

# STREAM HABITAT RESTORATION GUIDELINES

## CHAPTER 1

### INTRODUCTION

Few endeavors in resource and environmental management in the Pacific Northwest are more compelling than rapidly expanding efforts to restore the region's streams and rivers. The region's history and strongly held values are inseparably intertwined with our streams and rivers. In coastal and inland settings, historic and current settlement and development patterns have centered on streams for transportation, residential, municipal, agricultural, and industrial water supply, power generation, and crop irrigation. Pacific Northwest streams and rivers, and their floodplains provide; food, construction aggregates, and recreational opportunities. Their floodplains provide relatively flat, fertile agricultural land and their forested riparian zones historically supplied timber. However, competing uses of stream corridors in modern society, combined with large-scale alteration of watersheds, have directly and indirectly impacted the abundance, quality, and stability of stream and riparian habitats. Streams, with their associated floodplain and riparian ecosystems compose the sole habitat, or critical habitat elements for a majority of the region's native fish and wildlife. Approximately 85% of Washington's terrestrial vertebrate wildlife species depend on riparian habitats for all or critical portions of their life histories. This rich floral and faunal biodiversity is the basis for much of the state's cultural heritage, economy, and famous quality of life.

After more than a century of adverse impacts from a multitude of economic activities following Euro-American settlement, recognition of the need to restore streams has spread throughout the Puget Sound region, coastal watersheds draining directly to the Pacific Ocean, and the entire Columbia River watershed. Much of this awareness and activity is driven by the serious decline of the region's once robust anadromous runs of wild salmon, cutthroat, bull trout, smelt, and sturgeon. The accelerating interest in stream restoration also stems from a desire to restore wild populations of native resident salmonid fish species, including redband, cutthroat and bull trout, and other aquatic and riparian species, many of which have been listed as threatened or endangered under the federal Endangered Species Act and the Washington Wildlife Code.

Securing supplies of clean, cool water for a host of human and wildlife needs also depends on healthy stream systems in functionally intact watersheds. A majority of the state's major rivers and hundreds of tributary streams fail to attain federal and state water quality standards for a host of pollutants including heavy metals and toxic compounds and nutrients, and for temperature, turbidity, dissolved oxygen and biological oxygen demand parameters. Great progress has been achieved in reducing industrial and municipal point sources of water pollution, yet a large challenge remains to achieve and maintain reductions of urban, rural and wildland sources of non-point water pollution. The purpose of the Stream Habitat Restoration Guidelines (SHRG) is to promote process based natural stream restoration, rehabilitating aquatic and riparian ecosystems. These guidelines advance a watershed scale assessment of the stream system, establishing goals, objectives and design for restoring optimum sustainable native biodiversity, using principles of landscape ecology and integrated aquatic ecosystem restoration.

While a number of specific watershed assessment, characterization, project design and construction approaches are presented in this volume, these guidelines do not offer a “cookbook” approach that provides every step and equation along the way. Rather, the intent is to provide readers with a comprehensive list of factors and criteria to consider, which are essential to make informed decisions when planning and designing stream restoration and rehabilitation work.

**Readers are strongly cautioned not to pluck and apply individual techniques from these guidelines without first conducting the necessary watershed and reach based assessments and analysis.** The techniques presented in these guidelines are not meant to limit the designer. Other innovative stream restoration techniques may exist and are sure to be developed and included in future editions of this document.

Topics addressed in the SHRG include site, reach, and watershed assessment, problem identification, general approaches to restoring stream and riparian habitat, factors to consider in identifying and selecting an approach, approaches to solving common restoration objectives, and stream and riparian habitat restoration techniques. Watershed processes and conditions that shape stream channels, stream ecology, geomorphology, hydrology, hydraulics, planting considerations and erosion control, and construction considerations are also presented in the main text and appendices.

