Sandy River Basin
Aquatic Habitat Restoration Strategy
An Anchor Habitat-Based Prioritization of Restoration Opportunities

Prepared by the SANDY RIVER BASIN WORKING GROUP
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Cover photo of Salmon River side channel restoration project. Photograph by Duane Bishop, Zigzag Ranger District, Mt. Hood National Forest.

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EXECUTIVE SUMMARY

ABSTRACT

This report contains an anchor habitat-based, aquatic habitat restoration strategy for salmon and steelhead populations in the Sandy River basin. The Sandy River basin lies within close proximity to Portland, Oregon. Originating on Mt. Hood, the Sandy River flows west and then north, entering the Columbia River near the City of Troutdale. The Sandy River contains several species of native salmon and steelhead, all of which are federally listed under the Endangered Species Act. This aquatic habitat restoration strategy focuses on spring Chinook, fall Chinook, coho, and winter steelhead. Benefits to other fish and aquatic species and improvements to water quality are also anticipated from the restoration actions identified in this strategy.

Twelve entities participated during eight years of collaborative work to assess watershed and aquatic conditions in the basin, identify specific restoration actions, and develop this overall aquatic habitat restoration strategy. The 12 collaborative partners include: Association of Northwest Steelheaders, Bureau of Land Management, City of Portland Water Bureau, Clackamas County Department of Transportation and Development, East Multnomah County Soil and Water Conservation District, National Marine Fisheries Service, Oregon Department of Fish and Wildlife, Oregon Trout, Sandy River Basin Watershed Council, The Nature Conservancy, U.S. Fish and Wildlife Service, and U.S. Forest Service. Policy representatives from these agencies and organizations meet on a regular basis and work in a collaborative manner to improve fish habitat and water quality conditions within the basin. This group is known as the Sandy River Basin Partners (see www.sandyriverpartners.org).

Beginning with an assessment of anchor habitat for salmon and steelhead conservation at the basin-scale, members of the Sandy River Basin Working Group (Working Group) first identified geographic priority areas to focus aquatic habitat restoration activities. A total of eight anchor habitat watersheds are identified within the basin. These areas are the primary focus of aquatic habitat restoration. In priority order, the anchor habitat watersheds are: 1) Sandy River corridor (mouth of Sandy River to Zigzag River confluence), 2) Salmon River watershed, 3) Still Creek watershed, 4) Upper Sandy River watershed (upstream of and including Clear Fork Sandy River watershed), 5) Gordon Creek watershed, 6) Alder and Wildcat Creeks watershed, 7) Little Sandy River watershed, and 8) Trout Creek watershed. In addition, the Working Group identified a total of four non-anchor habitat watersheds as second tier priorities for aquatic habitat restoration. In priority order, the non-anchor habitat watersheds are: 1) Zigzag River watershed (not including Still Creek), 2) Lower Bull Run River watershed (below the City of Portland Water Bureau Headworks Municipal Water Diversion), 3) Beaver Creek watershed, and 4) Clear Creek watershed. The figure below shows the priority anchor habitat and non-habitat watersheds within the Sandy River basin. Two additional watersheds were identified for restoration actions (Cedar Creek watershed and Miscellaneous Tributaries to the Sandy River) in order to identify and prioritize restoration opportunities in all areas of the basin. While these two watersheds are not displayed in the figure below, restoration actions for these two areas are presented in Chapter 4 and included in the summary of basin-wide needs.

Mt. Hood and Sandy River.
Photograph by Josh Kling.

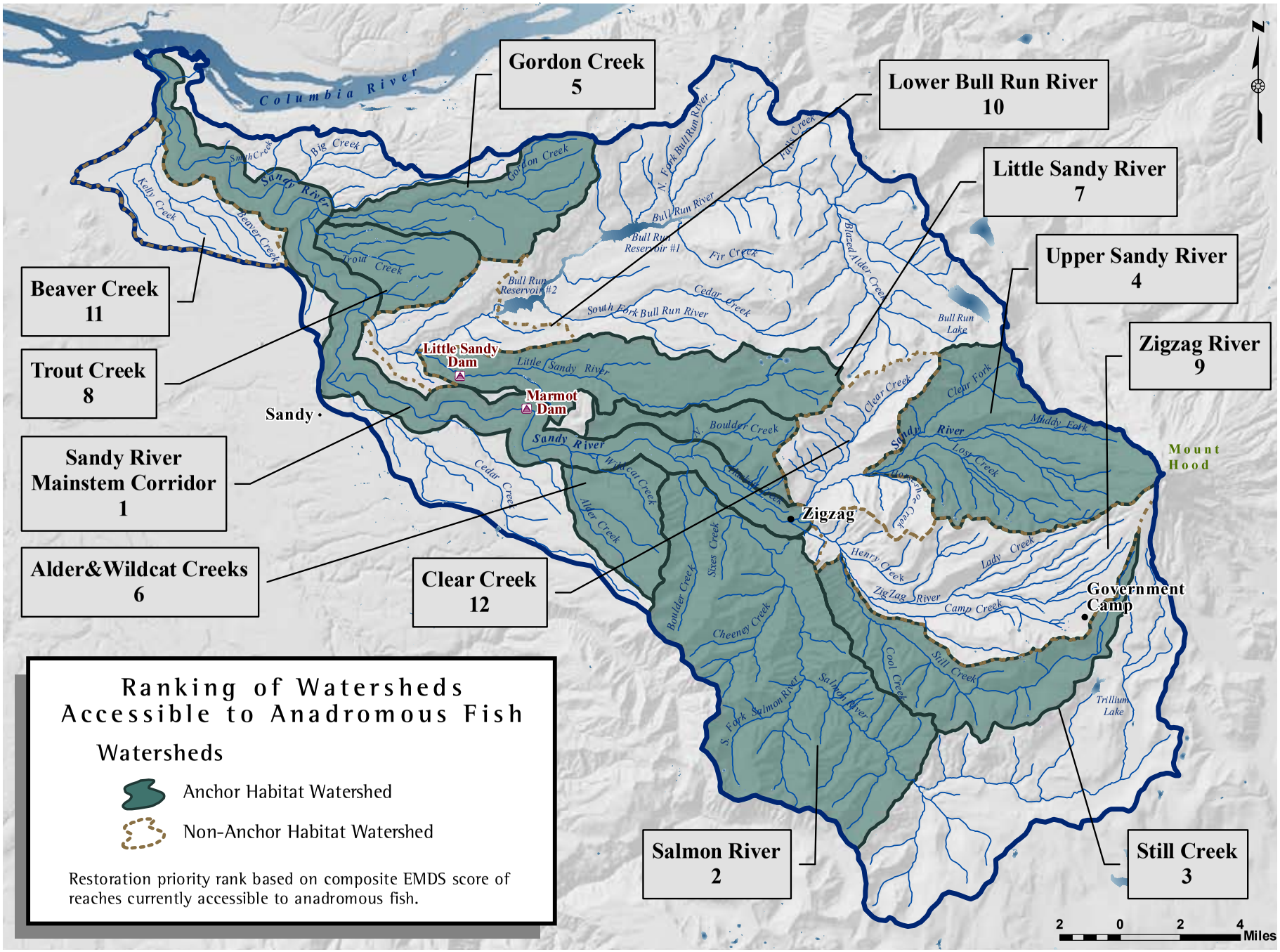

Figure 2.6. Sandy River Basin Aquatic Habitat Restoration: Geographic Focus.

This strategy relies upon a hierarchical framework developed from the geographic priority areas to guide the implementation of restoration actions in each watershed. A hierarchical framework (Roni et al., 2002) establishes a sequencing of restoration activities that takes a holistic watershed view, addressing the aquatic habitat restoration needs for recovery and long-term persistence of salmon and steelhead populations in the basin. The hierarchical framework is comprised of four tiers of restoration activity based on relative importance.

- **Tier 1 actions:** Reconnect Isolated Habitats – ensure that restoration activities focus first on restoring connectivity to historically accessible salmon and steelhead habitat. Examples of Tier 1 actions include correction of culvert-fish passage barriers and re-opening access to historic side channels, floodplains, and off-channel habitat.

- **Tier 2 actions:** Restore Long Term Processes (Roads, Water Quality, Marine Derived Nutrients, etc.) – ensure that restoration activities focus on addressing physical and biological processes important for sustained watershed function. The focus for Tier 2 actions is broad and encompasses the following categories of restoration actions: 1) road-related activities, 2) water quality improvements, 3) in-stream flows, 4) marine derived nutrients, 5) law enforcement, and 6) public education.

- **Tier 3 actions:** Restore Long Term Processes (Riparian Vegetation) – focus on restoring the primary ecological function of riparian areas for sustained riparian and aquatic habitat function. Examples of Tier 3 actions include riparian land acquisitions and easements; riparian planting; eradication of invasive weeds; and riparian thinning and conifer release.

- **Tier 4 actions:** Restore Short Term Processes (In-stream Habitat) – ensure that in-stream aquatic habitat conditions improve productivity in the short term while longer term restoration benefits from Tier 1, 2, and 3 actions accrue. An example of a Tier 4 action is the addition of large woody material to stream channels to restore structural habitat complexity and stream channel processes such as regulating the transport of sediment, gravels, and organic matter through the stream ecosystem.

The next step in developing this strategy involved examining the impairments to physical and ecological processes on a watershed-by-watershed basis, and determining those processes that have been altered and limit aquatic habitat productivity. Each geographic priority area was evaluated using existing information and data available from watershed assessments and the Sandy River Basin Characterization Report that contains results from an Ecosystem Diagnosis and Treatment (EDT) modeling effort of the basin. This process identified specific physical and ecological processes that have been impaired, as well as their limitations on aquatic habitat productivity as analyzed in the EDT model on a reach-by-reach basis for each watershed. The Working Group identified priority restoration actions to remedy the impaired physical and ecological processes, and to address factors limiting aquatic habitat production. The Working Group reviewed the 2002 comprehensive database of 157 restoration projects developed by a technical team of fish biologists and aquatic specialists working on the City of Portland Water Bureau's Habitat Conservation Plan (HCP). The majority of the projects were highly compatible with the hierarchical framework since they were originally identified on a reach-by-reach basis to address EDT limiting factors. Each of the 2002 projects is uniquely identified by number and name, and has a project description, objectives, measure of effectiveness, feasibility, estimated cost, and other associated information. The strategy identifies these projects as "known" projects, and those that have either been implemented or do not relate to aquatic habitat restoration are not included. Additionally, the Working Group identified new restoration actions not previously identified for specific watersheds and stream reaches in order to ensure that all altered watershed processes and limiting factors are addressed. The strategy identifies these actions as "new" projects which require further field investigation, validation, and development. The costs for "new" projects are unknown at this time and were not estimated for the development of this strategy.

This strategy identifies a total of 120 "known" actions and 105 "new" actions for all of the prioritized anchor habitat and non-anchor habitat watersheds in the basin. The strategy is intended to guide investments over the long term in a manner that works towards completing high priority restoration actions in the highest priority watersheds. This guidance is not intended to ignore the high priority restoration needs or opportunities that are present in those watersheds rated as lower priority. The Working Group recognizes there are likely to be some high priority restoration needs and opportunities in the lower priority geographic areas, and thus included a prioritization of restoration actions in alignment with the hierarchical framework for the four non-anchor habitat watersheds.

In an effort to provide a gross estimate of potential aquatic habitat restoration investment on a watershed-by-watershed basis for "known" actions only, the Working Group provided project-level cost estimates from the original 2002 comprehensive database of restoration actions. These project cost estimates were not adjusted upwards for inflation, nor do they include costs associated with planning and environmental compliance, design, permitting, project administration and implementation oversight, or monitoring. The table on the following page gives a summary of the gross cost estimates for "known" Tier 1 through Tier 4 restoration actions by priority geographic area. Cost estimates for "new" Tier 1 through Tier 4 restoration actions have not been determined, therefore, the gross cost estimates presented below are likely to be a significant under-estimate of total restoration need for most watersheds within the basin.

With the comprehensive strategy provided herein, the Sandy River Basin Partners and other participating entities can now coordinate future investments in aquatic habitat restoration in a manner that leverages limited resources so as to provide the greatest benefits to the long term recovery and healthy functioning of salmon and steelhead habitat in the basin.

Summary of Gross Cost Estimates for Tier 1 through Tier 4 "Known" Restoration Actions by Priority Geographic Area.

		ESTIMATED COST FOR "KNOWN" RESTORATION ACTIONS PER HIERARCHICAL FRAMEWORK[1]				
		TIER 1 ACTIONS	TIER 2 ACTIONS	TIER 3 ACTIONS	TIER 4 ACTIONS	
WATERSHED	GEOGRAPHIC PRIORITY	RECONNECT ISOLATED HABITATS	RESTORE LONG TERM PROCESSES (Roads, Water Quality, Marine Derived Nutrients, etc.)	RESTORE LONG TERM PROCESSES (Riparian Vegetation)	RESTORE SHORT TERM PROCESSES (In-stream Habitat)	ESTIMATED TOTAL COST
Sandy River Corridor	1	$ 1,485,000	per SA[2]	$ 7,549,600	$ 3,750,000	$ 12,784,600
Salmon River	2	$ 3,000,000	$ 3,500	$ 2,581,000	$ 4,136,000	$ 9,720,500
Still Creek	3	$ 370,000	$ 1,222,000	$ 32,400	included under Tier 1 costs	$ 1,624,400
Upper Sandy	4	no "known" actions	$ 12,960	$ 14,100	$ 20,000	$ 47,060
Gordon Creek	5	no "known" actions	no "known" actions	$ 46,800	$ 160,000	$ 206,800
Alder & Wildcat Creeks	6	$ 360,000	no "known" actions	$ 44,100	no "known" actions	$ 404,100
Little Sandy River	7	per SA[2]	per AIP[3] for HCP	no "known" actions	$ 72,000	$ 72,000
Trout Creek	8	no "known" actions	no "known" actions	$ 1,500	$ 51,200	$ 52,700
Zigzag River	9	$ 700,000	$ 2,950,500	$ 203,800	included under Tier 1 costs	$ 3,854,300
Lower Bull Run River	10	$ 260,000	per AIP for HCP	$ 4,500	per AIP for HCP	$ 264,500
Beaver Creek	11	$ 10,500,000	$ 4,580,000	$ 203,000	$ 80,000	$ 15,363,000
Clear Creek	12	$ 300,000	$ 3,710	$ 869,400	included under Tier 1 costs	$ 1,173,110
Cedar Creek	13	$ 5,200,000	$ 779,000	$ 4,500	$ 320,000	$ 6,303,500
Misc. Tributaries	14	$ 2,000,000	$ 300,000	$ 204,500	$ 48,000	$ 2,552,500
					BASIN TOTAL	**$ 54,423,070**

[1] Estimated costs for "known" restoration actions are based on the dollar value in 2002 and do not include planning, design, administrative, or monitoring costs.
[2] SA = settlement agreement
[3] AIP = agreement in principle

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The Sandy River Basin Working Group participants that contributed to the development of this aquatic habitat restoration strategy include: Mike Myrick, Association of Northwest Steelheaders; Dave Roberts, Bureau of Land Management; Steve Kucas and Janet Senior, City of Portland Water Bureau; Mark Mouser, Clackamas County Department of Transportation and Development; Julie Dileone, East Multnomah County Soil and Water Conservation District; Rob Markle, National Marine Fisheries Service; Todd Alsbury and Danette Ehlers, Oregon Department of Fish and Wildlife; Mark McCollister and Jason Miner, Oregon Trout; Russ Plaeger and George Hoyt, Sandy River Basin Watershed Council; Jonathon Soll, The Nature Conservancy; Brad Goehring, U.S. Fish and Wildlife Service, and Duane Bishop, Todd Parker, and Dan Shively, U.S. Forest Service.

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CHAPTER 1 – BACKGROUND

BACKGROUND AND PURPOSE

The decline of anadromous fish populations in the Pacific Northwest is often attributed to the effects of the "four H's": harvest (fishing), hatchery impacts, hydroelectric facility operations, and habitat degradation. The Sandy River Basin Working Group (Working Group), which developed the strategy presented in this document, chose to focus only on habitat, namely the habitat requirements necessary to rebuild Sandy River salmon and steelhead populations including direct benefits to water quality and other species as well. The Working Group acknowledged at the very beginning of this project, that a single "H" focus was necessary in order to keep the task manageable and complete a product. Furthermore, it was readily recognized that both harvest and hatchery issues had been recently addressed through the 2001 Sandy River Basin Fish Management Plan Amendment (ODFW 2001). Additionally, hydroelectric issues in the basin were explored and resolved through the Portland General Electric and Stakeholder's Settlement Agreement to decommission both Marmot and Little Sandy dams in 2007 and 2008, respectively (PGE 2002a and PGE 2002b). Aquatic habitat restoration needs for the Sandy River basin had remained unresolved at the basin scale until the effort leading to the development of the aquatic habitat restoration strategy described in this document. Factors involving harvest, hatcheries, or hydroelectric systems may influence or support habitat considerations for the Sandy River basin, and it can be expected that human decisions related to these three "H's" will continue to affect the health of the basin's fish populations. However, the Working Group intentionally focused on habitat restoration and did not revisit or debate past and potential future decisions regarding the other three "H's."

The entities with responsibilities and jurisdiction for improving habitat conditions for salmon and steelhead in the Sandy River basin currently spend, on average, an estimated $2 million annually for such purposes. These expenditures, for the most part, have been made on a project-by-project, site-by-site basis by each responsible entity without coordination of the timing, sequencing, priority, and geographic focus of actions based on species' needs or actions of other participating entities. To date, there has been no overall, basin-wide aquatic habitat restoration strategy to guide and coordinate the independent restoration investments made by the multitude of participating entities in the basin. With the comprehensive strategy provided herein, participating entities can now coordinate future investments in aquatic habitat restoration in a manner that leverages limited resources where they provide the greatest benefits to the long-term recovery and healthy functioning of salmon and steelhead habitat in the basin.

Agencies and organizations that fund aquatic habitat restoration activities often require an overall basin-wide strategy that is closely linked to a comprehensive assessment. These funding entities also require partnership, cost-leveraging, and demonstrable on-the-ground results. At a broad state-wide or regional scale, many of the funding agencies and organizations are developing their own policies and criteria to focus aquatic habitat restoration investments where there is a demonstrated need, articulated priorities, and clear restoration benefit. Funding for aquatic habitat restoration actions has become increasingly scarce and highly competitive in recent years, especially within public land management agencies. As a result, there has been a greater emphasis placed on funding high priority restoration actions in priority basins at the state-wide and regional scales. This shift is occurring for three reasons: 1) to demonstrate accountability and accomplish high priority restoration actions for whole watersheds in priority basins, 2) to focus available funding in a partnering and cost-leveraging manner, and 3) to achieve tangible, aggregated restoration benefits where they are most needed for rebuilding salmon and steelhead populations at the watershed-scale as opposed to a "shotgun approach" where many different restoration actions are implemented over a broad landscape making it difficult to detect a restoration benefit. With this paradigm shift occurring and a recognized need for a more cohesive, comprehensive, and collaborative approach that builds upon the breadth and diversity of existing partnerships, all of the participating entities in the basin readily supported the development of such a strategy for the Sandy River basin.

What is the Basin-wide Aquatic Habitat Restoration Strategy?

The aquatic habitat restoration strategy for the Sandy River basin provides a geographic focus and hierarchical framework for directing future investments (staff time and funding) toward high priority restoration needs that will aid in rebuilding salmon and steelhead populations. Specifically, the strategy:

- Identifies priority watersheds in the basin (at the 5th, 6th, and 7th field scales) that provide the cornerstones for addressing freshwater habitat restoration needs of Sandy River basin salmon and steelhead populations.
- Establishes the hierarchy, or sequence, in which actions should be pursued in order to achieve maximum resource benefits.
- Describes the factors limiting salmon and steelhead abundance, productivity, spatial distribution, and diversity. Many of these factors also limit water quality.
- Defines specific restoration actions (and types of restoration actions where they are not known site-specifically) in priority watersheds necessary to address limiting factors.

THE COLLABORATIVE PARTNERS OF THE SANDY RIVER BASIN

Several species of salmon and steelhead have been listed as threatened under the Endangered Species Act (ESA) in the Sandy River basin since the late 1990s. The ESA listings spurred an effort in 1999 to bring entities in the basin together in a collaborative manner to work toward salmon and steelhead recovery. The original group was founded by six of today's 14 partners: The City of Portland, Portland General Electric (PGE), National Marine Fisheries Service (NMFS), Oregon Department of Fish and Wildlife (ODFW), U.S. Fish and Wildlife Service (USFWS), and U.S. Forest Service (USFS). The six entities forming this initial group codified their mutual interests as stated in the primary goal of their 1999 Memorandum of Agreement:

> *The goal of the 1999 Sandy River Basin Memorandum of Agreement is for "The City of Portland, PGE, NMFS, USFWS, USFS, and ODFW ...to satisfy their respective obligations in the Sandy River Watershed under the ESA [Endangered Species Act] as well as their interests and responsibilities under other statutes and regulations, including the Clean Water Act."*

Formalization of this working relationship and commitment to fulfill responsibilities for salmon and steelhead recovery under the ESA provided an attractive forum. Several other entities joined the effort and collectively completed several significant accomplishments furthering conservation and recovery efforts for salmon and steelhead populations in the basin. In chronology, these accomplishments include:

- Multi-party negotiations beginning in the late 1990s that led to a 2002 settlement agreement for PGE's decommissioning of the Marmot and Little Sandy dams in 2007 and 2008, respectively (PGE 2002a and PGE 2002b). These actions will remove all major hydroelectric operations and impacts along the Sandy and Little Sandy rivers, reestablishing natural streamflows and free-flowing characteristics of both rivers and reestablishing access to 8.3 miles of blocked historical anadromous habitat in the Little Sandy River.

- A revision to ODFW's Sandy Basin Fish Management Plan in 2001. Prior to decommissioning in 2007, Marmot Dam served as a fish-sorting facility and allowed ODFW to manage the upper basin as a wild fish sanctuary (ODFW 2001). The plan revision established changes in hatchery practices within the basin anticipating the removal of Marmot Dam. The actual fish management plan was finalized in 2001 prior to the signed settlement agreement for decommissioning PGE's Marmot and Little Sandy dams. The Federal Energy Regulatory Commission (FERC) procedures and negotiations guiding the license surrender application process began in the late 1990s, but were put on hold pending resolution of issues pertaining to hatchery practices and fish harvest in the basin central to the issue of fish-sorting at Marmot Dam.

- The 2004 completion of a basin-wide salmon and steelhead habitat assessment using the Ecosystem Diagnosis and Treatment (EDT) Model by a group of local fisheries biologists known as the Sandy Tech Team (City of Portland 2004). The assessment compared current versus historical habitat conditions and identified factors limiting salmon and steelhead production. In addition, the Sandy Tech Team visited field sites and developed and catalogued over 100 aquatic habitat restoration actions throughout the basin to address limiting factors. These restoration actions were organized in a database, and they serve as the foundation for "known" restoration actions contained in this strategy presented in Chapter 4.

- A multi-party agreement in principle (AIP) in 2004 that outlines operational changes and actions that will serve as the proposed action in the development of a habitat conservation plan (HCP) under Section 10 of the ESA to bring the City of Portland Water Bureau's municipal water supply operations in the Bull Run River watershed into compliance with the ESA (SRBP 2004). This effort began in 1999, and the habitat conservation plan is still under development by the City of Portland, NMFS, and USFWS.

- Completion of the Sandy River Basin Total Maximum Daily Load Assessment by the Oregon Department of Environmental Quality in 2005 (ODEQ 2005). This assessment addresses segments of rivers and streams within the basin that are currently water quality limited or impaired. It provides the foundation for responsible agencies and entities to develop management plans outlining actions to be taken to restore water quality conditions such that they meet current standards for beneficial uses.

- Completion of the Sandy River Basin Anchor Habitat Assessment for Salmon and Steelhead Populations in 2006 by the Sandy River Basin Working Group, in coordination with the Sandy River Basin Partners (SRBWG 2006). To obtain a copy of this assessment, go to http://www.sandyriverpartners.org/pdfs/SandyHabRptFINAL_2.pdf. This Assessment identifies the most important segments of rivers and streams within the basin for the restoration of salmon and steelhead populations. It is described in more detail later in this chapter, and it serves as the foundation for the development of geographic focus areas of the aquatic habitat restoration strategy outlined in this document.

