ***Project Planning and Implementation***

#### ***Coordination & Communication***

- Develop and implement a communication plan to keep all players involved, interested, and informed.
- Establish clear project objectives. Have these objectives reviewed and approved by participants including the maintenance personnel and the region's Landscape Architect.
- List all project phases. Under each phase, catalogue and schedule all work items. For each work item, list the responsible parties and the dates the tasks must be completed. Identify and resolve timing conflicts. Build flexibility into the schedule (the Work Breakdown Structure).
- Ensure coordination between heavy equipment operators and hand crews.

#### ***Site Work***

- Sites often require earthwork before installing a soil bioengineering system. Resolve timing conflicts that occur between scheduling heavy equipment, hand labor work, plant collection, and use.
- Select the right equipment for the job.
- Identify and remove work hazards.
- Determine access route for people and machinery to minimize site disturbance. For example, limiting hand crews to one entrance and exit route will cause less soil disturbance to the site and adjoining areas.
- Temporarily divert excess water.
- Stockpile excavated soils. Place soil in windrows to allow soil organisms access to oxygen. The least amount of time the soil is stockpiled the better.
- Retain or salvage existing vegetation for later use. Salvage material from healthy, young plants.
- Provide temporary surface erosion and sediment control measures.

## Project Work

- Before beginning a project, conduct an on-site meeting. At a minimum, include team members with vegetation, local climate, and soils knowledge.
- Avoid earthwork in saturated soils. When possible, schedule heavy equipment work during periods of low precipitation.
- Round the top edge of a slope failure, which is often a vertical face. For project success, it is critical to address this “initiation point” or persistent source of erosion by removing or rounding off the slope overhang.
- Smooth all eroding areas such as rills or gullies. In addition, prepare a seed bed by slightly roughening the area. Do this by raking across the slope face, not downhill.
- Create terraces when slopes exceed 35 percent. Dig these terraces 10 to 14 inches deep across the slope face. Horizontal spacing usually varies from 14 to 10 feet depending on conditions. The steeper the slope, the closer the terraces should be to one another. The objective is to accelerate establishment of plants by reducing the slope angle of the planted locations.

Inspect project work daily.

Information on transplanting has been moved to [Chapter 800](#) in this manual.

## Techniques

Details for installation of live facines, live staking, brush layering, brush mattress, live cribwalls, and live gabions can be found at:

<http://www.wsdot.wa.gov/eesc/cae/design/roadside/SBwebsite/mainpage/Design/Techniques/specdetail.html>

Information on erosion control blankets can be found in Chapter 710, Erosion Control, of this manual and on the internet at:

<http://www.wsdot.wa.gov/eesc/environmental/programs/hazwqec/wqec.htm>

## Live Staking

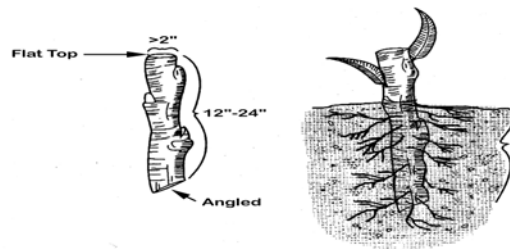


Figure 740.3 Live Staking

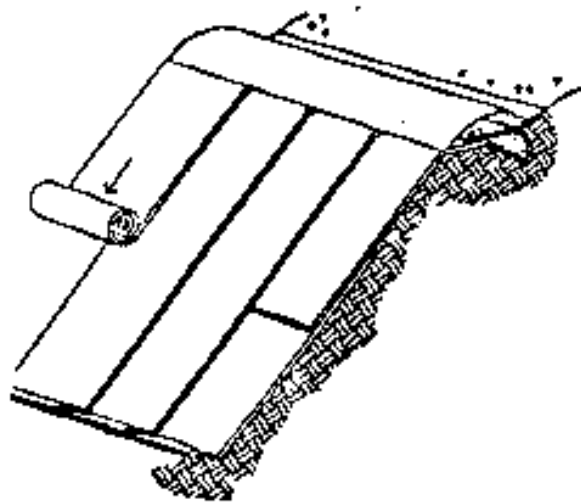
Live staking involves insertion and tamping of live, rootable vegetative cuttings (such as willow, cottonwood, and red-osier dogwood). If correctly prepared and placed during early spring, the live stakes will root and grow.

**Advantages:** A system of stakes creates a living root mat that stabilizes soil by reinforcing and binding soil particles together and by extracting excess soil moisture. This is an appropriate technique for repair of small earth slips and slumps that usually have moist soils.

**Disadvantages:** Does not solve existing erosion problems (excluding benefits from associated mulch). Staking is not a short-term solution for slope instabilities.

### ***Erosion Control Blanket***

Installation of erosion control blankets involves site preparation, trenching, application of grass, and/or forb seed mix and soil amendment, and installation of fabric. This technique is suitable for treating surface erosion areas; especially fill slopes where there is a concentration of surface water runoff. The erosion control blanket provides immediate protection of the soil from erosion. The seed mix will sprout, grow, and lock the underlying soil in place with its root mass.



**Figure 740.4 Erosion Control Blanket**

**Advantages:** Excellent for mitigating surface erosion. The blanket offers immediate and uniform slope protection from rain and overland water flow.

**Disadvantages:** Can be labor-intensive and expensive. Could require numerous wood stakes or live stems to secure the erosion control blanket. Too much grass within the blanket will lead to over competition



for moisture and high tree and shrub mortality if live stakes are used. If the seeding is too dense, the combined matting of these grasses with the blanket can prevent other grasses from emerging.

### ***Live Cribwalls***



**Figure 740.5 Live Cribwall Under Construction**

A live cribwall consists of a hollow, box-like interlocking arrangement of untreated log or timber members. The structure is filled with suitable backfill material, such as topsoil, and layers of live branch cuttings, such as willow, which root inside the crib structure and extend into the slope. Tilt the cribwall back into the sloped surface at a 10% angle. Once live cuttings root and become established, subsequent vegetation gradually takes over the structural functions of wood members. Consider the flow of runoff adjacent to the wall to ensure that the wall will not be undermined. Contact the materials engineer for help in calculating slope stress.



**Figure 740.6 Live Cribwall with Willow Stakes**

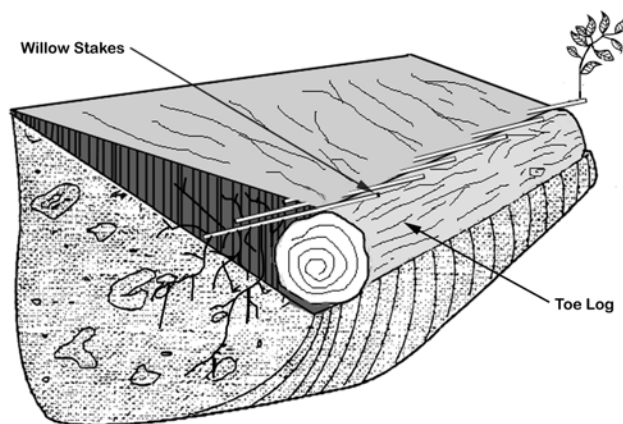
**Advantages:** Appropriate at the base of a cut or fill slope where a low wall, or log, might be required to stabilize the toe of a slope and reduce slope steepness. Useful where space is limited and a more vertical structure is required. Provides immediate protection from erosion and established vegetation provides long-term stability. Aesthetically more pleasing than gabion baskets.



**Figure 740.7 Live Cribwall 18 months after installation**

**Disadvantages:** Not designed for or intended to resist large, lateral earth stresses. Depending on soil quality of cut slope, may have to use commercial fill material. Can be labor intensive and expensive to construct. Can have high mortality if willow stems are not collected when dormant, are not properly stored, or are mishandled in transfer.

***Variation: Toe Log Technique***

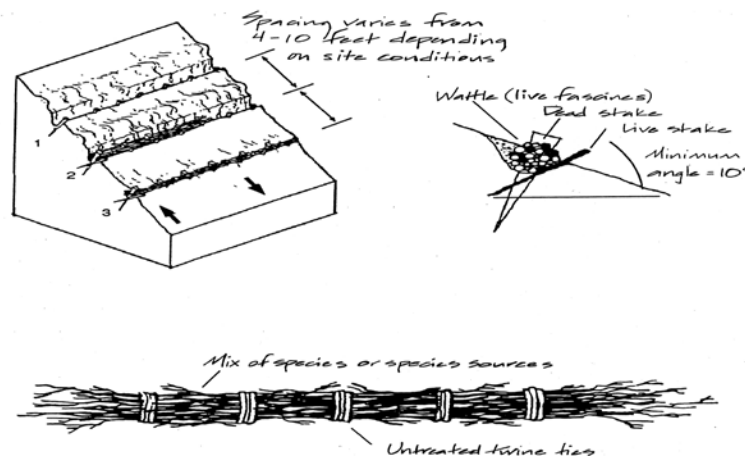


**Figure 740.8 Toe Log Technique**

This technique is handy for very small cut slope erosion features, for example, 3 m by 4.5 m (10 feet high by 15 feet) wide. Place a 500 mm to 635 mm (20 to 24 inch) diameter log along the base of the erosion site. Lay 1.75 m (5 feet) long and 12.5 mm to 38 mm (½ to 1½ inch) diameter trimmed, live branches on top of the log and sloping down into the cut bank. The purpose is to take full advantage of excess water at the slope base. Place soil behind the log with soils from the slope face. Toe logging is a quick and effective tool in stabilizing the base of slopes. However, the log must be outside the Design Clear Zone and the site must be small and only slightly over-steepened. It is very important to use the right size log for existing slope conditions. Contact the materials engineer for help in calculating slope stress.

As in any soil bioengineering technique, the initiation point or source of persistent erosion must be addressed. This is usually located at the upper boundary of the site. For project success, it is critical to remove or round off the slope overhang.

### **Live Fascines**



**Figure 740.9 Live Fascines**

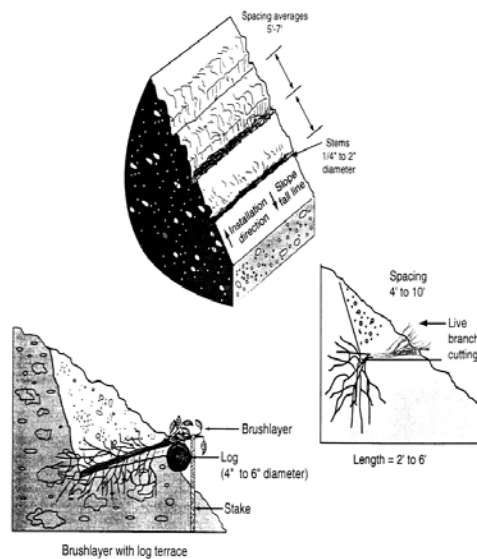
Live fascines are also referred to as contour or willow wattling. They are long bundles of branch cuttings bound together into sausage-like structures that are placed in a trench parallel to the slope contour. Live fascines root into the slope face and provide a permanent structure.

Note: Where soil moisture is not sufficient to support live materials, fascines can also be constructed of plant stems not intended for rooting. The bundle still traps and holds sediments and reduces slope length and steepness between terraces. Plant vegetation between the terraces. As in all projects, recovery is dependent upon successfully establishing live vegetation.

**Advantages:** Immediately reduces surface erosion or rilling. Suited to steep, rocky slopes where digging is difficult. Capable of trapping and holding soil on the slope face, thus reducing a long slope into a series of shorter steps. Can also be used to manage mild gully erosion and can serve as slope drains when bundles are slightly angled. Best suited for moist soil conditions.

**Disadvantages:** On steep or long slope lengths, high runoff velocities can undermine fascines. A significant quantity of plant material is required and can dry out if not properly installed. Best suited for riparian, moist soil conditions. Otherwise high plant mortality could occur.

### **Brushlayering**



**Figure 740.10 Brushlayering**

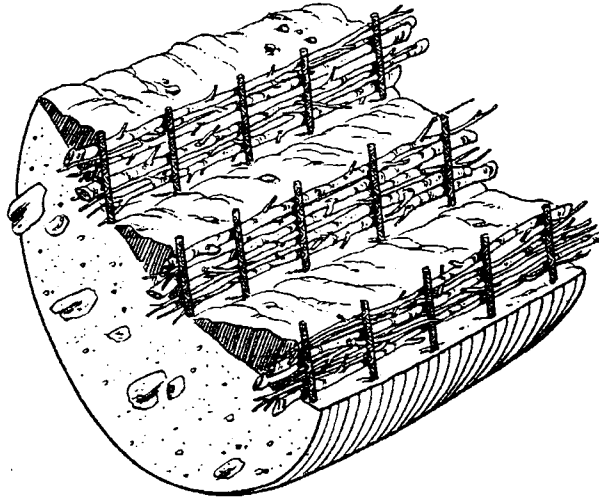
Brushlayering consists of placing live branch cuttings in small terraces excavated into the slope. Terraces can range from 0.6 m to 1 m (2 to 3 feet) wide. This technique is similar to live fascine systems because both involve cutting and placing of live branch cuttings on slopes. The two techniques differ in the orientation of the branches and the depth at which they are placed on the slope. In brushlayering, cuttings are oriented perpendicular to the slope contour. This placement is more effective for soil reinforcement and stability of the slope.

**Advantages:** Breaks up slope length into a series of shorter slopes separated by rows of brushlayer. Reinforces soil as roots develop thus adding resistance to sliding or shear displacement. Reinforces soil with unrooted branch stems. Provides slope stability and allows vegetative cover to become established. Traps debris on slope. Moderates soil

moisture by aiding infiltration on dry sites and drying excessively wet sites. Has a very high survival rate.

**Disadvantages:** Recommended on slopes up to 1V:2H in steepness and not to exceed 4.5 m (15 feet) in vertical height. Labor intensive.

### ***Willow Fencing with Brushlayering***



**Figure 740.11 Willow fencing with brushlayer**

Willow fencing with brushlayering is essentially a short willow fence supporting a brushlayer. Specifically, it is a short retaining wall built of living cuttings with a brushlayer at the base.

Sites where fine-textured soils can provide ample summer moisture, or where seepage of groundwater provides moisture, are suitable for willow/brushlayering fence installations.

These structures can also be constructed on drier sites. However, expect high willow mortality. In these situations, the willow/brushlayer shelf is considered a temporary planting platform. It is important, therefore, to establish deeper rooting shrubs and trees within the shelf.

When the structure begins to decay, root systems of the willows or the other plants will serve as the permanent feature.





**Figure 740.12 Willow Fencing With Brushlayer**

**(brushlayer is hidden below soil from construction).**

**Advantages:** These structures reduce slope angle, providing a stable platform in which vegetation can establish. Willow fences can help to trap rolling rocks and sliding debris and can protect vegetation growing lower on the slope. Willow fences provide support for small translational or rotational failures.

**Disadvantages:** Significant quantity of plant material is required. Moist site conditions are required for the fence to sprout and grow willows. Mortality rate of plant material in willow wall is significant.



**Figure 740.13 Leveling Line for the Next Willow Fence**

## ***Branchpacking***

Branchpacking consists of alternating layers of live branch cuttings and compacted backfill to repair small, localized slumps and holes.



**Figure 740.14 Branch Packing in Winter**

**Advantages:** As plant tops grow, branchpacking system becomes increasingly effective in retarding runoff and reducing surface erosion. Trapped sediment refills localized slumps or holes while roots spread throughout the backfill and surrounding earth to form a unified mass. Plant material has a high survival rate.

**Disadvantage:** Not effective in slump areas greater than 1.3 m (4 feet) deep or 1.6 m (5 feet) wide.

## ***Live Gully Repair***

Live gully repair uses alternating layers of live branch cuttings and compacted soil to repair small rills and gullies. Similar to branchpacking, this method is more appropriate for repair of rills and gullies.

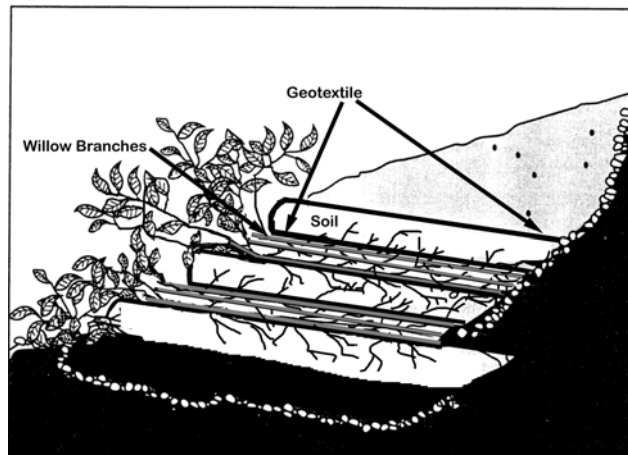


**Figure 740.15 Live Gully Repair**

**Advantages:** Offers immediate reinforcement to compacted soil, reduces velocity of concentrated flow of water, and provides a filter to reduce rill and gully erosion. Plant material in willow walls have a high mortality rate while plant material in the brushlayer component has a high survival rate.

**Disadvantage:** Limited to rills and gullies that are a maximum of 0.6 m (2 feet) wide, 0.3 m (1 foot) deep, and 5 m (15 feet) long.

### ***Vegetated Geotextile***



**Figure 740.16 Vegetated Geotextile**

This method uses synthetic or organic geotextile wrapped around lifts of soil with a mix of live branches placed between layers.

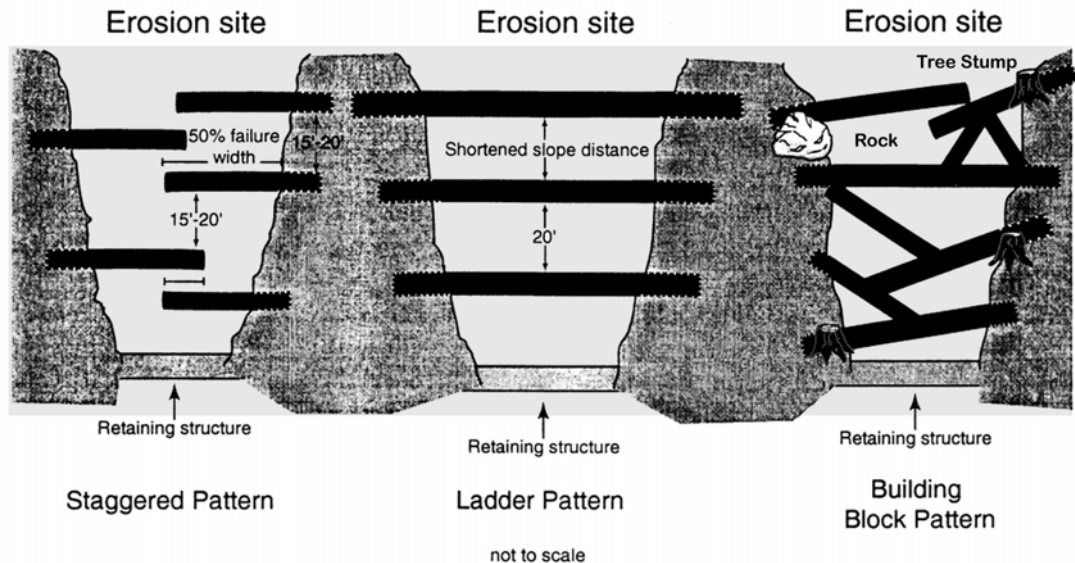
Note: Structural integrity is dependent upon compacted soil layers. Even with mechanized firming, soils support live cuttings.



**Advantages:** Retards rill and gully erosion and stabilizes fill banks. Is less expensive than other retaining walls such as gabion or Hilfiker baskets.

**Disadvantages:** Heavy equipment usually required to install lifts. Plants must be installed during their dormant season. Can be expensive.

### **Log Terracing**



**Figure 740.17 Three Toe Log Techniques**

The log terracing technique uses alternating terraced logs to stop surface erosion on eroding slopes. Stopping the erosion is critical for successful revegetation efforts. Log terracing shortens the slope length and gradient between each structure, providing stable planting areas throughout most of the slope face. Logs must be installed in trenches and staked into place.

Note: Use logs that are a minimum of 0.3 m (12 inches) in diameter. Logs that are 400 mm to 500 mm (16 to 20 inch) in diameter work best. The most common error in log terracing is using logs that are too small in diameter.

**Advantages:** Logs create terraces reducing length and steepness of the slope. Provides stable areas for establishment of other vegetation such as trees and shrubs.

**Disadvantages:** Labor intensive and with possible safety hazards because of the use of logs on a slope. Heavy equipment required to place large logs.

### **Key Points:**

- Involve all associated disciplines early in the process.
- Establish clear project objectives.
- Conduct predesign field review.
- Conduct plan-in-hand field review.
- Have a prework meeting with contractor to highlight key areas.
- Scheduling and timing of project is important when considering erosion outputs.
- When laying out the project, be consistent with the flagging.
- Ensure that terraces are level (on the contours) so that they do not act as stream channels. Level terraces will act to slow erosion.
- Diligent inspections of work-in-progress and timely feedback are critical. Develop a good working relationship with heavy equipment operators and hand crews. Poor inspection and poor communications can ruin a well designed project. Remember “You get what you inspect, not what you expect”!
- Monitor and document project effectiveness.
- Disseminate this information to colleagues and adjust future prescriptions based on monitoring results.
- Annual peer review by land managers provides good feedback and keeps them informed.

The complexity of the project dictates the level at which the aforementioned steps are performed.

An interdisciplinary team is necessary for all steps. The experience can also be very rewarding.

## **Maintenance**

Maintenance crews can request assistance with erosional problems on slopes in their area. The region’s Materials Engineer and the region’s Landscape Architect, or the OSC Roadside and Site Development Unit for regions with no Landscape Architect, are available to help with the design and implementation of soil bioengineering measures to treat erosional slopes or shallow rapid landslides.

For the first one to two summers after construction, additional watering might be necessary. Thereafter, the vegetated system will usually require little or no maintenance and will usually cut down on ditch cleaning requirements because erosion has been minimized.

## Additional Sources of Information

D. H. Bache and I. A. MacAskill. *Vegetation in Civil and Landscape Engineering*. London: Granada. 1984.

D. H. Barker, editor. *Vegetation and slopes: Stabilization, protection, and ecology*. New York: Thomas Telford. 1995.

N. J. Coppin and I.G. Richards. *Use of Vegetation in Civil Engineering*. London: Butterworths. 1990.

Donald H. Gray and Andrew T. Leiser. *Biotechnical Slope Protection and Erosion Control*. New York: VanNostrand Reinhold Co. 1982.

Donald H. Gray and Robbin B. Sotir. *Biotechnical and Soil Bioengineering Slope Stabilization: A Practical Guide for Erosion Control*. New York: John Wiley & Sons, Inc. 1996.

E.A. Lewis. *Soil Bioengineering: An alternative for Roadside Management: A Practical Guide*. United States Forest Service. San Dimas Technology and Development Center. San Dimas, California. 1999.

David F. Polster. "Soil Bioengineering for Steep/Unstable Slopes and Riparian Restoration." In *Watershed Restoration Technical Bulletin: Streamline*. Volume 4. No. 4. British Columbia Ministry of Environment.

Hugo Schiechl and R. Stern. *Ground Bioengineering Techniques for Slope Protection and Erosion Control*. Blackwell Science Publications, 1997. ISBN: 0-632-04061-0

Hugo Schiechl. *Bioengineering for Land Reclamation and Conservation*. University of Alberta Press. 1980.

State of Alaska website on streambank stabilization  
<http://www.state.ak.us/adfg/habitat/geninfo/webpage/techniques.htm>

Turner & Schuster, eds. *Landslides Investigation and Mitigation, Special Report*, Transportation Research Board. 1996.



## General

Washington State Department of Transportation (WSDOT) practices an ecologically based program of roadside vegetation design and management that seeks to produce low-maintenance, self-sustaining plant communities. The use of native plants planted in the right location is integral to this system. The *Roadside Classification Plan* provides policy on roadside character classifications and appropriate treatment levels for revegetation.

Revegetation plans are an important part of many highway projects and are required when the project disturbs the roadside. The inclusion of a WSDOT Landscape Architect in the design development process can aid the design process and improve the environmental and visual quality of Washington's roadsides.

## References

- *Construction Manual* M 41-01
- *Design Manual* M 22-01
- *Highway Runoff Manual* M 31-16
- *Hydraulics Manual* M 23-03
- *Integrated Vegetation Management for Roadsides*, WSDOT
- *Maintenance Manual* M 51-01
- *Roadside Classification Plan* M 25-31. (Includes the "Roadside Classification Log.")
- *Standard Specifications for Road, Bridge and Municipal Construction* M 41-10
- *Utilities Accommodation Policy* M 22-86
- Corridor management plans for Scenic and Recreational Highways
- **RCW 17.10** State Noxious Weed List. The site below links to information on noxious weeds:  
<http://www.wsdot.wa.gov/biz/maintenance/htm/weeds.htm>
- **RCW 47.40** Roadside Improvement and Beautification. Outlines permit process for persons wishing to use highway right of way for improvement and beautification. Establishes penalty for destroying native flora on state lands. Mandates litter removal, and authorizes state and local Adopt-a-Highway programs.

- [WAC 173-270-040](#) *Vegetation Management Program*. States that the purposes of vegetation management in highway rights of way are to establish and maintain stable plant communities that resist encroachment by undesirable plants, noxious weeds, and other pests; meet WSDOT operational, health, natural resources and environmental standards; be cost effective; and protect the public investment with minimal negative impacts on the environment. Requires a vegetation management program for all state highways with the Puget Sound basin.
- [WAC 468-34-340](#) Preservation, restoration and cleanup of areas disturbed through utility installation, maintenance and repairs. Outlines criteria for utility use of highway right of way, requires utilities to repair or replace unnecessarily removed or disfigured trees and shrub, and specifies vegetation management practices.

## **Resources**

The region's Landscape Architects

The region's Maintenance Office

HQ Design Office Roadside and Site Development Unit

HQ Horticulturist

HQ Maintenance & Operations Program (M&OP) Landscape Architect

Heritage Corridors Program (when working in a Scenic and Recreational Highway corridor)

Washington State Noxious Weed Control Board:

<http://www.wa.gov/agr/weedboard/index.html>

## **Definitions**

***blend*** To create a balanced, visually harmonious interface between adjacent elements. A roadside treatment strategy that integrates roadside elements to preserve roadside character continuity.

***buffer*** The zone contiguous with a sensitive area that is required for the continued maintenance, protection, insulation, function, and structural stability of the sensitive area. The critical functions of a riparian buffer (those associated with an aquatic system) include shading, input of organic debris and coarse sediments, uptake of nutrients, stabilization of banks, interception of fine sediments, filtering of pollutants, overflow during high water events, protection from disturbance by humans and domestic animals, maintenance of wildlife habitat, and room for variation of aquatic system boundaries over time due to hydrologic or climatic effects. The critical functions of terrestrial buffers include protection of

slope stability, attenuation of surface water flows from storm water runoff and precipitation, and erosion control.<sup>1</sup>

***climax vegetation*** A stable end-point to plant succession (“steady state”) where a group of species predominate and replaces itself.<sup>2</sup>

***corridor management plans*** A written document that specifies the actions, procedures, controls, operational practices, and administrative strategies to maintain the scenic, historic, recreational, cultural, archeological, and natural qualities of a Scenic and Recreational Highway.

***cuttings*** Live plant material without a previously developed root system. Source materials for cuttings should be dormant when the cutting is taken.

***ecological succession*** The natural tendency of plant communities to evolve over time.

***enclose*** A roadside treatment strategy, the aim of which is a more or less permeable buffer between two adjacent elements, typically the roadway and adjoining lands. Roadside treatments, such as berms, structures, or vegetation, are used to provide visual buffers along both sides of the road. In [Figure 800.1](#) vegetation provides a sense of enclosure for the roadway.



**Figure 800.1 Vegetation enclosing the highway**

***expose*** A roadside treatment strategy, the aim of which is to preserve or open a visual sight line, or remove vegetation for operational purposes, such as in the Design Clear Zone.

***forb*** An herbaceous plant, such as clover, which is not a grass, sedge, or rush.

***groundcover*** Low-growing plants that form a dense, extensive growth and tend to prevent weeds and soil erosion.

<sup>1</sup> [Highway Runoff Manual](#) M 31-16. WSDOT, pp Glossary 1-2.

<sup>2</sup> Oliver and Larson, p. 147.

**herb** Any flowering plant except those developing persistent woody bases and stems above ground.

**live poles** A form of cutting taken from woody vegetation with a diameter greater than 50 mm (2 inches).

**live stakes** A form of cutting taken from one to two year old woody vegetation with a diameter of less than 50 mm (2 inches).

**native plant** A plant occurring naturally in a particular region, ecosystem, or habitat at the time of European settlement.

**plant material** Trees, shrubs, ground covers, cuttings, live stakes, live poles, rhizomes, tubers, rootstock, and seedlings are referred to collectively as “plants” or “plant material.”

**reference site** An established undisturbed natural site that is used as a comparative design guide to help determine the desired plant composition and species densities for the created, or enhanced project site. It should be located near the project site, preferably within the same watershed, and have similar landscape setting, hydrology and topography.

**rhizome** A root-like, usually horizontal stem, growing under or along the ground that sends out roots from its lower surface and leaves, or shoots from its upper surface. The primary means by which some plants spread or reproduce.

**roadside classification** Any of five classifications given to a route or stretch of roadway through a review process conducted by WSDOT, and documented in the WSDOT “Roadside Classification Log.” Roadside character classifications fall within two categories: natural and built. *Natural* includes the Open and Forest roadside character classification. *Built* includes the Rural, Semiurban, and Urban roadside character classifications.

**roadside restoration** The use of planning, design, construction, and maintenance activities to restore roadside plant communities according to designated roadside character and [Roadside Classification Plan](#) provisions.

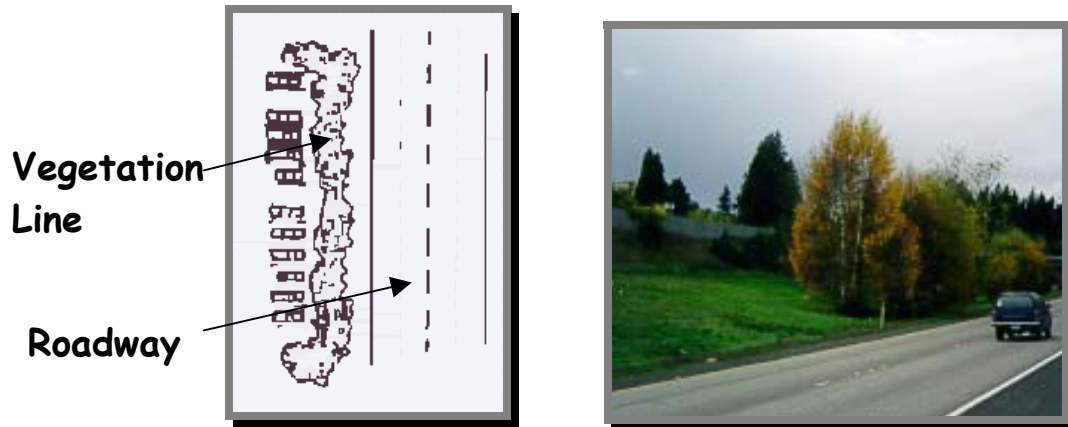
**roadside treatment strategies** Conceptual design strategies used to coordinate implementation of roadside guidelines and fulfill roadside functions. The three basic treatment strategies are enclose/screen, expose, and blend.

**Scenic and Recreational Highways** A public road having special scenic, historic, recreational, cultural, archeological, and/or natural qualities that have been recognized as such through legislation or some other official declaration. The terms “byway,” “road,” and “highway” are synonymous. They are not meant to define higher or lower functional classifications or wider or narrower cross-sections. Moreover, the terms State Scenic Byway, National Scenic Byway, or All-American Road



refer not only to the road or highway itself but also to the corridor through which it passes.

**screen** The use of roadside treatments such as vegetation, berms, or walls to visually block undesirable views, as seen in [Figure 800.2](#). In the picture to the right, below, vegetation is used as a permeable screen for the noise wall.



**Figure 800.2 Use of vegetation to screen a wall**

**seedlings** Plants grown from cuttings, seeds, or other approved propagation methods. They are generally under 3 years old and under 2 ft in height. Measurement is by height, in 3 inch increments, or by age and number of times transplanted.

**shrub** A low, woody plant having several stems.

**sustainable roadsides** Those roadsides that are designed with the intent of integrating successful operational, environmental, and visual functions with low life cycle costs.

**tuber** A swollen, usually underground stem, such as the potato, bearing buds from which new plant shoots arise.

**weed** Any plant growing in a location in which it is not desired. A plant growing out of place.

**wildflowers** Native flowering plants including flowering herbs, shrubs and trees.

**xeriscape** A landscaping concept based on water conservation through the use of plant materials and techniques appropriate for dry climates or site conditions.

