3.0 ENVIRONMENTAL CONSEQUENCES

3.1 GENERAL ENVIRONMENTAL SETTING

3.1.1 Clackamas River Watershed

The Project is within the Clackamas River Basin, which is located west of the Cascade Range and south of the Columbia River Gorge and includes part of the Portland metropolitan area (see Figure 1.0-1). The Clackamas River drains more than 940 square miles beginning on the slopes of Olallie Butte (elevation 6,000 ft) in the Cascade Mountains, and flows 82.7 miles to its confluence with the Willamette River near Gladstone and Oregon City (elevation 12 ft) (Metro, 1997). The basin incorporates portions of three physiographic zones: the High Cascades, Western Cascades, and the Willamette Valley. The topography of the basin includes two major types of terrain: (1) a mountainous upland region on the southwest slope of Mt. Hood within the boundaries of the MHNF; and (2) a low-elevation, low gradient, valley region of primarily privately-owned land.

The MHNF comprises the upper two-thirds of the Clackamas River Basin (see Figure 1.0-1). Douglas fir and western hemlock forest characterize the low elevation portions of the watershed to an approximate elevation of 3,500 ft and true fir and lodgepole pine forest characterize the areas above elevation 3,500 ft. Most of the forest is mid-seral and late-seral stage, interspersed throughout with old-growth trees and stands (USFS, 1996a, b). The upper reaches of the Clackamas River are characterized by rugged, relatively undeveloped terrain, with increasing development downstream. Land use in the middle portion of the watershed near Estacada includes agriculture, forestry, power generation, and rural residential uses. High density, suburban, residential development spans the lower portion of the basin from Estacada to the Willamette River, and industrial uses in this area include food processing, feedlot and dairy farm operations, and rock and aggregate mining (USFS, 1996a, b).

The Clackamas River Basin experiences varied climate conditions typified by cool, wet winters and warm, dry summers in the lower reaches and cold, wet winters and relatively dry summers in the upper reaches. Temperatures in Estacada fluctuate from an average low of 33ºF in January to an average high of 80ºF in July and August. Timothy Lake experiences temperatures from an average low of 23ºF in January to an average high of 68ºF in July and August.

3.1.2 Project Area

The Oak Grove Development, the uppermost of the four Project developments, includes structures on both the Clackamas River and its tributary,

the Oak Grove Fork. The remainder of the Project is located about 35 miles southeast of Portland and consists of the North Fork, Faraday, and River Mill developments on the mainstem of the Clackamas River. Elevations in the Project area range from 3,200 ft at Timothy Lake to approximately 390 ft at Estacada Lake. Most of the Oak Grove Development lies within the MHNF on lands administered by the USDA Forest Service. PGE owns the majority of lands within the Project boundary for the North Fork, Faraday, and River Mill developments.

The MHNF region is covered by the Northwest Forest Plan. This plan establishes land allocations on federal lands to protect important ecosystems such as old growth and late successional forest and riparian reserves. Special management standards and guidelines apply in these allocations to promote ecosystem functions within these lands.

The Eugene Water and Electric Board's (EWEB) Stone Creek Project (FERC Project No. 5264) is located on the Upper Oak Grove Fork about 1 mile downstream of Timothy Lake, but is not part of this relicensing process. It diverts the flow of the Upper Oak Grove Fork for power generation. Water is returned to the Upper Oak Grove Fork approximately 5 miles downstream, but above Lake Harriet. The Stone Creek Powerhouse is an automated hydroelectric plant operated by PGE for EWEB.

In this document we use the term "Project area" to include the lands and waters within the Project boundary for the existing license and immediately adjacent areas.

3.2 PROPOSED ACTION

3.2.1 Geology and Soils

3.2.1.1 Affected Environment

3.2.1.1.1 Geologic Setting

The Clackamas River Basin lies within three physiographic regions: High Cascades, Western Cascades, and Willamette Valley (see Figure 3.2.1.1-1).

The young basaltic volcanoes of the High Cascades and surrounding ash and lava deposits contain the headwaters of the Clackamas River Basin. The High Cascades region consists of Quaternary-age (<2 million year-old) basalt and andesite flows, which have formed the ridges and canyons that confine the Clackamas River. The rivers in this region produce a low sediment yield, because porous rocks allow water to infiltrate. This physiographic region occurs above elevation 3,500 ft and has relatively moderate slopes. In areas where basalt is incised by streams, the slopes can be steep. Slope instability in this region is caused by rock falls and large slump blocks rather than debris or earth flows.

Below elevation 3,500 ft to approximately elevation 300 ft, the Clackamas River and Oak Grove Fork run through the Western Cascades physiographic region. This region includes an older, inactive volcanic chain with associated deeply weathered rocks that date from 10 to 45 million years ago. It also contains Columbia River Basalt, which originated in lava flows of the Miocene age (15 to 16 million years ago). In the vicinity of the North Fork, Faraday, and River Mill developments, the river has incised into basaltic rocks and created steep canyon walls. The topography is steep in these sections, but has more gentle slopes in areas where the erosion processes include high sediment-yield earth and debris flows.

The Willamette Valley physiographic region occurs from Estacada to the confluence of the Clackamas and Willamette rivers. This area contains mostly flat-lying sedimentary rocks from as far back as the Pliocene age (1.6 – 5.3 million years ago) to as recent as 10,000 years ago. These sedimentary rocks comprise the Troutdale Formation and the Sandy River Mudstone, both of which are prone to slumping and instability, especially where river migration undercuts high terraces. This erosion has occurred for the last two million years as the Clackamas River creates successively lower floodplains by downstream transport. As the river cuts downward, it can abandon floodplains and leave them as terraces.

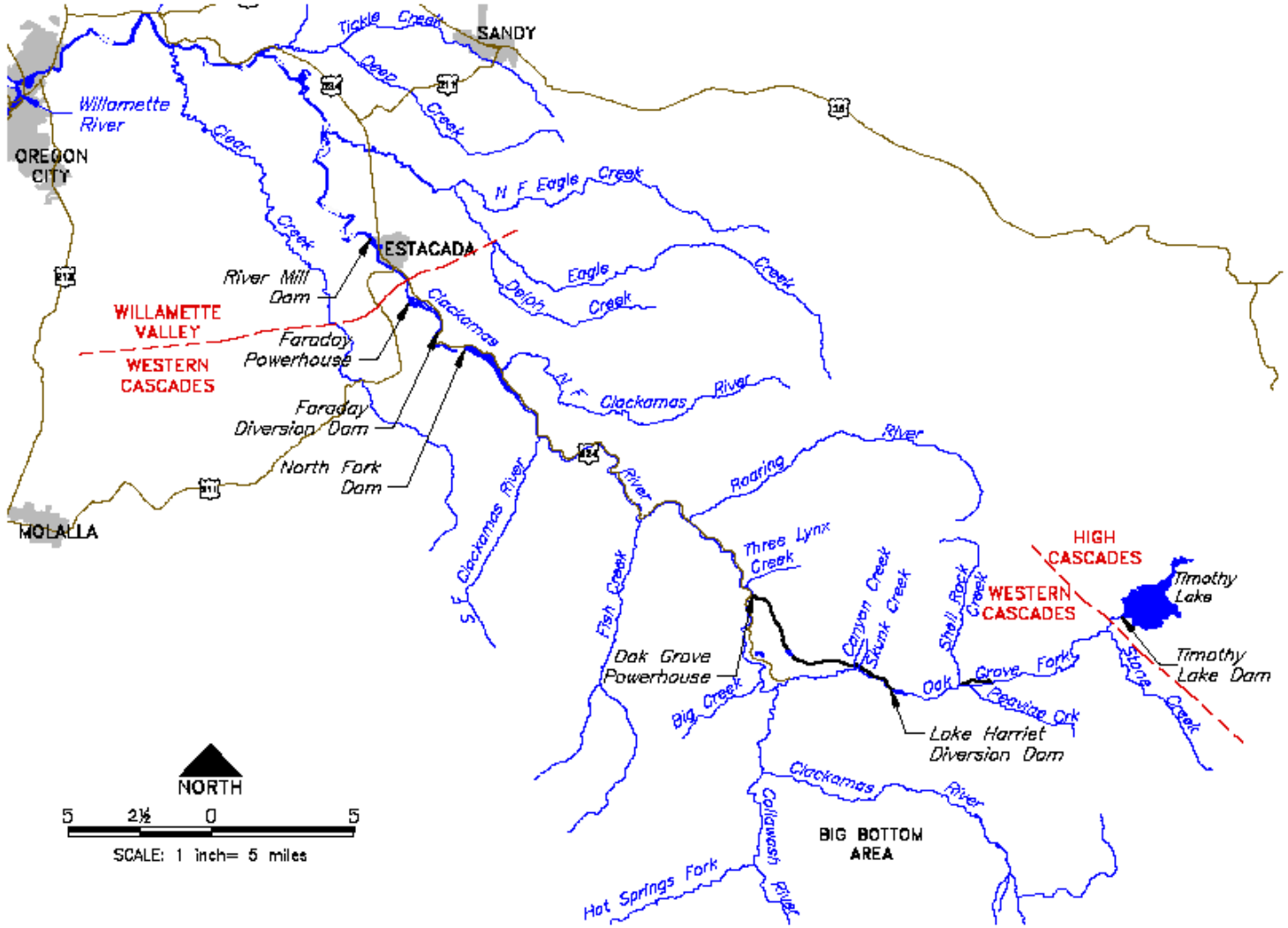


Figure 3.2.1.1-1. Location Map of the Clackamas River and the Oak Grove Fork with Approximate Geologic Boundaries of the High Cascades, Western Cascades, and Willamette Valley Physiographic Regions. (Figure Courtesy of McBain and Trush)

3.2.1.1.2 Erosion and Landslides

The lithologic and precipitation differences between the High Cascades and Western Cascades physiographic provinces result in disparities in geomorphic processes and drainage densities. The volcanics of the Western Cascades are relatively old and impervious. The High Cascades contain relatively young, permeable rocks. These two regions also differ in the type of precipitation they encounter. The High Cascades typically receive precipitation in the form of snow. The Western Cascades receive a combination of rain and snow. These differences result in a disparity in drainage density, or the total length of streams per unit area. The High Cascades region exhibits an average drainage density of 1.73 miles/square mile (mi/mi^2) while the Western Cascades averages 4.10 mi/mi^2 (McBain et al, 2001). These differences account for variations in hydrology and streamflow, which, in turn, influence erosion and hillslope stability.

Hillslope stability and issues of erosion and landslides are the greatest geologic concern of the Project area, especially in the Western Cascades. The heavy precipitation, steep slopes, and typically weak soil resulting from pyroclastic materials combine to create an environment susceptible to mass wasting (USFS, 1996a; USFS, 1995a). Mass wasting is the downslope movement of soil or rock material under the influence of gravity or water. It can occur as slides (e.g. debris slides, rock slides) or flows (e.g. earthflows, debris flows). The frequency of flood events has a substantial impact on mass wasting.

The High Cascades are a relatively stable region, but landslides can occur when shallow, permeable soils on top of less permeable bedrock are carried away by local high water events, such as a rain-on-snow event. The Western Cascades region is much more susceptible to mass wasting events. The volcanic deposits of this region weather to clay soils. These soils retain moisture and exhibit a plastic behavior. This behavior results in earthflows, where cohesive soils slide in large-scale mass movements. Debris slides also occur in this region when an accumulation of relatively permeable material overlying less permeable rock becomes saturated. As water infiltrates downward and reaches the impermeable zone, pore pressure increases and destabilizes the slope prompting a slide. These debris slides carry a wide range of sediment sizes and can travel substantial distances downstream.

The Willamette Valley exhibits much more subtle geomorphic processes than the High Cascades or Western Cascades. These processes include sediment transport and deposition, erosion of historic terraces, and some surficial mass wasting and erosion in the watershed. Mass wasting from the Western Cascades provides the primary sediment delivery process.

The issue of hillslope stability is of particular concern in certain Project areas. Frog Lake and portions of the Oak Grove pipeline occur on a large earth flow complex with an area of approximately 5 mi^2. This earth flow complex is a large ancient landslide that is sensitive to changes in hillslope hydrology. Sections of this complex move independently of each other, usually in the form of slumps or slow-moving earthflows. This instability can influence stream channel morphology by delivering sediment and organic matter to stream channels. Cracks and sinkholes develop as slides move due to the load of Frog Lake. The Frog Lake dam leaked excessively after its construction and was unable to fulfill its purpose. Groundwater levels outside the reservoir rose and numerous springs appeared down slope (Landslide Technologies, 2003). To address this issue, PGE constructed a new central embankment in 1997, which reduced the reservoir's load on the landslide. Following reconstruction, groundwater and slope stability conditions have dramatically improved (Landslide Technologies, 2003).

3.2.1.2 Environmental Effects

3.2.1.2.1 Proposed Action

The earth flow complex at Frog Lake comprises the most significant geologic concern in the Project area. Additional slope stability concerns occur at the following locations; however, existing monitoring programs adequately address these concerns:

- the left abutment landslide at Lake Harriet dam;
- the Frigid Creek Slide along the pipeline;
- the landslides along State Highway 224 above North Fork Reservoir; and
- the Faraday diversion canal landslides.

The earth flow areas at Timothy Lake, Lake Harriet, and the flowline and powerhouse segments are safe from geologic concerns with their existing structural conditions (FERC Part 12 Dam Safety Inspection, 2002). The 1997 construction of a new embankment at Frog Lake was completed to address the major hillslope stability issues. The complete renovation of Frog Lake in 1997 changed its configuration to rectify water seepage or sliding problems, reducing the reservoir’s surface area substantially from 13 ac to 6 ac. The reconstruction involved creating a 1,110-ft-long dike on the north and west sides. The reconfigured dam B was constructed from 330 ft of the original dam plus 780 ft of newly constructed dike. Frog Lake continues to allow cycling of the Oak Grove generating units to provide additional peak capacity.

The Proposed Action includes some wildlife and recreation improvements within the Earthflow Management Area as delineated in the MHNF Plan (see

Figure 3.2.1.2-1). The MHNF Plan states that hillslope stability should be maintained within the Earthflow Management Area to reduce the risk of re-activating or accelerating large, slow moving landslides and that any new development should not exceed 10 acres on high-risk earth flows. The proposed wildlife and recreational improvements would affect areas much smaller than 10 acres, would not destabilize hillslope stability, and would not be susceptible to stability problems.

The Proposed Action includes three measures that would require construction within the Earth Flow Management Area (see Figure 3.2.1.2-1). These measures include improvements to Forest Road 4630 (including road widening in some locations), constructing a shoreline access trail at Lake Harriet, and providing new/improved whitewater boating facilities including put-in and take-out areas along the Clackamas River. These proposed activities are small-scale projects that would affect less than the 10-acre threshold designated in the MHNF Plan. Care would be taken with the improvements to Forest Road 4630 to ensure that slopes are not destabilized, since the road runs along steep slopes. Other proposed construction activities would not destabilize hillslopes and would not be particularly susceptible to erosion, provided that PGE employs best management practices during construction.

3.2.1.3 Unavoidable Adverse Impacts to Geology and Soils

Implementation of the Proposed Action would create no unavoidable adverse impacts to the geology or soils of the Project area.

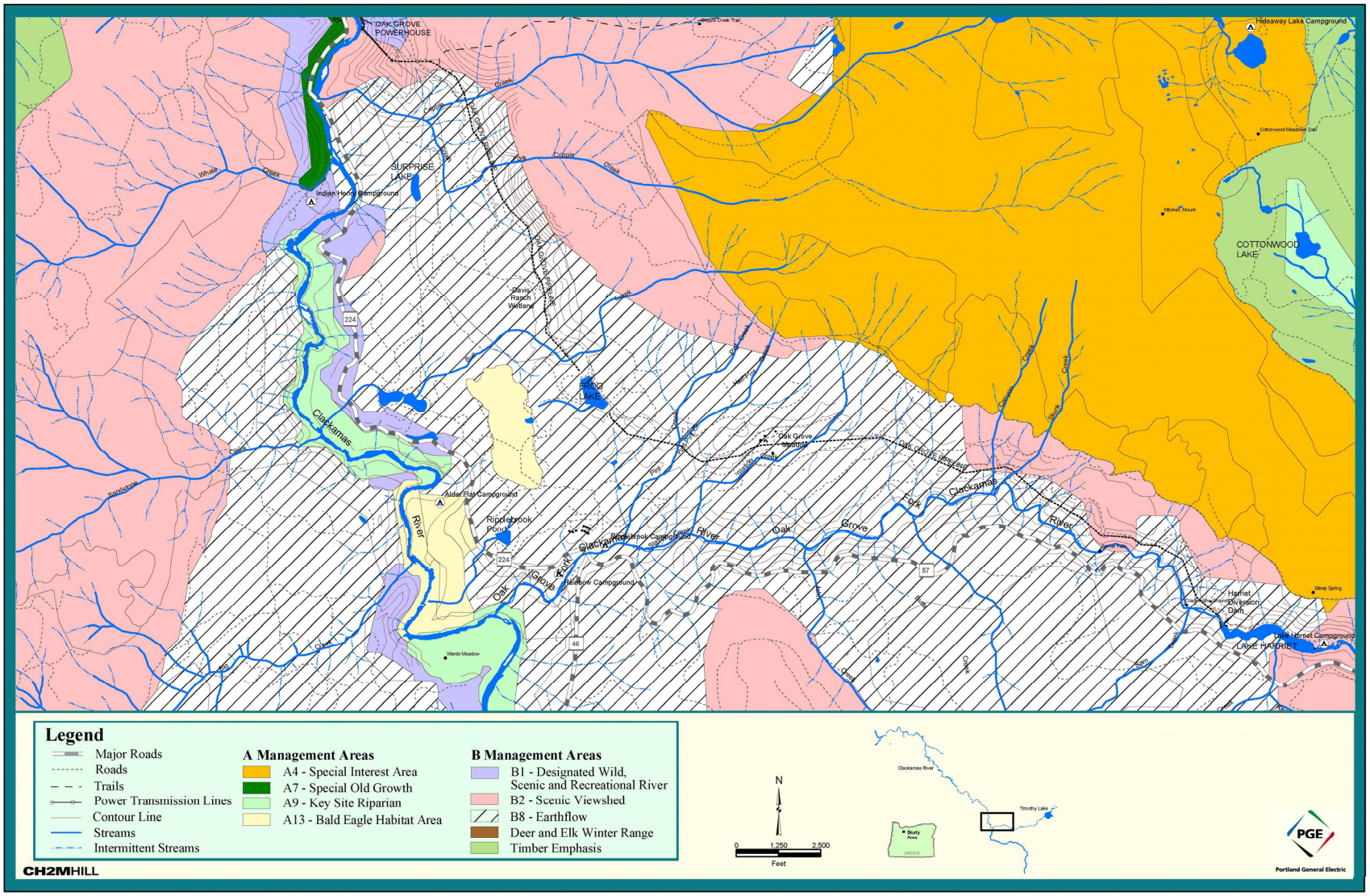


Figure 3.2.1.2-1 Earthflow Management Area

3.2.2 Water Quantity and Quality

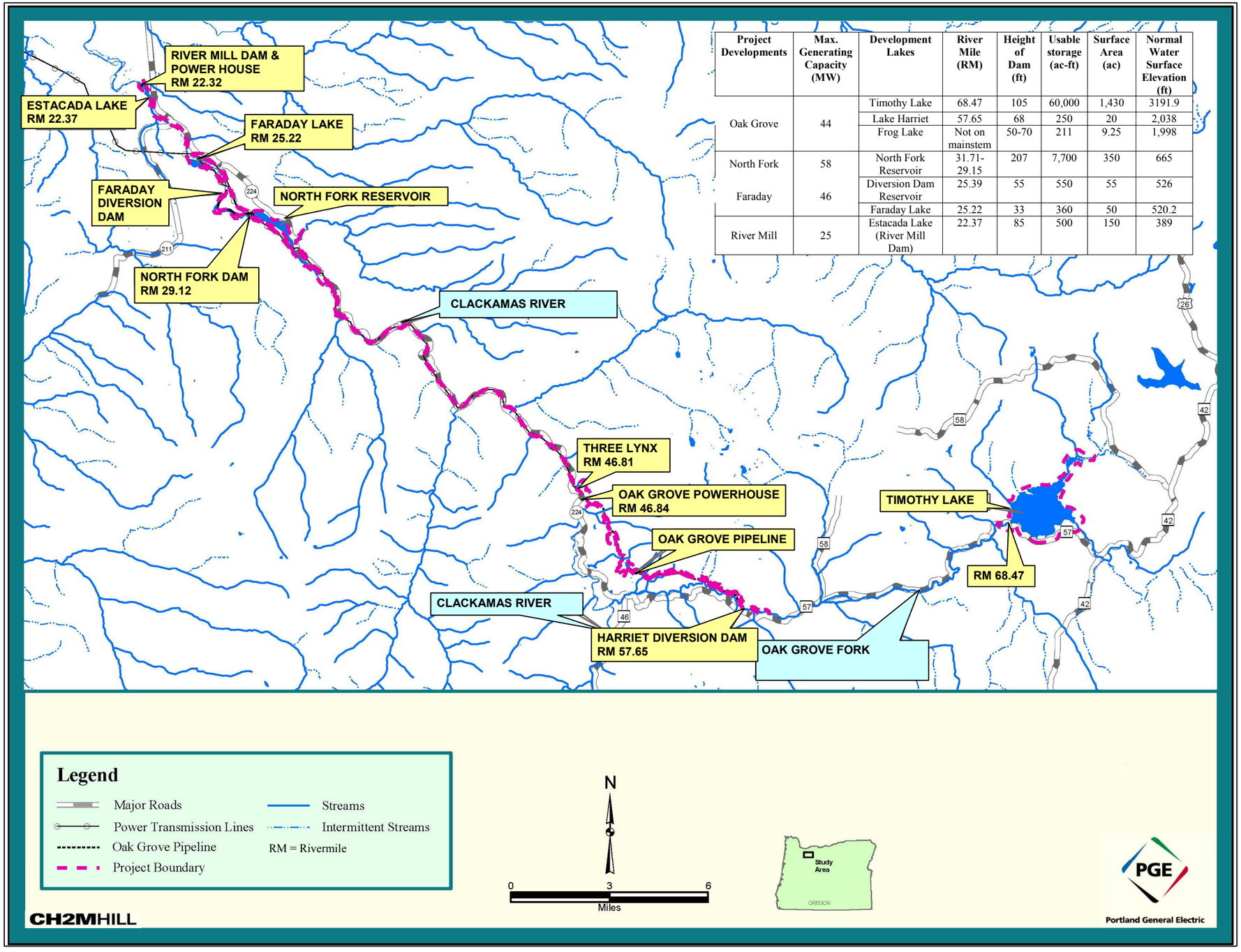
3.2.2.1 Affected Environment

This section describes the affected environment under current operations. No pre-Project flow data exists to describe unregulated flows in the Clackamas River or Oak Grove Fork, so simulated unregulated flows are used to analyze the cumulative effects on water quality and quantity that would exist under the Proposed Action. Simulated flows are also used to describe current flow conditions at specific points of interest (nodes) that do not have gaging stations in the Oak Grove Fork and Clackamas River (Figure 3.2.2.1-1).

3.2.2.1.1 Summary

This section provides a broad summary of the water quantity for the Project area. More detailed descriptions can be found in the following sections. Figure 3.2.2.1-2 (a) and (b) show simulated monthly average flows at set points in the system under current conditions. Starting at Timothy Lake, which is the most upstream portion of the Project area, water generally is released from the dam in the winter as rain and snow contribute precipitation. Under current conditions, Project operations begin to release less water as the spring progresses to maintain the lake elevation for recreation. Summertime releases are the smallest of the year, which results in the lowest flows of the year in the Upper Oak Grove Fork. After Labor Day, and the end of the lake's recreation season, project managers once again release water in greater amounts. This flow regime is mimicked downstream below Lake Harriet, but the Frog Lake diversion, which diverts 600 cfs of flow, results in extremely low flows immediately downstream of Lake Harriet (averaging zero in the summer and fall).

Once the Oak Grove Fork merges with the mainstem Clackamas River, the unregulated Clackamas River upstream of the Oak Grove Fork drives the flow regime. At the Three Lynx gage, there is a significant increase in flow in the late fall, frequent winter flooding, spring snowmelt and decreasing flow in the summer and early fall. Downstream of the confluence of the Oak Grove Fork and mainstem Clackamas River, the Faraday Diversion dam diverts a substantial portion of the river's flow. Flow patterns, however, remain the same with higher flows in the fall - indicative of a rainfall dominated physiographic system - fewer winter floods than upstream, and low flows in the summer and early fall. Downstream of River Mill dam, flows are largely unaffected by upstream operations in terms of both water quantity and flow patterns.

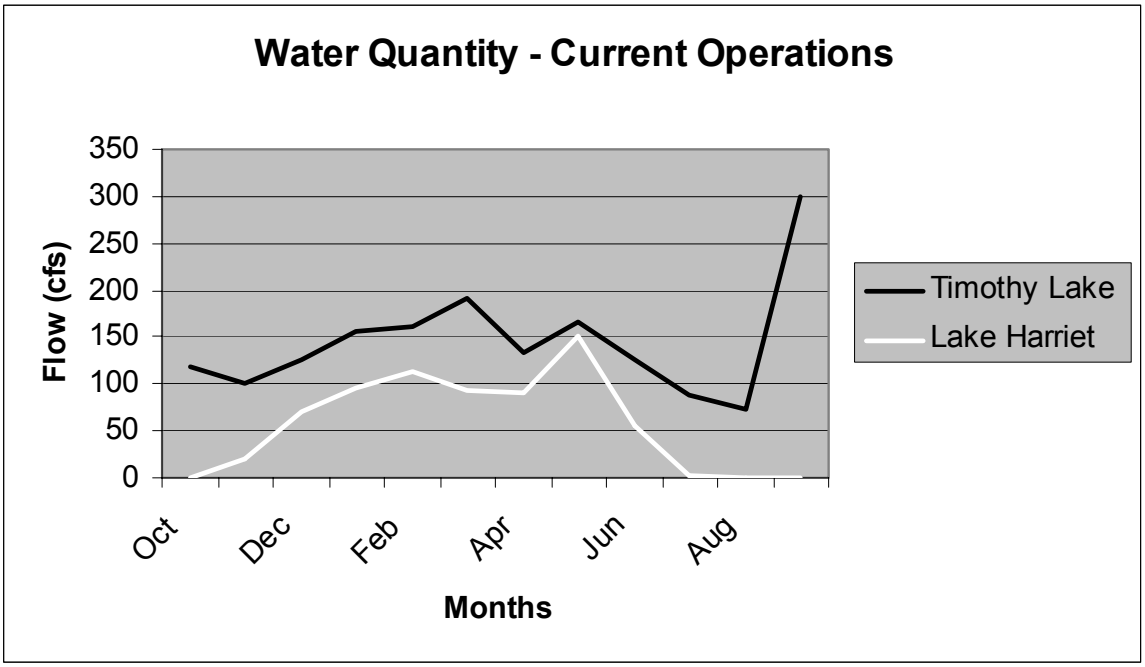


Project Developments	Max. Generating Capacity (MW)	Development Lakes	River Mile (RM)	Height of Dam (ft)	Usable storage (ac-ft)	Surface Area (ac)	Normal Water Surface Elevation (ft)
Oak Grove	44	Timothy Lake	68.47	105	60,000	1,430	3191.9
		Lake Harriet	57.65	68	250	20	2,038
		Frog Lake	Not on mainstem	50-70	211	9.25	1,998
North Fork	58	North Fork Reservoir	31.71-29.15	207	7,700	350	665
Faraday	46	Diversion Dam Reservoir	25.39	55	550	55	526
		Faraday Lake	25.22	33	360	50	520.2
River Mill	25	Estacada Lake (River Mill Dam)	22.37	85	500	150	389

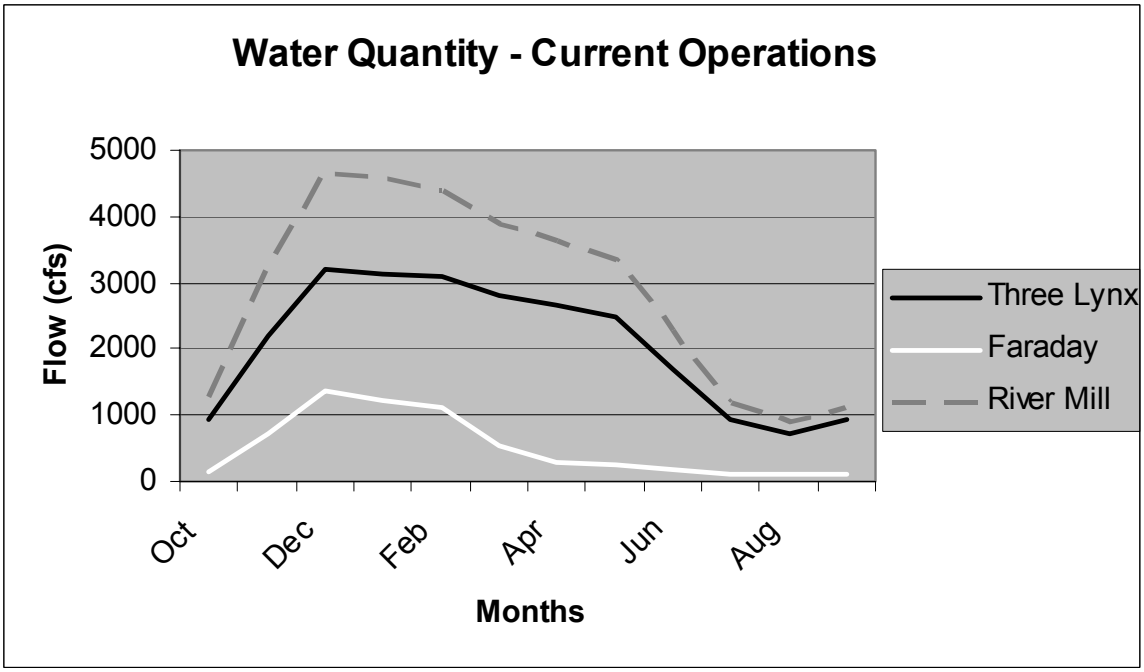
Figure 3.2.2.1-1. Summary of Project Facilities and Reach Designations

Figure 3.2.2.1-2 Monthly averages for flows in Clackamas River system

(a) Oak Grove Fork



(b) Clackamas River mainstem



3.2.2.1.2 Water Quantity

Water Flows

This section describes, reach by reach, flows under current operations in terms of magnitude, duration, frequency, and timing. Specifically, this section provides an analysis of hydrograph components and flood frequencies. For a full description of the detailed water quality and quantity analysis, refer to Appendix A. Hydrograph components are seasonal patterns of daily average flows, which recur from year to year (Trush, 2000). The hydrograph components that are the most useful for describing this system include summer and fall baseflows, fall floods, winter baseflows, winter floods, snowmelt flooding, and snowmelt recession. The flood frequency analysis provides information about the magnitude and frequency of flood flows under existing conditions.

Development of the hydrographs and flow frequency analyses relied primarily on existing flow and operational data for the system. The US Geological Survey (USGS) databases provided flow data for six gaging stations in the Clackamas River Basin. Average daily flows for these six stations were plotted and analyzed for temporal patterns and flow magnitude, duration, and frequency. Table 3.2.2.1-1 shows a summary of the six active gaging stations and three inactive stations that provided historic data.

To analyze the water flows on a reach-by-reach basis, a model was developed to synthesize hydrographs at locations not specifically monitored by a streamflow gage (Wamser, 2001). The model uses streamflow data, operational information, and hydrologic and hydraulic characteristics of the system to simulate flows at selected locations in the system.

Table 3.2.2.1-1. USGS gaging stations in the Clackamas River watershed with hydrologic data.

Gaging Station	14208000	14208500	14208700	14209000		14209500	14209700	14210000	14211000	14211010
Parameter	Clackamas River at Big Bottom	Oak Grove Fork at Timothy Meadows	Oak Grove Fork near Government Camp	Oak Grove Fork above Power Plant Intake Before dam	After dam	Clackamas River above Three Lynx	Fish Creek near Three Lynx	Clackamas River at Estacada	Clackamas River near Clackamas	Clackamas River near Oregon City
Drainage Area (sq mi.)	136	54	54.4	126	126	479	45.2	671	930	940
Period of Record	1920–1970	1913–1929	1956–1987	1910–1956	1957–1988	1909–2004	1989–2004	1908–2003	1962–1983	2001–2003
Length of Record (years)	50	15	31	46	31	86	15	95	21	2
Elevation (ft msl)	2,040	3,140	3,042	2,052	2,052	1,092	940	297	51	--
Average Discharge (cfs)	477	188	131	495	483	1,991	328	2,753	--	--
Record Maximum (cfs)	11,200	970	2,110	5,000	--	68,200	7,540	86,900	--	30,400
Date Maximum	12/22/64	1/7/23	12/24/64	1/7/23	--	12/22/64	2/7/96	12/22/64	--	4/14/02
Record Minimum (cfs)	184	90	3.7	--	208	261	6	285	--	549
Date Minimum	9/12/42	10/31/26	9/23/68	--	8/30/79	10/7/87	9/1-9/2/02	10/5/58	--	10/4/01

Source: USGS, 2003; Moffatt et al., 1990

Runoff determines the amount of water available to the system. The runoff hydrology of the Clackamas River Basin has a strong seasonal pattern dominated by high runoff from December to May and low runoff from June to November. Runoff reflects the seasonal precipitation pattern of wet winters and dry summers, but also reflects the fact that some winter precipitation is effectively stored as snow and ice, delaying the wet season runoff.

Timothy Lake and Upper Oak Grove Fork

Timothy Lake was created with the construction of Timothy Lake dam in 1956, flooding the former Timothy Meadows. The Timothy dam operational strategy is now to: 1) manage winter releases in response to downstream tributary flows so that flows do not spill over Lake Harriet dam; 2) capture much of the spring snowmelt runoff to fill Timothy Lake; 3) manage summer releases such that the Timothy Lake reservoir remains full through the summer; and 4) increase the flows in the fall to draw down the reservoir for coming winter and spring flows.

