Attachment A

CLACKAMAS RIVER PROJECT
WATER QUALITY MANAGEMENT AND
MONITORING PLAN

PREPARED BY:

Portland General Electric Company

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1.0 INTRODUCTION

1.1 Purpose

This *Water Quality Management and Monitoring Plan* (WQMMP) describes procedures that will be employed by Portland General Electric Company (PGE) to satisfy requirements of the 401 Water Quality Certification of the Clackamas River Project (Project) (FERC No. 2195). The Project is located in Clackamas County, Oregon, in the Clackamas River Basin. Details relating to nuisance algae and the creation of taste and odor issues in the Clackamas River (as discussed in the 401) can be found in the document entitled, "*Blue Green Algae Monitoring Plan*" (BGMP), which is being developed pursuant to License Appendix A, Condition 5 and License Appendix B, Article 12 (B). The BGMP will be distributed to the Blue Green Algae Team (BGT) for review. Once the BGMP has been reviewed by the BGT, and approved by DEQ, the document will be filed with FERC within six months of license issuance.

In addition, all quality assurance and quality control procedures and processes for the *Blue Green Algae Monitoring Plan* can be found contained in the plan itself.

This WQMMP provides information regarding State water quality goals and standards, the application of those goals and standards to the Project, measures designed to attain compliance, monitoring strategies, and reporting of monitoring results. PGE believes that this WQMMP, in combination with information contained in PGE's final application for 401 certification (Final 401 Application; PGE 2008), PGE's TMDL Implementation Plan (PGE 2009), and the Settlement Agreement filed with FERC on March 29, 2006 (PGE 2006a), provides the Oregon Department of Environmental Quality (ODEQ) with reasonable assurance that the Project will not contribute measurably to the violation of applicable water quality standards and criteria, that the physical, chemical, and biological water quality of waters potentially affected by the Project will not be degraded from existing conditions, that future Project operations will offset any ongoing contributions to non-attainment of water quality standard numeric or narrative criteria, and that such operations will also mitigate for any ongoing adverse impacts to designated beneficial uses.

To ensure that beneficial uses in and downstream of the Project are protected, PGE intends to comply with ODEQ's standards and criteria and will work with the Clackamas Fish Committee (Fish Committee), in the manner to be established pursuant to the Settlement Agreement and the new license, on matters outside the scope of the 401 certification. Management and monitoring activities beyond those stipulated in this document that will be undertaken in consultation with the Fish Committee are described in the *Fish Passage and Protection Plan* (FPPP), attached to the Settlement Agreement as Exhibit D.

1.2 Adaptive Management Considerations

In connection with the relicensing of the Project, PGE will undertake a number of actions that are expected, over time, to have a beneficial impact on water quality. Thus, PGE will implement gravel augmentation and habitat enhancements in the lower Oak Grove Fork. These measures are expected to reduce water temperatures at the mouth of the Oak Grove Fork beyond the decrease brought about by increasing baseflows (see below). Temperature reductions in the Oak

Grove Fork are expected to carry over to the mainstem Clackamas River, in the reach between the Oak Grove Fork mouth and the Oak Grove Powerhouse.

PGE has also undertaken a program of sampling inter-gravel dissolved oxygen (IGDO), to determine the appropriate DO standard in flowing waters affected by the Project; other studies will be conducted in the Oak Grove Fork and in the reaches of the Clackamas River below the Oak Grove Powerhouse and the Faraday Diversion Dam.

Finally, PGE's water quality modeling has predicted slight and infrequent temperature exceedances relative to modeled NTP conditions that PGE does not believe represent any actual impairment to beneficial uses in the system.

1.3 Project Setting and Water Quality Information

The Clackamas River flows northwest and drains an area of more than 940 mi2, emptying into the Willamette River near Gladstone, Oregon. The Project consists of the Oak Grove Development and the three mainstem developments: North Fork Dam, the Faraday Development, and River Mill Dam. The three mainstem developments are located in sequence on the Clackamas River between river mile (RM) 22.3 and RM 29.2. Water released from North Fork Dam is diverted by the Faraday Diversion Dam into Faraday Lake, except during high flows when flow exceeds the capacity of the Faraday Powerhouse, and a portion of total flow passes over the Faraday Diversion Dam and through the Faraday Diversion Reach. PGE currently supplies a year-round minimum flow of 180 cfs to the Faraday Diversion Reach. Water from Faraday Lake is released via the Faraday Powerhouse into Estacada Lake, which is formed by River Mill Dam. Water released from River Mill Dam flows into the lower Clackamas River. A complete description of the Project is available in the Final License Application to the Federal Energy Regulatory Commission (FERC), dated August 2004 (PGE 2004).

Historically, most water quality studies in the Willamette River Basin have not included sampling in the Clackamas River. Of 139 Willamette River Basin studies reviewed by the USGS (Altman et al. 1997), only seven included information from the Clackamas River and its tributaries. EPA's STORET database contains substantial data for only one location in the Clackamas River Basin: the Clackamas River at High Rocks. The USGS has collected limited groundwater data in the basin (Bonn et al. 1995, Harrison et al. 1995). Raymond et al. (1997) collected data from sites on the Clackamas River and in Project impoundments during summer 1996, and data from other sampling points on North Fork Reservoir were collected for the Atlas of Oregon Lakes (Johnson et al. 1985). Timothy Lake was sampled for the Atlas of Oregon Lakes (Johnson et al. 1985) and was again sampled in 1987 by Bullock et al. (1998). A summary of findings from these pre-relicensing studies is contained in Section 7.1.3 of the Final 401 Application.

As part of FERC relicensing, PGE conducted comprehensive water quality studies in, adjacent to, and downstream of the Project in 2000 and 2001. Thermaloggers were deployed at riverine and reservoir sites, and temperature profiles were measured in reservoirs. Descriptions of temperature and water quality sampling results are contained in the Final 401 Application, Doughty (2004a, 2004b), and EES Consulting (2004). A longitudinal macroinvertebrate survey—from upstream of Timothy Lake to Barton Park on the lower Clackamas River—was also conducted in 2000 and 2001. In addition to the longitudinal quantitative sampling, surveys were conducted to assess the presence of sensitive invertebrate taxa. See PGE (2006b, 2008) and Wisseman and Doughty (2004) for a description of methods and results of macroinvertebrate studies.

As discussed in the Final 401 Application, a predictive model (CE-QUAL-W2) of the Clackamas River system was developed to evaluate existing water quality conditions, to understand the physical processes controlling temperature and water quality, and to be used as a predictive tool for quantitative assessment of the impact of future Project operations on water quality (Battelle 2005). In addition, the model was used to compute natural thermal potential (NTP), i.e., temperatures in the absence of the Project under existing hydrologic and meteorological conditions.

1.4 Proposed Protection, Mitigation and Enhancement Measures

As part of the Settlement Agreement with resource agencies, tribes, and NGOs, PGE developed a suite of protection, mitigation, and enhancement measures (PMEs) to be implemented under the new FERC license, along with some interim measures to be implemented during the period between the filing of the Settlement Agreement and issuance of the new license. The PMEs include changes to Project operations, improved fish passage and protection measures, and enhancements of aquatic habitat. Improvements to water quality variables for which there are numeric criteria will be accomplished primarily through operations changes, whereas ODEQ's more encompassing standards, such as those related to beneficial uses and antidegradation, will be addressed by operational measures, fish passage structures, and habitat improvement PMEs.

During preparation of its Final 401 Application, PGE identified other measures that it proposes to implement to achieve compliance with the Total Maximum Daily Loads (TMDLs) for temperature established by ODEQ in September 2006 for the Clackamas River below River Mill Dam. These measures are described in Section 10.3 of the Final 401 Application. Measures that will result in improvements to water quality, as defined by ODEQ, are listed below and discussed in Sections 2 through 7 of this WQMMP, as applicable. (For detailed descriptions of the PMEs, refer Section 10 of the Final 401 Application.) PGE believes that these PMEs will provide ODEQ with reasonable assurance that Project operations will not cause waters within or downstream of the Project to violate relevant water quality standards.

Following issuance of the new FERC license, PGE will implement the following changes to Project operations: 1) more restrictive management of Timothy Lake levels; 2) increased minimum discharges, decreased maximum discharges, and more restrictive ramping rates at Timothy Lake Dam; 3) implementation of a flow regime in the Oak Grove Fork downstream of Lake Harriet, including minimum flows, winter floods for channel maintenance, and high flows in spring to simulate snowmelt runoff; 4) restrictions on ramping rates, especially downramping rates, in the Clackamas River downstream of the Oak Grove Powerhouse; 5) addition of cool water to the North Fork fish ladder at the proposed new North Fork adult sorting facility; 6) increased baseflow in the Faraday Diversion Reach; 7) channelization of Faraday Lake; and 8) discharge restrictions at River Mill Dam.

In addition to these operational PMEs, PGE will implement the following fish passage and protection measures: 1) improved bar racks to reduce fish entrainment at the Timothy Lake intake; 2) tighter spacing on the bar rack at the Frog Lake flowline intake to reduce entrainment into Frog Lake; 3) fish passage and protection enhancements at North Fork Dam, including a new 1,000-cfs surface collector, a guidance curtain/net to help guide smolts to the mouth of the new surface collector, strobe lights in front of the turbine intakes to reduce the potential for turbine entrainment of smolts, a retractable exclusion net in the forebay to reduce the loss of smolts during spill, and an upstream extension of the downstream migrant pipeline so that it extends from North Fork Dam to the River Mill Dam tailrace; 5) upgrades to the portion of the existing downstream bypass migrant pipeline that will continue to be used in the future; 6) a new adult fish sorting facility in the North Fork fish ladder; and 7) a 500-cfs surface collector installed in the River Mill forebay.

PGE will also implement the following habitat enhancement measures: 1) cutthroat trout habitat enhancement in Dinger Creek, a tributary to Timothy Lake; 2) cutthroat trout habitat enhancements in the Oak Grove Fork from the base of Timothy Lake Dam to Hammer Springs; 3) a program to increase the availability of side channel habitat and improve the quality of mainstem habitat in the lower Oak Grove Fork under the flow regime identified for this section of river (see above); 4) gravel augmentation in the lower Oak Grove Fork and the Clackamas River downstream of River Mill Dam; 5) replacement of impassable culverts on Dinger Creek and Anvil Creek (just downstream of Timothy Lake Dam); 6) a program to collect and store wood that accumulates in Lake Harriet and North Fork Reservoir for use in habitat restoration projects in the basin; 7) disruption of nonnative brook trout and kokanee reproduction in tributaries to Timothy Lake; 8) gravel augmentation in the Clackamas River downstream of River Mill Dam; 9) shading of tributaries to the lower Clackamas River; 10) creation of the Parsons groundwater side channel; and 11) creation of two additional side-channel habitat enhancement projects in the Clackamas River downstream of River Mill Dam. Measures that will be implemented in the Clackamas River below River Mill Dam are addressed in the TMDL Implementation Plan (PGE 2009).

Various management activities that will be conducted pursuant to this WQMMP, or pursuant to the terms and conditions of the new FERC license, may require PGE to conduct instream work. PGE will obtain any permits that may be required, such as a U.S. Army Corps of Engineers 404 permit, prior to conducting such activities. Greater detail regarding permits that may be necessary for undertaking certain PMEs is included in Section 2 of the Final 401 Application and in the lower Clackamas River Coarse Sediment Management Plan (Wampler 2005; see Appendix 3).

2.0 WATER TEMPERATURE MANAGEMENT PLAN

2.1 ODEQ Temperature Standard

The ODEQ temperature standard, as defined by OAR 340-041-0028, can be found in Section 9.3 of PGE's Final 401 Application.

2.2 Application to the Clackamas Project

As required by the Federal Clean Water Act, the temperature standard that must be satisfied is the most stringent applicable standard, which varies by reach within the Project area and by time of year, according to fish periodicities designated by ODEQ. The ODEQ temperature standard, as modified by the recently-completed Willamette River TMDL, restricts the Project from warming water (based on the seven-day moving average of the daily maximum temperature (7DADM)) within the Project area by more than 0.3 ºC over the applicable numeric criterion, or downstream of River Mill Dam by more than 0.15 ºC over a) the applicable numeric criterion, b) NTP, or, c) in waters with Threatened and Endangered species, the ambient summer (defined as June 1 – September 30) temperature in water bodies where maximum summer temperatures fall below the applicable biologically based criteria, whichever is applicable. A reach-by-reach characterization of temperature standards, as defined by ODEQ, is provided in Table 2-1.

Table 2-1. ODEQ temperature criteria that apply to riverine Project reaches of the Clackamas River and Oak Grove Fork.

Reach	ODEQ Standard[1,2] Temperature Criteria Based on Spawning or Rearing Use
Oak Grove Fork between Timothy Lake (RM 68.4) and Barrier Falls (RM 54.9)	16º C rearing criterion, Year-round
Oak Grove Fork from Barrier Falls (54.9) to mouth[3] (RM 52.2)	16º C rearing criterion, June 16 – August 31
	13º C spawning criterion, September 1 - June 15
Clackamas River mainstem, from Oak Grove Fork (RM 52.2) to Clear Creek (RM 8.0), excluding North Fork Reservoir and Estacada Lake[3]	16º C rearing criterion, June 16 – August 31
	13º C spawning criterion, September 1 - June 15
Fish Ladder[3]	Temperatures that do not impede fish passage, as determined by the Clackamas Fish Committee
Mainstem Clackamas, vicinity of Bonnie Lure State Park (RM 16.7)	16º C rearing criterion year-round; No designated spawning
Mainstem Clackamas; Clear Creek to mouth[3]	18º C rearing criterion, May 16 – October 14
	13º C spawning October 15 - May 15

1 When natural thermal conditions exceed the applicable numeric criterion, only limited warming, as defined by the TMDL, is allowed.
2 Warming defined as 0.15 ºC by PGE and 0.2 ºC from all point sources as approved by the TMDL
3 Waters with Threatened and Endangered species present that have ambient—i.e., under existing conditions, not NTP—summer (Jun 1 – Sep 30) 7-day average of daily maximum temperatures that fall below the applicable biologically based criteria, may not be warmed during summer (Jun 1 – Sep 30) more than 0.3 ºC above those ambient temperatures.

2.3 Facilities Modifications for Compliance

As part of the PME package identified in the Settlement Agreement ("SA Alternative"), PGE will undertake two facilities modifications that will result in improvements in water temperature (other facilities modifications will be made, but they relate to fish protection and do not have the potential to alter water quality). A minimum-flow facility will be installed at Harriet Dam that will allow the release of up to 100 cfs—i.e., the maximum planned base flow release proposed as part of the SA Alternative—to the Oak Grove Fork downstream of the dam. This will result in a significant reduction in water temperatures downstream of the dam during the warmer months of the year, thereby achieving compliance with relevant ODEQ temperature criteria in the lower Oak Grove Fork and in the Clackamas River between its confluence with the Oak Grove Fork and the Oak Grove Powerhouse (see Section 7.2.4.2 of the Final 401 Application).