# Vegetation

## ***Functions of Vegetation***

Vegetation has many functions and adds significant value to our environment. These functions include:

- Traffic calming
- Stress reduction
- Buffer or shade for pedestrian or park and ride facilities
- Stream bank stabilization
- Wetland mitigation
- Water quality improvement
- Water retention and smoother flows
- Air pollution mitigation
- Noise abatement
- Wildlife habitat
- Enclose, screen, expose, or blend
- Visual quality, quality of life
- Corridor continuity
- Roadside Character Classification as noted in the [Roadside Classification Plan](#)

## ***Roadside Vegetation***

Existing vegetation alone often meets roadside function requirements but revegetation projects are initiated after disturbance or for improvement projects. For revegetation of roadside areas disturbed during roadway projects, contact the region's Landscape Architect or the HQ Roadside and Site Development Unit in regions without a landscape architect. They will provide planting designs and seeding specifications. All planting plans require the stamp and signature of a Landscape Architect.

Revegetation activities range from seeding grasses to installing diverse plant communities. Roadside revegetation can include planting trees, shrubs, ground covers, live stakes, live poles, rhizomes, tubers, rootstock, seedlings, and seeds. See the [Standard Specifications](#) for information on plant specification.

Important additional functions of vegetation include:

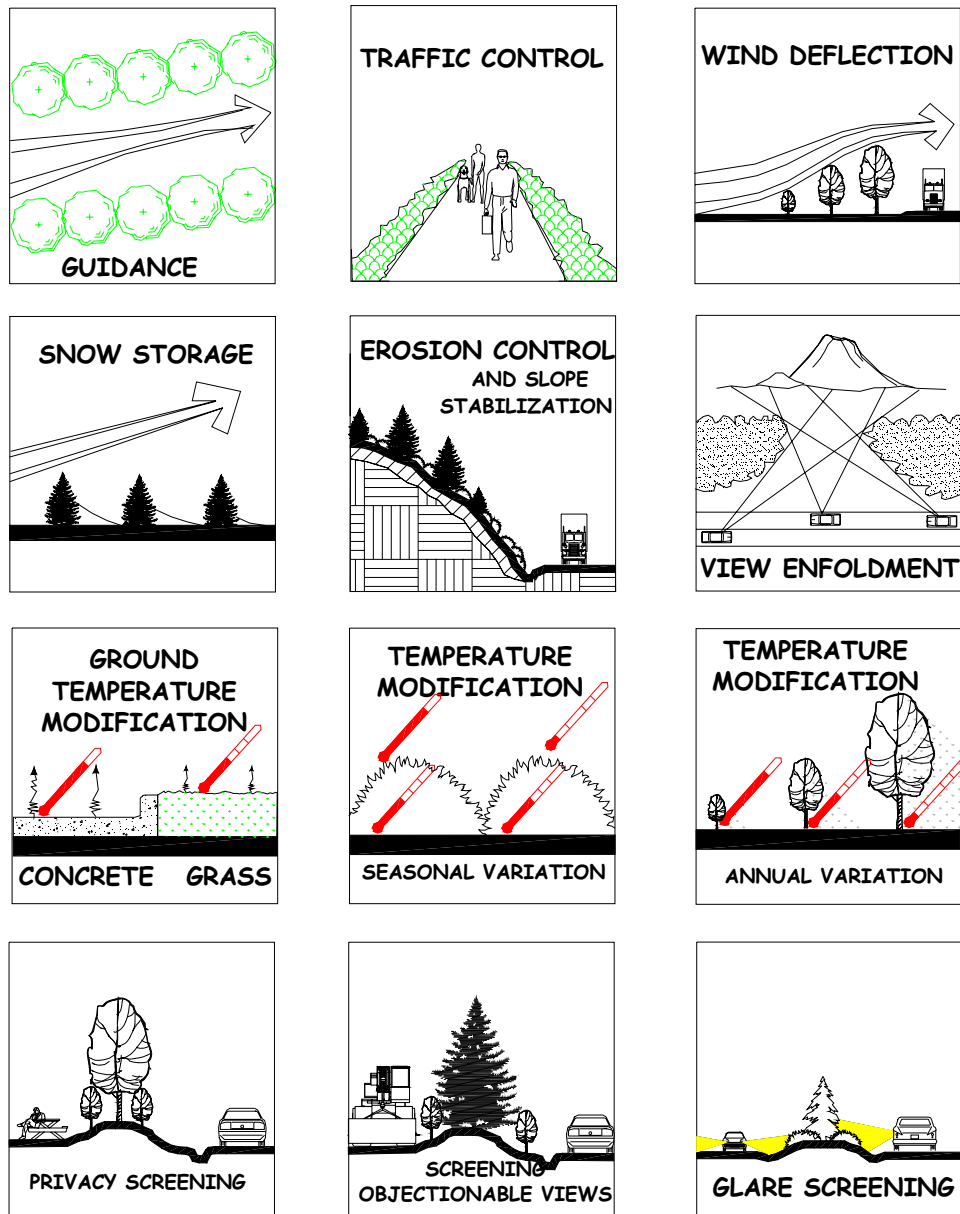


Figure 800.3 Examples of Some Functions of Roadside Vegetation

### General Guidelines for Roadside Vegetation

- Protect existing desirable vegetation.
- Maintain Design Clear Zone and sight distance according to the [Design Manual](#).
- Maintain, restore, or enhance roadside functions.

- Maintain, restore, or enhance roadside character classifications (Forest, Open, Rural, Semiurban, Urban).
- Implement Treatment Levels in the *Roadside Classification Plan*.
- Implement treatment strategies (enclose/screen, expose, blend).
- Choose the right plant for the right place, for example use shrubs on the outside of curves or within the clear zone.
- Provide complete vegetative cover, where possible.
- Encourage desirable volunteer growth by allowing natural succession to take place.
- Install, protect, and enhance desirable native plant material.
- Discourage invasive species and noxious weeds.
- Use Integrated Vegetation Management techniques.
- Perform soil analyses to determine if soil amendments are necessary.
- Provide topsoil and/or amend existing soils when installing projects where it will improve plant survivability.
- Design for self-sustaining plant communities to minimize long term maintenance.
- Minimize requirements for fertilizer and pesticide use.

## Planning

### *Roadside Classification Plan*

The RCP coordinates and guides the management of Washington State highway roadsides, including planning, design, construction, and maintenance activities. The RCP provides extensive roadside vegetation management guidance, including:

- Treatment level guidelines for Forest, Open, Rural, Semiurban, and Urban roadside character classifications.
- Treatment tools (landform, vegetation, and structure) used to restore roadside character.

The *Roadside Classification Plan* advocates the use of native plants, Integrated Vegetation Management, and a long-term management approach to achieve sustainable roadsides.

### ***Integrated Vegetation Management (IVM)***

Integrated Vegetation Management is a coordinated decision-making and action process that uses the most appropriate vegetation management

methods and strategy, along with a monitoring and evaluation system, to achieve roadside maintenance program goals and objectives in an environmentally and economically sound manner.

Tactics selected are site specific. Chemical controls are used only when needed. IVM uses plant growth characteristics, principles of succession, and knowledge of natural and human-related factors affecting environmental change to achieve management goals, while minimizing impacts on the environment. For details, refer to *Integrated Vegetation Management for Roadsides*.

### **Corridor Management Plans**

Corridor Management Plans identify the location of a Scenic and Recreational Highway route and its corridor. Revegetation plans can be affected due to the high visibility of these corridors. The maintenance of existing vegetation can also be affected.

## **Design**

It is WSDOT policy to use native plants, including wildflowers to the greatest extent practical. Wildflowers include native woody flowering shrubs and trees.

Species diversity, within the context of native plant associations, is encouraged. A diverse plant mix is less susceptible to disease and homogeneous decline.

Landscape Architects develop PS&E packages that include plant materials lists. Plant material selection is based on site-specific requirements.

Wherever practical, use a separate contract for planting projects. This usually results in better revegetation projects and it allows the roadway project to close out before the plant establishment period ends.

Landscape Plans, and any other plans that specify plants, require the stamp and signature of the Landscape Architect.

### **Design Criteria**

Refer to the maintenance Functional Zone Objectives in Division 1. Select and locate plants with the following criteria in mind to avoid future problems and to avoid increased or difficult maintenance.

- **Sight Distance** Design for and maintain sight distance for motorist, bicycle, and pedestrian traffic. Sight distance is also a security issue for safety rest areas, park and ride lots, pedestrian facilities, and bicycle facilities (see the [Design Manual](#)).

- **Design Clear Zone** The Design Clear Zone is a function of posted speed, side slope, and traffic volume. Do not locate trees that can grow over four inches in trunk diameter in the Design Clear Zone (see the [Design Manual](#)). Shrubs are appropriate for this zone.
- **Traffic Barriers** Set shrubs and ground cover plants a minimum of 2 ft and trees a minimum of 6 ft from traffic barriers to reduce maintenance.
- **Vertical Clearance** Provide appropriate setbacks for trees that might overhang the roadway. When trees do overhang the roadway, provide a minimum vertical clearance of 16 ft. Minimum vertical clearance over trails and pedestrian facilities is 10 ft.
- **Medians and Gore Areas** Design medians and gore areas to be a minimum of 10 ft wide. Narrower areas tend to be a problem for maintenance personnel, are expensive to irrigate, and generally are unsatisfactory for revegetation. Consider paving, stone, or other bare surface material in gore areas less than 10 ft wide.
- **Right of Way Line** Place trees and shrubs a minimum of 6 ft inside the right of way line.
- **Curb Lines of City Streets** Comply with local agency standards and WSDOT sight distance criteria for revegetation.
- **Structures** Locate trees as far back from structures as necessary to avoid operational conflicts and the need for excessive pruning.
- **Trails** Set back evergreen trees with branches less than 2 m (6 ft) from the ground a minimum of 6 m (20 ft) from trails. Select species native to the area wherever possible. Set back shrubs higher than 1.5 m (5 ft) a minimum of 2.4 m (8 ft) from trails, for security purposes.
- **Other Roadside Features** Do not locate vegetation that will interfere with signs, signals, or luminaires. Trees and shrubs can provide visual background for signs.
- **Utilities** Refer to the [Utilities Accommodation Policy](#) for guidance. Avoid impacting utility lines and sewer systems.
- **Corridor Management Plans** Where applicable consult these plans to enhance corridor continuity and to reinforce the character of the Scenic and Recreational Highway.

### ***Plant Material Selection***

Plant material selection is based on a site analysis of conditions, maintenance Functional Zone Objectives, plant availability, plant cost, plant success rates in the field, traffic speed, and other horticultural requirements.

Follow these general guidelines for plant material selection for grasses, herbs, shrubs, trees, and groundcovers.

### **Grasses and Herbs**

Consider the following criteria when selecting grass or herb plant material:

- Satisfaction of the functional requirements of the design.
- Ability to provide visual cues that reinforce changes in speed and driving conditions.
- Simplicity of appearance and compatibility with the speed of traffic and the overall landscape.
- Production of extensive root systems.
- Rapidity of establishment.
- Tolerance of site conditions.
- Resistance to insects and diseases.
- Availability from commercial suppliers.
- Ability to self-perpetuate.
- Compatibility with maintenance objectives.

Select species native to the area wherever practical.

Do not use herbs in roadside seed mixes where there are deer.

Do not use lupine adjacent to agricultural or grazing areas.

Do not use seed mixes that include species on the State Noxious Weed List (RCW 17.10). The site below links to information on noxious weeds.

[http://www.nwcb.wa.gov/weed\\_list/weed\\_listhome.html](http://www.nwcb.wa.gov/weed_list/weed_listhome.html)

### **Trees, Shrubs, and Groundcovers**

Consider the following criteria, in addition to the criteria for grasses and herbs, for shrubs, trees, and groundcover:

- Appropriate characteristics for desirable functions.
- Suitability for space and site conditions.
- Compatibility with natural plant succession.
- Ability to regenerate after damage.
- Longevity.
- Ability to maintain or enhance habitat values for wildlife, where this is desirable. This is determined on a site specific basis in conjunction with the region's environmental office.

- Ability to withstand traffic-generated stresses, such as air pollution and air turbulence.
- Compliance with state and county noxious weed control regulations.
- Select plant species that do not impact endangered or rare species.
- Select species native to the area wherever possible.
- Consider compatibility with the site's natural plant selection process.
- Consider compatibility with roadside maintenance objectives for the area.
- Native flowering shrubs and trees to satisfy the requirement for the use of wildflowers on federally funded projects.

### **Plant Sizing**

Plant size is based on:

- Guidelines of the *Roadside Classification Plan*
- Design requirements
- Commercially available sizes
- Vandal resistance
- Transplant survival
- Available funding
- Functional needs
- Maintenance requirements
- Smaller plants are usually more cost effective and more easily established than larger ones

### **Establishment of Vegetation: The Right Plant for the Right Place**

Plant survivability is improved and maintenance requirements are decreased when plants are matched to site conditions and proposed use.

Successful establishment of vegetation improves with:

- Soil conditions that support the desired plant community or outcome. Restore the soil as closely as possible to the qualities existing in adjacent undisturbed soils. (Create the situation that supports the desired outcome. Refer to adjacent soils and plant communities for an indication of what the area will support in terms of vegetation.)
- Consider the use of mycorrhizal inoculants in areas with no topsoil.
- An understanding of plant succession dynamics and natural processes. For example: physiological characteristics; life history;



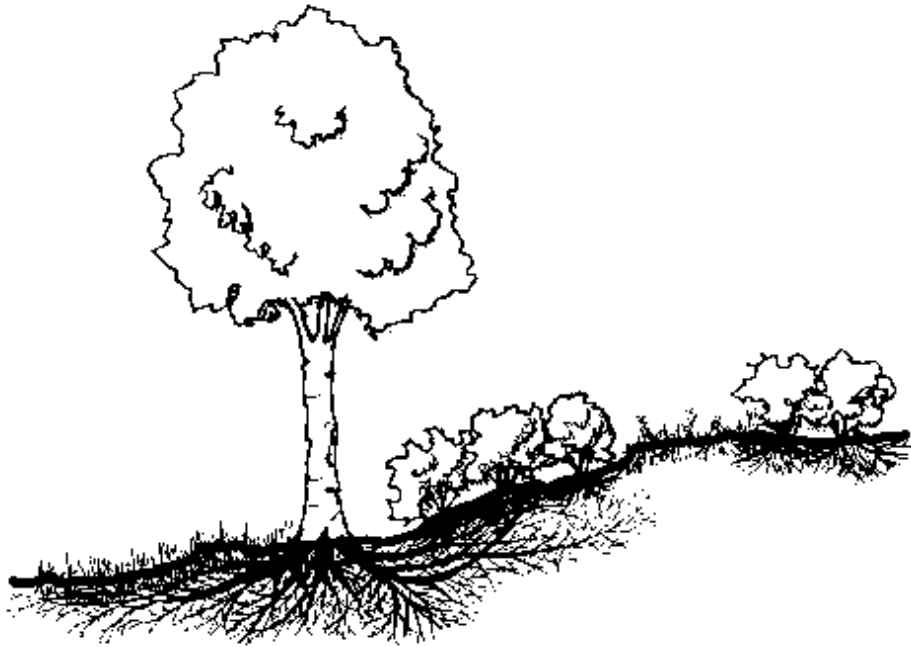
responses to competition; role within the plant community and successional pathway; and how the plant responds to management techniques.

- The addition of compost improves plant establishment as well as increasing the water-holding capacity of the soil and mitigating surface erosion. [Figure 800.4](#) shows the difference in grass establishment between the area above with no compost and the area below with compost.



**Figure 800. 4 Compost - No Compost**

- Mulches conserve soil moisture, reduce soil temperature, and provide a better environment for plant growth.
- Soil amendments can enhance the soil's moisture holding capacity thereby reducing and perhaps eliminating the need for irrigation.
- Soil nutrient availability can be an important determinant of species composition. Refer to the Soils and Soil Amendments chapter (700).
- Consider variations in rooting depths between grasses, shrubs, and trees. Complexity of underground root structure improves erosion control, slope stability, and minimizes the opportunity for invasion of undesirable vegetation. Note how the complexity of root type and depth locks up the soil to the greatest degree. The amount of vegetation above ground is related to the root volume below ground as seen below in [Figure 800.5](#).



**Figure 800.5 Relative root depths and volumes**

- Commercial water holding polymers and other similar products can be used during the plant establishment period to provide young plants with moisture.

See the Irrigation [chapter \(820\)](#) for guidance on irrigation of plant material.

Weed barriers can reduce weed competition until desired plants are able to compete for light and nutrients more effectively. They also moderate soil temperature and conserve moisture. Weed mats and bark or wood chip mulch are two examples of weed barriers.

### **Plant selection composition**

Restoration and revegetation projects are most practically planted in mixtures of native plant species. The mixture is composed of various species in balanced proportion to each other.

Factors that determine species percentages within a plant selection are:

- Desired ultimate composition of the plant community, for example forest, scrub-shrub communities.
- Function within the plant community, such as overstory, understory, shrub, groundcover, and herbaceous.
- Dominance in the plant community.
- Growth characteristics.

- Compatibility with other species:

Select fewer numbers of fast growing species, such as elderberry or cottonwood, to reduce conflict with slower growing species.

Slower growing species, such as vine maple, salal, and spruce may require a higher percentage of representation to be successful in the development of the plant association.

Some species may not be appropriate for the initial planting phase. Included are understory plants, such as cedar, salal, or vine maple that demand a microenvironment that can only develop over time.

## ***Spacing***

The distance between plants is determined by the following considerations.

- Weed control. Densely spaced vegetation minimizes the establishment of weeds.
- Some plant species need support from surrounding plants in order to compete and develop. These form functional plant associations. Examples are snowberry, rose, salal, mahonia, spiraea, and mock orange. Plant spacing is based on closure of the canopy after approximately 5 to 7 years. The shrubs form a thicket over time that can shade out weeds.
- Consider the developmental needs of individual plants.
- The following species are examples of species that may be considered for clustering: aspen, hazelnut, and oceanspray.
- Space climax vegetation to resemble the spread in the natural plant community as determined by the reference site.
- Space species such as red alder to quickly perform their function in the plant succession scheme without causing undesirable competition to other desirable plants. A management program that includes periodic removal of plants that have outlived their function will be necessary.
- See [Appendix D](#) for methods to calculate plant spacing.

## ***Determination of percentages within a plant selection mixture***

This section discusses a method for determining the numbers of plants per species to use in a revegetation plant mixture. The percentages of the species within a plant selection mixture are based on the desired spacing and distribution in the planting area.

- Decide on the native plant revegetation concept: Managed Succession or Accelerated Climax Community Development. (Refer to chapter 810 for more information on these concepts.)
- Develop the desired plant palette for the plant selection mixture.

For example, a roadside restoration mixture that follows Accelerated Climax Community Development principles is designed to consist of a shrub layer of snowberry, rose, and Oregon grape. Intermediate or understory species consist of oceanspray, hazelnut, and vine maple. The overstory is Douglas fir, western hemlock, red alder, and big leaf maple. Red alder is intended to function as a temporary cover crop (overstory) with most alders to be removed during the initial five to seven years.

- Establish an area size to base the calculations on. Metric and English examples are shown in the following three charts:

<b>Total planting area</b>	930 m <sup>2</sup>	10,000 sq ft
<b>Spacing</b>	1 m	3 ft
<b>Area per plant</b>	0.836 m <sup>2</sup>	9 sq ft
<b>Divide total by area per plant</b>	930 m <sup>2</sup> ÷ 0.836 m <sup>2</sup> =	10,000 sq ft ÷ 9 sq ft =
<b>Total number of plants</b>	1112*	1111*

\* Round to 1100 plants for this example.

For the overstory species of Douglas fir, western hemlock, red alder, and big leaf maple, determinations are made for the species mixture. Site conditions are less favorable for western hemlock; thus its percentage has been arbitrarily established at 2% of the total of 1100 plants. For the remaining species, the following calculations are made:

<b>Total planting area</b>	930 m <sup>2</sup>	10,000 sq ft
<b>Spacing</b>	5 m	15 ft
<b>Area per tree</b>	37 m <sup>2</sup>	400 sq ft
<b>Divide total by area per plant</b>	930 m <sup>2</sup> ÷ 37 m <sup>2</sup> =	10,000 sq ft ÷ 400 sq ft =
<b>Total number of trees</b>	25	25

Twenty-five trees is about 4% of the total number of plants or 1-1/3% for each species.

Because, of the three species listed above, Douglas fir is the least competitive on the chosen site, it is assigned 2%, with red alder and big leaf maple each making up 1% of the total species mix. Overstory species will total 6% (2 + 2 + 1 + 1).

For intermediate height, understory species such as oceanspray, hazelnut, and vine maple, spacing is desired as seen below: (In a managed

succession planting program these species would be added in subsequent years as the overstory develops and shade becomes available.)

<b>Total planting area</b>	930 m <sup>2</sup>	10,000 sq ft
<b>Spacing</b>	3 m	10 ft
<b>Area per tree</b>	9.3 m <sup>2</sup>	100 sq ft
<b>Divide total by area per plant</b>	930 m <sup>2</sup> ÷ 9.3 m <sup>2</sup> =	10,000 sq ft ÷ 100 sq ft =
<b>Total number of trees</b>	100	100

One hundred plants are about 10% of the total. Vine maple is arbitrarily assigned 4% and the oceanspray and hazelnut are assigned 3% each.

The remaining percentage of 84% is shared by the shrub layer of snowberry, rose, and Oregon grape. Observations of the reference site for this project have documented a forest floor dominated by snowberry with rose and Oregon grape interspersed in mostly small clusters. The decision is to assign snowberry with 50%, rose with 20%, and Oregon grape with 14% based upon the ratios at the reference site.

The shrub layer shades out undesirable competitors through early closure. It has been experienced that a 1 m (3 ft) spacing per plant will provide this benefit within the normal plant establishment period of 5 to 7 years.

The final mixture looks as follows:

<b>Plant Selection EXAMPLE</b>					
<b><u>Botanical name</u></b>	<b><u>Common name</u></b>	<b><u>%</u></b>	<b><u>Spacing</u></b>	<b><u>Quantity</u></b> 1100 Total*	<b><u>Notes</u></b>
Pseudotsuga menziesii	Douglas fir	2	3 m (10 ft) min.	22	-
Tsuga heterophylla,	western hemlock	2	3 m (10 ft) min.	22	-
Alnus rubra	red alder	1	3 m (10 ft) min.	11	-
Acer macrophyllum	big-leaf maple	1	3 m (10 ft) min.	11	-
Holodiscus discolor	oceanspray (creambush)	3	3 m (10 ft) min.	33	Clusters of 3 - 5
Corylus cornuta	beaked hazelnut	3	3 m (10 ft) min.	33	Clusters of 3 - 7
Acer circinatum	vine maple	4	2 m (6 ft)min.	44	-
Symphoricarpos albus	snowberry	50	1 m (3 ft) O C	550	-
Rosa gymnocarpa	wood rose	20	1 m (3 ft) O C	220	Clusters of 15-25
Mahonia aquifolium	Oregon grape	14	1 m (3 ft) O C	154	Clusters of 3 - 7

\* Quantities are based on the area in the example above. In a real project situation, the quantities will be calculated for the actual planting area that is designated for the plant selection.

### **Figure 800. 6 Plant Selection for the Example**

Notes: Average plant spacing of the plant mixture just under 1m (3 ft) on center. (930 m<sup>2</sup>/1100plants)

Trees are to be randomly distributed throughout the planting area.

OC = on center. Plant spacing measured from center to center of plant.

## **Construction**

Design documents consider construction requirements such as site accessibility and constraints such as contract timing. During construction:

- Do not deviate from plans without approval of the Landscape Architect.

- Protect existing trees from construction impacts.

Ideally, the root zone of vegetation is protected out to 1.5 times the diameter of the drip line. At a minimum, protect the root zone to the outermost reach of its branches (the drip line). If cuts or fills are required in the vicinity of trees to be saved, consider retaining walls, tree wells, gravel, or drainage systems to protect the root systems.

Heavy equipment stored, parked, or driven around the base of a tree can compact the soil and deprive the tree's roots of the water and air they need to survive. Stockpiling building materials or fill can have a similar effect. Refer to the Soils and Soil Amendments chapter for more information on soil compaction and its minimization.

Scraping soil from roots or cutting them too deeply or too close to the tree can cause the tree to die or have a weakened hold and blow down. This damage may not be visible for years.

- Contracts often include a one-year plant establishment guarantee period from the contractor.
- On projects operating under a Corridor Management Plan, the community has had significant input into the plans and deviation could cause problems.

Transplant guidelines have been moved from the Soil Bioengineering chapter to this location. The text remains the same.

### **Transplant Guidelines**

The reason for setting transplant guidelines is to increase the likelihood of plants surviving, growing to maturity, and reproducing. The chance of success is much greater if plants from the same altitude and ecosystem are used because they are adapted to that area's climate and elevation.

Collect plant materials during the dormant season. Keep them protected from wind and heat. Best results are obtained when installation occurs the same day materials are collected. However, some believe greater success can be realized with cuttings if stems are soaked in water 5 days prior to planting. Protecting stems from wind and keeping them cool and moist is essential.

### **Upland Plant Species**

Use local seed (collection) zones to identify the best areas to collect seeds, cuttings, or plants. A seed zone is an area with a defined boundary and altitudinal limits within which landform and climate are sufficiently uniform. The landscape architect or HQ horticulturist will be the source of information.

In 1966, seed zones were developed, based on climatic and physiographic information, to reduce the risk of maladapting commercial tree species and to provide structure for commercial seed trade. Each zone has geographic boundaries and is additionally divided into 500-foot

elevation intervals. Seed lots are coded by both seed zone and elevation band.

- When collecting seeds, cuttings, or plants for smaller projects (perhaps a one-time collection) the elevation band can extend approximately 250 feet above and below the site.
- Salvage and transplant while plants are dormant.
- Collect cuttings from 30 to 50 parent plants in good condition (if available). In general, take no more than 33 percent of the parent plant's material and take no more than 50 percent of cuttings or seed from a given area.
- For plant cuttings, use young shoots (1 to 2 years old). Older and larger stems tend to have higher mortality.
- Protect cuttings from wind by covering them with plastic sheeting or moist cloth.

### **Shrubs, Herbs, Grasses, and Riparian Species**

Use watershed boundaries as seed, cutting, plant collection, and transplant zones. In addition, collect necessary plant material within a 500-foot elevation band of the planting site.

### **Gene Pool Conservation Guidelines**

Making sure the seed lot, cuttings, or plant lots are genetically diverse is just as important as plant movement guidelines. To prevent loss of genes in the population, use a minimum of 30-50 unrelated donor plants. Collecting an equal number of seeds, cuttings, or plants from each donor plant or area will also ensure representation by as many parent plants as possible.

Separate donor plants by sufficient distance to the reduce risk of relatedness.

### **Planting**

- Plant salvaged plants within about 2 hours of lifting. Keep plants moist and free from wind and heat exposure.
- Dig holes 2 times the volume of the root ball. Larger holes will be required in more compacted soils.
- Planting holes must be deep enough so that the downslope side of the rootball is entirely buried.
- Plant the plant so the root collar is at the depth at which it was previously growing.



- Spread roots out so none are kinked or circling. Protect roots, especially fine root hairs on the main root system. Add water, if available, to reduce voids and increase root and soil contact.
- Use on-site soil to backfill the hole. Firmly tamp the soil around the plant. Be careful not to compact the soil.
- Transplanting a microsite: Depending on site conditions and project objectives, it might be preferable to salvage and transplant a small section of ground. This section usually contains several plants with roots, mycorrhizae, seed, soil, soil microorganisms, and duff materials. This technique provides great benefits to the area being revegetated. For transplanting small sections of ground, excavate an area large enough to “plant” the entire piece. Lay it in the excavated area and level with adjoining ground. Use excavated soil to secure edges of transplanted piece. Tap gently into place. Whenever possible, water the transplant.

### **Seed, Fertilizer, and Mulch**



**Figure 800. 7 Hand-Distribution of Mulch**

Hydroseed or broadcast seed, fertilizer, and mulch. Make sure seed is covered with the correct depth of soil if broadcasting. The depth will depend on the type of seed being used. Check with the HQ Horticulturist for correct planting depths for the seed mix. Composted organic amendments, in place of fertilizer, also work well. Some compost blowers are able to inject seed as the compost is blown onto the site.

Once seeded, it is necessary to protect the site from additional surface water flow, specifically overland flow from roads. Direct the water flow away from the project area with gravel drains, swales, culverts, or drainpipe.

Weed-free straw or wood cellulose fiber mulches can be used as a mulch to minimize rain splash erosion. When using straw as a mulch, use as

thin a layer as possible to cover the soil (1/4 inch). Grass seed cannot sprout if the mulch is too thick.

## ***Planting***

Correct plant handling and planting techniques play a major part in plant establishment.

- Keep the rootball moist and bare roots covered at all times.
- When planting, the root flare should be 10% of the root ball depth above ground level.
- Dig the planting hole so it is a minimum of 2 times the diameter of the rootball width.
- Plants smaller than 20-gallon container size do not need to be staked.
- Mulch should cover only the edge of the rootball. When planting is completed, there should be no additional soil and little or no mulch over the root ball for container plants.

Additional information on tree planting can be found at the following website: <http://hort.ifas.ufl.edu/woody/planting/index.htm>

## **Maintenance**

The maintenance supervisor in charge of the contract area reviews and comments on plans during the development of the PS&E. Maintenance review is essential because WSDOT maintenance crews maintain landscape projects after installation.

Before maintenance crews make significant changes in existing roadside landscaping, consult any applicable Corridor Management Plan and the region's Landscape Architect. Communication between all roadside partners is an important part of improving Washington's roadsides.

## ***Partnerships***

Some projects have special partnership arrangements, for example, WSDOT might require the project sponsor or partner to maintain plant communities. Corridor Management Plans will describe partnership agreements within the scenic highway corridor. Project sponsors have included cities, counties, tribes, Metro, Intercity Transit, and other agencies. In these cases, the partner, or partners, reviews design documents and plant material selection prior to installation; they can also contribute labor, funding, and materials.

## ***Security and Visibility: Safety Rest Areas and Weigh Stations***

WSDOT has a policy of not removing vegetation or limbing trees in the roadside to open views for adjacent property owners.

The following are general recommendations for areas where vegetation is creating security concerns or limiting visibility within Safety Rest Areas, weigh stations, etc. Visibility into a site is often needed or requested by agencies such as the Washington State Patrol.

The following actions have been used successfully in a number of areas to alleviate concerns while minimizing impacts on existing vegetation and the valuable functions it provides. These actions are only applicable to alleviate specific security and site visibility concerns, and are not intended as a standard treatment for every roadside area.

- Analyze the area to determine the source and extent of the concern.
- Evaluate all of the functions that the vegetation provides.
- Tailor all actions to balance any removal or thinning of vegetation with the functional value that the vegetation provides in the specific location.
- Complete removal of all vegetation (clearing) is not an acceptable method of alleviating every security concern. Strive for a win-win treatment that alleviates security and visibility concerns while retaining the functional value of the vegetation.

Where removal or thinning of vegetation is determined to be desirable, consider the following actions:

- Limb branches of large evergreen trees (Western Red Cedar, Douglas fir, etc.) to an approximate 9 ft elevation above the ground surface.
- Prune smaller deciduous trees to encourage an open habit with leaves above a 6 ft elevation (hazelnut, serviceberry, vine maple, etc.). Remove only branches that are within the direct line of vision.
- Trim shrubs and groundcover to a 2 ft height and do not allow to grow higher than 3 ft high before pruning again (salal, snowberry, Nootka rose, etc.).
- Information on correct pruning methods can be found at <http://hort.ifas.ufl.edu/woody/pruning/index.htm>

Consult with the region's Landscape Architecture Office or HQ Roadside & Site Development Unit for site and species specific pruning methods.

## Additional Sources of Information

- American Association of Nurserymen, *American Standard for Nursery Stock*, Washington, D. C., latest version
- "Native and Adapted Plants for the Inland Northwest" WSU Cooperative Extension, Spokane County
- Jerry F. Franklin and C. T. Dyrness, *Natural Vegetation of Oregon and Washington*. Oregon State University Press. 1988.
- C. Leo Hitchcock and Arthur Cronquist, *Flora and Fauna of the Pacific Northwest*. University of Washington Press. 1973.
- Liberty Hyde Bailey and Ethel Zoe Bailey, *Hortus Third: A Concise Dictionary of Plants Cultivated in the US and Canada*. Macmillan Publishing Company, New York, 1976.
- N. J. Coppin and I. G. Richards, *Use of Vegetation in Civil Engineering*, Construction Industry Research and Information Association (CIRIA), London, 1990.
- D. H. Bache and I. A. MacAskill, *Vegetation in Civil and Landscape Engineering*, Granada Publishing Ltd, London, 1984
- Michael Dirr, *Manual of Woody Landscape Plants*, Champaign, Illinois, Stipes Publishing Company, 1983.
- Richard W. Harris, *Arboriculture: Integrated Management of Landscape Trees, Shrubs and Vines*, Prentice Hall Career and Technology, Englewood Cliffs, New Jersey, 1983.