Hydrograph Component Analysis

Timothy Lake has altered the Oak Grove Fork hydrograph by temporarily storing water and thereby controlling downstream water availability. Figures 3.2.2.1-3 and 3.2.2.1-4 provide hydrographs of the simulated average and minimum daily flows downstream of Timothy Lake dam. Daily average flows at this location reflect High Cascades hydrology, with high baseflows, large magnitude snowmelt runoff, and infrequent floods. The hydrograph components of the gage data plots were analyzed, and the following conclusions were made concerning flow in the upper Oak Grove Fork under current conditions (McBain & Trush, 2003):

Figure 3.2.2.1-3. Simulation model results – Timothy Lake outflow: average flows (1970-2000).

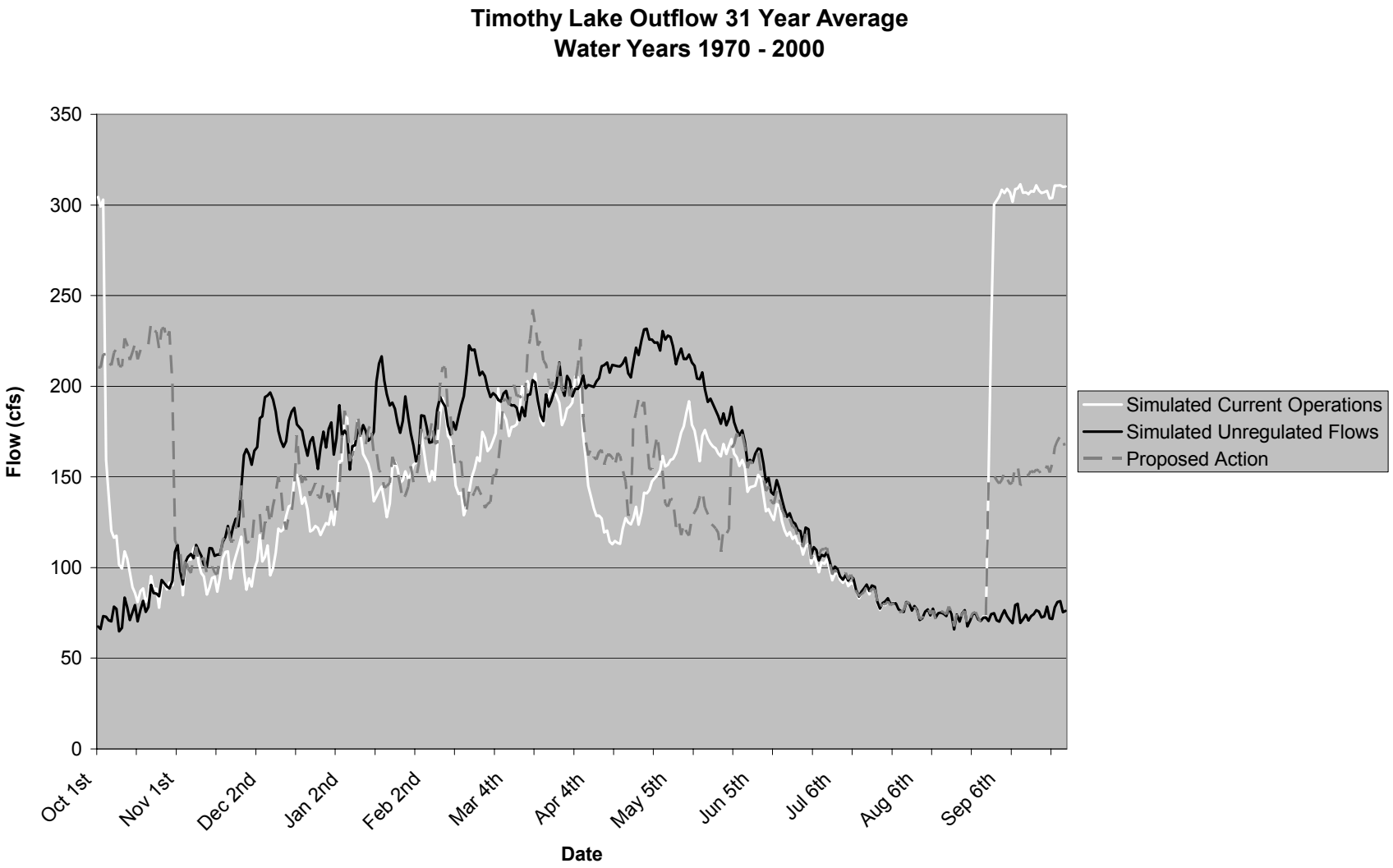
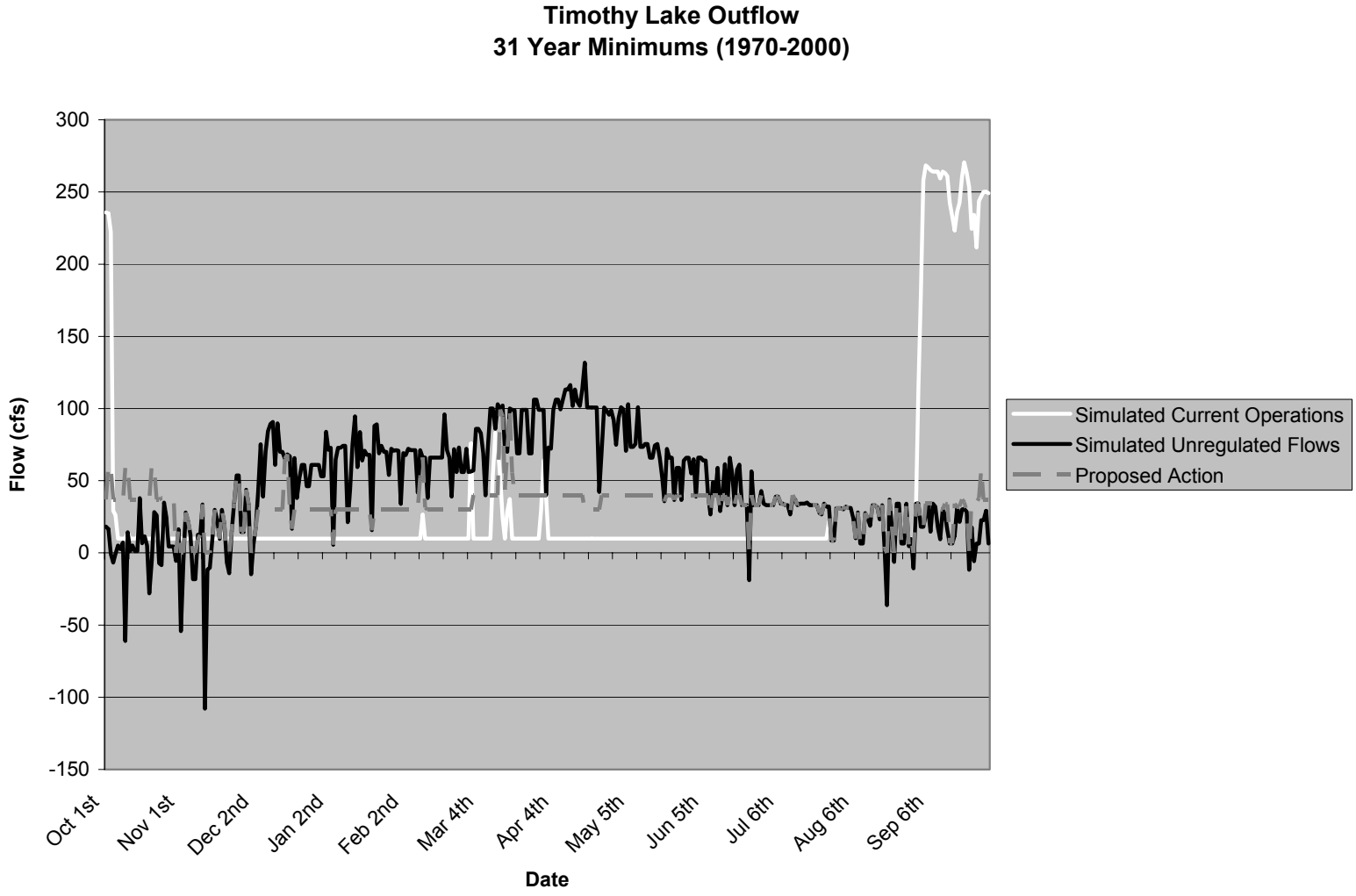


Figure 3.2.2.1-4. Simulation model results - Timothy Lake outflow: minimum flows (1970-2000).



- Timothy Lake operations do not appear to have substantially changed peak flow magnitudes, but they have shifted timing, duration, and frequency of those hydrograph components. With the exception of occasional winter or spring floods, the current hydrograph fluctuates irregularly between 30 and 350 cfs, reflecting Project operations. During the summer months, flow releases are usually the same as inflow, which maintains Timothy Lake at a stable elevation. As discussed in section 2, PGE does have the ability under the current license to fluctuate the reservoir by approximately 2.9 ft. These potential fluctuations do not, however, represent the usual management practice. Under simulated current operations, PGE maintained water levels in Timothy Lake above elevation 3,190.0 ft during the entire summer season for 26 of the 31 years from 1970 to 2000. In the other 5 years, water levels in Timothy Lake dropped below the minimum elevation of 3,189.0 ft, but water levels fell below this level for the entire summer only once. PGE adjusts the outlet on a weekly basis and outflow represents Timothy Lake inflow as adjusted weekly, not on a continuously varying outflow basis.

- Simulated pre-dam baseflows were stable throughout the year, typically ranging from 110 to 208 cfs during summer, fall, and winter for the range of water years. Computed unregulated baseflows from 1971 to 2000 show considerably lower baseflows, ranging from as low as 40 cfs during summer baseflows, to as high as 210 during winter baseflows (EES Consulting, 2004). Regulated baseflows have been reduced to a 30- to 35-cfs release for much of the year, punctuated by frequent flow releases in the 250- to 325-cfs range that last for several weeks or longer (see Figure 3.2.2.1-4).

- Fall storms are insignificant in the unregulated flow regime, but larger fall pulse flow releases from Timothy Lake are common under regulated conditions.

- Winter rainfall-driven storms are common under unregulated conditions, but are small compared to winter storms in downstream Western Cascade dominated reaches. Peak daily average flows exceeded 900 cfs in some water years. Winter floods still exhibit a similar range in magnitude, but large peaks may be slightly less frequent and of shorter duration under regulated conditions.

- Spring snowmelt floods are relatively predictable in magnitude and timing, with unregulated peaks up to 550 cfs in wetter years occurring between mid-April and mid-May. Following construction of Timothy Lake dam, the distinct spring snowmelt hydrograph component was virtually eliminated in all but the wettest water years.

Flood Frequency Analysis

Flood frequencies under current and unregulated conditions were also evaluated, and this analysis showed that storage within Timothy Lake has had a small impact on flood frequency immediately downstream of the dam. The 1.5-year flood was reduced from 400 cfs to 385 cfs. The 5-year unimpaired flood of 713 cfs was reduced to 617 cfs. The flood frequency data show that peak flows over the entire period of record were between 300 cfs and 1,000 cfs for all but one year, illustrating the low variability in annual peak flows (McBain & Trush, 2003).

Lake Harriet and Lower Oak Grove Fork

Lake Harriet dam diverts inflow up to approximately 600 cfs to the Oak Grove Powerhouse via a pipeline to Frog Lake. Flows in excess of 600 cfs are spilled over the uncontrolled spillway into the Lower Oak Grove Fork. PGE maintains Lake Harriet at a constant elevation of 2,038.0 ft with no active storage, so all inflow is diverted to Frog Lake or is spilled. Spills occur on average 39 days per year, based on data from 1983 to 1992 (Wamser, 2000).

The Lower Oak Grove Fork immediately downstream of Lake Harriet dam is dewatered most of the year, with the exception of spill events due to exceedance of the Frog Lake pipeline capacity and spills during Project facilities maintenance. Natural tributary and groundwater accretion provide baseflows in this reach, which increase in magnitude with increasing distance downstream from Lake Harriet dam. Figures 3.2.2.1-5 and 3.2.2.1-6 illustrate the 31-year daily average and minimum hydrographs for this reach, respectively. Figure 3.2.2.1-5 shows the 31-year average, but this figure is somewhat misleading, because it shows more water in the channel than typically occurs. This is because years of high flooding (such as 1996) bring the average to levels above normal. Figure 3.2.2.1-7 shows the flow for an average water year, when the river generally flows at minimum levels except during isolated high flow events.

Hydrograph Component Analysis

The hydrograph components for the Lower Oak Grove Fork indicate the following (McBain & Trush, 2003):

- Fall and winter baseflows in the Lower Oak Grove Fork are constant with little variability under existing conditions. Flow accretion is relatively small (2 to 20 cfs) compared to the unregulated baseflow magnitude (150 to 450 cfs). The diversion to Frog Lake corresponds to a 200- to 400-cfs reduction in both the magnitude and variability of unregulated baseflows.

Figure 3.2.2.1-5. Simulation model results - Lake Harriet outflow: average flows (1970-2000).

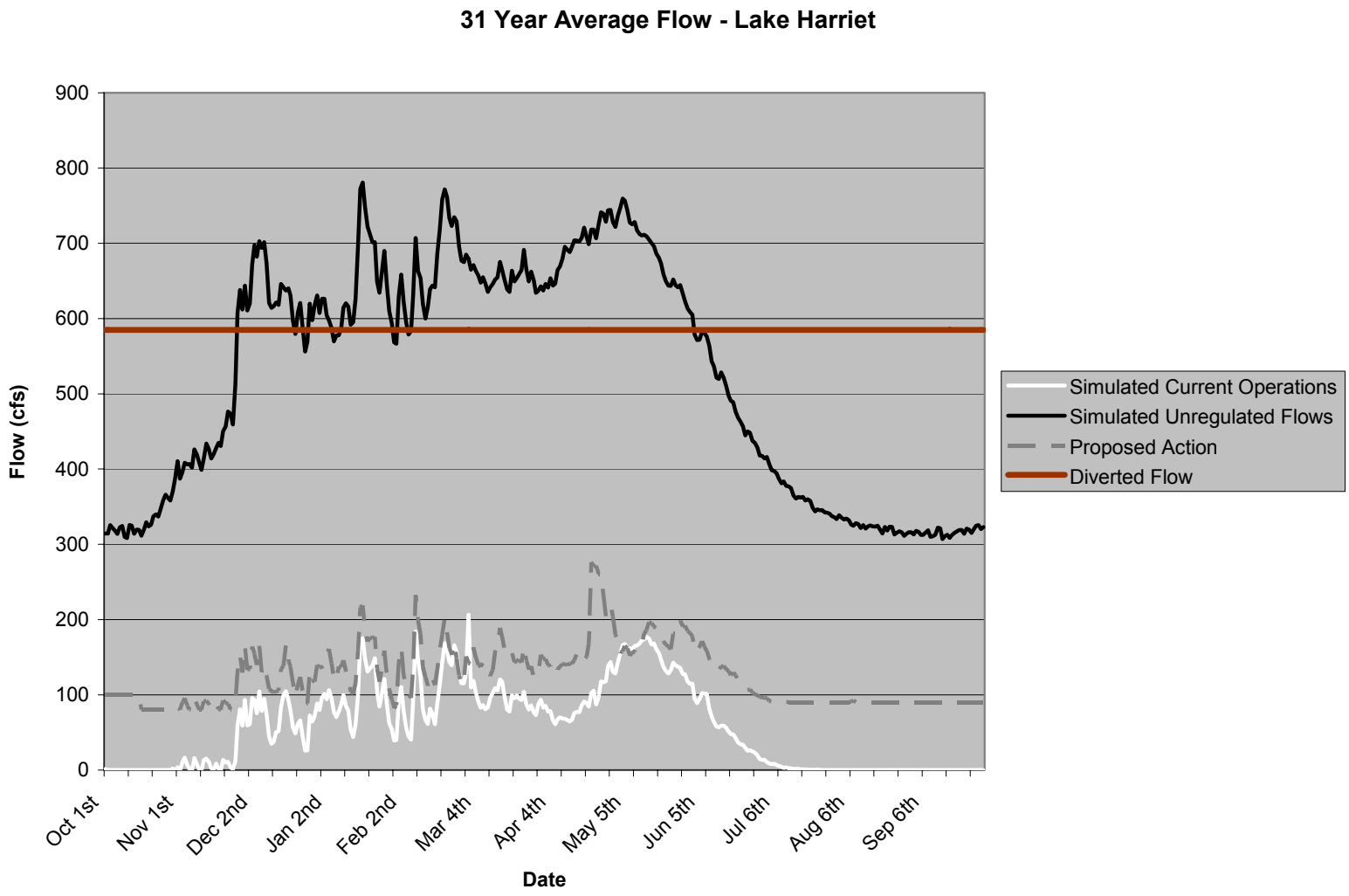


Figure 3.2.2.1-6. Simulation model results - Lake Harriet outflow: minimum flows (1970-2000).

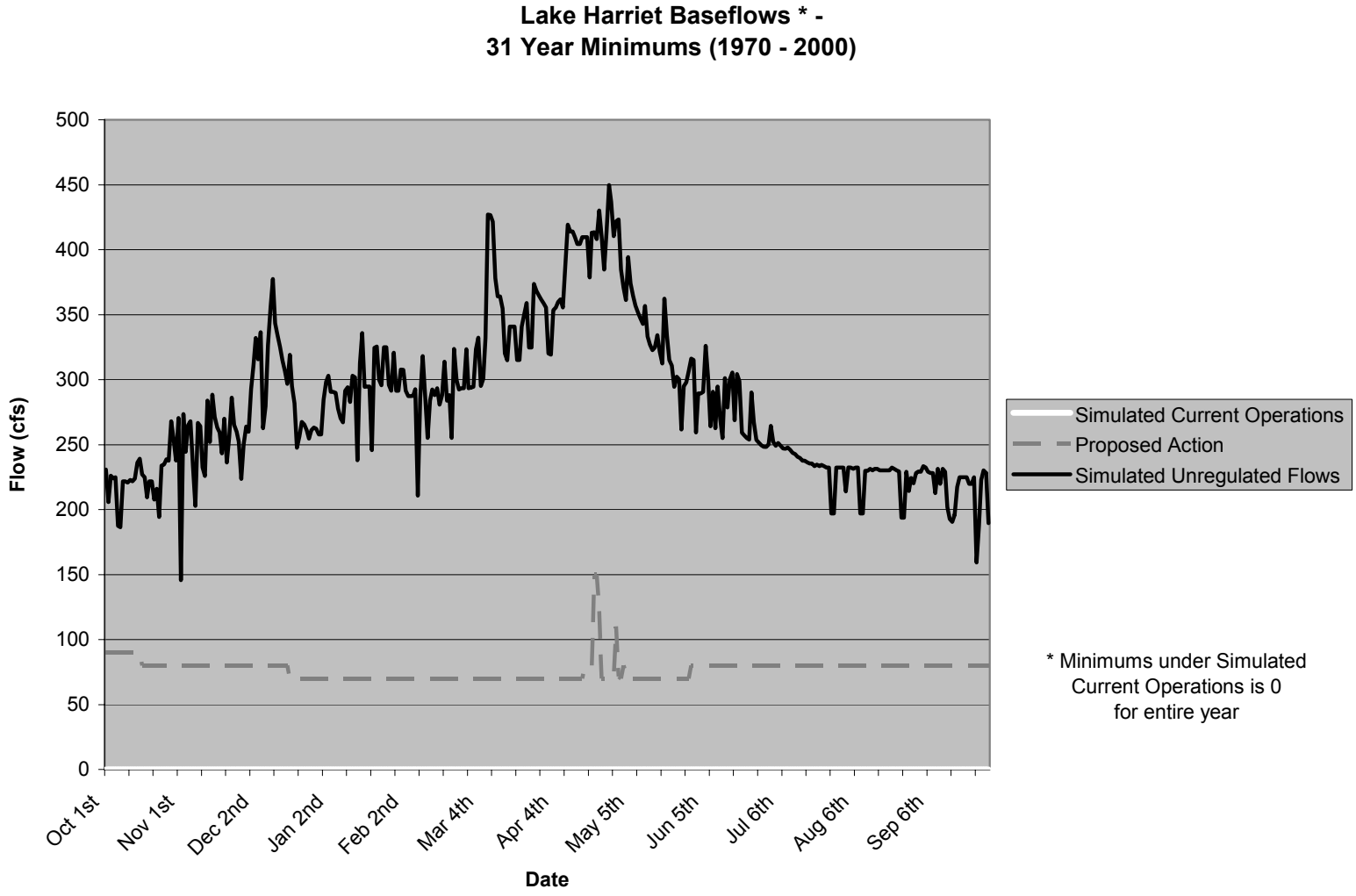
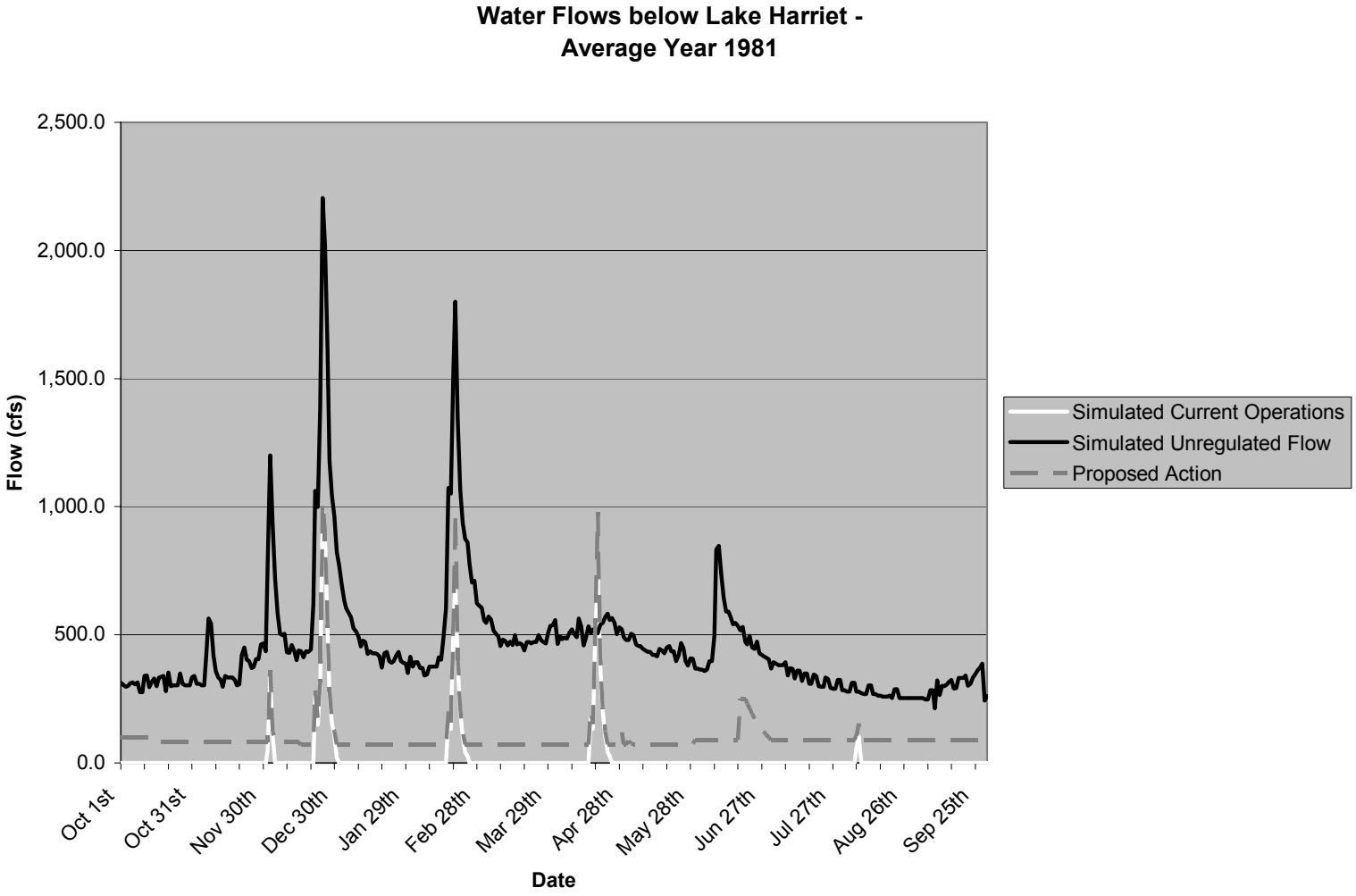


Figure 3.2.2.1-7. Simulation model results - Lake Harriet outflow: average water year (1981).



- The Lake Harriet dam reduced winter flood magnitude and frequency to the downstream reaches compared to pre-Project conditions. During water year (WY) 2002, the unregulated peak discharge of 1,360 cfs at the powerplant intake was reduced to approximately 750 cfs at the Cinnabar site and 1,120 cfs at Ripplebrook Campground. Fewer flood peaks occurred downstream of Lake Harriet dam during WY 2002, but the timing of peaks appears to have been unaltered.

Flood Frequency Analysis

The Frog Lake diversion has changed flood frequency in downstream reaches from pre-dam conditions by preventing any flows in the reach until inflow exceeds the diversion capacity (since Lake Harriet is full), and then reducing higher flows by approximately 600 cfs (see Figure 3.2.2.1-5). The reduction of flows by the diversion significantly reduced the magnitude of smaller, frequent floods (< 5 year recurrence), and decreased the effects of less common floods (> 10 year recurrence). The magnitude of 1.5-year floods, for example, has been reduced by over 50 percent, from 1,300 cfs to 600 cfs. The 10-year flood has been reduced by 14 percent, from 2,900 cfs to 2,500 cfs (McBain & Trush, 2003). This flood reduction is due primarily to the Frog Lake Diversion, but operations at Timothy Lake are also a contributing factor.

Clackamas River Above Oak Grove Powerhouse

Flow in the Clackamas River between the mouth of the Oak Grove Fork and the Oak Grove Powerhouse consists predominately of contributions from the Clackamas River upstream of Oak Grove Fork. During low flow periods (August to November) the contribution from Oak Grove Fork is most substantial (see Figure 3.2.2.1-8). During a dry year (1992), Clackamas River flow above the Oak Grove Powerhouse was between 200 and 375 cfs. Under current operations, natural inflow contributed by the Oak Grove Fork during this time period is typically 15 to 30 cfs, which amounts to 7 percent to 15 percent of Clackamas River flow.

Hydrograph Component Analysis

Figures 3.2.2.1-9 through 3.2.2.1-11 show hydrographs for the Clackamas River 31-year average flow, 31-year minimum flow, as well as flow in a dry year (1992). These hydrographs were analyzed and the following conclusions resulted:

Figure 3.2.2.1-8. Flow contributions – Clackamas River above Oak Grove Powerhouse.

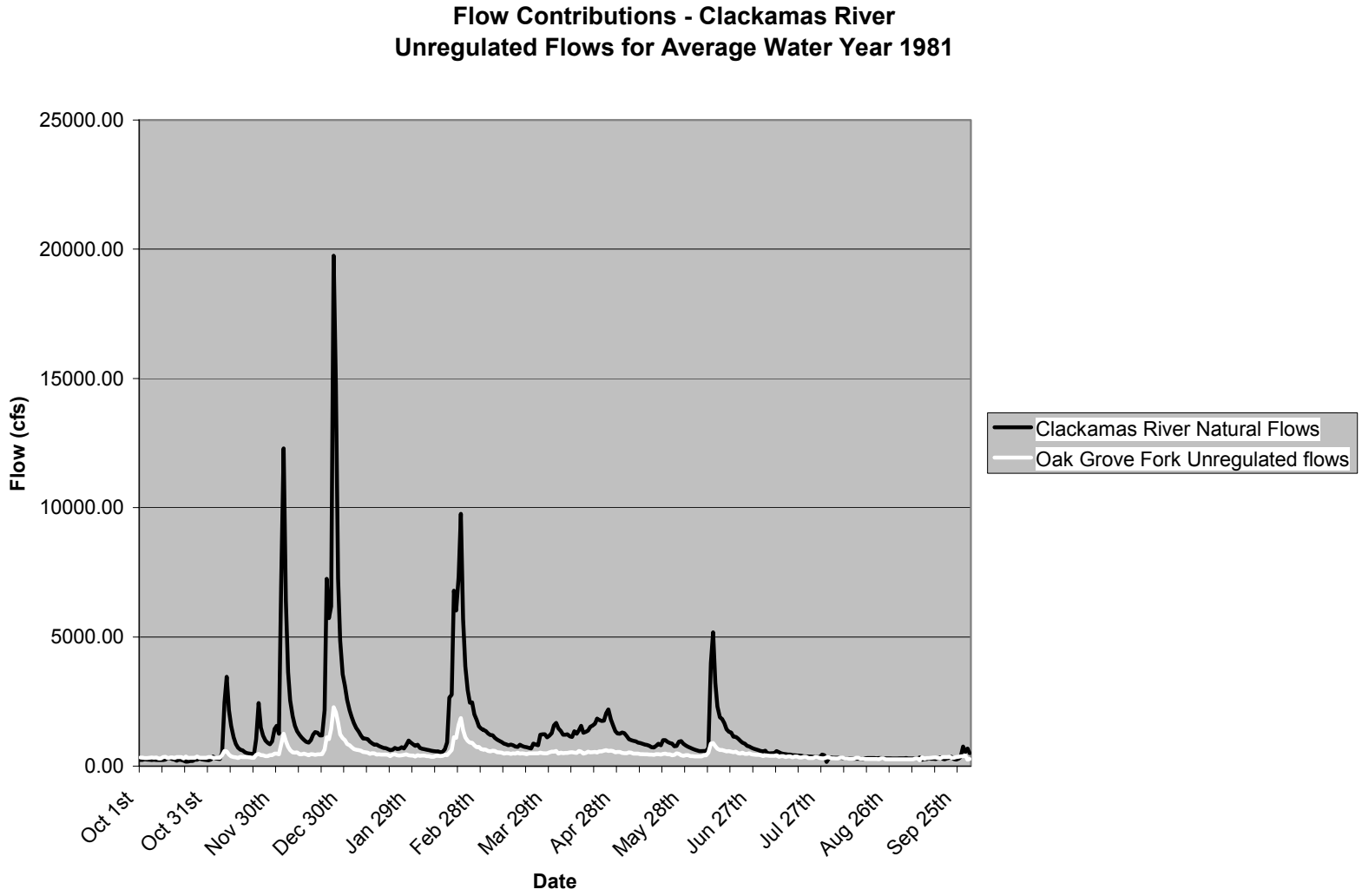


Figure 3.2.2.1-9. Clackamas River above Oak Grove Powerhouse – 31 year average flows (1970-2000).

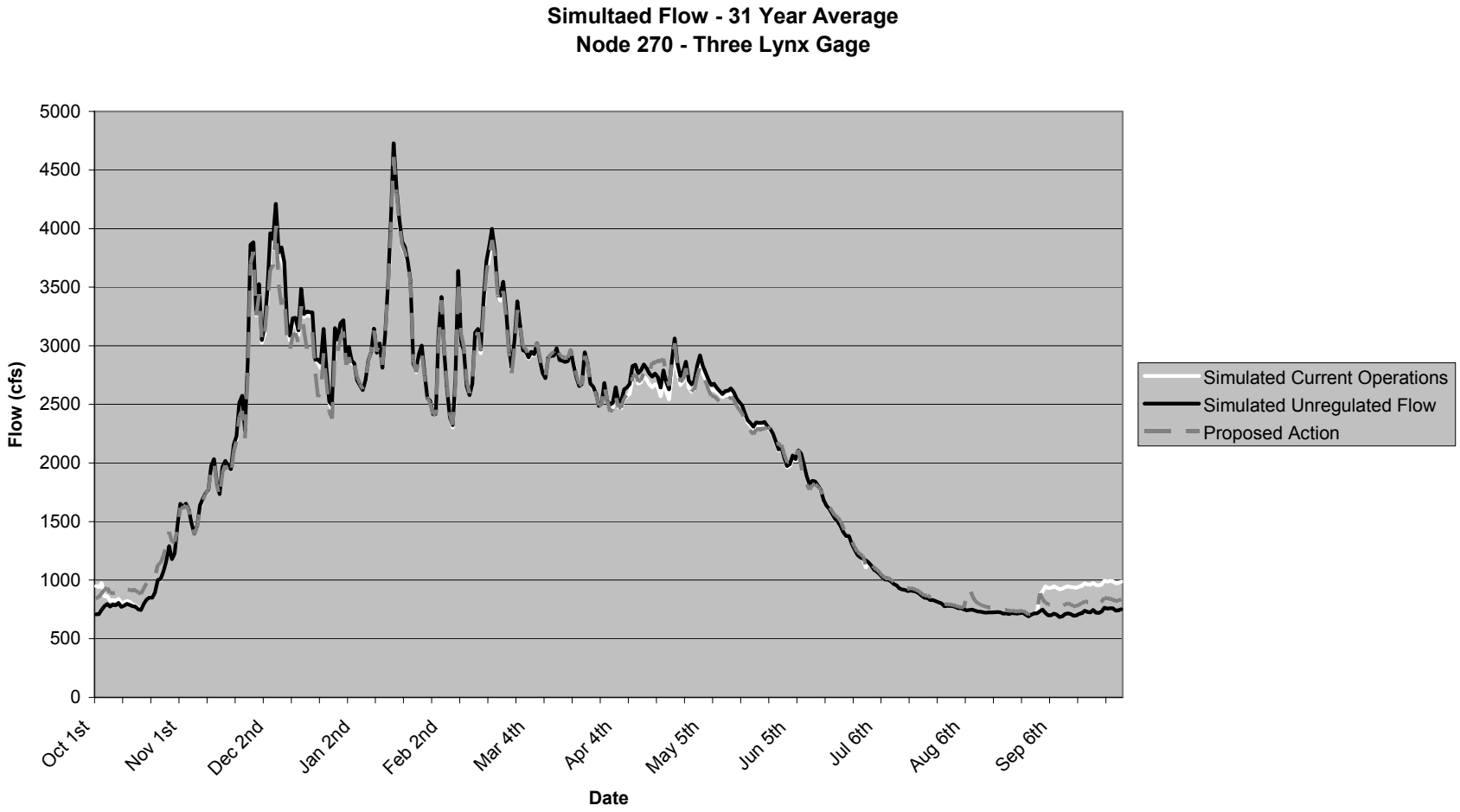


Figure 3.2.2.1-10. Clackamas River above Oak Grove Powerhouse – 31 year minimum flows (1970-2000).