As part of the efforts leading to the significant accomplishments described above, a stakeholder team of policy and technical representatives formed in 1999. The policy representatives of this stakeholder team became informally known as the Sandy River Basin Agreement Team (SRBAT), titled in reference to the original 1999 MOA. The companion technical representatives of this stakeholder team became informally known as the Tech Team. Members of the SRBAT and Tech Team participated in a facilitated, two-day workshop in 2000 during which they developed a new goal to guide their collaborative efforts in the basin:

[T]he Sandy River basin will provide watershed conditions that support:

1) Sustainable fish populations,

2) Recreational fishing opportunities,

3) Use of clean and dependable drinking water; and

4) Diverse aquatic recreational opportunities.

The primary focus of the SRBAT from 1999 to 2004 was the development of the 2004 AIP for the City of Portland Water Bureau's HCP. During the same timeframe, the Sandy Tech Team was very active in completing habitat assessments and restoration action scenarios in the basin using the Ecosystem Diagnosis and Treatment (EDT) Model by Mobrand Biometrics, Inc.

In 2004, after the completion of the AIP for the City of Portland Water Bureau's HCP, the policy representatives of the SRBAT agreed to continue their collaborative efforts and became the group presently known as the Sandy River Basin Partners (see www.sandyriverpartners.org). The original Tech Team supporting the functions of the SRBAT also converted into a new technical working group in 2004 to complete the Sandy River Basin Anchor Habitat Assessment and the Aquatic Habitat Restoration Strategy. This newly formed technical working group is referred to as Sandy River Basin Working Group (Working Group). The organizations and individual Working Group participants that contributed to the development of this strategy are listed in Table 1.

Table 1.1 Composition of the Sandy River Basin Working Group: Contributing Organizations to the Sandy River Basin Aquatic Habitat Restoration Strategy.

ORGANIZATION/INDIVIDUAL
Association of Northwest Steelheaders, Sandy Chapter
Bureau of Land Management (BLM), Salem District
City of Portland Water Bureau
Clackamas County Department of Transportation and Development
East Multnomah County Soil and Water Conservation District
National Marine Fisheries Service
Oregon Department of Fish and Wildlife (ODFW), North Willamette Region
Oregon Trout
Sandy River Basin Watershed Council
The Nature Conservancy
U.S. Fish and Wildlife Service (USFWS), Oregon State Office
U.S. Forest Service (USFS), Mt. Hood National Forest

OVERVIEW OF THE SANDY RIVER BASIN

A complete treatise characterizing many aspects of the Sandy River basin and its aquatic resources is found in the Sandy River Basin Characterization Report (SRBP 2005) (http://www.sandyriverpartners.org/background.html). A brief overview of the basin is contained in the following sub-sections below.

Geography and Basin Characteristics

The Sandy River basin is located on the western slopes of the Cascade mountain range of north-central Oregon, just to the east of the Portland metropolitan area (Figure 1). The headwaters of the Sandy River begin on the peak of Mt. Hood, Oregon's tallest mountain at 11,239 feet. The river flows west and then north from Mt. Hood for a total of 56 miles to its confluence with the Columbia River near the City of Troutdale. The river and its tributaries drain an area of 325,000 acres (about 508 square miles). Portions of the cities of Gresham, Troutdale and Sandy occupy part of the basin, as do the communities of Brightwood, Welches, Wemme, Rhododendron, Zigzag, and Government Camp.

Figure 1.1 Location of the Sandy River Basin.

The Mt. Hood National Forest manages about 70 percent of the Sandy River basin (221,428 acres), and the Bureau of Land Management manages about four percent (13,666 acres). Three percent of the basin is owned by State, local or regional governments; and 23 percent is privately owned. The substantial public ownership, especially that of the USFS, is largely in the upper portion of the basin. In contrast, the lower portion of the basin in nearly entirely privately owned except for a substantial amount of public land ownership along the Sandy River corridor.

The upper basin is high gradient relief, rugged and forested. Glaciers (Sandy, Palmer, Reid, and Zigzag) on the north and west sides of Mt. Hood feed the headwaters of the Sandy River and tributary Zigzag River. During summer months glacial till is released from melting glaciers, and large quantities are flushed into associated headwater streams such as the Muddy Fork, Zigzag, upper Sandy, and Salmon rivers. This results in the mainstem Sandy River often running turbid until weather conditions cool and glacial melt stops. Tributary Still Creek originates on the south-facing slope of Mt. Hood, hence is not glacially influenced and runs clear all year.

The middle portion of the basin has moderate topography with developed municipal water supply and hydroelectric facilities. The City of Sandy derives its water supply from Alder Creek, and the community of Corbett, in the lower Sandy River basin, derives its water supply from Gordon Creek.

The Bull Run River and its tributary, the Little Sandy River, comprise the Sandy River basin's largest watershed (about 28 percent of the basin). The Bull Run River originates from Bull Run Lake (elevation 3,160 feet). The mainstem of the Bull Run River is about 25 miles long. Historically, the Bull Run River and its tributaries (not including the Little Sandy River) provided about 39 miles of stream habitat for anadromous fish, and contributed a significant amount of the average annual flow of the Sandy River. In 1892 the Bull Run River watershed was declared a reserve for the City of Portland's water supply. Approximately 33 miles of anadromous habitat were lost with the construction of the 20-foot tall headworks dam built in 1927 at approximately river mile 6. Current demand for water and the resulting impoundment also alters flows in the lower Bull Run and lower Sandy rivers. Concurrent with the development of the Bull Run waterworks, Portland General Electric (PGE) built a diversion dam on the Little Sandy River at river mile 1.7 in 1913 blocking anadromous access at the site. PGE also built the Marmot Dam hydropower facility on the mainstem Sandy River at river mile 30. A fish ladder provided upstream passage beginning in 1913. PGE decommissioned Marmot Dam in September 2007 and will decommission Little Sandy Dam and other hydroelectric power facilities in 2008. The decommissioning of these two dams will restore both fish passage and flows.

The lower Sandy River basin is rolling hills, lower gradient, with agricultural lands and rapidly expanding urban development. Mechanization of farming in the 1940s resulted in abandonment of farms, and conversion to forest lands. This pattern has been recently reversed by urban development (SRBP 2005).

Extensive logging has occurred throughout the basin, beginning in the lower portion in the 1800s and moving upstream during the 20th century. On federal lands today, logging rates have dropped dramatically since implementation of the Northwest Forest Plan in 1994.

The Sandy River basin is a popular recreation destination, less than a one hour drive for over one million people. There are many recreational uses that directly and indirectly affect the river, including fishing, rafting, camping, swimming, skiing, and off-road vehicle use. Winter steelhead is the most popular sport fish. Other species popular among anglers are spring Chinook, coho, summer steelhead, and rainbow and cutthroat trout. The Oregon Department of Fish and Wildlife sets and regulates fishing seasons for these species.

Salmon and Steelhead Populations

Spring Chinook, fall Chinook, coho, and winter steelhead comprise the four Sandy River basin wild salmon and steelhead populations upon which this strategy is based. All four populations are listed under the Federal ESA as threatened (Table 2). The federal government listed spring Chinook, fall Chinook, and winter steelhead under the Federal ESA in the late 1990s, subsequently reviewing and reaffirming these listings in 2005. Oregon listed coho under the State ESA as endangered in 2000, at which time the species was undergoing petition and review for listing under the Federal ESA. On June 28, 2005, the federal government listed coho as threatened under the Federal ESA. The State of Oregon maintains its endangered status on the State ESA list.

Table 1.2 Federally-listed ESA Salmon and Steelhead Populations in the Sandy River Basin.

POPULATION	SPECIES	ESU[1]	ESA STATUS	RESPONSIBLE AGENCY	DATE
Spring Chinook	*Oncorhynchus tshawytscha*	Lower Columbia River Chinook	Threatened	NMFS	March 24, 1999; June 28, 2005
Fall Chinook	*Oncorhynchus tshawytscha*	Lower Columbia River Chinook	Threatened	NMFS	March 24, 1999; June 28, 2005
Coho	*Oncorhynchus kisutch*	Lower Columbia River Coho	Threatened	NMFS	June 28, 2005
Winter Steelhead	*Oncorhynchus mykiss*	Lower Columbia River Steelhead	Threatened	NMFS	March 19, 1998; January 5, 2006
Chum	*Oncorhynchus keta*	Lower Columbia River	Threatened	NMFS	March 25, 1999

[1]An Evolutionarily Significant Unit (ESU) as defined by NMFS is considered "distinct" (and hence a "species") under the Endangered Species Act in that it is reproductively isolated from other conspecific population units and represents an important component in the evolutionary legacy for the species (Waples 1991).

The Sandy River Basin Characterization Report (SRBP 2005) provides a thorough description of the four salmon and steelhead populations, describing for each: 1) life history characteristics and diversity, 2) current vs. historic distributions, 3) abundance and productivity, 4) current vs. historic hatchery production and plantings, 5) current vs. historic harvest, 6) factors (threats) for ESA listing, and 7) EDT limiting factors. Furthermore, the report (SRBP 2005) provides a detailed fish periodicity chart for each population, including cutthroat trout, describing timeframes and peak periods for adult immigration/holding, adult spawning, incubation/emergence, juvenile rearing, and juvenile emigration. Periodicity charts are presented for the lower portion of the basin below the old Marmot Dam site and for the upper portion of the basin upstream of the site. This restoration strategy only provides a brief summary below for each salmon and steelhead population. For more details and description of each population, see SRBP (2005).

Spring Chinook

Current spring Chinook distribution in the upper basin above the old Marmot Dam site closely mirrors historic distribution, with the majority of the spawning occurring in the Salmon River and Still Creek (ODFW 1997 and SRBP 2005). Few adult spring Chinook currently spawn in the lower basin below the old Marmot Dam site. The population historically had access to considerably more habitat in the lower basin prior to the construction of dams on the Bull Run River by City of Portland Water Bureau and the Little Sandy River by PGE. Approximately 31.5 miles of spring Chinook habitat has been blocked by dams. See Figures 3-8 and 3-9 in SRBP (2005) for detailed maps of current vs. historic distributions of spring Chinook in the basin.

Based on past hatchery practices, it is believed that the spring Chinook present in the Sandy River are primarily derived from inter-basin stock transfers from the Upper Willamette ESU, thereby bringing into question whether or not the existing run is representative of that found historically (NMFS 1998). Bentzen et al. (1998) completed a genetic evaluation of spring Chinook in the upper and lower portions of the basin and found that upper basin fish are statistically distinct from Upper Willamette ESU stock, using Clackamas River Hatchery fish as the indicator. The lower basin fish are likely a blend of native Sandy spring Chinook and Upper Willamette ESU stock.

Adult spring Chinook begin entering the lower Sandy River in mid-February, with the peak immigration occurring April through July. Adults hold throughout the spring and summer months in large pools of the mainstem Sandy River and larger tributaries. Beginning in mid-August, adult fish will ascend the river and its tributaries to spawn in riffles and pool tailouts. The peak of spawning occurs from September through early October. Eggs incubate during the late fall and winter months which often bring the most intense rain and storm events. Fry emerge from the gravels between November and mid-February, depending upon the date of spawning and local stream temperatures. Upon emergence, fry migrate downstream to larger rivers and mainstem areas where they rear and emigrate out of the basin as smolts following one of two life history strategies:

1) As age 1+ smolts in the spring of their second year (the majority of Sandy River spring Chinook are believed to follow this pattern), or
2) As sub-yearlings, age 0+, in the fall of their first year.

Once in the Columbia River mainstem, spring Chinook outmigrants are believed to feed and rear along their downstream journey through the Lower Columbia River Estuary as their bodies undergo physiological changes as part of smoltification. Upon ocean entrance, spring Chinook migrate north in the Pacific Ocean and feed off the shores of British Columbia and Alaska. Adult fish may spend from one to four years in the ocean before reaching maturity and returning to their natal stream to spawn. Most commonly, adult fish mature at four years of age (Myers et al. 1998)

The NMFS Willamette/Lower Columbia Technical Recovery Team (WLC-TRT) is responsible for compiling the scientific and technical information that will serve as a foundation for completing ESU-wide recovery plans under the Endangered Species Act. This team classified all extant populations as "core" and/or "genetic integrity" populations (McElhany et al. 2003). A "core" population is one that historically represented a substantial portion of the ESU's abundance or contained life history strategies specific to the ESU, while a "genetic integrity" population is one that may have had minimal genetic introgression from nonendemic fish due to artificial propagation or may exhibit important life history characteristics no longer found throughout much of historical ESU range. McElhany et al. (2003) identified the Sandy River spring Chinook population as both a "core" and "genetic integrity" population.

Fall Chinook

Current fall Chinook distribution is limited to the lower basin below the old Marmot Dam site. Historically, fall Chinook are believed to have been more widely distributed throughout the upper basin above the old Marmot Dam site and throughout the Bull Run River system in the lower basin. SRBP (2005) offer several explanations for the limited current distribution of fall Chinook below the old Marmot Dam site. See Figures 3-3 and 3-4 in SRBP (2005) for detailed maps of current vs. historic distributions of fall Chinook in the basin.

There are two stocks of fall Chinook in the Sandy River basin: early-fall returning "tule" stock and the late-fall/winter returning "Lower River Wild" stock. The "tule" stock is derived from a combination of naturalized offspring of hatchery fish released into the basin prior to 1977 and strays from other hatchery fall Chinook in

Gordon Creek, Sandy River basin.

other nearby Oregon and Washington rivers. The "Lower River Wild" stock is indigenous to the basin, and has maintained its genetic identity from other hatchery-influenced fall Chinook populations in the Sandy River and neighboring river basins in the Lower Columbia ESU.

Adult "tule" fish enter the Sandy River in August. Adults typically spawn from September through October, and thus are temporally segregated from the "Lower River Wild" stock. Adult "Lower River Wild" fish enter the Sandy River in October and typically spawn from November through December. There is an additional component of the "Lower River Wild" stock, returning and spawning even later, from December through early February, known as the winter or late bright stock (ODFW 1997). Given the stock differences for fall Chinook and the variance in adult spawning timeframes, fall Chinook fry emerge from the gravel from October through May. Soon after emergence, fry migrate downriver and typically rear for less than one year before undergoing smoltification and entering the ocean. The majority of juvenile fall Chinook emigrate to the estuary where they rear and feed for up to six months before entering the ocean in the summer or fall of their first year. At this critical life stage, the Lower Columbia River Estuary and its associated tidal marshes and wetlands play a crucial role as nursery habitat for juvenile fall Chinook. A small component of juvenile fall Chinook do not emigrate into the estuary and reside entirely in freshwater for their first year of life (Myers et al. 1998 and Cooney et al. 2003). After ocean entrance, most fall Chinook spend three to four years in the marine environment before returning to spawn as either four or five year-old fish.

The NMFS WLC-TRT identified the "Lower River Wild" stock of the Sandy River fall Chinook population as both a "core" and "genetic integrity" population (McElhany et al. 2003). The early-returning "tule" stock was not identified for either category, and would likely play a lesser role in the recovery of the ESU.

Coho

Coho are currently distributed throughout much of the lower and upper portions of the basin. The historical distribution for coho was much greater, and included rivers and streams where access is presently blocked (i.e., Bull Run River, Little Sandy River, and Cedar Creek). See Figures 3-18 and 3-19 in SRBP (2005) for detailed maps of current vs. historic distributions of coho in the basin.

There are two stocks of coho in the Sandy River basin: an early returning hatchery stock that returns and spawns September through October primarily in the lower basin and a later returning wild stock that returns and spawns October through November primarily in the upper basin. Adult coho begin entering the Sandy River in August and peak spawning occurs in September (early returning stock) or October/November (late returning stock). Fry emerge from the gravel in late fall through late winter depending upon the timing of spawning and local stream temperature. Fry quickly occupy stream margins and off-channel habitats (e.g., side channels and backwater habitats) where stream velocity is very low. During this initial rearing period, fry seek out areas with abundant woody material to serve as hiding cover from predators. Juvenile coho remain in freshwater during their first year and over-winter before typically emigrating to the ocean at age 1+ the following spring. Smolt outmigration typically occurs from March through early June, peaking in April and May. In colder, headwater streams juvenile coho may spend two years in freshwater before outmigrating as 2+ smolts. In the ocean, coho typically spend two summers and return as three year-old fish, with the exception of "jacks" which are sexually mature male fish returning to spawn after only one summer in the ocean.

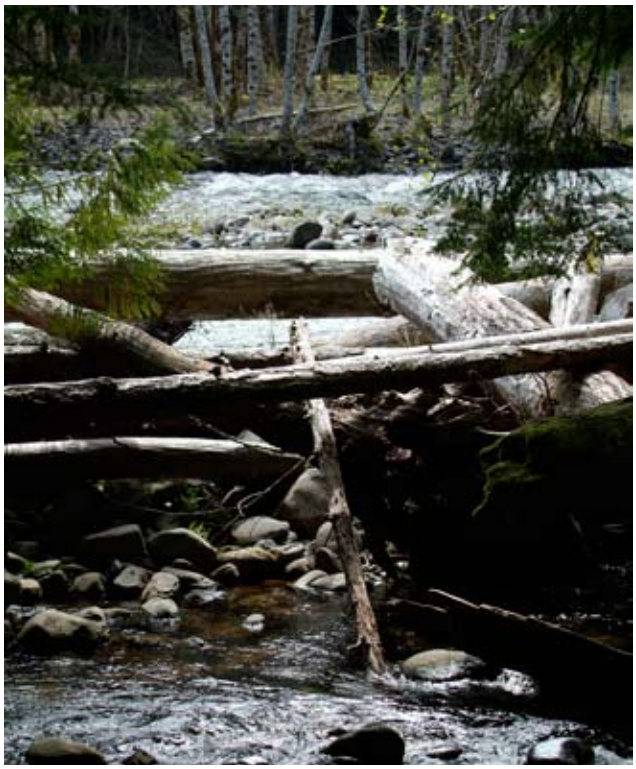
The NMFS WLC-TRT analyzed all extant Oregon coho populations within the ESU and concluded that populations in all strata (e.g., Coast, Cascade, and Gorge) are at significant risk of extinction as is the ESU as a whole (McElhany et al. 2006)

Winter Steelhead

Winter steelhead are currently distributed widely throughout the basin. Their distribution closely matches that for coho salmon; however, winter steelhead distribute further upstream in higher gradient, boulder and cobble-dominated streams. As for coho, historic distribution of winter steelhead extended into the Bull Run River, Little Sandy River, and Cedar Creek prior to dams and weir blockages. See Figures 3-13 and 3-14 in SRBP (2005) for detailed maps of current vs. historic distributions of winter steelhead in the basin. Since 2000 changes in hatchery management have resulted in all brood stock being derived from the wild population.

Winter steelhead adults enter the Sandy River in the late winter months (February) through spring (May). Adult migration into the upper basin peaks in March and April as indicated by previous fish counts at the old Marmot Dam site. Spawning occurs from February to early June, and typically peaks during mid-March through mid-May. Fry emerge from the gravel from March to August depending on the spawn timing and local stream temperature. Fry quickly move to lower velocity habitats along the stream margin. As juvenile steelhead grow larger, they move out into the main channel occupying swifter, deeper habitat in pools, riffles, and runs. The majority of juvenile steelhead reside in freshwater for two years and emigrate to the ocean as 2+ age smolts during the spring (March through early June). A smaller percentage of smolts reside an additional year in freshwater and emigrate as 3+ age smolts. Adult winter steelhead typically remain in the ocean for two years before migrating back to their natal stream to spawn. Some adult fish will remain in the ocean for three years before returning to freshwater to spawn. Unlike salmon, steelhead do not necessarily die after spawning and can return to spawn in subsequent years.

Winter steelhead in the Sandy River basin are identified as a "core" population by the NMFS WLC-TRT for the purposes of recovery planning.



Confluence of side channel with Salmon River, Sandy River basin.

Aquatic Habitat Conditions

The reduction in quality of salmon and steelhead habitat in the Sandy River basin is well documented. For example, the Sandy River Subbasin Salmon and Steelhead Production Plan (ODFW, 1990) and the Sandy Basin Management Plan (ODFW, 1997 and 2001) describe habitat related factors for salmon and steelhead decline, including:

- Flow diversion at Marmot Dam reduces flow attraction below the dam, and reduces spawning and rearing habitat in the 11-mile section between Marmot Dam and the mouth of the Bull Run River. [note: Marmot Dam was removed in September 2007]

- Construction of the Bull Run dams inundated historically accessible habitat and eliminated access above the dams.

- Marmot Dam reduces passage and natural production of fall Chinook upstream. [note: Marmot Dam was removed in 2007]

The most robust analysis of aquatic habitat conditions comes from the original Tech Team's comparison of current condition to historic condition using the EDT model. Fish biologists and aquatic specialists familiar with the Sandy River basin ran the EDT model using fish distribution and habitat information available. The EDT model is designed to quantify habitat conditions in terms of fish production, and to facilitate comparisons of potential fish production gains from selected preservation and restoration actions and strategies (Lestelle et al., 1996). The model incorporates stream habitat features, biological performance data, and other environmental information for the basin (SRBP 2005).

The EDT model outputs relate the condition of the environmental attributes to abundance (the equilibrium of the run size abundance, or average abundance under steady state conditions), productivity (the potential number of adult progeny produced per parent spawner in the absence of density dependent mortality), and life history diversity (the multitude of life history pathways temporally and spatially connected, representing life history segments available for the species to complete its life cycle) of the fish species investigated. The analysis describes the relative magnitude of effect that the various environmental attributes have on fish survival or productivity (SRBP 2005).

An output of EDT modeling is a listing of factors limiting salmon abundance, productivity and life history diversity. The results from the EDT modeling are described in detail in the 2005 Sandy River Basin Characterization Report (SRBP 2005). The limiting factors are briefly summarized in Chapter 3 of this document and were used to identify priority restoration actions in particular locations within individual watersheds in Chapter 4.

SUMMARY OF PRIOR EFFORTS FROM WHICH THIS STRATEGY WAS DEVELOPED

This strategy was developed using a variety of information, data, and results of assessments completed from 1995 through 2005. Many sources of information, data, and assessments are available in the basin; however, the Working Group relied most heavily on the following five sources.

The Tech Team's EDT Analysis and Identification of Restoration Actions

The original technical team supporting the policy-level SRBAT formed as a result of the 1999 MOA, known as the Tech Team, spent several years completing habitat assessments of the basin using the Ecosystem Diagnosis and Treatment Model developed by Mobrand Biometrics, Inc. (City of Portland 2004). These assessments analyzed the current and historical abundance, capacity, productivity, and diversity of spring Chinook, fall Chinook, coho, and winter steelhead populations in the basin. The EDT model is a freshwater habitat and life stage-based model that derives population-level parameters accounting for both in-basin and out-of-basin factors and life history variability. It provides a coarse-scale look at factors limiting salmon and steelhead production based on impairment of watershed processes and aquatic habitat conditions. EDT model runs were completed for each of the four focus species. The Tech Team used the model to contrast current aquatic habitat conditions with presumed historical conditions to identify areas where aquatic habitat is most heavily degraded and where restoration opportunities may yield the greatest biological benefits. In addition, the Tech Team spent several weeks during the spring and summer of 2002 identifying watershed-related restoration actions to address degraded aquatic habitat conditions and rebuild salmon and steelhead populations. The Tech Team divided into 2-3 person teams, each of which was assigned a smaller portion of the basin. Members of these smaller teams were more familiar with the areas assigned to them. Each smaller team thoroughly reviewed its assigned portion of the basin with the specific set of EDT limiting factors on a reach-by-reach basis. Each smaller team used the following step-wise procedure to develop a comprehensive list of restoration actions:

1. All EDT limiting factors (known as Level 3 attributes) affecting aquatic habitat quality on a species-by-species and reach-by-reach basis were examined.
2. Tech Team members assessed which life stage is most affected.
3. Tech Team members evaluated which Level 3 attributes were most changed from their historic condition.
4. Tech Team members examined primary and modifying Level 2 attributes to identify restoration goals and objectives based on the main life stage affected and the significant level 3 attributes.

Bull Run River, Sandy River basin.

5. Tech Team members identified the types of restoration actions that could positively influence the Level 2 (primary and modifying) attributes. Tech Team members were encouraged to be creative in identifying restoration actions and to bring forward any ideas that would be biologically feasible without regard for project cost. Two constraints guided Tech Team members: 1) they could not move buildings, facilities, or major roads and 2) they could not change current land use planning policies, regulations, and practices.
6. Tech Team members evaluated how each restoration action would translate into benefits affecting the primary and modifying Level 2 attributes in the focal reach as well as the corresponding downstream reaches that would also benefit. The EDT model was then run to evaluate the results and determine those actions, or sets of actions, having the greatest biological benefits.

