APPENDIX G

FISH ENTRAINMENT AND MORTALITY STUDY
-AMENDMENT-

MASON DAM PROJECT
BAKER COUNTY, OREGON
Project Number P-12686-001

Prepared for

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MASON DAM PROJECT FISH ENTRAINMENT AND MORTALITY STUDY
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1.0 Introduction

Baker County conducted a study to address potential effects of the proposed Mason Dam Hydroelectric Project on mortality of fish passing through Mason Dam (GeoSense 2011) according to directives provided by FERC during the May 20, 2010 agency coordination meeting. The directives were to focus primarily on changes in mortality, as entrainment would not be affected by the project.

Agency comments both pre and post study focused on addressing how the study results would translate to changes in mortality of individual species, as well as clarification of the range of baseline entrainment numbers, used to evaluate changes in mortality. In addition, new information has been developed regarding how water quality during the seasonal hydroelectric operating period could affect the previous entrainment estimates.

This report provides an amendment to the 2011 entrainment and mortality study. Specific objectives of the amendment are to:

- Revise the baseline entrainment and related mortality rates based on new information regarding deep reservoir intakes, particularly deep, gated intakes.
- Provide updated information on project operation as pertinent to fish species.
- Add a discussion of the potential for individual fish species impacts.
- Update the study with new information from other regional reservoirs, particularly those containing similar fish species as those found in the Mason Dam project area.
- Identify the range of impacts to be expected from the incremental effects of the hydroelectric project on the overall reservoir operation.

As an amendment, this report incorporates by reference the following reports:

- Initial Fish Entrainment and Mortality Study Report (GeoSense 2011) and the project description therein
- Mason Dam Water Quality Study Report (EcoWest 2009a)
- Combined Vegetation and Threatened, Endangered and Sensitive Species Study Report (EcoWest 2009b).

2.0 Mason Dam Project Description

The proposed Mason Dam project is described in detail in GeoSense (2011) and not repeated herein other than to clarify project details specific to fish entrainment and mortality. The full project description can be found in the previous report.

Based on numerous studies throughout the US, a number of factors have been identified as important in distinguishing the differences between entrainment and mortality under various circumstances (see for example, summaries in FERC 1995, EPRI 1997, Ch2MHill 2003, NAI 2009, Symbiotics 2009; detailed summary in Appendix A).

These factors include:

- Reservoir Characteristics: Operation type, depth, and changes in hydraulic head/surface water levels and pool volumes
- Intake Characteristics: Type, depth, velocity and water quality at intake
- Fish species, size and seasonal/daily movements

Each of these factors is discussed individually below.

Reservoir Characteristics

Philips Reservoir is an 2,234 acre-reservoir located behind Mason Dam. Mason Dam has a total height of 173 feet and a maximum hydraulic height of 157 feet. The reservoir has a total storage capacity of 95,500 acre-feet and an active storage capacity of 90,500 acre-feet. Average reservoir depths are 41 feet with a maximum depth of 125 feet (Shrader 2000). Approximately 13% of the full pool reservoir area is considered littoral habitat (areas less than 10 feet in depth, Shrader 2000).

Mason Dam is currently regulated for flood control and irrigation. Water is generally stored between October and March and released by the Baker Valley Irrigation District (BVID) for irrigation between May and September 30. As a result, releases average approximately 10 cfs between October and January and increase to an average of 20 to 50 cfs during February and March. During the irrigation season, releases generally remain above 100 to 200 cfs and can go up to 350 cfs.

The proposed project would be "run-of-release" and not change the dam operation. The Mason Dam hydroelectric project would only operate whenever releases by BVID exceed 100 cfs, and not operate at releases lower than 100 cfs. Releases greater than 100 cfs do not occur between October and January. Figure 1 depicts the frequency in which releases exceeding 100 cfs have occurred during the January 1 to September 30 period, based on historical flow release data provided by the Bureau of Reclamation. Between 1983 and 2012, flows exceeding 100 cfs on any one day of the month have occurred within three years in January and within four years in February (or 10 to 13% of years). Beginning in June and extending through August, releases exceeded 100 cfs in all years. Daily flows exceeding 100 cfs occurred in 26 of the 30 years examined in September. Between mid-March and mid-April, releases exceeded 100 cfs in 30% of the years . During the last two weeks of April, flows generally increase, exceeding 100 cfs on any one day of the month in 43 to 60% of the years.

The frequencies described above identify the number of years in which flows of 100 cfs or greater occur during a month, even if for only one day. Figure 1 also depicts the number of days within a month that flows would have been sufficient for the hydroelectric project to operate. Over the last

30 years, flows exceeding 100 cfs in January and February have occurred on 4.4 to 6.3% of the total number of days, with most of the days occurring in 1984, an extremely wet year. In all other years, flows have exceeded 100 cfs during January and February on 1.6 to 3.2% of the days. Except for 1984, the late winter flows were mostly isolated and not occurring on a sufficient number of days for the hydroelectric project to operate.

In March, the total percent of days in which flows have exceeded 100 cfs is 19.4%, most of which have occurred during the latter part of the month. April flows have also exceeded 100 cfs on 40.5% of the days, with most of the exceedances during the last two weeks of the month. On a daily basis, flows exceed 100 cfs most of the time between May and August. Although flows may reach 100 cfs on any one day in September in most years, daily flows only exceed 100 cfs on 35% of the days in September. In 70% of the years, flows exceeding 100 cfs cease by mid-September.

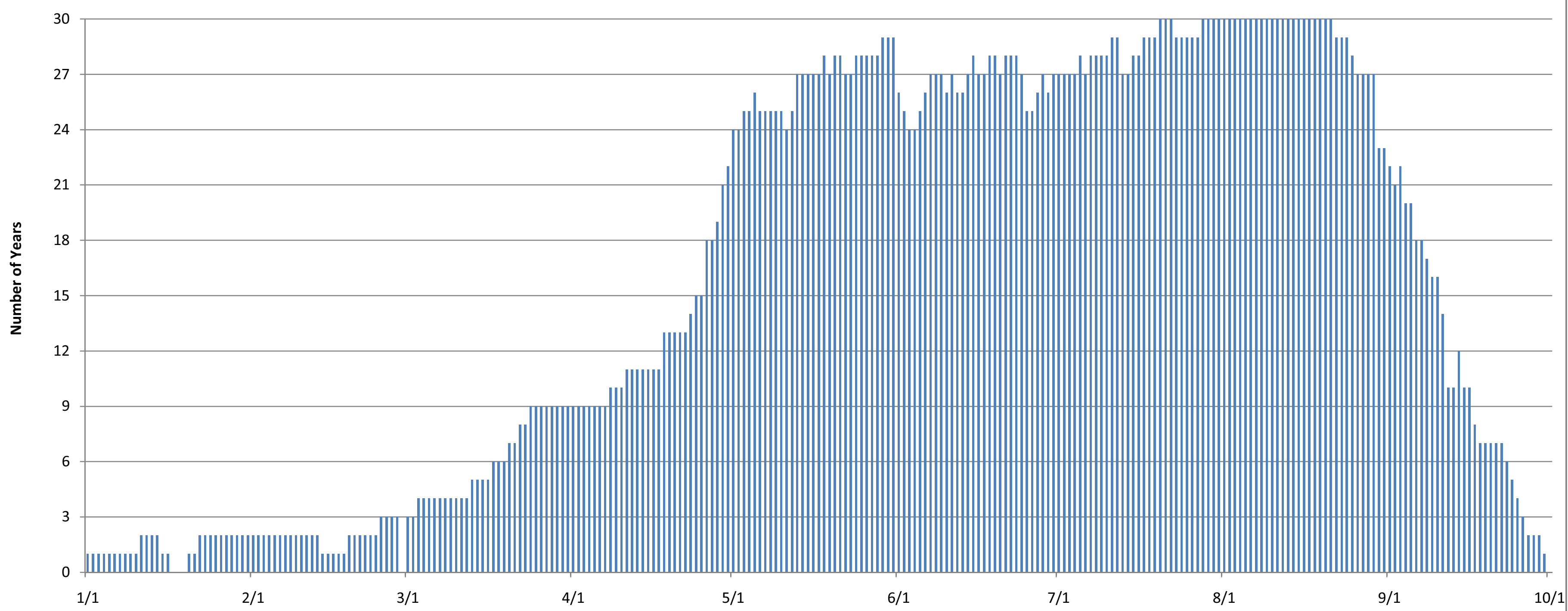
Table 1 presents the date on which the hydroelectric project would have ceased based on the selected representative years.

Table 1. Fall Dates on Which Flows Less than 100 cfs Occurred, Ending the Potential For Hydrolectric Generation In Representative Years.

Year	Year Type	End 100 cfs/End Hydro Operation	Notes
1984	Extremely Wet	August 31	-
1998	Wet	Sept 12	-
1990	Average	Sept 24	Intermittent between 8/30 and 9/24
2000	Average	Sept 19	Intermittent between 9/6 and 9/19
2007	Dry	Sept 4	-
1988	Extremely Dry	August 12	-

Based on the historical release data, the Mason Dam hydroelectric project would be expected to operate all or most of the time in all years between May 1 and August 30, but not at all between October 1 and January. In extremely wet years, the project could operate during January and February, but in the majority of years, the project would initiate operation sometime between mid-March to mid-April. During the third week of April, the project would be operational during an estimated 30% of the years, increasing to being operational 40 to 63% of the years during the last week of April. The hydroelectric project would cease operation during September, generally within the first one or two weeks of the month, with the project being able to continue until the end of September in only 30% of the years.

Figure 1. Frequency of Flows Exceeding 100 cfs Between January 1 and September 30. Based on Data from 1983-2012.



The Mason Dam full pool elevation is at 4062 feet above MSL or 87 feet over the intake top. Water surface elevations during the proposed Mason Dam hydroelectric operating period have varied both annually and during the year. The reservoir is generally at its highest elevation during spring (March-April) and is drawn down to its lowest level in October. Between 1983 and 2012, full pool elevations have ranged from above full pool level (4068 feet in 1984) to 4017 in 1988. Low water surface elevations have ranged from 4053 ft above MSL in 1988 to 3986 ft above MSL in 1984. Figure 2 depicts the water surface level changes between March and October in two extreme years (1984, extremely wet and 1988, extremely dry) as well as surface water level changes in representative wet, dry and average years. The representative years were chosen as follows:

- Average Year: Precipitation is approximately the same as the average annual precipitation of 10.31 inches as recorded at the NOAA Baker City airport weather station (#350412). The years selected were 1990 and 2000.

- Representative Wet Year: Precipitation approximately 1 standard deviation more than the average annual precipitation. The year selected was 1998.

- Representative Dry Year: Precipitation approximately 1 standard deviation less than the average annual precipitation. The year selected was 2007, which was also the year in which the project water quality sampling occurred.

Based on the previous 30-year record of operation (1983-2012), the reservoir surface water level was drawn down to a point between 78 feet over the intake in the wettest year (1984) to 11 feet over the intake in the driest year (1988, see Figure 2). Drawdown levels in the other years fell between these two extremes. Over the 30-year period, the reservoir was drawn down to a level less than 30 feet over the intake in 23% of the years (represented in Figure 2 by 2007), and to a level between 30 to 60 feet over the intake in 20% of the years (represented in Figure 2 by 1990). In the majority of the years (57% of the years), the reservoir was maintained at a level more than 60 feet over the intake during the entire irrigation season (represented in Figure 2 by 1998 and 2000; see also Figure 3).

In general, the end of irrigation season reservoir surface water level is very low in dry years, moderately low in some "average" precipitation years, and kept relatively high in other "average" precipitation and wet years. As noted above, the very low (less than 30 feet over the intake) drawdowns have occurred in 23% of the years, or slightly less than 1 in 4 years.

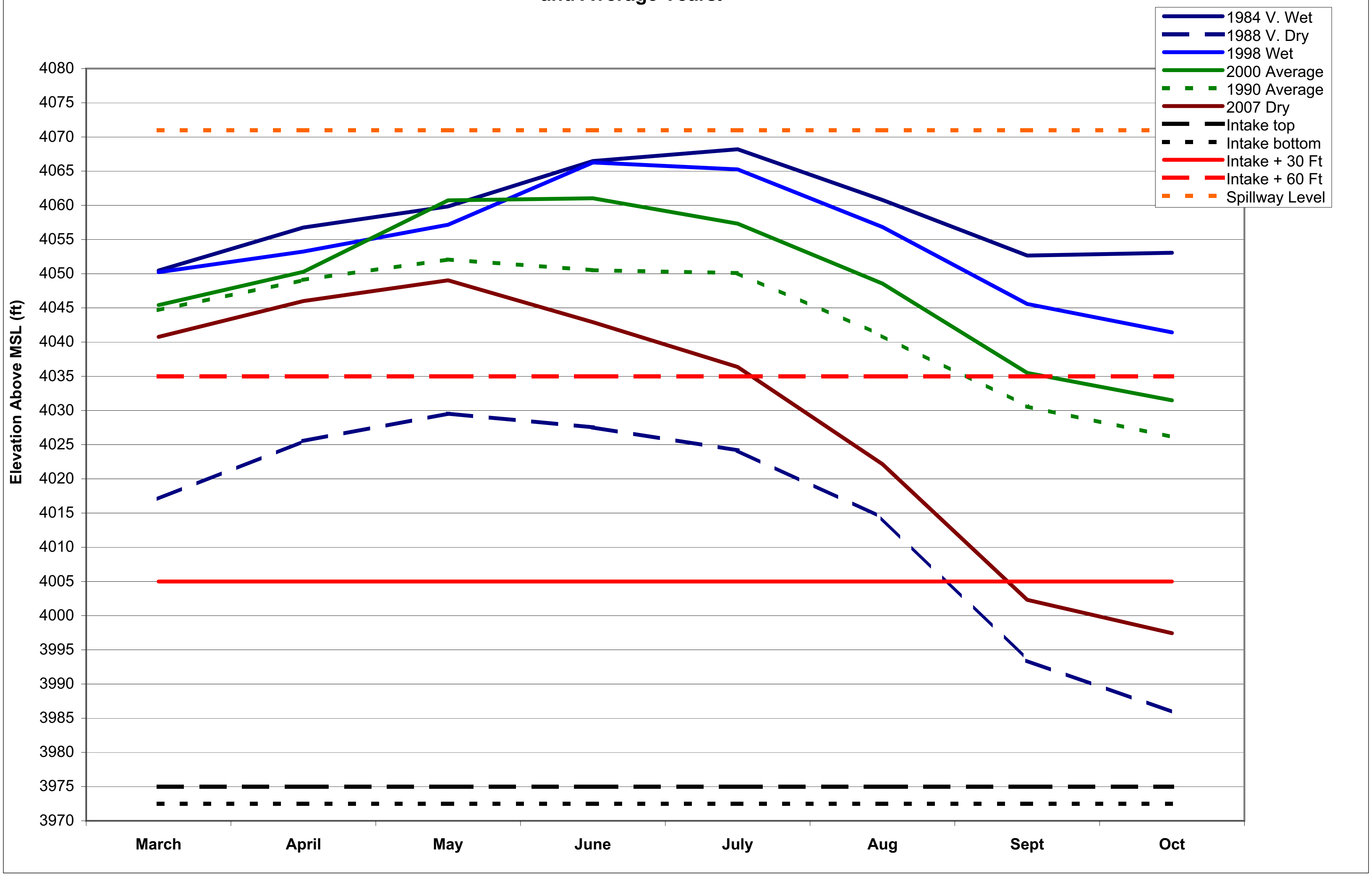
The timing of the low water level is also important, particularly if it occurs during a critical fish life history stage, such as spawning or migration. Except for extremely dry years, such as 1988, the reservoir level is not drawn down to a level less than 30 feet over the intake. In the years that the draw down is less than 30 feet over the intake, does not occur until mid-August. In the years when the reservoir level is lowered to a point between 30 to 60 feet over the intake, this level is also reached in mid-August. In all years, except the excessively dry 1988, the reservoir water level was at least 70 feet above the intake during the spring spawning periods for the fish species occurring within Philips Reservoir. In 1988, the reservoir levels were between 45-55 feet above the intake during the spawning period.

Another factor that is important to fish entrainment is the change in pool volume, particularly in the dry years. The Philips Reservoir pool volume has been drawn down to less than 10% of full pool volume six times in the last 30 years, and to between 10 to 15% of full pool volume in an additional 2 of the 30 years. Overall, pool volume has been drawn down very low, less than 15% of full pool volume, in 26.7% of the years, roughly similar to the frequency at which very shallow water is recorded over the intake (Figure 4).

There were three years in which pool volume was drawn down to levels between 15-25% of full pool. In the remaining years pool volumes were maintained at atleast 30% of full pool level.

Although long term average irrigation season releases through Mason Dam range between 100 and 350 cfs, discharges do vary from year to year. Figure 5 depicts the mean monthly discharges for each of the representative years depicted in Figure 2.

Figure 2. Changes in Philips Reservoir Surface Water Levels between March and October in Representative Wet, Dry and Average Years.



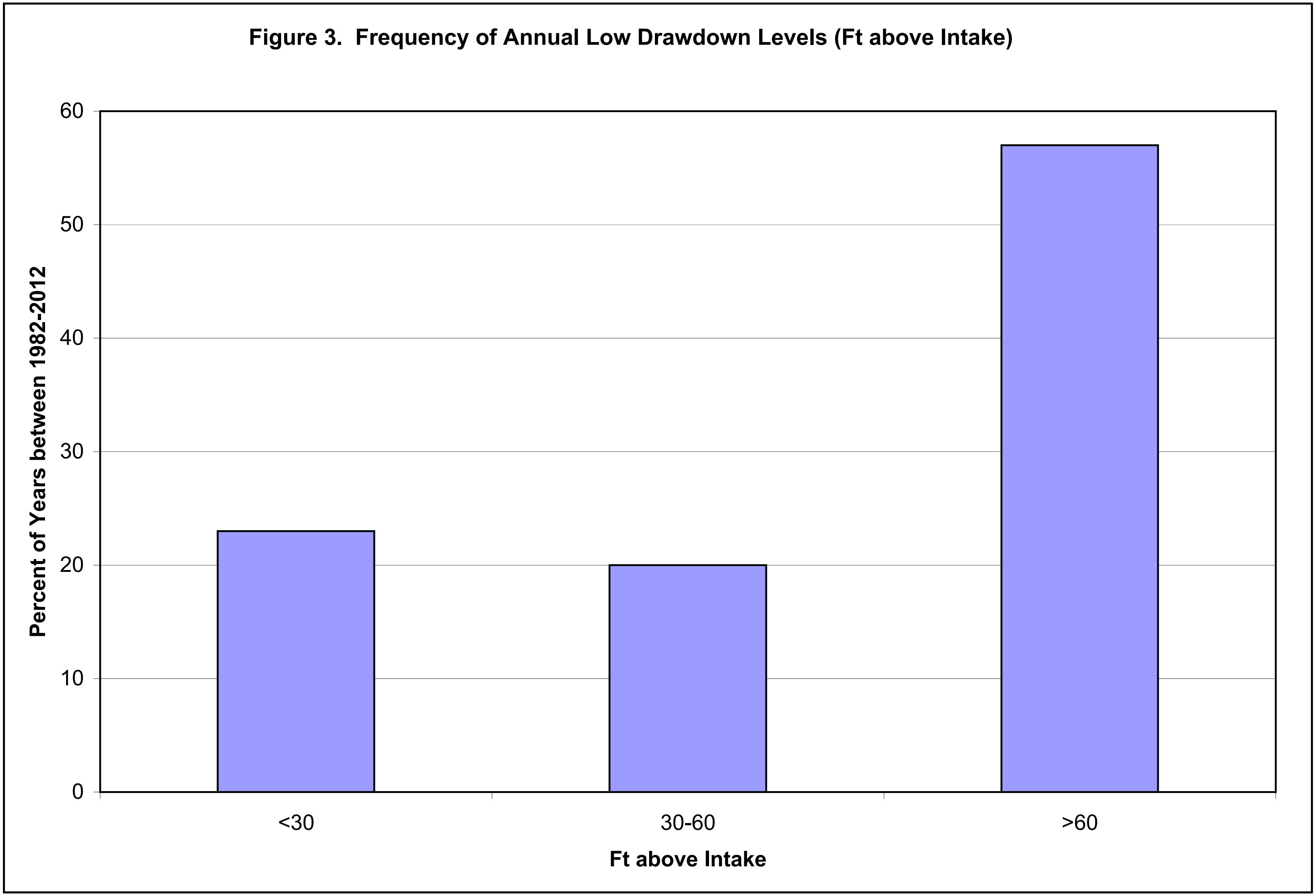


Figure 3. Frequency of Annual Low Drawdown Levels (Ft above Intake)
60
50
40
30
20
10
0
Percent of Years between 1982-2012
<30
30-60
>60
Ft above Intake

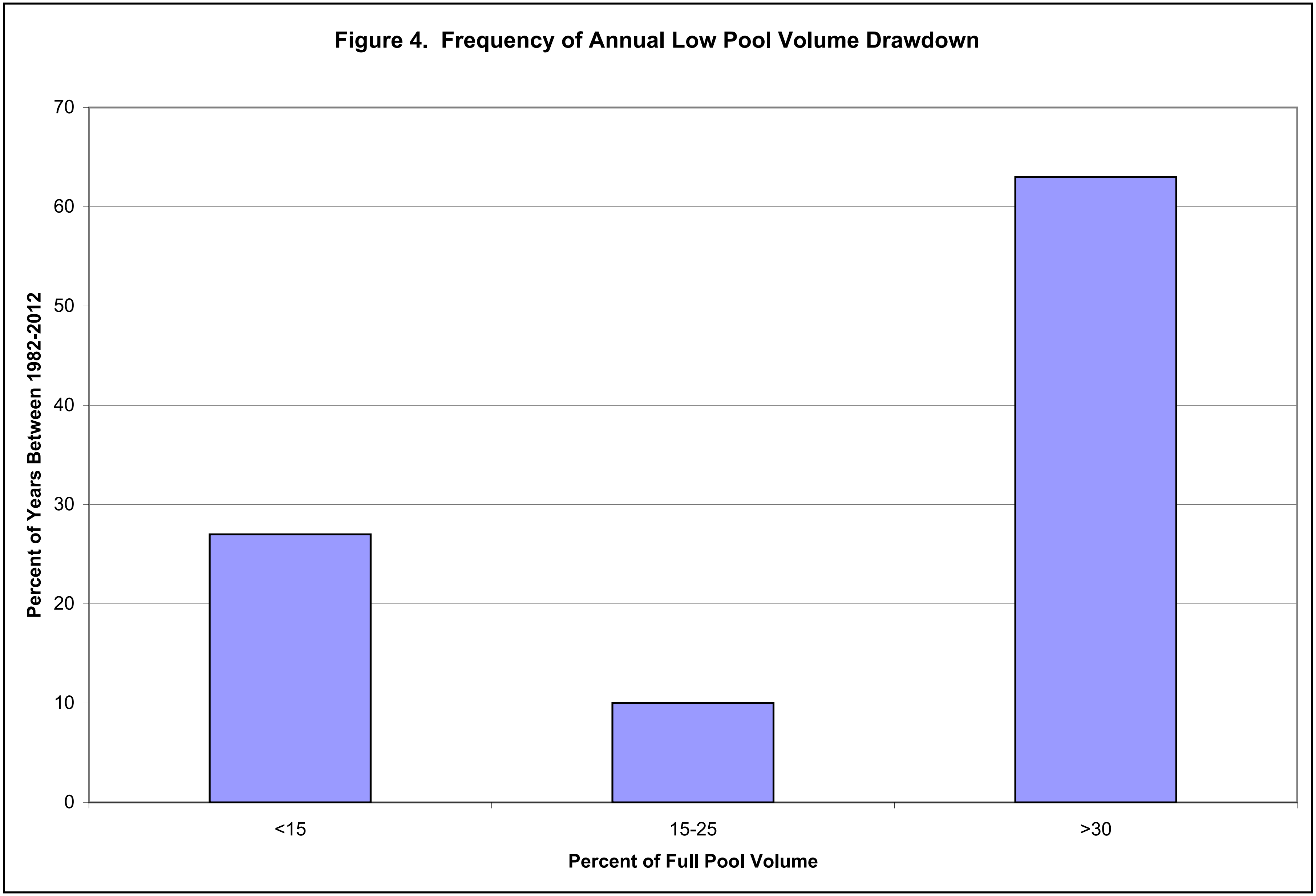
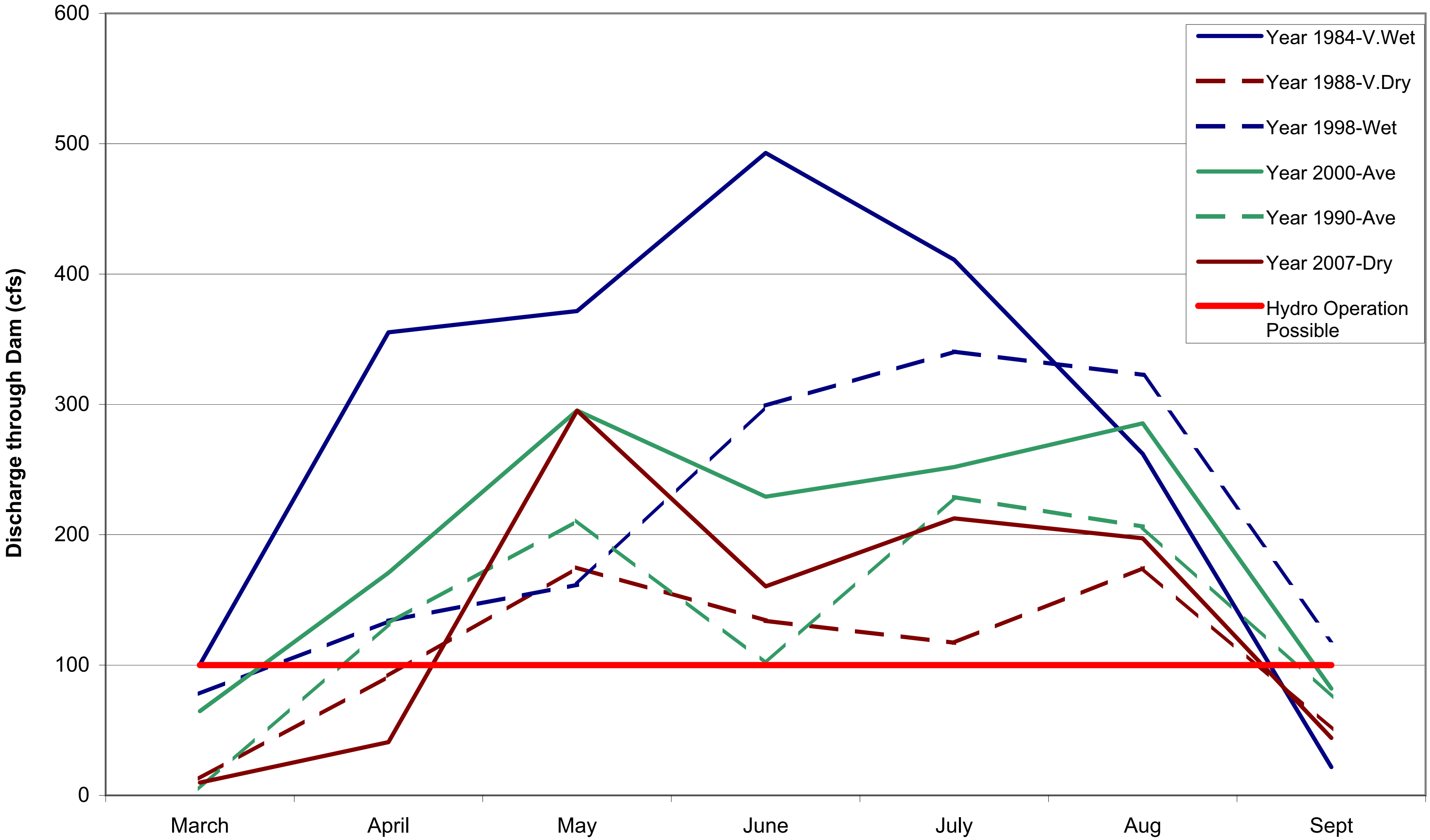


Figure 4. Frequency of Annual Low Pool Volume Drawdown
70
60
50
40
30
20
10
0
Percent of Years Between 1982-2012
<15
15-25
>30
Percent of Full Pool Volume

Figure 5. Mean Monthly Flows Through Mason Dam In Representative Wet, Dry and Average Years. Flows in Extremely Wet (1984) and Extremely Dry (1988) Years are also Depicted.



Intake Characteristics

The Mason Dam intake is approximately 13 feet high, ranging in elevation between 3,975 and 3,988.25 feet above MSL. The bottom of the intake is located at an elevation of 3,975 feet above MSL, or 87 feet below full pool depth (4,062 feet above MSL). The intake bottom is located within the dead storage area and the intake top is within the conservation pool area. The intake is located approximately 290 feet west of Black Mountain Road. It is a gated intake, with a regulated outlet that produces high velocity flows.

The intake itself consists of a cement structure 17.25 feet wide by 13.25 feet high, with a trash rack covering a 10.25 by 11.33 foot opening (see Figure 6). A 6.5 foot diameter concrete pipe extends 325 feet from the intake to the centerline of the dam, where it narrows into an approximately 4.7 foot (56 inch) diameter pipe, with a 1 foot diameter (12 inch) bypass flow pipe. The 56 inch pipe is subsequently bifurcated into two 33 inch (2.75 feet) pipes near the outlet. The regulating slide gates are contained within the two 33 inch pipes.

Flows of up to 875 cfs can be conveyed through the dam intake and pipe systems. There is a spillway for emergency flood releases greater than 875 cfs that has not been used since the dam was constructed. Since dam operation began in 1968, all flows have been through the deep intake. Mean irrigation season releases range between 100 and 350 cfs, with maximum releases between 490 and 570 cfs over the last 30 years. The spillway could be used if the reservoir exceeded an elevation of 4,070.50 feet above MSL, or 8.5 feet above full pool level.

At the beginning of the irrigation season when flows are less than 50 cfs, only one outlet is used with the slide gate typically only open 10% (or a width of 0.27 feet). Once flows exceed 50 cfs, both outlets are used. The slide gates are gradually opened to a maximum of 30 to 40% . Although the two outlet pipes are 2.75 feet in width, the actual opening through which water flows would generally be between 0.82 and 1.10 feet during the irrigation season.

During maximum irrigation releases (approximately 350cfs), intake approach velocities are approximately 1.0 feet per second (fps). As releases decrease, velocities decrease and are less than 1fps at discharges less than 350 cfs. Velocities up to 1.7 fps could occur with releases close to 875 cfs (BOR 2012). Once water enters the 4.7 foot pipe (midway through the dam), velocities increase to 5.8 fps at discharges of 100 cfs and 20.5 fps at discharges of 350 cfs. At the bifurcation point (near the outlet), the velocities accelerate again, with the velocities dependent on the degree of slide gate opening within the outlets. At 100 cfs, velocities would range between 21.0 fps (40% slide gate opening) to 84.2 fps (10% slide gate opening). At 350 cfs, the slide gate would be open between 20 to 40% resulting in velocities of 73.6 to 98.2 fps. Table 2 provides a summary of velocities for the range of slide gate openings used during the time period that the Mason Dam project would be operating.

Figure 6. Diagram of the Mason Dam Intake and Outlet Structures.