The second proposed facility modification is a new adult fish sorting facility in the North Fork fish ladder, which will replace approximately 22 cfs (56 percent) of ladder flow derived from the surface of the North Fork forebay with cold water drawn from 22 to 30 ft below the surface of North Fork Reservoir. The added cold water will lower overall fish ladder temperatures downstream of the sorting facility (located about 0.25 miles downstream of North Fork Reservoir), contribute to the lowering of water temperatures in the Faraday Diversion Reach, and increase attraction of adult fish at the North Fork fish ladder entrance.

2.4 Temperature Management

2.4.1 Evaluation of Temperature Management Measures

Model results and other relevant analyses indicate that implementation of the SA Alternative will result in compliance with ODEQ's temperature standards throughout most of the Project area. However, the SA Alternative may not achieve full compliance with the ODEQ temperature standard in the Clackamas River below River Mill Dam. As discussed in this section, additional operational and Project modifications and implementation of tributary shading, gravel augmentation and habitat modification below River Mill Dam will achieve compliance with relevant requirements.

Water Temperature Modeling

Under the SA Alternative, temperatures throughout the Oak Grove Fork will be below the relevant ODEQ temperature criterion and, therefore, in compliance throughout the year.

PGE believes that evidence indicates that temperatures in the reach of the Clackamas River between the Oak Grove Powerhouse and North Fork Reservoir are in compliance with ODEQ criteria. As explained in the Final 401 Application, about 5 miles downstream of the confluence of the Oak Grove Fork and the Clackamas River, the Oak Grove Powerhouse discharge enters the Clackamas River. At this point water diverted from the Oak Grove Fork at Lake Harriet is returned to the river. As a result, temperatures under existing conditions are essentially identical to what they would be in the absence of the Project, and therefore cannot result in impairment of beneficial uses.

Modeled temperatures under the SA Alternative in the North Fork tailrace, in the Faraday Diversion Reach and in the River Mill tailrace were calculated to be slightly inconsistent with ODEQ criteria during a small number of days during each modeled year. These occurrences are associated with periods when NTP declines rapidly in response to meteorological changes, i.e., cold fronts. These affect the NTP (i.e., what the model calculates) but have little effect on what occurs under existing conditions in a thermally buffered reservoir environment. The relative lack of variability associated with the reservoir creates an anomalous situation in that temperatures at these locations are well within compliance for an extended period and then, several days later, are suddenly and briefly inconsistent with the NTP criterion, when the actual temperature of the discharge has remained the same or decreased slightly from what it was days before. The observed pattern shows that discharge temperatures are consistently much cooler than ODEQ criteria. During the warm period of the year, when inconsistencies occur, maximum temperatures in the tailrace are nearly always lower than what they would be in the absence of the Project. Based on evaluation of the overall relationship between the temperature regime associated with the SA Alternative and ODEQ criteria, PGE believes that the apparent temperature lag at these locations results in no adverse consequences to beneficial uses. As a result, temperatures at these locations should be considered in compliance with ODEQ criteria.

ODEQ has determined that the NTP in the upper Clackamas River Basin (upstream of the Oak Grove Fork) is poorly understood, and temperatures in the mainstem Clackamas above the Oak Grove Fork at times exceed ODEQ's numeric criteria. These temperatures are not affected by the Project. As a result, for purposes of evaluating Project impacts, ODEQ has determined that the upstream boundary condition (i.e., the mainstem Clackamas River inflow) for this reach should be set so that temperatures do not exceed the numeric criteria that apply to the reach for a given time of year, because better information about the NTP for the boundary condition is lacking. In this way, the Project is only responsible for warming that occurs within the reach as a result of its impact on flows.

PGE contracted with Battelle to conduct a sensitivity analysis designed to evaluate the effect of scaling boundary condition temperatures on temperatures in the Clackamas River just upstream of the Oak Grove Powerhouse. Battelle developed an equation that scales the boundary condition temperatures such that maximum temperatures do not exceed 16 ºC or 13 ºC, depending on the time of year (i.e., which reflects fish life-history periodicity). Because the natural warming in the 5-mile reach between the Oak Grove Fork mouth and the Oak Grove Powerhouse is minimal, and because water from the Oak Grove Fork is substantially cooler than the Clackamas River mainstem during much of the year, scaling boundary condition temperatures from the upper Clackamas River so that they do not exceed the numeric criteria results in compliance with the relevant ODEQ criteria throughout the year in this reach.

Due to a phase shift induced by the uniform temperatures of water discharged from River Mill Dam, temperatures at the sites on the lower Clackamas River just upstream of Eagle Creek (CRUPEC) and near Oregon City (CRATOC) at times exceed NTP, the relevant ODEQ standard for most of the period when exceedances are occurring at these locations. Based on model results, temperatures at the Eagle Creek site under the SA Alternative exceed ODEQ criteria during 101 and 118 days during 2000 and 2001, respectively, and modeled temperatures at the Oregon City site exceed ODEQ criteria during 47 and 60 days in 2000 and 2001, respectively. In an attempt to develop a mitigation strategy for lower Clackamas River temperature exceedances, PGE explored the effects of a series of operational and structural alternatives aimed at achieving temperature compliance. PGE also explored the potential temperature benefits associated with gravel augmentation and habitat enhancement, particularly side-channel enhancement, in the lower river. The potential effects of operational alternatives and some facilities modifications were evaluated with the CE-QUAL-W2 model. Other potential structural alternatives were evaluated through engineering feasibility, effectiveness, and cost analyses. The approaches to evaluating the effectiveness of operational and structural measures, as well as gravel augmentation and habitat enhancement, are explained in Section 9.3.5 of the Final 401 Application.

Tributary Shading, Gravel Augmentation, and Habitat Enhancement

Because the operational and Project modifications discussed above will achieve partial compliance with the ODEQ temperature standard, PGE will also address temperature exceedances in the lower Clackamas River through a combination of tributary shading, gravel augmentation and habitat improvements, which will, in addition to producing a reduction in maximum temperatures, have geomorphic and biological benefits.

During discussions with the Water Quality Group following its filing of the December 2006 application, PGE agreed to implement a program of shading along tributaries to the lower Clackamas River. As described in Section 9.3.5 of the 401 Application, this program will lead to the shading of 30 miles of tributaries, with a concomitant reduction of heat loading to those tributaries and the lower Clackamas River.

To better understand the potential temperature benefit of gravel augmentation in the lower Clackamas River, and to inform potential adjustments to the gravel augmentation approach to maximize temperature benefits, PGE contracted with the USDA-FS, Pacific Northwest Research Station, to conduct a study of the effects of gravel augmentation. The study involved researching existing geomorphic and temperature conditions in the lower Clackamas River. Information from this phase of study was used to parameterize the existing CE-QUAL-W2 model so that it could be applied to estimate temperature sensitivity to gravel augmentation. The results of the sensitivity modeling provided an analysis of the likely magnitude, location, and variation of peak temperature reductions due to gravel augmentation in the lower river. Use of CE-QUAL-W2 also allowed investigation of temperature effects from alternative Project operation scenarios in conjunction with gravel augmentation.

In addition, gravel augmentation is expected to increase the coarse sediment storage and water surface elevations in side channels in the lower Clackamas River. Coarse sediment deposition in the channel will result in higher water surface elevations for a given river discharge. This will increase the amount of side channel habitat during low flow periods, which in turn will benefit temperature as described below.

As part of the SA Alternative, PGE will also augment gravel to increase the availability of salmonid spawning habitat in the lower Oak Grove Fork under the flow regime proposed in the SA Alternative. If this augmentation program reduces temperatures in a manner similar to that observed by Lewis et al. (2005), temperatures in the lower Oak Grove Fork will be reduced beyond the significant reduction predicted as the result of increased baseflows alone, which are expected to result in year-round compliance with ODEQ criteria.

In 2004 PGE constructed a 0.5-mile-long groundwater side channel downstream of Barton Bridge, at RM 12.0 (Parsons side-channel project). The channel was designed and constructed to create additional cold water summer rearing habitat for juvenile coho, Chinook, and steelhead. The project created approximately 1600 m^2 of new cool water summer habitat. Field studies in 2006 showed that average temperatures in the new channel are 2 to 4 °C cooler than mixed mainstem temperatures, and that these conditions provide ideal summer rearing temperatures and thermal refugia from mainstem river temperatures. Fish densities were shown to be higher in the side channel than in the mainstem.

During discussions with the Water Quality Group following its filing of the December 2006 application, PGE agreed to implement two additional habitat enhancement projects along the lower Clackamas River. As described in Section 9.3.5 of the 401 Application, these projects are planned to be located at McIver and Eagle Creek and are expected to provide a significant amount of cold water summer rearing habitat for juvenile coho, Chinook, and steelhead. Although these side channel improvements are not expected to significantly affect mainstem river temperatures downstream of River Mill Dam, they are expected to provide substantial benefits to juvenile salmonids, thereby increasing salmonid production and promoting beneficial uses designated for the lower river.

In 2006 PGE contracted with Cramer Fish Sciences to develop a life-cycle simulation model to estimate the loss of production potential in the lower Clackamas River as a result of temperature increases and to quantify the benefits to beneficial uses that will be created by measures to reduce temperature, thereby compensating for lost production potential (Cramer Fish Sciences 2008). The model provides a quantitative estimate of the amount of production loss that will be mitigated by the proposed habitat enhancement measures included in the SA Alternative and in the Final 401 Application. Life-cycle modeling, based on site-specific data collection, was selected as the preferred approach because proposed measures that reduce temperature increases have the potential to reduce fish production losses at different times during their life-histories, either by increasing survival of migrants passing through an impacted area or by increasing the capacity and survival of fish that spawn or rear in an area.

The CFS life-cycle model indicates that, based on differences in predicted smolt production in the NTP and current condition, losses in smolt production from the Project area due to current Project operations are estimated at 23 to 27 percent for all species combined, depending upon whether the analysis relies on average or maximum temperatures. As discussed in Section 9.3.5 of the Final 401 Application, the life-cycle model further indicates that the combination of operational changes to the Project, tributary shading, and habitat enhancement projects proposed as part of the Final 401 Application will significantly reduce or eliminate these impacts.

Temperatures in North Fork Fish Ladder under SA Alternative

Temperatures within the North Fork fish ladder will improve (i.e., become cooler) when the SA Alternative is implemented. This change, coupled with physical changes to the ladder, will create an environment in which upstream-migrating adult salmonids experience no delay. As a result, temperatures in the North Fork fish ladder will result in attainment of the relevant beneficial use (i.e., upstream salmonid migration), and thereby compliance with the relevant ODEQ criterion. Following issuance of the new license, the Fish Committee will evaluate upstream fish passage through the ladder pursuant to the provisions of the FPPP.

Temperatures in Project Reservoirs under SA Alternative

Temperatures in the Project reservoirs under the SA Alternative will be such that surface waters warm through the summer months and the volume of water meeting the rearing temperature criterion will decrease and lie deeper. Nevertheless, a substantial volume of the reservoirs will remain below the relevant criterion. Fish and other biota in the reservoirs congregate in regions conducive to their survival and growth, and thus will avoid regions where temperature standards are exceeded for short periods, so the Project reservoirs will be in compliance with ODEQ temperature criteria.

2.4.2 Temperature Management Operations

The proposed changes to Project operating protocol, which will affect temperature throughout the Project area, are outlined below. These changes are established by the Settlement Agreement or as a result of the analyses conducted during preparation of the Final 401 Application. Other operating changes included as part of the Settlement Agreement that are not expected to affect temperature are not discussed here.

Timothy Lake

- Achieve a surface elevation of 3,189 ft by Memorial Day
- Achieve a surface elevation of 3,190 ft by July 1, if sufficient flow is available (this may be constrained by minimum flow requirements of the upper Oak Grove Fork), but surface elevation will not exceed 3,191.5 ft from Memorial Day to Labor Day
- Maximum reservoir drawdown between Memorial Day and Labor Day of 1.5 ft
- No drawdown below 3,190 ft between Memorial Day and August 1, if 3,190 ft was achieved
- No reservoir drawdown below 3,189 ft before Labor Day
- Fall drawdown of the reservoir would begin no earlier than the day after Labor Day and would be accomplished according to the maximum flow release scenario described below under the Oak Grove Fork, Timothy Lake to Lake Harriet subheading.
- From the day after Labor Day to the day before Memorial Day, Timothy Lake may be drawn down to a normal minimum elevation of 3,170.0 feet, and the maximum elevation is not to exceed 3,191.9 ft.
- Subject to the maximum flow release scenario described below under the Oak Grove Fork, Timothy Lake to Lake Harriet subheading, PGE may draw Timothy Lake down to an extreme minimum of 3125.0 feet between the day after Labor Day and the day before Memorial Day, during the following extraordinary situations: (1) drawdown needed for safe passage of anticipated flood flows to minimize damage to life and property; (2) drawdown required to complete repairs on Project facilities (including spillway gates, the intake structures, or other dam structures); and (3) power emergencies, as defined in the

Western States Coordinating Council Minimum Operating Reliability Criteria (March 8, 1999), as such criteria may be amended during the license term.

Oak Grove Fork, Timothy Lake to Lake Harriet

Maximum flows:

- Memorial Day through Labor Day, 70 cfs over inflow
- Labor Day through September 30, 100 cfs over inflow
- October 1 through October 31, 150 cfs over inflow
- November 1 through February 28/29, 300 cfs over inflow. (During this period PGE will allow no more than three large-scale flow events, defined as a day or series of days in which Timothy Lake outflow exceeds inflow by 200 cfs or more. This limitation would not apply during system power emergencies or equipment failures at Timothy Lake Dam or Oak Grove Powerhouse.)
- March 1 through the day before Memorial Day, 100 cfs over inflow

Minimum flows:

- Memorial Day through November 30, 60 cfs or inflow, whichever is less
- December 1 through February 28/29, 30 cfs or inflow, whichever is less
- March 1 through Memorial Day, 40 cfs or inflow, whichever is less

Lower Oak Grove Fork

Baseflow releases

	Water year		
	Wet	Normal	Dry
Apr 1 – Sep 30	100 cfs	90 cfs	80 cfs
Oct 1 – Oct 15	100 cfs	100 cfs	100 cfs
Oct 16 – Dec 15	80 cfs	80 cfs	80 cfs
Dec 16 – Mar 31	70 cfs	70 cfs	70 cfs

“Wet,” “normal,” and “dry” water years are defined by the Settlement Agreement in Proposed License Article on the basis of forecasted April 1 to September 30 inflows to Lake Harriet:

	Forecasted April 1 – September 30 Inflows to Lake Harriet
Wet	>182,000 acre-ft
Normal	< 182,000 acre-ft and > 123,000 acre-ft
	< 123,000 acre-ft

PLA 8(b) further provides that within six months of license issuance, PGE will file a protocol, developed in consultation with the United States Geological Survey, to determine whether the year will be “wet,” “normal,” or “dry” as defined above. Until the protocol is approved by FERC, PGE will release the flows appropriate to a “normal” year.

