CLEAN WATER SERVICES

TUALATIN BASIN WATER SUPPLY PROJECT

Fish Habitat

Technical Report

Draft

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Note: This report does not include an analysis of the Willamette Pipeline, a proposed element of one of the Action Alternatives.

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1 INTRODUCTION

1.1 PURPOSE

This Fish Habitat Technical Report analyzes potential effects on fish habitat from portions of the Tualatin Basin Water Supply Project (TBWSP). The TR supports the TBWSP Draft Planning Report and Environmental Impact Statement (PR/EIS) being prepared in compliance with the National Environmental Policy Act (NEPA).

1.2 SCOPE AND LIMITATIONS OF THE TECHNICAL REPORT

This Technical Report evaluates potential impacts to fish habitat from Scoggins Dam modifications, the Tualatin River pumpback system and corresponding flow modifications. Effects from construction of the Raw Water Pipeline (RWP) were evaluated by CH2M Hill in a Technical Memorandum prepared for Murray Smith and Associates, Inc. (MSA) on June 30, 2005 and updated December 8, 2005 (CH2M Hill, 2005). The Technical Report is also limited to analysis of the proposed features contained in the project descriptions for the alternatives with the exception of the Willamette River Water Treatment Plant and associated pipeline, which are described in a separate analysis.

The methods chosen for this fish assessment and the list of target fish species considered were compiled after coordination with state and federal agency personnel. The target fish species of concern for this Technical Report are three native salmonids: summer steelhead, lamprey, and cutthroat trout. Project impacts on fish habitats are expected to result primarily from flow modifications associated with increased reservoir storage and operation of the pumpback systems.

1.3 STUDY AREA (TBWSP AREA OF POTENTIAL EFFECT)

Scoggins Dam and its reservoir, Henry Hagg Lake, are in southwestern Washington County, Oregon, in Township 1 South, Ranges 4 and 5 West, Willamette Meridian. The dam is located on Scoggins Creek, a tributary of the Tualatin River, approximately 5 mi (8 km) southwest of the city of Forest Grove and 25 mi (40 km) west of Portland.

Henry Hagg Lake and Scoggins Valley Park, which surrounds the reservoir, encompass approximately 2,581 acres.

The TBWSP Project Area of Potential Effect includes the following:

- The proposed Scoggins Dam modifications construction, staging and materials sources areas and all access roads and utility installations

- Hagg Lake and surrounding lands up to the maximum surface elevation of inundation

- Areas of road realignment construction, including bridges and culverts; replacement of recreation facilities; and areas affected by construction noise
- Tributary streams to Hagg Lake up to the maximum elevation of inundation
- Scoggins Creek downstream from Scoggins Dam to its confluence with the Tualatin River
- The Tualatin River from the confluence with Scoggin's Creek to the mouth.
- The construction corridor for the proposed RWP from Scoggins Dam to its terminus at the JWC Water Treatment Plant and the Springhill Pumping Plant.

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2 BACKGROUND

2.1 PURPOSE OF AND NEED FOR THE PROPOSED ACTION

The purpose of the Tualatin Basin Water Supply Project (TBWSP) is to provide substantially reliable and cost-effective water supplies to the year 2050 in order to meet future water supply needs for river flow restoration, municipal and industrial (M&I) water, and agricultural irrigation.

Based upon current growth projections, the Partners have determined that approximately 52,550 AF (17.2 billion gallons) of additional water per year could be needed by the year 2050 to meet demands. In addition, the Partners recognize that the water supplies must be substantially reliable and cost-effective. For example, while agricultural demand is not expected to increase, higher demand for M&I water could reduce the amount of water available for agriculture, especially during dry years. Therefore, a more reliable supply for all users, including agriculture, is needed. To adequately serve users and meet the current standards for provision of reliable M&I water supply, greater than 90 percent reliability (i.e., ability to meet demand in more than nine out of ten years) is needed.

2.2 DESCRIPTION OF EXISTING FACILITIES

Scoggins Dam is owned by Reclamation and was completed in 1975. Scoggins Dam is an embankment dam on Scoggins Creek, a tributary of the Tualatin River. The dam is located 5 mi (8 km) southwest of the city of Forest Grove, Oregon, and 25 mi (40 km) west of Portland, Oregon. The dam was completed in 1975 and is a principal feature of the Tualatin Project. Reclamation owns the dam; operation and maintenance are contracted to the Tualatin Valley Irrigation District (TVID). Henry Hagg Lake, the reservoir behind Scoggins Dam, is used for irrigation, recreation, flood control, and water quality control. The reservoir has a present storage capacity of 53,323 acre-feet at the top of active conservation. The active conservation level is 303.5 feet, which includes all waters released for useful purposes, such as municipal water supply, irrigation, and fish and wildlife conservation (Reclamation, 2003).

2.2.1 Dam Structure

The dam is a zoned embankment structure containing about four million cubic yards of material. The dam crest is 2,700 feet long at an elevation of 313.0 feet, the crest width is 30 feet, and the maximum structural height of the dam is 151 feet. The upstream face of the dam has a 2.5:1 (H:V) slope and a layer of riprap. The downstream face of the dam, which has a grass ground cover, has a slope of 2.5:1 from the dam crest to elevation 250, then a slope of 5:1 to the top of the dam (Reclamation, 2003).

A spillway and outlet works are located on the left abutment of the dam, as described below.

2.2.2 Spillway and Outlet Works

The concrete-lined spillway consists of an entrance channel protected by riprap, an intake structure, a chute varying in width from 43 feet at the upper end to 50 feet at the downstream end, a stilling basin structure, and an outlet channel with riprap protection. The outlet channel is used for both the spillway and outlet works. The overall length of the spillway structure is approximately 800 feet. The design discharge capacity of the spillway is 14,000 cubic feet per second at maximum reservoir water surface elevation of 305.8 feet (Reclamation, 2003).

The outlet works is in the left abutment and consists of a common section, a Scoggins Creek Branch, and an M&I Branch. The Scoggins Creek Branch is the river outlet works and includes a fish handling system, control house, and stilling basin, which joins the outlet channel. A fish handling facility is adjacent to the river outlet works structure; it has not been used since the early 1980s, and has been dismantled.

2.2.3 Spring Hill Pumping Plant

The Spring Hill Pumping Plant was constructed on the right bank of the Tualatin River at RM 56.10. Water was first delivered through the Spring Hill system in 1978. The facility is a cooperative venture between Reclamation and the City of Hillsboro. The pumping plant is an indoor type with nine vertical shaft turbine pumps for irrigation pumping and four vertical shaft turbine pumps that are used to pump M&I water to the JWC water treatment facility at Fern Hill. Portland General Electric provides the power to operate the pumping plant.

The nine irrigation pumps have a combined capacity of 148.2 cubic feet per second (cfs). There are four 350 horsepower pumps of 6.3 cfs each and five 150 horsepower pumps of 24.6 cfs each. The irrigation pumps are operated only during the irrigation season.

The four pumps used for delivering M&I water to the JWC Fern Hill water treatment facility consist of two 300-horsepower pumps of 28.9 cfs (1,300 gallons per minute) each and two 350-horsepower pumps of 34.5 (15,500 gallons per minute) each. The M&I pumps are operated year-round. Traveling screens have been installed in front of the pumps at the Spring Hill Pumping Plant to prevent debris from accumulating in the pump intakes. The screens were also intended to eliminate juvenile and adult fish from entering the pump intakes. The screens do not meet current NOAA Fisheries and ODFW criteria for effective passage of juvenile anadromous fish.

2.2.4 Roads and Utilities

The reservoir (Hagg Lake) is surrounded by a paved, perimeter road, which provides access to the reservoir, recreation sites on the shoreline, and surrounding properties. The county road also travels along the crest of Scoggins Dam. No road reconstruction or realignment is planned under the No Action Alternative. The road would continue to receive periodic maintenance, as determined by Washington County.

Potable and non-potable water is supplied to most recreational facilities in the park. Wastewater from permanent bathrooms at the park is routed to septic tank and leach field disposal systems.

Sewage from the restrooms at the Elks Picnic Area, at the south end of the park, is collected in two holding tanks and pumped as needed.

Overhead power lines distribute electricity to various facilities around the park.

2.3 DESCRIPTION OF ALTERNATIVES

Three alternatives are evaluated in this technical report: two action alternatives and, in accordance with NEPA requirements, a no action alternative. All three alternatives would incorporate water conservation and reuse methods, as well as aquifer storage and recovery (ASR). Combined, water conservation and reuse and ASR are expected to meet approximately 14 percent of the future (2050) M&I need of approximately 12 billion gallons (37,400 AF).

2.3.1 Alternative 1 – No Action

As defined by Reclamation guidelines, "no action represents a projection of current conditions to the most reasonable future conditions that could occur…without any action alternatives being implemented" (Reclamation, 2000a). The no action condition is not the same thing as the existing condition, since "reasonably foreseeable future conditions" may occur without major federal action.

Under the No Action Alternative, there would be no coordinated regional water development or management program. Instead, individual water providers in the Tualatin Basin would expand their existing facilities to fully utilize existing water rights and permits.

Reclamation is evaluating whether modifications need to be made to Scoggins Dam to meet current seismic design standards. If Reclamation determines that dam safety improvements are needed, such improvements would be made but the dam height would probably not be increased. There would be no increase in water storage in the reservoir.

Some Tualatin Basin water providers currently have contracts to purchase water from the City of Portland. The No Action Alternative assumes that contracts with the City of Portland would extend existing contract water quantities for 10 years or, potentially, 20 years. Over time, City of Portland contracts will become a less reliable source for Tualatin Basin water providers. Portland's first priority is to serve the water needs of its residents, and those needs are expected to increase, leaving less water available for contracts.

Under the No Action Alternative, the population of the Tualatin Basin would experience water shortages. Measures that could be taken in response to water shortages include moratoriums on building and development. Such moratoriums are limited by Oregon law to a two-year duration and should be considered as interim solutions only (see Oregon Revised Statute [ORS] 197.530). Other measures that could be implemented include severe water use restrictions (e.g., legal restrictions on outdoor landscaping, irrigation, and industrial and residential uses), depending on local decisions and rulemaking by local government entities. Under Oregon land use law (ORS 197.752), urban land is only "available for urban development concurrent with the provision of key urban facilities and services," so local governments could be required to limit growth if adequate water supplies are not available. Therefore, future water shortages could limit economic growth in Washington County.

Maximum reservoir water levels at Hagg Lake (when reservoir is full) would be the same as at present (normal full pool elevation of 303.5 feet). However, the additional water demands (water providers demanding full Hagg Lake contract amounts each year) would mean that the reservoir would be drawn down to lower elevations than under current conditions. The lowest water level in Hagg Lake during the 2001 dry year was about 245 feet. With the No Action Alternative, minimum water levels in Hagg Lake would be lower than 245 feet in about 90 percent of the years. The minimum operating level of Hagg Lake is the top of inactive pool at elevation 235.3 feet. Under Alternative 1, minimum reservoir water levels would reach within 5 feet of the top of inactive pool in about 75 percent of the years. Even with increased drawdown, Hagg Lake would still fill on a regular basis. Maximum reservoir water levels would reach within 5 feet or less of the normal full pool in about 85 percent of the years.

Clean Water Services would continue to augment Tualatin River flows with stored supplies from Hagg Lake and Barney Reservoir, but additional flow augmentation for water quality improvement would not occur. Clean Water Services would release all of its stored water each year for flow augmentation, with releases determined by river conditions and storage availability.

No changes to the Spring Hill Pumping Plant or the perimeter road around Henry Hagg Lake are proposed under Alternative 1. The dam would continue to be owned by Reclamation, with operation and maintenance contracted to the Tualatin Valley Irrigation District (TVID).

2.3.2 Alternative 2 – Scoggins Dam 40-foot Raise

Under Alternative 2, Scoggins Dam would be raised by 40 feet. The active storage capacity of the reservoir would be increased from 53,323 AF (17.4 billion gallons) to 105,873 AF (34.5 billion gallons). The raised dam crest elevation would be 343.5 feet. The 40-foot raise would require construction of a new spillway on the left abutment to replace the existing spillway. A second outlet works would be added. Portions of the perimeter road around the reservoir (Hagg Lake) would be relocated above the proposed new area of inundation. The road would continue to provide access to the reservoir, recreation sites on the shoreline, and surrounding properties.

While the original plans for Scoggins Dam expected that a M&I raw water pipeline would be constructed from the dam to the JWC Water Treatment Plant at Fern Hill, funding constraints at the time (1970s) prevented such pipeline improvements as part of the initial project development. Instead, a joint river intake and pumping station was built several miles downstream of the dam to supply both irrigation water to TVID and raw source water for the JWC Fern Hill Water Treatment Plant. This system relies on the natural channels of Scoggins Creek and the Tualatin River for conveyance of released water from Hagg Lake downstream to the Spring Hill Pumping Plant, where it is withdrawn and pumped either into the TVID system or the JWC Water Treatment Plant at Fern Hill.

Under Alternative 2, a raw water pipeline (RWP) would be constructed from Hagg Lake to the JWC Water Treatment Plant at Fern Hill with a connecting pipeline to the Spring Hill Pumping Plant. The RWP would begin at the base of Scoggins Dam and extend approximately 6.5 miles easterly to the pumping plant. During the peak season (June through October), when contract holders are releasing stored water from the reservoir, the RWP would deliver water by gravity directly to the JWC Fern Hill Water Treatment Plant. Some untreated Hagg Lake water would be routed through the connecting pipeline to the Spring Hill Pumping Plant, allowing Clean Water Services to release water to the Tualatin River mainstem just downstream of the pumping plant.

An expanded Hagg Lake would not meet the additional demands each year with only the natural inflow from the upstream drainage area. Therefore, in the winter (December through April), the RWP would operate in the reverse direction and would pump available winter water from the Tualatin River water withdrawn at the Spring Hill Pumping Plant into the reservoir to supplement the natural inflows from upstream and fill the reservoir. In years when such pump-back is needed (expected to be in dry and normal years), an average of about 30,000 AF and up to a maximum of almost 70,000 AF of river water would be withdrawn during winter and early spring flows at the Spring Hill Pumping Plant and pumped through the RWP to Hagg Lake. No additional pipelines would be required. The existing TVID pump station would be expanded to provide the required pumping capacity, to a maximum of 300 cubic feet per second (cfs) of capacity. Modifications to the inlet channel and the intake infrastructure would be made.

A new intake structure for the RWP would be constructed at Scoggins Dam. The intake would be below the maximum drawdown elevation of 235.3 feet. To construct the intake structure, a cofferdam would be temporarily placed behind the dam and removed after the intake structure is completed.

The Spring Hill Pumping Plant would be expanded to provide the required pumping capacity, to a maximum of 300 cfs. A new pump station would be built near the existing building, and new fish screens would be installed to serve both the existing pump station and the proposed expansion (Murray Smith and Associates [MSA], 2006). The new screens are expected to meet National Marine Fisheries Service (NMFS) approach velocity criteria. An existing rock weir would be replaced with an engineered diversion structure to maintain the minimum water surface elevation needed for the fish screens to function appropriately. Modifications to the approach channel would be made.

Some recreation facilities and associated utilities would be inundated with the dam raise. Affected facilities and utilities would be replaced as part of Alternative 2. Recreation facilities would be redeveloped at Scoggins Creek, Area C, Area A, Sain Creek, and the Elks Picnic Area. The park administration and maintenance yard would also be relocated.

The dam would continue to be owned by Reclamation, with operation and maintenance contracted to TVID. Park facilities and the perimeter road would also continue to be owned by Reclamation, with Washington County responsible for operation and maintenance. TVID and JWC would continue to operate the Spring Hill Pumping Plant, which is and would continue to be federally owned.

2.3.2.1 Construction

2.3.2.1.1 Scoggins Dam Raise

Dam construction would take approximately four to five years, with construction occurring throughout the year (Reclamation, 2006a). This estimate does not include the relocation of the road and recreation facilities, though it is assumed those activities could occur concurrently if desirable.

Two potential borrow areas have been identified that would provide suitable material for raising the dam. The first is the left abutment reservoir rim just upstream of the dam. The other is a borrow area used during original dam construction, on the right abutment above the dam. Borrow investigations would be conducted prior to final design to determine if the left abutment area can provide sufficient material for the raise.

For the dam construction, the staging area would be in the flat area immediately downstream of the dam. It is assumed that equipment parking and maintenance, construction trailers, rock processing plant, material stockpiles, laydown areas, and temporary storage areas would all be located there.

Trees would be cleared from the proposed borrow areas and most areas to be inundated (i.e., the main body of the Hagg Lake, but not into the narrower tributary arms). Standard forest practices would be employed, though advanced erosion protection measures would be used for all areas that drain into the reservoir. The specific logging plans will be developed during future design efforts.

2.3.2.1.2 Pipeline Installation

Typical construction for the RWP would be to place the 96-inch diameter pipeline within a trench approximately 12 feet wide and 18 feet deep, although depth would vary depending on conditions. The temporary construction easement along the pipeline corridor would be approximately 140 feet wide, centered on the pipeline. The permanent easement along the corridor would be approximately 60 feet wide (MSA, 2006).

Road and railroad crossings would be accomplished using either trenchless or open-cut methods. Trenchless crossings would likely be utilized where the pipeline would cross the intersection of Old Highway 47, P&W Railroad, and Scoggins Valley Road; and at the crossing of Highway 47 and the railroad. Open-cut crossings are proposed at SW Seghers Road and Spring Hill Road (MSA, 2006).

The RWP would cross the following streams: Scoggins Creek (twice), the Tualatin River, and an unnamed tributary to the Tualatin River. The Tualatin River would be a trenchless crossing, likely involving micro-tunneling methods (MSA, 2006). The upper crossing of Scoggins Creek would likely also be trenchless (tunneled). Open-cut dry or trenchless methods are being considered for the crossings of Scoggins Creek and the unnamed Tualatin tributary (MSA, 2006).

Staging areas for RWP construction have not been determined. Potential sites could be property adjacent to the JWC Water Treatment Plant and properties along the east side of Highway 47 and the P&W Railroad line (MSA, 2006).

RWP construction would take two to three years and would be scheduled to minimize conflicts with crop harvesting activities and other considerations (e.g., dam releases in Scoggins Creek) (MSA, 2006). Multiple construction crews would work simultaneously. Construction activities would occur throughout the year.

2.3.2.2 Inundation Area

2.3.2.2.1 Reservoir/Storage

Alternative 2 would increase Hagg Lake's active storage capacity from 53,323 AF at a gross pool elevation of 303.5 feet to 105,973 AF at a gross pool elevation of 343.5 feet. With the change, the area of inundation during normal full pool conditions would increase from 1,117 acres to 1,487 acres. Table 1 compares the reservoir pool characteristics at different capacity stages for Alternative 1 (No Action) and Alternative 2.

**TABLE 1.
POOL CHARACTERISTICS IN 2050, ALTERNATIVE 1
(NO ACTION) AND ALTERNATIVE 2**

Pool	Elevation (feet)		Surface Area (acres)		Active Storage (AF)	
	Alt. 1	Alt. 2	Alt. 1	Alt. 2	Alt. 1	Alt. 2
Normal full pool (gross pool/top of joint use)	303.5	343.5	1,117	1,487	53,323	105,873
Average drawdown, end of October	239.9	245.4	495.2	548.2	2,255	5,477
Maximum drawdown (drought)	235.4	235.7	449.6	452.9	28	177

2.3.2.2.2 Tributaries Upstream of Hagg Lake

Expansion of the reservoir would inundate portions of tributaries upstream of Hagg Lake. The increased total length inundated under the normal full pool of Alternative 2 as compared to baseline would be approximately 1.8 mi (2.9 km). This total is composed of 0.7 mi (1.1 km) of Scoggins Creek, 0.6 mi (1.0 km) of Sain Creek, 0.4 mi (0.6 km) of Tanner Creek, and 0.1 mi (0.2 km) of Wall Creek.

2.3.3 Alternative 3 – Multiple Source Option

Under Alternative 3, an additional water source—the Willamette River—would be used to serve the future needs of some of the Water Supply Partners, resulting in less future demand on Hagg Lake than Alternative 2. Because less water would need to be stored at the reservoir, Scoggins Dam would be raised by 25 feet, instead of 40 feet. Similar to Alternative 2, the RWP would be installed and used for both gravity flow and pump-back. An additional transmission pipeline would be installed to provide water from the Willamette River to TVWD, Tualatin, and Tigard for M&I use. Water from the Willamette would be treated at the existing Willamette River Water Treatment Plan in the city of Wilsonville.

With a Scoggins Dam raise of 25 feet (normal full pool elevation of 328.5 feet), the active storage capacity of the reservoir would be increased from 53,323 AF (17.4 billion gallons) to 84,317 AF (27.5 billion gallons). As with a 40-foot raise (Alternative 2), Alternative 3 would require construction of a new spillway, in a new location on the left abutment, and removal of the existing spillway. The new spillway would require a new approach channel, a new intake, and a new chute and stilling basin. Portions of the perimeter road around the reservoir (Hagg Lake) would be relocated above the proposed new area of inundation. The road would continue to provide access to the reservoir, recreation sites on the shoreline, and surrounding properties.

Similar to Alternative 2, JWC would build a RWP from Hagg Lake to the JWC Fern Hill Water Treatment Plant and Spring Hill Pumping Plant. The RWP would begin at the base of Scoggins Dam and extend approximately 6.5 miles easterly to the water treatment plant along Fern Hill Road. The RWP is being planned for gravity flow operation. The RWP would also be used to assist in the refill of Hagg Lake by withdrawing available winter water from the Tualatin River at RM 56.1 and pumping it into the reservoir as needed. In years when such pump-back is needed (expected to be in dry years and most normal years), an average of about 20,000 AF and up to a maximum of 40,000 AF of river water would be withdrawn during winter and early spring flows at the Spring Hill Pumping Plant and pumped through the RWP to Hagg Lake. The existing TVID pump station would be expanded to provide the required pumping capacity, to a maximum of 200 cfs of capacity. Modifications to the inlet channel and the intake infrastructure would be made.

To provide water to some of the Partners (TVWD and cities of Tualatin, Tigard, and Sherwood), Alternative 3 includes a water transmission pipeline ("Willamette Pipeline") that would begin at the existing Willamette River Water Treatment Plant in the city of Wilsonville and would extend northward to a proposed TVWD terminal storage facility (reservoirs) that would likely be built on the south side of Cooper Mountain, although a specific location has not yet been identified. Another pipeline would extend from the proposed reservoir to a TVWD connection point at SW Beaverton-Hillsdale Highway and SW Western Avenue in Beaverton. An additional reservoir would be built to serve the City of Tualatin. Delivery points with meter connections for the various Partners would be placed at numerous locations along the route. New and upgraded facilities at the Willamette River Water Treatment Plant would be contained within the existing treatment plant boundaries.

Operation and maintenance of the dam, related facilities, and the RWP would be the same for Alternatives 2 and 3.

It is expected that the Willamette River Water Coalition would continue to operate and maintain the Willamette River Water Treatment Plant in Wilsonville. Agreements related to responsibility for operation and maintenance of the Willamette Pipeline and related reservoirs have not yet been finalized.

2.3.3.1 Construction

Construction activities for the dam raise, road relocation, and recreation facilities would be similar to that described for Alternative 2. Construction of the 25-foot dam raise would take less time than for the 40-foot raise—approximately four years instead of four to five (Reclamation, 2006a).

RWP construction would be essentially the same as described for Alternative 2, although the open trench would be approximately 10 feet instead of 12 feet wide, and approximately 16 feet instead of 18 feet deep. Stream, road, and railroad crossings would be accomplished in the same manner as that proposed for Alternative 2—likely a combination of trenchless and open-cut crossings.

RWP construction would take two to three years and would be scheduled to minimize conflicts with crop harvesting activities and other considerations (e.g., dam releases in Scoggins Creek) (MSA 2006). Multiple construction crews would work simultaneously. Construction activities would occur year 'round.

Willamette Pipeline construction is estimated to take between one and three years to complete. Construction of each reservoir (TVWD and City of Tualatin) would take approximately one year.

The Willamette Pipeline is not evaluated in this report. The environment that could be affected by the Willamette Pipeline and potential impacts are described in the Draft PR/EIS for the TBWSP.

2.3.3.2 Inundation Area

2.3.3.2.1 Reservoir/Storage

Under Alternative 3, Scoggins Dam would be modified and raised by 25 feet. Hagg Lake's active storage capacity would increase from 53,323 AF at a gross pool elevation of 303.5 feet to 84,317 AF at a gross pool elevation of 328.5 feet. With the change, the area of inundation during normal full pool conditions would increase from 1,117 acres to 1,352 acres. Table 2 compares the reservoir pool characteristics at different capacity stages for Alternative 1 (No Action) and Alternative 3.

2.3.3.2.2 Tributaries Upstream of Hagg Lake

Expansion of the reservoir would inundate portions of tributaries upstream of Hagg Lake. The increased total length inundated under the normal full pool of Alternative 3 as compared to that under baseline would be approximately 1.6 mi (2.6 km). This total is comprised of 0.6 mi (1.0 km) of Scoggins Creek, 0.6 mi (1.0 km) of Sain Creek, 0.3 mi (0.5 km) of Tanner Creek, and 0.1 mi (0.2 km) of Wall Creek.

TABLE 2.
POOL CHARACTERISTICS IN 2050, ALTERNATIVE 1 (NO ACTION) AND ALTERNATIVE 3

Pool	Elevation (feet)		Surface Area (acres)		Active Storage (acre-feet)	
	Alt. 1	Alt. 3	Alt. 1	Alt. 3	Alt. 1	Alt. 3
Normal full pool (gross pool/top of joint use)	303.5	328.55	1,117	1,352	53,323	84.317
Average drawdown, end of October	239.9	248.1	495.2	572.2	2,255	6,939
Maximum drawdown (drought)	235.4	235.6	449.6	451.6	28	118

2.4 RELATED WORK/STUDIES

2.4.1 Tualatin Basin Water Supply Feasibility Study

The Tualatin Basin Water Supply Feasibility Study (WSFS) Final Report (MWH, 2004) was begun in 2001 and completed in 2004. It was funded and directed by a partnership of local water providers and the U.S. Bureau of Reclamation, and identified and assessed options to meet the long-term water supply needs in the Tualatin Basin. The Feasibility Study:

- Developed peak season water demand forecasts to 2050 and estimated future summer supply deficits;
- Screened a range of potential water supply options; and
- Evaluated three structural supply options in more detail to determine the technical, environmental, and economic feasibility of those options. The options included a 20-foot raise of Scoggins Dam, a 40-foot raise of the dam, and an irrigation exchange pipeline from the Willamette River.

WSFS activities included publishing a Notice of Intent to prepare an EIS and an announcement of public scoping meetings in the Federal Register. The announcement was published on December 13, 2001. Public scoping meetings were held and a public involvement program was implemented. The WSFS included a preliminary assessment of environmental impacts as well as mitigation measures. The Partners concluded that none, by themselves, were adequate to meet their long-term (year 2050) needs. For example, while a 40-foot raise of Scoggins Dam was evaluated in the WSFS, hydrologic analysis showed that it would not meet future needs with an acceptable level of reliability.

2.4.2 Raw Water Pipeline Preliminary Design Report

A preliminary design report was prepared for the RWP by MSA, with assistance from CH2M Hill (MSA, 2006). The preliminary design report included information, discussions, evaluations, and recommendations pertaining to RWP design and construction, including hydraulic concerns, operations, pump station backpumping, geotechnical issues, environmental considerations, property and rights of way, and other issues. Section six of this document discussed Environmental Considerations.

2.4.3 Upper Tualatin-Scoggins Watershed Analysis

A report documenting analysis of the Upper Tualatin and Scoggins watersheds was prepared by the U.S. Department of Interior, Bureau of Land Management (BLM) in cooperation with the Washington County Soil and Water Conservation District (BLM, 2000). The report includes a characterization of watershed features, essential watershed management issues, current conditions, pre-settled conditions, documentation of changes, recommendations for watershed management, and restoration of undesirable changes. The report includes discussions of existing land uses, water quality, aquatic and terrestrial habitats and species, and many other features pertaining to management of the watersheds.

2.4.4 Tualatin River Watershed Action Plan and Technical Supplement

The Tualatin River Watershed Council (TWRC) prepared an Action Plan (1999) and Technical Supplement (1998) in order to meet a key objective under the Watershed Enhancement Goal by providing a foundation for implementing coordinated resource enhancement and restoration projects. The Action Plan arose from the Council's 1996 strategic plan, organized around four main functional areas:

- Enhance the watershed
- Provide a forum for watershed issues
- Provide education about watershed improvement
- Develop the Council organization

The Tualatin River Watershed Action Plan provides information on the existing conditions of water, soil, plants and animals (biota), air quality, and the human component in the Tualatin basin and identifies watershed goals related to each of these areas.

2.4.5 Tualatin River Basin Water Supply Project Water Quality Technical Report

CH2M HILL (2006) prepared a TRWSP Water Quality Technical Report to document the water quality modeling methodology, assumptions, and effects of the TBWSP alternatives on water quality in Hagg Lake, Scoggins Creek, and the mainstem Tualatin River. The Technical Report supported the development of water quality analysis for the TBWSP PR/ES. The three project alternatives were evaluated to illustrate their range of effects on water quality using a model of Henry Hagg Lake that was developed by the U.S. Geological Survey (USGS). This model: (1) simulates lake circulation, temperature, and water quality, (2) helps to develop an understanding of the processes affecting circulation, temperature, and water quality, and (3) predicts changes in circulation, temperature, and water quality that could result from a set of proposed modifications to the dam and lake. Water quality models developed by USGS for Scoggins Creek and the mainstem Tualatin River were also used for the analysis.

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3 EXISTING ENVIRONMENT

This chapter provides a description of habitat in the project area and target fish species identified as potentially affected by the Proposed Action, including their federal and/or state status, life history, species range and occurrence in project area, and environmental baseline.

3.1 ENVIRONMENTAL SETTING

The Tualatin River watershed encompasses an area of approximately 707 sq. miles, with about half the basin forested and half comprised of a mix of agricultural, residential and urban lands (ODFW 1990). The mainstem Tualatin River originates in the Coast Range of northwestern Oregon and flows in an easterly direction to its confluence with the Willamette River at River Mile 28.6. Major tributaries include Fanno, Chicken, McFee, Rock, Diary, Gales and Scoggins creeks.

Flows in the Tualatin River are primarily dependent on precipitation occurring as rainfall during winter months, resulting in periods of high flows during the winter months and sustained low-flow periods during the summer months. Average historic monthly flows have ranged from 3,943.8 cfs in February to 52.5 cfs in August. In 1974 the Bureau of Reclamation (BOR) completed Scoggins Dam on Scoggins Creek, in part, to help modulate flows in the basin. Summer flows are typically quite low and can result in elevated temperatures. Since construction of Scoggins Dam, the Tualatin River receives additional flow during the summer months from Henry Hagg Lake via Scoggins Creek for water quality and irrigation purposes. Under the current, regulated conditions, mean monthly flows range from 4,830 cfs in February to 182 cfs in August.

Historically, the Tualatin River watershed likely supported populations of steelhead trout (*Oncorhynchus mykiss*) as well as Pacific lamprey (*Lampetra tridentata*). Chinook salmon (*O. tshawytscha*) reportedly migrate within lower portions of the mainstem river, but it is unlikely that the Tualatin River ever supported large runs of this species (Ward 1995). Leader (2002) reported finding 10 species of fish within three sites of the mainstem Tualatin, including three salmonid species – cutthroat trout (*O. clarkii*), coho salmon (*O. kisutch*), and Chinook salmon. The remaining seven species included an unidentified salmonid, carp, largescale sucker, largemouth bass, pumpkinseed, sculpin, and yellow perch.

The general lack of salmonid species in the mainstem reaches of the Tualatin River is likely related in part to the physical habitat characteristics of the stream channel as well as water quality conditions, including elevated water temperatures during the summer months. According to Oregon Department of Fish and Wildlife (ODFW) (1990), the majority of mainstem reaches are gently sloping and nearly flat, resulting in long, slow-moving segments of river. As a result, the substrates within the mainstem river are largely comprised of silts and sands; gravels suitable for salmonid spawning are generally absent.

3.2 BASELINE CONDITIONS

Baseline conditions in this analysis are assumed to be the status of species and habitats in the project area, as determined at the time this report was written. The baseline conditions described in the following sections were based on a review of existing information as well as data collected during reconnaissance and fish habitat surveys. The baseline condition is technically assumed to be the future-without-project condition; therefore, it is operationally (hydrologically) identical to Alternative 1 (No Action). Hydrologic conditions for Alternative 1 and baseline are different from existing conditions. It is not possible to accurately project the future condition of species and habitats in the project area, because the possible effects of factors such as habitat degradation and conversion, temporal population fluctuations, and restoration efforts cannot be determined.

3.3 TARGET SPECIES AND HABITAT IN AREA OF POTENTIAL EFFECT

3.3.1 Target Species

Target fish species were selected in consultation with state and federal agency personnel. The focus of this biological evaluation was on two anadromous and one resident species that were species of concern for local fisheries managers: winter steelhead, cutthroat trout, and Pacific lamprey. Although not native to the system, lower Columbia River coho salmon have established naturalized populations in the Tualatin River after years of hatchery stocking. Analyses of winter steelhead will be used to evaluate potential effects on these coho salmon, based on the assumption that their habitat requirements are similar to winter steelhead.

3.3.1.1 Upper Willamette River Steelhead

Tualatin River winter steelhead are part of the Upper Willamette River Steelhead Evolutionary Significant Unit (ESU) and are listed as threatened under the federal Endangered Species Act (ESA). On January 5, 2006, NMFS published a final listing determination for 10 distinct population segments (DPS) of West Coast steelhead (Federal Register 71:834). The NMFS Biological Review Team concluded that the Upper Willamette River steelhead ESU is “not at risk of extinction or likely to become endangered within the foreseeable future” and therefore concluded that the ESU would be listed as threatened. Critical habitat for the Upper Willamette ESU was revised on September 2, 2005 (Federal Register 70:52630). For Upper Willamette River steelhead, all watersheds within the Tualatin River subbasin were proposed to be excluded from critical habitat, with the exception of the Gales Creek watershed and the mainstem Tualatin from the mouth of Gales Creek to the mouth of McKay Creek.

The North and South Santiam Rivers are considered the core and legacy population of winter steelhead in the ESU. Although, there is some evidence of steelhead spawning in Gales Creek, it remains unclear whether the Tualatin River ever supported a self-sustaining population of winter steelhead (Myers et al. 2003). Populations of native winter steelhead within this ESU have been declining since 1971, with large fluctuations in annual abundance estimates (Busby et al. 1996; McElhany et al. 2003). Estimated abundance of Upper Willamette winter steelhead passing Willamette Falls has been based on a 5-year geometric mean of approximately 3,000 fish annually (ODFW 1998).

Steelhead are an anadromous form of *Oncorhynchus mykiss*, an adaptable salmonid that expresses both resident and migratory life histories. Juvenile steelhead can spend up to 7 years rearing in freshwater before migrating to the ocean as smolts; however, most steelhead smolts leave for the ocean after two or three years in fresh water. They will then spend up to 3 years in the ocean growing and maturing before returning to natal streams to spawn. Upper Willamette River steelhead are considered a late-migrating stock. Adults returning to spawn enter fresh water primarily in March and April (Busby et al. 1996; NMFS 1998) and spawn in late April and May (ODFW 1992). Steelhead are unique among Pacific salmon in that they can spawn more than once. After completion of a first spawning, a spent steelhead adult, termed a kelt, will migrate downstream to the ocean for an additional period of growth and return to spawn again in a later year (Shapovalov and Taft 1954; Moyle 1976).

Steelhead spawning typically occurs at the downstream end of pools (where they grade into a faster moving habitat type) or in riffles with gravel substrate (Moyle 1976). Optimal size of gravel substrate ranges from 0.2 to 4 in (0.6 to 10.2 cm) at the tail of the pool (Bjornn and Reiser 1991). The female digs a pit in the gravel where she deposits her eggs. Often more than one male will fertilize the eggs before the female covers the eggs with gravel, creating a redd or nest (Moyle 1976). During the egg incubation period, sufficient water must circulate through the redd to supply embryos with oxygen and remove waste products. Abundant fine sediments can interfere with this process and result in embryo mortality (Bjornn and Reiser 1991).

Juvenile steelhead emerge from the gravel after approximately 5 to 16 weeks, depending on water temperature (Shapovalov and Taft 1954; Moyle 1976; NMFS 1998). Young-of-the-year steelhead (e.g. steelhead produced that year) often utilize riffle and run habitat during the growing season (e.g. spring and summer) and move to deeper, slower water habitat during the high-flow months (Baltz and Moyle 1984; Hearn and Kynard 1986). Larger juvenile steelhead, usually yearlings or older, have been observed to use heads of pools for feeding (Cunjak and Green 1983; Baltz and Moyle 1984). The pools provide deeper water with sufficient cover to hide from predators and a food source as water enters the head of the pools carrying invertebrate prey.

ODFW stocked hatchery steelhead trout in the upper Tualatin River and Scoggins Creek between 1976 and 1998 to mitigate for loss of habitat from construction of Scoggins Dam. Approximately 10,000 smolts were planted each year in the Tualatin River and Scoggins Creek. ODFW discontinued release of hatchery steelhead trout into the system in 1999 in response to the federal listing of Upper Willamette steelhead as a threatened species (BLM 2000).

The mainstem Tualatin River does not currently support spawning habitat for steelhead (ODEQ 2001). Steelhead may ascend the Tualatin River during their spawning migrations and during the rearing phase of their life cycle. Steelhead run timing at Scoggins Dam can be estimated from passage counts at Willamette Falls. Adult steelhead migrate past Willamette Falls during November-May, with peak migrations in March (PGE and BHPC 2002). Juvenile steelhead migrate past the Falls during March-July (PGE and BHPC 2002). In the mainstem Tualatin River, winter steelhead were estimated to use 46 percent of the stream habitat between miles 7.5-44.6 for migration, 22 percent of stream habitat between miles 44.6-62.5 primarily for rearing and migration, and 15 percent of stream habitat between miles 62.5-74.9 primarily for rearing (StreamNet query on April 28, 2003, Troy Baker, MWH).

While the mainstem Tualatin River does not support steelhead spawning, the lower reach of Scoggins Creek and other tributaries may provide critical spawning habitat (ODEQ 2001). In January, February, and April 2003, field surveys of lower Scoggins Creek and an unnamed tributary to lower Scoggins Creek were conducted to determine whether steelhead were spawning. Neither steelhead nor their redds were observed in Scoggins Creek downstream of Scoggins Dam between Stimson Mainline Bridge and the gauging station (White 2003). Scoggins Creek was given a subjective rating of “Poor” to “Poor to Fair” based on the limiting factors for salmonids in Scoggins Creek (White 2003). These factors included spawning area, pool and riffle abundance, presence of undercut banks, aquatic invertebrate production, bank cover, and instream structure.