After all of the smaller teams completed this work in their assigned portions of the basin, the full Tech Team reconvened. All restoration actions were compiled into a single database. Each action was assigned a unique project number for tracking purposes. The following information was developed for each action:

- Project title – a unique, descriptive title
- Estimated cost – best estimate of cost based on recent similar actions (note: the estimated project cost does not include costs associated with planning, design, environmental analysis and review, permit acquisition, contract preparation and oversight, or monitoring).
- Type of restoration action – i.e., riparian, fish passage, water quality, easement, land acquisition, stream channel/habitat, etc.
- Status – i.e., proposed (not funded), in progress, etc.
- Objectives – brief statement of project objectives
- Description – 2-3 sentence project description
- Effectiveness – relation to known effectiveness of other similar actions based on research and documentation in the scientific literature
- Timeframe for completion – desired timeframe for implementation
- Land ownership – i.e., private, public, or both
- Feasibility – i.e., are the methods well known or only partly known?
- Level of support – what is the degree of public and agency support for implementation?
- Biological certainty – what is the degree of certainty with regard to achieving the project objectives?

Over 100 original restoration actions with an estimated cost of over $146 million were identified and entered into an Excel-based restoration database for the Sandy River basin. As part of the strategy contained herein, the Working Group utilized this database to identify and sequence high priority restoration actions as described in Chapter 4. The Working Group updated the original restoration project database, identifying those projects that have been completed and dropped certain proposed activities that do not pertain to the scope of this strategy.

Forest Service Watershed Analyses

The 1994 Northwest Forest Plan (USDA and USDI 1994) directs the USFS and BLM are directed to complete watershed analyses as one of the four components of the plan's Aquatic Conservation Strategy (ACS). This component of the ACS directs the agencies to complete comprehensive, interdisciplinary examinations of watersheds at the 5th field hydrologic unit code (HUC) scale. The three primary objectives of watershed analysis are to: 1) describe the current and historical physical, biological, and social characteristics of the watershed, 2) identify and analyze specific management issues, and 3) develop recommendations to assist in moving the watershed from its current condition toward its desired future condition (USDA 1995). These analyses focused primarily on federal lands, and began in 1995 with the completion of the Salmon River and Zigzag River watersheds (USFS 1995a and USFS 1995b, respectively). In 1996, the USFS completed the watershed analysis for the Upper Sandy watershed (USFS 1996), followed by the Bull Run Watershed Analysis in 1997 (USFS 1997). In 2004, the USFS completed an update to the original 1995 Zigzag River Watershed Analysis (USFS 2004). The results of this updated watershed analysis incorporated key components from the recently completed roads analysis of the Mt. Hood National Forest (USFS 2003), current smolt monitoring data, and EDT model results. The roads analysis identifies critical road segments in the watershed and how they alter watershed processes, ultimately affecting aquatic habitat conditions. The results serve as the core information used in the Still Creek Case Study which investigates the influence of roads on aquatic habitat conditions presented in Appendix B. Reports on the watershed analyses and Forest-wide roads analysis are available on-line at: http://www.fs.fed.us/r6/mthood/publications/

Sandy River Basin Characterization Report

The City of Portland Water Bureau prepared a report characterizing the Sandy River basin from several different perspectives in 2005 (SRBP 2005). The report provides both a geographic and natural resource overview of the basin with particular emphasis on fish and water resources. This report brings together all of the comprehensive watershed analysis findings and habitat assessment results (including very detailed limiting factors analyses) for the entire basin. It is a thorough treatise of the basin with regard to factors affecting anadromous salmonid production and water quality from a holistic watershed viewpoint. The report provides a general basin overview, including history of development; geology and climate; land ownership; existing land uses; zoning and land management; and population and economy. The report provides a detailed overview of the water resources (i.e., hydrography, hydrologic regime, history of floods and channel modifications, water rights, water quality, groundwater quality, drinking water quality, riparian resource, and wetland resources) and fish and wildlife resources (i.e., populations present and federal and/or state listing status). Chapter 3 of SRBP (2005), as mentioned earlier, provides a very detailed description of the basin's four species of anadromous salmon and steelhead (fall Chinook, spring Chinook, winter steelhead, and coho) and cutthroat trout. For each species, the following components are described in detail: life history and diversity, distribution (current and historic), abundance and productivity, hatchery production and plantings, in-basin harvest, and reasons for listing or threats to survival. Chapter 5 of SRBP (2005) provides a detailed description of each fifth-field watershed in the basin (Upper Sandy River, Middle Sandy River, Lower Sandy River, Salmon River, Bull Run River, and Zigzag River). For each fifth-field watershed, a general description of watershed conditions exists, followed by a detailed characterization of aquatic habitat conditions and limiting factors. The full report is available on-line at: www.sandyriverpartners.org

Culvert-Fish Passage Inventories on Federal, State, County, and Private Lands

Federal, state, county, and city government agencies completed independent assessments of road culverts that block or impede fish passage on rivers and streams in the Sandy River basin beginning in 2000. These assessments focus on federal, state, county, and private roads throughout the basin. The various government agencies within the basin evaluated all roads that may affect fish passage for juvenile and adult salmon and steelhead (Beak 2001, MCTD 2001, USFS 2001, CCSRT 2004, and ODFW 2005). Results from these assessments were reviewed in the development of this strategy and are presented in Appendix A.

Anchor Habitat Assessment

The Working Group recently completed Salmon and Steelhead Conservation: An Assesment of Anchor Habitat on the Sandy River, Oregon, which was the first phase in the development of this aquatic habitat restoration strategy. The Working Group identified important stream reaches for spring Chinook, fall Chinook, coho, and winter steelhead populations in the basin (SRBWG 2006). The collection of these reaches for each population is referred to as anchor habitat, defined as distinct stream reaches that currently harbor specific life history stages of salmon and steelhead to a greater extent than the stream system at large. Three sources of data were used to identify anchor habitat: empirical data (from spawning surveys), professional judgment data (obtained from independent interviews with three expert fish biologists that have extensive knowledge and in-the-field experience in the basin), and EDT model results. The assessment identifies 12 reaches (35.9 miles) as anchor habitat for spring Chinook; five reaches (12.5 miles) for fall Chinook; 11 reaches (17.5 miles) for coho; and 22 reaches (42.1) miles for winter steelhead. The Working Group constructed an EMDS decision-support model using Reynolds et al. (2002) in its effort to identify anchor habitat for the four salmon and steelhead populations in the basin. Results from the EMDS decision-support model, in the form of numerically scored reaches, allowed the Working Group to differentiate the relative importance of each reach for each population of salmon and steelhead. This proved critical and serves as the primary basis for establishing the geographic focus for this strategy presented in Chapter 2.

CHAPTER 2 – GEOGRAPHIC FRAMEWORK

RESULTS FROM ANCHOR HABITAT ASSESSMENT

After completion of the anchor habitat assessment (SRBWG 2006), the Working Group evaluated the importance of each stream reach for each of the four species which served as the basis for developing geographic priorities for restoration. The Working Group addressed two main questions:

1. *Are all stream reaches comprising anchor habitat for a population of salmon or steelhead equally important?*
2. *Are there particular watersheds that contribute to a population's anchor habitat at the basin-scale that are of greater importance than others?*

The Working Group used the EMDS decision-support model results from SRBWG (2006) to investigate both questions in detail.

The EMDS decision-support model used in the anchor habitat assessment relies on a series of fuzzy logic curves that provide truth values or scores, ranging from -1 to +1. A fuzzy logic curve displays the degree of certainty for a relationship between two or more variables of interest. A score of +1 indicates a high level of confidence that particular relationship holds true, whereas a score of -1 indicates a high level of confidence the relationship does not hold true. Scores that range in value from -1 to +1 express our degree of uncertainty for that relationship. In the case of anchor habitat, the scores illustrate the level of support for how well an individual stream reach meets the stated definition of anchor habitat. Each stream reach within the distribution of each population received a specific truth value or score, referred to as the "EMDS Score" in Tables 3.1, 3.2, 3.3, and 3.4 for spring Chinook, fall Chinook, coho, and winter steelhead, respectively, in SRBWG (2006). If a particular stream reach scores very close to or -1 for a given population, then there is very little or no support for that particular stream reach constituting part of the population's anchor habitat. If a particular stream reach scores very close to or 0 for a given population, then it remains largely undetermined whether that particular stream reach should constitute part of the population's anchor habitat. If a particular stream reach scores very close to or +1 for a given population, then there is a high level or full support for that particular stream reach constituting part of the population's anchor habitat.

In order to utilize the anchor habitat assessment data to answer the questions framed above, two things were necessary: 1) EMDS scores that ranged from -1 to +1 had to be converted to a positive numeric scale from 1 to 10, and 2) all data had to be normalized to account for the varying lengths of the stream reaches. These two adjustments were necessary so that the data could be summed at the reach and watershed scales to compare relative scores between areas. Stream reaches in a given area were aggregated into logical watershed boundaries at the 5th or 6th field scales to sum adjusted EMDS scores in a manner that most appropriately mirrors the presumed sub-population structure for salmon and steelhead at the basin-scale. The mainstem Sandy River from its mouth to its confluence with the Zigzag River was identified as a "mainstem corridor" (i.e., identified as a pseudo-watershed polygon) and constitutes its own geographic area of importance. It contains the primary spawning and rearing area for fall Chinook and also serves as the key migratory and rearing corridor for adult and juvenile life stages of spring Chinook, coho, and winter steelhead. The mainstem corridor was determined to be essential for the growth and abundance of these other three populations during EDT analysis. Finally, a Geographic Information System (GIS) was used to differentiate and display different anchor habitat portions of the basin that are of greater importance for each population. The higher the adjusted EMDS score for a stream reach, then the greater relative importance that stream reach is to the population. Similarly, the higher the summed adjusted EMDS reach scores at a watershed-scale, the greater relative importance that watershed area is to the population. It is important to realize that these summed, adjusted EMDS scores are relative from one stream reach to another and from one watershed to another. These results are only comparable on a relative basis for the Sandy River basin.

The Working Group made two investigations once the EMDS scores were adjusted and normalized. First, the Working Group investigated those areas with designated reaches comprising anchor habitat only on a species-by-species basis. These results are presented below for each population. They provide a focused, population-specific look at priorities within anchor habitat portions of the basin only. Second, the Working Group investigated all other areas of the basin outside of these anchor habitat reaches or watershed areas for the four populations (spring Chinook, fall Chinook, coho, and winter steelhead). Using the same methods described above, the Working Group calculated adjusted and normalized EMDS scores for all remaining non-anchor habitat reaches. These results were summed for all four populations. In this way, a cumulative score was obtained for watershed areas within the basin containing accessible habitat for salmon and steelhead; anchor habitat and non-anchor habitat watersheds alike. The summed watershed scores were then arrayed in relative rank order and are presented below for all four populations.

GEOGRAPHIC FOCUS FOR BASIN

Maps displaying geographic focus areas of aquatic habitat restoration priorities for spring Chinook, fall Chinook, coho, and winter steelhead are shown in Figures 2, 3, 4, and 5; respectively. The cumulative anchor habitat score for each area illustrates the relative priority of each area for each population. The mainstem Sandy River corridor, a unique geographic area including the main river corridor from the mouth of the Sandy River upstream to the Zigzag River confluence, rated as an exceptionally high priority for three of four fish populations (spring Chinook, fall Chinook, and winter steelhead). The mainstem Sandy River corridor was found to be of very high ecological value when considering the full life cycle and life history needs of the fish species, serving as an important rearing and migratory corridor for juvenile and adult salmon and steelhead. The mainstem Sandy River corridor also provides the majority of spawning habitat for fall Chinook.

Priority areas for spring Chinook are largely located within the upper basin and include Salmon River watershed, Still Creek watershed, and Upper Sandy River watershed (Figure 2.1). Priority areas for fall Chinook are largely located within the mainstem Sandy River corridor and two lower river tributaries; Gordon Creek watershed and Trout Creek watershed (Figure 2.2). Priority areas for coho are mostly in the upper portion of the basin; Salmon River watershed, Upper Sandy River watershed, and Still Creek watershed; however one lower river tributary (Gordon Creek watershed) is also identified (Figure 2.3). Priority areas for winter steelhead occur throughout the upper and lower portions of the basin; however, the areas in the upper basin are shown to have a higher relative composite anchor habitat score at the watershed-scale. Still Creek watershed, Upper Sandy River watershed, and Salmon River watershed are priority areas for winter steelhead in the upper basin, while Alder/Wildcat Creeks watershed, Little Sandy River watershed, and Trout Creek watershed are priority areas in the lower basin (Figure 2.4).

Figure 2.5 shows the overall geographic focus areas for all four species combined. The Working Group aggregated individual anchor habitat scores for each watershed by fish species to develop a composite basin map for all four species. Figure 2.5 displays these results for anchor habitat watersheds only, showing the combined anchor habitat score at the watershed-scale for all four fish species combined. A total of eight anchor habitat watersheds are identified for all four fish species combined in priority order as follows:

1. Sandy River corridor (mouth to Zigzag River confluence)
2. Salmon River watershed
3. Still Creek watershed
4. Upper Sandy River watershed (upstream of and including Clear Fork Sandy River)
5. Gordon Creek watershed
6. Alder and Wildcat Creeks watershed
7. Little Sandy River watershed
8. Trout Creek watershed

In addition, a total of four non-anchor habitat watersheds are identified and are also prioritized for aquatic habitat restoration actions. In priority order, the non-anchor habitat watersheds are:

9. Zigzag River watershed (not including Still Creek)
10. Lower Bull Run River watershed (below the City of Portland Water Bureau Headworks Municipal Water Diversion)
11. Beaver Creek watershed
12. Clear Creek watershed

Figure 2.6 shows the eight anchor habitat and four non-anchor habitat watershed priorities for the entire basin and indicates their overall ranked priority for aquatic habitat restoration.

Sandy River.

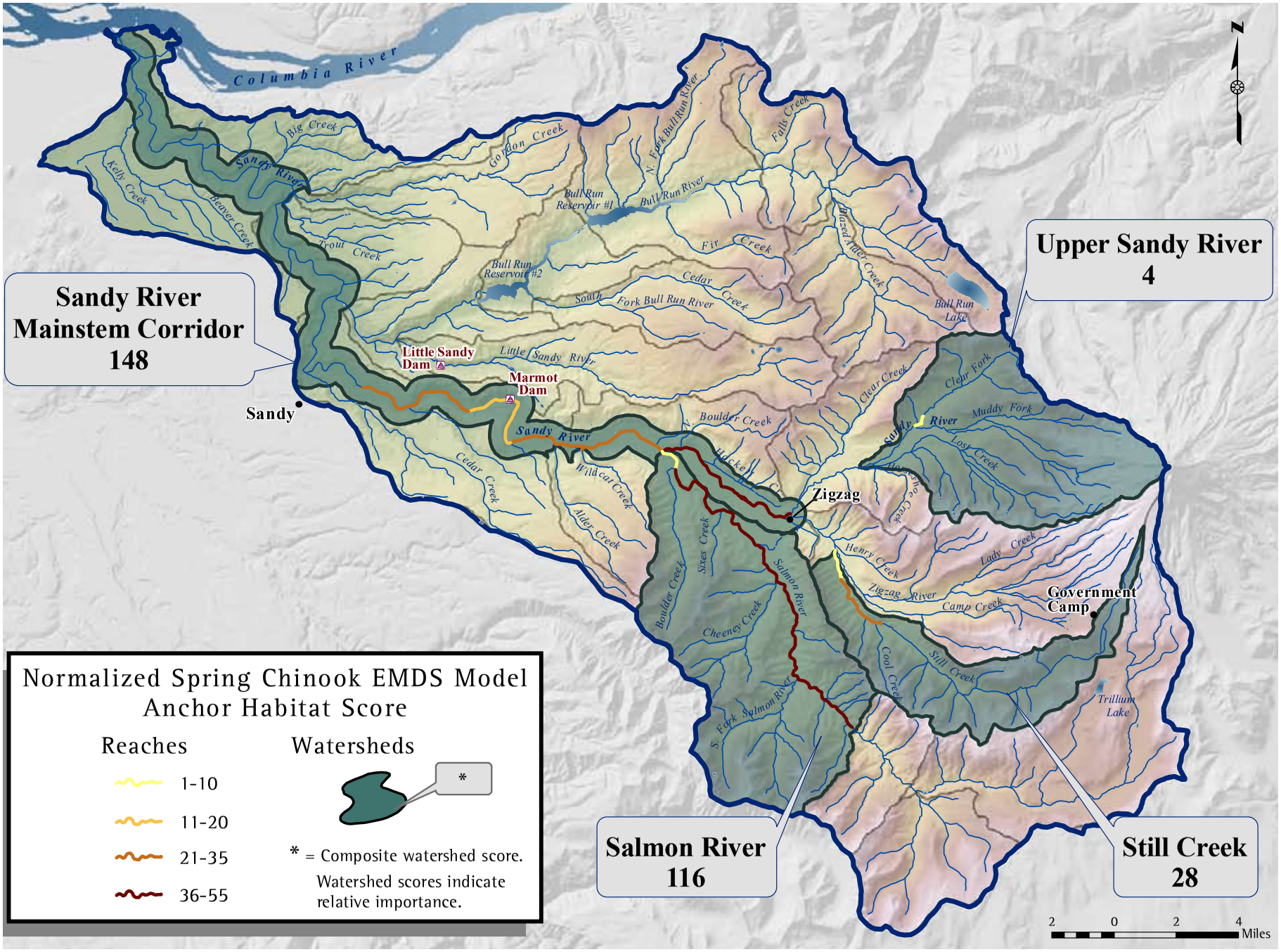


Figure 2.1 Sandy River Basin Aquatic Habitat Restoration: Spring Chinook Geographic Focus Areas.

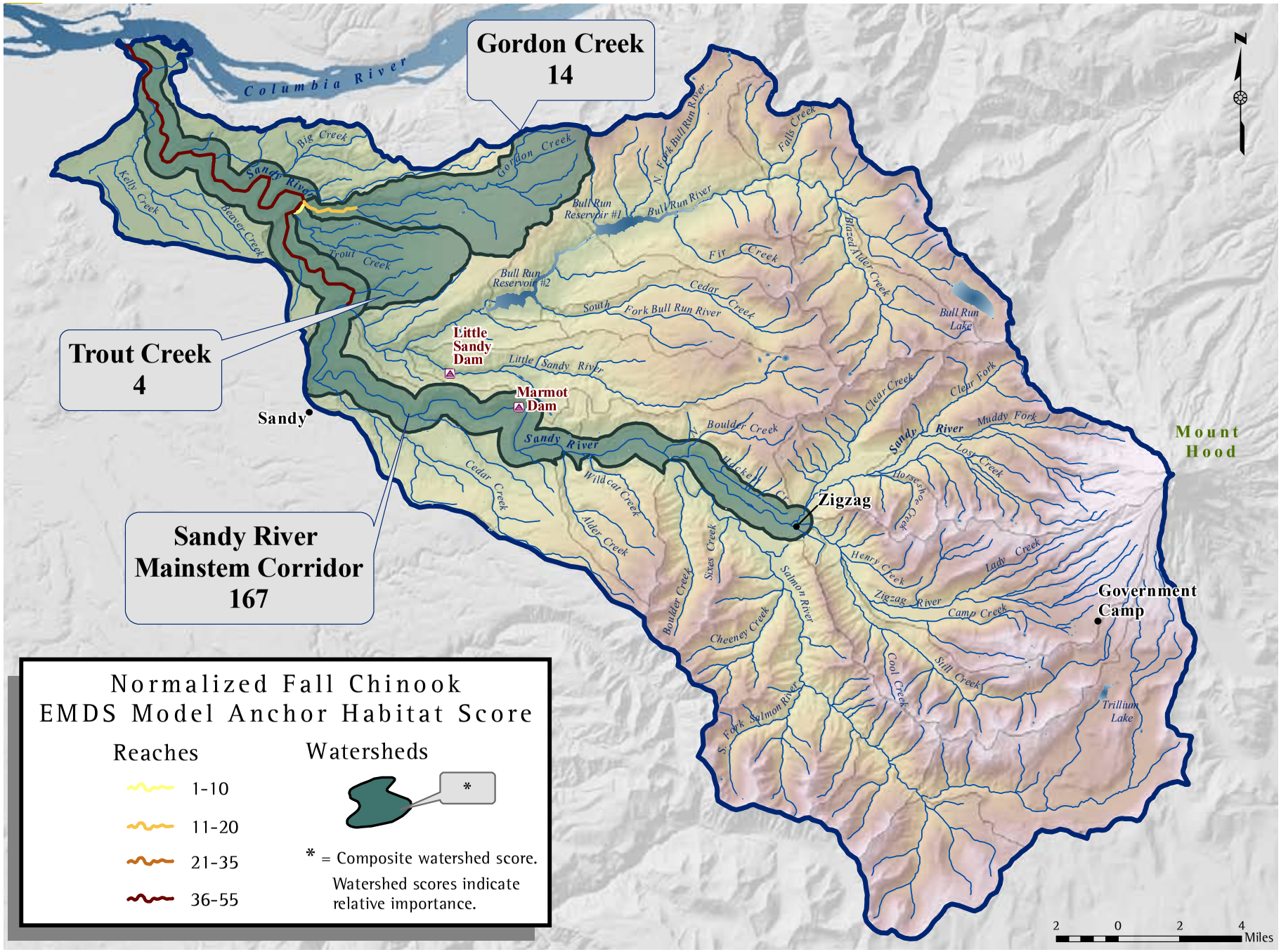


Figure 2.2 Sandy River Basin Aquatic Habitat Restoration: Fall Chinook Geographic Focus Areas.

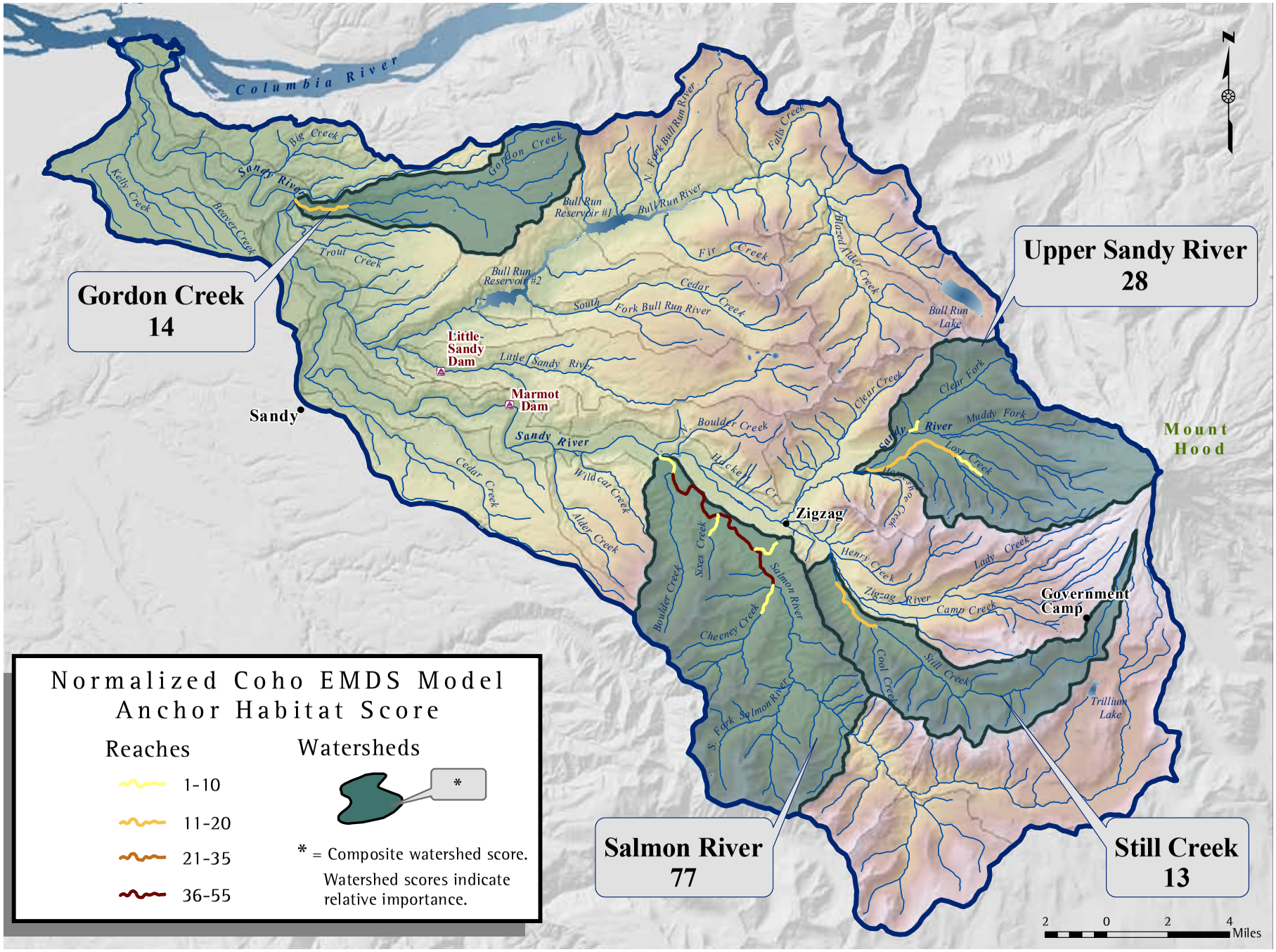


Figure 2.3 Sandy River Basin Aquatic Habitat Restoration: Coho Geographic Focus Areas.