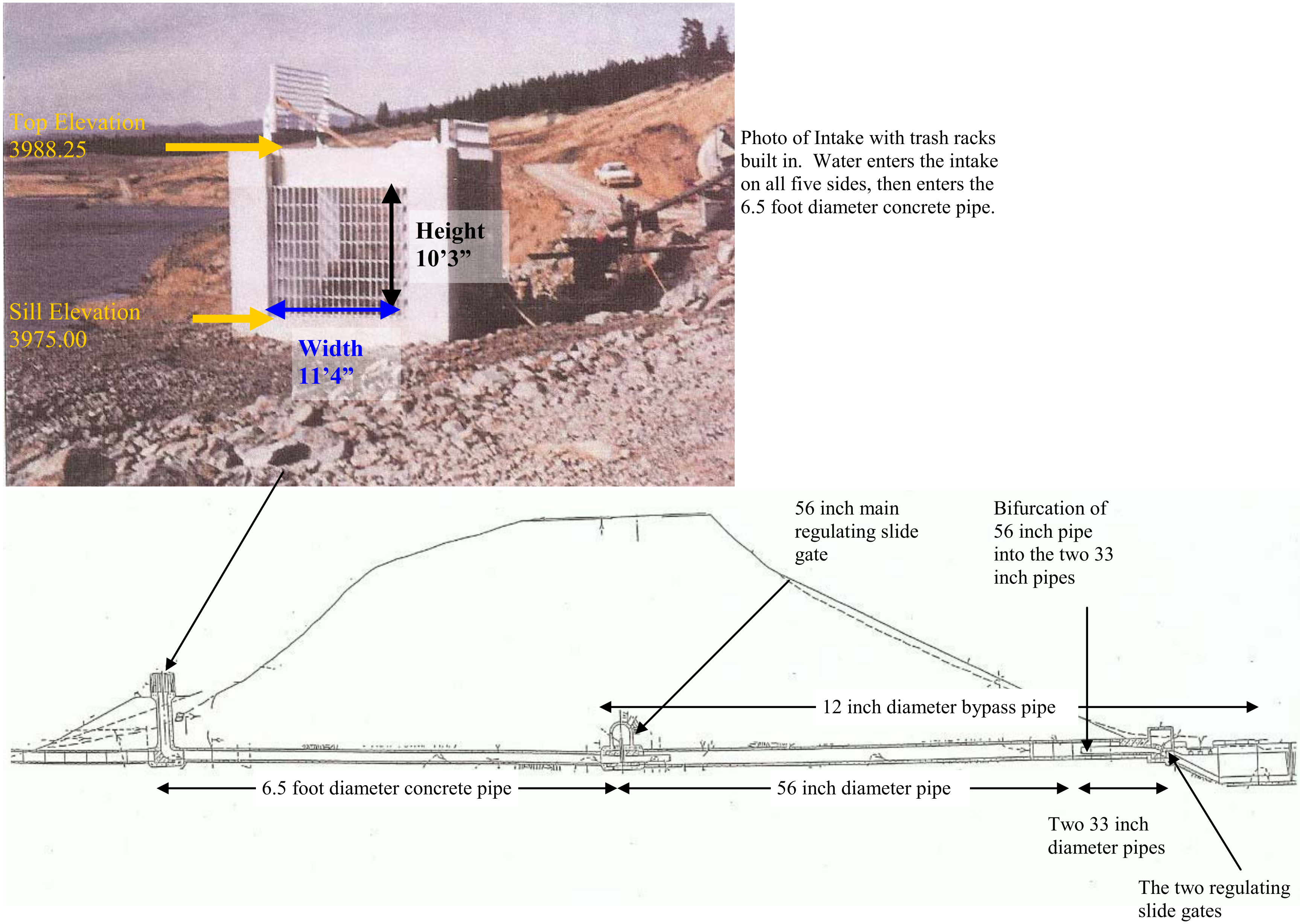


Table 2. Calculated Velocities (fps) through Mason Dam Outlets at Slide Gate Opening Sizes Used During the Irrigation Season.			
Flow (cfs)	**Percent of Slide Gate Opening and Opening Width**		
	10% (0.27 ft)	**30% (0.82 ft)**	**40% (1.10 ft)**
100	84.2 fps	28.1 fps	21.0 fps
150	126.3 fps	42.1 fps	31.6 fps
200	NA-would not occur	56.1 fps	42.1 fps
250		70.2 fps	52.6 fps
300		84.2 fps	63.1 fps
350		98.2 fps	73.6 fps
400		112.2 fps	84.2 fps

Philips Lake is apparently well aerated throughout the water column during the winter and spring (late November to mid April/early May) with dissolved oxygen (DO) values greater than 8 ppm throughout the profile in May (see EcoWest [2009] for full water quality data description). Winter temperatures are unknown but are less than 0 °C in the upper layers as portions of the lake freeze. Beginning in May, the lake starts to stratify with increasing temperatures near the surface and relatively constant temperatures near the bottom of the reservoir. These differences increase to 10 °C by July, as the surface layer warms to more than 20 °C, while the temperatures near the bottom of the reservoir near Mason Dam remain relatively constant between 10.4 to 11.2 °C.

Dissolved oxygen concentrations change as both the temperature changes and the reservoir starts to stratify according to temperature and water density. The surface layers (epilimnion) remain well oxygenated, but in the mid and lower layers (mesolimnion and hypolimnion) DO levels drop below 7 ppm beginning in June.

Table 3 depicts the range of water quality conditions at the intake between mid-May and October. Beginning in mid-June, DO concentrations drop below 6.0 ppm throughout the intake area and remain low until the beginning of September. Temperatures remain cool at the intake level until the beginning of August when they begin to exceed 15 °C and increase to 20.7 °C.

The water quality data were collected during 2007, which was considered a "dry year" and in which the reservoir surface level was 74 feet above the top of the intake at the beginning of May and was drawn down to a level 22 feet over the top of the intake at the end of September. A thermocline started to develop in June between 16.5 and 49.5 feet (or 5-15 meters) below the surface, with the thermocline between 33 and 49.5 feet (10 to 15 meters) below the water surface at its greatest development. Below the thermocline, water was anoxic.

During 1998, a "wet" year, the reservoir water surface ranged between 66 to 75 feet over the intake top between May and October. Because the thermocline develops with increasing surface temperatures, it is likely that in wet years, temperatures at the intake elevations would remain cool longer during the summer. Conversely, with the thermocline developing above the intake elevations, conditions would likely remain anoxic for a longer period of time (e.g., through September).

Table 3 Water Quality Conditions Within the Range of Mason Dam Intake Elevations During 2007.

Date	Intake Elevation (Ft below surface)		DO (ppm)		Temperature (° C)	
	Top	Bottom	Top	Bottom	Top	Bottom
11-May	72.3	59.4	8.6	8.6	11.1	11.1
17-May	70.6	57.8	8.1	7.6	9.1	8.9
25-May	69.3	56.4	7.6	7.3	10.8	10.2
1-Jun	68.0	55.1	6.7	5.9	10.1	10.0
9-Jun	66.3	53.5	7.4	6	12.9	10.8
15-Jun	64.4	51.5	6.6	6.6	13.0	13.5
22-Jun	64.4	51.5	5.8	4.2	12.9	11.3
28-Jun	62.4	49.5	5.2	4.8	14.5	14.2
6-Jul	59.7	46.9	3.5	3.5	12.7	12.7
17-Jul	55.4	42.6	2.6	0.9	14.9	12.0
24-Jul	51.8	38.9	1.8	1	15.0	13.5
7-Aug	43.6	30.7	6.0	0.1	20.7	14.8
14-Aug	38.9	26.1	5.2	0.1	20.1	17.0
21-Aug	33.7	20.8	6.2	2.3	19.5	18.9
13-Sep	25.4	12.5	9.6	7.4	17.7	16.9
21-Sep	24.1	11.2	5.8	7.7	15.4	17.0
28-Sep	23.1	10.2	6.0	5.7	13.4	15.4
5-Oct	22.4	9.6	6.2	6.2	No data	No data
12-Oct	21.8	8.9	6.5	6.5	10.8	10.8

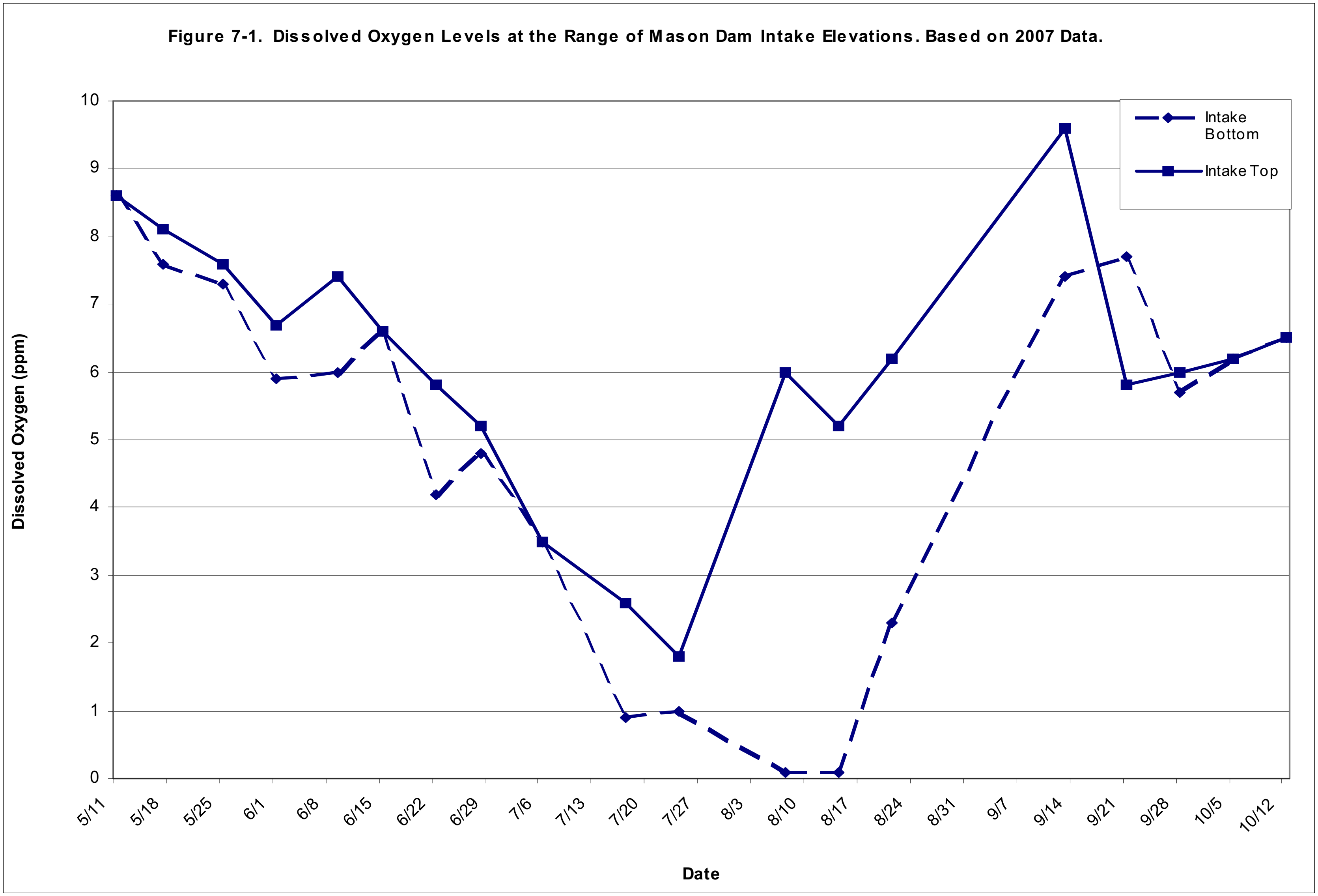
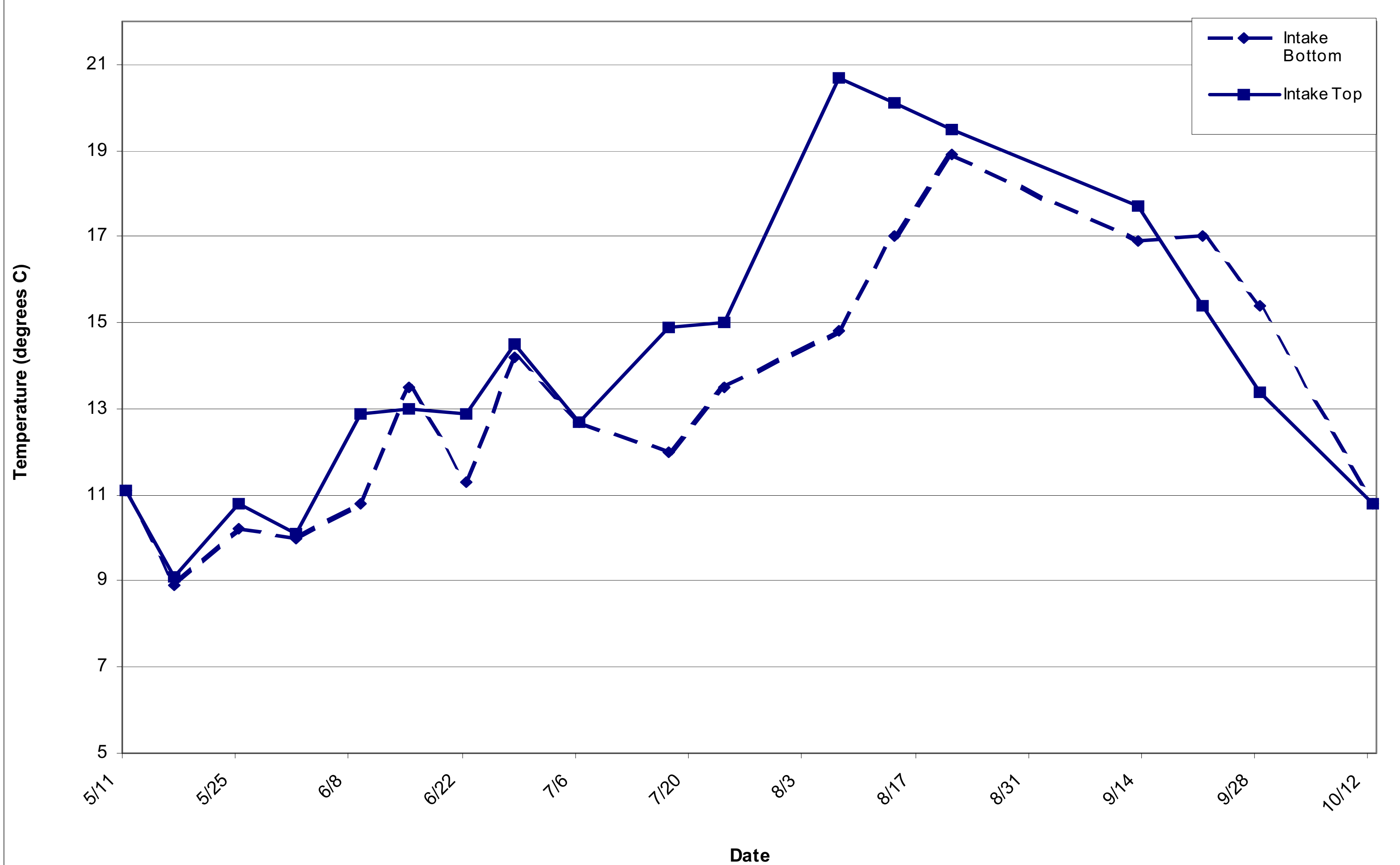


Figure 7-1. Dissolved Oxygen Levels at the Range of Mason Dam Intake Elevations. Based on 2007 Data.
Dissolved Oxygen (ppm)
10
9
8
7
6
5
4
3
2
1
0
Intake Bottom
Intake Top
5/11
5/18
5/25
6/1
6/8
6/15
6/22
6/29
7/6
7/13
7/20
7/27
8/3
8/10
8/17
8/24
8/31
9/7
9/14
9/21
9/28
10/5
10/12
Date

Figure 7-2. Temperatures at the Range of Mason Dam Intake Elevations. Based on 2007 Data.



Fish species
Philips Reservoir was treated with rotenone on October 7, 1977 and restocked in April, 1978 with 150,000 hatchery rainbow trout and an undetermined number of largemouth bass, crappie and coho salmon (PBWC 2001). Yellow perch and walleye were subsequently illegally introduced in the 1980's, with yellow perch first documented by ODFW within the reservoir in 1991. In 1993, ODFW stocked smallmouth bass and black crappie, although both species were present in the reservoir since at least 1985. PBWC (2001) identified that ODFW annually stocked up to 100,000 hatchery rainbow trout as both fingerlings and adults. However, currently, 33,600 legal (8 inches) adult rainbow trout are stocked throughout the summer, and 24,600 sublegal adult trout (6 inches) in September for an average annual stocking rate of 58,200 (T. Bailey, ODFW, Pers. Comm.). No fingerlings are currently stocked. All stocking occurs at the Union Creek boat launch, which is close to Mason Dam. The northern pikeminnow occurred in the Powder River prior to the construction of Mason Dam and still occurs in both the river and the reservoir, where it is fairly abundant (ODFW 2013).

Between 1985 and 1999, the densities of smallmouth bass and crappie declined by 82 and 96%, respectively, primarily due to competition with yellow perch (ODFW 2008). Conversely, the yellow perch population increased by 245% (Shrader 2000). Efforts to manage the number of perch within the reservoir have been conducted annually between 2009 and 2012 (Bailey 2012). These efforts have focused on netting the perch when they are concentrated in their spring littoral spawning areas. Since spawning occurs right after "ice-off", the netting typically occurs during a 7 to 10 day period in mid-April. The most productive perch spawning netting areas have varied within the reservoir. Productive areas include the north side of the reservoir near the Union Creek campground, the south side of the reservoir, and the northwestern edge of the reservoir near where the Powder River enters. When the reservoir is at full pool level, the last site appears to be the most productive spawning area. This site is also the furthest from the Mason Dam intake. Although yellow perch can spawn in any shallow embayment, Appendix B provides the location in which neeting has occurred over the past four years.

The April perch netting resulted in a low of 51,574 perch in 2009 and a high of 354,468 perch in 2011. Yearly total differences reflect the timing of the netting, the netting level of effort and the reservoir level and not population differences. Based on spring netting mark-recapture estimates and other studies, Bailey (2012) estimated a total population of 1,636,575 yellow perch in the reservoir.

Between 2009 and 2011, a total of 769,489 fishes comprising 8 fish species were caught during the April littoral netting (Table 4). Of these fishes, 99.6% of the individuals were yellow perch. Approximately 0.1% each of the individuals netted were northern pikeminnow, suckers and rainbow trout. Other species netted together comprised 0.1% of the catch and included bull trout (2), smallmouth and largemouth bass, and black crappie. [1]

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[1] The April littoral netting was focused on capturing yellow perch within a subset of habitats, and although yellow perch are the dominant fish in the reservoir, the overall spring netting results do not provide an accurate representation of species composition within the whole reservoir.

Fish species currently known in Philips Reservoir include hatchery and wild rainbow trout (redband), black crappie, smallmouth and largemouth bass, yellow perch, walleye, northern pikeminnow and various species of sucker (Baker County 2009). One thousand six hundred (1600) sterile tiger trout were introduced to the reservoir by ODFW in 2011 to help provide a sport fishery for trophy-sized trout (ODFW 2008). The dominant fish species in the reservoir is the yellow perch. Other species thought to be fairly abundant are the suckers and northern pikeminnow. Populations of crappie, bass and walleye are thought to be very low (Bailey 2013). Two subadult bull trout were found in the reservoir in 2011.

Future short term (i.e., 2-5 years) reservoir fishery management plans are to continue stocking six to eight inch rainbow trout at generally similar levels, continue to annually stock sterile tiger trout, and to continue to manage the yellow perch population through mechanical means and biocontrol via introduction of the tiger muskie (ODFW 2013). Although more than one million perch have been removed from the reservoir between 2009-2012, yellow perch continue to dominate the fishery. If the yellow perch population can be substantially reduced, the ODFW would return to stocking a variety of rainbow trout age classes, including fingerlings. The ability to achieve this long term goal and the time period in which achievement could occur is unknown and completely dependent upon the success of future efforts to reduce the perch population.

Table 4. Fish Species Known to Occur in Philips Reservoir.			
Species		**Native?**	**Percent of April Littoral Netting[1]**
Common Name	**Scientific Name**		
Yellow perch	*Perca flavescens*	No	99.6
Walleye	*Sander vitreus*	No	0
Smallmouth bass	*Micropterus dolomieui*	No	<0.01
Largemouth bass	*Micropterus salmoides*	No	<0.01
Black crappie	*Pomoxis nigromaculatus*	No	<0.01
Northern pikeminnow	*Ptychocheilus oregonensis*	Yes	0.1
Suckers (bridgelip, largescale)	*Catastomus columbianus* *Catostomus macrocheilus*	Yes	0.1
Rainbow trout (redband and hatchery)	*Oncorhynchus mykiss spp.*	Mix of native and non-native	0.1
Bull trout	*Salvelinus confluentus*	Yes	<0.0001
Tiger trout	*Salmo trutta X Salvelinus fontinalis*	No	0

[1] The April littoral netting was focused on capturing yellow perch within a subset of habitats, and although yellow perch are the dominant fish in the reservoir, the overall spring netting results do not provide an accurate representation of species composition within the whole reservoir.

3.0 Methods

A literature review was undertaken to identify key factors important to fish entrainment and mortality with a focus on studies since 1995. The literature review summary can be found in Appendix A. Based on the key factors identified in the literature review, a subset of studies were analyzed to provide an updated estimate of overall potential entrainment, entrainment by species and baseline mortality rates. The reservoirs selected met the following characteristics:

- Located within the Pacific Northwest region and containing a cold/coolwater fishery with a trout component.

- Dam height greater than 25 meters (82.5 feet) and with a deep intake. Intakes needed to be located either more than 75 feet below the water surface at full pool, or if less than 75 feet, containing species-specific trout data and/or end of season intake depths similar to those of Mason Dam.

- Reservoirs operated primarily for flood control/irrigation, as much as possible, or if operated for a different purpose then containing data on non-anadromous salmonid entrainment.

These criteria were used as general selection criteria. Other operational specifics such as seasonal drawdown levels and pool volumes changes, water quality characteristics and approach velocities were discussed in evaluating entrainment potential by species and age class.

Based on the three general screening criteria, 11 reservoirs were selected for analysis and comparison to Mason Dam. These reservoirs and their characteristics are listed in Table 5. Not all reservoirs had data for both mortality and entrainment rates (see Table 5). Of the 11 reservoirs, five were used to estimate baseline mortality rates and 10 contained species-specific data on entrainment. Only three of the reservoirs had data on full annual fish entrainment estimates. Only one reservoir, Fall Creek Reservoir, had data on all three items of interest for deep water intake-Pacific Northwest reservoirs: annual entrainment, entrainment by species and mortality rates. Data summaries developed for the Henry Jackson (Spada Lake) and Wickiup relicensing projects were also used in portions of the analysis (CH2MHill 2007, Symbiotics 2009).

The older entrainment data set from GeoSense (2011) was not used further as it contained only shallow reservoirs that do not stratify and Ch2MHill (2003) showed that shallow, non-stratified reservoirs had substantially greater entrainment rates than deeper reservoirs.

In addition, scientific studies on fish species life history, behavior, and swimming speeds were reviewed for the species known to occur in Philips Reservoir.

The mortality data for Mason Dam under the proposed project operation as described in GeoSense (2011) was used to identify how mortality rates might change under project operation for the species most likely to be entrained.

Table 5. General Characteristics of Regional Reservoirs with Deep Intakes, with Mason Dam Characteristics for Comparison.									
Reservoir Name	**State**	**Size**	**Intake Characteristics**		**Flow Range (cfs)**	**Operation**	**Data Type Available**		
		Acres/ Acre-Feet	**Depth (ft)**	**Type**			**Entrainment**		**Baseline Percent Mortality**
							Total	**Species-Specific**	
Cougar	W OR	1,280 (207,759)	92	Slide Gate	440-1000	Irrig, FC	X		X
Fall Creek	W OR	1,820 (115,100)	161	Slide Gate	450-1000	FC, Recr	X	X	X
Trail Bridge	W OR	73 (2,088)	59	Slide Gate	to 2,000	FC	X	X	
Blue River	W OR	1,420 (>80,000)	224	Slide Gate	300-2,400	FC, Recr			X
Wickiup	C OR	Unkn (200,000)	82	Tube Valve	100-2,000	Irrig		X	X
Tieton	E OR	2,530 (198,000)	198	Tube Valve	300-2,190	Irrig		X	X
Beulah	E OR	Unkn (59,212)	76	Jet Valve, Spillway	0-950, gen 300-400	Irrig		X	
Arrowrock	W ID	3,150 (286,600)	205	Clam Shell	54-3,000	Irrig, FC		X	
Timothy Lake	W OR	1,280 (Unkn)	79	Valve	0-300	Recr, FC		X	
Lake Lemolo	SW OR	415 (Unkn)	73	Unknown	436	Hydro		X	
Cooper Lake	AL	2,800 (Unkn)	32	Unknown	380	Hydro		X	
Philips Reservoir/ Mason Dam	E OR	2,234 (95,500)	87	Slide Gate	10-400	Irrig, FC			

4.0 Results

4.1 Entrainment

4.1.1 Estimated Annual Entrainment

Total annual entrainment has been measured at only a few regional reservoirs, with most studies primarily evaluating percent population entrainment or evaluating entrainment potential by species. Annual entrainment numbers were available for three reservoirs -- Cougar, Fall Creek and Trail Bridge, all located within Oregon and all containing gated outlets. These three reservoirs were selected as they represented the only regional reservoirs with cold/coolwater fisheries and deep intakes that also had total entrainment estimates (Table 6).

The comparison reservoirs contained many similarities to Philips Reservoir/Mason Dam, but also some differences in key factors affecting entrainment. These include:

- <u>**Reservoir Characteristics**</u>
  Operation Type: Cougar Reservoir is operated for flood control and irrigation, as is Philips Reservoir. The other two reservoirs are operated for flood control (Trail Bridge) or flood control and recreation (Fall Creek). All reservoirs undergo seasonal drawdowns and are operated so that a low pool occurs during the fall and winter.

  Flow Range: Flows are much higher at the comparison reservoirs than through Mason Dam, with minimum discharges exceeding the Mason Dam maximum discharges. Because no other regional studies were available with total entrainment numbers, and because higher rates of entrainment would be expected with higher discharges, the comparison reservoirs were still used as they would result in a more conservative (i.e., likely higher than actual) entrainment estimate.

- <u>**Intake Characteristics**</u>
  Depth: The Cougar Reservoir intake depth is similar to that of Mason Dam at full pool depth; Trail Bridge and Fall Creek Reservoir slide gate intake depths are similar to those of Mason Dam during seasonal low water levels. Fall Creek Reservoir differs from Philips Reservoir in that it also contains a set of "fish horns" as part of a downstream migrant passage system located 40 to 80 feet above the gated intake. As a result, when these horns are usable, fish can exit the reservoir at multiple locations within the water column.

  Water Quality Near Intake: Cougar and Fall Reservoirs thermally stratify, but do not chemically stratify. In contrast to Mason Dam, DO conditions at all three comparison reservoirs remain suitable for most species during the full year.

  Approach Velocities: Approach velocities at the Cougar and Fall Creek intakes are unknown, but are greater than 3.3 fps at Trail Bridge, which is higher than the 1.0 fps at Mason Dam.

- **Fish Species**

Full fish species composition and population numbers are not available at any of the reservoirs. However, the comparison reservoirs contained the following species in common with Mason Dam: rainbow trout (native and hatchery), bull trout, largemouth bass, smallmouth bass, walleye, crappie, and a variety of sucker species.

Differences in composition are that yellow perch are not a major component in the comparison reservoirs, and that the comparison reservoirs contain a large anadromous salmonid component, which Mason Dam does not have. The majority of fish entrained at the comparison reservoirs consisted of anadromous salmonid fish (from 78 to 96% of the fish entrained). Because anadromous fish are obligate downstream migrants, they are subject to much higher entrainment levels than other species (see Appendix A). The salmonid species in Mason Dam migrate upstream for spawning (or away from the intake) and are not subject to the episodic entrainment of downstream migrants.

Table 6. Estimated Annual Entrainment from Oregon Reservoirs with Deep Intakes, with Mason Dam Characteristics for Comparison.

Reservoir	Size		Intake Characteristics		Flow Range (cfs)	Entrainment (# fish)	
	Acres	Acre-Feet	Depth (ft)	Approach Velocity (fps)		All fish	All non-anadromous fish
Cougar	1,280	207,759	92	Unknown	440-1000	78,737	Unknown, almost all fish entrained were Chinook salmon; even if up to 49%, estimated as a maximum of 38,581
Fall Creek	1,820	115,100	161	Unknown	450-1000	254,200-354,800*	55,924-78,056*
Trail Bridge	73	2,088	59	> 3.3	Up to 2,000	up to 22,040	694
Philips Reservoir/ Mason Dam	2,234	95,500	87	1.0	10-400	Unknown	Unknown

* Estimates derived while multiple outlets throughout the water column were in use and up to 1 million fish were stocked annually.

There is no exact match between Mason Dam and the comparison reservoirs. The reservoir with the closest fit to the Mason Dam project is Cougar Reservoir as it is operated for both irrigation and flood control, has a similar intake depth, and is known to stratify. The non-anadromous fish composition is unknown but studies indicated that the majority of entrained fish were Chinook salmon. Even if non-anadromous fish comprised up to 49% of entrained fish, that would represent a maximum of 38,581 fish per year.

Fall Creek Reservoir has the most complete entrainment data set for any of the regional reservoirs examined. However, the Fall Creek Reservoir entrainment studies were all conducted when (1) fish were able to exit the reservoir at various locations throughout the water column and not just through the bottom slide gate intake, (2) during a period in which 1 million chinook salmon were annually stocked and (3)during operations that included very rapid fall drawdowns. Annual entrainment at Mason Dam is likely to be much lower than that measured at Fall Creek as a result of the seasonal water quality limitations near the intake, the low approach velocities, the single bottom gate outlet system and the vast difference in stocking quantities (i.e.,58,000trout vs 1,000,000salmon). This point is underscored by a more recent study at Fall Creek following the cessation of the heavy hatchery fish stocking program (Keefer et al. 2010). In this study, total annual entrainment was not estimated, but the total number of entrained fish over 889 days of sampling in a 4-year period was similar to the total number of fish previously enumerated in 54 days of sampling, indicating a substantial decrease in the number of entrained fish with a decrease in the number of stocked fish.

As a result, the total annual non-anadromous fish entrainment at Mason Dam was preliminarily estimated as similar to that of the maximum Cougar Reservoir estimate (38,581), with Fall Creek entrainment data used to identify conditions under which entrainment rates would be highest.

Much of the recent data collected on regional reservoirs has focused on species-specific entrainment and this general estimate was subsequently refined in light of the more detailed fish species information presented below in section 4.1.2.

4.1.2 Species-Specific Entrainment Potential Overview

Introduction

The entrainment potential for individual fish species or group of related fish species was based on the likelihood that a fish would occur near the intake during the Mason Dam hydrolectric project operating period of mid-March to September 30. The following factors were used to evaluate the entrainment potential:

- Species spawning habitat type and location, and spawning timing.
- Seasonal movement patterns.
- General location within the water column.
- Water quality requirements-particularly Dissolved Oxygen (DO), with temperature a secondary factor.

Potential entrainment was evaluated according to the following categories:

None: There is no habitat requirement/tolerance or fish behavior that would place the species near the intake during the Mason Dam operating period.

Minimal: The species may inadvertently occur near the intake, but the intake is generally located outside of species habitat tolerances.

Low: The species may occasionally occur near the intake, but the intake is generally located outside of species habitat preferences, or the project would only occasionally be in operation during the time period that species could occur near the intake.

Moderate: Species may routinely or seasonally occur near the intake during portions of the project operating period.

High: Species is very likely to occur near the intake during most of the project operating period.

In addition, entrainment potential was also evaluated according to the following question: "If a fish's behavior placed it in proximity to the intake, would it be able to swim out of the flow field which has a maximum allowable velocity of 1.7 feet/second (fps) at a release of 875 cfs, but a more normal approach velocity of 1.0 fps at a release of 350 cfs?"

Entrainment potential was evaluated for spawning, adult and juvenile life history stages.

4.1.3 Salmonids

Rainbow Trout Life History

According to the ODFW, there are two rainbow trout subspecies in Philips Lake, the native redband trout (a sensitive species) and the stocked rainbow trout.

Optimal lacustrine habitat for both subspecies is characterized by clear, cold, deep lakes. Both rainbow trout subspecies are primarily stream spawners and generally require tributary streams with gravel substrate in riffle areas for reproduction to occur (Raleigh et al. 1984). Locally, redband trout spawn in the spring between April and May in tributaries to Philips Reservoir (PBWC 2011). Migration timing is affected by water temperature and stream flow. After spawning, resident redband trout maintain restricted home ranges until migrating to overwintering areas in the fall (Thurow 1990). Juveniles of migratory forms typically move downstream to lakes or rivers after one to three years in natal streams. At any one time, there could be both fluvial and adfluvial populations in Philips Reservoir as well as non-reproducing juveniles (ODFW 2009).

Optimal oxygen levels for rainbow trout in general are at least 7 ppm, with oxygen needs increasing as the temperatures increases (Raleigh et al. 1984). The lethal DO level is 3 ppm, but the species exhibits strong avoidance behavior of water with DO levels less than 5 ppm. The optimal temperatures for rainbow trout are between 12 to 18 °C , with adults residing in lakes selecting waters with temperatures between 7 to 18 ° C and avoiding areas with temperatures greater than 18 ° C .