Low availability of suitable rearing or spawning habitat for steelhead is supported by information in Oregon’s StreamNet database. In lower Scoggins Creek, winter steelhead were estimated to use only 28 percent of stream habitat for spawning and rearing (StreamNet query on April 28, 2003, Troy Baker, MWH). The current number of steelhead that use lower Scoggins Creek is unknown, but is presumed to be very small. However, recent accounts in lower Scoggins Creek include observation of a steelhead redd in the creek below Scoggins Dam (personal communication from Rob Burkhart, Oregon Department of Environmental Quality, February 20, 2003) and several presumed coho salmon redds observed during a Project site visit in January 2006.

3.3.1.2 Pacific Lamprey

Pacific lamprey are an anadromous and parasitic species. The parasitic phase is restricted to the marine environment where lamprey can attach to large fish and marine mammals. Adult lamprey will leave the ocean to spawn in freshwater streams (Wydoski and Whitney 1979). Pacific lamprey are not thought to return to natal streams for spawning. Adult Pacific lamprey migrate upstream in July to October. They overwinter in freshwater and spawn from February through May in Oregon (Kostow 2002) when water temperatures are between 50°F (10°C) and 59°F (15°C) (Close et al. 1995). Both sexes construct a shallow nest in the stream gravel (Morrow 1976). Flowing water (1.6-3.3 fps) in low gradient sections is preferred for spawning (Close et al. 1995). After preparation of the nest, the female attaches herself to a rock with her oral sucker while the male attaches to the head of the female. The male and female coil together while the eggs and sperm are released. The fertilized eggs adhere to the downstream portion of the nest (Moyle 1976). The adults then cover the eggs with gravel. The process is repeated several times in the same nest site. Spawning Pacific lamprey are often observed during steelhead spawning surveys, and they often spawn in similar habitat (Jackson et al. 1996; Foley 1998). It is commonly thought that Pacific lamprey die after spawning but a recent ODFW report documents observation of out migrating lamprey and evidence of repeat spawning (Kostow 2002).

Juvenile Pacific lamprey, termed ammocoetes, swim up from the nest and are washed downstream where they burrow into mud or sand to feed by filtering organic matter and algae (Moyle 1976). The ammocoetes generally remain buried in the substrate for 5 or 6 years, moving from site to site (Wydoski and Whitney 1979). Such an extended freshwater residence makes them especially vulnerable to degraded stream and water quality conditions, including bedload disturbances. Larval lamprey transform to juveniles from July through October (Close et al. 1995). It is during this transition that they become ready for a parasitic lifestyle, developing teeth, tongue, eyes and the ability to adapt to saltwater. After metamorphosis, juvenile lamprey may remain in fresh water up to 10 months before passively migrating with the current downstream to the ocean in late winter or early spring (Wydoski and Whitney 1979). In Tenmile Creek located on the Oregon Coast, lamprey juveniles have been captured during their seaward migration in fall and winter, whereas on the nearby Rogue River, they were collected in spring and summer (Kostow 2002)

After reaching the ocean Pacific lamprey attach to and parasitically feed upon other fish (Moyle 1976). They may remain in saltwater for up to 3.5 years (Close et al. 1995). Pacific lamprey return to freshwater in the fall, overwinter, and then spawn in the spring (Close et al. 1995). They do not feed during the spawning migration. Pacific lamprey may reach a size of approximately 2 feet long (70 cm), at maturity (Hart 1973).

The overall abundance and distribution of Pacific lamprey in the Tualatin River Subbasin is not known. Until recently, fisheries work in the Tualatin River Subbasin focused on salmonids, thus data on lamprey distribution and abundance are extremely limited. In recent years, increased attention has focused on lamprey populations in the Columbia River Basin because of the widespread perception that Pacific lamprey populations are declining. Pacific lamprey was petitioned for listing under the Federal ESA but was determined Not Warranted.

Recent inventories of fish communities in Washington County streams suggest lamprey species are present throughout the Tualatin River Subbasin. During ODFW sampling in 1999-2000, Pacific lamprey were captured in Fanno Creek (RM 15.0), which is located within the Urban Growth Boundary (UGB) for Washington County, Oregon (Hughes and Leader 2000). Pacific lamprey also were captured in the lower reach of Chicken Creek (RM 25.9), which is located outside of the UGB (Hughes and Leader 2000). In other streams located outside the UGB, Western brook lamprey were the most abundant lamprey species, and Pacific lamprey were not noted (Leader and Hughes 2000). Unidentified lamprey species were found in the middle and upper reaches of Gales Creek (Leader and Hughes 2000).

Limited data are available to evaluate lamprey presence/absence in Scoggins Creek. During recent field surveys of lower Scoggins Creek and an unnamed tributary to lower Scoggins Creek, a single lamprey ammocoete was documented (White 2003). It is not known whether this ammocoete was an anadromous Pacific lamprey or the resident Western brook lamprey. A few lamprey (unidentified species) have been documented by ODFW during electrofishing surveys of Hagg Lake (ODFW unpublished data). Given that lamprey species are widely distributed throughout the Tualatin River Subbasin (Friesen and Ward 1996) and that a few lamprey have been documented in Scoggins Creek, and the increased concern over lamprey populations recently, Pacific lamprey were included as a target species for this EIS.

3.3.1.3 Coastal Cutthroat Trout

Because Willamette Falls acts as a complete barrier to cutthroat trout upstream passage, the Tualatin River, Scoggins Creek, and associated tributaries support the potomodromous (migration solely within freshwater) life history form of coastal cutthroat trout (*O. clarki clarki*). The discussion in this section focuses primarily on the potomodromous form, as fresh water ecology is similar for all forms of cutthroat trout.

Dimmick and Merryfield (1945) recognized fluvial and adfluvial-fluvial migratory forms of potomodromous coastal cutthroat trout in the Willamette River. Individuals that exhibit a fluvial form included those whose cycles of trophic, refuge, and reproductive migrations were confined within their stream home range. Adfluvial-fluvial migratory populations included those that leave mainstem rivers to enter tributaries for spawning, and at times feeding and refuge. Adfluvial-fluvial cutthroat trout generally migrate into spawning tributaries during autumn and winter. Fluvial fish inhabiting the upper extent of tributaries spawned as late as July.

In Oregon, the coastal cutthroat trout spawning season is thought to occur from December through July. Stolz and Schnell (1991) reported that cutthroat trout spawning is initiated at 10°C water temperature. Coastal cutthroat trout spawn in low gradient reaches of small tributaries, or in the lower regions of streams (Trotter 1997). Use of this spawning habitat is likely an adaptation to reduce competition from other, more competitive species such as steelhead (Stolz and Schnell 1991). The preferred spawning substrate is pea- to walnut-sized gravel, in 15-45 cm of water, with pools nearby for escape cover. Spawning by individual females may extend over a period of two to three days (Trotter 1997). Females will deposit anywhere from 200 to 4,400 eggs. Similar to other salmonids, the timing of incubation and emergence of cutthroat trout varies with water temperature. This is comparable to embryos incubating for 30 days at 10°C, with emergence occurring 15 to 20 days later (Stolz and Schnell 1991). Peak emergence occurs in mid-April although emergence may extend through June (Trotter 1997).

Similar to anadromous coastal cutthroat trout, adult potomodromous coastal cutthroat trout may become repeat spawners. As they can live to an age of 7 or 8 years, they may spawn repeatedly during their life (Trotter 1997). Some trout may spawn annually (Giger 1972) while others may not (Tomasson 1978). There is considerable variation in the age and size of maturity of cutthroat trout. The mean length of non-sea-run adults in coastal Oregon streams was less than half of sea-run coastal cutthroat with female adults reaching sexual maturity at approximately 15 cm (Sumner 1962; Lowry 1965).

Cutthroat trout are found in the mainstem Tualatin River; in tributaries to the Tualatin River, including Scoggins Creek and Gales Creek; and in Hagg Lake and its tributaries. The resident forms are found in the upper tributary habitats, as are the migratory forms that migrate into the Tualatin for a period of rearing and return to the tributaries to overwinter and spawn.

3.3.2 Fish Habitat in Lower Scoggins Creek and the Middle Tualatin River

Both Scoggins Creek and Tualatin River have been impacted by human activities. Scoggins Creek below the dam has been channelized for agricultural and flood control purposes. The Tualatin River has been bermed and channelized as a result of agricultural and urban development throughout the historic floodplain, and is dammed at approximately river mile 3.4. The channels in both systems are very uniform, highly entrenched, U-shaped, and lack habitat complexity. As the Tualatin River descends from the hills and enters the valley, the gradient declines dramatically; the river becomes wide, very flat, and the water slows accordingly (Table 3). For both systems, substrate generally consists of fine sediments or bedrock with some boulders. Limited cobble/gravel substrate suitable for salmonid spawning habitat exists within the Area of Potential Effect (APE); the two locations are approximately 1,000 feet downstream of Scoggins Dam on lower Scoggins Creek and upstream of the old Tualatin Valley Highway bridge. Riparian degradation contributes to poor aquatic habitats within the APE. Loss of large trees over time has resulted in a lack of large wood in the stream and consequently a loss of pool habitat. Non-native riparian species such as grasses and Himalayan blackberry (*Rubus discolor*) are abundant and provide little shade or cover for these systems.

TABLE 3. RANGES OF DEPTH, VELOCITY, AND LOCALIZED STREAM GRADIENT AT INSTREAM FLOW STUDY TRANSECTS IN THE TUALATIN RIVER.

Transect, location	Gradient (%)	Averaged Velocity (cm/sec)	Depth (ft)
Upper, Upstream of Spring Hill Bridge	0.04-0.04	-9.45 - 82.91	0.56 - 9.5
Middle, at pump station near RM 56	0.02	-21.95 - 84.73	0.16 - 7.4
Lower, Downstream of the Maple Street Bridge	0.03-0.06	-7.62 - 70.41	0.79 - 8.6

3.3.3 Seasonal Presence and Habitat Use

Critical for understanding the potential impacts to fish habitat is the knowledge of seasonal presence and absence (i.e., periodicity) of each fish species and life stage. For this study, periodicities were broadly determined for each of the species and life stages of concern for both Scoggins Creek (Table 4) and the Tualatin River (Table 5). These periodicities were reviewed with regional fish managers to ensure that they captured local variation in habitat use and timing.

TABLE 4. LIFE-HISTORY STAGE PERIODICITY CHART FOR SPECIES OF INTEREST IN SCOGGINS CREEK, OREGON.

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Steelhead Trout												
Spawning				X	X							
Incubation				X	X	X	X	X				
Fry	X	X	X	X	X	X	X	X	X	X	X	X
Juvenile	X	X	X	X	X	X	X	X	X	X	X	X
Cutthroat Trout												
Spawning	X	X	X	X	X	X	X	X				
Incubation	X	X	X	X	X	X	X	X	X			
Fry	X	X	X	X	X	X	X	X	X	X	X	X
Juvenile	X	X	X	X	X	X	X	X	X	X	X	X
Adult	X	X	X	X	X	X	X	X	X	X	X	X
Pacific Lamprey												
Spawning					X	X	X	X	X				
Ammocoetes	X	X	X	X	X	X	X	X	X	X	X	X

TABLE 5. LIFE-HISTORY STAGE PERIODICITY CHART FOR SPECIES OF INTEREST IN THE ASSESSMENT REACH OF TUALATIN RIVER, OREGON.

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Steelhead Trout												
Spawning												
Incubation												
Fry	X	X	X	X				X	X	X	X	X
Juvenile	X	X	X	X	X	X	X	X	X	X	X	X
Cutthroat Trout												
Spawning												
Incubation												
Fry	X	X	X	X	X	X	X	X	X	X	X	X
Juvenile	X	X	X	X	X	X	X	X	X	X	X	X
Adult	X	X	X	X	X	X	X	X	X	X	X	X
Pacific Lamprey												
Spawning												
Ammocoetes	X	X	X	X	X	X	X	X	X	X	X	X

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4 ENVIRONMENTAL CONSEQUENCES (EFFECTS)

4.1 ISSUES AND CONCERNS

The issue addressed in this TR was the impact that flow modifications may have on fish habitat in lower Scoggins Creek and the Tualatin River. Specifically, a Scoggins Creek and Tualatin River instream flow study was conducted to provide quantitative and qualitative information that could be used to evaluate impacts (positive and negative) and assess mitigation options related to the implementation of the two alternatives. The study objective focused on defining habitat – flow relationships and/or associations for target fish species and life history stages in three major stream segments:

- Scoggins Creek extending below Scoggins Dam to the confluence with the Tualatin River,
- Tualatin River extending from just below Scoggins Creek confluence to just above pumpback diversion point, and
- Tualatin River below pumpback diversion point.

4.2 STUDY METHODS

The Physical Habitat Simulation System (PHABSIM) was used to model habitat versus flow relationships for both Scoggins Creek and the Tualatin River. PHABSIM, which is the hydraulic modeling and habitat analysis component of the Instream Flow Incremental Methodology (IFIM), is a comprehensive set of microcomputer based models used to simulate habitat conditions in rivers and streams for various species and life stages of fish over a range of discharge conditions (Milhous 1979; Milhous et al. 1984). This methodology was developed and is currently supported by the Midcontinent Ecological Services Center (MESC) of the U.S. Geological Survey (formerly Instream Flow Group, U.S. Fish and Wildlife Service) to analyze the effects of alternative discharge regimes on the quantity and quality of habitat available to fish in rivers and streams (Bovee 1982).

Subtasks completed as part of this effort included: 1) assessment of fish habitat and stream channel conditions; 2) site reconnaissance and transect placement; 3) measurement of stream channel and hydraulic conditions at each transect/habitat area at three different flows, 4) development of habitat suitability index curves, and 5) hydraulic modeling and habitat modeling to determine the flow versus habitat relationship.

4.2.1 Assessment of Fish Habitat and Stream Channel Conditions

An assessment of fish habitat and stream channel conditions was completed to determine the diversity and distribution of available fish habitat within Scoggins Creek and the Tualatin River. The assessment was completed using remote sensing data including 2002 color aerial photographs of Scoggins Creek, 2004 color aerial photograph of the Tualatin River, and USGS topographic maps of the area. Verification of the aerial photograph assessment was completed using video taped images recorded during a helicopter flyover completed October 21, 2005. Assessment parameters included reach length, slope, habitat composition, stream channel and riparian condition, and the quantity of large woody debris. Results of this assessment are presented in a tabular form in Table 6.

4.2.2 Site Establishment – Selection of Transect/Habitat Area Selection

For this study, R2 generally followed the "Rule of Three" sampling protocol as described in CDFG (2004). This protocol consists of sampling three flows, in three units of each habitat type, with three transects placed within each habitat unit. This sampling design was recommended by ODFW (Appendix D). Based on results of habitat mapping, this type of an approach was most feasible for Scoggins Creek, where riffle-type habitats were identified in addition to glide habitats. Further details on the "Rule of Three" sampling protocol are presented in Appendix D.

A site reconnaissance visit was conducted with agency personnel on December 1, 2005 to provide an on-the-ground evaluation of habitat diversity and condition in both the Tualatin River and Scoggins Creek. From this, a preliminary selection of transects and/or areas warranting field assessment was made. Available habitat maps and aerial photographs of the Tualatin River and Scoggins Creek were used as part of this process. During this visit three sampling locations (Upper, Middle, and Lower) were established in Scoggins Creek and three transects were located in each of the three sampling locations (Figure 1). The Tualatin River consists of more predominantly glide type habitat from river mile 60 to 3.4 (Table 6). Thus, for that system, R2 established 3 transects (Upper, Middle, and Lower) to characterize this section of the Tualatin River (Figure 2). These transects were located in the area around the Spring Hill pump station where the greatest flow changes are expected based on hydrologic modeling.

4.2.2.1 Scoggins Creek - Upper Site

The Upper Scoggins PHABSIM site was located within the uppermost reach of Lower Scoggins Creek approximately 500 feet downstream of the Scoggins Dam (Figure 1). The localized stream gradient at this site was estimated at 0.09 percent. This reach functions primarily as transportation channel for water out of Hagg Lake but also contains several small patches of area (approximately 500 to 600 total sq-ft) with substrates suitable for salmonid spawning. Very little habitat diversity existed within this reach. Habitat mapping confirmed past reconnaissance surveys in showing that the reach was composed of 99 percent glide and 1 percent riffle habitat. At the upper end of the sampled riffle unit, substrate was dominated by gravels with some sand, silt and aquatic vegetation. Grasses were the dominant riparian vegetation in this reach, providing no in-stream cover or habitat structure.

TABLE 6. SUMMARY OF HABITAT AND CHANNEL CONDITIONS IN REVIEW

Reach Boundaries		Reach Length (miles)	Slope (%)	Habitat Composition	Riparian Condition	Channel Condition	LWD Quantity
Upstream	**Downstream**						
Scoggins Dam	Tualatin River	5.2	0.19	0.5% riffle 99.5% run/glide	Upper 1/3 of reach has very limited riparian veg. Lower 2/3 lined with med-large hardwoods	Upper most 2200 ft has been straightened & channelized, ave. width 15-20 ft	Low
Scoggins Cr.	Spring Hill Rd.	1.3	0.06	100% run/glide	Mostly shrubs with scattered med-large hardwoods	Moderately sinuous, limited channelization, ave. width 20-30 ft	Low
Spring Hill	Dilley Cr.	1.4	0.07	100% run/glide	Mostly shrubs with scattered med-large hardwoods	Moderately sinuous limited channelization, ave. width 20-30 ft	Occasional LWD jams
Dilley Cr.	Gales Cr.	1.44	0.06	100% run/glide	Narrow riparian width, mostly shrubs with scattered med-large hardwoods	Extensive ag. use along both banks, possible channelization, moderately sinuous, ave. width 20-30 ft	Low
Gales Cr.	Fern Hill Rd.	1.65	0.05	100% run/glide, some faster water associated with LWD	Well established riparian veg. with mostly med-large hardwoods	Moderately sinuous limited channelization, ave. width 40-60 ft	Moderate with occasional LWD jams
Fern Hill Rd.	Golf Course Rd.	4.4	0.07	100% run/glide, some faster water associated with LWD	Well established riparian veg. with mostly med-large hardwoods, narrow riparian width in some spots	Moderately sinuous, extensive ag. use along both banks, some active bank cutting on outside bends, ave. width 40-60 ft	Moderate to high with occasional LWD jams
Golf Course Rd.	River Mile 48	3.9	0.05	100% run/glide, some faster water associated with LWD	Well established riparian veg. with mostly med-large hardwoods	Highly sinuous, moderate ag. use, some active bank cutting on outside bends, ave. width 40-60 ft	Moderate to high with occasional LWD jams
River Mile 48	Dairy Cr.	3.7	0.05	100% run/glide, some faster water associated with LWD	Riparian veg. limited by adjacent land use, mostly med-large hardwoods	Extensive ag. use along both banks, some active bank cutting on outside bends, ave. width 40-60 ft	Moderate with occasional LWD jams
Dairy Cr.	Minter Bridge	3.25	0.05	100% run/glide	Riparian veg. limited by adjacent land use, mostly med-large hardwoods	Extensive ag. use along both banks, some active bank cutting on outside bends, ave. width 40-60 ft	Low-Moderate
Minter Bridge	Rock Cr	3.6	0.05	100% run/glide	Riparian veg. limited by adjacent land use, mostly med-large hardwoods	Extensive ag. use along both banks, some active bank cutting on outside bends, ave. width 40-60 ft	Low-Moderate
Rock Cr.	Farmington	5.4	0.05	100% run/glide some faster water associated with LWD	Riparian veg. limited by adjacent land use, mostly shrubs with med-large hardwoods	Extensive ag. use along both banks, some active bank cutting on outside bends, ave. width 50-75 ft	Low-Moderate

FIGURE 1. UPPER, MIDDLE, AND LOWER SAMPLING SITES ON SCOGGINS CREEK, OREGON.

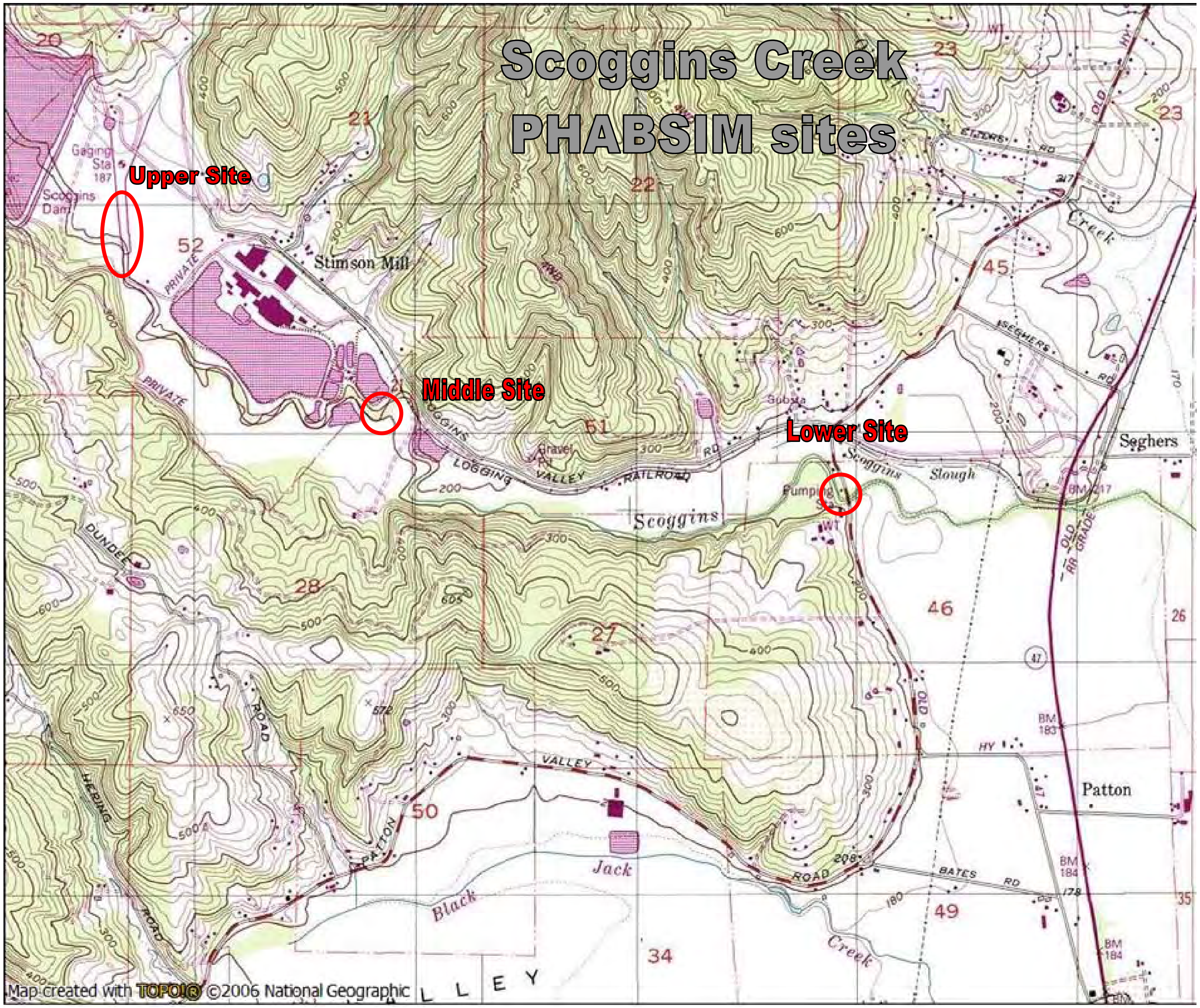
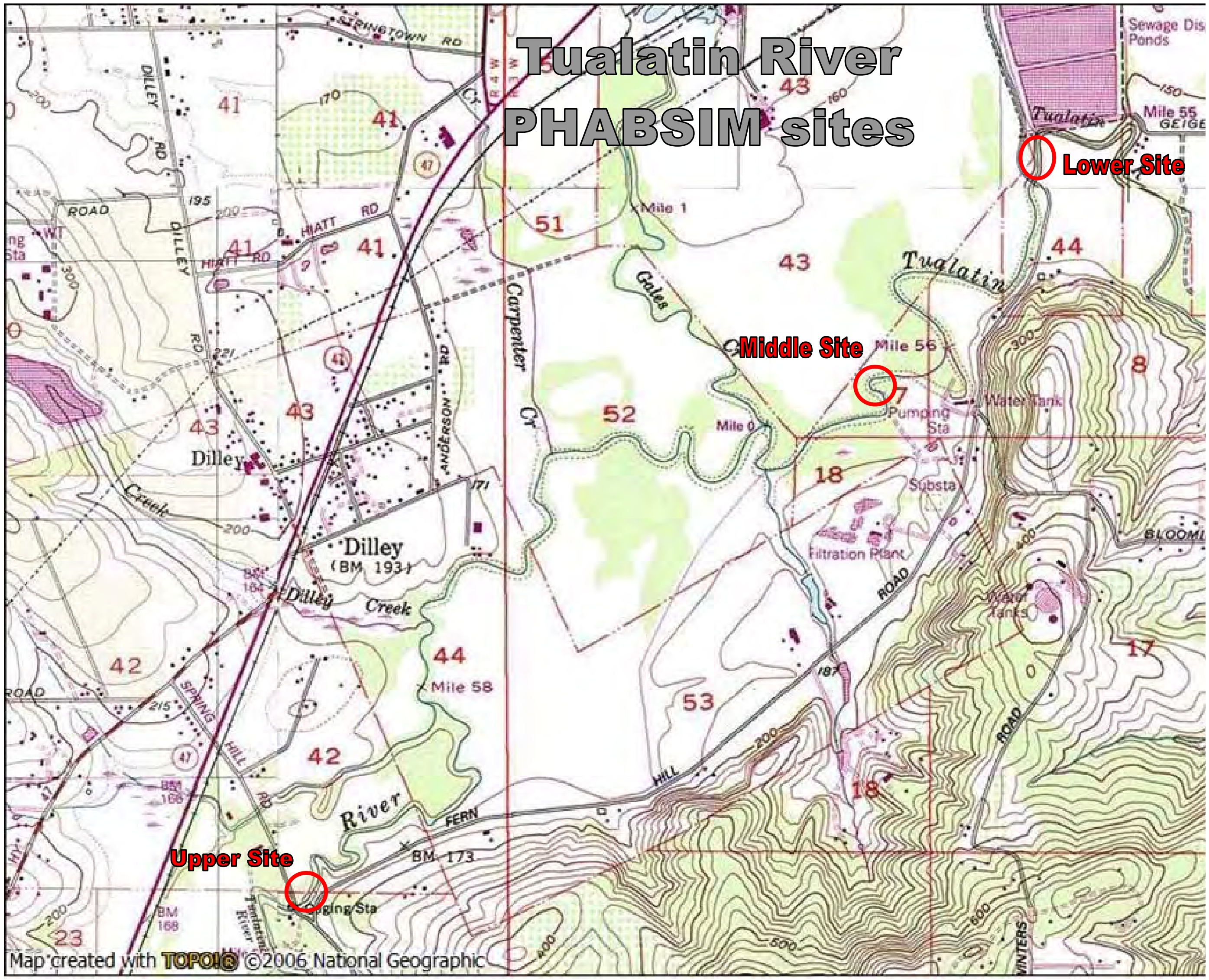


FIGURE 2. UPPER, MIDDLE, AND LOWER SAMPLING SITES ON THE TUALATIN RIVER, OREGON.



4.2.2.2 Scoggins Creek - Middle Site

The Middle Scoggins PHABSIM Site was located within the large expansive glide that runs for the majority of the length of Lower Scoggins Creek. It was located at the southern end of the Stimpson Lumber mill pond just downstream from the Walta Pond bridge (Figure 1). Within this section of the creek, the U-shaped channel is deeply entrenched (banks 9-15 ft high) with a localized stream gradient of 0.04 percent. Substrate was dominated by silt and sand. The riparian vegetation was limited to Himalayan blackberry and a few woody shrubs, grasses, and alders.

4.2.2.3 Scoggins Creek - Lower Site

The Lower Scoggins PHABSIM site was located 30 feet upstream from the Old Tualatin Valley Highway Bridge in the proximity of the Patton Valley pump station (Figure 1). Habitat mapping in this lower reach showed this portion of the river to be almost exclusively glide with the exception of the selected sampling site. This site encompassed some pool and riffle habitat that may have some potential for salmonid spawning. The substrate at this site was complex, with cobble as the dominant substrate and areas of bedrock, boulder, gravels, sand and silt also documented. The stream channel in this area was also deeply entrenched. There was a hydraulic drop towards the upstream end of this site resulting in a localized stream gradient of 2.4 percent. The site possessed a small riparian zone (estimated 10 ft on both banks) with young and mature deciduous trees and an understory dominated by Himalayan blackberry.

4.2.2.4 Tualatin River

Three IFIM transect sites were selected on the middle Tualatin River (Figure 2). The uppermost site was located just downstream of the Spring Hill Road bridge crossing. The middle site was located upstream of the pump station located near RM 56. The downstream most habitat unit was located just downstream of the Maple St. Bridge. All three sites were located within the extensive glide habitat that dominates the Tualatin River from RM 60 to RM 33; as a result, the three sites were very similar. Substrate within this glide habitat was dominated by silt and sand. In general, steep and incised channels characterized the channel morphology at all three sites. The absence of herbaceous vegetation along stream banks appeared to be indicative of highly fluctuating flow regimes. Willow (*Salix* sp.), highly adapted to disturbance, was the dominant plant within bankful width. Dominant riparian canopy species consisted of Douglas fir, red alder, and big-leaf maple. Subdominant canopy species include oak sp., western redcedar, and black cottonwood. Himalayan blackberry dominated the riparian shrub community at the upper site and lower site. Reed canary grass was the dominant ground cover species at the upper site. Common riparian shrub species present at all three sites included willow, Nootka rose, salmon berry, and trailing blackberry.

4.2.3 Channel and Hydraulic Measurements

Hydraulic measurements, including water surface elevations were measured at each transect during three (3) different flow conditions; water depth and velocity distributions across each transect were measured during the low to mid flow conditions. Based upon a review of flow records for the Tualatin River, a preliminary set of flow targets of 200 cfs, 400 cfs, and 800 cfs were selected for the Tualatin River. In order to model habitat at both existing and proposed future flow releases in Scoggins Creek, we selected three target flows ranging from 15-20 cfs, 50-75 cfs, and 125-150 cfs. Based upon guidelines established by the USFWS for instream flow studies, the target flows for the Tualatin River would allow for the development of habitat versus flow relationships for discharge conditions ranging from 80 cfs to 2,000 cfs; for Scoggins Creek, from around 8 cfs to over 300 cfs. A summary of the survey dates and stream discharges measured at each site is presented in Table 7.

TABLE 7. SUMMARY OF SURVEY DATES AND STREAM DISCHARGES DURING FIELD DATA COLLECTION FOR EACH OF THE PRIORITY STREAMS.

	Low Flow		Medium Flow		High Flow	
Stream	Date	Discharge (cfs)	Date	Discharge (cfs)	Date	Discharge (cfs)
Scoggins Creek						
Lower	02/14/06	29.3	02/15/06	62.1	02/16/06	172.9
Middle	02/14/06	23.8	02/15/06	64.3	02/16/06	162.8
Upper	02/14/06	20.3	02/15/06	52.8	02/16/06	153.7
Tualatin River						
Lower[1]	06/13/06	26.4	02/23/06	369.1	02/17/06	718.2
Middle	06/13/06	55.1	02/23/06	446.0	02/17/06	778.1
Upper	06/13/06	28.0	02/23/06	225.2	02/17/06	410.0
					03/09/06	597.8

[1]-Flow differences between the lower and middle Tualatin River sites result from water withdrawals made from the Spring Hill Pumping Plant PHABSIM site Lower Tualatin River is located downstream of the pump station.

4.2.4 Habitat Suitability Curve Review and Selection

Habitat suitability index (HSI) curves reflect species and life stage use and preference for selected habitat parameters (depth, velocity, and substrate) (Bovee 1982). Depending on the extent of data available, HSI curves can be developed from the literature (Category 1 curves), or from physical and hydraulic measurements made in the field over species microhabitats (Category 2 curves). When adjusted for availability, these latter curves may more accurately reflect species preference (Category 3 curves) (Bovee 1986).

Site specific HSI curves were not available for Scoggins Creek or the Tualatin River; therefore, HSI curves were developed using existing curves obtained from available literature. The literature curves used for this purpose were selected based upon their applicability to watershed and habitat conditions found in Scoggins Creek and the Tualatin River. Species and life-stage specific curves were developed during roundtable discussions (March 22, 2006) with agency biologists, using existing curve sets as a starting point and then applying alterations from personal knowledge and professional opinion. This information along with agency comments was used to finalize (with agency concurrence) a set of HSI curves considered appropriate for application in the Scoggins and Tualatin River Instream Flow Needs Study. The agency-approved HSI curves are presented in Appendix A.

4.2.5 Hydraulic and Habitat Measurements

The collection of physical and hydraulic measurements at each of the 12 instream flow transects were completed following the procedures for PHABSIM studies outlined by Bovee and Milhous (1978), Bovee (1982), and Trihey and Wegner (1984). The establishment of transects at each location were completed as follows:

- Locations of Transects –Transect positions were recorded and mapped in a field book and on a topographic map. The position of each transect were permanently established using wooden stakes pounded solidly into the ground.

- Establishment of Site Benchmark – A permanent benchmark was established at each transect. All survey measurements, including water surface and bed elevations, will be referenced to this benchmark. Each benchmark (large boulder or rebar) was placed above the floodplain of the river, and marked with fluorescent flagging for high visibility.

- Installation of Head Pins – Head pins (rebar) were installed on the side of the river near the starting point of each transect. These head pins served as a secondary vertical reference point for water surface and bed elevation measurements collected across the stream channel. Differences between transect benchmark and head pin elevations were used as a quality control check for surveying accuracy. The head pins were intended to serve as a backup benchmark given that the transect benchmark was disturbed.

- Establishment of Working Pins - Working pins (wooden stakes) were established on either bank of a transect. These working pins were positioned in such a way that the line connecting these points was perpendicular to the main flow of the river channel. A surveying tape was stretched across the river channel and connected to these points during the collection of instream flow data. This survey tape was tied to the working pin at the same position (e.g., 2 ft on the tape) during each sampling so that velocities could be measured at the same positions across the transect.

- Survey of Benchmark Elevations and Completion of Level Loop – Following the installation of the benchmarks at each transect, a level loop survey was completed to establish benchmark elevation. The elevation data was obtained using an Auto Level and stadia rod (0.01 ft accuracy). The level loop was considered accurate if closed to within 0.02 ft of the initial BM elevation.

Water surface elevations were measured at the right bank, mid-channel, and left bank of each transect under all of the specified “calibration” discharges. Velocity profiles were then obtained across each transect at the same tape positions under the low and mid “calibration” flow. Measuring velocities at the same locations (i.e., verticals) across a given transect was necessary in order to use the velocity-discharge regression calibration procedure. A log-linear regression was used by the hydraulic simulation model IFG4 to predict velocities at all simulation flows.

The following data was recorded at each transect:

- Site Location and Transect Number;
- Habitat Type – i.e., riffle, pool, glide;
- Sampling Date/Time/Investigators/Flow – Information regarding when data was being collected, who collected the data, and under what flow conditions the data was being collected;
- Water Surface Elevations (WSEs) – Measured to the nearest 0.01 ft. at least three locations in the channel: left bank, center of channel, and right bank, with more measurements obtained at complex transects;
- Photographs – Each transect was photographed from at least two different positions under each calibration flow condition (Appendix C).

Data were collected at established intervals across each transect following the protocols recommended by MESC. Depth, velocity, and substrate data were collected at each measurement point (verticals) across each transect as described below.

Water Depth was measured to nearest 0.1 ft. Depths were measured using top setting rod. Measured water depths were not used during hydraulic modeling process, since the IFG4 model calculates depths by subtracting bed elevations from water surface elevations. Depth measurements provided a useful quality control check of water surface elevations at each calibration flow.

Mean Column Water Velocity was measured to nearest 0.1 ft/sec. Velocities were measured using a calibrated Swoffer Model 2100 velocity meter. Velocities were measured at 6/10ths depth in the water column for depths less than 2.5 ft, and 2/10ths and 8/10ths depth in the water column for depths greater than 2.5 ft.

Dominant and subdominant substrate types were determined. Substrate types were recorded at each transect vertical under low flow conditions. Substrates were classified using standard substrate categories (bedrock, boulders, cobbles, large gravels, medium gravels, small gravels, sand, silt, and organic matter). The dominant substrate, subdominant substrate was recorded at each site.

4.2.6 Hydraulic Modeling

Hydraulic and habitat simulation modeling was conducted using PHABSIM Version II computer software (Milhous et al. 1989). Hydraulic simulations modeling included the following four steps:

1. Raw field data were entered into Excel spreadsheets, reviewed for data entry errors, and then reviewed for potential surveying and hydraulic measurement reading errors by a hydraulic engineer. Any errors were identified and corrected in a copy of the field notebook. Once quality control procedures were completed, these Excel spreadsheets were used to generate text format hydraulic data input files for the PHABSIM hydraulic simulation program IFG4. These IFG4 files have the same formatting as generated by the I4TEXT program. The IFG4 data files were then checked for any errors before proceeding to model calibration.

2. Stage-discharge relationships were developed using several different hydraulic simulation models, depending upon the hydraulic characteristics of individual transects. An initial stage-discharge calibration was conducted using the PHABSIM program IFG4. Depending upon the hydraulic characteristics of a given transect, a stage-discharge relationships was developed using one of three methods: a log-log regression method (rating curve developed using the IFG4 program), a channel geometry and roughness method (rating curve developed using the Manning's Equation based program MANSQ), or a step-backwater method (rating curve developed using the program WSP).

3. Velocities across each transect were then calibrated to provide a reasonable distribution of mean column velocities across the river channel for the entire range of flows employed in habitat simulations.

4. Finally, the calibrated IFG4 hydraulic simulation model was used to predict wetted perimeter, velocity, depth, substrate, and habitat cover conditions occurring at each transect for flows ranging from 12 cfs to 430 cfs for Scoggins Creek and 26.5 cfs to 2,000 cfs for the Tualatin River.

4.2.7 Habitat Modeling

Output from the hydraulic simulation modeling was used in conjunction with final HSI curves to simulate habitat conditions for each target species and life stage over a wide range of flows. Habitat simulations were conducted using the HABTAE/HABTAT habitat simulation modeling program. HABTAE uses average velocity values between adjacent verticals for use in habitat area calculations. Habitat simulations will be conducted using the multiple "single-velocity set" approach (i.e., Mannings "n" method), which is the most commonly used method since the early 1990s.

Weighted usable area (WUA) habitat versus discharge curves were calculated for each target fish species and life stage for all transects and reaches. WUA is a habitat index that combines the quantity and quality of that habitat provided by alternative flows. WUA is expressed in units of square feet of habitat area per 1,000 linear ft of stream (sq-ft per 1,000 ft); (Bovee 1982, Milhous et al. 1989). The WUA values for each transect were weighted according to the total length of habitat represented by the habitat type which the transect(s) represents. WUA curves are presented in Appendix B.