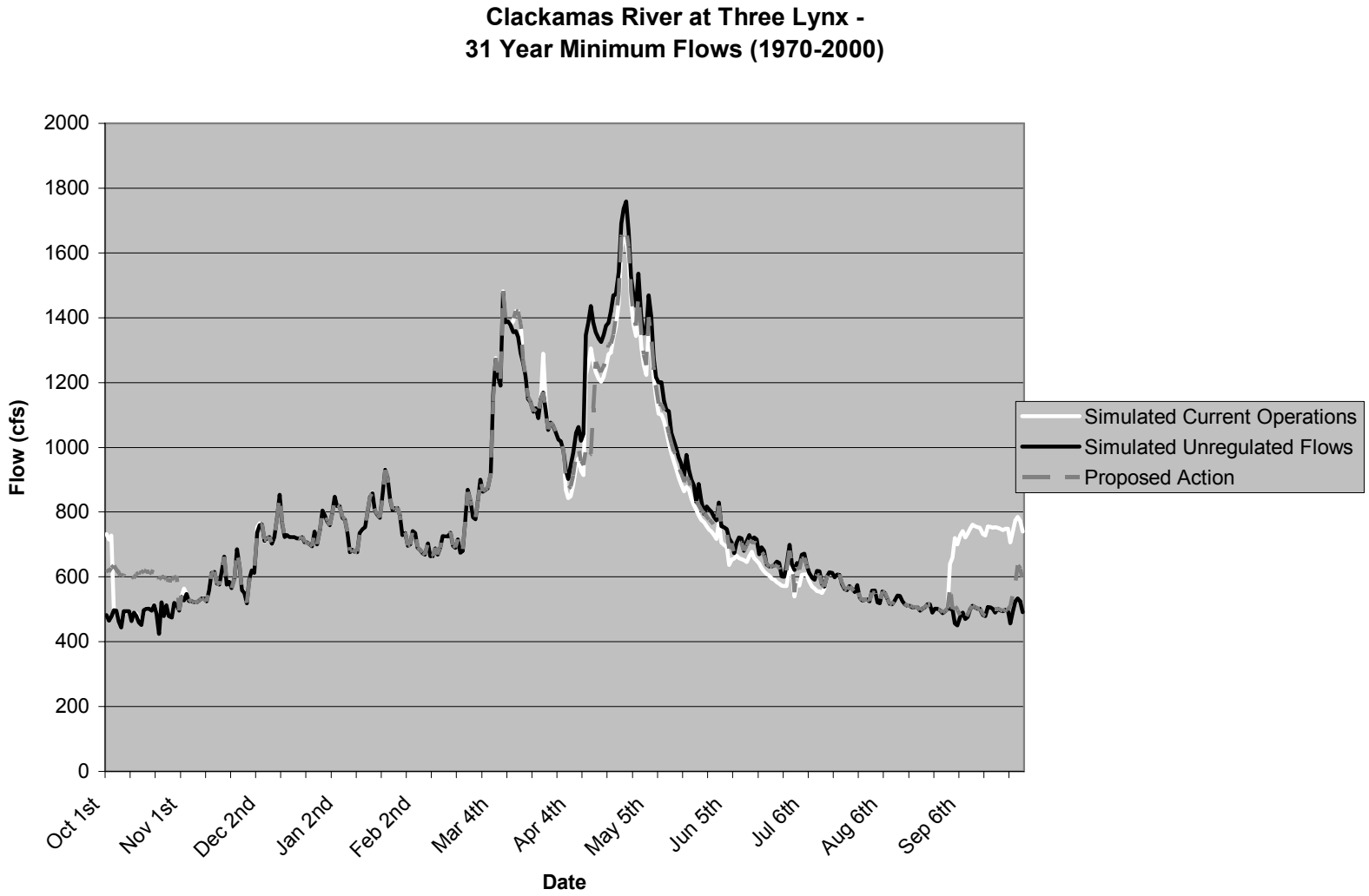
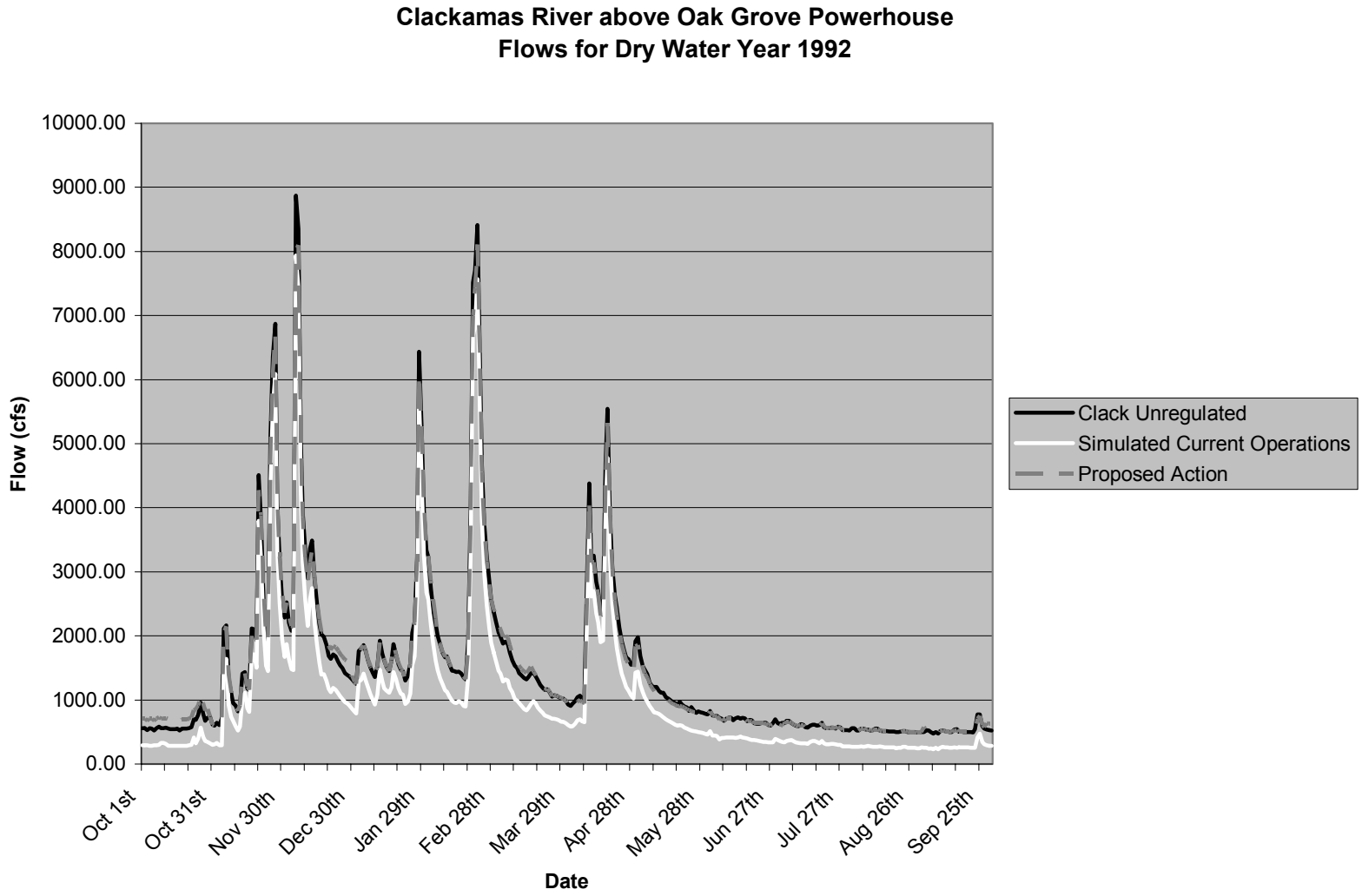


Figure 3.2.2.1-11. Clackamas River above Oak Grove Powerhouse – Flows for dry year 1992.



- The timing and variability of baseflows is nearly identical between simulated current operations and simulated unregulated flows (see Figure 3.2.2.1-10) with seasonal spikes occurring in March and April. Simulated current operations differs slightly from simulated unregulated flows in late August and September when they are roughly 200 cfs greater.

- Winter flood magnitude, timing, and frequency are identical under all conditions as shown in Figure 3.2.2.1-11, with floods ranging in magnitude from 5,000 to 9,000 cfs in the dry year of 1992.

- The snowmelt floods are a less dominant component of the Clackamas River hydrograph above Oak Grove Powerhouse than when compared to the Oak Grove Fork. In the average water year of 1981, flows in the Oak Grove Fork went from 776 cfs on June 7 to a peak of 5,284 cfs on June 9 and back down to 787 cfs on June 26.

Flood Frequency Analysis

Lake Harriet dam diverts inflow up to approximately 600 cfs to the Oak Grove Powerhouse via a pipeline to Frog Lake. Flows in excess of 600 cfs are spilled over the uncontrolled spillway into the Lower Oak Grove Fork. Therefore, estimates of flood frequency under Project operations are calculated by simply subtracting 600 cfs from the peak flows. Project operations have reduced the 1.5-year flood from 14,100 cfs to 13,500 cfs, which is within the sampling error for stream flow gages.

Clackamas River Downstream of Oak Grove Powerhouse

The volume of water diverted at Lake Harriet through the Frog Lake flowline has reduced flow in the Clackamas River from the confluence of the Oak Grove Fork to the Oak Grove Powerhouse. The Clackamas River downstream of the Oak Grove Powerhouse, however, includes flow diverted into the Frog Lake flowline. The annual yield at the Three Lynx gage downstream of the Oak Grove Powerhouse, therefore, has not been changed by the upstream PGE operations. At this location, water allocation in both space and time (at least in time increments of daily or greater – hourly variations still occur as a result of the peaking operation of the Oak Grove Powerhouse) has not been altered by the Project (see Figures 3.2.2.1-12 and 3.2.2.1-13).

Figure 3.2.2.1-12. Simulated Flow – 31 year average – node 270 - Three Lynx Gage.

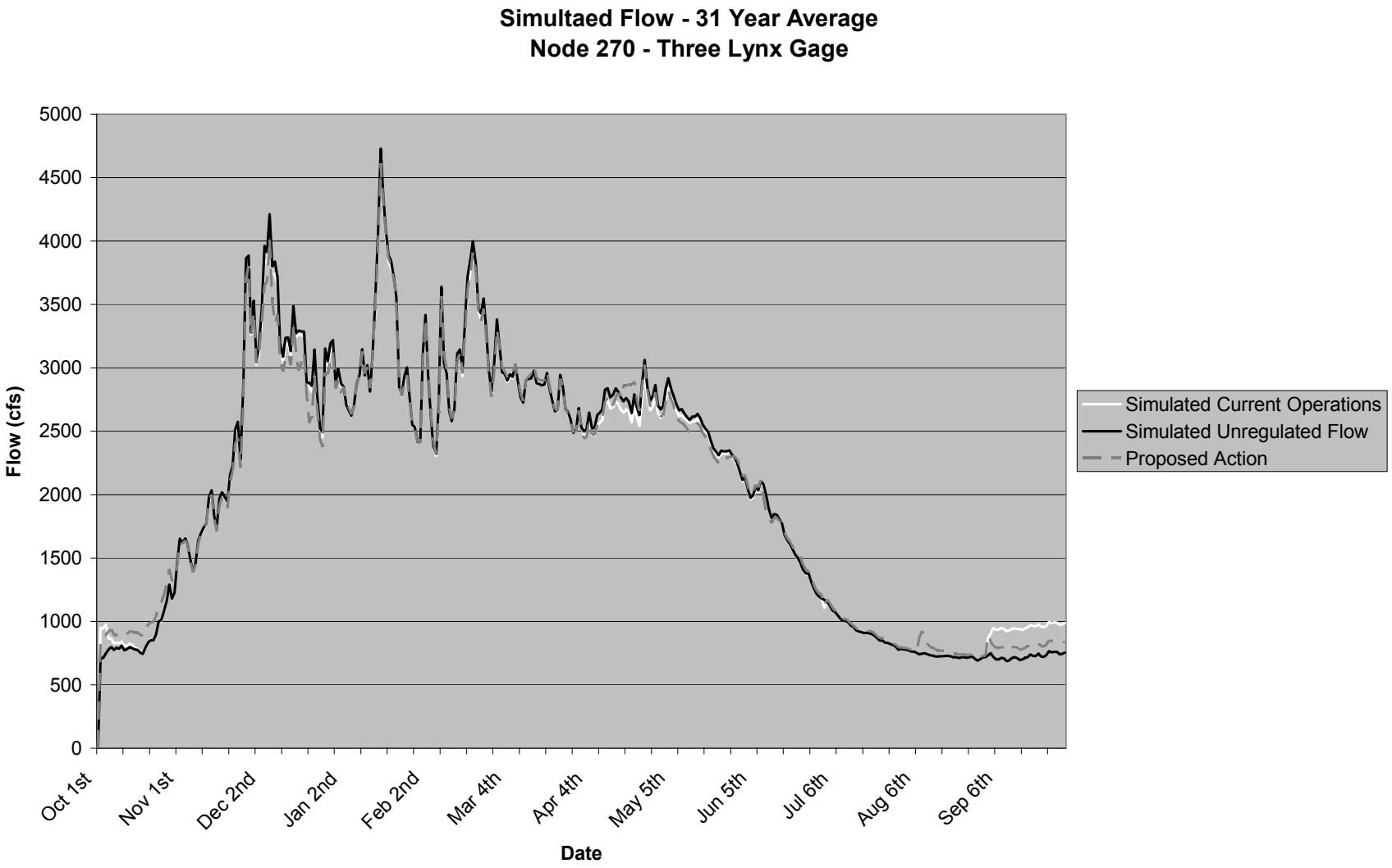
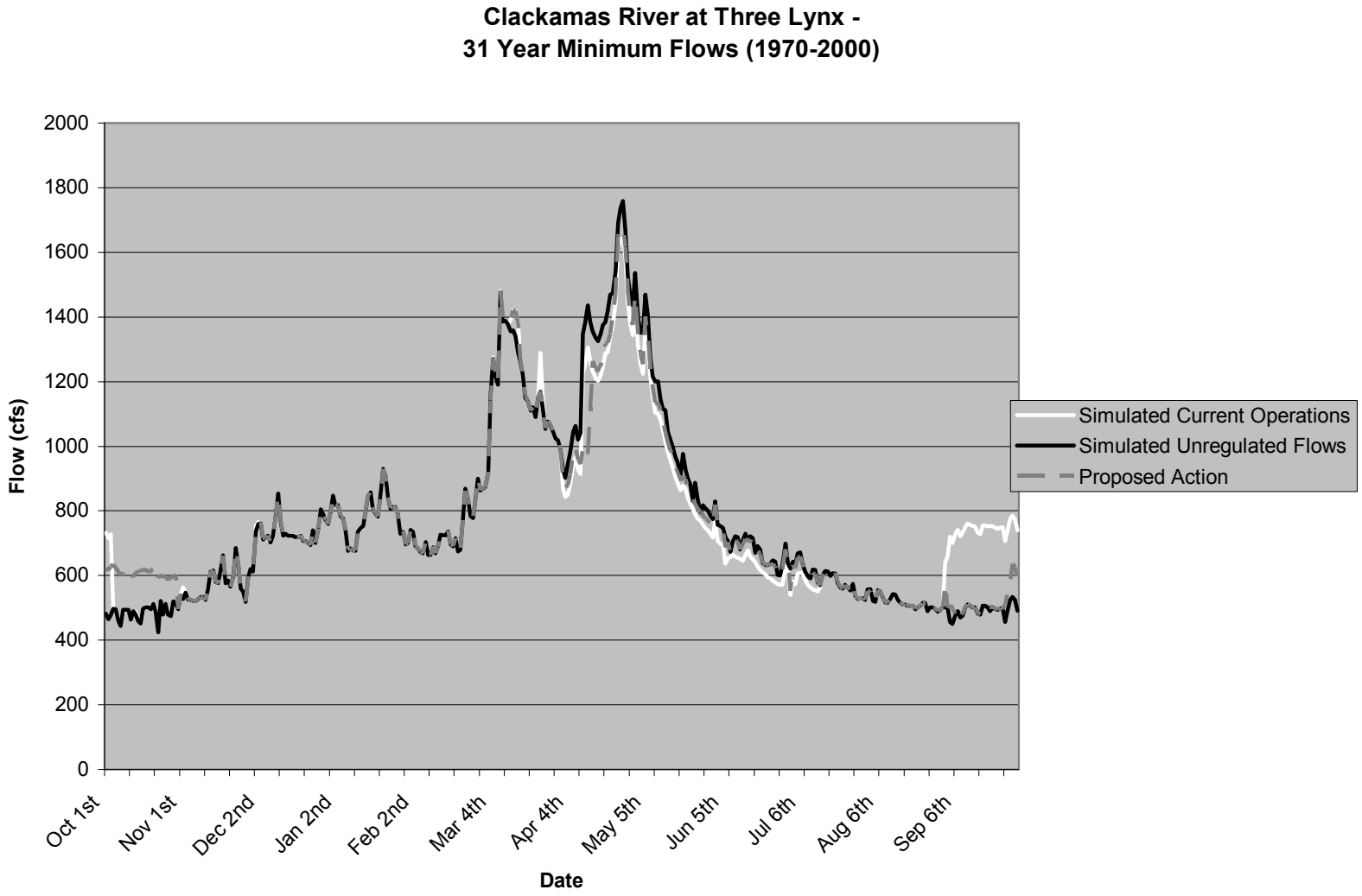


Figure 3.2.2.1-13. Clackamas River at Three Lynx Gage – 31 year minimum flows (1970-2000).



The Clackamas River in this reach is indicative of Western Cascade hydrology, where runoff and resulting geomorphic processes are dominated by larger rainfall or rain-on-snow flood events. Storm generated high flows in streams draining the Western Cascades can be over six times the magnitude of the snowmelt peak (McBain and Trush, 2003). As a result, Western Cascades streams typically have a moderate to low snowmelt hydrograph. High flow hydrology in the mainstem Clackamas River downstream of the Oak Grove Fork is dominated by runoff from the upper Clackamas and Collawash rivers, with high flows from the Oak Grove Fork providing only a moderate contribution.

Hydrograph Component Analysis

The hydrograph components under current operations for the Clackamas River above Three Lynx Creek were analyzed, and the following conclusions were made (McBain & Trush, 2003):

- Median winter baseflows in the Clackamas River at Three Lynx ranged from 1,400 to 2,400 cfs.

- Fall floods are a common hydrograph component. These floods ranged in magnitude from 6,800 to 22,000 cfs in wet water years.

- The timing and frequency of winter floods appear typical of a rainfall-dominated system and magnitudes also appear similar, ranging from minimum winter floods of 2,000 to 3,500 cfs up to daily average floods commonly exceeding 20,000 cfs. The largest daily average flood was the February 1996 flood of 39,100 cfs.

- Snowmelt floods were a less dominant component at the Three Lynx gage, with median values ranging from 4,700 to 7,300 cfs.

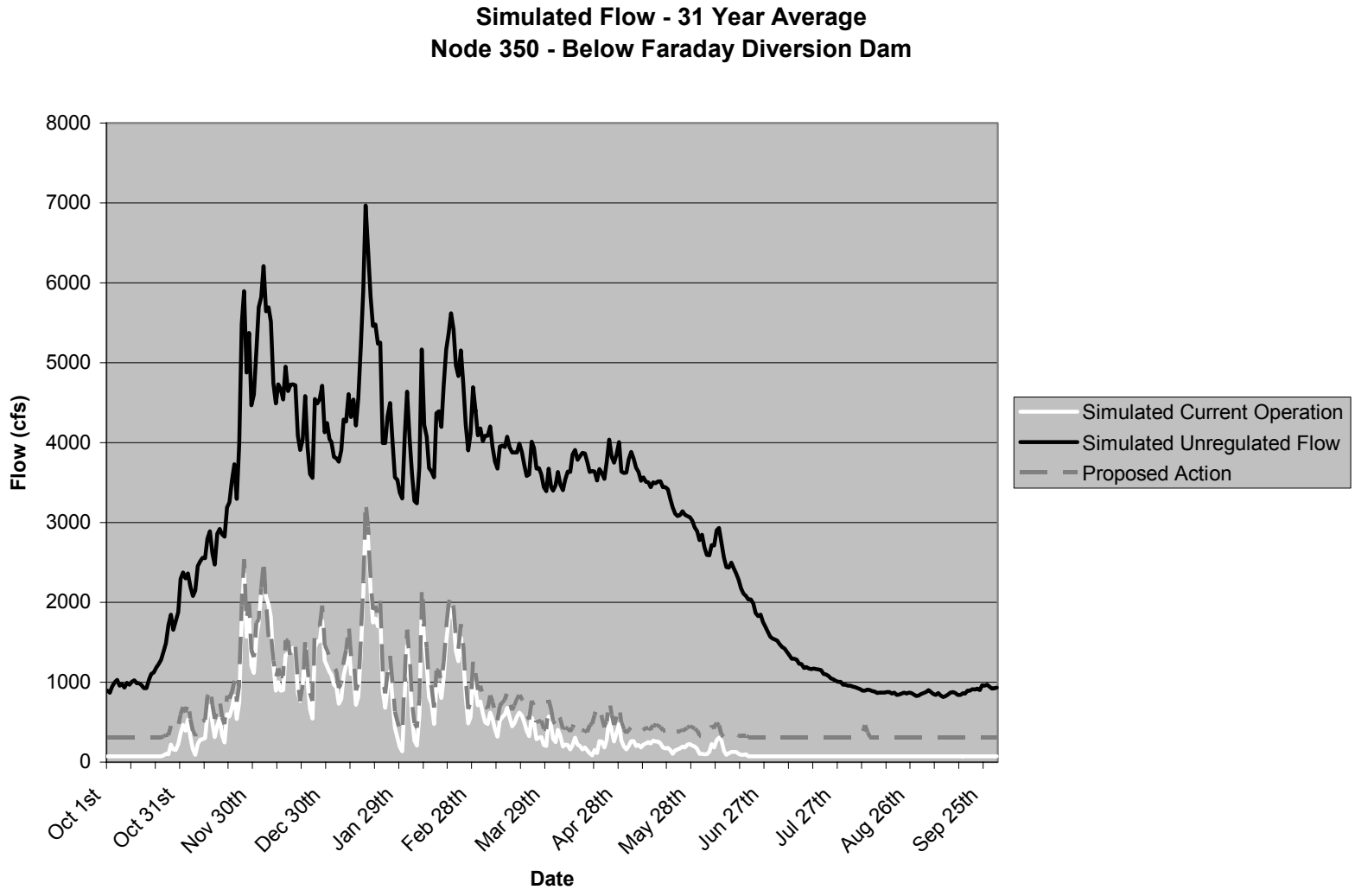
Flood Frequency Analysis

Flood frequency curves at the USGS gaging station above Three Lynx Creek under pre-dam and post-dam conditions show virtually no change in flood frequency downstream of Oak Grove Powerhouse (McBain & Trush, 2003).

Clackamas River (North Fork Reservoir to River Mill dam)

The volume of water in the Clackamas River between North Fork Reservoir and River Mill dam is affected by water diverted to Faraday Lake, which re-enters the river downstream of the Faraday Powerhouse (see Figure 3.2.2.1-14).

Figure 3.2.2.1-14. Simulated flow – 31 year average – node 350 – below Faraday Diversion Dam.



Flood Frequency Analysis

Flood frequency curves at the USGS gaging station above Three Lynx Creek under pre-dam and post-dam conditions show virtually no change in flood frequency downstream of Oak Grove Powerhouse (McBain & Trush, 2003).

Lower Clackamas River

Flow in the Clackamas River downstream of River Mill dam is unaffected by Project operations. Figure 3.2.2.1-15 shows that flow in this location is identical for all flow alternatives.

Water Use

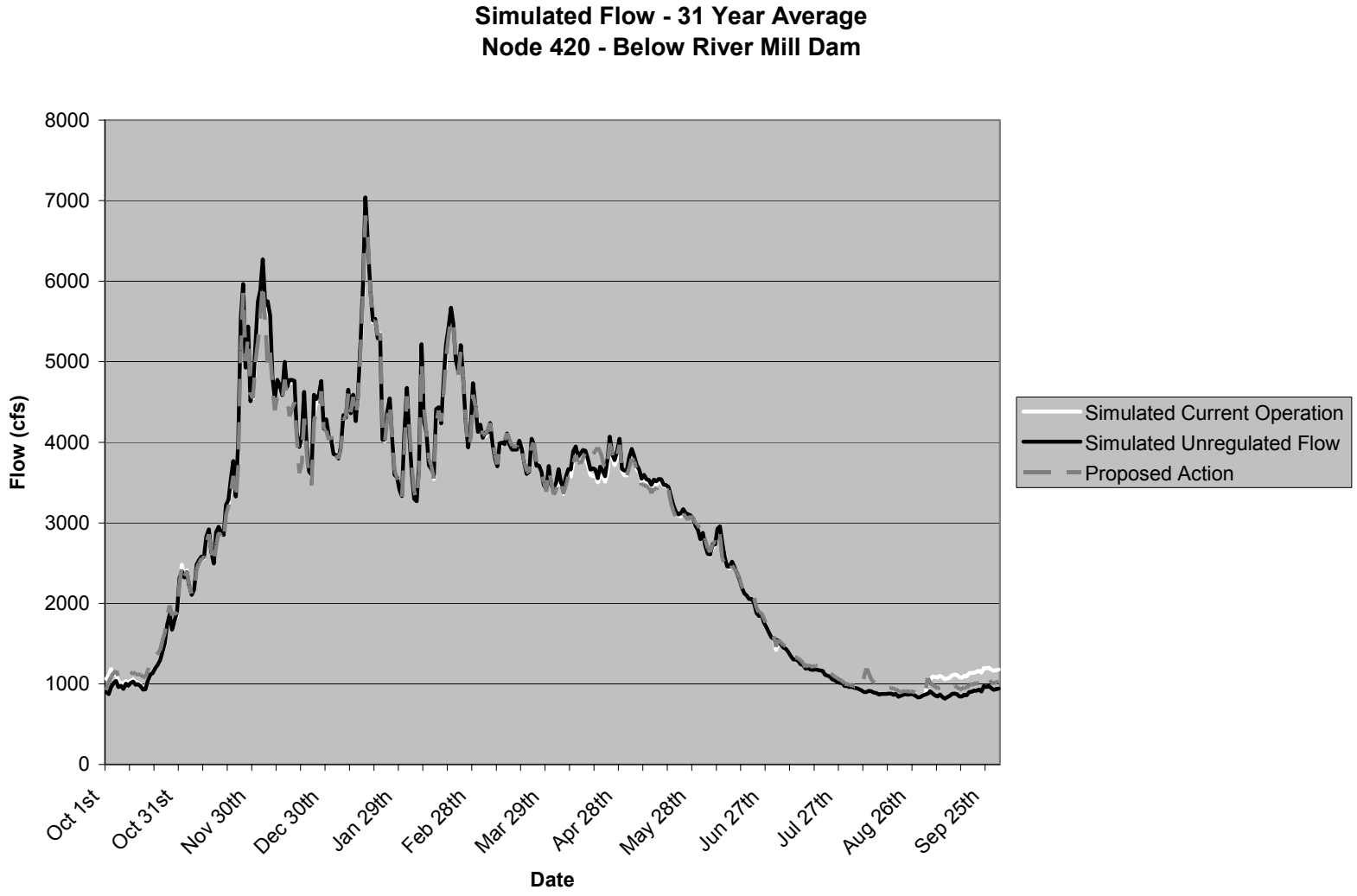
In addition to hydropower generation, the Clackamas River and its tributaries are used for irrigation, industrial supply, recreation, municipal and domestic supply, and instream flow for fish. Table 3.2.2.1-2 shows the water use on the Clackamas River (USGS, 2003).

Table 3.2.2.1-2. Water withdrawal along the Clackamas River by use type (1995 Data).

Use Type	Water Use (Million Gallons/day)
Public Supply	1.37
Commercial	63.73
Domestic	0.07
Industrial	0.00
Agricultural (Livestock & Irrigation)	9.14
Total, all uses	74.31

Source: USGS, 2003

Figure 3.2.2.1-15. Simulated flow – 31 year average – node 420 – below River Mill Dam.



The Clackamas River currently provides municipal water supply to about 200,000 area residents within Clackamas County and demand is expected to increase (PGE, 1999). Annual average water demand for drinking water supply in Clackamas County was 33 million gallons per day (mgd) in 1992, but could double to 67 mgd by 2050 (RWSP, 1996). Currently the only major (i.e., above 1 mgd) water withdrawal within the Project area is the City of Estacada's water supply intake from Estacada Lake. Municipal water providers on the lower five miles of the Clackamas River (Lake Oswego Municipal Water, Clackamas River Water, and South Fork Water Board) have developed a total of 66 mgd of intake and treatment capacity and are committed to developing an additional 22.5 mgd in supply. The Regional Water Supply Plan (RWSP) for the Portland Metropolitan Area (RWSP, 1996) estimates that 50 mgd above the currently committed 88.5 mgd can be withdrawn without significant adverse environmental effects.

Water Rights

Significant amounts of water from the Clackamas River are allocated for industrial, municipal, power generating, agricultural, and other purposes. The RWSP noted that only half of the water rights issued to the regional water providers for the Clackamas River are currently being used.

The State of Oregon issued licenses for several of the developments pursuant to Oregon's Hydroelectric Act. This Act requires a state license for a new project, or for additions to projects, built after February 26, 1932, which require additional water rights.

The Hydroelectric Commission of Oregon issued the following four state licenses, which include water rights, to PGE:

- No. 189 for the construction of Timothy Lake. Authorization to store, divert, and use 60,000 ac-ft in a 12-month period (April 1 to March 31), subject to a 300-cfs draft limitation, was issued with a priority date of March 18, 1953.

- No. 203 for the addition of Unit 6 at Faraday Powerhouse. A water right for 2,650 cfs was issued with a priority date of September 13, 1956.

- No. 202 for the construction of the North Fork Development. A water right for 5,400 cfs was issued with a priority date of September 1956.

- No. 220 for River Mill Unit No. 5. A water right of 950 cfs was issued with a priority date of March 4, 1960.

As noted above, the state licenses included water rights associated with the specific licensed development. PGE made pre-1909 Surface Water Registration (SWR) filings in December 1992, as required by Oregon's water rights adjudication process (ORS 539.240), for water rights associated with the remaining Project developments:

- SWR-386 for 4,641 cfs for the River Mill Development,
- SWR-387 for 602.5 cfs for the Oak Grove Development,
- SWR-388 for 2,370 cfs for Faraday units 1-5.

Additionally, as part of this relicensing process, the state will concurrently conduct its hydroelectric reauthorization process, forming a Hydroelectric Application Review Team (HART) pursuant to HB-2119, passed by the Oregon Legislature in 1995. The state process parallels the Commission relicensing process, allowing HART members to participate in a single relicensing effort that satisfies both state and federal obligations.

3.2.2.1.3 Water Quality

Project operations result in the storage of water in reservoirs, the diversion of flows from the mainstem of river reaches, the release of water for power generation, and the spilling of water. All of these activities can alter the temperature and water quality of the Oak Grove Fork and Clackamas River.

Water quality concerns associated with reservoirs are typically related to increased storage times and stratification, conditions which could lead to algal blooms with appropriate nutrient input. These impacts could then alter water quality and temperatures of the discharged water as well as affect water quality constituents such as dissolved oxygen (DO), chlorophyll a, and pH. The data in the Clackamas River system, however, show very low concentrations of nutrients, low levels of algal biomass and chlorophyll a, generally high DO concentrations, and pH within water quality limits. The data show that the water quality of the Clackamas River system remains relatively unaffected by the Project with little effect on DO and pH levels through most of the river reaches. Timothy Lake and North Fork Reservoir contain small concentrations of blue-green algal species, which are typically not observed in free-flowing river reaches.

The Project also includes flow diversions, which combined with the diversion of flows from the bypassed reaches, can also affect water quality,

particularly temperature, which tends to increase as a result of decreased volume of water and increased travel times through some of these diversions.

Water quality monitoring in the Project area indicates that the Clackamas River above River Mill dam has excellent water quality (USFS, 1995a). The most significant water quality issue in this system is water temperature. The ODEQ is required, pursuant to section 303(d) of the CWA, to maintain a list of stream and river segments that do not meet water quality standards. The 2002 303(d) list includes more than 13,300 stream miles in Oregon that are listed for at least one water quality pollutant. Fish Creek, a tributary of the Clackamas River, upstream of the North Fork development, is listed for temperature and represents the only stream segment above River Mill dam that is listed on the 303(d) list. The lower Clackamas River downstream of River Mill dam is listed on the 303(d) list for temperature and bacteria.

PGE conducted water quality studies in 2000 and 2001, focusing on water temperature as well as other parameters (DE&S, 2002; Framatome ANP DE&S, 2002; Battelle, 2004; EES, 2004). Table 3.2.2.1-3 lists the temperature monitoring stations used for these studies.

Recently, ODEQ established new water quality standards (OAR, Chapter 340, Division 041). Table 3.2.2.1-4 summarizes the major changes as they relate to the Clackamas River Project.

The following discussion details the water quality status of the various sections of the Oak Grove Fork and Clackamas River.

Clackamas River Upstream of Confluence with the Oak Grove Fork

The mainstem Clackamas River upstream of the Collawash River has a temperature regime indicative of a cold, spring-fed system. Water temperatures recorded in this section correspond with the optimum range of preferred temperatures for salmonids (USFS, 1994). Temperatures measured during the 2001 water year stayed below the 13°C threshold set by ODEQ for water quality (Table 3.2.2.1-4). Further downstream, but upstream of the confluence with the Oak Grove Fork, the mainstem Clackamas River warms to a maximum of 16.08°C in August and mean temperatures of 14.35°C and 14.62°C in July and August respectively (EES, 2004).