The depth distribution of adult lake rainbow trout is generally a function of dissolved oxygen, temperature, and location of food sources. Some reservoir studies have noted a strong tendency for rainbow trout to follow the 18 ° C isotherm, as long as DO remains at satisfactory levels. CH2MHill (2007) noted a tendency for rainbow trout within the Pacific Northwest to be surface oriented. Studies at the Carmen-Smith hydroelectric project in western Oregon (which includes Trail Bridge Reservoir) also noted that rainbow trout were rarely found below the thermocline, even when conditions in the hypolimnion were favorable (Stillwater Sciences 2006). The same study showed that young trout remained in shallow water with abundant vegetative cover and observed no trout more than 10 meters (33 feet) below the surface during spring and summer.

Rainbow trout swimming speeds have been identified as being similar to those of bull trout (Mesa et al. 2004), but studies in the eastern US have identified lower average swimming speeds of 4.3 fps (NY Power Authority 2005) and CH2MHill (2007) estimated maximum rainbow trout swimming speeds at 5 fps.

Rainbow Trout Entrainment Potential

CH2MHill (2007) reviewed 12 studies in the Pacific Northwest and northern California in which rainbow, cutthroat, brook and/or brown trout entrainment was measured. All of the study reservoirs contained cold and coolwater fisheries and had deep water intakes. No trout were entrained at 8 of the 12 reservoirs. Trout entrainment rates at the other four reservoirs were estimated as ranging from less than 0.001% to 3.2% of the trout population. Trout entrainment details for these reservoirs and their similarities/differences to Philips Reservoir are described below:

- One cutthroat trout out of an estimated 100,000 total cutthroat and rainbow trout population at Timothy Lake was entrained during spring and fall sampling conducted over a three year period. No rainbow trout were entrained in spite of annual stocking of 12,000 to 34,000 adult rainbow trout. Timothy Lake is a 1,280 acre reservoir in Oregon on the upper Clackamas River, with an outlet structure 80 feet deep at full pool. Although a smaller reservoir than Philips Reservoir, the total estimated trout population and maximum intake depth below the water surface are similar between the two reservoirs.

- At the Tieton project in eastern Washington, the total trout population is not known, but 60,000 rainbow trout are stocked annually. Entrainment studies identified 37 total rainbow trout, of which 28 were suspected to have been resident in the tailwater below the dam and not entrained fish. Regardless, less than 0.1% of the known rainbow trout population was entrained at this facility. The reservoir covers an area of 2,526 acres with a an intake depth of 200 feet at full pool. The Tieton reservoir covers a similar surface area as Philips Reservoir, but contains a larger volume and is twice as deep.

- During sampling occurring over a three-year period, 16 total trout out of an estimated 100,000 combined cutthroat and rainbow trout population were caught in entrainment studies, most or all of which were thought to be tailrace residents, at Lake Koocanus (Libby Dam) in Montana. This reservoir is much larger than Philips Reservoir (29,000 acres), with intake depths ranging from 50 to 90-140 feet below the water surface. The intake depths below the water surface are greater than those of Philips Reservoir during dry years, but similar to the levels during wet years and some average years.

- An average of 2.6% of the estimated 51,000 trout population is estimated as being entrained at Lake Lemolo on the North Umpqua River, Oregon. Almost all of the trout were juvenile brown trout (less than 100 mm or 3.94 inches) entrained in the fall as the reservoir was drawn down to its lowest level. In a high drawdown year, where the remaining pool was 12% of its full pool volume, and surface water levels were 36 to 44 feet above the intake, an estimated 1,632 fish were entrained, or 3.2% of the total population. In a low drawdown year in which water levels were 58 to 69 feet over the intake, an estimated 1,005 trout were entrained, or 1.9% of the population. The Lake Lemolo intake depth is similar to that of the Mason Dam intake at full pool. Additionally, although Lake Lemolo is rather deep (80 to 100 feet) directly behind the dam, most of the lake is shallower than 40 feet and the mean depth is only 30 feet at full pool with a large littoral area (Portland State University 2013).

Of the remaining eight studies reviewed by CH2MHill (2007) identifying a lack of rainbow trout entrainment, studies at Cooper Lake, Alaska were quite pertinent to the Mason Dam project. Cooper Lake has a similar surface area to Philips Lake, and although containing a smaller volume and shallower water depths, approach velocities of 1.57 fps are similar to those of the Mason Dam intake. In spite of a minimum pool depth of 8 feet at Cooper Lake, no rainbow trout were entrained (out of an 6,000 total trout population) during the studies.

Other regional studies examined in this report regarding trout entrainment included Fall Creek, Cougar and Trail Bridge Reservoirs in western Oregon, and Wickiup Reservoir in central Oregon. Only Trail Bridge provided detailed information on rainbow trout entrainment in relation to the total population.

- Entrainment studies at Trail Bridge Reservoir identified that 0.01% of the estimated reservoir rainbow trout population was entrained annually (Stillwater Sciences 2006). Trail Bridge is a small reservoir, much shallower than Philips Lake and with approach velocities above 3.3 fps.

- Entrainment studies at Fall Creek identified the number of rainbow trout in relation to the total number of entrained fish, but did not identify the relationship between entrainment and within reservoir populations. Homolka and Smith (1991) identified that most entrainment of rainbow trout and other non-anadromous species occurred when the reservoir was drawn down to levels of 30 feet above the intake and that rainbow trout comprised less than 0.6% of the total entrainment, with steelhead comprising another 1.7% of the entrained fish. More recent studies from 2006- 2009 identified that a mix of rainbow trout and steelhead comprised 0.12% of entrained fish (Symbiotics 2011). Both studies identified low rates of rainbow trout entrainment but no information was provided on the relationship to total population estimates.

- Wickiup Reservoir trout entrainment was thought to mostly occur when pool volume was 20% or less of full pool (Symbiotics 2008). Wickiup is a larger reservoir than Philips, but the intakes are located at similar depths.

Of the studies reviewed, key factors affecting rainbow trout (and related, non-anadromous trout species), the following factors appeared to be the most important in affecting entrainment[2]:

- **Changes in Intake Depths**. Studies evaluating entrainment in relation to water levels above the intake have indicated greater entrainment rates when surface water levels are less than 30 feet above the intake, with little to no entrainment when surface water levels exceed 50-60 feet above the intake. This relationship first identified in Homolka and Smith (1991), has been confirmed in many other studies, most recently by Keefer et al. (2010). Keefer et al (2010) identified that at Fall Creek Reservoir, approximately 100 fish per day passed through the dam when water levels were less than 30 feet over the bottom intake, with very minimal entrainment (i.e., 1 fish/day) when water levels were more than 60 feet over the slide gate intake and the multi-level DSM system was not in operation.

- **Reservoir Drawdown Volumes**. Trout entrainment is higher when pool volumes are 10-15% of full pool volume (20% at the larger Wickiup Reservoir).

- **Approach velocities**. During their review of regional studies, CH2MHill (2007) identified minimal risk to rainbow trout being entrained through deep intakes in cold and coolwater fisheries if approach velocities are 3.5 fps or less as long as the trout are greater than 6 inches. This point was underscored by the lack of entrainment at Cooper Lake in which surface water levels are drawn very low over the intake, but approach velocities are 1.57 fps.

- **Population Age Class Structure**. Most regional studies report a lack of subadult to adult (> 6 inches) trout entrainment.

In addition, many studies have identified that as although fish may move throughout a reservoir, as long as suitable habitat remains, trout will avoid areas with poor water quality conditions (see Appendix A).

These factors in relation to Philips Reservoir characteristics, local life history data and reservoir trout populations were used to evaluate the rainbow trout entrainment potential under current conditions and potential future conditions during later stages of the license period. The current condition is estimated as a rainbow trout population of between 60,000 to 100,000 fish, of which 58,200 6 to 8 inch fish are stocked annually. The future condition, is for a larger trout population with up to 200,000 rainbow trout fingerlings (3 inch) to be stocked annually along with annual stocking of tiger trout. There is no entrainment information on the tiger trout introduced by ODFW, but ODFW has indicated that tiger trout entrainment is expected to be similar to that of adult

[2] In addition to having a deep intake, location with the Northwest or adjacent states, and possessing a cold/cool water fishery with a trout component, which were study selection criteria.

rainbow trout (T. Bailey, ODFW, pers comm).

Spawning: Rainbow trout spawn in the Philips Reservoir tributaries which are located well away from and upstream of the intake. There is **no** potential for entrainment of spawning rainbow trout under either current or potential future conditions. Tiger trout are sterile hybrids and do not spawn.

Adults: Although redband and other rainbow trout are adapted to a wider range of environmental conditions than other salmonids, they still exhibit seasonal movements and are restricted by very low oxygen conditions. DO levels range from less than 5 ppm to anoxic conditions near the intake between mid June and mid August. During this time period, water levels are maintained at least 30 feet above the intake in all years, and 60 feet or more above the intake in average and wet years. With unsuitable DO conditions near the intake and availability of other habitat, rainbow trout would not be expected to occur near the intake during this time period.

Both temperature and DO conditions at the Mason Dam intake fall within adult rainbow trout tolerances in May to early June and within the preferred range in September. During the spring, water levels in all years except the extremely dry 1988 have been between 60 to 90 feet above the intake. Rainbow trout could occur near the intake during the spring, but if adult rainbow trout encountered the intake, they would be easily able to outswim the 1.0 fps approach velocities.

During September, DO and temperature conditions are quite suitable for rainbow trout near the intake. At this time the reservoir is drawn down to its lowest level with both depths over the intake and pool volume reduced. During September (and the rest of the fall period when the Mason Dam hydroelectric project would not be operating), rainbow trout would most likely be within the intake vicinity. The risk of entrainment would still be low due to the strong swimming speeds of adult trout in relation to the 1.0 fps intake approach velocities.

The overall risk of adult rainbow trout entrainment during the Mason Dam operational period is **none to minimal.** The same risk is expected for adult tiger trout.

Juveniles: As described for adults, juvenile rainbow trout would likely exhibit avoidance of deep water habitats near the intake during the spring when surface water levels are well above the intake and there is abundant available littoral habitat. Likewise, juveniles would also avoid the intake area between mid June and mid August when DO levels become anoxic near the intake.

Juvenile trout would likely occur in the intake vicinity as the reservoir is drawn down and DO levels increase in September. At this time, juveniles may or may not be able to outswim the intake velocities resulting in a risk of entrainment. The risk of entrainment would be higher in years in which pool volumes were drawn down to less than 15% or less than 30 feet over the intake. These conditions occur in approximately 25% of the years.

Healthy juveniles have burst speeds greater than the Mason Dam approach velocities. During most years in which pool volumes remain greater than 30% full volume, the risk of juvenile trout entrainment would be **minimal to low**. During dry years when fish are concentrated in a smaller volume (or approximately 1 in 4 years), entrainment risk would increase to **moderate**.

Only adult tiger trout are stocked in Philips Reservoir so no entrainment risk was evaluated.

Stocked Fish: Only subadult and adult rainbow trout are currently stocked in Philips Reservoir. Adults (6-8 inches) are stocked in June and subadults (6 inches) in September. The potential for stocked fish to be entrained would depend on their condition during the stocking period and the location of the stocking. Stocked fish tend to stay in the general vicinity of their release point for at least 7 to 10 days (Gonzalez 2012). Hatchery fish also experience a high level of stress, disorientation and other adverse effects from sudden changes in aquatic environments (from hatchery to truck to reservoir). The likelihood of stocked fish to be entrained if released in June, when water levels are quite high over the intake would be less than the likelihood of entrainment in September when water levels are low.

Because of the release point near the dam, and the initial period of disorientation, the entrainment potential is rated as low to moderate for spring releases and moderate to high for fall releases for an overall rating of **moderate.** The entrainment risk could be substantially reduced with fish stocking at other accessible locations around the lake.

In the future, and if yellow perch can be reduced, up to 200,000 fingerlings could be stocked near the Mason Dam intake in the fall. The combination of initial disorientation, low swimming speeds and a seasonal low pool volume, would place fingerlings at a **high** potential for entrainment. As noted above, the entrainment risk could be substantially reduced with fish stocking at other accessible locations around the lake.

Bull Trout Life History

Bull trout spawn in the late summer or fall, generally between mid September to October. The eggs hatch during the winter, with fry emerging from the gravel in April or May. Juveniles exhibit a strong benthic orientation, hiding within cobbles, boulders, woody debris and other cover during the day and are more active at night. Juveniles feed mostly on macroinvertebrates, shifting to a piscivorous diet when they reach sizes of 100 to 200 mm (or 2 to 3 years old, and 3.9 to 7.9 inches). Although juveniles can migrate to lakes at any age, it is unusual to find young less than 200 (7.9 inches) in lakes and reservoirs. The majority of adfluvial juveniles migrate to lakes when they are 2 or more years old (Pratt 1992, Goetz 1997, Flatter 2000).

Sexual maturity is not reached until at least four years of age, with an estimated longevity of 5 to 7 years, and up to 12 years (FWS 1998). Adults may spawn either every year or in alternate years. The bull trout can exhibit either migratory or resident life history strategies. Resident fish complete their life history cycle in the same stream in which they spawn. Migratory bull trout hatch and rear in tributary streams and then migrate to larger streams (fluvial form) or lakes (adfluvial form) to mature, returning to the smaller streams only to spawn. Both forms can co-occur and resident fish can produce migratory forms (FWS 1998).

Bull trout require among the coldest water temperatures of any native Pacific Northwest salmonid

(FWS 2002, FWS 2010), requiring temperatures between 2 to 15 °C with thermal refugia where temperatures exceed the upper limit, and with different temperature ranges necessary in different life history stages (e.g., optimal temperatures of 5 to 9°C for spawning, 2 to 4 °C for incubation, and 7 to 8 °C for growth). Bull trout also require well oxygenated water. DO levels > 8 ppm are preferred, with short term tolerances of DO levels between 6 to 8 ppm. The species can not tolerate DO levels less than 6 ppm.

Because of the requirement for cold, well oxygenated water, habitats used by migratory bull trout include bottoms of deep pools in streams and also large coldwater lakes and reservoirs. Within lakes and reservoirs, bull trout inhabit the cold, deeper sections and primarily occur within the upper hypolimnion (Goetz 1989, Fraley and Shepard 1989, McPhail and Baxter 1996, Flatter 2000, Petersen et al. 2002). Bull trout also forage in cool, shallow, littoral zones which tend to occur in the upper reservoir arms where tributaries enter the reservoir. However, bull trout location within a given lake or reservoir varies by season and type of lake.

There are a number of lakes/reservoirs in which bull trout have (1) been documented and (2) for which data on habitat preferences and seasonal movements exist. These include Beulah Reservoir (Gonzalez 1998, Schwabe et al. 1999, Schwabe et al. 2002, Petersen et al. 2002) and Lake Billy Chinook (Ratliff et al. 1996, Beauchamp and Van Tassel 2001) in Oregon, and Flathead Reservoir in Montana (Flatter 2000, Fraley and Shepard 1989). The two Oregon reservoirs differ in thermal regime. Beulah Reservoir temperatures rarely exceed 15 °C and DO levels generally remain above 6.5 ppm, without developing anoxic conditions. Lake Billy Chinook does thermally stratify with temperatures in the epilimnion reaching 15 to 21 °C during the summer. In both of these reservoirs, studies have shown that bull trout migrate out of the main body of the reservoirs during the spring into either upstream tributaries or the unstratified reservoir tributary arms (March to mid-May in Beulah and June to mid-July in Lake Billy Chinook). Migration back to the reservoirs, where the bull trout overwinter, occurs between late October and November.

At Flathead Lake in Montana, bull trout use all parts of the reservoir depending on the season, tending to use littoral zones in the spring and fall, deeper water in the winter and migrating out of the reservoir during the summer (Flatter 2000). The bull trout congregate at the upper end of the reservoir in the spring, moving into the tributaries by mid-June. They return between mid-September to mid-October to the upper portion of the reservoir, where they stay for several weeks before dispersing throughout the reservoir. Fraley and Shephard (1989) suggested that the seasonal movements out of the reservoir reflected a response to changes in temperature, photoperiod and discharge as the lake is oligotrophic, lacking strong stratification.

Philips Reservoir is characterized as a meso to eutrophic lake (Portland State University 2013). In meso and eutrophic lakes, such as Philips Lake, oxygen levels tend to be depleted during the summer. In these types of lakes, bull trout migrate out of the lake in the spring due to a complex set of factors which include changes in temperature and photoperiod (as in oligotrophic lakes), as well as moving within or out of the reservoir when conditions in the hypolimnion become unsuitable. In these lakes, bull trout return in the fall and use the water body primarily as overwintering habitat (see for example, Flatter 2000, Stoval 2001, Petersen et al. 2002 and 2003, McPhail and Baxter

1996).

The bull trout within Philips Reservoir are genetically similar to the Malheur River fish which begin to stage and outmigrate beginning in April (Gonzalez 2012). As for all other regional reservoirs in which bull trout have been studied, it is highly likely that beginning in June (or as early as April), any bull trout near the eastern end of Philips Lake would migrate to other areas according to photoperiod and temperature cues, and also exhibit strong avoidance of areas with unfavorable temperature and DO regimes.

Seasonal outmigration in other reservoirs has been linked to a point in which spring temperatures reach approximately 15 °C, which also tends to occur with increasing photoperiod. In Mason Dam, 15 °C temperatures coincide with the development of low (less than 6 ppm) DO conditions near the intake.

Adult bull trout (300 mm [11.8 inches] or greater) are able to swim at 15.08 fps, with burst velocities of 22.5 fps (Taylor and Lewis 2010). Juvenile bull trout (less than 200 mm or approximately 8 inches) have a maximum swimming speed of 1.79 fps.

Bull Trout Entrainment Potential

Bull trout entrainment data have been collected at Beulah and Trail Bridge Reservoirs in Oregon. Entrainment at Beulah was measured according to two different water release scenerios: through spillway releases and through a deep water intake located 75 feet below the full pool surface and approximately 3 feet above the bottom. With spillway releases, the entrainment risk was greatest in winter and spring. When the water releases occurred solely through the deep intake, bull trout entrainment was reduced by 80% in 2001, and subsequently reduced to 0 in 2002. Regardless of the release type, Schwabe et al. (2002) identified that entrainment was minimal between mid-June and October. At Trail Bridge Reservoir, 0 bull trout out of an estimated total 2,000 bull trout population were entrained during the monitoring period (Stillwater Sciences 2006).

As of spring 2012, there were no known adult bull trout in Philips Lake. Two subadults were found in 2011, but their status is unclear (i.e., entered reservoir during extremely high spring flows or resident). The analysis presented herein is for the population that currently occurs (2 subadults, 213-234 mm or between 8.4 and 9.2 inches) or any population that establishes in the future.

Spawning: Bull trout spawn in cold tributaries which are located well away from and upstream of the intake. There is **no** potential for entrainment of spawning bull trout.

Adults: Three general factors would affect adult bull trout entrainment at Mason Dam during the time period that the hydroelectric project would be operational.

(1) The tendency for seasonal outmigration in response to temperature and photoperiod cues. As for other reservoirs, it is highly likely that beginning in May to June (or as early as April), any bull trout near the eastern end of Philips Lake (where the intake is located) would migrate towards and up the

tributaries which enter the reservoir at the far western end. Migrating adult bull trout would return to the reservoir in the fall for overwintering.

(2) Development of low oxygen conditions near the intake. Bull trout are more sensitive than other salmonids to low dissolved oxygen conditions, not tolerating DO levels than 6 ppm. DO levels less than 6 ppm, and ranging to anoxic conditions, occur between mid-June and mid-August. As DO levels rise between mid-August and mid-September, temperatures remain quite high (see figures 7 and 8). It is highly likely that adult bull trout remaining in the reservoir between June and September, if any, would not occur near the intake during this time period due to highly unfavorable water quality conditions.

(3) The strong adult bull trout swimming speeds of 15 to 22 fps.

The only time period in which the project would be both (1) in full operation in most years, and (2) in which adult bull trout would likely be within the reservoir or occupy habitats near the intake would be between mid-April to May.

Any overwintering adult bull trout would occur at deep levels, such as near the intake. However, the Mason Dam hydroelectric project would not be operational during this time period and releases would be below 10 to 25 cfs with very low approach velocities.

Movements between deep wintering habitat and more shallow lake levels during the spring could put adults in the vicinity of the intake between mid-March and mid-April when the project would operate within one in 10 years (in late March) to three of 10 years (in early April).

Approach velocities between mid-March and May would be less than 1.0 fps, well under both maximum and sustained bull trout swimming speeds. Any fish entering the intake vicinity would easily be able to outswim the intake velocities. The potential for adult bull trout entrainment during project operation is **none to minimal.**

Juveniles: Temperature and DO conditions are more restrictive for juvenile bull trout. There would be no months during which the project would be in full operation each year and in which the water quality would be suitable near the Mason Dam intake for juvenile bull trout. The only time period during which both juvenile bull trout entrainment could occur and the Mason Dam project would be operational would be between mid-March and April, during which time, the project is anticipated to run approximately during 10 to 30% of the years.

If juvenile bull trout 200 mm (7.9 inches) or less entered the intake area, they may or may not be able to outswim the intake velocities. However, there is almost no likelihood of juveniles less than 200 mm even occurring within the reservoir, or if within the reservoir, outside of upstream littoral zones.

Two juvenile/subadult bull trout occur within the reservoir. They were netted in the littoral zone near the western end of the lake where the tributaries enter. These fish are greater than 8.4 inches and would likely forage in both the lake shallows and in the open reservoir area. Fish this size could swim at faster speeds than the 1 fps intake velocities.

The overall risk of juvenile to subadult bull trout entrainment is **none to minimal.**

4.1.4 Percids

Yellow Perch-Life History
Yellow perch often occur in meso and eutrotrophic lakes with adults preferring summer temperatures of 17.6 to 25 ° C. Spawning typically occurs at temperatures from 6.7 to 12.2 ° C. Yellow perch can successfully overwinter at temperatures from 4 to 6 ° C , although growth tends to stop below 8 to 10 ° C . They are active in the winter beneath ice or in deep water (Scott and Crossman 197, FWS 1983). Upper lethal temperatures are from 26 to 30 ° C.

Optimal DO levels for yellow perch are 5 ppm or greater, but the species is adaptable to a wider range of conditions (DO levels of 2 to 4 ppm, even as low as 1 ppm in some cases), and cooler temperatures. The ability to tolerate very low DO levels allows the species to inhabit deeper water of stratified reservoirs which are often very low in oxygen.

Yellow perch are slow swimmers with maximum speeds of 1.77 fps and average speeds closer to 0.88 fps. They do not accelerate quickly. As a result, yellow perch tend to travel in large schools of 50 to 200 fish which provides protection for younger fish and easier prey capture for older fish (Herman et al. 1959, Craig 1987). Young of the year perch tend to school more than older fish, which occasionally travel alone (Helfman 1979).

Perch exhibit strong diurnal behavior. They are active and feed during the day in open water or shoreline habitat. At night they appear to rest on the bottom and refrain from feeding. The exception occurs during spawning, as the perch become active both day and night.

Generally, yellow perch follow a seasonal migratory pattern that brings them in to littoral zones in the spring, to mid reservoir levels as temperatures rise in the summer, and into very deep water during the winter. They are typically found in water around 30 to 40 feet deep (9 to 12 m), but may seek deeper water in the winter.

Spawning in Philips Reservoir occurs immediately after ice-out, which generally occurs in mid-April. Littoral habitats found in shallow embayments are used for spawning. According to Bailey (2012), although perch generally spawn in water less than 10 feet deep, they have been reported spawning in water as deep as 25 feet.

Although tolerant of the temperatures and DO levels near the Mason Dam intake during most of the year, yellow perch seasonal behavior and depth preferences would place them near the intake most often between mid-July and September. In October when the pool is drawn down to 30 to 40 feet, they would be seeking the deepest water possible, which may or may not be near the intake.

Yellow perch typically inhabit lakes, ponds and reservoirs, but they can occur in river systems. In rivers, they occur in habitats similar to their typical lacustrine habitat, such as low velocity deep pools, backwaters and side channels. Rapidly flowing water does not provide suitable habitat for the species and young perch can not tolerate flows greater than 0.08 fps.

Yellow Perch-Entrainment Potential

Spawning: Spawning occurs in most if not all shallow embayments in Philips Reservoir in water generally around 10 feet deep, although spawning can occur in water up to 25 feet deep (Bailey 2012). Shallow, vegetated or other littoral habitat is located more than 850 feet from the Mason Dam intake which is almost always covered by at least 70 feet of water during the spring spawning period. There is **<u>no</u>** potential for entrainment of yellow perch in their spawning habitat, but there is some potential for entrainment as perch move from deep water to spawning habitats (see discussion below).

Adults and Juveniles: The temperature and dissolved oxygen conditions would be suitable for yellow perch at the intake most of the time the Mason Dam project would be in operation. Both the daily and seasonal perch migration patterns could place the perch in the intake proximity. The species' seasonal behavior and depth preferences would place them near the intake most often between mid-July and the end of September. In October when the pool is drawn down to its lowest level, they would be seeking the deepest water possible, which may or may not be near the intake. Because the Mason Dam hydroelectric project would not be operational in the fall or early winter, yellow perch behavior during these seasons was not considered in the entrainment potential analysis

Yellow perch are slow swimmers with average or sustained speeds less than or similar to the approach velocities (with velocities depending on discharge flows). Any yellow perch, adult or juvenile, that approached the intake too closely would likely be entrained. The tendency for yellow perch to travel in large schools could result in episodic entrainment events. Large numbers of dead yellow perch immediately below Mason Dam have been observed from mid-August to mid-October, underscoring the high potential for yellow perch entrainment from late summer into fall (Jeff Colton, BVID, Pers Comm; Leslie Gecy, observations made during other Mason Dam project biological studies).

The potential for both adult and juvenile yellow perch entrainment during project operation is **<u>high.</u>**

Walleye -Life History

Walleye are a highly piscivorous, cool, deepwater species whose native range is centered in the Great Lakes region (Scott and Crossman 1973). The species eyes' are highly sensitive to light which tends to result in a diurnal pattern of spending daylight hours in deep water and shallower waters in the evening or at other times when light is low, such as under thick ice or in other areas with underwater cover. Although described as an opportunistic feeder, the walleye's diurnal behavior of moving to different water depths at dawn and dusk tends to place them in frequent contact with yellow perch. As a result, where yellow perch and walleye coexist, yellow perch tend to be the walleye's primary prey. On a seasonal basis, walleye tend to follow a similar pattern as yellow perch as they move to shallow waters in the spring and to deeper reservoir areas in August and September. Lacustrine spawning habitat consists of shallow (1 to 6 ft deep) rocky shores or other areas with rip-rap or rubble, inlet streams or flooded marshes.

Preferred adult temperatures are from 20 to 24 ° C , with the greatest activity between 15 to 18 ° C , and adult growth stopping below 12° C . Spawning tends to occur between temperatures of 6 to 11 ° C and temperatures of less than 10 ° C are required for gonad mauration. Upper lethal temperatures are from 29 to 32 ° C (Kerr et al. 1997). Walleye prefer temperatures at or near the thermocline in stratified lakes, even if less than optimal dissolved oxygen levels (Fitz and Holbrook 1978).

Adult walleye can tolerate DO levels as low as 3 ppm for a short period of time, but prefer DO levels greater than 5ppm. DO levels below 2 ppm tend to be lethal (Kerr et al. 1997).

Juvenile fish require slightly warmer water than adults and tend to seek shallow water habitat in the spring and early summer. As summer progresses, juveniles tend to move to deeper habitats similar to those of adults.

Walleye are vigorous swimmers, with burst speeds measured from 6.02 fps for juveniles and up to 8.57 to 11.2 fps for adults (NAI 2009).

Walleye-Entrainment Potential
Although walleye were illegally introduced at a similar time as yellow perch, their abundance has remained very low (ODFW 2013).

Spawning: Spawning occurs in shallow water near rubble or rocky shores, flooded marshes or tributary inlets. The nearest tributary inlet or flooded marsh is located more than 2,000 feet from the dam intake. The nearest shallow, rocky shore habitat during the spring spawning period is located 65 to 100 feet from the Mason Dam intake. There is no potential for entrainment of walleye spawning in flooded marshes or lake tributary inlets. There is very limited potential for entrainment of walleye spawning on rocky shores, but with some potential for walleye to travel near the intake while moving between deepwater and shallower spawning habitats. Overall there is a **minimal** risk of spawning walleye entrainment.

Adults: The adult walleye diurnal and seasonal patterns of moving between deeper and shallow water mimic (in reverse) those of the yellow perch, its primary prey species. However, yellow perch can tolerate lower DO conditions than walleye. The walleye's general behavior could place it near the Mason Dam intake during most, but not all, of the time the project would be in operation. However, water quality conditions would limit the likelihood of the walleye being near the intake during the project operation to late summer and September.

If an adult walleye approached the intake during this time period, it would not likely be entrained as it is a vigorous swimmer well able to outswim the intake velocities. Even at less than optimal conditions, walleye's could easily escape the intake approach velocities. The exception could occur if walleye follow their yellow perch into very low oxygen areas, where their swimming ability would be severely comprised.

The potential for adult walleye entrainment during project operation is **minimal**.

Juveniles: Because juvenile fish require warmer water than adults, their behavior would limit their likelihood of being near the intake during project operation to late August and September when the intake is oxygenated. As for adults, juveniles are vigorous swimmers with both maximum and sustained speeds greater than intake velocities.

The potential for juvenile walleye entrainment during project operation is **minimal**.

4.1.5 Centrarcids

Bass and Crappie-Life History
Bass and crappie tend to occupy littoral habitats. Optimal conditions for largemouth bass are lakes with extensive areas of shallow water (i.e., less than 15-20 ft) to support submerged aquatic vegetation, but deep enough to allow overwintering (Scott and Crossman 1973).

Largemouth bass spawn during the spring in shallow, littoral habitats and remain to guard the young once hatched. Fry remain in shallow, protected habitats such as coves and flooded tributary mouths as the adults return to other shallow lacustrine habitats with abundant vegetation.

Smallmouth bass were originally limited in range to eastern central North America, but have been widely stocked elsewhere (Scott and Crossman 1973). Unlike the warm, weedy lakes and slow moving rivers preferred by the largemouth bass, cooler lakes, streams, and rivers are preferred by smallmouth bass. Lakes that hold populations of smallmouth bass are generally over 100 acres in size, over 30 feet deep and thermally stratified, and have clear water and large areas with rock or gravel substrate (Scott and Crossman 1973).

Smallmouth bass also move toward shore in early spring, but select sites with a clean stone, rock, or gravel substrate for spawning. As for largemouth bass, the smallmouth guard their young after hatching and the young remain in shallow protected areas after the adults leave. During winter, the adults tend to move to deeper water (Langhurst and Schoenike 1990). Smallmouth bass are found almost exclusively in the epilimnion during summer stratification in northeastern Wisconsin and Ontario, but frequent depths up to 40 ft in northern New York (NAI 2009).

Lacustrine black crappie habitat can be characterized as the littoral zone of large warmwater reservoirs and lakes, usually with some type of in-water cover such as sunken logs (Scott and Crossman 1973). Spawning occurs primarily in April, typically in coves and shallow embayments, near but just beyond the edge of submerged vegetation (approximately 6 to 16.5 ft deep, ODFW 2012). Although this species does not do well in the main body of large lakes, it can become abundant in shallow areas and bays (Scott and Crossman 1973). Crappie feed on the surface during dawn and dusk. During the winter, crappies often move to deeper water along vertical structure such as pilings or dams (NAI 2009).

In general, optimal temperatures for growth of adult bass range from 24 to 30˚ C, with very little growth below 15˚ C. However temperature tolerances differ among species. Lakes and rivers that are clear enough and rocky enough to be suitable for trout, but in which the water temperature is too high for trout, are generally suitable for smallmouth bass. Preferred smallmouth bass temperatures are between 16 ° C and 26 ° C , although nest building and spawning can occur at lower temperatures. Largemouth bass are considered warmwater species, preferring temperatures between 27 to 30 ° C . However, the largemouth bass is intolerant of low dissolved oxygen concentrations and is therefore susceptible to winterkill in its vegetated, high oxygen demand habitat

Optimal temperatures for black crappie are between 22 to 25˚ C; with no growth below 11˚ C or above 30˚ C .

Smallmouth bass require more than 6 ppm DO for optimal growth and largemouth bass more than 8 ppm. Both species can tolerate DO levels as low as 4 ppm, but show distress at these levels. Levels below 2 ppm cause mortality. DO requirements for black crappie are assumed to be above 5 ppm, the general level for warmwater fish. In lacustrine environments, these three species tend to select temperature strata with suitable oxygen levels, although, as noted above, the largemouth bass preference for shallow, high temperature vegetated areas tends to result in late season or winterkill mortality.