4.2.8 Time Series & Habitat Duration Curves

A habitat time series analysis was completed to identify differences in habitat duration curves and habitat exceedance statistics between the proposed flow regime and the current flow regime. The time series analysis, which was conducted using the IFIM Time Series computer programs, consisted of three basic steps.

First, using daily discharge values obtained from CleanWater Services and the USGS, daily flow records were converted into monthly flow records for habitat time series analysis.

Second, the monthly time series of current and proposed discharges were converted into the corresponding monthly time series of habitat values using the habitat area (HA) versus flow relationships developed for each species and life stage. The program then calculates a habitat time series record by reading in monthly flow values and converting these values into monthly habitat values by looking up the habitat area corresponding to each flow value from the HA versus flow curves.

Third, habitat duration curves were developed for each of the habitat time series records to effectively compare the differences in habitat conditions for each life stage under the current and proposed flow regimes in Scoggins Creek and the Tualatin River. Habitat duration curves were calculated for each alternative and existing conditions.

4.3 IMPACT ASSESSMENT

4.3.1 Alternative 1 – No No Action

There are no construction activities associated with this alternative. Hydrology under this alternative is the same as the baseline condition (Tables 8-10); therefore, there would be no effects from operations of the reservoir or RWP. Compared to current conditions, the reservoir water levels would remain within the current range (i.e., low water and high water elevations would be the same as at present). Maximum drawdown would likely occur earlier and more frequently, however the difference between current operations and those under the No Action (baseline conditions) have not been quantified.

Because there are no construction activities and no operational changes associated with this alternative, there would be no quantifiable effects on fish habitats.

TABLE 8. MONTHLY AVERAGE FLOWS (CFS) FOR SCOGGINS CREEK. VALUES REPRESENT THE WETTEST, DRIEST, OR MEDIAN FLOW VALUES OF ALL MODEL FLOWS FOR THAT MONTH.

Scenario	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Wettest Flow												
Baseline and Alternative 1	167	38	610	614	736	312	228	134	93	280	357	258
Alternative 2	141	33	25	356	579	312	224	134	72	226	295	203
Alternative 3	141	33	192	557	736	312	212	134	74	226	296	204
Driest Flow												
Baseline and Alternative 1	98	20	10	143	177	35	54	20	74	246	284	204
Alternative 2	72	25	25	25	25	25	50	25	54	191	223	149
Alternative 3	72	25	25	25	25	25	29	25	56	194	225	151
Median Flow												
Baseline and Alternative 1	36	20	10	10	10	10	10	10	34	88	98	73
Alternative 2	25	25	25	25	25	25	25	25	26	64	72	49
Alternative 3	25	25	25	25	25	25	25	25	27	64	73	52

TABLE 9. MONTHLY AVERAGE FLOWS (CFS) FOR THE TUALATIN RIVER AT DILLEY. VALUES REPRESENT THE WETTEST, DRIEST, OR MEDIAN FLOW VALUES OF ALL MODEL FLOWS FOR THAT MONTH.

Scenario	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Wettest Flow												
Baseline and Alternative 1	329	822	1,869	1,963	2,265	1,218	901	418	232	357	460	322
Alternative 2	303	827	1,533	1,576	2,108	1,214	930	416	210	302	402	270
Alternative 3	303	827	1,533	1,867	2,265	1,214	858	416	212	302	403	271
Driest Flow												
Baseline and Alternative 1	86	50	39	29	61	125	95	47	86	104	116	109
Alternative 2	75	46	51	44	76	140	108	57	72	81	93	84
Alternative 3	75	46	51	44	76	140	108	57	73	81	94	84
Median Flow												
Baseline and Alternative 1	164	220	507	756	750	472	297	112	131	287	323	248
Alternative 2	138	225	505	638	620	457	305	120	109	233	265	195
Alternative 3	138	225	505	638	653	461	287	120	111	235	267	196

TABLE 10. MONTHLY AVERAGE FLOWS (CFS) FOR THE TUALATIN RIVER AT SPRING HILL. VALUES REPRESENT THE WETTEST, DRIEST OR MEDIAN FLOW VALUES OF ALL MODEL FLOWS FOR THAT MONTH.

Scenario	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Wettest Flow												
Baseline and Alternative 1	540	1,505	3,192	3,185	3,896	2,266	1,434	629	283	187	245	212
Alternative 2	539	1,515	2,673	2,798	3,739	2,266	1,464	627	280	227	246	293
Alternative 3	539	1,515	2,774	3,090	3,896	2,266	1,391	627	283	231	246	293
Driest Flow												
Baseline and Alternative 1	73	23	29	25	54	178	118	30	35	60	69	68
Alternative 2	94	51	41	40	69	115	132	42	47	87	86	81
Alternative 3	91	36	41	40	69	115	132	42	50	96	91	89
Median Flow												
Baseline and Alternative 1	129	335	946	1,279	1,231	829	490	154	80	131	131	135
Alternative 2	181	345	668	914	919	728	504	162	84	161	187	213
Alternative 3	178	345	936	1,191	1,125	731	480	162	86	166	189	214

4.3.2 Alternative 2 – Scoggins Dam 40-foot Raise

Monthly flow data from the 73 year record are presented in Tables 8 through 10. Habitat Duration curves are presented in Figures 3 through 32. These tables and figures are presented along with summary descriptions of the changes in WUA between Baseline and the alternatives by species, life stage, and water body in the sections that follow.

4.3.2.1 Steelhead

4.3.2.1.1 Spawning and Incubation

The habitat duration curves for Scoggins Creek (Figures 3 and 4) showed that the WUA estimates for Alternative 2 exceeded those for Baseline conditions at the upper Scoggins Creek site approximately 60 percent of the time. The analysis indicated that Alternative 2 would decrease the effects of variation in WUA over time. Alternative 2 would be expected to slightly reduce the risks to steelhead associated with dewatering or scour of redds over time during spring and summer. The greatest increase in habitat would be expected during the peak spawning months of April and May and during incubation in July.

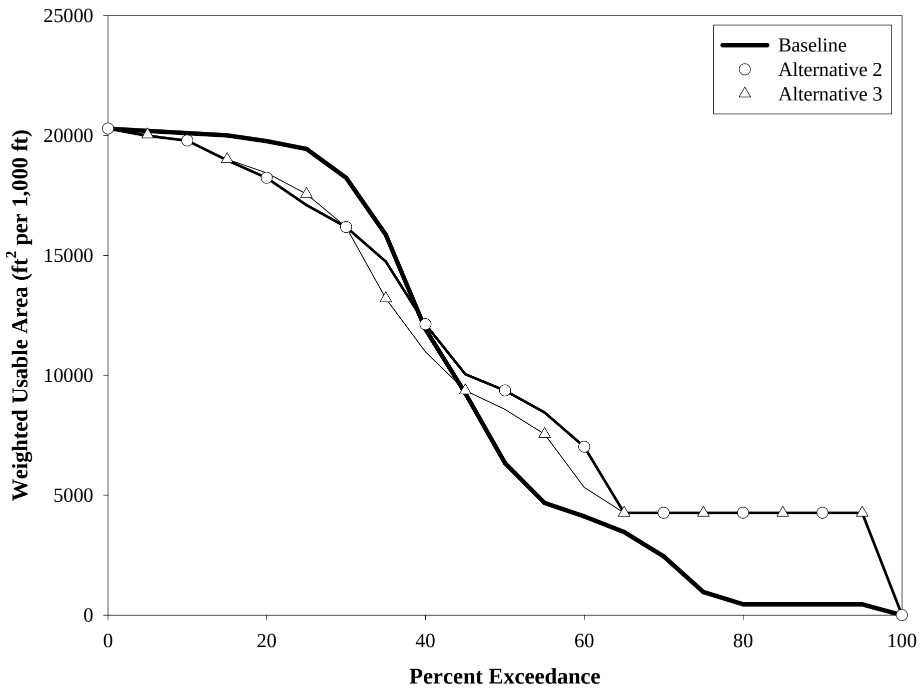


FIGURE 3. HABITAT DURATION CURVE SHOWING MODELED STEELHEAD SPAWNING HABITAT ESTIMATES IN UPPER SCOGGINS CREEK.

4.3.2.1.2 Juvenile Rearing and Adult Holding Habitat

Scoggins Creek

Duration curves for juvenile rearing and adult holding habitat are presented in Figures 5 -7. Modeling results predicted that at both the upper (Figure 5) and middle (Figure 6) Scoggins Creek sites Baseline WUA will exceed Alternative 2 WUA approximately 65 percent of the time. Habitat decreases would be expected most years from in late summer, fall and winter months. It is interesting to note that the decreases from Baseline that were evident in the habitat duration curves were occurring at high higher habitat levels. At the lower habitat levels, when weighted usable area was below 10,000 ft^2/1,000 ft stream, the WUAs for Alternative 2 exceeded the Baseline condition. This may be a reflection of increased minimum flows in Scoggins Creek under Alternatives 2, as well as the stream being comprised of nearly all glide habitat.

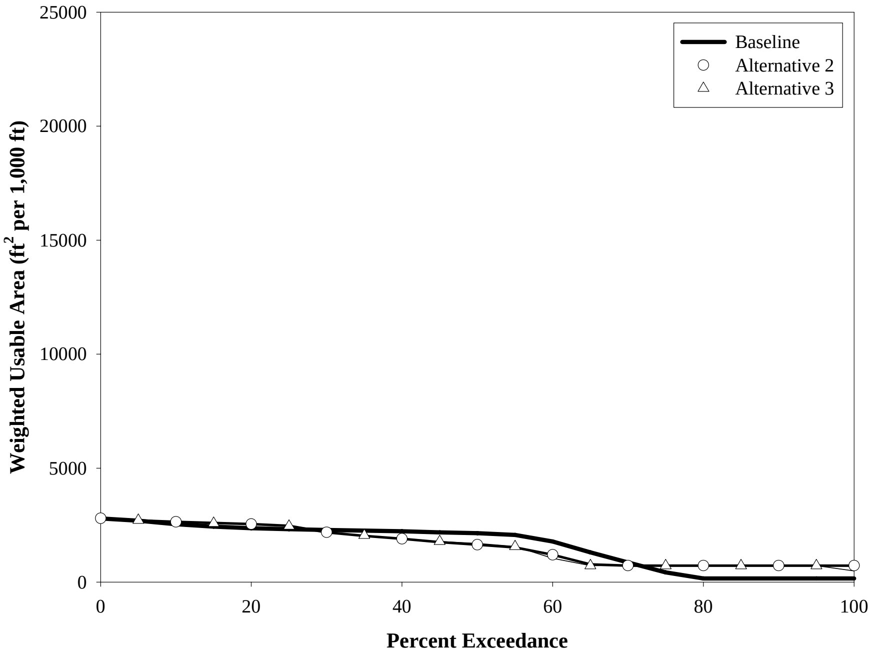


FIGURE 4. HABITAT DURATION CURVE SHOWING MODELED STEELHEAD SPAWNING HABITAT ESTIMATES IN LOWER SCOGGINS CREEK.

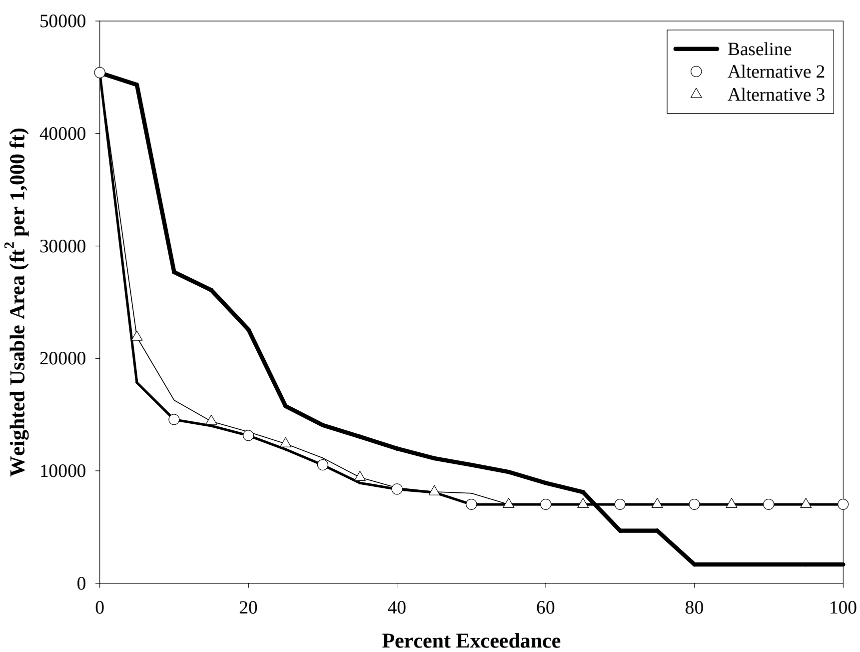


FIGURE 5. HABITAT DURATION CURVE SHOWING MODELED JUVENILE STEELHEAD REARING AND ADULT HOLDING HABITAT ESTIMATES IN UPPER SCOGGINS CREEK.

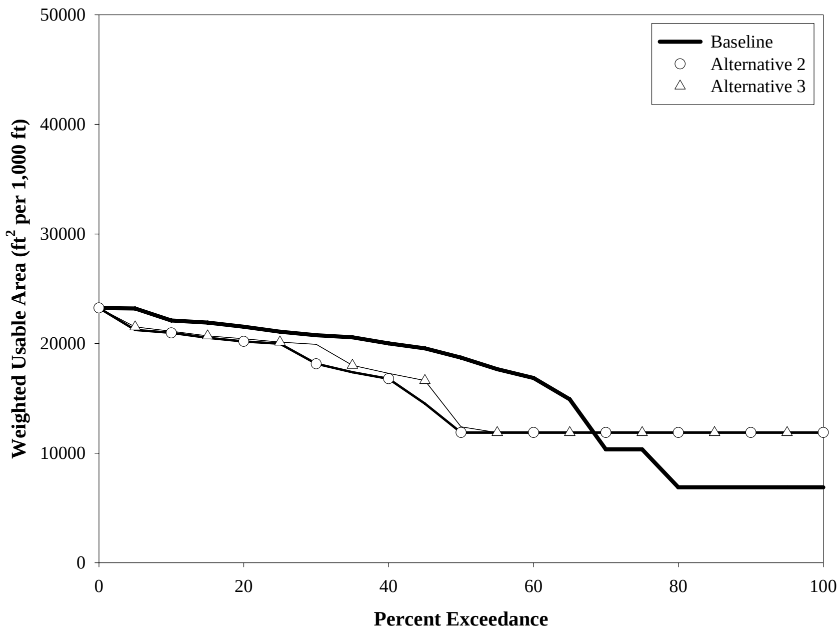


FIGURE 6. HABITAT DURATION CURVE SHOWING MODELED JUVENILE STEELHEAD REARING AND ADULT HOLDING HABITAT ESTIMATES IN MIDDLE SCOGGINS CREEK.

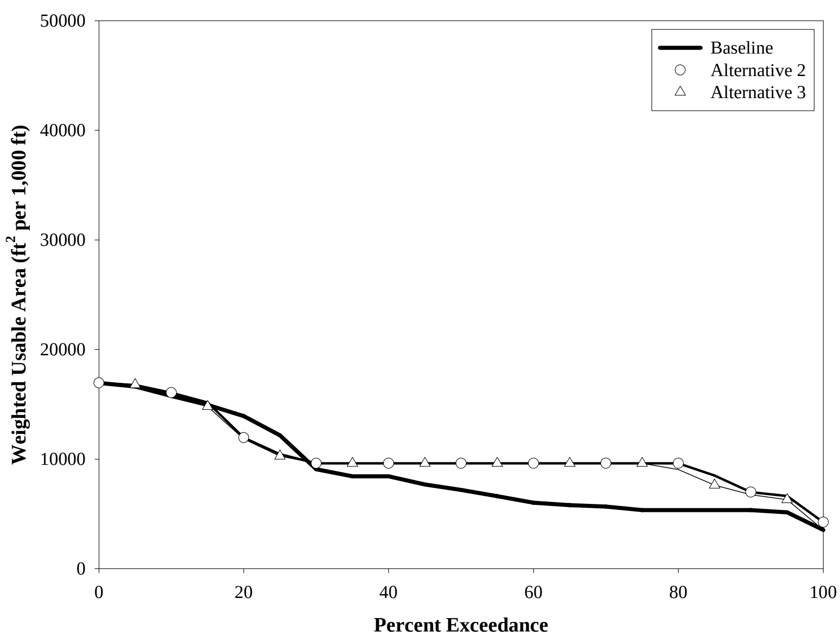


FIGURE 7. HABITAT DURATION CURVE SHOWING MODELED JUVENILE STEELHEAD REARING AND ADULT HOLDING HABITAT ESTIMATES IN LOWER SCOGGINS CREEK.

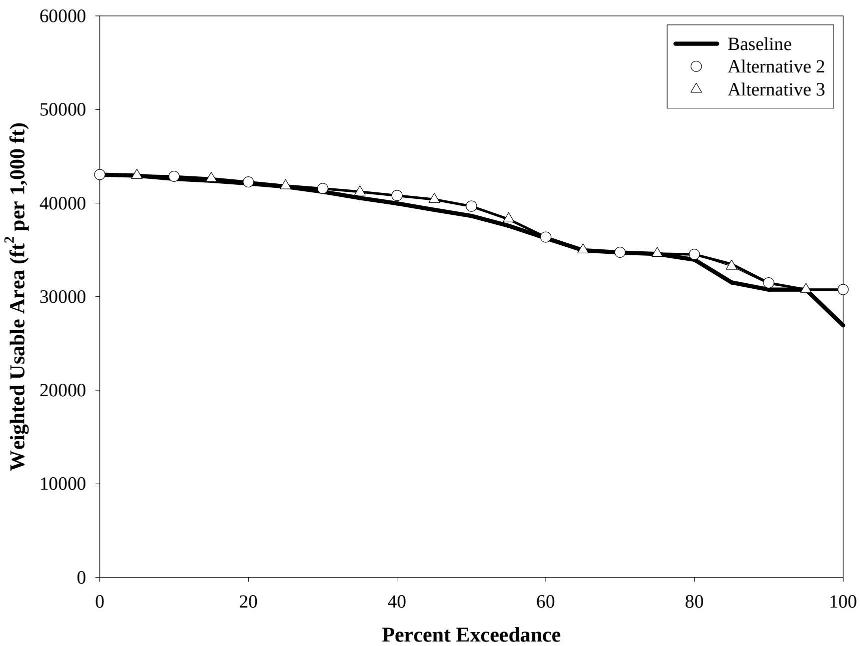


FIGURE 8. HABITAT DURATION CURVE SHOWING MODELED JUVENILE STEELHEAD REARING HABITAT ESTIMATES FOR THE UPPER SITE ON THE TUALATIN RIVER.

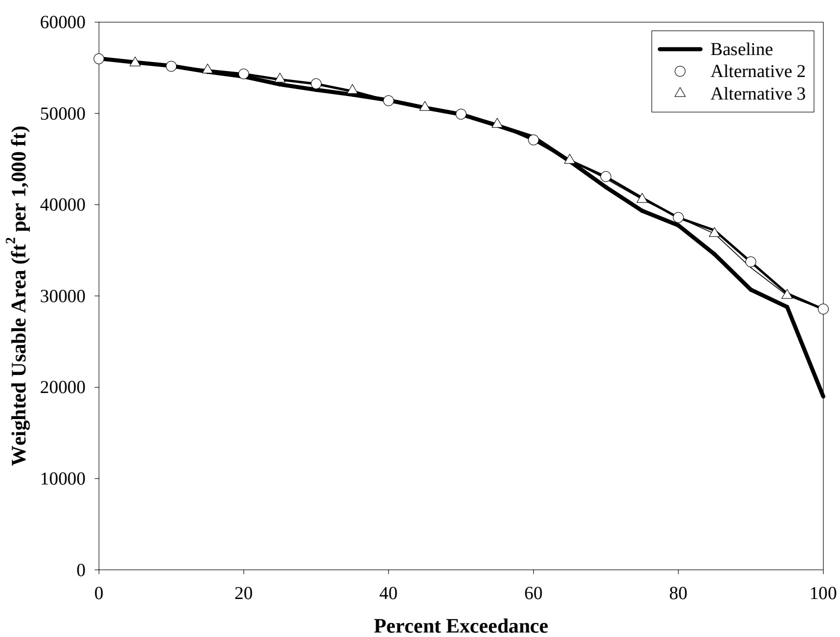


FIGURE 9. HABITAT DURATION CURVE SHOWING MODELED JUVENILE STEELHEAD REARING HABITAT ESTIMATES FOR THE MIDDLE SITE ON THE TUALATIN RIVER.

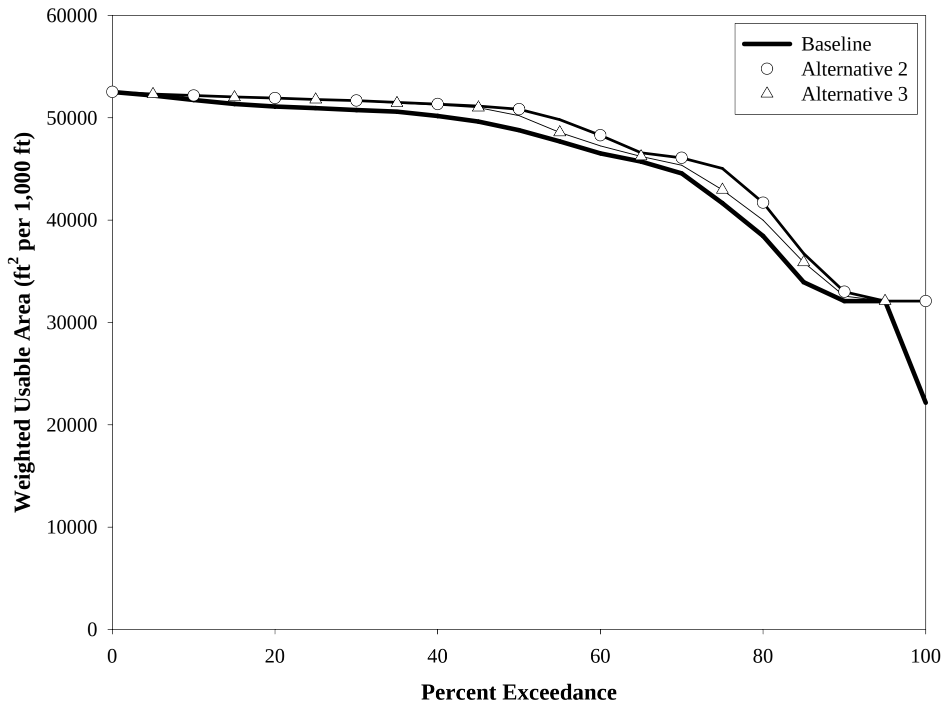


FIGURE 10. HABITAT DURATION CURVE SHOWING MODELED JUVENILE STEELHEAD REARING HABITAT ESTIMATES FOR THE LOWER SITE ON THE TUALATIN RIVER.

The habitat duration curve for lower Scoggins Creek was different from the other two sites (Figure 7). Most likely this difference resulted from the presence of an area of higher gradient riffle habitat as compared the other sites where uniform glide habitat was present. Here the Baseline and Alternative WUAs were more similar. The estimated WUA for Alternative 2 was predicted to be higher than Baseline approximately 70 percent of the time. WUA values for Alternative 2 were predicted to be similar to or greater than Baseline values for most months that juveniles would be rearing and adults holding.

Tualatin River

The habitat duration curves for steelhead rearing habitat were very similar at the three Tualatin sites, with the WUA under Alternative 2 increasing slightly from the upper to the lower site (Figures 8-10). As can be seen in the modeled WUA for Alternative 2 were similar or greater than Baseline at all times at these locations, and Alternative 2 had slightly greater estimates for WUA approximately 90 percent of the time at the lower site on the Tualatin (Figure 10).

Steelhead Summary

Overall, the increases in WUA for steelhead spawning and incubation habitat were greater in number and magnitude, suggesting positive impacts associated with Alternative 2. In addition, since WUA was more stable during spawning and incubation, the potential effects of dewatering and scours would be slightly reduced under this Alternative. Juvenile rearing/adult holding habitat in Scoggins Creek would be expected to see more decreases than increases in WUA, and substantial decreases were projected for essential summer rearing habitat. Thus, we anticipate that Alternative 2 would have significant negative impacts to steelhead rearing and holding habitat in Scoggins Creek. WUA for adult and juvenile habitat in the Tualatin River would be slightly higher or remain similar to Baseline conditions in most months at all sites, indicating a positive impact associated with Alternative 2 at this location.

4.3.2.2 Lamprey

4.3.2.2.1 Spawning and Incubation

Model results for the upper Scoggins site showed site-specific differences. Habitat duration curves showed Alternative WUA to increase above Baseline at higher habitat levels, above 10,000 ft^2 per 1,000 ft stream (Figure 11). Approximately 60 percent of the time, Alternative 2 exceeded the Baseline condition for WUA. However at habitat levels below 10,000 ft 2 per 1000 ft stream, conditions changed and approximately 30 percent of the time Baseline WUA exceeded those predicted for Alternative 2. Furthermore, 10 percent of the time the WUAs were similar. Monthly flow data indicated that the reduced WUAs associated with Alternative 2 would be expected to occur in summer. Under Alternative 2, the pattern of monthly fluctuations over the spawning and incubation period was predicted to remain similar to Baseline, with an increasing amounts of habitat over time from May through September.

Results for lower Scoggins Creek spawning habitat were very different from the upper site, likely due to the higher velocities present at the lower site. At this location on Scoggins Creek, modeled WUA was slightly lower than baseline 60 percent of the time and otherwise were similar to baseline (Figure 12). The pattern of month-to-month fluctuations in WUA were predicted to be similar between Baseline and Alternative 2.

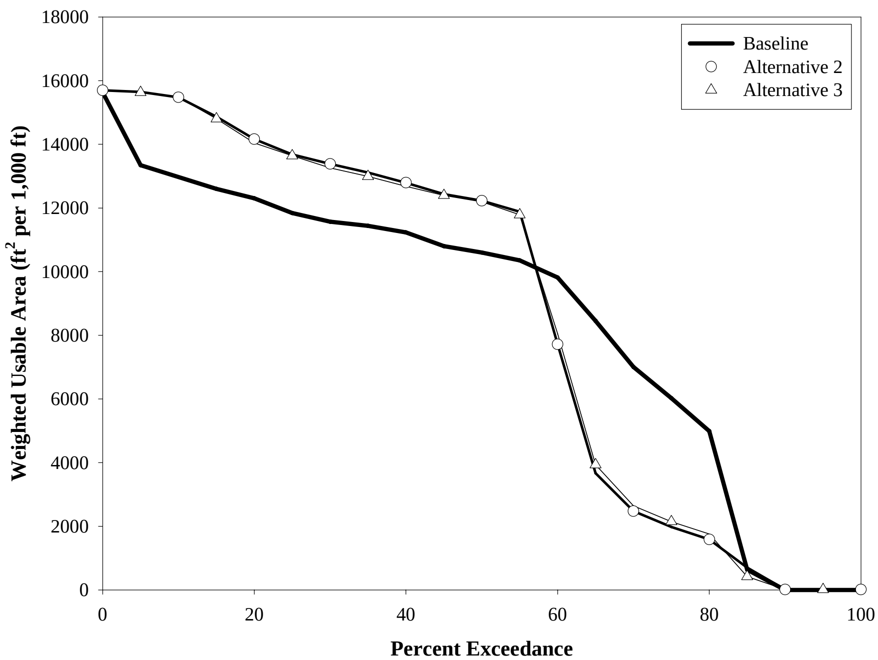


FIGURE 11. HABITAT DURATION CURVE SHOWING MODELED LAMPREY SPAWNING HABITAT ESTIMATES IN UPPER SCOGGINS CREEK.

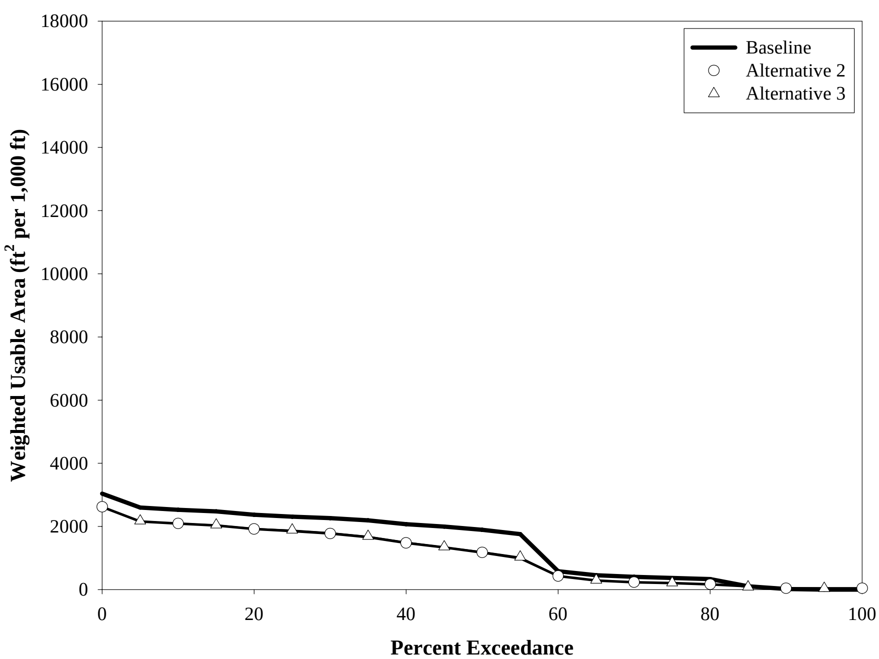


FIGURE 12. HABITAT DURATION CURVE SHOWING MODELED LAMPREY SPAWNING HABITAT ESTIMATES IN LOWER SCOGGINS CREEK.

4.3.2.2.2 Juvenile Rearing Habitat

Scoggins Creek

Lamprey ammocoete habitat was modeled for all three IFIM sites in Scoggins Creek. The habitat duration curve for the upper Scoggins site showed that approximately 60 percent of the time WUA under Alternative 2 was considerably lower than WUA for the Baseline condition (Figure 13). The remaining 40 percent of the time the predicted WUAs were very similar. At the middle site, only small changes (less than 10 percent) were predicted with WUA under Alternative 2 slightly greater than those for the Baseline all of the time (Figure 14). At the lowest site in Scoggins Creek, lamprey rearing habitat would stay the same or be improved approximately 80 percent of the time under Alternative 2 as compared to Baseline WUA (Figure 15).

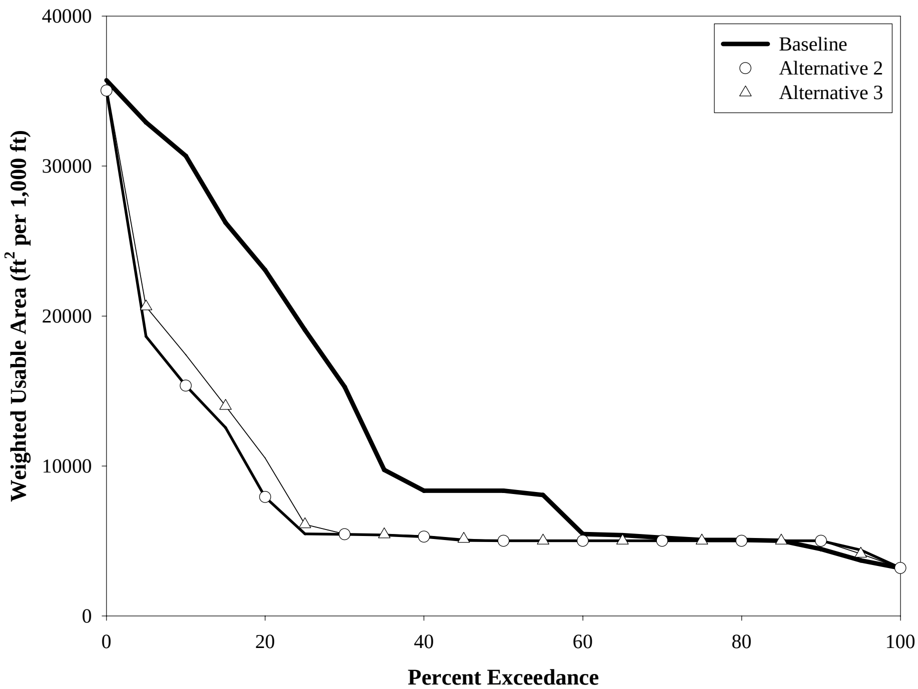


FIGURE 13. HABITAT DURATION CURVE SHOWING MODELED LARVAL LAMPREY (AMMOCOETE) REARING HABITAT ESTIMATES IN UPPER SCOGGINS CREEK.

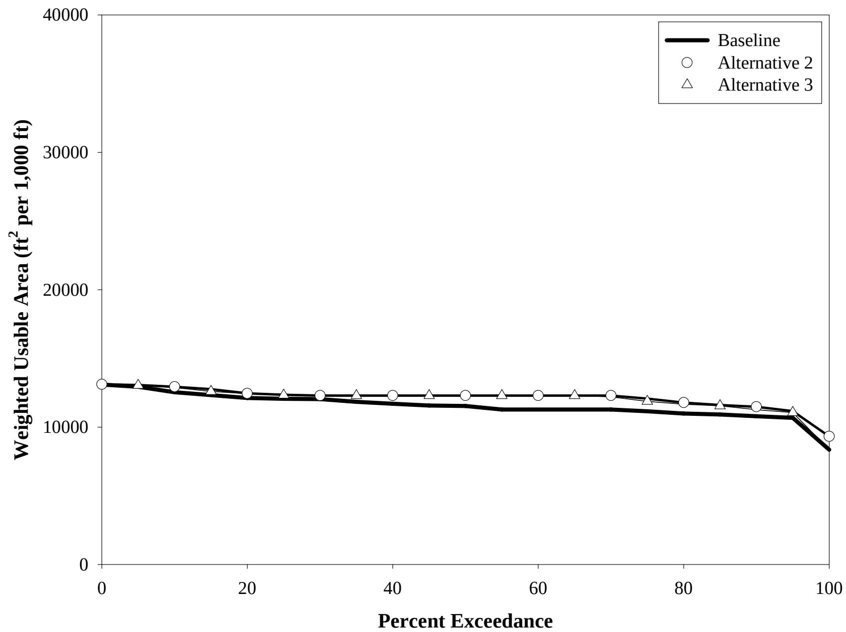


FIGURE 14. HABITAT DURATION CURVE SHOWING MODELED LARVAL LAMPREY (AMMOCOETE) REARING HABITAT ESTIMATES IN MIDDLE SCOGGINS CREEK.

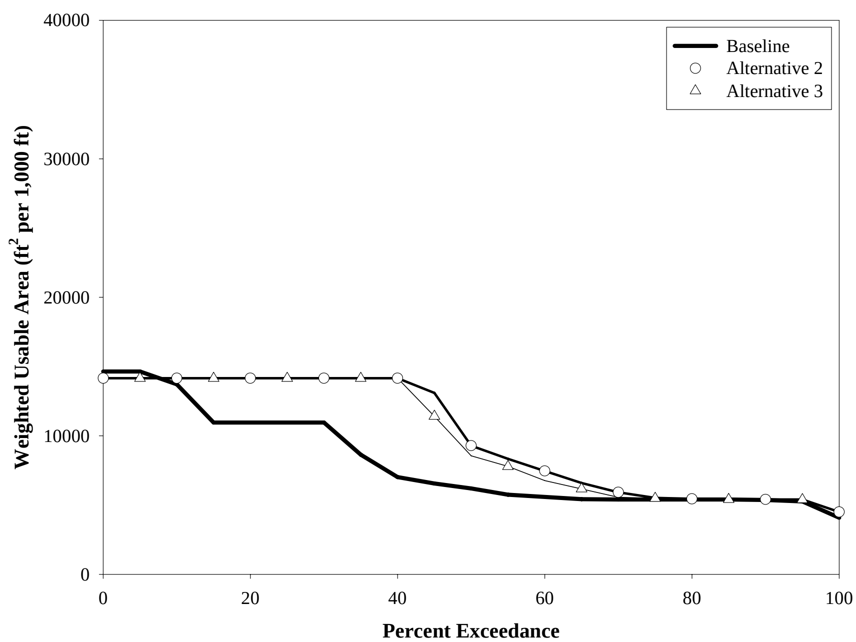


FIGURE 15. HABITAT DURATION CURVE SHOWING MODELED LARVAL LAMPREY (AMMOCOETE) REARING HABITAT ESTIMATES IN LOWER SCOGGINS CREEK.

Tualatin River

Lamprey ammocoete habitat was modeled for all three IFIM sites on the Tualatin River. At the upper and middle sites, the habitat duration curves for Baseline and Alternative 2 were similar and showed that WUA under Alternative 2 was similar to or exceeded the WUA for Baseline 90 to 95 percent of the time (Figures 16 and 17). At the upper site the Alternative 2 WUA exceeded Baseline WUA approximately 35 percent of the time, while at the middle site the exceedance of Alternative 2 WUA increased to approximately 60 percent of the time. Alternative 2 WUA at the lower Tualatin site would be reduced from Baseline WUA approximately 50 percent of the time, but would otherwise be similar to Baseline (Figure 18). Not surprisingly, the monthly average predictions for Alternative 2 showed very small changes from Baseline during most months and under all conditions.

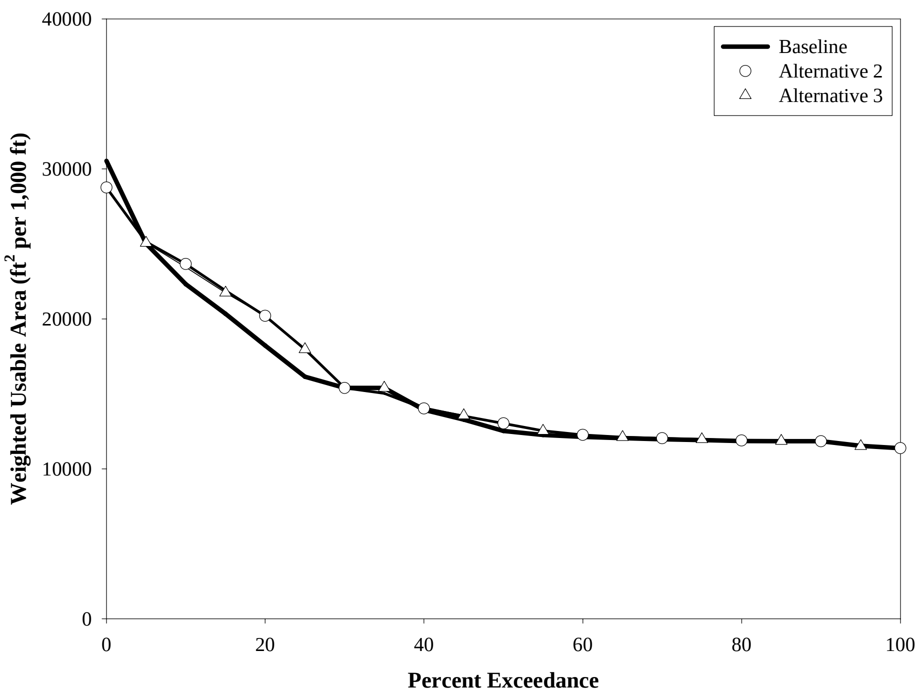


FIGURE 16. HABITAT DURATION CURVE SHOWING MODELED LARVAL LAMPREY (AMMOCOETE) REARING HABITAT ESTIMATES AT THE UPPER TUALATIN RIVER SITE.