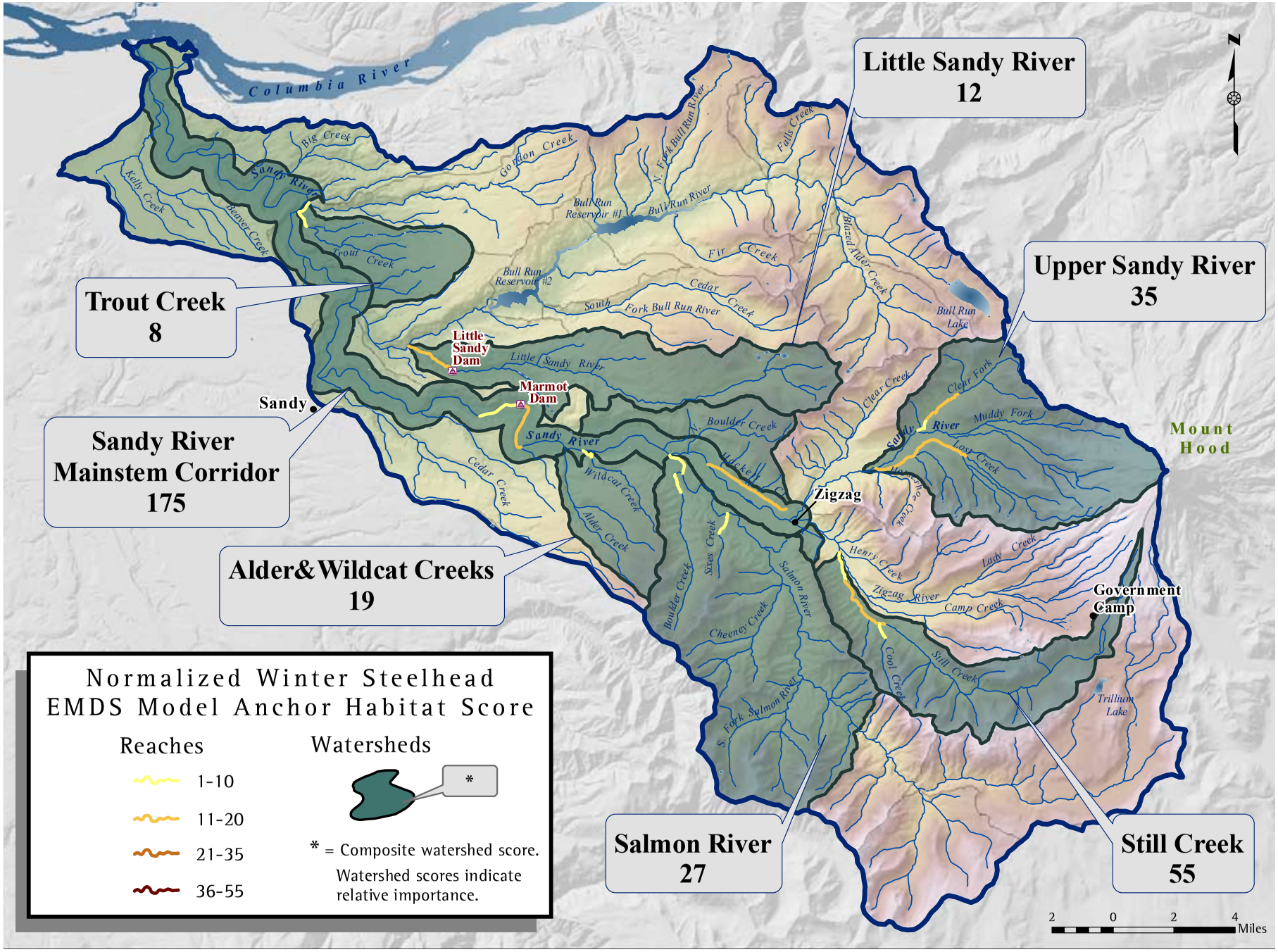


Figure 2.4 Sandy River Basin Aquatic Habitat Restoration: Winter Steelhead Geographic Focus Areas.

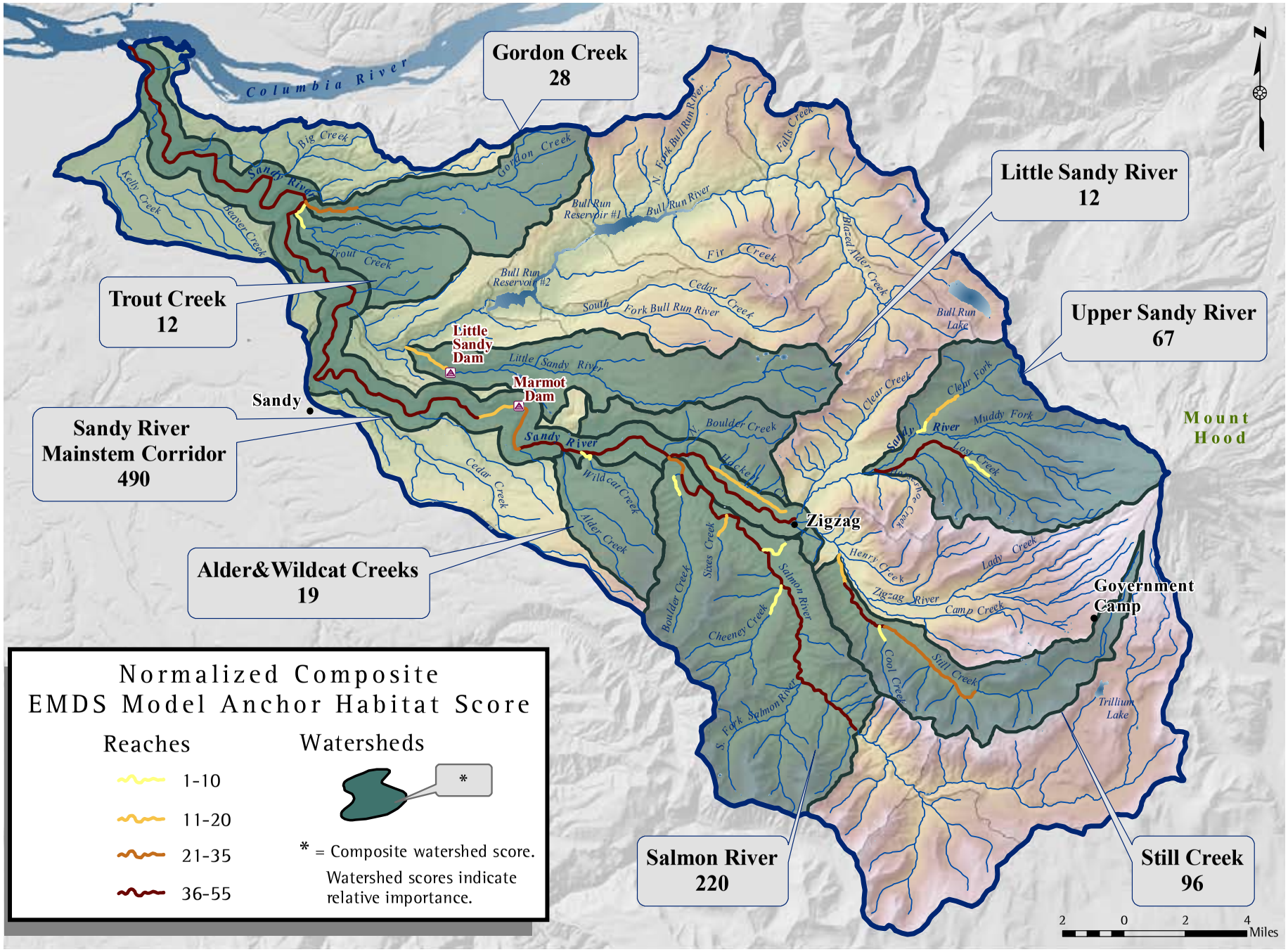


Figure 2.5 Sandy River Basin Aquatic Habitat Restoration: Composite Spring Chinook, Fall Chinook, Coho, and Winter Steelhead Geographic Focus Areas.

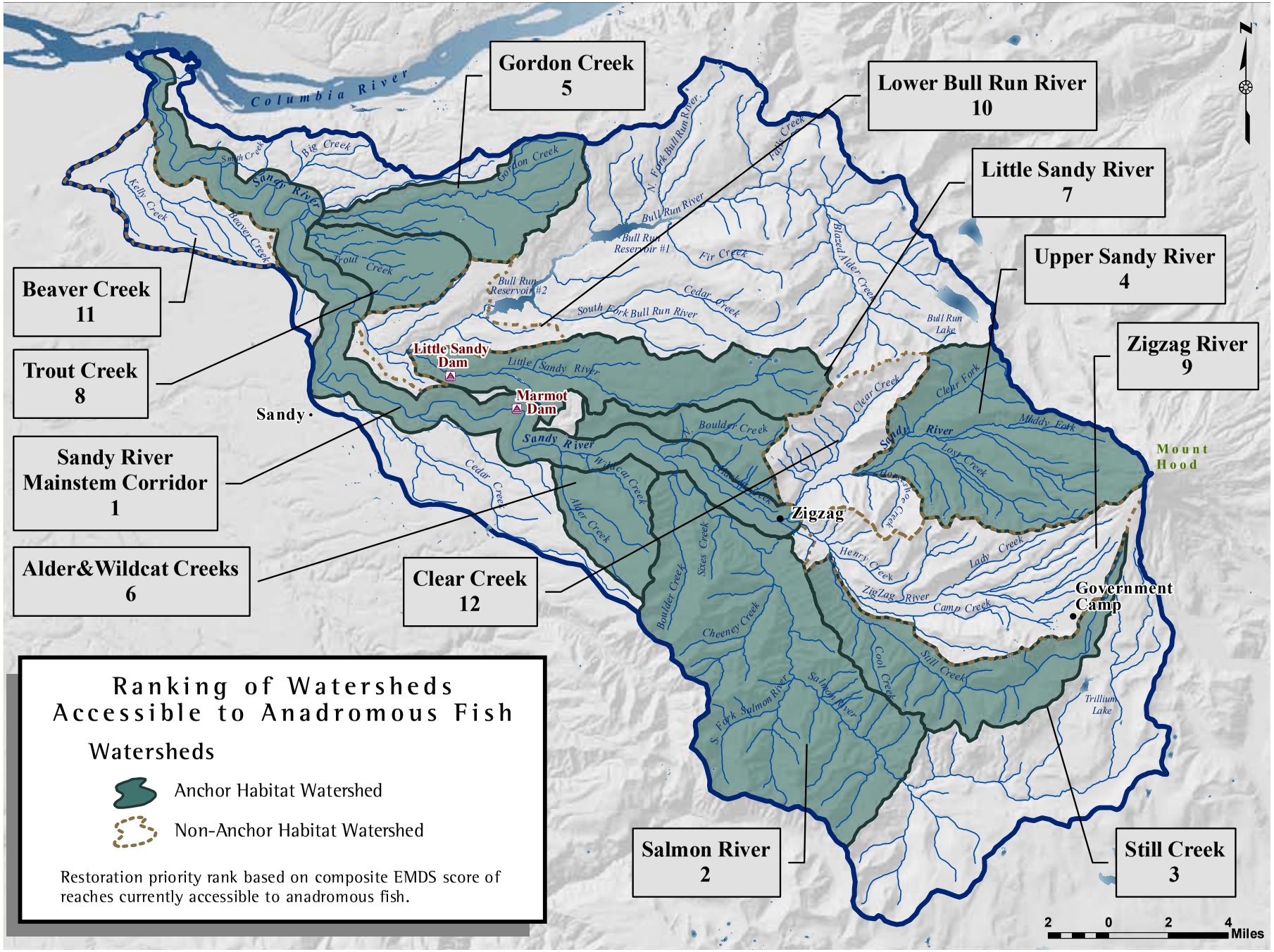


Figure 2.6 Sandy River Basin Aquatic Habitat Restoration: Geographic Focus.

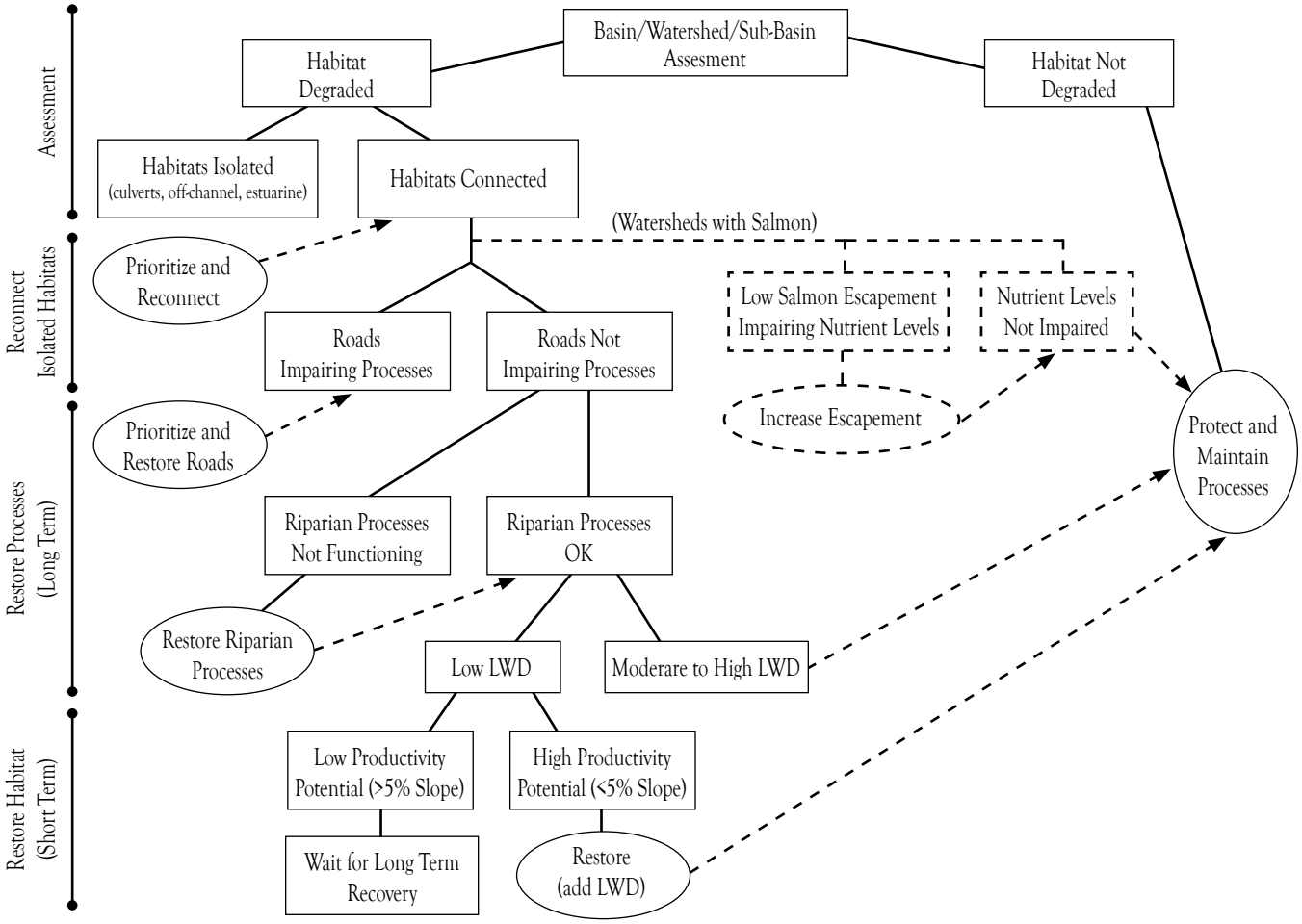
CHAPTER 3 - RESTORATION FRAMEWORK

HIERARCHICAL FRAMEWORK

In developing this strategy, the Working Group relied upon a hierarchical framework developed by Roni et al. (2002) to identify the sequence for implementing restoration actions in individual watersheds (Figure 8). The hierarchical framework ensures the appropriate types of restoration actions are identified and implemented in priority sequence to address the primary changes and alterations in watershed processes responsible for the factors limiting salmon and steelhead production. Restoration actions identified for treating the root causes of impaired habitat conditions are considered higher priority in order to ensure the achievement of greatest long-term restoration benefits. This is in contrast to implementing short-term actions that treat only the symptoms of aquatic habitat impairment. For example, consider a given stream reach that is lacking in riparian components (e.g., stand composition, age, and structure) to naturally recruit woody material, presently and into the future, and is also devoid of existing in-stream wood which together contribute largely to sub-optimal conditions. The hierarchical framework ensures a sequence of restoration actions that first promotes those aimed at achieving the desired riparian stand structure and composition, followed by those aimed at increasing in-channel wood density and improvement of aquatic habitat conditions. By following this hierarchical framework, restoration actions necessary to address and ensure the long term sustainability of aquatic habitat conditions will be prioritized at a higher level.

This hierarchical framework is not intended to diminish the biological value or importance of shorter-term actions, such as augmenting in-channel woody material levels. These actions may be critically important to address the current habitat deficiencies at the present time, when ESA-listed salmon and steelhead populations are at critically low levels. The Working Group's intent for adopting and utilizing the hierarchical framework is to emphasize and ensure that priority restoration actions are implemented in a sequence and manner that addresses the root causes of impaired aquatic habitat conditions. Past salmon and steelhead habitat restoration programs have been criticized for their lack of future focus or holistic watershed treatment, bringing into question the value of those efforts and financial investments.

Figure 3.1 Aquatic Habitat Restoration Strategy Hierarchical Framework, Modified from Roni et al. (2002).



Based on the hierarchical framework from Roni et al. (2002), as shown in Figure 8, the Working Group identified four tiers of restoration actions as follows:

Tier 1 – Reconnect Isolated Habitats

Tier 1 actions seek to restore aquatic habitat connectivity. The focus of Tier 1 actions is to restore connectivity to currently isolated habitat historically occupied by salmon and steelhead. The restoration goal for Tier 1 actions is to broaden the spatial distribution of fish populations, providing unimpeded access to historically available habitat.

Barriers blocking the upstream movement of fish, such as dams and culverts, would be remedied to restore access to historical habitat. The Working Group identified site-specific restoration actions that address known dam and diversion-related barriers, except for those in the Bull Run River watershed since fish passage issues there are addressed in the City of Portland Water Bureau's HCP. For road-related culvert fish passage barriers, the Working Group gathered existing surveys and information from various agencies and compiled a complete listing of known and suspected sites blocking historical anadromous fish habitat in the basin (Appendix A). Additional work is needed to verify suspected sites on non-federal lands and determine site-specific construction costs for road-related fish passage barrier sites listed in Appendix A.

Tier 1 restoration actions also address important habitat features, such as side channels and off-channel spawning and rearing areas, which have become isolated due to loss of floodplain connectivity. The Working Group identified specific reaches where the main channel has become disconnected from its floodplain, isolating historically accessible side channel and off-channel habitat.

Tier 2 – Restore Long Term Processes (Roads, Water Quality, Marine Derived Nutrients, etc.)

Tier 2 actions seek to restore long term watershed processes. The focus for Tier 2 actions is broad and encompasses the following categories of restoration actions: 1) road-related activities, 2) water quality improvements, 3) increasing in-stream flows, 4) addition of marine derived nutrients, 5) increased law enforcement efforts to curb poaching and illegal fishing, and 6) public education and outreach.

The Working Group recognized the importance of addressing road-related restoration actions. These actions would include such things as increased road maintenance, storm-proofing, decommissioning, and road upgrades where necessary to improve hydrologic conditions within watersheds and reduce sediment production and delivery. However, the Working Group lacked the time and resources to conduct a complete assessment of road-related impacts in all portions of the basin and identify potential actions. The only portions of the basin where data and information are readily available in GIS to complete such an assessment are on federal lands under Forest Service administration. As such, the Working Group was unable to identify specific road-related restoration actions, other than those pertaining to restoring fish passage included under Tier 1 actions. At a future time, the Working Group will need to review the various roads within the basin and identify specific restoration actions. To provide a framework for completing this future work, a case study on the Zigzag River watershed was completed (Appendix B) using existing information available from the recent analysis of Forest Service roads on the Mt. Hood National Forest (USFS 2003) and the 2004 Zigzag River watershed Analysis Revision (USFS 2004). The case study uses watershed-specific information and data to identify particular road segments at high risk of causing deleterious impacts to the aquatic ecosystem. From this detailed, watershed-specific assessment of road-related impacts, specific restoration actions for entire roads or road segments can be identified and brought forward for consideration. The case study provides a template for assessing road-related impacts and identifying road-related restoration actions in other watersheds throughout the basin.

Tier 3 – Restore Long Term Processes (Riparian Vegetation)

Tier 3 actions seek to restore long term processes in riparian areas, specifically focusing on riparian vegetation components. The focus is to restore the long term functioning and ecological components of riparian vegetative communities through project improvements as well as land acquisitions and easements. Restoration goals are to remove and eradicate invasive non-native species and re-establish native species where lacking. Additionally, restoration efforts are intended to focus on promoting the structural components, characteristics, and diversity of mature and developed riparian communities. Examples of specific types of restoration actions include riparian planting, eradication of invasive weeds and plants, thinning, and conifer release.

Tier 4 – Restore Short Term Processes (In-stream Habitat)

Tier 4 actions seek to restore in-stream fish habitat conditions to improve short term productivity while longer term restoration benefits begin to take effect. The primary emphasis is to restore large woody material to stream ecosystems, much of which was removed during the mid- to later part of the 20th Century. The addition of large wood provides structural habitat complexity in streams (i.e., creation of pool habitat, hiding cover for fish, etc.); helps trap and regulate the movement of sediment, gravels, and organic matter through the stream ecosystem; and aids in maintaining floodplain connectivity. The restoration goal for Tier 4 actions is, to the extent practicable, increase large wood densities and accumulations in a manner emulating natural or properly functioning stream ecosystems. An emphasis is placed on the creation of engineered log jams in a manner that emulates the natural deposition and accumulation of large woody material within a stream channel.

LIMITING FACTORS ANALYSIS

This strategy relies upon two sources to determine factors limiting salmon and steelhead habitat productivity: 1) watershed analyses and 2) the EDT model assessment. The Working Group examined results from watershed analyses for all watersheds where they were available, primarily on federal lands. This source of information was invaluable in determining both the habitat deficiencies for salmon and steelhead, and the altered watershed processes contributing to those deficiencies (i.e., riparian, hillslope, and road-related interactions). Moreover, the analyses were helpful in identifying specific stream reaches with habitat deficiencies and specific areas within the watershed to address altered riparian and hillslope processes.

Results from the EDT model assessment of the basin provided a more detailed look at specific factors limiting salmon and steelhead production, at the stream reach and watershed scales. While there have been several different iterations of the EDT model assessment conducted in the Sandy River basin over the last five years, SRBP (2005) contains the most up-to-date assessment with a detailed summary of results. SRBP (2005) summarizes the limiting factors from the EDT model at the population and watershed scales.

Small tributary, Sandy River.

