3.2.3 Fisheries Resources

3.2.3.1 Affected Environment

3.2.3.1.1 Fish Species

The Clackamas River Basin is the largest producer of anadromous fish within the MHNF, providing 142 miles of anadromous fish habitat (Stillwater Sciences, 1999). The basin also supports strong resident fish populations and is heavily used by recreational anglers for both anadromous and resident fish species.

Tables 3.2.3.1-1 and 3.2.3.1-2 present a summary of the major fisheries resource issues related to Project facilities and operations in the Clackamas River Basin and the desired future resource condition for each river segment affected by the Project. Additional information related to life history patterns and current and historic population levels for both resident and anadromous fish stocks in the Clackamas River Basin can be found in the Project Initial Information Package (PGE, 1999).

Table 3.2.3.1-1. Fish species in the Clackamas River Basin and Clackamas River Hydroelectric Project Area (PGE, 1999).

Species	Anadromous or Resident	Origin	Present in Oak Grove Fork	Present in Clackamas River above River Mill dam
Pacific lamprey (*Lampetra tridentata*)	Anadromous	Native	Unknown	Yes
Western brook lamprey (*Lampetra richardsoni*)	Resident	Native	Unknown	Yes
White sturgeon (*Acipenser transmontanus*)	Resident	Native	No	No
American shad (*Alosa sapidissima*)	Anadromous	Introduced	No	No
Summer steelhead (*Oncorhynchus mykiss*)	Anadromous	Introduced	Not since 2001	Not since 2001
Winter steelhead (*Oncorhynchus mykiss*)	Anadromous	Native and Introduced	Yes	Yes
Rainbow trout (*Oncorhynchus mykiss*)	Resident	Native and Introduced	Yes	Yes
Coho salmon (*Oncorhynchus kisutch*)	Anadromous	Native and Introduced	Yes	Yes
Spring and Fall Chinook salmon (*Oncorhynchus tshawytscha*)	Anadromous	Native and Introduced	Yes	Yes
Kokanee (Sockeye salmon) (*Oncorhynchus nerka*)	Resident	Introduced	Timothy Lake	No
Cutthroat trout (*Oncorhynchus clarki*)	Anadromous and Resident	Native and Introduced	Yes	Yes

Species	Anadromous or Resident	Origin	Present in Oak Grove Fork	Present in Clackamas River above River Mill dam
Brown trout (*Salmo trutta*)	Resident	Introduced	Yes	Yes
Brook trout (*Salvelinus fontinalis*)	Resident	Introduced	Yes	Yes
Bull trout (Salvelinus confluentus)	Resident	Native	Historically present, currently extirpated	Historically present, currently extirpated
Mountain whitefish (*Prosopium williamsoni*)	Resident	Native	Yes	Yes
Northern pikeminnow (*Ptychocheilus oregonensis*)	Resident	Native	No	No
Chiselmouth (*Acrocheilus alutacens*)	Resident	Native	No	No
Peamouth (*Mylocheilus caurinus*)	Resident	Native	No	No
Dace (*Rhinichthys* spp.)	Resident	Native	Unknown	Yes
Redside shiner (*Richardsonius balteatus*)	Resident	Native	No	Yes
Goldfish (*Carassius auratus*)	Resident	Introduced	No	Yes
Carp (*Cypinus carpio*)	Resident	Introduced	No	Yes
Largescale sucker (*Catostomus macrocheilus*)	Resident	Native	Yes	Yes
Mountain sucker (*Catostomus platyrhynchus*)	Resident	Native	Unknown	Yes
Brown bullhead (*Ameiurus nebulosus*)	Resident	Introduced	No	Yes
Stickleback (*Gasterosteus aculeatus*)	Resident	Native	No	No
Largemouth bass (*Micropterus salmoides*)	Resident	Introduced	No	No
Smallmouth bass (*Micropterus dolomieui*)	Resident	Introduced	No	No
Black crappie (*Pomoxis nigromaculatus*)	Resident	Introduced	No	No
White crappie (*Pomoxis annularis*)	Resident	Introduced	No	Yes
Bluegill (*Lepomis macrochirus*)	Resident	Introduced	No	Yes
Warmouth (*Lepomis gulosis*)	Resident	Introduced	No	No
Sculpin (*Cottus* spp.)	Resident	Native	Yes	Yes

Table 3.2.3.1-2. Major river segments affected by the North Fork and Oak Grove Projects and their relation to fisheries issues (Sources: Stillwater Sciences, 1999; USFS, 1996b; PGE, 1999; Cramer and Bullock, 2001).

River Segment	Existing fish resources[1/]	Issue/major obstacles to enhancement
Timothy Lake	Cutthroat trout, rainbow trout, brook trout, kokanee	Storage reservoir; recreational fishery due to poor productivity supported by introduced species and hatchery releases; oligotrophic; fall drawdown limits vegetation growth in riparian and shoreline zones; Timothy Lake dam barrier to upstream and downstream fish movement
Oak Grove Fork between Timothy Lake and Lake Harriet	Cutthroat trout; brook trout	Important fishery; short-term flow fluctuations; reduced baseflows; water temperature concerns;
Lake Harriet	Cutthroat trout, rainbow trout, brook trout, brown trout	Storage reservoir and diversion point; restriction of sediment transport; Lake Harriet Diversion dam barrier to upstream movement and restricts downstream fish movement to periods of spill. Mixed hatchery and native salmonid fishery management issues
Oak Grove Fork between Lake Harriet and Clackamas	Cutthroat trout; rainbow trout; steelhead, coho salmon, spring Chinook salmon	Bypass reach; no minimum instream flow release; elevated water temperature; natural fish passage barriers (~ ¼ and 1 mile downstream of Lake Harriet dam; habitat loss; limited off-channel habitat; reduced floodplain connectivity
Frog Lake	Cutthroat trout; rainbow trout; brown trout, brook trout	Small (252 ac-ft) re-regulating reservoir for peaking releases
Clackamas River between Oak Grove Fork and Three Lynx	Steelhead trout, coho salmon, spring Chinook salmon, cutthroat trout, rainbow trout	Bypass reach; possible delay or halt to anadromous fish at Oak Grove Powerhouse tailrace during upstream migration; reduced base flow
Clackamas River between Three Lynx and North Fork Reservoir	Steelhead trout, coho salmon, spring Chinook salmon, cutthroat trout, rainbow trout	Limited quantity of woody debris; flow fluctuations resulting from peaking-load following operations of Oak Grove Fork Powerhouse
North Fork Reservoir	Steelhead trout, spring Chinook salmon, coho salmon, rainbow trout, cutthroat trout, brown trout	Storage reservoir; restriction of sediment and wood transport; water temperature
Clackamas River between North Fork Reservoir and Faraday Diversion	Steelhead trout, spring Chinook salmon, coho salmon, cutthroat trout; rainbow trout	No specified minimum flow release below North Fork dam; water temperature; effects of spill on salmonid juvenile and smolt downstream migration; fluctuation in base flow release

River Segment	Existing fish resources[1/]	Issue/major obstacles to enhancement
Clackamas River between Faraday diversion and Faraday Powerhouse	Steelhead trout, spring Chinook salmon, coho salmon, cutthroat trout; rainbow trout	Bypass reach; 120-cfs minimum flow release; potential delay of upstream migration in fish ladder; adult passage and spawning within bypass reach; water temperature; restriction of sediment and wood transport
Clackamas River between Estacada Lake and River Mill dam	Steelhead trout, spring Chinook salmon, coho salmon, cutthroat trout, rainbow trout	Water temperature; passage of adult anadromous salmonids; restriction of sediment and wood transport
Clackamas River below River Mill dam	Steelhead trout, Chinook salmon, coho salmon, cutthroat trout, rainbow trout	Flow fluctuations; section 303(d) Water Quality limited; water temperature; fish ladder utilization; restriction of sediment and wood transport; potential delay of upstream migration; reduction in floodplain connectivity; limited riparian reserves

[1/] Includes species considered important to the recreational fishery.

Anadromous Fish

The Clackamas River Basin supports five native species of anadromous fish including wild late-run and naturalized early-run (naturalized hatchery stock) coho salmon (*Oncorhynchus kisutch*), spring-run (spring) and fall-run (fall) Chinook salmon (*O. tshawytscha*), winter- and summer-run steelhead trout (*O. mykiss*), and a remnant wild population of coastal cutthroat trout (*O. clarki clarki*) that are believed to be primarily fluvial (freshwater migrations), but may have components of the population that exhibit anadromy (sea-run). There is also an anadromous Pacific lamprey (*Lampetra tridentata*) population of undetermined size in the Clackamas River.

The taking of eggs from upmigrant salmon at the River Mill Fish Ladder and damage to the Faraday dam Fish Ladder severely restricted the upstream migration of anadromous fish from 1912 to 1939 (Stillwater Sciences, 1999). After 1939, cessation of egg taking at the River Mill Fish Ladder and rebuilding the ladder at Cazadero Diversion dam reopened the Upper Clackamas River Basin for anadromous fish stocks (Horning, 2001). A 20-foot high natural falls located approximately 1.0 mile below Harriet Diversion dam defines the upper extent of anadromous fish distribution in the Oak Grove Fork watershed.

Spring Chinook Salmon

Spring Chinook in the Clackamas River are part of the Upper Willamette River evolutionary significant unit (ESU). The National Marine Fisheries Service (NMFS) listed Chinook salmon in the Upper Willamette ESU as threatened in March 1999 (64 FR 14308). In contrast, in March 1998 NMFS determined that listing was not warranted for the Lower Columbia River summer-fall run ESU (63 FR 11482).

The Clackamas River was once considered one of the largest producers of spring Chinook in the Pacific Northwest. Historically, spring Chinook probably spawned throughout the length of the Clackamas River and in nearly all accessible large tributaries (Cramer and Associates, 2001). Today, spring Chinook primarily pass North Fork dam from April through October and spawn in the Upper Clackamas River from mid-August through October. Spawning in tributary streams (e.g. Oak Grove Fork) begins after significant rainfall in September and continues until mid-November. Spring Chinook salmon are also reared at the Clackamas Hatchery operated by ODFW. Fish management within and around the Project area is carried out by ODFW.

A 1997 survey of spawning activity along nearly 67 miles of stream channel in the upper basin documented most signs of spawning in 41.1 miles of the mainstem Clackamas River and 1 mile of Oak Grove Fork (Schroeder et al., 1998). The mainstem Clackamas River contained about 80 percent of the redds and 90 percent of the carcasses observed during the survey. Juvenile spring Chinook salmon do not appear to rear in

tributaries to the mainstem Clackamas River, but rather emigrate to the mainstem soon after emergence (Stillwater Sciences, 1999), with the majority of rearing occurring within the North Fork Reservoir (D. Cramer personal communication, 2004). Some juvenile spring Chinook may also rear in the Faraday, and River Mill reservoirs (Stillwater Sciences, 1999).

Spring Chinook salmon are a popular target of recreational anglers on the lower Willamette and Clackamas rivers. There is currently a moratorium on angling for wild spring Chinook salmon. Since 2001, a combination of management techniques including fin clipping, requirements that anglers release wild fish, and sorting of hatchery fish from wild fish allows ODEQ to manage the lower river for recreational fishing and simultaneously manage the upper basin for wild salmon.

Fall Chinook Salmon

In addition to the spring run, the Clackamas River Basin also supports a smaller fall run of Chinook salmon. Fall Chinook in the Clackamas River are part of the Upper Willamette River evolutionary significant unit (ESU). There is limited information regarding the historic distribution and abundance of fall Chinook in the basin because of the difficulty distinguishing fall Chinook spawners from returning spring Chinook. Fall Chinook generally return to the Clackamas River from late August through late September (Figures 3.2.3.1-1 and 3.2.3.1-2). This timing matches that of fall Chinook passing Willamette Falls on their way to other Willamette River Basin spawning grounds. Fall Chinook spawning is believed to be completed by the end of September.

Historically, fall Chinook may have spawned in the mainstem Clackamas River above the present site of North Fork dam (PGE, 1999). Since construction of the Project dams, however, few fall Chinook have been seen passing through the River Mill Fish Ladder. Today, fall Chinook are known to spawn and rear in the Clackamas River below River Mill dam and in the lower reaches of Clear Creek, but their presence elsewhere in the Clackamas River Basin is uncertain. No juvenile fall Chinook have been released in the Clackamas River Basin since 1981 (ODFW, 1992). However, juvenile fall Chinook are released in the Willamette River Basin and some of these hatchery-produced fish may stray into the Clackamas River.

Sport anglers caught an average of 208 fall Chinook annually in the basin from 1977 through 1986 (ODFW, 1992). Generally, however, fall Chinook are not popular with anglers because of their dark color and poor condition at the time they return to spawn.

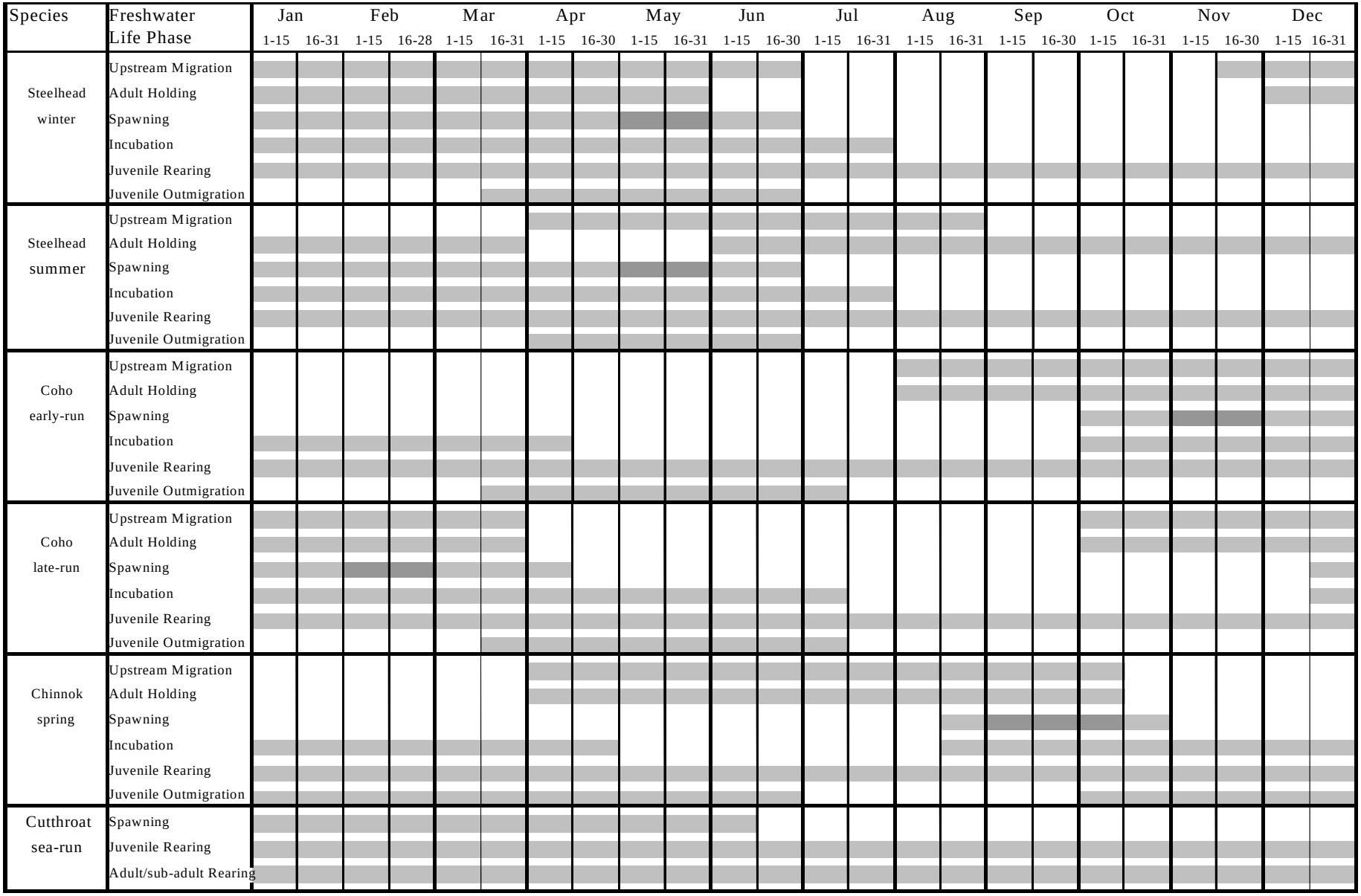


Figure 3.2.3.1-1. Temporal distribution of adult and juvenile salmonid habitat utilization in the Clackamas River.

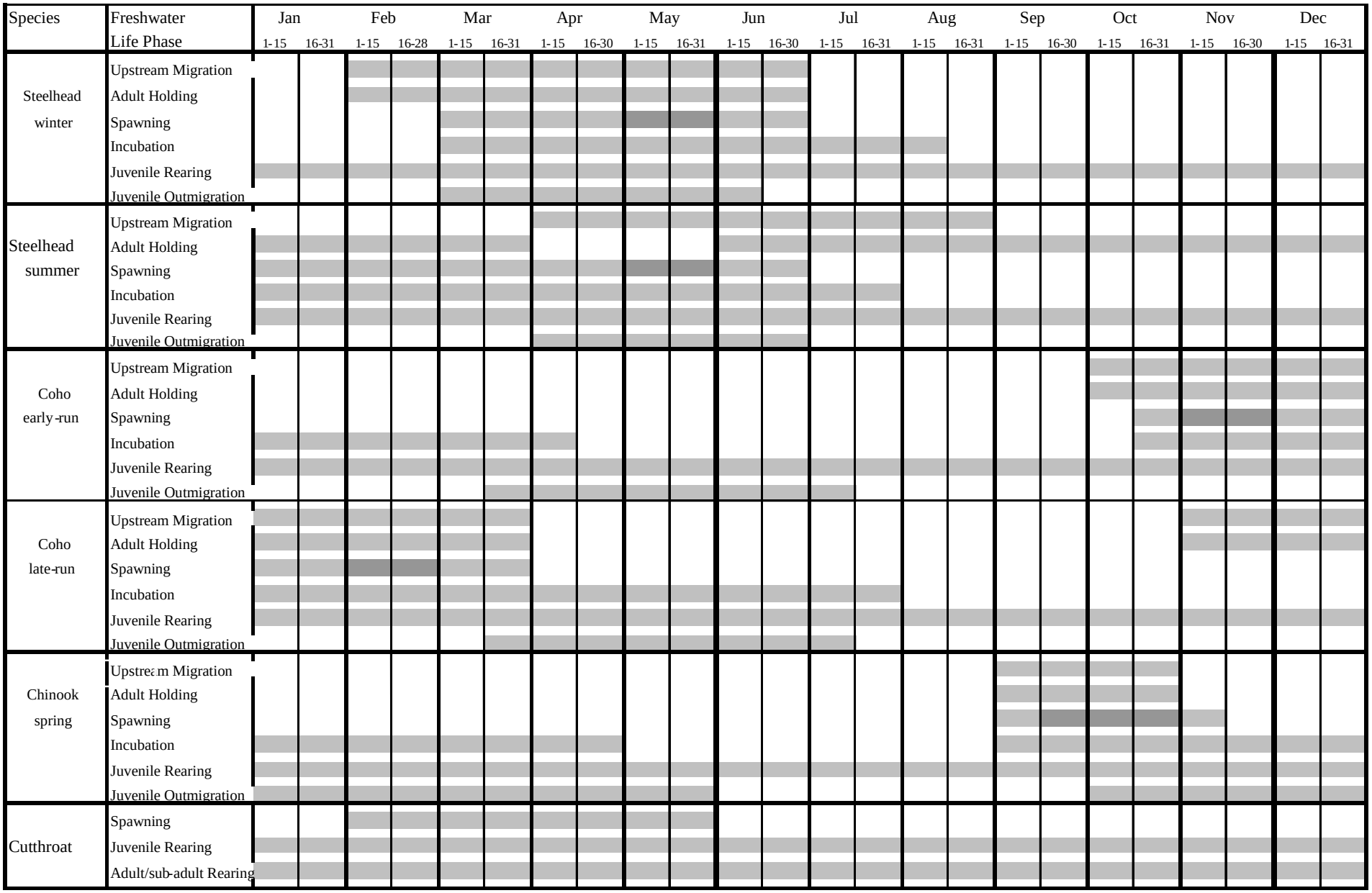


Figure 3.2.3.1-2. Temporal distribution of adult and juvenile salmonid habitat utilization in the Oak Grove Fork.

Coho Salmon

Coho salmon in the Clackamas Basin are part of the Lower Columbia River ESU. In July 1995, the NMFS concluded that the ESU was not at risk of extinction, but sufficient risks were present that its status as a candidate species was maintained (60 FR 38011). As a result of a September 2001 U.S. District Court Ruling (Alsea Valley Alliance v. Evans), the NMFS conducted a new status review of all 27 west coast salmon and steelhead ESUs (69 FR 33102). The proposed status of most ESUs did not change following the review, including that of Chinook and steelhead found in the Clackamas. However, NMFS proposed to change the status of the Lower Columbia River ESU from Candidate to a threatened species. The Lower Columbia River coho ESU was listed as threatened on June 28, 2005. Coho salmon are listed as endangered under the State of Oregon Endangered Species Act.

The Clackamas River Basin supports early-run and late-run coho salmon stocks. One component of the early-run derives from hatchery releases from Eagle Creek National Fish Hatchery. These hatchery fish return to the basin from September through December and spawn from October through early December. In addition, a self-sustaining naturalized segment also returns to the basin beginning in August and spawns naturally throughout the basin in November.

The Clackamas River Basin also supports a late coho run that is considered to be the last remaining viable wild coho population in the Columbia River Basin (Stillwater Sciences, 1999). This run enters the Clackamas River from November to January and spawns between January and March, mostly above North Fork dam.

The three lower Project reservoirs provide important rearing habitat for juvenile coho salmon (Stillwater Sciences, 1999). Juvenile coho salmon that rear in the Project reservoirs appear to grow faster and larger than young coho that rear in the Clackamas River (Stillwater Sciences, 1999). The availability of rearing habitat in the reservoirs may be particularly important to coho, in part, because of limited rearing habitat in the upper watershed, and the loss of off-channel rearing habitat (i.e., side channels) in the Lower Oak Grove Fork (Reach 1G) from the lack of an instream flow release at Harriet dam. Production of coho smolts has been shown to be related to the amount and quality of off-channel rearing habitats (Argue et al., 1979; Marshall and Britton, 1980; Peterson, 1980; Reeves et al., 1989; Beecher et al., 2002).

Many wild coho destined for the Clackamas River Basin are caught in mixed stock fisheries managed for hatchery stocks. Commercial harvest rates for ocean and Columbia River fisheries of Clackamas River late-run coho exceeded

90 percent of the annual run in the early 1970s and have continued to reach as high as 80 percent in recent years. Coho also contribute to a restricted sport fishery on the Clackamas River. Fishing usually occurs on the Clackamas River from the mouth to River Mill dam. Currently there is a moratorium on fishing for wild coho salmon. The Upper Clackamas River and tributaries above North Fork dam have been closed to salmon fishing since 1998 to protect late-run coho adults after they pass the dam.

Winter Steelhead

The Clackamas River Basin supports a wild winter steelhead run and two hatchery stocks reared at the Clackamas Hatchery, which is operated by ODFW, and the Eagle Creek Hatchery, which is operated by the USFWS Fish management within and around the Project area is carried out by ODFW. The hatchery stocks created an early winter steelhead run, which generally returns to the basin from January to April. The wild run returns later, between February and June. Although winter steelhead are known to spawn throughout most of the Clackamas Basin, the upper watershed provides more extensive spawning and rearing habitat (Stillwater Sciences, 1999).

The late-run winter steelhead are listed as federally threatened, as are naturally-spawned progeny of hatchery-produced winter steelhead. Winter steelhead of hatchery origin in the Clackamas River basin consist of two lineages: the Clackamas hatchery late-run steelhead program is considered to be part of the Lower Columbia River steelhead Distinct Population Segment (DPS), while the Eagle Creek National Fish Hatchery winter steelhead program is not part of the DPS.

Winter steelhead fry emerge between June and early August and rear in the river system for one to four years. They range throughout most of the Clackamas River Basin as they mature and will often move high into steep and fast-flowing stream reaches. Production of steelhead smolts is closely related to the amount and quality of large pools. Juvenile winter steelhead generally undergo smoltification in the spring and emigrate downstream from March through June.

The Clackamas River Basin winter steelhead run provides angling opportunities throughout the winter. Annual harvest in the basin averaged 3,645 winter steelhead from 1989 through 1994 (Massey and Keeley, 1996, as reported by PGE, 1999). In the early 1990s, harvest regulations in the basin were adjusted to protect wild steelhead (PGE, 1999). Since 1998 hatchery steelhead have been removed at the North Fork fish trap and hauled back downstream, and the upper basin managed for wild fish only. In addition wild broodstock are taken at the trap to replace the use of non-native stocks.

Summer Steelhead

Summer steelhead are not known to be native to the Clackamas River. However, early reports by Rudyard Kipling, early sport harvesting records, and ODFW's subbasin plan each indicate the possibility that summer steelhead at one time may have been present in the Clackamas River. Hatchery releases began in 1968 to provide summer angling opportunities within the Clackamas Basin. Records show that the number of naturally produced juvenile steelhead passing the Clackamas River dams doubled after hatchery summer steelhead smolt releases began (PGE, 1999). To address concerns about competition with wild winter steelhead and coho, summer steelhead releases ceased above North Fork dam after 1997, and adult summer steelhead were no longer allowed to pass above North Fork dam beginning in 1999.

In the past, adult summer steelhead passed the North Fork dam from May to October, with most of the run passing in June and July. In recent years, fewer summer steelhead adults have been returning to the Clackamas Basin, though smolt releases in the lower river have increased. From 1981 to 1990, about 162,500 summer steelhead smolts were released annually throughout the Clackamas Basin. About 75,500 pre-smolts were also released in the basin during three of these years. Currently, a total of about 150,000 summer steelhead smolts are released annually into lower reaches of the basin. In 1998, all summer steelhead smolts released were from the Clackamas Hatchery. It is expected that future smolt releases will be restricted to below River Mill dam to reduce impacts to native stocks above North Fork dam.

Prior to eliminating the practice of allowing adult summer steelhead to move above the North Fork dam in 1999, many adult summer steelhead were believed to spawn naturally in the upper basin. However, little was known about the location of natural production of summer steelhead in the basin. Efforts to define where they spawned and reared, and when they emigrated were hindered because naturally reproducing summer steelhead resembles naturally reproducing wild and hatchery-bred winter steelhead. While changes in the management of summer steelhead render the issue moot, upper Clackamas River mainstem and most tributaries above North Fork dam contain potential spawning and rearing habitat for summer steelhead if access were allowed.

The summer steelhead fishery in the Clackamas River Basin is extremely popular. The fish have a reputation for biting well and being good fighters. They also have a long period of adult freshwater residency and hold their condition (brightness). Most of the harvest traditionally occurred in the mainstem Clackamas River above North Fork dam and in the lower Clackamas River. Since 1999, their harvest has been restricted to areas below Faraday Diversion dam.

Native Coastal Cutthroat Trout

Coastal cutthroat trout are indigenous to the Clackamas River Basin and are found throughout the watershed, although most production occurs in the upper mainstem and tributaries (Stillwater Sciences, 2001). Resident and migratory cutthroat trout both occur in the Clackamas River Basin. Most of the cutthroat trout found in the basin are believed to be residents and remain in freshwater (ODFW, 1992, as reported in Stillwater Sciences, 1999). A small run of wild migratory cutthroat returns annually to the tributaries of the lower Clackamas River Basin. The fish move to spawning grounds in the mainstem and larger tributaries below River Mill dam in September and October.

Although very little is known about the abundance and distribution of migratory cutthroat trout in the basin, reports from local anglers suggest the population is declining. Anglers on the lower Clackamas River occasionally catch large cutthroat, particularly during the salmon and steelhead fishing seasons, but these catches are rare and do not occur every year.

The decline in migratory cutthroat production in the Clackamas River Basin suggests that migratory cutthroat may have been adversely affected by coho releases in the lower Clackamas River (PGE, 1999). Coho juveniles are known for their aggressive behavior and usually dominate in interactions with cutthroat.

Pacific Lamprey

Pacific lamprey is native to and present throughout the Clackamas River Basin. Based on limited observations in the existing fishways, it appears that adult migration through the Project area occurs from May to July. Large numbers are usually present in the River Mill Fish Ladder from mid-June through July. No counts are available, however, since these fish are able to pass largely undetected through the counting station at North Fork dam. There are no trend data with which to evaluate the condition of Clackamas River Pacific lamprey stocks, past or present. Although very little is known about the abundance and distribution of Pacific lamprey in the Clackamas basin, recent reports suggest that lamprey populations throughout the Columbia River basin have declined. The Oregon Natural Heritage database lists Pacific lamprey as a species of concern for the USFWS and state sensitive species in Oregon. Based on declines of lamprey counts at numerous dams, Pacific lamprey were petitioned for listing under the federal Endangered Species Act in January 2003.

Resident Fish

Resident fish inhabit all of the Project reservoirs and the stream reaches between the Project structures. The Clackamas River Basin supports resident populations of a number of species, including cutthroat trout, kokanee salmon, rainbow trout, brook trout, brown trout, and mountain whitefish. Cutthroat trout, rainbow trout, and mountain whitefish are indigenous to the Clackamas River Basin, while kokanee, brook trout, and brown trout have been introduced over the years. Bull trout were historically present in the Clackamas River Basin, but are believed to have disappeared in recent decades. Summary descriptions are provided for rainbow and cutthroat trout only. Information on other fish species found in the basin is provided in the IIP (PGE, 1999).

Cutthroat Trout

Year-round resident cutthroat trout, which remain within the Clackamas River Basin for their entire lifespan, are widely distributed throughout the basin, occurring in both mainstem and tributary reaches. Resident cutthroat production reaches into many of the basin's smaller tributaries, including several headwater streams with gradient barriers or falls that isolate the wild cutthroat populations from trout populations in lower reaches.

Resident cutthroat also reside in lakes and reservoirs. Small to large populations of cutthroat, for instance, exist in the Timothy Lake and Lake Harriet catchments. Some lakes in the Timothy Lake catchment are also stocked with Westslope cutthroat trout. These fish may be reproducing with native coastal cutthroat trout in the drainage, which could potentially reduce the genetic integrity of the area's native coastal cutthroat population (USFS, 1996, as reported in PGE, 1999).

Rainbow Trout

Rainbow trout are indigenous to the Clackamas River Basin and are widely distributed in the mainstem and tributaries, including reaches above impassable barriers. Below barriers, they often share habitat areas with steelhead juveniles. Above the barriers, isolated wild rainbow populations reside alone or with cutthroat populations.

Over the years, fish managers have often released hatchery rainbows in the basin to support growing sport fishing demands. A fishery report from 1936 states that the Oregon State Game Commission regularly liberated large numbers of fingerling trout in the Clackamas River and tributaries above Faraday Diversion dam (PGE, 1999). These included a release in September 1935 of 175,000

fingerling rainbow trout in the Clackamas River near the Oak Grove Ranger Station and above the dam on the Oak Grove Fork.

Currently, about 169,000 catchable-sized rainbow trout are released annually into the Clackamas River Basin. Up until 1999 over half these fish were released in the mainstem Clackamas River and North Fork Reservoir, while more than 10,000 fish were released in the mainstem Collawash River and Estacada and Faraday lakes. Since 1999 hatchery trout releases have been restricted to lakes and reservoirs to reduce impacts to wild stocks. Large numbers of catchable rainbow trout are released annually in Timothy Lake, Lake Harriet, and other area lakes. All of the planted rainbow trout are raised at hatcheries outside the basin. These releases support popular fisheries.

3.2.3.1.2 Aquatic Habitat Conditions

The interaction between geology, climate, and hydrology strongly influences other important watershed attributes such as topography, soils, and vegetation. Collectively, these factors represent the controls that govern hillslope and fluvial geomorphic processes, including runoff patterns, sediment delivery and transport, and LWD inputs, which in turn influence channel morphology, aquatic habitat, and water quality. Channel morphology provides a useful basis for describing streams and rivers because it:

1) Dictates habitat conditions used by the various life-history stages of salmonid species (Beechie and Sibley, 1997);
2) Directly influences the productive capacity of each habitat type (Vannote et al., 1980; Naiman et al., 1992; Paustian et al., 1992); and
3) Varies in terms of sensitivity and response to changes in inputs of water, sediment and wood from natural or anthropogenic disturbances (Paustian et al., 1992; Montgomery and Buffington, 1993; Rosgen, 1997).

Landuse actions influence watershed processes within the Project area. Hydroelectric dams have the potential to alter runoff patterns and interrupt the downstream transport of sediment and wood. Forest management activities may increase peak flows and sediment yield. Transportation corridors can interrupt the recruitment of large woody debris. Each of these factors have influenced stream reaches in the Project area to varying levels, with some geomorphic processes being highly modified in some reaches while other reaches have experienced little adverse effect.

The discussion of watershed processes included in this section focuses on sediment production and transport, and large woody debris (LWD) recruitment and transport under current operations. Current conditions of these processes, and

associated physical habitat elements are summarized below by reach. Current conditions of the hydrologic regime under current operations are described in section 3.2.2. A more detailed discussion of the current status of watershed processes, physical habitat elements, fish passage and water quality is provided in Appendix B to support the evaluation of existing conditions and the Proposed Action with respect to the NMFS Matrix of Pathways and Indicators (MPI).

The Project regulates or influences seven distinct segments of a 16-mile reach of the Oak Grove Fork, and as well, six segments of an approximate 30-mile reach of the Clackamas River (Table 3.2.3.1-3). The following sections describe on a reach by reach basis the current status of watershed processes, physical habitat elements, instream flows, macroinvertebrates, and water quality as they pertain to fisheries resources and their associated aquatic habitats.