North Fork Fish Ladder and New Sorting Facility

The water supply to the North Fork Fish Trap consists of a new intake located in the forebay of the North Fork Dam at a depth of approximately 22 to 30 ft below the normal forebay water level. This depth allows for a relatively cold water supply to augment the ladder flow during the summer when the forebay temperature stratifies, and warm water is drawn off the surface at the ladder exit. This colder water will serve as a gravity supply to the trap and supplements the flow in the existing ladder with approximately 22 cfs (50 percent) of ladder flow with cold water. The colder water will improve attraction at the ladder entrance in addition to improving ladder conditions in general.

Faraday Diversion Reach

Baseflow releases:

- Year-round base flow of 270 cfs
- If spillway entrainment of juvenile steelhead can be reduced by at least 50 percent at flows up to 4,000 cfs, base flow releases will be reduced to 250 cfs.

Additional flow releases mandated by State instream water right:

- July 1 – Sept. 15: As flows above Faraday Diversion Dam increase above 5,290 cfs (moving to 5,270 cfs if spillway entrainment of juvenile steelhead can be reduced by at least 50 percent at flows up to 4,000 cfs), flow in the Faraday Diversion Reach will be increased until it reaches 400 cfs. As flows above Faraday Diversion Dam increase above 5,420 cfs, additional flows will be routed through the Faraday Powerhouse.
- Sept. 16 – June 30: As flows above Faraday Diversion Dam increase above 5,290cfs (moving to 5,270 cfs if the above condition is met as above), flow in the Faraday Diversion Reach will be increased until it reaches 640 cfs. As flows above Faraday Diversion Dam increase above 5,660 cfs, additional flows will be routed through the Faraday Powerhouse.

Pulsed flows for inducing Chinook migration

- Between April 1 and October 31, PGE will provide pulsed flows of between 120 and 480 cfs, in addition to the base flows described above, at a duration and frequency determined pursuant to the Pulsed Flow Regime Study Plan included in the Settlement Agreement.

Faraday Lake

- Faraday Lake will be channelized and drawn down by approximately 1.5 feet from July 15 to September 15, thereby eliminating warming that now occurs as water enters and flows through Faraday Lake.

Flows below River Mill Dam

- Except as specifically provided below, PGE will operate River Mill Dam and Powerhouse to provide flow releases below River Mill Dam that equal inflow. Ramping for power generation will not be permitted.
- PGE will develop and implement a system to estimate River Mill ungaged inflow (RMU Inflow) based on measured flows at the USGS Estacada gage, and water level measurements in North Fork Reservoir, Faraday Diversion Dam Reservoir, Faraday Lake and Estacada Lake. The water level data will be used to estimate the flow deviation described below.
- PGE will control the River Mill development flow release to hold the flow deviation within 10 percent or 100 cfs (whichever is greater) of the USGS Estacada gage flow, for all river flows, except during emergencies, equipment failures that affect river flows below River Mill, or during scheduled maintenance activities that affect river flows below River Mill or that require reservoir level changes in the North Fork to River Mill reach.
- During scheduled maintenance activities that affect river flows below River Mill or that require reservoir level changes in the North Fork to River Mill reach, PGE shall not reduce flows below River Mill to less than 500 cfs or RMU Inflow, whichever is less.
- PGE will not adjust reservoir refill or draw down rates before and after maintenance events more than 50 cfs in any hour. If, during this flow adjustment period, the RMU Inflow changes at a rate of 50 cfs per hour or more, in the same direction desired for maintenance, then changes in the refill or drawdown rate of reservoirs in the North Fork to River Mill reach (i.e., the ramping of flows for maintenance) will stop and ramping of the flow release will equal the ramping rate of the RMU Inflow.

2.5 Temperature Monitoring Sites and Sampling Schedule

Temperature monitoring will be conducted at the sites listed in Table 2-2, which show monitoring locations, water quality variables sampled, and type and frequency of sampling. Descriptions of sampling protocols for each variable listed in the table are provided in the associated section of this WQMMP.

Table 2-2. PGE water quality monitoring locations and parameters ~~following issuance of FERC license~~.

Code	Site Name	Sampling Parameter	Sampling Type	Frequency
OGF01	Oak Grove Fork below Timothy Lake	Temperature	Continuous[1]	Monthly Download
		IGDO/Ambient DO	Grab	Biweekly Seasonal[2]
		TDG	Grab	Monthly Seasonal[3]
OGF02	Oak Grove Fork above Lake Harriett	IGDO	Grab	Biweekly Seasonal[2]
OGF03	Oak Grove Fork below Lake Harriett	Temperature	Continuous[1]	Monthly Download
		Ambient DO	Grab	Biweekly Seasonal[2]
		TDG	Grab	Monthly Seasonal[3]
OGF04	Oak Grove Fork near the Mouth	Temperature	Continuous[1]	Monthly Download
		IGDO/Ambient DO	Grab	Biweekly Seasonal[4]
CR01	Clackamas River upstream of the Oak Grove Fork	Temperature	Continuous[1]	Monthly Download
		DO	Grab	Monthly
CR02	Clackamas River upstream of the Oak Grove Powerhouse	Temperature	Continuous[1]	Monthly Download
		IGDO/Ambient DO	Grab	Biweekly Seasonal[4]
CR03	Clackamas River at the Oak Grove Powerhouse	Temperature	Continuous[1]	Monthly Download
		DO	Grab	Monthly
CR04	Clackamas River below the Oak Grove Powerhouse	Temperature	Continuous[1]	Monthly Download
		DO	Grab	Monthly
CR05	Clackamas River upstream of the North Fork Reservoir	Temperature	Continuous[1]	Monthly Download
		IGDO/Ambient DO	Grab	Biweekly Seasonal[4]
NF01	North Fork Dam below the Spillway	Temperature	Continuous[1]	Monthly Download
		TDG	Continuous[5]	Seasonal Download[6]
NF02	North Fork Fish Ladder at Top	Temperature	Continuous[1]	Monthly Download
NF03	North Fork Fish Ladder, immediately below new Adult Sorting Facility	Temperature	Continuous[1]	Monthly Download
NF04	North Fork Fish Ladder at Diffusers on Bottom	Temperature	Continuous[1]	Monthly Download
FAR01	Faraday Lake in Channel/Forebay	Temperature	Continuous[1]	Monthly Download
FAR02	Faraday Diversion Reach, above Faraday Powerhouse	Temperature	Continuous[1]	Monthly Download
FAR03	Faraday just below the Powerhouse	Temperature	Continuous[1]	Monthly Download
RM01	River Mill Dam below the Spillway	Temperature	Continuous[1]	Monthly Download
		TDG	Continuous[5]	Seasonal Download[6]

1 Continuous measurements will be taken at 1 h intervals after SA Alternative flow releases are implemented. See section 2.6.
2 Biweekly seasonal indicates sample DO collection April 15 - ~~June 15~~ September ~~under the proposed SA Alternative flow regimes or immediately after license issuance. Fall collections will not be made at these sites due to presence of only spring spawning species. See section 3.6~~.
3 Monthly seasonal indicates monthly collection July - November)
4 Seasonal indicates April 15 – June 15 and September 15 – November 15 under the proposed SA Alternative flow regimes or immediately after license issuance. See section 3.6 for more information.
5 Continuous data collections will be made at 30 minute intervals before and after SA Articles are implemented. See section 4.4 for more information.
6 Seasonal indicates monitoring under both natural and manmade spill conditions that generally occur from November to April. See section 4.4 for more information.

Temperature monitoring will be conducted in the Clackamas River immediately upstream of the Oak Grove Powerhouse (Table 2-2). Monitoring data will be used to evaluate temperature differences between the Clackamas River upstream of the Oak Grove Fork and immediately upstream of the Oak Grove Powerhouse, to assess actual warming, or cooling, that occurs in the reach.

To assess the extent of temperature reduction in the North Fork fish ladder resulting from the introduction of cold water at the new adult sorting facility, monitoring will be conducted at three locations in the fish ladder: at the top of the ladder just downstream of the inflow from North Fork forebay, just downstream of the new adult sorting facility, and just downstream of the diffusers at the entrance of the ladder (Table 2-2).

Temperature monitoring will continue for five years, or for a shorter period of time if PGE and ODEQ agree that further monitoring is not warranted to document temperature dynamics under a range of flow and meteorological conditions. With respect to temperature monitoring in the North Fork fish ladder, PGE will work with ODEQ, and the Fish Committee to evaluate results and determine whether monitoring should continue for more than five years.

2.6 Temperature Measurement Methods

Onset® temperature loggers (or equivalent), set at 1-h recording intervals, will be installed at all monitoring locations identified in Table 2-2. Data will be collected immediately before, during, and after periods of the year which under existing operations are out of compliance but are predicted to be in compliance when the SA Alternative flow releases are implemented. At all locations, data collected by temperature loggers will be downloaded monthly over the period of data collection. Quality assurance and quality control measures associated with data collection will be addressed in the Quality Assurance Project Plan (QAPP) as explained in Section 8.0.

2.7 Reporting

Reports will be produced in two forms: updates on water temperatures will be provided via email to ODEQ by the end of the month following the month in which data were collected, and an annual report will be submitted, by March 31 of each year that includes data from the previous calendar year. Reports will consist of a tabular summary of data and the raw data files from which the summary data were generated.

3.0 DISSOLVED OXYGEN MANAGEMENT PLAN

3.1 ODEQ Dissolved Oxygen Standard

The ODEQ dissolved oxygen (DO) standard, as defined by OAR 340-041-0016, can be found in Section 9.4 of the Final 401 Application.

3.2 Application to the Clackamas Hydroelectric Project

ODEQ DO criteria that apply to Project reaches of the Clackamas River and Oak Grove Fork are shown in Table 3-1. In the Oak Grove Fork above the barrier falls, the salmonid spawning criterion applies during winter and spring to account for resident cutthroat trout spawning, and the rearing criterion applies during the remainder of the year. In all other riverine reaches, the spawning and rearing criteria apply based on anadromous fish periodicities identified by ODEQ. In the North Fork fish ladder DO concentrations must be sufficient to ensure that upstream fish passage is not impeded, a determination to be made by the Fish Committee when post-license monitoring results become available, i.e., after temperature changes in the ladder occur as the result of introduction of cold water at the new North Fork ladder fish trap. In Project reservoirs, the relevant beneficial use is salmonid rearing.

Table 3-1. ODEQ DO criteria that apply to Project reaches of the Clackamas River and Oak Grove Fork.; 8 mg/L is the salmonid rearing criterion and 11.0 mg/L is the spawning criterion.

Reach	Period when criterion applies	ODEQ DO criterion
Oak Grove Fork, Timothy Lake to barrier falls	June 16 - Dec 31	8 mg/L [2]
	Jan 1 – June 15	11.0 mg/L
Oak Grove Fork, barrier falls to mouth	June 16 – August 31	8 mg/L
	September 1-June 15	11 mg/L
Clackamas River, Oak Grove Fork to Clear Creek	June 16 – August 31	8 mg/L
	September 1-June 15	11 mg/L
North Fork fish ladder	Jan 1 – Dec 31	DO concentrations that do not impede fish passage, as determined by the Clackamas Fish Committee
Clackamas River, vicinity of Bonnie Lure State Park (RM 16.7)	Jan 1 – Dec 31	8 mg/L
Clackamas River, Clear Creek to mouth	May 16 – Oct 14	8 mg/L
	October 16-May 15	11 mg/L

According to ODEQ standards, if IGDO measured as a spatial median is greater than or equal to 8.0 mg/L, then the applicable ambient (i.e., water column) DO criterion is 9.0 mg/L, instead of 11.0 mg/L. Currently, the ambient DO spawning criterion for the Oak Grove Fork, the Clackamas River from the Oak Grove Fork to Estacada Lake, and the Clackamas River downstream of River Mill Dam is 11.0 mg/L, because no information has been available regarding intergravel dissolved oxygen (IGDO) in the Project area. Recent data available to PGE suggest, however, that IGDO levels in the Project area are greater than 8.0 mg/L. This issue is addressed in greater detail in Section 3.4, *Approach to DO Management*.

3.3 Facilities for Compliance

As noted in Section 2, the PME package proposed under the SA Alternative includes two facilities modifications that will result in improvements in DO concentrations. A minimum flow facility will be installed at Harriet Dam, which will allow the release of up to 100 cfs—i.e., the maximum planned baseflow release to the lower Oak Grove Fork proposed as part of the settlement PME package. This will result in a reduction in lower Oak Grove Fork temperatures and a concomitant increase in DO during much of the year, mainly during warmer months (see Section 7.2.4.2 of the Final 401 Application). The second proposed modification is a new adult fish sorting facility in the North Fork fish ladder, which will replace about 50 percent of the fish ladder flow with cold water from the North Fork Reservoir hypolimnion. The added cold water will lower overall fish ladder temperatures downstream of the sorting facility, thereby increasing DO.

3.4 Approach to DO Management

Water quality modeling indicates that under the proposed SA Alternative flow regimes, DO concentrations will fall below the 11.0 mg/L criterion at times in all reaches of the Oak Grove Fork and Clackamas River (see Section 7.2.4.2 of the Final 401 Application). This noncompliance occurs in the Oak Grove Fork upstream of the barrier falls during a portion of the cutthroat trout spawning period. In the Oak Grove Fork downstream of the barrier falls and in all riverine reaches of the Clackamas River, DO levels below 11.0 mg/L occur just before the ODEQ criterion changes from the 11.0 mg/L spawning criterion to the 8.0 mg/L rearing criterion—as water in the river is warming during summer and DO is declining—and again just after the criterion changes back from 8.0 mg/L to 11.0 mg/L—when the river has not yet cooled sufficiently to allow DO concentrations to climb to or beyond 11.0 mg/L.

The 11.0 mg/L criterion, which has been used in the Final 401 Application to evaluate the SA Alternative, is the most stringent DO criterion and has been applied because sufficient IGDO data have not been available to allow for a determination of whether the 9.0 mg/L criterion should apply. ODEQ's rules stipulate that if the minimum IGDO concentration, measured as the spatial median of samples collected according to ODEQ protocol, is ≥ 8.0 mg/L, then the 9.0 mg/L ambient DO criterion applies. If the 9.0 mg/L criterion were to apply to the Oak Grove Fork and Clackamas Rivers, CE-QUAL-W2 results indicate that under the SA Alternative there would be no DO exceedances in any of the riverine reaches.

In 2005, PGE collected IGDO data in a number of locations in the Oak Grove Fork and Clackamas River (see Sections 4.5 – 4.7 and Appendix 1B). PGE and ODEQ have agreed that IGDO monitoring will continue following license issuance, when the flow regimes identified in the Settlement Agreement are implemented, and that these post-license IGDO measurements will be used to determine whether the 11.0 mg/L or 9.0 mg/L criterion is to apply in various Project reaches (see Section 9.4 of the Final 401 Application). IGDO monitoring in 2005 was, as future monitoring will be, conducted in reaches and at times where exceedances of the 11.0 mg/L ambient criterion are predicted by the CE-QUAL-W2 model to occur under operations proposed under the SA Alternative.