**General**

The guidelines in this chapter provide background for the development of effective vegetation restoration methodologies. Two basic restoration approaches are used: managed succession and accelerated climax community development<sup>1</sup>. They are based on the principles of plant succession in natural ecosystems. The decision on which approach to use depends on permitting requirements, project goals, and roadside functional objectives. The Landscape Architect shall be involved in all discussions concerning these decisions.

The following table gives a general indication of when the two methods are used.

<b>RCP Treatment Level</b>	<b>Managed Succession</b>	<b>Accelerated Climax Community Development</b>
<b>1</b>	<b>X</b>	
<b>2</b>	<b>X</b>	<b>X</b>
<b>3</b>		<b>X</b>

**Figure 810.1 Restoration Method Use**

When roadside areas are disturbed during roadway projects, the project's lead agency or Project Office is responsible for rehabilitating the roadside according to the policies stated in the [Roadside Classification Plan](#). The guidelines and discussion in this chapter will facilitate restoration of the roadside environment.

The use of native plants in roadside restoration will, over the long-term, reduce maintenance and life cycle costs of our roadsides. For example, the use of native plant communities reduces mowing costs over the life of the roadside.

**References**

[Roadside Classification Plan](#), M 25-31, WSDOT

<sup>1</sup> Not all experts accept the Climax concept, however because of its ease of use as a conceptual framework it will be used in this manual.

## Resources

Region's Landscape Architects  
HQ Design Office Roadside & Site Development Unit  
Region's Environmental Office  
HQ Environmental Affairs Office Biology Unit  
HQ Horticulturist

## Definitions

***accelerated climax plant community*** The process of restoring a site to a desirable climax plant community in reduced time when compared to natural processes.

***allogenic succession*** Changes in the composition of the plant community as a result of environmental forces.<sup>2</sup>

***autogenic succession*** Changes in the composition of a plant community due to plant interactions (facilitation or competition).<sup>3</sup>

***climax vegetation*** A stable end-point to plant succession ("steady state") where a group of species predominates and replaces itself.<sup>4</sup>

***enhancement*** Any improvement of a structural component to increase the level of ecological functioning of a site.

***genotype*** The genetic make-up of an organism.

***managed succession*** A technique that uses management activities to modify the rate and direction of succession.

***plant association*** A particular, consistent group of species growing in a particular, consistent type of habitat.

***plant community*** A general term describing the group of plants growing in an area.

***plant succession*** Directional, cumulative change in the species that occupy a given area through time.<sup>5</sup>

***reference site*** An established, minimally disturbed natural site that is used as a comparative design guide to help determine the desired plant composition and species densities for the created or enhanced project site. Preferably, the reference site is near the project site, within the same watershed, and has similar hydrology, soils, solar exposure and aspect, and topography. Multiple reference sites can be used resulting in a number of possible community outcomes.

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<sup>2</sup> Oliver and Larson, p. 29.

<sup>3</sup> Ibid., p. 29.

<sup>4</sup> Ibid., p. 147.

**restoration** The process of renewing and returning ecosystem function and health<sup>5</sup> (for systems that have been significantly altered by human activity).

## Succession

Plant communities are in a constant state of fluctuation due to changes in their environment. As a general rule, the composition of any given community can shift in response to changing conditions caused by disturbances. If the disturbance is small, the change in plant community will not be dramatic. If the disturbance is large, such as fire, a landslide, or road building activities, the change in the plant community will be dramatic. Species most suited to the new conditions will colonize in the greatest number. Over time, if no new disturbance occurs, new plants will colonize the area. The new species often tend to be larger, longer lived, and/or woody. This directional, cumulative change in the species present over time is plant succession.

Succession is governed by both external and internal forces. Allogenic (external) forces include human activity, animals, fire, wind, flooding, earthquakes, land slides, climate change, and pathogens and pests.

Autogenic (internal) forces include competition or facilitation between the plants themselves that bring changes in relative abundance of species. These internal changes include displacement of one species by another, shifts in population structure (relative percentage of any one species to the population as a whole), facilitation of increasing dominance by one species due to the conditions created by another, and changes in available resources (sunlight, soil, moisture, etc.).

### ***Disturbance and Succession***

Depending on the severity of a disturbance, two types of succession can take place. These are primary and secondary succession.

Primary succession is the initial stage of plant community restoration following a severe disturbance that leaves bare soil. Initial colonizers, known as pioneer species, establish themselves rapidly during the first growing season, providing cover and minimizing soil erosion. Many plants involved in primary succession are those that can tolerate a wide variety of conditions including the scarcity of water and nutrients. They reproduce rapidly and often spread large quantities of seed using wind or animals as carriers; characteristics of

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<sup>5</sup> Society for Ecological Restoration, 1995.

many weeds; for example Scotch broom in uplands or toad rush in a wetland.

Secondary succession begins either after the plant community of the primary successional phase has become established or following a more mild disturbance which leaves some of the predisturbance habitat in tact. Plants involved in secondary succession are generally longer lived and require somewhat more developed soil conditions to survive. They are often fast-growing trees or shrubs and serve to further stabilize and amend the soil. Examples of secondary succession include red alder colonizing a clear-cut, willow spreading into or along the edge of a wetland, or Douglas fir getting started in a windfall-caused clearing in a mature western hemlock forest.

Secondary succession can take place without the entire plant community being dominated by the new species. A single new species out-competing an established species for its niche habitat is an example of secondary autogenic succession.

## **Climax Plant Communities**

As conditions change across varying habitats, the plant community that dominates the area changes. Communities also change over time as plants and animals alter the microenvironment by changing the nutrient content, texture, and moisture levels in the soil. Their physical structures also provide shade and intercept rainfall, affecting the microhabitats within their canopies. These changes, coupled with disturbances, give other species a competitive advantage.

Over a long period of time, a series of subtly different communities dominate the site. Eventually, in the absence of disturbance, a more slowly evolving state is reached in which existing species thrive and new species are mostly excluded. This later example is known as a climax community and represents a mature, relatively stable system. Even climax communities can be sent back to an earlier successional stage by disturbances such as fire or beaver activity.

## **Genetic Diversity**

One goal in vegetation restoration is to match the genotype of plant materials as closely as possible to that which occurs in similar plant associations within the watershed. Unlike agriculture or forestry, which selects genetic strains for a limited number of desirable characteristics (such as a crop ripening at the same time for ease of harvest), restoration seeks to promote and retain the natural range of variation of genotypes that occur within nearby reference sites. Genetic diversity often allows for wide variability within the same species in a single plant community.



Appearance does not necessarily indicate the genetic adaptability of a plant. One member of a species might have characteristics that allow it to survive under stresses such as drought or pests. All members of the community can be of value.

Members of the same species found in different locations have different adaptations to their specific differences in habitats (for example soil type) or climate (for example blooming times might vary in accordance with local rainfall patterns). It is desirable to obtain plants grown from seeds or cuttings taken from within the same watershed whenever possible because these small differences can affect plant survival.

## **Vegetation Restoration Concepts**

### ***Managed Succession***

With the strategy of managed succession, the objective usually is to manipulate the introduction of native pioneer species to develop site conditions that are conducive to desirable climax, or later successional species. This method is less expensive than planting an accelerated climax plant community and utilizes the desirable quality of promoting natural processes.

There are often situations where a later successional community might not be desirable. Managing successional patterns (arresting succession at a stable shrub stage for example) through careful design, site preparation, and selective maintenance is appropriate and desirable in many situations.

Management of the site might include introduction of pioneer species and secondary successional species or it might allow pioneer species to come in on their own. Periodic removal of the pioneer species and gradual introduction or encouragement of climax or later successional species might also be necessary. We expect our “mature” sites to go through some successional changes.

Pioneer or primary successional species are often weedy grasses and herbs that can rapidly colonize large patches of bare ground.

### **Eastern Washington**

In much of Washington east of the Cascade Mountains, grasslands with herbs are often the climax species. Woody vegetation might be limited or nonexistent.

In grassland and prairie restoration, develop a seed mix of native grasses. See the region or HQ Landscape Architect for grass seed mixes for low moisture zones.

- The species chosen are dependent upon the site and precipitation amounts. Use reference sites and local native ecosystem associations as a guide.
- Growing contracts for grasses might require 2 years lead time to produce sufficient seed for WSDOT construction or restoration projects.
- Select a mixture that allows for quick erosion control and long-term soil structure enhancement.
- Add appropriate herbs to the seed mix for nitrogen fixing, nectar sources, and visual enhancement where wildlife forage will not contribute to a road-kill problem.
- Consider drill seeding native grasses. This gives the seed needed soil contact and protects the seed from wind and sun.
- Native grasses develop their root system before they develop top growth. Top growth might not be visible until the second or third year. Don't give up.
- Before using fertilizers in native grassland restoration, analyze the site and its soil chemistry. Native grasses cannot use large flushes of nutrients. When fertilizers are necessary, use a slow-release form.

Woody vegetation might consist of a sagebrush community, or trees that grow only on north-facing slopes or in riparian zones.

- Where it is practical and desirable to grow woody species, select plants that have been grown locally, whenever possible, because these will be hardy in that climate.
- If fertilization is needed, use only slow-release granular fertilizer.
- Some species in Eastern Washington can be considered pioneer as well as climax species. Quaking aspen, lodgepole pine, water birch, and Ponderosa pine are examples.

### **Lowland Western Washington**

Woody secondary successional species begin to dominate once the primary pioneers have thoroughly colonized and "improved" the site conditions. Suitable early successional plants for humid ecosystems in Washington are Douglas fir, black cottonwood, willows, red alder, bigleaf maple, paper birch (most common in Snohomish County and north), Oregon ash (most common in southern King County and south) and red osier dogwood. These plants essentially function as a cover crop and are also part of a mature forest.

It is desirable that the species selection be proportioned to represent the natural, early succession stages or representative plant communities occurring in the watershed or sub-basin. Refer to [Chapter 800](#) of this manual for an example of this calculation.

### ***Accelerated Climax Plant Community Development***

The objective is to restore a site to a desirable climax plant community, or “special” non-climax communities: such as Puget prairies & sedge meadow wetlands, in reduced time when compared to the natural process. This method is more expensive than managed succession, but can meet project goals and regulatory requirements. Desirable conditions can be reached within 5 to 7 years.

The process involves the introduction of representative species of the desired plant community. Management of the site includes initial control or removal of undesirable plants.

Understory species might be selectively introduced over time. Species are selected from the referenced native plant community. The plant selection is generally a simplified representation of the desired climax plant community.

Plant selection criteria include:

- [Roadside Classification Plan](#) treatment recommendations
- Native plant community
- Compatibility with site conditions
- Availability from commercial nursery sources
- Survival characteristics
- Functions to be provided by the plants
- Similar reference plant communities in the watershed or sub-basin

Factors limiting climax community development include the growth rate of the desirable species, development of upper soil horizons, and colonization by necessary insect, mycorrhizae, and animals.

## **Methods for Managing Succession**

Working *with* succession can assist the roadside manager to develop sustainable plant communities that require minimal ongoing management.

Management activities modify the rate and direction of succession. A management plan can be designed to either promote or hold succession at a given stage.

The three components of managed succession are:

- Designed disturbance
- Controlled colonization
- Controlled species performance

These are detailed further on succeeding pages. Each of these components can be used to enhance or arrest succession along the roadside. Note: arresting succession requires ongoing maintenance. (For example, mowing or burning to maintain open grassland rather than Scotch broom or forest.)

Examples of possible components of managed succession follow.

- Plant (or allow colonization by) desirable early successional species such as red alder or bigleaf maple (controlled colonization).
- Thinning of these trees can be done once they grow large enough to provide shade (designed disturbance). However, trees will eventually self-thin because of competition for light, water, and nutrients.
- Interplant shade tolerant trees, such as western red cedar or western hemlock, or understory shrubs, such as salal or huckleberry (controlled colonization).
- Soil can be amended to optimize growing conditions for desired species (controlled species performance).

The overall goal of using managed succession is to establish sustainable plant communities.

Sustainable plant communities meet *Roadside Classification Plan* goals with minimal maintenance force expenditures.

### ***Designed Disturbance***

Designed disturbance is any activity initiated to create or eliminate site availability for plant growth. Examples of designed disturbance activities include, but are not limited to:

- Burning
- Chopping
- Clearing
- Fertilizer application
- Herbicide application
- Mowing
- Soil pH manipulation

- Thinning
- Adding topsoil and mulch

Along with climate, elevation, surface and ground water attributes, and orientation factors, soils are a primary determinant of vegetation patterns. Of these four factors, soils are most easily manipulated at any given location by the addition of amendments, nutrients, cultivation, grading, and water. It is important to replicate the natural soils on which the desired plant community is typically found.

The soil requirements of different plant communities can be drastically different with regard to pH, organic content, moisture levels, and chemical composition. Be sure the plants being installed either are adapted to the soil conditions of the site or that the resources are available to change the soil conditions. See Soil and Soil Amendments in [Chapter 700](#) of this manual for more information.

### ***Controlled Colonization***

Controlled colonization usually involves adding plants to a site. Planting could range from seeding to planting large plants. In addition to introduced plants, desirable existing plants or seeds might be present on-site, or might be able to spread from adjacent sites. These plant starts will compete with, or augment, the ultimate design plant community. *Caution:* The introduction of exotic plants can seriously undermine vegetation restoration efforts. Every effort should be made to keep particularly troublesome species (for example English Ivy, Japanese knotweed, butterfly bush, Himalaya blackberry, purple loosestrife, Canada thistle, reed canarygrass, or Scotch broom) from becoming established at the site. Seed mixes, plantings and imported soils, should be guaranteed to be free of seeds, rhizomes, etc. If these noxious species are found they must be killed and removed immediately.

### ***Controlled Species Performance***

Controlled species performance uses various methods to decrease or enhance growth and reproduction of specific plant species. Successful controlled species performance recognizes the dynamic character of plant communities, and encourages specific plant communities that will resist invasion through competitive interactions. Individual species and their populations are targeted within this context. To accomplish this, the manager must have knowledge of species characteristics, including:

- Water, light, and nutrient requirements.

- Physiological characteristics, such as root structure, or plant shape.
- Responses to competition.
- Role within the plant community and successional pathway.
- How each species responds to proposed management techniques.

By understanding and using this information, the roadside manager can use common practices to control species performance. Some examples of controlled species performance practices are:

- Mowing undesirable species after flowering but before seed production to eliminate reproduction.
- Not mowing where desirable species (such as lupine) exist until after seed production to allow for next year's stand.
- Shading out shade intolerant invasive species with tree or shrub cover. (Not all invasive species are shade-intolerant, however.)
- Plant-specific application of selected herbicide.

### ***Evaluation***

To be successful, evaluate managed succession techniques until goals and objectives stated in the management plan are met, regulatory commitments are met, and the site is functioning. If a plant community is not developing according to the design set in the management plan, the region's maintenance staff, with the landscape architecture office, the Biologist, and the HQ Horticulturist will evaluate the situation and adjust practices and/or management plan goals accordingly.

## **Contracts and Schedules**

### ***Growing Contracts***

Because plants selected from genetic stock obtained from the same habitat as the project adapt better to those climatic conditions, growing contracts may be necessary to obtain sufficient numbers of desired plants. For woody vegetation, one to two years growing time may be necessary. Grass and herbs may require two years or more from seed collection to seed production in numbers sufficient to seed the project area.

Consider having vegetation grown from seeds or cuttings taken from the vegetation of the construction site before construction begins.

When practical, allow time in the landscape contract for growing contracts where insufficient stock is available. This is in addition to the 1 to 3 year plant survival clause in the landscape contract.

### ***Separate Roadside Revegetation Contracts***

Because of the specialized nature and timing of roadside revegetation and restoration work, it can be advisable to separate this part of the contract from the engineering component of the project. This can allow the engineering contract to close while the revegetation contract continues. Funding must be assured in advance.

Consider work sequencing over at least two seasons to allow for managed succession practices.

Consider adding minimum landscape contractor's qualifications and references to the contract. Contract inspectors shall include the restoration design team or the wetland design team to ensure the project is constructed as designed, that it will meet regulatory requirements, and to make necessary adjustments to meet unexpected soil or moisture conditions.

For grassland work, consider specifying no-till seed drilling for seeding without disturbing the soil layers. This can be done only where the existing vegetation has been eradicated using non-residual herbicides.

### ***Construction Scheduling***

Planting must be done during planting windows, per the [\*Standard Specifications\*](#) to allow for maximum growth during the rainy season.

### ***Woody Vegetation***

Plant stock one gallon or smaller in size, and use compost tilled into the soil with a bark or wood chip mulch layer to hold soil moisture and reduce weed competition. Continue to monitor plants during the first 3 to 5 years to determine plant moisture needs and supplement as practical and necessary.

### ***Grasses and Herbs***

The ideal seeding window is specified in the [\*Standard Specifications\*](#) to take advantage of seasonal rainfall.

It is possible that native grasses will not be visible the first year because they develop their root systems first before putting out top growth. A provision for initial erosion control must be made while the native vegetation becomes established. This can take the form of erosion control matting or a cover crop such as sterile wheat.

## Plant Establishment Maintenance and Monitoring

Maintenance of new plantings until they become established is critical to the success of revegetation projects. Landscape contracts must include provision for plant establishment and weed control.

Plant Selection Including Plant Establishment (PSIPE) should be enforced in all contracts. Under this provision, the contractor maintains and guarantees plant survival for the first 1-3 years depending on the contract.

Allow funds for maintenance of the site until desirable plants become fully competitive with weeds (generally 5 to 7 years). Maintenance can include planting additional plants to meet coverage requirements. The Landscape Architect can arrange for contractors to perform this maintenance. These provisions allow WSDOT to meet required standards of success in restoration permitting and to restore roadside functions after roadway construction.

Consider the following techniques:

- Selective weeding.
- Wicking with herbicides, or other selective herbicide treatments, where appropriate.
- Native prairies need regular disturbance in the form of mowing or fire to prevent invasion by woody species. Controlled burns might be done in coordination with local fire department training. Burn no more than 1/3 to 1/2 of the prairie acreage per year. This allows a refuge for insects (such as butterflies) to survive the disturbance.
- For prairie restorations, high mowing (6-12 inches) can be done once late winter/early spring growth starts - this can be as early as January in lowland Western Washington and again before seeds mature. Mowing during this time will encourage natives and cut back the nonnative species by removing the leaves, flowers, and immature seeds of fast-growing non-natives.

Monitor native prairie vegetation during the growing season. Native herbs and grasses go dormant during the dry season (July through September). Monitoring during this season will not provide complete plant community data.



## Additional Sources of Information

- M.G. Barbour, J.H. Burke, and W.D. Pitts. 1987. *Terrestrial Plant Ecology*, Benjamin/Commings, Inc. , Menlo Park, California.
- Kelly M. Cassidy. 1997. Land Cover of Washington State: Description and Management. Volume 1. In: Washington State Gap Analysis Project Final Report (K.M. Cassidy, C.E. Grue, M.R. Smith, and K.M. Dvornich, eds.). Washington Cooperative Fish and Wildlife Research Unit, University of Washington, Seattle. 260 p.
- Sarah S. Cooke (editor), 1997. *A Field Guide to the Common Wetland Plants of Western Washington and Northwestern Oregon*. Seattle Audubon Society. 417 p.
- Jerry F. Franklin and C. T. Dyrness, *Natural Vegetation of Oregon and Washington*. Oregon State University Press. 1988.
- Donald Harker, Sherri Evans, Marc Evans, and Kay Harker, *Landscape Restoration Handbook*, Lewis Publishers. Boca Raton, 1993.
- National Research Council, *Restoration of Aquatic Ecosystems*, National Academy of Sciences, Washington D.C., 1992.
- Chadwick D. Oliver and Bruce C. Larson, *Forest Stand Dynamics*, Update Edition, New York, John Wiley & Sons, Inc., 1996.
- Roberta Parish, R. Coupé, Dennis Lloyd, and Joe Antos (editors). *Plants of Southern Interior British Columbia*. Redmond Washington: Lone Pine Publishing. 1996.
- Jim Pojar and Andy MacKinnon (editors). *Plants of the Pacific Northwest Coast: Washington, Oregon, British Columbia and Alaska*. Lone Pine Publishing. 1994.
- Ronald J. Taylor. *Sagebrush Country: A Wildflower Sanctuary*. Mountain Press. 1992.



## General

Irrigation provides additional moisture to plants during establishment (3-5 years), during long dry periods, or in special cases, on a continuing basis. Irrigation is a high maintenance and high cost item; use only when absolutely necessary.

## References

*Backflow Prevention Assemblies Approved for Installation in Washington State.* Washington State Department of Health.

*Cross Connection Control Manual: Accepted Procedure and Practice.* Pacific Northwest Section - American Water Works Association.

*Design Manual* M 22-01, WSDOT

*Standard Specifications for Road, Bridge and Municipal Construction* M 41-10, American Public Works Association and WSDOT

## Resources

Regional or HQ Design Office Landscape Architects

Regional or HQ Utilities Section

Regional or HQ Maintenance Offices

## Definitions<sup>1</sup>

**approved** Refers to an approval in writing by the health authority or other agency having jurisdiction.

**atmospheric vacuum breaker(AVB)** A device that contains a float check (poppet), a check seat and an air inlet vent. When water pressure is reduced to a gauge pressure of zero or below, the float check drops. This allows air to enter the device to prevent backsiphonage. It is designed to protect against backsiphonage only.

**backflow** Refers to the flow of water or other liquids, gases, or solids from any source back into the customer's plumbing system or the serving utility's water distribution system.

**backflow prevention assembly** Refers to a backflow preventer that is designed to be in-line tested and repaired, and to meet the head loss

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<sup>1</sup> *Cross Connection Control Manual: Accepted Procedure and Practice*

and flow requirements of the recognized approval authority. The assembly consists of the backflow prevention unit, two resilient seated shutoff valves, and test cock(s).

***backpressure*** Refers to water pressure that exceeds the operating pressure of the purveyor's potable water supply.

***backsiphonage*** Backflow due to a negative or reduced pressure within the purveyor's potable water supply.

***check valve*** A generic term used for a variety of valves that specifically allow flow in only one direction.

***conduit*** A pipe containing electrical wiring.

***contamination*** An impairment of the quality of potable water (by sewage, industrial fluids, or waste) that creates an actual hazard to the public health through poisoning or the spread of disease.

***cross connection*** Any actual or potential physical connection between a potable water line and any pipe, vessel, or machine containing a nonpotable fluid, or having the possibility of containing a nonpotable fluid, such that it is possible for the non-potable fluid to enter the water system by backflow.

***double check valve assembly (DCVA)*** An approved assembly consisting of two independently operating check valves, loaded to the closed position by springs or weights, and having suitable connections for testing. It is installed as a unit with and between two resilient seated shutoff valves

***potable water*** Water that is safe for human consumption and free from harmful or objectionable materials as described by the jurisdictional health authority.

***pressure vacuum breaker assembly*** An approved assembly consisting of a spring loaded check valve loaded to the closed position, an independently operating air inlet valve loaded to the open position, and suitable connections for testing. It is installed as a unit with and between two resilient seated shutoff valves. It is designed to protect against backsiphonage only.

***reduced pressure backflow assembly*** An approved assembly consisting of two independently operating check valves, spring loaded to the closed position, separated by a spring loaded differential pressure relief valve loaded to the open position, and having four suitable test cocks for checking the water tightness of the check valves and the operation of the relief valve. It is installed as a unit with and between two resilient seated shutoff valves.

**service connection** The piping connection by means of which water is conveyed from the serving utility's distribution main to a customer's premises.

**sleeve** A pipe containing other irrigation pipe. Also called *casing pipe*. (See [Figure 820.1](#))

## Planning

### Source of Water

Sources of water for irrigation include municipal water systems and water pumped from a well, pond, stream, or irrigation district. When selecting a source of water, consider what permits and agreements might be needed as well as the cost and feasibility of bringing water from the source to the site. Show the location and water source on the irrigation plan. In some jurisdictions it might be necessary to calculate water use for the years of plant establishment. Calculate that cost and include it in the estimate.

### Municipal Water

Document in the project file:

- Location for the service meter. Define by contacting the serving utility.
- Location and depth of the municipal water main .
- Available liters per minute and the static water pressure in megapascals (or pounds per square inch [psi]) at the proposed meter location. Include this information on the plan sheet.
- Preliminary cost estimate for water meter and connection fee, monthly fees, and cost of water. An example of an irrigation system water cost estimate is found in the Appendix.
- Cost savings that might be realized on landscape rehabilitation jobs where there have been prior meters. Check for existing meters, their age, condition, and connections to the main.
- Water service agreement from the water supplier and an electrical service agreement with the electrical supplier. Work with the Utilities Section to obtain utility agreements.
- Cost for connections in the cost estimate.

## **Well, Pond, Stream, or Irrigation District**

Document in the project file:

- Desired location of pump (for pond, stream or irrigation canal only).
- Location and type of power source.
- Length of suction line required.
- Height of suction lift.
- Type of suction intake.
- Need for screening of contaminants.
- Provide pump data in accordance with the [\*Hydraulics Manual\*](#).

Obtain the needed permit(s) from the jurisdictional authority for water withdrawal.

Check with the serving utility about pipe and backflow details required.

## **Design**

### ***System Controls***

- In appropriate locations, use electric (110 volts), battery, wind, or solar operated automatic controllers.

### ***System Components***

Select products with proven desirable performance records. Consult with maintenance personnel to determine desirable products. When a system is designed using a certain product, include a note to the contractor stating that the system has been designed with that product; but the contractor may use other manufacturers' products that are approved by the Engineer as equal or better.

- A proprietary item request might be appropriate so that all components (for example, the same valve) in a maintenance area are the same. This allows for ease of maintenance and inventory control.
- Select durable, readily available, easy to operate, and vandal resistant irrigation components. Plastic rather than brass heads may be selected to discourage vandalism.
- Determine the size of service meter needed once the demand (gallons per minute) is known.

- Meter water use for type of consumption where appropriate, especially at safety rest areas to determine irrigation versus restroom water use.

## ***Layout***

Perform a site analysis prior to layout design.

- Consider current and potential locations of power source, signs, guardrails, maintenance areas, planting areas, and so forth, when locating irrigation lines.
- Consider prevailing wind direction and velocity and its effect on spray patterns.
- Where practical, set sprinkler heads at least 0.6 m from trails and sidewalks, or use pop-up spray heads in order to minimize vandalism.
- Space sprinkler heads at a distance of 50 to 60% of their diameter of throw for groundcover and shrub areas. For turf areas, space them at a maximum of 50% of their diameter of throw.
- Install irrigation lines along slope contours rather than running downhill.
- Minimize the use of partial pattern heads and strip spray heads.
- Match precipitation rates for uniform coverage of the planting area.
- Balance head distribution evenly for each valve zone. Consider pressure change due to elevation and pressure loss from friction.
- For drip irrigation systems, install emitters in multiples at shrubs, and trees, to ensure a wider and more uniform distribution of water over the entire plant root area.
- Install drip emitters up-slope of trees and shrubs.
- When using a subsurface dripline irrigation system, a self-cleaning pressure-compensating system is preferred to keep the dripline from plugging with soil particles. A dripline system that incorporates root intrusion treated components or chemical release water delivery is also a preferred system.
- When possible, mount automatic controllers inside a building, for security, in a location that is easily accessible to maintenance personnel. If it is not feasible to locate the controller inside a building, then locate it away from sprinklers and preferably at a location from which the irrigation system can be viewed in operation.

- Consider the need for winterization of irrigation systems to avoid freeze damage to system components. An air compressor fitting may be needed to blow out the lines for winter.

## **Piping**

Irrigation systems typically use PVC pipe. Refer to the [\*Standard Specifications for Road, Bridge and Municipal Construction\*](#) for irrigation pipe and installation specifications.

Minimize the number of pipe sizes in order to reduce the number of contract Bid Items, and the construction cost. Where practical, eliminate small quantities of one size of pipe by increasing the size to the next size used on the project.

Include pipe design calculations (Pressure Loss Calculations) in the project file. An example of irrigation system pressure loss calculations can be found in the Appendix.

See [\*Design Manual\*](#) for additional design documentation requirements.

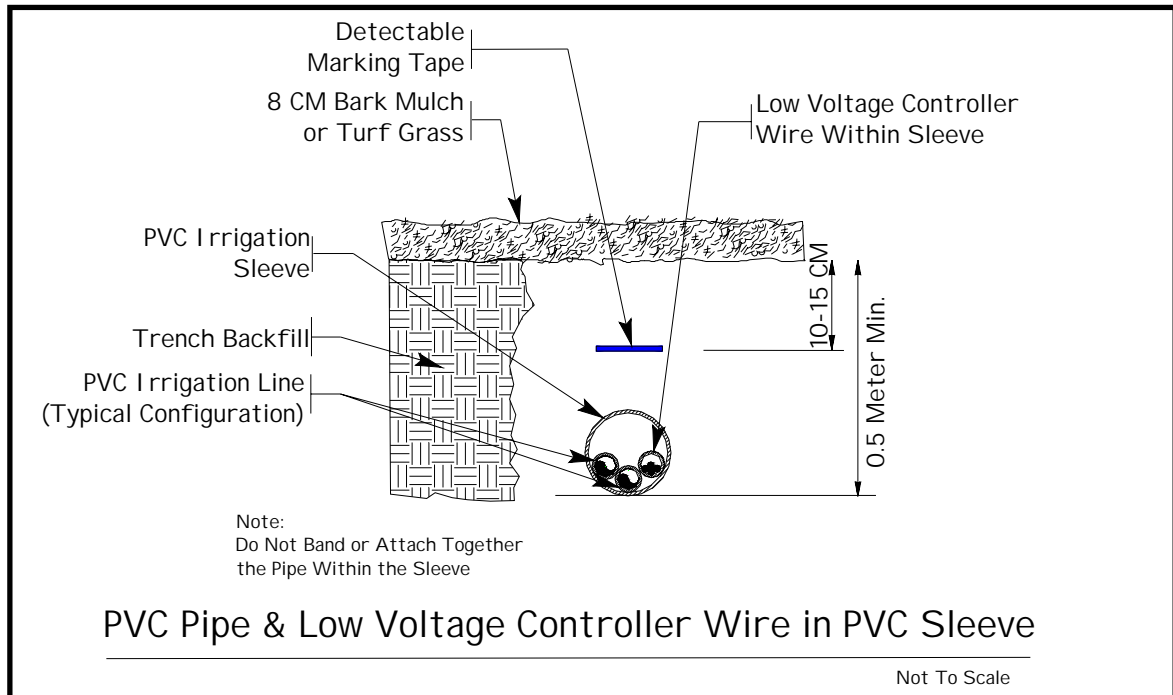
## **Sleeves**

When irrigation lines are to be installed under pavement, provide sleeves for pipes and wiring. Install sleeves prior to paving per [\*Standard Specifications for Road, Bridge and Municipal Construction\*](#).

- Sleeves must have smooth interior walls (not corrugated) and may be Class 200 PVC pipe, “Drain Pipe \_\_\_\_Diam.” or other pipe material that meets the specific load requirements.
- Size the sleeve so that the inside diameter (ID) is at least 2.5 times the combined outside diameters (OD) of the pipe(s) that are to be in it.
- Place metal locator strip above sleeve as noted in the drawing on the following page.

See the following Figure for an example of piping inside a sleeve.





**Figure 820.1 Irrigation Sleeve**

## Valves

### Master Remote Control Valve

Master remote control valves are recommended for use in main lines, especially where a break in the main line is likely to produce significant erosion or hazard. The valves are installed just down flow from the meter so the mainline is pressurized.

For added protection from breaks in irrigation lines a flow sensor may be used to shut off the water. See the HQ Design Office Roadside & Site Development Unit or the HQ Maintenance & Operations Program Landscape Architect for more information.

### Station Control Valves

Group valves in valve boxes for efficient maintenance access. Consider maintenance vehicle access when choosing locations.

### Wiring

- See *Standard Specifications for Road, Bridge, and Municipal Construction* for wiring specifications.
- Provide additional wire runs (one spare wire to each valve) for backup power source.
- Low voltage controller wire may be placed in the sleeve along with irrigation piping.