### ***1.1 Historic Impacts to Streams and Watersheds***

Degraded stream systems reflect degraded conditions in their contributing watersheds. Degraded or altered conditions in all watersheds in the working landscape reflect similar patterns, from forested or shrub-steppe wildlands managed for grazing and timber production, to agricultural lands, to intensively urbanized watersheds. These patterns of watershed “hardening” tend to increase the magnitude and frequency of high flows after precipitation events, and increase sediment and pollutant inputs into stream systems. The annual hydrograph, as differentiated from the storm event flow response described above, is also changed. High spring runoff flows often increase, while seasonal low flows (base flows) decline or cease. Direct alterations include channel straightening, dredging, widening, narrowing, levee construction, floodplain fill, and riparian zone modification. Indirect activities include those that alter the principal processes that create and maintain stream channel conditions. Timber harvest and forest management, road building, grazing, agriculture and urbanization all influence the supply and transport of water, sediment, energy (light and heat), nutrients, solutes, and organic matter (ranging from woody material to leaf litter).

Watershed hardening is obvious and intuitively understood in urbanized watersheds, and erosion associated with agriculture is well recognized by the public. Gains have been realized in broadening public awareness of adverse impacts resulting from draining and filling wetlands. Inappropriate logging practices from the past, road building, and overgrazing result in soil compaction and erosion. In working wildlands, snowmelt is accelerated when the tree canopy is opened or eliminated<sup>1</sup>, and runoff increases as soil infiltration declines. Reduced soil infiltration reduces bank storage (groundwater recharge), causing decline or cessation of summer and fall low flows in streams. Thus, increased stream flows after storms and snowmelt, combined with increased sediment inputs from erosion degrade stream channels, which evolved in dynamic equilibrium with the geological, biotic and climatic conditions of their drainages. These changes in stream flows and sediment inputs often destabilize stream channels, mobilizing more sediment

from their beds and banks. Stream restoration efforts applied solely on the stream and its riparian corridor will not succeed or persist if the degraded condition of the tributary watershed is not addressed beforehand or simultaneously.

Physical and ecological *processes* create stream channel and floodplain *structure*, in which habitat *functions* for fish and wildlife, and all other ecosystem components occur. These include the interaction of water, sediment and wood that create channels and shoreline structure, which are geomorphic processes. Geomorphic processes include hydrologic response, sediment transport, wood influences, erosion and accretion, fire, and channel evolution and migration. Changes in the behavior and routing of water in the watershed result in changes in geomorphic processes in stream systems. Biological processes that interact in complex pathways with geomorphic processes include nutrient cycling, riparian and upland vegetation dynamics, soil building and species mediated habitat-forming processes such as beaver activity.

Native fish and wildlife, including anadromous and resident salmonids, have coevolved and adapted to exploit the habitats created by these processes. Sustaining wild, naturally occurring populations of these species depends on sustaining the biotic and geomorphic ecological processes of watersheds and their aquatic ecosystems.

Watershed scale physical and ecological processes have been altered or lost historically in the Pacific Northwest, resulting from a broad array of human activities, including intensive beaver trapping, urban, suburban and industrial development, agriculture, timber harvest, mining, overgrazing, structural flood control and channelization, surface water withdrawal for agricultural irrigation, domestic, commercial and industrial use, construction and operation of roads, railroads, pipelines, electrical distribution lines, and construction and operation of dams and reservoirs for irrigation and power generation. Our society as a whole bears responsibility for these impacts, which have both, accompanied development of the region's diverse economy, and diminished our ecological resources, and the economic and recreational opportunity based on these assets. These impacts have also decreased potential for future economic opportunities.

Diverse land use and economic activities compete for water and floodplain real estate, while these same resources are vital for restoring and sustaining aquatic ecosystems, including those that support wild anadromous salmon and trout. While these guidelines suggest and recommend modifying land use activities within the watershed to restore the processes that create and maintain stream habitat, in-depth discussion of these issues lies outside the scope of these pages.