IGDO data collected in 2005 indicate that median IGDO values are above 8.0 mg/L at all times in most reaches and most of the time in the remaining reaches (see Section 4.7 for more detail). These IGDO values are likely to increase under the higher flow releases implemented after license issuance. If the expected increases occur, IGDO in Project-affected reaches will exceed 8.0 mg/L, in some cases significantly, during salmonid spawning and incubation periods. Therefore, the ambient DO criterion will be 9.0 mg/L in all reaches. Ambient DO currently exceeds 9.0 mg/L throughout the riverine reaches in the Project area during salmonid spawning and incubation periods, and based on this, ODEQ has reasonable assurance that ambient DO values in the Project area will be in compliance with ODEQ criteria during the term of the next license.

In Project reservoirs, a substantial volume of water will remain above the relevant criterion at the appropriate times. Fish and other biota in the reservoirs congregate in regions conducive to their survival and growth, and thus will avoid regions where DO concentrations are below criteria for short periods. Based on this, PGE believes that when operations associated with the SA Alternative are put into effect, DO concentrations in Project reservoirs will be in compliance with ODEQ criteria throughout the year.

3.5 IGDO and DO Monitoring Sites and Sampling Schedule

IGDO and DO measurements ~~will be~~ are being made at locations in the Oak Grove Fork and Clackamas River identified in collaboration with ODEQ ~~(Appendix 1A)~~. As explained above, IGDO monitoring results will be used to determine if the 9.0 mg/L ambient DO standard is applicable in the reaches and at the times in question. ~~Monitoring took place in 2005, and will continue following issuance of the new FERC license for two years, if ODEQ and PGE agree that post-license monitoring is needed. PGE and ODEQ will determine during the first two years after new operations are in place if IGDO and ambient DO sampling has been completed.~~

~~Post-license monitoring will be conducted in two phases.~~ For the Timothy Dam tailrace, monitoring ~~will take~~ took place during ~~the first~~ two years after license issuance; this ~~will~~ allowed evaluation of the extent to which, if any, the water quality model ~~fails~~ failed to account for the potential aerating effect of the Howell-Bunger valve. PGE, in consultation with ODEQ, may decide to measure the volume and DO concentration of groundwater input immediately downstream of Timothy Lake to evaluate its potential effect on overall DO concentrations. For the Oak Grove Fork below Lake Harriet, monitoring will take place ~~for two years~~ after the minimum flow release structure has been completed (see below).

PGE is currently applying for an amendment of its FERC license, which would allow the addition of small generating units at four locations at the Project: (i) below Timothy Lake Dam; (ii) below Lake Harriet Dam at Crack-in-the-Ground; (iii) below North Fork Dam; and (iv) below Faraday Diversion Dam. During the first two years after completion of the turbines at Timothy Lake Dam, PGE will monitor DO at Station OGF01, according to the methods shown in Table 2-2. Monitoring will be conducted from May through September (*i.e.*, the warm period of the year, when DO concentrations are expected to be lowest). If monitoring indicates that DO standards are not being met, PGE will consult with ODEQ to develop a formal plan to shift flow to the Howell-Bunger valve in a sufficient quantity to ensure that the DO standard will be met at all times.

PGE will monitor DO at Station OGF03, according to the methods shown in Table 2-2. The measurement period started when baseflow discharges from the sand trap began in 2012 and will continue until two years after completion of the turbine at Crack-in-the-Ground. Monitoring will be conducted from May through September (*i.e.*, the warm period of the year, when DO concentrations are expected to be lowest). If monitoring indicates that DO standards are not being met, PGE will consult with ODEQ to develop a plan to ensure compliance with the DO standard.

~~During the first two years after license issuance, r~~ Riverine IGDO and DO measurements will occur biweekly during the period of year when the 11.0 mg/L ambient DO criterion is currently applicable and model predictions indicate that DO levels less than 11.0 mg/L could occur under the proposed alternative; no riverine IGDO or ambient DO measurements will be conducted during the remainder of the year. Sampling protocol, including timing, is provided in the appropriate section below. If ODEQ determines that IGDO sampling results warrant a change to the 9.0 mg/L ambient standard, ambient DO sampling will be discontinued; if the 11.0 mg/L criterion remains in effect, PGE will work with ODEQ to determine when and how further ambient DO monitoring will take place.

3.6 IGDO and DO Data Collection Methods

IGDO and ambient DO sampling will be conducted during the spring and fall spawning and incubation periods when ambient DO concentrations are predicted to be below the 11.0 mg/L criterion; no data will be collected during periods when ODEQ's 8.0 mg/L rearing criterion applies. Sampling will be conducted every other week from April 15 through June 15 and from September 15 through November 15. No fall sampling will be conducted in Timothy Lake tailrace or in the Oak Grove Fork just upstream of Lake Harriet (see Table 2.2), because the only native salmonid that occupies the upper Oak Grove Fork (above the barrier falls) is cutthroat trout, which is a spring spawning species. In addition, at high flows when it is not safe for field personnel to stand in the stream and collect IGDO measurements, IGDO sampling will be suspended. When flow conditions return to a safe level, IGDO sampling will be reinstated. It is only during unsafe, high flow conditions that IGDO sampling will be suspended.
In addition, ambient DO may be taken as determined by PGE and DEQ based on IGDO results.

IGDO and ambient DO sampling will be conducted in areas where salmonids are known to spawn, or in areas with suitable substrate, depths, and velocities if little or no spawning takes place in a particular sampling reach. All sampling will be conducted to avoid disturbance of actively spawning adult salmonids or existing redds.

At each site, IGDO sampling will be conducted in three artificial redds, which will be constructed to mimic conditions created by adult salmonids when constructing redds. A standpipe will be placed in each artificial redd, and water to be sampled for IGDO will be pumped from inside the standpipe at its base or measured in the standpipe. Ambient DO above the artificial redd will be measured at the same time as the IGDO. A dissolved oxygen probe (Hydrolab™ or handheld YSI), will be used to measure IGDO and ambient DO concentrations, and Winkler titration will be used to verify the accuracy of the measurement device. Winkler titrations will also be performed at locations where

IGDO concentration is less than 8.0 mg/L. IGDO sampling and QA/QC protocol are provided in detail in section 8.0.

3.7 2005 IGDO Monitoring Results

Results of sampling conducted in 2005 show that IGDO concentrations in Project-affected reaches are nearly always high; detailed results of the 2005 IGDO data collection are available upon request. As explained in Section 9.4.2 of the Final 401 Application, if measured IGDO concentrations during salmonid spawning and incubation periods are ≥8.0 mg/L, ODEQ's surface water numeric DO criterion (i.e., ambient criterion) is 9 mg/L, instead of 11 mg/L. When spawning and incubation are not occurring, the applicable surface water criterion is 8 mg/L.

IGDO data were collected during spring 2005 on April 28–29, May 10–11, May 26–27, and June 14–15 at eight sites along a longitudinal profile of the Oak Grove Fork and Clackamas River: Timothy Lake tailrace, upstream of Lake Harriet, Ripplebrook Campground, Indian Henry Campground, upstream of North Fork Reservoir, in the Faraday Diversion Reach, McIver State Park, and in the Clackamas River near Eagle Creek. IGDO data were collected during fall 2005 on October 4–5, October 20–21, November 3–4, and November 16 at five sites on the Oak Grove Fork and Clackamas River: Ripplebrook Campground, Indian Henry Campground, upstream of North Fork Reservoir, in the Faraday Diversion Reach, and in the Clackamas River near Eagle Creek.

The ranges of the spatial median IGDO values, by site, during spring and fall 2005 are shown in Table 3-3. During spring 2005, median IGDO values were consistently above 8.0 mg/L at all sites, except at Ripplebrook Campground, where the low median IGDO concentration was 7.7 mg/L. During fall 2005, median IGDO values were above 8.0 mg/L at all sites, except at Indian Henry Campground and near Eagle Creek. At Indian Henry Campground, the low median IGDO concentration reached 7.7 mg/L. At Eagle Creek median IGDO values were at times very low (as low as 1.8 mg/L). However, temperatures within the artificial redd that yielded this result suggest that the low values resulted from groundwater intrusions and likely do not represent conditions that would occur in natural redds in this area.

Table 3-2. Ranges of spatial median intergravel dissolved oxygen (IGDO) values, by site, in the Oak Grove Fork and Clackamas River during spring and fall 2005.

	Range of spatial median of IGDO measurements (mg/L)	
Sampling site	**Spring 2005**	**Fall 2005**
Oak Grove Fork		
Timothy Lake tailrace	8.1 – 9.7	-
Upstream of Lake Harriet	8.6 – 10.3	-
Ripplebrook Campground	7.7 – 9.6	8.4 – 9.4
Clackamas River		
Indian Henry Campground	8.8 – 10.3	7.7 – 10.5
Upstream of North Fork Reservoir	8.1 – 10.0	9.3 – 10.3
Faraday Diversion Reach	8.7 – 10.1	9.4 – 10.8
McIver State Park	8.8 – 9.5	-
Near Eagle Creek	8.7 – 9.6	1.8 – 9.8[1]

1 DO measurements in artificial redds likely influenced by groundwater flow

As mentioned above, IGDO data collected in 2005 indicate that median IGDO values in and downstream of the Project are above 8.0 mg/L nearly all of the time, and these IGDO values are likely to increase under the higher flow releases implemented after license issuance. Therefore, it is likely that ODEQ will set the ambient DO criterion at 9.0 mg/L in all reaches, resulting in compliance with ODEQ ambient DO criteria throughout and downstream of the Project area.

3.8 Reporting

Reports will be produced in two forms: updates on ambient DO and IGDO concentrations will be provided via email to ODEQ twice annually, and an annual report will be submitted by March 31 of each year with the prior year's data to ODEQ. Reports will consist of a tabular summary of data and the raw data files from which the summary data were generated.

4.0 TOTAL DISSOLVED GAS

4.1 ODEQ Total Dissolved Gas Standard

The ODEQ total dissolved gas standard, as defined by OAR 340-041-0031, can be found in Section 9.8 of the Final 401 Application.

4.2 Application to the Clackamas Hydroelectric Project

The supersaturation of atmospheric gases in water may cause either crippling or lethal gas bubbles to form in the tissues of fish. ODEQ's total dissolved gas (TDG) standard is designed to prohibit discharges or activities that will result in atmospheric gases reaching known harmful concentrations. When excess water is spilled over the face of a dam, it entrains air as it plunges to the stilling or plunge pool at the base of the dam. If the momentum of the fall carries the water and entrained gases to great depths in the pool, the entrained gases are driven into solution, causing supersaturation of dissolved gases. The extent to which supersaturation occurs is a function of the physical characteristics of the spillway and the depth of the pool into which water plunges.

4.3 Approach to Total Dissolved Gas Management

As explained in the Final 401 Application, typical conditions for the development of excess TDG are not present at the Project (see Section 9.8.3 of the Final 401 Application). Spillway discharges from Project dams enter shallow water and do not plunge to great depth, and at the Oak Grove Powerhouse no air entrapment occurs, thus precluding TDG from reaching supersaturated levels at this facility. Data to support the conclusion that TDG is not a problem at the Project are provided in Section 9.8 of the Final 401 Application.

ODEQ has noted that TDG measurements at North Fork Dam are limited, ~~however,~~ with some taking place under controlled spills, which do not accurately characterize TDG concentrations under the relative flow distributions (spillway versus powerhouse) that would occur under a natural spill of the same volume (see Section 9.8.3 of the Final 401 Application for further explanation). ODEQ has requested that additional information be collected ~~following issuance of the new FERC license,~~ to verify that spill at North Fork Dam is in compliance with the ODEQ criterion.

PGE believes that TDG during natural spills at North Fork does not exceed the ODEQ criterion of 110% and, therefore, has no plans to modify facilities or operations at North Fork Dam in an attempt to influence TDG concentrations. Rather, PGE plans to monitor TDG concentrations during natural spills to demonstrate that there is no problem (see below).

As noted above, PGE is currently applying for an amendment of its FERC license, which would allow the addition of small generating units (i) below Timothy Lake Dam; (ii) below Lake Harriet Dam at Crack-in-the-Ground; (iii) below North Fork Dam; and (iv) below Faraday Diversion Dam. In addition to the monitoring being conducted below North Fork Dam, PGE will monitor TDG below Timothy Lake and Crack-in-the-Ground to confirm that discharges from the turbines at these locations do not exceed the applicable TDG standard.

4.4 Total Dissolved Gas Monitoring

TDG monitoring will occur in two-phases: for two years following license issuance and for two years following installation of the spillway exclusion net upstream of North Fork Dam. This approach should provide data for all spill conditions expected to occur during the term of the new license.

TDG monitoring at North Fork was conducted for two years following license issuance and will be conducted for two years following installation of the spillway exclusion net upstream of North Fork Dam. This approach should provide data for conditions expected to occur during the term of the new license. In addition, TDG monitoring will occur below Timothy Lake Dam and below Crack-in-the-Ground for two years following completion of the turbines at these locations.

This approach should provide data for a range of conditions expected to occur in the Oak Grove Fork during the term of the new license.

4.4.1 Monitoring Natural Spills

Monitoring will be conducted during "natural spills" for the first two years of the new FERC license period. "Natural spills" are defined as spills that occur because river flows at North Fork Dam exceed the powerhouse capacity (approximately 6,000 cfs) and PGE must pass the excess flows over the spillway. These "natural spills" generally occur from November to May. Measurements will be taken from approximately 6,000 cfs up to 21,000 cfs or a revised ten-year seven-day flood event. TDG measurements will be taken continuously, on 30 minute intervals, to account for the full range of "natural spill" conditions that occur during the first two years following license issuance. Continuous measurement allows PGE to sample all spills between November and May. Measurements will be made in the North Fork tailrace, as close to the dam as permitted by safety considerations, and below River Mill Dam to assess dissipation of TDG with distance from North Fork Dam. A Hydrolab MS5 will be used to measure total dissolved gas. At both sites (below North Fork and below River Mill dam) water temperature, total gas pressure, barometric pressure and percent gas saturation will be measured. Measurement equipment will be calibrated to local barometric pressure prior to use. In addition, flow will be obtained from the USGS Estacada gauging station.

PGE will meet with DEQ to review monitoring results and to decide either to develop possible measures to address potential TDG violations or to continue monitoring TDG.

a. If at any time during this two-year period, DEQ and PGE agree that PGE has obtained enough data to establish that natural spills will lead to violations of the TDG standard below North Fork Dam, PGE will consult with DEQ to develop possible measures to address the expected TDG violations.

b. If at the end of this two-year period, DEQ and PGE agree that PGE has not obtained enough data to establish that natural spills will lead to violations of the TDG standard below North Fork Dam, PGE will consult with DEQ to decide how to continue the TDG monitoring program under "natural spill" conditions.