- The main electrical supply lines (110 volts) must be installed in a separate conduit.
- Use wire splices as specified in Section 9-15 of the *Standard Specifications for Road, Bridge, and Municipal Construction*. Check with the HQ Design Office Roadside & Site Development Office if additional information is needed.

### **Cross Connection Control Devices**

The protection of public potable water supplies is accomplished by eliminating or controlling actual and potential cross connections (backflow). Cross connections might allow contamination to reverse flow into a potable water system or aquifer. Do not allow water to flow through the backflow device until the device has been tested by the serving utility. When a facility such as a safety rest area has no serving utility, backflow devices on wells are tested by an inspector with certification through Washington State Department of Health. Contact the HQ Maintenance Office for information.

Types of mechanical backflow devices are:

- Reduced pressure backflow assembly (RPBA).
- Double check valve assembly (DCVA).
- Pressure vacuum breaker assembly (PVBA).
- Atmospheric vacuum breaker (AVB).

All four types of mechanical devices provide adequate protection against a **low degree** of hazard contamination if installed correctly. Therefore, when selecting the type of device to be used against a low degree of hazard contamination, consider initial cost, serving utility requirements, and maintenance.

Of these four mechanical devices, the RPBA affords the greatest protection against backflow. The RPBA is the **only** mechanical device to be used where a backflow would produce a **high degree** of contamination hazard. The local serving utility is the ultimate approval authority for backflow prevention within their jurisdiction. It is therefore necessary to contact the local serving utility to ascertain what type of device they will require as a minimum.

Once the appropriate type of device has been determined, the device is selected from the current list in *Backflow Prevention Assemblies Approved for Installation in Washington State*, published and periodically updated by the Department of Health. Consult the HQ Design Office Roadside & Site Development Unit if you have questions.

A bore-sighted drain (sloped downward) to daylight must be

provided to ensure positive drainage whenever there is an underground vault installation of an acceptable backflow device. The vault drain must be sized in accordance with the requirements of the *Cross Connection Control Manual: Accepted Procedure and Practice*.

## Construction

As a minimum, all mechanical backflow devices are installed in accordance with the most current copy of the *Cross Connection Control Manual: Accepted Procedure and Practice*, published by the Pacific Northwest Section - American Water Works Association. In addition, they must be installed in accordance with the [\*Standard Specifications for Road, Bridge, and Municipal Construction\*](#), and their manufacturer's recommendations.

## Maintenance

Irrigation systems require regular maintenance to function properly.

- Backflow prevention devices are to be tested annually by an inspector with certification through the Washington State Department of Health. Contact HQ Maintenance & Operations Program for information.
- Winterize irrigation lines by draining or blowing out the lines prior to the first winter freeze.
- Check system as part of Spring start-up and throughout the season.
- Repair irrigation system promptly to avoid water loss and to prevent erosion from broken water lines.



# **Revegetation for Stream Restoration and Fish Passage Projects**

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830.01	<a href="#">General</a>
830.02	<a href="#">References</a>
830.03	<a href="#">Resources</a>
830.04	<a href="#">Definitions</a>
830.05	<a href="#">Planning</a>
830.06	<a href="#">Design</a>
830.07	<a href="#">Restoration Considerations</a>
830.08	<a href="#">Construction</a>
830.09	<a href="#">Maintenance (Plant Establishment)</a>
830.10	<a href="#">Additional Sources of Information</a>

## **830.01 General**

WSDOT will construct a large number of projects to replace culverts that have become impassable to migrating fish. This guidance represents minimum standards for the restoration of impacts resulting from these fish passage projects. The goal is to achieve efficiency and efficacy in the designs, as well as expediting the permitting process. This guidance meets WSDOT's policies while also responding to regulatory needs, including WSDOT's policy of practical solutions thinking.

The majority of fish passage barrier removal projects do not require state or federal mitigation in addition to the on-site restoration for buffer or wetland impacts. The benefits of the projects on aquatic resource functions and services generally outweigh the temporary impacts to the streams and wetlands. This is called a net-benefit or net-increase. For a project to have a net-benefit, maximum available onsite restoration is required to provide the highest possible function within the project limits. This may include retaining trees that are removed and replacing them onsite to benefit the stream and fish habitat.

Projects restore sites according to the strategies and guidance in the Roadside Manual. The designer applies best practices in developing the restoration plan with the intent of restoring the highest possible ecological and functional potential within the project limits. While the context, habitat needs, and system requirements are unique to each site and determine the restoration strategy for each project, this guidance ensures consistency in meeting regulatory and stakeholder needs and expectations.

This chapter deals with the restoration of stream banks and riparian systems. For help with installation of large woody material (LWM), or protecting the roadway embankment when a river is next to the roadway, contact the region or headquarters Hydraulics and Materials Engineers.

## **830.02 References**

[Environmental Procedures Manual](#), M 31- 11, WSDOT

[Highway Runoff Manual](#), M 31-16, WSDOT

[Hydraulics Manual](#), M 23-03, WSDOT

Roadside Manual, M 25-30, WSDOT Soil Bioengineering, Vegetation and Vegetation Restoration chapter

Integrated Streambank Protection Guidelines. Washington State Department of Fish and Wildlife. 2003. <https://wdfw.wa.gov/publications/00046>. This document focuses on repairing bank erosion and preventing future erosion while creating or enhancing habitat.

FISRWG 1998. Federal Stream Corridor Restoration Handbook (NEH-653). Stream Corridor Restoration: Principles, Processes, and Practices. By the Federal Interagency Stream Restoration Working Group (FISRWG)(15 Federal agencies of the US gov't). GPO Item No. 0120-A; SuDocs No. A 57.6/2:EN 3/PT.653. ISBN-0-934213-59-3.  
<http://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/water/manage/restoration/?&cid=stelprdb1043244>

National Engineering Handbook (210-VI-NEH) 2007. [Stream Restoration Design](#) (NEH-654. Bernard J., J.F. Fripp & K.R. Robinson (Eds.),. Washington, D.C.: USDA Natural Resources Conservation Service.  
<http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/water/quality/?&cid=stelprdb1044707>

The Practical Streambank Bioengineering Guide. User's Guide for Natural Streambank Stabilization Techniques in the Arid and Semi-arid Great Basin and Intermountain West. 1998. Bentrup, G. and J.C. Hoag, Contributors. USDA-NRCS Plant Materials Center, Interagency Riparian/Wetland Project.  
<http://www.plant-materials.nrcs.usda.gov/pubs/idpmcpu116.pdf>

Roadside Revegetation: An Integrated Approach to Establishing Native Plants, FHWA,  
[http://www.nativerrevegetation.org/learn/manual/ch\\_1.aspx](http://www.nativerrevegetation.org/learn/manual/ch_1.aspx)

[A Soil Bioengineering Guide for Streambank and Lakeshore Stabilization](#). 2002. USDA United States Forest Service (FS-683). <http://link.library.in.gov/portal/A-soil-bioengineering-guide-for-streambank-and/UTPqNYx4LEQ/>

[The Role of Large Woody Debris in Lowland Puget Sound Streams and Rivers](#). 2004. Booth, Derek B. and Fox, Martin J., Seattle, WA: Center for Water and Watershed Studies.

[Stream Habitat Restoration Guidelines](#). 2012. Cramer, Michelle L. (managing editor). 2012. Co-published by the Washington Departments of Fish and Wildlife, Natural Resources, Transportation and Ecology, Washington State Recreation and Conservation Office, Puget Sound Partnership, and the U.S. Fish and Wildlife Service. Olympia, Washington. This document focuses on watershed assessment, problem identification, and general approaches to restoring stream and riparian habitat.

[Why Streamside Buffers are Voluntary for Farms in Washington State](#). 2016. Northwest Treaty Tribes

WSDOT [Standard Specifications](#) and [Standard Plans](#)

### 830.03 Resources

STREAM IDT FOR DESIGN AND CONSTRUCTION. 2017 Stream Inter-Disciplinary Team Project. Involvement. Acronyms Used. BIO Biologist. BM Environmental Business Manager.

Environmental Bulletin. 2017. Page 1. Environmental Bulletin April 2012 Subject of the Month: What role do NWR Construction offices play in the Stream IDT.

## 830.04 Definitions

**Alluvial Fan Influence** Area within cone-shaped feature on the landscape where silt, gravel, sand, and sometimes boulders, have been deposited and continue to be susceptible to surface water sediment deposition.

**Green Infrastructure** An approach to water management that protects, restores, or mimics the natural water cycle. Green infrastructure is effective, economical, and enhances community safety and quality of life.

**Impervious Surface** A hard surface area that either prevents or retards the entry of water into the soil and from which water runs off at an increased rate of flow.

**Interdisciplinary Team** Group of related disciplines including engineers, biologists, landscape architects, real estate professionals, hydrologists, etc. working as a team to develop the project.

**Low Impact Development** Systems and practices that use or mimic natural processes that result in the infiltration, evapotranspiration or use of stormwater in order to protect water quality and associated aquatic habitat.

**Native Riparian Area** Areas adjacent to streams containing elements of both aquatic and terrestrial ecosystems that mutually influence each other. The width of these areas extends to that portion of the terrestrial landscape that directly influences the aquatic ecosystem by providing shade, fine or LWM, nutrients, organic and inorganic debris, insects, or habitat for riparian associated wildlife. 250' from OHWM is the standard buffer for shorelines of the state.

**O.C.** On Center

**Ordinary High Water Line (OHWL)** The mark on the shores of all water that will be found by examining the bed and banks and ascertaining where the presence and action of waters are so common and usual, and so long continued in ordinary years as to mark upon the soil or vegetation a character distinct from the abutting upland. Provided, that in any area where the ordinary high water line cannot be found, the ordinary high water line adjoining saltwater is the line of mean higher high water and the ordinary high water line adjoining fresh water is the elevation of the mean annual flood. (RCW 77.55.011)

**Practical Solutions** Practical Solutions is a performance-based data-driven approach to transportation decision-making using the latest tools and performance measures to support lower cost efficiencies in the operation and replacement of transportation infrastructure.

**Plant Establishment Crew** A landscape maintenance crew that works on roadside and environmental restoration planting areas. The purpose of the crew is to meet planting area permit and WSDOT policy obligations on a project-by-project basis. The goal for the plant establishment crew is to take advantage of task efficiencies to exceed expectations earlier than the anticipated project duration. Therefore, the project can closeout early. The funding for the crew comes from each individual project and early closeouts will keep Program costs down. An additional project completion goal is to release established planting areas to WSDOT area maintenance personnel in a condition that will minimize ongoing maintenance costs.

**Stream Simulation** Method of stream design based on the assumption that geologic and hydraulic conditions in natural channels define passage characteristics for migrating fish and that appropriate design of culverts/channel-spanning structures allow for relatively natural channel configurations / flows can achieve fish passage characteristics.

## 830.05 Planning

During the planning phase, best practices call for the use of an interdisciplinary team to determine goals and methods, and to ensure efficiency of delivery. The team brings knowledge to the table from all areas of expertise and avoids the redo loop that could occur when one area or concern is not included as the project moves forward.

The Interdisciplinary Team generally includes, but is not limited to:

- Project Engineer Office (PEO): The project is assigned to a PEO that is ultimately responsible for delivering the fish passage project.
- HQ Hydrology: Provides reach assessment, reference reach analysis, and large woody material recommendations.
- HQ Stream Hydraulics: The stream engineer/hydrologist determines the design of the stream channel, channel morphology, and bankfull width.
- HQ Bridge and Structures (B&S): The B&S office determines the type and design of a structure spanning the stream to accommodate the roadway.
- HQ Stream Restoration/ Fish Passage Biologist: The HQ Stream Restoration biologist verifies bank full width, writes the biological section of the Project Basis of Design (PBOD,) and provides guidance on fish passage and habitat components of the project design.
- Region Real Estate Services (RES): The RES office purchases property or sets up construction easements where needed, as determined by the PEO.
- Region Permit Coordinator: The region permit coordinator ensures that all regulatory requirements are identified and addressed, to facilitate efficient delivery.
- Region Biologist: The region biologist prepares the biological assessment and the stream mitigation report, which identifies the best practices to meet the environmental functions and needs within the context of the fish passage project.
- Region Landscape Architect: The landscape architect provides impact avoidance input, restoration plans, and oversight to meet permit needs and respond to the environmental needs through the plant establishment period. The Landscape Architect can also help identify site and system-specific opportunities to improve biological functionality.

### 830.05(1) Goals for the project

Overall, the goal is to restore fish passage by replacing culverts that are undersized, placed at too steep of a gradient, or have large drops that impede or block fish passage with more fish passable structures. Once the engineering aspects of the project are identified, the interdisciplinary team identifies functional goals for the project. Habitat components such as instream LWM, shade provided by a vegetative canopy, and available food for juvenile



salmonids provided by invertebrates in, above, and adjacent to the stream, improve functionality of the stream for aquatic life at road crossings.

The projects also address stakeholder concerns such as tribal and WDFW concerns, functional needs/goals and goals of the site, and transportation system requirements. Considerations include, but are not limited to:

- Continued roadway functionality
- Fully fish passable stream crossing
- Decreased water temperatures
- Stream inputs from vegetation
- Channel complexity to reduce or level water flow velocity
- Providing high-flow refugia for juvenile salmonids
- Erosion control for streambanks
- Habitat features for target species

To achieve the goals of the project most efficiently, the landscape architect performs a site analysis and works with the interdisciplinary team to identify the soil types, existing hydrology vs proposed hydrology, existing reference vegetation, desired restoration vegetation types, site context, and habitat needs. See [Section 830.06](#) Design for further discussion.



**Exhibit 1: SR 9 Lake Creek. Prior to restoration, the culvert was undersized and water was restricted. Post-construction, stream is free to move through the culvert and buffers are restored with native plants.**

### **830.05(2) Green Infrastructure Opportunities**

During the planning stage, the design team should explore opportunities to incorporate LID principles and practices. If the project site is conducive to this approach, strategize with the team how to implement such practices and have them programmed early on in the project scope of work. Examples of LID include bio retention areas (rain gardens), compost amended soils, natural dispersion of stormwater, retention of native vegetation (minimizing clearing and grading), using bioengineering techniques for stream bank stabilization, maintaining natural drainages, replacing curb and gutter with swales along roadways or using permeable paving where possible. By implementing LID principles and practices, water can be managed in a way that reduces the impact of built areas and promotes the natural movement of water within an

ecosystem or watershed. Coupled with LID practices, the stream restoration yields a balanced design that maintains or restores a watershed's hydrologic and ecological functions.

## 830.06 Design

### 830.06(1) General Process for Restoration Design

Generally, the biologist will identify a reference site within the vicinity of the project. The purpose of the reference site is to identify and describe locally native habitats and ecosystems and use those systematic relationships to guide the site's revegetation species selections. The reference site may also determine the quantity and type of habitat structures that would be consistent in that particular reach of the stream.

The landscape architect should use the reference site as an example to guide vegetation restoration. The proposed design will also be dependent upon the Roadside Character and constraints to habitat such as roadways, which might control the tree species selected due to the ultimate expected height or fragility of trees, or proximity to neighboring uses that may experience safety concerns. The site analysis will identify these constraints and opportunities and the landscape architect should adjust the design accordingly.

The stream's ideal restoration, its "potential," represents the highest ecological status an area can attain, given no political, social, or economic constraints (Prichard et al. 1993). However, this is not always achievable based on real situations. The restoration goals should identify the desired future condition that responds to and incorporates social, political, and physical realities. However, the project must still meet the environmental objectives and comply with permit requirements. For example, a neighbor who maintains their abutting property as a tended, mowed and pristine garden may not be compatible with a natural, unrestrained stream buffer restoration project, potentially making the restoration less sustainable over time. A best practice would be to meet with the neighbor to see if there is a way to design using the appropriate native buffer plants that will meet the ecological needs of the buffer with a layout that supports the neighbor's aesthetics. Further, the neighbor could desire permission to maintain areas within WSDOT right of way to ensure the level of care desired (weed removal, for example). If this is identified early in the project, in many cases, WSDOT can negotiate with permitting agencies and arrange to issue a permit to enter and do this work. This buy-in is even more important to achieve long-term sustainability on non-WSDOT-owned property where projects have been constructed.

Likewise, if a stream buffer is highly degraded with invasive plants located upstream and outside of the construction easement or right of way; it may not be a sustainable design solution to plant or restore the downstream buffer, knowing that the restoration effort is unlikely to succeed due to the weed infestation from upstream. It is the agency's responsibility to provide the highest level of restoration that will be sustainable and work with the agencies to develop that understanding. In such cases, the lower level expectation would need to be coordinated and communicated prior to the project permitting process. Discussions should occur earlier in the project planning process and include all relevant agencies and tribes.

The planning process is also the appropriate time to consider actions or partners that may help to address issues outside the scope of the project. For example, an invasive species infestation immediately adjacent to the project site may compromise newly planted vegetation but

coordination with the local noxious weed control board may be able to treat the infestation prior to construction.



**Exhibit 2: Surrounding conditions can make sustainable buffers a challenge. Treaty rights, agricultural land not owned by WSDOT, and other considerations require adaptation to the site as a key consideration in creating a sustainable stream buffer. When restoration cannot be sustained due to allowed land use, agencies should come to agreement on how to approach it.<sup>1</sup>**

### **830.06(2) Communication during design**

The project design process will be significantly more efficient and effective with open frequent meetings including the full design team. This enables the various disciplines to address problems as they arise, rather than getting too far along in the design, only to run into a slowdown due to an issue already known by a team member. Design will go more smoothly and construction is less likely to experience lapses or needs for change orders. For most projects, bi-weekly team meetings are sufficient. Other higher-level meetings such as community meetings may be needed as well.

Team progress communication can keep others up to date and precipitate questions and comments that will help provide high value solutions. People to consider including in frequent communications:

- Maintenance staff
- Interdisciplinary team
- Construction office
- Traffic

<sup>1</sup> Why Streamside Buffers are Voluntary for Farms in Washington State. Northwest Treaty Tribes. <https://nwtreatytribes.org/streamside-buffers-voluntary-farms-washington-state/> October, 31, 2016.

Higher level communication that may be needed includes:

- Public meetings
- Project neighbor communications
- Permitting agency meetings
- Issues to consider during these coordination meetings:
- Safety
- Constructability
- Type of structure (culvert, 3-sided culvert, bridge, etc.)
- Cost, including acquisition, installation, maintenance
- Construction and maintenance access (see Section 830.06(3) below)
- Measures to save vegetation
- Architectural treatment (texture, color, railing, fall restraint, etc.)
- Construction easements acquisition:
- Ideally, by 30% design completion
- Include construction access for the entire plant establishment period, not just the year of construction
- Permit obligations
- Neighborhood concerns
- Traffic management

### **830.06(3) Post Construction Maintenance Access Considerations**

#### **Background**

All water crossing structures require inspection, monitoring, and potential maintenance activities during their life cycle. The streambed channel within fish-bearing water crossing structures is periodically monitored to ensure fish passage, including the following requirements:

- Water crossings in the federal injunction area require streambed channel monitoring at least three times within the first five years after barrier correction, and then once every 10 years in perpetuity to ensure fish passage. Correction is required if the crossing is determined to be a fish barrier.
- WDFW Hydraulic Project Approval (HPA) permits require streambed channel monitoring on two to three occasions within the first 2 years after the water crossing structure is constructed to ensure it is performing as expected.
- WSDOT Bridge Preservation performs structural integrity inspections every 2 years for all structures with spans greater or equal to 8 feet. Note, these inspections are federally mandated for all structures with a Structural Clear Span greater or equal to 20 feet.

In recent years, inclusion of planned access roads has become a standard design aspect for some fish barrier correction projects. However, WSDOT environmental staff have received clear messages from multiple tribes and regulatory agencies that these access roads are considered potentially detrimental to the overall environmental benefit of the project. The primary concerns are reductions in riparian vegetation function and resultant risk of fine sediment and stormwater inputs to the stream. Therefore, such roads may conflict with the intent of the injunction.

The longer the expected life of the structure, the more likely it is to experience a disturbance event. Criteria to be considered when requesting a post construction maintenance access includes probability for debris deposition, depth of fill, frequency for routine inspections, vegetation management including noxious weed eradication, and large woody material adjustments.

Providing formal access to fish passage structures via an access road may be needed to provide access for large equipment with minimal impacts to the riparian vegetation, reach various engineered elements, or retrofit natural alterations of the stream bed. Otherwise, access by foot without the need for a formal access road is sufficient and preferable for required monitoring and inspections, as well most maintenance activities that may be required during the life of the structure, including emergencies. Therefore, providing access in some instances will assure WSDOT can meet performance standards as required in the permanent injunction.

### **Maintenance Access**

Each water crossing location has site specific considerations that must be evaluated to determine the appropriate maintenance access approach. By default, fish barrier correction projects should not include planned access roads unless one of the following circumstances is identified:

1. Site conditions which may warrant access in the future. In this case, a constructed and vegetated (no trees) access ramp, which could be quickly converted to a functional roadway, could be installed.
2. Site conditions which warrant access by large equipment. In this case, a constructed access may be justified. The access should be designed to minimize potential incidental transport of fine sediments and/or stormwater to the stream and, where possible, a vegetated riparian buffer should be maintained separating the access from the stream.

Additionally, when determining construction ingress and egress locations, consideration should be taken for long-term maintenance access needs. Efforts should be made to avoid environmentally sensitive areas such as erosion prone slopes, wetlands, and mature growth trees.

### **Direction to Designers**

Early coordination and field review with maintenance, regulatory agencies, and tribes prior to pre-BA meeting is recommended to expediate permitting. For design-build projects, if maintenance access is warranted, it must be evaluated by the design team and incorporated into the Request for Proposal (RFP) prior to advertisement. Maintenance access left in place

should blend naturally into the surrounding slopes ending landward of ordinary high water line (OHWL) elevation.

- If post construction maintenance access is requested, it should be restored in a fashion that limits or eliminates any pollution generating impervious surface (PGIS) producing features, stops above the OHWL, avoids all riparian vegetation, and is planted with cover such as grasses and shrubs which can be infrequently mowed. No trees shall be planted within the proposed maintenance access area.
- Contact regional Landscape Architects for appropriate revegetation strategies, including species selection and rough number of native plants on upland areas at the project sites.
- Structures implementing maintenance access recommendations will be recorded into Highway Activities Tracking System (HATS) for tracking, agreed up attributes, spatial extent, and performance standards.
- Refer to Standard Specifications 8-02.3 for guidance on de-compaction and revegetation of access areas.

### Considerations

The following criteria were developed to assess the need for long term access at fish passage barrier correction sites. Access recommendations, if warranted, will be included in the project scope by the Project Engineer in consultation with Regional Biologist, or Environmental Manager.

- If the total score reaches 13 points or higher (60% of maximum points) based on the values in Table 1, post construction access is recommended for the project location.

Criteria for Inclusion		
Alluvial Fan Influence <sup>2</sup>	No Sediment Concerns	1
(Chronic Environmental Deficiency)	Reoccurring Sedimentation	2
	Structure Within Deposition Area	3
Deep Foundations with Scour Countermeasures	No	1*
	Yes	3*
Amount of Fill Under Pavement	< 5'	1
	5 -10'	2
	10 - 20'	3
	> 20'	4
Access Driving Surface	Native Soil and Vegetation	1
	Gravel/Spalls	2
Potential Access Frequency	Low Potential for Maintenance	1

<sup>2</sup> Individual situations such as reoccurring alluvial deposition may be sole criteria justifying post construction access.

\*Provide maintenance access from the roadway to all scour countermeasures when a bridge abutment is supported by a deep foundation (e.g., piles, drilled shafts) and the foundation is designed assuming the soil protected by the scour countermeasures remain in place. See Design Manual 720.03(15) for more information.

	High Potential for Maintenance	2
Secure Access Off Roadway Required	No	1
	Yes (Dedicated Area)	2
Potential Human Use <sup>3</sup>	Low	1
	Medium	2
	High	3
Length of Access	Short - Parking Area	1
	Medium - Extended downslope	2
	Long – To OHWM	3
Width of Access	10'	1
	12'	2
	15'	3
	Maximum Total	<u>25</u>

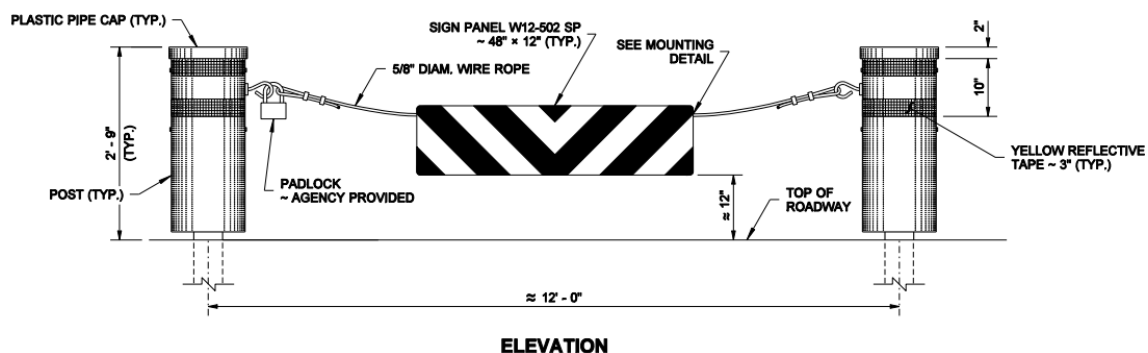
Table 1

### Approvals

The Assistant Regional Administrator for Development (or delegate) has the final approval for inclusion of maintenance access, unless as otherwise obligated above. As previously mentioned, it is good practice to consult Region Maintenance and the Bridge Preservation Office when evaluating Maintenance Access.

### Documentation

Decisions to include maintenance access shall be documented in the Basis of Design (BOD) and a design decision). The documentation should include conclusions for the aforementioned considerations, and approval.

Exhibit 2a Standard Plan L-70.10-01: Access Control Gate

<sup>3</sup> Potential human use includes expected foot traffic due to adjacent recreational activities or potential encounter with people experiencing homelessness. Evidence of desire paths during site analysis of existing conditions may provide insight on the degree of potential human use.

## **830.07 Restoration Considerations**

### **830.07(1) Site Analysis**

The entire design team (including specialty groups) should attend at least one of the site visits to mutually understand the scope of the project, summarize the overall project objectives and environmental goals, evaluate existing site conditions, constraints, and opportunities, and understand the site's contextual relationship with adjacent land use. Having diverse expertise onsite could highlight specific aspects of the site or project influences not typically captured when viewed through an individual lens.

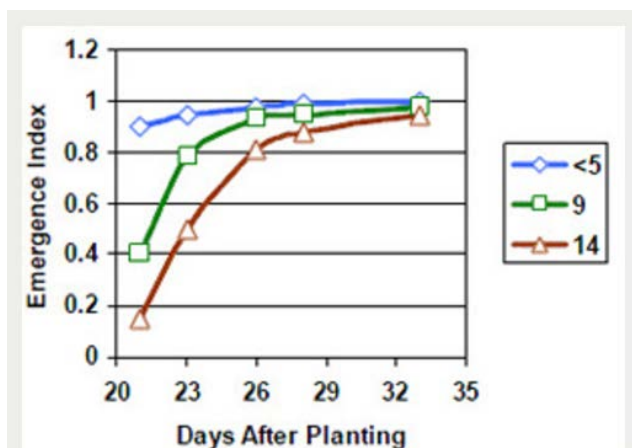
Plants have a very low likelihood of thriving in areas with sub-optimal soil conditions. During site analysis, identify the soil properties within the project limits. Different types of soils require different stabilization, amendment, and planting tactics. Identify areas of compacted soil or where the project will place an access road that will later be restored. These areas require careful planning and treatment.

Identify other site conditions that might affect the ability of plants to thrive. Direct sun, complete shade, steep slopes, and rocky conditions will all require special treatment during design. Water availability affects the success of the newly planted areas, especially for a new stream alignment location where vegetation did not previously exist. Determine if the site may need additional irrigation infrastructure during plant establishment and include this need during design development.

### **830.07(2) Soil**

While existing native species on the site suggest good native soils, the intrusion of workers, materials stockpiling and heavy equipment access will affect soil compaction, biology, and micro fauna. Compost, compost tea, and mycorrhizal inoculants have the capacity to restore soil biotics. Stockpiling and reuse of existing topsoil is a good idea, but sometimes impractical based on the duration of the project and difficulty with stockpiling. On-site stockpiling is challenging due to efforts to minimize impacts within sensitive areas and preventing inadvertent impacts. Soil stockpiling must be carefully considered because it greatly reduces or eliminates the biotic benefits of the existing soil. If adequate techniques are not employed for stockpiling, biotic benefits are harmed by length of time the soil is stockpiled, height of the stockpiles, compaction of the piles, quality of the material placed in the stockpile, etc.

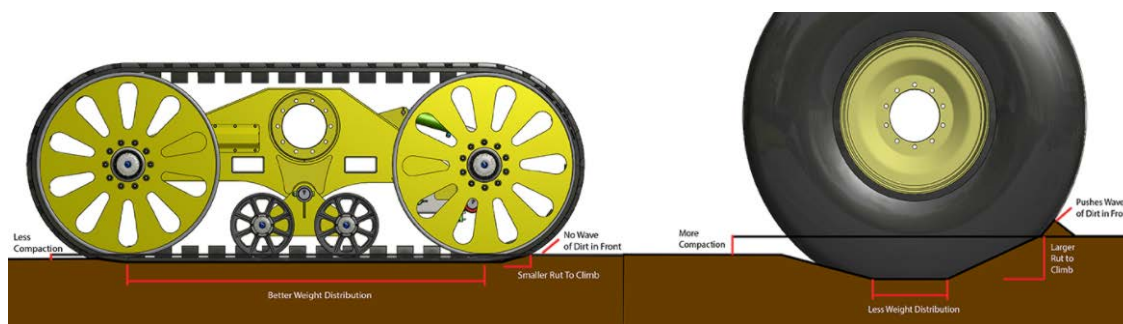




**Figure 3.** The effect of different degrees of compaction (axle loads) on plant emergence (11)

**Exhibit 3: Soil compaction and plant growth.**<sup>4</sup>

The type of equipment used to perform the stream and culvert construction will influence soil structure before the restoration work is expected to occur. A best practice is to limit equipment to 4 to 5 psi ground pressure equipment where planting is planned. This may seem like a significant limitation to the project, however, a substantial number of contractors can easily meet this specification with the equipment they already have on hand. This method has been used very successfully in several mitigation projects and in buffer areas.



**Exhibit 4: Effects of equipment type on soil.**<sup>5</sup>

<sup>4</sup> Tires, traction and Compaction. Jodi DeJong-Hughes, University of Minnesota Extension.  
<https://extension.umn.edu/soil-management-and-health/soil-compaction>

<sup>5</sup> Elmer's Manufacturing. (<https://elmersmfg.com/2016/04/benefits-tracks-vs-tires/>)

Traffic Over the Field

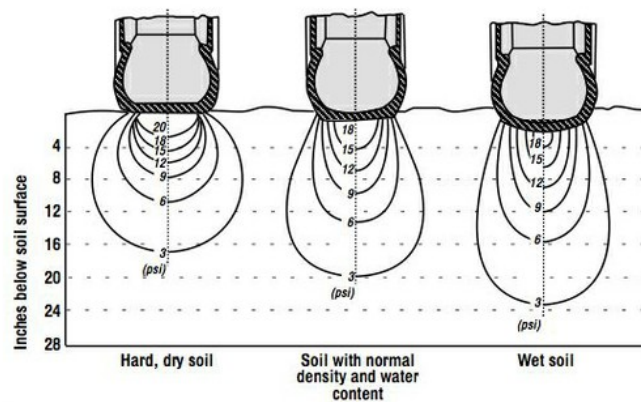


Exhibit 5: Effects of moisture on soil.



Exhibit 6: Examples of 4-5 psi ground pressure equipment.

### 830.07(3) Decompaction

Site conditions will dictate the treatment and type of equipment that is necessary to provide for good soil conditions for plant growth. When considering decompaction needs, first consider the location and safety needs. Be cautious about de-compaction on roadway prism areas, as the engineering and roadway safety needs for stable soils will always outweigh the desire to plant and grow woody plants. For example, roadsides where vehicles may leave the pavement may not be appropriate for decompaction and planting simply because the weight of vehicles would deform the soil surface, creating an unsafe situation.

Decompaction to a minimum depth of 12" is required. Tree restoration areas benefit from 24" depth decompaction. This is not always possible, but recognize that any compromise in this area must be compensated through other means. Long-term sustainable plant growth depends upon sufficient air, water flow, and nutrients in the soil.

For lightly compacted areas, simply applying and tilling in compost to a 10" depth will be sufficient to provide adequate growing conditions for the plants to thrive. This treatment is valuable on slopes flatter than 3:1, in fairly open spaces that are accessible to equipment.