Table 3.2.3.1-3. Stream reach definition for stream segments influenced by the Clackamas River Hydroelectric Project. (Adapted from McBain et al., 2001)[2]

Reach Designation	Stream	Location	River Mile(s)
1A	Oak Grove Fork	Above Timothy Lake	> 15.8
1B	Oak Grove Fork	Timothy Lake to Stone Creek Diversion	15.8 to 14.8
1C	Oak Grove Fork	Stone Creek Diversion to Stone Creek Powerhouse	14.8 to 9.4
1D	Oak Grove Fork	Stone Creek Powerhouse to Shellrock Creek	9.4 to 7.7
1E	Oak Grove Fork	Shellrock Creek to Lake Harriet dam	7.7 to 5.1
1F	Oak Grove Fork	Lake Harriet dam to the barrier falls	5.1 to 3.1
1G	Oak Grove Fork	Barrier falls to confluence with Clackamas River	3.1 to 0
2A	Clackamas River	Mouth of Oak Grove Fork to Oak Grove Powerhouse	53.0 to 48.1
2B	Clackamas River	Oak Grove Powerhouse to North Fork dam	48.1 to 31.1
2C	Clackamas River	North Fork dam to Faraday Diversion dam	30.1 to 27.9
2D	Clackamas River	Faraday Diversion dam to Faraday Powerhouse	28.4 to 26.2
2E	Clackamas River	Faraday Powerhouse to River Mill dam	26.2 to 23.4
2F	Clackamas River	Below River Mill dam	< 23.4

[2] Portland General Electric and McBain & Trush. 2001. Hypothesis matrix and study plan tracking binder for the Oak Grove Fork and Clackamas River between the Oak Grove Fork and River Mill dam. Prepared for Fish and Aquatics Workgroup.

Timothy Lake and Upper Oak Grove Fork Tributaries (Reach 1A)

Watershed Processes

Sediment Production and Transport

The Upper Oak Grove Fork watershed includes Timothy Lake and tributaries draining to the lake. The watershed upstream of the Timothy Lake dam lies in the High Cascades and is characterized by having low topographic relief, runoff dominated by spring flow and snowmelt, low gradient, unconfined channels, and low sediment supply. These attributes minimize the susceptibility to mass wasting, and as a result, the Upper Oak Grove Fork watershed has essentially no areas rated as having a high relative mass wasting susceptibility (Metro, 1997), suggesting that coarse sediment contributions to watercourses are naturally very low. However the Forest Service (USFS, 1996b) has identified increased sediment contributions from forest roads as a concern.

Sediment originating in the Upper Oak Grove Fork basin is routed to Timothy Lake. All coarse sediment (bedload) and part of the fine sediment (suspended load) from the upper watershed is trapped behind Timothy Lake dam. Although there are no quantitative sediment yield data for Timothy Lake from which to estimate average annual sedimentation, sediment contributions from the portion of the watershed above the dam relative to the watershed below the dam are likely very low.

LWD Recruitment and Transport

The majority of the watershed upstream of Timothy Lake is managed by the Forest Service and has experienced extensive logging. Aquatic habitats consist of four main tributaries to Timothy Lake (Dinger Creek, Cooper Creek, Crater Creek and the Upper Oak Grove Fork of the Clackamas River). The basin also contains several high elevation wetland meadow complexes and a number of small lakes. An increase in the amount of early seral stands in riparian reserves may have reduced LWD recruitment along some tributaries (USFS, 1996b). Given the small stream size and moderate to low gradients of tributaries, delivery of large wood (i.e. diameter >24 in; length > 35 ft) via fluvial transport is hypothesized to be low. Large woody debris is delivered directly to Timothy Lake by toppling of trees along the reservoir margins. Interviews with Project operators reveal that except for extremely rare events, operators do not remove wood from Timothy Lake at the dam, suggesting that inputs and transport through the reservoir are low.

Physical Habitat Elements

Stream channels in the Upper Oak Grove Fork Basin are generally small to moderate in size (channel widths between 10 and 60 feet), with low gradient areas in the meadow complexes and moderate gradient sections elsewhere. Substrate varies by channel type, and all tributaries currently have more than 20 percent surface fines (USFS, 1996b). Substrate is generally a function of gradient, with low gradient streams such as those located in meadow complexes naturally exhibiting finer substrate even under unmanaged conditions (Montgomery and Buffington, 1993).

The amount of LWD contained within the channels varies spatially. Wood is delivered to channels primarily by tree fall, and peak flows are generally too small to transport large pieces of LWD. Meadow areas have naturally low recruitment and thus naturally low LWD loading. Forested stream segments contain LWD, with wood loadings ranging from 19 to 128 large pieces per mile. Several of the tributaries (Dinger Creek and Cooper Creek) flow through clearcut areas. The Forest Service has installed a number of LWD structures in these streams as part of habitat restoration projects.

Pool frequencies in some channel types are strongly influenced by LWD, and pool frequencies are also variable in the Upper Oak Grove Fork basin. The Upper Oak Grove Fork and Crater Creek flow through low gradient meadows and contain long sections of “meadow trench habitat” that is probably more typical of this stream type than traditional pool-riffle sequences. Many of the pools in meadow areas are formed by beaver dams.

Steeper streams consist of pool-riffle or step pool sequences with low pool frequencies. Most pools are less than 3.3 ft (1 m) deep due to the small stream size; however beaver complexes may provide substantial areas of deep-water habitat, and pools greater than 3.3 ft deep were encountered.

Instream Flows

Streams entering Timothy Lake are unregulated. From June 1 through Labor Day, Timothy Lake dam is operated to keep the lake elevation above 3,190.0 ft. After Labor Day, outflows are increased and the reservoir is drawn down 10 to 12 feet. This has the effect of reducing flows in the Oak Grove Fork between Timothy Lake and Lake Harriet during the spring storage period and increasing flow during the fall drawdown period. The State Hydropower License No. 186 (Hydroelectric Commission of Oregon, 1953) requires a year-round minimum flow release of 10 cfs downstream from Timothy Lake dam and limits maximum draft to 300 cfs over inflow (Foster Wheeler, 1998).

Upper Oak Grove Fork from Timothy dam to Harriet dam (Reach 1B to 1E)

Watershed Processes

Sediment Production and Transport

The Oak Grove Fork downstream from Timothy Lake flows through a narrow canyon that marks the beginning of the transition from the High Cascades Physiographic Province to the Western Cascades Physiographic Province. The high gradient channel located downstream of Timothy dam has greater capacity to move sediment than low gradient meadow channels and small tributaries located upstream. Sediment yield to the Oak Grove Fork and tributaries downstream of Timothy dam is greater than in upstream reaches due to the steeper valley sideslopes, increased incidence for mass-wasting, and influence of the Western Cascades geology (McBain and Trush, 2004a). These factors lead McBain and Trush to conclude that trapping of coarse bedload material from upstream of Timothy dam does not substantially affect the overall character of the channel. Mobile gravel is currently stored in isolated patches downstream of the dam, while the bed consists primarily of stable boulders and large cobble.

A number of tributaries join the Oak Grove Fork in the reach between Timothy dam and Lake Harriet, beginning with Anvil Creek, which joins the Oak Grove Fork approximately 0.5 mile downstream of Timothy dam. Many of these tributaries are considered to have elevated rates of sediment delivery and mass wasting as a result of historic landuse activities (USFS, 1996b). Although the magnitude of increased coarse sediment inputs is unknown, elevated sediment yields from these tributaries may currently offset trapping of bedload from upstream of Timothy dam.

LWD Recruitment and Transport

As the Oak Grove Fork enters the Western Cascades Physiographic Region, the dominant riparian conifers transition to Douglas-fir, western red cedar, white fir and mountain hemlock. These large conifers occur along the low flow channel margin and extend upslope. Alluvial channel areas are limited in the reach between Timothy dam and Lake Harriet, but where present, often support a narrow band of willow and red alder. Large wood delivery is dominated by tree fall and wind throw due to the lack of landslides in this portion of the canyon. Floodplains are discontinuous to non-existent due to the confined nature of the valley bottom.

Physical Habitat Elements

Substrate in the reach between Timothy dam and Lake Harriet consists primarily of boulder and cobble, typical of high-gradient confined channels. Small gravel and other mobile sediments are stored in patches associated with stable obstructions.

Cramer and Associates (2001) report that large woody debris larger than 10 inches in diameter was abundant in the Oak Grove Fork downstream of Timothy dam (235 pieces per mile) in 1994, despite a reduction in the amount of LWD wetted by reduced flows in Reach 1C as a result of flow diversion at the Stone Creek Diversion dam. Raw data from Forest Service surveys conducted in 1995 indicate that the frequency of medium to large wood (>24 inches in diameter and longer than 50 feet) was 11.5 pieces per mile, suggesting that the majority of available wood consists of small pieces.

Downstream transport of wood is generally limited to those pieces that are shorter than the bankfull width of the channel (Lienkemper and Swanson, 1986; Nakamura and Swanson, 1993). As a result, the supply of large, long pieces of wood (>24 inches diameter and longer than 50 feet) from tributary streams is probably low. Although individual large flood events may transport a given piece of wood a substantial distance, pieces tend to become fragmented as they move downstream in small to moderate size channels. Benda and Martin (2001) report that the majority of pieces of wood (90 percent) in channels with a bankfull width of 10-20 meters move less than 500 meters over their lifetime. These studies support McBain and Trush's (2004a) conclusion that Timothy dam probably does not substantially reduce the amount of large wood supplied to the Oak Grove Fork between Timothy dam and Lake Harriet. Timothy dam likely does interrupt the movement of small wood fragments and debris through the fluvial system.

Pools currently account for about 7.1 percent of the low flow habitat in this part of the Oak Grove Fork. Diversion of flow at the Stone Creek Diversion dam reduces low flows in Reach 1C, and has been observed to result in a 9 percent decrease in the amount of total available fish habitat there (Bergamini and Bernards, 1994). The flow reduction resulting from the Stone Creek Diversion dam causes the flow depth to decrease, transforming some pool and glide habitats into riffles (Bergamini and Bernards, 1994). Flow reductions resulting from operation of Timothy Lake dam are believed to have a similar effect on the amount and quality of available pool habitat in Reach 1B. However, the average pool depth reported for this reach is 2.3 feet, and some pools greater than 3.3 ft (1 meter) deep are present (Cramer and Associates, 2001).

Cramer and Associates (2001) indicate that 27 side channel units were identified between Timothy dam and Lake Harriet in 1990. Flow diversion in Reach 1C was shown to result in a slight reduction in the percent composition of side channel (Cramer and Associates, 2001). Operation of Timothy dam is also presumed to reduce side channel connectivity throughout this part of the Oak Grove Fork during periods of reservoir refill or other times when flow releases are less than inflows.

Instream Flows

PGE is required to provide a minimum instream flow release of 10 cfs below Timothy Lake at all times. However, flows within this reach are influenced temporally and spatially by several other factors including: a) accretion flows via a series of springs located about 1,500 to 3,000 feet (Framatome ANP DE&S, 2002b) below the dam that supplement the 10-cfs minimum release; b) fluctuations in flow from Timothy Lake; and c) operation of the Stone Creek Project that reduces flows in the 5-mile reach that is bypassed by the diversion. The Stone Creek Project can divert as much as 250 cfs from the stream (USFS, 1996b). However, the Stone Creek Project license requires a minimum instream flow release below the diversion dam of 30 cfs from November through June and 40 cfs from July through October. The Stone Creek license also requires that at least 90 percent of assumed accretion flow be maintained in the reach as measured at the Stone Creek Powerhouse. Assumed accretion ranges from 106 to 130 cfs depending on month, which when coupled with the minimum instream flow releases at the diversion dam provides a flow gradient (i.e., a change in flow with increasing distance downstream of the diversion dam) within the diverted reach that is biologically important. Results of an IFIM study completed within the reach suggest the range of optimal flows for juvenile and adult cutthroat is around 90 to 120 cfs, respectively in this section of the Oak Grove Fork (CES, 1984; USFS, 1996b).

Spring seepage flow can contribute substantially to streams within the High Cascades (McBain and Trush, 2003b) and typically results in more stable flow regimes than Western Cascades streams. Flow increases sufficient to moderate water temperatures, for instance, have been observed within 3,000 feet below Timothy Lake dam (Framatome and DE&S, 2002a).

Flow fluctuations below Timothy Lake are common during fall, winter, and spring seasons. While ramping rates are restricted to no more than 0.33 feet per hour, daily fluctuations can be quite high, particularly in the fall during drawdown, and in the late spring during “rain-on-snow” events. The fall fluctuation typically is less than 300 cfs a day. Based on an analysis of 1998 gage data, for example, the greatest difference in flows during a single day occurred in early October and

was approximately 230 cfs (Figure 3.2.3.1-3). Daily flow fluctuations occurred in all months but were most frequent during February, during which time there were a number of days in which fluctuations exceeded 50 cfs (several days exceeded 100 cfs) (Figure 3.2.3.1-3). Though less common, daily fluctuations of 25 to 30 cfs did occur from April through August corresponding to periods of spawning, egg incubation and fry emergence of native cutthroat and redband trout. For the year, the 50 percent exceedance flow fluctuation was 5 cfs (i.e. 50 percent of the time the daily difference in maximum and minimum flows was 5 cfs or greater) (Figure 3.2.3.1-4). The maximum rate of up-ramping was as high as approximately 72 cfs (in 30 minutes) in early April, but was more commonly in the range of 5 to 10 cfs per 30 minutes for most of the year (Figure 3.2.3.1-5). Downramping rates (over a 30-minute period) followed a similar pattern; maximum rates were slightly above or close to 80 cfs per 30-minute period and occurred in early February, early April, and early October (Figure 3.2.3.1-6). More commonly, the downramping rates were in the range of 5 to 10 cfs per 30-minute period. Wamser (2001) calculated maximum and average unregulated downramping rates resulting from storm related flow recession ranging from 0.03 to 0.05 ft/hr (9.3 to 16 cfs/hr) and 0.015 to 0.021 ft/hr (4.8 to 7.5 cfs/hr), respectively (Table 3.2.3.1-4 and 3.2.3.1-5). In general, the greatest effects relate to downramping rates and the potential for stranding of fish (primarily fry and juvenile salmonids) as flows recede.

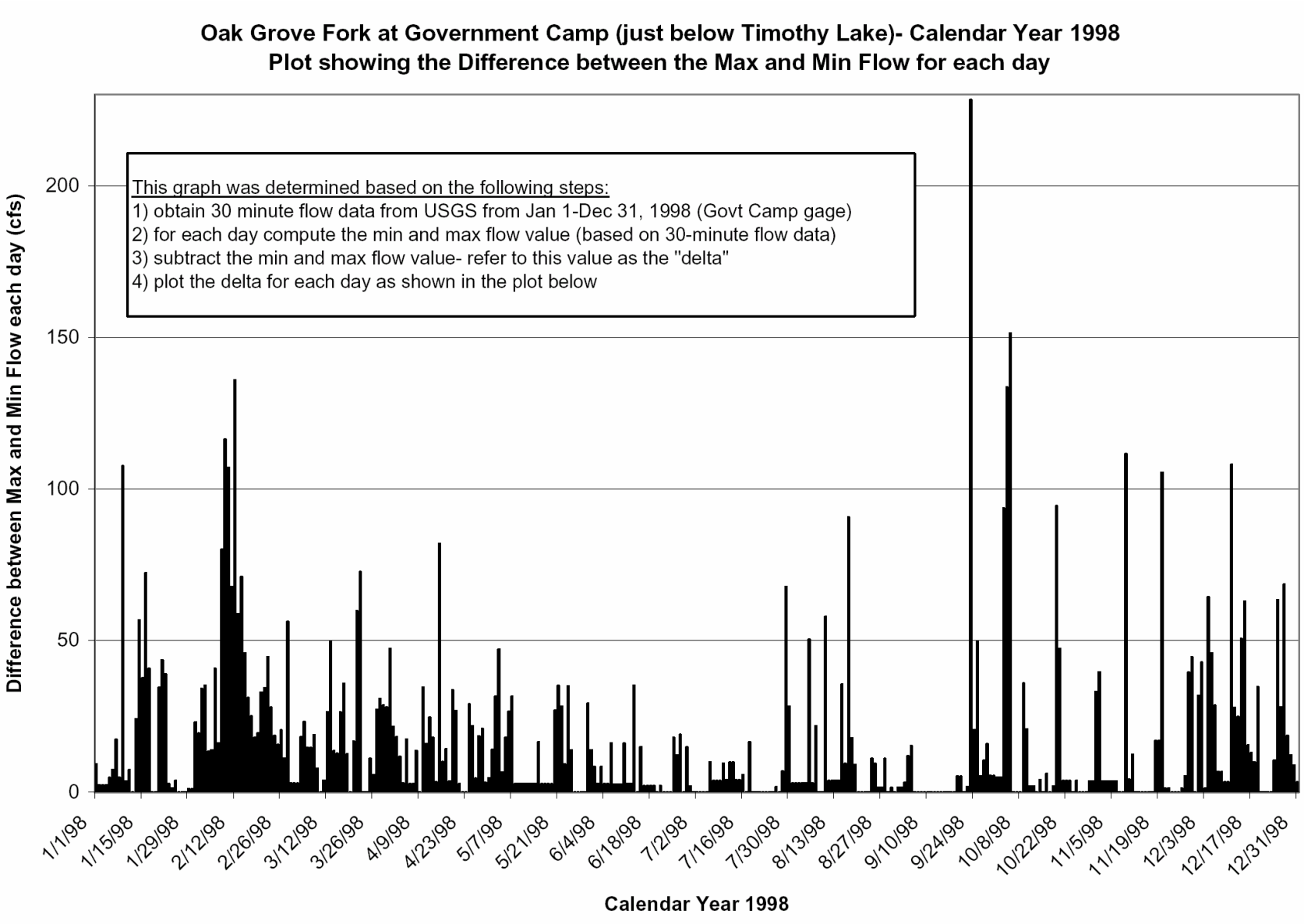


Figure 3.2.3.1-3. Daily flow fluctuations – Oak Grove Fork.

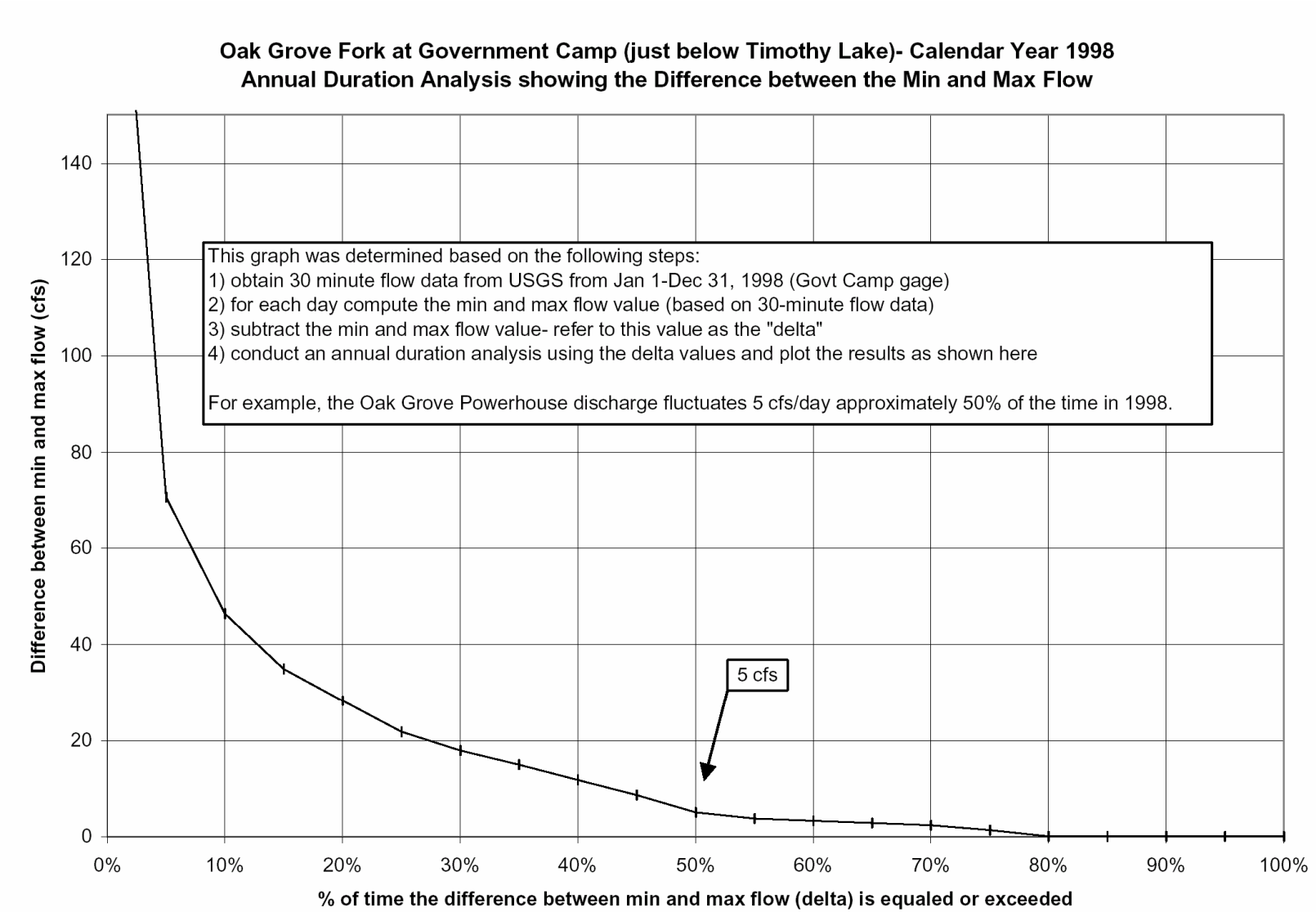


Figure 3.2.3.1-4. Annual flow fluctuations - Oak Grove Fork.

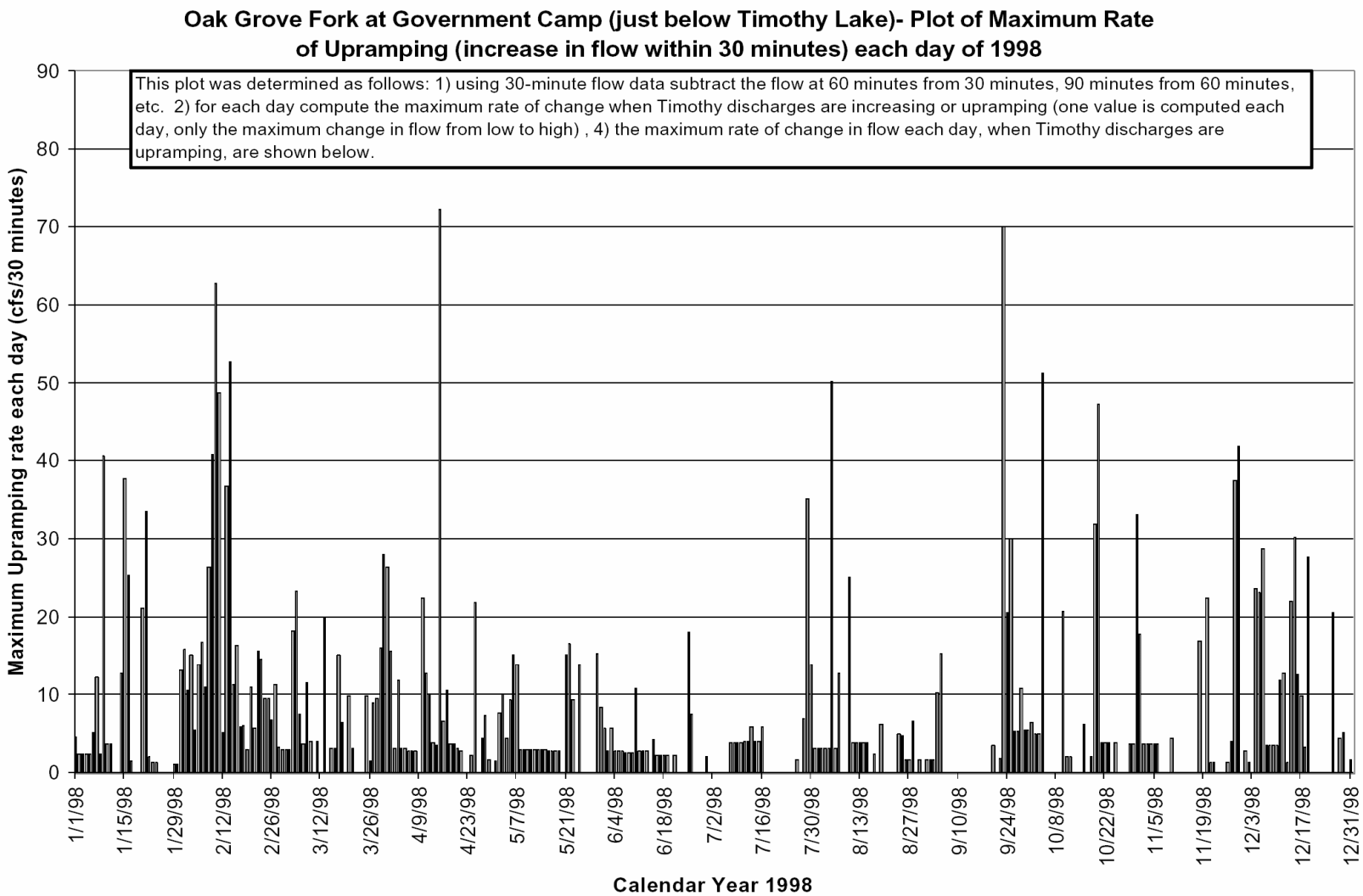


Figure 3.2.3.1-5. Upramping rates - Oak Grove Fork.

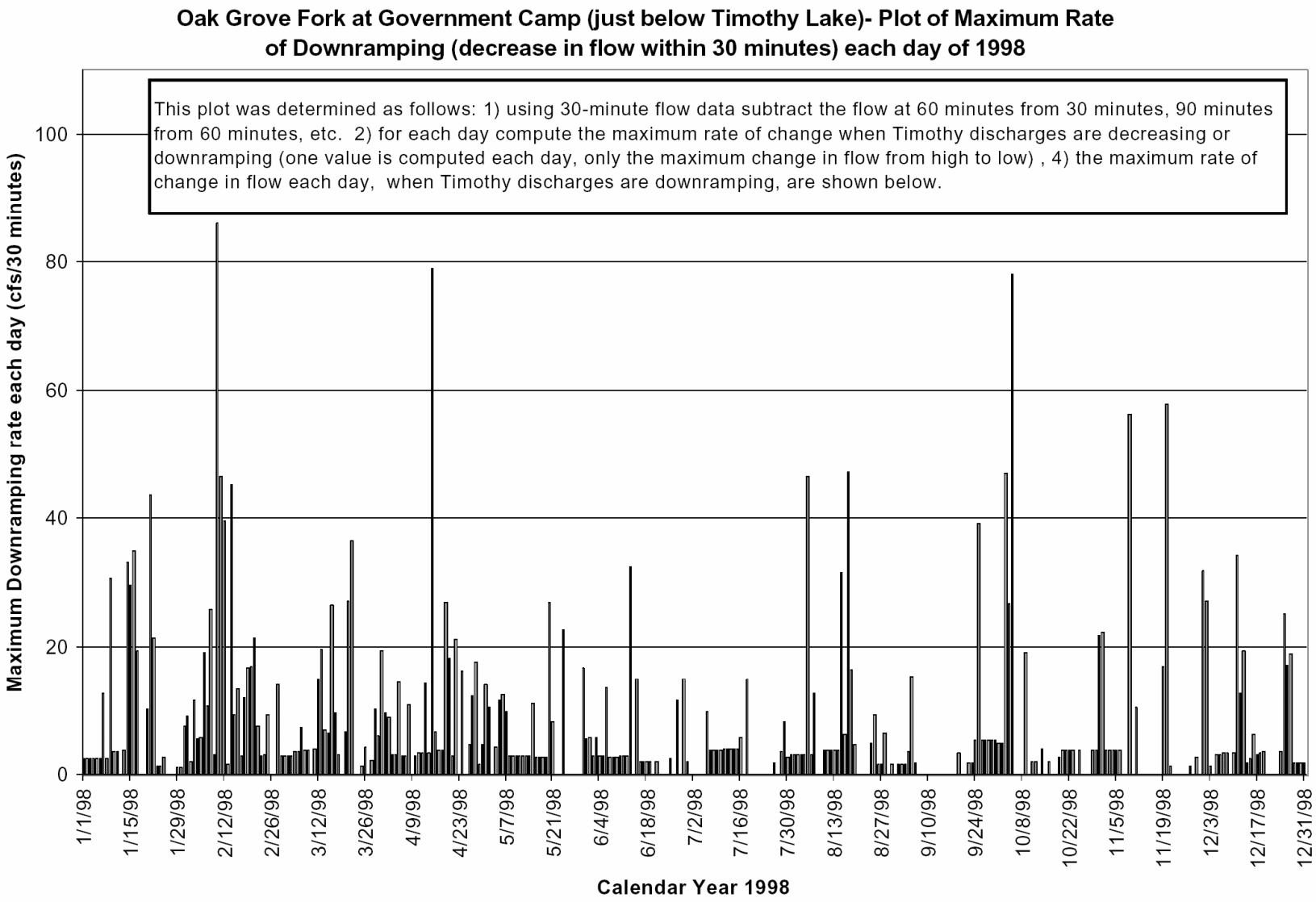


Figure 3.2.3.1-6. Down-ramping rates - Oak Grove Fork.

Table 3.2.3.1-4. Average rate of rise and fall below Timothy Lake.

AVERAGE RATE OF RISE AND FALL						
	Rising Hydrograph,			*Falling Hydrograph*		
	Date	*Flow*	*Stage*	*Date*	*Flow*	*Stage*
Regulated	10/31/86	45.0 cfs/hr	0.15 ft/hr	11/3/86	247.0 cfs/hr	0.62 ft/hr
	4/9/87	73.2 cfs/hr	0.27 ft/hr	5/19/57	46.5 cfs/hr	0.18 ft/hr
	5/15/87	74.0 cfs/hr	0.35 ft/hr			
Unregulated	1/20-24/19	8.0 cfs/hr	0.026 ft/hr	1/20-24/19	4.8 cfs/hr	0.015 ft/hr
	11/29-12/5, 1921	28.4 cfs/hr	0.080 ft/hr	11/29-12/5, 1921	9.2 cfs/hr	0.020 ft/hr
	1/5-16/23	14.6 cfs/hr	0.043 ft/hr	1/5-16/23	7.5 cfs/hr	0.021 ft/hr
	11/24-28/27	13.6 cfs/hr	0.042 ft/hr	11/24-28/27	6.3 cfs/hr	0.018 ft/hr

Table 3.2.3.1-5. Maximum rate of rise and fall below Timothy Lake.

MAXIMUM RATE OF RISE AND FALL						
	Rising Hydrograph,			*Falling Hydrograph*		
	Date	*Flow*	*Stage*	*Date*	*Flow*	*Stage*
Regulated	10/31/86	115 cfs/0.5 hr	0.35 ft/0.5 hr	11/3/86	168 cfs/0.5 hr	0.36 ft/0.5 hr
	4/9/87	86 cfs/0.5 hr	0.31 ft/0.5 hr	5/19/57	77 cfs/0.5-hr	0.30 ft/0.5 hr
	5/15/87	93 cfs/0.5 hr	0.47 ft/0.5 hr			
Unregulated	1/20-24/19	22 cfs/hr	0.08 ft/hr	1/20-24/19	16 cfs/hr	0.05 ft/hr
	11/29-12/5, 1921	61 cfs/hr	0.18 ft/hr	11/29-12/5, 1921	9.3 cfs/hr	0.03 ft/hr
	1/5-16/23	42 cfs/hr	0.12 ft/hr	1/5-16/23	12.3 cfs/hr	0.035 ft/hr
	11/24-28/27	35 cfs/hr	0.10 ft/hr	11/24-28/27	13.3 cfs/hr	0.035 ft/hr

Lower Oak Grove Fork Downstream of Lake Harriet Dam (Reaches 1F and 1G)

Watershed Processes

Sediment Production and Transport

Information on sediment production from the basin area delivering to Reaches 1F and 1G was derived from information on the amount of sediment that has accumulated in Lake Harriet. A detailed description of the original sediment yield assessment is presented in McBain and Trush (2001). Additional sediment yield and transport analyses conducted in support of this DEIS are described in Appendix C. The following discussion summarizes the results of those analyses.

McBain and Trush (2001) estimated that between 1924 and 1986, Lake Harriet trapped approximately 175,000 tons of sediment (suspended load and bedload). They hypothesized that Lake Harriet dam traps 100 percent of the coarse sediment from upstream reaches downstream of Timothy Lake.

Lake Harriet is a small reservoir with a gross storage capacity of approximately 300 acre-feet. Calculations of trap efficiency using the modified Brune Curve method (Linsley et al., 1982) reveal that the actual trap efficiency is between 0.3 to 10 percent (Appendix C), suggesting that McBain and Trush's assumption that Lake Harriet traps all of the sediment delivered from upstream is an overestimate. Assuming the actual trap efficiency is approximately 10 percent (i.e. that 10 percent of the total sediment load [bedload and suspended load] delivered to Lake Harriet deposits in the reservoir while the remaining 90 percent is transported downstream past the dam), the total sediment yield from upriver would be approximately 260 tons/mi^2/yr. Material depositing within Lake Harriet would consist of all of the bedload, and part of the suspended load.

McBain and Trush (2004) conclude that trapping 100 percent of the sediment produced in the Upper Oak Grove Fork basin in Lake Harriet reduces the total supply of sediment to the Lower Oak Grove Fork by 38 percent. Assuming that the actual trap efficiency of Lake Harriet is only 10 percent, the majority of the suspended sediment yield continues to pass through Lake Harriet, and the total annual sediment yield to Reach 1C is reduced by less than 10 percent.

Using McBain and Trush's assumption that bedload represents 10 percent of the annual sediment yield, the bedload yield to Lake Harriet would be equivalent to 26 tons/mi^2/yr. The watershed area downstream of Lake Harriet is located entirely within the Western Cascades Physiographic Province, and is therefore considered to have a higher sediment yield (510 tons/mi^2/yr). Despite the higher bedload inputs from downstream areas, interception of all of the bedload from upstream reaches in Timothy Lake and Lake Harriet under current operations reduces the annual bedload supply to Reach 1F and 1G by approximately 86 percent.

Current Harriet dam operations also reduce the magnitude, duration, and frequency of high flow events (see section 3.2.2), affecting the streams ability to transport bedload through Reaches 1F and 1G. However, bed mobility experiments conducted in 2003 suggest that gravel to cobble sized materials are selectively mobilized on an annual basis in Reach 1G; complete mobilization of gravel to cobble size sediment requires a flow of approximately 1,600 cfs (McBain and Trush, 2004a). An independent analysis of the sediment transport capacity conducted in support of this DEIS indicates that the Lower Oak Grove Fork is capable of transporting approximately 910 tons of bedload per year on average in Reach 1G (Appendix C).