Sustained swim speeds for small juvenile largemouth bass range from 1.01 to 1.64 fps within a temperature range of 15 to 30˚C (NAI 2009). Swim speeds were higher for larger juveniles and small adults (1.80-2.17 fps). Maximum juvenile or “burst” speeds are estimated at 3.2 to 4.2 fps and higher for adults.

Smallmouth bass sustained swim speeds have been estimated as 1.8 fps for juveniles and 3.9 fps for adults. Maximum speeds of 3.6 to 7.8 fps for juvenile and adults, respectively have been estimated (NAI 2009).

Black crappie swim speeds have not been studied. However, studies of the related white crappie indicate that crappies are quite slow swimmers, with speeds from 0.5 to 0.75 fps at optimal temperatures, and reduced to 0.18 fps in cold water. Maximum speeds have been estimated at 1.0 to 1.5 fps. However, poor orientation to current has also been exhibited (NY Power Authority 2005, NAI 2009).

Swimming speeds of all of the above species is reduced in cold water.

Bass and Crappie-Entrainment Potential

Most regional entrainment studies are focused on salmonids. Entrainment studies over a 2-year period at Fall Creek Reservoir (Downey and Smith 1992) identified that although anadromous salmonids comprised 77.5% of the total fish moving through the reservoir outlet, that black crappie comprised another 21.9% of the entrained fish. Crappie entrainment occurred almost entirely during November and December when the reservoir was drawn down to its lowest level, a point 30 feet above the intake. Some entrainment also occurred at reservoir levels between 30 to 60 feet over the intake (Ken Holmolka, ODFW, pers comm).

Spawning: All species spawn in shallow water. Largemouth bass tend to spawn in shallow, vegetated or other littoral habitat, which is located more than 850 feet from the intake. Black crappie spawn in shallow water (6-16.5 ft deep), which occurs well away from the Mason Dam intake, which is almost always covered by 70 feet of water during the spring spawning period. There is **no** potential for entrainment of spawning largemouth bass or black crappie.

Smallmouth bass spawn along shallow or rocky shorelines. The nearest potential habitat is located 65 to 100 feet north and east, respectively from the Mason Dam intake. Although the intake is relatively close to potential spawning habitat , smallmouth bass would not be spawning at the depth of the Mason Dam intake. There is **no** potential for entrainment of spawning smallmouth bass.

Adult: Both adult largemouth bass and black crappie prefer shallow, warm water habitats and not deep, cool open water areas. Largemouth bass, in particular are strongly oriented towards shallow, vegetated habitats limiting any exposure to a deep intake. There is **no** potential for entrainment of adult largemouth bass.

Although generally preferring shallow water, crappie approach the intake as the reservoir is drawn down or in moving towards deeper water during the winter. In approximately one-quarter of the years, the reservoir is drawn down to a level less than 30 feet above the intake. In these years, crappie would likely be concentrated in water near the intake. The time period in which this would occur would be from mid-August until the end of September. (Also continuing through the fall but the Mason Dam hydroelectric project would not be operational during that time period.) If crappie did occur near the intake, they would likely be entrained, as they are poor swimmers.

The potential for black crappie to be entrained during project operation would be restricted to a period from mid-August to late September, in some years. As a result, the overall potential for black crappie during project operation would be **moderate to high in dry years**, but **minimal to low in other years**. Because the population is extremely low, the actual number of fish entrained would be very low regardless of the year.

Smallmouth bass are cool water species with strong preferences for well-oxygenated water. Although smallmouth bass may overwinter in deep water, the Mason Dam hydroelectric project would not be operational during this time period. DO levels are suitable for smallmouth bass near the intake during the spring, but temperatures are too cold. As described for the salmonids, as temperatures warm near the intake, DO levels drop. This combination results in unsuitable smallmouth bass conditions during most of the project operational period. Smallmouth bass could occur near the intake during September. Because adult smallmouth bass are vigorous swimmers, they would not likely be entrained. The overall risk of adult smallmouth bass entrainment is **minimal**.

Juveniles: Juvenile bass and black crappie reside in shallow water but do forage outside of that area. Juvenile smallmouth bass would be vulnerable to entrainment if they occurred within the intake vicinity, but their preference for shallow littoral areas and protected coves limits their exposure to a deep intake. Larger juveniles could move from littoral habitats during the late season and occur within the intake vicinity during September. However, by this time, the larger juveniles bass would be able to escape the intake approach velocities. The crappie would not. The overall risk of juvenile bass entrainment is **none** for small juveniles and **minimal** for larger juveniles. The risk of juvenile crappie entrainment is rated as **moderate to high**.

4.1.6 Cyprinids

Northern Pikeminnow-Life History
The northern pikeminnow is a native fish that prefers lakes and slow-moving water. The species feeds on aquatic invertebrates as juveniles (up to 300 mm), with crayfish and small fish increasing in importance as the fish grows larger (Gadomski et al. 2001). Adults continue to feed on crawfish, molluscs, and other macroinvertbrates as well as fish. Preferred species include salmonids, sculpins and suckers. Although the pikeminnow has been identified as an important salmonid predator, a number of studies have identified crayfish as a key prey item (Zorich 2004).

Northern pikeminnow spawn in the spring when temperatures reach 12 to 18 ° C . Once spawning occurs, the adults leave the spawning area without parental care. Spawning habitat includes gravelly areas at tributary inlets, and clean rocky substrate along lakeshores in both shallow and deep littoral areas. Spawning typically occurs in slow-moving water.

Seasonally, the pikeminnow tends to move towards the shoreline areas in the spring and into deeper water later in the season (Martinelli and Shively 1997). Within rivers, they are frequently associated with riprap, rocky outcrops or structures (Zorich 2004).

Northern pikeminnow can tolerate a wide range of temperatures. No specific tolerances were located in the literature, but as a coolwater species, the temperature tolerances were assumed to be similar to that of the smallmouth bass.

The pikeminnow is not a strong swimmer with sustained speeds of 0.74 fps and maximum speeds of 1.6 to 2.7 fps (Mesa and Olsen 1993, Zorich 2004).

Northern Pikeminnow-Entrainment Potential

Spawning: Spawning habitats can include both shallow, gravelly areas in embayments and near tributaries, as well as rocky lakeshores. The nearest embayment/tributary habitat is located 850 feet the intake. There is no potential for nothern pikeminnow entrainment during spawning in these habitats. Based on an analysis of spring reservoir water levels in relation to a detailed BOR topographic map of the dam face and adjacent areas (maps on file with Baker County), the intake is located 65 to 100 feet from a rocky shore that could possibly be used for spawning. There is some potential for the pikeminnow to travel near the intake while moving between deepwater and shallower spawning habitats. Overall there is a **minimal** risk of spawning northern pikeminnow entrainment.

Adult: The combination of seasonal movements from shallow to deep water and the northen pikeminnow temperature preferences could place fish within portions of the intake vicinity between mid-August and September. The pikeminnow are relatively slow swimmers, and if they occur within the intake vicinity, would likely be entrained. Entrainment might also be high following the September rainbow trout stocking, which occurs near the dam. There is a **moderate potential** of adult northern pikeminnow entrainment during the late summer and early fall.

Juveniles: Juvenile pikeminnow tend to remain in shallow water areas where aquatic invertebrates and small fish are readily available. As the reservoir draws down in September and suitable temperature and DO conditions occur near the intake, juveniles could occur in the intake vicinity. If juveniles occur near the intake they would likely be entrained. Because the overall likelihood of juveniles being near the intake during project operation is low and restricted to the fall, the overall risk of juvenile northern pikeminnow entrainment during project operation is **minimal to low**.

4.1.7 Catastomids

Suckers-Life History

Suckers are very abundant throughout the Columbia River drainage (Scott and Crossman 1973). Because of their abundance, they have not been as extensively studied as rarer species, introduced species or predaceous fish (Schmetterling and McFee 2006). Their habitat generally occurs within slow-moving portions of rivers and in lakes. Largescale sucker fry feed on zooplankton, but juveniles and adults feed on benthic invertebrates, diatoms, filamentous algae and other plant material. Little is known about seasonal or daily sucker movements in lakes and reservoirs, but adults seem to be relatively sedentary benthic feeders outside of the spawning period. During the summer, adults have been caught both above and below the thermocline in stratified reservoirs.

Largescale suckers use a wide range of substrates and water depths for spawning and are not generally considered spawning-habitat limited. However, some studies have indicated a preference for sandy or gravelly lake shoals in the Columbia River system (Dauble 1986, Baxter 2002).

The bridgelip sucker occurs in lakes and river backwaters with sandy or muddy substrates. Spawning occurs in the spring shortly after ice-out. Their diet consists of aquatic insects, crustaceans and algae that is scraped off of bottom rocks.

Suckers in general prefer DO levels greater than 3 ppm and can not tolerate DO levels less than 2.4 ppm. There is little documentation on temperature preferences.

Sustained swimming speeds for various species of sucker have been measured at 1.4 to 4.9 fps, with maximum speeds from 4.0 to 7.9 fps (Baxter 2002).

Suckers-Entrainment Potential

Most regional entrainment studies have focused on salmonids. Entrainment studies over a 2-year period at Fall Creek Reservoir (Downey and Smith 1992) identified that anadromous salmonids and black crappie comprised 99.4% of the total fish moving through the reservoir outlet, with other fishes (including suckers) cumulatively totaling less than 1% of the annual entrainment. At the Blue River Reservoir, juvenile suckers comprised 4% and adult suckers 0.5% of the measured entrainment (Downey and Smith 1989). Most of the sucker entrainment occurred between October and December, a time period during which the Mason Dam hydroelectric project would not be operating.

Spawning: Reservoir sucker habitat can be varied but given the depth of the Mason Dam intake during the spring (more than 70 feet below the surface), it is not likely that spawning would occur within the vicinity. The nearest likely spawning habitat is located more than 1,000 feet from the intake. The potential for entrainment of spawning suckers is **none to minimal.**

Adult: As benthic feeders, adult suckers could occur within the intake vicinity during much of the time the project is in operation. The exception would be between July and August when the bottom near the intake is anoxic. The sucker feeding behavior could place them in close proximity to the intake in other months. Suckers are relatively strong swimmers and can outswim the approach velocities if aware of the intake. However, because sucker behavior would place them within the intake vicinity most of the time, the overall entrainment potential is rated as **Low to Moderate**.

Juveniles: Juveniles are also benthic feeders that could occur within the Mason Dam intake vicinity during much of the project operation. Details regarding juvenile bridgelip and largescale suckers movements within reservoirs are sparse. Because of the uncertainty or reservoir movements, the known benthic orientation, and the lower swimming abilities than adults, the overall entrainment potential for juvenile sucker entrainment is rated as **Moderate .**

4.2 Entrainment Summary

The fish species most susceptible to entrainment during both the proposed Mason Dam hydroelectric project 4 to 6 month operating period and the 6 to 8 month non-operating period include yellow perch, black crappie and stocked rainbow trout. Yellow perch behavior and low oxygen tolerance place them frequently within the intake vicinity and their low swimming speeds would likely result in entrainment if they were near the intake. There are an estimated 1,636,575 yellow perch in Philips Reservoir, with a high potential for entrainment, particularly during late summer and fall. Studies in reservoirs with high perch populations have indicated that from 1 to 3 % of the total perch population is entrained annually (see for example, summaries in Kleinschmidt [2011]). This would equate to an existing annual average entrainment rate of 16,366 to 49,097 yellow perch through Mason Dam. The perch entrainment numbers would decrease under the ODFW (2013) proposed new fish management plan.

Black crappie are poor swimmers and any movement within the intake vicinity would likely result in entrainment. Entrainment rates would be highest during the late summer and fall and during dry years. The crappie population number is unknown but Shrader (2000) identified that the population was in serious decline. With the known very reduced densities, the total number of entrained black crappie would likely be quite low.

Based on a study by CH2MHill (2007), trout entrainment at 11 of 12 other regional reservoirs that both support trout and contain a deep intake ranges from 0 to 0.1% of the population on an average annual basis, with no entrainment of adult trout and most rates less than 0.01%. At one reservoir operated strictly for hydropower production, Lake Lemolo, average annual trout entrainment was estimated at 2.6%, ranging from 1.9% in years in which the water surface remained close to 60 feet over the intake to 3.2% when water surface levels were drawn down much lower and pool volume reduced to 12%. The majority of the entrained fish were hatchery juveniles. Other studies have noted a correspondence between low pool volume and/or reduced intake depths with increased entrainment (see discussion in section 4.1.7). Critical levels appear to be when pool volumes were drawn down to less than 15% or less than 30 feet over the intake. These conditions would occur in approximately one of every four years within Philips Reservoir (or in dry years), beginning in mid-August.

Using the results from the regional studies and the entrainment potential evaluation from the previous section, the following trout population entrainment rates were used to estimate rainbow trout entrainment through Mason Dam.

- Native adult rainbow trout: 0 to 0.01% in all years, as per results of all regional studies.
- Native juvenile rainbow trout: 0.1 (wet years), 1.35% (average pool years) to 2.6% in dry years to reflect the general lack of juvenile trout entrainment in regional studies except in low water years.
- Spring-stocked adult hatchery fish: 0.12%. Although water levels are uniformly high during the stocking period and only a slightly greater entrainment rate than native adults would be expected, a very conservative entrainment estimate recommended by ODFW was used.
- Fall-stocked subadult hatchery fish: 1.9 (wet or high end of year pool conditions), 2.6% (average pool conditions) and 3.2% (dry or low end of year pool conditions). The full range of Lake Lemolo entrainment rates were used as the fall stocked fish would be the most susceptible to being entrained since they are stocked near the intake in the seasonal low pool condition.

With an estimated population of 60,000 to 100,000 rainbow trout (the annual stocking rate of 58,200 fish plus an unknown number of additional residents), this would equate to an average of between 541 to 1,698 rainbow trout being entrained[3] depending on the degree of pool drawdown, with the vast majority being stocked fish.

[3] The estimate assumed a population age class structure heavily dominated by juveniles and stunted adults. With a reduction in perch, larger sized rainbow trout would be expected with a corresponding reduction in entrainment.

Bull trout entrainment during the proposed project operating period is highly unlikely due to the bull trout's inability to tolerate the water quality conditions near the intake during most of the project operational period and its very strong swimming ability that would allow it to escape the relatively low intake approach velocities at other times.

Other species susceptible to entrainment during both the project operational and non-operational periods include the native northern pikeminnow and suckers. Although vigorous swimmers, walleye could occasionally be entrained while following their prey into less than optimal dissolved oxygen conditions. Adult suckers are also relatively strong swimmers, but their behavior would place them within the intake vicinity most of the time, potentially resulting in some inadvertent entrainment. Juvenile suckers would have a higher likelihood of being entrained.

The entrainment potential for other species during the proposed project operating period (smallmouth bass, largemouth bass) is nonexistent or very low. These species tend to be entrained in high numbers within reservoirs with shallow intakes located within littoral zones. Entrainment through a deep intake within a stratified reservoir, such as occurs at Mason Dam, is very unlikely.

The preliminary estimate of fish entrainment through Mason Dam was identified as a maximum of 38, 581 fish per year. Using species-specific entrainment data, data on seasonal drawdown levels and known Philips Reservoir population data (where available), the following fish species would be anticipated to be entrained on an annual basis. An annual basis was identified for those species that would be susceptible to entrainment both during project operation and outside the project operating period, as the existing data does not allow for accurate monthly entrainment estimates. Entrainment estimates are listed for wet/high average years, average years and dry years based on the degree of water surface drawdown and low pool volumes.

ESTIMATED ANNUAL ENTRAINMENT

Wet/High Average Years: Characterized by an end of year low pool volume of atleast 30% AND a surface water elevation more than 60 feet over the intake. These conditions have occurred in 56.7% of the last 30 years.

- 16,366 yellow perch
- 0 to 34 native rainbow trout, mostly juveniles
- 0 to 508 stocked hatchery rainbow trout
- 100 to 200 other fish. Based on other studies identifying the remaining species as typically comprising 1% or less of total entrainment, from 100 to 200 additional suckers, northern pikeminnow and occasional individuals of other species would likely pass through the outlets.
- Unknown number of black crappie. The population number is unknown but Shrader (2000) identified that the population was in serious decline. With the known very reduced densities, the total number of entrained black crappie would likely be quite low.

The following species would not likely be entrained during the proposed project operating period: bull trout, smallmouth bass and largemouth bass. Neither late fall/winter nor annual entrainment estimates were derived for these species.

- ▸ **Total revised wet/high average year estimate: 17,108**

Average Years. Characterized by an end of year low pool volume of between 15 to 25% and a surface water elevation between 30 to 60 feet over the intake. These conditions have occurred in 16.6% of the last 30 years.

- 32,732 yellow perch
- 0 to 452 native rainbow trout, mostly juveniles
- 0 to 680 stocked hatchery rainbow trout
- 100 to 200 fish. Based on other studies identifying the remaining species as typically comprising 1% or less of total entrainment, from 100 to 200 additional suckers, northern pikeminnow and occasional individuals of other species would likely pass through the outlets.
- Unknown number of black crappie. The population number is unknown but Shrader (2000) identified that the population was in serious decline. With the known very reduced densities, the total number of entrained black crappie would likely be quite low.

The following species would not likely be entrained during the proposed project operating period: bull trout, smallmouth bass and largemouth bass. Neither late fall/winter nor annual entrainment estimates were derived for these species.

- ▸ **Total revised wet/average year estimate: 34,064**

Dry Years: Characterized by an end of year low pool volume of less than 15% OR a surface water elevation less than 30 feet over the intake. These conditions have occurred in 26.7% of the last 30 years.

- 49,097 yellow perch
- 0 to 870 native rainbow trout, mostly juveniles
- 828 stocked hatchery rainbow trout
- 100 to 200 fish. Based on other studies identifying the remaining species as typically comprising 1% or less of total entrainment, from 100 to 200 additional suckers, northern pikeminnow and occasional individuals of other species would likely pass through the outlets.
- Unknown number of black crappie. The population number is unknown but Shrader (2000) identified that the population was in serious decline. With the known very reduced densities, the total number of entrained black crappie would likely be quite low.

The following species would not likely be entrained during the proposed project operating period: bull trout, smallmouth bass and largemouth bass. Neither late fall/winter nor annual entrainment estimates were derived for these species.

- **Total revised dry year estimate: 49,097**

Using a weighted average according to the frequency in which various levels of low pool volumes and water surface drawdowns have occurred, an average long term entrainment of fish through Mason Dam would be 28,970. The majority of the fish entrained under any conditions would be yellow perch (96% of the entrainment), with the next largest group being stocked hatchery fish.

The range of estimates according to variability in Philips Reservoir pool conditions encompasses the preliminary estimate derived from the maximum Cougar Reservoir entrainment number. The long term Mason Dam weighted entrainment average is less than the Cougar Reservoir maximum entrainment. This is to be expected, as the Cougar Reservoir number represented an absolute maximum and not an average value.

As total annual entrainment estimates, these number represent fish entrained both during the time the project is operational (from 33 up to 50% of the year, see Figure 1 in Section 2.0) and when the project is not running (from 50 to 67% of the year). The highest levels of entrainment are expected to occur during the late summer and fall and the project would only be operating within a portion of that time.

The Mason Dam entrainment estimates were derived using very conservative numbers, higher than the averages from other regional reservoirs, and represent maximum levels to be expected under current conditions. Under potential future conditions, the Philips Reservoir fish population could change with lower numbers of yellow perch and higher numbers of other species. In particular, if yellow perch can be reduced, the adult rainbow trout stunting currently observed would be reduced and 200,000 rainbow trout fingerlings would be released in the fall. The entrainment rate of the fingerlings would be high, with an estimated 3.2% of the release being entrained. This would equate to an annual entrainment of 6,400 rainbow trout fingerlings. Correspondingly, the number of entrained yellow perch would decline. The improved growth of native rainbow trout would also reduce their susceptibility to entrainment, thereby reducing total native rainbow trout entrainment numbers.

Table 7. Summary of General Habitat Requirements for Fish Species Known to Occur in Philips Reservoir.

Species	Water Quality Requirements				Swimming Speeds (ft/sec)		Reservoir Habitat Preferences
	Preferred		Tolerable		Max	Sustained	
	DO (ppm)	Temp (° C)	DO (ppm)	Temp (° C)			
Salmonids							
Rainbow trout subspecies	≥ 7	12-18	≥ 5	0-25	1.79 juv 4.3+ adult	4.3+ adult	Cool, oxygenated habitat, move within reservoirs based on temp, DO + food sources
Bull trout	> 8	2-15	6-8	0-22	1.79 juv 22.5 adult	15.1 adult	Cold, deep oxygenated water in winter, migrate to tributaries when lakes warm or stratify
Percids							
Yellow perch	≥ 5	17.6-25	<2	4-30	1.77	0.88	Move daily and seasonally between littoral or shoreline areas and deep water
Walleye	> 5	15-18	≥ 3	6-32	6.02-11.2	3.3-4.8	
Centrarchids							
Smallmouth bass	> 6	16-26	≥ 4	0-30	3.6-7.8	1.8 juv 3.9 adult	Rocky shorelines, move to deeper water in winter
Largemouth bass	> 6	27-30	≥ 4.5	? - 30	3.2-4.2	1-1.6 juv 1.8-2.2 adult	Shallow, vegetated habitats
Black crappie	> 5	22-25	≥ 4	? - 30	1-1.5	0.5-0.75	Shallow habitats, move to deeper water in winter
Cyprinids							
Northern pikeminnow	>5	16-26*	>3	0-30*	1.6-2.7	0.74	Seasonal movements between shoreline areas and deep water
Catastomids							
Suckers	>3		>2.4		4.0-7.9	1.3-4.9	Relatively sedentary benthic feeders

* estimated as similar to smallmouth bass, another "coolwater" species.

Table 8. Species Entrainment Potential during the Mason Dam Mid-March to Sept 30 Operating Period.		
Species	**Life Stage**	**Entrainment Potential**
Salmonids		
Bull trout	Spawning	None
	Adult	None to Minimal
	Juvenile	None to Minimal
Rainbow trout subspecies (and tiger trout)	Spawning	None
	Adult	None to Minimal
	Juvenile	Minimal to Low most years, Moderate in dry years
	Recently stocked fish	Moderate to High*
Percids		
Yellow perch	Spawning	None
	Adult	High
	Juvenile	High
Walleye	Spawning	Minimal
	Adult	Minimal
	Juvenile	Minimal
Centrarcids		
Smallmouth bass	Spawning	None
	Adult	Minimal
	Juvenile	None to Minimal
Largemouth bass	Spawning	None
	Adult	None
	Juvenile	None to Minimal
Black crappie	Spawning	None
	Adult	Minimal to Low in most years, Moderate to High in dry years
	Juvenile	Moderate to High

Table 8. Continued.		
Cyprinids		
Northern pikeminnow	Spawning	Minimal
	Adult	Moderate
	Juvenile	Minimal to Low
Catastomids		
Suckers	Spawning	None to Minimal
	Adult	Low to Moderate
	Juvenile	Moderate
* Entrainment risk could be reduced by movement of the hatchery fish release point to a location away from its current location near the intake.		

5.0 Mortality

5.1 Overview

Fish mortality from entrainment is generally related to two factors: (1) sudden differences in pressure from being entrained underwater to being suddenly ejected into atmospheric conditions, and (2) physical damage as a result of being thrown about at high velocities (Battelle Research Laboratory 1997). Both factors contribute to the overall mortality rate. For example, at the Tieton Project, pressure changes explained 56% of the observed mortality, with the remaining 44% of mortality resulting from physical damage (Cramer and Associates 2002).

Pressure differences change throughout the season and from year to year, depending upon the water surface elevation at the beginning of the irrigation season and the degree to which the reservoir is drawn down. This relationship has been noted at a number of the comparison reservoirs, particularly Fall Creek, Blue River, Wickiup and Tieton Reservoirs. A general summary of the relationships identified for each of these reservoirs is listed below and in Table 9, with more information provided in Appendix A-2.

- Fall Creek: Mortality studies identified an overall mean mortality of 41.0% through bottom slide gates (Homolka and Smith 1991), but with changes in mean mortality rates under different hydraulic head conditions. Mean mortality with a hydraulic head between 50 to more than 80 feet over the gated intake top ranged from 50.0 to 57.5%. Mortality with less than 15-18 feet of head over the intake was 6.8%. There were no data on conditions ranging between 18 to 50 feet of head.

- Blue River: Although mean mortalities were identified as ranging between 63 to 74%, mortality rates were between 30 and 60% at lower heads.

- Wickiup Reservoir: Symbiotics (2009) identified that mortality was highest between April and June when the hydraulic head was the highest. During these months direct mortality was always greater than 77%. In the fall, as the head was at its lowest, direct mortality was less than 50%.

- Tieton Reservoir: Cramer and Associates (2002) identified a direct relationship between mortality and pressure differential due to changes in water surface elevations . They developed the following regression equation: Mortality= -0.412 + 0.0197*(change in pressure in PSI), with the pressure changing with changes in water surface elevation.

In addition to mortality from changes in pressure, mortality occurs from physical damage. Experiments in open, non-pressurized spillways identified that physical injuries resulting in mortality were rare at velocities less than 50 fps (approximately 34 mph), with major injuries beginning at velocities of 60 fps (approximately 41 mph)(Bell 1991). Mortality rates rapidly increased as velocities increased from 60 fps (20% mortality) to 80 fps or 54 mph (100% mortality).

Table 9. Summary of Comparison Reservoir Mortality Results and Key Conditions During the Mortality Study Period(s).					
Reservoir Name	**Outlet Type**	**Conditions During Mortality Study Period**			
		Hydraulic Head (ft)	**Flow Range (cfs)**	**Velocities (mph)**	**Mortality Rates (%)**
Cougar	Slide gate	65-84	Unknown	Unknown	32.3-40.0 direct mortality only
Fall Creek	Slide gate	18->80	>700	18-43	41.0 chinook salmon
	Slide gate	>80	>700	38-43	57.5 salmon smolts
		50-80	>700	35-37	50.0 salmon smolts
		<18	>700	18-20	6.8 salmon smolts
	Slide gate	Unknown	Unknown	Unknown	29.6 steelhead fingerlings all studies direct and delayed mortality
Blue River	Slide gate	Unknown	Unknown	Unknown	63.0 salmon 74.0 other species direct and delayed mortality
	Slide gate	50-60	150-350	Unknown	30.0-60.0 direct and delayed mortality
Wickiup	Jet Valve	50-80	600-1800	Unknown	86.3 direct and delayed mortality
Tieton	Jet Valve	>60	300-2200	40-68	81.0 direct mortality only

Mean mortality rates associated with gated intakes are variable, ranging from 29.6- 74% (see Table 9), depending on the timing, reservoir conditions and operational parameters. Eliminating all studies through gated intakes either under a rapid drawdown scenario or that include downstream migrant systems data, results in a range of mean mortalities of 29.6 (fingerlings) to 41.0% (smolts) at Fall Creek, 32.3 to 40.0% at Cougar Resevoir (direct mortality only), and 63 to 74% at Blue River (30 to 60% at lower hydraulic heads).

Jet valves are typically identified as having higher mean mortality rates than slide gates (Symbiotics 2009), with jet valve mortalities of comparison reservoirs ranging from 60 to 86%, and mean mortalities approximately 81%. In general, velocities tend to be much higher through jet valves than through slide gates.

The Mason Dam outlets have characteristics in between those of other slide gates and jet valves. The Mason Dam slide gate openings are much smaller than those of the other gated reservoirs examined and are more similar in outlet size and velocities to jet valves at some discharges. Because velocities are related to both discharge and gate or valve opening size, not all comparison reservoirs have either the outlet velocity data or the data needed to calculate velocities. Data is available for the Fall Creek, Mason Dam and Tieton projects and is listed below.

- Mason Dam outlet velocities: Calculated at 14 to more than 76 mph during the time period that the Mason Dam hydroelectric project would be operating. (Slide gate opening range of 0.27 to 1.1 feet)

- Fall Creek outlet velocities: Calculated at 18 to 43 mph during the mortality study period, with slide gate openings ranging in size between 1 and 6 feet.

- Tieton outlet velocities: Measured at 40 to 68 mph during the mortality study period, with jet valve openings of 2.5 feet.

5.2 Overall Mortality Estimate Approach

The approach used to identify a literature-based mortality estimate through Mason Dam was to summarize the mortality data from comparison reservoirs, as well as the conditions under which the studies occurred. A particular emphasis was placed on identifying the hydraulic head and discharges/outlet velocities during the study periods. Using this review, the reservoir(s) with the mortality data collected under conditions most similar to Mason Dam in terms of operation, annual changes in head, and outlet velocities were identified in section 5.3.

Mortality rates were also modelled at Mason Dam using the regression equation developed for the nearby Tieton Project in Washington[4] (Cramer and Associates 2002) to identify the effects of pressure changes on mortality, and the equation developed by Bell (1991) to identify the effects of

[4] Mortality= -0.412 + 0.0197*(change in pressure in PSI); PSI=approximately 14.7* atmospheres

velocity on physical damage resulting in mortality. Recorded discharge and hydraulic head conditions during representative wet, dry and average years were used in the modelling. The same years used to portray water surface changes, and identified in Section 2.0 of this report, were used for the mortality analysis. The modelled results were then compared to the results from the comparison reservoirs. The modelling was not conducted to identify a precise mortality estimate. Instead, the primary purpose was to identify if the modelling of the Mason Dam recorded conditions could be used to clarify which reference reservoir(s) provided the best comparison(s) for the Mason Dam project.

5.3 Baseline Mortality Estimates

Comparison Reservoirs

The slide gate outlet reservoir with the most detailed mortality data is Fall Creek. The range of head conditions under which the studies were conducted mostly match the range of water surface changes Philips Reservoir is subject to. There are some key differences between Fall Creek and Philips Reservoirs.

- The Fall Creek outlets are much larger and at low head conditions, they are generally more than half open (6-foot opening) instead of the maximum outlet opening of 2.75 feet at Mason Dam. This means that for a given flow and with gates fully open, velocities would be much higher through the Mason Dam outlets. However, the Mason Dam gates are not operated at a full open level, and generally have openings between 0.82 to 1.10 feet during the period the hydroelectric project would be operating.

- Although flows through Fall Creek exceed those of Mason Dam, the calculated velocities do not. The Fall Creek velocities under the range of high discharge conditions and slide gate openings investigated were similar to those of Mason Dam at moderate discharges (i.e., between 200 to 250 cfs).

- No mortality studies were conducted at conditions of 20 to 50 feet of head meaning that mortality data is not available for the late season 30 to 60 foot hydraulic head conditions that are common in dry and low average years at Philips Reservoir.

- The Mason Dam hydrolectric project would not be operational at the extremely low head conditions observed during the Fall Creek mortality studies. For example, in 2007, a representative dry year, flows sufficient for the project to run would have ceased in September with 27 feet of head remaining over the Mason Dam intake. In 1988, an extremely dry year, the low water pool was only 10 feet above the intake. However, in this year flows sufficient to operate the hydroelectric turbine would have ceased on August 12, with 30 feet of head remaining over the intake.

The overall slide gate mortality rate at Fall Creek ranged from 6.8 (very low head and conditions under which the Mason Dam hydroelectric project would not be operational) to 57.5% (hydraulic head greater than 80 feet) with a mean of 41.0%.

Mortality rates in other comparison slide gate reservoirs (Cougar and Blue River) ranged between 30 to 60%, although indirect mortality was not always included. In all slide gate reservoirs, a minimum average of 30% mortality was observed.

Studies at both Wickiup and Tieton Reservoirs, which contain jet valves, have identified similar mortality rates (mean of 81%). The primary difference between these reservoirs and Philips Reservoir is that the hydraulic head conditions under which Wickiup and Tieton Reservoirs operate are mostly greater than those of Philips Reservoir. Although measured velocities at Tieton Reservoir overlap those through Mason Dam, they can be greater under some conditions. Velocities through Mason Dam would be similar to those at Tieton under the following conditions (Table 10):

- A 10% gate opening (or 0.27 feet) at 100 cfs or greater discharges.

- A 30% gate opening at discharges of more than 250 cfs.

- All flows greater than 300 cfs.

Table 10. Comparison of Flows at which Velocities through the Mason Dam Slide Gates would be Similar to those through the Fall Creek Slide Gates and the Tieton Jet Valves.

Mason Dam Velocities Similar to Fall Creek Slide Gate Velocities	• Flows up to 200 cfs at 30% slide gate openings • Flows up to 300 cfs at 40% slide gate openings
Mason Dam Velocities Similar to Tieton Jet Valve Velocities	• Any flow of 100 cfs or greater with a 10% slide gate opening • All flows greater than 250 cfs with a 30% slide gate opening • Flows greater than 300 cfs with a 40% slide gate opening

Modelled Mortality

Both velocities and pressure changes affect fish mortality. The modelled mortality at Mason Dam included the effects of both changes in hydraulic head and velocities. As previously noted, the modelling was not meant to identify precise mortality numbers but to identify, given the representative range of hydraulic head, discharge and velocity conditions associated with the Mason Dam outlets, the most appropriate comparison reservoir mortality rates to use.