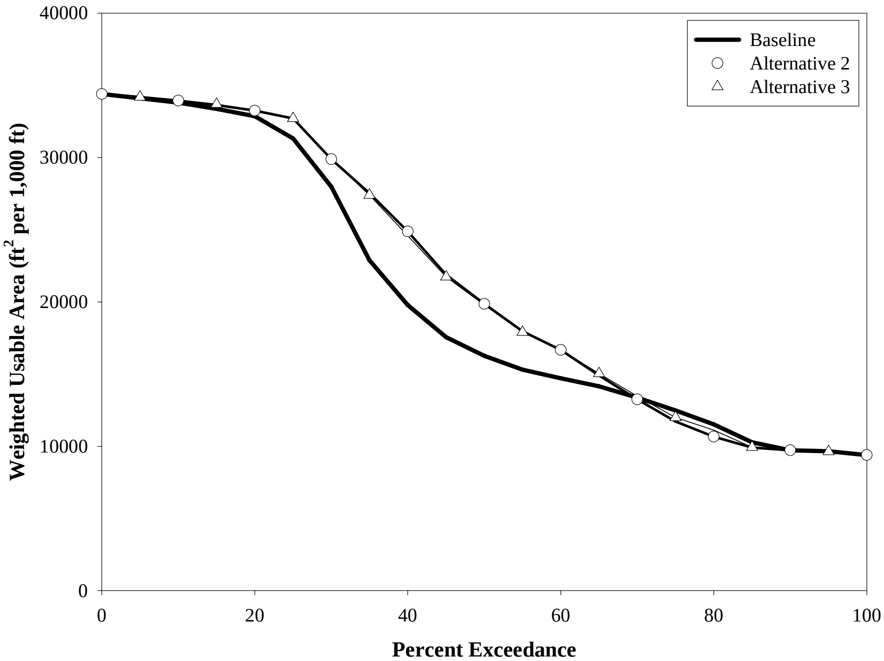


FIGURE 17. HABITAT DURATION CURVE SHOWING MODELED LARVAL LAMPREY (AMMOCOETE) REARING HABITAT ESTIMATES AT THE MIDDLE TUALATIN RIVER SITE.

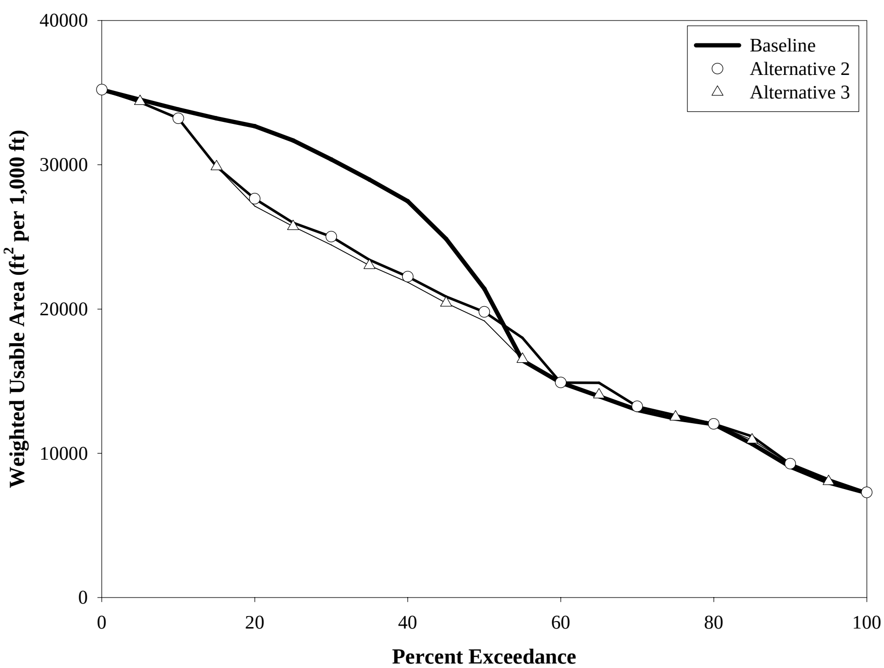


FIGURE 18. HABITAT DURATION CURVE SHOWING MODELED LARVAL LAMPREY (AMMOCOETE) REARING HABITAT ESTIMATES AT THE LOWER TUALATIN RIVER SITE.

Lamprey Summary

Analysis of WUA patterns indicated both positive and negative impacts would be expected under Alternative 2. Both increases and decreases in WUA would be expected for different life stages and at different locations. Since the spawning habitat at the upper site was more abundant and of better quality, we concluded that overall Alternative 2 would result in positive impacts to lamprey spawning and incubation. WUA for larval lamprey habitat would decrease in upper Scoggins Creek, with large reductions during summer months. In middle and lower Scoggins Creek this habitat was projected to increase, but the magnitude of the increases was very small during summer months when critical growth is needed. Given this consideration, we anticipate overall negative impacts to ammocoete habitat in Scoggins Creek.

PHABSIM results in the Tualatin River showed strong summer time increases that would benefit lamprey spawning, while the WUA at the lower Tualatin site showed large summer time reductions that would result in negative impacts at this location. Since no data is available to assess the quality of these locations for lamprey and the existing data indicates the habitat is similar at all sampling locations, we assumed the positive and negative changes in the Tualatin River that are expected under Alternative 2 would balance out and overall ammocoete habitat in the Tualatin River would be expected to be similar to Baseline with the implementation of Alternative 2.

4.3.2.3 Cutthroat Trout

4.3.2.3.1 Spawning and Incubation

Scoggins Creek

Model results for the upper Scoggins site showed substantial changes from Baseline habitat conditions (Figure 19). The duration curve for Alternative 2 predicted increases in cutthroat trout spawning habitat approximate 93 percent of the time. Monthly flow data showed that moderate to very large (1,212 percent) increases for the months of January through August. This window included the time that cutthroat trout would be spawning. It is also important to note that the month-to-month fluctuations in WUA evident under Baseline conditions were reduced under Alternative 2 and thus would be expected to reduce the risks to cutthroat associated with dewatering of redds.

Model results for lower Scoggins spawning habitat was different from the upper site. The habitat modeled under Alternative 2 would be expected to be similar to Baseline conditions approximately 40 percent of the time while Alternative 2 WUA would exceed Baseline 60 percent of the time (Figure 30). However, these improvements are small in magnitude. The reduced benefits to cutthroat trout spawning habitat at the lower site are likely due to the higher gradient habitat and larger substrate found there.

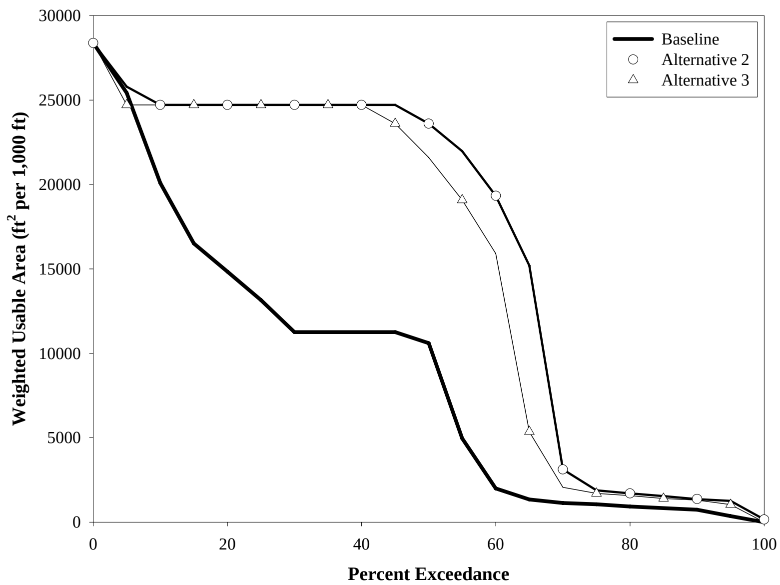


FIGURE 19. HABITAT DURATION CURVE OF MODELED CUTTHROAT TROUT SPAWNING HABITAT IN UPPER SCOGGINS CREEK.

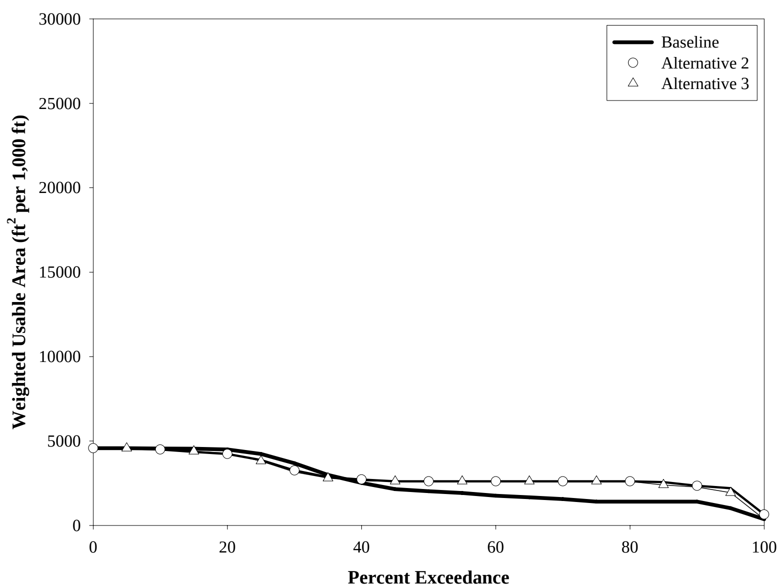


FIGURE 20. HABITAT DURATION CURVE OF MODELED CUTTHROAT TROUT SPAWNING HABITAT IN LOWER SCOGGINS CREEK.

4.3.2.3.2 Juvenile Rearing Habitat

Scoggins Creek

At the upper Scoggins Creek site, the habitat duration curve for juvenile rearing habitat showed that approximately 60 percent of the time the modeled WUAs under Alternative 2 were similar to Baseline (Figure 21). Approximately 40 percent of the time and at a wide range of WUAs, habitat under Alternative 2 was expected to be substantially reduced from Baseline. The projected decreases would occur in five out of 12 months including summer months when tributary rearing habitat is critical.

Model predictions were more similar for juvenile rearing habitat at the middle and lower Scoggins sites (Figures 22 and 23). At the middle Scoggins site, the habitat duration curves for Alternative 2 and Baseline were very similar all the time with only slight increases in habitat under Alternative 2 approximately 70 percent of the time (Figure 22). At the lower site the curves were indistinguishable 25 percent of the time (Figure 23). Alternative 2 WUA showed small increases over Baseline 45 percent of the time and slight reductions as compared to Baseline the remaining 30 percent of the time.

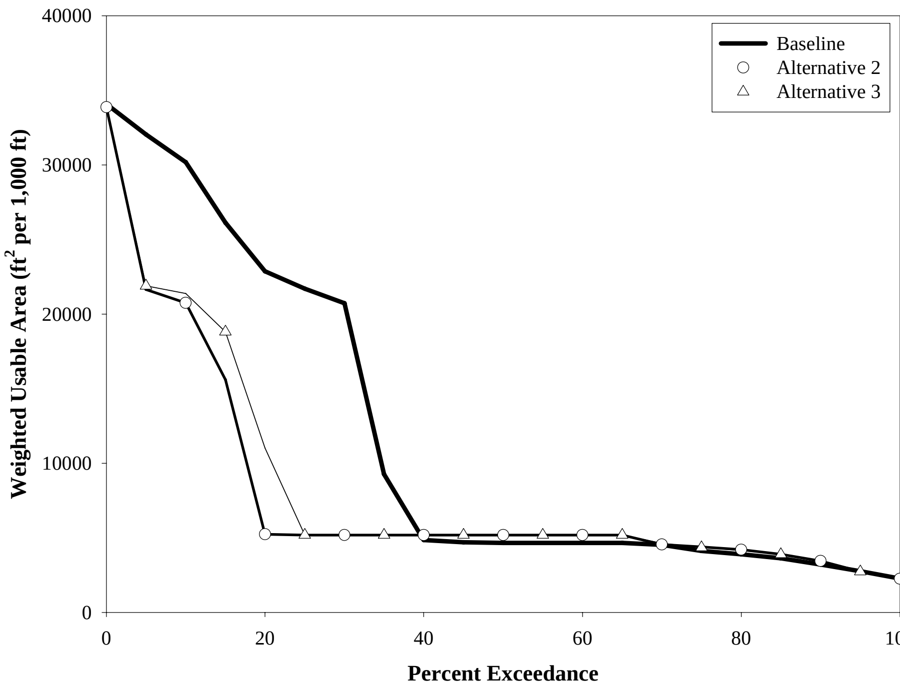


FIGURE 21. HABITAT DURATION CURVE OF MODELED HABITAT FOR JUVENILE CUTTHROAT TROUT REARING HABITAT IN UPPER SCOGGINS CREEK.

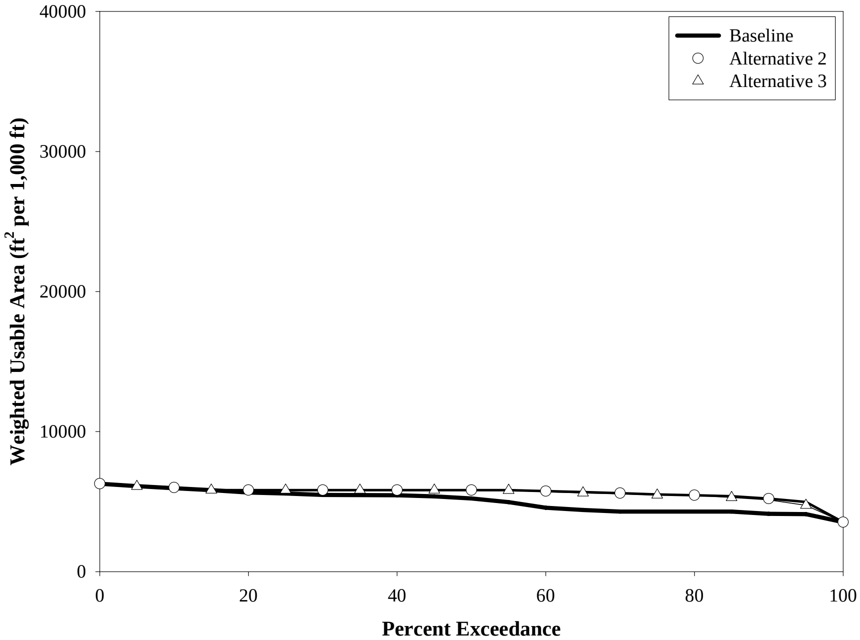


FIGURE 22. HABITAT DURATION CURVE OF MODELED HABITAT FOR JUVENILE CUTTHROAT TROUT REARING HABITAT IN MIDDLE SCOGGINS CREEK.

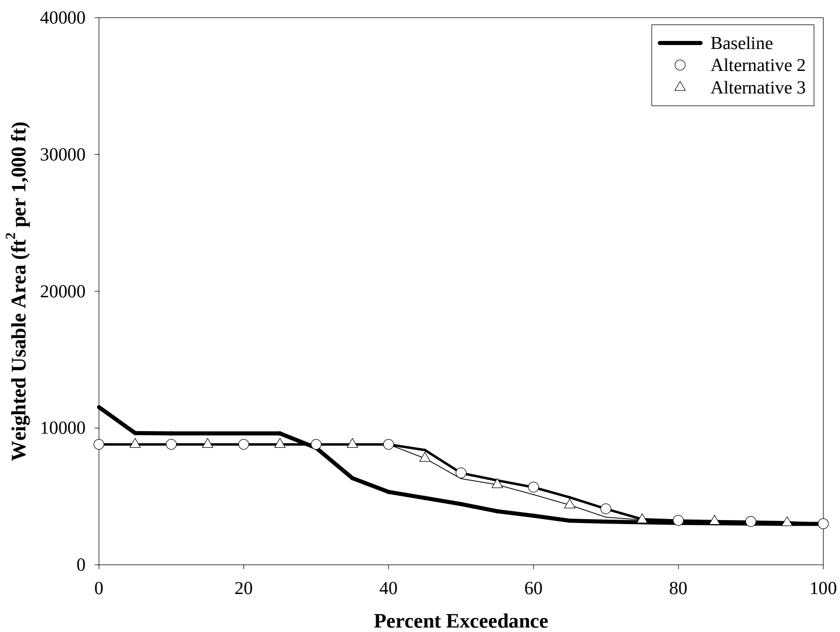


FIGURE 23. HABITAT DURATION CURVE OF MODELED HABITAT FOR JUVENILE CUTTHROAT TROUT REARING HABITAT IN LOWER SCOGGINS CREEK.

Tualatin River

The habitat duration curves for juvenile cutthroat trout habitat in the Tualatin River showed WUA projections that were very similar between Alternative 2 and Baseline at the upper and middle sites (Figures 24 and 25). The monthly average WUAs were predicted to be similar to Baseline in most months with small increases evident for spring summer and early fall and small decreases projected for winter.

The habitat duration curve for the Lower Tualatin River site showed a reduction from Baseline to Alternative 2 (Figure 26). The WUA for juvenile habitat would be expected to be reduced approximately 80 percent of the time and over a wide range of WUAs. More than thirty percent of the time Alternative 2 habitat values are very similar although lower than Baseline.

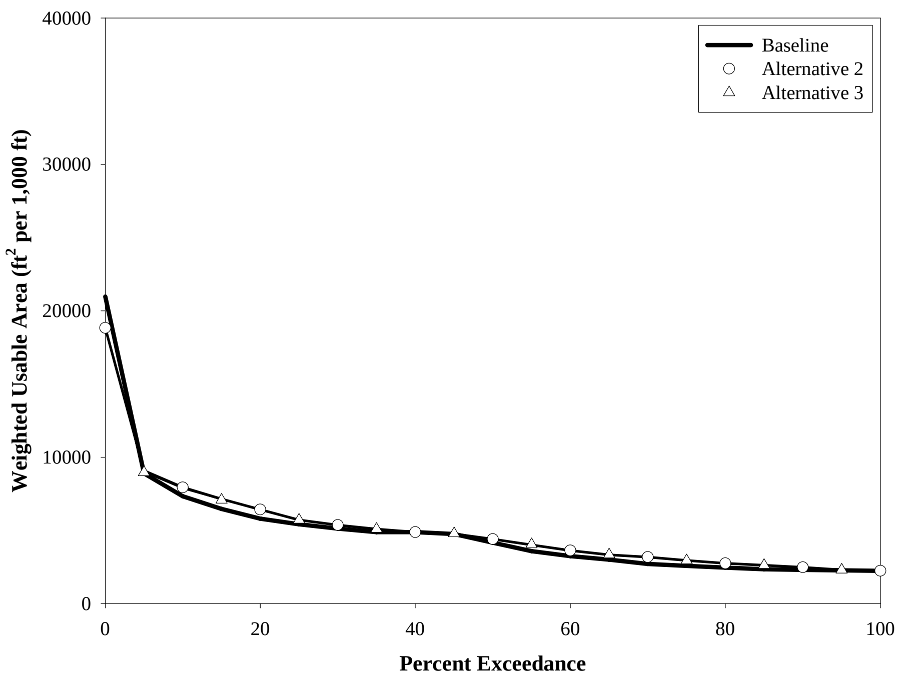


FIGURE 24. HABITAT DURATION CURVE OF MODELED HABITAT FOR JUVENILE CUTTHROAT TROUT REARING HABITAT AT THE UPPER TUALATIN RIVER SITE.

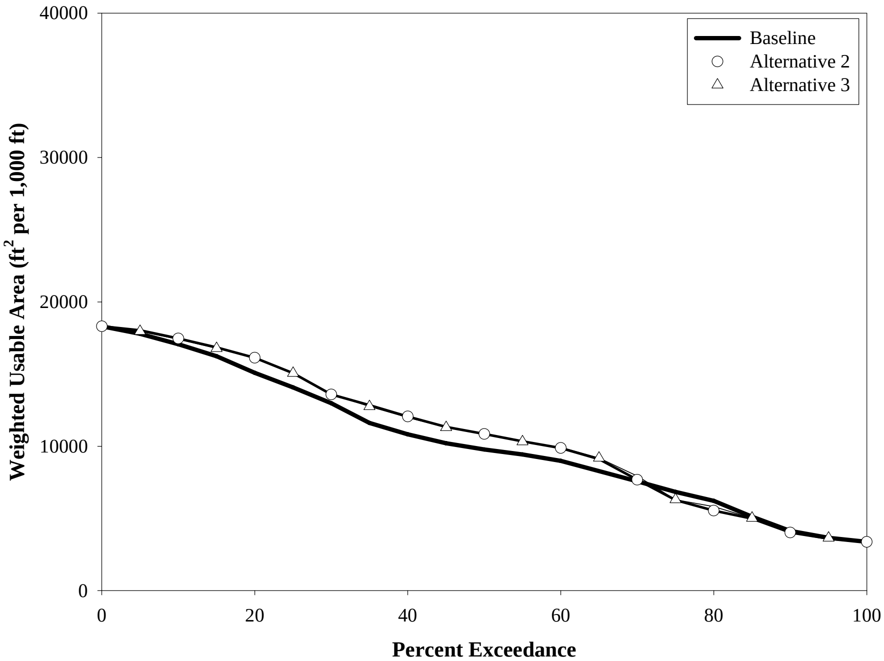


FIGURE 25. HABITAT DURATION CURVE OF MODELED HABITAT FOR JUVENILE CUTTHROAT TROUT REARING HABITAT AT THE MIDDLE TUALATIN RIVER SITE.

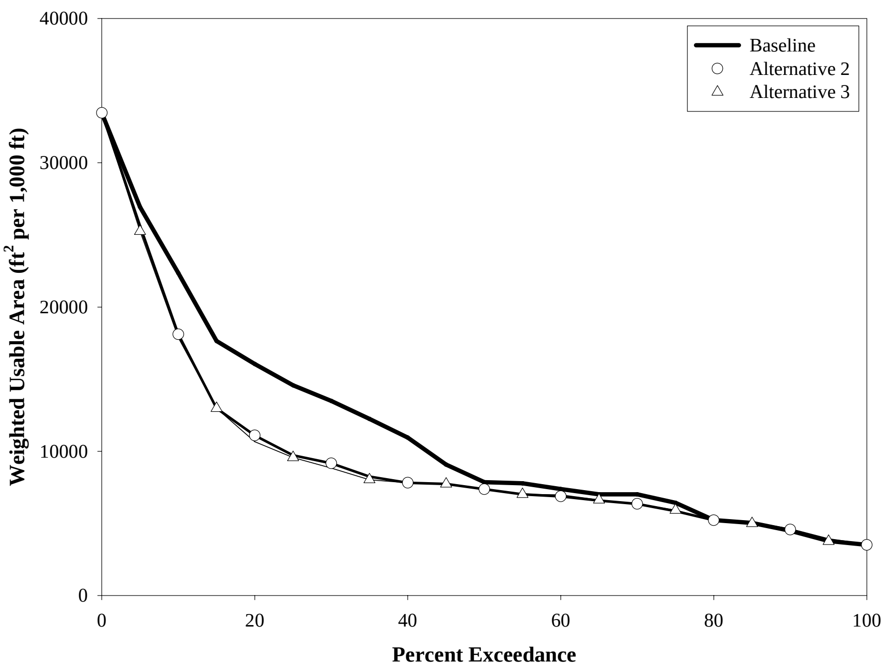


FIGURE 26. HABITAT DURATION CURVE OF MODELED HABITAT FOR JUVENILE CUTTHROAT TROUT REARING HABITAT AT LOWER TUALATIN RIVER SITE.

4.3.2.3.3 Adult Habitat

Scoggins Creek

The model predicted reductions in adult cutthroat trout habitat the majority of the time for upper and middle Scoggins creek, and habitat increases at the lower site. The similar reductions at the upper and middle site are depicted in Figures 27 and 28, respectively. Alternative 2 WUA was reduced from Baseline values approximately 70 percent of the time and at high habitat levels, ranging from 20,000 to 5,000 ft^2 per 1,000 ft stream at the upper site and from 15,000 to 5,000 ft^2 per 1,000 ft stream at the lower site. However when less habitat is available, the proposed flow changes at these sites would result in Alternative 2 WUA values greater than Baseline. More specifically, under Alternative 2 WUA for adult habitat will remain around 5,000 ft^2 per 1,000 ft stream, while under Baseline conditions the WUAs drop to approximately half that value at both locations. In lower Scoggins Creek, the habitat duration curve for Alternative 2 showed small to large increases over baseline at all times (Figure 29). Review of monthly flow data showed increases in Alternative 2 WUA values in 11 months as compared to Baseline and very similar habitat values between the two conditions in the twelfth month.

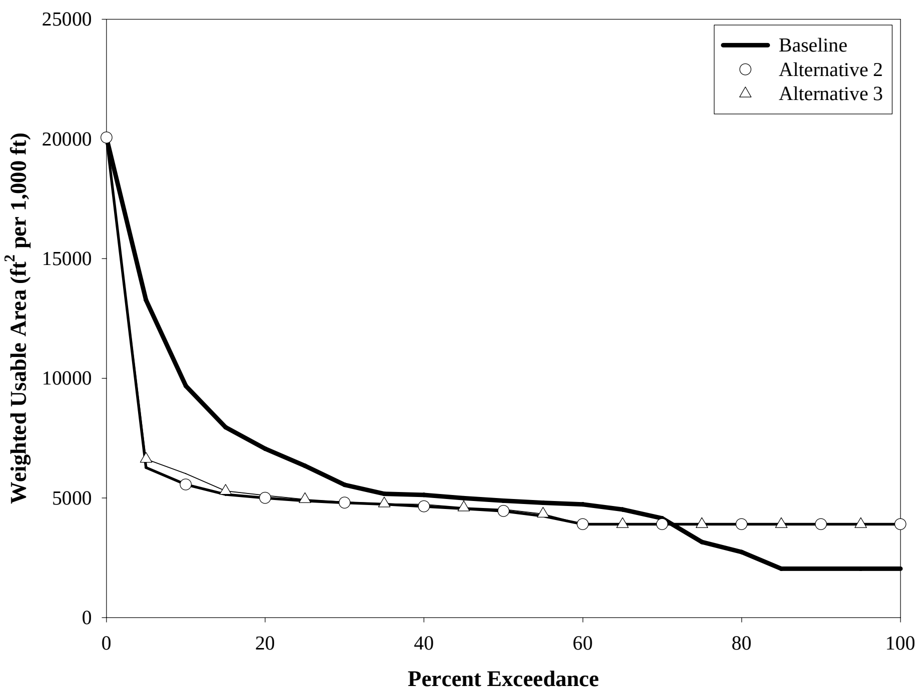


FIGURE 27. HABITAT DURATION CURVE OF MODELED HABITAT FOR ADULT CUTTHROAT TROUT REARING IN UPPER SCOGGINS CREEK.

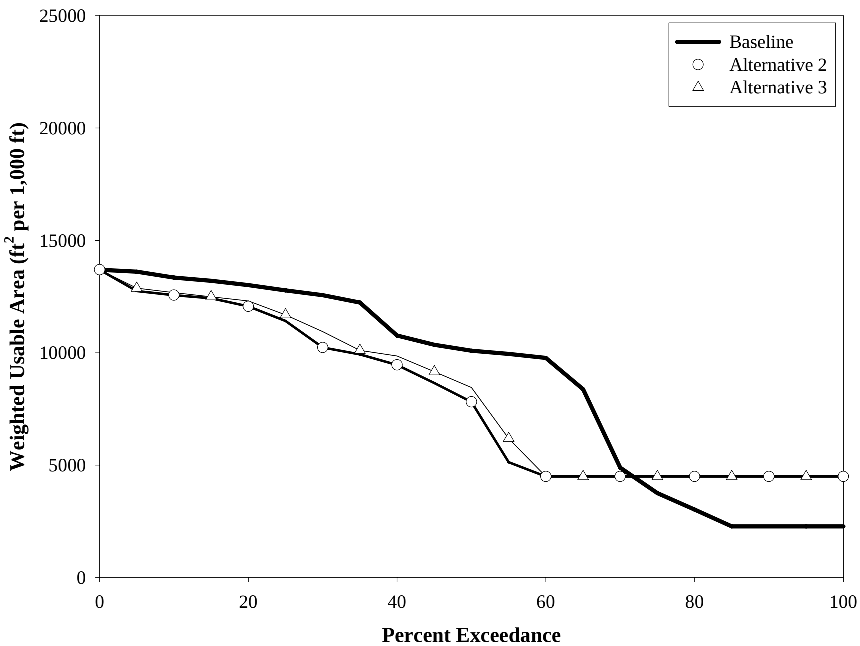


FIGURE 28. HABITAT DURATION CURVE OF MODELED HABITAT FOR ADULT CUTTHROAT TROUT REARING IN MIDDLE SCOGGINS CREEK.

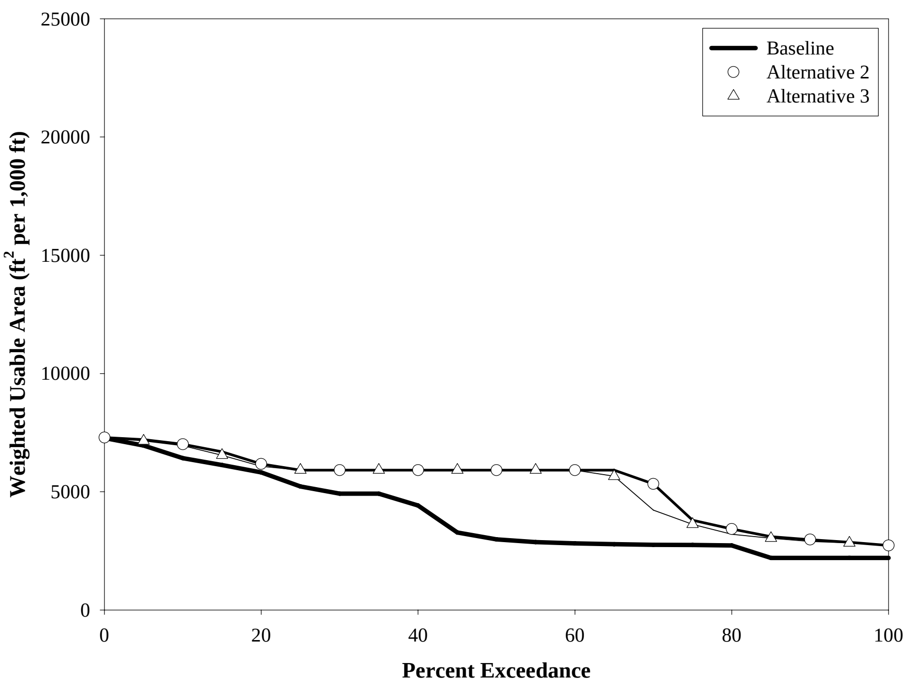


FIGURE 29. HABITAT DURATION CURVE OF MODELED HABITAT FOR ADULT CUTTHROAT TROUT REARING IN LOWER SCOGGINS CREEK.

Tualatin River

The model predicted similar adult cutthroat trout habitat changes for upper and middle Tualatin river sites but a different scenario at the lower site. At the upper (Figure 30) and middle site (Figure 31), Alternative 2 adult habitat projections were very similar to those projected for Baseline conditions. Alternative 2 was predicted to slightly increase WUA 65 percent of the time at the upper site and approximately 75 percent of the time at the middle site. At the lower Tualatin River site, the habitat duration curve for Alternative 2 showed small to moderate increases over baseline at all times (Figure 32). Review of monthly flow data showed increases in Alternative 2 WUA values in 11 months as compared to Baseline, and very similar habitat values between the two conditions in the twelfth month.

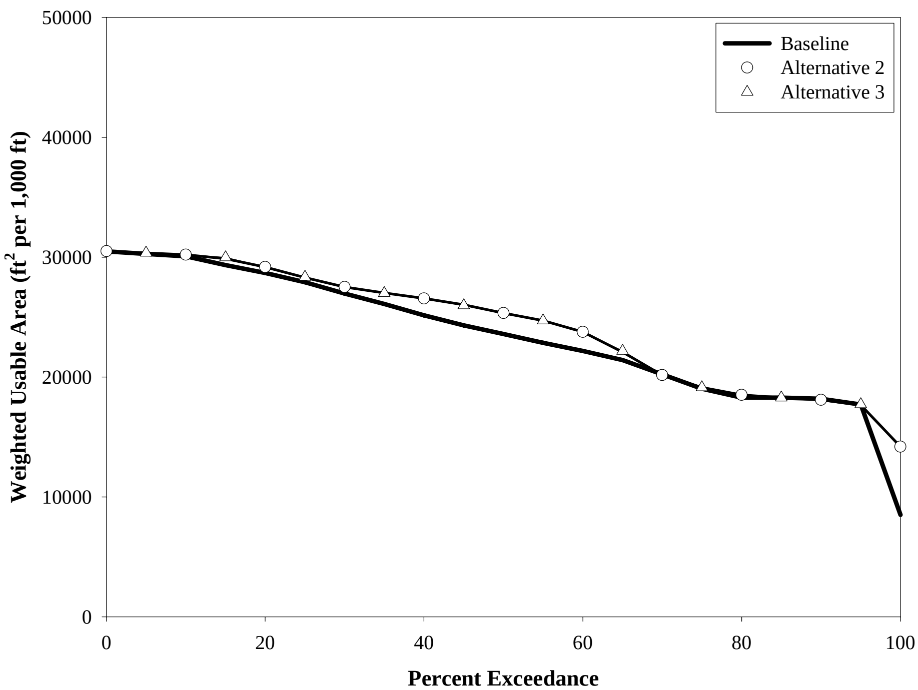


FIGURE 30. HABITAT DURATION CURVE OF MODELED HABITAT FOR ADULT CUTTHROAT TROUT HABITAT AT THE TUALATIN RIVER UPPER SITE.

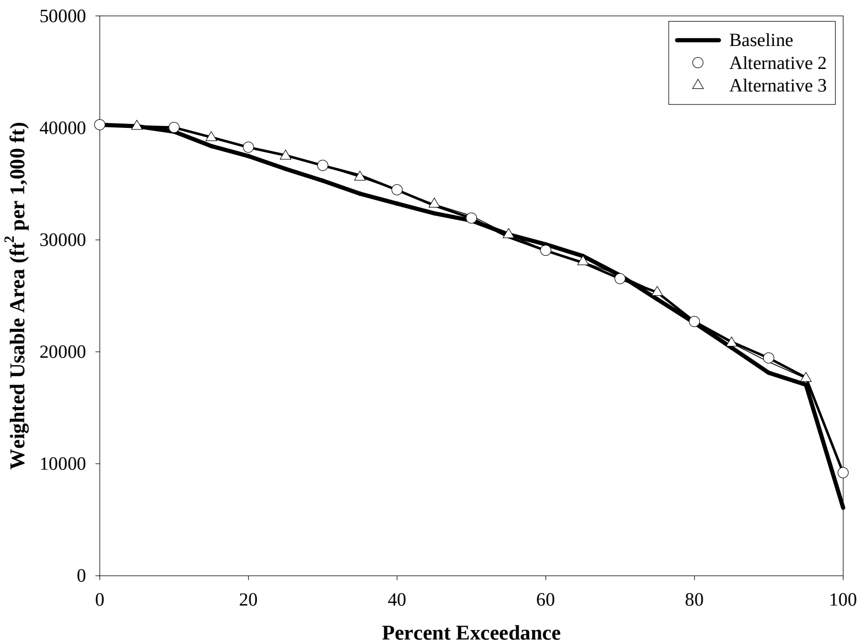


FIGURE 31. HABITAT DURATION CURVE OF MODELED HABITAT FOR ADULT CUTTHROAT TROUT HABITAT AT THE TUALATIN RIVER MIDDLE SITE.

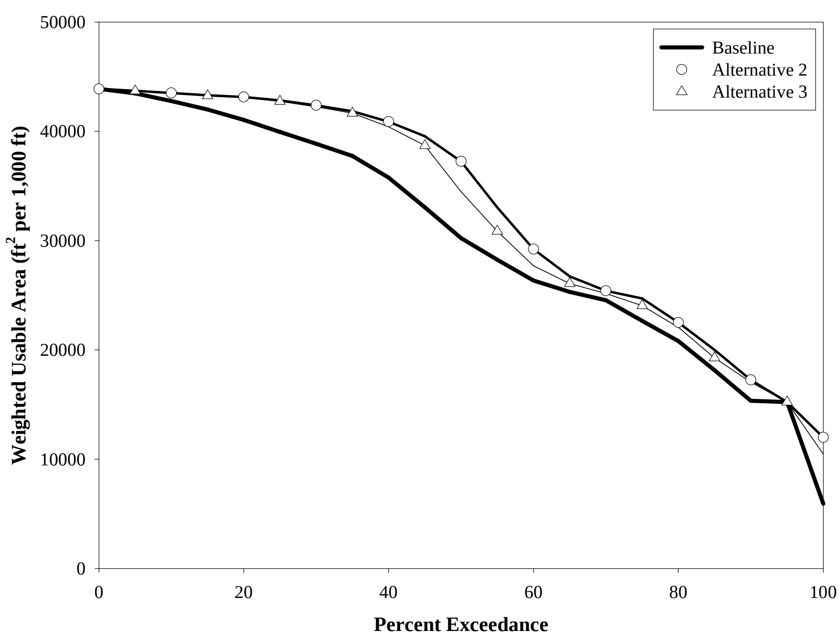


FIGURE 32. HABITAT DURATION CURVE OF MODELED HABITAT FOR ADULT CUTTHROAT TROUT HABITAT AT THE TUALATIN RIVER LOWER SITE.

Cutthroat Trout Summary

Spawning and incubation habitat is expected to see positive impacts associated with increased WUA under Alternative 2. This finding is consistent for spawning habitats in both upper and lower Scoggins Creek with greater overall increases in spawning habitat in upper Scoggins Creek.

Juvenile rearing habitat would be expected to see mixed impacts under Alternative 2 in Scoggins Creek. WUA at the upper site would see large reductions in habitat, some occurring during summer rearing when tributary habitats are essential refugia. In the middle and lower Scoggins Creek habitat increases are expected that would result in benefits to juvenile cutthroat trout but these increases are small in magnitude. Furthermore, in the Tualatin River, PHABSIM predicted slight increase at two sites and larger reductions at the lower site. Overall, juvenile cutthroat trout habitat would be expected to be negatively impacted under Alternative 2.