Turbidity is rarely a problem in the Upper Clackamas River, although cut banks along Forest Road 46 near River Mile (RM) 64 produce sediment that results in turbidity during high flow events (USFS, 1995a). The Collowash River and its tributary, Pansy Creek, provide large quantities of sediment from frequent

landslides. In general, though, sedimentation is not a problem in the upper portions of the watershed because of the high gradient and high energy streams that effectively route most of the sediment through the system (ODFW, 1990).

Table 3.2.2.1-3. Temperature monitoring stations during 2000-2001.

Code	Site Name	River Mile [1]
TIMICC	Timothy Lake Inflow from Crater Creek	
TIMIOG	Timothy Lake Inflow from Oak Grove Fork Tributary	
SRCMTH	Shell Rock Creek at Mouth	
02TIMA	Timothy Lake Main Site at 2m depth	
10TIMA	Timothy Lake Main Site at 10m depth	
28TIMA	Timothy Lake Main Site at 28m depth	
TIMOTR	Timothy Lake Outlet-1000 ft downstream at USGS Site	68.47/ 16.29
SRCMTH	Shellrock Creek at mouth	60.51/8.33
OGFHAR	Oak Grove Fork above Harriet at USGS Site	58.65/ 6.47
02HARL	Harriet Lake at 2m depth	57.65/ 5.47
09HARL	Harriet Lake at 9m depth	57.65/ 5.47
FROGLK	Frog Lake	
OGFUSC	Oak Grove above Skunk Creek	55.78/3.6
OGFMTH	Oak Grove Fork at Mouth	52.18/ 0
CRUOGF	Clackamas River Immediately Upstream of Oak Grove Fork	52.19
CROGPH	Clackamas River Immediately Upstream of Oak Grove Powerhouse	46.84
CROGTR	Clackamas River/Oak Grove Powerhouse Tailrace	46.81
CRUPRR	Clackamas River Immediately Upstream of Roaring River	42.83
RRMOTH	Roaring River at Mouth	42.81/ 0
CRUPFC	Clackamas River Immediately Upstream of Fish Creek	40.51
FCMOTH	Fish Creek at Mouth	40.36/ 0
CRUNFR	Clackamas River Upstream of North Fork Reservoir	33.3
NFCRMH	North Fork of the Clackamas River at Mouth	30.51/ 0.5
06NFUP	North Fork Reservoir Upper End at 6m depth	31.71
02NFLW	North Fork Reservoir Lower End at 2m depth	29.15
15NFLW	North Fork Reservoir Lower End at 15m depth	29.15
30NFLW	North Fork Reservoir Lower End at 30m depth	29.15
NFFLTP	North Fork Fish Ladder (top)	29.12
NFFLBM	North Fork Fish Ladder (bottom)	27.19
DIVDAM	Diversion dam section	25.39
NOFKTR	North Fork Tailrace	29.12
FARFOR	Faraday Forebay	25.22
02ESTA	Estacada Lake at 2m depth	22.37
09ESTA	Estacada Lake at 9m depth	22.37
RIMITR	River Mill Tailrace	22.32
CRMCIV	Clackamas River at lower boat ramp McIver Park	19.22
ECMOTH	Eagle Creek at Mouth	15.5/0.0
CRUPEC	Clackamas River Immediately Upstream of Eagle Creek	15.7
CRBART	Clackamas River at Barton	13.3
DCMOTH	Deep Creek at Mouth	12.1
CLCRMH	Clear Creek at Mouth	8.0/0.7
CRATCB	Clackamas River at Carver Bridge	7.9
CRACB2	Clackamas River at Carver Bridge alternate site	7.9
CRATOC	Clackamas River at Oregon City	2.5

1 River mile is based on Stationing as reported by McBain & Trush. River miles along the Clackamas River upstream of the quarry near Barton are 0.98 miles less than reported on USGS maps due to 1996 river channel change. River miles for Oak Grove Fork list distance from mouth of Clackamas River/ RM from mouth of Oak Grove. River mile for other tributaries list distance from mouth of Clackamas River/ RM from mouth of tributary.

Table 3.2.2.1-4. ODEQ 2004 Water Quality Standards.

Reach	ODEQ Standard[1,2] Temperature Criteria Based on Spawning or Rearing Use	DO Standard[1,2] DO (mg/L)	Temperature Annual Period 1/1/2000 = JD 1 1/1/2001=JD 365[3]
Oak Grove Fork between Timothy Lake (RM 68.4) and Barrier Falls (RM 54.9)	16º C (60.8º F) rearing criterion	8 mg/L (30 D[4])	JD 1 to JD 730
	NA	8 mg/L (30 D)	NA
Oak Grove Fork from Barrier Falls (54.9) to mouth[5] (RM 53.1)	16º C (60.8º F) rearing criterion	11 mg/L (7 D)	JD 167 to JD 244 JD 532 to JD 609
	13º C (55.4º F) spawning window September 1 - June 15	8 mg/L (30 D)	JD 1 to JD 166 JD 245 to JD 531 JD 609 to JD 730
Clackamas mainstem, from Oak Grove Fork (RM 53.1) to Clear Creek (RM 9.1), excluding North Fork Reservoir and Estacada Lake[5]	16º C (60.8º F) rearing criterion	11 mg/L (7 D)	JD 167 to JD 244 JD 532 to JD 609
	13º C (55.4º F) spawning window September 1 - June 15	8 mg/L (30 D)	JD 1 to JD 166 JD 245 to JD 531 JD 609 to JD 730
Fish Ladder[5]	16º C (60.8º F) rearing criterion	8 mg/L (30 D)	JD 1 to JD 730
	No designated spawning	11 mg/L (7 D)	NA
North Fork Reservoir[5]	16º C (60.8º F) rearing criterion	8 mg/L (30 D)	JD 167 to JD 365 JD 532 to JD 730
	13º C (55.4º F) spawning window January 1- June 15	11 mg/L (7 D)	JD 1 to JD 166 JD 366 to JD 531
Estacada Lake[5]	16º C (60.8º F) rearing criterion	8 mg/L (30 D)	JD 136 to JD 244 JD 501 to JD 609
	13º C (55.4º F) spawning window September 1- May 15	8 mg/L (30 D)	JD 1 to JD 135 JD 245 to JD 500 JD 609 to JD 730
Mainstem Clackamas, vicinity of Bonnie Lure State Park (RM 16.7)	16º C (60.8º F) rearing criterion year-round; No designated spawning	11 mg/L (7 D)	JD 1 to JD 730 NA
Mainstem Clackamas; Clear Creek to mouth[5]	18º C (64.4º F) rearing criterion	8 mg/L (30 D)	JD 136 to JD 288 JD 501 to JD 653
	13º C (55.4 º F) spawning window October 15 - May 15	8 mg/L (30 D)	JD 1 to JD 135 JD 289 to JD 500 JD 653 to JD 730

[1] When natural thermal conditions exceed the applicable numeric criterion warming is allowed
[2] Warming defined as 0.3ºC (0.5ºF)
[3] JD = Julian Day
[4] 30 D = 30 days; 7 D = 7 days
[5] Waters with Threatened and Endangered species present that have ambient—i.e., under existing conditions, not Natural Thermal Potential (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 0.3ºC above those ambient temperatures.

Timothy Lake

Timothy Lake is considered meso-oligotrophic for total nitrogen, total phosphorous, and Secchi disk transparency. It is classified as mesotrophic for total phytoplankton chlorophyll and shows more phytoplankton production than the lower three reservoirs (Table 3.2.2.1-5). Timothy Lake also differs from the other reservoirs at the Project with the presence of a strong thermal stratification during summer (usually from May to October) and a higher ratio of total nitrogen to total phosphorous (Framatome ANP DE&S, 2002a; EES, 2004). This ratio serves as an indicator of nutrient conditions that favor blue-green algal dominance. The reservoir usually remains well oxygenated throughout the year.

Available monitoring data indicate that water temperatures in the epilimnion of Timothy Lake were relatively warm while temperatures lower down into the hypolimnion were cool all summer. Temperatures in the epilimnion ranged from 15.1°C in mid June to a high of 21.1°C in August of 2001 (Framatome ANP DE&S, 2002a; EES, 2004). The metalimnion had temperatures between 14.9°C and 11.0°C in June to between 16.0°C and 9.2°C in mid-July when its depth had increased from 12m to 14m. The hypolimnion exhibited temperatures of 8.3°C, 8.5°C, and 9.1°C in June, July, and August, respectively.

Table 3.2.2.1-5. Mean values for water quality parameters for Clackamas River reservoirs, April 2000 through April 2001. All values mg/L except where noted.

	Secchi Disk (m)	TKN	N-N	NH_3	T-Phos	O-Phos	SiO_2	TOC
Timothy Lake Site A								
Photic Zone	6.53	0.200	0.006	0.024	0.009	0.006	19.2	0.91
1.0 m Off Bottom		0.210	0.006	0.024	0.008	0.006	19.1	0.81
Epilimnion (June-Sept)		0.205	0.005	0.024	0.009	0.006	19.4	0.94
Metalimnion (June-Sept)		0.286	0.005	0.024	0.007	0.006	19.7	1.00
Timothy Lake Site C								
Photic Zone	6.09	0.236	0.011	0.024	0.008	0.005	19.1	0.86
1.0 m Off Bottom		0.210	0.006	0.024	0.009	0.005	18.6	0.78
Epilimnion (June-Sept)		0.204	0.006	0.024	0.005	0.005	18.5	0.93
Metalimnion (June-Sept)		0.301	0.007	0.024	0.007	0.006	19.7	0.97
Harriet Lake								
Photic Zone	9.3*	0.212	0.006	0.024	0.014	0.012	19.3	0.20
North Fork Reservoir Upper Site								
Photic Zone	5.85*	0.201	0.008	<0.025	0.013	0.011	18.0	0.49
North Fork Reservoir Lower Site								
Photic Zone	6.4	0.167	0.012	0.024	0.014	0.010	19.6	0.61
Off Bottom		0.147	0.008	0.024	0.017	0.010	19.0	0.54
Epilimnion (June-September)	0.142	0.006	0.024	0.018	0.010	21.7	0.45	
Faraday Lake								
Photic Zone	5.0	0.163	0.010	0.024	0.015	0.010	18.7	0.57
Estacada Lake								
Photic Zone	6.0	0.795	0.012	0.024	0.014	0.011	18.5	0.65

Source: Framatome- ANP DE&S, 2002
* Secchi Disk generally on the reservoir bottom
TKN = total Kjeldahl nitrogen, as N
N-N = nitrite+nitrate as N
NH_3 = ammonia
T-Phos = total phosphorus as P
O-Phos = Orthophosphorus as P
TOC = total organic carbon
SiO_2 = silica

Oak Grove Fork

Tables 3.2.2.1-6 and 3.2.2.1-7 show that study sites in 2000 and 2001 on the Oak Grove Fork had a slightly basic pH (7.7 to 7.9), DO saturation between 97.6 and 101.1 percent, nitrate-nitrite levels between 0.006 and 0.014 mg/L, total Kjeldahl nitrogen concentration between 0.152 and 0.169 mg/L, and ortho-phosphate levels between 0.013 and 0.019 (Framatome ANP DE&S, 2002a; EES, 2003). Water temperatures in the Oak Grove Fork downstream of Timothy Lake dam remain relatively cool throughout the summer with accretion flows from cold springs keeping temperature readings near 8.5°C (USFS, 1996b).

PGE used a water quality model to simulate the effects of system wide hydrological conditions on specific water quality parameters at nodes throughout the basin. The model selected for this study was CE-QUAL-W2, version 3.1. It is a two-dimensional (vertical and longitudinal) water quality and hydrodynamic model that was originally developed for deep, long, and narrow waterbodies. CE-QUAL-W2 is supported by the U.S. Army Corp of Engineers Waterways Experiment Station (Cole and Buchak, 1995), and is recommended by U.S EPA, Oregon DEQ, and Washington State Department of Ecology for temperature and water quality modeling studies in streams and reservoirs. Version 2 of the model has been successfully used in more than 200 reservoir applications. Results of 67 reservoir temperature simulations covering a 143-year period demonstrate that the model is capable of simulating a variety of thermal regimes with minimal adjustment of hydrodynamic/temperature calibration parameters. The absolute mean error for temperature regimes for all sites analyzed was within $\pm$ 1°C, even when remote meteorological data were applied. The equations in Version 3.1 are based on Version 2 formulation but were re-derived so that the model could be applied to an entire watershed including rivers, reservoirs/lakes, and estuaries with variable river slopes (Cole and Wells, 2002)[1]. Version 3.1 has also been tested on several river systems including a 244-km section of the Lower Snake River, a multi-reservoir-river system on the Bull Run watershed, a series of 33 lakes and estuary segments in the Columbia Slough, and several other lake or reservoir systems.

[1] Cole, T.M., and S.A. Wells. August 2002. CE-Qual-W2: A Two-Dimensional, Laterally Averaged, Hydrodynamic and Water Quality Model, Version 3.1. User Manual (Draft). Instruction Report EL-02-1. Prepared for U.S. Army Corps of Engineers, Washington, DC

Table 3.2.2.1-6. Water quality results – Clackamas River system (2000 – 2001).

	TKN	N-N	NH_3	T-Phos	O-Phos	Si_{O2}	TOC
Timothy Lake							
TIMICC*	0.157	0.009	<0.025	0.021	0.020	25.3	0.3
GW-2	0.157	0.019	<0.025	0.023	0.023	30.3	0.1
TIMIOG	0.182	0.006	<0.025	0.016	0.012	25.1	1.4
TIMOUT	0.173	0.006	<0.025	0.007	0.003	19.2	0.6
GW-1	0.122	0.018	<0.025	0.021	0.018	18.3	0.2
Upstream of Oak Grove Powerhouse							
CRUOGF	0.157	0.008	<0.025	0.016	0.014	20.4	0.4
OGFMTH	0.157	0.014	<0.025	0.020	0.019	23.0	0.4
CROGPH	0.145	0.006	<0.025	0.018	0.014	20.6	1.6
Harriet Lake/Oak Grove Powerhouse							
OGFHAR	0.152	0.006	<0.025	0.017	0.014	19.0	0.3
CROGTR	0.169	0.006	<0.025	0.014	0.013	19.5	0.7
Mainstem Clackamas Oak Grove Powerhouse to River Mill dam							
CRUPRR	0.170	0.011	<0.025	0.016	0.013	20.0	0.4
CRUPFC	0.148	0.007	<0.025	0.015	0.012	19.9	0.5
CRUNFR	0.145	0.007	<0.025	0.014	0.011	17.9	0.6
NOFKTR	0.185	0.010	<0.025	0.017	0.011	19.1	0.6
Tributaries - Oak Grove Powerhouse to River Mill dam							
RRMOTH	0.119	0.017	<0.025	0.013	0.010	18.2	0.4
FCMOTH	0.204	0.025	<0.025	0.013	0.010	17.4	0.7
SFCRMH	0.170	0.021	0.027	0.010	0.008	18.3	0.7
NFCRMH	0.188	0.149	0.025	0.011	0.005	19.1	0.8
NFFLTP*	0.198	0.010	<0.025	0.014	0.008	18.7	0.8
NFFLBM*	0.171	0.013	<0.025	0.014	0.010	19.2	0.8
Mainstem – Downstream of River Mill dam							
RIMITR	0.181	0.012	<0.025	0.015	0.013	17.0	0.6
CRUPEC	0.171	0.009	<0.025	0.015	0.010	18.7	1.1
CRATCB	0.190	0.070	<0.025	0.017	0.011	18.4	1.6
Tributaries - Downstream of River Mill dam							
ECMOTH	0.212	0.236	<0.025	0.014	0.007	18.5	0.7
GW-3	0.381	12.902	0.026	0.066	0.027	27.8	0.7
DCMOTH	0.420	1.624	0.025	0.101	0.090	22.2	0.8
CLCRMH	0.280	0.397	0.025	0.019	0.013	23.9	1.9

* See Table 3.2.2.1-3

TKN = total Kjeldahl nitrogen, as N

N-N = nitrite+nitrate as N

NH_3 = ammonia

T-Phos = total phosphorus as P

O-Phos = Orthophosphorus as P

Si_{O2} = silica

TOC = total organic carbon

Table 3.2.2.1-7. Water quality results – Clackamas River system (2000 – 2001).

	pH (units)	Percent DO	Sp. Cond.	Total Alk.	Hard.	Turb. (NTU's)	TSS	TDS
Timothy Lake								
TIMICC*	7.9	99.2	65	35.4	28.2	0.5	0.3	39.7
GW-2	7.5	94.3	68	35.5	29.3	0.3	0.0	66.0
TIMIOG	7.6	99.5	51	28.6	21.8	0.6	0.5	37.0
TIMOUT	7.6	97.1	48	25.1	20.1	1.1	0.6	45.5
GW-1	8.3	80.5	67	34.5	28.8	0.6	2.1	43.5
Upstream of Oak Grove Powerhouse								
CRUOGF	7.9	99.8	58	26.2	20.2	0.6	0.5	44.2
OGFMTH	7.7	97.6	66	35.7	29.3	0.6	0.5	52.0
CROGPH	7.8	101.1	59	26.5	20.5	0.7	0.5	40.0
Harriet Lake/ Oak Grove Powerhouse								
OGFHAR	7.7	98.3	54	27.2	20.7	0.8	1.1	38.0
CROGTR	7.8	97.2	55	28.5	22.3	0.6	0.4	42.4
Mainstem Clackamas - Oak Grove Powerhouse to River Mill dam								
CRUPRR	7.8	99.1	56	26.9	20.8	1.1	0.6	34.2
CRUPFC	7.8	100.4	54	25.1	20.0	0.7	1.8	40.3
CRUNFR	7.9	101.9	54	24.6	20.1	1.0	1.5	29.7
NOFKTR	7.6	98.7	52	24.3	19.4	1.1	1.4	41.0
Tributaries – Oak Grove Powerhouse to River Mill dam								
RRMOTH	7.7	100.1	37	16.8	13.7	0.5	0.4	29.0
FCMOTH	7.7	100.6	41	19.0	15.1	0.7	0.5	38.0
SFCRMH	7.8	99.3	37	18.5	14.3	0.8	0.7	30.8
NFCRMH	7.6	98.6	33	14.5	11.6	1.3	1.1	31.3
NFFLTP	7.7	100.6	52	25.7	19.3	0.9	0.6	46.0
NFFLBM	7.8	100.3	52	24.2	19.4	0.9	0.5	54.0
Mainstem – Downstream of River Mill dam								
RIMITR	7.6	98.9	51	24.0	18.8	1.0	1.0	45.4
CRUPEC	7.9	102.5	52	25.0	19.9	1.0	1.6	38.6
CRATCB	8.0	102.4	52	23.7	19.2	1.5	2.6	45.7
Tributaries – Downstream of River Mill dam								
ECMOTH	7.7	98.2	38	16.2	13.2	1.3	1.4	34.8
GW-3	6.2	31.1	205	38.6	77.5	2.2	0.7	161.0
DCMOTH	7.9	99.9	88	30.8	28.7	4.8	5.3	71.0
CLCRMH	7.8	98.6	57	26.2	21.6	2.7	5.3	56.2

* See Table 3.2.2.1-3

percent DO = Percent DO saturation
Sp. Cond = Specific Conductance
Total Alk. = Total Alkalinity
Hard. = Hardness
Turb. = Turbidity
TSS = Total Suspended Solids
TDS = Total Dissolved Solids

This model is ideally suited for the Clackamas River system because it contains a series of hydropower reservoirs and river stream sections connected with each other. The development of stratification in the reservoirs, followed by supercritical flows in the fast flowing streams requires the model to be robust with regard to stability considerations. CE-QUAL-W2 version 3.1 is especially suited for these hydraulic conditions. In addition, CE-QUAL-W2 provides for internal calculation of equilibrium temperatures and coefficients of surface heat exchange or a term-by-term accounting of surface heat exchange. Multiple vertical layers within reservoirs can be assigned, and segment lengths for an entire watershed can be specified. Water surface elevations are solved implicitly, which permits larger time steps and reduces the time required to run the model. Long-term simulation is thereby possible. The model is well suited to evaluate the operational effects of hydroelectric projects on water quality. In addition to temperature modeling, CE-QUAL-W2 has routines for 33 water quality state variables including nutrient cycling, multi-species algal growth, and multi-particle size transport.

The initial model setup including (a) hydrodynamic calibration consisting of water flow balance, (b) temperature calibration, and (c) water quality calibrations, using data from April 2000 through October 2001, is described in detail in *Draft Water Quality Model of the Clackamas River, Clackamas Hydroelectric project* (Battelle, 2004). Following the initial calibration of the model, its use by PGE to assess the operating alternative proposed in its final FERC license application, and ODEQ's use of the model to develop a draft Total Maximum Daily load (TMDL) for temperature in the Willamette Basin, it became apparent based on evaluation of predicted Natural Thermal Potential (NTP)[2] that adjustments to the model, in particular channel geometry in the reach of the Clackamas main stem occupied by the Project reservoirs, were needed. These modifications and recalibration of the model are described in Battelle (2005, in preparation). Subsequent references to NTP in this application are based on the revised version of CE-QUAL-W2 discussed in the Battelle (2005) memorandum.

Also described in the memorandum is the recalibration of the reach of the Oak Grove Fork downstream of Lake Harriet. The lower Oak Grove Fork model was recalibrated, because the original calibration was based on existing conditions, in which extremely low flows are present in the reach, except during floods (Yang and Khangaonkar, 2004). ODEQ and PGE agreed that calibration based on this extreme condition was probably not suitable for predicting warming in this reach when substantially larger flows are present, i.e., as is the case under the Proposed Action.

[2] The NTP for the Clackamas River Project is defined as the temperature in the stream under natural conditions in the absence of anthropogenic influences (reservoirs and dams). The NTP is typically calculated using a temperature model of the system, applied using stream geometry and flow conditions best resembling a naturally flowing stream.

An additional memorandum (Battelle, 2004b) describes the basis for changes made at the connection between Timothy Lake and the upper Oak Grove Fork. Application of the previous iteration of the model revealed that an incorrect relationship between the Timothy Lake and upper Oak Grove Fork models resulted in under-prediction of DO concentration-based on comparison to empirical data- in the Timothy Lake tailrace during some times of the year.

The water quality model shows a decline in DO downstream of Timothy Lake dam, which is a function of contributing water from the hypoliminion of the lake and low DO groundwater. As the instream water temperature increases, the solubility of oxygen decreases, contributing to lower DO levels. The water being released from Timothy Lake also contributes to the lowering of DO in the Oak Grove Fork. In the summer and fall as the reservoir stratifies, DO levels in the hypolimnion drop to between 1 to 5 mg/L. This water is then released into the channel in the fall. Dissolved oxygen at the outlet, however, was at or near 100 percent saturation during most sampling events despite the low DO conditions at the lake intake depth. This is most likely due to the re-aeration of the water from the spray of the Howell-Bunger valve. DO concentrations immediately downstream of Timothy Lake exceeded ODEQ standards at all times except when the Howell-Bunger valve was releasing water.

Groundwater accretion is another factor contributing to low DO levels in the Upper Oak Grove Fork. Sampling in the seeps located immediately downstream of Timothy dam revealed water with low DO, ranging from 65 to 90 percent saturation, higher pH (8.0-8.5), and higher total alkalinity (36 to 45 mg/L) than water from Timothy Lake (EES, 2003). These seeps contribute to the drop in DO, which results in the water quality model showing current operations falling below state standards for 67 days in the 2000-2001 time period (Battelle, 2004). These periods are only for the Oak Grove Fork immediately downstream of Timothy Lake dam (RM 68.7 to 68.4). Further downstream, above Lake Harriet (RM 58.65), DO saturation was measured between 96 and 100.4 percent for the 2000 to 2001 study period (EES, 2003). This saturation results in DO levels between 10 and 12 mg/L year-round.

Water released from Timothy Lake remains relatively cool all year, with the highest temperature measured at 11.21°C (Table 3.2.2.1-8) (Batelle, 2004). Temperatures in the Upper Oak Grove Fork remain well below state maximum temperature standards. With all the water diverted to Frog Lake, however, temperature in the Oak Grove Fork tends to increase downstream of Lake Harriet and, under the water quality model, rises above state standards near Skunk Creek for 39 days in the two year period from 2000 and 2001. At the mouth of the Oak

Grove Fork, the water quality model shows that exceedences for state standards drop to 26 days (Battelle, 2004).

Table 3.2.2.1-8. Oak Grove Fork temperature summary (water quality model data 2000-2001).

Monitoring Site	River Mile	Hottest 7 days (range)	Days above Standard	Percent of Total Days	Highest Instantaneous Recorded Temperature[1] (ºC)
Timothy Lake Outlet	68.47	10/18 – 10/24/00 9/18 – 9/24/01	0	0	11.21
Lake Harriet USGS Site	58.65	7/27 – 8/2/00 8/10 – 8/16/01	0	0	11.33
Above Skunk Creek	55.78	7/28 – 8/3/00 8/8 – 8/14/01	39	7.3	16.32
Mouth of Oak Grove Fork	52.18	7/28 – 8/3/00 8/8 – 8/14/01	26	4.8	16.21 [2]

[1] ODEQ rearing standard is 16.0 °C;
[2] ODEQ spawning standard is 13.0 °C
Source: Battelle, 2004

Middle Clackamas River

The middle Clackamas River from the Oak Grove Powerhouse to North Fork Reservoir exhibits a slightly basic pH (7.6-7.9), DO saturation between 98.7 and 101.9 percent, nitrate-nitrite levels between 0.007 and 0.011 mg/L, total Kjeldahl nitrogen concentration between 0.145 and 0.185, and ortho-phosphate levels between 0.011 and 0.013 (Table 3.2.2.1-5) (Framatome ANP DE&S, 2002a; EES, 2003).

Temperature levels in the Clackamas River are found in Table 3.2.2.1-9. Downstream of the Roaring River, the Clackamas River's temperature begins to rise above the 16ºC Annual Maximum 7-day Running Average of Maximum Daily Water Temeprature (M7MMT) standard set by ODEQ. In several stream reaches temperatures naturally exceed the numeric criteria. In consideration of this fact, the compliance is based on meeting the NTP temperature during the period when NTP is greater than the numeric temperature criteria.

Table 3.2.2.1-9. Clackamas River Oak Grove Powerhouse to North Fork Reservoir temperature summary (water quality model data 2000 - 2001).

Monitoring Site	River Mile	Hottest 7 days (range)	Days Above Standard	percent of Total Days	Highest Instantaneous Recorded Temperature(°C)
Upstream of Oak Grove Powerhouse	46.84	7/28 – 8/3/00 8/8 – 8/14/01	82	15.3	19.42
Upstream of North Fork Reservoir	33.3	7/29 – 8/4/00 8/8 – 8/14/01	57	10.7	18.48
North Fork dam Tailrace	29.12	8/4 – 8/10/00 8/15 – 8/21/01	5	0.9	16.56

Source: Battelle, 2004

To evaluate the relative effect of the current Project operations on Clackamas River system temperatures, and to evaluate compliance with the temperature standards, the model was applied to simulate temperatures under flow conditions absent of the influence of Project dams and reservoirs. The model results, in combination with numeric temperature criteria, were used to evaluate compliance with temperature standards and to assess the effect of the Project on the temperature (Battelle, 2004).

Lower Reservoirs

The water quality of the three mainstem Clackamas reservoirs shows moderate to low nutrient conditions, low turbidity, slightly basic pH, and no thermal stratification in samples taken between 2000 and 2001(Framatome ANP DE&S, 2002a; EES, 2003). Table 3.2.2.1-10 shows the water quality data for these reservoirs.

Water quality sampling conducted in 1996 in North Fork Reservoir showed that the concentration of inorganic nitrogen and chlorophyll *a* along with the low counts of phytoplankton indicated an oligotrophic lake (Raymond et al, 1997). The concentration of phosphorous in the bedrock of the watershed led to high levels of phosphorous in the reservoir when compared to other oligotrophic lakes. While absolute abundance of phytoplankton was low, the dominance of *Anabaena* species in the phytoplankton community can be attributed to this increased level of phosphorous relative to nitrogen.

Table 3.2.2.1-10. Mean values for water quality parameters for Clackamas River reservoirs, April 2000 through April 2001.

	pH	Percent DO	Sp. Cond.	Total Alk.	Hard.	Turb. (NTU)	TSS	TDS
Timothy Lake Site A								
Photic Zone	7.91	49.7	96.9	26.1	20.0	1.20	0.60	40.4
1.0 m Off Bottom	7.17	56.5	48.7	25.9	20.1	1.39	1.08	42.5
Epilimnion (June-Sept)	8.21	102.7	45.8	26.5	19.6	0.84	0.80	35.5
Metalimnion (June-Sept)	7.90	103.9	48.1	27.2	19.6	1.72	1.00	40.0
Timothy Lake Site C								
Photic Zone	7.87	48.2	99.1	25.0	20.0	0.99	0.50	39.8
1.0 m Off Bottom	6.97	34.4	50.3	25.7	19.7	1.15	1.02	41.3
Epilimnion (June-Sept)	8.11	103.6	45.0	25.7	19.4	0.88	0.78	30.0
Metalimnion (June-Sept)	7.83	100.3	48.0	26.6	19.1	1.95	1.23	20.0
Harriet Lake								
Photic Zone	7.72	97.7	53.9	28.8	22.8	0.52	0.50	38.0
North Fork Reservoir Upper Site								
Photic Zone	7.69	98.0	53.6	24.9	19.1	0.8533	1.75	34.1
North Fork Reservoir Lower Site								
Photic Zone	7.63	98.3	53.2	25.5	19.5	0.8759	1.3015	23.6
Off Bottom	7.56	97.6	52.1	24.6	19.5	1.7457	1.2413	42.4
Epilimnion (June-Sept.)	7.59	99.1	55.2	29.5	22.1	0.69	0.3	50.0
Faraday Lake								
Photic Zone	7.72	99.8	51.1	24.5	19.2	0.996	0.8502	45.6
Estacada Lake								
Photic Zone	7.62	99.6	52.3	24.0	18.8	0.9606	0.6333	44.0

Source: Framatome ANP DE&S, 2002

percent DO = Percent DO saturation
Sp. Cond = Specific Conductance
Total Alk. = Total Alkalinity
Hard. = Hardness
Turb. = Turbidity
TSS = Total Suspended Solids
TDS = Total Dissolved Solids

As the first dam on the Clackamas River, North Fork Reservoir receives large quantities of sediment, especially from the Western Cascades physiographic province, which is susceptible to mass wasting events. These sediments tend to be transported through the Clackamas River because of its high gradient, but are deposited in the quiescent waters of North Fork Reservoir.

There are very few point source discharges upstream of River Mill dam. The only major discharge is from the City of Estacada's wastewater treatment plant, which discharges less than 1 mgd into Estacada Lake. The other minor discharges include wastewater discharges from the USDA Forest Service Timber Lake Civilian Conservation Center and Estacada Mobile Village.

Lower Clackamas River

The Clackamas River downstream of River Mill dam is on the state 303(d) list for violation of ODEQ temperature and bacteria standards. Taste and odor problems sometimes occur with nutrient increases during periods of low flow. The ODEQ water quality monitoring station near High Rocks (RM 1.2) shows that water quality is generally good throughout the year, despite the proximity of major population centers. Downstream of Carver Bridge (RM 7.9), the population growth of Gladstone and Oregon City places pressure on the Clackamas River, which occasionally exhibits high levels of fecal coliform, total phosphorous, and biochemical oxygen demand. Increased productivity is evidenced by the high temperatures and supersaturation of DO that come with summer low flow periods.

Despite these issues, the water in the lower watershed is considered "generally good compared to other regional sources" (RWSP, 1996). The ODEQ water quality index has shown that a slight, but statistically significant, improvement of water quality has occurred between 1980 and 1995 (ODEQ, 1996). Water quality data are found in Tables 3.2.2.1-6 and 3.2.2.1-7 and temperature values are found in Table 3.2.2.1-11.

Table 3.2.2.1-11. River Mill dam temperature summary, water quality model data 2000-2001.

Monitoring Site	River Mile	Hottest 7 days (range)	Days Above Standard	percent of Total Days	Highest Instantaneous Recorded Temperature (°C)
River Mill Tailrace	23.32	8/4 – 8/10/00 8/14 – 8/20/01	26	4.9	17.28
Eagle Creek	15.5	8/1 – 8/7/00 8/7 – 8/13/01	210	39.2	21.35
Oregon City	2.5	8/1 – 8/7/00 8/8 – 8/14/01	24	4.5	21.25

Source: Battelle, 2004

3.2.2.2 Environmental Effects

In this section, we describe the effects of the Proposed Action on flow and water quality in the Clackamas River Basin. In turn, we use the results of this analysis to evaluate the effects of the Proposed Action on other resources such as fish, wildlife, threatened and endangered species, and recreation.

3.2.2.2.1 Flow

In order to help evaluate the effects of the Proposed Action and various additional measures on flow and reservoir elevations, PGE commissioned the Clackamas River Operations Simulation Model (Gomez and Sullivan, 2001). The model uses available flow and operational data for a 31-year period (Water Years 1970 to 2000) to develop a hydraulic simulation of the existing system. The model allows accurate simulations of the effects of alternative operating scenarios on flow and reservoir elevations at various points of interest (referred to as nodes) in the watershed on an hourly and daily basis over the 31-year period and can be used to predict the quantitative effects of Project operations on flow.

An example of a constraint would be a flow limitation or a lake elevation. Some locations, or nodes, have no active constraints (i.e., no limits placed on the model at those locations), and the condition is the result of the constraints placed in other locations on the system. Ramping rates are operational constraints imposed independently of the flow and reservoir level controls. Viability of ramping rates and other operational issues are examined outside the model, but using the model results. These results indicate water availability in space and time for a given set of constraints and given set of precipitation data. The results, therefore, are a product of the constraints, the input data, the model assumptions, and the calibrations.

The model was first calibrated using existing flow and operating rules. This calibration process develops a current condition that adequately simulates a known set of conditions for a variety of inflows (wet, dry and average conditions). We determine the adequacy of the calibration by comparing model flow patterns and magnitudes (results) to the actual flows for that period.