Based on general relationships between pressure, velocity and mortality for representative years, the mean Mason Dam modelled mortality ranged from 24.7 to 53.1% (weighted mean of 44.1%), with mortality only modelled during the time period flows exceeded 100 cfs in the selected years (Table 11).

Table 11. Modelled Mason Dam Baseline Mortality Results Based on General Pressure Equations and Velocity-Mortality Relationships.		
Representative Year	**Year Type**	**Mean Mortality (%)[1]**
1998	Wet	49.3
2000	Average	53.1
2007	Dry	24.7
Weighted average from representative years		44.1
[1] Mortality was not modelled at 10% slide gate openings as the overall time of use is limited. However, almost 100% mortality would be expected under such low opening sizes.		

The modelled results indicate that although the slide gate velocities sometimes reach those of jet valves, the combination of velocity and hydraulic head changes that occur at Mason Dam are more similar to those of the comparison slide gate reservoirs than the comparison jet valve reservoirs. The primary reasons are that (1) the typical annual changes in hydraulic head are lower, and (2) velocities are lower through the Mason Dam slide gates than jet valves under some flow conditions.

In general, the modelled Mason Dam mortality rates were similar to those of Tieton Reservoir under conditions in which the hydraulic head was greater than 75 feet over the intake top with discharges greater than 160 cfs (regardless of slide gate opening size). These conditions typically occur in early to mid summer (later in some years).

Under conditions of moderate flows and lower heads, the modelled mortality rates were more similar to those measured at Fall Creek Reservoir. These typically occur in Mason Dam between mid summer and fall.

Although Mason Dam slide gate velocities often exceed those of comparison reservoir slide gates and the project would not operate under the very low head conditions observed at Fall Creek, the combination of hydraulic head and velocity changes indicates that the data collected from Fall Creek Reservoir provides the most appropriate comparison, with the mean mortality of 41.0% providing the best estimate of baseline mortality. Because of the differences noted above, 41.0% is a conservative (low end or minimum) average estimate of baseline mortality for Mason Dam.

5.4 Project Operation

GeoSense (2011) identified that mortality rates associated with installing Francis turbines would result in relatively constant mortality rates regardless of fish species, and that turbine type, turbine rotational speed and turbine size each affected fish survival in a predictable manner. GeoSense (2011) also identified that hydraulic head was not correlated with fish mortality through hydroelectric turbines, resulting in a relatively constant estimated mortality rate of 24.8% at the

Mason Dam hydroelectric facility.

Under baseline conditions, the mean estimated mortality rate would be 41.0%. According to the GeoSense (2011) post-project estimates, survival would be greater under post project conditions, resulting in an average increase in fish survival of 16.2%.

The overall entrainment potential at Mason Dam is low for most species, with only a few species likely to be entrained. Mortality is discussed below only for those species likely to be entrained during the project operational period. Table 12 provides a summary of the weighted entrainment summary and compares the estimated mortality between pre and post project conditions.

Table 12. Estimated Changes in Mortality Between Baseline and Post Project Conditions Based On Mean Entrainment Values. A "+" symbol indicates a decrease in mortality (increase in survival) and a "-" indicates an increase in mortality (and decrease in survival).

Fish Species Group	**Estimated Mean Number of Fish (#)**			
	Annual Entrainment	**Baseline Mortality**	**Project Mortality**	**Difference in Survival**
Native rainbow trout	327	134	81	+ 53
Stocked hatchery trout	622	255	154	+101
Yellow perch	27,822	11,407	6,900	+ 4,507
Other Fish	200	82	50	+32
Total Fish	**28,970**	**11,878**	**7,185**	**+4,693**

5.4.1 Salmonids

The potential for native adult rainbow trout entrainment is low, with most native trout entrainment consisting of juveniles. The potential for stocked hatchery rainbow trout is higher. Overall, from 0 to 870 native rainbow trout are estimated to be entrained annually, with a weighted annual average of 327 trout. From 508 to 828 hatchery stocked fish would be entrained (weighted annual average of 622 fish). Only a portion of the fish would be entrained during the Mason Dam operating period. Even if all entrainment occurred during project operation, there would be a net mean annual increase in survival of 53 native rainbow trout and 101 hatchery-stocked fish.

Bull trout entrainment is highly unlikely. If entrainment occurred, survival would be increased in the same manner described for rainbow trout. Additional detailed analysis specific to bull trout can be found in the project biological assessment (Baker County 2013).

4.2.4 Percids

There are an estimated 1,636,575 yellow perch in Philips Reservoir, with a high potential for entrainment, particularly during late summer and fall. From 16,366 to 49,097 perch would be entrained annually (weighted annual average of 27,822 fish).

Only a portion of the fish would be entrained during the Mason Dam operating period. Even if all entrainment occurred during project operation, there would be a net mean annual increase in survival of 4,507 yellow perch.

4.2.5 Other Fish (Centrarcids, Cyprinids, Catastomids)

The potential for entrainment of most other fish species is none to minimal, with an estimated annual entrainment of 200 other fish bass, primarily suckers, northern pikeminnow and crappie.

Only a portion of the fish would be entrained during the Mason Dam operating period. Even if all entrainment occurred during project operation, there would be a net mean annual increase in survival of 32 other fish.

4.2.6 Summary

Under the Mason Dam hydroelectric project operation, there would be an estimated average increase in survival of 16.2%. This would result in increased survival of 4,693 fish on average, most of which would be yellow perch. Other species with increased survival would include native and stocked rainbow trout, suckers, northern pikeminnow and crappie. Because the total number of entrained fish from these species would be fairly low, there would not be much difference between pre and post project conditions (i.e., annual increase in survival of 154 trout and 32 other fish).

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APPENDIX A-1: Entrainment and Mortality Background Summary

Numerous studies have been conducted at reservoirs and hydrolelectric facilities throughout the US and Canada. The results have shown variation in entrainment rates according to fish species composition, reservoir operation type and depth, and intake characteristics. However, some general trends have been observed and summarized in a number of reports (FERC 1995, EPRI 1997, Ch2MHill 2003, NY Power Authority 2005, CH2MHill 2007, NAI 2009, Symbiotics 2009, City of New York 2011):

Reservoir Characteristics

- Entrainment rates are much higher for shallow reservoirs than deeper reservoirs, with up to twice as many fish entrained in reservoirs with dams less than 50 feet high (15 meters) than those greater than 50 feet.

- Reservoirs that are operated to be drawn down over the winter and allow for spring storage can increase winter entrainment rates as more fish are placed in closer proximity to the intake.

Intake Characteristics

- Intakes adjacent to shorelines tend to entrain more fish than those located away from the shoreline as many fish species tend to follow shorelines or orient to the physical structure associated with shorelines.

- The littoral zone is the most productive area within a reservoir and many species spawn and rear there. Intakes in littoral zones entrain more species than deeper intakes.

- Poor water quality near the intake can form a barrier and reduce fish susceptibility to entrainment. This is particularly true if there is low dissolved oxygen in the hypolimnion.

Fish Species

- Entrainment is relatively low (less than 20 fish/hour) for most resident warmwater/coolwater fish communities. Entrainment from the coldwater fishery in Trail Bridge Reservoir was estimated at less than 1 fish/hour. Residents tend to be entrained inadvertently in relation to their use of habitats near the intake. Episodic entrainment events have been noted for anadromous salmon and other obligate downstream migrants, as well as fish species that travel in large schools.

- Entrainment rates vary by species and are not necessarily related to the relative composition of a water body. Yellow perch, northern pike and smallmouth bass are species that are particularly susceptible to entrainment. Species less susceptible to entrainment include rainbow trout and some sucker species.

- Species entrainment rates vary both diurnally and seasonally according to species behavior.

- Young-of-year (YOY) and juvenile fish are more susceptible to entrainment than adult fish.

Fish swim speeds in relation to velocities at the intake can also affect entrainment potential. The ability to avoid entrainment depends on both the fish's swimming speed, and its ability to detect and respond quickly to a change in velocity. Detection can be comprised by darkness, turbidity or cold temperatures. If a fish does not respond to a velocity acceleration until it can only maintain position in the flow, it would find itself quite close to the intake and may not have enough time or strength to scape. Detection for strong swimming fish is generally only an issue for river intakes or where approach velocities are greater than or equal to 5 ft/sec. Swimming performance can be decreased by as much as 50% when temperatures fall outside a species' preferred range (Bell 1997). This latter item most often occurs as winter approaches and temperatures cool.

Of all the factors examined by studies of reservoirs with deep intakes, the intake depth and the water quality near the intake tend to be the most important factors affecting fish entrainment. This is because the DO, temperature and depth in relation to other habitat features affect the fishes' potential to occur in the intake vicinity. The reservoir size is not as important.

Once entrained, a separate set of factors affects whether or not the fish survives. Fish mortality from entrainment is generally related to two factors: (1) sudden differences in pressure from being entrained underwater to being suddenly ejected into atmospheric conditions, and (2) physical damage as a result of being thrown about at high velocities (Battelle Research Laboratory 1997). Also important is the type of intake. Valve outlets appear to cause more mortality to fish than gate-controlled flow regulators, perhaps because of increased shear stress around the valve cone. Mortality rates associated with spillways are variable, influenced by velocity and head height, but tend to be lower than those of regulating structures. Multi-intake tower mortality rates are also variable as they draw water from different depths of the reservoir.

Other factors influencing fish mortality during entrainment includes fish species and size, and reservoir operation (e.g., type of operation, hydraulic head, discharge, water velocity). General mortality trends include:

- Young fish are more likely to be entrained and survive than mature fish; conversely mature fish are less likely to be entrained but if they are, their survival rate is lower. According to EPRI (1997), more than 90% of the fish entrained at hydroelectric projects are less than 4-8 inches (approximately 100 to 200 mm), and their high survival rate tends to reduce the overall entrainment impact on fish populations.

- Mortality tends to be positively correlated with both discharge and reservoir head. The higher the discharge and the higher the hydraulic head, the greater mortality will be.

- Mortality rates via pressure change vary by species, with perch, crappie and bass more susceptible to mortality than salmonids and minnows. Survival of percids tends to be very low, 0 to 10%, with large differences in pressure.

- Mortality due to pressure changes is reduced as the reservoir lowers.

- Mortality is relatively low in spillways with water velocities less than 50 fps, but increases sharply at velocities greater than that, with 100% mortality observed at velocities more than 80 fps.

APPENDIX A-2. Comparison Reservoir Mortality Studies

Fall Creek Reservoir is operated for flood control and recreation, with the reservoir generally having an annual change in hydraulic head of approximately 100 feet. Discharges range from a low of 150 cfs, up to 1,000 cfs. Flow is released through two 5.5 by 10 foot rectangular slide gates that can be regulated to decrease the openings to as little as 1 foot tall by 5.5 feet wide.

Mortality studies at the reservoir focused only on salmonids, specifically steelhead and chinook salmon. Both direct and delayed mortality were included in the total mortality rates. The studies identified a chinook salmon mortality rate of 70% with rapid drawdowns and very high discharges (more than 1,000 cfs). Studies conducted at more gradual releases identified mean mortality rates of 41.0 for salmon smolts and 29.6% for steelhead fingerlings. Homolka and Smith (1991) identified that mortality was related to both reservoir head and discharge. In re-examining their data for this study, mortality was separated out according to the following conditions:

- High Head, High Discharge: Discharges greater than 700 cfs (although at times total flow split between two gates), hydraulic head greater than 80 feet over the intake top. Calculated velocities of 38 to 43 mph through the gates based on the reported discharges, number of gates open and degree of gate openings. Mean mortality of 57.5%.

- Moderate Head, High Discharge: Discharges greater than 700 cfs (although at times total flow split between two gates), hydraulic head between 50 to 80 feet over the intake top. Calculated velocities of 35 to 37 mph through the gates. Mean mortality of 50.0%.

- Very Low Head, Moderate Discharges: Discharges between approximately 700 to 1,000 cfs (although at times total flow split between two gates), hydraulic head between 15-18 feet over the intake top. Calculated velocities of 18 to 20 mph through the gates. Mean mortality of 6.8%.

There were no data on conditions ranging between 18 to 50 feet of head.

The steelhead data identified a mean mortality rate of 29.6% under unknown flow, gate opening and velocity conditions.

<u>**Blue River Reservoir**</u> is operated for flood control and recreation. It has a hydraulic head of 92 feet with an annual change of approximately 33 feet. Discharges range between 440 and 1,000 cfs, released through two slide gates. Mortality studies conducted between mid July and mid December 1989 identified mortality rates of 63% (salmon) to 74% (other species) (Downey and Smith 1990). Both direct and delayed mortality were included in the total mortality rates.

There were little data on the full range of flows or gate conditions during the study. However, the study identified a strong relatively linear relationship between discharge and mortality under low head conditions, with mortality ranging from 30% at 150 cfs to 60% at 350 cfs. In this study, "low head" conditions were defined as 50 to 60 feet over the intake.

Cougar Reservoir is operated for flood control, irrigation and hydroelectric power. Discharges can range from 440 to more than 1,000 cfs. Flow is released through one of two intakes- one leading to the turbines and one leading to a pair of regulated slide gate outlets. The 3-foot diameter regulating outlet pipes subsequently discharge into an open spillway-type chute.

Between November 1998 and March 1999, Taylor (2000) examined the mortality rates associated with both the hydroelectric turbines and the regulating outlets. Only direct mortality was reported. The study was conducted during winter low pool conditions, with the water surface ranging between 65 to 85 feet over the regulating gate outlets and 10 feet higher over the turbine. The flows and associated velocities during the study are unknown. Mean mortality was 32.3% for chinook salmon and 40% for rainbow trout through the regulating gates. For comparison, the mean mortality rates through the turbines were of 7.1% chinook salmon and 20% rainbow trout.

Wickiup Reservoir is operated for irrigation, with a full hydraulic head of 82 feet. Flows are released through two 8-foot pipes that narrow to two 7.5-foot jet valves at the outlet. Discharges can range from 100 to 2,000 cfs, or 50 to 1,000 cfs through each outlet.

Mortality studies at the reservoir examined all fish species captured in traps below the outlet on five days a month, between April and October, 2005 (Symbiotics 2009). Both direct and delayed mortality were included in the total mortality rates. The range of flows during the study was from 600 to 1,800 cfs (or 300 to 900 cfs through each outlet). The hydraulic head changed by 20 feet during the study and the water surface at the end of the study was 50-60 feet over the outlet elevation.

The mean mortality, including both direct and delayed mortality, was 86.3%. As for the Fall Creek study, Symbiotics (2009) identified a relationship between hydraulic head and mortality. Mortality was highest between April and June when the hydraulic head was the highest. During these months direct mortality was always greater than 77%. In the fall, as the head was at its lowest, direct mortality was less than 50%.

There is no information on within pipe or valve velocities.

Tieton Reservoir is primarily operated for irrigation with a full hydraulic head of 192 feet and an annual hydraulic head change of up to 130 feet. Flows are released through two 5-foot jet valves that are generally operated with the openings at less than 2.5 feet (Cramer and Associates 2002). Velocities have been identified as 13 to 27 mph within the intake pipes and 40 to 68 mph through the jet valves themselves (Hardin 2001).

Mortality sampling downstream of the outlets occurred from August 27 through October 17, 2001 to coincide with the maximum seasonal water withdrawal for downstream irrigation. This was also to coincide with the season when entrainment was expected to be the highest. Discharges during the study ranged between 300 to 2,200 cfs (or 150 to 1,100 through each outlet). The results indicated an average mortality rate of 81%, with mortality identified for all entrained species (James 2002). Only direct mortality was identified.

APPENDIX B

LOCATION OF YELLOW PERCH SPAWNING SITES IN WHICH NETTING HAS OCCURRED BETWEEN 2009-2012.

From Bailey (2012)

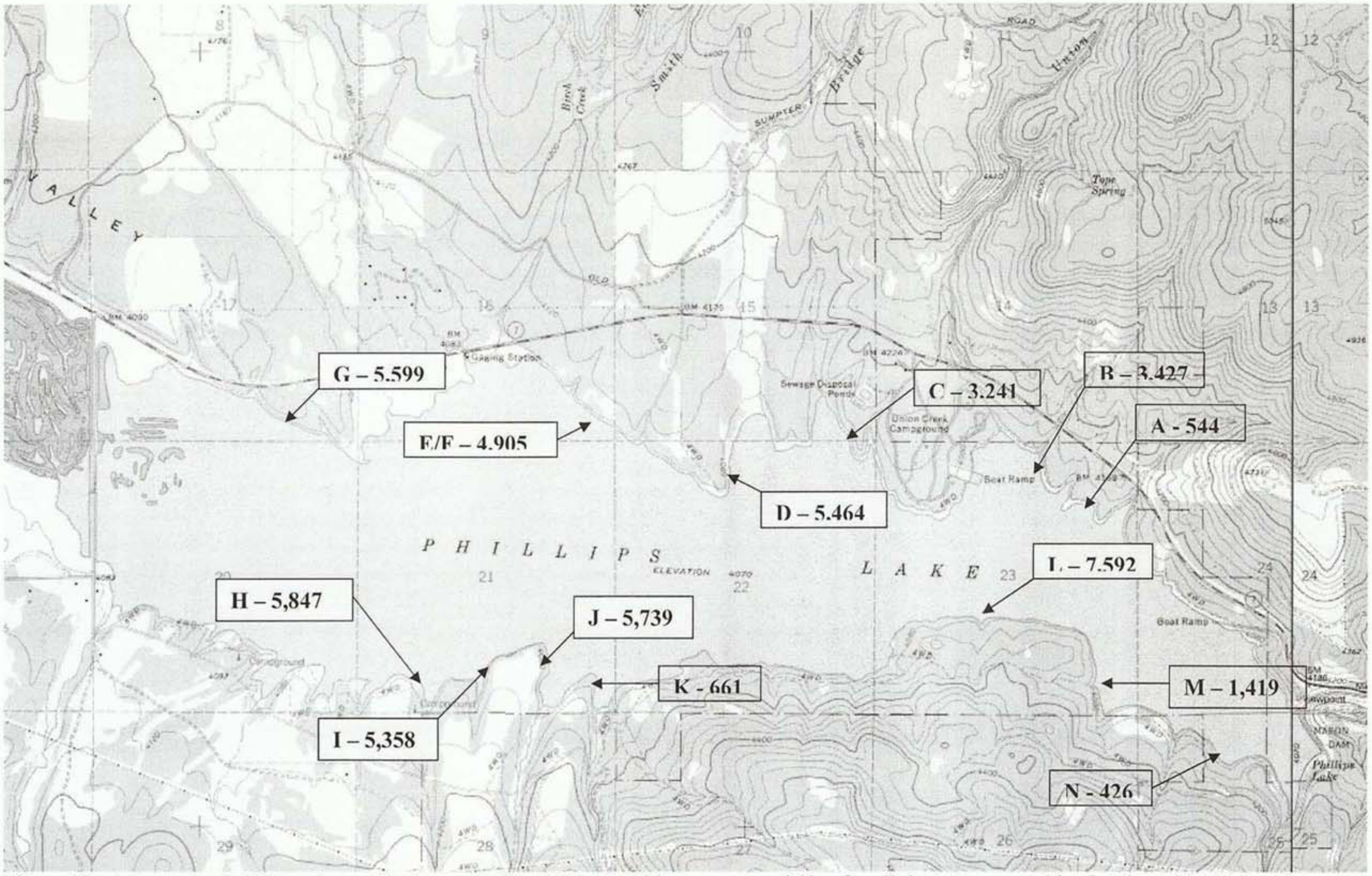


Figure 13. Aggregate of all Merwin trap deployment sites 2009-11, with average catch/day for all three years combined. Those highlighted in yellow were the most productive.

APPENDIX C

Report on Fish Entrainment and Mortality at Mason Dam, OR
Prepared for:
Baker County
Prepared by:
GeoSense
February 2011

Draft Technical Report

Report on Fish Entrainment and Mortality at Mason Dam, OR

Mason Dam Hydroelectric Project (FERC No. 12686)

Prepared for:

Baker County
Baker City, OR

Prepared by:

GeoSense
Idaho Falls, ID

February 2011

Introduction

The Federal Energy Regulatory Commission's (FERC) 9-Mar-2007 Study Plan Determination concurs with a Baker County proposal to screen the Mason Dam intake in lieu of performing a study of redband trout and bull trout entrainment through Mason Dam. Subsequent to this Determination, Baker County concluded that it would not be economically feasible to screen the dam intake due to its deep submergence in Phillips Reservoir. Baker County therefore conducted a study to address potential effects of the Mason Dam Hydroelectric Project on entrainment and mortality of fish passing through Mason Dam. The study was conducted by reviewing existing entrainment and mortality studies for projects having similar characteristics to the proposed project. The purpose of this work is to determine the potential changes in fish entrainment and mortality that would occur if the hydropower project was built.

Objectives

The objectives of this study are:

- Compile intake characteristics and turbine specifications for the Mason Dam project Hydroelectric Project;
- Conduct a literature study and select, from the large existing body of work on fish entrainment and turbine mortality, studies that will permit a comparison of entrainment and mortality between existing projects and the proposed project;
- Assess fish entrainment and turbine mortality for the proposed project in comparison to existing conditions at Mason Dam;

Background

Phillips Reservoir and the Powder River below Mason Dam support populations of resident and hatchery fish including both native and non-native species. Fish populations in both the reservoir and river have been significantly altered by the presence of man-made alterations of the Powder River system that have been in place since the early 1900's. Important man-made alterations include Mason Dam, extensive dredge mining in the riverbed upstream of Phillips Reservoir, and irrigation diversions both above and below Mason Dam.

Present Conditions

Fish species in Phillips Reservoir include rainbow trout (*Oncorhynchus mykiss*), crappie (*Pomoxis spp*), smallmouth and largemouth bass (*Micropterus dolomieui, M. salmoides*), yellow perch (*Perca flavescens*), walleye (*Sander vitreus*), northern pikeminnow (*Ptychocheilus oregonensis)* and various species of sucker (Baker County, 2009). Yellow perch and walleye were introduced in the 1980's and yellow perch have subsequently dominated the lake fishery. There have been several attempts to rid the lake of yellow perch, with the most recent attempt in 2010. Lake-wide netting resulted in the collection of 46,522 yellow perch and 1,047 other fish species in 2009, and 337,745 yellow perch and 1,069 other fish species in 2010 (ODF&W, personal communication).

The Powder River subbasin holds 4 distinct populations of redband trout. These occupy the Powder River from the mouth to Thief Valley Dam, Eagle Creek, the Powder River from Thief Valley Dam to Mason Dam and the Powder River above Mason Dam . Fingerling and catchable rainbow trout are stocked in the river annually. In addition, the Powder River below Mason Dam would likely contain populations of yellow perch and other Phillips Lake species that are entrained through the dam.

Bull trout are not known to occur in the immediate study area but do occur in the headwater tributaries of the Powder River. The U.S. Fish and Wildlife Service (FWS) has concluded that the operation and maintenance of Mason Dam by Reclamation is "not likely to adversely affect" bull trout (US Fish and Wildlife Service, 2005). No bull trout were captured during the 2009 lake-wide netting in Phillips Reservoir. There are no known bull trout in the Powder River below Mason Dam. Potential habitat is limited by large fluctuations in reservoir releases over the growing season and the lack of habitat complexity (Ecowest Consulting, 2009).

Mason Dam, which has been operating since 1968, is a barrier to upstream fish passage and an impediment to downstream fish passage. Since 1968, fish in Phillips Reservoir have been and continue to be subject to entrainment through Mason Dam into the downstream Powder River. Fish can enter the dam through a submerged intake into a 56-inch steel penstock (Figure 1). The sill of the intake structure is at a depth of 98 ft below the normal high water elevation of Phillips Reservoir.

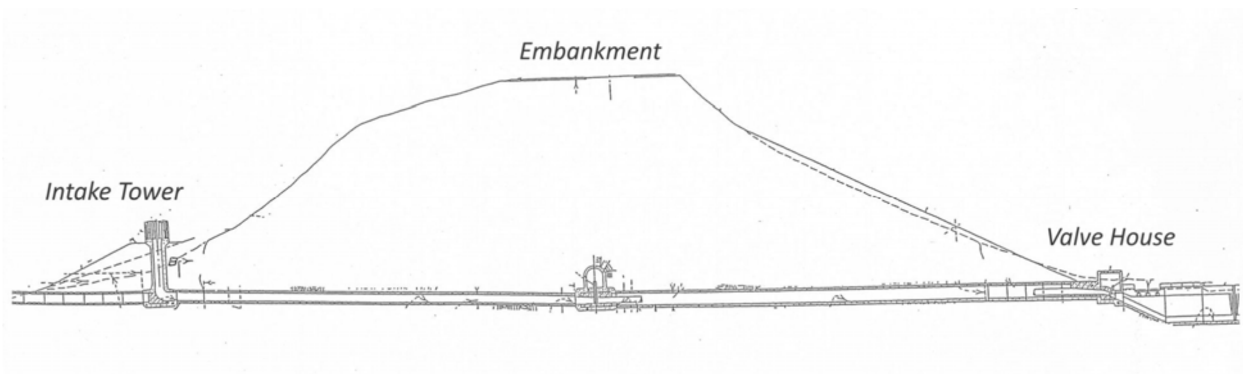


FIGURE 1. CROSS SECTION DRAWING OF MASON DAM (FROM RECLAMATION).

Once entrained, fish currently exit the dam through either of two 33-in slide gate valves. The slide gates operate by controlling the position of a rectangular steel plate within the flow path. During normal releases the flow path is partially blocked by the plate, causing the water to accelerate through the partial opening and exit the valve into the Powder River as a jet of water (Figure 2). An unknown percentage of these entrained fish experience injury or mortality during passage through the valves. Surviving fish become resident in the riverine habitat downstream of the dam.

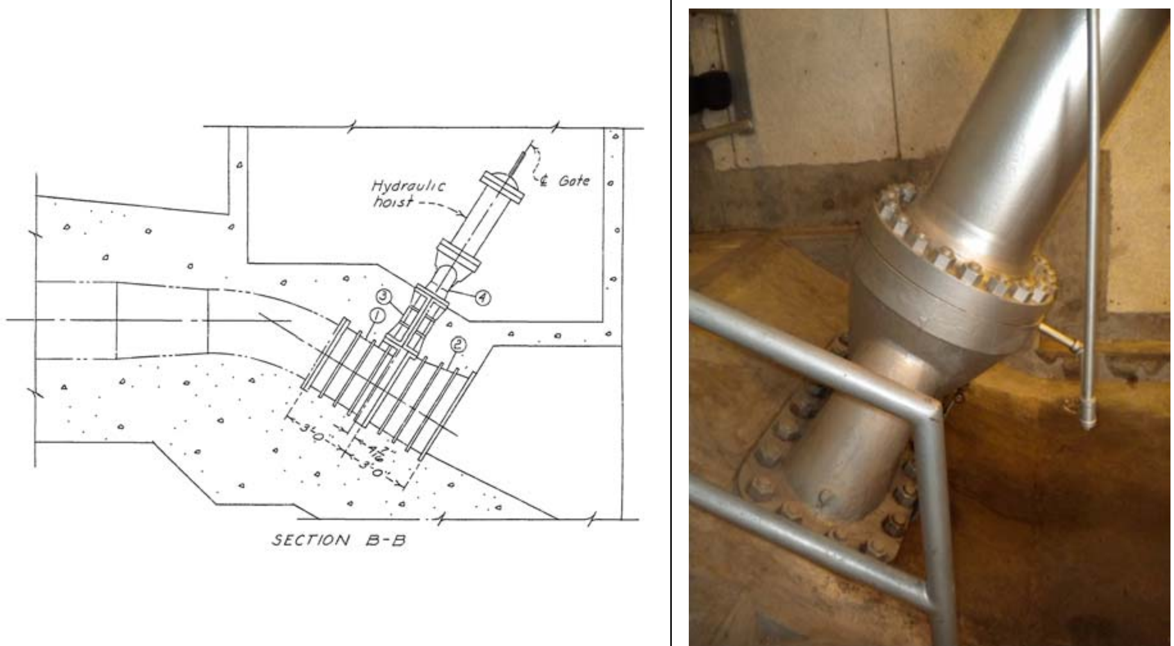


FIGURE 2. DRAWING AND PHOTOGRAPH OF A MASON DAM SLIDE GATE VALVE.

Proposed Conditions

The proposed Mason Dam Hydroelectric project would make no changes to the submerged intake structure that withdraws water from Phillips Reservoir. If constructed the project would only modify the outlet works on the downstream side of the dam. A bifurcation would be installed so that a portion of the withdrawn water flow, including any entrained fish, would pass through the project turbine rather than through the slide gate valves (Figure 3). Under the proposed project, as with existing conditions, fish that survive passage through Mason Dam would become resident in the riverine habitat downstream.

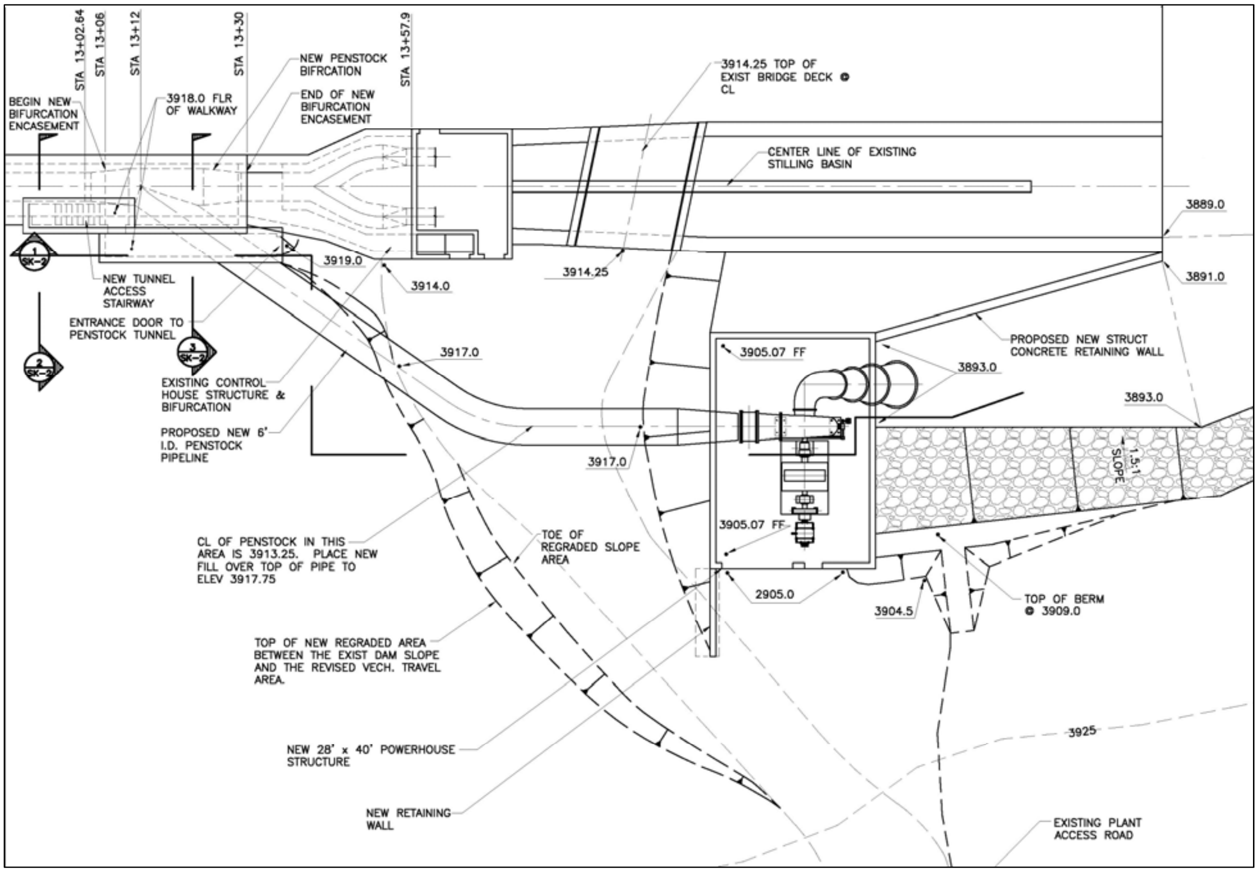


FIGURE 3. DRAWING OF PROPOSED MODIFICATION TO MASON DAM OUTLET WORKS.