4.4.2 Monitoring Under New Fish Passage Conditions

Monitoring will be conducted during the two-year period starting when the spillway exclusion net upstream of the North Fork spillway is in place and PGE has demonstrated the net's effectiveness as provided in PLA 12 of the Settlement Agreement. Monitoring will be conducted during the time periods, specified in PLA 12(b), when the generation limits are in effect and PGE is implementing the "forced spill" requirement to reduce entrainment of juvenile salmonids into the powerhouse intake. Sampling locations will remain the same as locations under natural spill conditions.

PGE will meet with DEQ to review monitoring results and to decide either to develop possible measures to address potential TDG violations or if it is necessary to continue monitoring TDG.

a. If at any time this two-year period, DEQ and PGE agree that PGE has obtained enough data to establish that the pattern of spillway releases will lead to violations of the TDG standard below North Fork Dam, PGE will consult with DEQ and the Fish Committee to develop possible measures to address the expected TDG violations.

b. If at the end of this two-year period, DEQ and PGE agree that PGE has not obtained enough data to establish that the pattern of spillway releases will lead to violations of the TDG standard below North Fork Dam, PGE will consult with DEQ to decide how to continue the TDG monitoring program.

At the end of this extended period of monitoring, PGE will meet with DEQ to review results and to decide either to develop measures to address potential TDG violations or to determine whether to continue monitoring for a further period established in consultation with DEQ. If, at any point, DEQ and PGE agree that PGE has obtained enough data to establish that the pattern of spillway releases will lead to violations of the TDG standard below North Fork Dam, PGE will consult with DEQ and the Fish Committee to develop possible measures to address the expected TDG violations.

4.4.3 Monitoring at Timothy Lake and Crack-in-the-Ground

TDG monitoring will be conducted for two years at Station OGF01 following completion of the turbines at Timothy Lake Dam according to the methods described in Table 2-2 and Section 4.4.1. Monitoring will be conducted one day per month (over a 4-hour period each monitoring day) from July through November in order to sample a range of flows released through Timothy Lake Dam. At the end of two years, PGE will meet with ODEQ to review Timothy Lake monitoring results and to decide whether to develop measures to address potential TDG violations or to continue monitoring TDG.

TDG monitoring will be conducted for two years at Station OGF03 following completion of the turbine at Crack-in-the-Ground according to the methods described in Table 2-2 and Section 4.4.1. Monitoring will be conducted one day per month (over a 4-hour period each monitoring day) from July through November in order to sample a range of flows released at Lake Harriet Dam and Crack-in-the-Ground. At the end of two years, PGE will meet with ODEQ to review Crack-in-the-Ground monitoring results and assess whether TDG concentrations are meeting ODEQ standards and if not whether to develop measures to address potential TDG violations or to continue monitoring TDG.

4.5 Reporting

Reports will be produced in two forms: updates on TDG monitoring will be provided via email to ODEQ within one month of the time measurements are made, and an annual report will be submitted, by March 31 of each year, to ODEQ.

5.0 NUISANCE ALGAE AND CREATION OF TASTE AND ODOR

Details relating to nuisance algae and the creation of taste and odor issues in the Clackamas River can be found in the document entitled, "*Blue Green Algae Monitoring Plan*" (BGMP), which is being developed pursuant to License Appendix A, Condition 5 and License Appendix

B, Article 12 (B). The BGMP will be distributed to the Blue Green Algae Team (BGT) for review. Once the BGMP has been reviewed by the BGT, and approved by DEQ, the document will be filed with FERC within six months of license issuance.

In addition, all quality assurance and quality control procedures and processes for the *Blue Green Algae Monitoring Plan* can be found contained in the plan itself.

6.0 OAK GROVE FORK GRAVEL AUGMENTATION

As part of the SA Alternative, PGE will implement coarse sediment augmentation programs, following issuance of the new FERC license, in the Clackamas River downstream of River Mill Dam and in the Oak Grove Fork between Lake Harriet and the confluence with the Clackamas River.

As explained in PGE's Final 401 Application, if gravel augmentation results in effects comparable to those reported by Lewis et al. (2005), temperatures in the lower Oak Grove Fork will be reduced beyond the significant reduction predicted as the result of increased baseflows, which alone are expected to result in year-round compliance with ODEQ criteria. In addition, potential gravel-induced temperature reductions in the Oak Grove Fork would be transmitted downstream, resulting in temperature reductions in the Clackamas River between the Oak Grove Fork and North Fork Reservoir.

As part of the SA Alternative, PGE proposes to augment gravel to increase the availability of salmonid spawning habitat in the lower Oak Grove Fork under the flow regime proposed in the SA Alternative. The initial gravel augmentation amount will range from 2,200 – 3,000 tons of fluvial rock at two sites (Crack-in-the-Ground and Ripplebrook Campground). The volume split between the two sites and the number of years needed to provide the initial placement of coarse sediment will be determined by PGE in consultation with the Fish Committee, but is anticipated to be completed over four or five years. Course sediment delivered to the Crack-in-the-Ground site is anticipated to be placed in the "notch" in the bedrock at this site and is anticipated to move downstream under moderate flows. The material deposited at the Ripplebrook Campground will be placed in bar forms using equipment and methods determined by PGE in consultation with the Fish Committee following license issuance. The annual volume of gravel can be "carried over" to subsequent years if not added in a given year. The majority of gravels would be placed at the Crack-in-the-Ground site, unless monitoring of spawning gravels in the Ripplebrook area indicates the need for supplementation there. If after year 5 of the initial augmentation effort coarse sediment does not appear to be moving downstream past the Barrier Falls, PGE will complete a feasibility analysis of two additional coarse sediment augmentation sites downstream of Crack-in-the-Ground.

If this augmentation program reduces maximum temperatures in a manner similar to that reported by Lewis et al. (2005), temperatures in the lower Oak Grove Fork will be reduced beyond what has been predicted as the result of increased baseflows; as shown in Section 7 of the Final 401 Application, increased baseflows alone will result in a significant temperature reduction in the lower Oak Grove Fork, one that will result in year-round compliance with ODEQ criteria.

7.0 PHYSICAL HABITAT ENHANCEMENT

As part of the SA Alternative, side channel habitat enhancements will be implemented in the Oak Grove Fork between the Barrier Falls and the confluence with the Clackamas River (see Settlement Agreement for more information). Additional 1+ coho salmon side channel habitat, beyond what will be obtained through increased baseflows, will be created through side channel manipulations, which may include excavation of side channel entrances, creation of large woody debris jams or other such structures downstream of side channel entrances to provide necessary inflows, placement of large woody debris at side channel entrances to protect against the entrance of high-velocity mainstem flows during spill or large flow events, excavation within the side channels to increase the total habitat area, and/or placement of large woody debris (including root wads) to enhance 1+ coho rearing habitat quality.

The goals of mainstem habitat enhancement in the Oak Grove Fork between the Barrier Falls and the confluence with the Clackamas River include beginning to restore natural stream processes, enhancing 2+ steelhead, anadromous salmonid spawning, and spring Chinook holding habitat, and providing a refuge for juvenile salmonids during high flows. Habitat enhancements will involve the placement of large wood structures at strategic locations within the main channel of the lower Oak Grove Fork.

Habitat enhancements and will also be implemented upstream of Lake Harriet. Aggregates of logs will be placed in Dinger Creek, a tributary to Timothy Lake (see Settlement Agreement for more detail). Habitat enhancement will also be implemented in the Oak Grove Fork between Timothy Lake Dam and Hammer Springs. At this location, boulders will be placed along channel margins to increase hydraulic roughness, thereby reducing the width of active channel at low flows, creating slower, deeper water (i.e., pool-like habitat) where there are currently shallow runs and riffles. Culvert replacements will be made on Dinger Creek and Anvil Creek; the latter is a tributary to the Oak Grove Fork just downstream of Timothy Lake Dam. Replacing these culverts will allow access to about 5.3 mi of stream currently inaccessible to upstream migrating cutthroat trout.

These habitat enhancement measures will be conducted using best management practices (BMPs) designed to minimize water quality impacts, including short-term introductions of fine sediment. Given the application of BMPs, the small spatial scale of individual enhancements, and the short time period needed to implement the enhancements, no water quality impairment is anticipated. All required permits will be obtained prior to initiating work on these projects, so any minor water quality issues resulting from construction will be addressed.

8.0 QUALITY ASSURANCE AND QUALITY CONTROL

8.1 Data Quality

The objective of the Quality Assurance Project Plan is to develop and implement procedures for field measurement, field sampling, chain of custody, laboratory analysis, and reporting that will provide results that are defensible, scientifically. Specific procedures for sampling, chain of custody, instrument calibration, and corrective action are described in other sections of this document. This section addresses the specific quality objectives for this study.

8.1.1 Data Quality Objectives

Data quality objectives (DQOs) are qualitative and quantitative statements that specify the quality of data required to support a specific environmental decision or action. To achieve the objectives of this study, the following DQOs have been defined:

- Ensure that all samples are representative of water quality in the study area at the time of the study
- Ensure that samples collected are of sufficient detail (i.e. spatial and temporal variability) to characterize the water quality in the study area
- Ensure that in situ water quality measurements are accurate (based on measurement performance criteria) and are performed using standard methods
- Ensure that water quality data produced are accurate (based on measurement performance criteria) and based on proven and accepted sampling and analytical methods

8.1.2 Measurement Performance Criteria

Measurement performance criteria, including the precision, accuracy, completeness, comparability and representativeness of the data will be used to assess the quality of all environmental measurements in relation to the DQOs. In order to meet the quality objectives, the data must be (1) of known quantitative statistical significance in terms of precision and accuracy; (2) representative of the actual site in terms of physical and chemical conditions; (3) complete to the extent that necessary conclusions may be reached; and (4) comparable to previous and subsequent data collected under this study.

8.1.2.1 Precision

The precision of a measurement is the degree to which two or more measurements are in agreement. That is, the precision measures the reproducibility or repeatability of a measurement under unchanged conditions. Precision will be calculated as the absolute value of the difference of duplicate field measurements and field measurement. PGE will obtain duplicates for 10% of samples (1 in 10 for each parameter) where possible (see Table 8.3 and each parameter section for information).

$$| x - y |$$

Precision values outside of the precision objectives (Table 8.1) will be rectified by recalibrating instrumentation and repeating measurements. If values remain outside of precision objectives, the data will be flagged and reported to the DEQ. Precision results will be reported as an absolute difference in units used for each parameter. If necessary, additional monitoring will occur outside of planned schedule or in additional locations in order to replace data or increase sample size.

Table 8.1. Measurement Quality Objectives for selected water quality parameters**.**

Analyte	Accuracy	Precision	Calibration
Temperature	≤± 0.5 ºC	≤± 0.5 ºC	Accuracy checked with NIST standards
Dissolved Oxygen/ IGDO	≤± 0.5 mg/L	≤± 0.5 mg/L	Winkler titration or calibrated oxygen sensor/probe
Total Dissolved Gas	1% or 5 mm Hg	1% or 5 mm Hg	Calibrated TDG sensor/probe
Barometric Pressure	1 mm Hg	1 mm Hg	Accuracy checked with NIST standards

8.1.2.2 Accuracy

Accuracy is defined as the extent of agreement between an observed value and the accepted or true value of the parameter being measured. Accuracy goals for the monitoring parameters are addressed in Table 8.1.

Field accuracy will be assessed by using measurement equipment calibrated at a frequency set to maintain field accuracy goals. In addition, accuracy will be determined as a comparison to NIST standards where applicable. All field equipment, where possible, will be returned for factory calibration annually.

Inaccuracies will be rectified by recalibrating equipment and repeating measurements where possible. If inaccuracies cannot be rectified, the data will be flagged and reported to the DEQ in absolute values based on the units of each parameter. If possible, data will be adjusted to account for inaccuracies. If necessary, additional monitoring will occur outside of planned schedule or in additional locations in order to replace data or increase sample size.

8.1.2.3 Completeness

Completeness is a measure of the amount of valid data obtained from a measurement system compared to the amount that was expected to be obtained for that measurement under normal or routine conditions. Events that may result in a reduction in measurement completeness include sample breakage during shipment, inaccessibility to a sampling location and sampling equipment errors.

Field completeness objectives are based on the amount of valid results obtained from the measurements made. The completeness criterion for all field measurements is 85% (i.e. 85% of the planned samples must be collected and accepted for analysis). Re-sampling may be required if the completeness criteria is not met for a specific field activity.

8.1.2.4 Representativeness

Representativeness is the degree to which data accurately and precisely typify a characteristic of a parameter at a sampling point.

Field data representativeness is dependent upon the proper design of the field sampling program. This performance criteria will be met by ensuring that sampling protocols are followed as discussed in later sections of this document. Also, the field sampling design was developed to provide data that are representative of the project area.

8.1.2.5 Comparability

Comparability is the confidence with which one data set can be compared with another. Data in one section of the project area may be compared to data from another area to allow for the relative comparison of collected data.

Field data comparability is assured by a properly designed field sampling program and by using and following proper sampling protocols as discussed in later sections of this document. Data comparability is maintained by the use of identical field instruments, analytical and data reporting methods.

8.1.3 Project Team Organization

The water quality specialist will oversee the implementation of the Water Quality Management and Monitoring Plan. The Project team is composed of a water quality specialist, hydrolicensing staff, field and contract support staff. Project personnel and their responsibilities are described in Table 8.2.

8.1.1 Training and Certification

No special training requirements or certifications will be necessary for conducting the monitoring outlined in the WQMMP. The field investigations include standard field sampling techniques, field analyses, laboratory analyses or data validation techniques for the parameters listed in Table 3. PGE will ensure that collection of data will be performed by personnel that are familiar with this document and sampling methods and techniques. Sampling will be performed in a consistent manner to ensure comparable data is collected.

Table 8.2. Project Team Organization: WQMMP personnel and areas of responsibility.

Title	Responsibilities
Water Quality Specialist	Overall management of the WQMMP in order to meet objectives and conditions within. Conduct field sampling; perform equipment calibration; data review, analysis and evaluation; quality control; preparation of reports.
Hydrolicensing	Management of contracts relating to TMDLs; review of reports; quality control.
Supervisor	Provide internal support in all aspects of implementation of the WQMMP.
Westside Fisheries Staff	Provide internal support in all aspects of implementation of the WQMMP; including field sampling collection; data review, analysis and evaluation.
Contract Staff	As needed, laboratory and contract staff will be used. Analyze water quality samples; prepare reports; collect field samples; quality control.

8.2 Data Generation and Acquisition

As part of the WQMMP, temperature (T), dissolved oxygen, including ambient (DO) and inter-gravel (IGDO) and total dissolved gas (TDG) will be monitored. The focus of this document is on compliance with parameters specified in the 401 Water Quality Certification and Conditions and the WQMMP. Refer to Table 8.3 for site descriptions, locations, and method, type, and frequency sampling.

8.2.1 Sampling Methods

8.2.1.1 Temperature

Temperature monitoring will be accomplished with Onset HOBO temperature loggers (or equivalent), set at 1-hour intervals and installed at several locations to perform continuous monitoring. Additional continuous monitoring temperature sites may be added, however, any additional sites will be monitored in the same manner.