The model results for adult cutthroat trout habitat also vary by site. Decreases in WUA were evident in upper and middle Scoggins Creek. These included moderate to large reductions in the summer that would likely have negative impacts on adult trout. However, in lower Scoggins Creek and at all three Tualatin River sites, there were small to moderate increases in WUA. These increases in WUA would likely benefit adult trout in these locations and would balance out the negative impacts at two Scoggins sites.

4.3.3 Alternative 3 – Multiple Source Option

Monthly flow data from the 73 year record are presented in tables 8 through 10. Habitat Duration curves are presented in Figures 3 through 32. These tables and figures are presented along with summary descriptions of the changes in WUA between Baseline and Alternative 3 by species, life stage, and water body in the sections that follow.

4.3.3.1 Steelhead

4.3.3.1.1 Spawning and Incubation

The habitat duration curves for the Scoggins Creek (Figures 3-5) showed that the WUA estimates for Alternatives 3 exceeded those for Baseline in upper Scoggins Creek approximately 55 percent of the time (Figure 3). Monthly estimates of WUA at the upper site indicated that the greatest increase in habitat would be expected during the peak spawning months of April and May as well as during incubation in July. Results for lower Scoggins spawning habitat (Figure 4) were similar to the upper site with projected increases by in WUA in May and July. It is also important to note that the month to month fluctuations in WUA evident under Baseline conditions are dampened somewhat under Alternatives 3 and thus, would be expected to slightly reduce the risks to steelhead associated with dewatering or scour of redds as flows change from April to May and June to July. These WUA increases associated with Alternative 3 are expected to be smaller and occur a little less often than increases over Baseline conditions expected under Alternative 2.

4.3.3.1.2 Juvenile Rearing and Adult Holding Habitat

Scoggins Creek

Duration curves for juvenile rearing and adult holding habitat are presented in Figure 5 - 7. Modeling results predicted that at both the upper (Figure 5) and middle (Figure 6) Scoggins Creek sites Baseline WUA will exceed estimated WUA for Alternative 3 approximately 65 percent of the time. Habitat decreases would be expected most years in late summer, fall and winter months. It is interesting to note that the decreases from Baseline that are evident in the habitat duration curves are occurring when habitat levels are greatest. At the lower habitat levels, when weighted usable area is below 10,000 ft^2/1000 ft stream, the WUAs for Alternative 3 were similar or exceed the Baseline values. This may be a reflection of increased minimum flows in Scoggins Creek under Alternatives 3. A comparison of Alternatives 2 and 3 shows that Alternative 3 WUA was slightly closer to Baseline WUA 20 to 55 percent of the time at the upper and middle sites respectively.

The habitat duration curve for lower Scoggins Creek was different from the other two sites (Figure 7). Most likely this difference resulted from the presence of higher gradient riffle habitat as compared the other sites where only glide habitat was present. At the lower Scoggins Creek site the Baseline and Alternative 3 WUAs were more similar. The estimated WUA for Alternative 3 was predicted to be somewhat higher than Baseline approximately 70 percent of the time. WUA values for the Alternatives were predicted to be similar to or greater than Baseline conditions for most months that juveniles would be rearing and adults holding during wet, average and dry years. A comparison of habitat duration curves for Alternatives 2 and 3 showed that the predicted WUA would be nearly identical in lower Scoggins Creek.

Tualatin River

The habitat duration curves for steelhead rearing habitat were very similar at the three Tualatin sites with the WUA under the Alternatives increasing slightly from the upper to the lower site (Figures 8-10). As can be seen in the habitat duration curves, WUA for Alternative 3 was similar or greater than Baseline at all times at these locations and Alternative 3 had slightly greater estimates of WUA approximately 90 percent of the time at the lower site on the Tualatin River (Figure 10). The habitat duration curves of Alternatives 2 and 3 were nearly identical at the upper and middle sites. At the lowest site, Alternative 2 produced minor increases in steelhead rearing habitat over Alternative 3.

Steelhead Summary

Overall, the increases in WUA for steelhead spawning and incubation habitat were greater in number and magnitude, suggesting positive impacts associated with Alternative 3 (shown in Figures 8-10. In addition, since WUA was more stable during spawning and incubation (as illustrated in Figures 3 and 4), the potential effects of dewatering and scours would be slightly reduced, similar to Alternative 2. Juvenile rearing/adult holding habitat in upper and middle Scoggins Creek would be expected to see more WUA decreases than increases, with substantial decreases projected for essential summer rearing (as illustrated in Figure 5). Thus, we anticipate that Alternative 3 would have significant negative impacts to steelhead rearing and holding habitat in Scoggins Creek. WUA for adult and juvenile habitat in the Tualatin River would be slightly higher or remain similar to Baseline conditions in most months at all sites, again indicating a positive impact associated with Alternative 3. Overall, Alternative 3 changes from Baseline were more moderated than Alternative 2. Thus, under Alternative 3 both the benefits and negative impacts to steelhead habitat would be reduced.

4.3.3.2 Lamprey

4.3.3.2.1 Spawning and Incubation

Model results for the upper Scoggins site showed site-specific differences. Habitat duration curves at the upper site where glide habitat dominated showed that at higher habitat levels, above 10,000 ft^2 per 1,000 ft stream, Alternative 3 was advantageous (Figure 11). Approximately 60 percent of the time, Alternative 3 exceeded the Baseline condition for WUA. However at habitat levels below 10,000 ft^2 per 1,000 ft stream conditions changed and approximately 30 percent of the time Baseline WUA exceeded those predicted for Alternative 3. The last 10 percent of the time the WUAs would be similar. Monthly flow data indicated that the reduced WUA associated with Alternative 3 would be expected to occur in summer. Under Alternative 3, the pattern of monthly fluctuations over the spawning and incubation period was predicted to remain similar to Baseline, with increasing habitat over time from May through September. The lamprey spawning habitat duration curves were nearly identical for Alternatives 2 and 3 at the upper Scoggins Creek site (Figure 11).

Results for lower Scoggins Creek spawning habitat were very different from the upper site, likely due to the higher velocity habitat present at the lower site. Modeled WUA for Alternative 3 were slightly lower than baseline 60 percent of the time and otherwise were similar to baseline (Figure 12). The pattern of month-to-month fluctuations in WUA was predicted to be similar between Baseline and Alternative 3. The lamprey spawning habitat duration curves were identical for Alternatives 2 and 3 at the lower Scoggins Creek site.

4.3.3.2.2 Juvenile Rearing Habitat

Scoggins Creek

Lamprey ammocoete habitat was modeled for all three IFIM sites in Scoggins Creek. The habitat duration curve for the upper Scoggins site showed that 60 percent of the time WUA under Alternative 3 would be considerably lower than that for the Baseline condition (Figure 13). The remaining 40 percent of the time the predicted WUAs were very similar. At the middle site only small changes (less than 10 percent) were predicted and the Alternative 3 WUA was slightly greater than that for the Baseline all of the time (Figure 14). At the lowest site in Scoggins Creek, lamprey rearing habitat would stay the same or be increased beyond Baseline values approximately 80 percent of the time under Alternative 3 (Figure 15).

A comparison of the habitat duration curves for the alternatives showed variable results. At the Upper Scoggins site the WUA for Alternative 3 was slightly greater than those for predicted for Alternative 2 for approximately 20 percent of the time. At the middle site the habitat duration curves predicted the same results for habitat under both alternatives. At the lowest site the WUA for Alternative 3 was slightly less than those for Alternative 2 approximately 30 percent of the time.

Tualatin River

Lamprey ammocoete habitat was modeled for all three IFIM sites on the Tualatin River. At the upper and middle sites, the habitat duration curves for Baseline and Alternative 3 were similar and showed that WUA under Alternative 3 was similar to or exceeded the WUA for Baseline 90 to 95 percent of the time (Figures 16 and 17). At the upper site the Alternative 3 WUA exceeded Baseline WUA approximately 35 percent of the time (Figure 16), while at the middle site the exceedance of Alternative 2 WUA increased to approximately 60 percent of the time (Figure 17). Alternative 2 WUA at the lower Tualatin site would be reduced from Baseline WUA approximately 50 percent of the time, but would otherwise be similar to Baseline (Figure 18). Not surprisingly, the monthly average predictions for Alternative 3 showed very small changes from Baseline during most months and under all conditions. Habitat duration curves for Alternatives 2 and 3 were indistinguishable, indicating no differences in ammocoete habitat impacts in the Tualatin River.

Lamprey Summary

Analysis of WUA patterns indicated both positive and negative impacts would be expected under Alternative 3. There would be both increases and decrease in WUA for different life stages and at different locations. Since the spawning habitat at the upper site was more abundant and of better quality, we would conclude that overall Alternative 2 would result in positive impacts to lamprey spawning and incubation. WUA for larval lamprey habitat would decrease in upper Scoggins Creek, with big reductions during summer months. In middle and lower Scoggins Creek this habitat was projected to increase, but the magnitude of the increases were very small during summer months when critical growth was needed. Given this consideration, we anticipate overall negative impacts to ammocoete habitat in Scoggins Creek.

In the Tualatin the PHABSIM results showed strong summer time increases that would benefit lamprey spawning, while the WUA at the lower Tualatin site showed large summer time reductions that would result in negative impacts at this location. Since no data was available to assess the quality of these locations for lamprey and the existing data indicated uniform habitat, we assume that the benefits and impacts that are expected in the Tualatin under Alternative 3 would balance out and the ammocoete habitat would be expected to be similar to Baseline if Alternative 3 is implemented.

The habitat duration curves for Alternative 2 and 3 were very similar at most location and for most life stages. The only differences concerned ammocoete habitat in Scoggins Creek. Based on these curves Alternative 3 impacts would be moderated compared to Alternative 2 with reduced habitat benefits and reduced negative impacts expected.

4.3.3.3 Cutthroat Trout

4.3.3.3.1 Spawning and Incubation

Scoggins Creek

Model results for the upper Scoggins site showed substantial changes from Baseline habitat conditions (Figure 19). The duration curve for Alternative 3 predicted increases in cutthroat trout spawning habitat approximately 93 percent of the time. Monthly flow data shows that moderate to very large (1,212 percent) increases for the months of January through August. This window includes the time that cutthroat trout would be spawning. It is also important to note that the month-to-month fluctuations in WUA evident under Baseline conditions were reduced under Alternative 3 and would be expected to reduce the risks to cutthroat associated with dewatering of redds. Comparing habitat duration curves for the two alternatives showed Alternative 3 had less benefit to cutthroat trout spawning habitat approximately 35 percent of the time.

Model results for lower Scoggins spawning habitat were different from the upper site. The habitat modeled under Alternative 3 would be expected to be similar to Baseline conditions approximately 40 percent of the time while increases in WUA would be expected the other 60 percent of the time (Figure 20). The reduced benefits at this site compared to upstream were likely due to the higher gradient habitat and larger substrates found there. A comparison of habitat duration curves showed that both alternatives would have similar impacts on cutthroat trout spawning habitat in lower Scoggins Creek.

4.3.3.3.2 Juvenile Rearing Habitat

Scoggins Creek

At the upper Scoggins Creek site, the habitat duration curve for juvenile rearing habitat showed that approximately 60 percent of the time the modeled WUA under Alternative 3 was similar to Baseline (Figure 21). Approximately 40 percent of the time and at a wide range of WUAs, habitat under Alternative 2 was substantially reduced from Baseline. The projected decreases were predicted to occur in five out of 12 months including summer months. The reductions in WUA predicted for Alternatives 3 were less than those for Alternative 2.

Model predictions were more similar for juvenile rearing habitat at the middle and lower Scoggins sites. At the middle Scoggins site (Figure 22), the habitat duration curves for Alternative 2 and Baseline were very similar all the time with only slight increases in habitat under Alternative 2 approximately 70 percent of the time. At the lower site (Figure 23), the curves were indistinguishable 25 percent of the time, Alternative 3 habitat showed small increases over Baseline habitat conditions 45 percent of the time, and slight reductions as compared to Baseline the remaining 30 percent. The habitat duration curves for the Alternatives 2 and 3 were indistinguishable at the middle site but at the lower site habitat increases under Alternative 3 were smaller than under Alternative 2.

Tualatin River

The habitat duration curves for juvenile cutthroat trout habitat in the Tualatin River showed habitat projections that were very similar between Alternative 3 and Baseline at the upper and middle sites (Figures 24 and 25). The monthly average WUAs were predicted to be similar to Baseline in most months with small increases evident for spring summer and early fall and small decreases projected for winter.

The habitat duration curve for the Lower Tualatin River site showed a reduction from Baseline to Alternative 3 as much as 80 percent of the time (Figure 26), although for approximately 30% of the time Alternative 3 habitat values even though lower were similar. The habitat duration curves for Alternatives 2 and 3 were indistinguishable, indicating similar impacts to juvenile cutthroat habitat in the Tualatin River.

4.3.3.3.3 Adult Habitat

Scoggins Creek

The model predicted reductions from Baseline levels of adult cutthroat trout habitat at upper (Figure 27) and middle (Figure 28) Scoggins creek sites but only increases at the lower site. Similar reductions were predicted to occur over the majority of the time at both these sites. Alternative 3 WUAs were reduced from Baseline approximately 70 percent of the time and at habitat levels ranging from 20,000 to 5,000 ft^2 per 1,000 ft stream at the upper site and from 15,000 to 5,000 ft^2 per 1,000 ft stream at the lower site. However, at lower levels of usable habitat, Alternative 3 habitat values were greater than Baseline. More specifically, under Alternative 2 WUA for adult habitat remained around 5,000 ft^2 per 1,000 ft stream, while under Baseline conditions the WUAs dropped to approximately half that value at both locations.

In lower Scoggins Creek, the habitat duration curve for Alternative 2 showed small to large increases over baseline at all times (Figure 29). Review of monthly flow data showed increases in Alternative 2 WUA values in 11 months as compared to Baseline and very similar habitat values between the two conditions in the twelfth month.

Tualatin River

The model predicted similar adult cutthroat trout habitat changes for upper and middle Tualatin river sites but a different scenario at the lower site. At the upper and middle site, Alternative 3 adult habitat projections were very similar to those projected for Baseline conditions. Alternative 2 was predicted to slightly increase WUA 65 percent of the time at the upper site (Figure 30) and approximately 75 percent of the time at the middle site (Figure 31). At the lower Tualatin River site, the habitat duration curve for Alternative 3 showed small to moderate increases over baseline at all times (Figure 32). Review of monthly flow data showed increases in Alternative 2 WUA values in 11 months as compared to Baseline and very similar habitat values between the two conditions in the twelfth month.

Cutthroat Trout Summary

Spawning and incubation habitat was expected to see positive impacts associated with increased WUA under Alternative 3. This finding was consistent for spawning habitats in both upper and lower Scoggins Creek with greater increases in spawning habitat evident in upper Scoggins Creek.

Juvenile rearing habitat would be expected to see mixed impacts under Alternative 3 in Scoggins Creek. WUA at the upper site would see large reductions in habitat and some during summer rearing when tributary habitats provide essential refugia. In the middle and lower Scoggins Creek overall increases in habitat that would result in benefits to juvenile cutthroat trout but these increases are small in magnitude. Furthermore, in the Tualatin River, PHABSIM predicted slight increase at two sites and larger reductions at the lower site. Overall, juvenile cutthroat trout habitat would be expected to be negatively impacted under Alternative 3.

The model results for adult cutthroat trout habitat also vary by site. Decreases in WUA were evident in upper and middle Scoggins Creek. These included moderate to large reductions in the summer that would likely have negative impacts on adult trout. However, in lower Scoggins Creek and at all three Tualatin River sites, there were small to moderate increases in WUA. These increases in WUA would likely benefit adult trout in these locations and would balance out the negative impacts at two Scoggins sites.

A comparison of alternatives showed that the potential impacts from Alternatives 2 and 3 would be the same for cutthroat trout spawning habitat and much of juvenile and adult habitat. Only three differences were evident. Alternative 3 impacts were moderated and as such would result in a reduced benefit for adult cutthroat trout habitat in middle Scoggins Creek, lower Scoggins Creek, and the Lower Tualatin River.

4.4 MITIGATION MEASURES

4.4.1 Alternative 1 (No Action)

No mitigation measures would be required under Alternative 1 because no effects are expected for any of the species analyzed.

4.4.2 Alternative 2

Table 11 shows the mitigation that has been proposed to offset potential flow-related impacts under Alternative 2.

TABLE 11. PROPOSED FISH HABITAT MITIGATION

Project Impact	Species Benefited	Project Component Description	Proposed Action	Miles impacted
Reduced flow in Scoggins Creek below Dam	• steelhead • cutthroat • lamprey	1). Flow management plan for Scoggins Creek. 2). Channel improvements below dam.	▪ *flows management to benefit spawning salmon*	~5 mi
Inundation of Scoggins Creek Tributaries above dam	• cutthroat • lamprey	Sain Creek Dam	▪ *remove dam*	~5 mi
		Roaring Creek and other Diversion Improvements (City of Forest Grove)	▪ *diversion improvements*	>1mi
Lower Scoggins and Tualatin rearing impact	• cutthroat • steelhead • lamprey	Stream channel improvement in Gales and McKay-Dairy watersheds.	▪ *culvert replacement/ repair, habitat enhancements*	>25

4.4.3 Alternative 3

Based on very similar impacts proposed mitigation for Alternative 3 is the same as that proposed for Alternative 2 (see Table 11).

4.5 UNAVOIDABLE ADVERSE EFFECTS

None.

4.6 CUMULATIVE EFFECTS

Cumulative effects are not expected, as no project effects are expected beyond those that would be effectively mitigated.

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APPENDIX A

HABITAT SUITABILITY INDEX (HSI) CURVES

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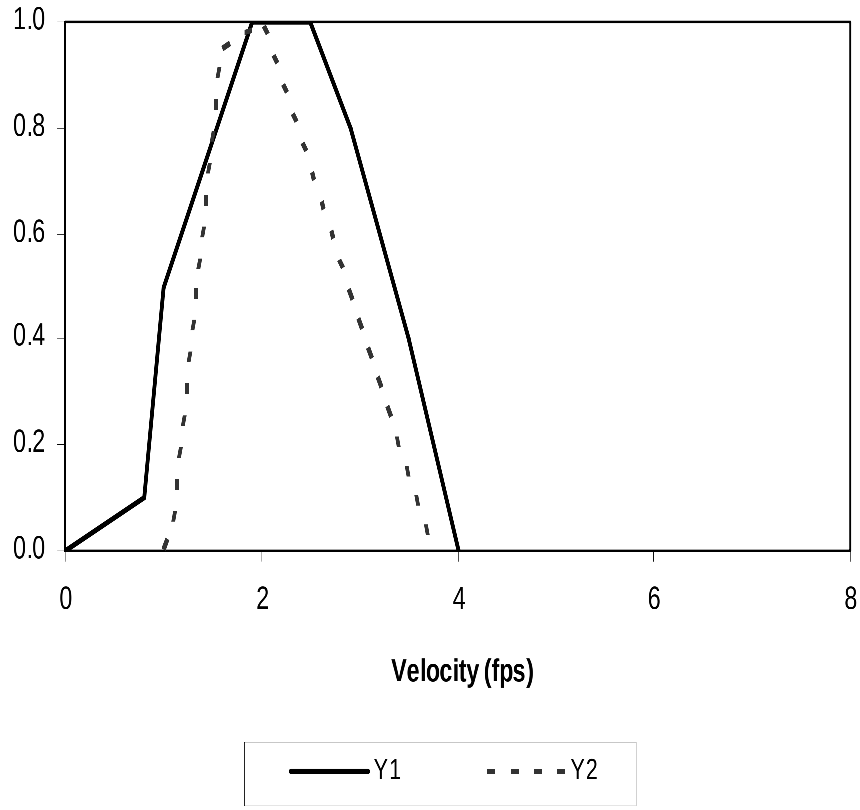
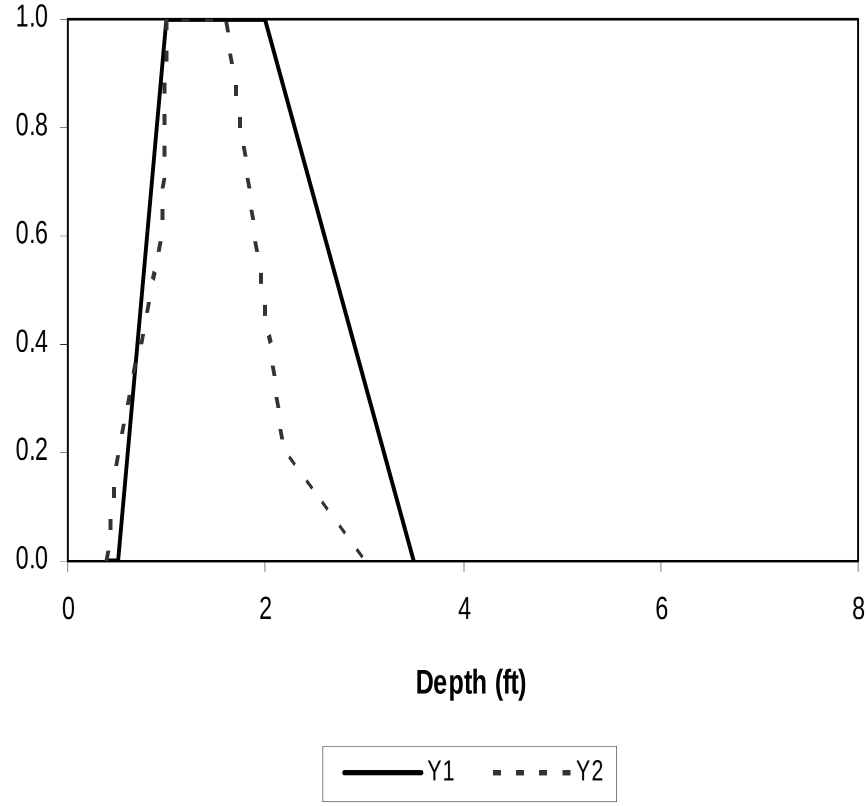
Velocity		
X	Y1	Y2
0.00	0.00	
0.50		
0.70		
0.80	0.10	
1.00	0.50	0.00
1.10		0.05
1.40		
1.60		0.95
1.50		
1.80		
1.90	1.00	
2.00		1.00
2.10		0.95
2.50	1.00	
2.90	0.80	
3.00		
3.50	0.40	
3.60		
3.75		0.00
4.00	0.00	
4.20		
4.50		
5.00		
6.00		



Location: Y1 – Tualatin R. and Scoggins Cr., OR
Source: Y1 – Agency Recommended, 2006
Y2 – Upper Tualatin River, OR
Y2 – CH2MHill, 1993.

Figure A-1a. Species: Steelhead trout; Lifestage: Spawning/Incubation

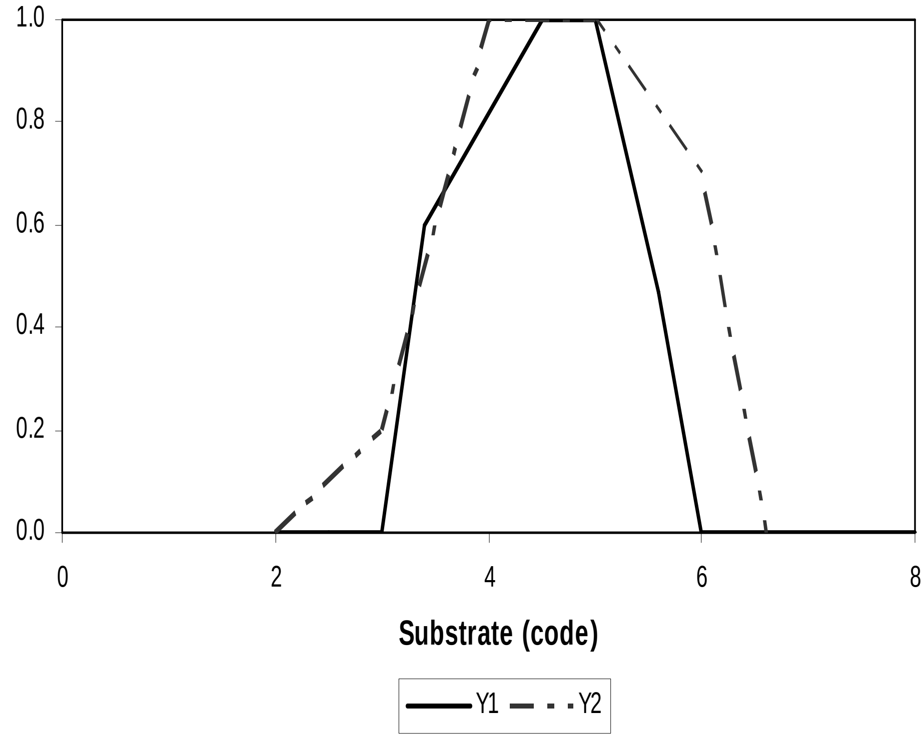
Depth		
X	Y1	Y2
0.00		
0.30		
0.40	0.00	0.00
0.50	0.00	0.20
0.60		
0.90		
0.95		0.60
1.00	1.00	1.00
1.25		
1.50		
1.60		1.00
1.90		
2.00	1.00	
2.20		0.20
2.40		
2.70		
3.00		0.00
3.50	0.00	
4.00		
5.00		
6.00		
8.00		



Location: Y1 – Tualatin R. and Scoggins Cr., OR
Source: Y1 – Agency Recommended, 2006
Y2 – Upper Tualatin River, OR
Y2 – CH2MHill, 1993.

Figure A-1b. Species: Steelhead trout; Lifestage: Spawning/Incubation

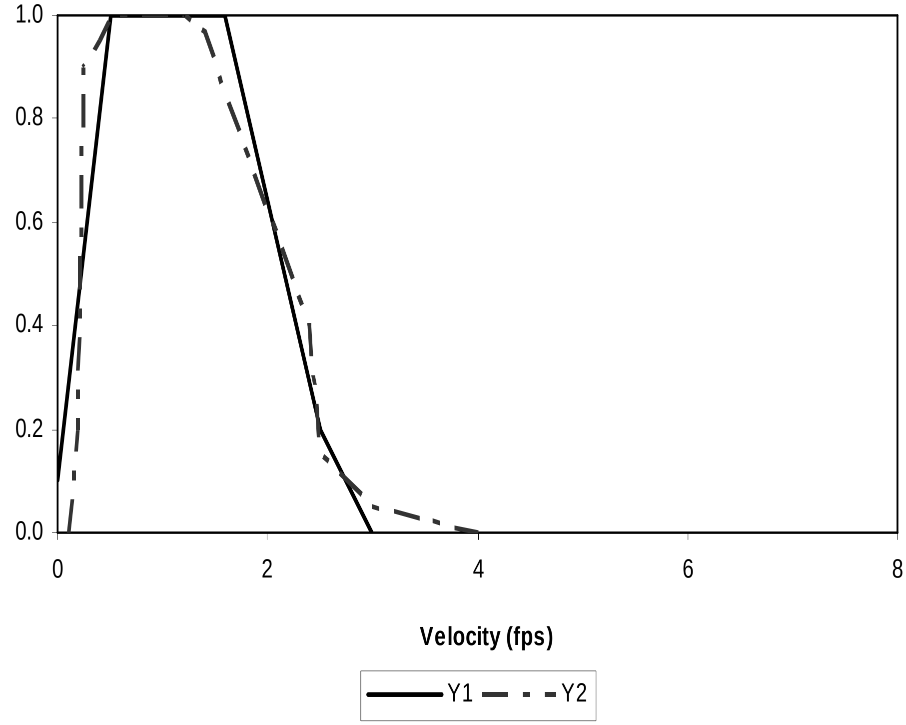
	Substrate		
Code	X	Y1	Y2
duff	0.00		
silt/clay	1.00		
	1.50		
sand	2.00	0.00	0.00
	2.50	0.00	
fine gravel	3.00	0.00	0.20
	3.40	0.60	
med. gravel	4.00		1.00
	4.50	1.00	
coarse gravel	5.00	1.00	1.00
	5.50		
	5.60	0.47	
	5.80		
small cobble	6.00	0.00	0.70
	6.50		
large cobble	6.60		0.00
boulder	7.00		
bedrock	8.00	0.00	



Location: Y1 – Tualatin R. and Scoggins Cr., OR
Source: Y1 – Agency Recommended, 2006
Y2 – Upper Tualatin River, OR
Y2 – CH2MHill, 1993.

Figure A-1c. Species: Steelhead trout; Lifestage: Spawning substrate

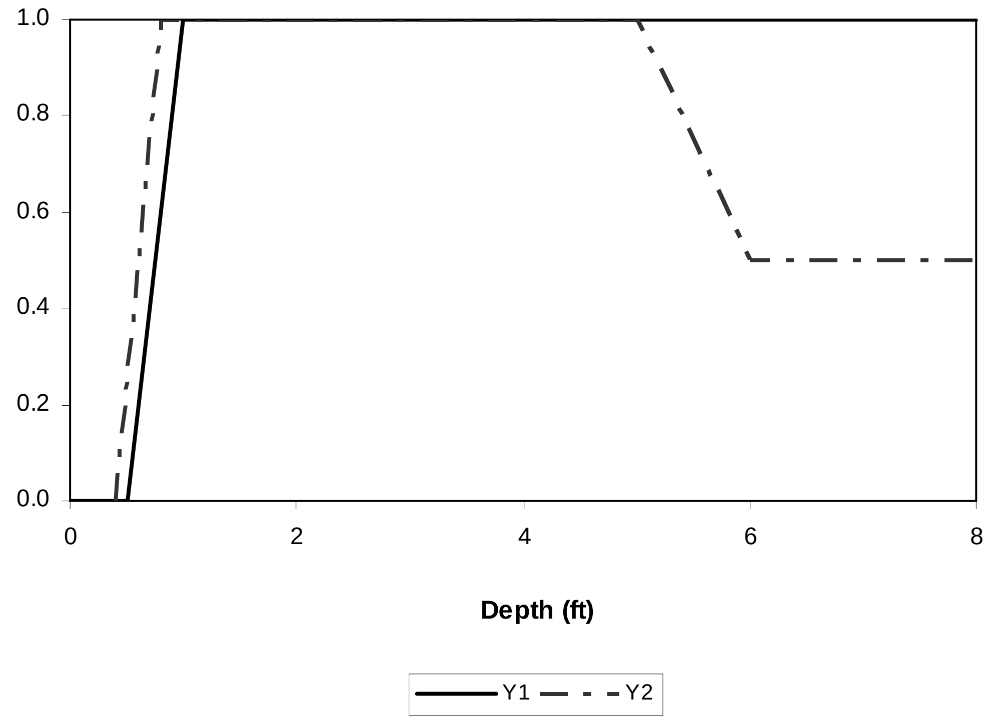
Velocity		
X	Y1	Y2
0.00	0.10	
0.10		0.00
0.15		0.10
0.20		0.20
0.25		0.90
0.40		0.95
0.50	1.00	1.00
0.60	1.00	
0.75		
1.00		
1.20		1.00
1.40		0.97
1.50		0.90
1.60	1.00	
2.00		
2.40		0.40
2.50	0.20	0.15
3.00	0.00	0.05
3.50		
4.00		0.00
4.30		
4.50		
7.00		



Location: Y1 – Tualatin R. and Scoggins Cr., OR
Source: Y1 – Agency Recommended, 2006
Y2 – Upper Tualatin River, OR
Y2 – CH2MHill, 1993.

Figure A-1d. Species: Steelhead trout; Lifestage: Juvenile rearing

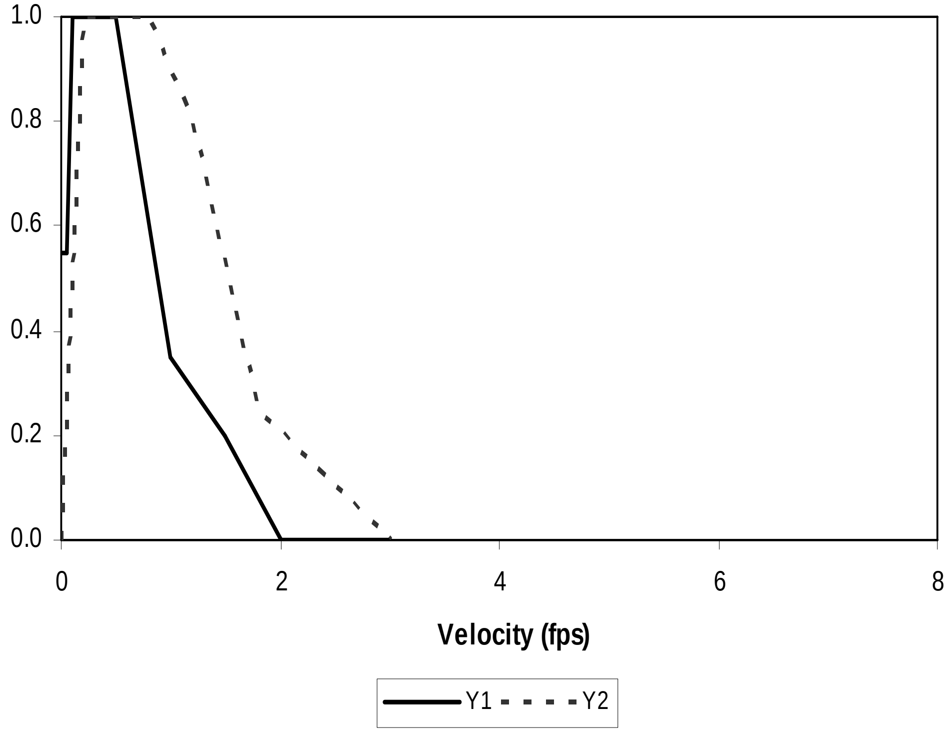
Depth		
X	Y1	Y2
0.00	0.00	
0.20		
0.30		
0.40		0.00
0.50	0.00	
0.60		
0.70		
0.80		1.00
1.00	1.00	
1.15		
1.20		
1.40		
1.50		
1.80		
2.00		
2.05		
2.10		
2.30		
2.50		
2.75		
3.75		
4.50		
5.00	1.00	1.00
6.00		0.50
8.00	1.00	0.50



Location: Y1 – Tualatin R. and Scoggins Cr., OR
Source: Y1 – Agency Recommended, 2006
Y2 – Upper Tualatin River, OR
Y2 – CH2MHill, 1993.

Figure A-1e. Species: Steelhead trout; Lifestage: Juvenile rearing

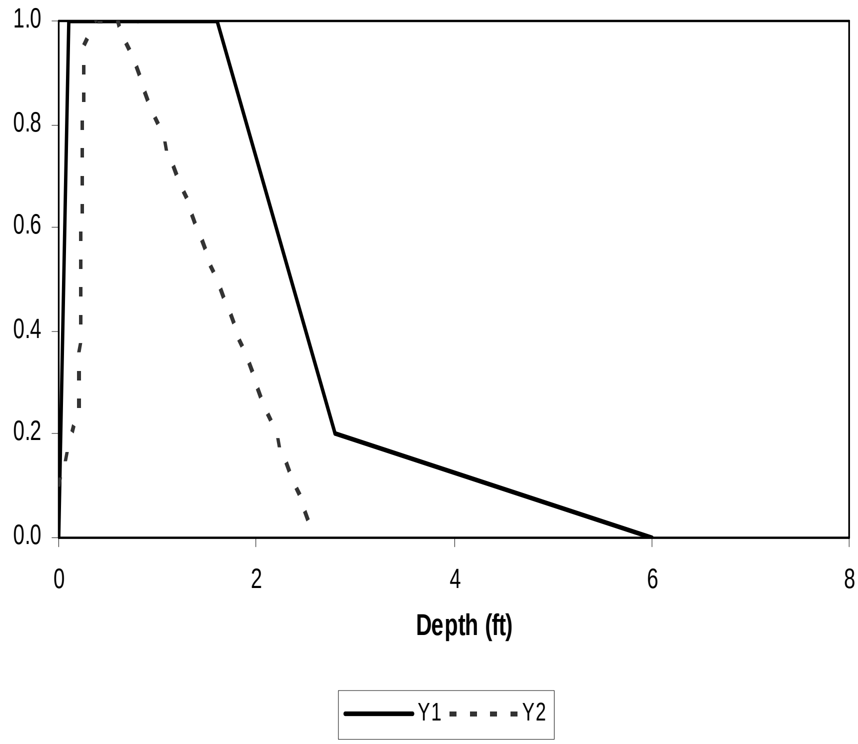
Velocity		
X	Y1	Y2
0.00	0.55	0.00
0.05	0.55	
0.10	1.00	
0.20		1.00
0.50	1.00	
0.60		
0.70		
0.80		1.00
1.00	0.35	0.90
1.20		0.80
1.50	0.20	
1.80		0.25
2.00	0.00	
2.10		
2.50		
2.70		
3.00	0.00	0.00
3.30		
6.50		
7.00		



Location: Y1 – Tualatin R. and Scoggins Cr., OR
Source: Y1 – Agency Recommended, 2006
Y2 – Upper Tualatin River, OR
Y2 – CH2MHill, 1993.

Figure A-1f. Species: Steelhead trout; Lifestage: Fry rearing

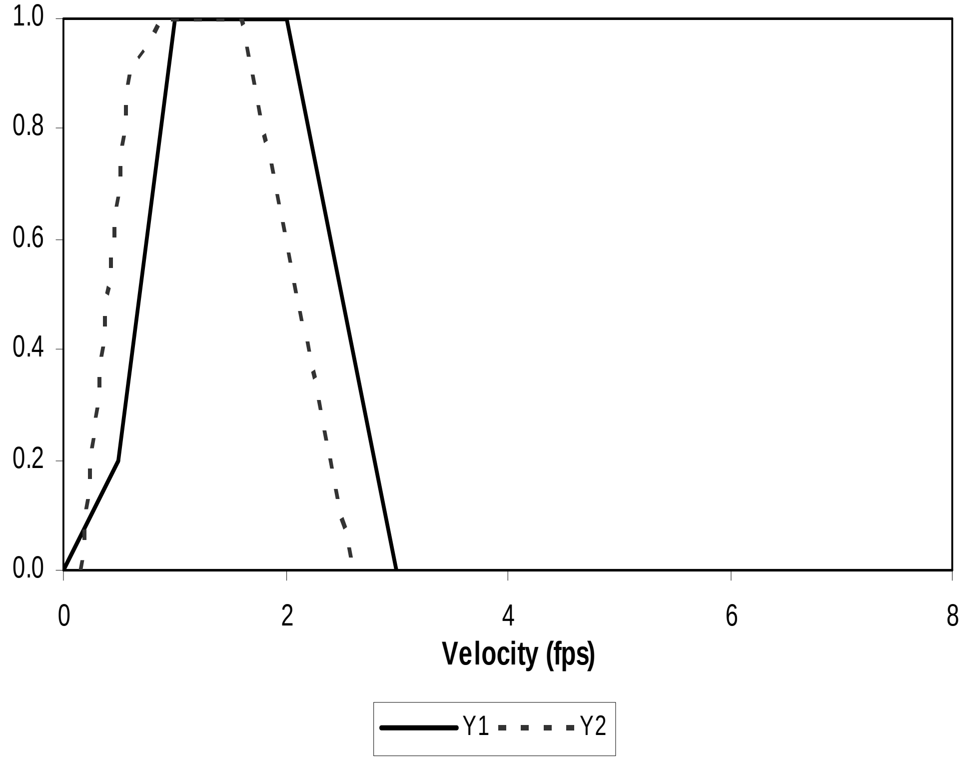
Depth		
X	Y1	Y2
0.00	0.00	0.10
0.05		
0.10	1.00	
0.20		0.25
0.25		0.95
0.40		1.00
0.60		1.00
0.80	1.00	
0.85		
1.00		
1.50		
1.60	1.00	
1.90		
2.00		
2.40		
2.60		0.00
2.80	0.20	
5.00		
5.01		
6.00	0.00	
10.00		



Location: Y1 – Tualatin R. and Scoggins Cr., OR
Source: Y1 – Agency Recommended, 2006
Y2 – Upper Tualatin River, OR
Y2 – CH2MHill, 1993.