Fish Entrainment

In its Preliminary Licensing Proposal, Baker County states that the proposed Mason Dam Hydroelectric Project would make no changes to the submerged intake structure that withdraws water from Phillips Reservoir, would not change the operating rules for Phillips Reservoir, and would not change the amount or timing of water withdrawals through Mason Dam (Baker County, 2009). Under these conditions the rate of fish entrainment would not change as a result of project construction. Fish would be entrained through Mason Dam at the same rate with or without the hydroelectric project.

Estimate of Entrainment Rate at Mason Dam

Entrainment rates through Mason Dam may be estimated by comparison with similar projects where entrainment rates have been measured by scientific studies. The approach for assessing fish entrainment was to compile existing study data from projects having characteristics similar to the proposed project and interpret these data in the context of known fishery data for the Powder River in the project vicinity. In the past 25 years there have been many entrainment studies conducted at dams in cold water and warm water environments similar to the expected conditions at the Mason Dam project site (FERC 1995). Potential physical factors affecting entrainment include reservoir size, water flow through the intake, and dam height/depth of intake. Potential biological factors include fish species, fish size, and seasonal and diurnal movements.

The potential magnitude of annual entrainment through the proposed dam was evaluated by first reviewing trends from entrainment field studies completed at other hydropower projects. Of about 50 studies performed priamily in the 1980s and 1990s, 24 were selected for review and are listed in Table 2 (EPRI 1992; FERC 1995; FERC 1996a; FERC 1996b; FERC 1997). These projects were selected because they have characteristics similar to the proposed Mason Dam Hydroelectric Project in that they are located on small, mainstem rivers with primarily warm water fisheries. Projects missing key information or representing obvious statistical outliers were eliminated from further review.

TABLE 1. ESTIMATES OF FISH ENTRAINMENT AT 24 HYDROPOWER PROJECTS LOCATED ON WARM WATER FISHERIES.

PROJECT/RIVER SYSTEM	STATE	RESERVOIR SIZE (ACRES)	DAM HEIGHT (FEET)	TOTAL HYDRAULIC CAPACITY (CFS)	OPERATING MODE[A]	TOTAL ANNUAL ENTRAINMENT (FISH)
Escanaba Dam 3/Escanaba	MI	182	31	1,250	ROR	21,762
Brule/Menominee	WI	545	63	1,377	PK	25,296
Tower/Black	MI	102	20	360	ROR	30,295
Cataract/Escanaba	MI	180	70	450	PK	31,094
Escanaba Dam 1/Escanaba	WI	75	25	1,175	ROR	45,552
Park Mill/Menominee	WI	539	22	2,500	ROR	46,138
Rogers/Muskegon	MI	610	39	2,400	ROR	55,875
Kleber/Black	MI	270	44	400	ROR	63,145
Crowley/NF Flambeau	WI	422	28	1,480	ROR	66,920
Pine/Pine	WI	180	33	624	ROR	67,977
Thornapple/Flambeau	WI	295	16	1,400	ROR	68,328
Buchanan/St. Joseph	MI	423	20	3,798	ROR	70,006
Caldron Falls/Peshtigo	WI	1,180	80	1,430	PK	78,335
Sandstone Rapids/Peshtigo	WI	150	42	1,400	PK	81,303
Moores Park/Grand	MI	240	21	1,200	ROR	85,848
Grand Rapids/Menominee	WI	300	28	3,870	ROR	91,646
Prickett/Sturgeon	MI	773	57	642	ROR	115,979
Mio/Au Sable	MI	860	36	2,700	ROR	120,323
White Rapids/Menominee	WI	435	29	5,188	PK	144,554
Foote/Au Sable	MI	1,800	52	4,050	PU	154,779
Loud/Au Sable	MI	790	31	2,600	PU	162,526
Rothschild/Wisconsin	WI	1,604	29	3,300	ROR	212,720
Croton/Muskegon	MI	1,209	40	3,700	ROR	219,761
Cooke/Au Sable	MI	1,320	48	3,600	PU	222,423
Mason Dam	*OR*	*2,234*	*153*	*875*	*ROR*	-

[a] PK = peaking; PU = pulsed (intermittent operation to maximize turbine efficiency); ROR = run-of-river

None of the studies available for comparison to Mason Dam had dam heights or overall size comparable to Mason Dam and Phillips Reservoir. The Caldron Falls/Peshtigo project, with an annual entrainment rate of 78,335 fish, was judged to be the best fit to the Mason Dam project with an emphasis on reservoir size and dam height. The Prickett/Sturgeon project, with an annual entrainment of 115,979 fish, was judged to be the best fit to the Mason Dam project with an emphasis on hydraulic capacity.

Reservoir size largely determines the turnover rate and habitat characteristics for a reservoir, which in turn can strongly influence fishery characteristics such as species abundance and composition of resident fishes subject to the risk of entrainment. Figure 4, which shows data from the 24 entrainment studies in Table 2, suggests that greater entrainment would be expected for larger reservoirs. On the basis of reservoir size alone, the proposed Mason Dam project would result in the entrainment of about 250,000 fish per year.

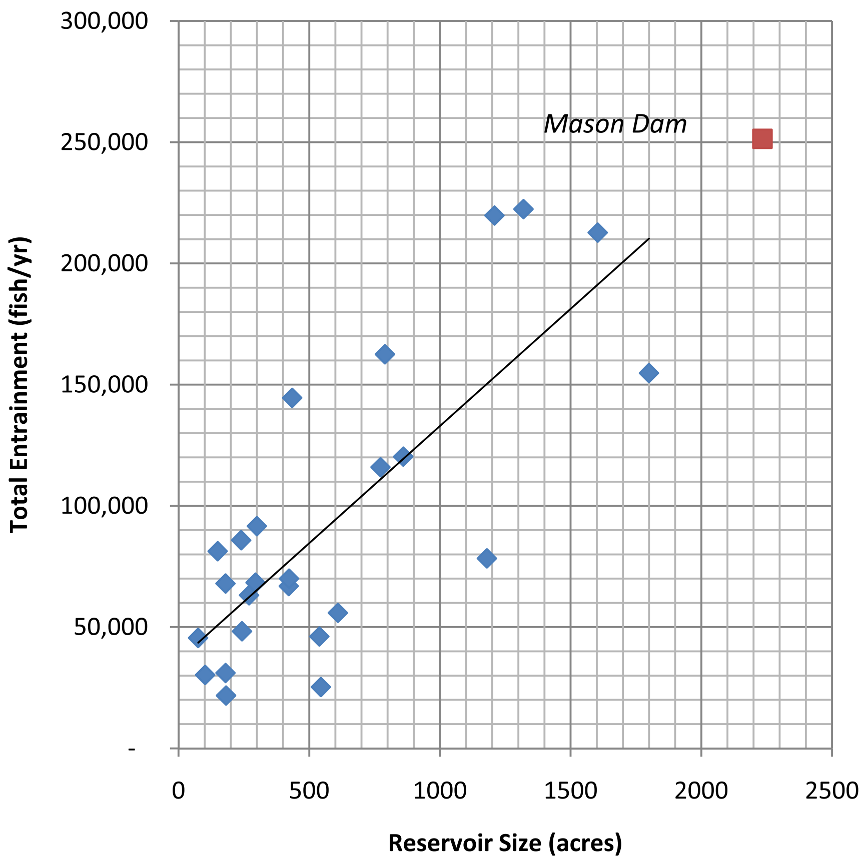


FIGURE 4. PLOT OF TOTAL ANNUAL ENTRAINMENT VS. RESERVOIR SIZE FOR STUDIES LISTED IN TABLE 2.

A project's hydraulic capacity might also be related to annual entrainment since it is an approximate measure of the water flow through the project. Figure 5 shows entrainment as a function of total hydraulic capacity for the Table 2 projects. The plot indicates that greater entrainment would be expected for projects having greater hydraulic capacity. On the basis of hydraulic capacity alone, the proposed Mason Dam project would result in the entrainment of about 74,000 fish per year.

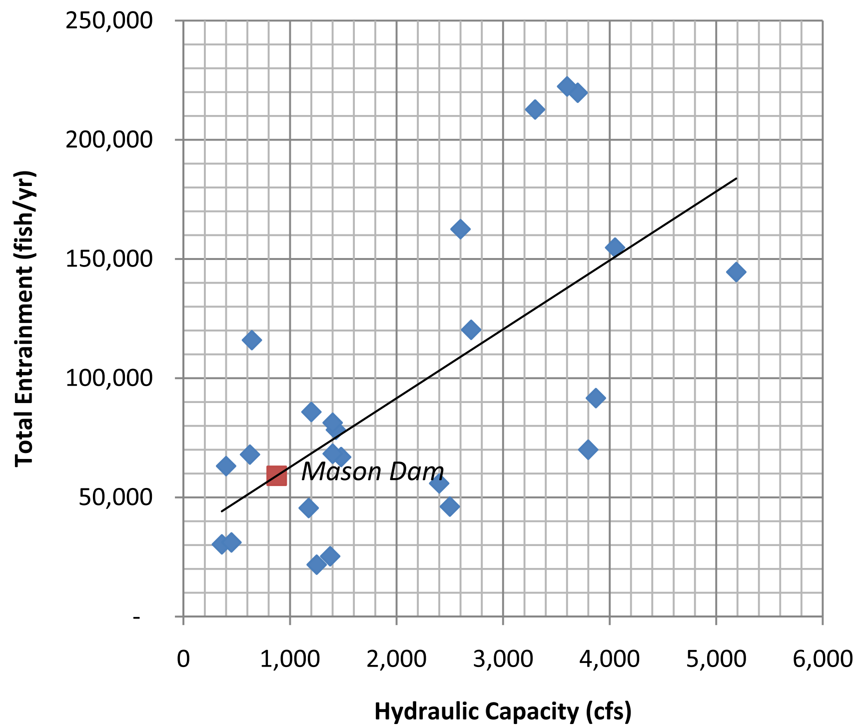


FIGURE 5. PLOT OF TOTAL ANNUAL ENTRAINMENT VS. HYDRAULIC CAPACITY FOR STUDIES LISTED IN TABLE 2.

Dam height might also be related to annual entrainment since abundant shallow water species are less likely to occupy the deep water habitat near high dams. However, the referenced literature contained few entrainment studies for dams over about 50 ft in height and no studies for dams over 80 ft. Mason Dam, with a hydraulic height of 153 ft, is considerably higher than the other dams in the entrainment database. An estimate of annual entrainment based on dam height for the Mason Dam project was therefore not attempted. A general discussion of water depth as a factor in entrainment is provided in the next section.

The various estimates of entrainment for Mason Dam based on comparison with existing projects are summarized in Table 3. The estimates range from about 75,000 to 250,000 fish annually, with an average of 130,130.

TABLE 2. SUMMARY OF ENTRAINMENT ESTIMATES FOR MASON DAM.

ESTIMATE	**ESTIMATE BASIS**	**TOTAL ANNUAL ENTRAINMENT (FISH)**
Caldron Falls/Peshtigo	Project with best overall fit with emphasis on reservoir size and dam height	78,335
Prickett/Sturgeon	Project with best overall fit with emphasis on hydraulic capacity	115,979
Reservoir size	Extrapolated from all 24 studies based on reservoir size	251,934
Hydraulic capacity	Interpolated from all 24 studies based on hydraulic capacity	74,273
	AVERAGE	130,130

Entrainment at Facilities with High Dams

Two reservoirs, Beulah Reservoir on the Malheur River in eastern Oregon and Arrowrock Reservoir on the Boise River in southwestern Idaho, were the subject of recent entrainment-related studies. Beulah and Arrowrock Reservoirs are impounded by relatively high dams with deep intakes as shown in Table 1. In each case, entrainment was qualitatively assessed by fish capture efforts in the river downstream of the reservoirs. Neither study was designed to distinguish between fish that were resident in the waters downstream of the dams versus fish that had been recently entrained through the dams.

TABLE 3. COMPARISON OF RESERVOIR FACILITY DIMENSIONS.

DIMENSION	**PHILLIPS RESERVOIR/MASON DAM**	**BEULAH RESERVOIR/AGENCY VALLEY DAM**	**ARROWROCK RESERVOIR/ARROWROCK DAM**
Elevation normal high water	4,062 ft	3,340 ft	3,216 ft
Hydraulic Height	153 ft	80 ft	257 ft
Spillway elevation	4,077	3,343	3,220
Intake elevation	3,975	3,263	3,012
Intake depth	87 ft	77 ft	204 ft
Valve type	Slide gates	Jet-flow	Clamshell

The Burn Paiute Tribe published a report on capture of bull trout below Agency Valley Dam from 1999 – 2005 (Fenton, 2006). In 2000, operations at Agency Valley Dam were modified to release water through a submerged intake structure rather than over the dam spillway. In the Agency Dam study, fish capture was compared before and after the operational change. Fish were collected downstream from the dam by rod and reel angling. In 1999, when releases were made over the spillway, one bull trout was collected downstream of the dam for every 20 angling hours. In 2000, when releases were made thorough the submerged intake, one bull trout was collected for every 100 angling hours and from 2001 to 2005 no bull trout were collected. These results suggest that bull trout are less susceptible to entrainment through a deep intake than through an intake that withdraws surface waters.

The Bureau of Reclamation published a technical report describing capture of bull trout below Arrowrock Dam on the Boise River in southwestern Idaho from 2000 – 2004 (Reclamation, 2005). The Arrowrock study, which was conducted in support of a project to replace the dam's primary release valves, reported that bull trout capture rates were related to the depth of water withdrawal:

> *"In addition, Reclamation drafted Arrowrock Reservoir to (>1% active pool capacity) in the Fall of 2003 and had a large sample of radio tagged bull trout that were monitored. Entrainment rates through Arrowrock Dam were documented to be significantly higher during the construction period (Salow & Hostettler, 2004). Since the replacement of the Ensign valves allows a higher discharge at a deeper depth in the water column, entrainment rates would be expected to decrease through time at Arrowrock Dam."*

On the basis of these studies at high dams in the region of Mason Dam, it seems likely that the Mason Dam project would entrain fewer fish than otherwise comparable shallow reservoirs. The average depth of the Mason Dam intake tower sill below the reservoir surface ranges form 55 – 74 ft, with shallower depths beginning in late summer and deeper depths occurring March to August (Table 4). The Mason Dam operator has observed yellow perch in the tailrace pool from about mid-August through early October, particularly in low water years, when water levels are low but water is still being released for irrigation (Baker County, personal communication).

TABLE 4. AVERAGE WATER ELEVATION AND DEPTH TO INTAKE SILL FOR PHILLIPS RESERVOIR FROM 1968 – 2008.

MONTH	AVG RESERVOIR ELEVATION (FT ASL)	AVG DEPTH TO INTAKE SILL (FT)
Jan	4031	56
Feb	4033	58
Mar	4038	63
Apr	4045	70
May	4047	72
Jun	4049	74
Jul	4046	71
Aug	4035	60
Sep	4029	54
Oct	4028	53
Nov	4028	53
Dec	4030	55

Size Composition

Of the studies that reported comprehensive size information, small or young-of-year fish generally comprised a large proportion of the fish that were entrained. Over 90% of the fish captured in some studies were less than four inches in length and in most cases over 90% were less than eight inches in length (Table 4). This is important from the standpoint that smaller fish passing through the turbines can generally be expected to suffer lower levels of mortality (usually <6%) and that the emigration of young-of-year fish from an impoundment usually constitutes a minimal impact to the harvestable component of the upstream population (EPRI 1992). The predominance of fish less than four inches in length at most sites suggests that many of the larger fish that could physically pass through the trashracks either avoid doing so or show an overall lower tendency towards downstream emigration than young-of-year fish.

TABLE 5. SIZE DISTRIBUTION OF ENTRAINED FISH (FROM EPRI 1992; FERC 1995; FERC 1996A; FERC 1997).

PROJECT AND LOCATION	STATE	SIZE DISTRIBUTION OF ENTRAINED FISH
Kleber	MI	46% < 3.9 in (100 mm) 96% < 7.9 in (200 mm)
Prickett	MI	84% < 4 in 99% < 8 in

PROJECT AND LOCATION	STATE	SIZE DISTRIBUTION OF ENTRAINED FISH
Tower	MI	50% < 3.9 in (100 mm) 82% < 7.9 in (200 mm)
Centralia	WI	95% < 3.9 in (100 mm)
Pine	WI	49% < 3.9 in (100 mm) 94% < 7.9 in (200 mm)
Wisconsin River Diversion	WI	96% < 3.9 in (100 mm)
Thornapple	WI	68% < 4 in 85% < 8 in
Escanaba Dam #1	MI	59% < 5.0 in 93% < 7.5 in
Escanaba Dam #3	MI	75% < 5 in 96% < 7.5 in
Rothschild	WI	88% young-of-year
Brule	WI	86% < 6 in
White Rapids	WI	82% < 4 in
Grand Rapids	WI	81% < 4 in
Park Mill	WI	79% < 4 in
Caldron Falls	WI	63% < 4 in 91% < 6 in
Sandstone Rapids	WI	93% < 4 in
Crowley	WI	78% < 4 in

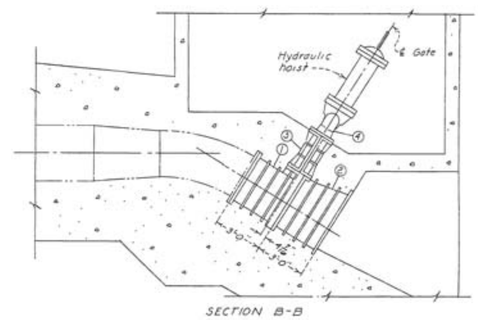
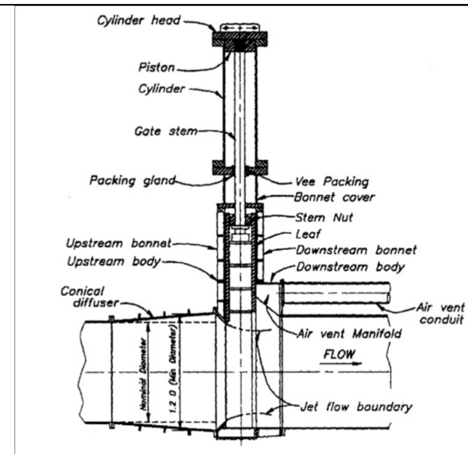
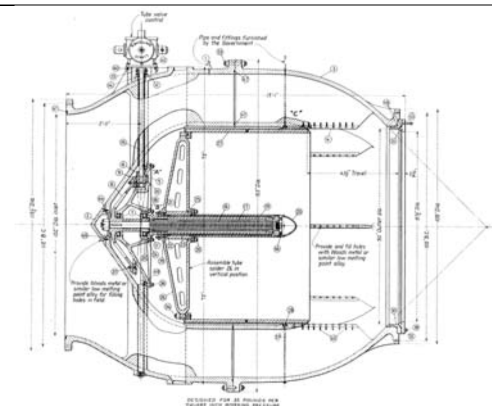
Species, and Seasonal Composition

Species composition data from entrainment studies show that the predominant species entrained through projects is highly variable. At Mason Dam, it seems reasonable to expect that the species composition of entrained fish would reflect the overall lake population, which is dominated by yellow perch. Walleye might be entrained at a higher rate than other species in Phillips Reservoir due to its habitat preference for deeper water. Perch, smallmouth bass, walleye and rainbow trout all spawn in the spring or early summer (Fisheries and Oceans Canada, 2010). Since spawning occurs in shallow water habitats, it is reasonable to expect that entrainment through the deep intake tower would be lower during the spawning period, when Phillips Reservoir is usually at or near its maximum water level. Similarly, entrainment may be higher in the late summer when reservoir levels are low and fish seek cooler, deeper water.

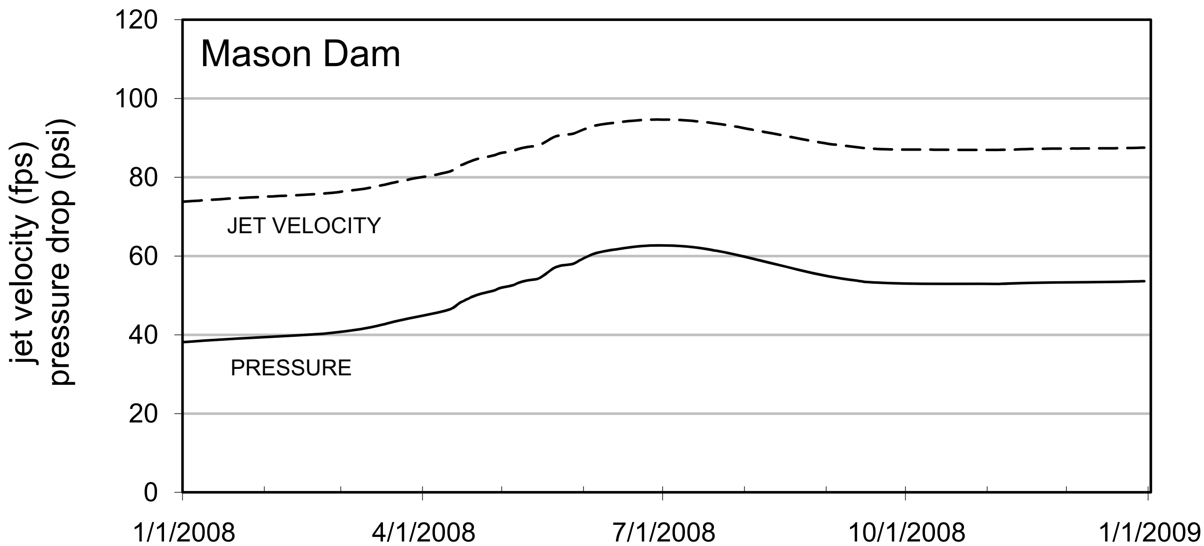
Valve Mortality

Currently, fish entrained through Mason Dam are ejected through two 2’ 9” slide gate valves into the tailrace below the dam. Fish mortality caused by passage through large release valves has not been extensively studied. However, mortality due to release valves has been previously studied at Tieton Dam on the Tieton River in Washington and at Wickiup Dam on the Deschutes River in Oregon. A comparison of the outlet works for these three dams is given in Table 6.

TABLE 6. COMPARISON OF OUTLET WORKS AT MASON DAM, WICKIUP DAM AND TIETON DAM.

PROJECT	**VALVE TYPE**	**AVG MONTHLY FLOW (CFS)**	**HEAD (FT)**	**VALVE DRAWING**
Mason Dam	2@ 33-in Slide Gate valve	10 – 270	68 - 157	
Tieton	2 @ 60-in Jet-Flow valve	90 – 1,600	46 – 210	
Wickiup	2 @ 90-in Fixed-cone (Tube) valve	160 - 1600	7 - 79	

Since jet-flow valves operate similarly to the slide gate valves used at Mason Dam, the mortality rate at Tieton Dam offers a first-order estimate of the mortality experienced by fish passing through Mason Dam. The FWS Biological Opinion for Tieton indicated that a conservative estimate of kokanee salmon direct mortality through the Tieton jet-flow valves is in the range of 60% to 80%, with mortality positively correlated with both head and flow (U. S. Fish and Wildlife Service, 2005). Mortality is likely caused by a combination of physical stresses and sudden pressure differences. Like Tieton, Mason Dam is a high head facility and water exiting the jet valves is expelled with great force. It is evident that passing through a valve causes physical stress to fish, which may strike hard surfaces at considerable speed. Entrained fish also experience a great pressure differential as they pass the outlet works because they experience the full head pressure of the reservoir just before they are suddenly ejected from the jet valve into the air, where the pressure is about 1 atmosphere (Figure 6). Due to the similarity in characteristics between Mason and Tieton dams, it is reasonable to expect a similar mortality rate for the existing jet valves at Mason Dam.



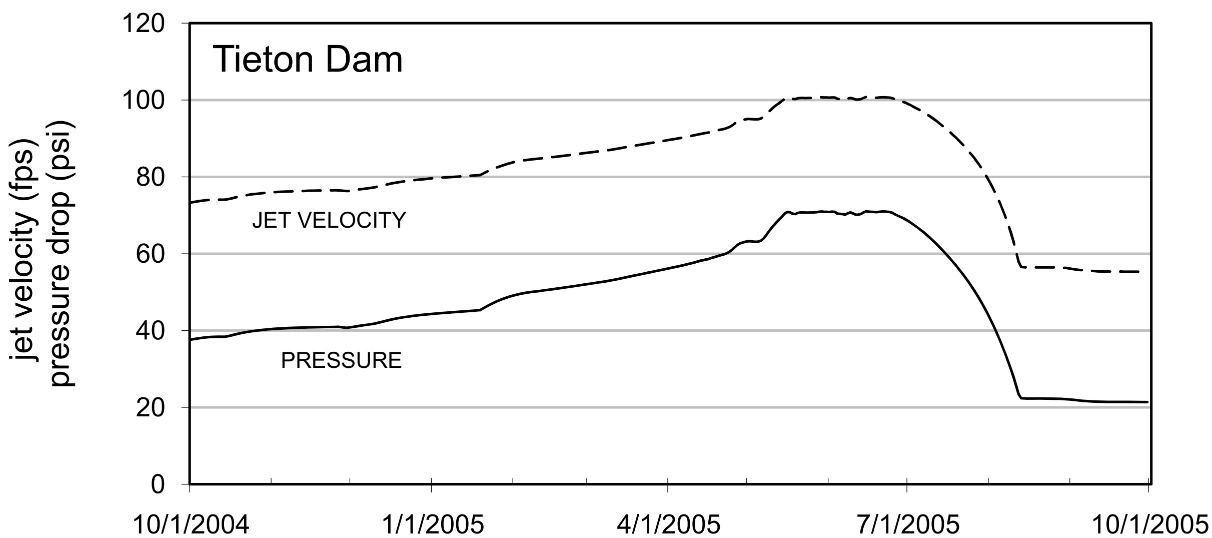


FIGURE 6. APPROXIMATE JET VELOCITY AND PRESSURE DROP EXPERIENCED BY FISH PASSING THROUGH VALVES AT MASON DAM (TOP) AND TIETON DAM (BOTTOM).

The overall direct mortality determined in the Wickiup Dam study was 81% (Symbiotics LLC, 2009). As in the Tieton study, mortality was positively correlated with head and flow. Although the Wickiup project employs cone valves rather than gate/jet-flow valves, cone valves are similar to the other valve types in the sense that they regulate flow by introducing a blockage into the flow path causing water to accelerate through the valve opening. Dead fish showed signs of both collision and pressure induced injuries.

The operator at Mason Dam has observed large numbers of yellow perch in the tailrace pool below Mason Dam during late fall, especially in low water years. The fish appear to be disoriented and unable to swim. The condition of these fish is consistent with the observations made at Tieton and Wickiup and it seems apparent that yellow perch experience at least some mortality passing through the gate valves at Mason Dam. Based on the similarity between Mason Dam and the dams where mortality studies have been conducted, it seems likely that the mortality rate at Mason Dam is probably also in the range of 60 – 80%.

Turbine Mortality

The study of turbine mortality was based on review and interpretation of the extensive literature on the subject. Mortality estimates for the proposed project are based on comparison to similar projects where mortality studies have been performed. Factors influencing turbine mortality include turbine type, project head, peripheral runner velocity, operating efficiency, and size of fish entrained.

Causes of Mortality

Known mechanisms of injury and mortality among fish passing through turbines (Cada 2001) include:

- rapid and extreme pressure changes
- cavitation - low water pressure causes the formation of vapor bubbles, which subsequently collapse
- shear stress
- turbulence
- strike (collision with structures including runner blades, stay vanes, wicket gates, and draft tube piers)
- grinding (squeezing through narrow gaps between fixed and moving structures).

Because the factors impacting fish in the turbine are complex and interrelated, it has been difficult for researchers to accurately identify and quantify which factors are having what impact. However, fish strike by the turbine blades is considered to be the major cause of fish mortality. Further, the size of fish is considered to be closely correlated to the probability of blade strike, and hence, to injury or death of the fish. That is, the smaller the fish, the greater the chance of survival, the larger the fish, the smaller the chance of survival.

In addition to blade strike, the most common mechanisms of injury or death are rapid changes in pressure and shear. A study by Mathur et al. (2000) estimated the proportion of injury caused by the various factors to be 50% due to blade strike/grinding, 19% due to pressure, 14% due to shear, and 17% due to a combination of other sources. Though cavitation is seen as a cause of fish injury, it is difficult to demonstrate and is highly dependent on the specifications of the particular turbine and how it is operated (i.e. efficiency and other technical attributes). Furthermore, most projects are designed to minimize cavitation to prevent turbine wear.

A Department of Energy publication (Odeh 1999) provides a general statement of mortality rates for Francis turbines. In studies since 1987, mortality rates of 16% and 4% were found for Francis and Kaplan turbines respectively. Basically, the number and speed of the turbine's runners are the main factors causing injury or death.

A review of 64 studies by Electric Power Research Institute (EPRI 1987) found that:

- Kaplan and Francis turbines present different challenges to safe fish passage. In Kaplan turbines, the primary injury mechanism is likely the crushing of fish between the blade tip and interior wall of the turbine. In Francis turbines, the main effect occurs at the entrance to the runner blade cage and is a function of the wicket gates, shape of the runner, and peripheral runner velocity.
- Head, a surrogate for force determined by the difference in elevation between forebay and tailwater, does not appear to be a significant independent determiner of mortality. However, head determines water velocity against the runner blades, and hence, the peripheral runner velocity.
- Subatmospheric pressures experienced by fish passing through the turbine appear to affect mortality rates.
- Difference in elevation between runner and tailwater seems to affect mortality, presumably because this difference results in subatmospheric pressure variations under the runner blades.
- Shear is assumed to be a factor in mortality but is a difficult mechanism to identify under test conditions.
- The average mortality for Francis turbines was 20%, vs. 12% for Kaplan turbines.

Comparison with Similar Projects

Though many factors contribute to fish mortality rates, peripheral runner velocity emerged in the EPRI review as the most critical:

> *Comparisons of turbine operational and design characteristics with mortalities in prototypes found few good cause-effect relationships. The best linkage with mortality was that of peripheral runner speed in the case of Francis units (EPRI 1987, p.iii).*

Table 7 presents the specifications for the turbines currently proposed for installation at the Mason Dam powerhouse. Oneida turbine specifications are also shown where available.

TABLE 7. TURBINE SPECIFICATIONS FOR THE MASON DAM HYDROELECTRIC PROJECT.

SPECIFICATION	**MASON DAM**
Number of turbines	1
Max flow per turbine (cfs)	300
Design Head (ft)	140
RPM	514
Peripheral velocity (ft/sec)	86
Runner diameter (ft)	3.2
Number of runner blades	13
Elevation of runner above tailwater (ft)	3.0
Average entrainment pressure (atm)	1.38

Table 8 lists projects utilizing Francis turbines where turbine mortality estimates have been performed and that have similar characteristics to the proposed project. Assuming that the principal mortality factor is peripheral velocity of the runner, with runner diameter, rpm, and head considered as important secondary factors, the Mason Dam project is most similar to the Glines, North Fork and Seton plants, which reported 36%, 26% and 9% average mortality respectively. Due to the comparatively high head at Glines, its mortality rate of 36% could be considered the upper limit of the estimated mortality for Mason Dam.

TABLE 8. AVAILABLE DATA ON FACTORS AFFECTING TURBINE MORTALITY FROM SPECIFIC SITES (ADAPTED FROM EPRI 1987).

PLANT	**HEAD (FT)**	**RPM**	**PERIPHERAL RUNNER VELOCITY (FT/S)**	**RUNNER DIAMETER (FT)**	**RUNNER ELEVATION ABOVE TAILWATER (FT)**	**AVERAGE PERCENT ESTIMATED MORTALITY**
Baker	250	300	80	5	-5	31
Cushman	450	300	108	6.9	11	41
Elwha	104	300	59	4.9	14	10
Faraday	120	360	62	3.3	10	4
Glines	194	225	86	7.7	7	36
Leaburg	89	225	88	7.5	11.9	17
Lequille	387	519	121	4.5	6.5	48
North Fork	136	139	82	9.7	5	26
Publishers	42	300	47	3	23	13
Puntledge	340	277	103	7.1	2	33
Ruskin	124	120	78	12.4	10	10
Seton	142	120	95	12	16	9
Shasta	410	138	111	13	3	39
Sullivan	42	240	64	6.2	23	20
Mason Dam	*140*	*514*	*86*	*3.2*	*3*	*24.8 (est.)*

Figure 7 shows the relationship of mortality vs. peripheral velocity for the 14 projects listed in Table 8. On the basis of peripheral runner velocity alone, the Mason Dam turbines are predicted to have a 24.8 percent mortality rate.