The effects of current operations on coarse sediment supply and transport capacity tend to offset each other, thus reach-scale channel morphologic

conditions are believed to be relatively unaffected by Lake Harriet dam (McBain and Trush, 2004). However, alterations in the sediment supply and transport capacity are believed to affect proportion of bed substrate consisting of gravel (Appendix C).

LWD Recruitment and Transport

In Reach 1F and 1G large conifers such as Douglas-fir, western red cedar and mountain hemlock are found along the channel margin and extend up the adjacent terraces and hillslopes (McBain et al., 2001). Recruitment of large wood to Reaches 1F and 1G occurs from shallow landsliding, debris flows, and wind throw (McBain et al., 2001). In alluvial portions of this reach, changes in the flow regime have allowed woody riparian vegetation to encroach onto point and lateral bars.

Physical Habitat Elements

Between Lake Harriet dam and the mainstem Clackamas River confluence, the Oak Grove Fork exhibits two general types of reach-scale channel morphology: Reach 1F is a single-thread, highly confined, minimally alluvial channel with a gradient of approximately 2 to 4 percent, and Reach 1G an unconfined single-thread channel, with a gradient of 1 to 2 percent and more common alluvial features (i.e., gravel bars). Channel morphology in Reach 1F is strongly influenced by bedrock control, thus the effect of current operations is most likely limited to a reduced frequency of mobile sediment patches. In Reach 1G the channel becomes more alluvial. Mobile gravel deposits are currently largely restricted to the outer edge of former point bars. Existing bed materials the size of those observed on alluvial features are still mobilized (McBain and Trush, 2004a), thus the major effects of current operations is most likely been a reduction in the number and extent of mobile sediment deposits and possibly an overall coarsening of the bed (Appendix C).

McBain and Trush suggest that the influence of current operations on the supply of LWD in Reaches 1F and 1G is negligible (McBain and Trush, 2004a). They conducted interviews with Project operators that reveal that wood is generally not removed from Lake Harriet. Flow passes over the top of Lake Harriet dam during spill, and even very large pieces may be routed over the dam. Wood can become trapped on the rock dam face, but is removed and deposited in the channel if that occurs (McBain and Trush, 2004a). However, wood that does become trapped along the log boom near the intake structure is removed on an as needed basis; there are no annual records that document the volume or number of pieces removed (McBain and Trush, 2004a). Wood was removed following the 1996 flood (Horning, 2004). Since large storms such as the 1996 flood are

typically responsible for the majority of LWD transport (NHC et al., 1992; Wampler, 2004), wood removal following such events may have a considerable effect on wood loading.

McBain and Trush (2004a) hypothesize that increased large wood residence time in the channel as a result of the existing low peak flows may slow the downstream transport rate of LWD through this reach (McBain and Trush, 2004a). The Forest Service has installed LWD stream enhancement structures throughout the area downstream of the falls. The LWD frequency is currently 56 to 63 pieces per mile (Cramer and Associates, 2001).

Cramer and Associates (2001) report average pool depths of 2.0 and 2.3 feet for Reaches 1F and 1G respectively, based on habitat surveys conducted in 1993. Data collected by the Forest Service in 1995 identified 137 pools in the approximately four miles of channel downstream of Harriet dam, equivalent to a frequency of 34 pools per mile. Approximately 37 percent of the pools identified by the Forest Service had maximum depths greater than 3-feet. However, low baseflows under current conditions affect pool depth.

Side channels are common in the lower portion of the Oak Grove Fork between Lake Harriet dam and the Clackamas River. The flows responsible for forming and maintaining side channels that become connected under the existing flow regime area typically very large flood events (e.g., > 20-year recurrence interval). Flows responsible for forming and maintaining side channels are not substantially affected by current operations (McBain and Trush, 2004a). However, the reduced frequency of moderate to low flows limit the extent and duration of channel connectivity under current operations.

Instream Flows

There are no instream flow requirements for the 4.3-mile-long reach of the Oak Grove Fork from Harriet dam to its confluence with the Clackamas River. Flows in this reach result from combined dam seepage along with accretion flow resulting from groundwater inflow, several small tributaries and spill events that exceed the Frog Lake flowline capacity. In combination, these sources are able to provide a gradient of increasing flows that reach a nominal instream flow during August and September of around 10 to 15 cfs near the lower portions of this reach (CES, 1996b).

Clackamas River from Oak Grove Fork to Oak Grove Powerhouse (Reach 2A)

Watershed Processes

Sediment Production and Transport

The mainstem Clackamas River downstream of the Oak Grove Fork is located within the Western Cascades Physiographic Province. Sediment production rates in the Upper Clackamas River Basin are naturally higher than rates estimated for the Upper Oak Grove Fork, reflecting the much larger contributing area of the mainstem Clackamas upstream of the Oak Grove Fork confluence and the greater contributions from the Western Cascades Physiographic Region (McBain and Trush, 2004a). The estimated total annual sediment yield of the Upper Clackamas Basin upstream of North Fork Reservoir is 510 tons/mi^2/yr (McBain and Trush, 2001).

Information provided by McBain and Trush (2001) was modified based on the revised estimated trap efficiency of 10 percent for Lake Harriet (Appendix C). Resulting analyses suggest that while the suspended sediment yield is not substantially affected by current operations, bedload contributions from the Oak Grove Fork to the mainstem Clackamas River are reduced. Coarse sediment inputs to the Clackamas River have been increased by road-related landslides (USFS, 1996a), and those increases may currently partially offset Project-related reductions. The magnitude of increased coarse sediment yields is unknown, and over time future coarse sediment inputs from National Forest Lands are expected to return to levels more representative of natural background conditions.

Because the magnitude and frequency of peak flows is largely unaffected by current operations (section 3.2.2), the sediment transport capacity is presumed to be unaffected by the Project. The Clackamas River between the Oak Grove Fork confluence and the Oak Grove Powerhouse is a high-energy mountain river that is constrained by hillslopes or bedrock along 97 percent of its length (Cramer and Associates, 2001) with extensive bedrock control. The continued high transport capacity, coupled with slight reductions in coarse sediment yield resulting from Project operations would be expected to slightly reduce the size and frequency of mobile sediment deposits within the Clackamas River channel, but does not change the overall geomorphic character of Reach 2A.

LWD Recruitment and Transport

Riparian vegetation along Reach 2A typically consists of a narrow band of red alder, bordered by forest stands consisting of Douglas-fir, white fir, western red cedar and mountain hemlock (McBain et al., 2001). The Forest Service

(1996a) reports that active vegetation management has been minimal along the river corridor. However, the presence of Highway 224 may limit LWD recruitment in some areas. The mainstem Clackamas River channel has an average bankfull width greater than 100 feet even at low flows (Cramer and Associates, 2001), and is wider than the length of LWD typically delivered to the channel. As a result, most wood delivered to the channel is readily transported by high flows and tends to accumulate along channel margins. This lateral depositional process tends to minimize the role of LWD in shaping channel morphology in this reach (McBain et al., 2001).

Recent research suggests that the lifetime travel distance of individual pieces of LWD is less than 6,500 feet (2,000 m), even in channels as wide as 65 feet (Martin and Benda, 2001). The reason is that individual pieces, particularly large pieces with intact rootwads, are mobilized only during very large floods or episodically when debris jams break up (Benda and Sias, 1998). In addition, wood tends to become fragmented as it is moved. The implications of these studies are that most large pieces of wood (e.g., >24 inches in diameter and longer than 50-feet) are recruited to large rivers such as the Clackamas from treefall or bank erosion rather than fluvial transport. Tributary streams such as the Oak Grove Fork are therefore not expected to be a major source of large pieces of wood, although they may contribute large volumes of wood fragments and small woody debris. In contrast, although little published material is currently available describing LWD dynamics in large rivers (100 feet wide), observations of wood transport in large rivers in western Washington suggests that intact trees can be transported substantial distances (miles) during floods (R2 Resource Consultants, unpublished data).

Physical Habitat Elements

The channel morphology of the mainstem Clackamas River in Reach 2A is moderately to highly confined, ranging from semi-alluvial containing periodic alternate bars, to highly confined between basalt valley walls (McBain and Trush, 2004a). The existing substrate consists predominantly of cobble and boulders, which is consistent with what would be expected for this type of channel. However, reduced bedload inputs from the Oak Grove Fork may limit the size and frequency of mobile gravel deposits, particularly immediately downstream of the confluence.

As noted above, LWD does not play an important role in shaping channel morphology in large, bedrock-controlled channels such as the mainstem Clackamas River. However, LWD does provide important cover for fish and substrate for macroinvertebrates. Large woody debris is currently scarce within

Reach 2A; Cramer and Associates (2001) report an overall frequency of 5.4 pieces per mile.

Cramer and Associates (2001) report that the frequency of pools in Reach 2A is currently low (12.4 pools per mile). However, the pools that are present are large and comprise approximately 27 percent of the total habitat area at low flow. No data are available on pool depth or quality. Because of the prevalence of bedrock controls and minimal geomorphic role of LWD, the abundance of pools is not considered to be a function of LWD in this reach. Pool habitat may be reduced by Oak Grove Development operations, which limit baseflows and thus the overall area of habitat in the late summer and fall during periods of naturally low flows in this stretch of the river.

Side and off-channel habitats are typically not common in steep confined channels. Side channels represent approximately 3 percent of the low-flow habitat area in Reach 2A (Cramer and Associates, 2001). Fluvial processes responsible for forming and maintaining the side channels via coarse sediment mobility, scour, and redeposition occur during larger magnitude floods, and not substantially affected by current operations. However, the area and connectivity of side channel habitat available at baseflow is limited by Project operations.

Instream Flows

There are no instream flow requirements for this reach of the Clackamas River. Streamflows within this reach are influenced by Project operations as a result of the diversion of the majority of flow (up to approximately 600 cfs) from the Oak Grove Fork to the Oak Grove Powerhouse.

Scheduled maintenance shutdowns in the Oak Grove Powerhouse typically occur in July and August. During this period flows are low enough so that only one generator is needed to maintain powerhouse operation. Shutdown of the two generators is done sequentially so there is no interruption in water diversion. Infrequent emergency outages can occur creating rapid increases and subsequent decreases (once the powerhouse becomes functional) in flows within this reach.

Clackamas River from Oak Grove Powerhouse to North Fork Dam (Reach 2B)

Watershed Processes

Sediment Production and Transport

Sediment supply and transport in Reach 2B are similar to Reach 2A. Although current operations reduce bedload contributions from the Oak Grove

Fork to the Clackamas River, increased contributions from downstream sources ameliorate the influence of reduced Oak Grove Fork inputs. Two major tributaries, Fish Creek and Roaring River, substantially increase the area contributing sediment to the Clackamas River downstream of the Oak Grove Powerhouse. By the time the river reaches the North Fork reservoir, the reduction in sediment supply attributable to the Oak Grove Development represents approximately 10 percent of the estimated Clackamas River coarse sediment load. Similar to the reach above the Oak Grove Powerhouse, coarse sediment inputs to the Clackamas River have been increased by road-related landslides (USFS, 1996a), further offsetting the effect of the Oak Grove Development.

Flows diverted at Lake Harriet are delivered back to the Clackamas River at the Oak Grove Powerhouse, re-establishing full flows on an annual basis. Although Project operations at Timothy Lake and the Oak Grove Powerhouse have minor, short-term effects on flows at the Three Lynx gage and in the lower river, the annual yield at the Three Lynx gage downstream of the Oak Grove Powerhouse has not been changed by the upstream PGE operations. The sediment transport capacity is therefore unaffected by current Project operations.

LWD Recruitment and Transport

Riparian areas adjacent to Reach 2B are generally intact and large conifers are common along the channel margins between the Oak Grove Powerhouse and North Fork dam. The Forest Service (1996a) reports that active vegetation management has been minimal along the river corridor. The valley floor in Reach 2B downstream of the Oak Grove Powerhouse is wider than in Reach 2A, but remains constrained by bedrock or hillslopes for most of its length and is too narrow to facilitate development of an extensive floodplain. Like Reach 2A, LWD pieces delivered to the channel are small relative to the channel width, thus high flows redistribute most LWD to the channel margins. Therefore, wood is not expected to play an important role in pool formation in this reach.

Physical Habitat Elements

Downstream of the Oak Grove Powerhouse, the valley becomes wider and the Clackamas River is a meandering, semi-alluvial river (Duke Engineering and Services, 2001). Mobile sediment deposits occur primarily as point bars composed of cobbles and boulders mixed with gravel and sand. As noted above, the Oak Grove Development does not substantially change the amount of coarse sediment delivered to this reach. Sixteen large gravel deposits associated with pool tailouts or glide habitat units have been identified in this reach (Cramer and Associates, 2001). These deposits are considered to be suitable for spawning by

anadromous salmonids. Substrate is typical of what would be expected in this channel type.

Few quantitative data on existing large woody debris loadings were located for Reach 2A. Cramer and Associates (2001) state that LWD "was present" during surveys conducted in July 1999. Forest Service survey data from 1991 reported LWD frequencies less than 0.1 pieces per mile (USFS, 1996a).

Pools present in Reach 2B are deep, and represent good holding habitat for upstream migrating salmonids. Pool formation in steep, bedrock-controlled channels is typically not a function of LWD. Data compiled by Cramer and Associates (2001) indicate that the pool frequency is currently 2.8 pools per mile in this Reach.

Side channels in Reach 2B are usually associated with alluvial deposits (e.g. flowing along the back side of point bar) and are less complex than those in the Oak Grove Fork, suggesting that most are formed and maintained by currently active fluvial geomorphic processes. Current operations do not substantially alter the magnitude and duration of daily flows in Reach 2B and thus have little influence on side channel maintenance or seasonal connectivity. However, peaking operations at the Oak Grove Powerhouse can alter the available area and quality of off-channel habitat on an hourly basis.

Instream Flows

There are no instream flow requirements associated with this approximately 14-mile-long reach of the Clackamas River. Existing operations of the Oak Grove Powerhouse may subject this segment of the river to daily flow fluctuations resulting from power peaking operations. Daily flow fluctuations are most likely to occur when flow at Lake Harriet drops below 500 cfs, which is only about 12 percent of the time. In 1998, the difference in daily minimum and maximum flow from the Oak Grove Powerhouse was approximately 300 cfs 50 percent of the time (Wamser, 2000). During the summer (July and August), the Oak Grove Powerhouse discharge constitutes a large percentage of the overall flow in the Clackamas River (Figure 3.2.3.1-7). During runoff periods (December through May), powerhouse discharge constitutes a much smaller amount of the mainstem flow.

The current maximum upramping rate for the Oak Grove Powerhouse is 64 cfs per 5 minutes; there are no limits on downramping rates under current operations. Upramping and downramping rates have been just above 600 cfs per hour, but are more typically in the range of 100 to 200 cfs per hour (Wamser, 2001; Figures 3.2.3.1-8 and 3.2.3.1-9). Flow attenuation and inflow from a

number of other tributaries (e.g. Fish Creek, Roaring River, others) reduces the magnitude of the stage change of these flow fluctuations in lower portions of the reach. For example, when flows were dropped rapidly at the Oak Grove Powerhouse from ~ 530 cfs to ~ 400 cfs on August 15, 2001(Doughty, 2004). The corresponding reduction in stage at the Three Lynx gaging station was approximately 0.25 ft, whereas approximately 2-3 miles downstream the stage change was 0.22 ft. Farther downstream, the commensurate maximum decrease in stage was around 0.15-0.17 ft. In addition to this decreased drop in stage, the rate at which stage decreased also declined in the downstream direction: the rate of decrease in stage at sites 2 to 3 miles downriver was approximately 0.42 ft/hr (5 in/hr), whereas farther downstream the decrease was approximately 0.16 ft/hr (2 in/hr) (Doughty, 2004). Because of attenuation, current and future ramping operations would be expected to have greatest potential for adverse effects closest to the powerhouse, and decreasing potential in the downstream direction.

Flow fluctuations caused by operation of the Oak Grove Powerhouse may affect juvenile salmonids in the mainstem Clackamas River through stranding or availability of side channel habitat. Effects of ramping operations on juvenile outmigration are unknown. Radio telemetry studies suggest that adult coho stage near the Oak Grove Powerhouse during upstream migration, but given that the average holding time for 25 radio tagged coho at the Oak Grove Powerhouse was 7.5 hours in one study (PGE, 2001b), it is unknown if ramping operations affect passage delay at the powerhouse in a meaningful manner. Another concern has been temporary dewatering of redds and potential effects on spawning behavior. These effects have been studied to varying degrees, but not to the extent of demonstrating the magnitude of the effect. Doughty (2004) observed two stranded juvenile salmonids near the Three Lynx gage during the August 14-16, 2001 peaking study when flow was adjusted from 630 cfs to 400 cfs, however the spatial and population-level extents to which stranding occurs have not been studied.

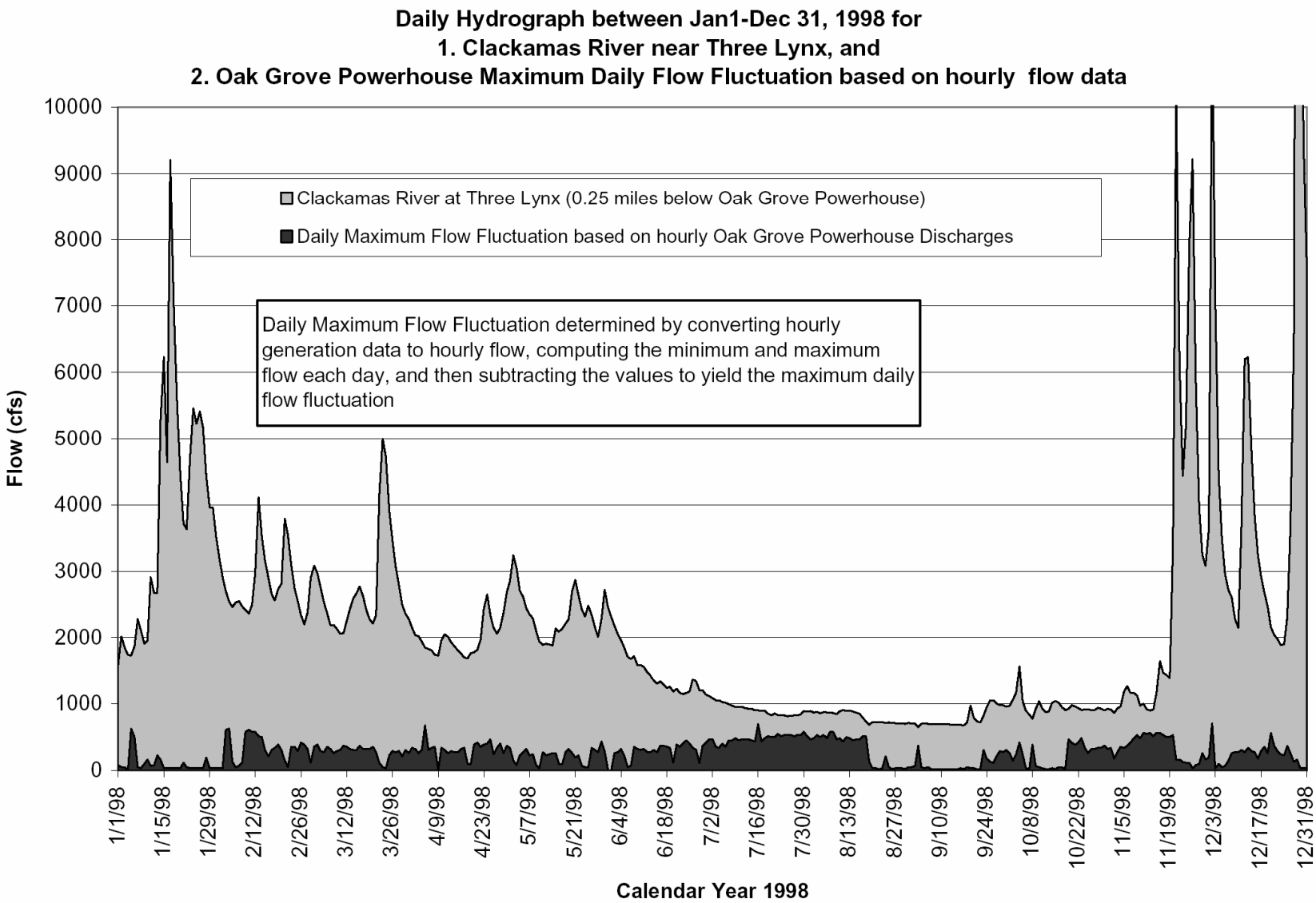


Figure 3.2.3.1-7. Instream flows - Clackamas River and Oak Grove Powerhouse discharge.

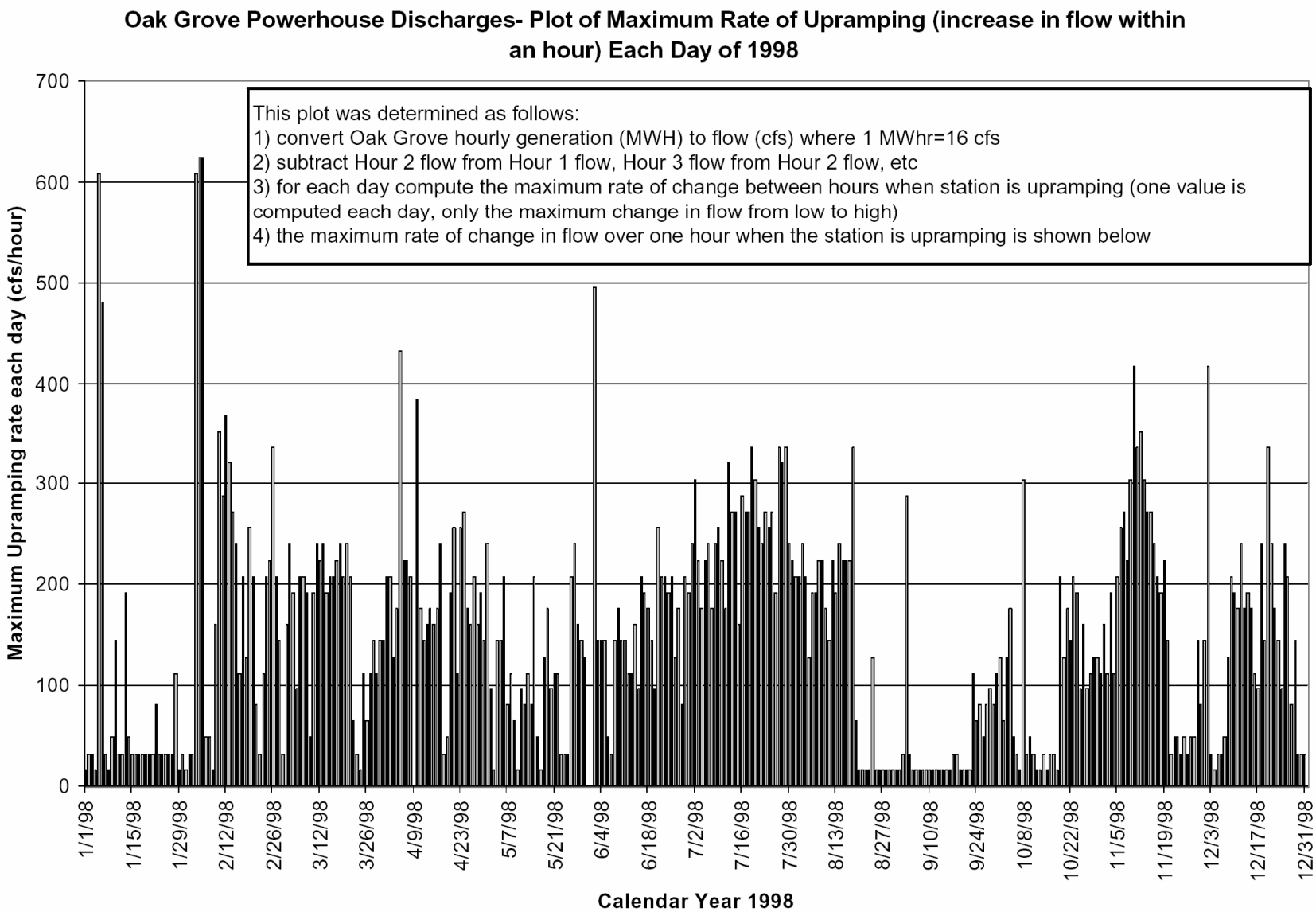


Figure 3.2.3.1-8. Oak Grove Powerhouse discharges- upramping rates.

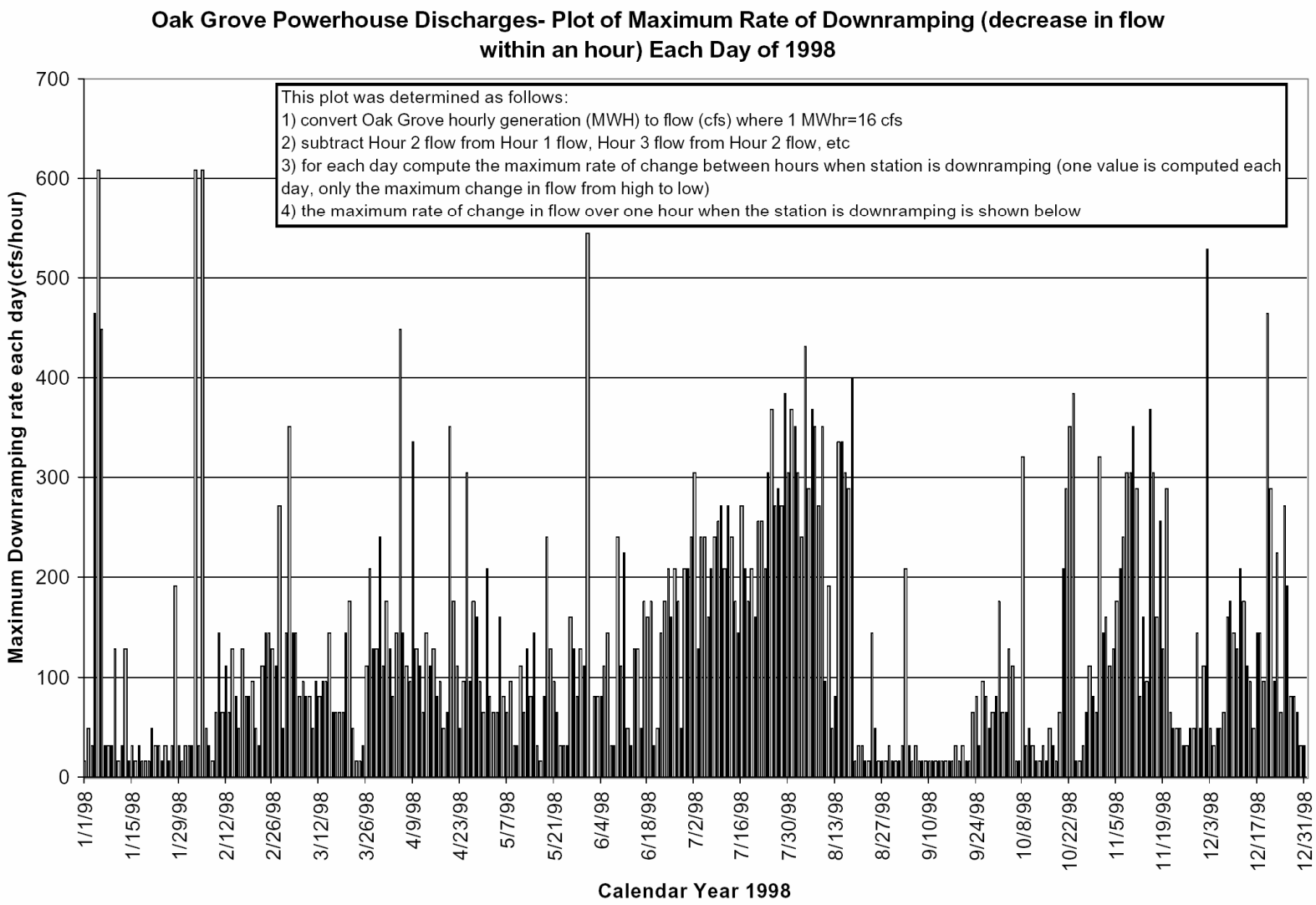


Figure 3.2.3.1-9. Oak Grove Powerhouse discharges- down-ramping rates.

Clackamas River from North Fork Dam to Faraday Diversion Dam (Reach 2C)

Watershed Processes

The Clackamas River downstream of the North Fork dam consists of a 1.5-mile-long impounded reach upstream of the Faraday Diversion dam. There is only about 500 feet of free-flowing river within this segment before backwater effects induced by the Faraday Diversion dam occur. The North Fork dam essentially eliminates upstream sediment supply and LWD recruitment to this segment of the river.

Physical Habitat Elements

The Clackamas River is confined within Reach 2C. Substrate is composed of large bed elements (primarily cobble and boulders) and bedrock. Habitat types consist primarily of slow moving, pool-type habitats created by the diversion dam. About 500 feet of riffle habitat connects the tailrace of the North Fork dam with the impounded waters from the diversion dam.

Instream Flows

There are no instream flow requirements or ramping rate restrictions within this 0.25 mile section of the Clackamas River extending below North Fork dam to the reservoir created by the Faraday Diversion dam. PGE has recently begun to operate the North Fork Development in a peaking mode by fluctuating reservoir levels by about up to 2 feet on a daily basis. This has resulted in daily flow fluctuations that in 1998 were more than 3,000 cfs on several occasions and were commonly greater than 700 cfs (Wamser, 2001). The fluctuations are reregulated with the Faraday Diversion pool.

Clackamas River from Faraday Diversion Dam to Faraday Powerhouse (Reach 2D)

Watershed Processes

The stretch of river downstream of the Faraday Diversion dam consists of an approximate 1.8-mile-long reach. Like the Clackamas River above the North Fork Reservoir, the reach is located within the Western Cascades Physiographic Province. All coarse sediment from upstream is trapped behind the North Fork dam. Water for the Faraday Powerhouse is diverted to Faraday Lake (Figure 3.2.3.1-10).

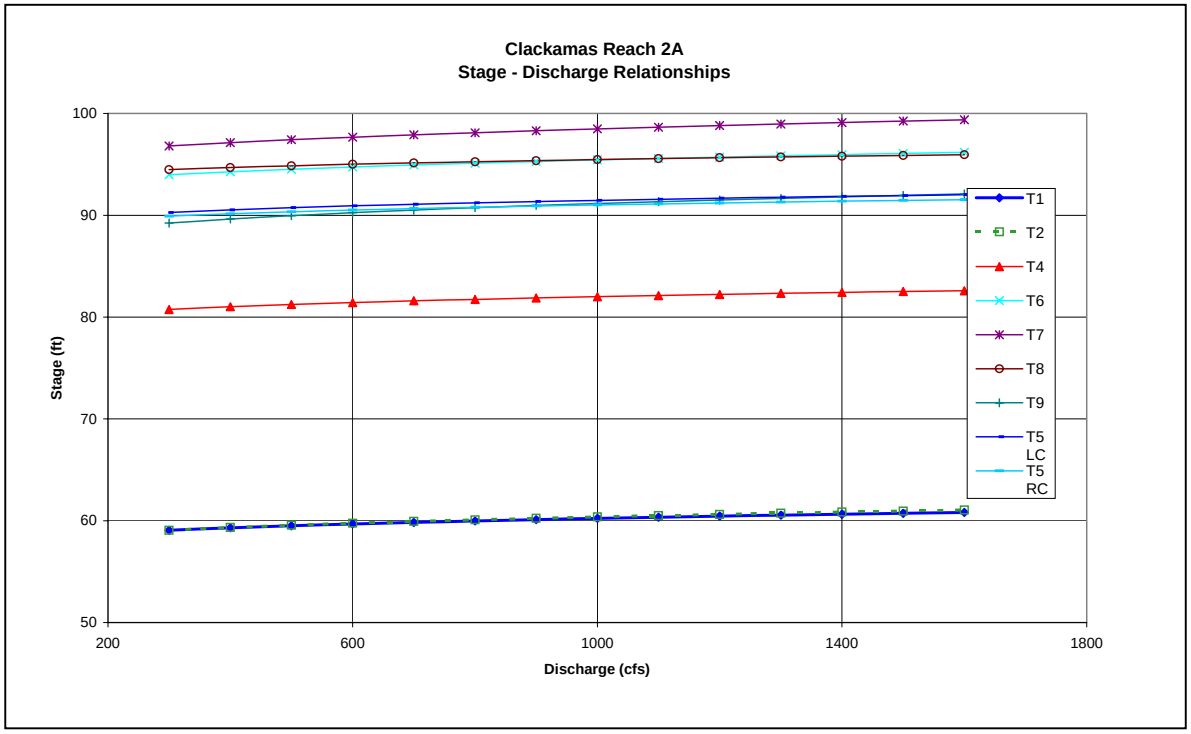


Figure 3.2.3.1-10. Stage-discharge relationship for Clackamas River reach 2A transects (From Doughty 2004).

Physical Habitat Elements

This section of river is composed predominantly of pool (45 percent) and riffle (27 percent) habitat types, with substrates dominated by boulder and cobble (54 percent) (Cramer et al., 1997). Several pools greater than 10 feet deep occur within the reach. There are four relatively steep (approximately 8 percent or greater) segments within the reach, one of which could result in potential upstream migration delay of adult anadromous fish. However, radio telemetry studies of coho and steelhead conducted as part of relicensing did not indicate any delay associated with these steep sections.

Instream Flows

Minimum instream flow releases of 50 to 90 cfs are required within this reach under current operations. However, PGE's general practice is to maintain a minimum instream flow of 120 cfs, which includes 43 cfs from the fish ladder as well as supplemental attraction flow released in the North Fork fish trap and at the diffusers near the fish ladder entrance. Following large spill events at North Fork

dam, the amount of flow passing Faraday Diversion dam is maintained for a period of 2 days post-spill as a 50:50 split in flow between the Faraday Canal and the Faraday Diversion dam. This action by PGE is designed to facilitate the downstream transport of any fish remaining between North Fork dam and the Faraday Diversion dam that may have entered the reach during spill over the North Fork dam.

Clackamas River from Faraday Powerhouse to River Mill Dam (Reach 2E)

Watershed Processes

The North Fork dam essentially eliminates upstream sediment supply and LWD recruitment to Reach 2E.

