Washington State
Department of Transportation

Roadside Manual

M 25-30.05

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Engineering and Regional Operations
Development Division, Design Office

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Chapter 830 Revegetation for Stream Restoration and Fish Passage Projects

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.
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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.nativerevegetation.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 Green infrastructure is 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 The term low impact development (LID) refers to 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 vegatative canopy, and available food for juvenile salmonids provided by invertabrate 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 surrounding 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.

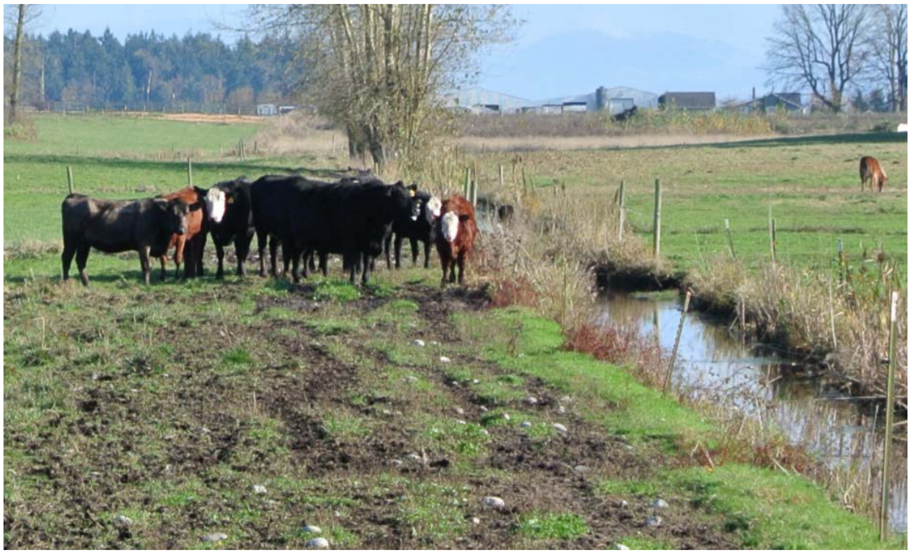

Exhibit 2: Surrounding conditions can make sustainable buffers a challenge. Treaty rights, agricultural land not owned by WSDOT, and other considerations require adaptation to the site as a key consideration in creating a sustainable stream buffer. When restoration cannot be sustained due to allowed land use, agencies should come to agreement on how to approach it.[1]

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

[1] 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

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. Early coordination and field review with maintenance, regulatory agencies, and tribes prior to pre-BA meeting is recommended to expediate permitting. 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 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.

1. If the total score reaches 13 points or higher (60% of maximum points) based on the values in Table 1, post construction access should be considered for the project location.

Criteria for Inclusion		
Alluvial Fan Influence[2]	No Sediment Concerns	1
(Chronic Environmental Deficiency)	Reoccurring Sedimentation	2
	Structure Within Deposition Area	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
	High Potential for Maintenance	2
Secure Access Off Roadway Required	No	1
	Yes (Dedicated Area)	2
Potential Human Use[3]	Low	1

[2] Individual situations such as reoccurring alluvial deposition may be sole criteria justifying post construction access.
[3] 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.

	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	**22**

Approvals

The Assistant Regional Administrator for Development (or delegate) has the final approval for maintenance access. As previously mentioned, it is good practice to consult Region Maintenance and the Bridge Preservation Office when evaluating Maintenance Access.

Documentation

Decisions regarding maintenance access shall be documented in the Basis of Design (BOD) or a design decision and included in the Design Documentation Package (DDP). The documentation should include conclusions for the aforementioned considerations, and concurrence from the approval authority.

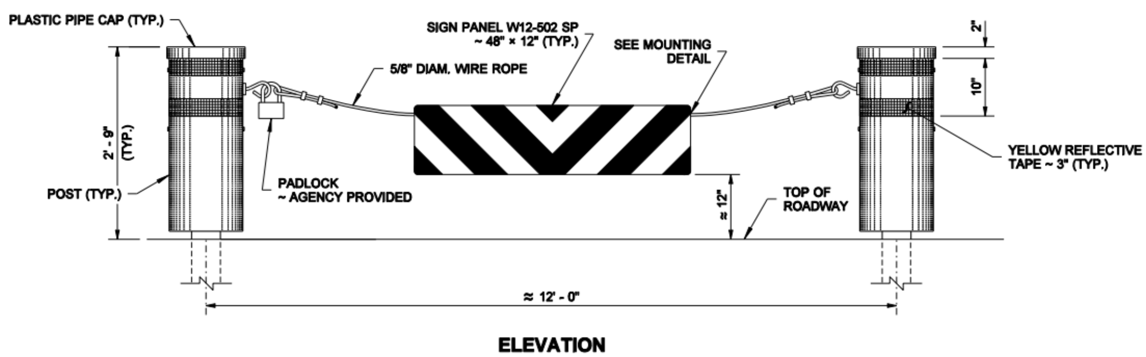

Exhibit 2a Standard Plan L-70.10-01: Access Control Gate

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.