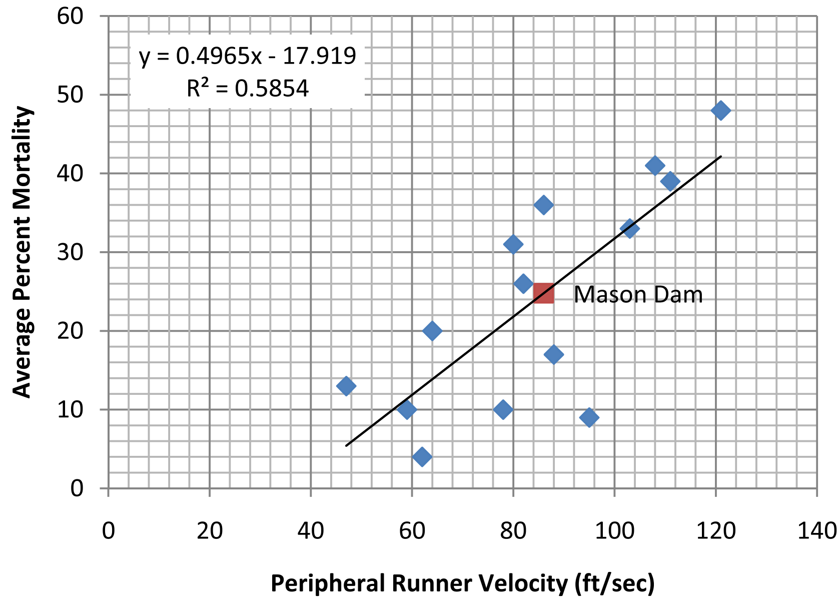


FIGURE 7. PLOT OF AVERAGE PERCENT MORTALITY VS. PERIPHERAL RUNNER VELOCITY FOR STUDIES LISTED IN TABLE 5.

Summary

The main results of this analysis may be summarized as follow:

The Caldron Falls/Peshtigo project, with an annual entrainment rate of 78,335 fish, was judged to be the best fit to the Mason Dam project with an emphasis on reservoir size and dam height. The Prickett/Sturgeon project, with an annual entrainment of 115,979 fish, was judged to be the best fit to the Mason Dam project with an emphasis on hydraulic capacity.

- The proposed project would not change the rate of fish entrainment at Mason Dam because the project would not alter the intake structure or change the amount or timing of water withdrawal.
- Entrainment rates at the two projects with the closest similarity in terms of hydraulic capacity and reservoir size/dam height to the proposed Mason Dam project were 115,979 fish/yr (Prickett/Sturgeon) and 78,335 fish/yr (Caldron Falls/Peshtigo).
- Using reservoir area and hydraulic capacity as the primary factors influencing entrainment, fish entrainment at the proposed Mason Dam project range from 74,000 to 250,000 fish per year.
- The entrainment rates estimated by comparison with other projects are probably conservative maximum values because Mason Dam has a high dam (153 ft) with a deep water intake structure, and the entrainment estimates were based on small dams (< 80 ft) with shallow water intake structures.

- Mortality due to passage through the Mason Dam slide gate valves is estimated to be in the range of 60% – 80%, based on comparison with two projects employing similar valves.
- Turbine mortality for 24 similar projects that utilize Francis turbines ranges from 4% to 48%.
- Mortality rates at the three projects with the closest similarity in terms of runner velocity and head to the proposed Mason Dam project were 36% (Glines), 26% (North Fork) and 9% (Seton).
- Based on peripheral runner velocity as the primary factor influencing mortality, the Mason Dam project is estimated to have a mortality rate of 24.8%

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APPENDIX D

Consultation Record

Mason Dam Entrainment Report
Elizabeth A OsierMoats to: jyencopal 12/10/2012 10:48 AM
Cc: "Gonzalez, Daniel -FS", gary_miller, "Ken Homolka", "Timothy Bailey"

History: This message has been forwarded.

Jason,
Please see ODFW's comments on the Mason Dam Hydro Project (FERC P-12686) Entrainment Report.
Feel free to contact me if you have any questions.

Sincerely,

Elizabeth A. O. Moats
Hydropower Coordinator, Northeast Region
Oregon Dept. of Fish and Wildlife
107 20th Street
La Grande, OR 97850
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ODFWcomments-Rev2EntrainmentRpt.pdf

Oregon
John A. Kitzhaber, MD, Governor

Department of Fish and Wildlife
Northeast Region
107 20th Street
La Grande, OR 97850
(541) 963-2138
FAX (541) 963-6670

December 10, 2012

Jason Yencopal
Baker County
1995 Third Street
Baker City, Oregon 97814

Subject: Mason Dam Hydroelectric Project (FERC 12686)
Report on Fish Entrainment and Mortality at Mason Dam

Dear Mr. Yencopal,

Oregon Department of Fish and Wildlife (ODFW) received the Fish Entrainment and Turbine Mortality Preliminary Draft Report on October 18, 2012. ODFW understands that this report is a "work in progress." ODFW, therefore, provides the following comments to inform the development of the Mason Dam Hydro Project Fish Entrainment and Turbine Morality Report.

1. Page 4, 5th paragraph – A description of water level and thermocline in relation to the water surface is presented. A graphic of this relationship would be helpful.

2. Page 5, Fish Species –Please correct then statement regarding the rotenone treatment and restocking. The treatment was conducted in the fall of 1977 and the reservoir was restocked in the spring of 1978.

3. Page 6, 1st Paragraph – The total number of yellow perch netted per year is presented. Effort, timing and location of nets have varied by year. These data cannot be used to demonstrate population trend because there are too many variables. Yellow perch population estimates have been developed for 2011 and 2012, but the difference is not statistically significant.

4. Page 6, 2nd Paragraph – Please make note that Merwin nets used are designed to capture littoral migrating species such as yellow perch. They are particularly effective to capture yellow perch during their spawning activities when they are moving to spawning grounds. Other open water species were not targeted during this netting and therefore, this data does not present an accurate representation of species composition in Philips Reservoir. Gillnet data could provide a better understanding of species composition.

5. Page 10 – Many references are made to anadromous fish and the proportion of anadromous fish that are captured. Please include a discussion of the importance of anadromy in the analysis and interpretation of entrainment data. Further, please explain why each aspect used to

compare Mason Dam to other entrainment studies is important. Also include a discussion of why other aspects are not included for comparison, such as flow range.

6. Table 4 – How did the species composition of these reservoirs compare with the species composition of Philips Reservoir? In our comments dated March 15, 2011, ODFW noted that fish communities at the studies used for comparison could have an influence on the level of entrainment.

7. Page 18-19 – Entrainment of stocked rainbow trout. In addition to the annual stocking of adult rainbow trout in June, 6-inch sub-adult rainbow trout are stocked in September. ODFW disagrees that the potential impact to these fish is "low to moderate", as is indicated on page 19. As stated in Appendix A, EPRI reports that 90% of all fish entrained at dams are between 4 to 8 inches. Further, the release location of these stocked fish is within the vicinity of the dam and occurs when the water level is generally nearing its lowest point. Additionally, the dissolved oxygen and temperature data presented in Figures 2 and 3 indicate that conditions at the intake are likely to be suitable for sub-adult rainbow trout when they are stocked in September. Therefore, ODFW believes the entrainment risk is at least "moderate."

8. ODFW requests that the fisheries management of Philips Reservoir be considered in the analysis of entrainment impacts. Tiger trout were stocked in 2011 and plans are underway to stock tiger muskie in the future. These species are being stocked in an effort to help control the yellow perch population and provide a unique fishing opportunity. Please include a discussion of the entrainment risks to these species. Additionally, the stocking regime for Philips Reservoir is likely to change during the life of the license. The current stocking regime for rainbow trout includes the stocking of adult fish in the summer and sub-adult fish in the fall. To meet the fisheries management goals for Philips Reservoir the long-term stocking goal is to instead stock fingerling rainbow trout. In addition to adult and sub-adult rainbow trout, the report should address the impact of entrainment and turbine mortality on stocked fingerling rainbow trout. In the past 100,000 to 200,000 fingerlings were stocked annually. ODFW requests the report assess impacts on the stocking of 200,000 3-inch fingerling rainbow trout.

9. Page 28, Entrainment Summary – Based on the species entrainment risk and additional studies, an entrainment estimate is provided for the major species. A range of entrainment rates is presented for rainbow trout. The high end of the range (2.6%) is stipulated because the reservoir it represents is regularly drawn down to 12% of its total volume. How does this proportion of drawdown and frequency compare to Philips Reservoir? How often could this be expected during the life of the license? An estimate of the number of rainbow trout entrained through Mason Dam presented based on a population estimate. It does not appear that empirical data are used to inform this estimate; therefore the upper end of the range should be used. Further, does the entrainment estimate include the impacts to stocked sub-adult and adult rainbow trout, as well as juvenile rainbow trout?

10. Page 28, Entrainment Summary, 2nd paragraph – ODFW appreciates the effort to analyze entrainment study results that are more compatible with Mason Dam. The factors influencing fish entrainment are not well understood. The potential entrainment range presented (17,325 to 61,875) is a reasonable estimate based on available information. However, without a scientific field study at Mason Dam, the actual entrainment is unknown. For the purposes of assessing the impacts of the Mason Dam hydroelectric project, ODFW requests further discussion of the final entrainment estimate.

ODFW appreciates the opportunity to work collaboratively with Baker County in the preparation of this report. We look forward to cooperating with you in the future. If you have any questions, please feel free to contact me at 541-962-1832 or Elizabeth.A.OsierMoats@state.or.us.

Sincerely,

Elizabeth A O Moats

Elizabeth A. O. Moats
NE Region Hydropower Coordinator

C: Ken Homolka, ODFW
Tim Bailey, ODFW
Gary Miller, USFWS
Dan Gonzales, USFS

FW: Mason Dam approach velocities
Rieber, Richard W to: jyencopal@bakercounty.org 11/27/2012 06:22 AM

Jason- below is information from Karl Ames, an Engineer's located in our Area Office. If there are any more specific questions related to this, I would recommend contacting Karl either by email (kames@usbr.gov) or phone – (208)383-2268.

Thanks

Rick

Richard W. Rieber
Fishery Biologist
Bureau of Reclamation
1150 N. Curtis Rd
Boise, Id 83706
(208)378-5313
(208)378-5066 fax
rrieber@usbr.gov

From: Ross, Robert W
Sent: Monday, November 26, 2012 1:35 PM
To: Rieber, Richard W
Subject: FW: Mason Dam approach velocities

Rick – see below – less than 2'/sec

From: Ames, Karl S
Sent: Monday, November 26, 2012 1:33 PM
To: Ross, Robert W
Subject: RE: Mason Dam approach velocities

I had that same question about a year and a half ago from the Baker County hydro guy. I came up with a velocity of 1.7 feet per second at the intake trashracks, at the outlet works capacity of 875 cfs.

You have the four intake sides, 10.25' x 11.33', and the top of the intake 10.58' square = an area of 576.5 ft^2. Less the trashrack bars, four intake sides, 21 bars each at 5/8" x 10.25' and the top bars, 20 bars at ¾" x 10.58' = 58.1 ft^2. Open area (A) at intake = 576.5 – 58.1 = 518.4 ft^2. With a capacity (Q) of 875 cfs, the velocity (V) = Q/A = (875 ft^3/sec)/518.4 ft^2 = 1.7 ft/sec. This meets Reclamation's dam intake trashrack design guideline of less than 2 ft/sec. The normal high flow through the outlet is 500 cfs, so the velocity normally would not exceed one foot per second.

If you have any questions on this let me know.

Karl

meeting follow-up
Rieber, Richard W to: jyencopal@bakercounty.org 11/23/2012 09:54 AM
Cc: "Ross, Robert W", "Vidergar, Dmitri"

History: This message has been forwarded.

Jason- I have asked some of our folks to address a few of the questions that came up at this week's meeting. As soon as I hear back, I'll let you know.

In regards to water quality impacts to bull trout near the intake pipe; at this time, Reclamation is not in a position to share information from our draft Biological Assessment. However, we have provided all of the water quality information to you that we have for Phillips Lake and hope that you can make your own interpretations from that information.

If you have any further questions, please contact either myself or Bob Ross.

Thanks

Rick

Richard W. Rieber
Fishery Biologist
Bureau of Reclamation
1150 N. Curtis Rd
Boise, Id 83706
(208)378-5313
(208)378-5066 fax
rrieber@usbr.gov

Entrainment Study Work Session Reminder

Jason A Yencopal to: Audie Huber, Carolyn Templeton, Carl Stiff, Colleen Fagan, GRIFFIN Dennis, Fred Warner, Gary Miller, Kenneth Hogan, 11/15/2012 02:34 PM

Cc: Heidi Martin, Jason A Yencopal

Hello All,

I just wanted to remind those who plan on attending that the work session will be November 20th at 10:00 am, at the Baker County Courthouse on 1995 Third Street in Baker City. For those participating by phone please call 877-820-7831 with a pass code of 8204693#.

Thank you and talk with you soon,
Jason Yencopal
Community Development Director
1995 Third Street
Baker City, OR 97814
541.523.9669 Office
541.523.8201 Fax
jyencopal@bakercounty.org

No formal meeting minutes where taken because this was a working session. Those in attendance either by phone or in person:

Gary Miller	USF&W
Ken Homolka	ODF&W
Elizabeth OsierMoats	ODF&W
Rick Rieber	BOR
Dan Gonzalez	USFS
Jason Yencopal	Baker County
Leslie Gecy	Baker County
Randy Joseph	Baker County Citizen

FISH ENTRAINMENT AND MORTALITY STUDY AMENDMENT COMMENTS

Gonzalez, Daniel -FS to: jyencopal 11/13/2012 05:03 PM

Cc: "Bonanno, Kristen T -FS", "Tomac, Jeff -FS" , "Archuleta, Shannon R -FS"

Jason:

Thanks for the opportunity to provide comments for the preliminary draft fish entrainment and mortality study-amendment. In general the report documented and highlighted the issues and concerns many of the stakeholders had from the original report. However, many of the conclusions regarding entrainment of various fishes are unsupported. By way of example, the conclusions describing the level of entrainment for fish species found in Phillips Reservoir as describe in the report (none, minimal, low, moderate, and high), did not provide the rationale or justification to ensure the validity of the determinations.

Please review the comments provided and I will contact you and Leslie tomorrow to go over the report and see if I can further assist with developing the draft.

Thank you,

Daniel Gonzalez
Energy Coordinator
PNW Forestry and Range Sciences Lab
1401 Gekeler Lane
La Grande, OR 97850
Office: 541-962-6533
Fax: 541-962-6504

FISH ENTRAINMENT AND MORTALITY STUDY_WORD ONLY_October_2012 DG and KTB Comments 11_09_12.docx

Field Code Changed

FISH ENTRAINMENT AND MORTALITY STUDY
-AMENDMENT-
PRELIMINARY DRAFT

MASON DAM PROJECT
BAKER COUNTY, OREGON
Project Number P-12686-001

Prepared for

Baker County
1995 Third Street
Baker City, Oregon 97814

Prepared by

EcoWest Consulting, Inc.
Baker, OR 97814

October 2012

1.0 Introduction

Baker County conducted a study to address potential effects of the proposed Mason Dam Hydroelectric Project on entrainment and mortality of fish passing through Mason Dam (GeoSense 2011). Agency comments both pre and post study focused on addressing how the study results would translate to changes in mortality of individual species, as well as clarification of the range of baseline entrainment numbers. In addition, new information has been developed regarding how water quality during the seasonal hydroelectric operating period could affect the previous entrainment estimates.

This report provides an amendment to the 2011 entrainment and mortality study. Specific objectives of the amendment are to:

- Revise the baseline entrainment and related mortality rates based on new information regarding deep reservoir intakes, particularly deep, gated intakes.

- Provide updated information on project operation as pertinent to fish species.

- Add a discussion of the potential for individual fish species impacts.

- Update the study with new information from other regional reservoirs, particularly those containing similar fish species as those found in the Mason Dam project area.

2.0 Mason Dam Project Description

The proposed Mason Dam project is described in detail in GeoSense (2011) and not repeated herein other than to clarify project details specific to fish entrainment and mortality.

Based on numerous studies throughout the United States (US), a number of factors have been identified as important in distinguishing the differences between entrainment and mortality under various circumstances (see for example, summaries in FERC 1995, EPRI 1997, Ch2MHill 2003, NAI 2009, Symbiotics 2009; detailed summary in Appendix A).

These factors include:

- Reservoir Characteristics: Operation type, depth and changes in hydraulic head
- Intake Characteristics: Type, depth, velocity and water quality at intake
- Fish species, size and seasonal/daily movements

Each of these factors is discussed individually below.

Reservoir Characteristics
Philips Reservoir is a~~n~~ 2,234 acre-reservoir located behind Mason Dam. Mason Dam has a total height of 173 feet and a maximum hydraulic height of 157 feet. The reservoir has a total storage capacity of 95,500 acre-feet and an active storage capacity of 90,500 acre-feet. Average reservoir

depths are 41 feet with a maximum depth of 125 feet (Shrader 2000). Approximately 13% of the full pool reservoir area is considered littoral habitat (Shrader 2000).

Mason Dam is currently regulated for flood control and irrigation. Water is generally stored between October and March and released by the Baker Valley Irrigation District (BVID) for irrigation between May and September 30. The BVID has an agreement with the Oregon Department of Fish and Wildlife (ODFW) to release enough water to meet a 10 cfs (cubic feet per second) minimum instream flow at Smith Dam, which is about 10 miles below Mason Dam. As a result of this requirement and the need to release water for flood storage during the spring, releases average approximately 10 cfs between October and January and increase to an average of 20 to 50 cfs during February and March. During the irrigation season, releases generally remain above 100 to 200 cfs and can go up to 350 cfs.

The proposed project would be run-of-release and not change the operation. The Mason Dam hydroelectric project would operate whenever releases by BVID exceed 100 cfs. These releases do not occur between October and January. Beginning in June and extending through September, releases exceed 100 cfs in 100% of the years. Between mid-March and mid-April, releases exceed 100 cfs in 10% of the years. Figure 1 depicts the frequency in which releases exceeding 100 cfs would occur during the January to June period.

As a result, the Mason Dam project would be expected to operate all or most of the time between May 1 and September 30, but not at all between October 1 and mid-March. The project would operate 10% of the time between mid-March to mid-April. During the last two weeks of April, the project would be operational between 30 to 70% of the time. Any potential entrainment mortality issues associated with the project operation would mostly occur between mid-April and the end of September, and occasionally between mid-March and mid-April.

Intake Characteristics

The Mason Dam intake is approximately 13 feet high, ranging in elevation between 3,975 and 3,988.25 feet above MSL. The bottom of the intake is located at an elevation of 3,975 feet above MSL, or 87 feet below full pool depth (4,062 feet above MSL). The intake bottom is located within the dead storage area and the intake top is within the conservation pool area. The intake is located approximately 290 feet west of Black Mountain Road. It is a gated intake, with a regulated outlet that produces high velocity flows.

Flows of up to 875 cfs can be conveyed through the dam for emergency purposes. There is a spillway for emergency flood releases that has not been used since the dam was constructed. Since dam operation began in 1968, all flows have been through the deep intake. Under current operation irrigation season releases range between 100 and 350 cfs.

From the intake, the concrete tunnel narrows midway through the dam to a main 56 inch pipe, with a 12 inch bypass flow pipe. The 56 inch pipe is subsequently bifurcated into two 33 inch pipes near the outlet. The regulating slide gates are contained within the 33 inch pipes.

Comment [ktb1]: Please explain where BVID releases water relative to Mason Dam.

Comment [DG 2]: This is a little confusing. Please clarify whether the 10cfs instream flow requirement is for the water between Mason and Smith Dams or is it supplemental water to meet a 10cfs water release at Smith Dam?

Comment [DG 3]: Please explain what "run-of-release" means.

Comment [DG 4]: Does this statement mean the project will also notrun or operate if the flows fall below 100cfs?

Comment [DG 5]: Please explain what 100% of the years refers to. Does this refer to data recorded from all years between June and Sep and does the data show that flows exceed 100cfs from June to Sept? Have the flows ever gone below 100 cfs? Please cite the data sources are you using – gauging stations, BVID flow data, etc..

Comment [DG 6]: Please explain why the project would not operate between Oct1 – mid March.

Comment [DG 7]: Please explain whether this statement means the flows will be above 100cfs during this time as well.

Comment [DG 8]: This is a big range. Please explain why the Project would operate from 30 to 70%. Does the data show a trend in flows that give that range of conclusion. Please also identify whether the data shows that flow during this time are sufficient to operate the project and still maintain flows above 100cfs.

Comment [DG 9]: Please spell out this acronym and explain what it means.

Comment [DG 10]: Please explain where these emergency releases would occur from, i.e., spillway, or over the top of the dam?

During irrigation releases, intake approach velocities are approximately 1.7 feet per second (fps), with a maximum allowable approach velocity of 2 fps. Once water enters the 56 inch pipe (midway through the dam), velocities increase to 5.8 fps at discharges of 100 cfs and 20.5 fps at discharges of 350 cfs. At the bifurcation point (near the outlet), velocities suddenly accelerate again to between 36 fps (at 100 cfs) to 127 fps (at 350 cfs) in the smaller 33" pipes, or up to 86 miles per hour at 350 cfs releases.

Philips Lake is apparently well aerated throughout the water column during the winter and spring (late November tomid April/early May) with dissolved oxygen (DO) values greater than 8 ppm throughout the profile in May (EcoWest 2009). Winter temperatures are unknown but are less than 0 EC in the upper layers as portions of the lake freeze. Beginning in May, the lake starts to stratify with increasing temperatures near the surface and relatively constant temperatures near the bottom of the reservoir. These differences increase to 10 ^{B}C by July, as the surface layer warms to more than 20 ^{B}C, while the temperatures near the bottom of the reservoir near Mason Dam remain relatively constant between 10.4 to 11.2 ^{B}C.

Dissolved oxygen concentrations change as both the temperature changes and the reservoir starts to stratify according to temperature and water density. The surface layers (epilimnion) remain well oxygenated, but in the mid and lower layers (mesolimnion andhypolimnion) DO levels drop below 7 ppm beginning in June.

Table 1 depicts the range of water quality conditions at the intake between mid-May and October. Beginning in mid-June, DO concentrations drop below 6.0 ppm throughout the intake area and remain low until the beginning of September. Temperatures remain cool at the intake level until the beginning of August when they begin to exceed 15 EC and increase to 20.7 EC.

The water quality data were collected during 2007, which was considered a "dry year" and in which the reservoir surface level was 18 meters above the top of the intake during May and was drawn down to a level just 3 meters over the top of the intake in September. A thermocline started to develop in June between 5 and 15 meters below the surface, with the thermocline between 10 to 15 meters below the water surface at its greatest development. Below the thermocline, water was anoxic.

During 2010, a "wet" year, the reservoir water surface ranged between 16 to 23 meters over the intake top between May and October. Because the thermocline develops with increasing surface temperatures, it is likely that in wet years, temperatures at the intake elevations would remain cool longer during the summer. Conversely, with the thermocline developing above the intake elevations, conditions would likely remain anoxic for a longer period of time (e.g., through September).

Comment [DG 11]: This description is confusing, especially when trying to relate it to fish tolerance and escapement. Please explain these flows in a way that is consistent with fish limitations, similar to how it's described later on in the document. It's hard to follow cfs to fps to mph. Consider using consistent measurements.

Comment [DG 12]: Please explain what well-aerated means and what it's being compare to?

Comment [DG 13]: If winter temps are not recorded or unknown, please explain where the data that is provided here is coming from and where the data came from for the rest of the year, i.e., May, July.

Comment [DG 14]: Please cite to where this data and information is coming from.

Comment [DG 15]: Please identify who collected the data. This matters because it may give the USFS a better idea of the protocols and methods used particularly if its ODFW or other agency.

Comment [DG 16]: From the beginning of the document to this point the measurement have gone back and forth between metric and standard. Please pick one format to maintain consistency throughout the document.

Table 1. Water Quality Conditions Within the Range of Mason Dam Intake Elevations During 2007.

Date	Intake Elevation (m below surface)		DO (ppm)		Temperature (E C)	
	Top	Bottom	Top	Bottom	Top	Bottom
11-May	21.9	18.0	8.6	8.6	11.1	11.1
17-May	21.4	17.5	8.1	7.6	9.1	8.9
25-May	21.0	17.1	7.6	7.3	10.8	10.2
1-Jun	20.6	16.7	6.7	5.9	10.1	10.0
9-Jun	20.1	16.2	7.4	6	12.9	10.8
15-Jun	19.5	15.6	6.6	6.6	13.0	13.5
22-Jun	19.5	15.6	5.8	4.2	12.9	11.3
28-Jun	18.9	15.0	5.2	4.8	14.5	14.2
6-Jul	18.1	14.2	3.5	3.5	12.7	12.7
17-Jul	16.8	12.9	2.6	0.9	14.9	12.0
24-Jul	15.7	11.8	1.8	1	15.0	13.5
7-Aug	13.2	9.3	6.0	0.1	20.7	14.8
14-Aug	11.8	7.9	5.2	0.1	20.1	17.0
21-Aug	10.2	6.3	6.2	2.3	19.5	18.9
13-Sep	7.7	3.8	9.6	7.4	17.7	16.9
21-Sep	7.3	3.4	5.8	7.7	15.4	17.0
28-Sep	7.0	3.1	6.0	5.7	13.4	15.4
5-Oct	6.8	2.9	6.2	6.2	No data	No data
12-Oct	6.6	2.7	6.5	6.5	10.8	10.8

Fish species

Philips Reservoir was treated with rotenone on October 7, 1997, and restocked in April, 1978 with 150,000 hatchery rainbow trout and an undetermined number of largemouth bass, crappie and coho salmon (PBWC 2001). Yellow perch and walleye were subsequently illegally introduced in the 1980's, with yellow perch first documented by ODFW within the reservoir in 1991. In 1993, ODFW stocked smallmouth bass and black crappie, although both species were present in the reservoir since at least 1985. PBWC (2001) identified that ODFW annually stocked up to 100,000 hatchery rainbow trout as both fingerlings and adults. However, currently, 33,600 adult rainbow trout on average are stocked throughout the summer, and 24,600 six inch trout in September for an average annual stocking rate of 58,200 (T. Bailey, ODFW, Pers. Comm.). No fingerlings are currently stocked. All stocking occurs close to Mason Dam. The northern pikeminnow occurred in the Powder River prior to the construction of Mason Dam and still occurs in both the river and the reservoir.

Between 1985 and 1999, the densities of smallmouth bass and crappie declined by 82 and 96%, respectively. Conversely, the yellow perch population increased by 245% (Shrader 2000). Efforts to reduce the number of perch within the reservoir have been conducted annually between 2009 and 2011 (Bailey 2012). These efforts have focused on netting the perch when they are concentrated in their spring littoral spawning areas. Since spawning occurs right after

Comment [DG 17]: Please explain what size constitutes an adult in comparison to a 6 inch trout.

Comment [DG 18]: Please explain how the northern pikeminnow got there. Is there data or information that identifies pikeminnows present prior to construction?

Comment [DG 19]: To the extent known, please explain why bass and crappie declined and yellow perch increased.

"ice-off", the netting typically occurs during a 7 to 10 day period in mid-April. The most productive perch spawning areas have varied within the reservoir based on reservoir level, but have included the north side of the reservoir near the Union Creek campground, the south side of the reservoir, and the western edge of the reservoir where the Powder River enters. When the reservoir is at full pool level, the last site appears to be the most productive spawning area. This site is also the furthest from the Mason Dam intake.

The April perch netting resulted in a low of 51,574 perch in 2009 and a high of 354,468 perch in 2011. Yearly total differences reflect the timing of the netting and the reservoir level. ODFW estimates that there are currently 1,636,575 yellow perch in the reservoir (Bailey 2012).

Between 2009 and 2011, a total of 769,489 fishes comprising 8 fish species were caught during the April littoral netting. Of these fishes, 99.6% of the individuals were yellow perch. Approximately 0.1% each of the individuals netted were northern pikeminnow, suckers and rainbow trout. Other species netted together comprised 0.1% of the catch and included bull trout (2), smallmouth and largemouth bass, and black crappie.

Fish species currently known in Phillips Reservoir include hatchery and wild rainbow trout (redband), black crappie, smallmouth and largemouth bass, yellow perch, walleye, northern pikeminnow and various species of sucker (Baker County 2009). One thousand six hundred (1600) sterile tiger trout were introduced to the reservoir in 2011.

Comment [DG 20]: Please identify where the last site appears and whether it is where the Powder River enters the reservoir. This area would not seem preferable to yellow perch and other warm-water fish considering temperature during ice-off are relatively cold with elevated silt loads.

Comment [DG 21]: If this is an estimate, consider round if off to the nearest 1000.

Comment [DG 22]: Please explain what "littoral netting" is.

Comment [DG 23]: Please explain why sterile tiger trout were recently introduced. These fish, once they reach maturity, will play a large role in predator/prey balances and will inevitably change the behavior of piscivores especially bull trout.

Table 2. Fish Species Known to Occur in Philips Reservoir.			
Species		**Native?**	**Percent of April Littoral Netting**
Common Name	**Scientific Name**		
Yellow perch	*Percaflavescens*	No	99.6
Walleye	*Sander vitreus*	No	0
Smallmouth bass	*Micropterusdolomieui*	No	<0.01
Largemouth bass	*Micropterussalmoides*	No	<0.01
Black crappie	*Pomoxisnigromaculatus*	No	<0.01
Northern pikeminnow	*Ptychocheilusoregonensis*	Yes	0.1
Suckers (bridgelip, largescale)	*CatastomuscolumbianusCatostomu smacrocheilus*	Yes	0.1
Rainbow trout (redband and hatchery)	*Oncorhynchusmykiss spp.*	Mix of native and non-native	0.1
Bull trout	*Salvelinusconfluentus*	Yes	<0.0001
Tiger trout	*Salmotrutta X Salvelinusfontinalis*	No	0

3.0 Methods

A literature review was undertaken to identify key factors important to fish entrainment and mortality with a focus on studies undertaken since 1995. The literature review summary can be found in Appendix A. Based on the key factors identified in the literature review, a subset of studies were analyzed to provide an updated estimate of overall potential entrainment, entrainment by species and baseline mortality rates. The reservoirs selected met the following characteristics:

- Located within the Pacific Northwest region.
- Dam height greater than 25 meters and with a deep intake.
- Reservoirs operated primarily for flood control/irrigation, as much as possible, or if operated for a different purpose then containing data on salmonid entrainment.

Comment [DG 24]: Please reference what "deep" means, i.e., greater than 40'?

Based on these criteria, 11 reservoirs were selected for analysis and comparison to Mason Dam. These reservoirs and their characteristics are listed in Table 3. Not all reservoirs had data for both mortality and entrainment rates. Of the 11 reservoirs, five were used to estimate baseline mortality rates and 10 contained species-specific data on entrainment. Only three of the reservoirs had data on full annual fish entrainment estimates. Only one reservoir, Fall Creek Reservoir, had data on all three items of interest for deep water intake-Pacific Northwest reservoirs: annual entrainment, entrainment by species and mortality rates. Data summaries developed for the Henry Jackson (Spada Lake) and Wickiup relicensing projects were also used in portions of the analysis (CH2MHill 2007, Symbiotics 2009).

The older data set was not used further as it contained only shallow reservoirs that do not stratify and Ch2MHill (2003) showed that shallow, non-stratified reservoirs had substantially greater entrainment rates than deeper reservoirs.

Comment [DG 25]: Please clarify what "older data set" refers to. Is this from the Ch2MHill study?

In addition, scientific studies on fish species life history, behavior, and swimming speeds were reviewed for the species known to occur in Philips Reservoir. Tiger Trout ~~Newly introduced non-native species for which consultation with FWS is ongoing~~ were not addressed.

The mortality data for Mason Dam under the proposed project operation as described in GeoSense (2011) was used to identify how mortality rates might change under project operation for the species most likely to be entrained.