Physical Habitat Elements

This reach is nearly all impounded by the River Mill dam.

Lower Clackamas River Downstream of River Mill Dam (Reach 2F)

Watershed Processes

Sediment Production and Transport

Near Estacada, the Clackamas River emerges from the canyon and enters the broad valley dominated by the Willamette River. Sediment from the High Cascades and Western Cascades Physiographic Provinces, including glacial outwash from the last episode of glaciation, has collected within the Willamette Valley Physiographic Province (Wampler, 2003). In addition, a series of glacial outburst floods originating at Lake Missoula more than 10,000 years ago, sent huge volumes of sediment down the Columbia River, and backed up the Willamette and Clackamas Rivers, depositing over 10 feet of silt in some areas (Wampler, 2003). Thus, in Reach 2F the Clackamas River cuts through a series of weakly consolidated mudstones and alluvial deposits as it flows towards the Willamette River.

The three lower Project dams trap all of the bedload and much of the finer sediment that would otherwise be delivered to the lower Clackamas River. An estimated 269,000 tons of sediment are trapped each year behind the North Fork dam (McBain and Trush, 2002), and approximately 30 percent of this material is believed to consist of coarse bedload sediment (Wampler and Grant, 2003). Current sediment inputs between the North Fork dam and River Mill are smaller than that previously provided by fluvial transport, and originate from Holocene

terraces, bank erosion and, historically, spoils from the River Mill dam construction (Wampler and Grant, 2003).

Sediment storage within Reach 2F is believed to be reduced by current Project operations, although no quantitative bedload transport modeling has been completed to date, and Project effects are confounded by long-term changes in sediment transport resulting from fluctuating climatic and geological processes. The current net export of sediment from the 2-mile reach downstream of River Mill dam is estimated to be between 2,700 and 8,000 tons/year (Wampler and Grant, 2003). Channel incision and erosion of margin deposits was documented using topographic data, gage analysis and observations of root crowns (Wampler and Grant, 2003).

LWD Recruitment and Transport

In large alluvial rivers, both direct recruitment from stream banks and fluvial transport of wood from upstream can be major sources of LWD. Direct recruitment from banks via bank erosion or channel migration contributes entire trees with attached rootwads that can serve as key pieces that initiate debris jam formation (Abbe and Montgomery, 1996). Channel migration and avulsion remain common in some areas on the lower Clackamas River downstream of River Mill dam. At other locations, the natural tendency towards incision has resulted in the channel eroding deep "ruts" into the underlying mudstones, cutting deep pools, and fixing the channel in the same location for hundreds to thousands of years (Wampler, 2003). Channel incision following dam construction has resulted in the abandonment of some low-flow side channels in the 2-mile reach immediately downstream of River Mill dam (Wampler and Grant, 2003). Floodplain connectivity downstream is further restricted by the presence of levees and bank revetments.

Riparian stands adjacent to large alluvial rivers in the Willamette Valley Physiographic Province typically consist of mixed deciduous trees and conifers. Rural and agricultural development reduce LWD recruitment from streamside forests, particularly in the lower portions of Reach 2F. The dominant LWD input process in Reach 2A under current conditions appears to be lateral erosion.

Physical Habitat Elements

Trapping of bedload behind the North Fork, Faraday, and River Mill dams affects the availability of spawning gravel in the lower Clackamas River (Wampler, 2003). However, pockets of spawning gravel are still present, supplied by erosion of Holocene terraces (Wampler, 2003). Habitat surveys conducted in July 2000 found that cobble is the predominant bed material for the first 9.1 miles

of river downstream of River Mill dam, and boulder or bedrock is typically subdominant. Gravel accounts for around 5 to 15 percent of the material in riffles, except in the first 0.8 miles below the dam, where only 1 percent of the substrate consists of gravel. The bed material of the river downstream of about River Mile 14 consists primarily of gravel and cobble.

Pool habitat accounts for about 20 percent of the total habitat area downstream of River Mill dam, but pool frequency is low (Cramer and Associates, 2001). Pools tend to be large, very deep (up to 28 feet at low flow) and formed by bedrock. Data from similar large alluvial rivers suggest that LWD (if present) can play an important role in pool formation (Collins et al., 2002).

Wampler (2004) completed a reconnaissance evaluation of LWD in the lower Clackamas River. That study concluded that large wood is contributed to the lower Clackamas River by lateral erosion during floods, mass wasting, and fluvial transport from the upper watershed (Wampler, 2004). An analysis of LWD loading over a time series of aerial photographs suggests that large floods significantly increase the amount of in-channel LWD. Under current conditions, wood from the upper watershed must pass North Fork, Estacada and River Mill dams. In the absence of the Project dams, much of that wood would eventually be transported into Reach 2A.

A wood count conducted based on aerial photos from 2000 documented approximately 8.1 pieces of LWD per mile between RM 8 and RM 23.5 (Wampler, 2004). LWD loadings in the same section of river in 1997, following the 1996 flood were similar (7.1 pieces per mile). However, a large increase in the amount of LWD in the lower Clackamas River was observed following the 1964 flood.

Instream Flows

PGE provides a minimum flow of 300 cfs and at most times 500 cfs below the River Mill dam. This release is to ensure an adequate supply of water for pumps at the ODFW Clackamas River Hatchery and to meet requirements of downstream water providers (PGE, 2001a). There are no upramping or downramping restrictions, although prior to 1999, for downstream safety considerations PGE voluntarily operated with a maximum ramping rate of 360 cfs per 10 minutes (PGE, 2001a). In 1998, daily upramping and downramping rates have been as high as 1,200 cfs per hour, but are more commonly in the range of 180 to 190 cfs per hour (Figures 3.2.3.1-11 and 3.2.3.1-12).

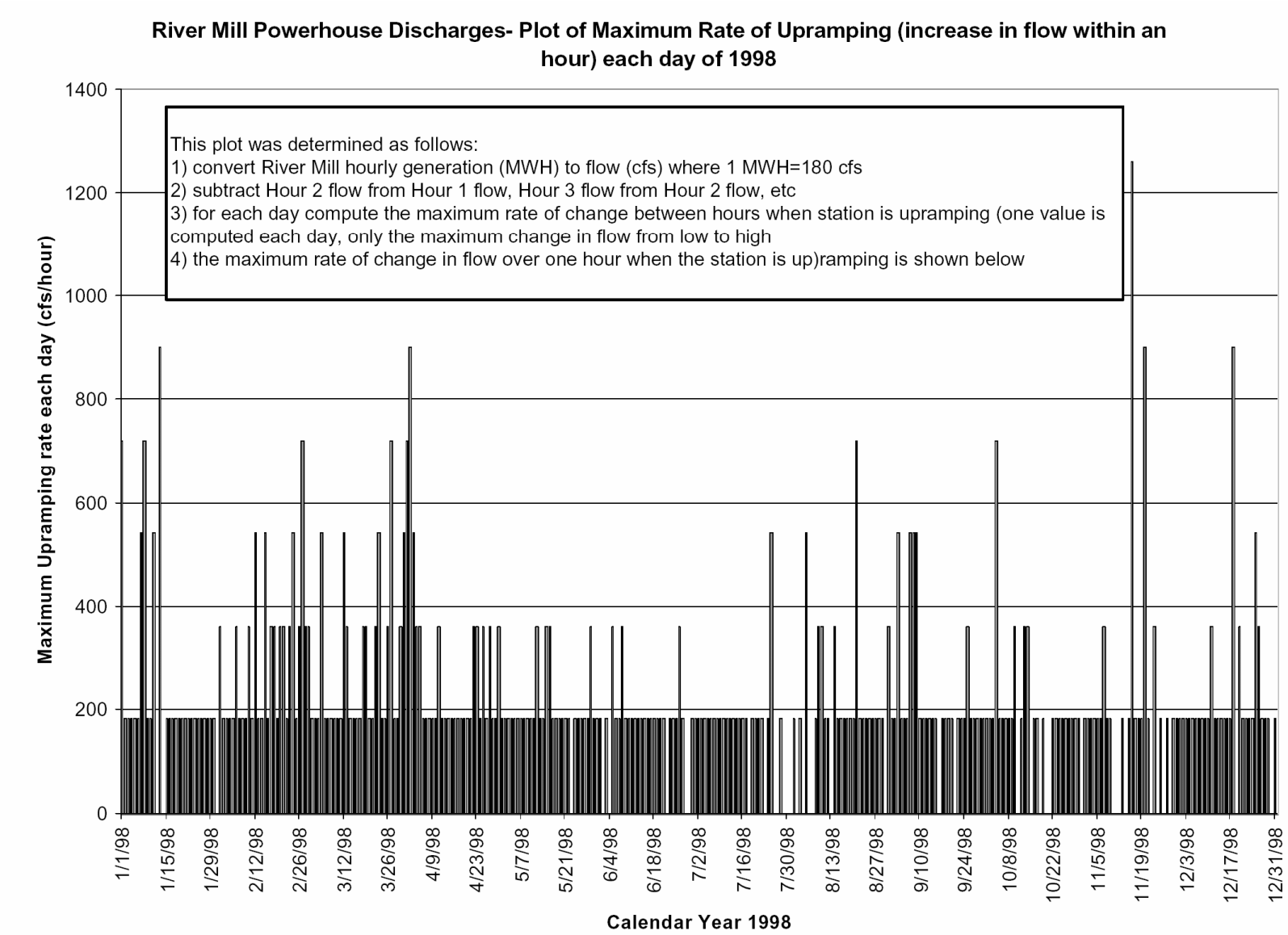


Figure 3.2.3.1-11. River Mill Powerhouse discharges- upramping rates.

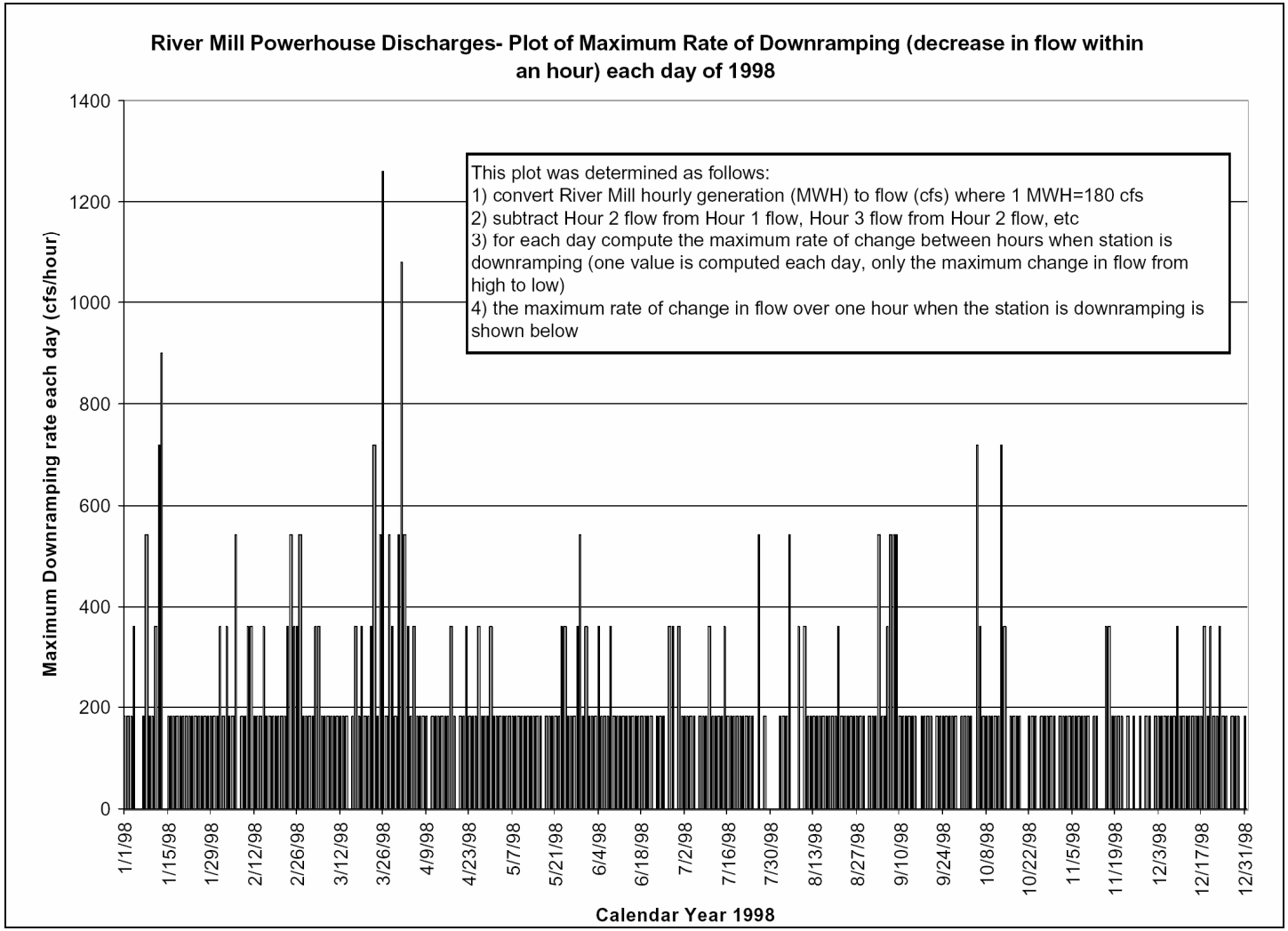


Figure 3.2.3.1-12. River Mill Powerhouse discharges- down-ramping rates.

3.2.3.1.3 Benthic Invertebrates

The relative abundance and diversity of aquatic invertebrates are indicators of water quality and aquatic ecosystem health. Aquatic invertebrates are also the primary food source for trout and juvenile salmonids, and are thus used to describe the status of the food base for important fish populations. However, unlike trout and salmon, most aquatic invertebrates in streams and rivers live on or within the bottom of the stream. Therefore, an increased amount of flow does not always mean an increased amount of available habitat if the extent of wetted channel does not appreciably increase as well. Increased flow can result in increased habitat for some benthic invertebrates if the flow maintains wetted side channels or edge habitat that would otherwise be dry at lower flows, or creates hydraulic conditions (e.g. water velocity) that are more conducive to certain invertebrate production. Repeated fluctuations in discharge as a result of peaking operations and ramping rates can result in decreased invertebrate diversity, typically from the exclusion of long-lived species or poor colonists (Hershey and Lamberti, 1998). Increased stream flow can also affect benthic invertebrates indirectly if it affects water temperatures, scour or deposition of gravel, or flushing or input (from bank erosion) of fine sediments. In addition, reservoirs act as a sink for the downstream transport of detritus, often reducing the food source for invertebrate shredders in quiescent habitats downstream (those that feed on coarse particulate organic matter such as tree leaves). The abundance of shredders in the tailrace reaches of the Oak Grove Fork and Clackamas rivers are predicted to be low regardless of operations affecting discharge, peaking, or ramping rates given the limited likelihood of large leaf litter concentrations in these swifter currents.

As part of PGE's relicensing studies, stream benthic communities were sampled at 44 stations within the Project area at different times (Aquatic Biology Associates (ABA) & EES Consulting (EES), 2004). Reach specific benthic invertebrate conditions are described below in section 3.2.3.1.2, Aquatic Habitat Conditions.

Oak Grove Fork

ABA & EES (2004) noted that within the entire Oak Grove Fork, total invertebrate abundance for samples varied widely between the margin habitat, shallow riffles, and in the deep riffles. Aquatic invertebrate abundance in the Oak Grove Fork at the three sampling stations upstream of Timothy Lake was high; taxa richness was moderate. Invertebrate communities in this section of the Oak Grove Fork and other headwater tributaries flowing into Timothy Lake were dominated by cold-water biota.

Comparisons of invertebrate community composition just upstream of Timothy Lake with those in the immediate area of the Timothy dam tailrace revealed that:

- Similar taxa were present above Timothy Lake and in its tailrace.
- While abundance of intolerant taxa was lower in the tailrace than upstream, taxa richness was the same at both sites, and both were indicative of high water quality without impairment both up- and downstream.
- Total and EPT (Ephemeroptera, Plecoptera, and Trichoptera or mayfly, stonefly, and caddisfly species, respectively) taxa richness was moderate above the reservoir and in the Timothy tailrace.
- The proportion (percent) of tolerant taxa was somewhat higher in the tailrace.
- Filterers accounted for a small proportion of the community both above & below Timothy Lake.
- Scraper abundance was higher in the tailrace, and was attributed to abundant algae that provides a food source in this area.
- Long-lived taxa abundance was lower in the tailrace but taxa richness was similar.
- Deep release of water from the reservoir and groundwater accretion likely contribute to the maintenance of cold-water biota downstream of the dam.

The Oak Grove Fork drops about 1,000 feet in elevation over 10 miles between Timothy Lake and Lake Harriet. Aquatic invertebrate community richness peaks at the station just above Lake Harriet, where 80 taxa occurred in the deep riffle habitat, with 45 of these being EPT taxa that are indicative of good water quality. ABA & EES (2004) concluded that the invertebrate community in the Lake Harriet dam tailrace was impoverished due to the lack of flow below the dam. However, within the five miles of bypass reach below Lake Harriet, values of most indicators recovered (due to tributary inflow and groundwater accretion) to levels comparable to those upstream of Lake Harriet; intolerant taxa richness and abundance showed less recovery than other invertebrate metrics. The invertebrate fauna (i.e., species composition) found above and below Lake Harriet was generally the same except for a few taxa and taxonomic groups: flatworms, segmented worms, intolerant snails, crustaceans, and intolerant stoneflies; however, these faunal differences do not reflect water quality (as opposed to water quantity) impairment.

Clackamas River

ABA & EES (2004) subdivided the Clackamas River into three reaches: 1) upper - above the confluence with the Collawash River; 2) middle - from the Collawash River to River Mill dam; and 3) lower - downstream of River Mill dam.

Major trends reported by ABA & EES (2004) concerning the invertebrate communities found in these locations include:

- Moderate invertebrate densities occur in riffle habitats throughout the mainstem, indicating low levels of nutrients.
- Invertebrate assemblages in river margin cobbles (dominated by chironomids – midges) differed from those in riffles throughout the river.
- Most fauna collected are widespread and commonly found in western North America.
- While species richness (a measure of diversity) richness decreased in a downstream direction for most categories of taxa from the upper and middle river upstream of North Fork Reservoir, invertebrate abundance for most taxa increased, particularly for the more tolerant species.
- Intolerant taxa (cold water biota) richness and abundance were greatest in the upper Clackamas River and declined downstream to low levels just upstream of mainstem impoundments. Abundance and richness of intolerant taxa were near zero in the lower river except for a single intolerant species that was abundant in the Faraday bypass reach.
- The proportion (percent) of communities dominated by tolerant taxa (warm water biota) increased in a downstream progression for the upper river and generally peaked in riffles upstream of North Fork Reservoir.
- Changes in metric values appear to be either consistent with natural longitudinal trends or within the range of variation seen at stations in the vicinity above and below the Oak Grove Powerhouse.

Potential trends in the benthic invertebrate communities in the Clackamas River that are likely associated with existing PGE's reservoirs and operations include:

- PGE impoundments influence downstream dispersal of certain components of the benthic invertebrate community, particularly intolerant mayflies, stoneflies and true flies.
- River margin habitat in the mainstem dam tailraces and Faraday bypass channel supports high densities of benthic invertebrates, dominated by more tolerant taxa, principally certain chironomid midges, than river margins above and below the impoundment area.
- Coolwater releases from some of PGE's Project facilitates appear to extend the distribution of certain intolerant taxa (an indicator of good water quality) further downstream through the Project area and River Mill tailrace than would occur naturally. The opposite is true for some of the more tolerant taxa due to

generally nutrient poor releases low in particulate matter, which impedes colonization of tolerant filtering taxa.

- *Nostoc*, a bluegreen algae, and the midge that lives in it, occasionally occur within the Faraday bypass channel. Both the algae and midge are intolerant of warm water, and both were more abundant in the upper river.
- Abundance of several taxonomic groups in Timothy, North Fork, Faraday and River Mill tailraces was low, ostensibly due to multiple factors including high water velocities in tailraces where the channel is naturally constricted, cool water temperatures resulting from bottom withdrawal from North Fork Reservoir, and a disruption of downstream drift. Abundance generally increased downstream of River Mill dam near McIver Park.

Several species of rare, sensitive, Federal Species of Concern (additional information needed to support a proposal to list under the Endangered Species Act), and species listed in the Oregon Record of Decision (ROD) were found in springs and tributaries draining to the Project area (FPA, 2000). Each species is relatively restricted to specialized habitats, such as springs and high elevation streams. *Lyogyrus new species #1* (Columbia dusky snail), which is currently listed as a Record of Decision, Survey and Manage aquatic invertebrate (ROD, 1994), is common to abundant in the Upper Oak Grove Fork. Controlled flow and constant cool temperatures in the Timothy Lake tailrace favor this species. The Columbia dusky snail was found throughout the Oak Grove Fork and in the mainstem Clackamas River but only in one of the sampling sites where it was observed in deep water downstream of the Oak Grove Powerhouse. Populations appear to be quite secure throughout the basin. More broadly, the Columbia dusky snail is known to occur very sporadically in the central and eastern Columbia Gorge, Washington and Oregon and is reported to be restricted to springs and spring outflows with cold, well oxygenated water in shallow, slow flowing water with no macrophytes (Furnish and Monthey, 1998).

The Cascades apatanian caddisfly is generally restricted to high elevation (>2,000 ft) stream habitats in the Oregon Cascades (FPA, 2000). Because species level taxonomy is based on the adult stage, positive species identification was not possible for the aquatic (larval) samples (FPA, 2000). Likely specimens of Cascades apatanian caddisfly were found in only two sampling sites in Oak Grove Fork: in margin habitats at the tailrace of Timothy Lake and near the mouth of the river. The Cascades apatanian caddisfly was absent in all of the Clackamas River sampling sites downstream of the mouth of Oak Grove Fork, although it was observed in two sites (margin habitats) upstream of Oak Grove Fork.

3.2.3.1.4 *Water Quality - Water Temperature, Dissolved Oxygen, and pH*

This section presents information on three water quality parameters (temperature, dissolved oxygen (DO) and pH) that are important to the protection and propagation of aquatic biota and, in particular, important to fishery resources (anadromous and resident salmonids) that may be influenced by the Clackamas River Hydroelectric Project. Two of the parameters, water temperature and DO are often closely linked to streamflow conditions and hence can be affected by changes in flow regime resulting from the Proposed Action.

With respect to temperature, salmonids are coldwater fish that require specific ranges of temperature for different life history stages including migration, spawning, egg incubation, and juvenile rearing (See Bjornn and Reiser, 1991). Temperatures that exceed these ranges can result in migration delays, decreased egg survival, and reduced growth. Benthic macroinvertebrates which are an important food source for fish are likewise influenced by water temperatures; certain taxa are more or less tolerant of various temperature ranges. Thus, changes in the thermal regime of rivers resulting from flow regulation can result in changes in the suitability of habitats to support fish and other aquatic biota.

Dissolved oxygen is linked to water temperature (colder water can contain higher DO concentrations than warm water) and can likewise be affected by changes in flow regime. Salmonids require relatively high concentrations of DO (>80 percent saturation; >5 mg/l; Bjornn and Reiser, 1991) to support migration, spawning, and rearing activities. Many benthic invertebrates likewise rely on oxygen rich waters. In general changes in flow regime can affect DO concentrations in two ways; a) via temperature change resulting in changes in DO saturation levels; or b) via changes in re-aeration due to low flows and reduced turbulence and mixing of atmospheric air.

The pH of water is a measure of its concentration of hydrogen ions. Low pH values indicate high concentrations of ions or acid conditions. High pH values (>9) are associated with hydroxide ion concentrations, or basic conditions. The general range of pH considered to be harmless to freshwater aquatic biota is from pH 6.5 to 9.0 (EPA, 1987). Flow induced shifts in pH may result from changes in algae composition and production which influence hydrogen and hydroxide levels in the water.

This section presents the existing conditions relative to water temperature, DO, and pH, and provides the basis for comparisons with conditions resulting from the Proposed Action. The existing conditions as simulated using the CE-QUAL-W2 model developed by Battelle (2003, 2004a) are summarized by reach. The output values of water temperature, DO, and pH derived from runs of the

model are analyzed and summarized in Appendix A. That appendix contrasts both the existing condition and the two alternatives in comparison with ODEQ's most recent water quality criteria revisions for the three parameters. ODEQ's water quality criteria are dependent both on the particular reach and salmonid life-stage activity.

The water quality criteria values against which the alternatives were compared are shown in Table 3.3.2.1-6. The table contains the anadromous salmonid rearing and spawning criteria for each of seven reaches as designated in an ODEQ comment letter dated December 23, 2003 (A. Newell letter, 2003). The current water quality analysis separates the Project area into the same reach designation as defined by ODEQ. Table 3.2.3.1-7 provides a comparison between the ODEQ water quality standards reaches to the Clackamas River hydroelectric Project reaches.

Numerical values for the percent exceedance of each applicable water quality criterion for temperature and DO were determined from cumulative frequency figures shown in Appendix A and are summarized for each reach in the sections below. For the river reaches, exceedances are measured as the percentage of the 7-day average-daily-maximum (7DADM) for temperature greater than the criteria values for each life-stage activity in each reach. For DO, exceedances are the percentage of the hourly DO values that fall below the respective criteria in Table 3.2.3.1-6.

The ODEQ water quality criteria for anadromous salmonid life-stages were established with the goal of achieving optimum conditions in Oregon streams and rivers for the protection, propagation and growth of threatened or endangered species. Exceedance of protective criteria values does not necessarily mean that such populations can not survive and prosper. The technical advisory committee convened to review the new criteria for temperature (TAC, 2003) found that 18°C was as protective of salmonid rearing as 16°C. The TAC found that although the 16° criterion is protective of "core rearing" habitat values, core rearing habit values are not actually being used to determine where this use should be designated. They also found that application of 18°C as a 7-day average maximum is protective of salmonid rearing because if 18°C were applied as a 7-day average maximum to the warmest (furthest downstream) rearing habitat, colder habitat will be available upstream. The TAC also found that 14°C was highly protective for spawning compared to the 13°C criteria adopted. Moreover, an EPA technical advisory committee (EPA, 2001) reviewing salmonid temperature tolerance literature while establishing ESA-related water quality criteria listed continuous exposure temperatures (5-day) of 20 to 22°C as lethal threshold for juvenile salmonids.

Table 3.2.3.1-6. ODEQ standards for temperature, dissolved oxygen, and pH.

Reach	Rearing				Spawning			
	Period	Temp (˚C)	DO (mg/L) [1]	pH	Period	Temp (˚C)	DO (mg/L) [2]	pH
Oak Grove Fork between Timothy Lake and Barrier Falls	Jan – Dec	16	8	6.5-8.5	NA	NA	NA	NA
Oak Grove Fork from Barrier Falls to Mouth	Jan – Dec	16	8	6.5-8.5	Sep 1 – Jun 15	13	11	6.5-8.5
Clackamas Mainstem from Oak Grove Fork to Clear Creek (Excluding North Fork Reservoir and Estacada Lake)	Jan – Dec	16	8	6.5-8.5	Sept 1 – Jun 15	13	11	6.5-8.5
Fish Ladder	Jan – Dec	16	8	6.5-8.5	NA	NA	NA	6.5-8.5
North Fork Reservoir	Jan – Dec	16	8	6.5-8.5	Jan 1 – Jun 15	13	11	6.5-8.5
Estacada Lake	Jan – Dec	16	8	6.5-8.5	Sep 1 – May 15	13	11	6.5-8.5
Mainstem Clackamas from Clear Creek to the Mouth	Jan – Dec	18	8	6.5-8.5	Oct 15 – May 15	13	11	6.5-8.5

[1]Note that if physical conditions inhibit the ability to meet the rearing DO criterion, the applicable criterion is 90 percent saturation
[2]Note that if physical conditions inhibit the ability to meet the spawning DO criterion, the applicable criterion is 95 percent saturation

Table 3.2.3.1-7. Water quality standard reach and Project reach comparison.

ODEQ Water Quality Standards Reach Designation	Stream	Clackamas River Hydroelectric Project Reach Definition
Oak Grove Fork between Timothy Lake and Barrier Falls	Oak Grove Fork	1B, 1C, 1D, 1E, & 1F
Oak Grove Fork from Barrier Falls to Mouth	Oak Grove Fork	1G
Clackamas Mainstem from Oak Grove Fork to Clear Creek (Excluding North Fork Reservoir and Estacada Lake)	Clackamas River	2A, 2B, 2C, 2D, 2E, & 2F
North Fork Reservoir	Clackamas River	2B
Estacada Lake	Clackamas River	2E
Mainstem Clackamas from Clear Creek to the Mouth	Clackamas River	Below Project, not defined

The 7-day mean minimum criteria have been as low as 6.5 mg/L (EPA, 1987), suggesting the ODEQ criteria of 8 mg/L is highly protective. Since 7DADM values are used for temperature comparisons to criteria and average daily minimum DO values are used, temperatures less than criteria or DO levels greater than the criteria are by definition experienced by fish in the daily diurnal cycle that occurs in natural streams and rivers. Therefore, where differences in exceedances of a few percent of protective water quality criteria occur between operational alternatives, they are not likely to be of biological significance to the populations in question.

Table 3.2.3.1-8 summarizes the exceedance values for the Oak Grove Fork and Clackamas River. The absence of continuous water quality monitoring data or CE-QUAL-W2 modeling output for the fish ladder, North Fork reservoir and Estacada Lake precluded analyses similar to those for the Oak Grove Fork and Clackamas River reaches.

Oak Grove Fork from Timothy Dam to Barrier Falls

The 7DADM temperatures in the Oak Grove Fork from Timothy dam to Barrier Falls range from 3°C to 12.4°C. The <1 percent exceedance of the rearing criterion for existing conditions is not likely of biological significance. DO concentrations in this reach range from 5.8 mg/L to 12.8 mg/L and have an exceedance of the rearing criterion of 9.0 percent. It was noted in section 3.2.2.2. that the Howell-Bunger valve on the Timothy Lake dam was not operational during part of the data monitoring period, with the concern that modeling based on that data may not accurately reflect the beneficial increase in downstream DO its

use would provide. PGE continues to work with the agencies to address water quality issues and obtain the water quality certification for the Project.

Table 3.2.3.1-8. 7DADM temperature and dissolved oxygen exceedance of the rearing and spawning criteria for existing conditions.

Reach	7DADM Temp (˚C)		Water Column Dissolved Oxygen (mg/L)	
	Rearing (% Exceedance)	Spawning (% Exceedance)	Rearing (% Exceedance)	Spawning (% Exceedance)
Oak Grove Fork between Timothy Lake and Barrier Falls	0.6	NA	9.0	NA
Oak Grove Fork from Barrier Falls to the Mouth	0.8	8.2	0	40.3
Clackamas Mainstem from Oak Grove Fork to Clear Creek	17.5	14.3	0	26.1
Mainstem Clackamas from Clear Creek to the Mouth	19.6	20.5	0	32.2

Oak Grove Fork from Barrier Falls to Mouth

The 7DADM temperatures in the Oak Grove Fork from Barrier Falls to Mouth range from 3.7°C to 16.2°C. The <1 percent exceedance of the rearing criterion for existing conditions is not likely of biological significance. An 8.2 percent exceedance of spawning temperature was associated with the existing condition scenario and is likely directly related to the lack of any instream flow release from Lake Harriet under existing conditions.

DO concentrations in this reach range from 9.3 mg/L to 12.9 mg/L with no DO values less than the 8.0 mg/L rearing criterion. However, DO concentrations during the spawning period are frequently below the required 11 mg/L with an exceedance value of 40 percent. However, this exceedance value is based on a criterion of 11 mg/L and does not take into account periods when this concentration is unattainable due to temperature or barometric pressure

limitations. Bjornn and Reiser (1991) suggested that with respect to salmonid egg incubation, DO concentrations should be at or near saturation, with temporary reductions no lower than 5.0 mg/L.

Clackamas River from the Oak Grove Fork to Clear Creek (excluding North Fork Reservoir and Estacada Lake)

Both the rearing and spawning temperatures are exceeded a moderate amount of time; 17.5 percent for rearing and 14.3 percent for spawning.

No DO values less that 8.0 mg/L occurred year-round in this reach for existing conditions. DO spawning criteria are frequently exceeded with an exceedance value of 26.1 percent.

North Fork Reservoir

Continuous daily temperature monitoring or modeled data are unavailable for North Fork Reservoir, precluding exceedance frequency analysis. However, quarterly vertical profiles of temperature are available and shown in section 3.2.2.1. Vertical temperature profile figures in this section show that they are in compliance with the 16°C rearing criteria in the spring, fall and winter data sets. During summer profiles (7/18/2000 and 8/16/2001) surface water temperatures reached approximately 19°C and 21°C, respectively. Deeper waters remained below 16°C at depths greater than approximately 20ft. in July 2000 but remain above 17°C at all depths in August 2001, providing colder habitat refugia for any anadromous or resident juveniles.

While it is doubtful that any substantial spawning takes place in the reservoir, temperatures remained below the 13°C spawning criteria in October and December of 2000 and in April of both years of monitoring.

The available profile data for DO presented in figures in section 3.2.2.1 show values greater than 8 mg/L throughout the vertical profiles for all monitoring months. Spawning criteria of 11 mg/L were met throughout the water column in the October through April profile data for DO.

Estacada Lake

Continuous daily temperature monitoring or modeled data are unavailable for Estacada Lake, precluding exceedance frequency analysis. However, quarterly vertical profiles of temperature are available and shown in section 3.2.2.1. These figures show that temperatures are in compliance with the 16 C rearing criteria in the spring, fall and winter data sets. During summer profiles (7/18/2000 and

8/16/2001) surface water temperatures reached approximately 17°C and 19°C, respectively. Deeper waters remained below 16°C at depths greater than approximately 20 ft. in July 2000 and 55ft in August 2001, providing colder habitat refugia for any anadromous or resident juveniles.

While it is doubtful that any substantial spawning takes place in the lake, temperatures remained below the 13°C spawning criteria in October and December of 2000 and in April of both years of monitoring.

The available profile data for DO shows values greater than 8 mg/L throughout the vertical profiles for all monitoring months.

Spawning criteria of 11 mg/L were met throughout the water column in the October through April profile data for DO.