Once the model is calibrated, the flow constraints, such as minimum and maximum flows and lake levels, are altered at the desired locations to change the rules by which the model allocates water. The results of these model runs are then compared at unconstrained locations to determine if the controls placed on the system at other nodes achieve the target results.

Water Quality

The results of the Simulation Model can help determine the effects that different operations scenarios will have not only on water quantity, but also on water quality. The water quality of the Clackamas River within the Project area is generally excellent with very low concentrations of nutrients, high DO levels, and pH values within state standards. There are several construction activities proposed as part of the Proposed Action that would disturb land and have the potential to result in erosion, sedimentation, and increased stormwater runoff that could adversely affect water quality. These construction activities, however, would be of short duration and affect a very small area. Standard sediment/erosion control and stormwater management best management practices would minimize potential water quality impacts.

Components of the Proposed Action would involve the construction of new sanitation facilities and RV dump stations. Although these facilities could potentially serve as sources of pollution, the overall provision and proper maintenance of these sanitation facilities would improve water quality. There may, however, be some small increase in erosion due to construction, use, and maintenance of these facilities.

The primary Project-related water quality concern is temperature. In order to evaluate the effects of the Proposed Action and various additional measures on water temperature, PGE commissioned a detailed water quality model developed off the platform CE-QUAL-W2 for the Clackamas River (Battelle, 2003) based on data collected by PGE between April 2000 and September 2001. The Simulation Model, combined with the water quality model allows for predicting water quality – and specifically water temperatures – under various flow and release conditions.

Reservoirs warm surface water, which can adversely affect many of the cold water-dependent fish species common in the Project area. Since the temperature issue is closely related to flow management, we have integrated the discussion of Project effects on flow and water quality below.

3.2.2.2.2 Proposed Action

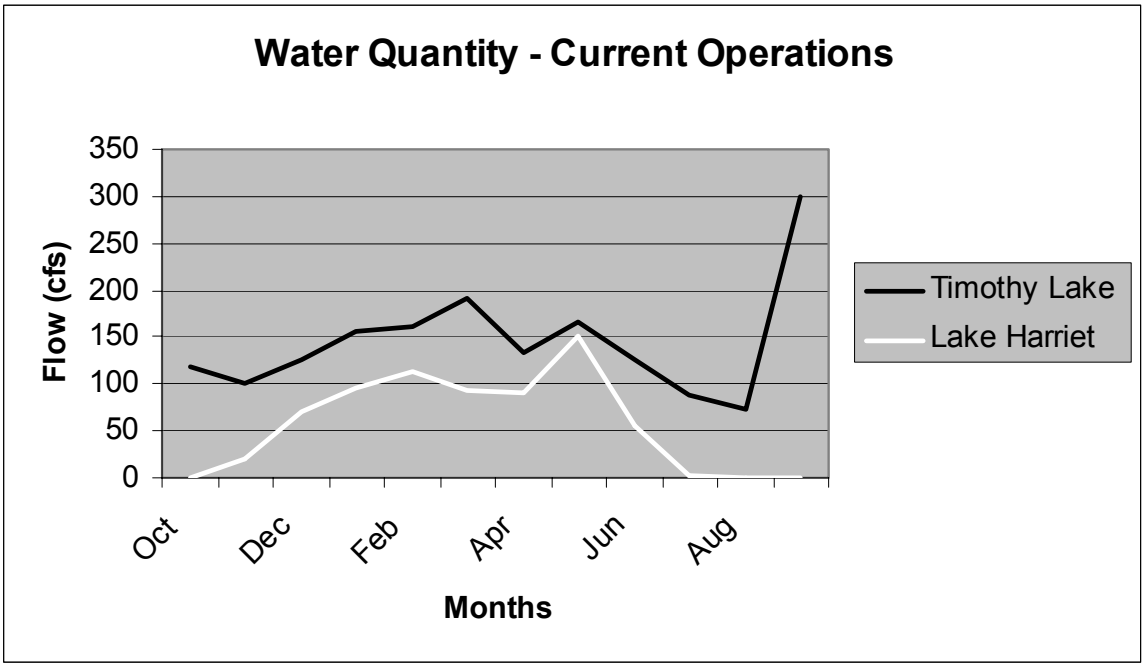
Summary

This section seeks to offer a broad summary of the water quantity for the Project area based on the Proposed Action. More detailed descriptions can be found in the following sections. Figures 3.2.2.2-1 (a) and (b) and 3.2.2.2-2 (a) and (b) show simulated monthly average flows at set points in the system. Starting at Timothy Lake, which is the most upstream portion of the Project area, water generally is released from the dam at Timothy lake in the winter as winter rains and snows contribute precipitation. Through the winter, the maximum release is the same under current operations, but large scale flow releases are limited to three events. In the spring and early fall, the Proposed Action would increase the minimum release and decrease the maximum release to produce a more smooth and less flashy hydrograph. This is most evidenced by the lower, sustained flows in the fall. In the summer, water is released the least and this results in the lowest flow in the Upper Oak Grove Fork. Even though the Proposed Action would result in an additional 60 cfs being released in the summer, monthly average flows from May to August would be essentially the same under the Proposed Action as under current operations. Under simulated current operations, PGE maintains water levels in Timothy Lake above elevation 3,190.0 ft during the entire summer season for 23 of the 31 years. In the other 8 years, water levels in Timothy Lake dropped below the minimum elevation of 3,189.0 ft, and 7 of these summers falls below this level for the entire summer. These low water levels are attributable to increased minimum flow releases from Timothy Lake, which prevent the lake from filling in the spring during years with a small snow pack. This flow regime is mimicked downstream below Lake Harriet.

The Proposed Action calls for water to be released at Lake Harriet, rather than being passed through the Frog Lake diversion. The flow release proposal is complex and is summarized in Table 2-1 and described in detail in the Settlement Agreement (available at www.ferc.gov), but in general, releasing between 70 and 100 cfs year-round would provide more sustained flow that mimics natural patterns. Under the Proposed Action flow volume would increase throughout the fall and into the winter, providing much more water instream than under current conditions. The Proposed Action calls for high flow events to be released in the Winter as well as snowmelt simulation in the Spring. The result, again, would be more water in the stream channel. The effects of the Proposed Action on flows would be most significant at low flow periods (summer, early fall) when the channel is mostly dewatered under current conditions.

Figure 3.2.2.2-1 Oak Grove Fork Water Quantity

(a) Current Operations



(b) Proposed Action

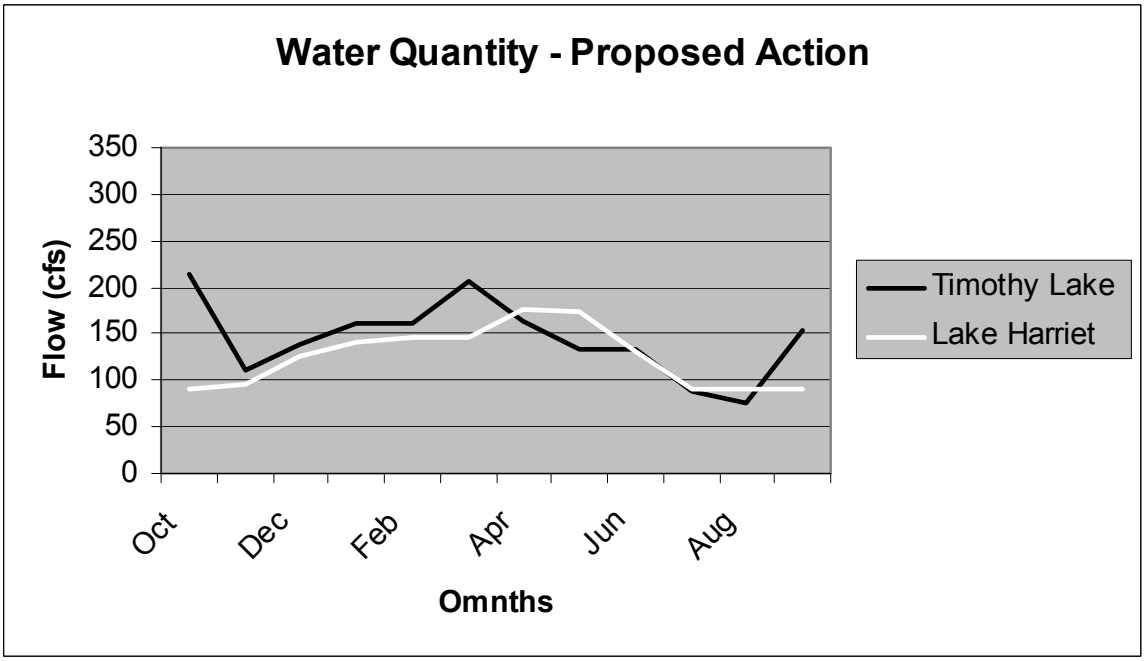
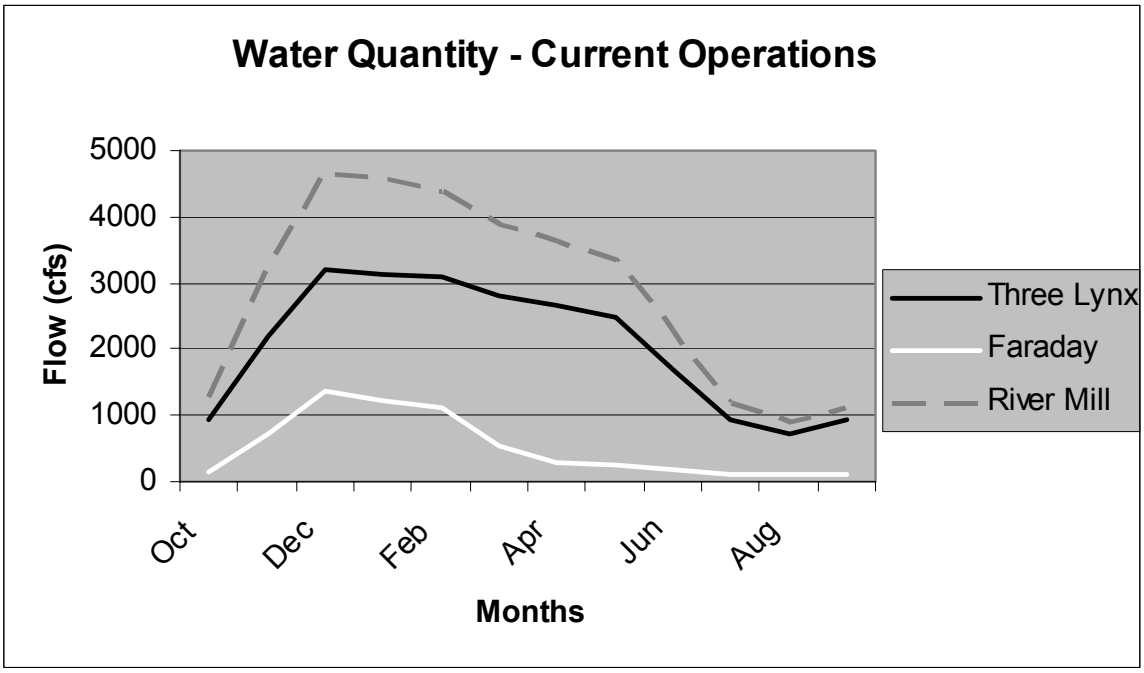
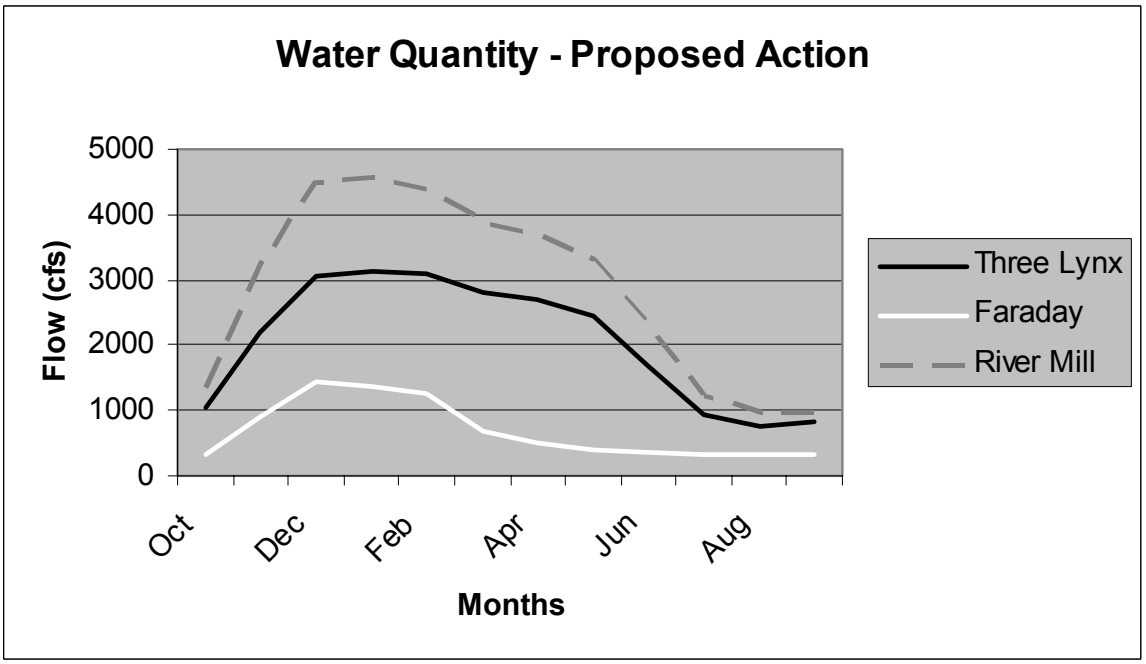


Figure 3.2.2.2-2 Clackamas River Water Quantity

(a) Current Operations



(b) Proposed Action



Once the Oak Grove Fork merges with the mainstem Clackamas, the unregulated Clackamas River upstream of the Oak Grove Fork drives the flow regime. This is evidenced by the fact that even though much more water is being released at Lake Harriet, the station at Three Lynx remains relatively unchanged between current operations and the Proposed Action. At the Three Lynx gage, flow resembles simulated unregulated conditions with significant increase in flow in the late fall, frequent winter flooding, spring snowmelt and decreasing flow in the summer and early fall. The next station is located downstream of the Faraday Diversion, where currently a substantial portion of the flow is either diverted to Faraday Lake or retained by Faraday Diversion dam. The river here follows the typical patterns with higher flows in the fall, indicative of a rainfall dominated physiographic province, fewer winter floods, and low flows in the summer and early fall. Downstream of River Mill, flows more closely mimic a simulated, unregulated system in both water quantity and flow patterns.

Under the Proposed Action, more water would be released from the Diversion dam, and this, coupled with a larger drawdown from North Fork Reservoir, would result in greater amounts of water in the channel at this location. Water levels in this reach would still be much lower than under simulated unregulated conditions, but the roughly 300 cfs of extra flow would have a significant effect, especially during the low flow periods of late summer and early fall.

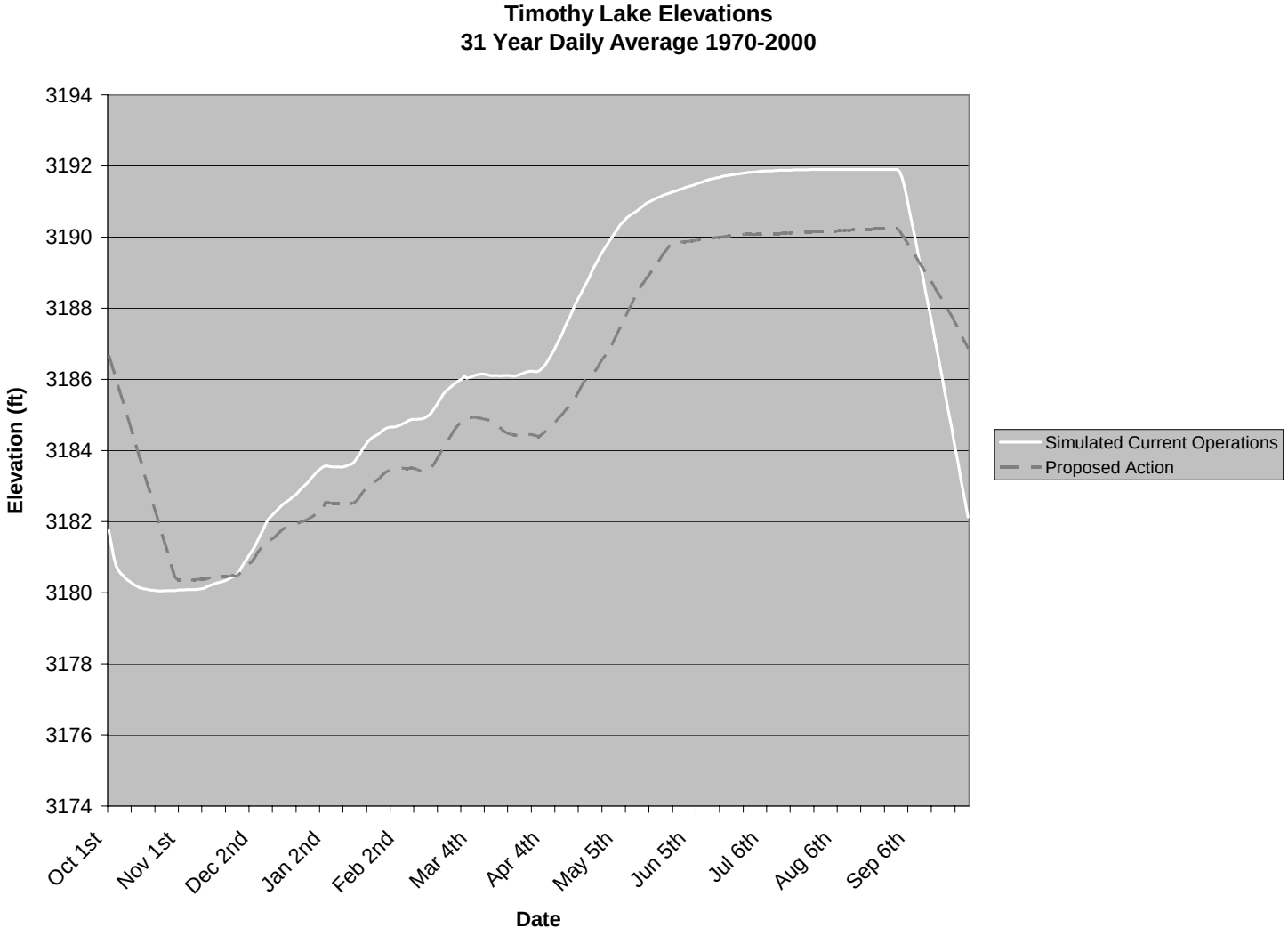
Table 2.2-1 provides a detailed description of the Proposed Action. We discuss the effects of this proposal on water quantity (flow and reservoir water levels) and water quality (temperature and other parameters) on a reach-by-reach basis below.

Timothy Lake

Water Quantity

Carson (2004) simulated the effects of the Proposed Action on water elevations and flows over a 31-year period (1970 to 2000). Figure 3.2.2.2-3 shows the simulated average water elevation under current operations and the Proposed Action. The Proposed Action would result in lower water levels (1 to 2 feet) for most of the year, but it also would result in more water in the reservoir for September and October.

Figure 3.2.2.2-3. Simulation model results – Timothy Lake level elevations: average elevation (1970-2000).



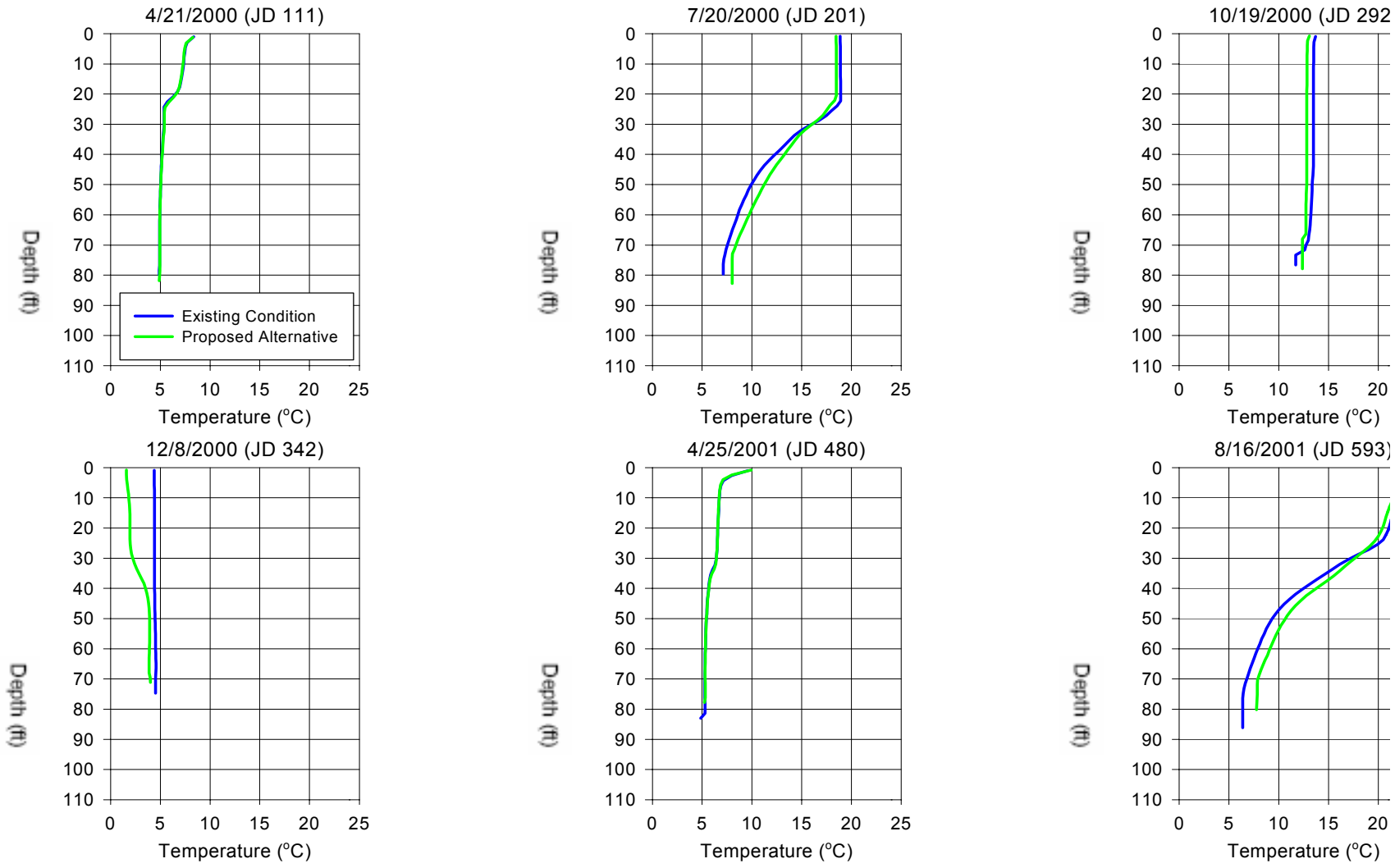
Under PGE's current operations, Timothy Lake surface elevation is held at 3,189 ft or higher from Memorial Day to Labor Day. Surface elevation in summer varies by 2-3 ft depending on starting elevation. Fall drawdown occurs following Labor Day, with the rate of drawdown and the date at which refill begins varying in relation to snowpack and expected precipitation. Typical fall drawdown is 10 to 15 ft, but reservoir surface elevation also varies during a given year depending on snowpack and expected precipitation. Surface elevation also varies in winter as water is stored or released to minimize spills downstream at Lake Harriet to conserve water for generation; water is stored when accretion and surface runoff below Timothy Lake result in flows above 600 cfs into Lake Harriet, or the capacity of the Frog lake flowline.

Under the Proposed Action Timothy Lake's elevation would be 3,189 ft by Memorial Day, with a goal of achieving a surface elevation of 3,190 ft by July 1, if possible (constrained by minimum flow), but never higher than 3,191.9 ft. No drafting of the reservoir below 3,189 ft would occur before Labor Day, with a maximum drawdown before Labor Day of 1.5 feet. No drafting of the reservoir below 3,190 would occur before August 1, with a potential delay until August 15 if indicated by annual amphibian surveys. During the remainder of the year, elevation could be as high as 3,191.9 feet. Fall drawdown of Timothy Lake would begin no earlier than the Tuesday after Labor Day and would be accomplished according to the maximum flow release scenario described below under the "Upper Oak Grove Fork" subheading. From the day after Labor Day through the day before Memorial Day, the normal minimum elevation of Timothy Lake would be 3,170 ft, with an extreme minimum of 3,125 ft.

Water Quality

Temperature modeling indicates that the Proposed Action would have little effect on Timothy Lake temperature and stratification (see Figure 3.2.2.2-4). Overall there are only small differences between the simulated temperatures of the existing conditions and the Proposed Action: in both cases, stratification begins to develop in April. Under simulated existing conditions stratification was evident during the summers of 2000 and 2001, with surface temperatures reaching almost 20°C and 23°C during the summers 2000 and 2001, respectively. The simulated temperature profile for the Proposed Action shows a slight increase in temperature at depths relative to existing conditions. Simulated reservoir turnover occurred by mid October for both the existing conditions in October 2000 and the Proposed Action; the second-year simulation period ends prior to turnover.

Figure 3.2.2.2-4. Predicted temperature profiles – Timothy Lake.

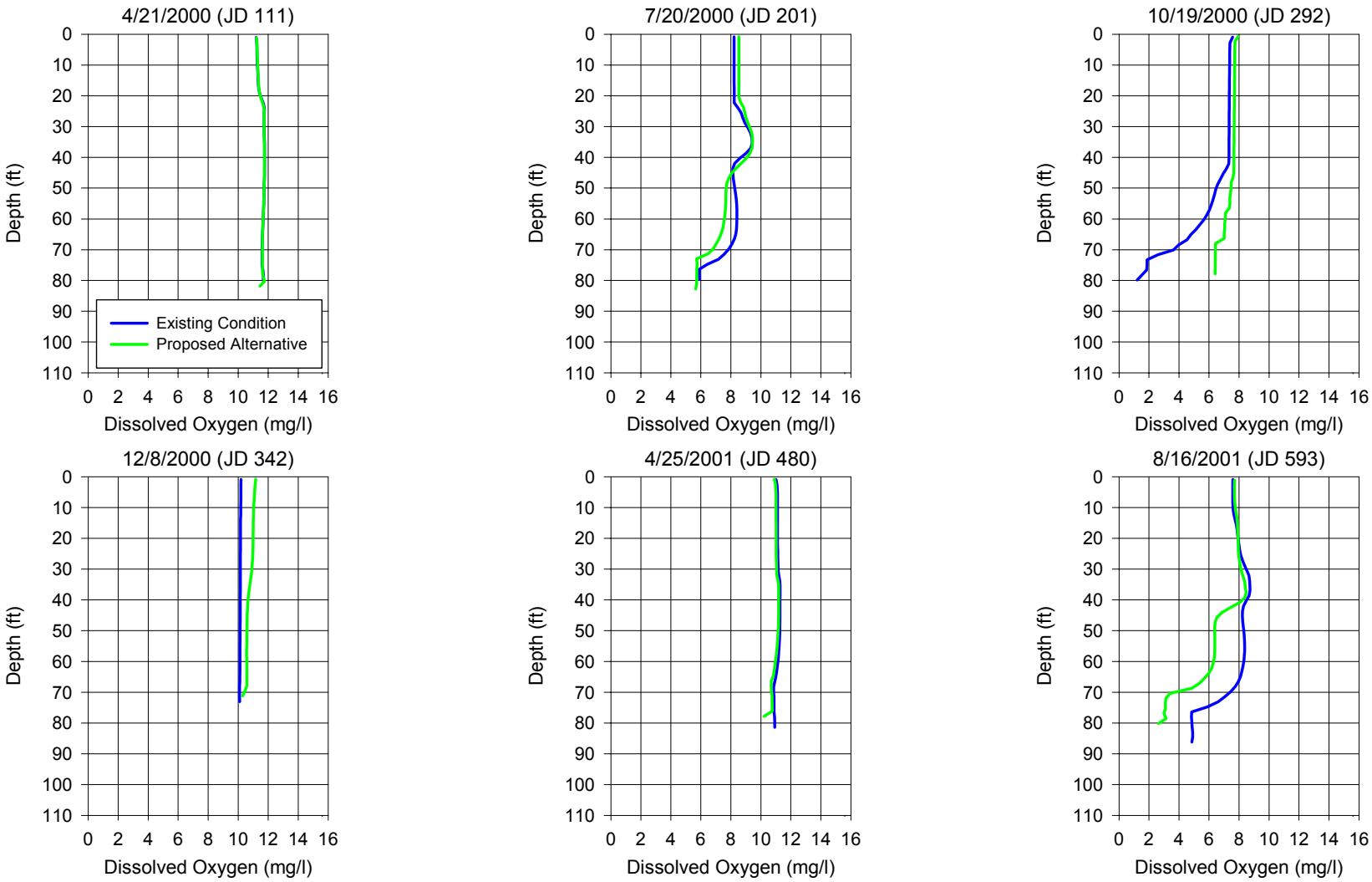


The Timothy Lake water quality modeling shows slight differences between Proposed Action and existing conditions for temperature and DO in the late summer and early fall (Figures 3.2.2.2-4 and 3.2.2.2-5). During the winter and early spring periods of both 2000 and 2001, DO was high and relatively constant throughout the water column for both scenarios. During early summer through fall, surface DO decreased corresponding to the rise in temperature (7/19/2000, 10/18/2000, and 8/15/2001). There was also a decline in DO in the hypolimnion of Timothy Lake during summer and fall 2000 and summer 2001. During the summer 2000, these hypolimnetic declines in DO were larger for the existing conditions than for the Proposed Action. For the summer 2001, the situation was reversed, with the Proposed Action having lower DO in the hypolimnion. The larger outflow for the Proposed Action during summer 2000 appeared to increase the mixing of DO into the hypolimnion. During summer 2001, the lower water surface elevation combined with lower flows appears to have had an effect on hypolimnetic DO for the Proposed Action.

On October 18, 2000, modeled DO in Timothy Lake, under existing conditions and the Proposed Action, was below the ODEQ criterion of 8.0 mg/L throughout the water column. However, the CE-QUAL-W2 model appears to under-predict DO in Timothy Lake during warmer months. Profile data collected at the TIMC site on October 18, 2000 show that DO concentration ranged from 9.2 mg/L at the surface of the reservoir to about 1.3 mg/L at a depth of 25 m.

DO concentrations at the Timothy Lake outlet are similar throughout the year, and consistently above 10 mg/L under both the Proposed Action and existing conditions (see Figure 3.2.2.2-5). DO concentrations at this site are in compliance when the 8.0 mg/L rearing criterion applies, but fall below the 11.0 mg/L criterion when it is in effect. Model outputs suggest that ambient DO would have been less than 11.0 mg/L during 23 and 105 days in 2000 and 2001, respectively, under the Proposed Action. However, these inconsistencies with ODEQ criteria would have been very slight and it is unclear to what extent they would have been attributable to Project operations or accounted for by the allowable error associated with the CEQUAL-W2 model. In addition, the inconsistencies are to some degree a result of the stepped structure of ODEQ's DO criteria. If the criteria changed gradually to reflect the way DO concentrations change under natural conditions, the observed inconsistencies would be of shorter duration or might not occur at all. Because the apparent inconsistencies during the period when the 11.0 mg/L criterion applies are so slight, PGE believes that they do not result in impairment of beneficial uses, in this case cutthroat trout spawning.

Figure 3.2.2.2-5. Predicted dissolved oxygen profiles - Timothy Lake.



Moreover, dissolved oxygen at this location under the Proposed Action would not fall below the 9.0 mg/L criterion that would apply if intergravel dissolved oxygen (IGDO) levels are greater than 8.0 mg/L. As a result, PGE is measuring IGDO concentrations throughout the Project area to determine whether the 11.0 mg/L or the 9.0 mg/L ambient DO criterion applies during salmonid spawning and incubation periods. Based on a limited dataset, the IGDO criterion (i.e., 8.0 mg/L) is generally met at pristine sites in Oregon. The only site where IGDO has not been met is Bear Creek in the Rogue Basin in southern Oregon, a site with algae, surface dissolved oxygen, and pH water quality problems that were addressed with TMDLs for ammonia, biological oxygen demand, and phosphorus in 1992 (A. Newell, ODEQ, personal communication). Based on water column DO concentrations in the Oak Grove Fork and Clackamas River, it is likely that IGDO concentrations equal or exceed 8.0 mg/L during spawning and incubation periods. As a result, it is highly probable that the 9.0 mg/L criterion will apply throughout the Project area, and the 11.0 mg/L criterion will not apply.

Upper Oak Grove Fork

Water Quantity

Under PGE's current FERC license, the year-round minimum discharge from Timothy Lake is 10 cfs, which takes priority over Timothy Lake surface elevation requirements. Maximum discharge from Timothy Lake is 300 cfs plus inflow to the lake, and the ramping rate is restricted to no more 0.33-ft/hr of stage change, as measured at the USGS Government Camp gage below Timothy Lake. Implementation of the Proposed Action would result in significant changes to the flow regime below Timothy Lake — maximum flows would be 70 cfs over inflow from Memorial Day to Labor Day, 100 cfs over inflow from Labor Day to September 30, 150 cfs over inflow from October 1 through October 31, 300 cfs over inflow from November 1 through February 28, and 100 cfs over inflow from March 1 - Memorial Day. During the period from November 1 through February 28, PGE would 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. Minimum flows under the Proposed Action would be as follows: Memorial Day to November 30, 60 cfs or inflow, whichever is less; December 1 through February 28, 30 cfs or inflow, whichever is less; and March 1 through Memorial Day, 40 cfs or inflow, whichever is less. Year-round downramping rates below Timothy Lake would be no more than 0.2 ft/hr. Upramping rates would be no more than 0.2 ft/hr except during days associated with inflow events that result in average daily inflows exceeding 600 cfs. PGE would attempt to minimize the frequency with which the upramping rate exceeds 0.2 ft/hr and will also attempt to minimize the

duration of any such events. Flows below Timothy Lake would be monitored via a satellite telemeter at the USGS Government Camp gage.