The Watershed Planning Act, RCW 90.82, was passed in 1998, providing a framework for developing local solutions to meet the water supply needs, including instream flows, for each watershed. It primarily addresses water quantity, but the watershed plans may also address water quality and habitat issues. Watershed Planning is being implemented in 42 of Washington's 62 water resource inventory areas (WRIAs). The Growth Management Act (GMA), RCW 36.70A, and Shoreline Management Act (SMA), RCW 90.58, also specifically address protecting fish and wildlife habitat through analyzing and regulating land use with locally developed and implemented programs. Under the Watershed Planning Act, instream flows are established. Under the GMA and SMA, fish and wildlife habitat areas are to be protected and managed with appropriate buffers and regulations. The SMA guidelines for developing and adopting new

Shoreline Master Programs (WAC 173-26) require inventory and analysis of landscape scale ecological, hydrologic and geomorphic processes which determine shoreline ecological function.

They also require that updated Shoreline Master Programs contain a shoreline restoration plan, which may include regulatory and nonregulatory measures, and must also include benchmarks and other measures for assuring that the restoration plan is achieved over time.

### **1.2 Stream Habitat Restoration Guidelines within the Aquatic Habitat Guidelines Program.**

The *SHRG* are part of a series of guidance documents produced through the Aquatic Habitat Guidelines (AHG) program. The AHG program is a joint effort among state and federal resource management agencies in Washington, which include the Washington Departments of Ecology, Fish and Wildlife, and Transportation, the United States Fish and Wildlife Service, and the United States Army Corps of Engineers. The Aquatic Habitat Guidelines are designed to address the urgent need for increased and broadly accepted technical guidance, to ensure that stream restoration efforts, including those for salmon and trout recovery, and watershed restoration are strategic, ecologically appropriate, and optimize the effective investment of public and private resources. Aquatic Habitat Guidelines do not replace existing regulatory requirements, though they are designed in part as technical guidance supporting regulatory streamlining, and grant application review for stream restoration proposals. Other AHG guidance documents include the Integrated Streambank Protection Guidelines<sup>2</sup>, Design of Road Culverts for Fish Passage<sup>3</sup>, Fishway Guidelines for Washington State<sup>4</sup>, and Fish Protection Screen Guidelines for Washington State<sup>5</sup>. All of these may be viewed as .pdf files at the AHG website, maintained by the Washington Department of Fish and Wildlife (WDFW) at: <http://www.wdfw.wa.gov/hab/ahg/>. This website also presents an overview of the AHG program, executive summaries of the White Papers, AHG Guiding Principles, draft guidance documents, and news of upcoming training and other events.

Many of the ecological and resource management issues addressed in these guidance documents have been explored in a series of state-of-the-knowledge white papers produced by regional and national experts as part of the AHG program series. These White Papers may also be viewed and downloaded from the AHG website.

### **1.3 The Watershed Approach**

As with all of the AHG documents, informed by the AHG Guiding Principles, the *SHRG* emphasizes analyzing and characterizing physical and ecological watershed processes, leading to process-based stream habitat restoration or rehabilitation. Watersheds usually cover multiple land ownerships, often complex patchworks of private and public lands latticed with networks of transportation infrastructure and utility easements. Planning stream restoration requires some level of participation by the many different stakeholders in the watershed, leading to public consensus and support for the work, which dramatically increases the likelihood of success and positive long term outcomes. These guidelines do not address the specifics of public participation in watershed planning and stream habitat restoration design, but focus primarily on the technical aspects of ecological process evaluation and restoration design. The interested reader should consult the excellent multi-agency federal publication, Stream Corridor Restoration: Principles, Processes, and Practices<sup>6</sup>, published in 1998.

Additional guidance for local public participation is available through Watershed Planning Units, local governments planning under the Growth Management Act and Shoreline Management Act, local Conservation Districts and Resource Conservation and Development entities, and other local resource management units working at the watershed scale.

### **1.4 Restoration or Rehabilitation**

Veterans of resource management and historical efforts at ecological restoration have long been aware that restoring ecosystems and habitats which existed prior to Euro- American settlement is supremely difficult, and rarely if ever achieved. Achieving aquatic ecosystem *restoration* is a worthy goal, yet it implies a clear understanding of what ecological conditions were before Euro- American settlement, and current and future circumstances which will allow full restoration, including full control of all human and economic activities in the affected watersheds. These conditions are approximated only in certain park and wilderness areas, not in the region's working landscape.