Clackamas River from Clear Creek to Mouth

The 7DADM temperatures in the reach of the Clackamas River from Clear Creek to the Mouth range from 3.4°C to 21.4°C and exceed the rearing and spawning criterion by 19.6 percent and 20.5 percent, respectively.

No DO values less that 8.0 mg/L occurred year-round in this reach for existing conditions. However, during the spawning period, DO concentrations are often less than the criterion with an exceedance value to 32.2 percent.

3.2.3.1.5 Existing Upstream Fish Passage Facilities And Programs

Two fish ladders facilitate upstream passage at the Project. The River Mill Fish Ladder provides passage over River Mill dam into Estacada Lake and the Faraday-North Fork Fish Ladder provides passage over both Faraday Diversion dam and North Fork dam. The River Mill Fish Ladder was originally constructed in 1912, was rebuilt with some modifications in 1972, and rebuilt again in 2006 as part of ESA consultation that was occurring independent of the Project relicensing process. Prior to the 2006 rebuild the ladder did not meet NMFS or ODFW design criteria.

A natural 20-foot high waterfall located approximately one mile downstream of Lake Harriet dam blocks access to the remainder of the Oak Grove Fork by anadromous fish. There are no upstream fish passage facilities at either the Lake Harriet or the Timothy Lake dams. Thus, these facilities only block the upstream passage of resident fish in the Oak Grove Fork.

Flows in the Faraday diversion reach are maintained at about 120 cfs unless the river flows are higher than the capacity of the Faraday powerhouse. Upstream migration rates in this section of river are lower than in other reaches. Upstream migrants will continue to experience minor delays due to false attraction of the Faraday powerhouse as well as more significant delays, possibly related to elevated water temperatures, in the Faraday/North Fork Fish Ladder.

Upstream fish passage issues of concern within the Project area are summarized in Table 3.2.3.1-9.

3.2.3.1.6 Existing Downstream Fish Passage Facilities and Programs

The dams on the Oak Grove Development are not equipped with any fish screens to protect resident fish. However, the intake trash rack at Lake Harriet has narrow spacing (1 5/16 inches) that excludes larger adult fish. Entrainment studies were conducted at Timothy Lake and Lake Harriet in 2000, 2001, and 2002 (Shibahara and Filbert, 2003). These studies indicate that salmonids are entrained at Timothy Lake and these fish suffer high rates of injury and mortality as they pass through the Howell-Bunger valve. The majority of the entrained salmonids were kokanee. The study results suggest that few native cutthroat trout are entrained. At Lake Harriet, salmonids are also entrained and move downstream into Frog Lake. Although few cutthroat trout were captured in the studies, it is not known whether the low numbers represent low entrainment levels or whether the entrained cutthroat are heavily preyed upon by large resident brown trout in Frog Lake.

The primary downstream fish passage facility at the mainstem Project is the collection and bypass system that is located at North Fork dam. The collection system utilizes 245 cfs of attraction water to direct the downstream migrants into the Faraday/North Fork adult fish ladder. A separator facility located near Faraday Diversion dam concentrates the downstream migrants into a 20-inch bypass pipe that delivers them to the tailrace of River Mill dam.

Table 3.2.3.1-9. Summary of upstream passage issues and current conditions by Project reach.

Reach	Upstream Passage Issue	Current Conditions
River Mill dam	Passage through existing ladder	Outside of FERC relicensing, new ladder will be constructed by 2005 to improve passage conditions.
Faraday Powerhouse	False attraction from powerhouse flows.	Radio telemetry studies (Shibahara et al., 2001; Shibahara, 2002) indicate that coho and steelhead median holding times in the Faraday tailrace were 4.5 and 15.4 hours, respectively.
Faraday Diversion Reach	Shallow flow depth due to the low flows in the diversion reach (120 cfs). Water temperatures higher than Faraday Powerhouse discharge.	Radio telemetry studies (Shibahara et al., 2001; Shibahara, 2002) suggest that migration rates of coho through this reach are lower than other sections of river while steelhead pass rapidly. No studies have been completed for Chinook, some of which occupy the diversion reach during the warm summer months
Faraday/North Fork Ladder Entrance	Migration delays at ladder entrance	Radio telemetry studies (Shibahara et al., 2001; Shibahara, 2002) indicate that coho and steelhead median holding times near the fish ladder entrance were 4.5 and 2.2 days, respectively
Oak Grove Powerhouse	False attraction from powerhouse flows	Radio telemetry studies (Shibahara et al., 2001; Shibahara, 2002) indicate median holding times at the powerhouse discharge of less than 1 hour for coho and steelhead.
Lake Harriet	No upstream passage provided	A natural barrier one mile below Lake Harriet prevents anadromous access to Upper Oak Grove Fork. Lake Harriet dam precludes upstream passage of resident fish. Impacts to resident stocks is unknown.
Timothy Lake	No Upstream passage provided	A natural barrier one mile below Lake Harriet prevents anadromous access to Upper Oak Grove Fork. Impact of dam passage barrier on resident cutthroat trout causes a barrier to exchange of genetic material between the two isolated populations.

Numerous PIT tagging studies have been conducted since 1995 to evaluate the effectiveness of the North Fork collection bypass system. Based on the results of these studies, Beamesderfer et al. (2002) concluded that the effectiveness of the system in collecting actively migrating Chinook, coho, and steelhead averaged 51 percent, 72 percent, and 92 percent, respectively. In contrast, radio telemetry studies have suggested significantly higher collection effectiveness especially for Chinook based on fish entering the upstream end of the existing North Fork outmigrant bypass collection system (Karchesky et al., 2003, 2004). However, counts at the separator in the North Fork ladder using radio telemetry found similar results to those based on PIT tags that are counted just downstream of the separator. None of the test data have been normalized by any controls and handling is likely an issue especially for Chinook. Consequently, the low effectiveness for Chinook could be partially related to mortalities associated with handling. For effectiveness measured at the separator, another possibility is predation within the fish ladder. The average transit time from the upstream end of the system to passing the separator was 9.1 days for radio tagged Chinook compared to 1.7 days for coho and 2.7 days for steelhead (Bullock and Cramer, 2003). Consequently, the Chinook are exposed to potential predation for three to five times longer than the other species. For that study, 68 Chinook were radio-tagged and released in North Fork forebay. Forty-seven (47) of those were detected entering the bypass system while only 24 were detected at the separator (69 percent bypass effectiveness measured at bypass entrance, 35 percent at separator). While the cause of this difference is unknown, mortality within the fish ladder (due to delayed handling mortality, predation, or other causes) is a possible cause.

Those fish that do not enter the North Fork bypass system either pass through the turbines, through the spillway, or do not pass downstream. Gunsolus and Eicher (1970) conducted turbine mortality tests at North Fork using coho juveniles. They estimated that the mortality rate for those tests was between 25.5 percent and 31.6 percent. Gunsolus and Eicher also report spillway mortality tests that suggest that the spillway mortality is between 0 and 8 percent. Those tests were conducted at high river flows (13,000 to 25,000 cfs). More recent tests with spill of 700 to 2000 cfs (Heisey et al., 2001) suggest spillway mortality rates ranging from 12 percent to 20 percent for Chinook and coho. Mortality rates for steelhead ranged from 4 percent to 14 percent.

Attempts to assess the influence of turbine discharge or spill on passage route selection have been inconclusive. However, limited available data suggest that Chinook passage through turbines is relatively low when flows are low (Timko et al., 2001), but could increase significantly when river flows exceed 3,000 cfs (Karchesky et al, 2003). Tests in the fall of 2003 suggest that at

relatively high powerhouse discharge, 80 percent of the Chinook entered the bypass and 20 percent passed through the powerhouse (Karchesky et al, 2004)

Based on years of testing and sampling of smolt passage and smolt passage efficiency, the existing bypass system seems to perform relatively well for outmigrant steelhead and coho, but relatively poorly for Chinook.

Fish passing through the North Fork turbines or spillway travel downstream and either enter Faraday reservoir or pass over Faraday Diversion dam. Gunsolus and Eicher (1970) report that 40 to 60 percent of the fish enter the Faraday canal when North Fork dam is spilling. PGE (2003) conducted a pilot study to evaluate this issue with similar results but somewhat higher passage over the spillway than reported by the earlier investigations. No data are available regarding survival of fish passing Faraday Diversion dam or through Faraday turbines. There are no fish passage facilities incorporated into the Faraday Powerhouse.

After passing through the Faraday complex, downstream migrating fish then must pass River Mill dam. Exit routes include the turbines, the spillway, and a small bypass system built into the powerhouse trashrack. Outside of the FERC relicensing process, as part of ESA consultation, PGE is making spillway improvements to increase survival of downstream migrants. The spillway improvements include placing smooth concrete over the exposed rock and concentrating the spill at low spill rates. No spillway passage survival studies have been conducted at River Mill, but it is anticipated that the survival of smolts passing over the spillway will improve significantly. A small provisional bypass has been incorporated into the turbine intake trash racks that attracts a portion of the entrained fish and diverts them into a downstream collection chamber. Based upon a limited sample size, passage efficiency at the provisional bypass is relatively low, with recaptures of PIT tagged fish of 2 to 5 percent (D. Cramer, PGE biologist, personal communication, 1998).

Tests were conducted in 2001, 2002, and 2003 to evaluate the potential for bypassing large numbers of smolts at River Mill through use of controlled spill. The effectiveness of the controlled spill was estimated to be 81 percent for Chinook and 70 percent for steelhead in 2001(Hanson et al., 2002); 42 percent of steelhead smolts in 2002 (Royer and Mathur, 2003); and 100 percent of coho smolts in 2003 (Karchesky and Brush, 2003). In 2001, the spill flows were generally maintained in the range of 400 cfs representing 6 to 29 percent of river flows. In 2002, the spill flows were held at approximately 160 cfs representing 5 to 6 percent of river flows, and in 2003 approximately 30 percent of the total river flow was spilled.

Downstream fish passage issues of concern within the Project area are summarized in Table 3.2.3.1-10.

Individual downstream migrating fish experience varying risks of injury or mortality in passing through the Project depending on the pathway they take. The primary existing downstream fish passage facilities for the Project are the collection and bypass system at North Fork dam. Fish have alternative pathways past North Fork dam that include passage through the turbines and passage through the spillway. These alternative routes expose downstream migrants to either the Faraday Diversion dam spillway or the Faraday turbines and then further expose these fish to the River Mill turbines or spillway.

Given the complexity of the various routes the fish can take and the variety of alternatives available to potentially improve downstream passage, the Fish Passage Subgroup of the Fish and Aquatics Workgroup developed the Downstream Migrant Mortality Model (DM3) to evaluate system-wide mortality based on estimates of mortality along specific routes, periodicity of a target species and flow dependent passage routes (R2, 2002). The model does not predict mortality with absolute certainty, but is useful primarily as a sensitivity model to compare different alternatives, and as a tool to assist decision makers in formulating a basin-wide approach to the provision of effective fish passage.

Table 3.2.3.1-10. Summary of downstream passage issues and current conditions by Project element.

Project Element	Downstream Passage Issue	Current Conditions
Timothy Lake	Entrainment of resident fish into intake or outlet works.	There are currently no screens on the intake. The intake is 80 feet deep at full pool and the trash rack has 1 5/16 openings. Tests conducted from 2000 to 2002 indicate that entrained fish suffer a very high mortality rate passing through the Howell-Bunger valve. Most of the fish entrained were kokanee. Entrainment rate estimates for cutthroat ranged from .04 fish/hr to .09 fish/hr. For kokanee, entrainment estimates ranged from .32 fish/hr to 1.97 fish/hr (Shibahara and Filbert, 2003)
Lake Harriet	Entrainment of resident fish into intake or outlet works.	The trash rack on the intake has spacing that limits entrainment of larger adult fish. Tests conducted from 2000 to 2002 suggest that entrainment rates of cutthroat trout are relatively low based on low overall capture rates combined with high recapture rates (Shibaraha and Filbert, 2003). Entrainment could be higher than believed if there is extensive predation of young cutthroat by adult brown trout.
Frog Lake	Entrainment of resident fish into intake or outlet works.	There are currently no screens on the intake. No information is available about entrainment of fish at the intake.
North Fork Reservoir	Migration delays	PIT tag, radio tag and acoustic tag studies all suggest that a significant percentage of downstream migrants (particularly Chinook) do not pass the dam.
North Fork dam Downstream Migrant Collection System	Bypass efficiency	A significant number of downstream migrating Chinook are not successfully bypassed. Some migrants pass through the turbines, some through the spillway, some enter the bypass and are apparently lost, and some do not pass the dam. Tests suggest that the bypass efficiencies for coho and steelhead are considerably higher than Chinook.
North Fork Downstream Migrant Bypass System	Migration delays Predation in fish ladder Injury at the separator Injury in the pipeline	Bullock and Cramer (2003) report that the separator and bifurcation box both cause significant migration delays. Also, there were a large number of fish that entered the bypass system but were unaccounted for at downstream locations. Their fate is unknown.

Project Element	Downstream Passage Issue	Current Conditions
North Fork Turbines	Injury and Mortality	Gunsolus and Eicher (1970) report mortality rates of 28 percent for fish passing through the North Fork Turbines. Test suggest that the number of Chinook smolts passing through the turbines is low when river flows are low, but may rise at higher river flows (Normandeau and Assoc., 2003)
North Fork Spillway	Injury and Mortality	Spillway survival studies conducted in 2001 (Heisey et al., 2002) indicate that injury and mortality rates are relatively high for the North Fork Spillway (4 percent to 20 percent). The number of migrants passing through spill is unknown.
Faraday Diversion dam Spillway	Injury and Mortality	No studies have been done to evaluate injury or mortality at the spillway. Low mortality rates would be anticipated given the height and configuration of the spillway.
Faraday Powerhouse	Injury and Mortality	No studies have been conducted to evaluate injury or mortality through the turbines. Fish passing through the North Fork turbines or spillway can enter Faraday Lake and must exit through turbines.
River Mill Powerhouse	Injury and Mortality	No studies have been conducted to evaluate injury or mortality through the turbines. Usage of the interim fish bypass system at River Mill by downstream migrants is very limited (PGE, 1999)
River Mill Spillway	Injury and Mortality	No studies have been done to evaluate injury or mortality at the spillway.

The DM3 model was written in Visual Basic and provides a user interface that allows the user to investigate the effects of various passage efficiencies and component mortality rates on overall system survival for selected fish species. The model is a daily simulation model that routes water and fish through various flow routes in the system. At each dam facility, flow is first apportioned to the bypass, then to the powerhouse and finally to the spillway. The model incorporates user specified periodicity of fish passing through the Project. The annual run is apportioned into biweekly time periods based on historic data. Within each two-week period, the model has the ability to adjust the number of smolts that approach the Project based on river flows. The "flow response factor" employs an algorithm that weights the number of migrants passing the Project on a daily basis depending on the river flow. A response factor of zero has an equal number of fish passing each day during a period as specified by the species periodicity. For a response factor of 1, the number of fish passing through the Project on a given day in the period is approximately proportional to the river flow. For higher response factors, the number of fish passing on a particular day would be even more sensitive to flow.

The model uses daily flow records for the period 1909 to 2001. Incorporated into the model are mechanisms to alter the percentage of fish that pass via various routes as a function of river flow. Thus when river flows are high, the model can simulate more fish passing over the spillway or through the turbines. Along each potential route, the model utilizes user specified route specific mortality rates. For instance, the spillway at North Fork dam can be modeled with a 10 percent mortality rate for all migrants passing through that route.

The simulation model provides a number of output options. Users can review summary information for the entire historic period of available river flows or an individual year. Information can be displayed in both tabular and graphical formats. The output can also be printed or saved to a file.

The DM3 model was used to provide an index of system mortality under existing conditions for Chinook, coho, and steelhead. Table 3.2.3.1-11 summarizes the results of the modeling. The model estimates that the average annual system mortality rates of downstream migrating Chinook, coho and steelhead under existing conditions for the North Fork Complex are 25, 5, and 3 percent, respectively.

Table 3.2.3.1-11. Average, maximum and minimum annual mortality estimates based on DM3 model results for chinook, coho, and steelhead smolts.

Species	Annual Mortality[1]		
	Average	Maximum	Minimum
Chinook	24.6 percent	31.7 percent	14.8 percent
Coho	5.0 percent	8.5 percent	3.6 percent
Steelhead	2.7 percent	7.4 percent	2.0 percent

[1]Mortality of the total population passing North Fork

The input parameters used in the model as well as model results can be found in Appendix D. The parameters are very similar to the ones presented in the February 11, 2003 DM3 microgroup meeting with the exception of a significantly higher estimated mortality for the existing North Fork bypass system and a significantly lower mortality rate for the River Mill spillway. The higher bypass mortality estimate is based on the apparent differences in the radio tagging results for fish that enter the bypass system compared to PIT tagged fish that are counted at the separator. The bypass was assigned a mortality of 10 percent for Chinook, 3 percent for coho and 2 percent for steelhead based on a review of the data. Lower mortality from the River Mill Spillway is anticipated after the completion of improvements in 2004. It was assumed that the spillway improvements would limit spillway mortality to 10 percent. The percentage of fish entering the turbines was based on the values selected at the microgroup meeting. The fall 2003 tests (Karchesky et al, 2004) suggest that the entrainment of Chinook into the turbines may not be as high as believed based on the 2002 tests. At this time, however, no modifications have been made these DM3 as selected by the microgroup. At the microgroup meeting, the fish/flow route selection parameters were agreed upon for Chinook but not the other species. Consequently, parameters were selected based on an interpretation of available data.

Although PIT tag and radio tag data indicate that a certain percentage of the smolts do not pass the North Fork dam, these fish were not considered for this evaluation. Some studies have suggested that 30 percent of Chinook (Timko et al, 2001) and 20 percent of coho (Karchesky et al., 2004) do not pass the North Fork dam. It is unknown whether they do not pass because they cannot find an outlet, whether they do not attempt to migrate, or whether they are weakened or die as a result of handling and tagging. Should some alternatives affect the number of smolts that pass the dam, this analysis will not account for those differences.

The DM3 model (Figure 3.2.3.1-13) suggests that turbine passage at North Fork constitutes the greatest source of system mortality for Chinook (7.7 percent) followed closely by the North Fork bypass system (7.0 percent). This conclusion is driven by the limited data that suggests that smolts are attracted to the turbines as river flows rise above about 3,000 cfs and the assignment of a relatively high mortality for Chinook that enter the bypass system. A relatively high mortality is also associated with turbine passage at

Faraday (5.9 percent). This conclusion is also partially driven by the high turbine passage assumed for North Fork dam.

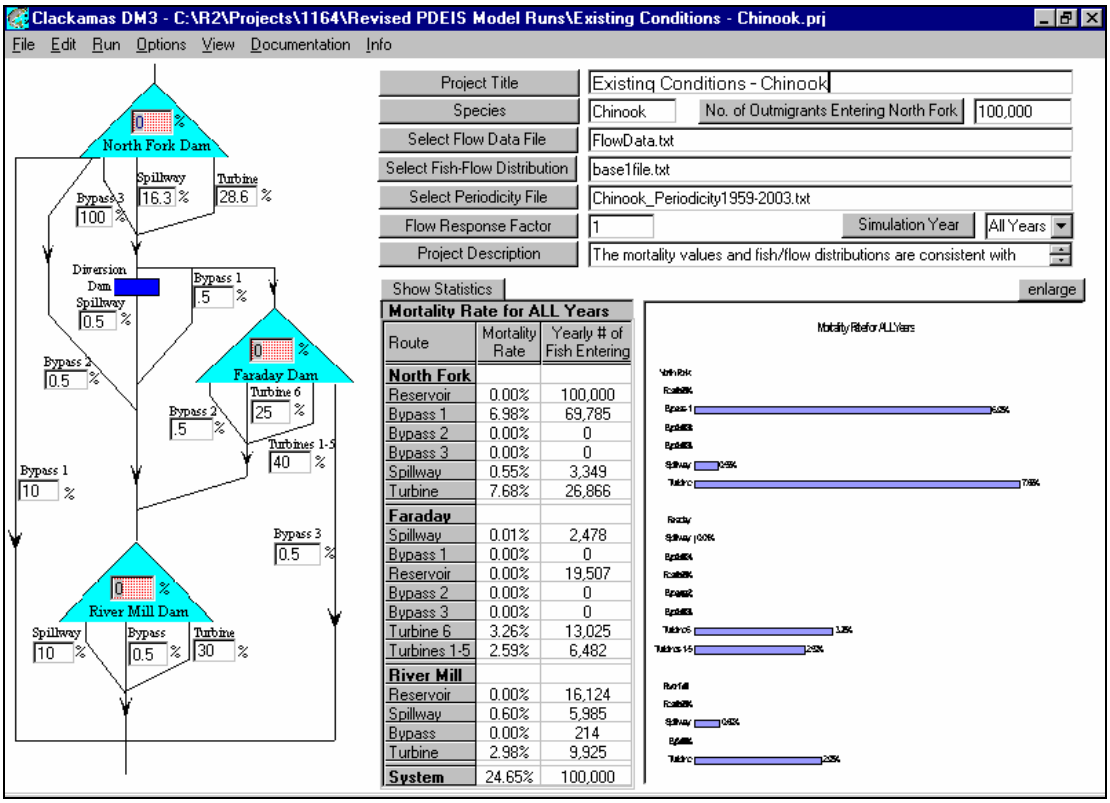


Figure 3.2.3.1-13. DM3 model output for existing conditions, Chinook smolts.

3.2.3.2 Environmental Effects

The provision of instream flows of sufficient magnitude, timing and duration are a necessary component of properly functioning conditions (PFC) for anadromous salmonids (NMFS, 1996b). Instream flows are also important for sustaining other important aquatic fauna and flora including resident fish species, aquatic invertebrates, amphibians, aquatic macrophytes (e.g. cold water corydalis), and riparian plant communities that are included in the USFS Aquatic Conservation Strategy (ACS). The ACS objectives are targeted toward improvements in aquatic ecosystem function, where ecological conditions are maintained or restored to conditions that provide functions that pattern more closely historical conditions. The objectives do not stipulate that historical conditions need to be attained, only that progress toward historical conditions be made, which should improve ecosystem function.

PGE worked with members of the Fish and Aquatics Workgroup on a number of instream flow studies designed to identify and develop flows to enhance three specific flow/habitat functions relative to fish and fish habitat:

- Flows that provide physical habitat;
- Flows that serve to maintain fluvial geomorphological processes that form riverine habitat; and
- The rate of change in managed flow releases (ramping rate).

The Proposed Action incorporates all fisheries and aquatic resource conservation recommendations made by the agencies during the Settlement Process. In addition, the Proposed Action provides for the support of a Fish Committee to coordinate implementation of fish and aquatic resource license conditions throughout the life of the new license and to facilitate consultation between PGE, the agencies, NGOs, and Tribes. Ongoing support of the Fish Committee would ensure that license conditions relative to fish and aquatic resources are met and that any new issues that arise during the course of the new license are addressed. Article 1 of the Settlement Agreement – Implementation Committees lists the members of the Fish Committee.

Staff assessed the No-Action and the Proposed Action alternatives in the context of the flow requirements, and ACS goals for all reaches, and in particular several key reaches of importance to the resource agencies. Key reaches include Reach 1B of the Oak Grove Fork downstream of Timothy Lake and Reach 1F and 1G of the Oak Grove Fork downstream of Lake Harriet. Reach 1B downstream of Timothy Lake supports a cutthroat trout population but experiences only a 10-cfs minimum instream flow release from Timothy dam. Reaches 1F and 1G represent stream segments for which there are no current instream flow requirements below Lake Harriet dam (the reach receives some accretion and tributary flow) and yet the lower portion of the reach is used by anadromous salmonids. Substantial habitat (both main-channel and side-channel) gains could result in these reaches under various additional instream flows from upstream releases, adding significantly to the value of these areas for critical life stages of listed salmonids from all three flow perspectives. Table 3.2.3.2-1 compares the existing instream flow releases and ramping rate requirements (No-Action Alternative) with the proposed instream flow releases and ramping rate requirements under the Proposed Action.

3.2.3.2.1 Proposed Action

The following section describes the potential effects of implementation of the Proposed Action on aquatic habitat conditions (watershed processes, physical habitat elements, and instream flows), benthic invertebrates, water quality, upstream passage and

downstream passage within the Project area of the Clackamas River and Oak Grove Fork of the Clackamas River.

Aquatic Habitat Conditions

Timothy Lake and Upper Oak Grove Fork Tributaries (Reach 1A)

Watershed Processes

Changes in facilities and operations implemented under the Proposed Action would not alter the current conditions of watershed processes in the Oak Grove Fork basin upstream of Timothy dam.

Physical Habitat Elements

Under the Proposed Action, PGE would install approximately 3 aggregates of 10-15 logs each in Dinger Creek, and install weirs to disrupt spawning kokanee and brook trout in tributaries to Timothy Lake. These measures would benefit cutthroat trout by reducing competition for habitat. These changes implemented under the Proposed Action would improve current conditions of physical habitat elements in the Oak Grove Fork basin upstream of Timothy dam for cutthroat trout. PGE would also establish and implement a blue green algae monitoring program to establish the effectiveness of blue-green algae blooms as an indicator of toxic conditions; characterize the link, if any, between Project operations and bloom formation, and identify linkages between algal conditions, taste and odor problems, and potential toxicity.

Instream Flows

Changes in facilities and operations implemented under the Proposed Action would not alter instream flows in the Oak Grove Fork basin upstream of Timothy dam. Therefore, there were no instream flow studies completed for this reach (Table 3.2.3.2-1).

Table 3.2.3.2-1. Summary of existing and proposed instream flow release and ramping rate requirements for the Clackamas River Hydroelectric Project (PGE, 1999; Wamser, 2000; USFS, 1996a, b).

Project Development	Segment	Instream Flow Requirements (No-Action Alternative)	Ramping Rate Require ments (No-Action Alternative)	Conditions under the Proposed Action
Oak Grove Fork Reach 1A	Above Timothy Lake	None – tributaries to Timothy Lake are unregulated	None – tributaries to Timothy Lake are unregulated	None – tributaries to Timothy Lake are unregulated
Oak Grove Fork Reach 1B	Below Timothy Lake to Stone Creek Diversion dam	Yes[1] - 10 cfs minimum instream flow as required by State Hydropower License.	Yes - the maximum ramping rate allowable under the existing license is 0.33 foot per hour stage change, as measured at the USGS Government Camp gage below Timothy Lake dam.	Seasonally adjusted minimum and maximum instream flows ranging from 30 cfs to inflow + 300 cfs. Ramping rates would not exceed 0.2 ft (2.4 inches) per hour stage change.
Oak Grove Fork Reaches 1C-1E	Stone Creek Diversion dam to Lake Harriet	PGE: 10 cfs minimum instream flow must be provided to the Stone Creek Diversion dam; EWEB responsible for instream flows below the dam. EWEB: minimum instream flow release below the diversion dam of 30 cfs from November through June and 40 cfs from July through October; license also requires that at least 90 percent of assumed accretion flow be maintained in the reach as measured at the Stone Creek Powerhouse.	PGE: The maximum ramping rate allowable under the existing license is 0.33 foot per hour stage change, as measured at the gage below Timothy Lake dam. EWEB: does not operate Stone Creek Project as peaking operation.	Regulated by EWEB. Flows as influenced by license conditions listed for *Timothy to Stone Creek Diversion*

Table 3.2.3.2-1. Summary of existing and proposed instream flow release and ramping rate requirements for the Clackamas River Hydroelectric Project (PGE, 1999; Wamser, 2000; USFS, 1996a, b).

Project Development	Segment	Instream Flow Requirements (No-Action Alternative)	Ramping Rate Require ments (No-Action Alternative)	Conditions under the Proposed Action
Oak Grove Fork Reaches 1F-1G	Lake Harriet to confluence with Clackamas River	None - no instream flow requirements for the 5.1-mile reach of the Oak Grove Fork below Harriet dam to its confluence with the Clackamas River.	None – the reach is a bypass segment and is not subjected to peaking operations.	Release agreed-upon minimum base flows throughout the year, combined with higher flow releases during winter floods and spring runoff events, using water withdrawn through the Harriet Lake intake and tunnel to a new pipeline terminating at the river's edge. Base flow releases vary depending on classification as dry, normal, or wet year: Between January 1-March 31, pass all flow >1,300 for ~10 hours, then resume 600 cfs diversion, for first 4 events of year separated by ≥5 days apart. Release flows that simulate snowmelt runoff beginning anytime between April 20 and May 15, followed by ramping down to base at 10 cfs/day. Fall pulse flows would be considered if members of Fish Committee provide information that shows the need for such flows
Oak Grove Fork Reach 2A	Clackamas River from mouth of Oak Grove Fork downstream to Oak Grove Powerhouse	None - no instream flow requirements for this reach; stream flows within this reach are influenced by Project operations as a result of the diversion of up to 585 cfs from the Oak Grove Fork to the Oak Grove Powerhouse.	None – only time this reach experiences rapid flow changes is in response to natural flows, Project outages or scheduled maintenance activities.	Flows as influenced by lower Oak Grove Fork flow regime

Table 3.2.3.2-1. Summary of existing and proposed instream flow release and ramping rate requirements for the Clackamas River Hydroelectric Project (PGE, 1999; Wamser, 2000; USFS, 1996a, b).

Project Development	Segment	Instream Flow Requirements (No-Action Alternative)	Ramping Rate Require ments (No-Action Alternative)	Conditions under the Proposed Action
Clackamas River Reach 2B	Clackamas River from Oak Grove Powerhouse to North Fork dam	None - no instream flow requirements for this approximately 14-mile-long reach; stream flows influenced by peaking operations from Oak Grove Powerhouse	None – turbine operations limit upramping rate to 64 cfs per 5 minutes; no downramping rate; daily flow fluctuations within the reach commonly ± 250 cfs	Maximum discharge of 740 cfs. Maximum upramping rate of 0.4 ft/hr year round except during spinning reserve call events. Maximum downramping rate of 0.3 ft/hr or 0.17 ft/hr if flow is < 1,200 cfs February 1 through September 30. Complete two juvenile salmonid stranding studies; modify October rate to 0.17 ft/hr if necessary depending on results.
Clackamas River Reach 2C	Clackamas River from North Fork dam to Faraday Diversion dam	None – no instream flow requirements within this 0.25-mile reach; only small portion of reach exhibits riverine characteristics, remaining section influenced by Faraday Diversion dam.	None – Project operates in a peaking mode by fluctuating reservoir levels by about 1 foot on a daily basis; resulting daily flow fluctuations can be more than 3,000 cfs.	Maintain year round water levels as follows: 526.0 ft maximum, 521.0 ft normal minimum, 516.0 ft extreme minimum

Table 3.2.3.2-1. Summary of existing and proposed instream flow release and ramping rate requirements for the Clackamas River Hydroelectric Project (PGE, 1999; Wamser, 2000; USFS, 1996a, b).

Project Development	Segment	Instream Flow Requirements (No-Action Alternative)	Ramping Rate Require ments (No-Action Alternative)	Conditions under the Proposed Action
Clackamas River Reach 2D	Clackamas River from Faraday Diversion dam to Faraday Powerhouse Tailrace	Yes - minimum instream flow releases of from 50 – 90 cfs are required under Article 29 of existing FERC license; PGE generally maintains a minimum flow of 120 cfs, which includes 43 cfs from the fish ladder as well as supplemental attraction flow released from the Faraday Diversion dam. Following spill events at North Fork dam, PGE voluntarily maintains the amount of flow passing Faraday Diversion dam for a period of 3 days post-spill as a 50:50 split in flow between Faraday Canal and the Faraday Diversion dam. This action is designed to facilitate downstream transport of fish that entered the reach during spill.	None – the reach is a bypass segment and is not subjected to peaking operations	Maintain year round base flow of 270 cfs. Baseflow may be reduced after 2013 if spillway entrainment reduced by at least 50 percent by spillway exclusion net at spills up to 4,000 cfs. NOTE – State Instream water right with varying minimum flows below Faraday corresponding to July 1-Sept 15 of 400 cfs, and Sept 16-June 30 of 640 cfs. Provide pulsed flow releases from April to October between 120-480 cfs (frequency and duration of pulsed flows vary
Clackamas River Reach 2E	Clackamas River from Faraday Powerhouse Tailrace to River Mill dam	None – no instream flow requirements within this short segment; tailrace adjoins directly to Estacada Lake; reach receives the 120 cfs released from Faraday Diversion dam as well as powerhouse releases.	None – Project can operate over a range of 0 to 4,800 cfs	Maintain Estacada Lake levels as follows: 389.0 ft maximum, 387.0 ft normal minimum (flashboards up), and 384.5 ft extreme minimum (flashboards down). Limit lake level fluctuations to 2.0 ft during periods when winter steelhead and coho redds are present

Table 3.2.3.2-1. Summary of existing and proposed instream flow release and ramping rate requirements for the Clackamas River Hydroelectric Project (PGE, 1999; Wamser, 2000; USFS, 1996a, b).

Project Development	Segment	Instream Flow Requirements (No-Action Alternative)	Ramping Rate Require ments (No-Action Alternative)	Conditions under the Proposed Action
Clackamas River Reach 2F	Clackamas River below River Mill dam	None - PGE voluntarily provides a minimum release of 300 cfs and at most times 500 cfs below the dam; the release is to ensure an adequate supply of water for pumps at the Clackamas River Hatchery and to meet requirements of downstream water providers.	None – prior to 1999, for downstream safety considerations PGE volitionally operated with a maximum ramping rate of 360 cfs per 10 minutes.	Operate the Project in an inflow-matching mode to provide flow releases below River Mill dam that equal inflow. During maintenance activities, maintain minimum flow of 500 cfs or inflow, whichever is less. Flow adjustments not to exceed 50 cfs per hour. Ramping prohibited. Manage flows as described in Table 3 of the Environmental Assessment accompanying the River Mill license amendment

[1]Also required by the Project's existing FERC license.

Upper Oak Grove Fork from Timothy Dam to Harriet Dam (Reaches 1B to 1E)

Watershed Processes

Under the Proposed Action, LWD and sediment from the Upper Oak Grove Fork would continue to be intercepted by Timothy Lake. McBain and Trush (2004b) estimate that historically little sediment and LWD was transported into Reach 1B from the watershed above Timothy dam. As a result, continued interruption of sediment and wood transport would not be expected to result in channel morphologic changes from current conditions in Reaches 1B, 1C and 1D.