CHAPTER 4 – RESTORATION OPPORTUNITIES

The Working Group applied the Roni et al. (2002) hierarchical framework to each of the watersheds in the basin – anchor habitat and non-anchor habitat alike. For each particular watershed, the Working Group integrated the results and conclusions from watershed analysis and the EDT model assessment in a top-down, step-by-step manner with the hierarchical framework to identify necessary restoration actions. The original Tech Team had previously identified many restoration actions, and these actions were put in the "known restoration activities" category. Some of these restoration actions require further site-specific review, validation, and feasibility assessment. Where specific restoration actions had not been previously identified by the Tech Team, the Working Group determined the type of restoration actions needed and their approximate locations. The Working Group did not attempt to further develop actions in this "new restoration activities" category at this time since field inventories and site reconnaissance are needed to validate the need for these actions and determine their feasibility, cost, and landowner cooperation in cases involving private lands.

The following tables identify high priority restoration actions for each watershed in order of the basin-wide priority established in Figure 7. The highest priority geographic area is the Sandy River Mainstem Corridor. While this area is not a watershed-unit, it serves as a critical corridor for adult immigration and holding, as well as juvenile rearing and emigration for all four populations of salmon and steelhead in the basin. Therefore, restoration actions addressing riparian, floodplain, and side-channel habitat functions throughout the Sandy River Mainstem Corridor are a critical need, in addition to the restoration actions outlined for specific watersheds that flow into the mainstem corridor. The Working Group fully recognized that in order to restore particular elements (i.e., water quality, hydrologic regime, etc.) of the corridor itself, this would require a series of actions in contributing watersheds over a substantial timeframe in a manner and scale that would result in cumulative downstream benefits. The following are the series of restoration actions for each of the 12 watersheds (anchor habitat and non-anchor habitat watersheds), in priority order and arranged sequentially in accordance with the four tiers of restoration actions from the Roni et al. (2002) hierarchical framework:

Tier 1 – Reconnect Isolated Habitats
Tier 2 – Restore Long Term Processes (Roads, Water Quality, Marine Derived Nutrients, etc.)
Tier 3 – Restore Long Term Processes (Riparian Vegetation)
Tier 4 – Restore Short Term Processes (In-stream Habitat)

The Working Group clearly recognized that there will always be high priority restoration actions in lower priority ranked watersheds, including watersheds where anchor habitat was not identified. If funding opportunities or landowner willingness arises in lower priority watersheds where clear high priority restoration actions have been identified, then the hierarchical structure and sequencing provided below will help guide restoration investments in those areas. Based on this understanding, the Working Group identified all of the high priority restoration actions for each of the 12 priority ranked watersheds. Within the Little Sandy River watershed, the Working Group also identified high priority restoration actions for the portion of the watershed currently inaccessible to anadromous salmon and steelhead because access is anticipated in 2008 with PGE's planned removal of the Little Sandy River Dam. In addition, the Working Group identified high priority restoration actions in the Cedar Creek watershed (also currently inaccessible to anadromous salmon and steelhead) and an assemblage of accessible, miscellaneous tributaries to the mainstem Sandy River Corridor that fell outside of the geographic focus watershed areas due to their small size and collectively small watershed area. Current discussions and planning have been underway to provide fish access into Cedar Creek, currently blocked at the ODFW Sandy River Fish Hatchery weir. Given recent progress, the Working Group saw value in identifying all of the high priority restoration actions for the entire Cedar Creek watershed, even though it was not considered in the anchor habitat assessment for the basin (SRBWG 2006).

The Working Group provided a gross estimate of potential aquatic habitat restoration costs (investment needs) on a watershed-by-watershed basis for "known" actions only. These cost estimates come from the original 2002 Sandy Tech Team's project-level cost estimates contained in a comprehensive database of restoration actions for the basin. The Working Group did not adjust cost estimates upwards for inflation, nor do estimates include costs associated with planning and environmental compliance, design, permitting, project administration and implementation oversight, or monitoring. Cost estimates for "new" restoration actions have not been determined since further field validation and project planning is necessary.

Table 4.1. Sandy River Mainstem Corridor (1) [from mouth of Sandy River to Zigzag River confluence].

HIERARCHICAL RESTORATION STRATEGY	ALTERED WATERSHED PROCESS (FROM WA)	CORRESPONDING LEVEL 3 SURVIVAL FACTORS (FROM EDT)	EDT REACH	RESTORATION ACTIONS (KNOWN)	RESTORATION ACTIONS (NEW)
Tier 1. Reconnect Isolated Habitats	Isolated side channels in the lower Sandy River	HQ, HD CS, O HQ, O, HD	Sandy 1 Sandy 1 Sandy 7-8	Project 2 - Sandy 1 Channel Reconnection ($300,000) Project 4 – Sandy 1 Reestablishment of River Mouth ($885,000) Project 74 – Sandy 7 Reduce and/or Eliminate Diking ($300,000)	Post-Project 4 implementation: Enhance old mainstem channel into winter/side channel Side Channel Enhancement in Sandy 1/2/3 and Sandy 7/8
Tier 1 Actions				**Sub Total= $1,485,000**	
Tier 2. Restore Long Term Processes (Roads, Water Quality, Marine Derived Nutrients, etc.)	Instream flow	Fl	Sandy 1-5	Project 65 – Sandy 6 Remove Marmot Dam (restores natural stream flow regimes in Sandy and Bull Run rivers); PGE to implement in 2007 per Settlement Agreement	Instream flow restoration (eliminate illegal water withdrawals)
	Increased fine sediment delivery, mass wasting, and hydrologic impacts relating to upper basin roads	SL, CS	Sandy 1-3, 5-8	None	Road-related restoration actions in upper basin watersheds
	Elevated chemical concentrations	C	Sandy 1-3	None	Stormwater detention/ treatment to reduce non-point source inputs
	Poaching	H/P	Sandy 1-8	None	Increase law enforcement in high likelihood poaching areas
Tier 2 Actions				**Sub-Total = per SA**	
Tier 3. Restore Long Term Processes (Riparian Vegetation)	Elevated Stream Temperature	T	Sandy 1-8	Project 5 - Sandy 1 Riparian Easement ($77,000) Project 8 – Sandy 2 Preservation Riparian Treatment ($256,000) Project 9 – Sandy 2 Riparian Easement ($434,000) Project 51 - Sandy 3 Riparian Easement; 1 spt ($1,792,000) Project 58 - Sandy 4 Riparian Easement; 1 spt ($992,000) Project 62 - Sandy 5 Riparian Easement; 1 spt ($360,000) Project 66 – Sandy 6 Riparian Easement; 1 spt ($384,000)	None Identified

Table 4.1 Continued on following page

Abbreviations of EDT Survival Factors for the Sandy River Basin:
Channel Stability = CS; Chemicals = C; Flow = Fl; Food = Fo; Habitat Diversity = HD; Harassment/Poaching = H/P; Obstructions = O; Predation = P; Sediment Load = SL; Temperature = T; Withdrawals = W; Key Habitat Quantity = HQ.

Table 4.1 (*Continued*). Sandy River Mainstem Corridor (1) [from mouth of Sandy River to Zigzag River confluence].

HIERARCHICAL RESTORATION STRATEGY	ALTERED WATERSHED PROCESS (FROM WA)	CORRESPONDING LEVEL 3 SURVIVAL FACTORS (FROM EDT)	EDT REACH	RESTORATION ACTIONS (KNOWN)	RESTORATION ACTIONS (NEW)
Tier 3. Restore Long Term Processes (Riparian Vegetation)	Elevated Stream Temperature	T	Sandy 1-8	Project 70 – Sandy 6/7 Upstream Marmot Dam Site Acquisition ($853,600) Project 75 – Sandy 7 Riparian Easement; 1 spt ($800,000) Project 112 – Sandy 8 Riparian Easement; 1 spt ($1,472,000)	None Identified
	Lack Riparian LWD Recruit.	HD, CS	Sandy 1-8	All projects listed above also address lack of riparian LWD recruitment.	None Identified
	Invasion of Noxious Weeds	SL, HD	Sandy 1-3, 5-8	Project 3 – Sandy 1 Preservation –Noxious Weed Control ($16,500) Project 7 – Sandy 2 Preservation – Noxious Weed Control ($37,500) Project 50 – Sandy 3 Preservation – Noxious Weed Control ($18,000) Project 56 – Sandy 4 Preservation –Noxious Weed Control ($12,000) Project 61 – Sandy 5 Preservation – Noxious Weed Control ($4,500) Project 64 – Sandy 6 Preservation –Noxious Weed Control ($6,000) Project 73 – Sandy 7 Preservation – Noxious Weed Control ($18,000) Project 111 – Sandy 8 Preservation –Noxious Weed Control ($16,500)	Identify new sites based on updated inventories and implement eradication treatments
Tier 3 Actions				**Sub-Total = $7,549,600**	
Tier 4. Restore Short Term Processes (In-stream Habitat)	Lack of in-stream LWD, Habitat simplification, Channelization	HQ, HD, CS	Sandy 1-2, 7-8	Project 1 - Sandy 1 and 2 Log Jam Placements ($500,000) Project 71 – Sandy 6/7/8 Log Jam Placement ($3,250,000)	Remap FEMA floodplain using LIDAR or other techniques that will assist county land use planning to prevent further residential encroachment Educate floodplain homeowners about healthy river processes and the importance of instream woody material
Tier 4 Actions				**Sub-Total = $3,750,000**	
All Actions				**Total = $12,784,600**	**Cost of new projects to be determined**

Abbreviations of EDT Survival Factors for the Sandy River Basin:
Channel Stability = CS; Chemicals = C; Flow = Fl; Food = Fo; Habitat Diversity = HD; Harassment/Poaching = H/P; Obstructions = O; Predation = P; Sediment Load = SL; Temperature = T; Withdrawals = W; Key Habitat Quantity = HQ.

Table 4.2. Salmon River (2).

HIERARCHICAL RESTORATION STRATEGY	ALTERED WATERSHED PROCESS (FROM WA)	CORRESPONDING LEVEL 3 SURVIVAL FACTORS (FROM EDT)	EDT REACH	RESTORATION ACTIONS (KNOWN)	RESTORATION ACTIONS (NEW)
Tier 1. Reconnect Isolated Habitats	Isolated Side Channels and Off-channel Habitats	HQ	Salmon 1-3	Project 95 – Salmon 1/2 Floodplain Connection ($3,000,000)	Side channel & floodplain re-connection in Salmon 3
Tier 1 Actions				**Sub-Total = $3,000,000**	
Tier 2. Restore Long Term Processes (Roads, Water Quality, Marine Derived Nutrients, etc.)	Loss of Marine Derived Nutrients	FO	All EDT reaches	Project 99 – Salmon 2 Carcass Placement ($3,100) Project 110 – Sixes 1 Carcass Placement ($400)	Carcass placement on all other EDT reaches
	Increased fine sediment delivery, mass wasting, and hydrologic impacts relating to upper basin roads	SL, CS	Salmon 1-3	None	There are no known or potential road-related projects in the lower Salmon River Watershed (anadromous portion). Conduct road inventory in upper basin (non-anadromous portion) to identify potential high priority road treatment projects; implement treatments
	Harassment and Poaching	H/P	Salmon 1-3	None	Increase law enforcement in high likelihood poaching areas
Tier 2 Actions				**Sub-Total = $3,500**	
Tier 3. Restore Long Term Processes (Riparian Vegetation)	Elevated Stream Temperature	T	Salmon 1, 2, Wee Burn 1	Project 93 – Salmon 1 Riparian Easement; 1spt ($228,000) Project 102 – Salmon 2 Riparian Easement; 1spt ($1,152,000) Project 106 – Salmon 3 Riparian Easement; 1spt ($84,000) Project 100 – Salmon 2 Miller Quarry Acquisition ($250,000) Project 101 – Salmon 2 Miller Road Quarry Restoration ($355,000)	Investigate FLIR survey results for temperature hot spots on Boulder 0 and Boulder 1; identify and implement projects to increase riparian shade along Boulder 0 and Boulder 1 Dredge Wee Burn Creek Ponds

Table 4.2 Continued on following page

Abbreviations of EDT Survival Factors for the Sandy River Basin:
Channel Stability = CS; Chemicals = C; Flow = Fl; Food = Fo; Habitat Diversity = HD; Harassment/Poaching = H/P; Obstructions = O; Predation = P; Sediment Load = SL; Temperature = T; Withdrawals = W; Key Habitat Quantity = HQ.

Table 4.2 (*Continued*). Salmon River (2).

HIERARCHICAL RESTORATION STRATEGY	ALTERED WATERSHED PROCESS (FROM WA)	CORRESPONDING LEVEL 3 SURVIVAL FACTORS (FROM EDT)	EDT REACH	RESTORATION ACTIONS (KNOWN)	RESTORATION ACTIONS (NEW)
Tier 3. Restore Long Term Processes (Riparian Vegetation)	Lack Riparian LWD Recruitment	HD, CS	Salmon 1, 2, Boulder 0-2, Sixes 1, Wee Burn 1	All projects listed above addressing elevated stream temperature also address lack of riparian LWD recruitment. Project 90 – Boulder Creek Riparian Improvement No. 1 ($101,500) Project 91 – Boulder Creek Riparian Improvement No. 2 ($406,000)	Conduct inventories to identify opportunities for riparian silvicultural projects along Sixes 1 to promote riparian LWD recruitment
	Riparian Disturbance via Disp. CG's	SL, HD	Salmon 2, 3	None	Dispersed Campground Rehabilitation along Salmon 2/3
	Invasion of Noxious Weeds	HD, CS	Salmon 1, 2	Project 97 – Salmon 1/2 Preservation-Noxious Weed Control ($4,500)	None Identified
Tier 3 Actions				**Sub-Total = $2,581,000**	
Tier 4. Restore Short Term Processes (In-stream Habitat)	Lack of in-stream LWD, Habitat simplification, Channelization	HD, HQ, CS	Boulder 0, 1, Salmon 1-3, SF Salmon 1	Project 89 – Boulder 0/1 LWD Placement ($36,000) Project 96 – Salmon11/2 Log Jam Placement ($1,750,000) Project 98 – Salmon 2/Wee Burn 1 Stream Restoration ($360,000) Project 104 – Salmon 2 LWD Additions ($240,000) Project 108 – Salmon 3 Log Jam Placement ($1,750,000)	Log jam placement and LWD additions in SF Salmon Remap FEMA floodplain using LIDAR or other techniques that will assist county land use planning to prevent further residential encroachment Educate floodplain homeowners about healthy river processes and the importance of instream woody material
Tier 4 Actions				**Sub-Total = $4,136,000**	
All Actions				**Total = $9,720,500**	**Cost of new projects to be determined**

Abbreviations of EDT Survival Factors for the Sandy River Basin:
Channel Stability = CS; Chemicals = C; Flow = Fl; Food = Fo; Habitat Diversity = HD; Harassment/Poaching = H/P; Obstructions = O; Predation = P; Sediment Load = SL; Temperature = T; Withdrawals = W; Key Habitat Quantity = HQ.

Table 4.3. Still Creek (3).

HIERARCHICAL RESTORATION STRATEGY	ALTERED WATERSHED PROCESS (FROM WA)	CORRESPONDING LEVEL 3 SURVIVAL FACTORS (FROM EDT)	EDT REACH	RESTORATION ACTIONS (KNOWN)	RESTORATION ACTIONS (NEW)
Tier 1. Reconnect Isolated Habitats	Isolated Side Channels and Off-channel Habitats	HD, HQ	Still 1A	Project 150 – Still 1, 1A, 2 LWD Placement ($370,000) – listed below under Tier 4 actions also	None Identified
Tier 1 Actions				**Sub-Total = $370,000**	
Tier 2. Restore Long Term Processes (Roads, Water Quality, Marine Derived Nutrients, etc.)	Loss of Marine Derived Nutrients	Fo	All reaches, esp. Still 1A	None	Still 1, 1A, 2, 3 and Cool 1 salmon carcass enrichment treatments
	Increased Fine Sediment from Hwy 26 Sanding, Road 12, and summer home spur roads	SL	Still 3, 4	Project 152 – Still 5 Road Water Quality Improvement ($5,000)	Treat upper segment of Road 12 with one of two options pending NEPA outcome: 1) stormproof (i.e., increase cross drains, surface roadbed, stablize cut- and fill-slopes, etc.) or 2) decommission
			Still 1, 1A, 2-4	None	
	Increased Mass Wasting from upper segments of Road 12	SL	Still 2-4	None	Surface summer home spur roads
					Same as above – treat upper segment of Road 12 with one of two options pending NEPA outcome
	Altered Wood and Sediment Routing	HD, CS	Still 2-4	None	Same as above – treat upper segment of Road 12 with one of two options pending NEPA outcome
	Hardening of Streambanks and Channels	CS	Still 1, 1A, 2	Project 149 – Still 1, 1A Summer Home Modifications ($1,209,000)	Still 1A Streambank Stabilization via LWD Bank Revetments
	Increase in Chemical Concentrations in Water	C	Still 1, 1A, 2	None	Still 1, 1A, 2 Summer Home Outreach and Education (improve practices that will aid in reducing use of chemicals and associated runoff)
	Harassment or Disturbance of Spawning Salmon	H/P	Still 1, 1A	Project 148 – Still 1, 1A Harassment Prevention ($8,000)	
Tier 2 Actions				**Sub-Total = $1,222,000**	

Table 4.3 Continued on following page

Abbreviations of EDT Survival Factors for the Sandy River Basin:
Channel Stability = CS; Chemicals = C; Flow = Fl; Food = Fo; Habitat Diversity = HD; Harassment/Poaching = H/P; Obstructions = O; Predation = P; Sediment Load = SL; Temperature = T; Withdrawals = W; Key Habitat Quantity = HQ.

Table 4.3 (*Continued*). Still Creek (3).

HIERARCHICAL RESTORATION STRATEGY	ALTERED WATERSHED PROCESS (FROM WA)	CORRESPONDING LEVEL 3 SURVIVAL FACTORS (FROM EDT)	EDT REACH	RESTORATION ACTIONS (KNOWN)	RESTORATION ACTIONS (NEW)
Tier 3. Restore Long Term Processes (Riparian Vegetation)	Lack of Riparian LWD Recruitment	HD, CS	All EDT reaches esp. Still 1, 1A, 2	Project 153 – Still Creek #1 Riparian Habitat Improvement Project ($14,400)	Still 1, 1A, 2-4, and Cool 1 Riparian Enhancement (planting, hardwood conversion, and thinning)
	Modification of Riparian Stand Structure and Composition due to Summer Home Impacts	HD, CS	Still 1, 1A, 2	None	Same as above – Still 1, 1A, 2-4, and Cool 1 Riparian Enhancement
	Increase in Fine Sediment Delivery and Detrimental Soil Compaction	SL, HD	Still 1, 1A, 2 Connection to Still 5	Project 151 – Still 5 Campground Improvement Project ($15,000)	Still 1, 1A, 2 Dispersed Campground Rehabilitation
	Invasion of Noxious Weeds	HD, CS	Still 1, 1A, 2	Project 147 – Still 1 Preservation-Noxious Weed Control ($3,000)	Expand scope of Project 147 to include Still 1A, 2
Tier 3 Actions				**Sub-Total = $32,400**	
Tier 4. Restore Short Term Processes (In-stream Habitat)	Lack of Instream LWD and Loss of Aquatic Habitat Diversity	HD, HQ	All reaches, esp. Still 1, 1A, 2	Project 150 – Still 1, 1A, 2 LWD Placement (Cost listed above)	Remap FEMA floodplain using LIDAR or other techniques that will assist county land use planning to prevent further residential encroachment Educate floodplain homeowners about healthy river processes and the importance of instream woody material
Tier 4 Actions				**Sub-Total = listed above (Tier 1)**	
All Actions				**Total = $1,624,400**	**Cost of new projects to be determined**

Abbreviations of EDT Survival Factors for the Sandy River Basin:
Channel Stability = CS; Chemicals = C; Flow = Fl; Food = Fo; Habitat Diversity = HD; Harassment/Poaching = H/P; Obstructions = O; Predation = P; Sediment Load = SL; Temperature = T; Withdrawals = W; Key Habitat Quantity = HQ.

Table 4.4. Upper Sandy River (4) [upstream from and including Clear Fork].

HIERARCHICAL RESTORATION STRATEGY	ALTERED WATERSHED PROCESS (FROM WA)	CORRESPONDING LEVEL 3 SURVIVAL FACTORS (FROM EDT)	EDT REACH	RESTORATION ACTIONS (KNOWN)	RESTORATION ACTIONS (NEW)
Tier 1. Reconnect Isolated Habitats	Isolated Side Channels and Off-channel Habitats	None	N/A	None	None Identified
Tier 1 Actions				**Sub-Total = no known actions**	
Tier 2. Restore Long Term Processes (Roads, Water Quality, Marine Derived Nutrients, etc.)	Increase in Mass Wasting and Altered Wood and Sediment Routing	HD	Gowan 1	None	Implement road-related storm-proofing treatments along Lolo Pass road (esp. area near 1999 mass failure).
	Loss of Marine Derived Nutrients	Fo	All EDT Reaches	Project 124 – Clear Fk 1a, 1b, 1c, 1d Carcass Placement ($12,960)	Additional salmon carcass enrichment treatment for Sandy 10-12; Lost 1a, 1b, and Horseshoe 1
Tier 2 Actions				**Sub-Total = $12,960**	
Tier 3. Restore Long Term Processes (Riparian Vegetation)	Lack of Riparian LWD Recruitment	HD/HQ	Sandy 10, 11 Lost 1a, 1b Clear Fk 1a, 1b	Project 126 - Clear Fork 1b Riparian Planting ($900) Project 129 - Lost Creek 1A Riparian Improvement Project($13,200)	Sandy 10, 11, Lost 1b, and Clear Fk 1a Riparian Improvements
	Modification of Riparian Stand Structure and Composition due to Dispersed Camping	HD, CS	Lost 1a, 1b	None	Lost 1a, 1b, rehabilitate dispersed campsites along spur roads in old maid flat area
	Invasion of Noxious Weeds	SL, HD	Sandy 10 Clear Fk 1a, 1b Lost 1a, 1b	None	Identify new sites based on updated inventories and implement eradication treatments
Tier 3 Actions				**Sub-Total = $14,100**	
Tier 4. Restore Short Term Processes (In-stream Habitat)	Lack of Instream LWD and Loss of Aquatic Habitat Diversity	HD/HQ	Clear Fk 1a, 1b Sandy 10, 11 Lost 1a, Horseshoe 1	Project 125 - Clear Fork 1b LWD Placement ($20,000)	LWD enhancement projects on Sandy 10, 11; Lost 1a, 1b; Cast 1; and Horseshoe 1 Remap FEMA floodplain using LIDAR or other techniques that will assist county land use planning to prevent further residential encroachment Educate floodplain homeowners about healthy river processes and the importance of instream woody material
Tier 4 Actions				**Sub-Total = $20,000**	
All Actions				**Total = $47,060**	**Costs of New Projects to be determined**

Table 4.5. Gordon Creek (5).

HIERARCHICAL RESTORATION STRATEGY	ALTERED WATERSHED PROCESS (FROM WA)	CORRESPONDING LEVEL 3 SURVIVAL FACTORS (FROM EDT)	EDT REACH	RESTORATION ACTIONS (KNOWN)	RESTORATION ACTIONS (NEW)
Tier 1. Reconnect Isolated Habitats	Isolated Side Channels along River	HQ	Gordon 2a, 2b	None	Gordon 2a, 2b Side Channel Enhancement
Tier 1 Actions				**Sub-Total = no known actions**	
Tier 2. Restore Long Term Processes (Roads, Water Quality, Marine Derived Nutrients, etc.)	Loss of Marine Derived Nutrients	Fo	Gordon 1a, 1b, 2a, 2b	None	Gordon 1a, 1b, 2a, 2b Salmon Carcass Enrichment
	Increased fine sediment delivery, mass wasting, and hydrologic impacts relating to upper basin roads	SL, CS	Gordon 1a, 1b, 2a, 2b	None	Identify problem roads and other sources of sediment; develop and implement restoration actions
	Harassment and Poaching	H/P	Gordon 1a	None	Increase law enforcement in high likelihood poaching areas
Tier 2 Actions				**Sub-Total = no known actions**	
Tier 3. Restore Long Term Processes (Riparian Vegetation)	Elevated Stream Temperature	T	Gordon 1a	Project 26 – Gordon 1a, 1b Riparian Enhancement; 100 ft buffers ($46,800)	None Identified
	Lack Riparian LWD Recruitment	HD, CS	Gordon 1a, 1b, 2a, 2b	Projects listed above addressing elevated stream temperature also address lack of riparian LWD recruitment.	None Identified
	Riparian Disturbance via Disp. CG's	HD, CS	Gordon 1a	None	Gordon 1a Dispersed Site Rehabilitation
	Invasion of Noxious Weeds	SL, HD	Gordon 1a, 1b, 2a, 2b	None	Continue ongoing surveys for new sites, implement treatments
Tier 3 Actions				**Sub-Total = $46,800**	
Tier 4. Restore Short Term Processes (In-stream Habitat)	Lack of in-stream LWD, Habitat simplification	HD, HQ, CS	Gordon 1a, 1b, 2a, 2b	Project 28 – Gordon LWD Placement ($160,000)	Investigate opportunity for LWD placement in Gordon 2a, 2b, if feasible, design and implement LWD addition project
Tier 4 Actions				**Sub-Total = $160,000**	
All Actions				**Total = $206,800**	**Cost of new projects to be determined**

Abbreviations of EDT Survival Factors for the Sandy River Basin:
Channel Stability = CS; Chemicals = C; Flow = Fl; Food = Fo; Habitat Diversity = HD; Harassment/Poaching = H/P; Obstructions = O; Predation = P; Sediment Load = SL; Temperature = T; Withdrawals = W; Key Habitat Quantity = HQ.