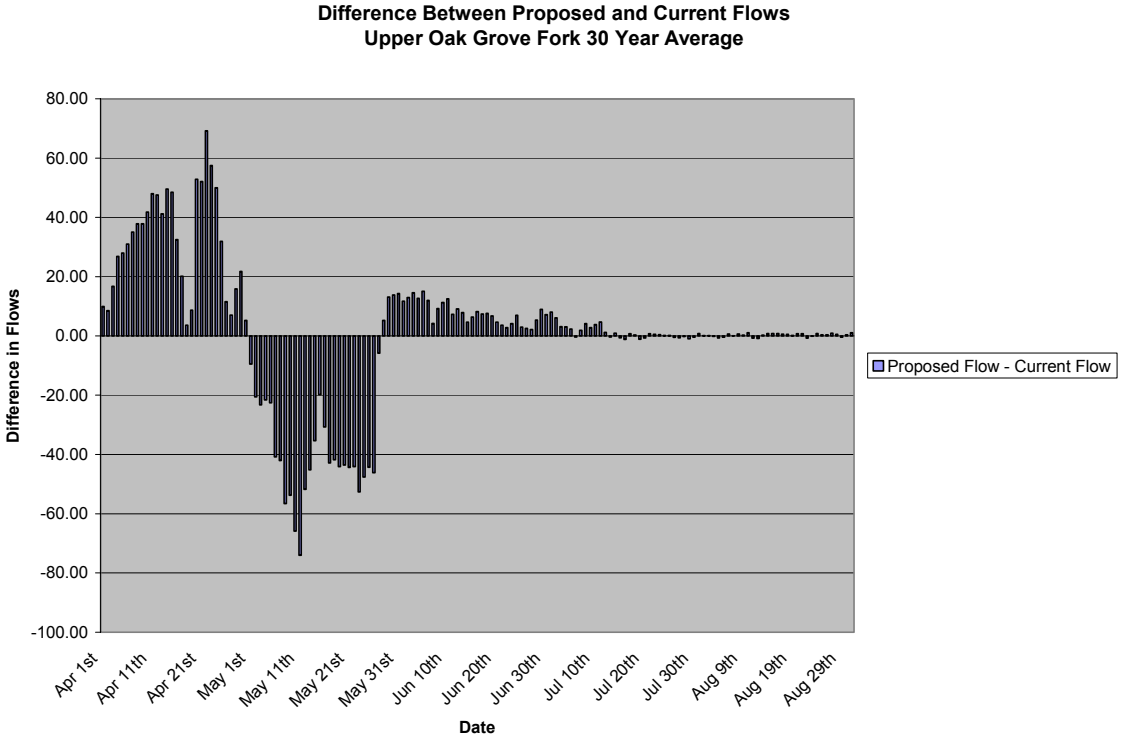
This proposed regime contrasts with current operations where PGE generally operates in a run-of-river mode at Timothy Lake with outflow approximating inflow until about Labor Day. PGE then rapidly increases releases to approximately 300 cfs above inflow. In a typical year under current operations, for example, releases from Timothy Lake increase from approximately 70 cfs to 300 cfs between August 31 and September 3. The Proposed Action would result in gradually increasing releases rather than the sharp peaks and drops in flow under current operations. Under the Proposed Action flows would rise from 70 to 150 cfs during the same four days. The Proposed Action would also result in extending the period of high flows in the fall until October 30, as opposed to current operations, which reduce high flows on October 4. Once the reservoir is drawn down, usually by early November, releases from Timothy Lake under the Proposed Action are similar to current operations for the rest of the year.

The overall effect of these changes would be to provide higher base flows throughout the year with greater variability (see Figure 3.2.2.1-4), and to reduce the magnitude of the releases associated with drawing down Timothy Lake in the early Fall. Figure 3.2.2.1-3 shows the 31-year average outflow from Timothy Lake for both alternatives. Figure 3.2.2.2-6 shows the difference in the 31-year average between existing and proposed flow releases from Timothy Lake into the Upper Oak Grove Fork for the spring and summer months. The negative values in this chart indicate times when the Proposed Action would result in lower flow below Timothy than under current operations.

The overall effect of these changes would be to provide higher base flows in the Upper Oak Grove Fork from late Fall through late summer (see Figure 3.2.2.1-4), and to reduce the magnitude of the releases associated with drawing down Timothy Lake in the early Fall. Figure 3.2.2.1-3 shows the 31-year average outflow from Timothy Lake for both alternatives. Figure 3.2.2.2-6 shows the difference in the 31-year average between existing and proposed flow releases from Timothy Lake into the Upper Oak Grove Fork. The negative values in this chart indicate times when the Proposed Action would result lower flow below Timothy than under current operations. During this time period, the applicant proposes to maintain a minimum flow of 40 cfs or inflow and a maximum of 100 cfs. This minimum inflow would be than greater than under current operations, and the maximum outflow is less than current operations. Therefore, during April, when the Proposed Action would provide more water to the Upper Oak Grove Fork, the minimum release provides more water to the river. When the current operational scenario releases more water in May, maximum flows from Spring snowmelt runoff dominate the hydrograph. The Proposed Action serves to

provide more water instream overall, but also stabilize the major fluctuations inherent under current operations.

Figure 3.2.2.2-6 Flow differences between proposed and Current Action



Water Quality

The proposed flow regime would have little effect on stream temperature in the Upper Oak Grove Fork. Temperatures in this reach are controlled more by the large volume of groundwater (distributed inflow) than by outflow from Timothy Lake (Battelle, 2003). Comparison of the seven day running average of the daily maximum (7DADM) temperatures between the current operations and Proposed Action shows little difference (Figure 3.2.2.2-7). However; an increase in temperature would occur under the Proposed Action compared to simulated existing conditions for Fall 2000. Nevertheless, temperature under the Proposed Action is predicted to be in compliance with the relevant ODEQ temperature criteria of 13.0°C and 16.0°C, when they apply.

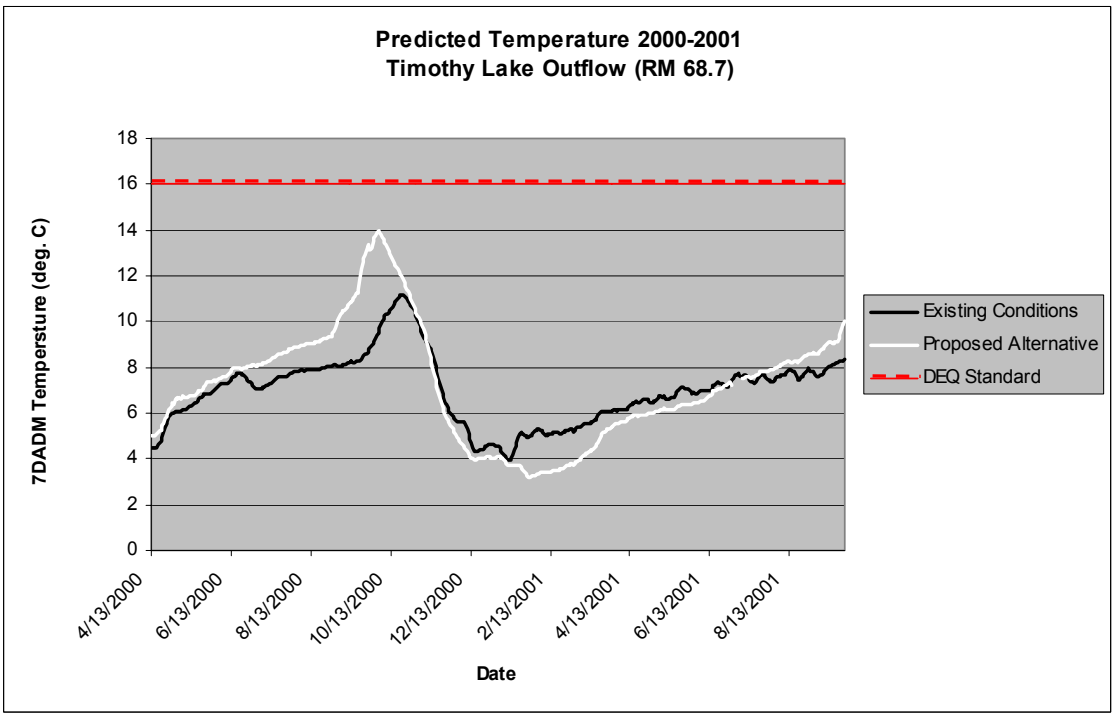
The gage used for temperature readings in Figure 3.2.2.2-7a is located upstream of this natural inflow. At this point, therefore, temperature differences can be attributed to operations at Timothy Lake. The greatest difference between existing conditions and the Proposed Action occurs in late September and early October, when temperature is as much as 3°C greater under the Proposed Action. This difference is most likely due to the more gradual releases of deep, cool reservoir water (7° to 8°C between 70 and 80 ft depth) under the Proposed Action. Even with a 3°C increase, temperatures would still be well below state standards.

Figure 3.2.2.2-7b shows temperature readings above Lake Harriet in a location that accounts for the distributed inflow from upstream sources. This accretion flow lowers the water temperature in summer and fall and minimizes differences between current operations and the Proposed Action. According to simulated conditions in October 2000 the only difference between these the proposed and current operational scenarios occurs when the Proposed Action is a roughly 1°C increase under the Proposed Action over current temperatures. This increase would most likely be due to the reduced magnitude of fall releases under the Proposed Action.

Figure 3.2.2.2-8 shows DO readings above Lake Harriet. The DO readings are similar to existing conditions throughout the year with a small increase in DO readings in the Timothy Lake dam outflow.

Figure 3.2.2.2-7. Water quality results – temperature Upper Oak Grove Fork.

a.



b.

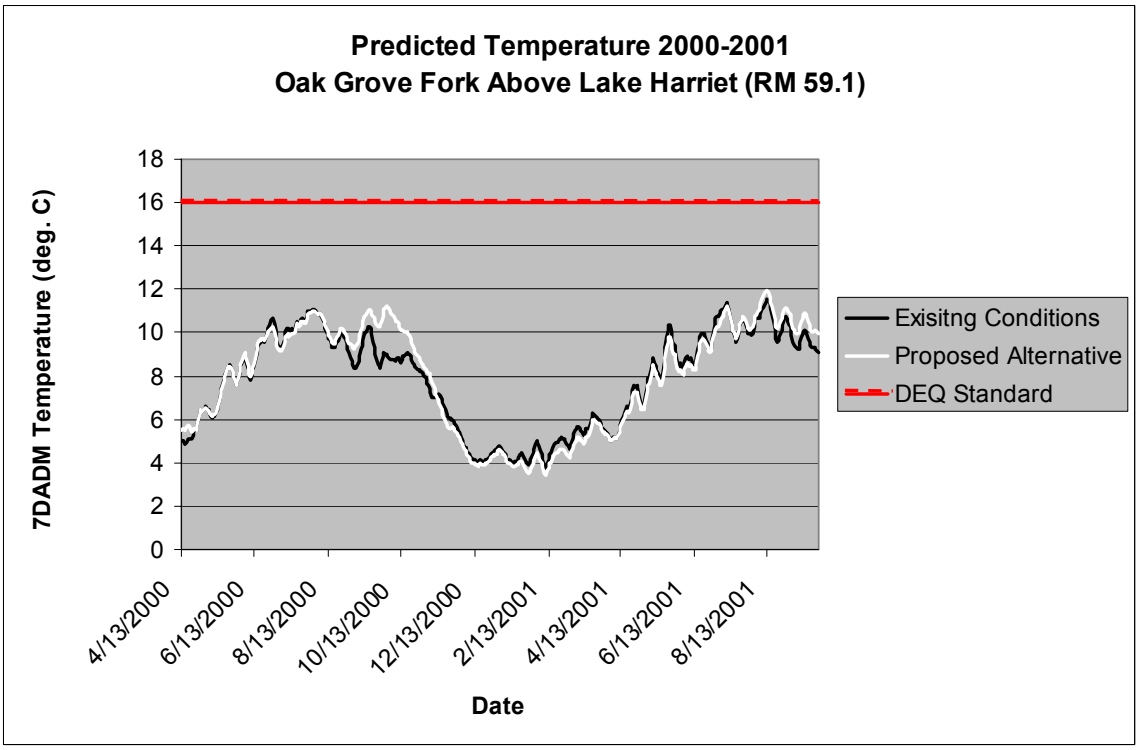
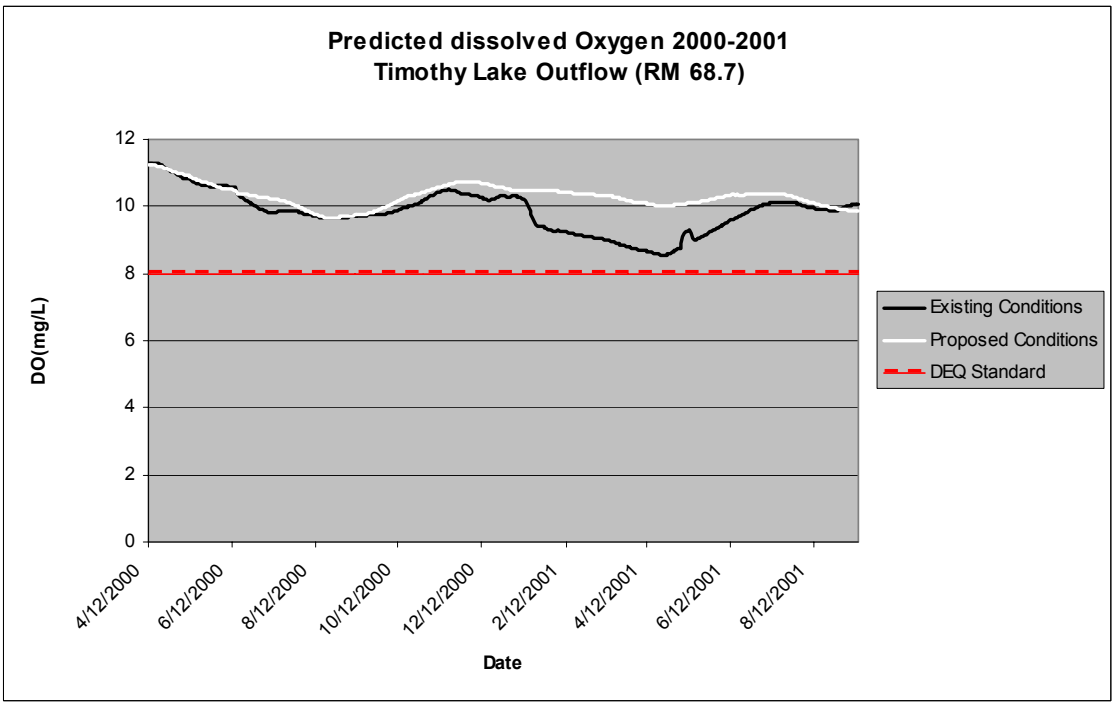
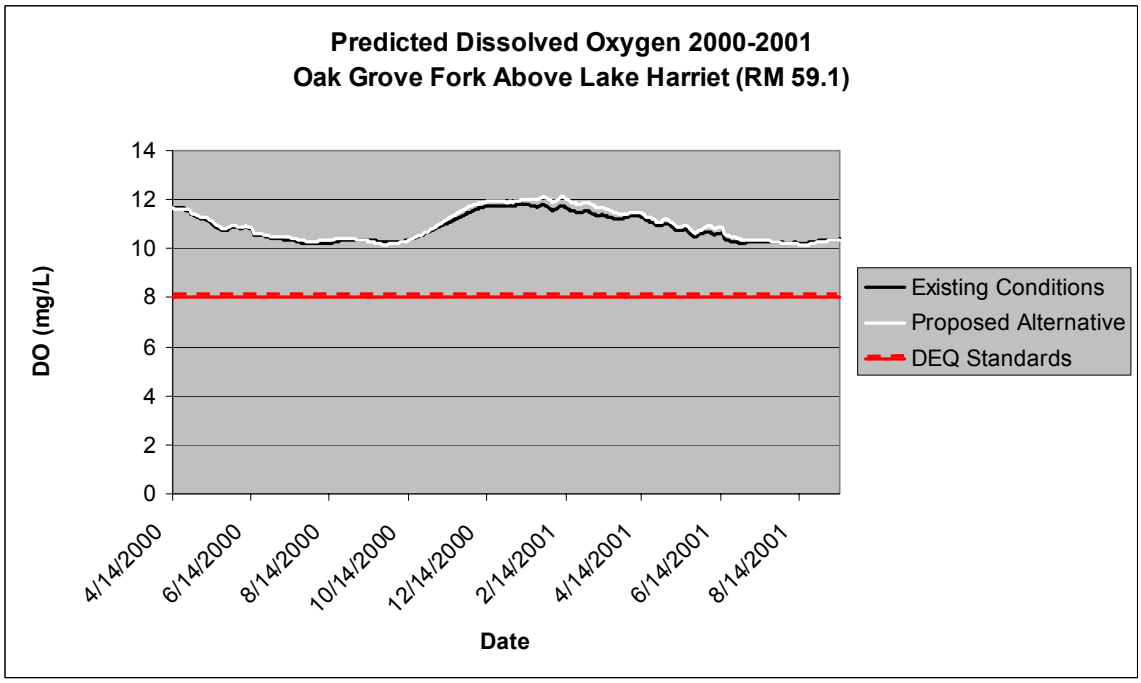


Figure 3.2.2.2-8. Water quality results – dissolved oxygen Upper Oak Grove Fork.

a.



b.



Lake Harriet

Water Quantity

Under existing conditions, there is no minimum flow release to the Oak Grove Fork below Lake Harriet. Flows in excess of the Frog Lake flow line capacity (600 cfs) result in spills to the lower Oak Grove Fork under high flow conditions. Most of the time, all flow in the lower Oak Grove Fork is the result of groundwater accretion and tributary input. Minimum flows released from Lake Harriet dam under the Proposed Action are described in the Lower Oak Grove Fork section, below. The Proposed Action flow regime would also involve the passing of some winter floods and a portion of snowmelt runoff, also discussed in the subsequent section of the lower Oak Grove Fork. Under the Proposed Action, the year-round surface elevation of Lake Harriet would be increased by 1 ft.

Water Quality

Under the Proposed Action, Lake Harriet's surface elevation would be 2,039.0 ft, with a minimum elevation of 2,020.0 ft. The new flow regime and the increase in reservoir surface elevation would not significantly affect temperature in Lake Harriet (see Figure 3.2.2.2-9). The short residence time in Lake Harriet ensures that the temperature in the reservoir is very close to the incoming temperature. The slightly higher temperature modeled during fall 2000 can be attributed to inflow temperatures from the upper Oak Grove Fork and operations at Timothy Lake. Temperature under the Proposed Action would be well below the salmonid rearing criterion of 16.0°C.

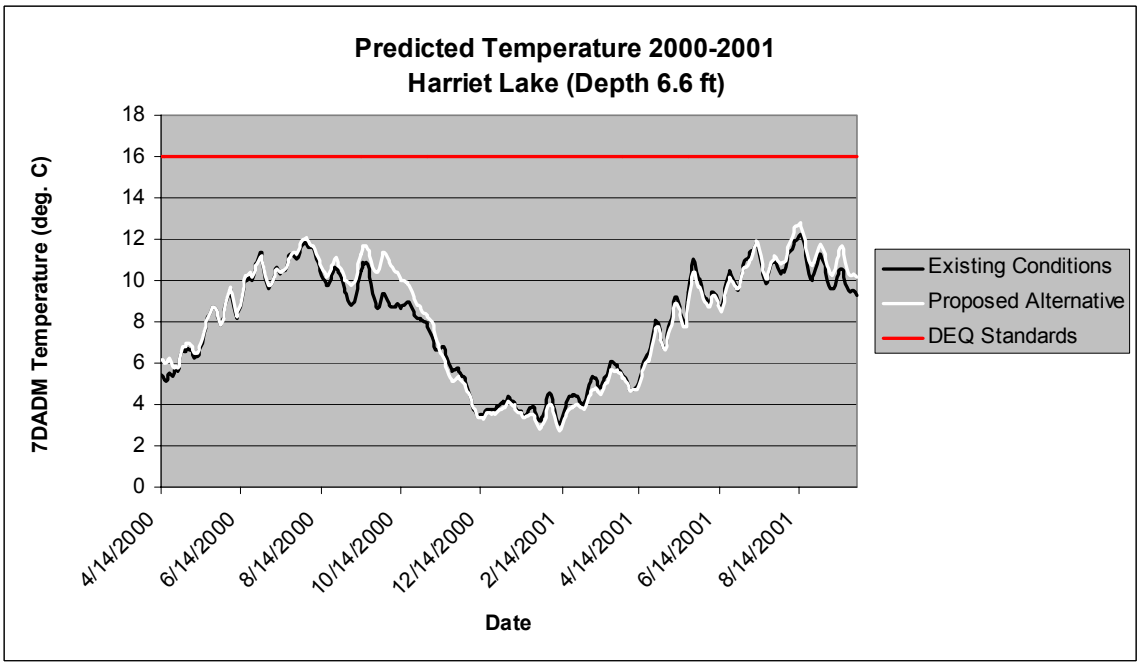
Frog Lake

Water Quantity

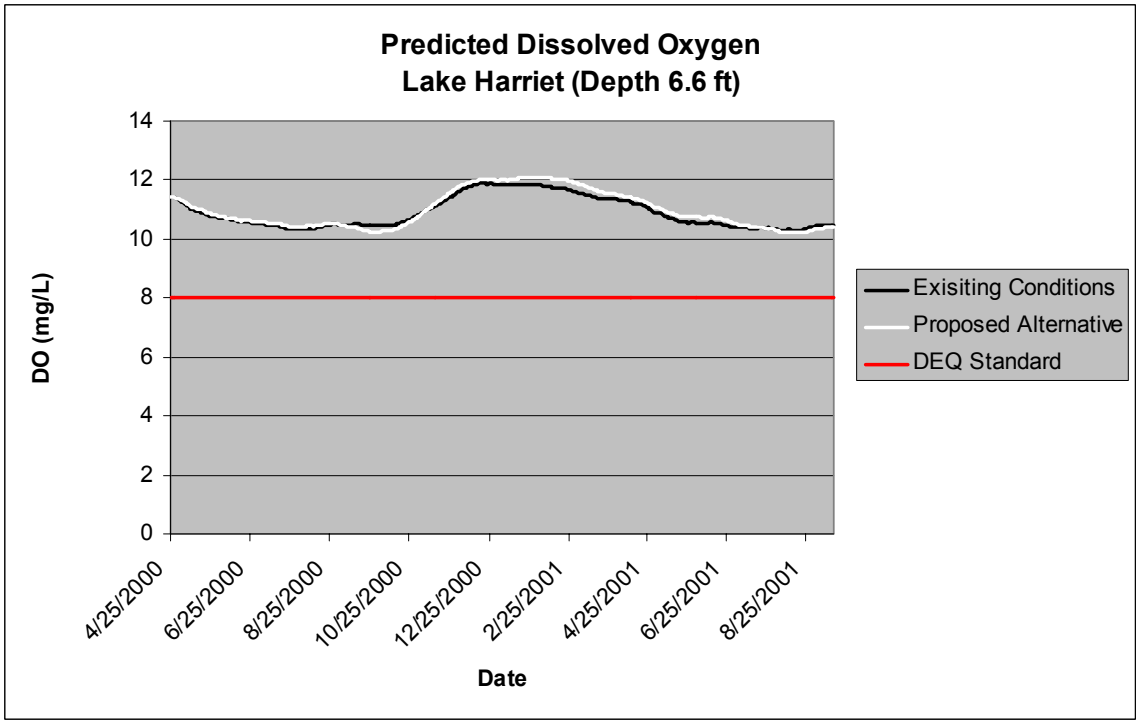
Under existing conditions during high inflow, Frog Lake is typically operated at about El. 1978, to produce the maximum flow in the Frog Lake FIowfine. In these conditions there is little fluctuation of Frog Lake and the Oak Grove Powerhouse is running at a constant high load. During low inflow conditions Frog Lake is held full to provide spinning reserve storage. Frog Lake is not fluctuated in these low inflow periods as the nighttime refill of the lake is not possible when inflows are very low. Under the proposed action Frog Lake's elevation would fluctuate between 1988.0 ft maximum, 1970.0 ft normal minimum, and 1958.0 ft extreme minimum

Figure 3.2.2.2-9. Water quality results – Harriet Lake

a.



b.



A comparison of DO concentrations between the existing conditions and the Proposed Action at the Oak Grove Fork above Lake Harriet site (RM 58.7) is shown in Figure 3.2.2.2-8. Simulated DO concentrations are above the 8.0 mg/L criterion when it applies, but fall slightly below the 11.0 mg/L criterion during some of the time that it applies for both scenarios, and reflect essentially the same situation that occurs in the Upper Oak Grove Fork near the Timothy outfall, as discussed above. Under the Proposed Action ambient DO would have been out of compliance during 29 and 38 days in 2000 and 2001, respectively. However, these violations would have been very slight and it is unclear to what extent they would have been attributable to Project operations or accounted for by the allowable error associated with the CE-QUAL-W2 model. In addition, the violations are also, to some degree, a result of the stepped structure of ODEQ's DO criteria. If the criteria changed gradually to reflect the way DO concentrations change under natural conditions, the violations would be of shorter duration or might not occur at all. Also, the effect of the Project on flows at this station is slight during much of the year, and DO concentrations primarily reflect natural conditions, e.g., that associated with surface and groundwater accretion flows between Timothy Lake dam and Lake Harriet, which account for a large volume of water. Regardless of the cause of the apparent violations, however, they are slight and of short duration and they do not result in impairment of beneficial uses, i.e., cutthroat trout spawning.

Moreover, as in the Upper Oak Grove Fork, DO concentration at this location under the Proposed Action would be greater than the 9.0 mg/L criterion that would apply if IGDO levels are greater than 8.0 mg/L. PGE's IGDO study throughout the Project area should determine whether the 11.0 mg/L or the 9.0 mg/L ambient DO criterion applies during salmonid spawning and incubation periods.

Lower Oak Grove Fork

Water Quantity

Under existing conditions, inflows to the lower Oak Grove Fork originate from infrequent spills from Lake Harriet. The primary flow source during most of the simulation period is distributed inflow along the length of the lower Oak Grove Fork. The Proposed Action would provide for the following minimum flows from Lake Harriet to enhance fish habitat in the lower Oak Grove Fork (below):

	Water year type		
	Wet	Normal	Dry
Oct l—Oct l5	100 cfs	l00 cfs	l00 cfs
Oct l6—Dec l5	80 cfs	80 cfs	80 cfs
Dec 16—Mar 31	70 cfs	70 cfs	70 cfs
Apr l—Jun l5	100 cfs	90 cfs	80 cfs
Jun l6—Aug 3l	100 cfs	90 cfs	80 cfs
Sep l—Sep 30	100 cfs	90 cfs	80 cfs

The Proposed Action would also involve the passing of some winter floods and a portion of the spring snowmelt runoff. Between January 1 and March 31, the first four instantaneous peak flows greater than 1,300 cfs (measured at the gage just upstream of Lake Harriet) that were separated by 5 or more days would be passed for 10 hr. After 10 hours, the 600 cfs diversion to Frog Lake would resume for the duration of the high flow event. When fewer than four 1,300 cfs events occur in a given year, all flow events with peaks greater than 1,300 cfs would be passed for 10 hr.

In addition to passing winter peak floods, a portion of the snowmelt runoff each year would be passed downstream of Lake Harriet dam, with the volume of water and duration of passage varying with water year as follows:

- 150 cfs would be passed for 54 days during wet years;
- 250 cfs would be passed for 3 days, ramping down to 150 cfs at 20 cfs /day during normal years; and
- 200 cfs would be passed for 3 days, ramping down to 150 cfs at 20 cfs /day during dry years.

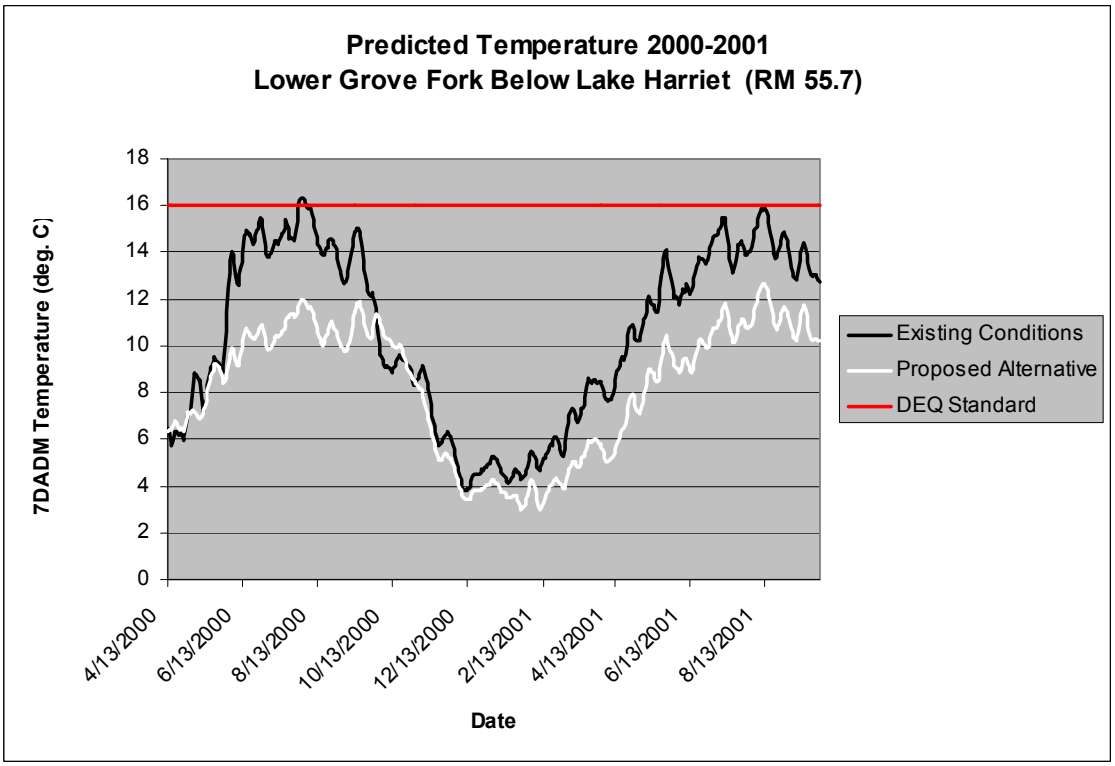
The Proposed Action would shift water that would otherwise be used to generate electricity at the Oak Grove Powerhouse to these minimum flow commitments in the Lower Oak Grove Fork. We discuss the reduced power output in section 4. The Proposed Action would eliminate the dry period seen during most of the year under current operations (see Figure 3.2.2.1-7). It would increase baseflow from zero under current operations (see Figure 3.2.2.1-6) to between 75 and 150 cfs year round. Tributary accretion flow also adds water to the channel downstream of Harriet dam, but as Figure 3.2.2.1-8 shows, it only averages 15 to 25 cfs for most of the year. Resource agencies recommending pulsed flows below Harriet dam to mitigate flow-related effects on habitat, but Commission consultation and approval would be required to implement pulse flows. The Commission will consider fall pulse flows if members of the Fish Committee provide information that shows the need for such flows.

Water Quality

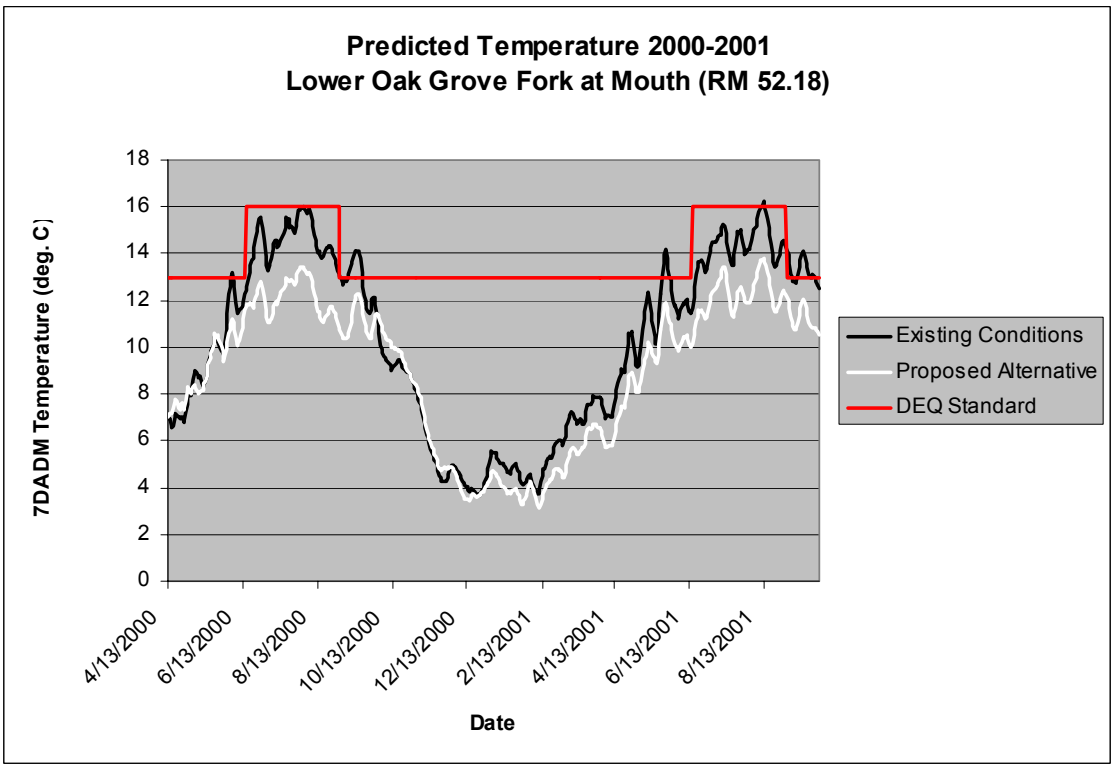
Temperature modeling indicates that the Proposed Action would result in significant reductions in water temperatures in the Lower Oak Grove Fork relative to existing conditions (Figure 3.2.2.2-10). These results are consistent with field data collected during spills at Lake Harriet in 2000, which indicate that flows released from Lake Harriet were cooler than accretion flow in the lower Oak Grove Fork, resulting in cooler temperatures in the lower Oak Grove Fork. Under the Proposed Action, modeling predicts that temperatures just above Skunk Creek would be up to 5°C cooler during the warmest part of summer relative to existing conditions, and the maximum reduction in temperature at the mouth would be about 2°C. At both sites, temperatures under the Proposed Action would comply with the relevant ODEQ temperature criteria of 13°C and 16°C, when they apply.