In most cases, soil profiles, soil microbial and mycorrhizal communities, plant communities, and hydrologic conditions are permanently altered or subject to unpredictable fluctuations driven by urbanization and other watershed hardening, irrigation diversions, wetland reductions, etc. Sediment inputs are also frequently increased from elevated erosion, or reduced in tailwater streams below dams. Additional missing or greatly attenuated ecological processes include nutrient cycling from reduced or lost anadromous fish runs. Other altered conditions that won't be immediately improved include water quality parameters. Accelerated action toward water pollution reduction under the federal Clean Water Act is underway in the form of Total Maximum Daily Load (TMDL) plans, emphasizing control of nonpoint sources. However, these plans will be years in implementation. Thus, the watershed based analysis and characterization yields awareness that conceptually, stream habitat *rehabilitation* is a more accurate, achievable and defensible approach in most cases.

There will be circumstances where restoring a stream's natural channel morphology from a ditched and straightened condition is a highly feasible opportunity, with regard to planform geometry or meander form, and longitudinal profile including pools, riffles, runs and sediment composition. In these cases *creation* is a legitimate design approach.

Stream *restoration* may also be best implemented in riparian corridor protection through livestock exclusion, acquisition in fee simple, or less than fee alternatives like conservation easements, in circumstances where the degree of degradation is moderate enough to facilitate a healing response without requiring invasive earth moving, structural measures or revegetation. Other measures include critical area designation under the Growth Management Act, or appropriate environment designation and restoration planning under the Shoreline Management Act and local Shoreline Master Programs, as noted above.

Protective measures voluntarily executed through deed amendments or contracts are often more durable and effective than regulatory measures. Protective measures may also result in rapid stream corridor response if adequate evaluation of the watershed and treatment reach has been conducted. Additional protective measures include addressing watershed degradation in uplands, including land use, agricultural best management practices, improved grazing and range

restoration, and improved timber harvest and road building practices. The importance of considering and addressing degraded conditions and ecological processes throughout the watershed cannot be overstated, and is critical to any stream habitat restoration design.

### **1.5 Restoration Sequencing**

Stream habitat restoration or rehabilitation begins with an adequate assessment of watershed conditions, and fits within a continuum ranging from passive measures such as modifying land use activities within the watershed to aggressive channel realignment and structural measures, all evaluated and designed in the context of an adequate assessment of watershed conditions. The essential first step in stream habitat restoration is to conduct an adequate comprehensive watershed analysis and assessment, which characterizes watershed processes outlined in preceding paragraphs. Many such efforts are completed or underway throughout Washington, supporting or implementing the Salmon Recovery Act (ESB 2496) limiting factors analysis, Washington Department of Natural Resources watershed assessment, watershed planning under RCW 90.82, subbasin assessment conducted as part of the Interior Columbia Basin Ecosystem Management Plan, Shoreline Master Programs updated comprehensively updated under the new Shoreline Master Program Guidelines of 2003, and many others. Watershed-scale assessment should include adequate evaluation of hydrology and geomorphology of the subject stream system, to characterize flows and extent of channel degradation or relative integrity.

In all cases, the preferred approach to stream habitat restoration or rehabilitation should be stream restoration accompanying watershed restoration. Less invasive design approaches including riparian livestock exclusion and ecologically appropriate revegetation are preferred over more invasive and aggressive channel modifications or structures, including log or root wad placement. Channel modifications require terraforming and expensive machine time, in addition to extensive engineering, hydraulics and hydrologic design, and construction oversight.