Figure A-1g. Species: Steelhead trout; Lifestage: Fry rearing

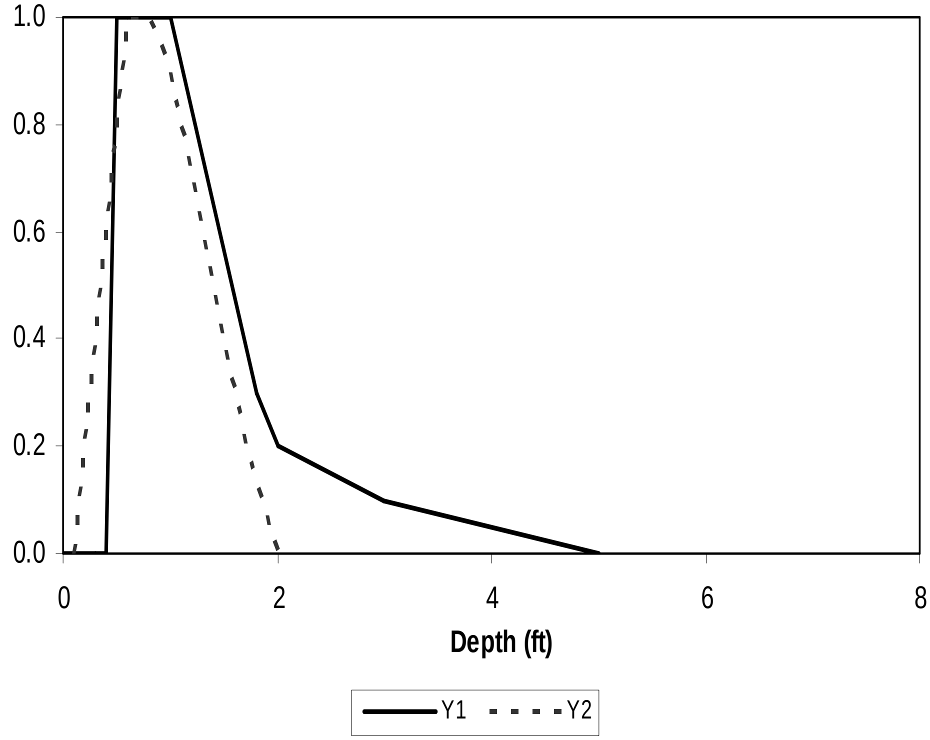
Velocity		
X	Y1	Y2
0.00	0.00	
0.15		0.00
0.20		0.10
0.50	0.20	
0.60		0.90
0.90		1.00
1.00	1.00	
1.10		
1.20		
1.40		
1.60		1.00
1.80		
2.00	1.00	
2.30		
2.60		0.00
3.00	0.00	
3.20		
3.50		
4.00		
5.00		
5.50		



Location: Y1 – Tualatin R. and Scoggins Cr., OR
Source: Y1 – Agency Recommended, 2006
Y2 – Upper Tualatin River, OR
Y2 – CH2MHill, 1993.

Figure A-2a. Species: Cutthroat trout; Lifestage: Spawning/Incubation

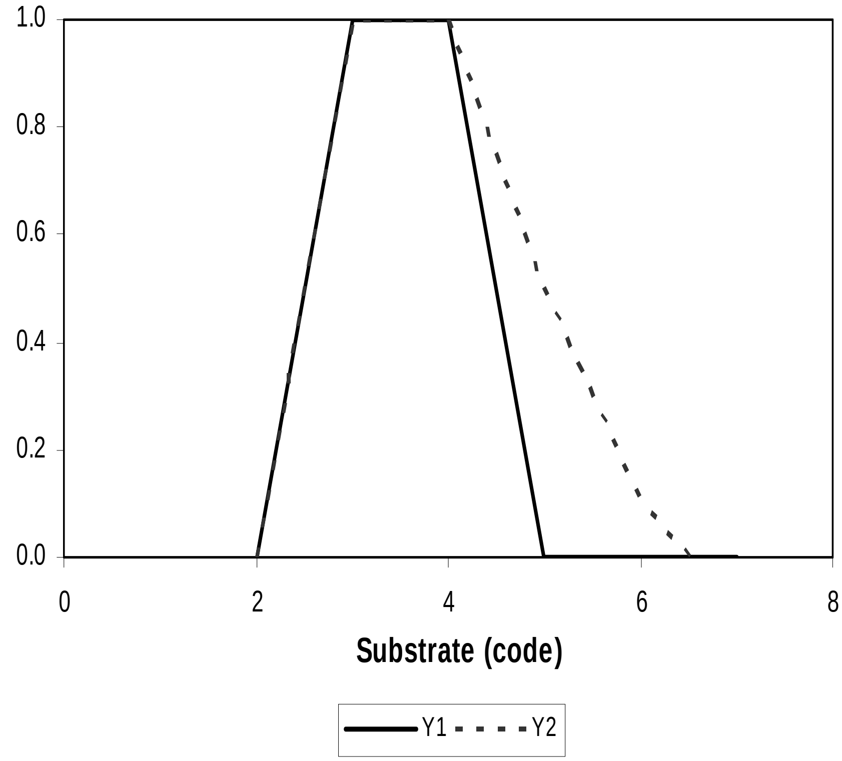
Depth		
X	Y1	Y2
0.00	0.00	
0.10		0.00
0.30	0.00	
0.40	0.00	
0.50	1.00	
0.60	1.00	1.00
0.70		
0.80		1.00
1.00	1.00	0.90
1.60		
1.80	0.30	
1.70		0.20
2.00	0.20	0.00
3.00	0.10	
5.00	0.00	
8.00		



L
ocation: Y1 – Tualatin R. and Scoggins Cr., OR **Source**: Y1 – Agency Recommended, 2006
Y2 – Upper Tualatin River, OR
Y2 – CH2MHill, 1993.

Figure A-2b. Species: Cutthroat trout; Lifestage: Spawning/Incubation

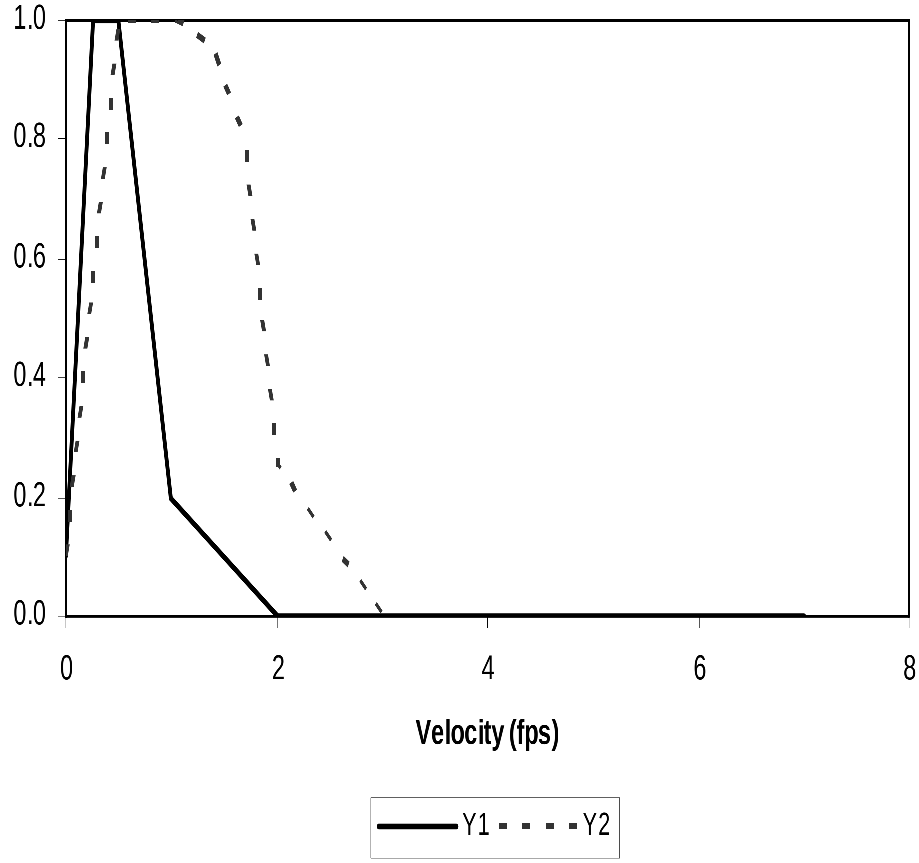
Substrate			
Code	X	Y1	Y2
duff	0.00		
silt/clay	1.00		
	1.50		
	1.80		
sand	2.00	0.00	0.00
	2.50		
fine gravel	3.00	1.00	1.00
	3.50	1.00	
med. gravel	4.00	1.00	1.00
	4.50		
coarse gravel	5.00	0.00	0.50
	5.50		
small cobble	6.00		0.10
	6.50		0.00
large cobble	7.00	0.00	
	7.70		
boulder	8.00		



Location: Y1 – Tualatin R. and Scoggins Cr., OR
Source: Y1 – Agency Recommended, 2006
Y2 – Upper Tualatin River, OR (trout spawning)
Y2 – CH2MHill, 1993.

Figure A-2c. Species: Cutthroat trout; Lifestage: Spawning Substrate

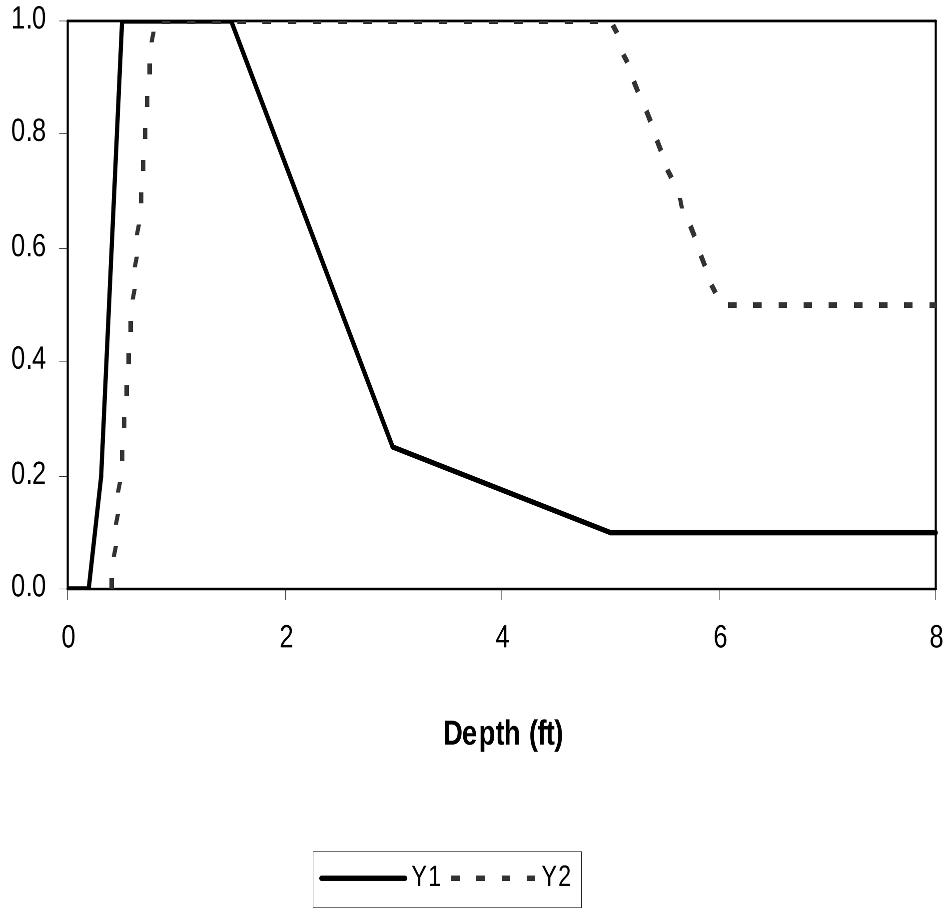
Velocity		
X	Y1	Y2
0.00	0.10	0.10
0.10		
0.15		
0.25	1.00	
0.50	1.00	1.00
0.65		
0.70		
0.75		
1.00	0.20	
1.05		1.00
1.30		
1.40		0.95
1.50		0.90
1.60		0.85
1.70		0.80
2.00	0.00	0.3
2.25		
2.35		
3.00		0
3.25		
3.55		
3.75		
3.90		
7.00	0.00	



Location: Y1 – Tualatin R. and Scoggins Cr., OR
Source: Y1 – Agency Recommended, 2006
Y2 – Upper Tualatin River, OR
Y2 – CH2MHill, 1993.

Figure A-2d. Species: Cutthroat trout; Lifestage: Juvenile rearing

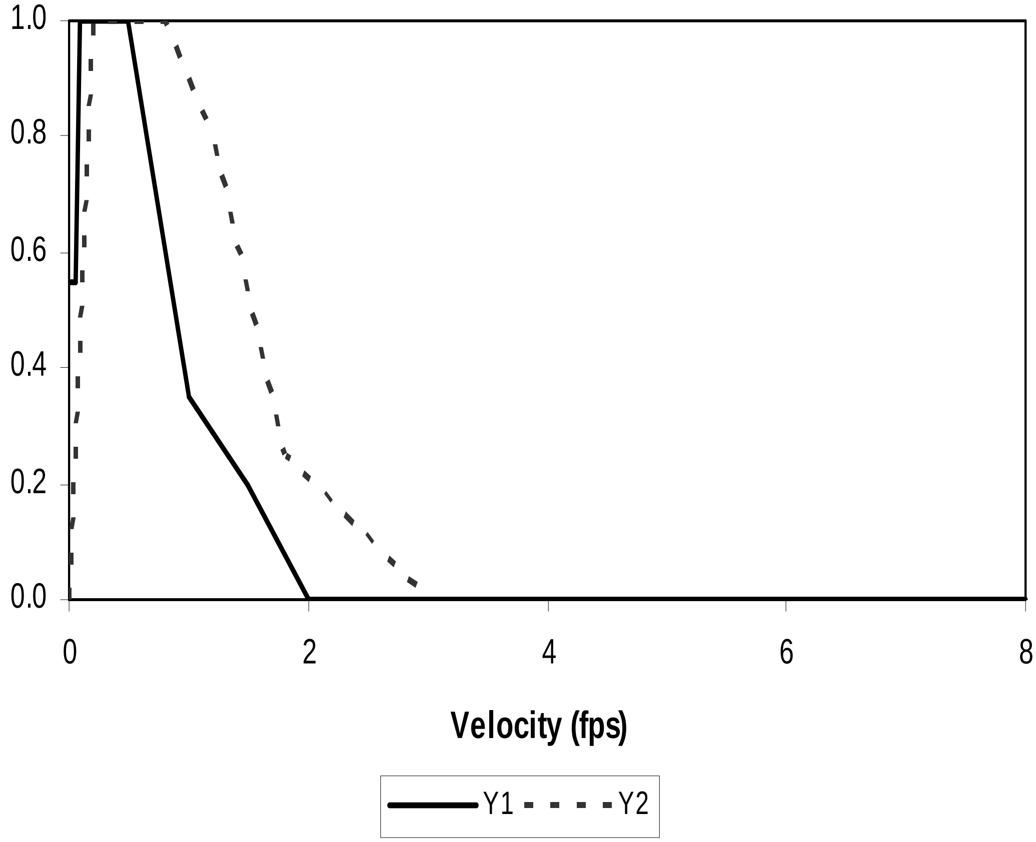
Depth		
X	Y1	Y2
0.00	0.00	
0.10		
0.20	0.00	
0.30	0.20	
0.40		0.00
0.50	1.00	
0.70		
0.80		1.00
1.00		
1.05		
1.25		
1.30		
1.50	1.00	
1.65		
1.75		
1.80		
1.95		
2.00		
2.10		
2.25		
2.30		
2.45		
2.65		
2.75		
3.00	0.25	
4.00		
5.00	0.10	1.00
6.00		0.50
8.00	0.10	0.50



Location: Y1 – Tualatin R. and Scoggins Cr., OR
Source: Y1 – Agency Recommended, 2006
Y2 – Upper Tualatin River, OR
Y2 – CH2MHill, 1993.

Figure A-2e. Species: Cutthroat trout; Lifestage: Juvenile rearing

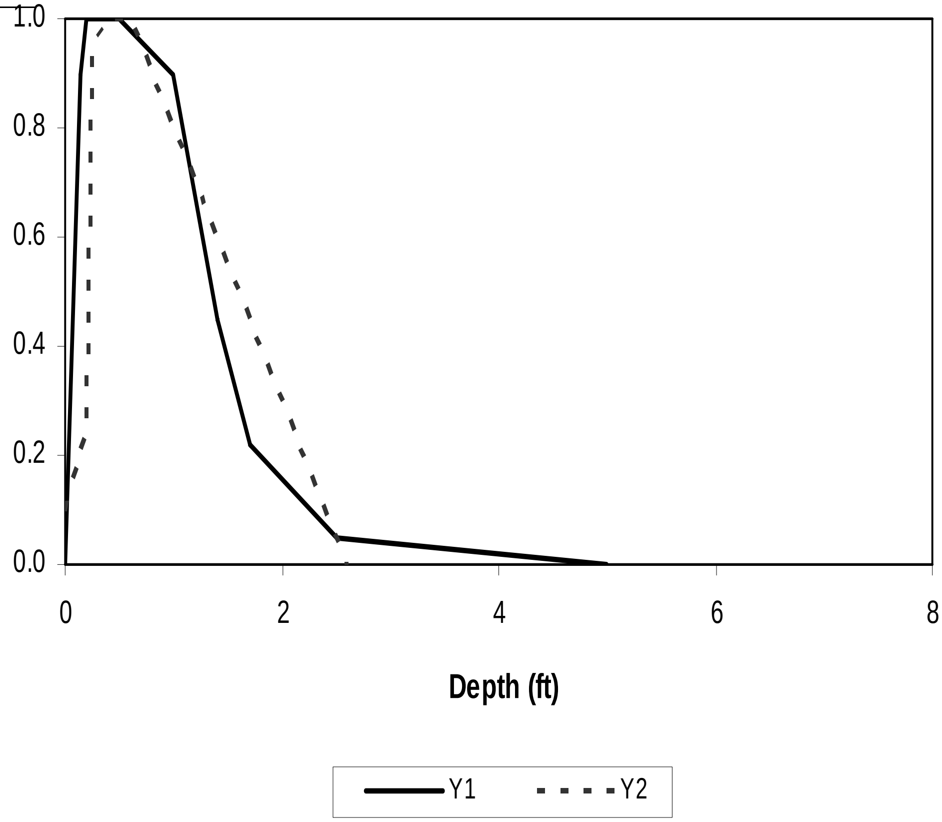
Velocity		
X	Y1	Y2
0.00	0.55	0.00
0.05	0.55	
0.10	1.00	
0.20		1.00
0.25		
0.36		
0.45		
0.50	1.00	
0.70		
0.80		1.00
0.95		
1.00	0.35	0.9
1.20		0.8
1.50	0.20	
1.80		0.25
2.00	0.00	
2.30		
2.60		
3.00		0
3.30		
8.00	0.00	



Location: Y1 – Tualatin R. and Scoggins Cr., OR
Source: Y1 – Agency Recommended, 2006
Y2 – Upper Tualatin River, OR
Y2 – CH2MHill, 1993.

Figure A-2f. Species: Cutthroat trout; Lifestage: Fry rearing

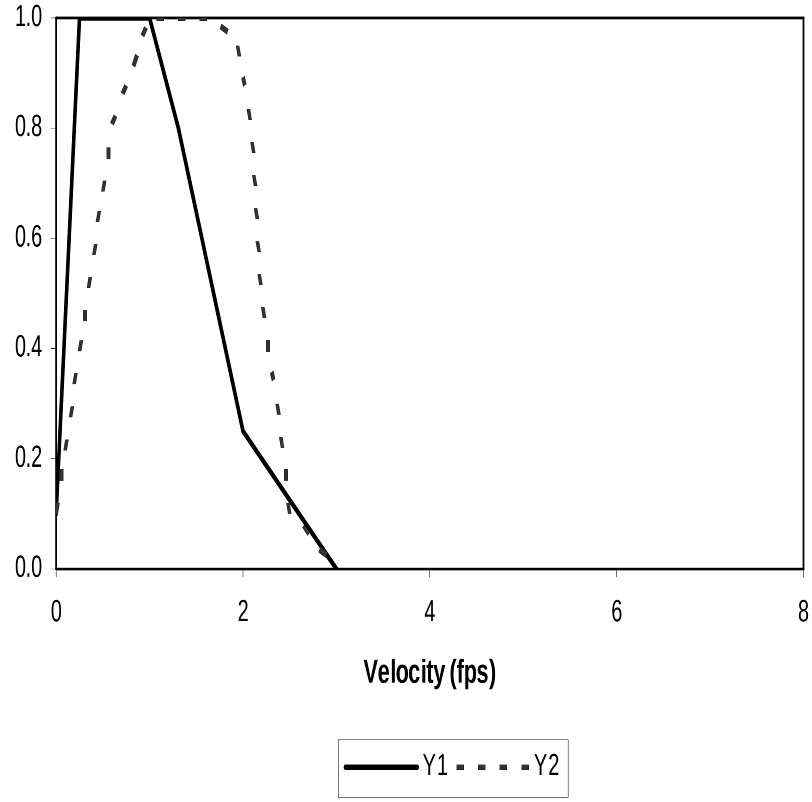
Depth		
X	Y1	Y2
0.00	0.00	0.10
0.05		
0.15	0.90	
0.20	1.00	0.25
0.25		0.95
0.30		
0.40		1.00
0.50	1.00	
0.60		1.00
0.70		
0.85		
0.90		
1.00	0.90	
1.25		
1.30		
1.40	0.45	
1.70	0.22	
2.50	0.05	
2.60		0.00
5.00	0.00	
5.01		
8.00		



Location: Y1 – Tualatin R. and Scoggins Cr., OR
Source: Y1 – Agency Recommended, 2006
Y2 – Upper Tualatin River, OR
Y2 – CH2MHill, 1993.

Figure A-2g. Species: Cutthroat trout; Lifestage: Fry rearing

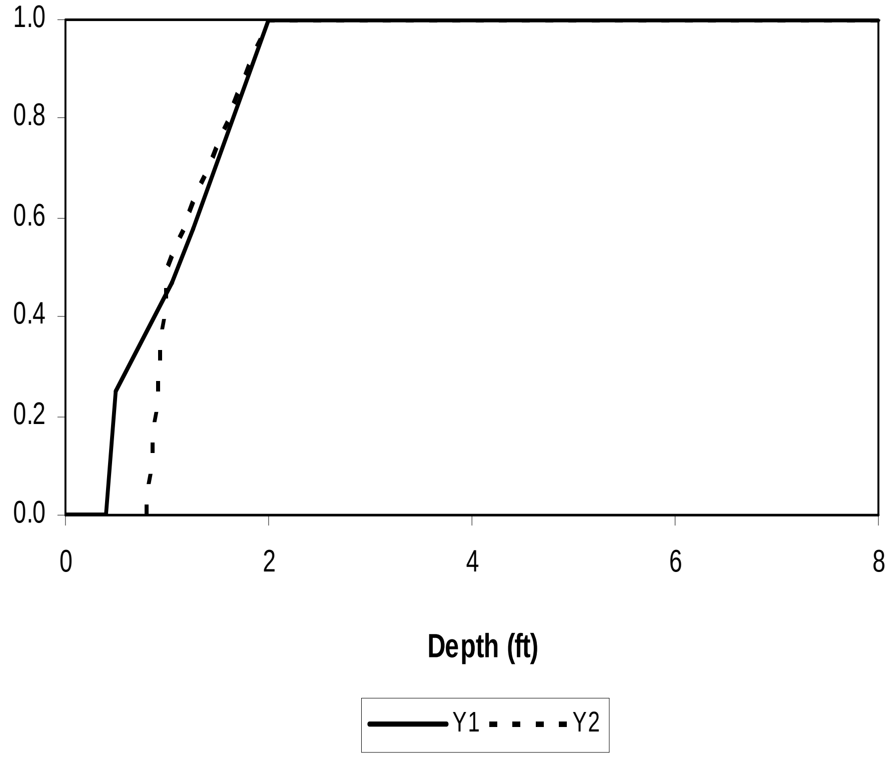
Velocity		
X	Y1	Y2
0.00	0.10	0.10
0.10		
0.25	1.00	
0.50		
0.60		0.80
0.75		
1.00	1.00	1.00
1.15		
1.30	0.80	
1.55		
1.70		1.00
1.95		0.95
2.00	0.25	
2.10		0.8
2.20		0.50
2.45		0.20
2.50		0.10
3.00	0.00	0.00
3.55		
3.75		
3.90		
7.00		



Location: Y1 – Tualatin R. and Scoggins Cr., OR
Source: Y1 – Agency Recommended, 2006
Y2 – Upper Tualatin River, OR
Y2 – CH2MHill, 1993.

Figure A-2h. Species: Cutthroat trout; Lifestage: Adult

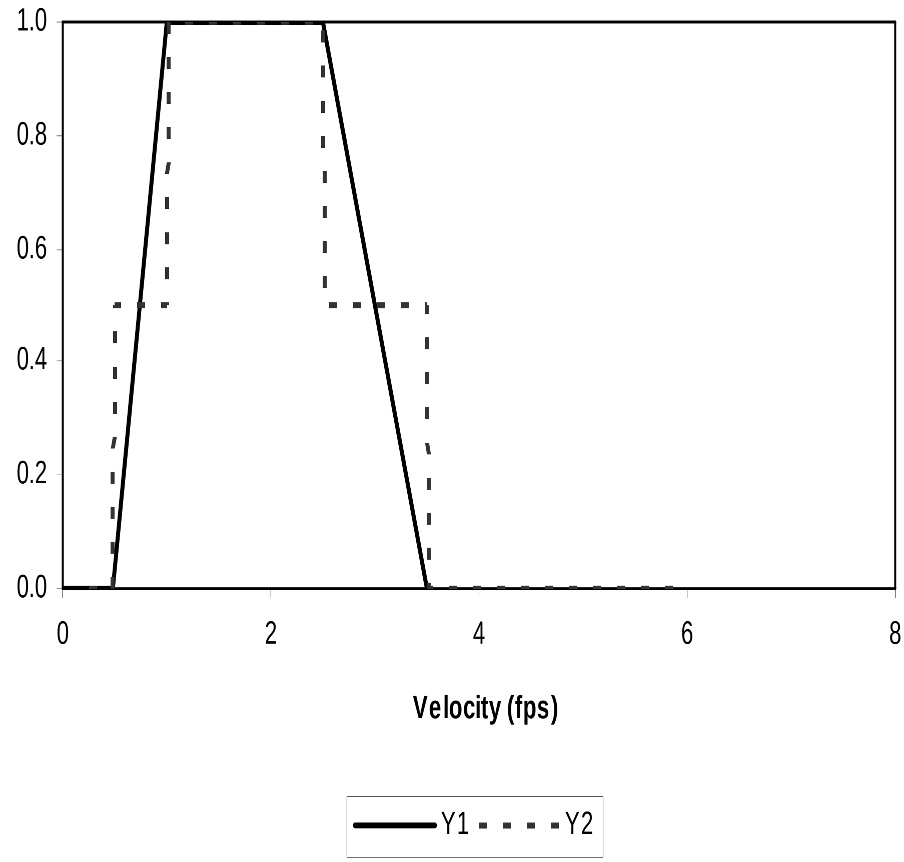
Depth		
X	Y1	Y2
0.00	0.00	
0.10		
0.20		
0.30		
0.40	0.00	
0.50	0.25	
0.70		
0.80		0.00
1.00		0.50
1.05	0.47	
1.25	0.58	
1.30		
1.50		
1.65		
1.75		
1.80		
1.95		
2.00	1.00	1.00
2.10		
5.00		
6.00		
8.00	1.00	1.00



Location: Y1 – Tualatin R. and Scoggins Cr., OR
Source: Y1 – Agency Recommended, 2006
Y2 – Upper Tualatin River, OR
Y2 – CH2MHill, 1993.

Figure A-2i. Species: Cutthroat trout; Lifestage: Adult

Velocity		
X	Y1	Y2
0.00	0.00	
0.25	0.00	0.00
0.49	0.00	0.00
0.50		0.50
0.75		
1.00	1.00	0.50
1.01	1.00	1.00
1.50		
1.51	1.00	
1.75		
2.00		
2.25		
2.50	1.00	1.00
2.51		0.50
3.00		
3.25		
3.50	0.00	0.50
3.51	0.00	0.00
4.00		
4.50		
5.00		
6.00		0.00

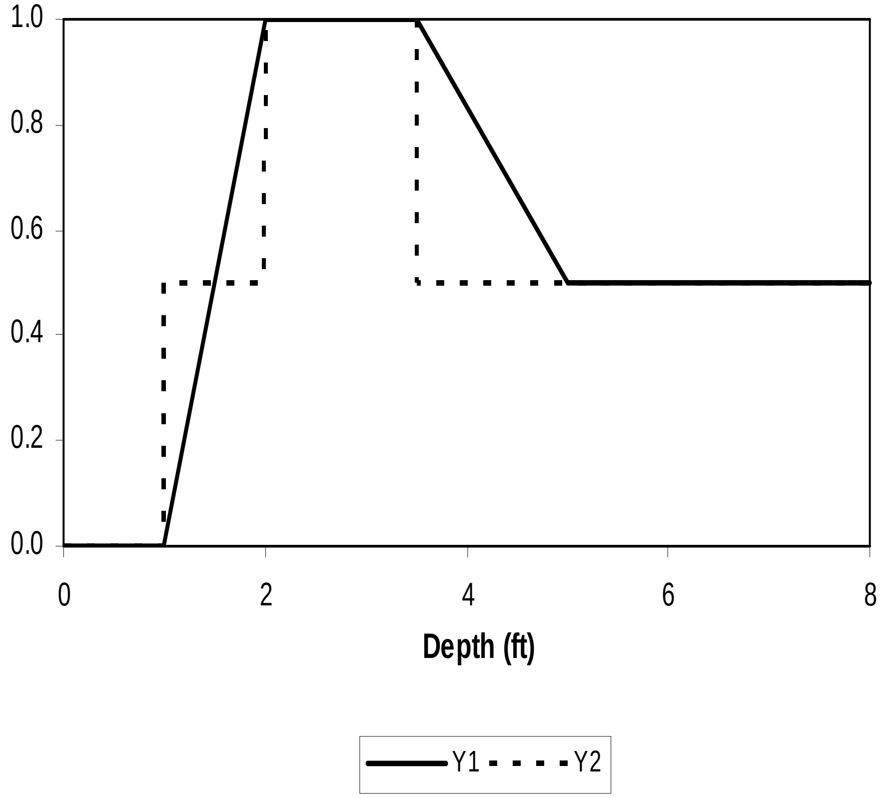


Location: Y1 – McKenzie River, OR
Source: Y1 – EWEB, 2004 (composite)
Y2 – McKenzie River, OR
Y2 – EWEB, 2004 (binary)

Figure A-3a. Species: Pacific Lamprey; Lifestage: Spawning/Incubation

Depth

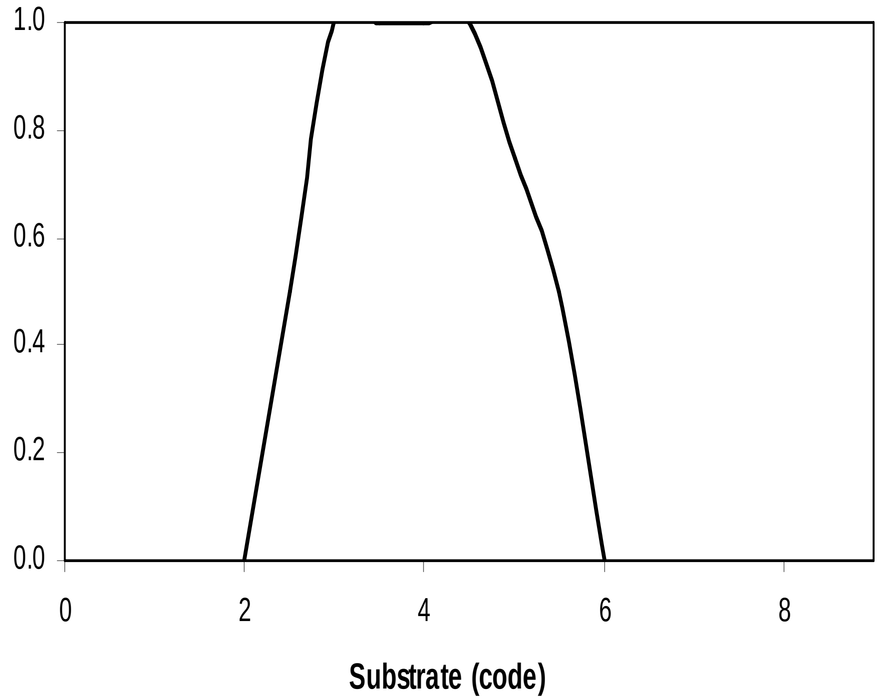
X	Y1	Y2
0.00	0.00	0.00
0.20		
0.30		
0.50		
0.60		
0.65		
0.70		
0.75		
0.99		0.00
1.00	0.00	0.50
1.99		0.50
2.00	1.00	1.00
3.50	1.00	1.00
3.51		0.50
4.50		
5.00	0.50	
6.00		
8.00	0.50	0.50



Location: Y1 – McKenzie River, OR
Source: Y1 – EWEB, 2004 (composite)
Y2 – McKenzie River, OR
Y2 – EWEB, 2004 (binary)

Figure A-3b. Species: Pacific Lamprey; Lifestage: Spawning/Incubation

	Substrate	
Code	X	Y1
	0.00	
silt/clay	1.00	
	1.50	
sand	2.00	0.00
	2.50	0.50
fine gravel	3.00	1.00
	3.50	1.00
med. gravel	4.00	1.00
	4.50	1.00
coarse gravel	5.00	0.75
	5.50	0.50
small cobble	6.00	0.00
	6.50	
large cobble	7.00	
	7.50	
boulder	8.00	

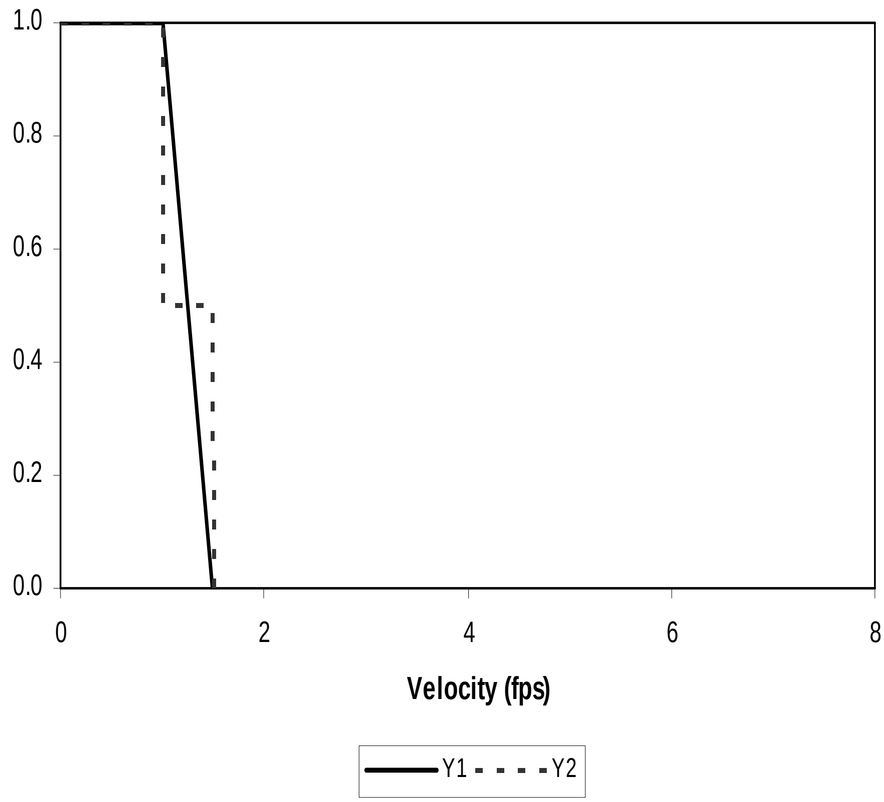


Location: Y1 – OR & WA stream composite

Source: Y1 – EWEB, 2004

Figure A-3c. Species: Pacific Lamprey; Lifestage: Spawning substrate

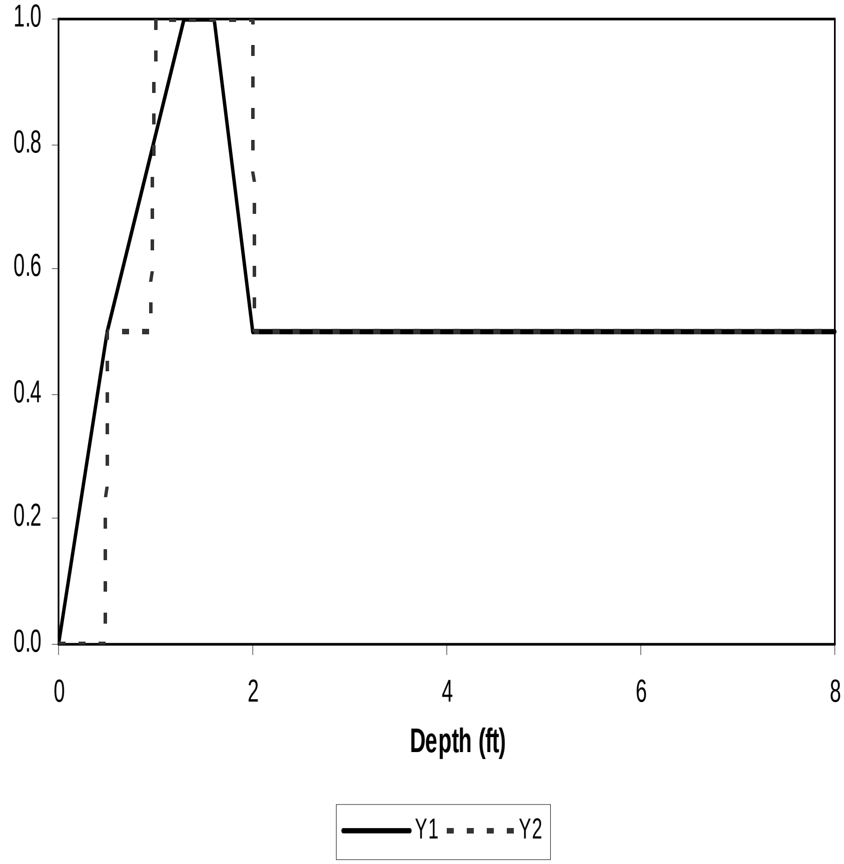
Velocity		
X	Y1	Y2
0.00	1.00	1.00
0.10		
0.20		
0.25		
0.30		
0.50		
0.60		
0.65		
0.80		
0.90		
0.95		
1.00	1.00	1.00
1.01		0.50
1.25		
1.50	0.00	0.50
1.51		0.00
2.00		
3.00		
4.00		
6.00		
8.00		