Table 4.6. Alder & Wildcat Creeks (6).

HIERARCHICAL RESTORATION STRATEGY	ALTERED WATERSHED PROCESS (FROM WA)	CORRESPONDING LEVEL 3 SURVIVAL FACTORS (FROM EDT)	EDT REACH	RESTORATION ACTIONS (KNOWN)	RESTORATION ACTIONS (NEW)
Tier 1. Reconnect Isolated Habitats	Reconnection of Isolated Habitats	HQ	Alder 1	Project 83 – Alder 1 Fish Passage Project ($300,000) Project 85 – Alder 1a Fish Passage Project ($60,000)	None Identified
Tier 1 Actions				**Sub-Total = $360,000**	
Tier 2. Restore Long Term Processes (Roads, Water Quality, Marine Derived Nutrients, etc.)	Elevated chemical concentrations	C	Alder1, 1a	**None**	Investigate opportunities for bioswales and/or detention facilities along roads treated with deicer compounds
	Loss of Marine Derived Nutrients	Fo	Alder 1, Wildcat 1, 2	**None**	Alder 1 and Wildcat 1, 2 Salmon Carcass Enrichment
	Increased fine sediment delivery, mass wasting, and hydrologic impacts relating to roads	SL, CS	Alder 1, 1a, Wildcat 1, 2	**None**	Inventory watershed for source areas of sediment and road-related impacts. Implement restoration treatments
Tier 2 Actions				**Sub-Total = no known actions**	
Tier 3. Restore Long Term Processes (Riparian Vegetation)	Elevated Stream Temperature	T	Alder 1a, 2	Project 84 – Alder 1 Preservation-Noxious Weed Control ($1,500) Project 86 – Alder 1a/2 Riparian Improvement ($25,800)	None Identified
	Lack Riparian LWD Recruitment	HD, CS, HQ	Alder 1a, 2 and Wildcat 1-3	See Project 86 Project 87 – Wildcat 1/2 Riparian Enhancement ($16,800)	None Identified
	Invasion of Noxious Weeds	SL, HD	Alder 2, Wildcat 1, 2	None	Inventory noxious weed infestations and implement eradication treatments
Tier 3 Actions				**Sub-Total = $44,100**	
Tier 4. Restore Short Term Processes (In-stream Habitat)	Lack of in-stream LWD, Habitat simplification, Channelization	HD, HQ, CS	Alder 1, 1a, 2, Wildcat 1,2	None	Property Acquisition and Channel Improvement associated with Trout Farm on Whiskey Creek Investigate Opportunity for Alder 1a, 2 and Wildcat 1, 2 LWD Projects, if feasible, implement
Tier 4 Actions				**Sub-Total = no known actions**	
All Actions				**Total = $404,100**	**Cost of new projects to be determined**

Abbreviations of EDT Survival Factors for the Sandy River Basin:
Channel Stability = CS; Chemicals = C; Flow = Fl; Food = Fo; Habitat Diversity = HD; Harassment/Poaching = H/P; Obstructions = O; Predation = P; Sediment Load = SL; Temperature = T; Withdrawals = W; Key Habitat Quantity = HQ.

Table 4.7. Little Sandy River (7) [including inaccessible portion of watershed above Little Sandy Dam].

HIERARCHICAL RESTORATION STRATEGY	ALTERED WATERSHED PROCESS (FROM WA)	CORRESPONDING LEVEL 3 SURVIVAL FACTORS (FROM EDT)	EDT REACH	RESTORATION ACTIONS (KNOWN)	RESTORATION ACTIONS (NEW)
Tier 1. Reconnect Isolated Habitats	Isolated Habitat	HQ	Little Sandy 1	Project 46 – Little Sandy 1 Remove Little Sandy Dam; PGE to implement in 2008 per Settlement Agreement (SA)	None Identified
Tier 1 Actions				**Sub-Total = per SA**	
Tier 2. Restore Long Term Processes (Roads, Water Quality, Marine Derived Nutrients, etc.)	Potential Future Water Use	Fl	Little Sandy 1, 2	Project 48 – Little Sandy Flow Agreement (per AIP for HCP)	None Identified
	Loss of Marine Derived Nutrients	Fo	Little Sandy 1, 2	None	Little Sandy 1, 2 Salmon Carcass Enrichment
	Increased fine sediment delivery, mass wasting, and hydrologic impacts relating to upper basin roads	SL, CS	Little Sandy 2	None	Identify and prioritize roads for storm-proofing and/or decommissioning; implement restoration treatments
Tier 2 Actions				**Sub-Total = AIP for HCP**	
Tier 3. Restore Long Term Processes (Riparian Vegetation)	Elevated Stream Temperature	T	Little Sandy 1, 2	None	Little Sandy 1, 2 Riparian Acquisition and Riparian Improvements
	Lack Riparian LWD Recruitment	HD, CS	Little Sandy 1, 2	None	Same as above
	Invasion of Noxious Weeds	SL, HD	Little Sandy 1, 2	None	Identify new sites based on updated inventories and implement eradication treatments
Tier 3 Actions			Little Sandy 1, 2	**Sub-Total = no known actions**	
Tier 4. Restore Short Term Processes (In-stream Habitat)	Lack of in-stream LWD, Habitat simplification	HD, HQ, CS		Project 45 – Little Sandy 1 LWD Introduction ($72,000)	Little Sandy 2 LWD Introduction
Tier 4 Actions				**Sub-Total = $72,000**	
All Actions				**Total = $72,000**	**Cost of new projects to be determined**

Abbreviations of EDT Survival Factors for the Sandy River Basin:
Channel Stability = CS; Chemicals = C; Flow = Fl; Food = Fo; Habitat Diversity = HD; Harassment/Poaching = H/P; Obstructions = O; Predation = P; Sediment Load = SL; Temperature = T; Withdrawals = W; Key Habitat Quantity = HQ.

Table 4.8. Trout Creek (8).

HIERARCHICAL RESTORATION STRATEGY	ALTERED WATERSHED PROCESS (FROM WA)	CORRESPONDING LEVEL 3 SURVIVAL FACTORS (FROM EDT)	EDT REACH	RESTORATION ACTIONS (KNOWN)	RESTORATION ACTIONS (NEW)
Tier 1. Reconnect Isolated Habitats	Isolated Side Channels along River	HQ	Trout 1a, 2a	None	Trout 1a, 2a Side Channel Enhancement
Tier 1 Actions				**Sub-Total = no known actions**	
Tier 2. Restore Long Term Processes (Roads, Water Quality, Marine Derived Nutrients, etc.)	Loss of Marine Derived Nutrients	Fo	Trout 1a, 2a	None	Trout 1a, 2a, 3a Salmon Carcass Enrichment
	Increased fine sediment delivery, mass wasting, and hydrologic impacts relating to upper basin roads	SL, CS	Trout 1a, 2a	None	Identify problem roads and other sources of sediment; develop and implement restoration actions
	Harassment and Poaching	H/P	Trout 1a	None	Increase law enforcement in high likelihood poaching areas
Tier 2 Actions				**Sub-Total = no known actions**	
Tier 3. Restore Long Term Processes (Riparian Vegetation)	Elevated Stream Temperature	T	Trout 1a	None	Trout 1a, 2a Riparian Enhancement
	Lack Riparian LWD Recruitment	HD, CS	Trout 1a, 2a	None	Same as above
	Invasion of Noxious Weeds	SL, HD	Trout 1a, 2a, 3a	Project 29 – Trout 1 Preservation- Noxious Weed Control ($1,500)	Continue ongoing surveys for new sites, implement treatments
Tier 3 Actions				**Sub-Total = $1,500**	
Tier 4. Restore Short Term Processes (In-stream Habitat)	Lack of in-stream LWD, Habitat simplification	HD, HQ, CS	Trout 1a, 2a	Project 30 - Trout 1a Instream Enhancement ($40,000) Project 31 – Trout 2a Riparian Enhancement ($11,200)	None Identified
Tier 4 Actions				**Sub-Total = $51,200**	
All Actions				**Total = $52,700**	**Cost of new projects to be determined**

Abbreviations of EDT Survival Factors for the Sandy River Basin:
Channel Stability = CS; Chemicals = C; Flow = Fl; Food = Fo; Habitat Diversity = HD; Harassment/Poaching = H/P; Obstructions = O; Predation = P; Sediment Load = SL; Temperature = T; Withdrawals = W; Key Habitat Quantity = HQ.

Table 4.9. Zigzag River (9).

HIERARCHICAL RESTORATION STRATEGY	ALTERED WATERSHED PROCESS (FROM WA)	CORRESPONDING LEVEL 3 SURVIVAL FACTORS (FROM EDT)	EDT REACH	RESTORATION ACTIONS (KNOWN)	RESTORATION ACTIONS (NEW)
Tier 1. Reconnect Isolated Habitats	Isolated Side Channels and Off-channel Habitat	HD, HQ	Zigzag 1a, 1b, Camp 1a, 1b	Project 154 – Zigzag 1a, 1b Channel Design ($200,000)	Camp 1a, 1b stream habitat restoration
	Isolated Habitat from Road-Culvert Passage Barriers (3 sites)	O	Henry 1, Little Zigzag 1	Project 141 – Henry 1 Culvert Replacement ($200,000) Project 144 – Little Zigzag 1 Fish Passage ($300,000)	None Identified
Tier 1 Actions				**Sub-Total = $700,000**	
Tier 2. Restore Long Term Processes (Roads, Water Quality, Marine Derived Nutrients, etc.)	Loss of Marine Derived Nutrients	Fo	All reaches, esp. Camp 1a, 1b, 1c, Zigzag 1a, 1b, 1c	Project 136 – Camp 1a, 1b, 1c Carcass Placement ($13,500) Project 159 – Zigzag 1a, 1b, 1c Carcass Placement ($20,000) Project 138 – Camp 1b Road Water Quality Improvement ($5,000)	None Identified
	Increased Fine Sediment from Hwy 26 Sanding, ski area, Camp Creek CG, and summer home spur roads	SL	Camp 1c, Zigzag 1c, Camp 1a, 1b	Project 157 – Zigzag 1a, 1b Road Water Quality Improvement ($10,000) Project 139 – Camp 1c Ski Area Improvement ($30,000) Project 137 – Camp 1b Campground Improvement ($5,000)	Surface summer home spur roads
	Hardening of Streambanks and Channels	CS	Camp 1a, 1b, Zigzag 1a, 1b	Project 135 – Camp 1a, 1b Summer Home Improvement ($315,000) Project 158 – Zigzag 1a, 1b Summer Home Modification ($2,536,000)	None Identified
	Increase in Chemical Concentrations in Water	C	Camp 1a, 1b, Zigzag 1a, 1b	None	Camp 1a, 1b, Zigzag 1a, 1b Summer Home Outreach and Education (improve practices that will aid in reducing use of chemicals and associated runoff)
	Harassment or Disturbance of Spawning Salmon	H/P	Camp 1a, 1b, Zigzag 1a, 1b	Project 134 – Camp 1a/1b Harassment Treatment ($8,000) Project 155 – Zigzag 1a/1b Harassment Prevention ($8,000)	None Identified
Tier 2 Actions				**Sub-Total = $2,950,500**	

Table 4.9 Continued on following page

Abbreviations of EDT Survival Factors for the Sandy River Basin:
Channel Stability = CS; Chemicals = C; Flow = Fl; Food = Fo; Habitat Diversity = HD; Harassment/Poaching = H/P; Obstructions = O; Predation = P; Sediment Load = SL; Temperature = T; Withdrawals = W; Key Habitat Quantity = HQ.

Table 4.9 (*Continued*). Zigzag River (9).

HIERARCHICAL RESTORATION STRATEGY	ALTERED WATERSHED PROCESS (FROM WA)	CORRESPONDING LEVEL 3 SURVIVAL FACTORS (FROM EDT)	EDT REACH	RESTORATION ACTIONS (KNOWN)	RESTORATION ACTIONS (NEW)
Tier 3. Restore Long Term Processes (Riparian Vegetation)	Lack of Riparian LWD Recruitment	HD, CS	All reaches, esp. Camp 1a, 1b, 1c Henry 1, Lady 1 Zigzag 1a, 1b, 1c	Project 143 – Lady 1 Riparian Enhancement ($9,000) Project 156 – Zigzag 1a, 1b Riparian Easement ($184,800)	Camp 1a, 1b, 1c Riparian Enhancement (promote planting, hardwood conversion, and thinning)
	Mod. of Riparian Stand Structure & Comp. due to Summer Homes and/or Rock Pits	HD, CS, SL	Camp 1a, 1b Zigzag 1a, 1b Little Zigzag 1	Projects 135 and 158 listed above Project 145 – Little Zigzag 1 Rockpit Rehabilitation ($10,000)	Camp 1b Laurel Hill Rock Pit Rehabilitation
	Invasion of Noxious Weeds	SL, HD	Zigzag 1a, 1b, Camp 1a, 1b, Henry 1, Devils Canyon 1a, Lady 1, Little Zigzag 1	None	Identify new sites along summer homes including access roads and Highway 26 based on updated inventories and implement eradication treatments
Tier 3 Actions				**Sub-Total = $203,800**	
Tier 4. Restore Short Term Processes (In-stream Habitat)	Lack of Instream LWD and Loss of Aquatic Habitat Diversity	HD, HQ, CS	All reaches, esp. Zigzag 1a, 1b, Camp 1a, 1b, 1c, Henry 1, Little Zigzag 1	Project 154 – Zigzag 1a, 1b Channel Design (cost listed above)	Camp 1a, 1b, 1c LWD Additions Henry 1 LWD Additions Little Zigzag 1 LWD Additions Remap FEMA floodplain using LIDAR or other techniques that will assist county land use planning to prevent further residential encroachment Educate floodplain homeowners about healthy river processes and the importance of instream woody material
Tier 4 Actions				**Sub-Total = included in Tier 1**	
All Actions				**Total = $3,854,300**	**Cost of new projects to be determined**

Abbreviations of EDT Survival Factors for the Sandy River Basin:
Channel Stability = CS; Chemicals = C; Flow = Fl; Food = Fo; Habitat Diversity = HD; Harassment/Poaching = H/P; Obstructions = O; Predation = P; Sediment Load = SL; Temperature = T; Withdrawals = W; Key Habitat Quantity = HQ.

Table 4.10. Lower Bull Run River (10) [downstream from City of Portland Water Bureau Headworks Project].

HIERARCHICAL RESTORATION STRATEGY	ALTERED WATERSHED PROCESS (FROM WA)	CORRESPONDING LEVEL 3 SURVIVAL FACTORS (FROM EDT)	EDT REACH	RESTORATION ACTIONS (KNOWN)	RESTORATION ACTIONS (NEW)
Tier 1. Reconnect Isolated Habitats	Isolated Habitat from Road-Culvert Passage Barriers	O	Bull Run 1-4	Project 36 – Bull Run 3 Walker Creek Culvert Replacement ($260,000)	None Identified
Tier 1 Actions				**Sub-Total = $260,000**	
Tier 2. Restore Long Term Processes (Roads, Water Quality, Marine Derived Nutrients, etc.)	Loss of Marine Derived Nutrients	Fo	Bull Run 1-4	None	Bull Run 1-4 Salmon Carcass Enrichment
	Altered Flow Regime	Fl	Bull Run 1-4	Project 35 – Bull Run 2, 3 Steelhead Spawning Flows and Winter Rearing Habitat (per AIP for HCP) Project 39 – Bull Run Dams – Improvement of Lower Bull Run Water Quality (per AIP for HCP)	City of Portland Water Bureau to implement Flow and Water Temperature Commitments in Bull Run 1-4 as per AIP for HCP
	Altered LWD and Sediment Routing	HQ, S, CS	Bull Run 1-4	Project 34 – Bull Run 2, 3 Spawning Gravel Placements (per AIP for HCP)	Bull Run Res. No. 1 LWD Stockpiling and transportation to other sites in the Sandy River Basin
Tier 2 Actions				**Sub-Total = per AIP for HCP**	
Tier 3. Restore Long Term Processes (Riparian Vegetation)	Elevated Stream Temperature	T	Bull Run 1-4	Project 38 – Bull Run Dam 2 Tower Improvements (per AIP for HCP)	City of Portland Water Bureau to implement Flow and Water Temperature Commitments in Bull Run 1-4 as per AIP for HCP
	Lack Riparian LWD Recruitment	HD, CS	Bull Run 1-4	Project 43 – Bull Run 1-3 Preservation-Riparian Habitat Action (per AIP for HCP)	None Identified
	Invasion of Noxious Weeds	SL, HD	Bull Run 1-4	Project 32 – Bull Run 1 Preservation-Noxious Weed Control ($4,500)	None Identified
Tier 3 Actions				**Sub-Total = $4,500**	
Tier 4. Restore Short Term Processes (In-stream Habitat)	Lack of in-stream LWD, Habitat simplification	HD, HQ, CS	Bull Run 1-4	Project 34 – Bull Run 2, 3 Spawning Gravel Placements; as amended in developing HCP (per AIP for HCP)	Investigate Opportunity for Bull Run 4 LWD Placement, if feasible then implement treatment
Tier 4 Actions				**Sub-Total = per AIP for HCP**	
All Actions				**Total = $264,500**	**Cost of new projects to be determined**

Abbreviations of EDT Survival Factors for the Sandy River Basin:
Channel Stability = CS; Chemicals = C; Flow = Fl; Food = Fo; Habitat Diversity = HD; Harassment/Poaching = H/P; Obstructions = O; Predation = P; Sediment Load = SL; Temperature = T; Withdrawals = W; Key Habitat Quantity = HQ.

Table 4.11. Beaver Creek (11).

HIERARCHICAL RESTORATION STRATEGY	ALTERED WATERSHED PROCESS (FROM WA)	CORRESPONDING LEVEL 3 SURVIVAL FACTORS (FROM EDT)	EDT REACH	RESTORATION ACTIONS (KNOWN)	RESTORATION ACTIONS (NEW)
Tier 1. Reconnect Isolated Habitats	Isolated Habitat from Road-Culvert Passage Barriers	O	Beaver 2, Kelly 1	Project 14 – Beaver Creek Culvert Replacements; 8 sites ($7,500,000) Project 19 – Kelly 1 Culvert Replacements; 3 sites ($3,000,000)	Identify Pvt. Road and non-inventoried culvert barriers for anadromous fish species. Validate upper distribution of historical anadromy on Beaver Creek. Determine if addt'l culvert barrier projects exist.
Tier 1 Actions				**Sub-Total = $10,500,000**	
Tier 2. Restore Long Term Processes (Roads, Water Quality, Marine Derived Nutrients, etc.)	Increased fine sediment delivery, mass wasting, and hydrologic impacts relating to upper basin roads	SL, CS	Beaver 1a, 1b, 1c, 1d (including tributaries)	Project 10 – Beaver 1 (Sesters) Riparian Improvement Project ($230,000) Project 15 – Beaver Creek Detention Retrofit Project ($300,000)	Stormwater detention/ treatment to reduce non-point source inputs, Beaver Creek Headwaters Riparian Easement (expand scope of Project 10)
	Elevated chemical concentrations	C	Beaver 1a, 1b, 1c, 1d (including tributaries)	Project 13 – Beaver Creek Basin Flow Moderation ($3,000,000) Project 16 – Beaver Creek Water Quality Retrofit Project ($300,000) Project 20 – Kelly 1 Flow Moderation ($750,000)	Stormwater detention/ treatment to reduce non-point source inputs Address point source pollutants from nursery/ agriculture operations in upper Beaver Creek.
	Loss of Marine Derived Nutrients	Fo	Beaver 1a, 1b, 1c, 1d (including tributaries)	None	Assess current nutrient levels especially nitrogen which may be elevated due to fertilizers and septic systems. If warranted, implement carcass enrichment projects in Beaver 1 a, 1b, 1c, 1d.
	Reduced Dissolved Oxygen	Ox	Beaver 1a, 1b, 1c, 1d	See riparian projects below	None Identified
Tier 2 Actions				**Sub-Total = $4,580,000**	

Table 4.11 Continued on following page

Abbreviations of EDT Survival Factors for the Sandy River Basin:
Channel Stability = CS; Chemicals = C; Flow = Fl; Food = Fo; Habitat Diversity = HD; Harassment/Poaching = H/P; Obstructions = O; Predation = P; Sediment Load = SL; Temperature = T; Withdrawals = W; Key Habitat Quantity = HQ.

Table 4.11 (*Continued*). Beaver Creek (11).

HIERARCHICAL RESTORATION STRATEGY	ALTERED WATERSHED PROCESS (FROM WA)	CORRESPONDING LEVEL 3 SURVIVAL FACTORS (FROM EDT)	EDT REACH	RESTORATION ACTIONS (KNOWN)	RESTORATION ACTIONS (NEW)
Tier 3. Restore Long Term Processes (Riparian Vegetation)	Elevated stream temperature	T	Beaver 1a, 1b, 1c, 1d (including tributaries)	Project 10 – Beaver 1 (Sesters) Riparian Improvement Project (cost listed above) Project 11 - Beaver 1a Riparian Enhancement Project ($12,000) Project 18 - Burlingame 1 Riparian Improvement Project ($18,000) Project 21 - South Fork Beaver Creek Riparian Preservation ($155,000) Project 17 – Beaver Creek Water Temperature Control Project ($18,000)	None Identified
	Lack of Riparian LWD Recruitment	HD, CS, HQ	All Beaver Creek reaches (including tributaries)	All projects listed above addressing elevated stream temperature also address lack of riparian LWD recruitment.	None Identified
	Invasion of Noxious Weeds	SL, HD	Beaver 1a, 1b, 1c, 1d, Burlingame1, Kelly 1	None	Identify new sites based on updated inventories and implement eradication treatments
Tier 3 Actions				**Sub-Total = $203,000**	
Tier 4. Restore Short Term Processes (In-stream Habitat)	Lack of in-stream LWD, Habitat simplification, Channelization	HQ, HD, CS	Beaver 1, 2	Project 12 - Beaver 1c, 1d LWD Placement ($80,000)	None Identified
Tier 4 Actions				**Sub-Total = $80,000**	
All Actions				**Total = $15,363,000**	**Cost of new projects to be determined**

Abbreviations of EDT Survival Factors for the Sandy River Basin:
Channel Stability = CS; Chemicals = C; Flow = Fl; Food = Fo; Habitat Diversity = HD; Harassment/Poaching = H/P; Obstructions = O; Predation = P; Sediment Load = SL; Temperature = T; Withdrawals = W; Key Habitat Quantity = HQ.

Table 4.12 Clear Creek (12).