Figure 3.2.2.2-10. Water quality results – Lower Oak Grove Fork Temperature

a.



b.



DO concentrations for the Proposed Action would generally be slightly higher than under existing conditions as a result of the lower temperatures from proposed flow releases (Figure 3.2.2.2-11). Under the Proposed Action DO falls below the 11.0 mg/L criterion during parts of the year at both sites. The model predicts that ambient DO at the site upstream of Skunk Creek fell below the 11.0 mg/L criterion during 98 and 78 days in 2000 and 2001, respectively. DO predicted under the Proposed Action for the mouth of the Oak Grove Fork would be out of compliance during 100 and 79 days in 2000 and 2001, respectively. If ODEQ's DO criteria changed gradually to reflect the way DO concentrations change under natural conditions, the apparent exceedance might be of shorter duration or might not occur at all, but the criteria currently change abruptly from 11.0 mg/L to 8.0 mg/L and back again during a single day.

As with upstream locations, DO at both the Skunk Creek and mouth of Oak Grove Fork would, under the Proposed Action, not fall below the 9.0 mg/L criterion that would apply if intergravel dissolved oxygen (IGDO) levels were greater than 8.0 mg/L.

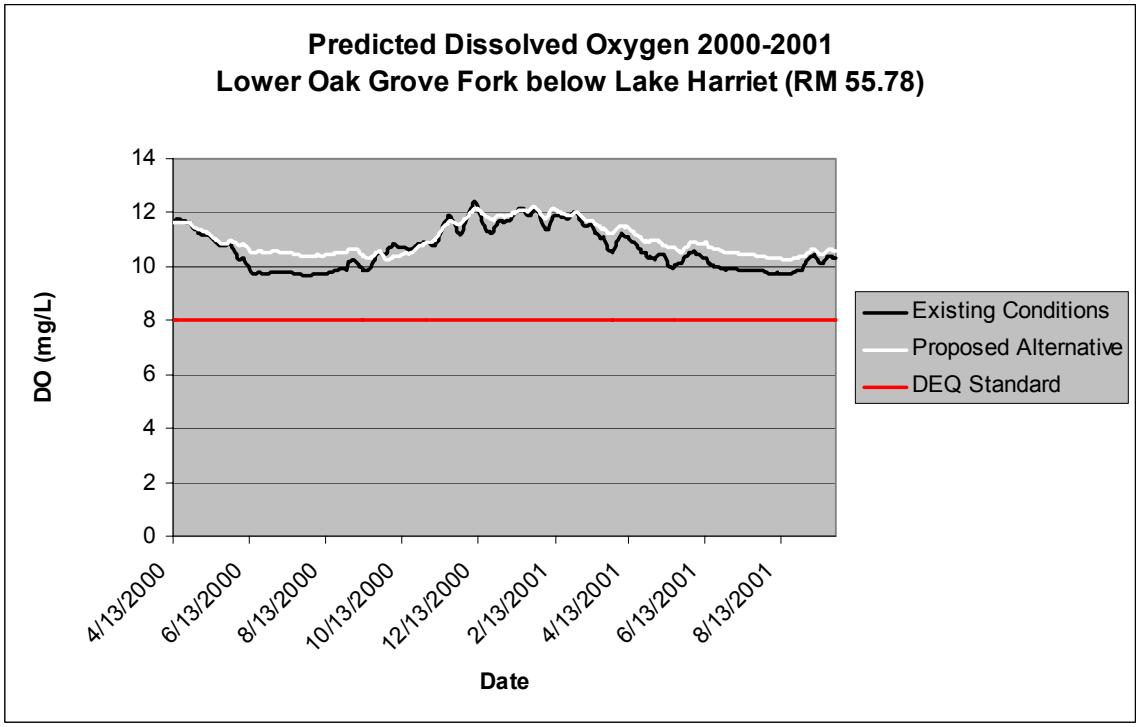
Clackamas River (Oak Grove Fork Confluence to Oak Grove Powerhouse)

Water Quantity

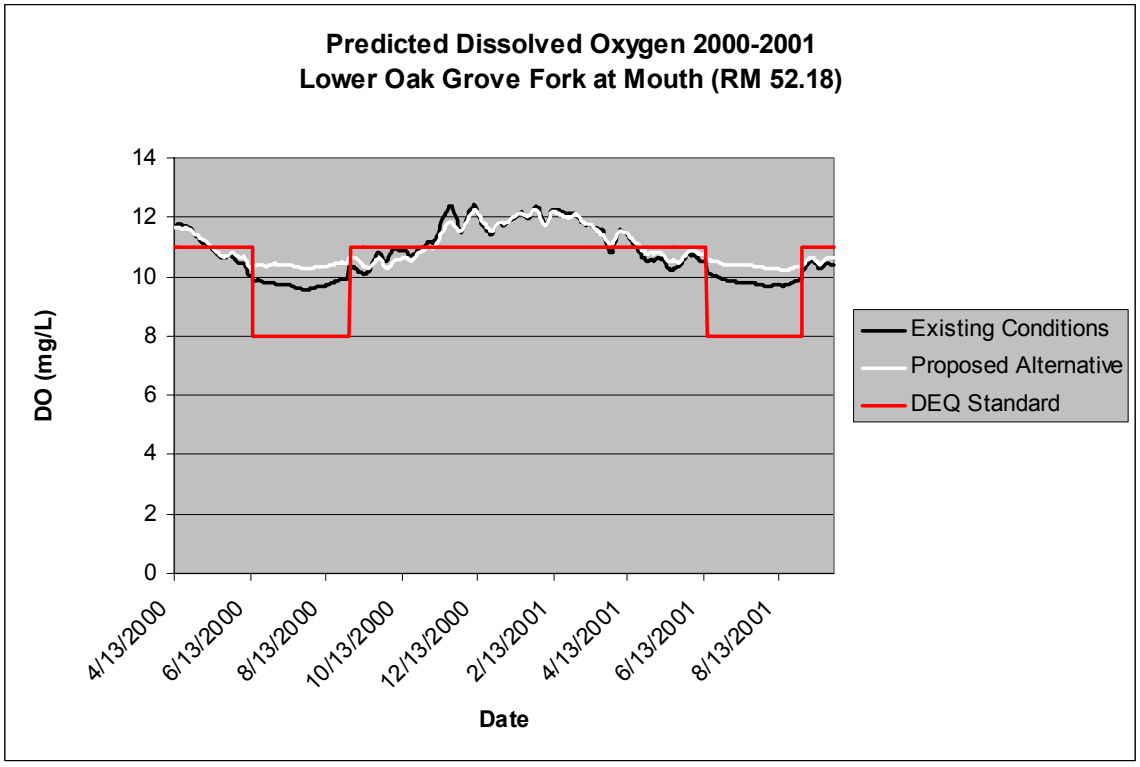
Upstream of the confluence with the lower Oak Grove Fork, the inflow from the mainstem Clackamas River would be the same under the Proposed Action as it is under existing conditions. As explained previously, under existing conditions, flows in the lower Oak Grove Fork originate from infrequent spills at Lake Harriet and accretion from distributed inflows along its length. The Oak Grove Powerhouse, which receives flow from Frog Lake, discharges into the upper Clackamas River. This discharge represents the return of all water diverted from the Oak Grove Fork at Lake Harriet, bringing the Clackamas River back to its full, natural flow from the Oak Grove Powerhouse downstream to North Fork Reservoir. During summer, the powerhouse flows represent a significant portion (at times as much as 50 percent) of the flow in the Clackamas River downstream of the powerhouse.

Figure 3.2.2.2-11. Water quality results – Lower Oak Grove Fork Dissolved Oxygen

a.



b.



Under the Proposed Action, flows in the lower Oak Grove Fork would consist primarily of releases from Lake Harriet. The flows in the lower Oak Grove Fork associated with the Proposed Action would increase flow in the Clackamas River upstream of the Oak Grove Powerhouse relative to existing conditions. The Clackamas River flow in this location is approximately 350-400 cfs at low flow. The Proposed Action would increase this contribution to 80 cfs from June 16 to September 30, raise that amount to 100 cfs between October 1 and 15, and return to 80 cfs until December 15. This would amount to a maximum contribution of the Oak Grove Fork to the Clackamas mainstem of between 40 percent and 50 percent.

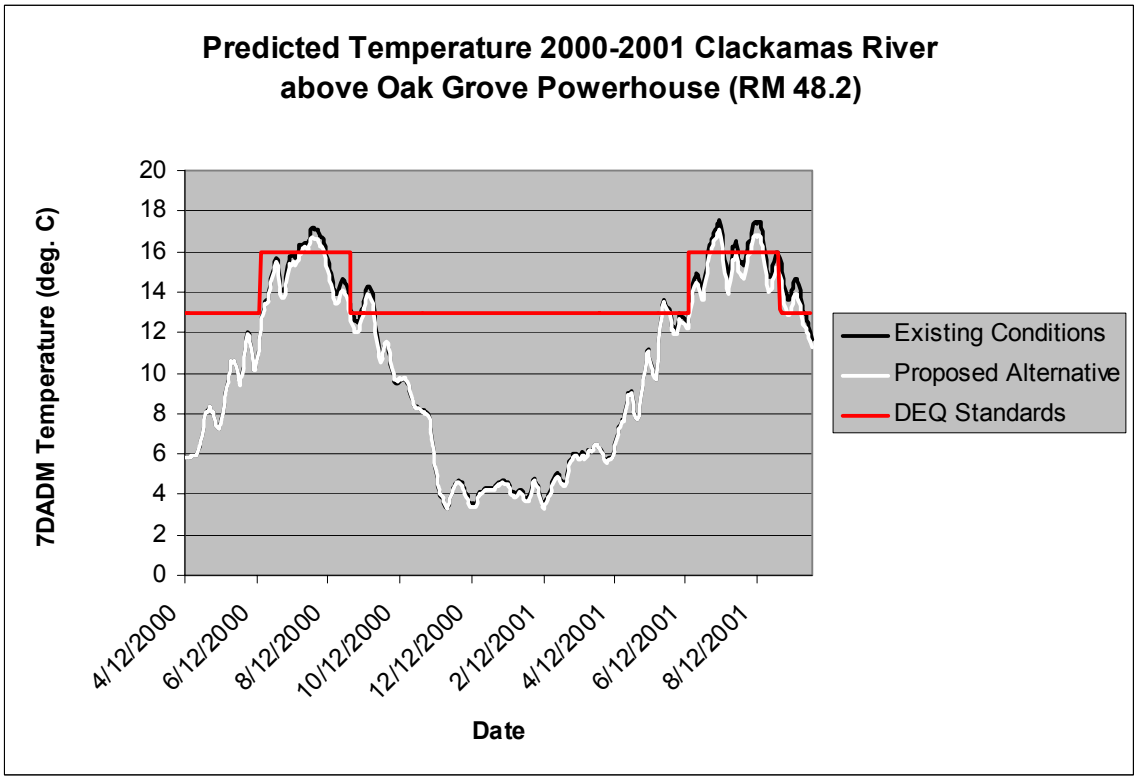
Water Quality

Based on model output and on limited data defining NTP of upstream boundary conditions, temperatures under the Proposed Action just upstream of Oak Grove Powerhouse exceeded ODEQ criteria during only 16 and 28 days during 2000, and 2001, respectively (Figure 3.2.2.2-12). For purposes of evaluating Project impacts, ODEQ determined that the upstream boundary condition (i.e., the mainstem Clackamas River inflow) for the reach between the Oak Grove Fork and Oak Grove Powerhouse should be set so that temperatures do not exceed the numeric criteria that apply to the reach for a given time of year. In this way, the Project would only be responsible for warming that occurs within the reach as a result of its impact on flows. Temperature in the Clackamas River between the Oak Grove Fork and the Oak Grove Powerhouse under the Proposed Action is lower than under existing conditions.

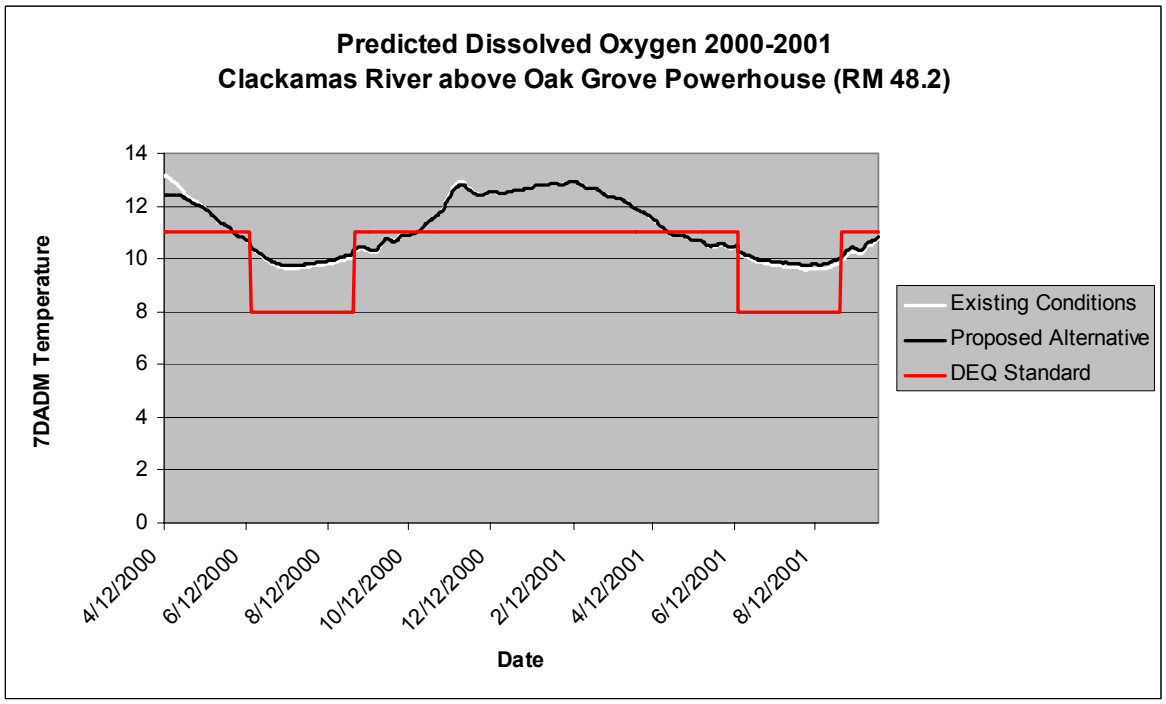
PGE contracted with Battelle (2005b) to conduct a sensitivity analyses designed to evaluate the effect of scaling boundary condition temperatures on temperatures in the Clackamas River just upstream of the Oak Grove Powerhouse. Battelle developed an equation that scales the temperatures of flows from the upper Clackamas River such that maximum temperatures do not exceed 16°C or 13°C, depending on the time of year. Because the natural warming in the 5-mile reach between the Oak Grove Fork mouth and the powerhouse is minimal, and because water from the Oak Grove Fork is substantially cooler than the Clackamas mainstem during much of the year, scaling boundary condition temperatures from the upper Clackamas so that they do not exceed the numeric criteria results in compliance with the relevant ODEQ criteria throughout the year in this reach.

Figure 3.2.2.2-12. Predicted water quality results – Upper Clackamas River, RM 48.2.

a.



b.



DO in the reach of the Clackamas River between the Oak Grove Fork and the Oak Grove Powerhouse is slightly higher under the Proposed Action than under existing conditions, due to the decrease in temperature predicted as the result of adding flow to this reach via the Oak Grove Fork. Even so, just upstream of the Oak Grove Powerhouse show periods when DO would fall below the relevant ODEQ criterion (11.0 mg/L) in this reach under the Proposed Action: 60 and 80 days in 2000 and 2001, respectively. The apparent modeled DO "notations" are again somewhat an artifact of the stepped structure of ODEQ's DO standard. If the DO criteria changed gradually to reflect the way DO concentrations change under natural conditions, the observed exceedance would be of shorter duration or might not occur at all. DO at this location under the Proposed Action would be above the 9.0 mg/L criterion that would apply if IGDO levels were greater than 8.0 mg/L (explained in section 9.0). Based on water column DO concentrations in this portion of the Clackamas River, it is likely that IGDO concentrations equal or exceed 8.0 mg/L during spawning and incubation periods. As a result, it is highly probable that the 9.0 mg/L criterion would apply throughout the Project area, and the 11.0 mg/L criterion would not apply.

Clackamas River (Oak Grove Fork Powerhouse to North Fork Reservoir)

Water Quantity

The Proposed Action would require maintenance of Frog Lake at a surface elevation of 1988.0 ft, with normal and extreme minimums of 1970.0 ft and 1958.0 ft, respectively. The maximum discharge at the Oak Grove Powerhouse would equal the powerhouse's 740 cfs turbine capacity, with a maximum upramping rate of 0.4 ft/hr year round except during spinning reserve call events and maximum downramping rates as follows:

- 0.3 ft/hr from November 1 through January 31;
- 0.3 ft/hr if flow is greater than 1200 cfs or 0.17 cfs if flow is less than 1200 cfs February 1 through September 30; and
- 0.3 ft/hr during October.

The Proposed Action would not differ from current operations in terms of flow between the Oak Grove Powerhouse and North Fork Reservoir, because water diverted at Lake Harriet is currently discharged into the Clackamas River at the Oak Grove Powerhouse. The flow model for Three Lynx, which is located immediately downstream of the Oak Grove Powerhouse discharge at RM 46, shows nearly identical average flows for both current conditions and the Proposed Action (see Figure 3.2.2.1-12). The baseflows in this reach would be slightly different, though, with the Proposed Action providing 200-300 more cfs in the dry year of 1992 (see Figure 3.2.2.1-11).

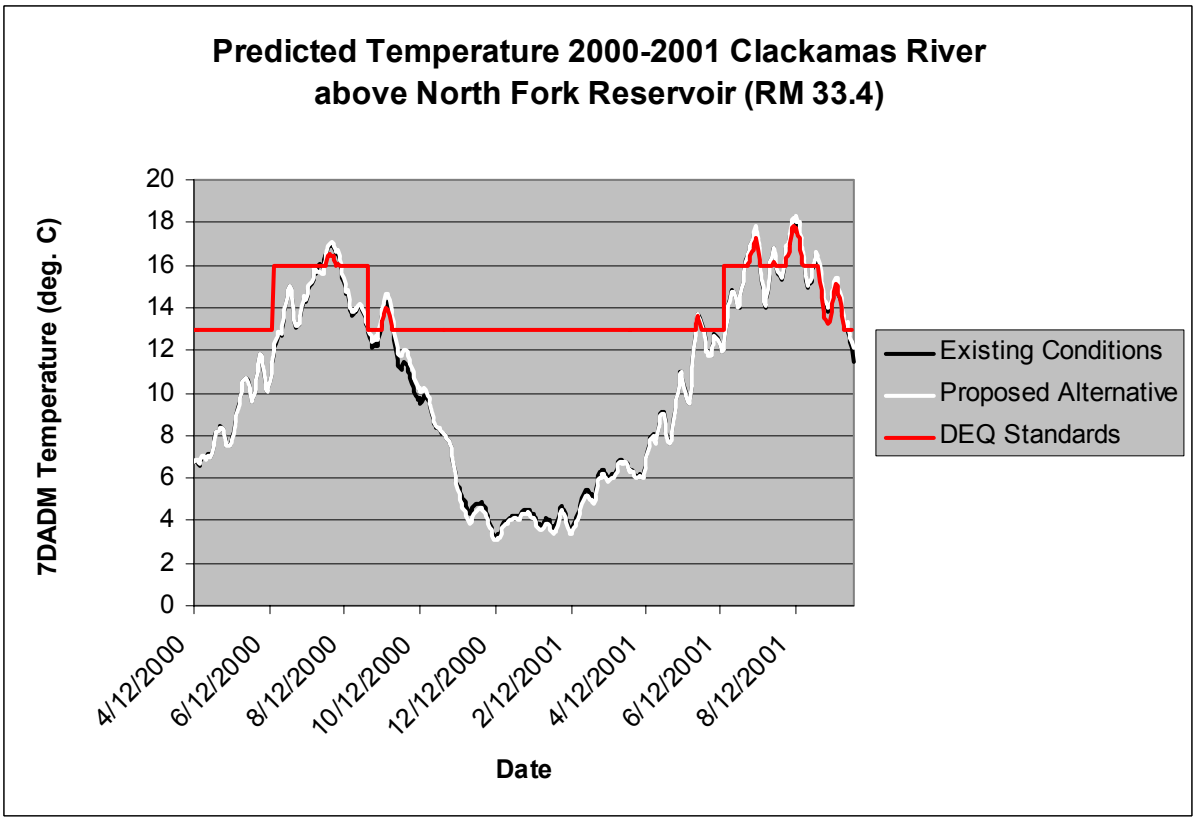
Water Quality

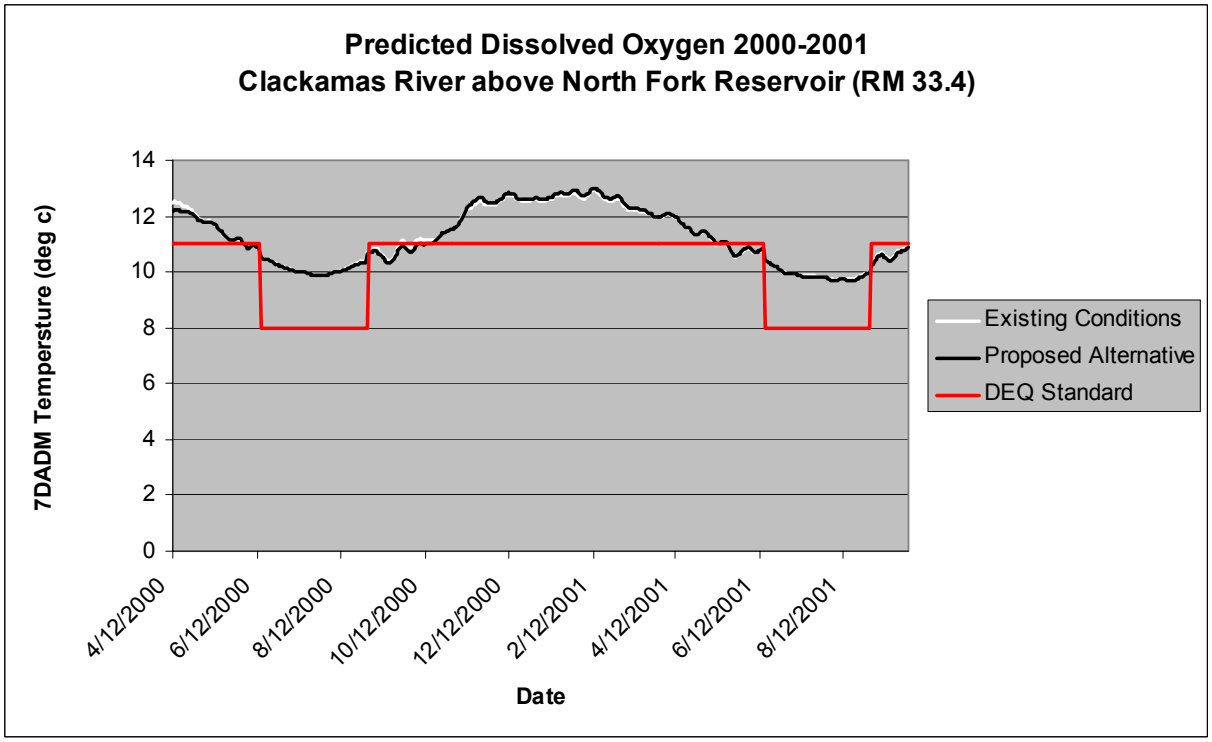
The Oak Grove Powerhouse discharge enters the Clackamas River approximately 5 miles downstream of the confluence of the Oak Grove Fork. As a result, temperatures under existing conditions are similar to what they would be in the absence of the Project, and therefore would comply with ODEQ criteria.

The model indicates that temperatures at the site just upstream of North Fork Reservoir in 2000 and 2001 would have been slightly inconsistent with ODEQ criteria (essentially the calculated NTP), on 22 and 55 days, respectively under the Proposed Action (Figure 3.2.2.2-13). However, the observed pattern for the Proposed Action would not differ significantly from NTP conditions during the time of year when NTP applies. Because of this, conditions under the Proposed Action would be just as suitable to aquatic biota as NTP conditions would be. That is, beneficial uses would not be adversely affected by proposed Project discharge temperatures in the reach between the Oak Grove Powerhouse and North Fork Reservoir, and conditions under the Proposed Action would comply with ODEQ criteria.

Under the Proposed Action, DO at this location would have fallen below the 11.0 mg/L ODEQ criterion on 52 and 54 days in 2000 and 2001, respectively, according to the model's results. The occurrences would have been slight and of short duration, and given that flows in this reach are not significantly altered by the Project, i.e., all flow diverted at Lake Harriet from the Oak Grove Fork has been returned to the river, it is unclear to what extent the predicted DO levels would have been attributable to Project operations. In addition, the violations would have been to some degree a result of the stepped structure of ODEQ's DO criteria. As before, if the criteria changed gradually to reflect the way DO concentrations change under natural conditions, the observed situation would be of shorter duration or might not occur at all. Simulated DO at this location does not fall below the 9.0 mg/L criterion that would apply if IGDO levels are greater than 8.0 mg/L (see section 9) under the Proposed Action. The short duration and timing of the non-compliance at the time when the standard changes from 11.0 mg/L to 8.0 mg/L suggests that this is a naturally occurring condition. Based on water column DO concentrations in this portion of the Clackamas River, it is likely that IGDO concentrations equal or exceed 8.0 mg/L during spawning and incubation periods. As a result, it is highly probable that the 9.0 mg/L criterion would apply here as well.

Figure 3.2.2.2-13. Predicted water quality results –Clackamas River above North Fork Reservoir, RM 33.4.



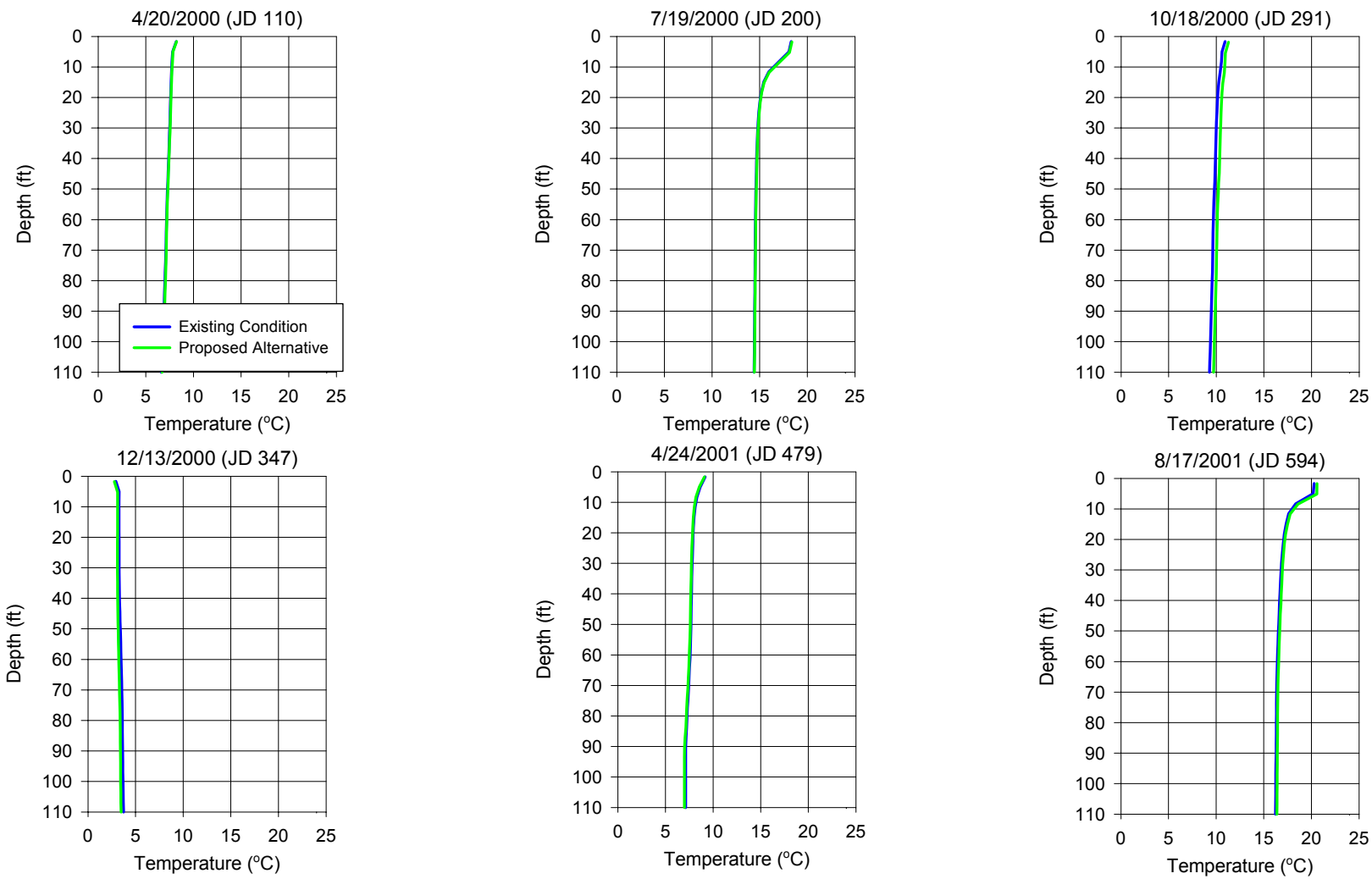


North Fork Reservoir to River Mill dam

Water Quantity

The Proposed Action would have significant effect on the existing flow regime of the Clackamas River between North Fork Reservoir and River Mill dam (Figure 3.2.2.1-14). PGE proposes changes in Project operations at the Faraday Diversion dam, which include maintaining a year round base flow of 270 cfs along with pulsed flow releases (120 – 480 cfs) from April to October, and could result in flows much more similar to the simulated unregulated flow.

Figure 3.2.2.2-14. Predicted temperature profile – North Fork Reservoir.



Water Quality

There is little change in the temperature profile in the North Fork Reservoir between the Proposed Action and current operations (see Figure 3.2.2.2-14). No water quality-related change in operations is planned for North Fork Reservoir under the Proposed Action. Flows pumped into the North Fork forebay floating surface collector would be pumped back to the forebay, resulting in no change to the temperature of water discharged into the North Fork tailrace, as compared to existing conditions. Therefore, there would be little change in temperature profiles between existing conditions and the Proposed Action. The simulated profiles show only slight variation with depth during summer, indicating that slight stratification occurs at those times. For the Proposed Action, the simulated DO concentration profiles are nearly identical to existing conditions for the entire simulation period (Figure 3.2.2.2-15).

Modeled temperatures in the North Fork tailrace, RM 29.2 (NOFKTR) under the Proposed Action are inconsistent with ODEQ criteria on 4 and 6 days in 2000 and 2001, respectively (Figure 3.2.2.2-16). These inconsistencies are modeling artifacts associated with periods when NTP rapidly declines in response to meteorological changes, i.e., cold fronts. These affect the NTP (i.e., what would occur in a river channel) 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 where temperatures in the North Fork tailrace are well within compliance for an extended period and then, several days later, are suddenly and briefly inconsistent with the 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, 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 Proposed Action and ODEQ criteria, PGE believes that the apparent temperature lag in the North Fork tailrace is an artifact of modeling that results in no adverse consequences to beneficial uses, primarily salmonid rearing. As a result, PGE believes that temperatures at this location should be considered in compliance with ODEQ criteria. Again, pH is within the range of compliance with ODEQ's standards. In contrast, modeled DO concentrations fall below the 11.0 mg/L threshold during spring and fall, and this is more pronounced in 2001 when flows were lower (Figure 3.2.2.2-15). Modeling results indicate that in the North Fork tailrace under the Proposed Action, DO would have fallen below ODEQ criteria on 63 and 54 days in 2000 and 2001, respectively. However, DO at this location under the Proposed Action would not fall below the

Figure 3.2.2.2-15. Predicted dissolved oxygen profiles – North Fork Reservoir.