Data from continuous temperature loggers will be downloaded on monthly intervals. Data summaries of continuous temperature data will include seven-day moving means of the daily maximum temperature. Duplicates will be collected for 10% of all samples. Duplicates will be collected by deploying two HOBO temperature loggers and comparing data obtained. Duplicate sample locations will be chosen at random using a random number table.

All temperature loggers will be checked against National Institute of Standards and Technology (NIST) before and after field deployment. If a temperature logger's reading varies by more than ±0.5°C from the NIST thermometer, it will be sent to the manufacturer for re-calibration. The Hydrolab DS5 Temperature sensor will also be checked against a NIST thermometer. All probes will be recalibrated on an annual basis.

Table 8.3. Monitoring locations, accuracy and precision measures for water quality parameters measured in the WQMMP.

Code	Site Name	Sampling Parameter	Sampling Type	Accuracy Measure	Precision Measure
OGF01	Oak Grove Fork below Timothy Lake	Temperature	Continuous	NIST[1]	Random Duplicate[2]
		IGDO/Ambient DO	Grab	Winkler Titration[3]	Random Duplicate[2]
		TDG	Grab	Paired Reading[4]	Paired Reading[4]
OGF02	Oak Grove Fork above Lake Harriett	IGDO/Ambient DO	Grab	Winkler Titration[3]	Random Duplicate[2]
OGF03	Oak Grove Fork below Lake Harriett	Temperature	Continuous	NIST[1]	Random Duplicate[2]
		Ambient DO	Grab	Winkler Titration[3]	Random Duplicate[2]
		TDG	Grab	Paired Reading[4]	Paired Reading[4]
OGF04	Oak Grove Fork near the Mouth	Temperature	Continuous	NIST[1]	Random Duplicate[2]
		IGDO/Ambient DO	Grab	Winkler Titration[3]	Random Duplicate[2]
CR01	Clackamas River upstream of the Oak Grove Fork	Temperature	Continuous	NIST[1]	Random Duplicate[2]
		Dissolved Oxygen	Grab	Winkler Titration[3]	Random Duplicate[2]
CR02	Clackamas River upstream of the Oak Grove Powerhouse	Temperature	Continuous	NIST[1]	Random Duplicate[2]
		IGDO/Ambient DO	Grab	Winkler Titration[3]	Random Duplicate[2]
CR03	Clackamas River at the Oak Grove Powerhouse	Temperature	Continuous	NIST[1]	Random Duplicate[2]
		Dissolved Oxygen	Grab	Winkler Titration[3]	Random Duplicate[2]
CR04	Clackamas River below the Oak Grove Powerhouse	Temperature	Continuous	NIST[1]	Random Duplicate[2]
		Dissolved Oxygen	Grab	Winkler Titration[3]	Random Duplicate[2]
CR05	Clackamas River upstream of the North Fork Reservoir	Temperature	Continuous	NIST[1]	Random Duplicate[2]
		IGDO/Ambient DO	Grab	Winkler Titration[3]	Random Duplicate[2]
NF01	North Fork Dam below the Spillway	Temperature	Continuous	NIST[1]	Random Duplicate[2]
		TDG	Continuous	Paired Reading[4]	Paired Reading[4]
NF02	North Fork Fish Ladder at Top	Temperature	Continuous	NIST[1]	Random Duplicate[2]

Code	Site Name	Sampling Parameter	Sampling Type	Accuracy Measure	Precision Measure
NF03	North Fork Fish Ladder, immediately below new Adult Sorting Facility	Temperature	Continuous	NIST[1]	Random Duplicate[2]
NF04	North Fork Fish Ladder at Diffusers on Bottom	Temperature	Continuous	NIST[1]	Random Duplicate[2]
FAR01	Faraday Lake in Channel/Forebay	Temperature	Continuous	NIST[1]	Random Duplicate[2]
FAR02	Faraday Diversion Reach, above the powerhouse	Temperature	Continuous	NIST[1]	Random Duplicate[2]
FAR03	Faraday just below the Powerhouse	Temperature	Continuous	NIST[1]	Random Duplicate[2]
RM01	River Mill Dam below the Spillway	Temperature	Continuous	NIST[1]	Random Duplicate[2]
		TDG	Continuous	Paired Reading[4]	Paired Reading[4]

1 Temperature probes will be calibrated and checked with the National Institute of Standards and Technology standard reference data before and after deployment in the field. In addition, probes will be recalibrated annually.
2 Random duplicate refers to duplicate measurements performed on 10% of samples (1 in 10). The duplicate locations will be chosen at random using a random number table.
3 Winkler titrations, which are widely used to perform instrument checks and calibrations, will be used for dissolved oxygen parameters.
4 Paired readings indicate that a newly calibrated TDG probe will be paired with a deployed TDG probe on a biweekly basis to ensure accuracy of reading. Precision results from continuous monitoring instruments cannot be estimated from duplicate measurement (Pickett 2004), thus variability in TDG results will be determined in this manner.

8.2.1.2 Dissolved Oxygen: Ambient and Intergravel

A handheld YSI ProODO probe will be utilized for all dissolved oxygen collections in riverine locations. This probe will also be equipped with a DO sensor that utilizes optical or ODO® dissolved oxygen technology. Monitoring will occur biweekly and seasonally; April to June and September to November, except at sites OGF01 and OGF03, where monitoring will be conducted from May through September (*i.e.*, the warm period of the year, when DO concentrations are expected to be lowest).

To monitor IGDO, three artificial redds, at each of five locations (total 15 redds), will be constructed to mimic, to the extent possible, the conditions created by adult salmonids when creating redds, i.e., gravel will be moved vigorously until sediment and gravel are entrained in the water column. A 25-cm-deep depression ("egg pocket") will be made in each artificial redd, and a standpipe will be placed in the depression and covered with gravel from the upstream side of the redd, to a depth of about 25 cm. Holes will be pre-drilled into the lowest 10 cm of each standpipe to facilitate water exchange. At locations where vandalism potential or high water velocities could jeopardize the stability of standpipes, a 4-cm-diameter reinforced water filter (filter size for sand and grit), with a porous face measuring approximately 30 cm in length and attached to a 6.35 mm I.D. hosing, will be buried in the egg pocket so that the porous surface of the filter is at a depth between 15 cm and 25 cm. The filter hose can then be connected to the pump hose for sample collection. DO concentrations will be sampled within each artificial redd (i.e., IGDO), and in the water flowing over each artificial redd (i.e., ambient DO), during each data collection period at each sampling location.

Water will be pumped from inside the pipe at its base. A handheld peristaltic pump (Masterflex easyloader 7518 pump head with LS16 hosing) will be used to draw a sample from the pipe. This pump works based on vacuum pressure and does not introduce air into the sample. Water will be pumped into a flask and allowed to overflow. Approximately 600 – 1,000 ml of water will be slowly pumped and discarded before continuing to pump the sample for analysis. This purges the pipe. Pumping will be at a low rate of approximately 150 ml/min to minimize the forced introduction of surface water down into the constructed redd.

A dissolved oxygen probe (Hydrolab, YSI or equivalent) will be used to measure DO inside the standpipe and a modified Winkler titration will be used to verify data collected by the DO probe as a duplicate. In 10% of the samples, a Winkler titration will be performed as a random sample (determined by a random number table) by collecting a second purge and pump sample from the standpipe, or surface water. If the two readings differ by more than 0.5 mg/L, the instrument will be recalibrated. In addition, a modified Winkler titration will be performed at all locations where an IGDO concentration of 8.0 mg/L or less is measured with the probe. Both values will be flagged and reported to the DEQ. The DO probe will be calibrated at the beginning and at the end of each field day, according to the manufacturer's protocol (Hydrolab 1999, Wetlabs 2000) using a Winkler titration as the standard. All data collected by the probe and titrations will be recorded by hand and entered into the office computer on return from the field.

8.2.1.3 Total Dissolved Gas

Total dissolved gas (TDG) monitoring will occur in two riverine locations on the mainstem of the Clackamas River. These locations are: below the spillway of the North Fork Dam and below the Spillway of the River Mill Dam. TDG will be collected continuously using a Hydrolab MS5 sonde equipped with a TDG sensor. Samples will be taken on a continuous basis, in 30 minute intervals, during manmade and natural spill events from 6,000 cfs of up to 21,000 cfs. These spills will generally occur seasonally; from November to April. Continuous monitors ensure a range of spill events and temperatures will be monitored. Specific site selection has not occurred for TDG monitoring, however, sites will be within a ½ mile of each spillway in secure locations. PGE will be consulting the Washington Department of Ecology, Romey and Associates with approval by Oregon DEQ regarding site location selection to ensure representativeness of sample site.

In addition, TDG monitoring will occur below Timothy Lake Dam (OGF01) and below Crack-in-the-Ground (OGF03) for two years following completion of the turbines at these locations. This approach should provide data for a range of conditions expected to occur in the Oak Grove Fork during the term of the new license. Monitoring will be conducted one day per month (over a 4-hour period each monitoring day) from July through November to sample a range of flows released through Timothy Lake Dam and at Lake Harriet Dam and Crack-in-the-Ground, respectively.

Each sample site will be equipped with one Hydrolab MS5 sonde. The sonde will be ~~housed~~ placed inside a PVC ~~standpipe~~ housing designed to allow flow-through. ~~This standpipe will be located 5m below low water and will extend above the surface (for access) while being affixed to a permanent structure.~~ The sonde will be ~~placed~~ deployed inside the ~~standpipe~~ PVC housing to a depth below the compensation depth. It will be retrieved and replaced with a second, newly calibrated sonde, every two weeks, except at sites OGF01 and OGF03, where monitoring will be conducted one day per month (over a 4-hour period each monitoring day); at these locations the sonde will not be replaced. Any measurements taken above the compensation depth will be considered biased and excluded from analysis.

To calibrate the sonde, we will follow the manufacturer's specifications for calibration using barometric pressure. Barometric pressure (BP) will be obtained from a BP unit located in the vicinity (within 1-2 miles of both sampling locations) and checked against NIST standards. If the BP reading differs by more than 1 mm Hg, the sonde will be recalibrated. The BP monitor will be continuously collecting BP for the duration of the deployment of the sonde; in addition, periodic spot measurements will be collected of BP at the sampling locations and compared to the BP monitor located at fixed site.

When and where sondes are being replaced on a biweekly interval, paired readings will be taken and when possible, a third meter will be used for a three way reading to determine accuracy and precision of the probe. At sites OGF01 and OGF03, where monitoring will be conducted one day per month (over a 4-hour period each monitoring day), pre and post deployment calibrations will be conducted each sampling day. The precision of the results from continuous monitoring instruments cannot be estimated from duplicate measurement (Pickett 2004). TDG variability will be indicated by the agreement or disagreement of the results of two or more instruments. If the paired readings vary by more than 5 mm Hg, than the difference will be recorded and the sonde recalibrated. The deployed sonde will store data until downloaded on an office computer.

All other variables associated with TDG measurements are collected as part of the Hydrolab MS5 datasonde. Thus, these measurements are calibrated and checked for accuracy and precision as part of the datasonde maintenance. BP is used for calibration of equipment and percent saturation measurements of TDG and thus must be considered a separate variable.

8.2.2 Sample Handling and Labeling

Sample labels will be attached to individual sample containers for each investigation or quality control sample. Project, sampling site, date, and time will be recorded on each label. Other information will vary according to sampling parameter. All labels will be affixed to sample containers prior to field mobilization and will be filled out in waterproof ink. Sample labeling will pertain mainly to the collection of DO samples for Winkler titrations if one cannot be performed immediately in the field. In addition, it may become necessary to collect a sample for laboratory analysis.

8.2.3 Equipment and Instrument Maintenance

Equipment/instrument maintenance is needed to ensure that all field and laboratory equipment functions as intended. Specific maintenance procedures usually provided by the manufacturer should be followed to ensure reliability of the instruments. All equipment will be inspected prior to each sampling round or on a scheduled periodic basis to confirm it is in good operating condition. This includes checking the manufacturer's operating manual and the instructions for each instrument to ensure that all maintenance requirements are observed.

8.2.3.1 Field Equipment

Equipment must be kept in good operating condition. Field notes from previous sampling trips will be reviewed so that any prior equipment problems are not overlooked, and all necessary repairs to equipment have been carried out. Critical spare parts will be kept on hand to avoid delays and reduce downtime. Backup instruments and equipment, when possible, must be available to avoid delays in the field schedule.

8.3 Data Validation and Management

The following sections describe how project data and information will be documented and tracked from its generation in the field to its final use and storage.

8.3.1 QAPP Distribution and Control

The Water Quality Specialist for the implementation of the WQMMP will be responsible for distributing copies of the approved QAPP and any subsequent revisions to individuals on a distribution list composed of project team and agency members. A complete copy of the original QAPP and any revisions will be maintained in the project file.

Document control procedures will be used to identify the most current version of the QAPP. Each revision will be differentiated with a new revision number and date. A sign off sheet will be used to document that all members of the Project team (including subcontractors) have read the QAPP and will perform tasks as described.

8.3.2 Data Management, Validation and Reporting

Proper documentation of field activities is important for the attainment of the DQOs outlined for this study. Data management describes the practices and procedures that properly manage the full data lifecycle. Data collected in accordance with this QAPP will be managed in spreadsheet or database and maintained by the Water Quality Specialist. Parameters measured in the field will be recorded manually on a standard form and entered into a database or spreadsheet upon return from the field.

Data validation is the process of ensuring that a program operates on clean, correct and useful data. Validation of field data by following a set of validation rules that check for the correctness of data. These rules are as follows:

- Size: the number of characters in a data entry will be checked
- Format: format of the data will be checked in terms of units, significant figures, etc.
- Consistency: the data should be consistent with the parameter collected

- Range: the data will be checked that it lies in a reasonable range for the parameter collected

Data will be checked against these set of rules during entry into a spreadsheet or database. If the data do not meet the expectations set forth by these rules, after entry into a spreadsheet or database, the data will be flagged and reported to the DEQ. Once the data meet all validation rules, the database will be labeled as final.

Data reporting is the detailed description of the data deliverables used to completely document the calibration, analysis, quality control measures and calculations. Data acquired from the field will be reported only after reduction and validation by the responsible technical staff.

8.3.3 Project Documentation and Records

The water quality specialist will be responsible for maintaining a file that will be the central repository for all documents that constitute evidence of sampling and analysis activities as described in the QAPP. Sample collection records include field notes, analysis (e.g. logbooks, chain of custody records, field QC checks and data assessment records (field audit results, corrective action reports, data validation reports). Electronic copies of all project files and deliverables such as electronic databases will be routinely backed-up and archived.

8.3.4 Reports

Reports for collected data will generally be in two forms: monthly email reports and annual written reports. Monthly email reports and annual written reports will be submitted to ODEQ, in conjunction with the annual submittal of all data. Results from the monthly report will be submitted by the end of the month following data collection and annual reports will be submitted by March 31 for previous year's data. A copy of all reports will be kept in an electronic project database.

The data review, verification, and validation procedures and criteria used will identify and qualify data that do not meet the established measurement performance criteria.