For areas used for staging or access, more aggressive equipment such as rippers will be necessary.

Ripping for deeper decompaction can be accomplished to a depth of approximately 18". To decompact to a 24" depth requires other equipment such as a backhoe or track hoe bucket to dig and turn the soil. Deep decompaction requires large equipment, so is not feasible in small spaces. It is useful in flatter areas, but very difficult in steeper areas. It is also not economically feasible for very large areas, so apply judiciously.

A fair amount of controversy has been published over the efficacy of ripping the soil, though most of the research has been done on agricultural fields. For transportation projects where compaction can present very difficult conditions for plant growth, these measures have been used successfully for years.

Tilling and ripping should be done across slopes, rather than uphill and downhill, to avoid rilling. In general, soil protection during construction is the preferred direction for cost savings, efficiency, and effectiveness.



**Exhibit 7: Contour tilling is used extensively in farming for soil preservation. For stream passage projects, contour tilling also controls erosion within buffers disturbed by construction.**

When restoring the soils after construction, consider soil preservation and restoration needs. If incorporating soil amendment, tilling along the contours reduces erosion potential and accomplishes:

- Better plant growth
- Increased infiltration
- Reduced runoff
- Better water quality
- Reduced hydrophobic soil layers

**830.07(4) Habitat**

During site analysis, determine feasibility of using downed and cleared vegetation to create habitat as part of the restoration design. Though not the primary purpose of reusing cleared vegetation onsite, scattering cleared trees and shrubs on the bank may save costs, making this more attractive to the project manager, while providing the desired ecological benefit.

The project team must consider issues such as:

- Where will the material be stored during construction?
- How much will the materials have to be moved during phases of the project?

A well-orchestrated plan determines and prepares appropriate staging areas to receive material from clearing and grubbing efforts. Site conditions could limit the practicality of this approach, so be sure that it is feasible before committing to it in the permits or requiring it in a contract. In many cases, the costs and challenges of retaining existing plant material or logs on site prove to be impractical, except in small quantities or on very large sites.

Most research regarding the use of wood in stream and buffer areas is related to natural stream morphology and development. Because fish passage projects restore at least a portion of stream with each with each project, WSDOT often uses LWM as an engineering tool to provide stream bank protection and/or improve aquatic habitat. The WSDOT Hydraulics Manual contains background information and a detailed description of the use and design of LWM in fish passage and stream restoration projects.

Best practices in habitat creation indicate higher levels of wood retained or replaced in the new channels. Smaller<sup>6</sup> channels with well-developed riparian zones usually have wood located throughout the channel, because these smaller streams lack the power to mobilize the wood. Distribution is random and related to the inputs of riparian vegetation (decay, debris flows, floods, etc). Larger rivers have more organized LWM accumulations determined by key wood pieces, water conditions, and the sources of wood adjacent to the river (see the WSDOT Hydraulics Manual for additional background).

*Booth and Fox (2004) provide advice for project planning:*

*“Site conditions and the choice of project objectives determine the prospects for using LWD. If project objectives are primarily for ecological improvement, then the sites that are likely to show the greatest biological response are those where physical disturbance of the channel is the greatest substantive impact (in contrast to, for example, hydrologic alteration or water-quality degradation) and where recruitment potential from adjacent and upstream riparian areas is high. If these conditions are not met, LWD will be a necessary but not sufficient component of ecosystem improvement; in addition, active support for long-term recruitment will be needed. If the project is being constructed primarily for channel stability and (or) grade control, few sites are precluded outright if LWD will be used as an engineered bed or bank reinforcement. But, as*

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<sup>6</sup> Fox, Martin & Bolton, Susan. (2007). **A Regional and Geomorphic Reference for Quantities and Volumes of Instream Wood in Unmanaged Forested Basins of Washington State**. North American Journal of Fisheries Management. 27. 342-359. 10.1577/M05-024.1.



*with other channel-stabilization methods, success is likely to be limited during a phase of active channel deepening or steepening (e.g., Simon 1989).”<sup>7</sup>*



**Exhibit 8: Logs and rocks used in restoration.**

In addition to wood and rocks used for in-channel effect, leaving large and small slash (brush piles) on a site, where social and ecological considerations allow, can provide potential micro-habitat benefits to plant establishment through water retention, shading, and wind protection. The brush piles provide benefits in increased animal life and input of invertebrates to the adjacent stream. These benefits are associated with increased wood and leaf litter in the stream for invertebrates, which in turn contribute to the aquatic food chain.

<sup>7</sup> Derek B. Booth, Ph.D., P.E., P.G., Martin J. Fox, Ph.D., September 10, 2004. **The Role of Large Woody Debris in Lowland Puget Sound Streams and Rivers.** Center for Water and Watershed Studies

**830.07(5) Estuarine Sites**

In estuarine environments, recognize that soil salinity will limit all but the most adapted species at newly installed culverts or crossings. Be certain that the specified plant species are tolerant to the location's conditions. Use the Biology Assessment report and the reference site data to guide selections towards fitting the restoration into the native locale.

**830.07(6) Vegetation<sup>8</sup>**

Work with the design office during the early phases of design to save desirable vegetation<sup>9</sup>. It is often possible to vary slopes in the grading plan or slightly realign the stream to avoid having to remove significant vegetation. However, this is only practical if done very early in the design process.

Choose restoration plant species based on natural associations or native plant communities, generally as spelled out in reference community documentation by the project biologist. Incorporate horizontal diversity (multiple species on the site), vertical diversity (variability in ultimate plant heights at maturity), stream dynamics influence, appropriateness to roadway proximity for safety, and appropriateness for bioengineering functions. Maintenance practices may affect design strategy. Know what the maintenance practices and issues are prior to making design decisions on plant spacing, locations and species selection. Other external factors could influence plant selection. Identify the presence of beavers or other animals on the project vicinity and consider alternative types of plants (or fencing) that will facilitate coverage requirements.

Fast-growing, early seral stage, or pioneer, deciduous species such as cottonwood and red alder can provide quick shade for the stream, will help shade-loving species fill in more quickly, and provide a source of leaf litter and natural wood recruitment. Most native coniferous/evergreen species in the Pacific Northwest have evolved to grow in the shade of these deciduous trees. Plant larger conifers in locations that would provide spring/summer/fall shading. Be sure to apply appropriate setbacks for these tree species to minimize future risk and maintenance issues. Where safety issues preclude longer-term presence of the pioneer species, consider in some cases using them as sacrificial plants, tools to assist in the establishment of the permanent community, knowing they will be cleared towards the end of plant establishment. This strategy requires communication with Maintenance and the permitting agencies in advance to ensure a common understanding of the plan.

Plant spacing depends upon location and species, but generally, when using live stakes, install at 3' o.c. spacing to account for projected mortality after the plant establishment period is over. For container shrubs, plant at 4' o.c. spacing to avoid plant die-out due to overcrowding. Trees should not be planted closer than 8' o.c. spacing, but 10-12' o.c. is more aligned with full canopy cover, without overcrowding. The species rate of growth can influence the decisions for on-

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<sup>8</sup> WAC : 220-660-120(13)(j) The department must approve species composition, planting densities, and a maintenance plan for replanting on a site-specific basis. The species composition should be similar to the surrounding native vegetation whenever feasible.

<sup>9</sup> WAC: 220-660-120(4)(d) Limit removal of native vegetation to one side of the channel to maintain the best shade coverage whenever feasible. Locate the project access site to minimize the need to remove woody vegetation. Woody vegetation greater than four inches diameter that must be removed to construct the hydraulic project must be marked in the field by the applicant and approved for removal by the department.

center spacing; the purpose is to ensure appropriate shading for cooler water, reduction in weed pressure, and providing the earliest possible habitat benefits.

### **830.07(7) Current best practices**

#### **830.07(a) Stream buffer design requirements**

Depending on the context of the project, the stream buffer treatment will vary. For instance, adjacent land use, limited right of way or maintenance practices will influence vegetation selection within the stream buffer with regard to growth habit and height at maturity. Operational setbacks or visual clearance (sight distance) is necessary for the roadway, bridges, utilities and guardrail. Due to adjacent property constraints, careful plant selection is necessary to determine the right place for the right plant. Ideally, planting grass would be limited, and the majority of the impacted area be planted with a diverse set of native shrubs and trees common to the area<sup>10</sup>. Incorporate annual grass so it does not compete with the newly established plants if grass is necessary for preliminary or temporary erosion control.

Stream buffer design should also consider access for the duration of construction easements, which is required throughout all years of plant establishment, whether provided in contract or by State forces. Provide access for inspection and safe pull off for personnel. Maintenance practices may affect design strategy so know what the longer-term maintenance issues are prior to making design decisions. See Section 830.06(3) about post construction maintenance access considerations. The engineer on the fish passage project will often use logs and rocks for bank stabilization. However, they are also valuable from a habitat restoration perspective: “logs and woody debris from headwaters forests are among the most ecologically important features supporting food chains and instream habitat structure in Pacific Northwest Rivers from the mountains to the sea (Maser and Sedell 1994).”<sup>11</sup>

Leave downed trees and plant as much as feasible around downed logs remaining in the floodplain to serve as habitat nurse logs. This will not only save on material hauling costs, but this effort will benefit the habitat in the area. Additionally, placing coir-wrapped soil lifts over the tops of the streambank logs allows for planting, as well as stabilizing the water edge during peak flows.

The surrounding stream corridor and landscape have a strong influence on the potential for success. Investigate the type of stream or channel to determine the appropriate plant community for the project. The plant community might very different from location to location due to soil types, flooding frequency, surrounding plant communities, and soil moisture conditions. Localized differences in erosion and deposition of sediment add complexity and diversity to the types of plant communities that naturally become established. Observe these typologies in the native landscape surrounding the project (reference site) to identify good examples to follow.

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10 Washington State Department of Ecology Native Plant Selection Guide: <https://www.jeffersonmrc.org/media/18204/wa-ecology-slope-stabilization-plant-selection-table-ecology.pdf>

11 FISRWG 1998. *Federal Stream Corridor Restoration Handbook* (NEH-653). Stream Corridor Restoration: Principles, Processes, and Practices.

The Agricultural or residential development are often located near lower gradient, larger streams with less steep terrain. These land uses affect the typical plant communities in the middle and lower reaches of streams, while the upper reaches would require different plant communities due to gradient, size, and water flows. In the lower reaches with nearby human uses, pressure may exist to keep the vegetation clear to support those adjacent land uses, so it is important to communicate the need for and type of restoration with neighbors and get their buy-in to make the restoration sustainable.

Additionally, due to the higher human influence in highway roadsides, weed pressure is frequently high. This weed pressure may indicate a situation in which a sustainable vegetation restoration is difficult. Where plant communities are not reasonably sustainable, due to high weed pressure from aggressive weeds upstream of the project, planting only for the purpose of erosion control stabilization could be the most practical solution. As mentioned above, this should be discussed with the permit coordinator so that the agencies are brought into the decision making process and a sustainable solution is reached that meets environmental needs.

#### **830.07(b) Planting Area Preparation and Weed Control**

WSDOT standard specifications require preparation of all planting areas to ensure a weed free condition. For strategies regarding situations of weed infestation upstream or outside the project footprint, refer to the previous sections, “General Process for Restoration Design” and “Stream Buffer Design Requirements”. Many stream buffers have a proliferation of particularly difficult weeds such as knotweed, purple loosestrife, and reed canary grass. Prolific weeds at planting area locations may require Contract special provisions that call for specific control methods for weed control. The first step is to determine what species are present on site and decide what best management practices is the most effective. Best practices for these species require clearing and appropriate disposal to ensure limited dispersal and further spread of these very aggressive species.

The [Washington State Noxious Weed Control Board](#) includes information on weed laws, identification tools and resources on how to control noxious weeds. The local County Noxious Weed Control Board, local Conservation district or WSU extension office can provide technical assistance as well.

King County Noxious Weed Control Program<sup>12</sup> Best Management Practices for knotweed:

- If growing beside water (stream or ditch that frequently holds moving water), do not allow plant parts to enter water or beach. Plant parts move by water and will re-grow elsewhere.
- Do not mow green canes in the fall; stem pieces can re-sprout and you will scatter seed.
- Remove the entire plant including all roots and runners using a digging tool. Juvenile plants can be hand-pulled depending on soil conditions and root development. Remove dirt 15 feet around plants to prevent root spreading.

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<sup>12</sup> King County Noxious Weed Control Program Best Management Practices

<http://www.kingcounty.gov/services/environment/animals-and-plants/noxious-weeds/weed-control-practices/bmp.aspx>



- Double bag all plant parts, including dirt, and dispose of in the trash to prevent reestablishment and disposed of in an approved landfill.
- Place tarps around the excavation area to capture plant material and root debris. Dispose in an approved landfill.

Best practices for reed canary grass include a cut/regrow/spray/regrow/spray protocol prior to excavation, where possible. However, where excavation is expected to remove the majority of the root mass, a single spray may achieve adequate control to prepare for planting. King County Noxious Weed Control BMPs can provide additional guidance on reed canary grass control. Recognize that the first year of plant establishment is the most critical time for achieving as close as possible to eradication of the invasive species, so extreme vigilance during construction is necessary.

As the project progresses, consider requirements for decontamination of equipment used for weed control to prevent spread of seeds and plant parts. The recommendation from WDFW includes:

*Follow Level 1 Decontamination protocol for low risk locations. Thoroughly remove visible dirt and organic debris from all equipment and gear (including drive mechanisms, wheels, tires, tracks, buckets and undercarriage) before arriving and leaving the job site to prevent the transport and introduction of invasive species. Properly dispose of any water and chemicals used to clean gear and equipment. For contaminated or high risk sites please refer to the Level 2 Decontamination protocol. You can find this and additional information in the Washington Department of Fish and Wildlife's Invasive Species Management Protocols (November 2012), available online at <http://wdfw.wa.gov/publications/01490/>.*

### **830.07(c) Planning for plant communities**

Highly productive and diverse biological communities, such as bottomland hardwoods, establish themselves in the deep, rich alluvial soils of the floodplain. The slower flow in the channel also allows emergent marsh vegetation, rooted floating or free-floating plants, and submerged aquatic beds to thrive. The changing sequence of plant communities along streams from source to mouth is an important source of biodiversity and resiliency to change. Although many, or perhaps most, of a stream corridor's plant communities might be fragmented, a continuous corridor of native plant communities is desirable. Restoring vegetative connectivity in even a portion of a stream will usually improve conditions and increase beneficial buffer functions. Keep in mind that planting efforts may not be a direct translation of the desired end state. For example, establishment of floating plants such as pond lily is extremely difficult and time-consuming, and rarely successful. Assuming the seed source exists upstream, it may be sufficient to focus on the woody vegetation to create the conditions for the pond lily to naturally recruit. The purpose of the vegetation restoration is to set a trajectory for the site to continue to develop into the desired end-state. The designer may also adaptively manage the site to move it incrementally towards its desired end-state during plant establishment. See the Adaptive Management section for more information.

### **830.07(d) Biodiversity in restoration**

Biodiversity is commonly identified at three levels. This has to do with the variety of ecosystems on Earth.

- **First**, genetic diversity is the diversity of genes within a species. There is a genetic variability among the populations and the individuals of the same species.
- **Secondly**, species diversity, which is diversity among species in an ecosystem. "Biodiversity hotspots" are excellent examples of species diversity.
- **Third**, ecosystem diversity is diversity at a higher level of organization, the ecosystem.<sup>13</sup>

Each location has a different regional biological structure, so to avoid adverse consequences, it is critical to understand the intended goals for the project. Some projects set a goal for genetic diversity, such as on National Forest Service land, while most WSDOT project goals outside of Federal lands are set at the species diversity level. Objectives for restoration should relate to the regional and landscape scale, providing the maximum biodiversity possible while incorporating targeted species as identified by the biological assessment. Generally, however, the goal should be to develop the restoration to support a diverse community based on the composition of an appropriate reference site.

The biological diversity of the plant communities on a site is important because plant ecosystems support animal ecosystems. While transportation projects cannot predict with accuracy which communities of animals will use a site, we can set the trajectory to support the types of native animal life usually found in the region. It would be virtually impossible to collect the empirical data for all species within a region, so the goal is to set the stage for natural processes to expand the diversity of the site.

#### **830.07(e) Erosion control for bank slopes**

In most cases, the construction of a new fish passable crossing under a highway will leave the stream banks vulnerable to erosion and bank surface failure unless specific efforts are undertaken to provide temporary stabilization. The objective of temporary erosion control is to arrest accelerated erosion until native vegetation becomes able to take over the function. Appropriate design solutions vary from simple sod cover for temporary erosion purposes along low intensity streams, to intensive bioengineering or potentially, rock and wood where stream flows are heavy or offsite development causes flashy high flows. Consult with the stream hydraulics engineers/hydrologists to identify the expected flows. The engineers are responsible for the design of the rock and heavy wood portions of the streambank stabilization. The landscape architect should examine the design to identify what other erosion control treatments are necessary. These may include:

- **Streambank surface complexity:** The purpose of surface complexity is to slow overbank water velocities and trap sediment and seed. Vegetation can be used for this purpose. On larger streams or streams with steeper profiles, larger diameter live stakes may provide surface complexity when planted in high density. Something as simple as compost socks with emergent plants can be sufficient to provide roughening along streambanks of low power, low-flow streams.

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<sup>13</sup> The above text is excerpted from the Wikipedia article "[Biodiversity](#)", which has been released under the [GNU Free Documentation License](#).



**Exhibit 9: SR 18 stream restoration – use of woody material, coir lifts, and planting for bank protection.**

- Turf reinforcement mat: The mat must have wide enough holes for seed or plants to be successful. It is only useful with seeding, since installation of container plants would require cutting the mats to install plants, which reduces their strength and defeats the purpose. Avoid designs that require cutting mats, where possible. Mats must be biodegradable for stream bank areas.
- An alternative for turf reinforcement mats on stream banks could be brush mattresses. The brush mattress consists of a lashed down six-inch to one-foot layer of native conifer branches over the surface of the stream bank. The mattress collects sediment during higher flows while it protects from erosion. Live stakes may be inserted within the brush mattress allowing for live growing material to become established in the bank areas. It is also possible to place brush mattress materials around planted conifers or other container-grown plants; the mattress protects the soil from eroding and helps hold the plant in place until its roots become established.
- If erosion control fabric is used, stake down the fabric and place above the OHWM to reduce the risk of it coming loose and washing downstream.
- Seeding vs sod for lining ditches: Sod is a very easy ditch liner that provides instant erosion control, so it is preferable to seeding, which will require delay of returning the stream to the channel, and therefore, contract completion, while waiting for the seed to germinate and establish.



**Exhibit 10: Application of hydromulch for erosion control.**

**Mulches:**

- Wood chip mulch yields better weed control, has more water holding capacity, and prevents seed germination better than bark mulch.
- Bark mulch is used where it needs to be blown in.
- Hog fuel is an unrefined mix of coarse chips of bark and wood fiber. Hog fuel is any type of wood byproduct or waste that can be burned for fuel but cannot be categorized as chips, shavings, bark, or sawdust. It is recommended for temporary use to protect soils in access road locations, but not as a planting area mulch.
- Use compost socks, wattles, or coir logs to hold mulch in place.

All erosion control materials that will remain onsite must be composed of 100% biodegradable materials or materials made of natural plant fibers. In addition, straw used for erosion and sediment control, must be certified free of noxious weeds and their seeds per the standard specifications. Where appropriate, consider using wood straw, which appears to perform very well at these sites.

Avoid placing mulch below OHWM and within floodplain areas that are likely to be inundated in the near future. This reduces the risk of having mulch transported and deposited in locations where it is not desirable. An example would be spreading mulch over an entire floodplain and having mulch end up in the creek upon the first high water event. In smaller sites, mulch may be used if cover is provided as mentioned above.

**830.07(f) Stream bank and site considerations for steeper slopes**

Depending on the scope of work and condition of slopes above the ordinary high water level, utilize supplemental techniques to stabilize the stream bank in addition to conventional vegetative treatment and erosion control efforts. Soil bioengineering uses plant material, living or dead, to alleviate environmental problems such as shallow sliding soil, eroding slopes, and streambanks. Chapter 740 of the Roadside Manual further



discusses soil bioengineering. Select the appropriate technique for the site to achieve successful restoration. At a minimum, consider climatic conditions, topography and aspect, soils, water (hydrology), erosion process and surrounding vegetation. Select the technique that matches the strength of protection against the strength of attack that will perform most efficiently when tested by the strongest erosive process and the type of critical failure mechanism expected. The most commonly used bioengineering techniques include coir wrapped slopes or soil lifts, live fascines, coir logs and brush mattresses.



**Exhibit 11: US 195 Cheney Spokane Interchange. The left photo shows coir wrapped layers prior to vegetation establishment. The photo on the right shows vegetation establishment after two years.**

Key points about soil bioengineering techniques:

- Bioengineering is most useful for steeper slopes.
- Soil cohesiveness, gravel lenses present in the banks, surrounding land use and runoff, and potential for human or animal incursion could affect the type of bioengineering selected.
- Coir lifts, or coir wrapped layers, consist of biodegradable fabric around lifts of soil. Coir wrapped layers are suitable for high-energy areas needing a stronger level of bank protection. History has shown that coir lifts, live fascines, or other bioengineering efforts are more effective than erosion control mat placed on the soil surface. They should be used along the shoreline (above OHWM) above the rock or hard stabilization designed by the engineers, particularly where the erosive effects from the stream may back cut, undercut, or otherwise damage the newly constructed bank configuration and allow sediments into the stream.
- Secure the toe of slope on all stream projects. For lower energy systems, place compost socks to keep mulch out of stream gravel. Consider a more secure technique to secure the toe of slope for higher energy systems and steeper slopes (logs, rocks, etc.). Wherever new streambank is created with fill material, soil lifts and fascines can provide stability to the new edges.
- Fascines are suitable for lower energy systems. Place live fascines horizontally along the bank edge to curtail simple stream erosion. Install perpendicular to the

channel to dissipate floodwater energy and encourage deposition. Place these with care, ensuring the potential deposition site is in an advantageous location.

- Brush mattresses are extremely effective at trapping sediments, preventing erosion, and stabilizing the bank while establishing planted vegetation.
- Consider planting sequence of work with regard to construction schedule. If planting within rock areas, soil is needed to provide the growing medium for the plants. Install plants (cuttings) together with rock placement to facilitate proper installation and decrease damage to plants. Filling voids in between rocks after rock placement is not successful, as it does not provide adequate soil for plants to grow, and the soil is not connected to ground water.
- When choosing vegetation for coir lifts, select plant materials (large live stake cuttings and perennials such as lady fern or some species of *Carex*) that withstand deposition for surface complexity.
- The simpler the stream edge plant mix, the better. However, to avoid having to remove established vegetation later, incorporate utility and roadway setbacks and height restrictions during design. For example, use shrubs under power lines and a consistent tree/shrub mix elsewhere.



**Exhibit 12: Live Fascines ready for installation.**

#### **830.07(g) Installing plants within rock areas**

The rock and gravel areas along the stream banks are high-risk highly dynamic zones. These zones have an increased risk of movement. Indicate in the plans or special provisions that adjustments will be required for planting locations based on the movement of gravel. Plantings may disappear or die because of the dynamic nature of the system. During the permitting process, consider what is appropriate and reasonable to guarantee.

Planting within streambed gravel must be planned well and is most successful in low-energy systems. In lower energy systems, planting can occur after the stream is released into the channel. If planted prior to the introduction of the stream, plant failure is highly likely due to lack of water availability. The permit coordinator should check to see if delayed planting requires permit language to allow personnel to access the near-bank edges for planting after the stream is opened to flows.

For requests to plant within the stabilization rock, carefully analyze the necessary conditions before committing to the regulatory agencies for standards of success. Sometimes, agreement to plant without a guarantee of success is the most prudent route in attempting restoration within rock areas that would become inaccessible for plant establishment activities once the engineer removes construction access. Plants require soil and water to establish and thrive, so work with engineers to ensure the correct conditions are in place to be able to plant within the rock areas.

Consult the hydraulics engineer during discussions about incorporating logs, anchoring needs, and rock placement. The landscape plans will either reference or include these features, so close coordination with the engineer is crucial to clearly communicate material selection and placement. For example, the engineer determines the streambed gravel limits, rock size and type, and the decision to locate log structures downstream of high-energy systems. The landscape designer should understand the limits and intent of these engineering decisions in relation to the revegetation efforts (including supplemental erosion control needs) to provide a balanced design approach to the natural system.

## **830.08 Construction**

Early and close coordination with the Construction project is key to maximizing efficiency in site preparation efforts (early weed control) and to ensure that during clearing and grading, the Contractor saves existing vegetation to the greatest extent feasible. Vegetation to be saved must be indicated on the plan sheets during design. Understand the schedule laid out for the project and identify key times to attend Contractor's weekly meetings. Engage in discussions that involve any work on weed control, moving the soil, placement of materials (gravel, rock, logs) and planting.

If using State forces to perform any pre-project work such as weed control ensure the right of entry is in place for construction easement areas prior to scheduling Maintenance to be on the site. This may take coordination with Real Estate Services to ensure the proper length of time and appropriate windows of work are available. While coordinating for pre-construction easements, be sure to coordinate the length of access needed to cover plant establishment. Also refer to Section 830.06(3) about post construction maintenance access considerations.

Soil compaction from the use of heavy equipment affects success of plant establishment. For areas used as staging or not otherwise identified in the plan sheets, identify highly compacted areas prior to planting and develop a strategy with the construction office to remedy the compacted soils.



**Exhibit 13: SR 92 Pilchuck River Chronic Environmental Deficiency Repair – constructing bank protection and bank protection during first storm.**

It is important to consider the project needs not only during construction (when weather is likely to be good) but also how the site will perform under extreme conditions. If bank work is done well and the calculations are good at predicting actual conditions, the project holds together as shown above. However, the project cannot fully hold the Contractor responsible since planted areas within these zones have an increased risk of movement. The contract should specify that adjustments be required to respond to the movement of gravel. Plantings may disappear or die because of the dynamic nature of the system. Replanting may be required in subsequent years but might change from the original planned configuration. Place plants closer to the wetted channel wherever possible.

The engineer generally identifies project timeline based on the expected time that the contractor will be using the site to install the culvert. To meet the five year monitoring of the permit requirements, the crews maintaining the area will need access for the full five years.

### 830.09 Maintenance (Plant Establishment)

Plant establishment<sup>14</sup> begins when the Contractor installs all plants, and the construction office grants acceptance to the contractor for planting areas. Total years of plant establishment varies depending on permit requirements and can range from three to five years for stream restoration projects. Standard plant establishment activities include but are not limited to: weed control for target weeds within planting areas (chemical applications, hand weeding and removal), fertilizing, watering, litter and debris removal, pruning, insect and disease control, erosion control methods and procedures, plant replacement and irrigation system management (if applicable).

Plant establishment activities for stream restoration projects tie to monitoring and performance criteria set forth by the permit obligations. For monitoring and performance criteria, link performance of planting areas to goals set for the site. Make goals as simple and unambiguous as possible. Many permits require five years of monitoring, though some require as few as three.

<sup>14</sup> WAC: 220-660-120(13)(k) Complete replanting during the first dormant season (late fall through late winter) after project completion. Maintain plantings for at least three years to ensure at least eighty percent of the plantings survive. Failure to achieve the eighty percent survival in year three will require that a person submit a plan with follow-up measures to achieve requirements or reasons to modify requirements.

WAC: 220-660-120(13)(l) The department may waive the requirement to plant vegetation where the potential for natural revegetation is adequate or where other factors preclude it.



Typical standards for vegetation include qualitative assessment of percent vegetative cover, species density, size distribution, plant survival, bird and wildlife use, and aerial photography documentation to support the data provided.

During the first year of plant establishment, the landscape architect meets regularly with the Contractor, documents observations for the project inspector and makes recommendations to ensure Contract conditions are on track at the end of each plant establishment year. Documentation includes photos, observation of weeds, erosion issues and plant health. It is the Contractor's responsibility to resolve the issues identified by the project inspector. Second year plant establishment will not begin until first year plant establishment obligations are met (for example, 100% plant survival and weed free planting areas).

For second year and beyond (typically up to year five), the plant establishment efforts may remain with the contractor or they may turn over to the plant establishment crew. The crew or contractor performs work on the site as often as needed to address site issues. For example, expect to meet the crew on site four to five times a year to address high weed pressure (reed canary grass or knotweed control). Under good conditions and low weed pressure, expect to meet the contractor or crew on site a minimum of two to three times a year. Establish tolerances or triggers with the Contractor or the restoration crew to proactively manage and prevent recolonization of invasive species. For example, setting percent cover of invasive species close to zero at years two and three is advantageous to allow new plantings a chance to establish.

### **830.09(1) Alternative Actions**

Because restoration involves natural systems, unexpected consequences of restoration activities can occur. The four basic options available are as follows:

- **No action.** If the restoration is generally progressing slower than or at the expected rate, but will probably meet restoration goals within a reasonable amount of time, no action is appropriate.
- **Maintenance.** Physical actions might be required to keep restoration development on course toward its goals.
- **Adding, abandoning, or decommissioning plan elements.** The project requires significant changes in parts of the implemented restoration plan that entail revisiting the overall plan, as well as considering changes in the design of individual elements.
- **Modification of restoration goals.** Monitoring might indicate that the restoration is not progressing toward the original goals, but is progressing toward a system that has other highly desirable functions. In this case, the participants might decide that the most cost-effective action would be to modify the restoration goals rather than to make extensive physical changes to meet the original goals for the restoration. This is adaptive management.

### **830.09(2) Adaptive Management**

The first fundamental rule during design is to set proper expectations for the restoration effort. Be clear about expectations versus experimental techniques. When including experimental techniques, accommodate some risk of failure or be flexible to make midcourse corrections.

One effective way to set reasonable expectations from the beginning is to acknowledge uncertainty, evaluate performance, and make adjustments as part of the game plan.



**Exhibit 14: Phases of Adaptive management.** (Conservation Measures Partnership - Open Standards for the Practice of Conservation, Public Domain, <https://commons.wikimedia.org/w/index.php?curid=6925415> )



**Exhibit 15: Plant protection may become necessary during plant establishment.**

Adaptive management involves adjusting management direction as new information becomes available. It requires willingness to experiment scientifically and prudently, and to accept occasional failures (Interagency Ecosystem Management Task Force 1995). Since restoration is a

new science with substantial uncertainty, expect adaptive management to incorporate new midcourse information. Moreover, adaptive management has capacity to focus on and correct specific problems. Restoration is uncertain. Therefore, allow contingencies to address problems during or after restoration implementation. Assess the progress of the system annually, document the changes, and keep the permitting agencies informed.

### **830.10 Additional Sources of Information**

- In-stream flow workshop: University of WA
- Streams and hydrology: training offered by tribal entities
- Geomorphology of stream channels: University of WA extension courses



## General

Design enhancement is the incorporation of manmade elements in the landscape to accomplish goals such as expression of community character, marking a community entrance, providing corridor continuity on a scenic or recreational highway, and as mitigation for visual impacts. Design enhancement can be found on tunnel portals, bridges, noise walls, community entrances, rest areas, and park and ride lots. It may consist of a landform, water feature, wall or barrier texture, color, pavement type, brick variation, site furnishings, or a combination of elements. Enhanced designs can lend a distinctive character to towns and cities when used appropriately. The continuation of a theme throughout a corridor provides interest and continuity.

The WSDOT Programs Offices administer a separate Enhancements Program described in Chapter 62 of the *Local Agency Guidelines* (LAG) Manual. The design enhancements described in this chapter are very appropriate for Scenic Byways described in the LAG Manual.

## References

*Design Manual*, (M 22-01) WSDOT, Chapters 700, 1130, and 1140 and Instructional Letter IL 4053.00

*Roadside Classification Plan*, (M 25-31) WSDOT, Chapter 5

*Traffic Manual*, (M 51-02) WSDOT, Chapter 2

*Local Agency Guidelines*, WSDOT, Chapter 62

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

*Roadside Design Guide*, 2002, AASHTO

*Flexibility in Highway Design*, FHWA

WSDOT/FHWA *Agreement for Community Entrance Identification Plaques/Markers*

## Resources

State Bridge and Structures Architect, WSDOT Bridge and Structures Office, Olympia

Region's Landscape Architect or HQ Roadside & Site Development Unit (for regions without a Landscape Architect)

HQ Assistant State Design Engineers  
Rural Community Partnership Office in HQ Highways and Local  
Programs (formerly the Heritage Corridors Program)  
Region's Project Engineers  
Region's Traffic Engineers for assistance with gateway markers and  
signs  
Region's Local Programs Engineers for assistance with agreements or  
leases<sup>1</sup>  
Real Estate Services Office for assistance with leases.