Physical Habitat Elements

Implementation of the Proposed Action would slightly alter physical habitat in Reaches 1B, 1C and 1D. Water depth in both pools and riffles would increase in Reach 1B as a result of the greater wetted area associated with increased baseflows released from Timothy dam. As part of the Proposed Action PGE also proposes to install approximately 225 boulders and incorporate LWD to the extent possible in Reach 1B between Timothy dam and Hammer Springs to increase pool depth at flows less than or equal to 60 cfs. Installation of boulders along the channel edges would increase the hydraulic roughness along channel edges, and reduce the flow width at low flow, thereby increasing the water depth. This measure would improve habitat for cutthroat trout, especially during low flows when deeper habitats are sparse.

Flow diversions at EWEB's Stone Creek diversion dam would continue under the Proposed Action. Increased baseflows released from Timothy dam would not necessarily result in increased flows within Reach 1C. Large woody debris loading and pool frequency in Reaches 1C and 1D would be the same as for current conditions.

Instream Flows

Table 3.2.3.2-2 describes the flow releases that PGE would provide below Timothy dam under the Proposed Action. These releases would be made by a combination of the Howell-Bunger valve, the hydro turbine in the dam outlet works, and the spillway gates at the crest of Timothy dam.

Table 3.2.3.2-2. Timothy dam Flow Releases under the Proposed Action

Date	Flow Release, cfs		Notes
	Minimum	Maximum	
Memorial Day through Labor Day	60 cfs or inflow, whichever is less	Inflow + 70	
Day after Labor Day through Sept 30		Inflow + 100	
Oct. 1 through Oct 31		Inflow + 150	
Nov. 1 through Nov 30		Inflow +300	Limit of three large scale flow events during this period
Dec. 1 through Feb. 28/29	30 cfs or inflow, whichever is less		
Mar. 1 through day before Memorial Day	40 cfs or inflow, whichever is less	Inflow +100	

The Proposed Action would increase the minimum instream flow release below Timothy Lake dam from the existing condition of 10 cfs, to 30 cfs (or inflow) during the period December 1 through February 28/29, 40 cfs or inflow from March 1 through Memorial Day, and 60 cfs or inflow from Memorial Day through November 30. Maximum flow releases computed as "inflow + x cfs" vary by specific dates as noted in Table 3.2.3.2-2 and range from inflow + 70 cfs from Memorial Day to Labor Day, to inflow + 300 cfs from November 1 though February 28/29. The flow releases target the reach of the Oak Grove Fork extending from just below Timothy dam downstream to the Stone Creek Diversion dam.

Studies to evaluate flow-habitat relationships in this reach have included habitat mapping (Framatome ANP DE&S, 2002b), hydrologic and operational analysis (Wamser, 2001), comparisons of channel cross-sectional geometry under different flows (McBain and Trush, 2003), and supplemental cross-sectional measurements at six target flows that included a cell-based habitat analysis (Doughty and Blum, 2004; EES, 2004). A PHABSIM study (CES, 1984) conducted as part of licensing activities for the Stone Creek Project provided additional information relative to habitat-flow relationships in the 5.4-mile segment of stream from the Stone Creek Diversion dam to the Stone Creek Powerhouse.

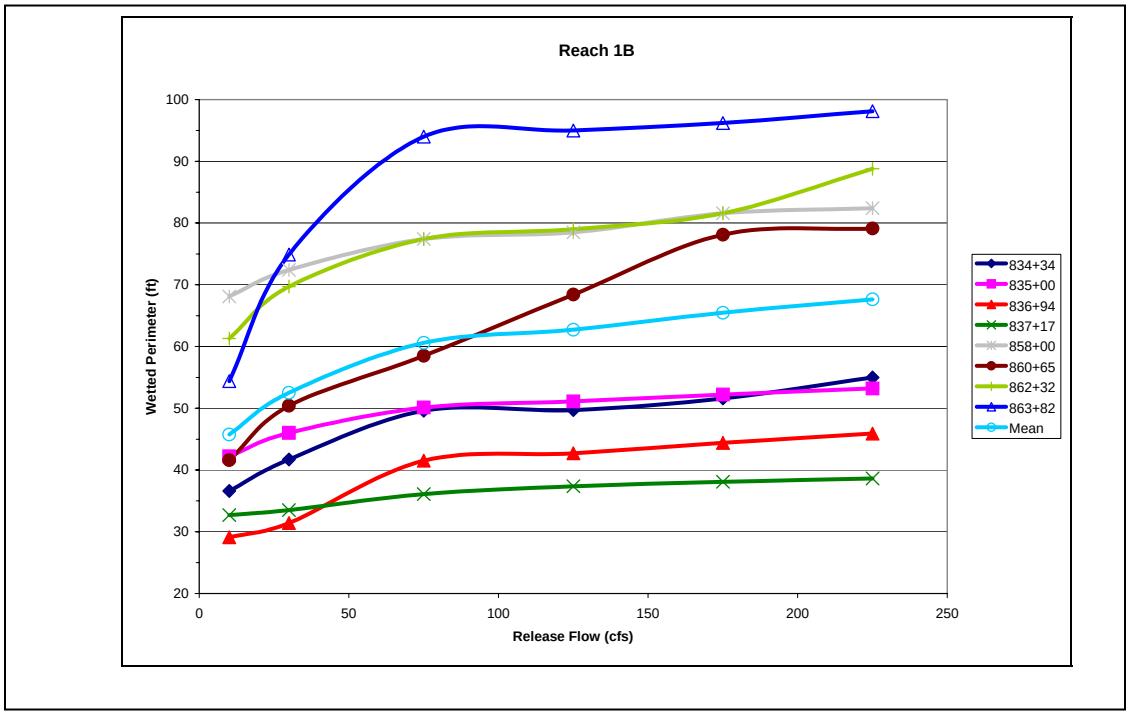
All of the minimum flow releases in the Proposed Action would provide more cutthroat trout habitat in this reach than would exist under current minimum flow conditions. Results of channel geometry measurements within this segment computed

over a range of flows from 30 to 300 cfs indicated that gains in wetted perimeter ranged from 11.4 to 34.7 feet depending on cross-section location (McBain and Trush, 2003a), an increase of about 22 percent to 37 percent more adult habitat and from 6 percent to 28 percent more juvenile habitat over current conditions. Although the early channel geometry measurements were not taken at a 10-cfs release flow, the regression equation derived from the other flows indicated that a gain of about 9 ft (averaged between several transects) in wetted perimeter would occur in the upper reach with changes in flows from 10 to 30 cfs. Results of the most recent studies (EES, 2004; Doughty and Blum, 2004) under six flow conditions ranging from 10 to 225 cfs predict that wetted perimeter changed an average of 21.9 ft (based on the eight transects). The cell-based habitat analysis indicated that adult and juvenile cutthroat trout habitats would peak with release flows of around 175 cfs and 75 cfs, respectively. The flow range of 30 to 60 cfs as proposed under the Proposed Action would provide an average increase in wetted perimeter ranging from 6.7 to about (interpolated) 12 ft over that which would occur under the current conditions.

In consideration of the influence of flow accretion, Doughty and Blum (2004) provided a comparison of adult and juvenile rearing habitat that would be provided under different release flows both above and below Hammer Springs, one of the more prominent springs located in the upper portion of the reach. Based on the results of this analysis the Proposed Action would result in a 7 percent-180 percent increase in adult and juvenile cutthroat habitat above and below Hammer Springs. A detailed discussion of this analysis is included in Appendix E.

The computed average usable widths (based on binary HSI curves) for cutthroat trout adult and juvenile rearing provided under the No-Action release flow of 10 cfs were 5.40 ft (range 0.00 to 12.45 ft) and 11.47 ft (range 1.05 to 30.10 ft) respectively. These average widths represent about 33 percent of the maximum overall average usable width for adult cutthroat trout, and about 62 percent of the maximum overall average usable width for juveniles. The release of 30 cfs would provide about 55 percent of the maximum overall average usable width for cutthroat trout adult habitat, and 68 percent of the maximum overall average for juvenile habitat; releases of 60 cfs would provide about 70 percent and 90 percent of the maxima for adult and juvenile cutthroat trout habitat. Based on overall averages, the Proposed Action flow releases would thus provide from about 22 percent to 37 percent more adult habitat and from 6 percent to 28 percent more juvenile habitat than the No-Action alternative (See Appendix E) (Figure 3.2.3.2-1).

Figure 3.2.3.2-1. Wetted perimeter length and mean length at eight transects located in reach 1B of the Oak Grove Fork of the Clackamas River (Source: EES, 2004).



Under the Proposed Action, PGE would also seasonally regulate the magnitude of release flows from Timothy dam as a means to prevent the spiking of flows that currently occur shortly after Labor Day each year when reservoir drawdown begins. PGE would control ramping rates (both downramping and upramping) below Timothy Lake as measured at the USGS Government Camp gage, as follows:

- decreases in stream stage (downramping) at the USGS gage would not exceed 0.2 ft during any one hour period year-round;
- increases in stage (upramping) would not exceed 0.2 ft per hour except during days with inflow events that result in average daily inflows to Timothy Lake exceeding 600 cfs.
- Flows that must be passed through the tainter (spillway) gates because flows are above the capacity of the Howell-Bunger valve would not be subject to ramp rate restrictions.

For comparison, natural rates of increasing and decreasing river stage in this area have ranged as high as 0.18 feet per hour for increasing stage, and as high as 0.05 feet per hour for decreasing stage (McBain and Trush, 2003a; Gomez and Sullivan, 2001). An analysis of regulated flow conditions revealed that there have been a few instances where ramping rates have been much higher than the current operating guidelines. Worst-case conditions (based on period of record) apparently occurred in 1986 when ascending stage

change was 0.7 feet per hour (230 cfs per hour) and decreasing stage was 0.72 feet per hour (336 cfs per hour; McBain and Trush as modified from Gomez and Sullivan, 2001).

Ramping rates under the No-Action alternative are restricted to no more than 0.33 feet per hour. However, daily fluctuations can be quite high, particularly in the fall during drawdown, and in the late spring during "rain-on-snow" events. EES (2003) evaluated the effects of a 0.33 ft/hr upramping rate on cutthroat trout habitat. Stage was determined to increase between approximately 0.32 ft and 0.90 ft depending on transect geometry, with rates of change in stage varying within the reach between 0.14 ft/hr to 0.38 ft/hr. No studies were conducted regarding effects of downramping. Wetted perimeter data for most transects measured indicate a critical flow rate below 10 cfs. The State of Washington, based on the review of Hunter (1992), currently recommends biologically protective downramping rates of 1 to 2 inches (0.08 to 0.17 feet) per hour depending on time of year and life stages present; the more restrictive 1 inch per hour pertains to periods under which anadromous salmonid fry may be present. In a review of ramping rate limits proposed for Timothy dam, Carson (2003) determined that a 1 in/hr ramping rate would not significantly affect total generation at the Oak Grove Powerhouse, or flows delivered to the Three Lynx Creek confluence. Principal effects were determined to be "reduced flexibility in responding to changes in streamflow and runoff, delays of 4 to 10 hours in making large flow changes, and a significant reduction in the availability of Oak Grove generation during power system emergencies." This analysis however, included restrictions on both up-ramping and down-ramping and was therefore more restrictive than would be needed if just down-ramping is considered. The ramping rates proposed under the Proposed Action (0.2 ft; 2.4 inch per hour) are more protective than those under the No-Action alternative (0.33 ft per hour; 3.9 inch per hour).

Lower Oak Grove Fork downstream of Lake Harriet dam (Reaches 1F and 1G)

Watershed Processes

Bedload delivered to the river between Timothy dam and Lake Harriet would continue to be intercepted by Lake Harriet. The Proposed Action would augment approximately 2,200-3,000 tons of gravel during the first three years of the license in Reach 1G downstream of the barrier falls to increase spawning habitat, and generally initiate restoration of geomorphic and ecological processes. This would be followed by 50-80 tons/yr additions in subsequent years. The goal of the gravel supplementation program is to provide increased spawning habitat. Placement would be directed at areas with suitable depth and velocity for spawning and conducted in conjunction with placement of holding structures. The amount of improvement that would occur under this program cannot be quantified at this time, but would be as part of future monitoring efforts.

Some of the LWD delivered to Lake Harriet would continue to be trapped in the reservoir. PGE would transport all woody debris captured in Lake Harriet around the dam and deposit it downstream, which represents an improvement over existing conditions. However, in the past, PGE voluntarily made LWD removed at the dam available for habitat enhancements (Horning, 2004). The Proposed Action should result in a net improvement in available habitat complexity downstream of Lake Harriet compared to current conditions.

Physical Habitat Elements

The gravel augmentation program implemented under the Proposed Action would increase the availability of spawning gravel in Reach 1G. There may be an overall increase in LWD frequency under the Proposed Action downstream of Harriet dam, which could improve fish habitat conditions and gravel storage. Based on information developed by McBain and Trush (2004a), increasing minimum flows to around 65 cfs would maintain the year round connectivity of approximately 8 additional side channels representing an additional length of 2,300 feet as compared to current conditions.

Instream Flows

There are currently no instream flow requirements for these reaches. Thus, the greatest effect of the Project on this reach has been reduced baseflows, in particular, within the anadromous salmonid reach, beginning at the Barrier Falls (a complete barrier to upstream migration) and extending to the Clackamas River (a total of 23,400 ft of mainstem channel). The stakeholders identified the following anadromous resident salmonid species and life stages for habitat analysis in the Lower Oak Grove Fork are:

- Coho salmon: spawning, incubation, emergent fry, and 1+ rearing,
- Spring-run Chinook salmon: spawning, incubation, emergent fry, and juvenile rearing,
- Winter-run steelhead: spawning, incubation, emergent fry, 1+ rearing, 2+ rearing (and older).
- Cutthroat trout: spawning, incubation, emergent fry, rearing.

In addition to the effect of mainstem flows on these species, stakeholders were interested in flows that would connect and provide important rearing and spawning habitats in a number of side channels located below the barrier falls.

The flow releases downstream of Lake Harriet dam under the Proposed Action would increase and enhance fish and aquatic habitats within the main-channel of the Oak Grove Fork and provide some flow into 11 of the 26 side channels identified within this reach. From April 1 through September 30 the specific release flows are defined by water year type (Wet, Normal, Dry) classified by the forecasted April 1 to September 30

inflows to Lake Harriet (see Settlement Agreement Project Operating Plan, PGE, 2006, and Table 3.2.3.2-3). Releases of 100 and 70 cfs would nominally and periodically wet approximately 4,438 feet of side channel habitats in the 11 channels that would receive some flow (McBain and Trush, 2003a). Given preliminary accretion estimates (11 to 22 cfs) provided by CES (1996), the above release flows would likely translate into instream flows in the lower segments of the stream (i.e. Reach 1G) that are from 10 to 20 cfs higher than the release flow; (e.g. 80 cfs release translates into from about 90 to 100 cfs in Reach 1G). Our analysis of habitat:flow relationships considered this accretion but we completed our assessment based on direct comparisons to the various species and life stage habitat:flow relationships.

Table 3.2.3.2-3. Harriet dam Flow Releases Proposed Under the Proposed Action

Date	Base Flow Release, cfs		
	Wet Year*	Normal Year*	Dry Year*
April 1 to June 15	100	90	80
June 16 to August 31	100	90	80
Sept. 1 to Sept. 30	100	90	80
Oct. 1 to Oct. 15	100	100	100
Oct. 16 to Dec. 15	80	80	80
Dec. 16 to March 31	70	70	70

*Water year types are based on forecasted April 1-September 30 Inflows: Wet > 182,000 acre-ft; Normal <182.000 acre-ft and >123.000 acre-ft; and Dry < 123.000 acre-ft

Because of the biological significance of this reach, the Flow – Geomorphology Subgroup (FG-subgroup) of the Fish & Aquatics Workgroup and PGE spent substantial effort in identifying and considerable resources in collecting information and data needs from which to derive flow recommendations that would be based on "best available science." Three separate but related instream flow methods were used to assess flow needs for this reach including a traditional one-dimensional (1-D) Physical Habitat Simulation (PHABSIM) study, (CES and Caldwell Associates, 1996b), a two-dimensional PHABSIM analysis (applied in two selected reaches; Addley et al., 2003), and an "Expert Habitat Mapping" (EHM) approach (applied in the same areas as the 2-D modeling; McBain and Trush, 2004). Appendix E contains a more detailed description of each method and associated results. In addition, Huntington and Cramer (2003) completed an abbreviated Indicators of Hydrologic Alteration (IHA) (Richter et al., 1996) analysis using streamflow data available for the unregulated Oak Grove Fork above

Harriet dam (USGS Gauge 14209000; water years 1910-55). The three methods resulted in the development of up to six different species -specific habitat-flow response curves, depending on life stage considered (See Appendix E). The Micro-Group selected three curve sets they considered would most accurately represent habitat flow relationships for a given species and lifestage. These included:

- Anadromous spawning habitat – 2-D Adjusted binary curve (Figure 3.2.3.2-2; occurs September through June)
- Steelhead 2+ Rearing – Weighted EHM curve (Figure 3.2.3.2-3; occurs year-round)
- Coho 1+ Rearing – Weighted EHM curve (Figure 3.2.3.2-4; mainstem but with special emphasis on side-channels, and occurs year-round)

These curve sets were intended for evaluating mainstem flows only; a separate flow-habitat relationship was developed for side-channels. For comparative purposes, We normalized the habitat-flow curves for each species and life stage to allow comparison of like-habitat unit types by calculating the percentage of maximum habitats produced for each curve set over the range of modeled flows. Normalized habitat values were replotted as Percentage of Maximum Habitat versus Flow. Flows and habitat amounts at 5 or 10 percent increments of maximum habitat were then calculated by linear interpolation (Tables 3.2.3.2-4, 3.2.3.2-5, and 3.2.3.2-6) to compare flow values at given percentages of maximum habitat. For comparative purposes, we computed the percentages of maximum habitats by life stage and species based on the three habitat-flow relationships selected by the Micro-Group (spawning – 2-D Adjusted Binary; 2+ steelhead – Weighted EHM; 1+ coho – Weighted EHM; Table 3.2.3.2-7) for the Proposed Action.

Spawning Habitat

Overall, the three different methods resulted in estimated maximum anadromous spawning habitat availability occurring over a range of flows between 97 cfs (Weighted EHM) and 180 cfs (2D-PHABSIM, and 2D - reduced 40 percent; Table 3.2.3.2-7). The percent of maximum habitat available at different flows using the different methods is highly variable at flows less than about 90 cfs and at flows greater than about 150 cfs. At 90 cfs the different methods provide a range of estimated habitats that are from about 72 (EHM) to 93 (1D-PHABSIM) percent of maximum spawning habitat. At 150 cfs, the methods range between about 83 (1D-PHABSIM) to 98 (2D-adjusted, 2D-PHABSIM, EHM) percent of maximum habitat. Visual inspection suggests that agreement among the curves (in terms of shape) is highest between about 100 and 150 cfs and would achieve about 83 percent or more of maximum habitat.

Figure 3.2.3.2-2. Recommended anadromous salmonid spawning habitat availability curve for the lower Oak Grove Fork (Reach 1G).

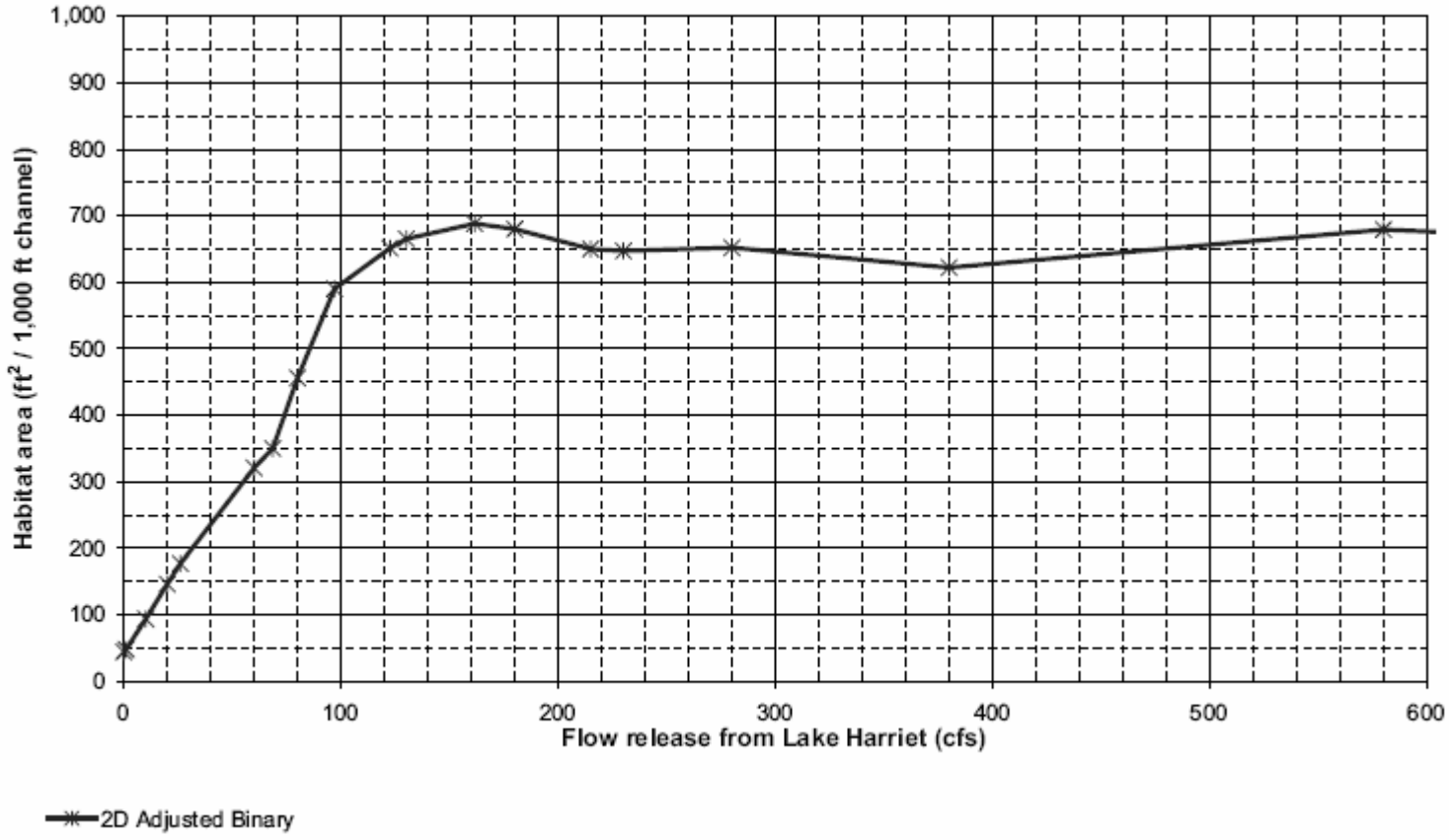


Figure 3.2.3.2-3. Recommended 2+ steelhead rearing habitat availability curve for the lower Oak Grove Fork (Reach 1G).

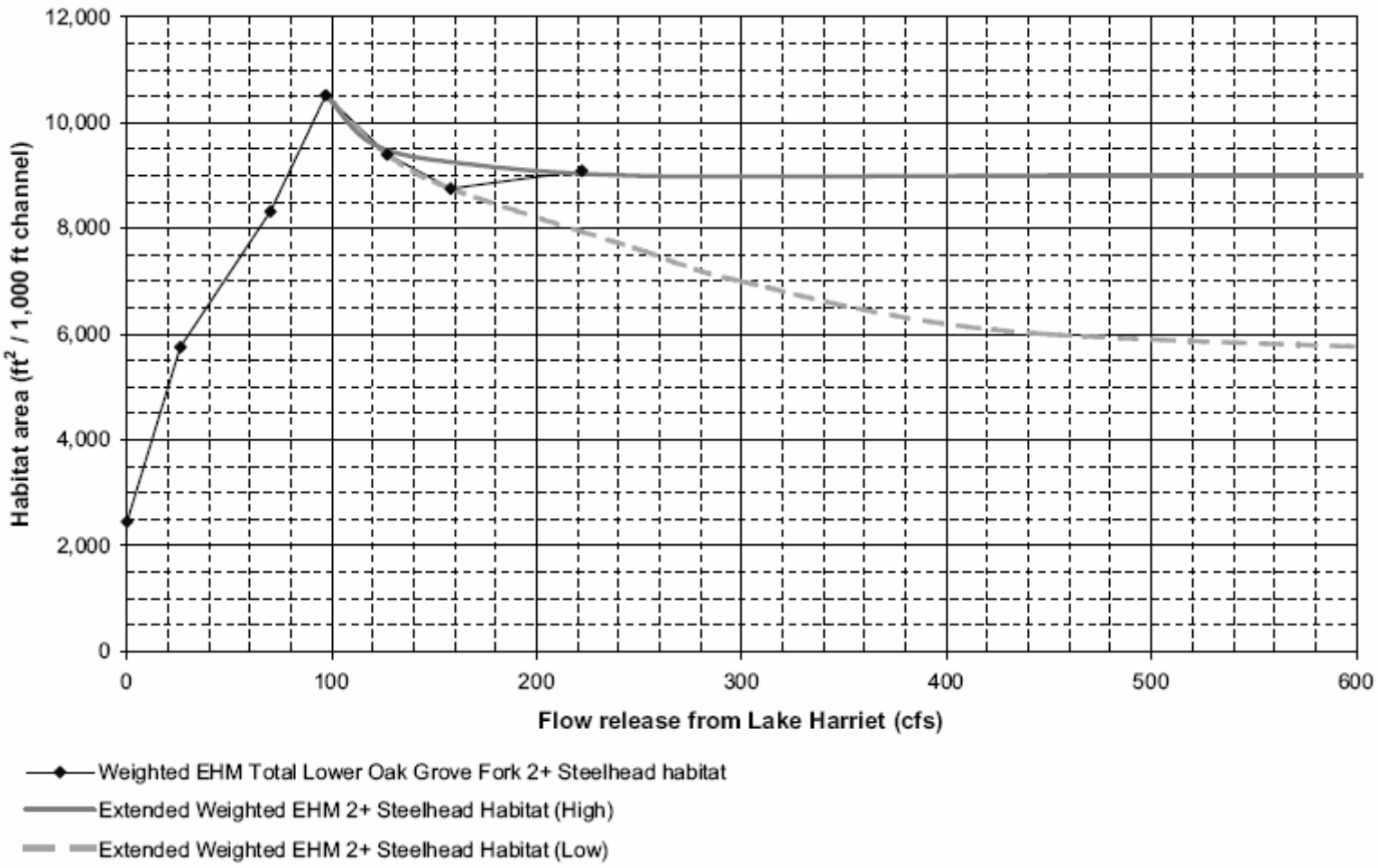


Figure 3.2.3.2-4. Recommended 1+ coho rearing mainstem habitat availability curve for the lower Oak Grove Fork (Reach 1G).

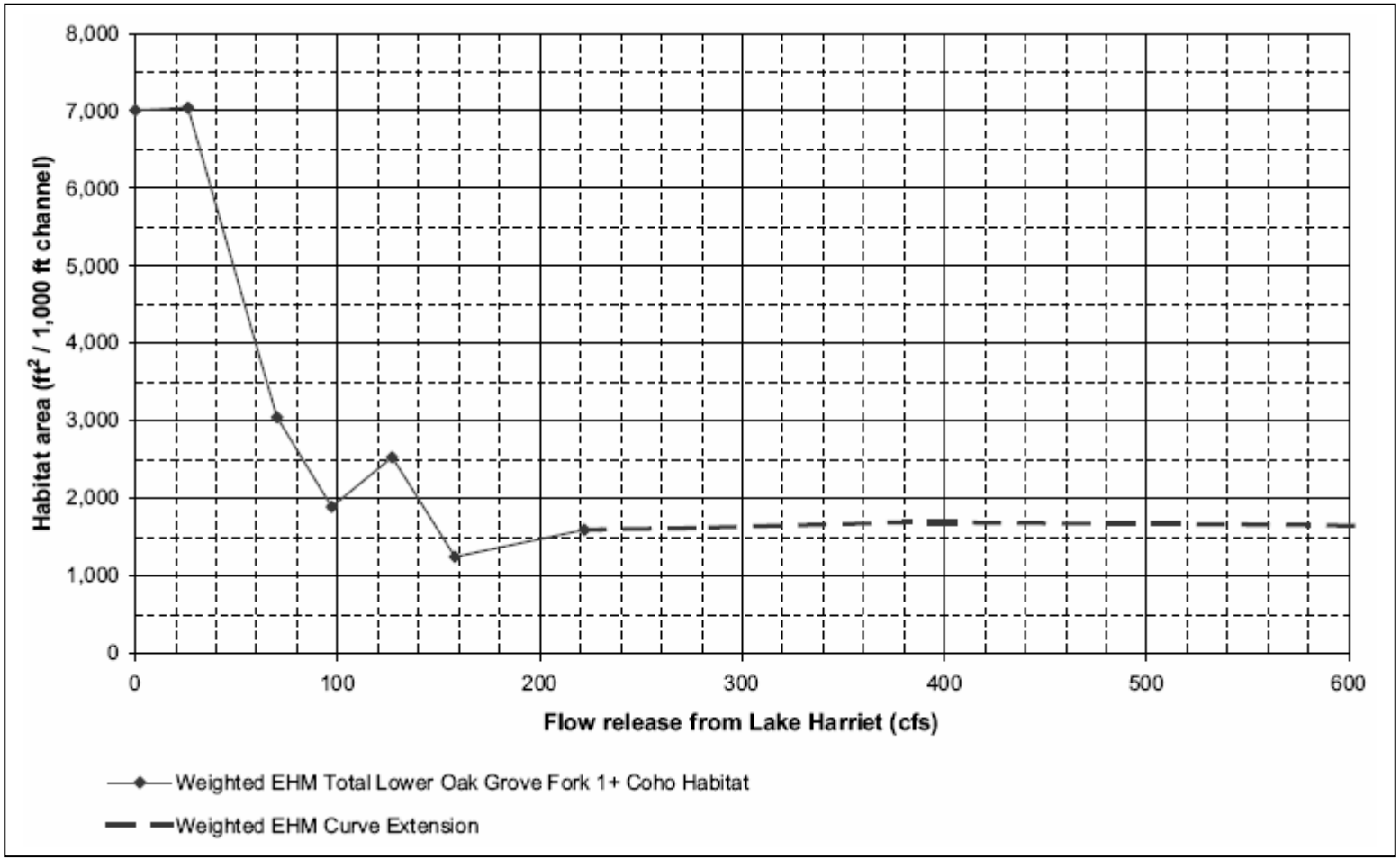


Table 3.2.3.2-4. Flow and habitat at different percentages of maximum habitat derived from the four methods used to develop instream flow recommendations for coho salmon age 1+ in the mainstem Lower Oak Grove Fork.

Percent of Max Habitat	Micro-Group Recommended Weighted EHM		EHM		2D - Binary		1D – Binary		2D - Beecher Crit		2D - Binary, No Overlap	
	Flow (cfs)	Habitat (ft^2 per 1,000 ft)	Flow (cfs)	Habitat (ft^2 per 1,000 ft)	Flow (cfs)	Habitat (ft^2 per 1,000 ft)	Flow (cfs)	Habitat (ft^2 per 1,000 ft)	Flow (cfs)	Habitat (ft^2 per 1,000 ft)	Flow (cfs)	Habitat (ft^2 per 1,000 ft)
100	26	7,042	0	5,475	20	15,728	30	3,215	0	2,859	0	8,925
90	34	6,338	31	4,927	48	14,155	24	2,893	4	2,573	12	8,032
80	42	5,633	39	4,380	60	12,582	19	2,572	8	2,287	18	7,140
70	49	4,929	46	3,832	81	11,009	15	2,250	14	2,001	26	6,247
60	57	4,225	54	3,285	136	9,437	13	1,929	20	1,715	36	5,355
50	65	3,521	61	2,737	N/A	N/A	11	1,607	91	1,429	57	4,462
40	75	2,817	69	2,190	N/A	N/A	9	1,286	N/A	N/A	119	3,570
30	92	2,113	N/A	N/A	N/A	N/A	7	964	N/A	N/A	N/A	N/A
20	N/A	N/A	N/A	N/A	N/A	N/A	5	643	N/A	N/A	N/A	N/A
10	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Table 3.2.3.2-5. Flow and habitat at different percentages of maximum habitat derived from the four methods used to develop instream flow recommendations for age 2+ steelhead in the Lower Oak Grove Fork.

Percent of Max Habitat	Micro-Group Recommended Weighted EHM		EHM		2D - Binary		1D – Binary	
	Flow (cfs)	Habitat (ft^2 per 1,000 ft)	Flow (cfs)	Habitat (ft^2 per 1,000 ft)	Flow (cfs)	Habitat (ft^2 per 1,000 ft)	Flow (cfs)	Habitat (ft^2 per 1,000 ft)
100	97	10,519	125	8,581	80	9,312	150	1,901
95	91	9,993	87	8,152	56	8,847	99	1,806
90	84	9,467	77	7,723	47	8,381	95	1,711
85	78	8,941	69	7,294	39	7,915	92	1,616
80	71	8,415	61	6,864	36	7,450	84	1,521
75	63	7,889	54	6,435	32	6,984	75	1,425
70	54	7,363	46	6,006	29	6,519	69	1,330
60	35	6,311	32	5,148	22	5,587	60	1,140
50	22	5,260	22	4,290	16	4,656	53	950
40	14	4,208	16	3,432	11	3,725	46	760
30	6	3,156	10	2,574	6	2,794	38	570
20	N/A	N/A	4	1,716	0	1,862	32	380
10	N/A	N/A	N/A	N/A	N/A	N/A	23	190
0	N/A	N/A	N/A	N/A	N/A	N/A	5	0

Table 3.2.3.2-6. Flow and habitat at different percentages of maximum habitat derived from the four methods used to develop instream flow recommendations for anadromous salmon spawning in the mainstem Lower Oak Grove Fork.