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WQMMP APPENDIX 1
Lower Clackamas River Coarse Sediment Management Plan

DRAFT
Lower Clackamas River
Coarse Sediment Management Plan

Submitted by Peter Wampler
Submitted to the Settlement Working Group
(Fish & Aquatics Subgroup)
February 8, 2005

Key Provisions of the Coarse Sediment Management Plan

- The broad goal of the proposed course sediment management plan is to begin reversing observed geomorphic changes below River Mill Dam by restoring a portion of the historic coarse sediment supply that has been trapped behind River Mill and North Fork dams.
- Plan implementation is scheduled to proceed as follows:
  - Year 1 and 2 (First two full years of license) - Baseline data collection and numerical modeling.
  - Year 3 and 4 – Construction planning, engineering, and permitting.
  - Year 5 – Construction of sediment extraction and transport infrastructure.
  - Year 6 – Initial sediment placement at the augmentation location.
  - Year 6 to 10 – Annual sediment augmentation; and downstream monitoring of erosion and deposition.
  - Year 10 - Monitoring results will be compiled and analyzed. Coarse sediment introduction rates and caps will be adjusted to achieve the intended beneficial channel morphology changes, and monitoring frequency and methods will also be evaluated to determine which measures are providing the most useful data.
- The coarse sediment management plan for the lower Clackamas River calls for incremental coarse sediment introduction below River Mill Dam. A volume of 8,000 yd^3 will be introduced 850 feet downstream of River Mill Dam on the right bank. Coarse sediment will be placed during low flow (July-September) in a geomorphically favorable location where recruitment by the river will occur during moderate flows (> 10,000 cfs).
- The average annual rate of coarse sediment introduction is anticipated to be approximately 8,000 yd^3/year for the life of the license, until course sediment sources on PGE property are exhausted, or it is determined that augmentation is no longer warranted. Winter replenishment at the introduction site may occur up to three times per year depending on high flow recruitment, but the overall annual volume will be limited to a maximum of 20,000 yd^3. Annual replenishment rates and caps will be reevaluated after five years of augmentation.
- The full range of grain sizes will be used to allow the river to hydraulically sort gravel in the channel; washing or sorting of augmentation material is not planned.

INTRODUCTION

River Mill Dam on the lower Clackamas River was completed in 1911 to provide hydroelectric power to the burgeoning city of Portland, Oregon. Hydrologic changes from the dam are minimal; however, a set of dam-induced geomorphic changes resulting from sediment supply changes have been documented (Wampler, 2004). Channel incision immediately below the dam is minor due to the presence of erosion-resistant bedrock. However, regularly spaced bedrock pools up to 10 m deep, eroded into bedrock for 3 km below the dam, and may be related to sediment supply reduction and channel degradation below the dam.

Other geomorphic changes below the dam include: 1) increase in surface grain-size; 2) reduction in side channel area; 3) reductions in coarse sediment bar storage; 4) increase in bedrock exposure; and 5) lowering of water surface elevations.

Substantial improvements to the physical channel characteristics below River Mill Dam may be possible without complete replacement of historic coarse sediment supply. Floodplain development, which has occurred within the context of the current sediment transport regime, could be impacted by large scale coarse sediment augmentation due to flood height changes, lateral erosion, and increased channel dynamism. Therefore, we recommend that the volume of coarse sediment introduced annually should fall between the long term historic coarse sediment supply and the current sediment transport regime.

OBJECTIVES OF THE PROPOSED AUGMENTATION PROGRAM

The goal of the proposed course sediment management plan is to begin reversing observed geomorphic changes below River Mill Dam by restoring a portion of the historic coarse sediment supply that has been trapped behind River Mill and North Fork dams (Table 1). Physical channel changes resulting from coarse sediment augmentation would also provide potential biological benefits in the form of increased spawning and rearing habitat for salmonids. Less predictable changes to water quality, water temperature, and improved invertebrate production may occur as a result of increased coarse sediment storage and exchange between groundwater (hyporheic flow) and surface water.

Table 1. Approximate reservoir trap data and transport data below River Mill Dam (Washington Infrastructure Services Inc., 2001; McBain and Trush, 2002; Wampler, 2004).

	yd^3	m^3
River Mill Dam (51 years)	5,080,404	3,884,248
River Mill Dam Bedload[a]	1,524,121	1,165,274
Annual volume of coarse bedload trapped	**29,900**	**22,800**
North Fork Dam (42 years)	10,443,100	7,984,323
North Fork Dam Bedload[a]	3,132,930	2,395,297
Annual volume of coarse bedload trapped	**74,600**	**57,000**
Combined (93 years)	15,523,504	11,868,570
Combined Bedload[a]	4,657,051	3,560,571
Annual volume of coarse bedload trapped	**50,100**	**38,300**
Maximum bedload transport based on GIS analysis (1938-2003)[b]	402,083	307,414
Annual bedload transport out of the 2-mile reach below River Mill Dam	**6,200**	**4,700**

[a]Bedload defined as > sand-size (assumed 30% of total sediment trapped).

[b]see Wampler (2004) for details on this estimate

The fundamental questions surrounding coarse sediment augmentation are:

- How much coarse sediment should be added to achieve measurable geomorphic changes?
- What type of coarse sediment should be added and what range of grain sizes?
- How often should coarse sediment be added to achieve desired geomorphic changes?
- Where and when should coarse sediment be introduced to achieve the maximum benefits?
- What regulatory constraints will be imposed on the timing, size, type of coarse sediment, and total volumes of coarse sediment added?

PROPOSED ACTION

The timeline for implementation of the coarse sediment plan will begin after the license has been granted. Initial sediment introduction will take place after planning, permitting, and construction (Figure 2).

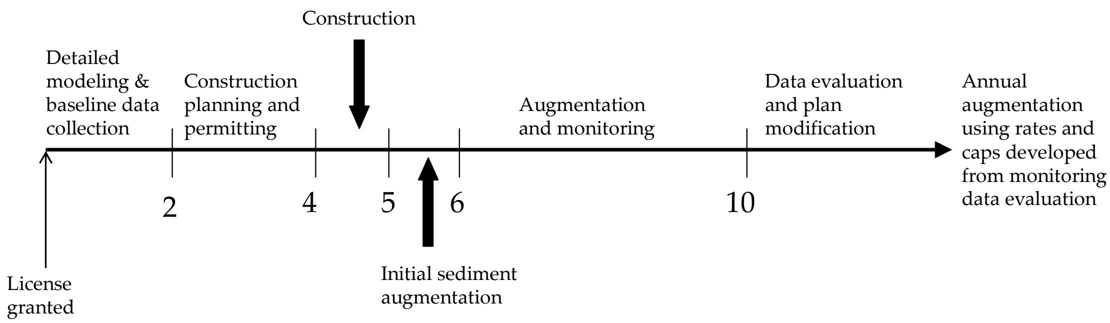

Figure 2. Implementation timeline for the coarse sediment management plan.

In the first full year of gravel augmentation, a volume of 8,000 yd^3 will be introduced 850 feet downstream of River Mill Dam on the right bank. The location needs to be close to both River Mill Dam and sediment resources to allow efficient access. The size and precise location of the introduction site may be adjusted to accommodate hydraulic conditions. Course sediment will be extracted from PGE property on the right bank and transported to the augmentation location by truck or conveyor. Coarse sediment will be placed in a lateral bar on the right bank up to five feet thick during low flow (August-September) at a location where recruitment by the river will occur during moderate flows (> 10,000 cfs).

The average annual rate of coarse sediment introduction is anticipated to be about 8,000 yd^3/year for the life of the license, until course sediment sources on PGE property are exhausted, or it is determined that augmentation is no longer warranted. PGE will dedicate the vast majority of the gravel supply located on its property adjacent to the augmentation site for this purpose. Any other use of this gravel that exceeds 600 yd^3/yr will need to be approved by the Fish Committee. The Fish Committee will evaluate these requests for coarse sediment based on the amount of available material and the average annual volume of material being added to the river through this augmentation program.

During the second full year of augmentation, the portion of the original 8,000 yd^3 eroded will be replenished during low flow (August-September). If most or all of the augmentation material is eroded early in the water year (November-January), winter-time replenishment will be implemented. Replacement of the 8,000 yd^3 bar will occur up to three times following high flow events, with the maximum volume added during any year limited to 20,000 yd^3.

After the first five full years of augmentation, annual rates and caps will be evaluated and adjusted to achieve the desired beneficial changes. For example, 1) the cap for annual introduction may be increased by as much as 25% (25,000 yd^3); 2) the number of times in a given winter that sediment is added may be increased to five; and 3) the amount of erosion in a single erosive event that would trigger adding augmentation material will be 25-75%. Hydrologic events over the first five years will be analyzed to establish if flow conditions are average, wetter than normal, or dryer than "normal," and this information will be reflected in Fish Committee recommendations regarding alteration of augmentation volumes and/or augmentation schedule.

Downstream monitoring and numerical modeling will help determine whether this augmentation strategy is supplying sufficient volume of coarse sediment to achieve management objectives. Natural coarse sediment dispersion, erosion, and deposition will occur as coarse sediment is transported downstream from the introduction location. Monitoring will attempt to document trends in erosion and deposition, which will influence yearly modifications to gravel augmentation volumes.

Hydraulic/sediment transport modeling

Computer models such as the one developed by Yantao Cui are a combination of two distinct numerical models. The hydraulic model calculates hydraulic conditions (e.g., water surface elevations, shear stress) across a range of flow conditions, and the sediment transport model predicts coarse sediment transport rates, aggradation (bed raising), and degradation (bed lowering) based on those hydraulic conditions. The predicted sediment transport rates are based on the ability of the water to move sediment, and assume that sediment supply is not limiting.

All numerical models are built upon assumptions and input data which limit the accuracy of the models. One of the limiting factors of the sediment transport portion of the model is that all the sediment transport relations are developed for a specific set of empirical sediment transport data, and assume that sediment supply is not limiting.

In a coupled one-dimensional sediment transport and routing model, results should be interpreted from a reach-average perspective because complicated features in a natural river, such as pool-riffle sequences and deep pools are not accurately modeled by a 1-D hydraulic and sediment transport model.

The model will predict reach-average sediment aggradation and degradation over a series of flow events. In addition, the model can be used to compare different combinations of sediment-size and input volume for various water year discharge scenarios (e.g., wet and dry years), which will help develop preferred gravel augmentation scenarios and save money over the long-term. The output of the one-dimensional model is aggradation and degradation thickness over the entire channel width at measured cross sections. The model will also provide valuable sediment routing data and predict areas of long-term aggradation at risk of elevated water surface elevations.

A one-dimensional sediment transport model will not accurately predict specific locations where sediment will deposit (aggrade) or erode (degrade). For example, the model might be able to predict that there will be aggradation in the reach between river mile 22.5 and 22.7, but it will not predict whether a gravel bar will form in front of Dog Creek. The hydraulic conditions are simply too complex to achieve this level of model accuracy.

Location, Method, and Timing of Coarse Sediment Introduction

The coarse sediment augmentation location was selected to be as near to the dam as possible to achieve the maximum potential benefit to the affected reach. The augmentation site is also near land owned by PGE with abundant course sediment resources, is readily accessed from PGE property, is compatible with conveyor delivery, and is near existing PGE infrastructure. Additional locations were considered, but the bench on the right bank, 850 ft downstream of River Mill Dam, provided the best combination of access, simplicity, and proximity to the base of River Mill Dam.

The USGS stilling well for the Estacada gage is located across from the augmentation location. Resolution of concerns regarding this gage and possible relocation will need to be addressed prior to plan implementation.

Several coarse sediment placement methods are possible at the augmentation location. Direct coarse sediment placement using trucks and loaders, although feasible, may not be a preferred method due to cost, in-water working restrictions, and the necessity of building and maintaining access roads near the river. A permanent conveyor system with a removable extension near the river could provide flexibility, lower cost, and minimal in-water work.

Coarse Sediment Augmentation Rates and Grain-Size

Steep channel slopes and flow restriction within narrow canyon walls below River Mill Dam result in high bedload transport capacity during large floods. Therefore, we have adopted a coarse sediment augmentation strategy that allows the river to recruit coarse sediment placed within the bankfull channel rather than a more complicated placement to create specific habitat features (e.g., spawning riffles). Recruitment and downstream transport by the river will create bars, reduce particle size, and form the desired habitat features.

Coarse sediment augmentation that mimics a natural lateral bar is proposed so that coarse sediment is mobilized from the introduction site during moderate to large flows and the augmentation site maintains a relatively natural look. Topography and water surface elevation data collected prior to introduction will help define the frequency of inundation for the augmentation location. It is anticipated that gravel mobilization from the augmentation site will occur several times per winter. Flows in excess of 10,000 cfs occur, on average, seven times per winter based on long-term historic records at the USGS Estacada gage.

We anticipate that most or all of the course sediment placed in the first full year of augmentation will be eroded during the first winter after augmentation. If all the course sediment is removed over the winter, and downstream monitoring suggests additional course sediment is needed, augmentation will be done up to three times during subsequent winters up to a maximum yearly volume of 20,000 yd^3 (Figure 4).

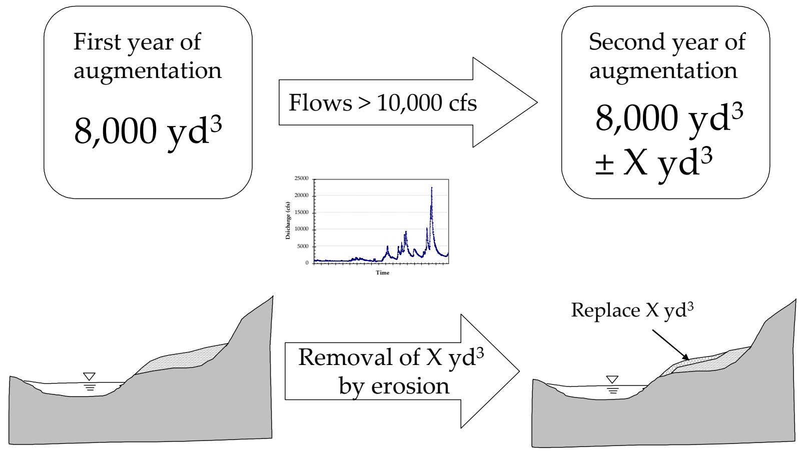

Figure 4. Conceptual diagram showing course sediment introduction.

Annual course sediment replenishment will place up to 8,000 yd^3 each year prior to winter floods (July-September), and replenish the site up to three times following selected high flow events. Winter replenishment from year to year may vary considerably; drier years may require no additional coarse sediment augmentation, while wetter years may require more than 8,000 yd^3. Therefore, we recommend that coarse sediment augmentation during any given year be flexible, but capped to a maximum augmentation volume of 20,000 yd^3/yr and three gravel introductions.

Monitoring of channel response downstream and numerical modeling will guide annual adjustments to targeted coarse sediment augmentation rates. At the end of the first five full years of augmentation, monitoring results will be analyzed and course sediment introduction rates and caps will be reconsidered to better achieve the intended beneficial channel morphology changes. The frequency and methods used for monitoring will also be evaluated at this time to determine which measures are providing the most useful data. The frequency of evaluations after the first full five years augmentation will be based on the rate of geomorphic changes occurring.