## **Regulations**

### **Jurisdiction**

Within the limits of incorporated cities and towns, jurisdictional responsibility for Design Enhancements on the roadsides of state highways is consistent with [Chapter 47.24.020 RCW](#) and as clarified in Instructional Letter IL4053.00

#### **Chapter 47.24 RCW**

##### **CITY STREETS AS PART OF STATE HIGHWAYS**

##### **47.24.020 Jurisdiction, control.**

(2) The city or town shall exercise full responsibility for and control over any such street beyond the curbs and if no curb is installed, beyond that portion of the highway used for highway purposes. However, within incorporated cities and towns the title to a state limited access highway vests in the state, and, ... the department shall exercise full jurisdiction, responsibility, and control to and over such facility. The full text of the law can be found at:

<http://www.leg.wa.gov/RCW/index.cfm?fuseaction=section&section=47.24.020>

### **Signs**

All design enhancements are to be devoid of any advertising or other informative messages.

**RCW 47.42.020(8)** - Signs are defined in part as “any outdoor sign, display, device, figure, painting, drawing, message, placard, poster, billboard, or other thing which is designed, intended, or used to advertise or inform.”

**RCW 47.42.080(5)** - No signs may be permitted on the right of way contrary to law or department adopted regulations.

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<sup>1</sup> WSDOT makes the determination whether the lease or agreement is needed.

**WAC 468-66-010 (17)** under Definitions, states "Sign" means any outdoor sign, display, device, figure, painting, drawing, message, placard, poster, billboard, or other thing which is designed, intended or used to advertise or inform, any part of the advertising or informative contents of which is visible from any place on the main-traveled way of the interstate system or other state highway.

**WAC 468-66-030(10)** under General Provisions states:

"Notwithstanding any other provision of the act or these regulations, no signs visible from the main-traveled way of the interstate system, primary system, or scenic system which have any of the following characteristics shall be erected or maintained:" (10) "Signs which are erected or maintained upon trees, power poles, or painted or drawn upon rocks or other natural features."

In other words, nothing that displays a trade name or product or other commercial type of content, will be allowed within state highway right of way.

## Planning

When first considering a design enhancement, goals must be clearly stated and entered into the project Design Documentation Package if there is a state project. Define the purpose of the design enhancement and identify the agency requesting the enhancement.

## Funding

Within the limits of incorporated cities and towns, funding responsibility for Design Enhancements on the roadsides of state highways is consistent with [Chapter 47.24.020 RCW](#) and as clarified in Instructional Letter IL4053.00. On managed access highways in incorporated cities and towns, the local jurisdiction has funding responsibility for roadside design enhancements unless amended by agreement.

On limited access highways, Washington State Department of Transportation (WSDOT) generally does not allocate special funding for enhanced designs or community gateways. WSDOT has incorporated additional design elements into proposed structures, at minimal cost, on a few select projects as visual mitigation for project impacts and where the location was highly visible. This has been done at the discretion of the Regional Administrator and the Project Engineer.

As WSDOT will not normally provide for design enhancements on limited access highways, funding must be clearly defined. For example, if a city is requesting and funding the design enhancement, either in whole or in part, this must be clearly stated and agreements must be signed in the planning stage of a project.

For example, WSDOT will pay for the cost for standard form liners for walls and a local jurisdiction will pay for the additional costs associated with an enhanced design. Some jurisdictions have funding available, such as “1% for the Arts” type funds, which might be used in this type of partnership project. Contact the region’s Landscape Architect for other possible grant sources early in the project-planning phase.

For stand-alone pieces, such as a gateway marker, funding will come from the community. The marker will have maintenance and repairs provided by the local community. A long-term agreement or lease will need to be negotiated with the local jurisdiction, community groups, etc. to cover these elements and outline responsibilities for maintenance and repairs.

Where agreements are needed, the Local Programs, Utilities Office, or Real Estate Services Office can assist in determining the type of agreement or lease required. Include WSDOT early in the project to avoid conflicts in negotiations. (The appropriate office varies by region.)

[Figure 910.1](#) is an example of the type of project that can be funded by a combination of state and local funds. If testing determines that a noise wall is necessary, WSDOT will cover the cost of a standard noise wall. A local government can, through an agreement, fund the additional cost of form liners to create the enhanced design on the noise wall. This is also true for median elements or enhanced barrier designs.



**Figure 910.1 Noise wall enhancement in Mill Creek**



## Design

On managed access highways inside incorporated cities and towns, design responsibilities for community gateways or other design enhancements are divided at the curb line, with the cities having design responsibility outside the curb and WSDOT having design responsibility between the curbs. Where no curb exists, the cities have design responsibility for the area outside the paved shoulder, and WSDOT has design responsibility for the paved area.

Regardless of who is designing the element, safety for roadway users and for those viewing the design is critical. Nothing placed on the roadside is to be a distraction for the driver, or a hazard to vehicle occupants.

Design enhancements must not violate the clear zone policy, or create sight distance problems. The photos in this chapter illustrate the types of designs that have been safe and effective on our highways. Designs that “grab the eye” or slow traffic are not appropriate. When any type of structure is involved, such as a wall, the Bridge and Structures Office must be consulted and their approval is required.

Design enhancements can be a part of the visual, functional, or architectural character of a facility. This can include the incorporation of impressions into a wall, barrier, or bridge structure.



**Figure 910.2 Leaf Pattern on retaining wall at I-90 Sunset Interchange**

[Figure 910.2](#) shows a pattern done on retaining walls as visual mitigation for highway improvements within limited right of way. Designs should be easily comprehended so that drivers are not distracted. Design enhancements can also be a stand-alone piece such as a landform,

waterform, or sculpture in a community entrance, roadside park, safety rest area, or park and ride lot.

## **Process**

Follow Context Sensitive Design principles when incorporating enhanced design elements into a transportation facility. Information on these principles can be found at: <http://www.fhwa.dot.gov/csd/index.htm>

For projects planning the use of state right-of-way, the early inclusion of all stakeholders in the project will ensure a better product. To facilitate the approval process, the State Bridge and Structures Architect and the region's Landscape Architect will serve on the design team, along with community representatives and their contracted artists. WSDOT has the final approval on all design elements on WSDOT right of way.

As a first step, the stakeholders and WSDOT should determine the goals of the enhanced design elements. The theme should be consistent with highway's and the local area's character. The statement of goals and objectives will guide development and help keep the project on track.

When planning the location of design enhancements on state right-of way, the region's Landscape Architect and the State Bridge and Structures Architect, along with other stakeholders, will do a visual assessment to determine placement.

The following questions, and their answers, can help guide design:

Question
• What is the purpose of design enhancement?
• What is the community character?
• What is the historical significance?
• What is the cultural significance?
• How does enhancement contribute to corridor continuity?
• Who is the audience?
• Driver & passengers
• Transit and rail users
• Pedestrian or recreational users
• Community/neighborhood residents
• How long will the design enhancement be viewed?
• Is it on a bridge portal that is seen for long moments on approach?
• Is it on the side of the road and seen only briefly?
• Is it at an intersection where drivers will be stopped at a light?
• Is it at a park and ride lot or safety rest area?
• Is the design enhancement in a publicly accessible area (such as a viewpoint, park, or plaza)?
• How great is the potential for vandalism on the site?
• Will the design enhancement create a distraction or act as a fixed object that can be a hazard?
• Will the design enhancement block sight lines (to signs, merging traffic, etc.) or infringe on safety?
• Will the design enhancement be lighted?
• Will lighting create a distraction or glare problem?
• Can the lighting be developed to enhance visibility for both road users and pedestrians?
• How high is the chance that the design could become an attractive nuisance?
• What are the dimensions of the design enhancement?
• Does its scale relate to its context?

Figure 910.3 Questions to be answered for 30% review

## Location

Incorporation of art into the design of a facility is an option for some projects. For a corridor project, a repeating element or pattern can be designed to be incorporated throughout its length. This might include wall textures, luminaire design, railing design, site furnishings, etc.



Figure 910.4 Site furnishings in Palouse

Site furnishings include such things as bicycle racks, street tree grates, trashcans, or benches.

## Community Gateways

The WSDOT *Traffic Manual* Chapter 2, “Signs” has a section on “City/Community Entrance Markers” (under “Miscellaneous Signing”) that provides guidelines on these areas. It can be found at the following website:

<http://www.wsdot.wa.gov/fasc/EngineeringPublications/Manuals/Traffic.pdf>

Where community gateway markers are within WSDOT rights-of-way, an agreement or lease is necessary. Approval by FHWA is required on the Interstate System. Maintenance of the gateway will be defined in the lease or agreement. Anything placed in these areas must meet clear zone and all other safety requirements described in the *Design Manual*.

Figure 910.5 shows an example of a subtle and effective gateway into Seattle. The text above the portal reads “SEATTLE – PORTAL TO THE PACIFIC.”



**Figure 910.5 Tunnel portals can be an ideal location for a statement of community identity**

Figure 910.6 shows another type of community gateway marker that meets the requirements found in the *Traffic Manual*.



**Figure 910.6 Stand-alone community gateway marker**

### ***Cost Estimating***

Costs for enhanced designs on structures can be determined by checking bid tabs for similar projects at:

<http://www.wsdot.wa.gov/biz/contaa/BIDTAB/default.htm>

The State Bridge and Structures Architect is available to assist designers in determining additional costs of unique form liners for these elements. Each project is unique so there is no standard formula for determining the cost of a special form liner – it depends upon the design complexity.

The use of standard-size panels will minimize costs.

## **Coordination**

Is the design acceptable to the community?

- City, arts commissioner, or jurisdictional agency involvement.
- Stand-alone art pieces, such as community gateways, might require a city building permit.

## **Approvals**

For use of state right-of-way:

- Materials approval, including primer, paints, and sealers, from HQ Materials Laboratory
- Design approval for Bridges and Structures from WSDOT, as stated in the *Design Manual* Chapter 1130.04(5) and 1140.04
- Design approval for signs and illumination from the region's Traffic Engineer.
- Design approval for stand-alone elements, vegetation, or earth forms from the region's Landscape Architect
- Project design approval from the Regional Administrator and Project Engineer
- Final project design approval from the Assistant State Design Engineer
- Approval by FHWA for all community gateway (entrance) markers or other enhancements located within the Interstate right-of-way

At no time will any design enhancement be placed on, or incorporated into, WSDOT property without approval as stated above.

## **Maintenance**

When a design enhancement is part of a WSDOT facility, such as a portal, wall, or bridge, then WSDOT maintains the structure.

The group proposing any physically separate design enhancement is responsible for its maintenance. Designs are to require no additional work for WSDOT maintenance crews.

## **Removal**

The local authority is responsible for relocating or removing any city/community sponsored entrance markers or other enhancements displaced because of highway improvement projects, such as roadway widening. City/community markers or enhancements not relocated by the local authority will be removed and disposed of by WSDOT, with removal and disposal costs billed to the local authority.<sup>2</sup>

The local authority is also responsible for relocating and/or removing any stand-alone structures that are repeated targets of vandalism, such as graffiti or damage to property. Structures not relocated or removed by the local authority will be removed and disposed of by WSDOT, with removal and disposal costs billed to the local authority.

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<sup>2</sup> WSDOT *Traffic Manual*. March 2002, p 2-32,  
<http://www.wsdot.wa.gov/fasc/EngineeringPublications/Manuals/Traffic.pdf>





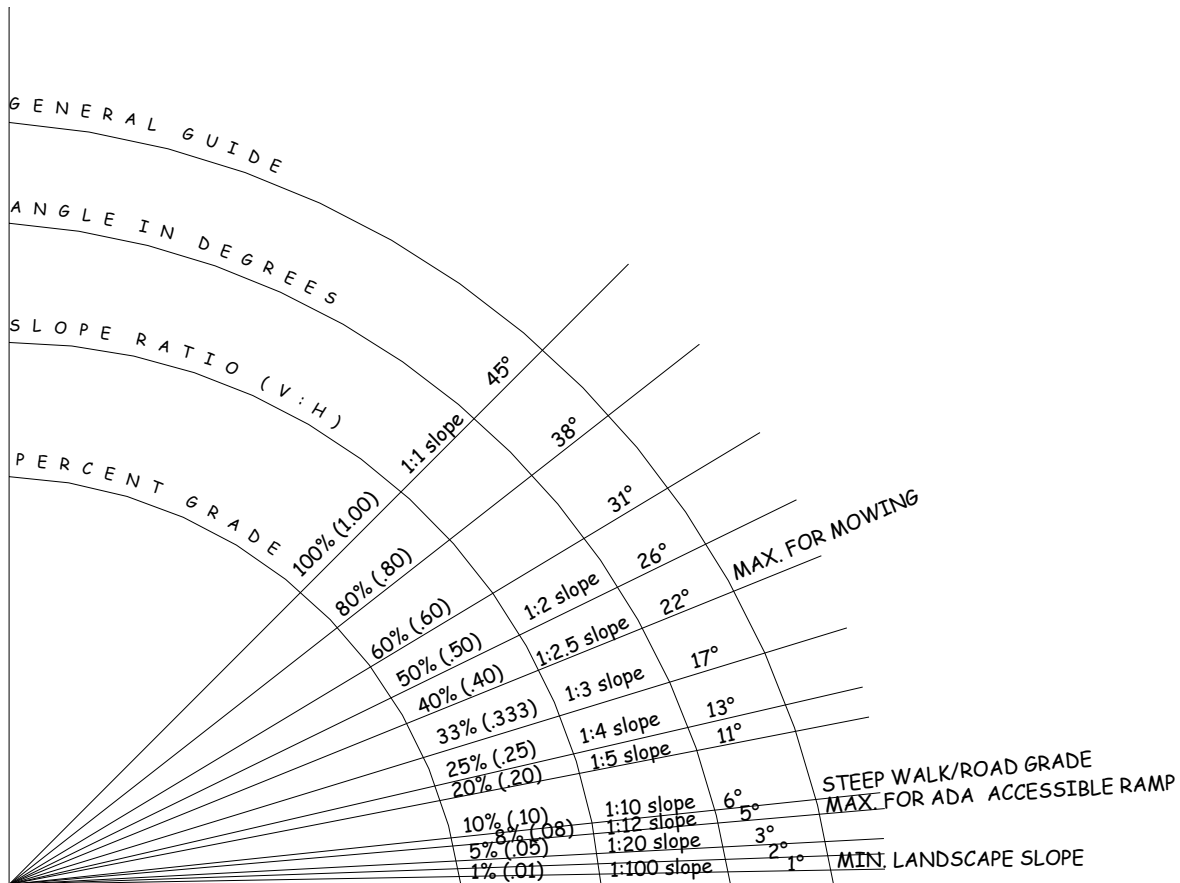
## **Landscape Architects**

- Roadside Restoration Plans
- Wetland Mitigation Plans
- Contour Grading Plans
- Planting Plans
- Site Development Plans
- Irrigation Plans
- Co-signatory on Soil Bioengineering Plans, with Geotechnical Engineer or Engineering Geologist



## Appendix B

## Slope Visualization Diagram



### Notes:

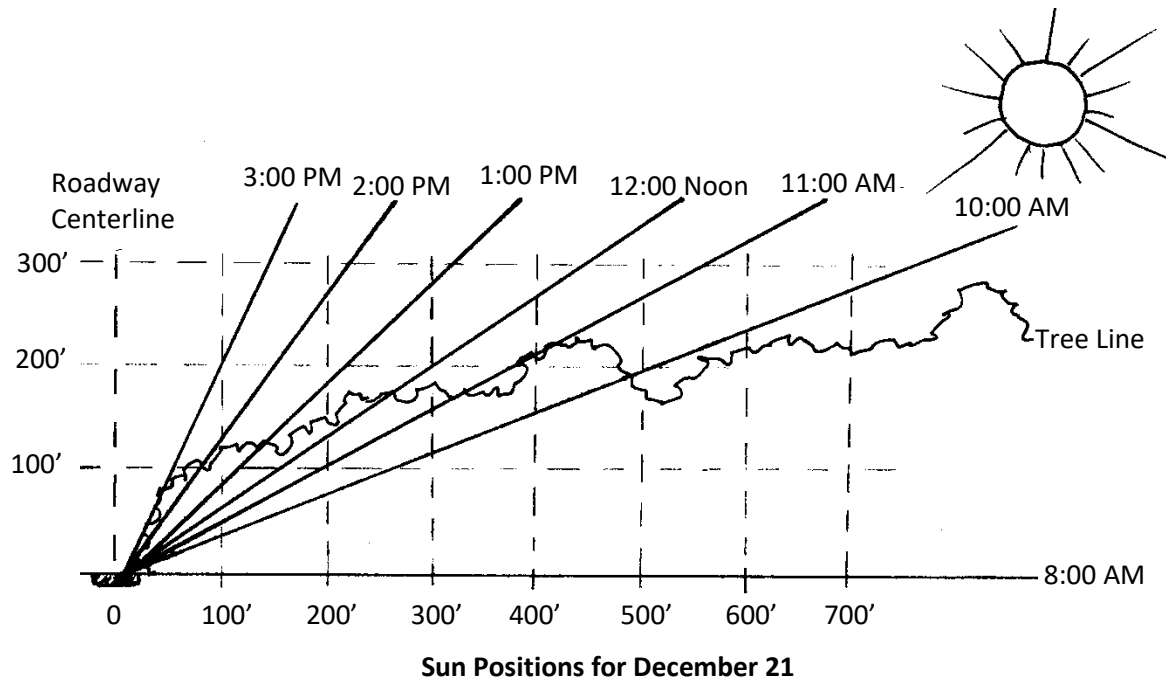
- Maximum slopes for cut and fill depend upon the materials involved. Refer to the Region Materials Engineer and the [Standard Specifications for Road, Bridge and Municipal Construction](#) 2-03.3(14) for guidance.
- The preferred slope for mowing is 1V:3H or flatter. Refer to the [Maintenance Manual](#) for more specific information.



## Appendix C

## Sun Angles and Solar Exposure

Exhibit C-1 shows hourly sun angles for December 21 on a highway with a southwest– northeast road alignment, with a tree canopy height that might be typical for forested areas where shading is a concern. The drawing shows that for this road alignment, shading is caused by vegetation far outside the average right of way dimensions. For example, at 11:00 AM trees that shade the roadway are a minimum of 300 to 400 feet beyond the roadway centerline.



**Exhibit C-1 Southwest to Northeast Road Alignment**

Exhibit C-2 shows hourly sun angles for November 21 and January 21 on a road having an East–West alignment. It also depicts a tree canopy height that might be typical for forested areas where shading is a concern. The drawing shows that for this road alignment, shading is caused by vegetation far outside the average right of way dimensions. For example, at this time of year, for this road alignment, shading at 12:00 noon is caused by vegetation 500' to 600' beyond the roadway centerline. At no time during the day, for this example, does the sun reach an angle where it could reach the roadway.

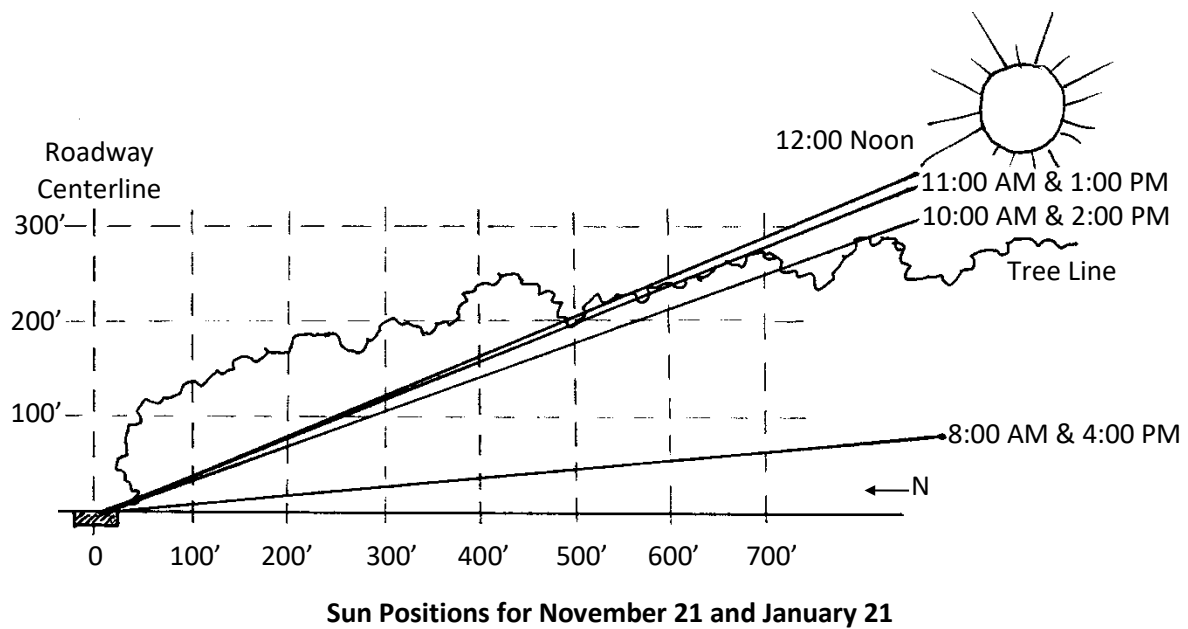
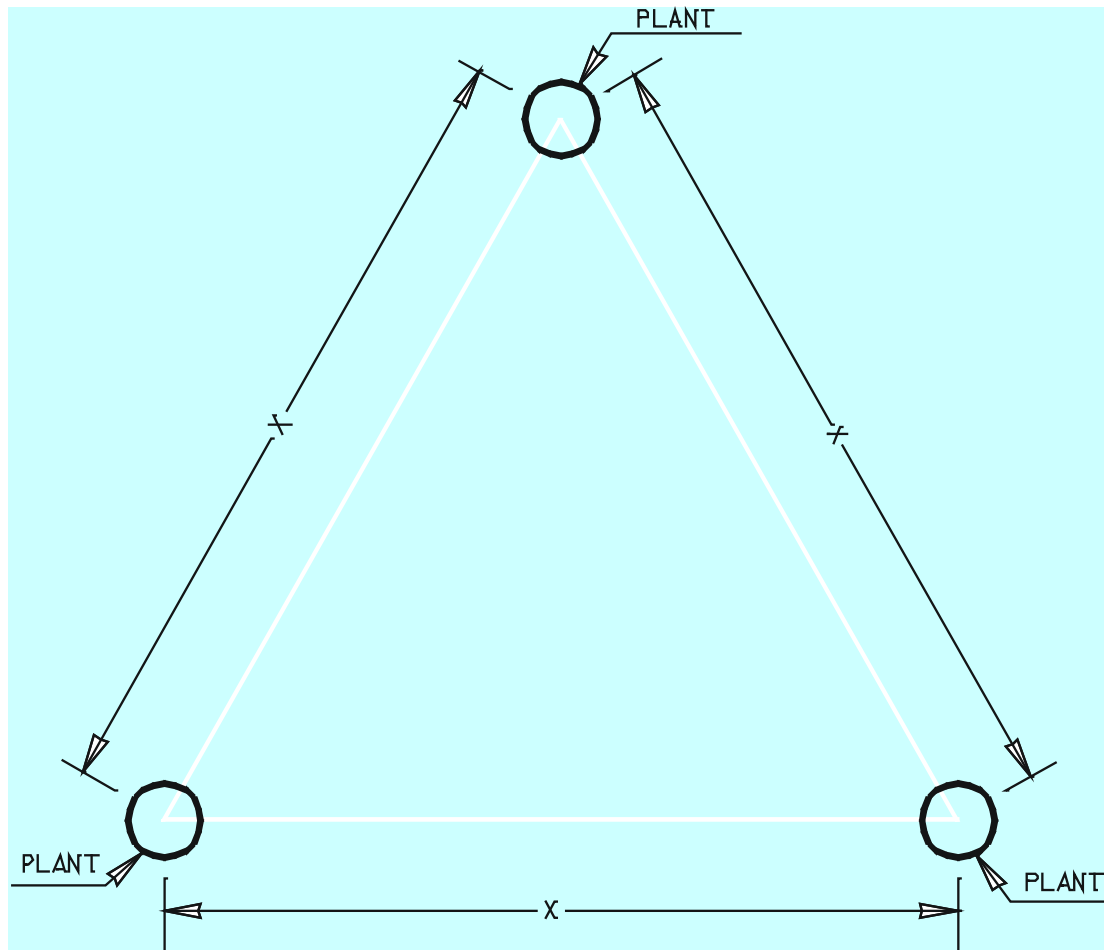


Exhibit C-1 East–West Road Alignment

## Assumed geometric pattern for plant spacing



If this is the geometric shape in which plants will be spaced, the area of the equilateral triangle is:

$$\text{Area} = 2 * X / 2 * \sqrt{(X^2 - X^2 / 4)} = X^2 / 2 * \sqrt{3}$$

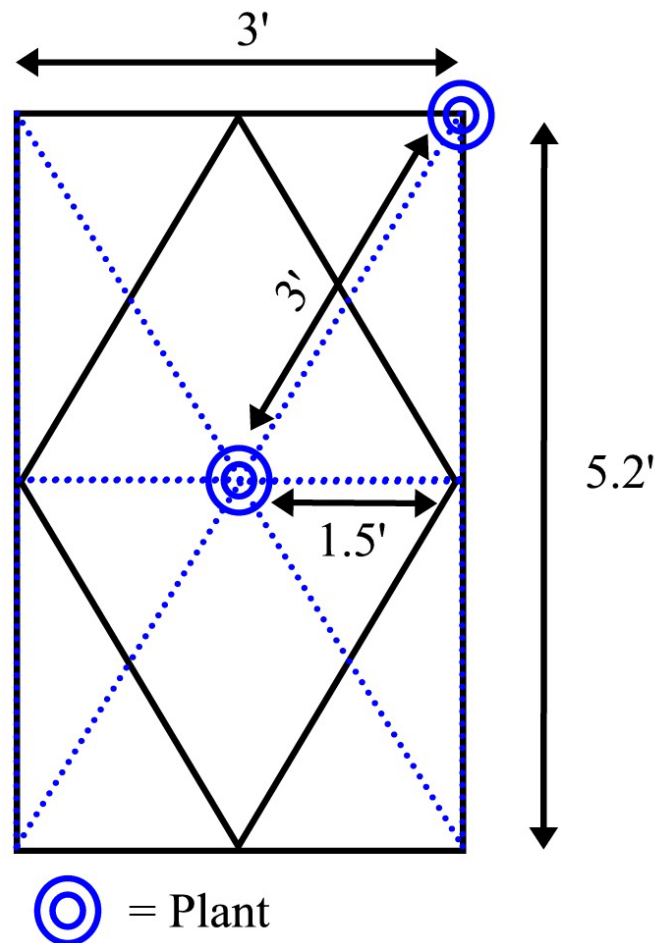
There will be one plant for each equilateral triangle shaped area throughout the area to be planted, plus two extra plants.

Therefore, the number of plants that will be needed for an area in acreage is:

$$\text{No. of plants} = \text{acreage to be planted} * 43560 \text{ sq. ft. per acre} / X^2 / 2 * \sqrt{3} \text{ (where X is the plant spacing in ft.)} + 2 \text{ more plants}$$

(Formula first developed by Julie Nelson, P.E. for the SCR WSDOT Environmental Office.)

## DRAFT Plant Spacing Formula for Vegetation Mitigation Projects



Assuming a 3' on-center planting requirement, the following applies:

- A. Total Area of Above:  $3' \times 5.2' = 15.6$  sq. ft.
- B. Two (2) plants per 15.6 sq. ft. or one plant per 7.8 sq. ft.
- C. If at first you don't think it will work, try stacking the rectangles side by side and top to bottom and you will start to see how it works.
- D. The only possible flaw would be around the edges of a large area to cover, where it may come up a little short.
- E. When used in the Selah project, the planting numbers came out just right.
- F. In the field, construction of the formula is not expected to be exactly 3' on-center for each plant. Some variation will occur.
- G. There may be room for improvement so if you have suggestions, please forward them to the SCR WSDOT Environmental Office (your comments are greatly appreciated).
- H. Formula easily changed for 2', 4', 5', 8', or 10' on-center calculations.



## Appendix E

## Native Plant List - Eastern

For more information and other region native plant lists, please refer to the Native Plant List website at: <http://plantnative.org/rpl-imw.htm>



home | plants | how-to | nursery | community | professional

### NATIVE PLANT LIST

#### Idaho, Eastern Oregon, and Eastern Washington



This is a "starter" list of native plants for Idaho, eastern Oregon and eastern Washington. It is intended for residential or commercial landscapers who want to create attractive and varied native landscapes.

Find another Native Plant List!

Select a Region

TREES   SHRUBS   FLOWERING PERENNIALS   GRASSES

#### Trees

Common Name	Scientific Name	Sun	Soil Moist.	Height	Comments
Big-tooth Maple	<i>Acer grandidentatum</i>	F-P	A-W	8-40'	Fall foliage varies from orange to yellow.
Water Birch	<i>Betula occidentalis</i>	F	A-W	15-25'	An excellent choice for Rocky Mtn. states.
Netleaf Hackberry	<i>Celtis reticulata</i>	F	D	10-30'	Reddish orange berries in the fall.
Western Juniper	<i>Juniperus occidentalis</i>	F	D	20-30'	Blue-green cones appear in the spring.
Western Larch	<i>Larix occidentalis</i>	F	A	150'	This deciduous conifer turns golden in fall.
Blue Spruce	<i>Picea pungens</i>	F-P	A	30'	Large evergreen with a silver-blue color.
Pinyon Pine	<i>Pinus edulis</i>	F	D	10-20'	Requires full sun and good drainage.
Western White Pine	<i>Pinus monticola</i>	F-P	A	150'+	Grows best in sun with moist, well-drained soil.
Ponderosa Pine	<i>Pinus ponderosa</i>	F	D	130'	Yellow brown, sweet-scented bark on old trees.
Quaking Aspen	<i>Populus tremuloides</i>	F	W	50'	Leaves turn gold in fall, shimmer in wind.
Black Cottonwood	<i>Populus trichocarpa</i>	F	W	100'	Oval leaves are glossy dark green.
Douglas Fir	<i>Pseudotsuga menziesii</i>	F-P	A	200'	Best in full sun with well-drained soil.
Rocky Mountain Ash	<i>Sorbus scopulina</i>	F-P	W	13'	Bet in moist, well-drained acidic soil.

For more info, enter a plant name

Find a Nursery in: ID OR WA

Find Community Services: ID OR WA

Check Neighboring States?

Sun Exposure	Soil Moisture
F = Full Sun	W = Wet
P = Part Sun	A = Average
S = Shade	D = Dry

#### Shrubs

Common Name	Scientific Name	Sun	Moist.	Height	Comments
Rocky Mountain Maple	<i>Acer glabrum</i>	F-P	A-W	8-25'	Showy fall foliage is red, orange, and yellow.
Saskatoon Serviceber.	<i>Amerlanchier alnifolia</i>	P	A	5-20'	White flowers April-May become purple fruit.
Kinnikinnick	<i>Arctostaphylos uva-ursi</i>	P	A	6"	Mat-forming shrub has pink flowers Mar-Apr.
Silver Sagebrush	<i>Artemisia cana</i>	F	D-A	3-5'	Semi-evergreen shrub with silver foliage.