Location: Y1 – McKenzie River, OR
Source: Y1 – EWEB, 2004 (composite)
Y2 – McKenzie River, OR
Y2 – EWEB, 2004 (binary)

Figure A-3d. Species: Pacific Lamprey; Lifestage: Ammocoetes

Depth		
X	Y1	Y2
0.00	0.00	0.00
0.49		0.00
0.50	0.50	0.50
0.59		
0.80		
0.95		0.50
1.00		1.00
1.30	1.00	
1.60	1.00	
1.55		
1.75		
2.00	0.50	1.00
2.01		0.50
2.75		
3.00		
3.25		
3.30		
3.40		
3.75		
3.90		
4.50		
4.75		
5.00		
5.25		
8.00	0.50	0.50



Location: Y1 – McKenzie River, OR
Source: Y1 – EWEB, 2004 (composite)
Y2 – McKenzie River, OR
Y2 – EWEB, 2004 (binary)

Figure A-3e. Species: Pacific Lamprey; Lifestage: Ammocoetes

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APPENDIX B

WEIGHTED USABLE AREA (WUA) CURVES

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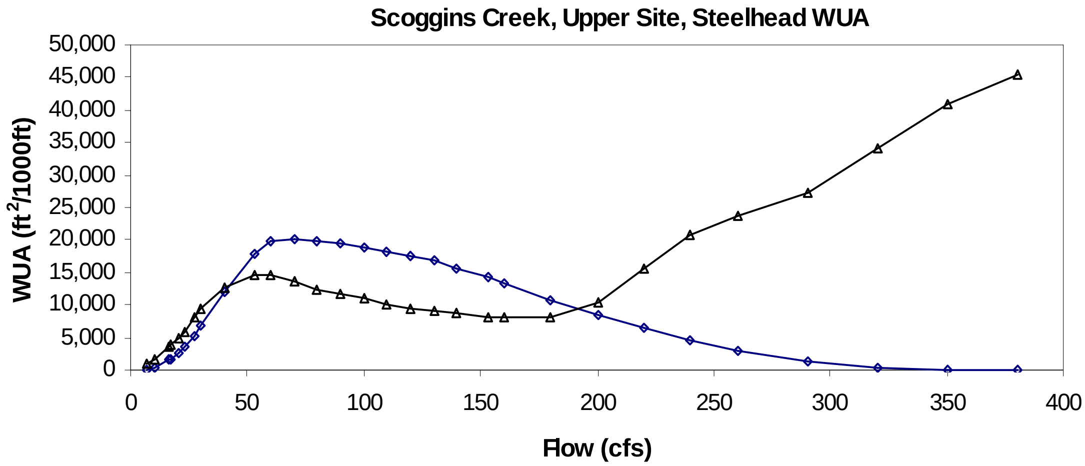
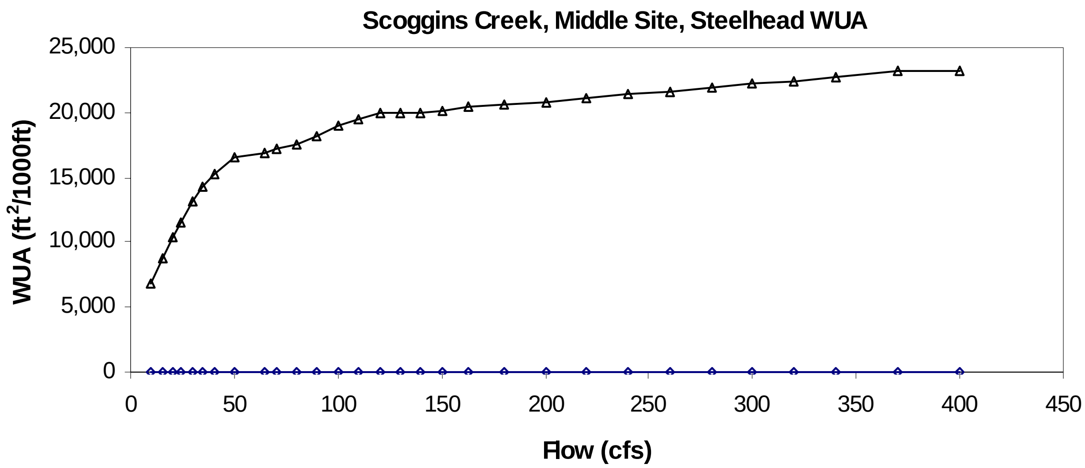
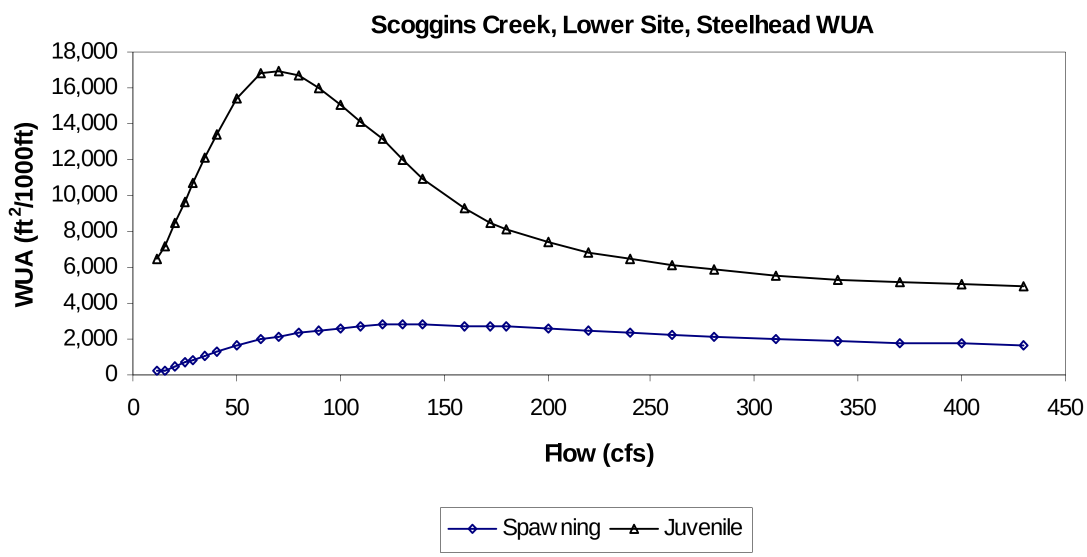
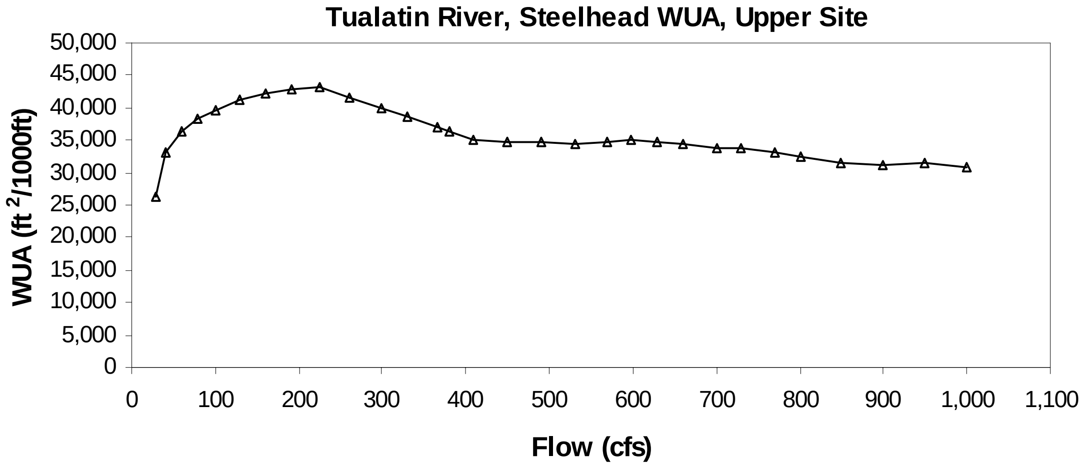
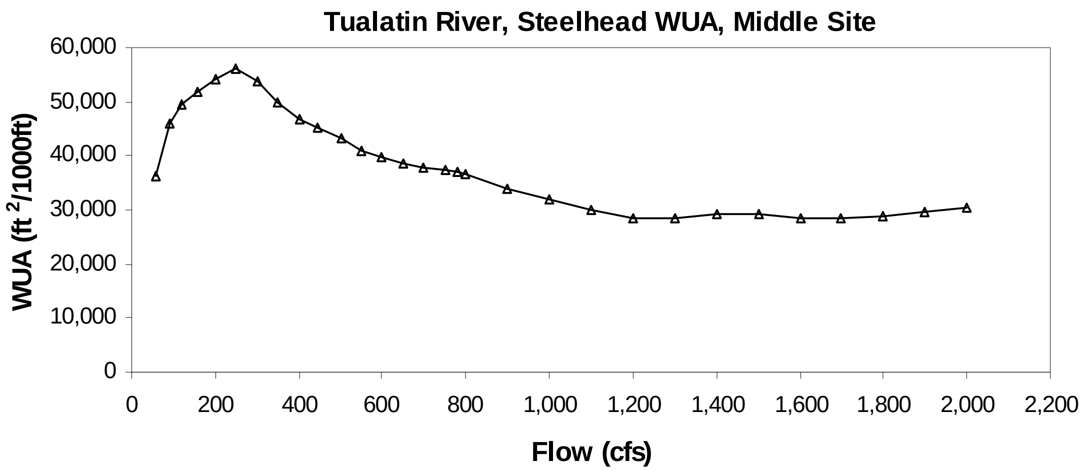

Scoggins Creek, Upper Site, Steelhead WUA
WUA (ft²/1000ft)
Flow (cfs)


Scoggins Creek, Middle Site, Steelhead WUA
WUA (ft²/1000ft)
Flow (cfs)

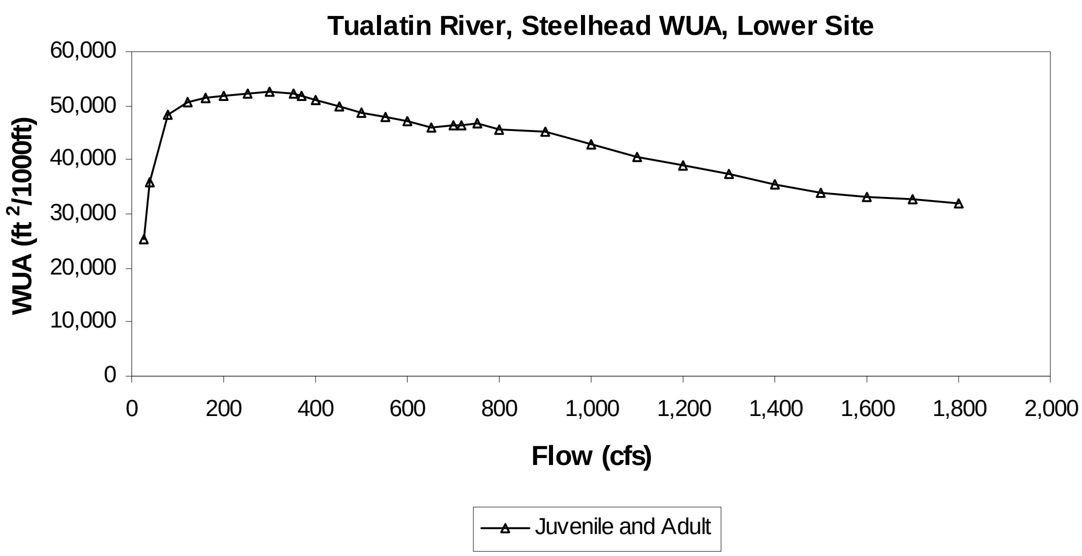

Scoggins Creek, Lower Site, Steelhead WUA
WUA (ft²/1000ft)
Flow (cfs)
Spawning
Juvenile



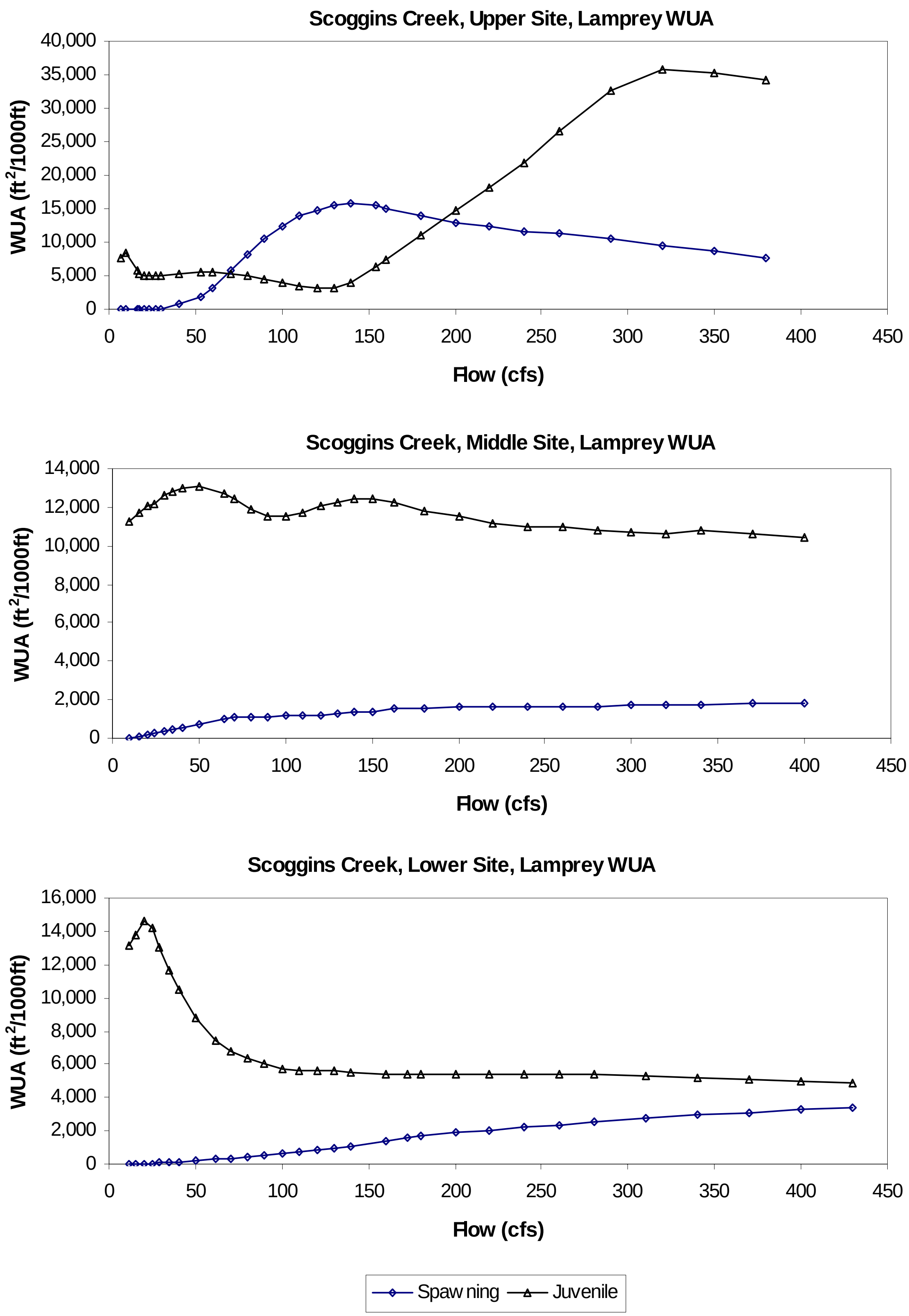
Tualatin River, Steelhead WUA, Upper Site
WUA (ft 2/1000ft)
50,000
45,000
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
0
100
200
300
400
500
600
700
800
900
1,000
1,100
Flow (cfs)

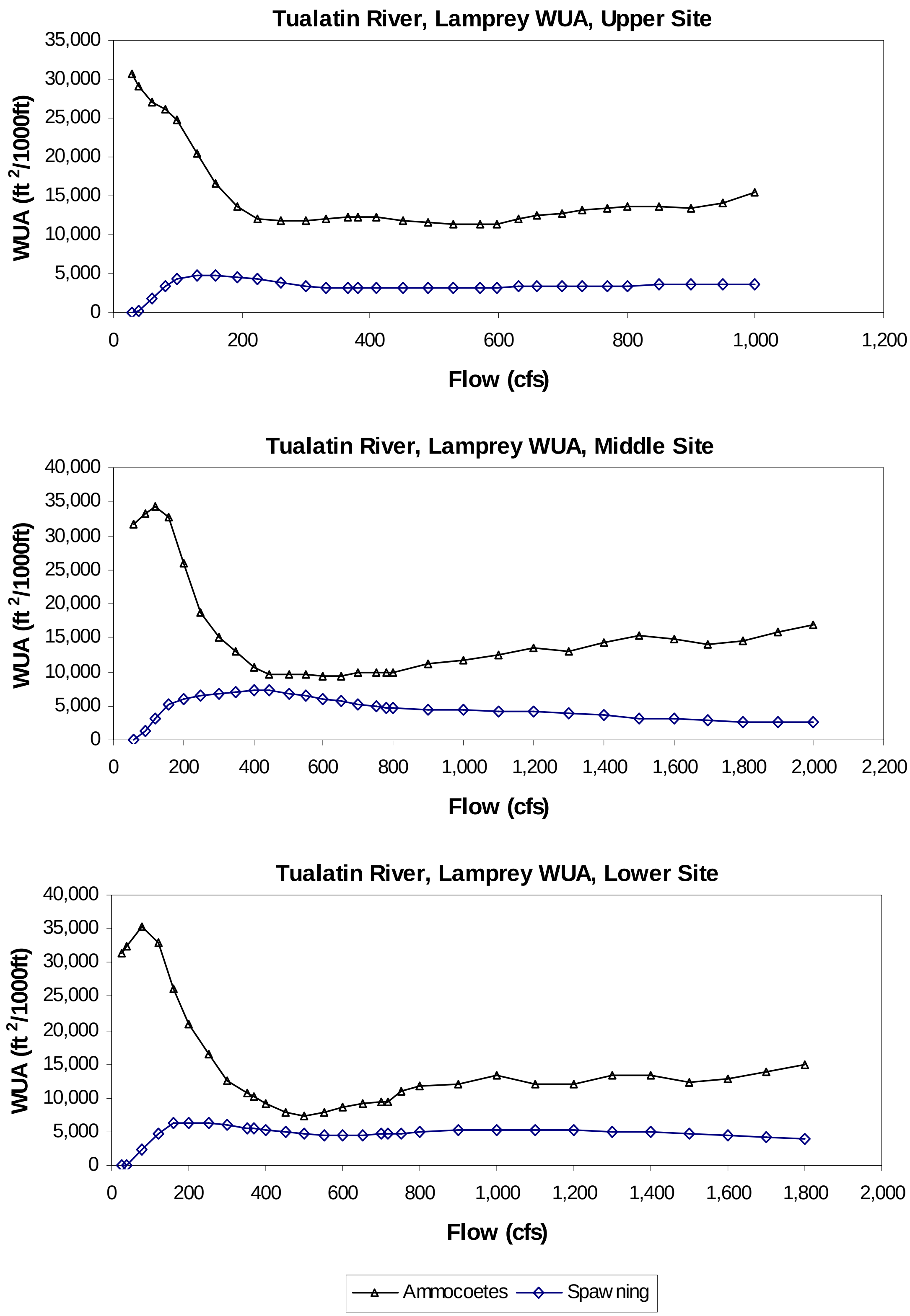


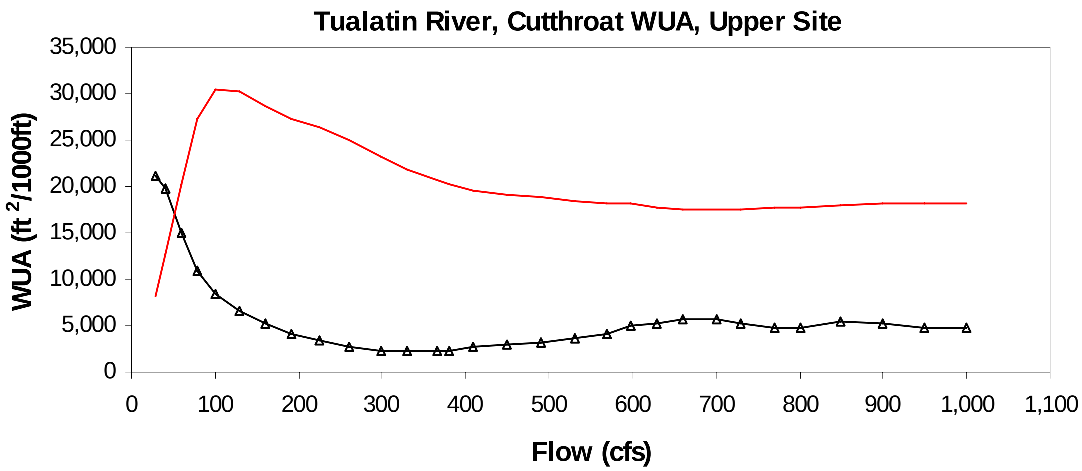
Tualatin River, Steelhead WUA, Middle Site
WUA (ft 2/1000ft)
60,000
50,000
40,000
30,000
20,000
10,000
0
0
200
400
600
800
1,000
1,200
1,400
1,600
1,800
2,000
2,200
Flow (cfs)

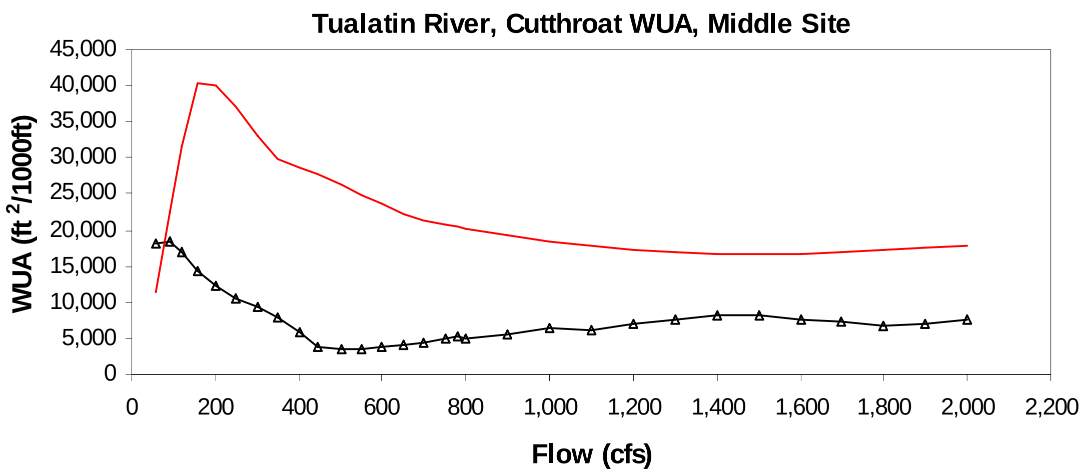


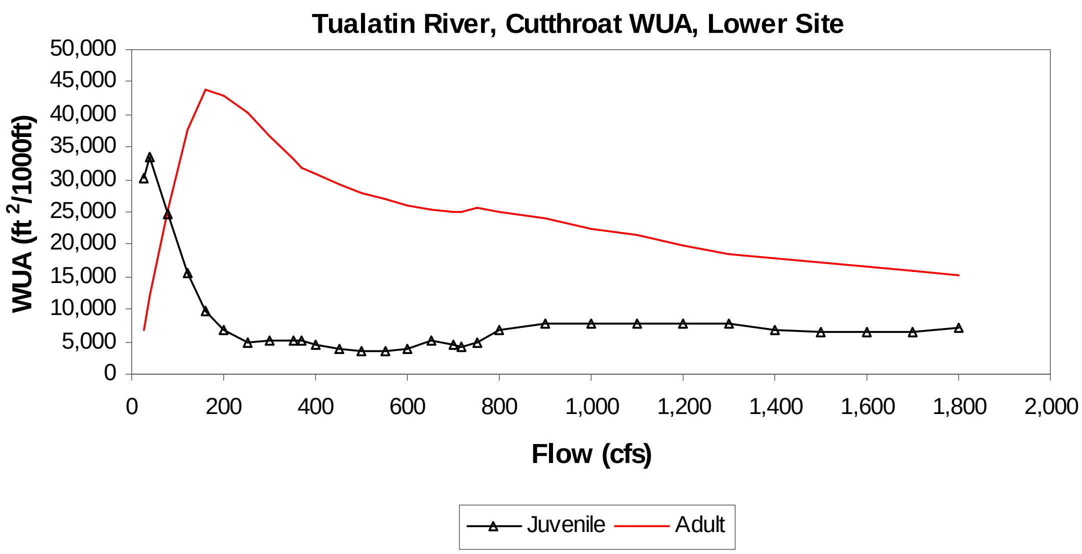
Tualatin River, Steelhead WUA, Lower Site
WUA (ft 2/1000ft)
60,000
50,000
40,000
30,000
20,000
10,000
0
0
200
400
600
800
1,000
1,200
1,400
1,600
1,800
2,000
Flow (cfs)
Juvenile and Adult

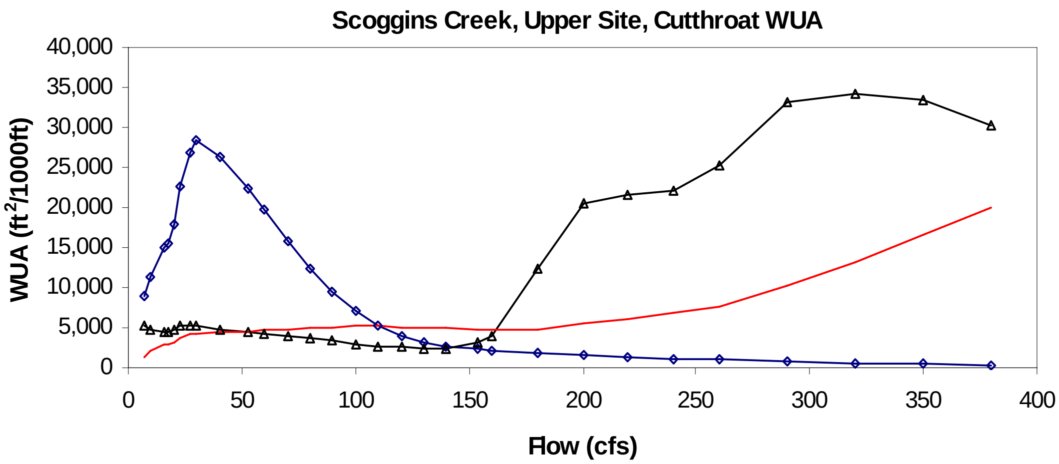

Scoggins Creek, Upper Site, Lamprey WUA
WUA (ft²/1000ft)
Flow (cfs)
Scoggins Creek, Middle Site, Lamprey WUA
WUA (ft²/1000ft)
Flow (cfs)
Scoggins Creek, Lower Site, Lamprey WUA
WUA (ft²/1000ft)
Flow (cfs)
Spawning
Juvenile

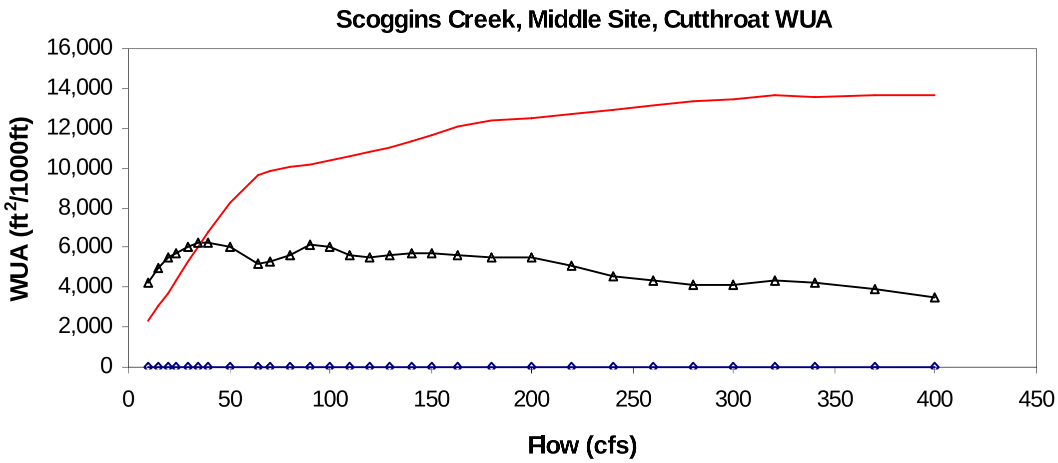

Tualatin River, Lamprey WUA, Upper Site
WUA (ft 2/1000ft)
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
0
200
400
600
800
1,000
1,200
Flow (cfs)
Tualatin River, Lamprey WUA, Middle Site
WUA (ft 2/1000ft)
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
0
200
400
600
800
1,000
1,200
1,400
1,600
1,800
2,000
2,200
Flow (cfs)
Tualatin River, Lamprey WUA, Lower Site
WUA (ft 2/1000ft)
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
0
200
400
600
800
1,000
1,200
1,400
1,600
1,800
2,000
Flow (cfs)
Ammocoetes
Spawning

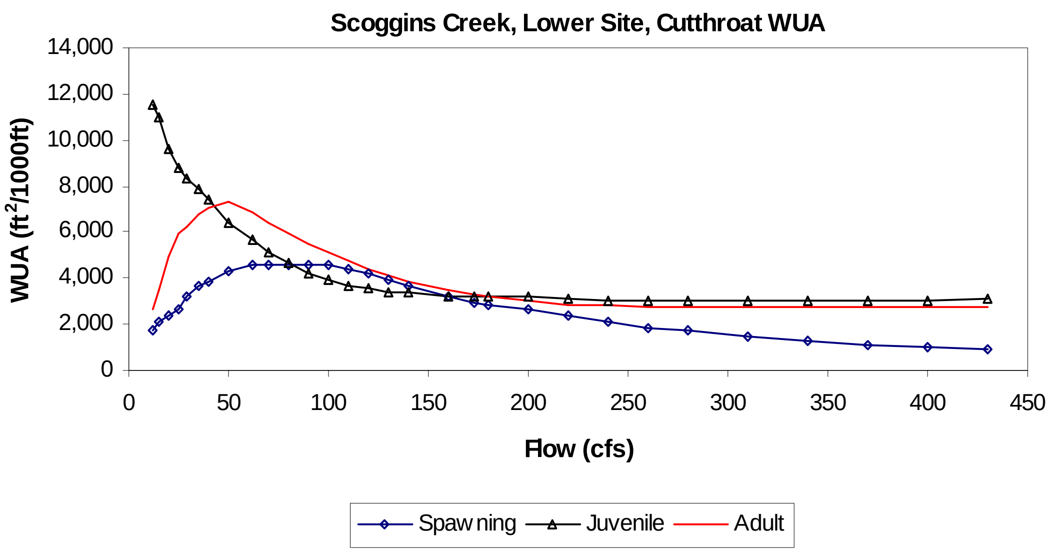

Tualatin River, Cutthroat WUA, Upper Site
WUA (ft ^{2}/1000ft)
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
0
100
200
300
400
500
600
700
800
900
1,000
1,100
Flow (cfs)

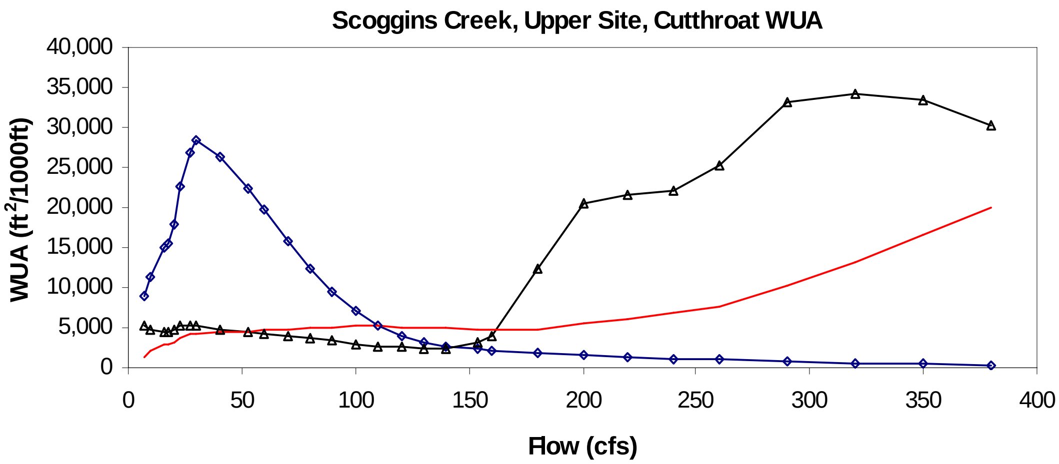

Tualatin River, Cutthroat WUA, Middle Site
WUA (ft ^{2}/1000ft)
45,000
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
0
200
400
600
800
1,000
1,200
1,400
1,600
1,800
2,000
2,200
Flow (cfs)

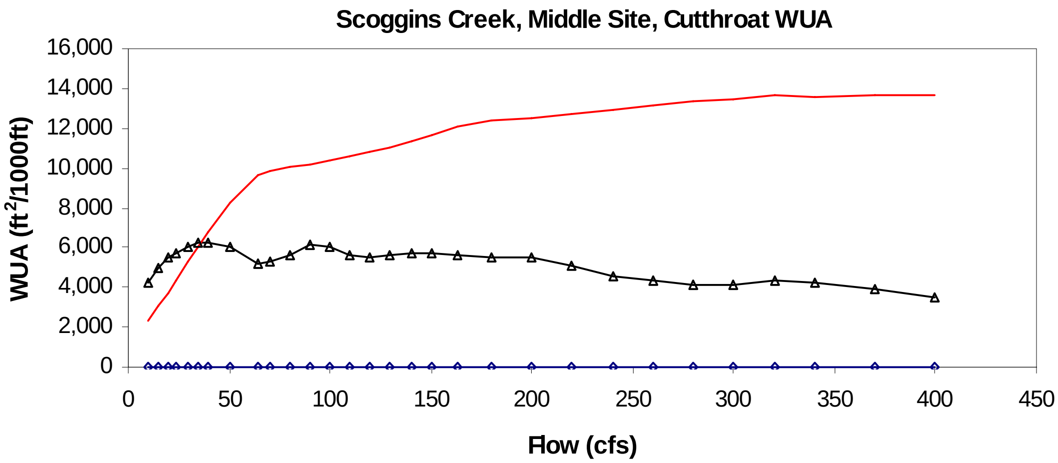

Tualatin River, Cutthroat WUA, Lower Site
WUA (ft ^{2}/1000ft)
50,000
45,000
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
0
200
400
600
800
1,000
1,200
1,400
1,600
1,800
2,000
Flow (cfs)
Juvenile
Adult

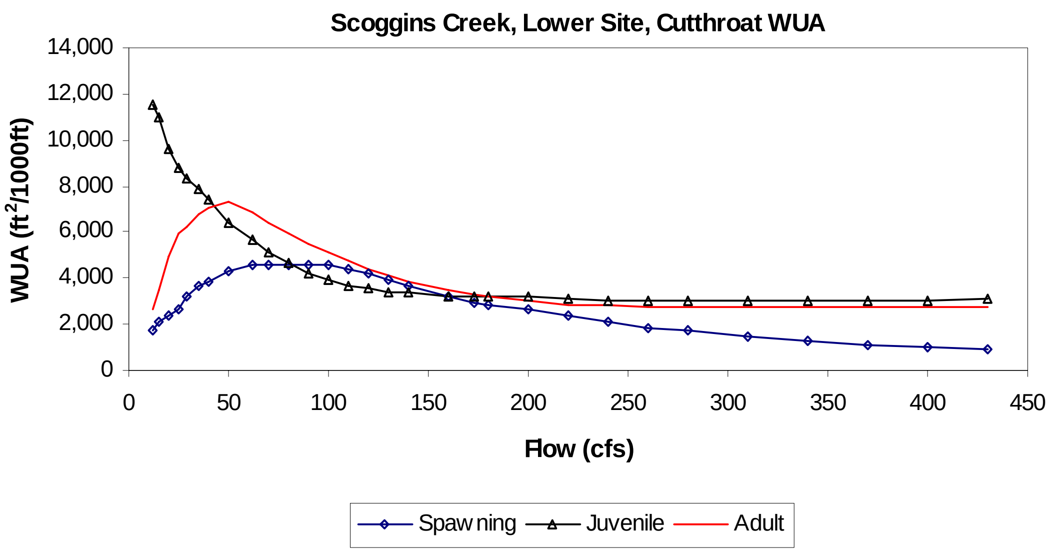

Scoggins Creek, Upper Site, Cutthroat WUA
WUA (ft²/1000ft)
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
0
50
100
150
200
250
300
350
400
Flow (cfs)


Scoggins Creek, Middle Site, Cutthroat WUA
WUA (ft²/1000ft)
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
0
50
100
150
200
250
300
350
400
450
Flow (cfs)


Scoggins Creek, Lower Site, Cutthroat WUA
WUA (ft²/1000ft)
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
0
50
100
150
200
250
300
350
400
450
Flow (cfs)
Spawning
Juvenile
Adult


Scoggins Creek, Upper Site, Cutthroat WUA
WUA (ft²/1000ft)
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
0
50
100
150
200
250
300
350
400
Flow (cfs)


Scoggins Creek, Middle Site, Cutthroat WUA
WUA (ft²/1000ft)
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
0
50
100
150
200
250
300
350
400
450
Flow (cfs)


Scoggins Creek, Lower Site, Cutthroat WUA
WUA (ft²/1000ft)
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
0
50
100
150
200
250
300
350
400
450
Flow (cfs)
Spawning
Juvenile
Adult

APPENDIX C

SITE/TRANSECT PHOTOGRAPHS

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Lower Scoggins

Transect 1

Looking Downstream

Lower Scoggins

Transect 1

**Looking
Left to Right**

Lower Scoggins

Transect 2

**Looking
Left to Right**

Lower Scoggins

Transect 3

**Looking
Left to Right**

Lower Scoggins

Transect 3

Looking Downstream

Middle Scoggins

Transect 2

Looking Downstream from Right Bank

Upper Scoggins

Transect 1

Looking Downstream

Upper Scoggins

Transect 1

Looking
Left to Right

Upper Scoggins

Transect 2

Looking
Left to Right

Upper Scoggins

Transect 3

Looking
Right to Left

Lower Tualatin

Transect 1 –
Low & Mid-Flow

Looking Downstream From Bridge

Middle Tualatin

**Transect 2 –
Low & Mid-Flow**

Looking Upstream

Upper Tualatin

Transect 3

Looking Downstream from Bridge

Upper Tualatin

Transect 3

Looking Left to Right

Upper Tualatin

Transect 3

Looking Right to Left

APPENDIX D

"RULE OF THREE" SAMPLING PROTOCOL

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December 21, 2005

Tom VanderPlatt
Clean Water Services
2550 SW Hillsboro Hwy
Hillsboro, OR 97123

RE: Draft Tualatin River and Scoggins Creek Instream Flow Study – Draft Study Plan, November 25, 2005

Dear Tom,

At our last meeting I agreed that ODFW could provide you some written comments of the above draft study plan (plan). ODFW's comments are below.