Permitting and Environmental Compliance

Two activities associated with the proposed coarse sediment management plan may require permitting by state and federal agencies: 1) coarse sediment extraction; and 2) coarse sediment placement within the Clackamas River.

Coarse sediment (sand and gravel) extraction in Oregon is regulated by the Oregon Department of Geology and Mineral Industries (DOGAMI) Mined Land Reclamation Program. Preliminary discussions with DOGAMI suggest that mining near the River Mill Dam location on PGE land would qualify for a Total Exemption from mine permitting because: 1) the coarse sediment will not be mined for commercial purposes; and 2) it will not be transported off PGE property except by the river. A final determination of exemption status will be provided once application has been made to DOGAMI. Land-use authority for coarse sediment extraction will need to be obtained from Clackamas County. The county may consider the site exempt from county jurisdiction if it is exempt from DOGAMI rules. Extraction permitting is likely to take 1-3 months if an exemption is granted and 3-16 months if a full mining permit is required.

Placement of coarse sediment below River Mill Dam within the bed and banks of the Clackamas River will require a Fill and Removal Permit from the Division of State Lands (DSL) and from the Army Corps of Engineers (ACOE). Both DSL and ACOE coordinate their permit process with other state and federal agencies. Coordinating agencies include: Oregon Department of Environmental Quality (DEQ); Oregon Department of Fish and Wildlife; U.S. Fish and Wildlife; National Marine Fisheries Service (NMFS) and others. Coordinating agencies provide comments and recommendations about the proposed activity.

Since the lower Clackamas River has been designated essential salmon habitat, any fill in excess of one cubic yard of rock requires a permit. Typically, a fill and removal permit requires extensive review and consultation prior to issuance and may take several months to obtain. An individual permit may be required by ACOE due to the scale of the project. Individual permits are site specific and require a 30-day public comment period in addition to the more time-consuming internal review and outside coordination with other agencies. A scenic waterway consultation will be required with Oregon State Parks for modifications within the waterway. This may influence the infrastructure used to transport and store the augmentation gravel.

A special permit from DSL, intended for fisheries enhancement projects, may be appropriate for this project. If augmentation is to occur in the winter months, a variance (obtained from the District Biologist) to the in-water work period may be necessary from the Oregon Department of Fish and Wildlife (ODFW).

Since there is some potential to change flood heights as a result of coarse sediment augmentation, it may be necessary to demonstrate that the activity is in compliance with the Federal Emergency Management Agency's (FEMA's) floodplain ordinance. Clackamas County enforces this ordinance. The volumes of material proposed are not likely to raise 100-year flood heights by more than one foot. Numerical models developed for initial design could be used to predict flood heights under different course sediment introduction scenarios.

Permit requirements imposed to mine or place the sediment may influence the economics and permitting of the plan. This would include requirements to wash gravel, restrictions on infrastructure, visual impacts, or in-water work restrictions.

Supplemental Permitting Information

Specific permits, estimated timelines, and key issues for each permitting authority are provided to clarify and provide additional details regarding the permitting of Lower Clackamas River Coarse Sediment Management.

Oregon Department of Environmental Quality (DEQ)

Permitting Authority: Section 401 of the Clean Water Act.

Timeline: It is anticipated that 401 certification will be obtained as part of the FERC relicensing documents. This project would not fit into the standard storm water or point source discharge classifications.

Key Issues: Obtaining a 401 certification will hinge on the way that sediment added to the river is regulated and whether DEQ will allow some turbidity to occur as a part of the restoration of a more natural sediment regime.

Oregon Department of Geology and Mineral Industries (DOGAMI)

Permitting Authority: Oregon Revised Statutes (ORS) section 570, Mining Laws

Timeline: Total Exemption (30-60 days); Operating Permit (3-12 months)

Key Issues: Mining sediment resources near the River Mill Dam location, on PGE land would likely qualify for a Total Exemption from mine permitting because: 1) the coarse sediment will not be mined for commercial purposes; and 2) it will not be transported off PGE property except by the river. However, the expense and degree of difficulty permitting mining of augmentation resources will depend on this determination. If the mining does not qualify for an exemption, a full operating permit will be required by DOGAMI.

Oregon Division of State Lands (ODSL)

Permitting Authority: ORS 541.605-695 requires that permits be obtained from the Division of State Lands prior to any fill and removal of material from the bed or banks of any stream.

Timeline: State law requires DSL to determine whether an application for a joint removal-fill permit is complete within 30 days of receipt and to issue a decision within 90 days of the completeness determination. The applicant may request a deadline extension.

Key Issues: Sediment placed in the river is considered fill and will likely require compliance with Oregon Fill and Removal law. The Clackamas River from below River Mill Dam to Carver is designated as a Scenic Waterway (ORS 390.805-390.925) and specifies that all fills and removals in State Scenic Waterways require a permit from the DSL.

Army Corps of Engineers

Permitting Authority: 404 certification; fill and removal in waters of the U.S.

Timeline: 90-120 days

Key Issues: Many projects that require a DSL removal-fill permit also will require a federal permit from the U.S. Army Corps of Engineers. The DSL and the Corps use a joint permit application form. This allows the Corps to address any concerns voiced by the DSL, but the joint permit is actually granted by the Corps.

Oregon Parks and Recreation Department (OPRD)

Permitting Authority: Scenic Waterway compliance coordination with DSL

Timeline: OPRD has authority to make recommendations to DSL regarding Scenic Waterway compliance.

Key Issues: The only outstanding issue is the visual impact and temporary disturbance that the sediment introduction site will cause below the dam. Since the site is located near the dam may not be as controversial as if it were located in an undisturbed area.

Clackamas County Planning Department

Permitting Authority: Floodplain compliance; Department of Land Conservation and Development (DLCD) land use compatibility.

Timeline: The county has 90 days to provide a Land use compatibility statement. If Clackamas County requires a change in land use zoning or a Conditional Use Permit (CUP) the permitting processes could take 6 months to 2 years.

Key Issues: Clackamas County will be asked to provide a land use compatibility statement by DOGAMI which verifies that mining of sediment resources is compatible with county Land use zoning. Clackamas County may also require that fill within the river does not result in a net rise of flood levels of more than one foot. Computer modeling used to predict sediment transport may provide the necessary floodplain alteration documentation to demonstrate "no net rise".

Oregon Department of Fish and Wildlife

Permitting Authority: Although the ODFW does not issue permits directly they do have authority to work with other agencies to address the restoration of native stocks of salmon and trout to historic levels of abundance, pursuant to ORS 496.435.

Timeline: There is no defined time limit for a decision from ODFW since they serve an advisory role. Typically, other coordinating agencies do not hold up a permit process for ODFW comment.

Key Issues: The main issue related to the ODFW is the in-water work period and whether sediment addition could take place outside this window for fish enhancement purposes.

National Marine Fisheries Service (NMFS)

Permitting Authority: Endangered Species Act

Timeline: The timeline for this approval is tied to the Biological Opinion regarding the hydro license project impacts.

Key Issues: The most important issue surrounding endangered species is the incidental take of a protected species in the process of placing gravel at the introduction location. The current plan calls for placing material on the channel margin rather than into the river, therefore the chance of incidental take is minimal. The other issue that may arise is the alterations to habitat for protected species. Since the goal of the project is to improve habitat for these species this issue should be resolved by coordination of the plan with NMFS during the process.

United States Fish & Wildlife Service (USFWS)

Permitting Authority: Endangered Species Act

Timeline: The timeline for this approval is tied to the Biological Opinion regarding the hydro license project impacts.

Key Issues: The most likely species to merit consultation with the USFWS is the Bald Eagle. Potential risks of disturbed nesting, could require alternations in scheduling the gravel extraction or transport to the river. At a minimum documenting any bald eagle nesting sites in the area will be required.

DESIGN METHODS

Detailed baseline topography of the augmentation site is needed prior to coarse sediment introduction. Topographic data will be collected by standard surveying methods using a combination of global positioning system (GPS) and total station surveying methods. Bathymetry data will be collected using single beam sonar or an acoustic Doppler profiler coupled with a GPS for horizontal position.

Grain-size analysis of coarse sediment augmentation sources will be performed to determine the grain size distribution of augmentation resources. This will include a bulk sample from the proposed extraction area to determine the precise grain-size distribution.

In order to evaluate the potential benefits of different augmentation scenarios, we recommend that a coupled sediment transport and one-dimensional hydraulic model be applied to predict sediment dispersion and reach-scale aggradation and degradation. Natural sediment pulses, introduced by landslides, have been successfully simulated by this method (Cui et al., 2003). Model predictions could be evaluated by monitoring of the channel after coarse sediment introduction has started to both validate the modeling and refine the parameters used in the model. Real-time bedload sampling, during 2-3 high flow events, is also needed as a way to calibrate the numerical sediment transport model. Numerical modeling and baseline data collection will occur during the first two full years of the license.

HYPOTHESIZED BENEFICIAL CHANNEL MORPHOLOGY CHANGES

Injection of coarse sediment is hypothesized to result in the following beneficial changes to the reach between River Mill Dam (RM 23.3) and two miles downstream (RM 21.2):

1. Increase in bedload transport rate. Introducing coarse sediment will increase the bedload transport rate during bed-mobilizing flows. Mobile bedload will be available to reform channel bed forms and geomorphic features such as bars and riffles.
2. Decrease in surface and subsurface grain size. Many areas that are presently armored will likely be covered with a layer of coarse sediment with a smaller average grain size than presently exists. Newly formed bars will have a surface and subsurface grain size which is more comparable to pre-dam conditions. There should be an increase in bar and channel area with D_{50} between 10 mm and 128 mm, which should increase the area

available for salmonid spawning, reduce superimposition of redds, and increase egg-to-emergence success.

3. Decrease in area of exposed bedrock and increase of bar area. Channel margin and in-channel areas of exposed bedrock will be repopulated with coarse sediment. As sediment transport increases during peak flow events, many bedrock shelves and armored channel sections will be covered with coarse sediment deposits.
4. Increase in hyporheic flow, potential temperature moderation, and increase the amount of intergravel flow in this river reach.
5. Increase in coarse sediment storage and water surface elevations (WSE) in side channels. Coarse sediment deposition in the channel will result in higher water surface elevations for a given river discharge. This will increase the amount of side channel habitat during low flow periods. Coarse sediment will be available for complex bedforms.

MONITORING METHODS

Channel morphology changes will be measured once each summer for the first five years following coarse sediment introduction and possibly less frequently in subsequent years, depending on monitoring results. Proposed monitoring methods are outlined below:

1. Coarse sediment augmentation volumes and dispersal patterns will be determined by repeat ground survey of the augmentation site, as well as repeat surveys of the channel topography and bathymetry downstream. An accounting of total volume added to the augmentation site each year will be derived either from ground survey or by recording the rate of replenishment by truck or conveyor methods.

2. If safe and feasible, bedload transport will be estimated by direct measurement during 2-3 high flow events with boat-mounted bedload sampling equipment. Acoustic bedload measurements will be made at the same time boat-based measurements are being done. Once acoustic methods have been calibrated to measured bedload transport, acoustic methods may be used to provide a means of estimating bedload during higher flows when direct bedload sampling is not feasible. Bedload measurement and acoustic measurements taken after coarse sediment augmentation can be used to quantify bedload transport changes resulting from coarse sediment introduction.

3. Ten to 20 Wolman Pebble Counts and subsurface grain-size sample sites will be selected for the augmentation reach. Sample sites will be selected to incorporate diverse flow and geomorphic settings (bar heads, mid-bar, bar tails, in-channel, and side channels) where changes are expected to occur due to coarse sediment augmentation. Sample sites will be accurately surveyed so that they can be resampled in consecutive years to determine temporal grain-size trends. A photographic record of 1 square meter sites will be taken each year to document changes. In-channel grain size will be determined by collecting 6-10 freeze core samples from riffles. Freeze core sample locations will be surveyed so that sample locations can be relocated to provide temporal changes of in-channel grain-size following coarse sediment replenishment.

4. Ground-based topographic surveying and boat-based bathymetry measurements for the augmentation reach will be used to evaluate coarse sediment storage changes and aggradation and incision trends in the 3 km reach below River Mill Dam. Below the 3 km reach, more widely spaced cross sections will be used to evaluate channel geometry changes and channel migration rates. Bar deposition in the vicinity of the Dog Creek confluence will be included as one of the index reaches monitored. Topographic and bathymetric data will be collected prior to coarse sediment injection and annually for the first five years following injection. Ground-based monitoring will be supplemented with aerial photography as warranted.

5. Twelve to 20 Onset temperature probes will be installed to monitor temperature changes in the reach below River Mill Dam. Probes will be placed in several geomorphic settings to monitor the effect of coarse sediment storage changes on river temperatures.

6. Water surface elevations at several key side channel habitat areas will be recorded using electronic stage height recorders so that WSE trends can be correlated with coarse sediment introduction volumes.

7. Permanent ground photo locations will be established to document visual changes in the channel morphology.

8. In order to measure changes to the available spawning area, steelhead, spring Chinook, and fall Chinook redds will be mapped in the augmentation reach before and after coarse sediment introduction. Fish populations are influenced by many factors unrelated to gravel presence or absence. Therefore, physical measures of geomorphic change rather than the degree of utilization of augmentation gravel for spawning will be used to evaluate the success of the augmentation plan. If possible, pre-augmentation baseline data will be collected to determine which species to monitor. Spring-run Chinook may be the easiest species to monitor, since they spawn during the low-flow period when redd mapping could be more readily accomplished.

Supplemental Baseline Data Collection

The numbers referred to in this section are the same used in the Draft Lower Clackamas River Coarse Sediment Management Plan.

1, 4 – Volumetric analysis using 3D surveying of the channel and channel margins rather than cross-sections is recommended. For this size reach it is feasible to complete ground surveying with sufficient details with 2 weeks or less of field work. More time and effort will be spent each year surveying areas of change. The 3D survey data will be used with a Geographic Information System (GIS) to calculate volumetric change from year to year and quantify sediment storage changes.

3 – Each subsurface sample will be sieved in a lab to determine the grain size distribution. Freeze cores will be subdivided into 10 cm depth increments to obtain a vertical distribution of grain size.

5 – In order to characterize the modern temperature regime under current conditions, temperature and water quality monitoring within the channel and in selected gravel bars is needed. Prior to deciding upon exact temperature recording stations and a sampling strategy to capture the exchange between alluvial groundwater storage and the river, it would be useful to undertake a reconnaissance level study. This goal of a reconnaissance study would be to determine the optimal areas for sampling and capturing the inherent thermal variability of the river system in the affected reach. The reconnaissance level study should take place as soon as possible so that baseline data can begin to be collected.

7 – One meter squares will be photographed at numerous locations to allow for digital measurements of surface grain size. The locations of the one meter squares will be surveyed so that they can be relocated and photographed.

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