HIERARCHICAL RESTORATION STRATEGY	ALTERED WATERSHED PROCESS (FROM WA)	CORRESPONDING LEVEL 3 SURVIVAL FACTORS (FROM EDT)	EDT REACH	RESTORATION ACTIONS (KNOWN)	RESTORATION ACTIONS (NEW)
Tier 1. Reconnect Isolated Habitats	Isolated Side Channels and Off-channel Habitats	HD, HQ	Clear 1a, 1b, Little Clear 1, Sandy 9	Project 119 - Clear 1a Channel Design ($200,000)	Clear 1b and Little Clear Creek reconnect and enhance side channels Sandy 9 floodplain reconnection (i.e., remove bank revetment and riprap), working with private land owners in reach.
	Isolated Habitats from Road-Culvert Passage Barriers	O	Little Clear 1	Project 127 - Little Clear 1 Culvert Replacement ($100,000)	None Identified
Tier 1 Actions				**Sub-Total = $300,000**	
Tier 2. Restore Long Term Processes (Roads, Water Quality, Marine Derived Nutrients, etc.)	Loss of Marine Derived Nutrients	Fo	All EDT reaches	Project 123 - Clear 1a, 1b Carcass Placement ($3,710)	Salmon carcass enrichment treatments in other reaches
	Increased Fine Sediment from channel entrenchment and native surface roads	SL, CS	Clear 1a, Little Clear 1, Sandy 9	None	Surface and/or stormproof native surface roads
Tier 2 Actions				**Sub-Total = $3,710**	
Tier 3. Restore Long Term Processes (Riparian Vegetation)	Modification of Riparian Stand Structure and Composition due to Disp. CG's, Power Line Right-of-Way, Private land Mod.	HD, HQ	Clear 1a, 1b, Sandy 9, Little Clear 1	Project 116 – Sandy 9 Riparian Improvement ($420,000) Project 120 – Clear 1a Powerline Treatment ($5,000) Project 121 – Clear 1a Riparian Easement ($406,000) Project 128 – Little Clear 1 Riparian Enhancement ($14,400) Project 114 – Sandy 9 Dispersed Campground Improvement ($15,000)	Clear 1a, 1b, and Little Clear 1 Riparian stand improvements Work with private land owners along Sandy 9 to improve riparian stand conditions
	Invasion of Noxious Weeds	HD, CS	Sandy 9, Clear 1a, 1b, Little Clear 1	Project 115 – Sandy 9 Noxious Weed Prevention ($9,000)	Noxious Weed Control Clear 1a, 1b and Little Clear 1
Tier 3 Actions				**Sub-Total = $869,400**	
Tier 4. Restore Short Term Processes (In-stream Habitat)	Lack of Instream LWD and Loss of Habitat Diversity	HD, HQ	Sandy 9, Clear 1a, 1b, Little Clear 1	Project 119 - Clear 1a Channel Design (cost listed above)	LWD placement in Sandy 9 LWD placement in Clear 1b LWD placement in Little Clear 1.
Tier 4 Actions				**Sub-Total = included in Tier 1**	
All Actions				**Total = $1,173,110**	**Cost of new projects to be determined**

Table 4.13. Cedar Creek (13) [including inaccessible portion of watershed above ODFW Fish Hatchery weir]

HIERARCHICAL RESTORATION STRATEGY	ALTERED WATERSHED PROCESS (FROM WA)	CORRESPONDING LEVEL 3 SURVIVAL FACTORS (FROM EDT)	EDT REACH	RESTORATION ACTIONS (KNOWN)	RESTORATION ACTIONS (NEW)
Tier 1. Reconnect Isolated Habitats	Isolated Habitat from ODFW Hatchery Weir	O	Cedar 1	Project 79 – Cedar 1 Sort and Pass Wild Fish at Cedar Creek Hatchery ($5,200,000 for facility improvements only)	None Identified
	Isolated Side Channels	HQ, HD	Cedar 2-4	None	Cedar 2-4 Side Channel Enhancement Inventory
Tier 1 Actions				**Sub-Total = $5,200,000**	
Tier 2. Restore Long Term Processes (Roads, Water Quality, Marine Derived Nutrients, etc.)	Decreased summer flows	Fl, T	Cedar 1-3	Project 82 – Cedar Creek Purchase Water Rights ($750,000)	Inventory other water diversions, identify restoration actions
	Elevated stream temperature	T	Cedar 1-4	Project 82 – Cedar Creek Purchase Water Rights (cost listed above) Project 81 – Cedar 2, 3 Riparian Improvement ($29,000)	Cedar 4 Riparian Improvement Inventory
			Beaver (Cedar trib.)	None	Inventory possible Beaver Creek Riparian Improvements, implement restoration actions
Tier 2 Actions				**Sub-Total = $779,000**	
Tier 3. Restore Long Term Processes (Riparian Vegetation)	Loss of Marine Derived Nutrients	Fo	Cedar 1-4	None	Assess current nutrient levels especially nitrogen which may be elevated due to fertilizers and septic systems. If feasible, implement Cedar 1-4 salmon carcass enrichment
	Harassment and Poaching	H/P	Cedar 1	None	Cedar 1 Harassment and Poaching Prevention
	Invasion of Noxious Weeds	SL, HD	Cedar 1-4	Project 77 – Cedar 1 Preservation – Noxious Weed Control ($4,500)	Cedar 2-4 Noxious Weed Inventory and Control Cedar 1-3 Riparian Easement and Improvement Cedar 4 Riparian Improvement
	Lack of Riparian LWD Recruitment	HD, CS	Cedar 1-4	Project 81 – Cedar 2, 3 Riparian Improvement (cost listed above)	None Identified
Tier 3 Actions				**Sub-Total = $4,500**	
Tier 4. Restore Short Term Processes (In-stream Habitat)	Lack of instream LWD, Habitat Simplification	HD, CS	Cedar 1-4	Project 80 – Cedar 2, 3 LWD Placement; evaluate and implement opportunities to improve off-channel habitats ($320,000)	Cedar 1, 4 LWD Placement (evaluate and implement opportunities to improve off-channel habitats)
	Channelization due to Riprap and bank hardening	HD, CS	Cedar 2	None	Evaluate opportunities to reduce or replace bank hardening structures.
Tier 4 Actions				**Sub-Total = $320,000**	
All Actions				**Total = $6,303,500**	**Cost of new projects TBD**

Table 4.14. Misc. Tributaries to Sandy River Mainstem (14): Non-Anchor Habitat.

HIERARCHICAL RESTORATION STRATEGY	ALTERED WATERSHED PROCESS (FROM WA)	CORRESPONDING LEVEL 3 SURVIVAL FACTORS (FROM EDT)	EDT REACH	RESTORATION ACTIONS (KNOWN)	RESTORATION ACTIONS (NEW)
Tier 1. Reconnect Isolated Habitats	Reconnection of Isolated Habitats and Off-channel Habitat	O	Buck 1, Hackett 1	Project 24 – Buck Creek Bridge ($2,000,000)	Inventory culvert-related fish passage problems along Hackett Creek; identify, prioritize, and implement projects Hackett 1 Wetland/Side Channel Reconnection
Tier 1 Actions				**Sub-Total = $2,000,000**	
Tier 2. Restore Long Term Processes (Roads, Water Quality, Marine Derived Nutrients, etc.)	Increased fine sediment delivery, mass wasting, and hydrologic impacts relating to upper basin roads	SL, CS	Bear 1, Buck 1, Hackett 1, N. Boulder 1	Project 133 – North Boulder Settling Pond ($300,000)	Survey and assess sediment sources and implement remediation actions
	Loss of Marine Derived Nutrients	Fo	Buck 1	None	Buck 1 Salmon Carcass Enrichment
Tier 2 Actions				**Sub-Total = $300,000**	
Tier 3. Restore Long Term Processes (Riparian Vegetation)	Lack of riparian LWD recruitment	HD, CS	Bear 1, Buck 1, Hackett 1, N.Boulder 1	Project 132 – North Boulder Riparian Enhancement ($203,000)	Inventory and survey project opportunities for riparian area improvements; implement restoration actions
	Invasion of Noxious Weed	HD	Bear 1, Buck 1, Hackett 1, N. Boulder 1	Project 23 – Buck 1 Preservation - Noxious Weed Control ($1,500)	Inventory noxious weed sites on Bear 1, Hackett 1, and N. Boulder 1; implement eradication treatments
Tier 3 Actions				**Sub-Total = $204,500**	
Tier 4. Restore Short Term Processes (In-stream Habitat)	Lack of in-stream LWD, Habitat simplification, Channelization	HQ, HD, CS	Bear 1, Buck 1, Hackett 1, N. Boulder 1	Project 131 – North Boulder LWD Placement ($48,000)	Inventory opportunities for LWD enhancements for Bear 1, Buck 1 Hackett 1, and N. Boulder 1; prioritize and implement projects
Tier 4 Actions				**Sub-Total = 48,000**	
All Actions				**Total = $2,552,500**	**Cost of new projects to be determined**

Abbreviations of EDT Survival Factors for the Sandy River Basin:
Channel Stability = CS; Chemicals = C; Flow = Fl; Food = Fo; Habitat Diversity = HD; Harassment/Poaching = H/P; Obstructions = O; Predation = P; Sediment Load = SL; Temperature = T; Withdrawals = W; Key Habitat Quantity = HQ.

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APPENDIX A

Table A1. Known and Suspected Fish Passage Barriers for Salmon and Steelhead.

STREAM	5TH FIELD WATERSHED	RIVER MILE (RMI) OR RIVER METER (RME)	TYPE OF STRUCTURE	BARRIER (YES OR UNKNOWN)	DATA SOURCE	NOTES
Henry Creek	Zigzag River	RMi 0.33	Culvert	Yes	USFS	Henry Creek Road, Resurveyed 2005
		RMi 5.8	Culvert	Unknown		Arlie Mitchel Road, Need to validate
Little Zigzag River	Zigzag River	RMi 0.4	Culvert	Yes	USFS	Kiwanis Camp
		RMi 0.65	Culvert	Yes	USFS	Kiwanis Camp
Clear Creek	Upper Sandy River	N/A	Culvert	Unknown	USFS	From 1990 stream survey, Need to validate
Little Clear Creek	Upper Sandy River	RMi 0.6	Culvert	Yes	USFS	From 1995 stream survey
Hacket Creek	Middle Sandy River	RMe 98	Culvert	Unknown	ODFW	Dooney Dell Lane, (2) 1.5 m diameter
		RMe 215	Culvert	Unknown	ODFW	E. Relton Lane, (1) 2.0 m diameter
		RMe 280	Bridge	Unknown	ODFW	Barlow Trail Road
		RMe 783	Bridge	Unknown	ODFW	Private Road
		RMe1,156	Culvert	Unknown	ODFW	E. Mtn. Creek Circle, (3) 1.5 m diameter
		RMe 1,296	Foot Bridge	Unknown	ODFW	
		RMe 1,316	Culvert	Unknown	ODFW	Private Road, (3) 1.2 m diameter
		RMe 1,638	Culvert	Unknown	ODFW	E. Hideaway Road, (3) 1.5 m diameter
		RMe 1,803	Foot Bridge	Unknown	ODFW	Private Drive
		RMe 1,980	Bridge	Unknown	ODFW	Private Drive
		RMe 1,990	Culvert	Unknown	ODFW	Private Drive, (3) 1.1 m diameter
		RMe 2,081	Bridge	Unknown	ODFW	Private Drive
		RMe 2,140	Foot Bridge	Unknown	ODFW	Private Drive
		RMe 2,157	Foot Bridge	Unknown	ODFW	Private Drive
		RMe 2,175	Foot Bridge	Unknown	ODFW	Private Drive
		RMe 2,387	Bridge	Unknown	ODFW	Private Drive
		RMe 2,412	Bridge	Unknown	ODFW	Private Drive
		RMe 2,517	Bridge	Unknown	ODFW	Private Drive
		RMe 2,579	Bridge	Unknown	ODFW	Private Drive
		RMe 3,021	Culvert	Unknown	ODFW	Private Drive, (1) 1.2 m diameter
		RMe 3,200	Culvert	Unknown	ODFW	Private Drive
		RMe 3,326	Culvert	Unknown	ODFW	1 culvert for pond
Alder Creek	Middle Sandy River	RMe 143	Weir	Unknown	ODFW	Weir
		RMe 1,729	Weir	Unknown	ODFW	City of Sandy wooden weir
Whiskey Creek	Middle Sandy River	RMe 428	Bridge	Yes	ODFW	Beginning of Trout Farm
		RMe 428	Culvert	Yes	ODFW	Trout Farm
		RMe 507	Culvert	Yes	ODFW	Trout Farm
		RMe 544	Culvert	Yes	ODFW	Trout Farm
		RMe 1,130	Culvert	Unknown	ODFW	Hwy 26 crossing, rectangular culvert
Cedar Creek	Middle Sandy River	RMe 1,610	Weir	Yes	ODFW	Sandy Hatchery Weir
		RMe 2,031	Bridge	Yes	ODFW	
		RMe 2,471 Bridge	Yes	ODFW	Ten Ecke Road	
		RMe 3,447 Bridge	Yes	ODFW	Coalman Road	
		RMe 3,661 Bridge	Yes	ODFW	Walking Bridge	
		RMe 3,704 Bridge	Yes	ODFW	Private Bridge	
		RMe 4,038 Bridge	Yes	ODFW	Private Bridge	
		RMe 4,490 Bridge	Yes	ODFW	Private Bridge	
		RMe 4,562 Bridge	Yes	ODFW	Private Bridge	

Table A1 (*Continued*). Known and Suspected Fish Passage Barriers for Salmon and Steelhead.

STREAM	5TH FIELD WATERSHED	RIVER MILE (RMI) OR RIVER METER (RME)	TYPE OF STRUCTURE	BARRIER (YES OR UNKNOWN)	DATA SOURCE	NOTES
Cedar Creek	Middle Sandy River	RMe 4,901	Bridge	Yes	ODFW	Private Bridge
		RMe 5,977	Bridge	Yes	ODFW	Private Bridge
		RMe 8,717	Bridge	Yes	ODFW	Private Bridge
		RMe 9,701	Bridge	Yes	ODFW	Foot Bridge
		RMe 10,255	Bridge	Yes	ODFW	Highway 26 Bridge (1 of 2)
		RMe 10,282	Bridge	Yes	ODFW	Highway 26 Bridge (2 of 2)
		RMe 10,646	Bridge	Yes	ODFW	Private Bridge
		RMe 11,124	Bridge	Yes	ODFW	Private Bridge
		RMe 11,709	Bridge	Yes	ODFW	Private Bridge
		RMe 13,163	Bridge	Yes	ODFW	Logging Bridge
		RMe 13,368	Bridge	Yes	ODFW	Foot Bridge
		RMe 19,971	Culvert	Yes	USFS	FS Road 3090, open-bottom arch
		RMe 21,089	Culvert	Yes	USFS	FS Road 3401, 2.7 m diameter
Sandy River	Middle Sandy River	RMi 30.0	Dam	Partial	PGE	PGE hydroelectric diversion dam, to be decommissioned in 2007
Little Sandy River	Bull Run River	RMi 1.7	Dam	Yes	PGE	PGE hydroelectric diversion dam, to be decommissioned in 2008
Buck Creek	Lower Sandy River	RMi 0.1	Culvert	Unknown	SRBTT	
		RMi 1.0	Culvert	Yes	Mult. Co.	Deverell Road M.P. 0.248
		RMi 3.0	Culvert	Yes	Mult. Co.	Deverell Road M.P. 1.879
		RMi 4.0	Culvert	Yes	Mult. Co.	Gordon Creek Road M.P. 1.271
Beaver Creek	Lower Sandy River	RMi 2.0	Culvert	Yes	Mult. Co.	Troutdale Road M.P. 2.476
		RMi 2.4	Culvert	Yes	Mult. Co.	Stark Street M.P. 1.129
		RMi 3.2	Culvert	Yes	Mult. Co.	Division Street M.P. 2.109
		RMi 3.2	Culvert	Yes	Mult. Co.	Division Street M.P. 1.763
		RMi 3.3	Culvert	Yes	Mult. Co.	Cochrane Road M.P. 0.096
		RMi 4.6	Culvert	Yes	Mult. Co.	Troutdale Road M.P. 0.815
		RMi 4.6	Culvert	Yes	Mult. Co.	Division Street M.P. 0.940
		RMi 6.1	Culvert	Yes	Mult. Co.	302nd M.P. 2.066
		RMi (unknown)	Culvert	Yes	Mult. Co.	Oxbow Drive M.P. 1.228, need to verify river mile location
		RMi 7.5	Culvert	Yes	Mult. Co.	Oxbow Drive M.P. 1.513
		RMi 8.3	Culvert	Yes	Mult. Co.	Lusted Road M.P. 3.015
Burlingame Creek	Lower Sandy River					None documented, Mt. Hood CC pond?
Kelly Creek	Lower Sandy River	RMi 1.0	Culvert	Yes	Mult. Co.	257th M.P. 2.790
		RMi 1.2	Culvert	Yes	Mult. Co.	282nd M.P. 0.840
		RMi 2.0	Culvert	Yes	Mult. Co.	Division Street M.P. 0.482

Data compiled by: Steve Kucas (City of Portland Water Bureau), Todd Alsbury (Oregon Department of Fish and Wildlife), and Duane Bishop (U.S. Forest Service) on July 26, 2005. **Data Sources:** Mult. Co. Fish Passage Culvert Project Scores (Multnomah County Fish Passage Culvert Projects. 2001. Multnomah County Transportation Division, Portland, Oregon); Clackamas Co. Fish Passage Projects 2004 (Prioritizing Fish Passage Projects in Clackamas County. 2004. Clackamas County Salmon Recovery Team, Oregon City, Oregon); City of Portland Water Bureau Stream Surveys (Summary of Sandy River Basin Culvert Surveys. 2001. Technical Memorandum, Beak Consultants, Inc., City of Portland Bureau of Water Works, Portland, Oregon); ODFW Statewide Fish Barrier Survey (Oregon Fish Passage Barriers Survey. 2005. Natural Resources Information Management Program. Oregon Department of Fish and Wildlife, Salem, Oregon); and USFS Stream and Culvert Surveys 1990-2005 (Fish Passage at Road Crossings Assessment. Project Completion Report 1999-2001. Mt. Hood National Forest, Sandy, Oregon).

APPENDIX B

ZIGZAG RIVER WATERSHED CASE STUDY ON ASSESSING ROAD-RELATED IMPACTS

The Working Group recognized the importance of addressing road-related restoration actions. These actions would include such things as increased road maintenance, storm-proofing, decommissioning, and road upgrades to improve hydrologic conditions within watersheds and reduce sediment production and delivery. However, the Working Group lacked the time and resources to conduct a complete assessment of road-related impacts in all portions of the basin and identify potential actions. The only portions of the basin where data and information are readily available in GIS to complete such an assessment are on federal lands under Forest Service administration. As such, the Working Group was unable to identify specific road-related restoration actions, other than those pertaining to restoring fish passage included under Tier 1 actions. At a future time, the Working Group will need to review the various roads within the basin and identify specific restoration actions. To provide a framework for completing this future work, a case study on the Zigzag River watershed was completed using existing information available from the recent analysis of Forest Service roads on the Mt. Hood National Forest (USFS 2003) and the 2004 Zigzag River Watershed Analysis Revision (USFS 2004). The case study uses watershed-specific information and data to identify particular road segments that are high risk for deleterious impacts to the aquatic ecosystem. From this detailed, watershed-specific assessment of road-related impacts, specific restoration actions for entire roads or road segments can be identified and brought forward for consideration. The case study provides a template for assessing road-related impacts and identifying road-related restoration actions in other watersheds throughout the basin.

USFS (2003) completed an analysis of Forest Service roads throughout the entire Mt. Hood National Forest. The objective of this analysis was to yield information that will allow the Forest Service to manage the Forest transportation system in a manner that provides for user safety, convenience, and efficiency of operations in an environmentally responsible manner and to achieve road-related ecosystem restoration within current and predicted future funding levels. The analysis addressed the access benefits and ecological costs of road-associated effects. It also identified priorities for reconstructing and maintaining needed roads, decommissioning unneeded roads, or, where appropriate, converting them to other less costly and more environmentally beneficial uses (i.e., conversion of roads to trails). A primary component of the analysis was to assess the impacts of roads on the condition of aquatic systems. To do so, several aquatic key questions were addressed. The pertinent aquatic key questions to this case study are:

- Where do roads affect riparian areas and floodplains?
- Where do roads affect slope stability?
- Where do roads generate excessive surface erosion?
- Where do roads create more rapid runoff and sediment delivery?
- Where do roads affect wetlands?

One question (Where do roads impede fish passage?) was not incorporated into the case study provided herein since this issue is dealt with separately in the Roni et al. (2002) hierarchical framework described above.

Where Do Roads Affect Riparian Areas and Floodplains?

Roads located near streams have the potential to affect stream processes by disrupting how riparian areas and floodplains function. Examples include removal of streamside vegetation resulting in loss of shade and wood recruitment, restricting lateral channel migration, and disconnecting the main channel from its secondary channels and off-channel habitats. To determine the influence that valley bottom roads and other roads located within riparian areas can have on stream processes and the relative magnitude of how these may affect fish, a GIS map was created of all road segments within 200 feet of a stream channel (perennial, intermittent, and ephemeral) within the watershed. Road segments located within 200 feet of a stream channel were assigned a score dependent upon their direct association with fish habitat: anadromous fish-bearing stream (10); resident fish-bearing stream (5); and non-fish bearing stream (2). Figure B1 shows these road segments and their proximity to fish habitat for the Zigzag River watershed.

Where Do Roads Affect Slope Stability?

Roads located in geologically unstable areas can reduce hillslope stability, thereby increasing the frequency and magnitude of landslides in a watershed. Increased sediment delivery to aquatic systems from mass wasting can negatively affect habitat for salmon and steelhead. Forest Geologist Tom DeRoo with the Mt. Hood National Forest mapped the watershed's landslide hazard risk based on several factors including landform type and slope steepness. Landslide hazard risk is assessed as low, medium, or high. To investigate the potential for roads affecting slope stability, GIS was used to overlay the existing road network with the landslide hazard mapping of the watershed. Specific road segments were then categorized by landslide hazard risk. Each road segment was assigned a score dependent upon its landslide hazard risk: low (1), medium (4), and high (10). Figure B2 shows the existing road network in contrast with the landslide hazard mapping for the Zigzag River watershed.

Figure B1. Zigzag River watershed roads within 200 feet of streams.