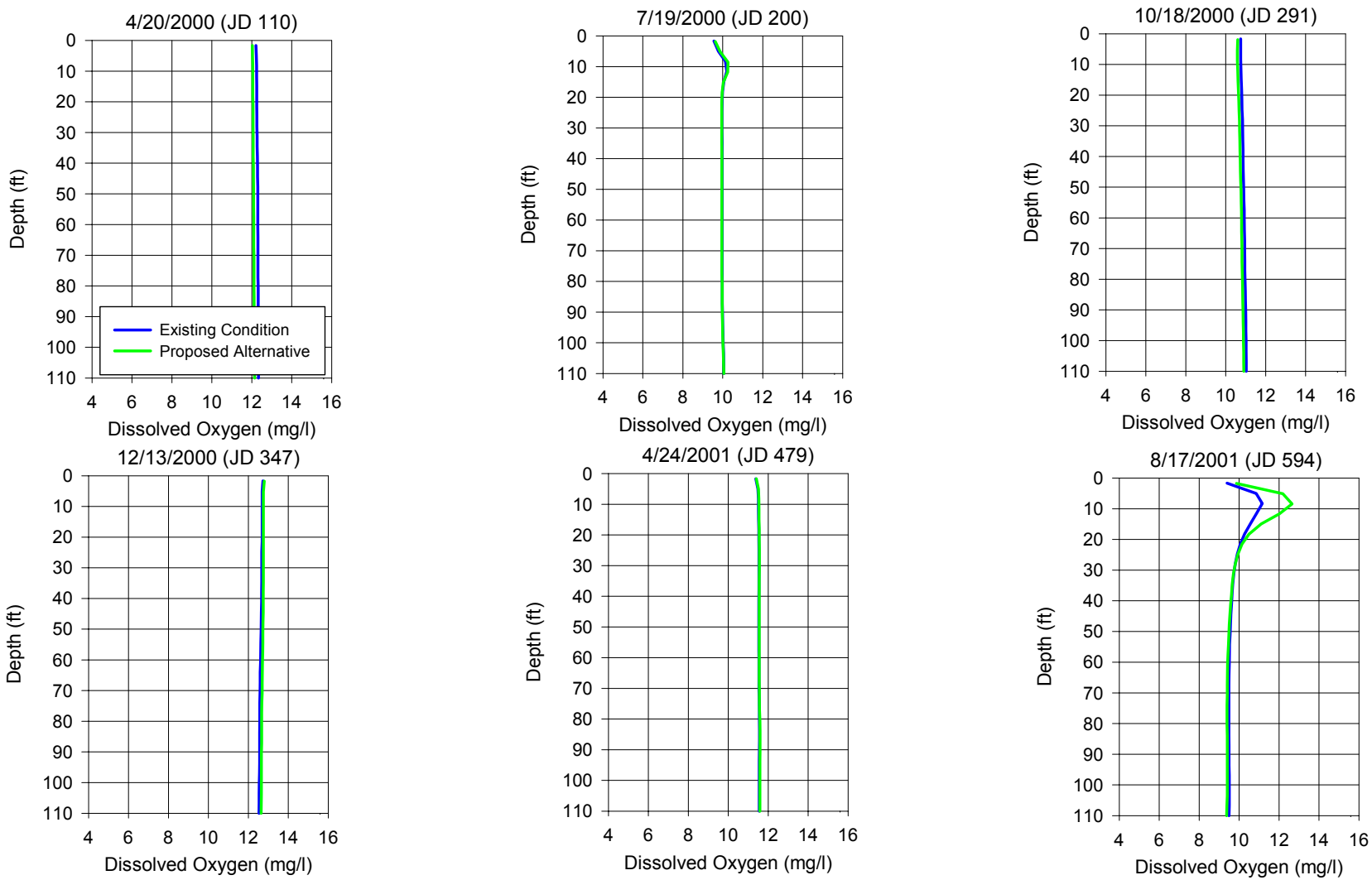
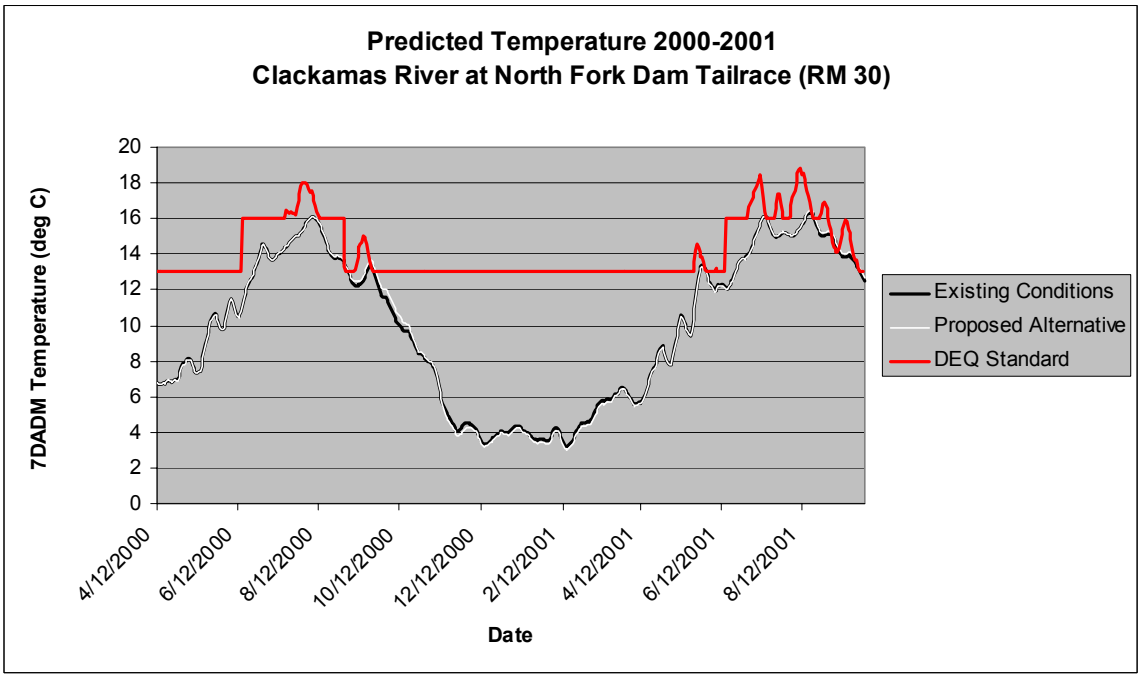
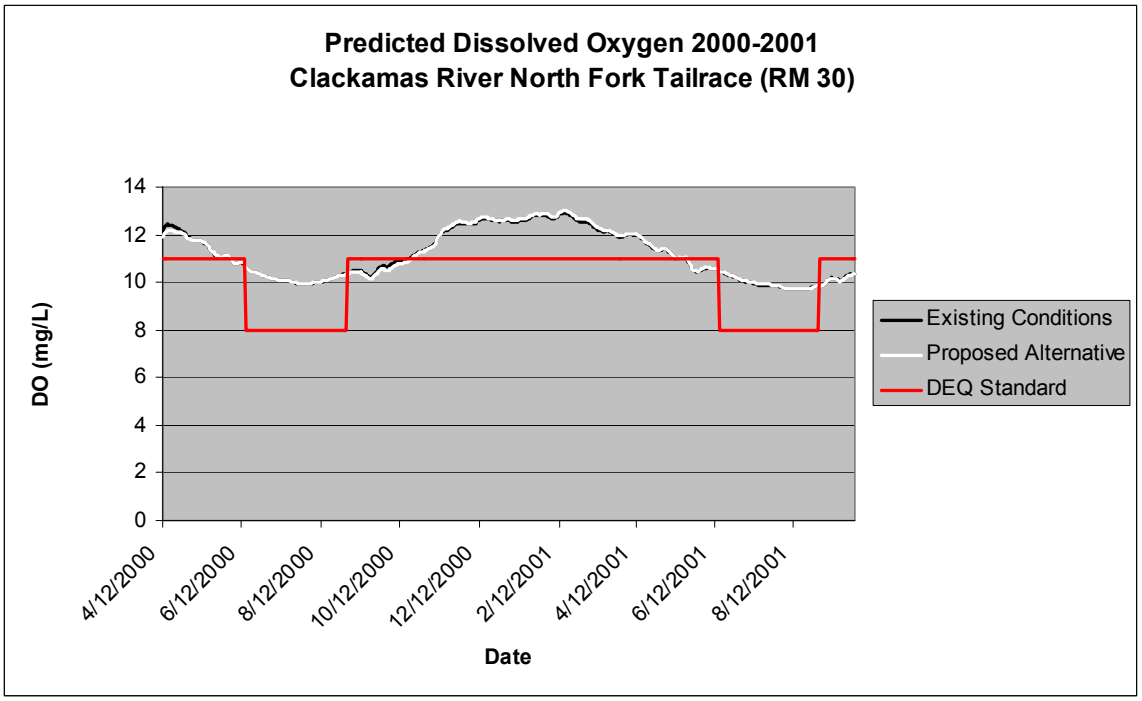


Figure 3.2.2.2-16. Predicted water quality results– North Fork tailrace.





9.0 mg/L criterion that would apply instead of the 11.0 mg/L criterion if IGDO levels are greater than 8.0 mg/L. The short duration and timing of the non-compliance at the time when the standard changes from 11.0 mg/L to 8.0 mg/L suggests that this is a naturally occurring condition.

If fish protection PMEs implemented as part of the Proposed Action failed to achieve agreed-upon juvenile fish survival rates by a specified date, PGE would install a 3,000-cfs surface collector in the North Fork tailrace. This surface collector would be plumbed to the powerhouse intake, so that all surface water withdrawn by the facility (up to 3,000 cfs) would be routed through the powerhouse. PGE contracted with Battelle (2005b) to conduct sensitivity analyses to evaluate if such a surface collector in North Fork Reservoir would affect water temperature in the Lower Clackamas River. The sensitivity analysis was based on the following operating regime:

- March 1 - June 30: all surface flow up to 3,000 cfs routed to North Fork Powerhouse;
- July 1 - October 14: no surface withdrawal;
- October 15 - January 14: all surface flow up to 3,000 cfs routed to North Fork Powerhouse; and
- January 15 - February 28: 500 cfs of surface flow routed to North Fork Powerhouse.

Model results showed very little difference between the discharged temperatures due to the installation of a surface collector. As a result, the surface collector should result in no discernible deviation from the results described in this application for the Clackamas River from North Fork dam downstream to the confluence with the Willamette River.

Lower Clackamas River

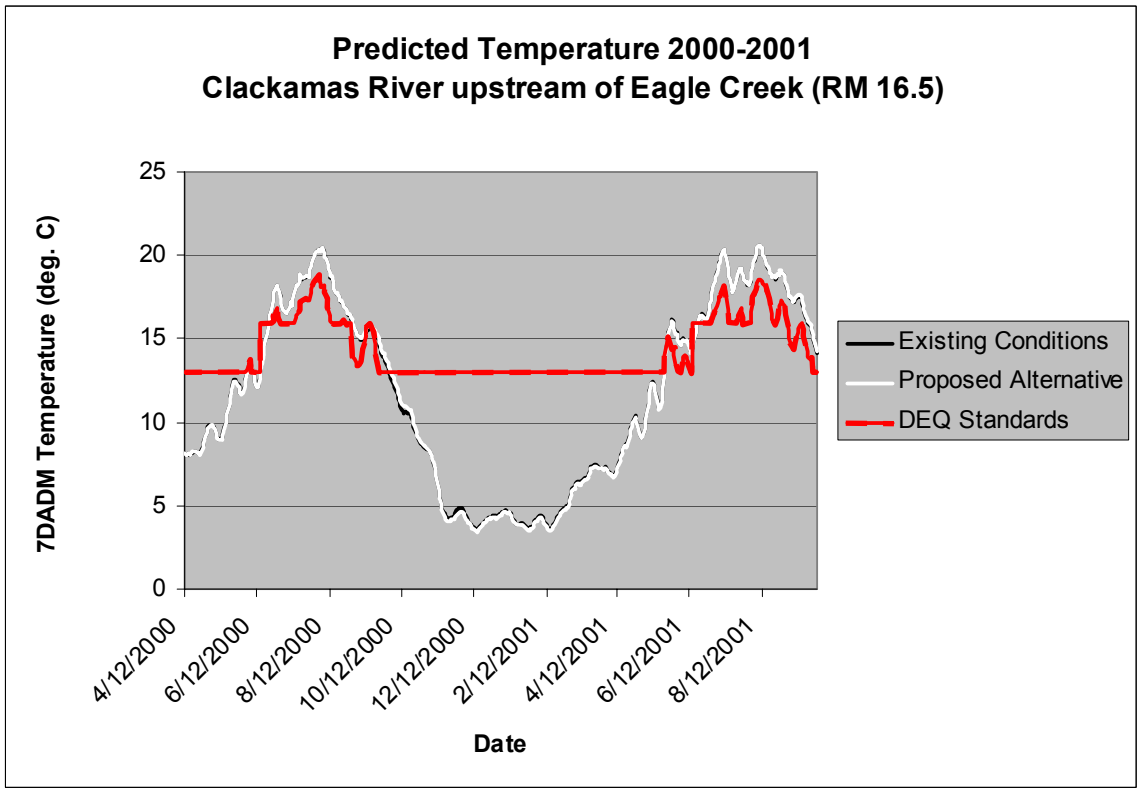
As part of the Proposed Action, baseflow in the Faraday Diversion reach would increase to 270 cfs (from the existing 120 cfs). In addition, 25 cfs of cold water derived from deep in the North Fork forebay would replace warmer water in the fish ladder at the new adult sorting facility, located about 0.25 miles downstream of North Fork dam. In addition, PGE, in consultation with federal and state resource agencies (fish committee or FC) would develop a study plan to examine the effect of pulsed flows on the upstream passage success of salmonids, spring Chinook in particular, through the Faraday diversion reach. Following the study, PGE would, in consultation with the FC, develop and implement a pulsed flow protocol.

As a result of the new baseflows and flow exchange in the Faraday Diversion dam fish ladder, water temperatures in the Faraday diversion reach would improve, but modeling indicates, again, a slight divergence between calculated temperatures associated with the Proposed Action and ODEQ temperature criteria, i.e., during 23 and 51 days during 2000 and 2001, respectively (Figure 3.2.2.2-17). The observed divergence, like that observed at the North Fork dam tailrace, is an artifact of modeling associated with periods when NTP rapidly declines in response to cold fronts. Again, the relative lack of variability associated with the reservoir creates an anomalous situation in that temperatures in the Faraday diversion reach are well within compliance for an extended period and then, several days later, are suddenly and briefly inconsistent with the criterion, when the actual temperature of the discharge has remained the same or decreased slightly from what it was days before. Based on evaluation of the overall relationship between the temperature regime of the Proposed Action and ODEQ criteria, the apparent temperature lag in the Faraday diversion reach is an artifact of modeling that results in no adverse consequences to beneficial uses, primarily salmonid rearing.

As with much of the Project area, DO concentrations under the Proposed Action would fall below the ODEQ spawning criterion (11.0 mg/L) during some periods of the year: 63 and 52 days in 2000 and 2001, respectively (Figure 3.2.2.2-17). However, DO at this location under the Proposed Action would be above the 9.0 mg/L criterion that would apply instead of the 11.0 mg/L criterion if IGDO levels were greater than 8.0 mg/L. The short duration and timing of the noncompliance at the time when the standard changes from 11.0 mg/L to 8.0 mg/L suggests that this is a naturally occurring condition.

Water quality in Estacada Lake under the Proposed Action would be similar to existing conditions: models predict no significant differences between the Proposed Action and existing conditions for temperature or DO. Weak stratification occurs in Estacada Lake, indicated by a small temperature increase in the surface layers during the summer months (Figure 3.2.2.2-18). This weak stratification leads to little variation in DO concentration with depth (Figure 3.2.2.2-19).

Figure 3.2.2.2-17. Predicted water quality results – Lower Clackamas River, RM16.5.



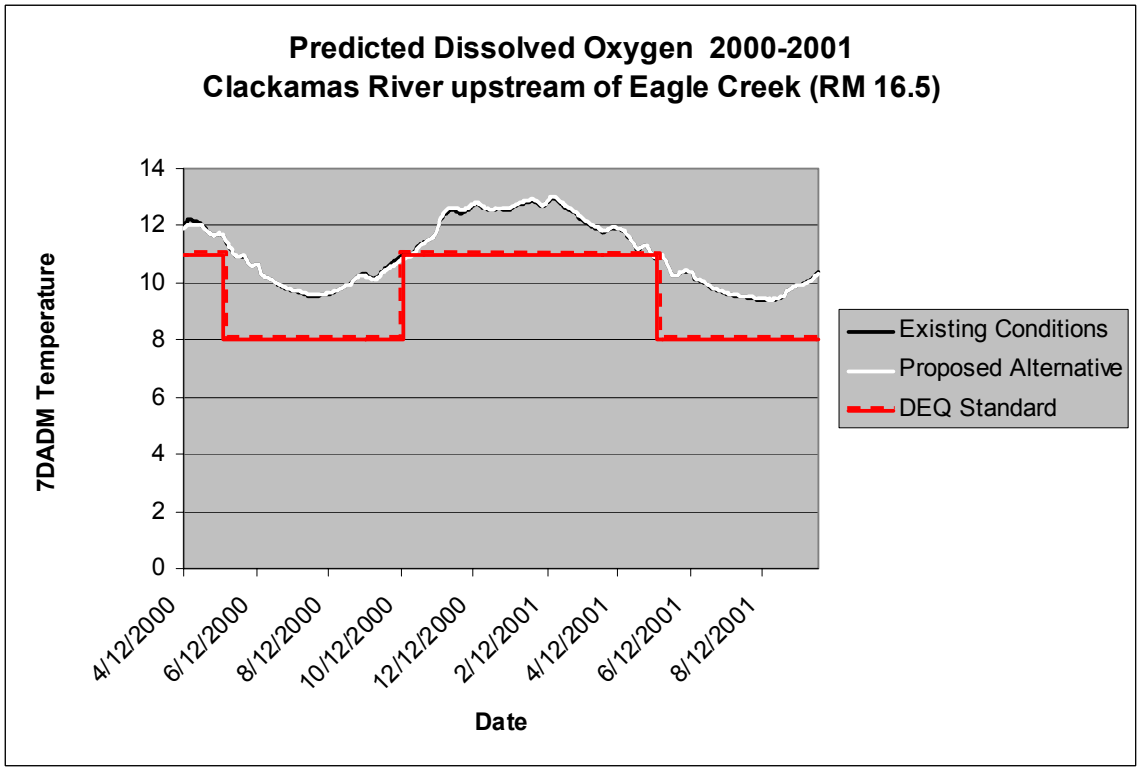


Figure 3.2.2.2-18. Predicted temperature profiles – Lake Estacada.

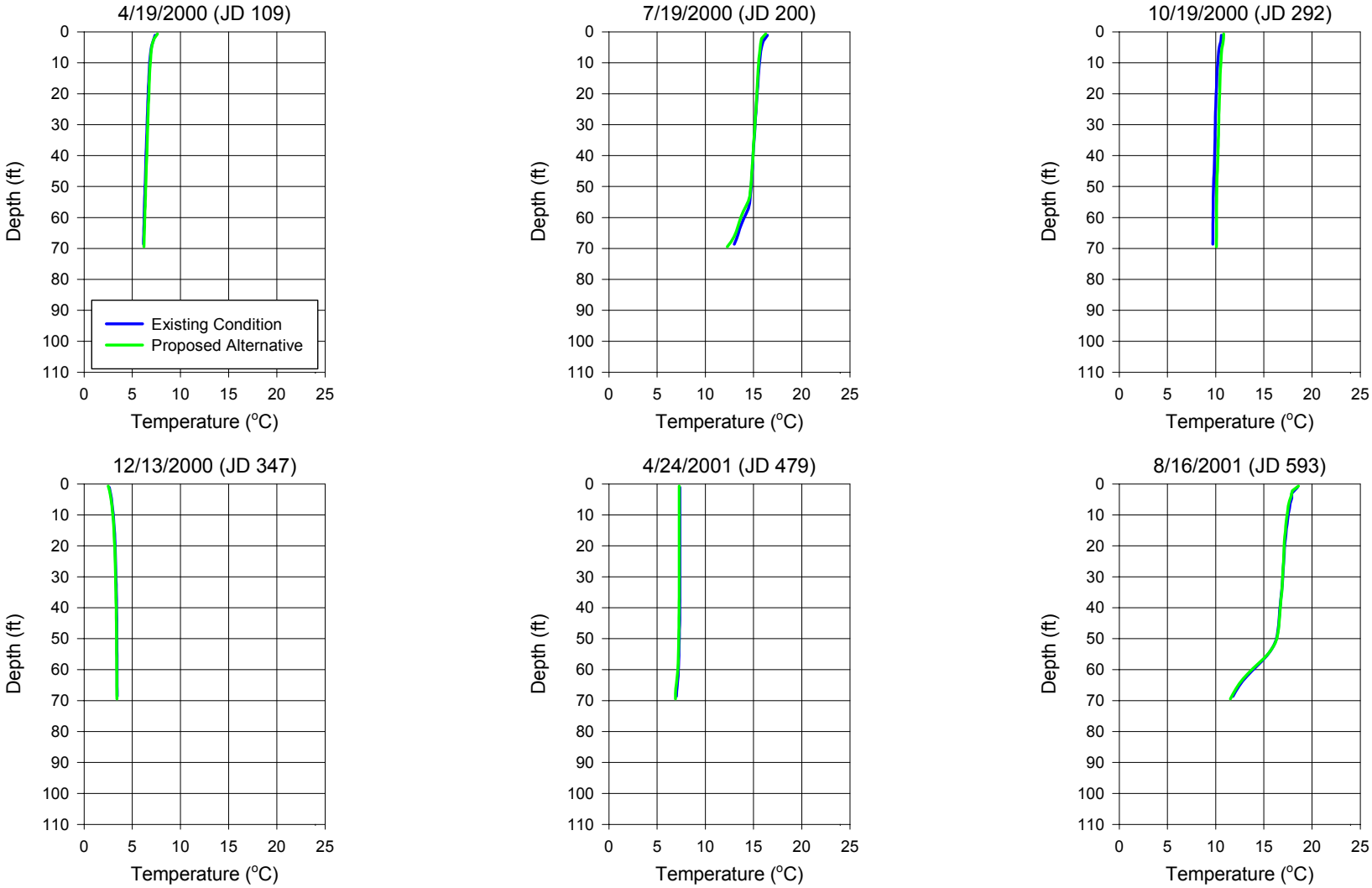
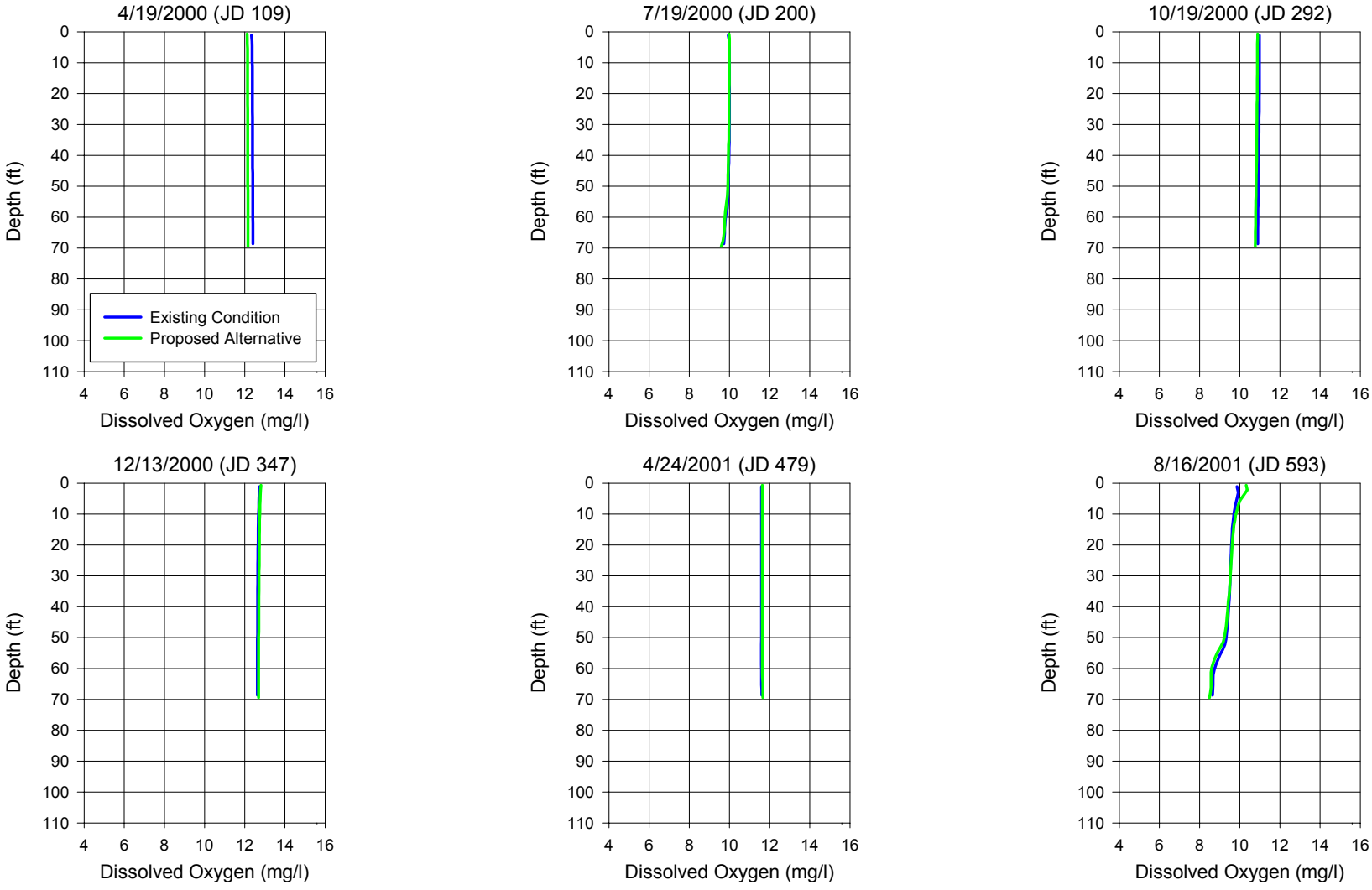


Figure 3.2.2.2-19. Predicted dissolved oxygen profiles – Lake Estacada.

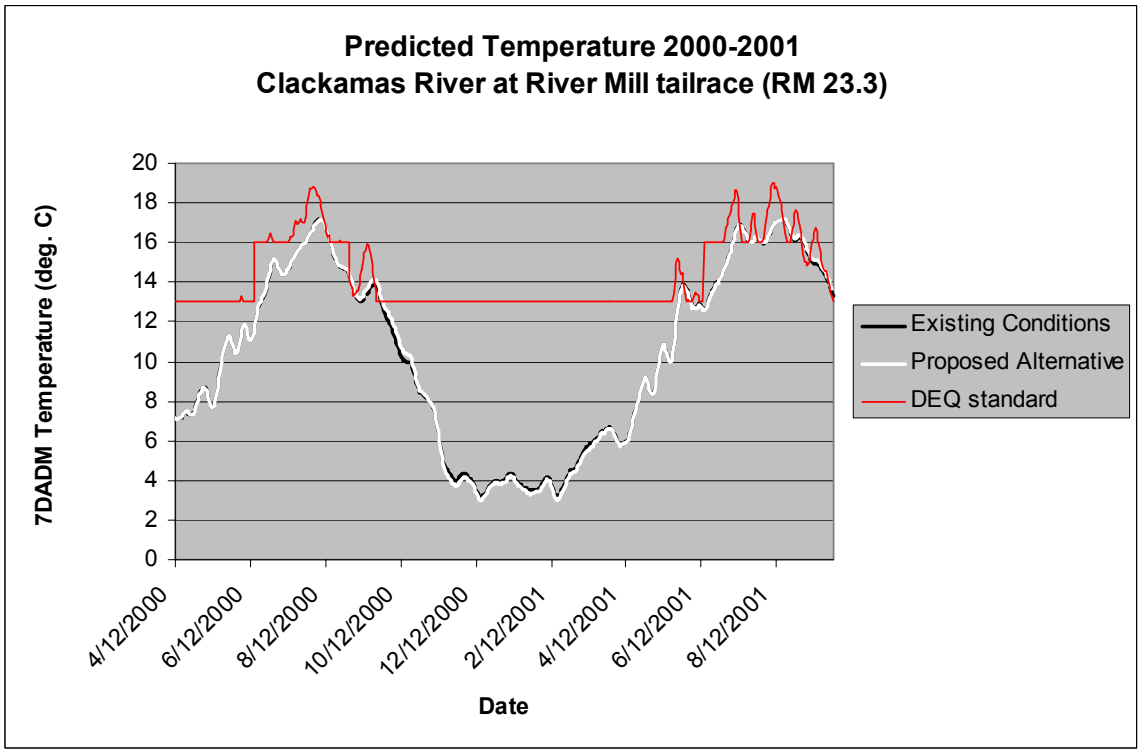


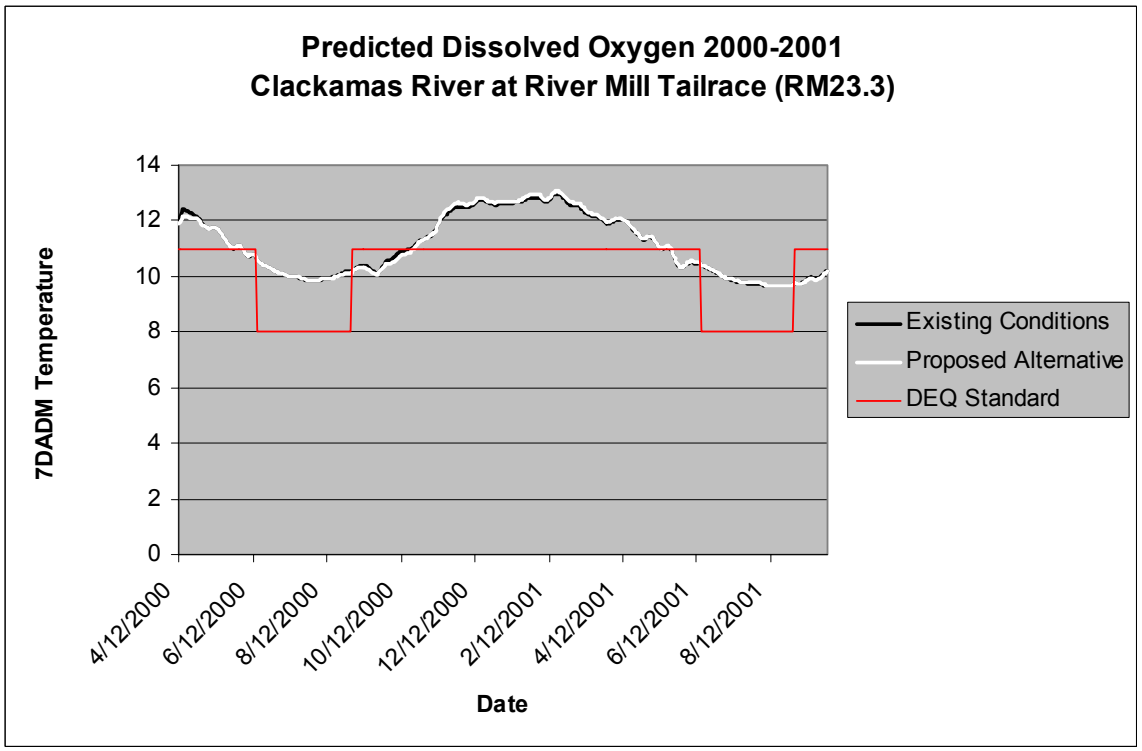
PGE would control the River Mill development flow release to hold the flow deviation within 10 percent, or 100 cfs (whichever is greater), of the USGS Estacada gage flow for all river flows. The flow deviation restrictions would not apply during emergencies, equipment failures that affect river flows 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 would not reduce flows below River Mill to less than 500 cfs or inflow, whichever is less.

Temperature and water quality conditions in the River Mill tailrace, RM 23.3 (RIMITR), are similar to those in Estacada Lake under existing conditions, and would be similar under the Proposed Action. Simulated temperatures for 2000 and 2001 indicated inconsistencies within relevant ODEQ criteria during only 8 days in 2000 and 19 days in 2001 in the tailrace (Figure 3.2.2.2-20). These rare inconsistencies in the River Mill tailrace are modeling artifacts associated with periods when NTP rapidly declines in response to meteorological changes, e.g., cold fronts. These affect the calculated NTP but have little effect on what occurs in a thermally buffered reservoir environment. The relative lack of variability associated with the reservoir creates an anomalous situation in that temperatures in the River Mill tailrace are well within compliance for an extended period and then, several days later, are suddenly and briefly inconsistent with the 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 NTP. During the warm period of the year, when inconsistencies occur, 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 resulting from the Proposed Action and ODEQ criteria, temperatures at this location probably do not result in adverse effects on beneficial uses.

Modeled DO falls below the 11.0 mg/L criterion during some times of the year: the model indicated inconsistencies with ODEQ criteria on 63 and 52 days in 2000 and 2001, respectively (Figure 3.2.2.2-20). However, DO at this location under the Proposed Action remains above the 9.0 mg/L criterion that would apply instead of 11.0 mg/L, if IGDO levels were greater than 8.0 mg/L. The short duration and timing of the varying temperatures at the time when the standard changes from 11.0 mg/L to 8.0 mg/L suggests that this is a naturally occurring pattern.

Figure 3.2.2.2-20. Predicted water quality results – River Mill Tailrace, RM23.3.





Because the flows under existing conditions and the Proposed Action are nearly identical for the simulation period at a location approximately 6.5 miles downstream of River Mill dam, just above Eagle Creek (RM 15.7, CRUPEC), temperature and water quality results, are nearly identical as well. Under the Proposed Action, temperatures during the warmer months would exceed the relevant ODEQ criterion at the Eagle Creek site, which is NTP for most of the period when exceedances would occur. Based on model results, temperatures under the Proposed Action would exceed ODEQ criteria during 95 and 117 days during 2000 and 2001, respectively (Figure 3.2.2.2-21).

3.2.2.3 Unavoidable Adverse Impacts to Water Quality and Quantity

Operation of Project facilities under the Proposed Action would continue to affect water quality and quantity in the Clackamas River system. The reservoirs would result in the storage of water, the diversion of flows from the mainstem of river reaches, the release of water for power generation, and the spilling of water. All of these activities could alter the temperature and water quality of the Oak Grove Fork and Clackamas River. These unavoidable impacts would be more significant in the Oak Grove Fork and a relatively short segment of the Clackamas River from the mouth of the Oak Grove Fork to the Oak Grove Powerhouse. Downstream of the confluence of the Oak Grove Fork and the Clackamas River, conditions have not changed substantially because the unregulated contributions of the Clackamas River outweigh the regulated flow of the Oak Grove Fork. Reaches immediately downstream of Project dams would be more likely to be affected than reaches further downstream because of the mitigating influence of accretion flow. Water level fluctuations, temperature levels, alteration of hydrograph components at certain locations, and lake stratification would be the most substantial water quality concerns based on flows as described in the Proposed Action. Although the Proposed Action would perpetuate minor deviations from state water quality standards, the effects of these deviations on fisheries resources would be minimal as discussed in Section 3.2.3.2.