Fringed Sagebrush	<i>Artemisia frigida</i>	F	A	8-18"	Foliage is metallic silver.
Louisiana Sage	<i>Artemisia ludoviciana</i>	F	A	12-18"	Smells strongly of sagebrush.
Big Sagebrush	<i>Artemisia tridentata</i>	F	D-A	3-12'	Yellow inconspicuous flowers in the fall
Four-wing Saltbush	<i>Atriplex canescens</i>	F	D-A	4-5'	Yellow inconspicuous flowers mid-spring
Curl-leaf Mtn. Mahog.	<i>Cercocarpus ledifolius</i>	F	D-A	8-15'	Evergreen; dark green leaves, gray bark
Mountain Mahogany	<i>Cercocarpus montanus</i>	F-P	A	5-10'	White flowers Apr-May, Plumes persist into fall
Fern Bush	<i>Chamaeb. millefolium</i>	F	A	6-8'	White flowers in summer
Rubber Rabbitbrush	<i>Chrysoth. nauseosus</i>	F	D-A	2-7'	Dark yellow flowers late summer into fall
Green Rabbitbrush	<i>Chrysoth. viscidiflorus</i>	F	D-A	3'	Leaves green, shiny, and sticky
Red-osier Dogwood	<i>Cornus stolonifera</i>	F-S	A	3-9'	White flowers May-Jun, berries attract birds
Douglas Hawthorn	<i>Crataegus douglasii</i>	F-P	A	8-20'	Showy clusters of white flowers mid spring
Mormon Tea	<i>Ephedra viridis</i>	F	D	2-5'	Yellow flower-like cones and berry-like fruits.
Apache Plume	<i>Fallugia paradoxa</i>	F	D-A	4-6'	White to rose flowers late spring-early summer
Winterfat	<i>Kraschen. lanata</i>	F	D	1-3'	Tolerates highly alkaline soil, needs drainage
Creeping Oregon Grape	<i>Mahonia repens</i>	P-S	D-A	1'	Holly-like leaves; drought and shade tolerant
Mockorange, Syringa	<i>Philadelphus lewisii</i>	F-P	D-A	4-10'	Incredibly fragrant flowers begin late spring
Ninebark	<i>Physocarp. malvaceus</i>	F-S	A	3-6'	White flowers (spring); red fall color
Shrubby Cinquefoil	<i>Potentilla fruticosa</i>	P	A	3'	Yellow flowers early summer- mid fall
Bitter Cherry	<i>Prunus emarginata</i>	F-P	A	6-8'	Fragrant white flowers become red cherries
Chokecherry	<i>Prunus virginiana</i>	F-P	A	10-20'	White flowers in spring become red-purple fruit
Antelope Bitterbush	<i>Purshia tridentata</i>	F	D	5-8'	Yellow highly fragrant flowers Apr-May.
Smooth Sumac	<i>Rhus glabra</i>	F-P	A	4-20'	Compound, blue-green leaves turn red in fall.
Oakleaf Sumac	<i>Rhus trilobata</i>	F-P	D-A	3-6'	Leaves turn a bright red to orange color in fall.
Golden Currant	<i>Ribes aureum</i>	F-P	A	3-6'	Bright yellow flowers in early spring.
Red-flowering Currant	<i>Ribes sanguineum</i>	P	A	3-5'	Pale to dark pink flower spikes in early spring.
Woods' Rose	<i>Rosa woodsii</i>	F-S	D-A	3-4'	Pale to dark pink flowers bloom in late May.
Blue Elderberry	<i>Sambucus cerulea</i>	F-P	W	8-12'	Small white flowers in late spring; attracts birds
Silver Buffaloberry	<i>Shepherdia argentea</i>	P	W-A	10-15'	Dense form of silver foliage, good bird habitat
Russet Buffaloberry	<i>Shepherdia canadensis</i>	F-P	D-A	3-12'	Leaves are blue-green, often with rusty dots
Common Snowberry	<i>Symphoricarpos albus</i>	P-S	A	4-6'	Pink to white flowers bloom in May or June

For more info, enter a plant name



Find a Nursery in:

ID OR WA

Find Community Services:

ID OR WA

Check Neighboring States?

Sun Exposure

F = Full Sun

P = Part Sun

S = Shade

Soil Moisture

W = Wet

A = Average

D = Dry

## Flowering Perennials (Wildflowers)

Common Name	Scientific Name	Sun	Moist.	Height	Comments
Western Yarrow	<i>Achillea millefolium</i>	F	D	1-3.5'	White flowers fading to cream from spring-fall
Parry's Agave	<i>Agave parryi</i>	F	D	24"	Light gray to green foliage is broad and flat
Pearly Everlasting	<i>Anaphalis margaritacea</i>	F-P	A	6-18"	White flowers bloom prolifically Jun-Sep
Rosy Pussytoes	<i>Antennaria spp.</i>	F-P	A	4-8"	Pink and white flowers Jun-Jul; drought tolerant
CO Blue Columbine	<i>Aquilegia caerulea</i>	P	A	12-30"	Blue and white unique blooms Jun-Aug

Western Columbine	<i>Aquilegia formosa</i>	P	A-W	2-3'	Unique red and yellow flowers spring-summer
Wild Aster	<i>Aster spp.</i>	F	A	12-36"	Purple, light blue to cream flowers
Arrowleaf Balsamroot	<i>Balsamorhiza sagittata</i>	F	A	12-24"	Plants don't flower until they are five years old
Blue Camas	<i>Camassia quamash</i>	F	W	1-2'	Blue petals and yellow stamen blooms May-Jun
Purple Coneflower	<i>Echinacea purpurea</i>	F-P	A	2-3'	Continuously blooms (purple) summer-fall
Cut-leaf Daisy	<i>Erigeron compositus</i>	F	D	6"	Numerous white to lavender flowers in spring
Wyeth Buckwheat	<i>Eriogon. heracleoides</i>	F	A	6-16"	Creamy white flowers; drought tolerant
Snow Buckwheat	<i>Eriogonum niveum</i>	F	A	6-18"	White flowers in the summer and fall
Sulfur Buckwheat	<i>Eriogonum umbellatum</i>	F	A	1'	Yellow flowers with hints of reddish orange
Woolly Sunflower	<i>Eriophyllum lanatum</i>	F	A	6-12"	Yellow flowers in the spring; drought tolerant
Blanket Flower	<i>Gaillardia aristata</i>	F-P	A	24"	Flower rays a mix of red, yellow or orange
Sticky Geranium	<i>Gerani. viscosissimum</i>	F-P	A	12-30"	Pink to lavender flowers with red veins May-Sep
Prairie Smoke	<i>Geum triflorum</i>	F-P	A	18"	Reddish to purplish flowers
Texas Red Yucca	<i>Hesperaloe parviflora</i>	F	D	4'	Red blooms in summer reach 5'; slow-growing
Scarlet Gilia	<i>Ipomopsis aggregata</i>	F-P	A	12-24"	Red flowers (Jun) attract hummingbirds
Wild Blue Flax	<i>Linum perenne</i>	F-P	A	8-24"	Blue flowers all spring and summer; drought tol
Silver Lupine	<i>Lupinus argenteus</i>	F-P	A	8-24"	Blue to white flowers; nitrogen fixing
MO Evening Primrose	<i>Oenoth. missouriensis</i>	F	D	6-12"	Yellow flowers Jun-Sep; slightly fragrant
Prickly Pear Cactus	<i>Opuntia spp.</i>	F	D	12"	Flowers of yellow, pink, or red bloom Jun-Jul
Pagoda Penstemon	<i>Penstemon angustifolius</i>	F	A	1'	Comes in various shades of blue to lavender
Scarlet Bugler	<i>Penstemon barbatus</i>	F	A	2-3'	Distinctly bright red corolla, flowers Jun-Sep
Dark Blue Penstemon	<i>Penstemon cyaneus</i>	F	A	12-28"	Dark blue to violet flowers May-Aug
Hot Rock Penstemon	<i>Penstemon deustus</i>	F	A	8-18"	Small creamy white flowers May-Jun
Firecracker Penstemon	<i>Penstemon eatonii</i>	F	A	3'	Flower stalks lined with bright red flowers
Shrubby Penstemon	<i>Penstemon fruticosus</i>	F	A	18"	Blue/lavender to light purplish flowers May-Jun
Palmer Penstemon	<i>Penstemon palmeri</i>	F	D-A	2-4'	Large pink fragrant flowers attract hummingbird
Pine-Leaf Penstemon	<i>Penstemon pinifolius</i>	F	A	6-18"	Red flowers attract hummingbirds
Rydberg's Penstemon	<i>Penstemon rydbergii</i>	F-P	A	8-28"	Bluish-purple flowers in whorls around stem
Showy Penstemon	<i>Penstemon speciosus</i>	F-P	A	2-6"	Bright purple to violet flowers May-Jun
Rocky Mtn. Penstemon	<i>Penstemon strictus</i>	F	A	1-3'	Blue to violet blooms Jun-Jul
Lovely Penstemon	<i>Penstemon venustus</i>	F	A	36"	Stunning flowers lavender-purple May-Jun
Whipple's Penstemon	<i>Penstemon whippleanus</i>	P	A	8-24"	Flowers usually creamy white-green Jul-Aug
Prairie Clover	<i>Petalostem. purpureum</i>	F	D	1-2.5'	Pinkish purple flowers May-Sep; fixes nitrogen
Goldenrod	<i>Solidago spp.</i>	F	A	2-5'	Yellow flowers cover plant late summer-fall
Desert Globemallow	<i>Sphaeralcea ambigua</i>	F	A	20-40"	Orange to brick red flowers Mar-Jun
Gooseberry-leaf Globe.	<i>Sphaera. grossulariifolia</i>	F	D-A	12-24"	Salmon colored flowers in the summer
Orange Globemallow	<i>Sphaeralcea munroana</i>	F	D-A	12-24"	Apricot-pink to reddish-orange flowers
Prince's Plume	<i>Stanleya pinnata</i>	F	D	3-4'	Spikes of lacy yellow flowers spring-summer
Narrowleaf Yucca	<i>Yucca glauca</i>	F	A	3-6'	Creamy white bell shaped flowers in July

For more info, enter a plant name

Go

Find a Nursery in:

ID

OR

WA

Find Community Services:

ID

OR

WA

Check Neighboring States?

Sun Exposure

F = Full Sun

P = Part Sun

S = Shade

Soil Moisture

W = Wet

A = Average

D = Dry

## Grasses

Common Name	Scientific Name	Sun	Moist.	Height	Comments
Indian Ricegrass	<i>Achnather. hymenoides</i>	F	D	12-16"	Beautiful inflorescence when it goes to seed
Little Bluestem	<i>Andropogon scoparium</i>	F	A	12-36"	Blue-green warm season grass; reddish in fall
Blue Grama	<i>Bouteloua gracilis</i>	F	D	4-12"	Mat forming warm season grass
Buffalograss	<i>Buchloe dactyloides</i>	F	D	3-5"	Long blue-gray to green blades; reddish in fall
Bottlebrush Squirreltail	<i>Elymus elymoides</i>	F	D	13-24"	Unique tufted seed head in mid-spring
Idaho Fescue	<i>Festuca idahoensis</i>	F-P	A	18"	Gray-blue blades in early summer
Sheep Fescue	<i>Festuca ovina</i>	F-P	D-A	18"	Does not do well in continuously wet sites
Great Basin Wildrye	<i>Leymus cinereus</i>	F	D	4-6'	Bluish tan blades with wheatlike seed heads
Bluebunch Wheatgrass	<i>Pseudo. spicata</i>	F	D	13-24"	Bluish cast, decorative inflorescence
Sand Dropseed	<i>Sporobolus cryptandrus</i>	F	D	8-16"	Stays green in heat of summer; resists fire if mowed annually

TREES   SHRUBS   FLOWERING PERENNIALS   GRASSES

## IMPORTANT CONSIDERATION:

1. While the plants listed above are native to and appropriate for their indicated regions, please recognize that, in some instances, human development alters the characteristics of a site such that it may be advisable to use plants from a neighboring region. For example, plantings in urban and suburban areas may receive reflected heat from streets, sidewalks and/or walls or be in media that receives less moisture than normal (e.g., next to a paved area – the pavement blocks rain from entering soil). Accordingly, using plants from a neighboring region that support higher temperatures and/or drier conditions may be more appropriate.
2. While a plant is native to a region, that does not mean that it will grow everywhere in that region. The characteristics of any site will typically vary from place to place and some plants may do better than others at various places within a site. In other words, a little experimentation might be required.
3. The above list is a starter list. Though adequate for most residential and commercial landscapes, there are many more native plants and should you want to consider them, please inquire at a [listed nursery](#), [community service organization](#), [reference book](#) or other resources.

## CREDITS:

**1. Landscaping with Native Plants of the Intermountain Region**

US Department of the Interior Bureau of Land Management in cooperation with Boise State University and the Pahove Chapter of the Idaho Native Plant Society  
[www.id.blm.gov/publications/TR1730-3/cover\\_p7.pdf](http://www.id.blm.gov/publications/TR1730-3/cover_p7.pdf).

**2. Idaho Native Plant Society.**

P.O. Box 9451, Boise, ID 83707  
[www.idahonativeplants.org/](http://www.idahonativeplants.org/)

**3. PlantNative Staff.**

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## Appendix F

## Native Plant List - Western

For more information and other region native plant lists, please refer to the Native Plant List website at: <http://www.plantnative.org/rpl-orwa.htm>



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### NATIVE PLANT LIST - Western Oregon and Western Washington



This is a "starter" list of native plants for western Oregon and western Washington. It is intended for residential or commercial landscapers who want to create attractive and varied native landscapes.

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[TREES](#)   [SHRUBS](#)   [PERENNIALS-SUN](#)   [PERENNIALS-SHADE](#)

#### Trees

Common Name	Scientific Name	Sun	Soil Moist.	Height	Comments
<b>Deciduous:</b>					
Vine Maple	<i>Acer circinatum</i>	F-S	A-W	25'	Attractive fall colors. Shade, ornmtl, undrstry.
Big Leaf Maple	<i>Acer macrophyllum</i>	F-P	A	30-100'	Yellow fall color. Excellent shade.
Alder (Red)	<i>Alnus rubra</i>	F	W	40-100'	Good along streams for erosion control, shade.
Pacific Madrone	<i>Arbutus menziesii</i>	F	A	40-80'	Reddish bark, shiny leaves, white flowers.
Paper Birch	<i>Betula papyrifera</i>	F-S	A	80'	Peeling white bark. Yellow fall color.
Black Hawthorne	<i>C. douglasii</i>	F	W	20-30'	Low-growing. Berries for birds. Erosion control.
Pacific Dogwood	<i>Cornus nuttallii</i>	F-P	A	30-50'	White flowers, pink-red berries.
Oregon Ash	<i>Fraxinus latifolia</i>	F	W	40-75'	Gray/brown bark, olive green leaves.
Crab Apple	<i>Malus spp.</i>	F-P	A-W	15-35'	Small green to red fruit, yellow/red fall color.
Indian Plum	<i>Oemleria cerasiformis</i>	F-P	D-A	16'	Blooms Jan, Feb. White flowers, purple plums.
Aspen (Quaking)	<i>Populus tremuloides</i>	F	A-W	40-80'	Food source for deer & other mammals.
Black Cottonwood	<i>Populus trichocarpa</i>	F	W	70-100'	Nesting for large birds. Fast-growing.
Bitter Cherry	<i>Prunus emarginata</i>	F-P	A	20-60'	White flowers, conspicuous red seeds.
Oregon White Oak	<i>Quercus garryana</i>	F	D-A	30-100'	Only native OR oak. Wide spreading branches.
Cascara	<i>Rhamnus purshiana</i>	F-P	A	30'	Silver grey bark. Berries attract birds.
Pacific Willow	<i>Salix lasiandra</i>	F	W	20'	Yellow bark, good along streams and ponds.
<b>Evergreen:</b>					
Grand Fir	<i>A. grandis</i>	F-P	D-A	100-200'	Tall, straight, stately, gray-brown bark.
Noble Fir	<i>A. procera</i>	F			Symmetrical, conical, smooth. Good Xmas tree.
Sitka Spruce	<i>Picea sitchensis</i>			100-150'	
Ponderosa Pine	<i>Pinus ponderosa</i>	F	D-W	60-130'	Scaled, colored bark. Vanilla fragrance.
Douglas Fir	<i>Pseudotsuga menzies</i>	F	D-W	75-200'	OR state tree. Can live over 1000 years.
Giant Sequoia	<i>Sequoiadendron giganteum</i>	F	A	200	Gray-green foliage and reddish brown bark.
Western Redcedar	<i>Thuja plicata</i>	P	A-W	100-175'	Great for wildlife cover, restoration, ornamental.
Western Hemlock	<i>Tsuga hereophylla</i>			125-200'	



For more info, enter a plant name <input type="text"/>	Find a Nursery in: OR WA	<table border="1"> <tr> <th>Sun Exposure</th> <th>Soil Moisture</th> </tr> <tr> <td>F = Full Sun</td> <td>W = Wet</td> </tr> <tr> <td>P = Part Sun</td> <td>A = Average</td> </tr> <tr> <td>S = Shade</td> <td>D = Dry</td> </tr> </table>	Sun Exposure	Soil Moisture	F = Full Sun	W = Wet	P = Part Sun	A = Average	S = Shade	D = Dry
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F = Full Sun	W = Wet									
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Go	Find a Community Org: OR WA									
Check Neighboring States?										

### Shrubs

Common Name	Scientific Name	Sun	Moist.	Height	
Vine Maple	Acer circinatum			5-35'	hjhghvg
Serviceberry	Amelanchier alnifolia	F	A	4-15'	Red fruit attracts birds. Imprtn browse for deer.
Hairy Manzanita	Arctostaphylos columbiana			10-15'	
Kinnikinnick	Arctostaphylos uva-ursi	F-P	A	12"	Dark green leaves, red edible berries.
Tall Oregon Grape	Berberis aquifolium			8-10'	
Snowbrush	Ceanothus velutinus			9'	
Red-osier dogwood	Cornus stolonifera	F-S	W	15'	Red stem, white flowers, white berries.
Western Hazelnut	Corylus cornuta var. cal.			5-12'	
Salal	Gaultheria shallon	F-S	A	6'	Lustrous leaves. Spreads where other shrbs fail.
Ocean Spray	Holodiscus discolor	P-S	D-W	3-20'	Creamy white flowers. Riparian restoration.
Western Honeysuckle	Lonicera ciliosa			vine	
Twinberry	Lonicera invlucrata			4-8'	
Creeping Oregon Grape	Mahonia nervosa	F-S	D-W	12"	Holly-like leaves, dark blue edible berries.
Indian Plum	Osmaronia cerasiformis			15-20'	
Mock Orange	Philadelphus lewisii	F-P	D-A	4-10'	Aromatic white flowers attract bees & butterflies.
Pacific Ninebark	Physocarpus capitatus	F-S	W	10'	Clusters of white flowers, maple-like leaves.
Bald-hip rose	R. gymnocarpa	F	D	5'	
Wood rose	R. woodsii			1-8'	Large, pink flowers. Attracts birds, mammals.
Cascara buckthorn	Rhamnus purshiana			1-8'	
Red Flowering Currant	Ribes sanguineum	F-P	A	10-35'	Beautiful. Attracts butterflies, hummingbirds.
Nootka rose	Rosa nutkana			8-10'	
Salmonberry	Rubus spectabilis	F-P	A-W	12'	Forms dense thickets. Yellow/red edible fruits.
Red Elderberry	S. racemosa	F-S	A	1-8'	Fast-growing. White flowers, red berries.
Western Spirea	Spiraea douglasii	F-P	A-W	3-6'	Leggy. Pink/purple flowers in July. Ornamental.
Snowberry	Symphoricarpos spp.	F-P	D-W	8-20'	Attractive foliage. Waxy berries through winter.
Black Huckleberry	Vaccinium membranaceum			2-6'	
Evergreen Huckleberry	Vaccinium ovatum			4'	
Red Huckleberry	Vaccinium parvifolium			2-8'	
				3-12'	

For more info, enter a plant name <input type="text"/>	Find a Nursery in: OR WA	<table border="1"> <tr> <th>Sun Exposure</th> <th>Soil Moisture</th> </tr> <tr> <td>F = Full Sun</td> <td>W = Wet</td> </tr> <tr> <td>P = Part Sun</td> <td>A = Average</td> </tr> <tr> <td>S = Shade</td> <td>D = Dry</td> </tr> </table>	Sun Exposure	Soil Moisture	F = Full Sun	W = Wet	P = Part Sun	A = Average	S = Shade	D = Dry
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Go	Find a Community Org: OR WA									
Check Neighboring States?										

## Perennials - Sun

Common Name	Scientific Name	Sun	Moist.	Height	
Red Columbine	Aquilegia formosa	F-P	A-W	to 3'	Soft foliage, drooping red to yellow flowers.
Shooting Star	Dodecatheon hendersonii	F	A-W		Magenta to lavender flowers on singular stalk.
White Fawn Lily	Erythronium oregonum	F-S	A		Lance-shaped leaves, white nodding flower.
Tiger Lily	Lilium columbianum	F			Bright orange flowers with red or purple spots.
Big Leaf Lupine	Lupinus polyphyllus	F	A-W	3-4'	Nitrogen fixer. Blue to violet pea-like flowers.
Oregon Stonecrop	Sedum oregonum	F-P	A-W		Yellow to pink flowers. Good for rock gardens.
Yellow-Eyed Grass	Sysyrinchium californicum	F-P	W		Yellow flowers on short stalks. Spreads easily.

For more info, enter a plant name

Go

Find a Nursery in:

OR

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Find a Community Org:

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WA

Check Neighboring States?

Sun Exposure

F = Full Sun

P = Part Sun

S = Shade

Soil Moisture

W = Wet

A = Average

D = Dry

## Perennials - Shade

Common Name	Scientific Name	Sun	Moist.	Height	Comments
Dwarf Dogwood	Cornus canadensis	S	W		Low, trailing. White flwrs, red berry-like drupes.
Bleeding Heart	Decentra formosa	S	W	1-2'	Fern-like. Pink/purple heart-shaped flowers.
Early Blue Violet	Viola adunca	S	W	to 4"	Heart-shaped leaves, yellow flwrs, purple lines.

TREES

SHRUBS

PERENNIALS-SUN

PERENNIALS-SHADE

## IMPORTANT CONSIDERATION:

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## CREDITS:

## 1. East Multnomah SWCD 2006 Native Plant Descriptions

East Multnomah Soil and Water Conservation District  
2701 NW Vaughn St. Suite 450, Portland, OR 97210

## 2. PlantNative Staff.

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***accelerated climax plant community*** The process of restoring a site to a desirable climax plant community in reduced time when compared to natural processes.

***accessible route of travel*** This is defined in the *Washington Administrative Code (WAC) 51-40* as “a continuous unobstructed path connecting all accessible elements and spaces in an accessible building or facility that can be negotiated by a person using a wheel chair and that is usable by persons with other disabilities.”<sup>1</sup>

***ADA*** *Americans with Disabilities Act* 42 U.S.C. 12201  
<http://www4.law.cornell.edu/uscode/42/ch126.html#PC126>

***aesthetics*** Evaluations and considerations with the sensory quality of resources (sight, sound, smell, taste, and touch) and especially with respect to judgment about their pleasurable qualities.<sup>2</sup>

***allogenic succession*** Changes in the composition of the plant community as a result of environmental forces.<sup>3</sup>

***alluvial fan*** A sloping fan-shaped mass of sediment deposited by a stream where it emerges from an upland onto a plain.

***anadromous*** Born in fresh water, migrating to and living in salt water, and then returning to freshwater to reproduce.<sup>4</sup>

***ancillary services*** Those secondary services provided at safety rest areas that include, but are not limited to, vending machines, interpretive signing, telephones, recreational vehicle (RV) sanitary disposal facilities, trails, scenic viewpoints, commercial and public information displays, and visitor information centers.

***angle of repose*** The angle between the horizontal and the maximum slope that a soil assumes through natural processes.

***atmospheric vacuum breaker (AVB)*** A device that contains a float check (poppet), a check seat and an air inlet vent. When water pressure is reduced to a gauge pressure of zero or below, the float check drops. This allows air to enter the device to

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<sup>1</sup> Accessibility Design for All, p. 6.

<sup>2</sup> U. S. Department of the Interior, Bureau of Land Management. BLM Manual: visual resource management, Washington D. C. 1977.

<sup>3</sup> Oliver and Larson, p. 29.

<sup>4</sup> Johnson and Stipula. 1993. p. G1

prevent backsiphonage. It is designed to protect against backsiphonage only.

**autogenic succession** Changes in the composition of a plant community due to interplant interactions (facilitation or competition).<sup>5</sup>

**backflow** Refers to the flow of water or other liquids, gases, or solids from any source back into the customer's plumbing system or the serving utility's water distribution system.

**backflow prevention assembly** Refers to a backflow preventer that is designed to be in-line tested and repaired, and to meet the head loss and flow requirements of the recognized approval authority. The assembly consists of the backflow prevention unit, two resilient seated shutoff valves, and test cock(s).

**background** The distant part of a landscape. Generally, the landscape area located from 4 miles to infinity from the viewer.<sup>6</sup>

**backpressure** Refers to water pressure that exceeds the operating pressure of the purveyor's potable water supply.

**backsiphonage** Backflow due to a negative or reduced pressure within the purveyor's potable water supply.

**berm** The continuous artificial contouring of a slope or water-channel bank.<sup>7</sup>

**Best Management Practices (BMPs)** Physical, structural, and/or managerial practices that, when used singly or in combination, reduce the downstream quality and quantity impacts of stormwater.<sup>8</sup>

**biofiltration** the cleaning of surface water using plants and other biological methods to extract or retain sediment and pollutants.

**bioregion** A geographic region based on topography and biological similarities such as watersheds, plant/animal ecosystems, or relative elevations.

**biosolids** Treated wastewater residuals or solids used as a soil amendment.

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<sup>5</sup> Oliver and Larson.

<sup>6</sup> U.S. Department of Agriculture, U.S. Forest Service, *Landscape Aesthetics: A Handbook for Scenery Management*, December 1995.

<sup>7</sup> Hugo Schiechl, *Bioengineering for Land Reclamation and Conservation*, University of Alberta Press, 1980.

<sup>8</sup> *Highway Runoff Manual* M 31-16. WSDOT, pp Glossary 1-2.

- blend** To create a balanced, visually harmonious interface between adjacent elements. A roadside treatment strategy that integrates roadside elements to preserve roadside character continuity.
- buffer** The zone contiguous with a sensitive area that is required for the continued maintenance, function, and structural stability of the sensitive area. The critical functions of a riparian buffer (those associated with an aquatic system) include shading, input of organic debris and coarse sediments, uptake of nutrients, stabilization of banks, interception of fine sediments, overflow during high water events, protection from disturbance by humans and domestic animals, maintenance of wildlife habitat, and room for variation of aquatic system boundaries over time due to hydrologic or climatic effects. The critical functions of terrestrial buffers include protection of slope stability, attenuation of surface water flows from storm water runoff and precipitation, and erosion control.<sup>9</sup>
- check dam** a small barrier, such as quarry spalls, sand bags, or silt fencing, that slows water velocity and allows solids to settle out behind the barrier.
- check valve** A generic term used for a variety of valves that specifically allow flow in only one direction.
- clay** Mineral soil particles with a diameter of less than 0.002 millimeter. A fine-grained soil that has a high plasticity index in relation to liquid limits.<sup>10</sup>
- clear zone** The total roadside border area, starting at the edge of the traveled way, available for use by errant vehicles.
- climax vegetation** Relatively stable vegetation in equilibrium with its environment and with good reproduction of the dominant plants.<sup>11</sup> A stable end-point to plant succession (“steady state”) where a group of species predominate and replaces itself.<sup>12</sup>
- coherence** Quality of state of being united in principles and relationships or to be logically and aesthetically connected.
- cognition** The mental process or function by which knowledge is acquired.

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<sup>9</sup> *Ibid*

<sup>10</sup> Donahue, Roy L., John C. Shickluna, and Lynn S. Robertson, *Soils: An Introduction to Soils and Plant Growth*, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1971, p. 509.

<sup>11</sup> *Ibid*, p. 510.

<sup>12</sup> Oliver and Larson, p. 147.

**color** The property of reflecting light of a particular wavelength that enables the eye to differentiate otherwise indistinguishable objects. A hue (red, green, yellow, blue, and so on). as contrasted with a value (black, white, or gray).<sup>13</sup>

**compensatory mitigation** The attempt to compensate for wetlands impacts. It usually involves the creation, preservation, restoration, or enhancement of a wetland to replace functions lost due to unavoidable impacts.

**complexity** The multiple qualities in a landscape that provide visual interest such as the combination of form, color, and texture.

**compost** Stable, mature, decomposed organic solid waste that is the result of the accelerated, aerobic biodegradation and stabilization under controlled conditions. The result has a uniform, dark, soil-like appearance.

**conduit** A pipe containing electrical wiring.

**control** The driver's ability to safely drive the vehicle.

**constructed wetlands** Areas "created or restored specifically to treat either point or nonpoint source pollution wastewater."<sup>14</sup> Although a constructed wetland might look the same as a created wetland, different regulations apply. Design and maintenance of constructed wetlands is determined according to their stormwater and hydraulic functions. Vegetation is used to maximize the desired functions.

**contamination** An impairment of the quality of potable water (by sewage, industrial fluids, or waste) that creates an actual hazard to the public health through poisoning or the spread of disease.

**context sensitive design** A collaborative, interdisciplinary approach that involves all stakeholders to develop a transportation facility that fits its physical setting and preserves scenic, aesthetic, historic, and environmental resources, while maintaining safety and mobility. Context Sensitive Design is an approach that considers the total context within which a transportation improvement project will exist.<sup>15</sup>

**contour** An imaginary line on the surface of the earth connecting points of the same elevation.

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<sup>13</sup> U. S. F. S., December 1995.

<sup>14</sup> TRB, 1996

<sup>15</sup> U.S. Department of Transportation, Federal Highway Administration. <http://www.fhwa.dot.gov/csd/>

**contour interval** The difference in elevation between two contours.<sup>16</sup>

**contrast** Diversity or distinction of adjacent parts. Effect of striking differences in form, line, color, or texture of a landscape.

**corridor continuity** The overall coordination and sequence of visual features as experienced by the roadway user.

**corridor management plans** A written document that specifies the actions, procedures, controls, operational practices, and administrative strategies to maintain the scenic, historic, recreational, cultural, archeological, and natural qualities of a Scenic and Recreational Highway.

**created wetlands** Those wetlands that have been constructed on a non-wetland site specifically to compensate for wetland losses permitted under Section 404 of the Clean Water Act.<sup>17</sup>

Created wetlands can also be created to compensate for impacts under local permits or WSDOT directive. Wetlands can also be accidentally created as a result of construction activities.

**critical area** See *sensitive area*.

**critical habitat** (A) Specific areas within the geographical area occupied by the species, at the time it is listed, on which are found those physical or biological features both essential to the conservation of the species, and which may require special management considerations or protection. (B) Specific areas outside the geographical area occupied by the species, at the time it is listed, that the U. S. Secretary of the Interior or the U. S. Secretary of Commerce determines are essential for the conservation of the species.<sup>18</sup>

**cross connection** Any actual or potential physical connection between a potable water line and any pipe, vessel, or machine containing a nonpotable fluid, or having the possibility of containing a nonpotable fluid, such that it is possible for the non-potable fluid to enter the water system by backflow.

**cross section** The representation of a landform as it would appear if cut by an intersecting plane.

**cultural element** Attributes in a human-altered landscape; generally, scenically positive cultural elements, most of which have

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<sup>16</sup> Morris M. Thompson, *Maps for America*, U.S. Department of Interior, Geological Survey National Center, Reston, Virginia, 1987.

<sup>17</sup> TRB, 1996

<sup>18</sup> Endangered Species Act (ESA), 1973

historical backgrounds or nostalgic connotations. Examples include split-rail fences, stone walls, barns, orchards, hedgerows, and cabins.<sup>19</sup>

**cut** That part of the ground surface that, when graded, is lower than the original ground.<sup>20</sup>

**cuttings** Live plant material without a previously developed root system. Source materials for cuttings should be dormant when the cutting is taken.

**datum** In surveying, a reference point, line, or surface for computing or correlating the results of surveys. In surveying, there are two principal types of datums: vertical and horizontal.

**dBA (A-Weighted Sound Level)** The sound pressure levels in decibels measured with a frequency weighting network corresponding to the A-scale on a standard sound level meter as specified by ANSI S1.4-1971. The A-scale tends to suppress lower frequencies (below 1,000 Hz) and best approximates the sound as heard by the normal human ear.

**decibel** A decibel is a unit used to measure and describe the intensity of sound. A decibel is one-tenth of a Bel. A Bel is defined as the common logarithm of the ratio of two powers. Mathematically, a decibel is defined as:

$$dB = 10 \log_{10} (P_1/P_2),$$

Where  $P_2$  is the reference pressure and is equal to  $2 \times 10^{-5} \text{ N/m}^2$  (0.0002  $\mu$  bars).

**decision sight distance** The sight distance required for a driver to 1) detect an unexpected or difficult-to-perceive information source or hazard, 2) interpret the information, 3) recognize the hazard, 4) select an appropriate maneuver, and 5) complete the maneuver safely and efficiently.

**delineated wetland** A wetland whose boundary has been identified by a qualified biologist using a standard delineation methodology evaluating soils, vegetation, and hydrology. A right of entry might be required to formally delineate a wetland for project purposes if it does not occur entirely on WSDOT right of way. The delineated boundary is flagged in

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<sup>19</sup> U. S. F. S., December 1995.

<sup>20</sup> Steven Strom and Kurt Nathan, *Site Engineering for Landscape Architects*, Van Nostrand Reinhold, New York, 1992.

the field and surveyed. The biology report will include the delineation survey with flag locations and numbering.