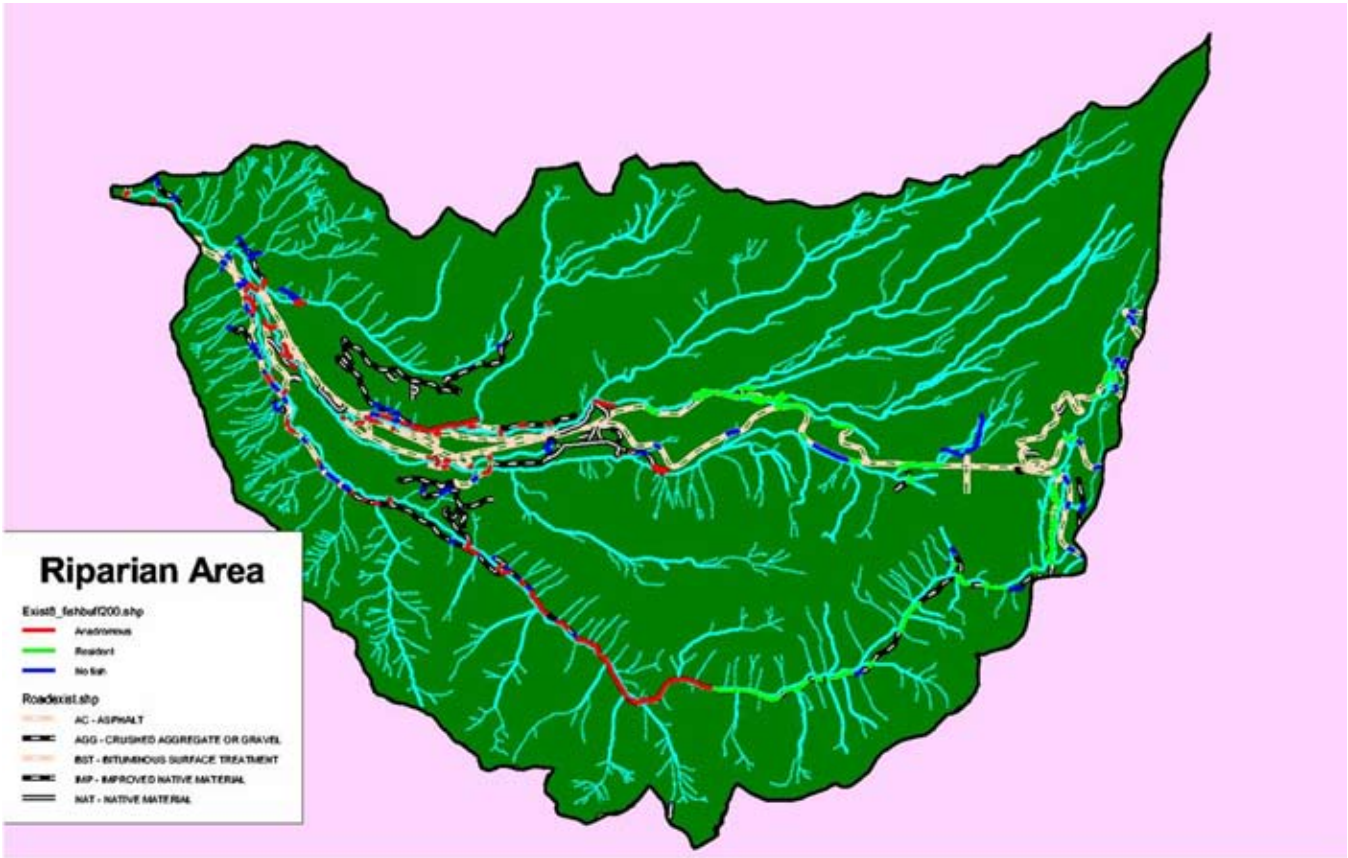
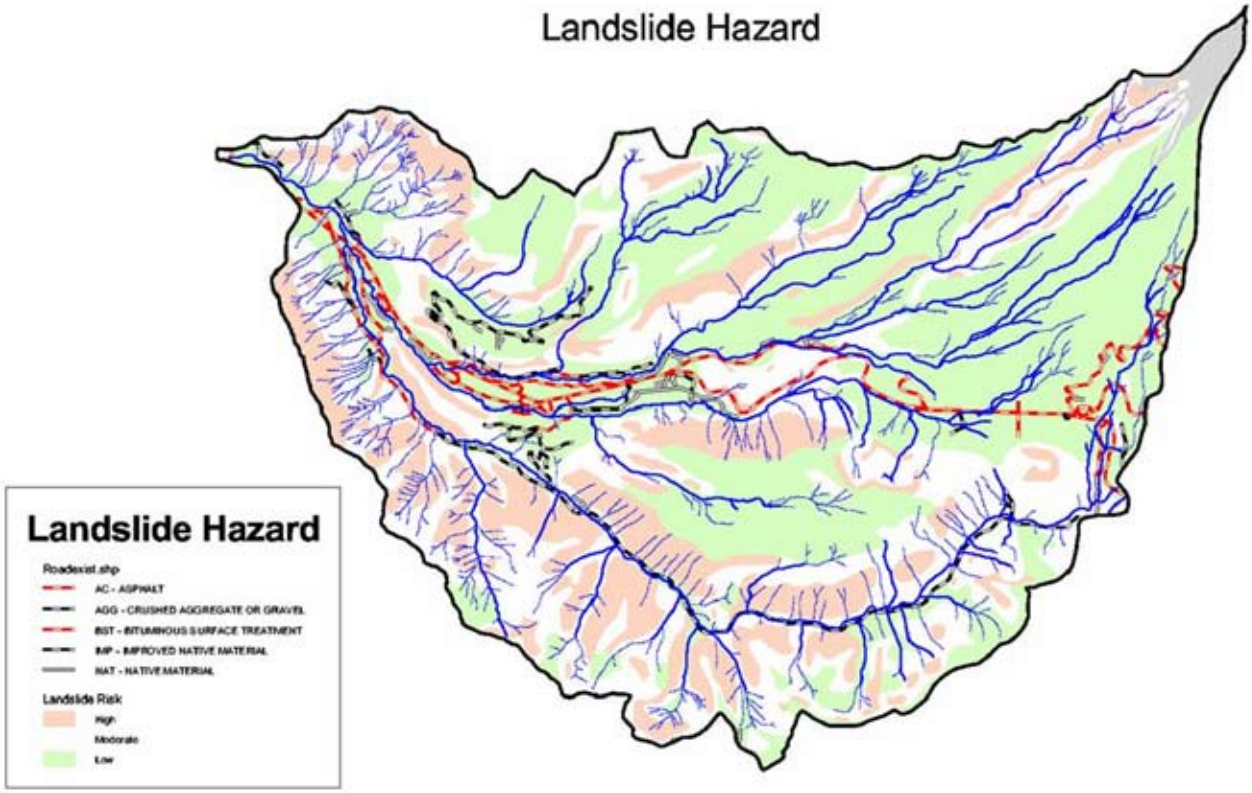


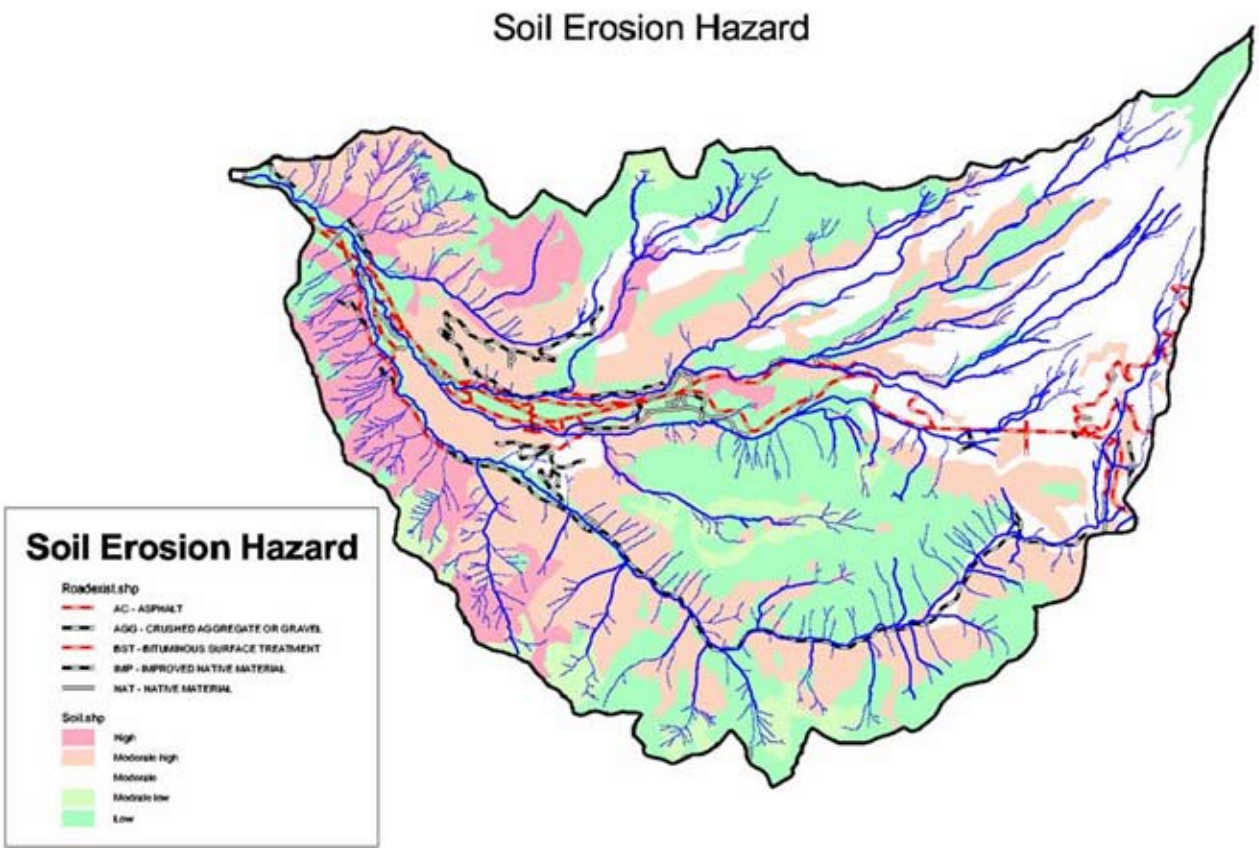
Figure B2. Zigzag River watershed landslide hazard of roads.



Where Do Roads Generate Excessive Surface Erosion?

Surface erosion is another type of erosion process by which roads produce sediment. As with sediment delivered from road-related landslides, sediment from roads generated by surface erosion can also negatively affect habitat for salmon and steelhead. A soil resource inventory (SRI) was completed for the Mt. Hood National Forest in 1978. One of the management interpretations included in the SRI is "cut-slope and fill-slope erosion potential." This was selected as the most appropriate management interpretation to use during the roads analysis process (USFS 2003) to approximate the surface erosion hazard of roads. Surface erosion hazard is assessed as one of five categories: low, low-medium, medium, medium-high, and high. To identify particular roads or road segments with a surface erosion concern, GIS was used to overlay the existing road network with the watershed's surface erosion hazard. Specific road segments were then categorized by surface erosion hazard. Road segments were assigned scores dependent upon their surface erosion hazard: low (2); low-medium (4); medium (6); medium-high (8); and high (10). Figure B3 shows the existing road network overlaying the surface erosion hazard for the Zigzag River watershed.

Figure B3. Zigzag River watershed surface erosion hazard of roads.



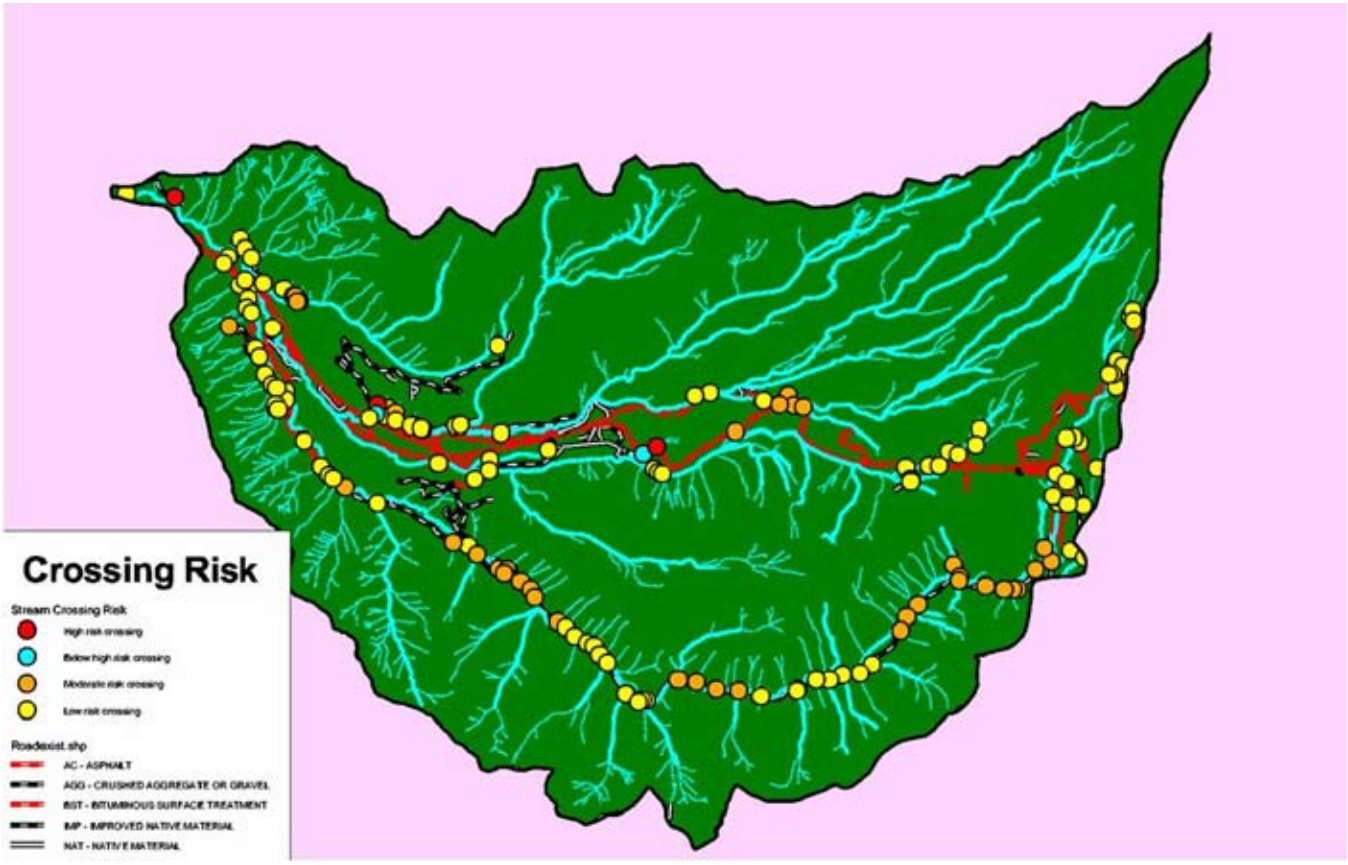
Where Do Roads Create More Rapid Runoff and Sediment Delivery?

USFS (2003) used three separate indicators to evaluate which roads or road segments in a watershed create more rapid runoff and sediment delivery: hydrologic hazard, high risk stream crossings, and stream crossing density.

The transient snow zone (TSZ) was used to evaluate a road's level of risk with regard to hydrologic hazard. Rain-on-snow events can occur in the TSZ, which is defined as the elevation band at which snow accumulates and rapidly melts during rain events several times over the course of a winter. Such hydrologic occurrences tend to result in more rapid, or flashy, flow events and higher stream discharges. A digital elevation model (DEM) was used to map the areas of the Forest that are within the transient snow zone of 1,200 to 3,600 feet elevation. The existing road network was overlaid with the watershed's transient snow zone map using GIS. The hydrologic hazard for individual road segments was assessed and scored as: low – road segment located above TSZ (2); medium – road segment located below TSZ (5); and high – road segment located within TSZ (10).

There are several risk factors to consider in assessing the likelihood that a road may fail at a stream crossing. These include the potential for culvert blowouts, dam-break floods, debris flows, diversions, and cascading failures. Using GIS, all perennial and intermittent stream crossings located on high landslide-risk terrain were identified. Each road segment was then scored with respect to the level of risk for catastrophic road failure at stream crossings as follows: no stream crossing (0); intermittent stream crossing not located on high landslide-risk terrain (5); intermittent stream crossing located downstream of a stream crossing on high landslide-risk terrain (6); intermittent stream crossing located on high landslide-risk terrain and perennial stream crossing not located on high landslide-risk terrain (7); perennial stream crossing located downstream of a stream crossing on high landslide-risk terrain (8); and perennial stream crossing located on high landslide-risk terrain (10). Figure B4 shows the perennial and intermittent stream crossings by level of risk for catastrophic road failure for the Zigzag River watershed.

Figure B4. Zigzag River watershed road-stream crossing failure risk.



Stream crossing density was the third indicator used to evaluate which roads or road segments in the watershed create more rapid runoff and sediment delivery. Key factors tied to stream crossing density are stream channel network expansion and stream crossing failure. GIS was used to quantify the number of times roads intersected streams within each 7th field watershed. These results were then divided by watershed area in square miles in order to normalize values between 7th field watersheds of different sizes. Watersheds, and the roads or road segments within them, were rated into one of five categories and scored as follows: very low – 0-1 stream crossing/mi2 (2); low – 2-4 stream crossings/mi2 (4); moderate – 5-7 stream crossings/mi2 (6); high – 8-12 stream crossings/mi2 (8); and very high – 13-21 stream crossings/mi2 (10). Figure B5 shows the stream crossing density and associated risk for the Zigzag River watershed.

Where Do Roads Affect Wetlands?

Roads in close proximity to wetlands have the potential to adversely affect these sensitive areas. The presence of roads in wetland areas can alter surface and subsurface movement of water, introduce sediment into wetlands, or provide access for vehicles leaving the roadway and traveling onto wetlands resulting in further damages to wetlands. The majority of wetlands in the Zigzag River Watershed occur in the headwaters of Still and Camp creeks in the form of high elevation meadow-wetland complexes. Each road segment was scored in regards to relative potential impacts to wetlands as follows: no risk – road segment is not within 200 feet of a wetland (0) and high risk – road segment is within a 200 feet of a wetland (10).

What Are Combined Road-Related Effects on Aquatic Systems?

In an effort to take an integrated look at the combined road-related effects on aquatic systems, USFS (2003) assembled a cumulative weighted score for each road segment in a watershed based on the individual factors scored above, referred to as the "aquatic risk composite rating" (ARCR). Each individual factor was weighted based on its estimated relative importance as follows: riparian area/floodplain (weighting factor = 1); landslide hazard (weighting factor = 2); surface erosion hazard (weighting factor = 1); hydrologic hazard (weighting factor = 2); high risk stream crossings (weighting factor = 2); stream crossing density (weighting factor = 2); wetlands (weighting factor = 1); and fish passage (weighting factor = 3). USFS (2003) included fish passage as a heavily weighted factor in their (its) roads analysis effort, taking into consideration inventoried culvert-fish passage barriers for both resident and anadromous species. Since, the issue of habitat connectivity (i.e., correction of road-related fish passage barriers) is considered in the first hierarchical step of the Roni et al. (2002) framework utilized in the development of the restoration strategy developed herein, it was not considered as an important element of the Zigzag River watershed case study. Furthermore, the Working Group focused its time and attention on anadromous fish species only, and did not assess habitat restoration needs for resident fish species occurring upstream of the range of anadromous fish distribution. Given the inclusion of fish passage in the aquatic risk composite rating by USFS (2003) and the Working Group's inability to de-couple that factor from the case study analysis, be aware that it is included in the final results below. Therefore, the lowest possible score for a road segment's ARCR is six and the highest is 140. The actual ARCR scores for road segments in the Zigzag River watershed varied from 6 to 126. The higher a road segment's score, the higher potential exists for it to have adverse impacts on aquatic systems. The ARCR for each road segment was translated into one of five categories from low to high using natural breaks in the data distribution as follows: low (ARCR = 6 to 28); low to moderate (ARCR = 29 to 41); moderate (ARCR = 42 to 52); moderate to high (ARCR = 53 to 68); and high (ARCR = 69 to 126). Figure B6 shows the existing road network for the Zigzag River watershed overlaid by the five ARCR score categories.

Figure B5. Zigzag River watershed stream crossing density.

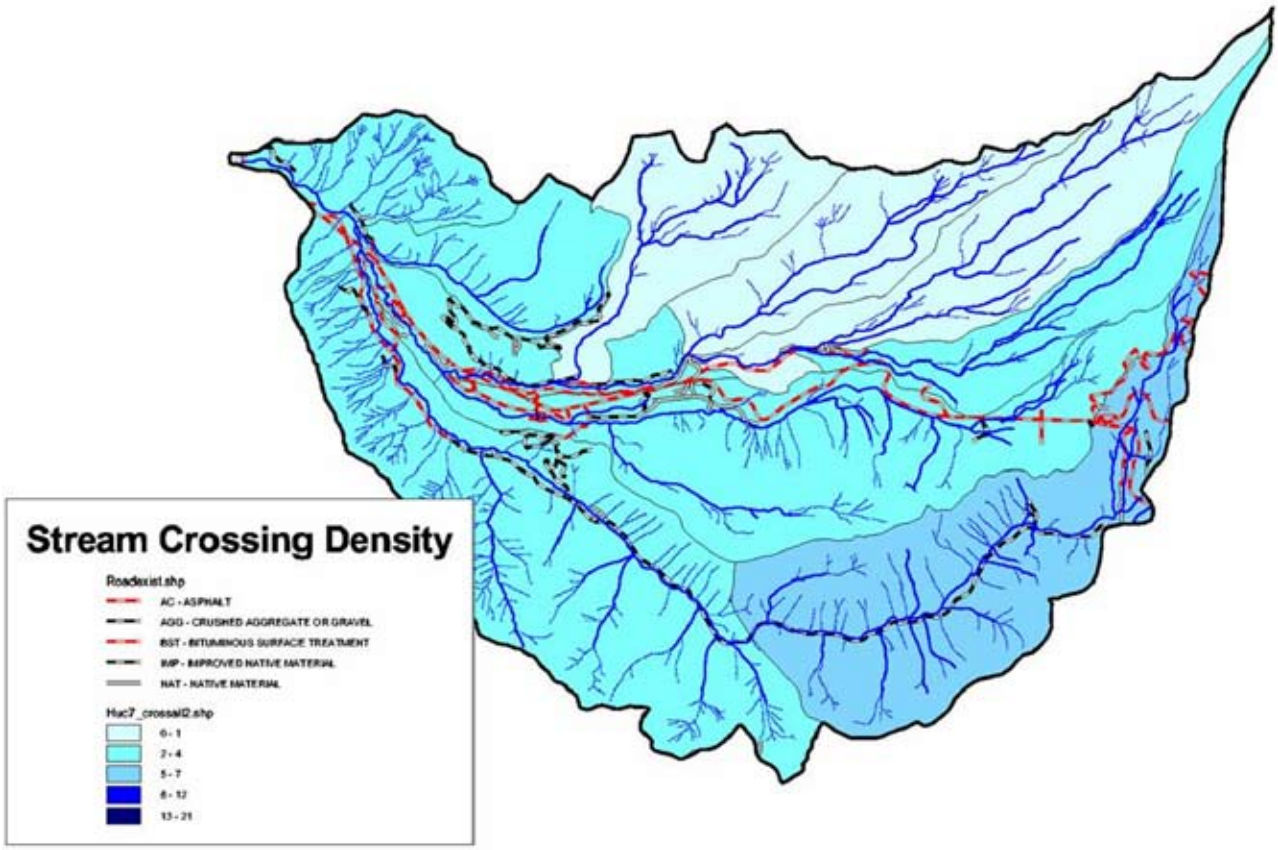
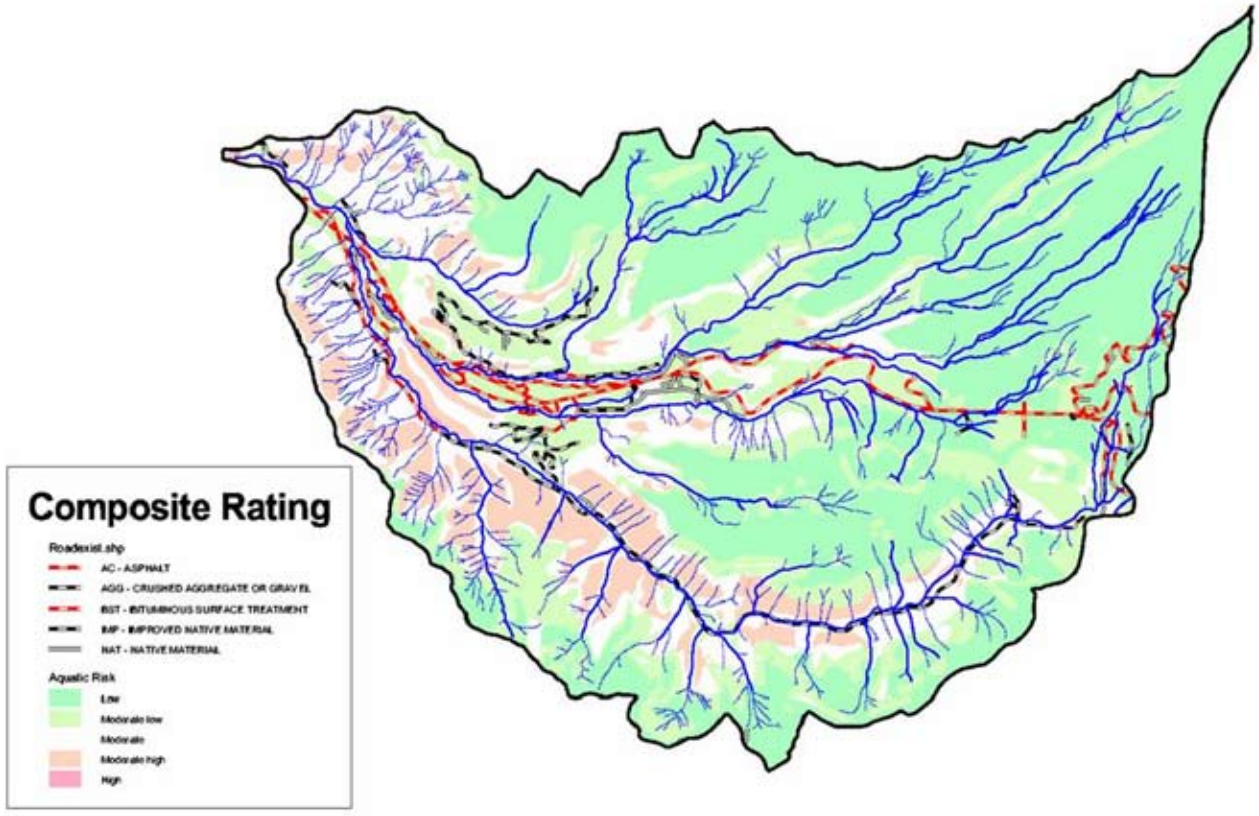



Figure B6. Zigzag River watershed aquatic risk composite rating of road-related impacts.