Here is a quick overview of edits:

1) Sources of information need to be referenced and included in a reference section in the plan.
2) Plan objectives need to reflect the expected changes in flow levels as outlined in previous meetings.
3) Available habitat maps of the Tualatin River and Scoggins Creek must be used assist in determining the best locations for transects.
4) If no habitat maps are available, preliminary on-the-ground habitat surveys should be conducted and transects selected using this information.
5) Types of possible habitats in the Tualatin River and Scoggins Creek need to be listed out and include river bed (substrate) information.
6) Transect establishment section needs to be expanded to clearly reflect how data will be collected from transects, including pictorial representations.
7) The "rule of three" should be followed to capture variability in similar types of habitats. (See below and attached document.) Transects will need to be increased in each river/stream reach.
8) List any other quality control measures that can be used to back up information gathered at transects.
9) Non-PHABSIM measurements section needs to provide more information on vegetation, substrate, channel or side-channel formations, elevations and the like and how measurements will be gathered.
10) Better explanation of why the representative flows were picked and breaking down flows by reach is needed. References should back up the selection.
11) Information should also be gathered on habitats and substrates that may be important to Pacific lamprey.

ODFW requests the following to be included for adequate collection of data to determine the needs of all life stages of winter steelhead, coho and Chinook salmon, resident trout and, as much as possible, lamprey species.

- Follow the "rule of three" as much as possible, particularly for Scoggins Creek, but also where important habitats are to be sampled in the Tualatin, if appropriate for the flow methodology. This means at least three mesohabitats, such as pools, should be sampled and within each pool microhabitats, such as the head, middle or other important habitat, such as boulders, and tail-out of the pool should be sampled to adequately represent the pool habitat. Also at a minimum, water depth & velocity measurements should be taken at three different flows. (CA Dept. Fish & Game, Feb. 2004, "Application and use of the Instream Flow Incremental Methodology and Physical Habitat Simulation System", white paper) ODFW has used this protocol for other flow studies. If habitats are limited, such as only one pool in a reach, then the protocol should apply to the microhabitats within the pool and three flows for each microhabitat. This method better captures the variability within and between habitats and flows and avoids the cost of purely statistical approaches. If a river reach is perceived as relatively homogenous, selection of three transects of the dominant habitat type would help capture any unperceived variability. Other important habitat locations, such as deltas, should have transects as well.

Other data, information or process needs:

1) Modeling of the wet, dry and "normal" hydrograph for the Tualatin River and Scoggins Creek should be developed and project operations superimposed upon these results to determine the possible range of effects on flows.
2) Study plan drafts, meeting presentations and decisions made along the way should be in writing. If presentations are made at meetings, a copy of the presentation should be available to the participants, either in hard copy or on disk or both.
3) Most importantly, informational and negotiation meetings should occur as the flow study and other environmental data is collected, developed and analyzed. Developing the results should be a collaborative process so that all parties can agree on the end product.

Thank you for your time. Please contact me at 503-947-6092 if you have any questions.

Sincerely,

Jill Zarnowitz
Water Policy Coordinator
Water Quality/Quantity Program
Fish Division

C By USPS & e-mail:
ODFW - Todd Alsbury, Rick Kepler, Jeff Boechler, Rick Kruger
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California Department of Fish and Game

Application and Use of the Instream Flow Incremental Methodology And Physical Habitat Simulation System

The California Department of Fish and Game recommends application of the Instream Flow Incremental Methodology (IFIM) in instream needs assessments and water allocation decisions. IFIM is a comprehensive framework of analytical techniques and approaches. It provides a considered and incremental approach to instream evaluations and related decision making processes. The Physical Habitat Simulation system (PHABSIM) was specifically developed as a component of IFIM. PHABSIM includes two major analytical components, river hydraulics and species life stage microhabitat suitability, and was designed to incorporate these two components to develop information on microhabitat and flow relationships in specific streams and rivers (rivers).

IFIM/PHABSIM has been used extensively in California in water allocation decisions, and it is anticipated the complex will be extensively used in the future. Applicability and utility of IFIM/PHABSIM weighted usable area (WUA)/discharge models and relationships are dependent upon many factors. Among these are:
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1. Adequately sampling a range of river flows, mesohabitats (e.g., run, riffle, pool, etc.) present within river reaches, and the hydraulic and physical conditions (i.e., microhabitat) within those mesohabitats.
2. Use of appropriate fish species life stage habitat suitability criteria as model input.
3. Development of well calibrated hydraulic and physical models.
4. Procedures followed to evaluate and develop aquatic and riparian habitat flow regimes.
5. Verification/validation of model output (spatial distribution of suitable and unsuitable habitat areas). The following describes the California Department of Fish and Game's (Department) position regarding the application and use of PHABSIM in California.

It is virtually impossible to measure a vast array of river discharges, and 100% of the distribution of hydraulic and physical variables available at each specific discharge, to develop WUA/flow relationships. Therefore, it is often necessary to sample subsets of such variables. Many PHABSIM analyses follow sample designs that entail characterizing meso- and microhabitats by:
***

1. Partitioning the river under consideration into generally homologous river segments.
2. Delineating available mesohabitats within each segment.
3. Sampling and simulating microhabitat conditions within specific mesohabitat units, within each homologous river segment at specific discharges.

***This approach defined as the mesohabitat delineation technique, and is the Department's preferred technique.

***The representative reach technique is an alternative approach. Representative reach sample designs entail:

1. Partitioning the river under consideration into generally homologous river segments.
2. Delineating available mesohabitats within each segment.
3. Identifying a reach of the river under consideration that includes proportional representation of each mesohabitat type identified.
4. Sampling and simulating microhabitat conditions within specific mesohabitat units, within each representative reach at specific discharges.

Other PHABSIM analyses employ the representative reach sample design. With this approach, a river reach is evaluated and, if judged to be representative of the balance of a homologous segment, its mesohabitats are sampled for model development.

For one dimensional hydraulic analyses, physical conditions (e.g., water depth and velocity, cover, and substrate or channel index) within mesohabitat units are generally measured along cross-sectional transects established within the mesohabitat units.

Two dimensional hydraulic analyses typically employ the representative reach sample design. For two dimensional hydraulic analyses, physical variables are measured throughout an extensive, variable shaped (i.e., polygon), sample grid of a representative reach that includes at least one example of all available mesohabitat types under consideration.

The following applies to one and two dimensional analyses' mesohabitat delineation and representative reach sample designs.

BASIC SAMPLING DESIGN - RULE OF THREE PROTOCOL

A statistical approach to determining sample designs to evaluate riverine needs is an effective means of ensuring macro-, meso-, and microhabitat variability are adequately considered and included in riverine evaluations, and resultant conclusions, recommendations, and management decisions. A statistical approach, however, may be lengthy and costly, due to the complexity, frequency, and distribution of various hydraulic and habitat parameters and incorporated into PHABSIM habitat/river flow modeling, the variability within and between these parameters for like meso- and microhabitats, and to the general requirement that preliminary estimates of population variances and means be determined to form the foundation of sample needs.

The number and range of river flows, mesohabitats/reaches, and transects sampled within river segments influence the extrapolation range, representativeness, applicability, reliability, and utility of any PHABSIM model. It is critical that river flows, mesohabitats, and microhabitats be effectively sampled in order to develop applicable and usable PHABSIM simulations. To that end, it is the Department's position that PHABSIM analyses include: a) sampling three distinct river flows; b) three units of each significant mesohabitat type within each generally homologous river segment; and c) at least three transects within each mesohabitat unit. This is defined as the Basic Sampling Design - Rule of Three Sampling Protocol (protocol). This protocol is a systematic decision tree that provides stepwise decisions to determine flow, mesohabitat, and microhabitat sample size requirements. It is designed to ensure simulation applicability and utility over the full range of historical and anticipated future hydrology conditions for the stream segments under consideration. The various parties involved should assure the protocol is applied in a collaborative manner.

The protocol considers PHABSIM sampling needs related to simulating a river's hydraulic, physical, and habitat variability *in lieu* of a statistical approach. The protocol was developed to provide an acceptable approach to PHABSIM streamflow assessments, while minimizing assessment costs. The protocol is intended to ensure that within and between river flows, mesohabitats, and microhabitat variability are considered and adequately sampled. It avoids high costs associated with purely statistical approaches (e.g., basing sample needs on preliminary estimates of variance and other population information).

***The protocol approaches sample size needs from the perspective that a sample of one does not allow within or between mesohabitat, microhabitat (i.e., water depth and velocity, substrate, cover, etc.), or flow variability to be introduced into a model. A sample size of two would allow some variability to be introduced, but results could be biased and/or misleading if a sample data were somehow not representative of the overall reach. A sample size of two would not provide verification of presence or absence of bias. A minimum sample size of three is required to develop an estimate of variance, and is a first step to minimize the potential effects of including biased/misleading samples within the model. Therefore, a sample of at least three units of each mesohabitat type present per each homologous river reach, at least three microhabitat transects per each mesohabitat unit, and at least three water depth and velocity calibration flows is the initial start point. The actual number of mesohabitat units, microhabitat transects per unit, and river flows necessarily sampled for PHABSIM model development and aquatic habitat simulation is dependent upon river reach heterogeneity; mesohabitat and microhabitat frequency, distribution, and variability; and flow characteristics' variability. In specific cases, it may be appropriate to sample less or more than three replicates of each mesohabitat unit, three microhabitat transects per unit, and water depth and velocity characteristics at three flows. Collaborating parties should evaluate sampling design and needs in the field.

Complexities and variability inherent in river flows, mesohabitats, and microhabitat sub-units generally require several transects be sampled within each mesohabitat. Microhabitat sub-unit or mosaic distribution, complexity, and variability within each mesohabitat dictate the number of transects necessary per each mesohabitat. The more microhabitat sub-units, the more transects. Each specific microhabitat sub-unit should be delineated by an up- and downstream boundary depicting a row of cells, within which the physical variables are assumed to be uniform. The variables across each transect will vary, and the number of cells across each transect is dictated by this variability. As channel geometry, substrate, and/or cover complexity and distribution increases within a given microhabitat unit, the number of transects necessary to capture the linear microhabitat variation within a mesohabitat also increases. It is not unusual for 10 or more transects to be used to describe a riffle-pool sequence in a small stream that has a diversity of physical features (e.g., boulders, broken ledge rock, gravel, cobbles, areas of fine deposition, large woody debris, etc.). For larger alluvial streams, several transects may be required to capture the features of a relatively simple pool-crossing bar sequence due to the significant change in river depth in the linear dimension and edge effects where features such as root wads, undercut banks, eddies, etc. are common and are critically important fish habitat features. Sample sizes smaller than three must be documented with written explanation/justification.

Rule of Three Protocol Procedures

HYDROLOGY

1. Develop unimpaired [i.e., natural, without project(s)] annual flow time series and exceedance information for the period of record, and extend this hydrological information from the point of measurement (e.g., gaging station) to the stream segments under consideration.
2. ***Identify three discharges that, if each were sampled for depth/velocity characteristics, well calibration data sets and hydraulic models would allow for PHABSIM WUA/discharge information to be extrapolated to flows ranging between 90 and 10% unimpaired flow exceedance values (i.e., typically a PHABSIM extrapolation range of approximately 40% of the lowest flow to approximately 250% of the highest flow sampled). Evaluate the three flows identified. Determine if sampling water depth and velocity characteristics at fewer or more flows three flows would be necessary. This determination shall be based on the hydraulic and physical microhabitat variability present within each mesohabitat at the three flows, and is to be made collaboratively. If all parties cannot agree whether fewer or more than three flows should be sampled, three flows remains the default sample size. Regardless of the number of river flows sampled, those sampled must be of a sufficient magnitude to allow development of habitat time series for flows ranging from the 90 to 10% exceedance flows, applicable and reliable habitat duration values for these exceedance flows, and the 50% exceedance habitat duration metric for various runoff or water year types.

SAMPLING

1. Partition the river in question into generally homologous segments.
2. ***Delineate all mesohabitat types (e.g., run, riffle, pool, etc.) throughout each segment at an unimpaired, moderate river discharge. Mesohabitat definitions included in the Third Edition of the Department's "California Salmonid Stream Habitat Restoration Manual " (1998), Level III and potentially Level IV definitions, should be used when delineating mesohabitats. Extremely low and high flows should be avoided for mesohabitat delineation. If the range of natural and/or simulation flows is large, habitat delineation at more than one flow may be necessary. Each mesohabitat distribution should be used for its respective habitat simulation flow range. Ground survey habitat delineation techniques are the preferred techniques. Mesohabitat delineation via aerial or photogrammetric techniques, may be acceptable, and, if used, must be verified by ground surveys. A frequency distribution of available habitat types, frequencies, and distribution per river segment shall be the basis for subsequent sample design development. The Department's concurrence with mesohabitat types definitions should be obtained prior to habitat delineation.
3. Evaluate specific mesohabitat types that may be hazardous to sample, and/or that may be exceedingly difficult or impossible to model. If all interested parties agree that specific mesohabitats should be deleted from subsequent PHABSIM sampling and modeling, determine how these mesohabitat types will be considered during stream needs assessment(s). Alternatives include interested parties agreeing upon: a) different assessment methods if the type comprises a significant percent of a river reach, and/or if the mesohabitat includes an important function for target species; b) deleting these mesohabitat types from sampling, model development, and stream needs assessment(s); and c) assuming that results of assessment valuations for other mesohabitats will be applicable to mesohabitats that may be hazardous and/or may not be modeled.
4. Evaluate the biological importance of each mesohabitat that comprises less than 5% of the total linear distance of the homologous reach. Include all biologically significant

mesohabitat types in subsequent sampling, WUA/discharge development, and streamflow needs assessment(s).

5. One Dimensional Hydraulic Analyses:
   a. ****Mesohabitat Selection for Mesohabitat Delineation Analyses* - Prepare a sample design including each samplable mesohabitat type comprising 5% or greater of the total linear distance of each homologous reach, and for any biologically important mesohabitat type comprising less than 5% of the total linear distance. Randomly select three representative units of each mesohabitat type identified (e.g., three runs, three riffles, etc.) within each homologous river segment. There are various procedures to introduce randomness into mesohabitat selection. The method selected shall be determined in a collaborative manner. If an acceptable approach cannot be agreed upon by all interested parties, then complete random selection is the default. Document the decision making process and random approach selection.

      Determine if it would be appropriate to sample fewer than three units of each samplable mesohabitat. This determination shall be based on the number of units of a specific mesohabitat type within a single reach, the hydraulic and physical microhabitat variability present in the specific mesohabitat type, and on a units biological significance. This determination shall be made collaboratively. If all parties cannot agree whether less than three units should be sampled, three units remains the default sample size. Often only a single unit of a unique mesohabitat type may be present within an entire stream segment (e.g., an island complex or backwater area at the mouth of a small intermittent tributary). In such cases, one or two mesohabitat units captures 100% of the variability present in the segment.

      Ground truth each sample mesohabitat unit selected to verify that the reach and unit indeed does represent the appropriate mesohabitat type. Randomly select additional units as needed.

   b. ****Mesohabitat Selection for Representative Reach Analyses* - Select a representative reach, or reaches, that include(s) at least three units of each samplable mesohabitat type that comprises at least 5% of the total linear distance of each homologous reach, and any biologically important mesohabitat type comprising less than 5% of the total linear distance. Document the selection process. Two or more representative reaches my be needed to capture three units of each mesohabitat type. Fewer than three units of each mesohabitat type may be acceptable in relatively short stream segments where only one or two units of a particular mesohabitat type are present within the segment.
      Determine if it would be appropriate to sample fewer than three units of each samplable mesohabitat per reach. This determination shall be based on the number of units of a specific mesohabitat type within a single reach, the hydraulic and physical microhabitat variability present in the specific mesohabitat type, and on a units biological significance. This determination shall be made collaboratively. If all parties cannot agree whether less than three units should be sampled, three units per representative reach remains the default sample size. Often only a single unit of a unique mesohabitat type may be present within an entire stream segment (e.g., an island complex or backwater area at the mouth of a small intermittent tributary). In such cases, one or two mesohabitat units captures 100% of the variability present in the segment.

Ground truth each represent reach and sample mesohabitat unit selected to verify that the reach and units represent the appropriate river and mesohabitat types. Randomly select additional reaches or units as needed.

c. ****Transect Selection for Mesohabitat Delineation and Representative Reach Analyses* - The preferred approach is to sub-divide each mesohabitat into relatively homogeneous microhabitat sub-units, each delineated by an upstream and downstream boundary. Randomly place a transect within each microhabitat sub-unit, and then ground truth all transects to verify that the significant microhabitat features of each mesohabitat are captured by the transects and associated habitat cells.

Evaluate each mesohabitat sample unit to determine how many transects are needed to describe the microhabitat features and variability within each mesohabitat unit. Determine the number of acceptable transects and document the decision making process. Transect(s) sample size decision making process shall be based on the hydraulic and physical microhabitat variability present within the specific mesohabitat type, and shall be made collaboratively. In specific, limited cases, such as hydraulically uniform or extremely simple mesohabitat units, it may be appropriate to use fewer than three habitat transects. If all parties cannot agree whether less than three habitat transects should be sampled, three transects for habitat simulation is the default sample size.

Pools shall have at least three transects. At least one transect shall be placed in the head, one in the body, and one in the tail section of each pool sampled. Large and/or complex pools may require additional transects. Pool tail-outs and transition zones upstream of the next downstream habitat type shall be considered components of pool tails. Unusual circumstances (e.g., very small pools and low habitat variability) may justify evaluation of whether three habitat transects are necessary. If all parties cannot agree whether fewer or more than three habitat transects should be sampled, three habitat transects remains the default sample size.

Ground truth each transect selected for sampling within each mesohabitat sample unit to determine whether the transect represents the mesohabitat unit, and samples the hydraulic and physical microhabitats available within the unit. Select additional transects (using the agreed upon selection technique) within the mesohabitat unit as needed, with ground truthing.

To allow extrapolation over the full range of historic flows, and use of the several options in the PHABSIM library, it is necessary that the downstream hydraulic control for each mesohabitat be identified, and included with the sample design in a addition to microhabitat representation transects. The hydraulic control transect is used in the step back water sub-program to simulate water surface elevations for the full range of flows under consideration, and generally is not used to simulate habitat.

d. ****Transect Microhabitat Measurements* - Measure hydraulic and physical microhabitat conditions (e.g., water depth and velocity, substrate, cover, etc.) along each transect at three distinct river discharges (e.g., low, moderate, and high). Transects shall be extended up the bank to allow for simulations over the full range of flows in the hydrological time series. Hydraulic and physical conditions along each transect shall determine measurement cell width. A minimum of 20 cells shall be required for each transect, unless collaborating parties agree fewer cells would be appropriate. Cell width shall be sufficiently sized and spaced (i.e., the more complex the microhabitat, the narrower the cells) to capture all important habitat variables, and to permit application of the habitat suitability function selected. Cell boundaries shall be placed at changes in physical and/or hydraulic characteristics. Cells should not include conflicting hydraulic or physical features, such as up- and down- stream water currents within a single cell, eddies, shear zones, substrate differences, etc.

e. Proceed with hydraulic and physical habitat sampling, PHABSIM model development, and streamflow needs assessment(s). Data collected should be compatible with habitat components generally described within the Habitat Suitability Criteria Section, below.

6. Two Dimensional Hydraulic Analyses:

a. ****Mesohabitat and Sample Area Selection* - Select a reach, or reaches, that include(s) at least three units of each samplable mesohabitat type that comprises at least 5% of the total linear distance of each homologous reach, and any biologically important mesohabitat type comprising less than 5% of the total linear distance. Delineate location and distribution of mesohabitats within the representative reach. Maintain records based on this delineation.

   Two or more representative reaches my be needed to capture three units of each mesohabitat type. In some cases, it may be necessary to establish more than one sample reach within a stream segment in order to describe all mesohabitats present. In other cases, a river segment may be relatively short (e.g., 100 yards) and may be included in its entirety for habitat sampling If all collaborators agree, fewer than three units of each mesohabitat type may be acceptable in relatively short stream segments where only one or two units of a particular mesohabitat type are present within the segment.

   Ground truth each represent reach and sample mesohabitat unit selected to verify that the reach and units represent the appropriate river and mesohabitat type(s). Select additional reaches or units as needed per the agreed upon selection process.

b. ****Microhabitat Measurements* - Hydraulic and physical microhabitat conditions should be measured throughout each mesohabitat within each sample reach at three distinct river discharges (e.g., low, moderate, and high). The sampling grid should be sufficiently fine to capture important habitat variables. Point measurements may be made as described for one dimensional hydraulic analyses, with additional measurements made throughout the reach using the Global Positioning System (GPS) to delineate important geometry and habitat features between transects (e.g., tracing the thalweg; profiling large boulders, pocket water, undercut banks; etc.). Sampling should outline all important physical features (e.g., islands, gravel and cobble patches, fine sediment depositional areas, erosional areas, vegetation patches, water edge, linear and vertical bank profiles, etc.). Particular emphasis should be given to overbank depressions and vegetation patches that provide important habitat when inundated.

c. *Model Development* - Predicted river discharge, water surface elevations, and calibrated water velocities should be compared with measured values to validate predicted velocities and model calibration. Make appropriate adjustments to water surface elevations to improve calibration(s).

If agreement regarding flows, mesohabitats, transect sample size requirements, and/or two dimensional grid size cannot be reached through the collaborative process, three river flows, three mesohabitat units within each homologous segment, and microhabitat transect placement as described for one dimensional hydraulic analyses continues to be the minimum sample size.
Proceed with hydraulic and physical habitat sampling, PHABSIM model development, and streamflow needs assessment(s). Data collected should be compatible with habitat components generally described within the Habitat Suitability Criteria Section, below.

If agreement regarding flows, mesohabitats, transect sample size requirements; mesohabitat or representative reach approaches, and/or one or two dimensional techniques and analyses cannot be reached through the collaborative process, three river flows, three mesohabitat units within each homologous segment or representative reach, microhabitat transect placement, and/or grid size as described above for one or two dimensional hydraulic analyses continues to be the minimum sample size.

Regardless of the approach used to determine mesohabitat, transect, and/or grid sample sizes, the range of river flows sampled must be of a sufficient magnitude to allow:

1. Development of habitat time series for flows ranging from at least the 90 to 10% exceedance flows.
2. Development of applicable and reliable habitat duration values for these exceedance flows.
3. Development of an accurate and reliable 50% exceedance habitat duration metric for specific runoff or water year types.

STATISTICAL APPROACH

If there is disagreement regarding the Department's IFIM/PHABSIM Rule of Three Protocol and sample requirements, use of a statistical approach to determine sample size needs and subsequent sampling is acceptable. The number of mesohabitats and transects necessary to develop representative WUA/discharge relationships within prescribed statistical limits may be statistically determined by developing preliminary estimates of population variance, and applying appropriate formulas.

To use a statistical approach effectively, it is necessary to identify sample size needs regarding the number of mesohabitats and types within each homologous reach, as well as the number of microhabitat units within each mesohabitat type. Mesohabitat parameters such as type, length, minimum and maximum width, water depth and velocity (e.g., range, average, etc.), slope, edge type. and physical habitat features (e.g., substrate size and distribution, cover, bank and vegetation edges and types), shall be considered to statistically determine the required mesohabitat sample size(s). Parameters such as water depth and velocity (e.g., range, average, etc.), substrate, vegetation, cover type, distance to escape cover, distance to shear zones, etc. at specific stations along transects within each mesohabitat type must also be considered to statistically determine transect sample size(s).

HABITAT SUITABILITY CRITERIA

Habitat suitability criteria (HSC) are functions that define the suitability (on a scale of 0.0 to 1.0) of environmental factors, such as water depth and velocity, substrate, cover, and other habitat components, for specific species life stages. An alternative that may be considered for certain species life stages is use of binary habitat suitability indices to delineate unique habitat areas that remain fixed in place, regardless of the amount of flow covering the area (e.g., certain areas are either suitable with a channel index value of 1.0, or unsuitable with a value of 0.0). The hydraulic conditions of flow can further determine the degree of suitability as a function of flow only for the areas (cells) given a channel index value of 1.0. A common example is the area in immediate proximity to the vegetated edge along a stream bank that comprises critical rearing habitat for fry and small juvenile trout when the velocity is essentially zero. When the flow is reduced, moving the water edge away from the vegetated edge into the unsuitable interior portion of the channel, the rearing habitat along those transects becomes zero. On the other hand those areas over bank that would comprise suitable habitat for rearing during flood flows that provide zero velocities should be given a channel index of 1.0.

These criteria are input values to PHABSIM, and are key components to the applicability and utility of PHABSIM analyses. PHABSIM results can be sensitive to many input variables, but reliable HSC are one of the most important components. Biased HSC lead to biased results, and questionable decisions and flow regimes. For example, if habitat availability is not included in the basic study design, or accounted for in data compilation, biased criteria likely result. Hence, care must be used in selecting HSC to use during such analyses and evaluations. Emphasis should be placed on developing HSC that describe a species life stage actual meso- and microhabitat selection/avoidance characteristics.

The Department's protocol for HSC selection, in order of priority, is:

1. Development and use of site specific HSC in PHABSIM analyses is the preferred approach.
2. Development and use of regional HSC.
3. Consideration of literature HSC if site specific or regional species life stage of interest HSC are not available, or cannot be developed. Transferability and applicability of candidate HSC to the river or river section under consideration is evaluated, statistically tested, confirmed or rejected.
4. Professional judgement modification of literature same species and life stage HSC. The applicability of such modified HSC is evaluated, statistically tested when possible, and confirmed or rejected.
5. Consideration of similar species and life stage(s) HSC from the river segment being evaluated, if same species life stage HSC are not available in the literature. Transferability and applicability of candidate HSC is evaluated, statistically tested when possible, and confirmed or rejected.
6. Professional judgement modification of similar species and life stage(s) HSC from the river segment being evaluated may be considered. Transferability and applicability of candidate HSC is evaluated, statistically tested when possible, confirmed or rejected.
7. Consideration of similar species and life stage(s) literature HSC if same species life stage(s) literature HSC, or onsite similar species life stage(s) are not available. Transferability and applicability of candidate HSC should be evaluated, statistically tested when possible, and confirmed or rejected.

8. Professional judgement modification of similar species and life stage(s) literature HSC. Applicability of such modified HSC is evaluated, statistically tested when possible, and confirmed or rejected.
9. Consideration of professional judgement HSC. The applicability of professional judgement HSC is evaluated, statistically tested when possible, and confirmed or rejected.

When developing HSC, it is necessary to sample a wide range of flows, mesohabitats, and hydraulic and physical conditions in order to avoid introducing unknown bias.

There are a number of field methods available to collect data to develop HSC. The preferred method is use of underwater, or, in certain circumstances, above water, direct observation techniques. If other methods are used (e.g., electrofishing, radio tagging), the validity and applicability of such technique(s) and resultant data must be compared with, and verified by, direct observation data.

The following procedures are designed to ensure collection of usable field data and HSC development. They were derived to address the matter of habitat availability in HSC development. These procedures focus on development of site specific criteria. However, the general concepts apply to development of regional criteria as well.

1. Identify and evaluate at least three river flows (e.g., low, medium, and high) to sample. Sampling fewer than three flow levels very likely would result in biased criteria, and should be avoided. Flows sampled shall be based on the hydraulic and physical microhabitat variability present within mesohabitat types, and shall be made collaboratively. Regardless of the number of flows sampled, flows sampled and data obtained must allow for development of HSC applicable to PHABSIM models that facilitate extrapolation of WUA/discharge relationships to flows ranging between 90% and 10% unimpaired (i.e., natural) exceedance flows. If all parties cannot agree whether fewer or more than three flows should be sampled, three flows remains the default sample size.
2. Partition the river in question into generally homologous segments. If regional HSC are being developed, riverine systems should be partitioned by stream type, elevation, gradient, and/or other appropriate characteristics.
3. Delineate all mesohabitat types (e.g., run, riffle, pool, etc.) at an unimpaired, moderate river discharge throughout each segment. Extremely low and high flows should be avoided for mesohabitat delineation. Identify each mesohabitat type comprising at least 5% of the total linear distance of each homologous reach, and all biologically important mesohabitat types comprising less than 5% of the total linear distance.
4. Evaluate specific mesohabitat types and/or river flows that may be hazardous to sample. If all interested parties agree that specific mesohabitats and/or flows should be deleted from subsequent HSC data collection, determine how deletion of such data may affect HSC development and utility. Incorporate appropriate measures to reduce identified impacts. Document the decision making process, and conclusions.
5. Prepare a sample design for each homologous stream segment. Randomly select three units of each mesohabitat type comprising 5% or greater of the total linear distance of each homologous segment, and those biologically important mesohabitat types comprising less than 5% of the total linear distance. There are various procedures to introduce randomness into mesohabitat selection. The method selected shall be determined in a collaborative manner. If an acceptable approach cannot be agreed upon by all interested parties, then complete random selection is the default. Document the decision making

process and random approach selection.

6. Ground truth each mesohabitat unit selected for sampling to determine whether the unit indeed does represent the appropriate mesohabitat type. Randomly select additional units as needed.
7. Collect data within each mesohabitat unit. Data may be collected through 100% sampling of each unit, or by a Department approved sub-sampling technique (e.g., transects, grids, etc.). Ground truth transect/grids/etc. selected for sub-sampling within each mesohabitat sample unit to determine whether they represent the mesohabitat unit, and sample the hydraulic and physical microhabitats available within the unit. Select additional transects (using the agreed upon selection technique) within the mesohabitat unit as needed, with ground truthing. This item does not apply to two dimensional data collection.
8. Partition data collection by riverine type, flow, and meso- and microhabitat type. Data should be partitioned diurnally and seasonally whenever possible. Data from different categories should be compared, and data for significant individual categories included, as appropriate, within PHABSIM analyses and water allocation decisions.
9. ***Sample all sample periods/conditions/components/flows/etc. equally. If not sampled equally, appropriate steps (e.g., mathematically adjust sample sizes to attain equality) should be taken to address and minimize potential biases. These steps should be developed collaboratively. However, the Department reserves the option of determining the acceptable technique.
10. ***The target sample size is at least 150 observations per species life stage per river flow, homologous reach, season, and diurnal period sampled. A single fish or group of fish in the same location is considered an observation. More than 150 obserations may be needed to develop HSC. Actual sample sizes and partitioning components are dependent upon specific circumstances, and should be determined in a collaborative manner. Identify and account for influencing factors. Sampling should not be discontinued once 150 observations is reached if doing so would compromise equal sampling design needs (e.g., effort, area, etc.). Each condition is a specific requirement. For example, if 150 observations have been collected, but equal area sampling requirements have not been met, sampling must continue until the sample area requirements have also been met.
11. ***Address habitat availability for each river flow, mesohabitat, and/or representative reach, season, diurnal period, etc. sampled, and account for habitat availability in HSC development. Habitat availability may be accounted for in the basic fish observation sample design (e.g., sample a wide range of flows, hydraulic conditions, physical conditions, seasons, etc.), or in data compilation (e.g., proportional habitat use divided by proportional habitat availability). If habitat availability data are not included in HSC development, resultant HSC are suitable for habitat analyses only for the limited conditions existing during data collection.
12. Collect hydraulic and physical data. These data include:
    a. Total water depth and average velocity.
    b. Fish focal point velocity.
    c. Stream margin edge type.
    d. Cover type components.
    e. Substrate components.
    f. Vegetative components
    j. Distance to and type of nearest components described above.
    k. Other factors as appropriate.
13. Compile observation and habitat availability data in such a way that unequal sizes do not bias resultant HSC. For example, individual data sets may be normalized or equalized

prior to data compilation. The procedures used should be developed collaboratively. However, the Department reserves the option of determining the acceptable technique.

14. ***Address anomalies in HSC distributions. Determine if additional data are required to address the anomalies, or if the effect of the anomalies should be minimized and/or included in analyses. An example of minimizing anomaly effects is by smoothing or curve fitting techniques, and/or professional judgement. Smoothing and curve fitting techniques are preferred. Procedures used should be developed collaboratively. The Department reserves the option of determining the acceptable technique.
15. Determined whether the above procedures provide sufficient sample sizes and/or do not account for habitat availability. Evaluate and select alternative procedures through a collaborative process. The Department reserves the option of approving appropriate methods.

PHABSIM COMPILATION

PHABSIM data compilation procedures, hydraulic model calibration, and model validation requirements are considered elsewhere.

PHABSIM EVALUATION AND FLOW RECOMMENDATIONS

Use PHABSIM WUA/discharge relationships with hydrological time series to identify river flow regimes that address intra- and inter-annual riverine needs, and for evaluating project impacts and potential tradeoffs. To fully incorporate the abilities and utility of PHABSIM into water allocation procedures, WUA/discharge relationships must be combined with river flow hydrologic time series to develop a time series of total habitat across hydrologic year types and time. This enables evaluation of inter- and intra-annual hydrologic habitat availability and riverine resource and habitat needs, and development of flow regimes that closely resemble habitat conditions available under natural flow conditions

Care must be taken in compiling PHABSIM models and simulations to contribute to meaningful water allocation decisions. Failure to consider potential biases results in misrepresentations and misinterpretations. The following describes the Department's position regarding assessment of riverine flow needs and project evaluation:

1. Develop total WUA/discharge relationships per homologous river segment. Weight species life stage individual transect WUA/discharge relationships, which are produced as WUA/1,000 linear ft, per the specific transect's contribution to the specific mesohabitat sampled (e.g., a transect represents 15% of the mesohabitat's total length). Extrapolate individual transect simulations to simulate the total WUA/discharge relationship per individual mesohabitat. Proportionally weight each mesohabitat simulation, and extrapolated each simulation to attain each mesohabitat type's contribution to total WUA/discharge relationship within each stream segment. Sum the total mesohabitat WUA/discharge relationships to produce the segment-wide total WUA/discharge relationship.
2. Partition the unimpaired [i.e., natural, without project(s)] annual flow exceedance information into critically dry, dry, below median, above median, wet, and extremely wet water or runoff year (collectively water year) categories (100-90, 90-70, 70-50, 50-30, 30-10, 10-0% annual flow exceedance ranges, respectively).
3. ***Develop species life stage daily habitat time step series in monthly increments for each water year category. This effort uses total stream segment WUA/discharge habitat

relationships from a hydrologic record that includes at least three representative years within each water year type category (unless the flow record is long, there may not be three years within some water year categories) to develop daily flow time series as input variables. If it is collaboratively determined that time steps other than monthly increments and daily discharges are appropriate, such time steps should be considered. The Department reserves the option of determining the appropriate time step.

4. Develop species life stage monthly habitat exceedance, or duration, information for each year type, based on the habitat time series.
5. Identify species life stage monthly 50% exceedance habitat duration value for each water year type. Determine the flow in the total stream segment necessary to provide the respective 50% exceedance habitat duration values on a monthly and year type basis. The 50% exceedance habitat duration metric is based on the biological significance of the median representing a measure of central tendency. This flow is defined as the flow needed to maintain the riverine species life stages under consideration. This flow regime does not address the need for channel/riparian flows and dynamics. These latter flows should be considered, and included within final flow regimes.
6. Develop overall year type flow regime recommendations for fish and other aquatic/riparian species by evaluating species life stage tradeoffs. Species and species life stages of special concern should receive priority consideration during such evaluations. However, other species and life stages should not necessarily be placed at risk. Such an evaluation process should emphasize multi-species and life stages needs, and should be developed collaboratively. The Department reserves the option of determining the appropriate process.
7. Conduct an impact analyses by developing total stream segment habitat time series, and then comparing this time series with habitat time series values developed for unimpaired conditions, the above described flow regime (item 6), and the existing (i.e., with project) flow regime. Several analytical approaches are available, and should be developed collaboratively. However, the Department reserves the option of determining the appropriate process.

PHABSIM MODEL OUTPUT VERIFICATION/VALIDATION

Verifying that suitable versus unsuitable stream habitat cells as simulated with PHABSIM are in agreement with actual fish distribution in the mesohabitats and stream is an important verification/validation step for IFIM applications. Unless previous habitat suitability criteria have been tested for transferability to the stream under consideration, or PHABSIM model output has been validated for the species in similar streams in the region, a field test must be conducted onsite.

The following describes the Department's position regarding field testing of PHABSIM model output.

1. Select a sample of each mesohabitat (or representative reach) that was sampled for PHABSIM modeling as described above.
2. Prepare a map of the mesohabitats (or reaches) showing water's edge at the discharge to be tested. This should not be at the discharge that was used as input for the PHABSIM model.
3. Flag the transects at water edge and generally delineate the habitat cells using field

markers (e.g., weights with flagging placed on the stream bed, buoys, etc.) across the stream.

4. Use direct observations techniques as described for developing HSC, above, to identify habitat cells that are occupied and those that are not. To assure a constant flow rate, determine the discharge before and after the observations are made.
5. Determine whether observed fish are in suitable or unsuitable cells. If all fish observations are within cells that were predicted to be suitable (and with more in the cells with the highest suitability values), the model may be considered valid for use for habitat simulations for the stream under consideration.
6. *** If some fish observations fall within the model's predicted unsuitable cells, determine and evaluate possible causes, and potential remedies. Acceptance or rejection of use of unsuitable and suitable cells shall be based on the results of statistically analyses such as Chi-square observed versus expected analyses. The habitat simulation model may be further "calibrated" by developing additional onsite HSC, or, in the event of use of literature based or professional judgement HSC, evaluation of the HSC, and potential adjustment until all observed fish fall within suitable cells. When literature or professional judgement HSC are modified, it is necessary that the validation test be conducted again at a different flow and with additional fish observations. This process is repeated until there is agreement that the model output is a good fit to the field observations, or the model is rejected for use on the stream under consideration. This process should be conducted collaboratively. However, in the event agreement is not attained, the Department reserves the decision.
7. Randomly partition fish observation data into two data sets when HSC are developed onsite as described above for the preferred option. Use one data set to develop HSC, while reserving the second set for model output testing.