***Design Clear Zone*** The minimum target value used in highway design.

***designated lands*** Lands that have been officially recognized or identified for their special functions. Many of these are managed for environmental functions as well as other uses, such as recreation. These can include: National Wildlife Refuges; National Forests; National Parks; state, county, and local jurisdiction parks; Wild and Scenic Rivers; Scenic and Recreational Highways; designated critical habitat for threatened or endangered species such as spotted owls; or priority habitat areas such as oak woodlands, agricultural lands, and sensitive plant habitat.

***detention facility*** An above or below ground facility, such as a pond or tank, that temporarily stores stormwater runoff and subsequently releases it at a slower rate than it is collected by the drainage facility.

***detention pond*** A type of drainage facility designed to hold surface and stormwater runoff for a short period of time and then release it over time via adjacent surface water bodies or aquifers.

***ditches*** Narrow depressions designed to collect, convey, and discharge stormwater runoff from roadway surfaces, adjacent right of way, and groundwater discharge from adjacent slopes. Many ditches are diverted streams and creeks. Because of this hydraulic function, it is not uncommon to see wetland (hydrophytic) vegetation growing in roadside ditches.

***double check valve assembly (DCVA)*** An approved assembly consisting of two independently operating check valves, loaded to the closed position by springs or weights, and having suitable connections for testing. It is installed as a unit with and between two resilient seated shutoff valves

***ecological succession*** The natural tendency of plant communities to

***ecosystem*** a complex of biological communities and the physical and chemical environment forming a functioning whole in nature. Wetlands, upland forests, lakes, and streams are examples of types of ecosystems.<sup>21</sup>

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<sup>21</sup> Transportation Research Board. "Report 379: Guidelines for the Development of Wetland Replacement Areas." Washington D.C.: National Academy Press. 1996. p. 72.

**elevation** Vertical distance of a point above or below a reference surface or datum.<sup>22</sup>

**enclose** A roadside treatment strategy, the aim of which is a more or less permeable buffer between two adjacent elements, typically the roadway and adjoining lands. Roadside treatments, such as berms, structures, or vegetation, are used to provide visual buffers along both sides of the road.

**endangered species** Any species of plant or animal that is in danger of extinction throughout all or a significant portion of its range.<sup>23</sup>

**enhancement** Any improvement of a structural component to increase the level of ecological functioning of a site.

**Environmental Resource Area** Areas that have been identified in the field by a biologist as having high environmental resource value. Environmental Resource Areas may include (but are not limited to): stream corridors; oak woodlands, or other high quality habitat areas designated as locally or regionally important; known habitats for state or federal endangered, threatened, or priority species; and rare or sensitive plant communities.

**erosion** The wearing away of the land surface by running water, wind, ice, or other geological agents, including such processes as gravitational creep. Also detachment and movement of soil or rock fragments by human and animal activities.

**erosion prevention and sediment control** Any temporary or permanent measures taken to reduce erosion, control siltation and sedimentation, and ensure that sediment-laden water does not leave a site.

**exotic species** A species found in but not native to a particular area.

**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.

**expose** A roadside treatment strategy, the aim of which is to preserve or open a visual sight line, or remove vegetation for operational purposes, such as in the Design Clear Zone.

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<sup>22</sup> Thompson, 1987

<sup>23</sup> ESA, 1973



- facility*** All or any portion of buildings, structures, vehicles, equipment, roads, walks, parking lots, or other real or personal property or interest in such property.<sup>24</sup>
- fascine*** A tied bundle of plant stems or branches, laid in a trench or a terrace on the contour and staked into position. Used to slow water velocities, trap sediment and establish vegetation. Used on basically stable slopes that have a shallow, unstable surface layer.
- feature*** A visually distinct or outstanding part, quality, or characteristic of a landscape.
- fill*** That part of the ground surface that, when graded, is higher than the original ground.<sup>25</sup>
- finish grading*** Minor changes to finalize a prepared earth surface to its desired grade.
- fixed service item*** A stationary facility or structure such as a utility box or light standard.
- forb*** An herbaceous plant, such as clover, which is not a grass, sedge, or rush.
- foreground*** Detailed landscape generally found from the observer to 100 meters (300 feet) away.
- form*** The mass or shape of an object. Usually considered to be three dimensional.
- friable*** readily crumbled
- genotype*** The genetic make-up of an organism.
- grading*** Modification of the ground surface by cuts and/or fills.
- groundcover*** Low-growing plants that form a dense, extensive growth and tend to prevent weeds and soil erosion.
- groundwater*** Water that occurs below the surface of the earth, which is contained in pore spaces. It is either passing through or standing in the soil and underlying strata and is free to move under the influence of gravity.<sup>26</sup>
- guidance*** The process of directing the course of the driver through signing and other visual clues.

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<sup>24</sup> Subpart A, 49 CFR Part 27.

<sup>25</sup> Strom and Nathan, 1992.

<sup>26</sup> TRB, 1996

***gully*** A channel or miniature valley cut by concentrated runoff but through which water commonly flows only during and immediately after heavy rains or snowmelt.

***habitat*** The environment occupied by individuals of a particular species, population, or community.<sup>27</sup>

***herbaceous plant*** Any flowering plant except those developing persistent woody bases and stems above ground.

***humus*** Decomposed organic matter that remains once visible plant structure can no longer be determined.

***hydraulic conveyance system*** Natural and man made drainage facilities that collect, contain, and provide for the flow of surface and stormwater from the highest elevations down to a receiving water. The natural elements of the conveyance system include swales, and small drainage courses, streams, rivers, lakes, and wetlands. The man made elements of the conveyance system include gutters, ditches, pipes, channels, and most retention/detention facilities.<sup>28</sup>

***hydrology*** The science that relates to the occurrence, properties, and movement of water on the earth. It includes water found in the oceans, lakes, wetlands, streams, and rivers, as well as in upland areas, above and below ground, and in the atmosphere.<sup>29</sup>

***impact*** An action that adversely affects a wetland or other ecosystem; for example, road construction, timber clearing, or agricultural activities that result in wetland conversion or degradation.<sup>30</sup>

***impervious surface*** A hard surface area that either prevents or retards the entry of water into the soil. Common impervious surfaces include roof tops, walkways, driveways, parking lots, concrete or asphalt paved roadways, gravel roads, packed earthen materials, and oiled surfaces.

***indicator*** One of the specific environmental attributes measured or quantified through field sampling, remote sensing, or compilation of existing data from maps or land use reports,

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<sup>27</sup> TRB, 1996

<sup>28</sup> [Highway Runoff Manual](#), WSDOT

<sup>29</sup> TRB, 1996

<sup>30</sup> TRB, 1996

used to assess ecosystem condition or functions or exposure to environmental stress agents.<sup>31</sup>

***infiltration*** The downward movement of water from the surface to the subsoil.

***information display*** A kiosk that includes a map of Washington, local travel services, and attractions. In selected safety rest areas, commercial travel information is provided. The display may be free standing or mounted.

***insertion loss*** The actual acoustical benefit derived from a noise barrier.

***intactness*** Untouched or unaltered, especially by anything that harms or diminishes its character.

***integrated vegetation management:*** (IVM) A vegetation management approach focusing on using long-term solutions to establish stable, low-maintenance roadside plant communities compatible with highway safety, maintenance objectives, neighbors' concerns, and environmental quality, while at the same time deterring invasion of undesirable plants.

***interpolation*** The determination of the elevation of a location between two known points. Done by calculating the slope between known points and using the horizontal distance from the known point to the intermediate point to calculate the elevation of the intermediate point.

***invasive vegetation*** Those (typically) nonnative plant species that will often outcompete native plant communities.

***jurisdictional wetlands*** All naturally occurring wetlands, wetlands unintentionally created as the result of construction activities, and those created specifically for the compensation of wetland losses. These wetlands are regulated by the Army Corps of Engineers and local jurisdictions.

***kiosk*** A conveniently located structure accommodating ancillary services such as vending machines, traveler information, or telephones. The kiosk might also include a sheltered area for serving refreshments on a donation basis.

***landscape*** An area composed of interacting ecosystems that are repeated because of geology, land form, soils, climate, biota, and human influences throughout the area. Landscapes are

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<sup>31</sup> TRB, 1996

generally of a size, shape, and pattern that is determined by interacting ecosystems.<sup>32</sup>

**leaching** The removal of materials ( $\text{CaCO}_3$ ,  $\text{MgCO}_3$ , and other more soluble materials) in solution from the soil.

**legibility** The quality in a landscape that allows the viewer to understand or comprehend it and to make decisions about future actions.

**Leq** A statistical descriptor that provides a single number to describe the varying traffic noise levels. It is a constant, average sound level that, over the specified period of time, contains the same amount of sound energy as the varying levels of the traffic noise.

**line** The path, real or imagined, that the eye follows when perceiving abrupt differences in form, color, or texture. Within landscapes, lines may be found as roads, ridges, skylines, structures, changes in vegetative types, or individual trees and branches.<sup>33</sup>

**listed species** Any species listed by a state or federal agency as threatened or endangered under the Endangered Species Act of 1973.

**live poles** A form of cutting taken from woody vegetation with a diameter greater than 50 mm (2 inches).

**live stakes** A form of cutting taken from one to two year old woody vegetation with a diameter of less than 50 mm (2 inches).

**loam** A soil texture class that contains 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand.<sup>34</sup>

**maintenance pull-off** A widened shoulder area near fixed service items. Suggested width 4 meters minimum. Suggested length 30 meters maximum.

**microorganisms** Forms of life that are either too small to be seen with the unaided eye, or are barely discernible.<sup>35</sup>

**middleground** The zone between the foreground and the background in a landscape. The area located from 100 meters to 4 miles from the observer.

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<sup>32</sup> U. S. F. S., December 1995.

<sup>33</sup> BLM, 1977

<sup>34</sup> Ibid, p. 536.

<sup>35</sup> Ibid, p. 538.

**migration corridor** An area that is usually used by migrating wildlife to move between suitable habitat.

**monitoring** The collection of information after construction to assess if the replacement project is successful and to keep the regulatory agencies and construction agency informed about the status of the replacement project.<sup>36</sup>

**mottling** Soils irregularly marked with spots of color. The presence of orange mottling usually indicates soils that have been through periods of saturation interspersed with periods where the soil had dried out.

**mycorrhizae** A beneficial group of fibrous fungi that engulf soil particles and pore spaces to absorb water and nutrients in solution and transfer this solution to the roots of plants. In effect, they multiply the plants' root systems many times.

**mystery** Characteristics in a landscape that excite wonder, curiosity, or surprise.

**native plant** A plant occurring naturally in a particular region, ecosystem, or habitat at the time of European settlement.

**natural wetlands** Wetlands in existence due to natural forces alone, or unintentionally developed through construction or management practices. Natural wetlands can be found in unusual areas, including filled areas, ditches, borrow pits, ponds, and agricultural fields. Natural wetlands are protected by federal, state, and local regulations as well as WSDOT's internal policies. (See Division 2.)

**navigation** Trip planning and execution.

**nonjurisdictional wetlands** Nonjurisdictional wetlands include those artificial wetlands intentionally created from nonwetland sites, including, but not limited to, irrigation and drainage ditches, canals excavated in uplands, stormwater detention ponds, wastewater treatment facilities created in uplands, and certain agricultural activities and landscape amenities created in uplands. Grass-lined swales and wastewater treatment facilities can be constructed in wetlands but must be so designated and specifically designed for water treatment purposes. Mitigation will be required to compensate for the wetland lost to such a facility

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<sup>36</sup> TRB, 1996

***old growth forest*** A late successional or climax stage in forest development. In western Washington, ancient or old growth forests have a canopy of very large living conifers, shade-tolerant trees beneath the canopy, and abundant large snags and logs.<sup>37</sup>

***OTED*** Office of Trade and Economic Development. Their website is found at: <http://www.oted.wa.gov/aboutoted.htm> Provides leadership and support to promote sustainable economic vitality throughout the state.

***physiographic*** a geographic unit with discrete physical characteristics, such as elevation, aspect, and rainfall patterns.

***pioneer species*** Fast growing plants that are quick to establish on poor soils. Nodules on their roots fix nitrogen giving them a competitive edge in disturbed soil environments.

***plant association*** A particular, consistent group of species growing in a particular, consistent type of habitat.

***plant community*** A general term describing the group of plants growing in an area.

***plant material*** Trees, shrubs, ground covers, cuttings, live stakes, live poles, rhizomes, tubers, rootstock, and seedlings are referred to collectively as “plants” or “plant material.”

***plant succession*** Directional, cumulative change in the species that occupy a given area through time.<sup>5</sup>

***point of interest*** A scenic, historical, natural, or other attraction of sufficient interest to travelers to warrant construction of a pullout and/or viewing area within WSDOT right of way. The site might include interpretive displays, potable water, or other ancillary services. A Point of Interest might be located within a larger roadside park or safety rest area.

***pollutant*** An element that enters a biological pathway or becomes concentrated to the extent that it might cause injury to living organisms or the functioning of environmental systems.

***pore space*** Total space not occupied by soil particles in a bulk volume of soil, commonly expressed as a percentage.<sup>38</sup>

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<sup>37</sup> Norse, Elliott A. *Ancient Forests of the Pacific Northwest*, Washington, DC: Island Press. 1990. p. 287.

<sup>38</sup> Ibid, p. 546.

**potable water** Water that is safe for human consumption and free from harmful or objectionable materials as described by the jurisdictional health authority.

**pressure vacuum breaker assembly** An approved assembly consisting of a spring loaded check valve loaded to the closed position, an independently operating air inlet valve loaded to the open position, and suitable connections for testing. It is installed as a unit with and between two resilient seated shutoff valves. It is designed to protect against backsiphonage only.

**profile** The representation of a landform seen from the side.

**old growth forest** A late successional or climax stage in forest development. In western Washington, ancient or old growth forests have a canopy of very large living conifers, shade-tolerant trees beneath the canopy, and abundant large snags and logs.<sup>39</sup>

**ramp** Any directional route of pedestrian travel having a running slope between 2% and 8.3%.

**receiver** Any human that could potentially experience wayside noise from vehicles on a roadway at a given location.

**receptor** A coordinate point in three dimensional space for which the decibel level is either measured or calculated. Receptor may also be referred to as a “receiver point”.

**recreational vehicle (RV)** A general term used to describe motorized vehicles designed for pleasure travel. The cabin design frequently includes sleeping, eating, and toilet facilities.

**recreational vehicle account** *In Washington*, an account funded by an annual recreational vehicle license fee. Proceeds fund the construction, maintenance, and operation of RV sanitary disposal facilities in safety rest areas on federal-aid highways as authorized by [RCW 46.68](#).

**Recreational Vehicle Citizens Advisory Committee** A volunteer advisory committee established under [RCW 46.10.063](#), which provides for input from “citizen representatives of the recreational vehicle user community.” The committee provides guidance on the expenditure of funds from the Recreational Vehicle Account and advises WSDOT on operation of sanitary disposal facilities.

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<sup>39</sup> Norse, Elliott A. *Ancient Forests of the Pacific Northwest*, Washington, DC: Island Press. 1990. p. 287.

***reduced pressure backflow assembly*** An approved assembly consisting of two independently operating check valves, spring loaded to the closed position, separated by a spring loaded differential pressure relief valve loaded to the open position, and having four suitable test cocks for checking the water tightness of the check valves and the operation of the relief valve. It is installed as a unit with and between two resilient seated shutoff valves.

***reference site*** An established undisturbed natural site that is used as a comparative design guide to help determine the desired plant composition and species densities for the created, or enhanced project site. It should be located near the project site, preferably within the same watershed, and have similar landscape setting, hydrology and topography.

***restoration*** Ecological restoration is the process of assisting the recovery and management of ecological integrity. Ecological integrity includes a critical range of variability in biodiversity, ecological processes and structures, regional and historical context, and sustainable cultural practices.<sup>40</sup>

***retention*** The process of collecting and holding surface and stormwater runoff with no surface outflow.

***retention/detention facility (R/D)*** A type of drainage facility designed either to hold water for a considerable length of time and then release it by evaporation, plant transpiration, and /or infiltration into the ground; or to hold surface and stormwater runoff for a short period of time and then release it to the surface and stormwater management system.

***retention pond*** A type of drainage facility designed to hold water for a considerable length of time allowing it to evaporate or infiltrate into the soil.

***rhizome*** A root-like, usually horizontal stem, growing under or along the ground that sends out roots from its lower surface and leaves, or shoots from its upper surface. The primary means by which some plants spread or reproduce.

***rills*** A small, intermittent water course with steep sides, usually only a few inches deep.

***riparian*** The interface of aquatic and terrestrial systems in flood plains, rivers, and streams. Riparian systems are valued for diverse functions such as flood reduction, groundwater

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<sup>40</sup> <http://nabalu.flas.ufl.edu/ser/definitions.html>



supply, streambank stabilization, habitat and migration corridors for wildlife, erosion control, and preservation of water habitats.<sup>41</sup>

**ripping** Deep cultivation using specialized soil ripping equipment, usually done on compacted soils to increase pore space and improve soil structure for plant growth and infiltration of surface water.

**roadside classification** Any of five classifications given to a route or stretch of roadway through a review process conducted by WSDOT, and documented in the WSDOT “Roadside Classification Log.” Roadside character classifications fall within two categories: natural and built. *Natural* includes the Open and Forest roadside character classification. *Built* includes the Rural, Semiurban, and Urban roadside character classifications.

**roadside function:** Any activity or role for which the roadside is specifically required, suited and used.

**roadside:** The *roadside* is the area outside the traveled way. This applies to all lands managed by WSDOT and may extend to elements outside the right of way boundaries.<sup>42</sup> This includes unpaved median strips and auxiliary facilities such as rest areas, roadside parks, viewpoints, heritage markers, pedestrian and bicycle facilities, wetlands and their associated buffer areas, stormwater treatment facilities, park and ride lots, and quarries and pit sites.

**roadside park** A roadside user facility for safe vehicular parking off the traveled way. These sites might be equipped with features or elements such as a point of interest, picnic tables, and/or chemical toilets. Unlike a safety rest area, a roadside park does not *necessarily* provide a permanent rest room building.

**roadside partner** A person who’s work influences or impacts the roadside either directly or indirectly. Examples include but are not limited to: Architects, Environmental Offices, Heritage Corridors Program, Hydraulics Office, Landscape Architects, and Maintenance personnel.

**roadside restoration** The use of planning, design, construction, and maintenance activities to restore roadside plant communities

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<sup>41</sup> TRB, 1996. p. 76.

<sup>42</sup> WSDOT owns and manages the land within the right of way boundaries. WSDOT also owns, or has partial investment in, properties outside of the right of way boundaries; for example, wetland mitigation sites. In addition, WSDOT has an interest in elements outside the right of way boundaries which may affect roadway safety.

according to designated roadside character and *Roadside Classification Plan* provisions.

***roadside treatment strategies*** Conceptual design strategies used to coordinate implementation of roadside guidelines and fulfill roadside functions. The three basic treatment strategies are enclose/screen, expose, and blend.

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

***rotational failure*** a slide that moves along a surface of rupture that is curved and concave.<sup>43</sup>

***runoff*** That portion of the precipitation on a drainage area that is discharged as overland flow. Types include surface flow, groundwater flow, and seepage.

***Safety Rest Area Roadside Master Plan*** A map of existing and projected safety rest areas and roadside parks. The Master Plan considers a 20 year planning horizon.

***safety rest area (SRA)*** A roadside facility equipped with permanent rest room building(s), parking area, potable water, picnic tables, refuse receptacles, illumination, telephones, and other ancillary services. SRAs might include traveler information.

***Safety Rest Area Team*** A WSDOT working group representing various divisions, regions, service centers, and offices responsible for safety rest area planning, programming, design, construction, maintenance, and operation. The team assists the Heritage Corridors Program in the development of short and long term plans and budgets.

***sand*** A mineral soil particle between 0.05 and 2.0 mm in diameter. A soil textural class.<sup>44</sup>

***scale*** The degree of resolution at which ecological processes, structures, and changes across space and time are observed and measured.

***Scenic and Recreational Highways*** A public road having special scenic, historic, recreational, cultural, archeological, and/or natural qualities that have been recognized as such through legislation or some other official declaration. The terms

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<sup>43</sup> Turner & Schuster, eds, 1996, *Landslides Investigation and Mitigation, Special Report, Transportation Research Board*, pp. 56-57.

<sup>44</sup>Donahue, et al., p. 550.

“byway,” “road,” and “highway” are synonymous. They are not meant to define higher or lower functional classifications or wider or narrower cross-sections. Moreover, the terms State Scenic Byway, National Scenic Byway, or All-American Road refer not only to the road or highway itself but also to the corridor through which it passes.

**screen** The use of roadside treatments such as vegetation, berms, or walls to visually block undesirable views.

**section** See *cross-section*.

**seedlings** Plants grown from cuttings, seeds, or other approved propagation methods. They are generally under 3 years old and under 600 mm (2 ft) in height. Measurement is by height, in 75mm (3inch) increments, or by age and number of times transplanted.

**sensitive areas** (also called critical areas) Places in the landscape that are subject to natural hazards or that support unique, fragile, or valuable natural resources. In many cases, these areas have been designated as sensitive by local jurisdictions under the state Growth Management Act (GMA) and thus may have special regulations attached to them. Each jurisdiction has its own definition of what constitutes a sensitive area and has its own set of regulations that address the restrictions associated with these areas.

The Shoreline Management Act and Growth Management Act include as nonjurisdictional those wetlands created after July 1, 1990, that were unintentionally created as a result of the construction of a road, street, or highway. WSDOT has a “no net loss” policy regarding wetlands and will mitigate impacts to wetlands created after that date.

These areas can be highly susceptible to disturbance. Examples of sensitive areas include: streams, wetlands, steep slopes, erosion hazard areas, coal mine hazard areas, landslide hazard areas, seismic hazard areas, and floodplains, and smaller watersheds feeding into shellfish harvest areas.

**service connection** The piping connection by means of which water is conveyed from the serving utility’s distribution main to a customer’s premises.

**settleable solids (SS)** Settleable solids are the materials which settle out of suspension within a defined period (typically one hour). It is reported on a volume basis (milliliter per liter,

mL/L), but can also be reported on a weight basis (milligrams per liter, mg/L).

**shape** Contour, spatial form, or configuration of a figure. Shape is similar to form, but shape is usually considered to be two-dimensional.

**shrub** A low, woody plant having several stems.

**sight distance** The length of highway visible to the driver.

**silt** A mineral soil separate consisting of particles of 0.05 and 0.002 mm in diameter. A soil textural class.<sup>45</sup>

**sleeve** A pipe containing other irrigation pipe. Also called *casing pipe*. (See Figure 840.1)

**slope gradient** the angle of the slope as expressed in a percentage.

**soil** The unconsolidated mineral and organic matter on the surface of the earth that has been subjected to and influenced by genetic and environmental factors of parent material, climate (including moisture and temperature effects), macro and microorganisms, and topography, all acting over a period of time and producing a product – soil – that differs from the material from which it is derived in many physical, chemical, biological, and morphological properties and characteristics.<sup>46</sup>

**soil bioengineering** the use of live plant materials and engineering techniques to reinforce soil and stabilize slopes.

**soil erosion** The part of the overall process of denudation that includes the physical breakdown, chemical dissolving, and transportation of material by agents such as water, wind, ice, and gravity.<sup>47</sup>

**soil horizons** A layer of soil approximately parallel to the land's surface and differing from adjacent genetically related layers in physical, chemical, and biological properties or characteristics, such as color, structure, texture, consistency, amount of organic matter, and degree of acidity or alkalinity.<sup>48</sup>

**soil organic matter** The organic fraction of the soil that includes plant and animal residues at various stages of decomposition, cells and

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<sup>45</sup> Ibid, p. 552.

<sup>46</sup> Ibid, p. 553.

<sup>47</sup> TRB, 1996

<sup>48</sup> Ibid, p. 558.

tissues of soil organisms, and substances synthesized by the soil population.<sup>49</sup>

**soil structure** The combination or arrangement of primary soil particles into secondary particles or units. The secondary units are characterized and classified on the basis of size, shape, and degree of distinctness into classes, types, and grades respectively. Examples are: platy, prismatic, columnar, blocky, granular, and crumb.<sup>50</sup>

**solar exposure** refers to the exposure of the road surface to the rays of the sun. Solar exposure can be blocked by land forms, structures, and vegetation adjacent to the roadway.

**species** Includes any subspecies of fish, wildlife, or plants; any distinct population segment of any species of vertebrate fish or wildlife that interbreeds when mature.<sup>51</sup>

**steppe** A grass covered semi-arid plain, such as those found in Washington east of the Cascade mountain range.

**stormwater** That portion of precipitation that does not naturally percolate into the ground or evaporate, but flows via overland flow, interflow, channels, or pipes into a defined surface water body or infiltration facility.

**Stormwater Site Plan (SSP)** A plan that shows the measures that will be taken during and after project construction to provide erosion, sediment, and stormwater control. Specific elements of the plan are outlined in the [Highway Runoff Manual](#).

**swale** A shallow drainage conveyance with relatively gentle side slopes, generally with flow depths less than one foot. May be designed for infiltration, biofiltration, or water conveyance.

**subsoil** The soil layers below the topsoil that contain little or no organic matter.

**sustainable roadsides** are those roadsides that are designed and maintained with the intent of integrating successful physical, environmental and visual functions with low life cycle costs.

**Temporary Erosion and Sediment Control (TESC) Plan** A plan required on any project involving earthwork. The specific elements are outlined in the [Highway Runoff Manual](#).

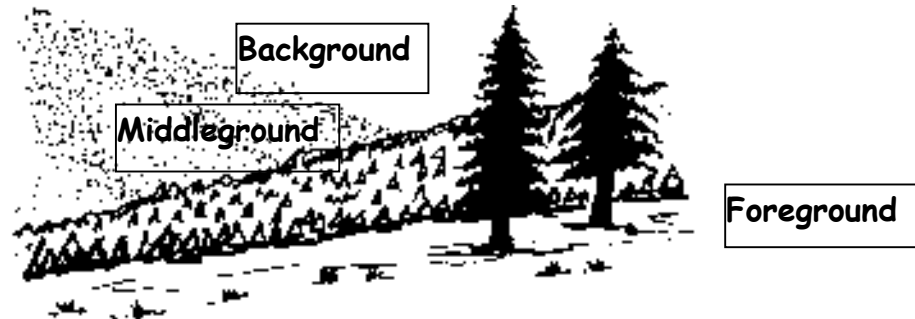
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<sup>49</sup> Ibid, p. 561.

<sup>50</sup> Ibid, p. 561.

<sup>51</sup> Endangered Species Act, 1973

**texture** The visual interplay of light and shadow created by variations in the surface of an object. Grain or nap of a landscape or a repetitive pattern of tiny forms. Visual texture can range from smooth to coarse as seen in the sketch below.



**Figure 500.1 Texture**

**threatened species** Any species of plant or animal that is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.<sup>52</sup>

**tilth** The physical condition of soil as related to its ease of tillage, fitness as a seedbed, and ease of seedling emergence and root penetration.<sup>53</sup>

**topsoil** The original or present, dark-colored, upper soil that ranges from a few millimeters to a meter thick at different locations.<sup>54</sup>

**Total Suspended Solids (TSS)** The entire weight of organic and inorganic particles dispersed in a volume of water, expressed in milligrams per liter (mg/L).

**traffic barrier** Any type of longitudinal barrier, including bridge rails, guardrails, earthen berms, or impact attenuators used to redirect vehicles from hazards located within the Design Clear Zone; to prevent median crossovers; to prevent errant vehicles from going over the side of a bridge structure; or to protect workers, pedestrians, or bicyclists from vehicular traffic.

**translational failure** a slide mass that displaces along a planar or undulating surface of rupture and slides out over the original ground surface. Translational slides frequently grade into

<sup>52</sup> ESA, 1973

<sup>53</sup> Ibid, p. 570.

<sup>54</sup> Ibid, p. 570.

flows or spreads. Generally, translational slides are relatively shallower than rotational slides.<sup>55</sup>

**traveler information** Commercial and non-commercial information that informs and orients the traveling public. Examples include access information for food, gas, lodging, local attractions, regional tourist attractions, roadway conditions, and construction schedules.

**tuber** A swollen, usually underground stem, such as the potato, bearing buds from which new plant shoots arise.

**turbidity** The visual clarity of the water as measured in Nephelometric Turbidity Units (NTUs). The turbidity, or clarity, of surface streams is an important determinant of its condition and productivity. Turbidity in water is caused by suspended and colloidal matter, such as clay, silt, organic and inorganic matter, and microorganisms. Turbidity does not settle out of water in a reasonable time period. The turbidity of drinking water is less than 1 NTU, while the turbidity of stream water can vary from fewer than 10 NTUs to greater than a few hundred NTUs.

**unity** Landscape with a quality or state of being made whole or a condition of harmony.

**“unsuitable soils”** Generally organic soils that are not appropriate for engineering functions. These soils might be ideal for roadside restoration and revegetation functions.

**vicinity zones** Areas on the National Highway System and on Scenic and Recreational Highways that need a safety rest area or roadside park facility in order to meet WSDOT service objectives.

**view** Something that is looked toward or kept in sight, especially a broad landscape or panorama. Act of looking toward an object or scene

**visitor information center** A staffed or non staffed facility that displays and dispenses free tourist and travel maps and brochures.

**vista** A confined view, especially one seen through a long passage, as between rows of trees or down a canyon. A vista often focuses upon a specific feature in the landscape.

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<sup>55</sup> Turner & Schuster.

***Volunteer Refreshment Program*** A program that allows non-profit service organizations to serve refreshments to the traveling public on a donation basis.

***water bars*** Small logs, or concrete barriers, usually less than 15cm in diameter, placed along a trail or slope to intercept the downhill flow of precipitation and direct it to a desired location.

***water quality standards*** The discharge of polluted waters to waters of the state is a violation of the Washington State Water Pollution Control Law ([RCW 90.48.080](#)). Ecology establishes surface water quality standards ([WAC 173-021A](#)) as required by the Environmental Protection Agency (EPA). These standards are intended to protect surface waters of the state for beneficial uses including: public health, enjoyment, and the propagation and protection of fish, shellfish, and wildlife. State water quality criteria are defined for classifications of waters and include turbidity, fecal coliforms, dissolved oxygen, temperature, and pH. All water discharged from construction sites shall meet the water quality standards for turbidity at the discharge point into the surface water resource. There is not a “dilution” or “mixing zone.” Turbidity shall not exceed 5 NTUs over the water resource’s turbidity when the water resource’s turbidity is 50 NTUs or less, or have more than a 10 percent increase in turbidity when the water resource’s turbidity is more than 50 NTUs.

***watershed*** An area of land surface defined by a topographic divide that collects precipitation into a stream or river. Sometimes referred to as a drainage basin.

***wattle*** A length of straw contained in a sausage-shaped netting. These are biodegradable and are generally buried to half their depth along the contour to slow water flow and trap sediment.

***weed*** Any plant growing in a location in which it is not desired. A plant growing out of place.

***wetland*** Wetlands are defined under the Clean Water Act as “those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes,



bogs, and similar areas.” Areas do not need to have surface water throughout the year to qualify as wetlands.<sup>56</sup>

**wetland banking** A form of compensatory mitigation where typically a large mitigation site is developed using creation and/or restoration. This is developed in advance of project wetland impacts. Credit is withdrawn from the bank to compensate for unavoidable wetland impacts. This is generally accomplished through a written agreement signed by regulatory agencies governing the use of the bank.

**wetland buffer** The area adjacent to a wetland that serves to protect the wetland from outside influences. Wetland buffers also contribute to the integral functions of the wetland. Regulated buffer widths vary depending upon the quality of the wetland and guidelines established by the local jurisdiction under the state Growth Management Act. Required buffer widths will be identified in the project’s wetland/biology report. Wetland buffers must be shown on contract plans sheets. No work may occur within an identified wetland buffer area unless it has been approved by the appropriate permitting agency.

**wetland functions** The physical, chemical, and biological processes that can be attributed to a wetland ecosystem. Wetland functions are generally grouped into three categories: (1) *habitat* (providing the factors and conditions necessary to support wetland-dependent species); (2) *water quality* (improving the quality of downstream surface and groundwaters through the uptake of contaminants, sediment retention, nutrient retention, supply, and so forth); (3) *hydrology* (moderating surface and groundwater flows, including flood attenuation, maintenance of base flow, and so forth).<sup>57</sup>

**wildflowers** Native flowering plants including flowering forbes, shrubs and trees.

**wildlife** Any undomesticated animals, including vertebrates and invertebrates.

**xeriscape** A landscaping concept based on water conservation through the use of plant materials and techniques appropriate for dry climates or site conditions.

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<sup>56</sup> Clean Water Act, 1972

<sup>57</sup> Transportation Research Board. *Report 370: Guidelines for the Development of Wetland Replacement Areas*. Washington, D.C.: National Academy Press, 1996. pp 71-8.