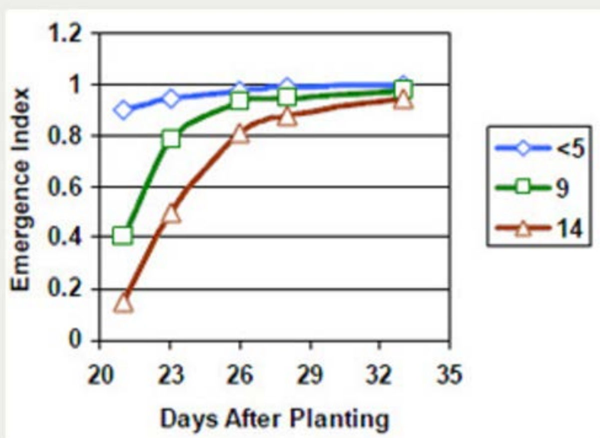

Figure 3. The effect of different degrees of compaction (axle loads) on plant emergence (11)

Exhibit 3: Soil compaction and plant growth.[4]

[4] Tires, traction and Compaction. Jodi DeJong-Hughes, University of Minnesota Extension. https://extension.umn.edu/soil-management-and-health/soil-compaction

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.

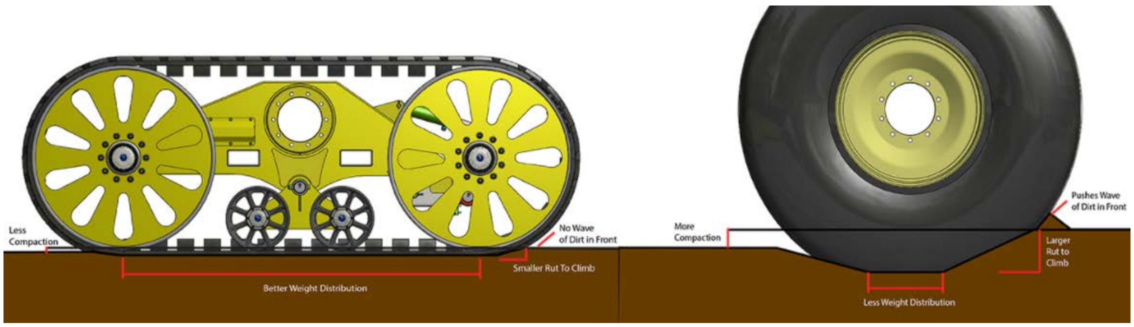

Exhibit 4: Effects of equipment type on soil. [5]

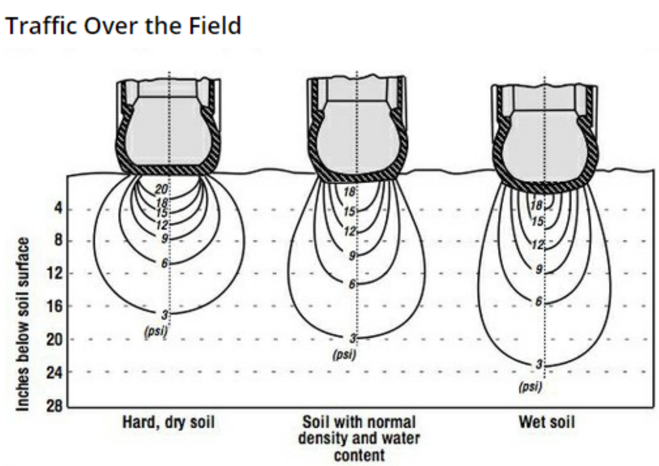

Exhibit 5: Effects of moisture on soil.

[5] Elmer's Manufacturing. *(https://elmersmfg.com/2016/04/benefits-tracks-vs-tires/)*

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 de-compact 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[6] 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 with other channel-stabilization methods, success is likely to be limited during a phase of active channel deepening or steepening (e.g., Simon 1989)."[7]

[6] 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.
[7] 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

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.

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[8]

Work with the design office during the early phases of design to save desirable vegetation[9]. 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-center spacing; the purpose is to ensure appropriate shading for cooler water, reduction in weed pressure, and providing the earliest possible habitat benefits.

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[8] 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.

[9] 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.

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[10]. 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)."[11]

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 toing 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.

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

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.

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[12] 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.
- 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.

[12] 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

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.[13]

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.

[13] 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 banks 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[14] 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.

[14] 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