Instream restoration activities as stand-alone restoration techniques are only appropriate if the cause of stream degradation can be isolated to a specific in-stream cause. Creating habitat features that existing watershed and channel conditions cannot maintain produces only short-term benefits, if any, and usually requires long-term maintenance. When the cause of stream degradation lies outside the stream, such as excessive stormwater runoff from the watershed, restoration activities should focus on watershed and riparian restoration to reinstate the processes that naturally create and maintain stream habitat over the long term. Watershed and riparian restoration activities are less intrusive and disruptive to the aquatic ecosystem than aggressive in-stream activities, thus posing less environmental risk. Restoration planners should also note that streams have a remarkable ability to heal over time once the cause of their degradation is removed. For this reason, approaches that address degrading and destabilizing changes in the watershed, such as modifying land use within the watershed to reduce surface erosion of fine sediment into the stream, are often sufficient and more appropriate than aggressive instream activities to “clean” fines from gravels. Restoration sequencing is discussed in detail in Chapter 4 of this document, *Developing a Restoration Strategy*.

### **1.6 Monitoring and Adaptive Management**

To optimize probability of success, stream restoration and rehabilitation efforts must adequately provide for and assure ongoing long term monitoring. Monitoring protocols must be based on

developing easily observed and measures parameters of success, including water quality, channel morphology, stability after high flow events, progress in establishing native plant communities, measuring fish and wildlife use and presence. Since stream restoration and rehabilitation will inevitably proceed in the face of some technical uncertainties and unforeseen circumstances, the principles of adaptive management should be incorporated into watershed restoration plans.

Adaptive management is *not* a trial and error approach. Adaptive management is predicated on designing and monitoring resource management programs and ecological restoration using principles of experimental design, so that adequate data are gathered and statistically analyzed to identify effective alterations to a management program or rehabilitation project. In stream restoration and rehabilitation, this means testing the hypotheses that a rehabilitation program or design is based on a good understanding of watershed processes, and appropriately addresses adverse changes in these processes and ecological functions. Monitoring stream restoration and rehabilitation efforts at adequate levels of scientific rigor costs money, and must be conducted for years after the initial fencing, construction, or plantings are completed. These costs should be anticipated and incorporated into overall project design and grant proposals. Stream restoration efforts which are part of larger watershed restoration initiatives are more likely to succeed not only because of the availability of good watershed analysis and characterization, but also from the increased likelihood of adequately funded long term monitoring, which should be based in principles of adaptive management.

## 1.7 References:

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<sup>1</sup> Wildland Watershed Management, Donald R. Satterlund; Paul W Adams, New York : Wiley, ©1992. \* ISBN: 0471811548

<sup>2</sup> Cramer, M., K. Bates, D. Miller, K. Boyd, L. Fotherby, P. Skidmore, and T. Hoitsma. 2003. Integrated Streambank Protection Guidelines. Co-published by the Washington departments of Fish & Wildlife, Ecology, and Transportation. Olympia, Washington. 435 pp. <http://www.wdfw.wa.gov/hab/ahg/strmbank.htm>

<sup>3</sup> Bates, K., B. Barnard, B. Heiner, J. P. Klavas, and P.D. Powers. 2003. Design of Road Culverts for Fish Passage. Washington Department of Fish and Wildlife. Olympia, Washington. 110 pp. <http://wdfw.wa.gov/hab/ahg/culverts.htm>

<sup>4</sup> Bates, K. 2000. DRAFT Fishway Guidelines for Washington State. Washington Department of Fish and Wildlife, Olympia, Washington. <http://www.wdfw.wa.gov/hab/ahg/fishways.htm>

<sup>5</sup> Nordlund, B. and K. Bates. 2000. DRAFT Fish Protection Screen Guidelines. Washington Department of Fish and Wildlife, Olympia, Washington. <http://www.wdfw.wa.gov/hab/ahg/screens.htm>

<sup>6</sup> Federal Interagency Stream Restoration Working Group. 1998. Stream Corridor Restoration: Principles, Processes, and Practices". By the Federal Interagency Stream Restoration Working Group (15 Federal agencies of the US government). GPO Item No. 0120-A; SuDocs No. A 57.6/2:EN 3/PT.653. ISBN-0-934213-59-3.