	Micro-Group Recommended 2D - Adjusted Binary		EHM		Weighted EHM		2D - Binary		1D - Binary		2D - Reduced 40 percent	
Percent of Max Habitat	**Flow (cfs)**	**Habitat (ft^2 per 1,000 ft)**	**Flow (cfs)**	**Habitat (ft^2 per 1,000 ft)**	**Flow (cfs)**	**Habitat (ft^2 per 1,000 ft)**	**Flow (cfs)**	**Habitat (ft^2 per 1,000 ft)**	**Flow (cfs)**	**Habitat (ft^2 per 1,000 ft)**	**Flow (cfs)**	**Habitat (ft^2 per 1,000 ft)**
100	162	688	160	653	97	450	180	1,148	100	907	180	689
90	109	619	115	587	93	405	109	1,033	48	817	109	620
80	92	550	94	522	90	360	81	918	38	726	81	551
70	83	482	89	457	86	315	66	803	31	635	66	482
60	75	413	84	392	83	270	54	689	27	544	54	413
50	67	344	78	326	79	225	43	574	23	454	43	344
40	49	275	73	261	75	180	33	459	20	363	33	275
30	33	206	60	196	72	135	22	344	17	272	22	207
20	18	138	36	131	40	90	13	230	14	181	13	138
10	5	69	16	65	9	45	3	115	11	91	3	69
0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Table 3.2.3.2-7. Percentages of potential habitat maxima of anadromous salmonid spawning, 2+ steelhead rearing, 1+ coho rearing (main stem only and main stem and side channel combined) habitats provided by the Proposed Action instream flow releases for the Lower Oak Grove Fork below Lake Harriet dam. Estimates based on the habitat – flow response relationships recommended by the Flow-Geomorphology Sub-Group; spawning – 2-D Adjusted Binary; 2+ Steelhead – weighted EHM; 1+ coho main stem – weighted EHM, side channel – 1:10 main stem v side channel adjustment ratio.

	Jan	Feb	Mar	Apr[1]	May[1]	June[1]	July[1]	Aug[1]	Sept[1]	Oct[2]	Nov	Dec[2]
Settlement Agreement Proposal cfs	70	70	70	100/ 90/80	100/ 90/80	100/ 90/80	100/ 90/80	100/ 90/80	100/ 90/80	100/ 80	80	80/70
percent of Max Spawn Hab	≈55	≈55	≈55	~85W~ ~80N ~65D	~85W ~80N ~65D	~85W ~80N ~ 65D	~85W~~ 80N ~65D	~85W~~ 80N ~65D	~85W ~~80N ~65D	85/ 65	≈65	≈ 65/ 55
percent of Max 2+ SH Hab	≈80	≈80	≈80	~100W ~95N ~86D	~100W ~95N ~86D	~100W ~95N ~86D	~100W~ 95N ~86D	~100W~ 95N ~86D	~100 W ~95N ~ 86D	≈ 100/ 86	≈86	≈ 86/ 80
percent of Max 1+ Coho Hab (MS only)	≈45	≈45	≈45	~28W ~30N ~38D	~28W ~30N ~38D	~28W ~30N ~38D	~28W ~30N ~38D	~28W ~30N ~38D	~28W ~30N ~38D	~28/ 38	≈38	≈ 38/45
percent of Max 1+ Coho Hab (MS & SC)	≈30	≈30	≈30	≈ 50/40/ 35	≈ 50/40/ 35	≈ 50/40/ 3 5	≈ 50/40/ 35	≈ 50/40/ 35	≈ 50/40/ 35	≈ 50/ 35	≈35	≈ 35/30

[1]Represent flows corresponding to Wet, Normal, and Dry water year classifications
[2]Flows during first and second half of each month

Staff note that the flows under the Proposed Action would provide approximately 55 percent of the maximum spawning habitat from late December through March (coho, steelhead and cutthroat spawning). During a Normal water year type, the Proposed Action flows would provide about 80 percent of maximum spawning habitat from April through September (steelhead, Chinook). The flows during the first half of October (100 cfs) would provide 85 percent of maximum spawning habitat (Chinook, coho), with flows of 80 cfs during the last half and extending through the first half of December providing about 65 percent of the maximum. Importantly, the 80 cfs represents 80 percent of the spawning flow, which is consistent with the recommendation of Thompson (1974) who suggested that incubation flows be at least 2/3 (66 percent) of the flows that occur during the spawning period.

Steelhead 2+ Rearing

All three methods produced similar habitat availability curves for 2+ steelhead rearing habitat; maximum habitat would be achieved at flows of around 100 cfs, providing close to 11,000 ft^2/1000 ft of channel. A sharp but modest decrease in habitat occurs with increasing flows from 100 cfs to 160 cfs (about 8,800 ft^2/1,000 ft), and then a slight increase in habitat occurs from 160 cfs to 225 cfs (9,000 ft^2/1,000 ft). The highest flow mapped (225 cfs) provides about 80 percent of the maximum habitat attainable at 100 cfs; a flow of 80 cfs provides the equivalent amount of habitat when considering the ascending limb of the relationship. All of the curves indicate that from 95 to 100 percent of maximum habitat can be achieved at about 100 cfs.

Staff's analysis of the Proposed Action flows relative to 2+ steelhead rearing habitat indicate that habitats would be maintained at approximately 80 percent of maximum levels or higher depending on a given month. During Wet water year types, 2+ steelhead habitat would be maximized by flow releases from April through October (see Table 3.2.3.2-4).

Results of both 1-D and 2-D modeling suggest the Proposed Action flows would also provide close to the maximum amount of cutthroat trout habitat (see Table 3.2.3.2-4), while also providing substantial juvenile coho and Chinook habitats.

Mainstem 1+ coho rearing habitat

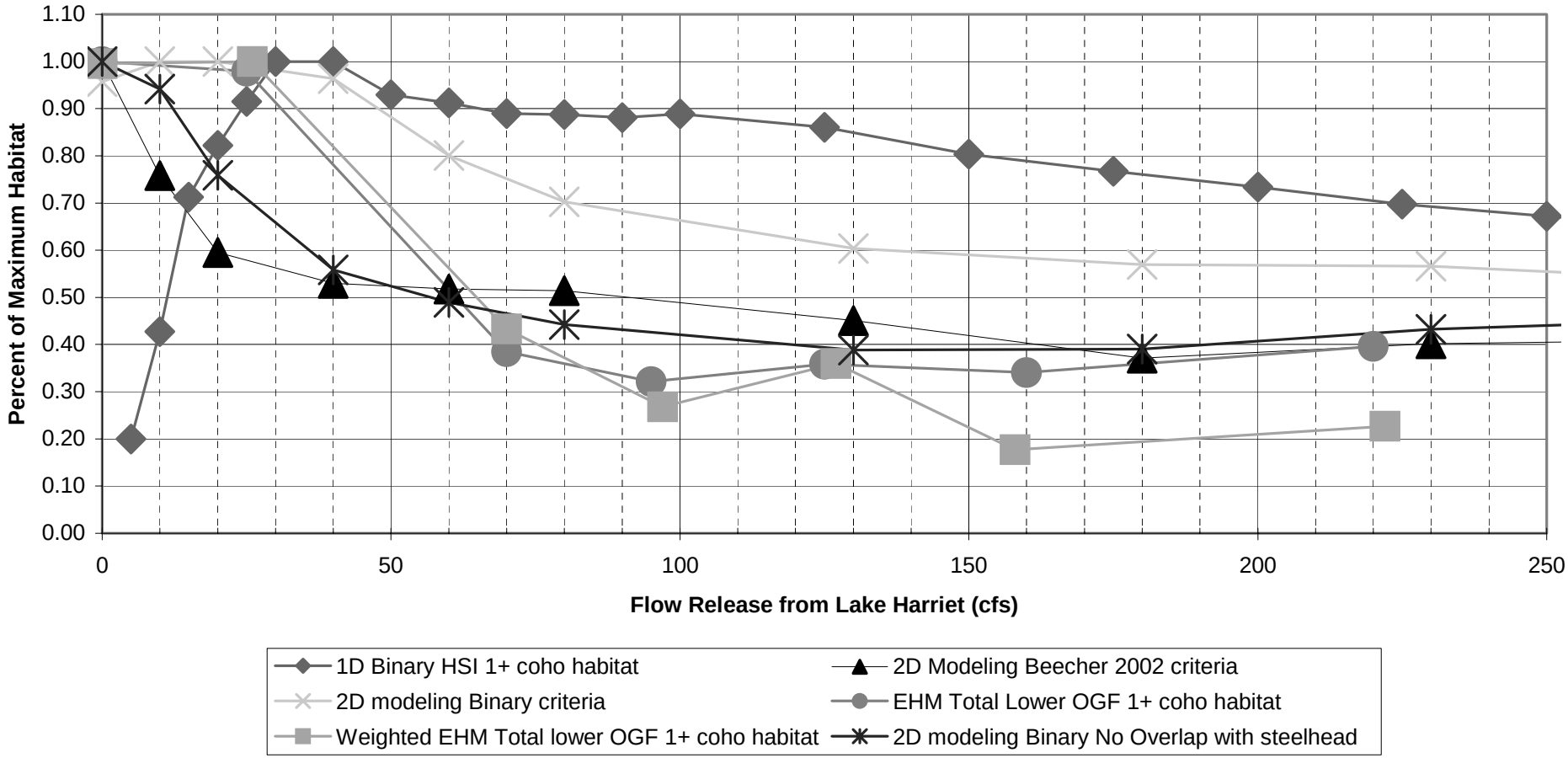
The three methodologies generated similarly shaped 1+ coho habitat rating curves (See Appendix E), but the 2-D and EHM curves differed substantially in habitat magnitude, a result of different mapping and surveying locations, and in the case of one of the 2-D model runs completed by Addley et al. (2003),

application of stricter habitat criteria (Beecher et al. (2002) criteria were applied). Above 75 cfs, EHM and Beecher et al.'s (2002) methodologies predict similar habitat densities. The different methods (EHM, Weighted EHM, 2D-PHABSIM, 2D-Beecher, 2-D-no overlap, and 1D-binary) estimated maximum mainstem coho habitat availability between 0 (EHM, 2-D-Beecher, 2-D-no overlap) and 30 (1-D-binary) cfs (Table 3.2.3.2-7). All of the curves suggest declines in habitat availability with increasing flows over 40 cfs, a likely result of the slow velocities reflected in the coho HIS curves. However, the FG-subgroup recognized that the best potential 1+ coho habitat existed in the side-channels to the mainstem Oak Grove Fork, the majority of which have been largely disconnected from the main channel due to lack of flow. Specific studies were conducted to evaluate flow-side channel connectivity relationships.

Side-Channel Habitats – Coho 1+ Rearing

McBain and Trush (2003a) identified 26 potential side channels within the reach that could be wetted at various flows and conducted an analysis of the flow thresholds that would afford fish access and use in these side channel areas (See Appendix E). Since juvenile coho favor side-channel over main channel habitats, the FG-group concluded that a scaling of mainstem to side-channel habitat value was warranted. Review of local data from Fish Creek and the mainstem Clackamas River suggested that ratios of mainstem to side-channel habitat could range from 1:5 (Fish Creek) to about 1:29 (mainstem Clackamas River). Figure 3.2.3.2-5 depicts the relationship of total 1+coho habitat area as a function of flow for three scaling factors, including 1:5 and 1:29, and an intermediate ratio of 1:10. All three adjusted curves indicate that total 1+ coho habitat would be maximized around 125 cfs, which in the case of the 1:5 ratio would provide about 200,000 ft^2 of habitat; for the 1:10 ratio about 340,000 ft^2 and for the 1:29 ratio about 880,000 ft^2 of habitat (Figure 3.2.3.2-5).

Figure 3.2.3.2-5. Habitat availability curves for 1+ coho rearing in the lower Oak Grove Fork using 1-D, 2-D, and EHM methodologies.



The Proposed Action flows would provide permanent connections to only 4 of the 26 side channels in the Lower Oak Grove Fork, resulting in the provision of about 18,600 ft^2 of 1+ coho habitat. As a result, PGE would physically manipulate some of the other side channels to create additional side channel habitat that in combination with the habitat provided via flow increases would total approximately 40,000 ft^2. Without physical manipulation, provision of these amounts of side channel habitat would require flow releases in excess of 500 cfs (see Figure 3.2.3.2-5).

Summary of the effects of the Proposed Action on instream flows

The Proposed Action for instream flows downstream of Harriet dam incorporates flexibility to account for interannual variability in precipitation. In wet years the Proposed Action includes a 100-cfs release from April 1 through October 15, which would be reduced to 80 cfs from October 16 until December 16, and then decreased to and remaining at 70 cfs until April 1 of the following year. During normal years the Proposed Action would maintain a 90-cfs release from April 1 through September 30, a 100-cfs release from October 1 though October 15, an 80-cfs release from Oct 16 through December 15, and a 70-cfs release from December 16 through March 31 of the following year. During dry years the Proposed Action would maintain a 80-cfs release from April 1 through September 30, a 100-cfs release from October 1 though October 15, an 80-cfs release from Oct 16 through December 15, and a 70-cfs release from December 16 through March 31 of the following year. In no case would the minimum flow downstream of Harriet dam be below 70 cfs under the Proposed Action. Releases between 100 and 70 cfs would wet approximately 4,438 ft of side channel habitats in the 11 channels that would receive some flow. Using the 1:10 main stem to side-channel habitat adjustment ratio, flows of 100 cfs and 80 cfs would for the months of May 1 through September 30 provide around 170,000 ft^2 and 120,000 ft^2 of combined main stem and side-channel 1+ coho habitat, respectively (see Figure 3.2.3.2-5). However, under the Proposed Action some of these wetted side channel areas may become disconnected as flows are reduced from 100 to 70 cfs.

The Proposed Action specifies release flows of 100-80 cfs for the period April 1 through about August 30 to provide for egg incubation and fry emergence of steelhead and cutthroat trout. The 80 cfs represents 80 percent of the spawning flow, which is consistent with the recommendation of Thompson (1974) who suggested that incubation flows be at least 2/3 (66 percent) of the flows that occur during the spawning period. Flows released during this period would also be important for providing juvenile rearing habitats. Results of both 1-D and 2-D modeling suggest that flows of around 70 cfs (about 85 cfs in Reach 1G) would provide close to the maximum amount of juvenile steelhead and cutthroat trout habitat, and steelhead 2+ habitat (see Appendix E) (Table 3.2.3.2-8), while also

providing substantial juvenile coho and Chinook habitats. The 80-cfs release flow would allow a surface flow connection with 11 of the 26 side channels identified in the reach.

Table 3.2.3.2-8. Comparison of flows that maximize (and represent 80 percent of maximum) spawning, steelhead 2+ and coho 1+ habitats as determined from PHABSIM -1D, PHABSIM - 2D and Expert Habitat Mapping (EHM) studies completed in the Lower Oak Grove Fork (Reach 1G) below the barrier falls.

METHOD	Q of Maximum Spawning Habitat (Q 80 percent of Max)	Q of Max. Steelhead 2+ Habitat (Q 80 percent of Max)	Q of Maximum Coho 1+ Habitat (Q 80 percent of Max)
PHABSIM – 1D Model (CES 1984; Framatome ANP DE&S, 2003)	100 cfs (≈ 40 cfs)	125 (≈ 90 cfs)	30-40 cfs (≈ 15-20 cfs)
PHABSIM – 2D Model (Addley et al., 2003)	200 cfs (SH) (≈ 100 cfs) 250 cfs (Co) (≈ 110 cfs)	100 cfs (≈ 80 cfs)	30-40 cfs (≈ 10-20 cfs)
Expert Habitat Mapping (EHM)(McBain and Trush 2003a)	100 cfs (≈ 40 cfs)	120 cfs (≈ 65 cfs)	10-20 cfs (0-20 cfs same as 100 percent)

The Proposed Action specifies a minimum flow release of 100-70 cfs below Harriet dam for the remainder of the year (i.e., August 16 through April 30), with the annual minimum flow occurring from December 16 to March 31. Based on the 1-D and 2-D modeling, a flow of 70 cfs provides close to 90 percent main stem juvenile habitat for coho and Chinook salmon, and substantial juvenile steelhead habitat as well (See Appendix E). However, as noted above, it would be less than half of the flow needed to maximize 1+ coho side channel habitats. The flow would provide some coho and Chinook spawning habitats (more than 70 percent of maximum coho and Chinook spawning habitats based on 2-D modeling; more than 95 percent of maximum spawning habitat based on 1-D modeling).

In regulated systems, flows designed to maintain channel morphology, and promote habitat diversity and ecological function are important for mimicking portions of the natural hydrograph that transport and flush sediments, move LWD, and promote connectivity with side channels. These flows may also be linked to the riparian communities that are dependent on seasonal flow changes. Poff et al. (1997) and more recently Postel and Richter (2003) among others have all demonstrated the ecological importance of integrating components of a natural flow regime into regulated systems, to include considerations of flow magnitude, duration and timing. Studies have suggested that a reasonable approximation of a

channel forming flow can be related to hydrologic events, which for gravel-bed rivers, has been estimated to be equivalent to a 1.5–year flood event (Reiser et al., 1989; Rosgen, 1982). According to McBain (personal communication with Scott McBain, 2004), the pre-dam 1.5-year flood for the Oak Grove Fork is approximately 1,330 cfs, and the post-dam 1.5-year flood is approximately 745 cfs (computed by subtracting 600 cfs from the annual peaks from the gage upstream of Lake Harriet and the Frog Lake Diversion). Review of flood-frequency information provided in McBain and Trush (2004) indicates that a flow of 745-1,330 cfs occurs naturally approximately every 2.5 to 3 years under existing conditions and would continue to do so under future conditions (assuming no increased diversion).

The Proposed Action includes provisions for these types of flows in the form of both Winter Flood Flows and Snowmelt Runoff Events. The provision of Winter Flood Flows would occur during the period January 1 to March 31. During this period, Harriet dam would be operated to pass all instantaneous peak flows greater than 1,300 cfs for about 10 hours. This would require shutting down the Frog Lake flowline diversion for about 10 hours to allow all flow to pass downstream below Harriet dam. PGE would provide up to four such events in any given year.

Snowmelt runoff events would be provided from April 20 to May 15, with the magnitude and duration of the flow releases varying depending on water year types (See Settlement Agreement Project Operating Plan, PGE, 2006).

The Proposed Action includes downramping rates of 10-20 cfs/hr below Lake Harriet when shifting from Snowmelt Runoff Event flows to base flows. PGE operates the Oak Grove development to minimize spill at Lake Harriet, so spills would only occur as part of the Winter Flood Flow releases (during January 1 to March 31) or Snowmelt Runoff Events that vary by water year type and may be provided from April 20 through May 15. These low ramping rate restrictions , if implemented relatively steadily, should not result in significant, if any, stranding of fish.

There are no ramping rate restrictions for making monthly or mid-monthly adjustments in the flow releases over the range of flows from 70 to 100 cfs. Theoretically, this could mean an instantaneous flow reduction of around 20 cfs (e.g. mid-month adjustment in October from 100 cfs to 80 cfs). As a further protective measure, inclusion of a ramping rate restriction of 10 cfs/hr could be applied when making adjustments in flow releases.

The Proposed Action would also augment approximately 2,200-3,000 tons of gravel at two sites (Crack-in-the-Ground and Ripplebrook Campground). This

would be followed by 50-80 tons/yr additions in subsequent years. There is evidence supporting the need for gravel:

- gravel recruitment from sources upstream of Harriet dam was essentially eliminated since dam construction;
- periodic spills of sufficient magnitude to transport gravel-sized materials have occurred since dam construction;
- there are relatively few sources (only 2 to 3 small tributaries) of gravel recruitment below the dam; and
- channel gradients are relatively steep so that transport capacity would be relatively high during periods of spill.

The combination of these factors supports a hypothesis that coarse gravel supply could be limited within this reach. However, as noted by McBain and Trush (2004) and confirmed by our additional analysis, the combination of reduced transport capacity and reduced sediment supply have served to somewhat offset the resulting downstream effects of each other to the extent that changes in pre- versus post-Project channel morphologies (including substrate characteristics) within the reach may be subtle, as suggested by McBain and Trush (2003a). Nevertheless, the proposed gravel augmentation and monitoring activities would enhance habitats downstream. The placement of gravels could be associated with entrapment by large wood structures proposed for 6 sites to improve gravel retention and provide fish habitat.

Clackamas River from Oak Grove Fork to Oak Grove Powerhouse (Reach 2A)

Watershed Processes

Gravel added to the Oak Grove Fork under the Proposed Action would eventually be delivered to the Clackamas River. We do not expect that addition of 80 tons of gravel or less per year would appreciably increase the Clackamas River bedload yield relative to current conditions, nor should changes occur in the frequency or magnitude of flows capable of transporting coarse sediment.

Implementation of the Lake Harriet LWD management plan and addition of LWD to the Oak Grove Fork would not substantially increase LWD recruitment to the mainstem Clackamas River. Downstream travel distance of LWD in streams the size of the Oak Grove Fork below Harriet is generally small (Martin and Benda, 2001), and wood that is transported to the Clackamas River would likely have a length of less than 50-feet in general, and thus would not increase the frequency of large pieces (>24 inch diameter and 50 foot length).

Physical Habitat Elements

Gravel augmentation in the Oak Grove Fork would result in a slight increase in the amount of gravel delivered to the Clackamas River as compared to current conditions. This could result in small increases in the size or frequency of gravel patches within Reach 2A. Increased minimum flows could result in small increases in the extent and quality of pool habitat and off-channel habitat. The amount and quality of available habitat area that would be provided under the Proposed Action is discussed in detail below.

Instream Flows

This reach of the Clackamas River is influenced by flows from the Oak Grove Fork, and hence, the increase in flows resulting from the Proposed Action in reaches 1F and 1G of the Lower Oak Grove Fork (see above). There are no specific instream flow releases or ramping rate restrictions proposed in the Proposed Action for this reach of the Clackamas River, so the flows in this reach would continue to be influenced by the lower Oak Grove Fork's flow regime. Assuming the greatest effect of the Oak Grove Fork flows would occur during periods of low summer – early fall flows (July – October; average monthly flows in the Clackamas River above Oak Grove Powerhouse range from 378 cfs (September) to 557 cfs (July) (PGE, 2003), the instream flows in the Oak Grove Fork under the Proposed Action would contribute nominally from greater than 80 to more than 100 cfs to this reach. The contribution of Flow from the Oak Grove Fork could contribute between 40 percent and 50 percent of the total flow in the Clackamas River mainstem, but because of the size of the mainstem river channel, such flow increases would likely have only a small positive effect on physical habitats (expressed as changes in wetted perimeter and usable habitat widths (PGE, 2003; see Figures 5.4 and 5.5 in that report) within this reach; both spawning and juvenile rearing habitats peak around 500 cfs. However, the water temperatures of the Oak Grove Fork are colder compared to the mainstem Clackamas River and the increased flows during the warmer summer months would likely reduce temperatures in portions of this reach, compared to the No-Action alternative, but only minimally (See water quality section; See Appendix E for more detailed analysis of habitat – flow relationships for this reach).

Clackamas River from Oak Grove Powerhouse to North Fork Dam (Reach 2B)

Watershed Processes

Gravel augmentation in the Oak Grove Fork could result in small increases in bedload supply to Reach 2B; however, the overall bedload yield would continue to be dominated by sources in the Upper Clackamas basin and unregulated tributaries to the Clackamas River in this reach. No significant changes in LWD recruitment or loading would occur as a result of the Proposed Action.

Physical Habitat Elements

No changes in physical habitat elements would be expected in Reach 2B under the Proposed Action.

Instream Flows

This reach of the Clackamas River is influenced by a combination of the flows entering from reach 2A (which in turn are influenced by Oak Grove Fork flows), and the flows discharged from the Oak Grove Powerhouse. There are no specific minimum instream flows or channel maintenance flows specified for this reach in the Proposed Action, although normal water levels in the North Fork Reservoir would be between 663.0 and 665.0 ft except during winter drawdown to allow for drawdown during spinning reserve events and peaking operations, and flows in the North Fork fish ladder would be approximately 43 cfs. The major Project-related flow effect occurring in this reach of the Clackamas River relates to the peaking and load-following operations of the Oak Grove Powerhouse.

Under the Proposed Action, PGE would be allowed to operate the Oak Grove Fork powerhouse under certain flow conditions largely in accordance with historical operations, with a proposed downramping rate of 0.3 ft per hour. This ramping rate would apply under all flow conditions during the period November 1 through January 31, but is contingent on prevailing flows during the period February 1 through September 30. During that time, if flows are ≥ 1,200 cfs in the mainstem, then the 0.3 ft/hr rate applies; if flows are < 1200 cfs, then a more restrictive ramping rate applies, 0.17 ft/hr. However, the sufficiency of the lower ramping rate would be further evaluated as part of a site-specific ramping rate study conducted during the period July through September. Under the Proposed Action, PGE would also be able to conditionally apply ramping rates of 0.3 ft/hr during October provided flows are ≥ 1,200 cfs, but, this would likewise be evaluated as part of a proposed "October Study" that would specifically evaluate stranding potential during this time.

Past studies indicate that the average daily maximum downramping rates (average for all transects for all days in a given year) for July 1 through August were 0.26 ft/hr (3.1 in/hr) in 1998 and 0.13 ft/hr (1.6 in/hr) in 1999 (Framatome ANP, 2003). Maximum daily downramping rates ranged between 0.38 ft/hr on Transect 7 and 0.66 ft/hr (8 in/hr) on Transect 12 in 1998, and between 0.31 ft/hr on Transect 7 and 0.72 ft/hr on Transect 9 in 1999 (Framatone ANP revised data, 8/21/03).

Staff reviewed available information to evaluate effects of power peaking below the Oak Grove Powerhouse on the quality and availability of anadromous salmonid rearing and spawning habitat, redd de-watering, juvenile salmonid stranding, spring Chinook holding habitat, and lateral margin habitat for macroinvertebrates in the Clackamas River. Staff modeled changes in salmonid and non-salmonid habitat over a range of peaking flows typically encountered in summer and fall (See Appendix E for detailed analyses). This is the time period when flow fluctuations from power peaking comprise the highest fraction of total flow, with changes of 230 cfs to 450 cfs in Reach 2B, which represent the extremes that would not occur under non-peaking operations (Framatome ANP, 2003; Doughty, 2004). Spring Chinook and early-run coho fry have grown prior to the onset of the summer baseflow periods when peaking has the greatest potential for stranding fry. Steelhead fry may be present in July and August, hence ramping could affect both fry and juvenile lifestages during the summer.

Fluctuations in flows as a result of rapid or large-volume ramping rates can directly affect salmonid fry and juveniles in two ways: through stranding and trapping. The flow below which prescribed ramping rates become necessary for protecting fish from either stranding or trapping has been defined as the 'critical flow rate' (Hunter, 1992). The ‘critical ramping rate' is that rate below which stranding is unlikely to occur. Previous studies have determined that manipulation of ramping rates influences stranding mortality more strongly than trapping mortality, which can also occur naturally depending on the river (Hunter, 1992; Bradford, 1997; DeVries et al., 2001). Hence, effects of the Project are evaluated primarily in terms of stranding mortality, which operational changes have the greatest potential to benefit.

Several physical factors directly influence salmonid stranding and trapping including: local streambed gradient; substrate size and embeddedness; presence, type, and location of riverbed depressions; woody debris distribution; distribution of water velocities; and distance between gravel bars and the powerhouse because of flow attenuation (Hunter, 1992; DeVries et al., 2001). Stranding of salmonid fry occurs most frequently on gradually sloping streambeds when the bed gradient is less than about 4 percent (Bauersfeld, 1978; Woodin, 1984; Olson, 1990). The

relationship between substrate condition and stranding frequency is influenced by the size range of substrates present, where coarser substrates with low fine sediment and low embeddedness provide a greater number of micro-depressions in which fry and juveniles can become stranded as water levels fall. For example, Bauersfeld (1978), Woodin (1984), and Olson (1990) have all reported salmonid fry stranding on gravel and cobble substrates, with clean (low embeddedness) substrates posing the greatest risk. Substrate composition appears to be less important with respect to trapping. In general, the influence of substrate appears to be determined by the size of the fish relative to the size of the larger particles and their surrounding micro-depressions, the size of the pore spaces between substrate particles, and behavioral affiliations of fish to specific substrates (plus depth and velocity) prior to and during downramping.

A reconnaissance study in August 2001 targeted the most sensitive channel locations in evaluating stage and wetted perimeter changes due to power peaking (PGE, 2003b; Doughty, 2004). Plan maps of 15 study transects documented changes in wetted area between the two calibration flows of 400 cfs and 630 cfs as measured at the USGS' Three Lynx gage. Side-channel water surface fluctuations were measured over the range of summer/fall baseflows to quantify the sensitivity of side-channels to peaking operations. Three side-channels were monitored, two of which were hydraulically connected to the main channel flow by shallow wetted segments (PGE, 2002). The study measured fish stranding potential based on stage height changes measured under the various flows.

The reconnaissance study observed that wetted perimeter changes varied from 2 to 30 ft during a 450-cfs peaking flow fluctuation when the mainstem daily flow at the Three Lynx gage was 850 cfs (Framatome ANP, 2003). While this level of peak flow is larger than what PGE would release with a low Clackamas River baseflow of 850 cfs, in general, the data indicate that stranding effects are most likely when flows drop below approximately 800-900 cfs. Stage decreases between 0.56-0.87 ft at the 12 surveyed transects as flows decrease from 800 cfs to 400 cfs (Doughty, 2004). The wetted perimeter data suggest that significant ramping effects would not occur at flows higher than about 900 cfs. However, the several cross-section bed profiles and water surface elevation data presented in Doughty (2004) indicate that six transects (2, 3, 8, 9, 10, 15) are associated with sideslopes less than 4 percent and cobble and large gravel substrates that could be associated with stranding when flow decreases begin starting closer to about 1,000 cfs. Of these, only Transects 3 and 15 have more extensive bars that could be associated with significant stranding potential depending on ramping rate. Transect 3 is located near the bottom of Reach 2B (~RM 37). Hence, stranding potential exists throughout the length of Reach 2B as flows drop under certain flow conditions. Flows are rarely below 400 cfs (Doughty, 2003), so the data suggest collectively that greatest potential for stranding effects in Reach 2B occurs

within the approximate flow range of 400-1,000 cfs. Staff assume that the 1,200 cfs flow threshold (i.e." critical flow"- when flows ≤ 1,200 cfs) noted in the Proposed Action that triggers a more stringent ramping rate (0.17 ft/hour) was conservatively based on these analyses.

Downramping rates in the range of 0.08 ft/hr (1 in/hour) to 0.17 ft/hr (2 in/hour) are generally considered safe for avoiding fry and juvenile salmonid stranding (Hunter, 1992). There have not been reports of large numbers of stranded salmonids at other locations during field surveys, so overall stranding frequency in this reach may be low, but Doughty (2004) suggests that the potential for stranding could exist in several reaches. To address this potential effect, the Proposed Action includes a provision for two studies to assess the issue of fry and juvenile stranding potential more thoroughly, and the results would be used to guide future operations under the license. If the results of the October stranding study indicate the need, and upon Commission approval, the downramping rate could be adjusted down to a 0.17 ft/hr rate, consistent with Hunter's (1992) recommendations.

The side channels studied in Reach 2B remain watered as flows drop to 400 cfs (Doughty, 2004). Some side channels become disconnected from the main channel flow at the lower flow during late summer/early fall baseflows, where fish may become trapped temporarily until the next upramp. The two side-channels with greatest changes in stage correspondingly remain connected hydraulically to the main channel over the range of peaking flows. Water surfaces in the side-channels fluctuated from 0.01 ft to 0.46 ft. Nonetheless, depths in the side channels are relatively shallow, and the possibility exists that if fry were present they could be stranded or trapped around the side channel margins, because local bed slopes are less than 4 percent in many locations where the riverbed is composed of cobble and large gravel substrate. Alternatively, it is possible that water temperatures could rise during the day in many side channels after flows have dropped to 400 cfs. It is unknown if temperatures would be sufficient to stress or kill trapped salmonid fry or juveniles; side channel water temperature would depend on the balance between inflow, air temperature and cloud cover. Staff assume these factors would be evaluated as part of the site-specific ramping rate studies.

Clackamas River from North Fork dam to Faraday Diversion dam (Reach 2C)

Watershed Processes

The Proposed Action would maintain the current flow regime and would not alter watershed processes in Reach 2C as compared to current conditions.

The Proposed Action includes a wood management plan for wood removed at North Fork dam. The wood would be stockpiled for placement in the channel downstream of the dam and placed in the channel as part of the LWD placement program, allowed to redistribute down the channel naturally, or made available for habitat restoration projects elsewhere in the basin. Implementation would likely increase LWD recruitment to Reach 2E. Any LWD placement program would be most beneficial if focused on the 2-mile reach immediately downstream of River Mill dam, where Wampler and Grant (2003) identified the most pronounced Project-related effects. Wampler (2004) quantified existing levels of in-channel wood in the lower Clackamas, and observed 1 piece in the 2-mile long reach downstream of the dam on aerial photos dating from 2000. Improving the current LWD frequency (0.5 large pieces /mile) in this 2-mile reach to a level consistent with NMFS MPI standards for Properly Functioning Habitat (80 large pieces /mile) would require placement of approximately 159 pieces of large wood (diameter >24 inches; length > 50 feet) over the 2.0 mile long reach. Increased LWD frequency could increase the number of pools and would enhance pool quality and overall habitat complexity in this stretch.

An evaluation of historic fluctuations in LWD in the lower Clackamas River confirms that even the largest pieces of LWD in this portion of the river are mobilized by flood flows (Wampler, 2004). The potential also exists for loss of engineered log jams through drying, rotting, and subsequent flood damage. As a result LWD placement would likely require periodic replacement to maintain over time the habitat values gained by LWD placement.

Physical Habitat Elements

The Proposed Action would not alter physical habitat elements in Reach 2C compared to current conditions.

Instream Flows

This 1.5-mile-long reach is nearly all impounded with only about 500 ft of free-flowing river before backwater effects from the Faraday Diversion dam occur. The Faraday-North Fork fish ladder provides upstream fish passage over and past the Faraday Diversion dam and reservoir directly to North Fork Reservoir. The North Fork bypass system provides downstream fish passage, although some fish pass downstream to the Faraday Diversion reservoir via the North Fork turbines and spillway.

There are currently no instream flow or ramping rate restrictions at North Fork dam. The Proposed Action likewise does not specify any instream flow

releases to this reach, or impose any ramping rate restrictions. The flow regime within this reach may be affected as a result of specific fish passage requirements that are described in more detail in BA. For example, under the Proposed Action, PGE would limit generation at the North Fork powerhouse under certain conditions until the downstream fish passage collector is in operation. Once the fish collector is installed, the generation limitation would change but remain in place until it is demonstrated that the overall project survival will not be diminished by removing the limitation, at which point it could be removed. PGE would also maintain water levels between North Fork dam and Faraday Diversion dam between 526.0 ft and 521.0 ft under normal conditions with a 516.0 ft extreme minimum and maintain a 43 cfs flow in the North Fork fish ladder. These water level bounds would provide 5 feet of storage to re-regulate peaking operation of North Fork Powerhouse.

Clackamas River from Faraday Diversion dam to Faraday Powerhouse (Reach 2D)

Watershed Processes

The Proposed Action would maintain the current peak flow regime, sediment yield and LWD recruitment in Reach 2D, and would not alter watershed processes as compared to current conditions.

Physical Habitat Elements

The Proposed Action would not alter physical habitat elements in Reach 2D as compared to current conditions

Instream Flows

This approximately 1.8-mile-long reach is dominated by pool (45 percent) and riffle (27 percent) habitat (Cramer et al., 1997). Subject to Commission approval, PGE would release a minimum instantaneous flow of 270 cfs at the Faraday Diversion dam. The amount of flow however, is subject to a State instream flow water right that is triggered when flows above the Faraday Diversion dam exceed 5,270 cfs. Two time frames are associated with this, corresponding to a period from July 1 to September 15 during which if flows ≥ 5,270 cfs than additional flow (above the 270 cfs release) would be released below the dam up to 400 cfs. From September 16 to June 30, when flows are ≥ 5,270 cfs additional flows would be released until flows equal 640 cfs. PGE would also maintain water levels in Faraday Lake between 520.2 ft and 515.0 ft with a 510.2 ft extreme minimum. Under the No-Action alternative, PGE would continue to provide release flows of about 120 cfs. Under the Proposed Action PGE would

maintain Faraday Lake water level at a 520.2 ft maximum, with a 515.0 ft minimum, and 510.2 ft extreme minimum year-round.

Members of the collaborative identified a number of flow related issues pertaining to this reach which generally focus around adult upstream passage and to some degree juvenile rearing. The issue of upstream passage includes two concerns; 1) the provision of flows that allow for the physical, unimpeded passage of adult fish through the reach; and 2) the provision of flows that are of suitable water quality, in particular water temperatures that are conducive to adult upstream passage. This latter component is particularly important since results of some temperature monitoring suggest summertime water temperatures in this reach can exceed temperatures from Faraday Powerhouse release flows by 1 – 2°C (DE&S, 2002).

The FG-Subgroup completed a field reconnaissance survey of this reach in 2002 to view selected sections under different flow releases; flows of 120 cfs, 270 cfs, and 520 cfs were provided. In September 2004, the FG-Subgroup completed a more detailed instream flow assessment of this reach using a combined EHM and PHABSIM approach (McBain and Trush, and EES Consulting, 2004) Over a range of four release flows (120 cfs, 180 cfs, 250 cfs, and 500 cfs). The EHM analysis focused on 2+ steelhead rearing habitats, while the PHABSIM analysis targeted Chinook, coho, steelhead and cutthroat trout spawning habitat. In addition, wetted perimeter vs. flow, as well as stage-discharge relationships were determined. Results of the EHM as defined for one of the study reaches are depicted in Figure A-17; (see Appendix E). In general, results suggest that close to the maximum amount of 2+ steelhead, as well as Chinook and coho spawning could be provided at flows around 300 cfs. The WP vs. flow relationships for the four transects all contained noticeable inflection points at flows from about 270 cfs to around 220 cfs (see Figure 6 in McBain and Trush and EES Consulting, 2004). Staff review of the study indicates that a 270-cfs release flow would provide substantially more 2+ steelhead rearing, and Chinook and coho spawning habitat than would be provided under the No-Action alternative in which the release flow would be maintained around 120 cfs.

There are no specific ramping rates associated with this reach. However, the Proposed Action provides for both a Spill Protocol that would be followed to protect downstream migrating smolts, as well as a Pulse Flow Study that would evaluate different pulse flow releases as a means to attract adult salmon and steelhead and expedite their migration through this reach. The spill protocol is designed to prevent stranding and trapping of smolts and other juvenile salmonids that may have been transported below Faraday dam during uncontrolled spill events at the North Fork dam. The protocol includes the following provisions:

- Until spillway exclusion net has been shown to effectively prevent spillway entrainment at flows of up to 4000 cfs, during periods of unscreened spill at North Fork dam greater than 1 hour during major smolt migrations (from April 1 through June 30, and October 1 through December 15), spill 50 percent of flow at Faraday Dam and spill a minimum of 400 cfs at River Mill Dam.

- For unscreened spill duration at North Fork Dam lasting from 1 hour to 12 hours and with unscreened spill volumes less than 2,000 cfs, continue to spill at Faraday Dam for 24 hours after the cessation of spill at North Fork Dam.

- During unscreened spills at North Fork Dam that last longer than 12 hours, or during spills greater than 2,000 cfs, regardless of duration, continue to spill at Faraday Dam for 48 hours after the cessation of spill at North Fork Dam.

- After the spillway exclusion net has been shown to prevent spillway entrainment effectively at flows of up to 4000 cfs, spill 50% of the river's flow when spill at North Fork Dam exceeds the capacity of the spillway exclusion net.

- Implement a revised flow protocol as per the Settlement Agreement (PGE, 2006).

This protocol would remain in effect until the spillway exclusion net is constructed (see BA) and proven effective at preventing entrainment of fish up to 4,000 cfs. Refinements in this protocol are further explained in the Settlement Agreement (PGE, 2006).

The Proposed Action also specifies the design and conduct of a Pulsed Flow Study to be implemented in 2007. The study would form the basis for developing a pulse flow regime for the Faraday Diversion Reach that would 1) minimize holding time at and attraction to the Faraday Powerhouse tailrace; 2) minimize migration time through the bypass reach; and 3) avoid exaggerated holding times below the diversion dam and ladder rejection at the North Fork ladder. The plan is being developed within an adaptive management framework in which results of the study would be used to revise an interim pulse flow protocol.

Clackamas River from Faraday Powerhouse to River Mill Dam (Reach 2E)

This reach is nearly all impounded by the River Mill dam. The Proposed Action proposes to maintain water levels in Estacada Lake between 389.0 ft and 387.0 ft, with a 384.5 ft extreme minimum, and limit lake level fluctuations to 2.0 ft when winter steelhead or coho redds are present (winter and spring). PGE may make changes within an already determined range of elevations and may change the

time periods, in consultation with the Fish Committee. No changes are expected in the status of watershed processes, physical habitat elements, or instream flows within this reach.

Clackamas River Downstream of River Mill Dam (Reach 2F)

Watershed Processes

Under the Proposed Action , the North Fork dam and River Mill dam would continue to interrupt the downstream transport of LWD and sediment from the upper Clackamas basin, limiting recruitment of spawning gravel and LWD to Reach 2F. LWD recruitment and transport would be the same as for current conditions.

The Proposed Action includes a plan to restore channel morphology below River Mill dam. PGE would place 8,000 cubic yards of gravel 850 feet below the dam on the right river bank, and would augment approximately 8,000 cubic yards of gravel per year on average below River Mill dam for the life of the license, to offset current gravel export and to potentially increase in-channel gravel storage (Wampler and Grant, 2003). The amount may be increased to 20,000 cubic yards in some years depending on flows. These amounts exceed an estimated annual bedload transport rate of approximately 6,200 cubic yards, as reported in the coarse sediment management plan of the Settlement Agreement (PGE, 2006). While the proposed input rates are well below the annual transport capacity given that flood peaks would essentially not be attenuated by River Mill dam, it is possible that augmentation could have beneficial effects to channel morphology and fish habitat. A monitoring program would be implemented to determine effects and benefits.

Physical Habitat Elements

Gravel augmentation could maintain or increase the amount of suitable spawning habitat downstream of River Mill dam. Gravel placement could result in some pool infilling; however, because existing pools are generally formed by bedrock and have depth well in excess of 3.3 ft (1 meter), adverse effects to pool quality would not be expected. Large woody debris frequency would remain the same as for current conditions.

Instream Flows

Under the Proposed Action, there are no specified minimum flow releases below River Mill dam. Rather, the flow releases below the dam would be structured to essentially reduce the overall flow-related effects of the Project (i.e.

upstream flow regulation that occurs at North Fork dam and Faraday Diversion dam) on the Clackamas River below River Mill dam. This would occur via the release of flows in an inflow-matching mode, with no ramping and with no flow adjustments over 50 cfs per hour, that would essentially match the flows that would otherwise occur if the Clackamas Project facilities from North Fork dam through River Mill dam did not exist. Thus, the flow releases below River Mill dam would closely approximate (within 10 percent accuracy, or 100 cfs) the inflow values to the Project at North Fork.

These measures would establish a flow regime that when coupled with development and implementation of a Coarse Sediment Management Plan which is focused on replenishment of coarse sediments back into the reach of the Clackamas River affected by the Project, would prove beneficial to aquatic habitat diversity, productivity and fisheries downstream.

3.2.3.2.2 Benthic Invertebrates

The following describes the effects of the Proposed Action on benthic invertebrates in the Oak Grove Fork and Clackamas River.

Oak Grove Fork

The flow releases proposed under the Proposed Action from the Timothy Lake dam would increase the amount of wetted edge habitat in Reach 1B of Oak Grove Fork, and thus likely result in some increased production of benthic invertebrates. However, the increase in species richness abundance, or overall production has not been estimated quantitatively.

The benthic invertebrate community in the Lower Oak Grove Fork immediately downstream of Lake Harriet is sparse (Framatome-ANP DE&S, 2002b). However, the values of almost all invertebrate measures recover with distance downstream of Lake Harriet, though intolerant taxa richness (e.g. stoneflies) and abundance, show less recovery than other measures. Increased flow releases under the Proposed Action would increase the wetted habitat downstream of Lake Harriet. Increases in wetted habitat would open an equivalent opportunity for both species richness and abundance to respond with potentially significant increases as in the case of fish production discussed above. Addley (2003) estimated (based on results of 2-D modeling) that benthic invertebrate habitat (defined as velocities up to 3 feet per second and depths from about 0.5-0.7 feet to about 3 feet) would be maximized in this reach at flows around 100 cfs. The combination of diverse habitat types available under various flow release scenarios, the high quality water and stable flow management under

any of the scenarios, and the species richness immediately upstream of Lake Harriet all indicate that invertebrate production would likely improve in this reach under the Proposed Action.

Clackamas River

Benthic invertebrate communities in the Clackamas River were sampled above and below the Oak Grove Powerhouse to assess power peaking effects. Invertebrate abundance, total number of taxa, and total number of EPT taxa (i.e., mayflies, stoneflies, and caddisflies) in September 2001 were similar above and below the powerhouse (FPA, 2002). Mayflies and caddisflies, however, were more abundant upstream of the powerhouse. Peaking and load following activities can influence salmonid food availability due to loss of functional/productive invertebrate habitat along the margins of the channel (Gislason, 1985). This area, which is referred to as the "varial zone," is defined as the area demarcated by the range of flows during "typical" peaking operations. Because the area is subjected to daily cycles of watering-dewatering corresponding to peaking cycles, it cannot support a viable invertebrate community. In general, the size of the varial zone depends on the range of flows within the peaking cycle as well as channel morphology. The area of the varial zone relative to the total wetted low flow area would influence whether the lost production in turn influences salmonid production and survival. Doughty (2004) estimated the area of the varial zone in Reach 2B under a maximum downramping event of 450 cfs when summer baseflow is around 736 cfs, and determined the varial zone constituted 0.6 percent of the total baseflow wetted area (about 5,400 m^2 out of 900,000 m^2). With the limited stage variation and wetted area variations measured over the extremes in flow fluctuations downstream of the Oak Grove power house, we find that the varial zone effects would also be limited to a few locations and likely of small consequence to total macroinvertebrate production in Reach 2B.

The Proposed Action for reaches of the Clackamas River below the North Fork dam and downstream would not likely appreciably affect the benthic invertebrate communities. Some slight shift in composition and density could occur in the segment immediately below the Faraday Diversion dam and fish ladder entrance in response to subtle changes in temperatures. Likewise, there could be some slight adjustment in benthic invertebrate community structure in the lower reaches of the river related to the overall slightly warmer mainstem temperatures resulting from increased flows in the Lower Oak Grove Fork.

3.2.3.2.3 Water Quality

This section compares the water quality modeling results of the Proposed Action to the existing conditions as presented in section 3.2.3.1.4. Similar to the

existing conditions section, the discussion of the Proposed Action follows the reaches designated by the ODEQ water quality standards. The exceedance values for temperature and DO for each river reach are summarized in Table 3.2.3.2-9. The findings regarding the Proposed Action as compared to the existing conditions are summarized for convenience in Table 3.2.3.2-10. See Appendix A for the water quality exceedance curves and tables and a description of how they were developed. pH is not discussed in any of the reaches since values were found to be within the ODEQ criteria for all reaches, as shown by the exceedance plots in Appendix A.

Table 3.2.3.2-9. 7DADM temperature and dissolved oxygen exceedance (expressed as a percentage of data) of the rearing and spawning criteria for the Proposed Action.

Reach	7DADM Temp		Dissolved Oxygen	
	Rearing	Spawning	Rearing	Spawning
Oak Grove Fork between Timothy Lake and Barrier Falls	0	NA	0	NA
Oak Grove Fork from Barrier Falls to the Mouth	0	0	0	17.5
Clackamas Mainstem from Oak Grove Fork to Clear Creek	0	0	0	27.4
Mainstem Clackamas from Clear Creek to the Mouth	20.5	0.9	0	33.1

Table 3.2.3.2-10. Water quality comparison between existing conditions and the Proposed Action.

Reach	Temperature		Dissolved Oxygen		pH	
	Rearing	Spawning	Rearing	Spawning	Rearing	Spawning
Oak Grove Fork between Timothy Lake and Barrier Falls	Improvement over existing conditions. No standard violations for the Proposed Action.	NA	No significant change. All alternatives exceed standards by about 3 mg/L about 10 percent of time.	NA	No standards violations; minor differences between alternatives.	NA
Oak Grove Fork from Barrier Falls to mouth	Improvement over existing conditions. No standard violations for the Proposed Action.	Minor differences between alternatives; all exceed standards about 10 percent of time by a max of 1˚C.	No standards violations; minor differences between alternatives.	No significant change. All alternatives exceed standards approx. 40 percent of time, and existing conditions by a larger magnitude.	No standards violations; minor differences between alternatives.	No standards violations; minor differences between alternatives.
Clackamas mainstem from Oak Grove Fork to Clear Creek	Minor differences between alternatives; all exceed standards about 15-20 percent of time by a max of 3.5˚C.	Minor differences between alternatives; all exceed standards about 15 percent of time by a max of 4.5˚C.	No standards violations; minor differences between alternatives.	Minor differences between alternatives; all exceed standards about 30 percent of time by a max of 2 mg/L.	No standards violations; minor differences between alternatives.	No standards violations; minor differences between alternatives.
Mainstem Clackamas from Clear Creek to the mouth	Minor differences between alternatives; all exceed standards about 20 percent of time by a max of 3.5˚C.	Minor differences between alternatives; all exceed standards about 20 percent of time by a max of 6˚C.	No standards violations; minor differences between alternatives.	Minor differences between alternatives; all exceed standards about 35 percent of time by a max of 3 mg/L.	No standards violations; minor differences between alternatives.	No standards violations; minor differences between alternatives.

Oak Grove Fork from Timothy Dam to Barrier Falls

The 7DADM temperature in the Oak Grove Fork from Timothy dam to Barrier Falls for the Proposed Action ranges from 3.0˚C to 14.3˚C. The temperature in this reach improves from existing conditions and does not exceed the rearing temperature criteria.

DO concentrations for the Proposed Action range from 6.1 mg/L to 12.5 mg/L. DO exceeds ODEQ's rearing and spawning criteria.

Oak Grove Fork from Barrier Falls to Mouth

7DADM temperatures in this reach range from 3.3˚C to 13.7˚C and do not exceed either the rearing or spawning temperature criteria. The Proposed Action improves (reduces) temperatures over existing conditions suggesting the proposed flow augmentation regime would be beneficial to rearing and spawning habitat water quality conditions.

DO concentrations for the Proposed Action range from 10 mg/L to 12.7 mg/L. Rearing criteria were not exceeded, however spawning criteria were frequently exceeded about 17.5 percent of the time. DO concentrations slightly improved from existing conditions for lower concentrations and slightly declined for higher concentrations. However, the 1.6 percent change in exceedance related to the DO concentrations between the existing conditions and the Proposed Action are not likely biologically significant.

Clackamas River from the Oak Grove Fork to Clear Creek (excluding North Fork Reservoir and Estacada Lake)

The 7DADM temperature simulation range in this reach under the Proposed Action is from 3˚C to 19.6˚C, similar to existing conditions. The rearing temperature is still often exceeded about 17 percent of the time and 14 percent of the time for spawning. The 1 percent difference in exceedance values for both rearing and spawning between existing conditions and the Proposed Action is not likely biologically significant.

Like existing conditions, no DO values less than 8.0 mg/L occurred year-round in this reach for the Proposed Action. The Proposed Action slightly increases the exceedance of DO spawning criteria to 27.4 percent, however the difference in exceedance from existing conditions is not likely biologically significant.

North Fork Reservoir

Quarterly vertical profiles of simulated temperature, dissolved oxygen, and pH for the North Fork Reservoir are available and shown in section 3.2.2.1. No substantial difference between the temperature of existing conditions and the Proposed Action are

evident in upper layers where exceedances occurred. There is a slight increase in temperature from the existing condition in both the October 2000 and August 2001 profiles.

Estacada Lake

There are no substantial differences in the quarterly profile plots of temperature, DO, or pH between existing conditions and the Proposed Action as presented in section 3.2.2.1.

Clackamas River from Clear Creek to Mouth

The 7DADM temperature in this reach ranges from 3.4˚C to 21.5˚C and does not significantly change the temperature from the existing conditions. The rearing temperature is still often exceeded about 20.5 percent of the time and 21 percent of the time for spawning. The 1 percent increase in exceedance values for both rearing and spawning between existing conditions and the Proposed Action is not likely biologically significant. The slightly higher temperatures are likely the result of the higher minimum instream flows provided by the Proposed Action in the reach of the Oak Grove Fork below Lake Harriet. These flows then co-mingle with the Clackamas River and are subject to atmospheric warming as they flow downstream. The flows released below Lake Harriet would otherwise be diverted into the pipeline that leads to Frog Lake and ultimately discharged via the Oak Grove Powerhouse. Water diverted into the pipeline would remain cooler than waters released below Lake Harriet. The net result is an overall slight increase in water temperature in the lower segments of the Clackamas River under the Proposed Action.

Like existing conditions, no DO values less than 8.0 mg/L occurred year-round in this reach for the Proposed Action. The Proposed Action slightly increases the exceedance of DO spawning criteria to 27.4 percent and is also increased relative to the neighboring upstream section. However the difference in exceedance between the existing conditions and the Proposed Action is not likely biologically significant.

3.2.3.2.4 Upstream Fish Passage Facilities and Programs

There are two upstream fish passage facilities at the Project – the River Mill Fish Ladder provides passage over the River Mill dam into Estacada Lake and the Faraday-North Fork Fish Ladder provides passage over both the Faraday Diversion dam and the North Fork dam. The River Mill Fish Ladder has been replaced to comply with current resource agency guidelines as part of a separate license amendment proceeding. A barrier falls on the Lower Oak Grove Fork represents an insurmountable barrier for anadromous fish. There are no upstream passage facilities at Lake Harriet or Timothy Lake for resident fish.

A number of upstream passage studies have been conducted in recent years at the Project, but the results of those studies are inconclusive regarding (1) the causes and extent of migration delays, and (2) whether any apparent migration delays adversely affect the timing of reaching spawning grounds or survival rate to those grounds. Additionally, there is also no indication that adult migrants are injured at turbine draft tubes or other Project facilities.

Under the Proposed Action, PGE would modify the Faraday-North Fork Fish Ladder to improve fish passage conditions and to enhance fish passage operations and maintain the ladder for the term of the new license. The minimum instream flow would be increased from 120 cfs to 270 cfs in the Faraday Bypass Reach to improve passage conditions and provide additional attraction flow. They would also conduct studies to evaluate the need for additional facilities or operational modifications to reduce mortality, injury, or delay of upstream migrants.

The fish ladder modifications include: (1) entrance alterations with increased attraction flow, (2) removal of the existing fish trap and construction of a new sorting facility at an upstream location in the ladder and (3) removal of the juvenile separator and rerouting the juveniles into a bypass pipe at North Fork dam rather than passing them into the ladder.

The upstream passage studies would include near-field studies to identify problem facilities or reaches and far-field studies to evaluate delayed effects of passage on adult distribution or survival. Pulse flow studies would also be conducted for the Faraday Bypass Reach to evaluate whether this flow regime could reduce potential migration delays. Based on the results of these studies, PGE would develop a list of potential modifications or additions to Project operations and Project facilities that would improve upstream passage conditions. Subsequently, with FERC approval, PGE would implement specific modifications or additions to Project operations or facilities.

For resident fish in the Oak Grove Fork, the Proposed Action includes replacement of impassable culverts on Dinger Creek and Anvil Creek. Providing passage to these tributary streams affords connectivity of an additional 4.5 miles of habitat for cutthroat trout within the Project area. Under the Proposed Action, no upstream passage facilities are proposed for Harriet or Timothy Lake dams. However, the Proposed Action includes provisions for future studies to evaluate the need to transfer cutthroat trout from below Timothy Lake dam to above the dam in order to improve genetic diversity and benefit ecological function. If these studies indicate that such a transfer would be beneficial, PGE would implement such a program.

The Proposed Action also includes additional measures focused on the upstream passage of Pacific lamprey past the main stem Clackamas River dams. These measures

include rounding off 90-degree corners at critical junctures in the North Fork fish ladder, installing infrared lighting at any counting stations, modifying ladder entrances, eliminating predator access, incorporating measures into the new sorting/trapping facility to allow monitoring of adult Pacific lamprey passage, preventing lamprey access to the existing North Fork trap facility after it is discontinued, and implementing other modifications identified through regional and/or national Pacific lamprey research. If passage problems are identified, PGE would implement a plan for specific improvements to correct those problems.

Many of the potential benefits to upstream passage that may be provided by the Proposed Action can not be quantified at this time because they are contingent upon studies that must be completed. At a minimum, the changes proposed for the Faraday-North Fork Ladder and the increase in the minimum instream flow in the Faraday Bypass Reach should improve overall upstream passage conditions at the Project. Additional benefits can be anticipated if specific studies can identify problems and solutions can be implemented.

Downstream Fish Passage Facilities and Programs

Timothy dam and Harriet dam do not have any downstream fish passage facilities or screens on the intake structures for resident fish (the barrier falls downstream of Lake Harriet represent an insurmountable barrier for the upstream migration of anadromous fish). Under the Proposed Action, PGE would modify the Timothy Lake outlet to reduce entrainment of surface-oriented cutthroat trout within 2 years of license issuance by replacing the top bar rack section with a solid panel to 29 feet below the water's surface at 3190.0 ft and replacing the lower panels with a bar rack that has narrower openings (¾ inch). This is intended to provide additional protection to cutthroat trout that tend to be surface-oriented. At Harriet dam, the existing outlet bar rack has narrow openings (¾ inch). After construction of the new minimum release facilities, PGE would monitor the facilities for 2 years to determine whether non-native fish are escaping to the river below Harriet dam. If the monitoring indicates that non-native fish are escaping, PGE would modify the bar rack to exclude the fish subject to Commission approval. Subject to Commission approval, PGE would also replace the bar rack at Frog Lake with a new one with ¾-inch openings and an approach velocity of approximately 1 ft/second and install cleaners at the new bar rack if needed. This measure would be expected to reduce entrainment of trout in the Frog Lake flowline.

The Project currently includes several primary downstream fish passage facilities: the downstream migrant collection facility at North Fork that directs smolts into the fish ladder, the juvenile bypass separator, and the bypass pipe that delivers fish to the tailrace of the River Mill dam. River Mill dam currently has a prototype outmigrant bypass; no fish passage facilities exist at the Faraday Powerhouse. Multiple outmigrant pathways past North Fork dam include passage through the turbines and passage over the spillway.

These alternative routes expose downstream migrants to either the Faraday Diversion dam spillway or the Faraday turbines and then further expose these fish to the River Mill turbines or spillway. Some fish that pass the North Fork spillway or through the turbines are not exposed to the Faraday Powerhouse.

The Proposed Action includes provisions to construct certain facilities and modify their operations and then monitor and evaluate, based on a tiered decision making process, whether additional facilities may be needed, depending on a system-wide survival estimate of downstream migrants. Under the terms of the Settlement Agreement (PGE, 2006), the future fish passage alterations would be needed subject to achieving the overall goal of a systemwide Project-passage survival of 97 percent or higher for each migrant species. Under current operations (See Appendix D), the modeled passage survival estimates for Chinook, coho, and steelhead are approximately 75 percent, 95 percent, and 97 percent, respectively (see section 3.2.3.1.6).

Under the Proposed Action, PGE would:

- Manage flows downstream of River Mill dam to match inflow at North Fork Reservoir.
- Adhere to the Faraday Diversion Dam spill protocol when spills are greater than spillway net capacity.
- Close the boat launch in Timber Park.
- Within 3 years of license issuance, design and construct a 500 cfs-capacity juvenile downstream fry criteria fish screening facility to accommodate full powerhouse flow at River Mill dam, and operate the River Mill dam juvenile prototype bypass until the permanent bypass facility is completed.
- Until the spillway exclusion net is shown to effectively prevent spillway entrainment at flows up to 4000 cfs, during periods of unscreened spill at North Fork dam lasting 1-12 hours, commence spill of a minimum of 400 cfs at River Mill with spill at North Fork dam and continue for 36 hours after cessation of spill at North Fork dam
- Until the spillway exclusion net is shown to effectively prevent spillway entrainment at flows up to 4000 cfs, during periods of unscreened spill at North Fork dam lasting longer than12 hours, or spills greater than 2,000 cfs regardless of duration, commence spill at River Mill with spill at North Fork dam and continue for 60 hours after cessation of spill at North Fork dam.
- Develop a plan and schedule to complete the River Mill bypass and pipeline and sampling/counting facility within 6 months of license issuance if they are not completed prior to license issuance.
- In 2007, retrofit the existing bypass screens at North Fork dam with screening material that is compliant with NMFS criteria.

- In 2008, rebuild the juvenile bypass pipeline, extending it up to North Fork dam, build a new downstream migrant sampling facility, and decommission the existing downstream migrant separator and bifurcation box.
- Within 2 years of license issuance, build a 500 cfs-capacity surface collection facility at River Mill dam, and build a 1,000 cfs-capacity surface collection facility at North Fork dam within 4 years of license issuance.
- Within 3 years of license issuance, construct a retractable exclusion net blocking the spillway bays at North Fork dam for spill flows up to 4,000 cfs. Also after completion of the net, PGE would limit generation at North Fork to one unit for river flows between 3,500 cfs and 7,500 cfs. This generation limitation would continue until the new surface collector is operational at North Fork and the survival standards have been met.
- Adjust generation at North Fork to maintain a spill volume of 4,000 cfs at North Fork dam when river flows at North Fork are between 7,500 and 11,500 cfs.
- Within 5 years of license issuance, construct a surface collector at North Fork with a hydraulic capacity of 1,000 cfs, a guidance net/curtain from the south bank leading to the surface collector, and strobe deterrents to guide fish toward the surface collector. PGE would also limit generation to one unit for flows between 3,500 cfs and 7,500 cfs from April 1-June 30, and October 15-December 31.
- Within 6 years of license issuance, design and implement evaluations of the physical and hydraulic suitability of the North Fork Fish Ladder for adult Pacific lamprey, subject to Commission approval. PGE would implement measures to correct potential impediments to lamprey passage including rounding 90 degree corners in the ladder, replacing bright lights, modifying ladder entrances, eliminating predator access, eliminating access to the decommissioned North Fork trap facility, and other impediments or problems identified through lamprey research. PGE would also incorporate monitoring capabilities into the new sorting/trapping facility, and install a new screening system with a capacity of 500 cfs at the existing North Fork bypass. This system would be installed depending on system survival.

After completion of the above items which are designated as “A” and “B” measures in the Settlement Agreement (PGE, 2006), biological tests would be conducted to evaluate the survival of smolts passing through the three mainstem dam complex. If the system survival is determined to be at least 97 percent for each species, no additional measures would be required. If the survival of any one species is less than 88 percent, PGE would design and install a 3,000-cfs collector that is plumbed to the North Fork powerhouse (“D” measure).

If the biological tests indicate that the system survival is between 88 percent and 97 percent, “C round 1” measures would be implemented. These measures might include construction of a new 500-cfs screen at the existing North Fork juvenile bypass or a

number of other potential options. After the completion of "C round 1" measures, additional biological testing would be performed. If the survival rates of all species are greater than 97 percent, no additional measures would be required. If the survival rates for any species is less than 91 percent after "C Round 1" measures, PGE would proceed with design and construction of the 3,000-cfs collector at North Fork. For intermediate survival rates between 91 percent and 97 percent, PGE would implement "C Round 2" measures.

If testing after "C Round 2" measures indicates that the survival rates for all species are greater than 97 percent, no more measures would be required. If survival rates for any species are less than 95 percent, PGE would construct the 3,000-cfs collector. For an intermediate survival level between 95 percent and 97 percent for any species, a population level assessment would be made to determine whether the "D" measure is warranted. If warranted, PGE would implement the measure.

Staff currently lacks sufficient information to determine the likelihood that implementation of the "A" and "B" measures would achieve the 97 percent system survival performance criteria. The major uncertainty in system performance, and therefore outmigrant survival, is the route selection used by migrants to pass North Fork dam. Attempts to assess the influence of turbine intake flows or spill volumes relative to baseflows on passage route selection have been inconclusive. However, limited available data suggest that Chinook passage through turbines is relatively low when flows are low (Timko et al., 2001), but could increase significantly when river flows exceed 3,000 cfs (Karchesky et al, 2003). Tests in the fall of 2003 suggest that at relatively high powerhouse discharges, 80 percent of the Chinook entered the bypass and 20 percent passed through the powerhouse (Karchesky et al, 2004).

Huntington et al. (2004) utilized the DM3 model to evaluate the effectiveness of a conceptual 1,000-cfs surface collector at North Fork and concluded that the survival of Chinook smolts would be about 94 percent. The key modeling assumption that drives that conclusion relates to the percentage of smolts that would be entrained into the turbines when river flows are high. The entrainment assumption was based on tests reported by Karchesky et al. (2003) that suggested that high numbers of smolts may be entrained into turbines for flows that exceed 3,000 cfs. Additional tests in Fall, 2003 (Karchesky et al, 2004) suggest that the entrainment of Chinook into the turbines may not be as high as the Huntington et al. modeling suggests.

The Proposed Action includes a fish passage measure (termed "D" measure) that would entail the construction of a 3,000-cfs collector at North Fork. This measure is similarly based on limited testing that suggested high entrainment of Chinook smolts when river flows exceed 3,000 cfs (the 2003 results). The North Fork powerhouse has a capacity of 6,000 cfs. Thus, this measure would limit the attraction flow to the low-level turbine intakes to 3,000 cfs with the remaining flow entering the collection screening

facility prior to passing into the turbine intakes. Utilizing the DM3 model, Huntington et al. (2004) suggest that survival of Chinook would approach 98 percent if the 3,000-cfs collector were constructed.

There is currently no generally accepted method for tracking juvenile lamprey. PIT tags at the Willamette Falls Project (FERC No. 2233) were inconclusive because of extremely low recovery of tagged individuals (6 percent or less with live animals). Methods to evaluate juvenile lamprey passage and survival are still under development.

Given the tiered decision-making implementation program incorporated into the Proposed Action , it is probable that system survival rates of at least 95 percent would be achieved for all species. Also, based on currently available information, the 97 percent survival goal appears to be achievable. As noted earlier, under current operations, the estimated survival of Chinook smolts through the Project is 75 percent. Consequently, implementation of the Proposed Action would significantly improve downstream passage conditions for Chinook.

3.2.3.2.5 Clackamas River Hydroelectric Project Mitigation and Enhancement Fund

As part of the Proposed Action, PGE would develop and implement a plan for a Clackamas River Hydroelectric Project Mitigation and Enhancement Fund (the Fund), subject to Commission approval. The 2005 *Clackamas River Basin Action Plan (*the *Action Plan)* describes more than 100 specific projects that could be undertaken in the Clackamas Basin to improve habitat, fish passage conditions and water quality. The Fund would be used to support projects identified in the *Action Plan* that have a direct nexus to the Project, including land acquisition or lease of riparian, wetlands, and associated uplands; instream habitat improvements; protection and enhancement of riparian corridors and wetlands; water quality improvements or enhancements; water conservation projects which yield legally protected instream water rights; acquisition and maintenance of conservation easements; construction, improvement, or removal of fish passage facilities and barriers; and acquisition or lease of water rights.

The Fund would provide necessary resources for specific measures that have been identified by PGE and other stakeholders on the Clackamas River Basin Council to address natural resource challenges in the Clackamas River Basin. The Fund would also provide a mechanism for PGE to address Project effects that may not be directly addressed by other environmental measures in the Proposed Action, and an additional mechanism to address Project-related impacts in the event that the other environmental measures included in the Proposed Action do not achieve their expected effects.

The plan for the Fund would establish a Mitigation Fund Committee consisting of representatives of PGE and the Settlement parties. The Mitigation Fund Committee would provide input into the selection of projects to be funded. Projects supported by the

Fund would be implemented either by PGE, Mitigation Fund Committee members, or private contractors. Although the Mitigation Fund Committee would provide input into selection of projects to be funded and selection of appropriate parties to implement the projects, PGE would retain sufficient control over the Fund for the Commission to ensure the satisfaction of the underlying project purposes supporting the Fund. PGE would define the roles and responsibilities of the Mitigation Fund Committee in the plan for the Fund, subject to approval by the Commission.

3.2.3.3 Unavoidable Adverse Impacts

The Project would continue to have unavoidable adverse impacts on fish, including listed salmonids. Implementation of the Proposed Action would likely continue to impede fish passage to some extent. The Project would likely continue to have a net negative impact on salmonid habitat by impeding transport of LWD and sediment, and loss of habitat through reservoir inundation and altered flow regimes. The Project would also continue to cause some loss of individual fish through entrainment and impingement-related injury and mortality at the Project dams, and continue to stress fish that must be handled to separate hatchery and wild fish at North Fork Dam.