Table 3. General Characteristics of Regional Reservoirs with Deep Intakes, with Mason Dam Characteristics for Comparison.											
Reservoir Name	**Location**	**Size**		**Intake Characteristics**		**Flow Range (cfs)**	**Operation**	**Data Type Available**		
		Acres	**Acre-Feet**	**Depth (m)**	**Type**			**Total Entrainment**	**Species-Specific Entrainment**	**Baseline Percent Mortality**
Cougar	W OR	1,280	207,759	28	Slide Gate	440-1000	Irrig, FC	X		X
Fall Creek	W OR	1,820	115,100	49	Slide Gate	450-1000	FC, Recr	X	X	X
Trail Bridge	W OR	73	2,088	18	Slide Gate	to 2,000	FC	X	X	
Blue River	W OR	1,420	> 80,000	68	Slide Gate	300-2,400	FC, Recr			X
Wickiup	C OR	Unkn	200,000	24.7	Tube Valve	100-2,000	Irrig		X	X
Tieton	E OR	2,530	198,000	60	Tube Valve	300-2,190	Irrig		X	X
Beulah	E OR	Unkn	59,212	23	Jet Valve, Spillway	0-950,gen 300-400	Irrig		X	
Arrowrock	W ID	3,150	286,600	62	Clam Shell	54-3,000	Irrig, FC		X	
Timothy Lake	W OR	1,280	Unkn	24	Valve	0-300	Recr, FC		X	
Lake Lemolo	SW OR	415	Unkn	22	Unknown	436	Hydro		X	
Cooper Lake	AL	2,800	Unkn	9.7	Unknown	380	Hydro		X	
Philips Reservoir/ Mason Dam	E OR	2,234	95,500	30	Slide Gate	10-400	Irrig, FC			

4.0 Results

4.1 Entrainment

4.1.1 Estimated Annual Entrainment

Total annual entrainment has been measured at only a few regional reservoirs, with most studies primarily evaluating percent population entrainment or evaluating entrainment potential by species. Annual entrainment numbers were available for three reservoirs -- Cougar, Fall Creek and Trail Bridge, all located within Oregon and all containing gated outlets. All contain anadromous fish. Of these reservoirs, only Cougar is known to stratify, but it does not become anoxic near the intake.

Comment [DG 26]: Please clarify this conclusion as it seems to say stratification causes anoxic conditions, which may not be necessarily what was intended in this description.

Table 4. Estimated Annual Entrainment from Oregon Reservoirs with Deep Intakes, with Mason Dam Characteristics for Comparison.

Reservoir	Size		Intake Characteristics		Flow Range (cfs)	Entrainment (# fish)	
	Acres	Acre-Feet	Depth (m)	Approach Velocity (fps)		All fish	All non-anadromous fish
Cougar	1,280	207,759	28	Unknown	440-1000	78,737	Unknown, almost all fish entrained were Chinook salmon
Fall Creek	1,820	115,100	49	Unknown	450-1000	77,000-275,000	17,325-61,875
Trail Bridge	73	2,088	18	> 3.3	Up to 2,000	up to 22,040	694
Philips Reservoir/ Mason Dam	2,234	95,500	30	1.7	10-400	Unknown	Unknown

The majority of fish entrained at these reservoirs consisted of anadromous fish (from 77 to 96% of the fish entrained). Non-anadromous fish entrainment ranged from an estimated 694 to 61,875 fish per year. At Trail Bridge Reservoir, video monitoring identified entrainment rates as less than 1 fish per hour (even with approach velocities greater than 3.3 fps) between May and September, with higher rates during chinook salmon migratory periods.

Comment [DG 27]: There are too many comparisons here that are relative but not in comparison. For example, the description goes from % entrained to entrainment per year to entrainment per hour. Interesting info but hard to relate unless more info about each system is provided and how it relates to the project area.

The reservoir with the closest fit to the Mason Dam project is Cougar Reservoir as it is operated for both irrigation and flood control, has a similar intake depth, and is known to stratify, but the non-anadromous fish composition is unknown. As a result, the range of annual non-anadromous fish entrainment at Mason Dam was preliminarily estimated as similar to that of Fall Creek (17,325 to 61,875). However, Fall Creek Reservoir does not stratify and its discharges well exceed those of Mason Dam (i.e., Fall Creek Reservoir minimum discharges exceed Mason Dam maximum discharges). Annual entrainment at Mason Dam is likely to be much lower as a result of the seasonal water quality ~~barriers~~ limitations near the intake and the low approach

Comment [DG 28]: This statement would have more meaning if the importance of stratification to fish and lake systems was explained.

velocities. Much of the recent data collected on regional reservoirs has focused on species-specific entrainment and this general estimate was subsequently refined in light of the more detailed fish species information presented below in section 4.1.2.

Comment [DG 29]: Please reference similar studies to validate this statement.

4.1.2 Species-Specific Entrainment PotentialOverview

Introduction

The entrainment potential for individual fish species or group of related fish species was based on the likelihood that a fish would occur near the intake during the Mason Dam hydroelectric project operating period of mid-March to September 30. The following factors were used to evaluate the entrainment potential:

- Species spawning habitat type and location, and spawning timing.
- Seasonal movement patterns.
- General location within the water column.
- Water quality requirements-particularly Dissolved Oxygen (DO) and Temperature.

Comment [DG 30]: Please clarify this statement and whether it was intended to describe where fish are generally located in the reservoir. If so, please explain whether stratification of the lake changes these locations too.

Potential entrainment was evaluated according to the following categories:

None: There is no habitat requirement/tolerance or fish behavior that would place the species near the intake during the Mason Dam operating period.

Minimal: The species may inadvertently occur near the intake, but the intake is generally located outside of species habitat tolerances.

Comment [DG 31]: Please explain whether this statement refers to a fish's general life history needs or some arbitrary threshold for the types of habitats they will use?.

Low: The species may occasionally occur near the intake, but the intake is generally located outside of species habitat preferences, or the project would only occasionally be in operation during the time period that species could occur near the intake.

Moderate: Species may routinely or seasonally occur near the intake.

High: Species is very likely to occur near the intake during most of the project operating period.

In addition, entrainment potential was also evaluated according to the following question: "If a fish's behavior placed it in proximity to the intake, would it be able to swim out of the flow field which has a maximum allowable velocity of 2 feet/second (fps), but a more normal approach velocity of 1.7 fps or less?"

Comment [DG 32]: Please clarify whether this statement refers to the water velocity at the intake valve or something else.

Entrainment potential was evaluated for spawning, adult and juvenile life history stages.

4.1.3 Salmonids

Bull TroutLife History

Bull trout spawn in the late summer or fall, generally between mid-September to October. The eggs hatch during the winter, with fry emerging from the gravel in April or May. Juveniles exhibit a strong benthic orientation, hiding within cobbles, boulders, woody debris and other cover during the day and are more active at night. Juveniles feed mostly on macroinvertebrates, shifting to a piscivorous diet when they reach sizes of 100 to 200 mm (or 2 to 3 years old). Although juveniles can migrate to lakes at any age, it is unusual to find young less than 200 mm in lakes and reservoirs. The majority of adfluvial juveniles migrate to lakes when they are 2 or more years old (Pratt 1992, Goetz 1997, Flatter 2000).

Sexual maturity is not reached until at least four years of age, with an estimated longevity of 5 to 7 years, and up to 12 years (FWS 1998). Adults may spawn either every year or in alternate years. The bull trout can exhibit either migratory or resident life history strategies. Resident fish complete their life history cycle in the same stream in which they spawn. Migratory bull trout hatch and rear in tributary streams and then migrate to larger streams (fluvial form) or lakes (adfluvial form) to mature, returning to the smaller streams only to spawn. Both forms can co-occur and resident fish can produce migratory forms.

Comment [DG 33]: Please provide a study reference to support this statement.

Habitats used by migratory bull trout include bottoms of deep pools in streams and also large coldwater lakes and reservoirs. Within lakes and reservoirs, bull trout inhabit the cold, deeper sections and primarily occur within the upper hypolimnion (Goetz 1989, Fraley and Shepard 1989, McPhail and Baxter 1996, Flatter 2000, Petersen et al. 2002). Bull trout also forage in cool, shallow, littoral zones which tend to occur in the upper reservoir arms where tributaries enter the reservoir. However, bull trout location within a given lake or reservoir varies by season and type of lake.

There are a number of lakes/reservoirs in which bull trout have (1) been documented and (2) for which data on habitat preferences and seasonal movements exist. These include Beulah Reservoir (Gonzalez 1998, Schwabe et al. 1999, Schwabe et al. 2002, Petersen et al. 2002) and Lake Billy Chinook (Ratliff et al. 1996, Beauchamp and Van Tassel 2001) in Oregon, and Flathead Reservoir in Montana (Flatter 2000, Fraley and Shepard 1989). The two Oregon reservoirs differ in thermal regime. Beulah Reservoir temperatures rarely exceed 15 EC and DO levels generally remain above 6.5 ppm, without developing anoxic conditions. Lake Billy Chinook does thermally stratify with temperatures in the epilimnion reaching 15 to 21 EC during the summer. In both of these reservoirs, studies have shown that bull trout migrate out of the main body of the reservoirs during the spring into either upstream tributaries or the unstratified reservoir tributary arms (March to mid-May in Beulah and June to mid-July in Lake Billy Chinook). Migration back to the reservoirs, where the bull trout overwinter, occurs between late October and November.

At Flathead Lake, bull trout use all parts of the reservoir depending on the season, tending to use littoral zones in the spring and fall, deeper water in the winter and migrating out of the reservoir during the summer (Flatter 2000). The bull trout congregate at the upper end of the reservoir in the spring, moving into the tributaries by mid-June. They return between mid-September to mid-October to the upper portion of the reservoir, where they stay for several weeks before dispersing throughout the reservoir. Fraley and Shephard (1989) suggested that the seasonal movements out of the reservoir reflected a response to changes in temperature, photoperiod and discharge as the lake is oligotrophic, lacking strong stratification.

In meso and eutrophic lakes, such as Phillips Lake, oxygen levels tend to be depleted during the summer. In these types of lakes, bull trout migrate out of the lake in the spring when conditions in the hypolimnion become unsuitable, returning in the fall and using the water body primarily as overwintering habitat (see for example, Flatter 2000, Stoval 2001, Petersen et al. 2002 and 2003, McPhail and Baxter 1996). As for other reservoirs, it is highly likely that beginning in June (or earlier), any bull trout near the eastern end of Philips Lake would migrate to areas with more favorable temperature and DO regimes. A seasonal migration to more favorable habitats would likely occur when temperatures reach approximately 15 EC, consistent with the patterns observed within other lakes used as overwintering and foraging habitat, which is also when the water quality barrier in the vicinity of the Mason Dam intake develops. The documentation of two bull trout within the Philips Lake littoral zone in April 2011 is consistent with the seasonal patterns observed in other reservoirs.

Bull trout require among the coldest water temperatures of any native Pacific Northwest salmonid (FWS 2002, FWS 2010), requiring temperatures between 2 to 15 EC with thermal refugia where temperatures exceed the upper limit, and with different temperature ranges necessary in different life history stages (e.g., optimal temperatures of 5 to 9EC for spawning, 2 to 4 EC for incubation, and 7 to 8 EC for growth). Bull trout also require well oxygenated water. DO levels > 8 ppm are preferred, with short term tolerances of DO levels between 6 to 8 ppm. The species can not tolerate DO levels less than 6 ppm.

Adult bull trout (300 mm or greater) are able to swim at 15.08 fps, with burst velocities of 22.5 fps (Taylor and Lewis 2010). Juvenile bull trout (less than 200 mm) have a maximum swimming speed of 1.79 fps, similar to that of yellow perch.

Bull Trout Entrainment Potential

Bull trout entrainment data has been collected at Beulah and Trail Bridge Reservoirs in Oregon. Entrainment at Beulah was measured according to two different water release scenerios: through spillway releases and through a deep water intake. With spillway releases, the entrainment risk was greatest in winter and spring. When the water releases occurred solely through the intake, bull trout entrainment was reduced by 80% in 2001, and subsequently reduced to 0 in 2002. Regardless of the release type, Schwabe et al. (2002) identified that entrainment was minimal between mid-June and October. At Trail Bridge Reservoir, 0 bull trout out of an estimated 2,000 fish population were entrained during the monitoring period (Stillwater Sciences 2006).
As of spring 2012, there were no known adult bull trout in Philips Lake. Two subadults were found in 2011, but their status is unclear (i.e., entered reservoir during extremely high spring flows or resident). The analysis presented herein is for the population that currently occurs (2 subadults, > 200 mm) or any population that establishes in the future.

Comment [DG 34]: This statement would be stronger if the data that supports these types of characteristics for Philips Lake is cited to here.

Comment [DG 35]: Please describe what unsuitable conditions are being referred to here. Bull trout have many other factors that trigger spring movement. This seems to state that a condition at the bottom of the lake causes their movement? Without clarification, this statement is incorrect and should be better described to understand the meaning of what "unsuitable conditions" cause bull trout to move.

Comment [DG 36]: Seasonal movement in bull trout is primarily triggered by declining photoperiods, discharge influences, competition, predator/prey balances – all thereby enhanced by cold temperatures (Fraley and Shepard 1989; Rode 1990, Brenkman 1998). Please explain why bull trout would chose to move when temperatures reach 15 degrees C. Also please explain what water quality barriers or parameters you're referring to that affect bull trout life histories.

Comment [DG 37]: Please specify what patterns are being referred to, i.e., movement, foraging, thermal, etc..

Comment [DG 38]: Please reference the study or information used to support this statement.

Comment [DG 39]: Please explain whether 2,000 fish are the total fish population in the reservoir or otherwise what this number means.

Spawning: Bull trout spawn in cold tributaries which are located well away from and upstream of the intake. There is **no** potential for entrainment of spawning bull trout.

Adults: Although temperatures are suitable for adult bull trout at the intake elevation during much of the summer, they are not suitable in August and September. Conversely, DO concentrations are not suitable during the summer and begin to increase in September. The combination of low DO concentrations and high temperatures through the range of the dam intake elevations effectively creates a water quality barrier to adult bull trout movement around the intake and adjacent deep water areas between mid-June to mid-September (see figures 2 and 3). As for other reservoirs, it is highly likely that beginning in May to June (or earlier), any bull trout near the eastern end of Philips Lake (where the intake is located) would migrate to areas with more favorable temperature and DO regimes. A seasonal migration to more favorable habitats would likely occur when temperatures reach approximately 15 EC. The only time period in which the project would be both (1) in full operation in most years, and (2) in which the water quality would be suitable near the Mason Dam intake for adult bull trout would be between mid-April to May. If there are adult bull trout in the reservoir, they would overwinter at deep levels, such as near the intake. Movements between deep wintering habitat and more shallow lake levels during the spring could put adults in the vicinity of the intake between mid-March and mid-April when the project would operate 10 to 30% of the time.

Approach velocities between mid-March and May would be less than 1.7 fps, well under both maximum and sustained bull trout swimming speeds. Any fish entering the intake vicinity would easily be able to outswim the intake velocities. The potential for adult bull trout entrainment during project operation is **none to minimal.**

Juveniles: Temperature and DO conditions are more restrictive for juvenile bull trout. There would be no months during which the project would be in full operation each year and in which the water quality would be suitable near the Mason Dam intake for juvenile bull trout. The only time period during which both juvenile bull trout entrainment could occur and the Mason Dam project would be operational would be between mid-March and April, during which time, the project is anticipated to run approximately 10 to 30% of the years. If juvenile bull trout 200 mm or less entered the intake area, they may or may not be able to outswim the intake velocities. However, there is almost no likelihood of juveniles less than 200 mm even occurring within the reservoir, or if within the reservoir, outside of upstream littoral zones. Juvenile bull trout between 200 to 300 mm could occur outside of littoral zones. Fish this size could swim at faster speeds than the intake velocities

The overall risk of juvenile bull trout entrainment is **none to minimal.**

Rainbow TroutLife History

According to the ODFW, there are two rainbow trout subspecies in Philips Lake, the native redband trout and the stocked rainbow trout.

Comment [DG 40]: These conditions do not entirely create a barrier to any fish. If prey is available or escapement is preferable in the general vicinity of the intake, fish will use it. Adult fish tend to use shallow areas for food sources where temps and DO are naturally low. Please provide references here to support this document's conclusions.

Comment [DG 41]: The primary reason adult bull trout would migrate during these periods is for spawning and not to find areas of higher DO and lower temps. Please provide references here to support this conclusion.

Comment [DG 42]: Adult bull trout would more likely be found near the mouth of their natal streams staging for migration to spawning areas during this time of the year. What is typically found are subadultsmoving into adult niches in search of food and cover. This makes subadults and juveniles vulnerable to entrainment during springtime. Some subadults will stage and even make attempts to migrate but generally turn back as flows recede and the prey-base (generally outmigrants) settle in the shallows of the reservoir. Please explain in more detail the rationale for the "none-minimal" call made on entrainment potential base on the information provided in this comment.

Comment [DG 43]: This is why ODFW caught 2 subadults/juveniles last year during their spring surveys. Juveniles and/or outmigrants spend up to 3 years in a reservoir system until they reach spawning maturity. Fish are naturally curious and will venture to all areas of their reservoir home which makes them particularly vulnerable for entrainment. Please elaborate on the rationale for determining a "none to minimal" call for risk of juvenile entrainment.

Comment [DG 44]: Please explain or clarify what is meant by "littoral zones." Littoral Zone by definition is the shallows of a lake or large body of water or the edges of a waterbody system. This could be contradictory to earlier statements in the document where it says that low DO and higher temps are water barriers to fish, when a majority of their food sources are found in these areas.

Comment [DG 45]: Similar to what was stated in comment 43 and 44, juveniles are more at risk of entrainment. The determination should be reflected as "moderate" to illustrate these possibilities. Please provide additional information and cited literature to validate the current call of "none to minimal" .

Optimal lacustrine habitat for both subspecies is characterized by clear, cold, deep lakes. Both rainbow trout subspecies are primarily stream spawners and generally require tributary streams with gravel substrate in riffle areas for reproduction to occur (Raleigh et al. 1984). Redband trout spawn in the spring between April and May in tributaries to Philips Reservoir. Migration timing is affected by water temperature and stream flow. After spawning, resident redband trout maintain restricted home ranges until migrating to overwintering areas in the fall (Thurow 1990). Juveniles of migratory forms typically move downstream to lakes or rivers after one to three years in natal streams. At any one time, there could be both fluvial and adfluvial populations in Philips Reservoir as well as non-reproducing juveniles (ODFW 2009).

Comment [DG 46]: Please provide evidence to support this statement.

Optimal oxygen levels for rainbow trout in general are at least 7 ppm, with oxygen needs increasing as the temperatures increases (Raleigh et al. 1984). The lethal DO level is 3 ppm, but the species exhibits strong avoidance behavior of water with DO levels less than 5 ppm. The optimal temperatures for rainbow trout are between 12 to 18 EC, with adults residing in lakes selecting waters with temperatures between 7 to 18 EC and avoiding areas with temperatures greater than 18 E C .

The depth distribution of adult lake rainbow trout is generally a function of dissolved oxygen, temperature, and location of food sources. Some reservoir studies have noted a strong tendency for rainbow trout to follow the 18 EC isotherm, as long as DO remains at satisfactory levels. CH2MHill (2007) noted a tendency for rainbow trout within the Pacific Northwest to be surface oriented. Studies at the Carmen-Smith hydroelectric project in western Oregon also noted that rainbow trout were rarely found below the thermocline, even when conditions in the hypolimnion were favorable (Stillwater Sciences 2006). The same study showed that young trout remained in shallow water with abundant vegetative cover and observed no trout more than 10 meters (33 feet) below the surface during spring and summer.

Rainbow trout swimming speeds have been identified as being similar to those of bull trout (Mesa et al. 2004), but studies in the eastern US have identified lower average swimming speeds of 4.3 fps (NY Power Authority 2005) and CH2MHill (2007) estimated maximum rainbow trout swimming speeds at 5 fps.

Rainbow TroutEntrainment Potential

CH2MHill (2007) reviewed 12 studies in the Pacific Northwest and northern California in which trout entrainment was measured. All of the study reservoirs contained cold and coolwater fisheries and had deep water intakes. No trout were entrained at 9 of the 12 reservoirs. Trout entrainment rates were estimated at two Oregon reservoirs as less than 0.001% of the population (1 trout out of an estimated 100,000 at Timothy Lake on the upper Clackamas River, Oregon) and 2.6% of the population (at Lake Lemolo on the North Umpqua River, Oregon). At Lake Lemolo, almost all of the trout were juvenile brown trout (less than 100 mm) entrained in the fall as the reservoir was drawn down to its lowest level, which was 12% of its full pool volume. Lake Lemolo is also operated specifically for hydropower production, which is different than the other reservoirs examined in the study. At the Tieton project in eastern Washington, the total trout population is not known, but 60,000 rainbow trout are stocked annually. Entrainment studies

Comment [DG 47]: Please provide what the total population at Lemolo is.

identified 37 total rainbow trout, of which 28 were suspected to have been resident in the tailwater below the dam and not entrained fish. Regardless, less than 0.1% of the known rainbow trout population was entrained at this facility. During their review of regional studies, CH2MHill (2007) identified minimal risk to rainbow trout being entrained if approach velocities are 3.5 fps or less as long as the trout are greater than 6 inches.

Entrainment studies at Trail Bridge Reservoir identified that 0.01% of the estimated reservoir rainbow trout population was entrained.

Spawning: Rainbow trout spawn in the Philips Reservoir tributaries which are located well away from and upstream of the intake. There is **no** potential for entrainment of spawning rainbow trout.

Adults: Although redband and other rainbow trout are adapted to a wider range of environmental conditions than other salmonids, they still exhibit seasonal movements and are restricted by very low oxygen conditions. The temperature and DO conditions at the Mason Dam intake are not tolerable by adults between the end of June and the end of August. Conditions would fall within adult rainbow trout tolerances in May to early June and within the preferred range in September. The most likely time for adult rainbow trout to occur within the intake vicinity during project operation would be in September. If adult rainbow trout encountered the intake, they would be easily able to outswim the maximum 1.7 fps approach velocities. Other regional studies of adult trout entrainment with deep intakes show that it is highly unlikely for entrainment to occur. Based on the regional trout studies, the water quality conditions at the Mason Dam intake and the strong rainbow trout swimming speeds, the adult rainbow trout entrainment potential is **none to minimal.**

Juveniles: Juvenile rainbow trout would also exhibit intake avoidance due to temperature and DO conditions and would not be expected to use the habitat in the intake vicinity. The tendency of redband trout to both (1) remain within tributaries before moving to reservoirs or (2) as subadults to remain within littoral or other shallow water areas would limit the potential for entrainment outside of the fall when the reservoir is at it lowest level. If occurring within the intake vicinity, juveniles may or may not be able to outswim the intake velocities. Because of the very low likelihood that native juveniles would occur in the intake vicinity during project operation, their overall entrainment potential is **minimal.**

Stocked Fish: Only subadult and adult rainbow trout are currently stocked in Philips Reservoir. The potential for these fishes to be entrained would depend on their condition during the September stocking period. Hatchery fish are released in September near the intake and would likely come into contact with the intake at a higher rate than resident or native species. If in good condition, the newly released fish would be able to outswim the intake velocities. However, if disoriented the newly released fish could be entrained. As a result, the overall potential for stocked fish to be entrained is rated as **low to moderate**. The entrainment potential would be highest in dry years in which the intake is relatively close to the low water surface.

Comment [DG 48]: Rainbow trout can tolerate higher temperatures and have been known to grow faster than those in constant colder regimes. See **Temperature influences on California rainbow trout physiologicalperformance.** C. A. Myrick_ and J. J. Cech, Jr., 2000. It would be better described to illustrate how higher temperatures could affect the use of the intake areas by trout. Please also indicate the level of temperatures expected at the intake and why and how this would differ from the rest of the reservoir temperatures.

Comment [DG 49]: Similar to the temperature comments in 48 (above) Dissolved Oxygen would make a better case for this call but is unsupported without other studies or references to justify and validate the determination. Please add references of studies or research that verifies the determination here.

Comment [DG 50]: Depending on the infrastructure of the intake system, it is possible that DO levels could be higher through the generation of water movement and transfer. Short-term use of higher temperature is not necessarily a barrier to trout. Please explain these ideas with more details on the relationship of possible fish uses in and around the intake system vs long and short term use of littoral areas particularly when subadults and adults are constantly moving throughout the reservoir in search of forage, prey, and other life history needs. With constant fish movement, there is always a potential of entrainment. As long as water is going over the dam or through an unscreened system, fish, including rainbow trout, have the potential for entrainment especially outmigrants, juveniles and subadults.

Comment [DG 51]: Emigration of juvenile trout from natal streams back to reservoir systems have been known to occur between April through May. Their presence and life history needs while in the reservoir will increase the chance of entrainment particularly when discharge from the reservoir peaks at the same time juvenile are entering the reservoir. Please include the rationale used to verify this determination or consider adjusting the call to a 'moderate' possibility given the information in this comment. Please use the following as references to assist with a revised determination: Russell F. Thurow[a], Danny C. Lee[a]&Bruce E. Rieman.1997.Distribution and Status of Seven Native Salmonids in the Interior Columbia River Basin and Portions of the Klamath River and GreatBasins **DOI.** ... [1]

Comment [DG 52]: Experience shows that stocked fish tend to stay in the general vicinity of their release point for at least 7-10 days if not lnoger. Hatchery fish endure a high level of stress, disorientation, gas saturation, and crowding from the time they are taken from the hatchery and loaded into trucks. Then, to add more stress and complications, when they are released, there is a short period of shock and awe they go through when their bodies have to adjust to their new environments. Here in eastern Oregon, it's generally poorer water quality conditions and the fact that they no longer have a human hand feeding them. ... [2]

4.1.4 Percids

Yellow Perch-Life History

Yellow perch often occur in meso and eutrotrophic lakes with adults preferring summer temperatures of 17.6 to 25 E C. Spawning typically occurs at temperatures from 6.7 to 12.2 E C. Yellow perch can successfully overwinter at temperatures from 4 to 6 EC , although growth tends to stop below 8 to 10 E C . They are active in the winter beneath ice or in deep water (Scott and Crossman 197, FWS 1983). Upper lethal temperatures are from 26 to 30 E C.

Optimal DO levels for yellow perch are 5 ppm or greater, but the species is adaptable to a wider range of conditions (DO levels of 2 to 4 ppm, even as low as 1 ppm in some cases), and cooler temperatures. The ability to tolerate very low DO levels allows the species to inhabit deeper water of stratified reservoirs which are often very low in oxygen.

Yellow perch are slow swimmers with maximum speeds of 1.77 fps and average speeds closer to 0.88 fps. They do not accelerate quickly. As a result, yellow perch tend to travel in large schools of 50 to 200 fish which provides protection for younger fish and easier prey capture for older fish (Herman et al. 1959, Craig 1987). Young of the year perch tend to school more than older fish, which occasionally travel alone (Helfman 1979).

Perch exhibit strong diurnal behavior. They are active and feed during the day in open water or shoreline habitat. At night they appear to rest on the bottom and refrain from feeding. The exception occurs during spawning, as the perch become active both day and night.

Generally, yellow perch follow a seasonal migratory pattern that brings them in to littoral zones in the spring, to mid reservoir levels as temperatures rise in the summer, and into very deep water during the winter. They are typically found in water around 30 to 40 feet deep (9 to 12 m), but may seek deeper water in the winter.

Spawning in Philips Reservoir occurs immediately after ice-out, which generally occurs in mid-April. Littoral habitats found in shallow embayments are used for spawning. The embayments most commonly used for spawning are located a minimum of 1,700 feet from the dam intake (measured from data presented in Bailey [2012]).

Although tolerant of the temperatures and DO levels near the Mason Dam intake during most of the year, yellow perch seasonal behavior and depth preferences would place them near the intake most often between mid-July and September. In October when the pool is drawn down to 30 to 40 feet, they would be seeking the deepest water possible, which may or may not be near the intake.

Yellow perch typically inhabit lakes, ponds and reservoirs, but they can occur in river systems. In rivers, they occur in habitats similar to their typical lacustrine habitat, such as low velocity deep pools, backwaters and side channels. Rapidly flowing water does not provide suitable habitat for the species and young perch can not tolerate flows greater than 0.08 fps.

Yellow Perch-Entrainment Potential

Spawning: Spawning occurs in shallow embayments and the nearest known spawning habitat is 1,700 feet from the Mason Dam intake. There is **no** potential for entrainment of spawning yellow perch.

Comment [DG 53]: Please provide references in support of the conclusion that verifies spawning locations of yellow perch in the reservoir.

I don't know of any but would seem to think Tim might have creel surveys that may give better information and relevance to this statement. From my recreational and work related investigations I've done at the lake there seems to be more spawning habitats that are conducive to perch on the south and north side of the reservoir that are within 500 feet of the dam. The likelihood of entrainment would be more palatable at minimal to moderate primarily because of their movements in early spring when they are searching for suitable spawning habitats. Please describe your rationale that indicates no other spawning areas for this species are found or available within 1700 feet of the dam and the site indicated in this statement.

Adults and Juveniles: The temperature and dissolved oxygen conditions would be suitable for yellow perch at the intake most of the time the Mason Dam project would be in operation. Both the daily and seasonal perch migration patterns could place the perch in the intake proximity. The species' seasonal behavior and depth preferences would place them near the intake most often between mid-July and the end of September. In October when the pool is drawn down to 30-40 feet, they would be seeking the deepest water possible, which may or may not be near the intake. Because the Mason Dam hydroelectric project would not be operational in the fall or early winter, yellow perch behavior during these seasons was not considered in the entrainment potential analysis

Yellow perch are slow swimmers with average or sustained speeds much less than the approach velocity and maximum speeds roughly equal to the intake velocities. Any yellow perch, adult or juvenile, that approached the intake too closely would likely be entrained. The tendency for yellow perch to travel in large schools could result in episodic entrainment events. Large numbers of dead yellow perch immediately below Mason Dam have been observed from mid-August to mid-October, underscoring the high potential for yellow perch entrainment from late summer into fall (Jeff Colton, BVID, PersComm; Leslie Gecy, observations made during other Mason Dam project biological studies).

The potential for both adult and juvenile yellow perch entrainment during project operation is **high.**

Walleye-Life History

Walleye are a highly piscivorous, cool, deepwater species whose native range is centered in the Great Lakes region (Scott and Crossman 1973). The species eyes' are highly sensitive to light which tends to result in a diurnal pattern of spending daylight hours in deep water and shallower waters in the evening or at other times when light is low, such as under thick ice or in other areas with underwater cover. Although described as an opportunistic feeder, the walleye's diurnal behavior of moving to different water depths at dawn and dusk tends to place them in frequent contact with yellow perch. As a result, where yellow perch and walleye coexist, yellow perch tend to be the walleye's primary prey. On a seasonal basis, walleye tend to follow a similar pattern as yellow perch as they move to shallow waters in the spring and to deeper reservoir areas in August and September. Lacustrine spawning habitat consists of shallow (1 to 6 ft deep) rocky shores or other areas with rip-rap or rubble, inlet streams or flooded marshes.

Preferred adult temperatures are from 20 to 24 EC , with greatest activity between 15 to 18 E C , and adult growth stopping below 12 E C . Spawning tend to occur between temperatures of 6 to 11 E C and temperatures of less than 10 E C are required for gonad mauration. Upper lethal temperatures are from 29 to 32 EC (Kerr et al. 1997). Walleye prefer temperatures at or near the thermocline in stratified lakes, even if less than optimal dissolved oxygen levels (Fitz and Holbrook 1978).

Adult walleye can tolerate DO levels as low as 3 ppm for a short period of time, but prefer DO levels greater than 5ppm. DO levels below 2 ppm tend to be lethal (Kerr et al. 1997).

Juvenile fish require slightly warmer water than adults and tend to seek shallow water habitat in the spring and early summer. As summer progresses, juveniles tend to move to deeper habitats similar to those of adults.

Walleye are vigorous swimmers, with burst speeds measured from 6.02 fps for juveniles and up to 8.57 to 11.2 fps for adults (NAI 2009).

Walleye-Entrainment Potential

Spawning: Spawning occurs in shallow water near rubble or rocky shores, flooded marshes or tributary inlets. The nearest tributary inlet or flooded marsh is located more than 2,000 feet from the dam intake. The nearest shallow, rocky shore habitat during the spring spawning period is located more than 65 to 100 feet from the Mason Dam intake. There is no potential for entrainment of walleye spawning in flooded marshes or lake tributary inlets. There is no potential for entrainment of walleye spawning on rocky shores, as the intake is located away from the nearest potential habitat, but there is some potential for walleye to travel near the intake while moving between deepwater and shallower spawning habitats. Overall there is a **minimal** risk of spawning walleye entrainment.

Adults: The adult walleye diurnal and seasonal patterns of moving between deeper and shallow water mimic (in reverse) those of the yellow perch, its primary prey species. However, yellow perch can tolerate lower DO conditions than walleye. The walleye's general behavior could place it near the Mason Dam intake during most, but not all, of the time the project would be in operation. However, water quality conditions would limit the likelihood of the walleye being near the intake during the project operation to late summer and September.

If an adult walleye approached the intake during this time period, it would not likely be entrained as it is a vigorous swimmer well able to outswim the intake velocities. Even at less than optimal conditions, walleye's could easily escape the intake approach velocities. The exception could occur if walleye follow their yellow perch into very low oxygen areas, where their swimming ability would be severely comprised.

The potential for adult walleye entrainment during project operation is**minimal**

Juveniles: Because juvenile fish require warmer water than adults, their behavior would limit their likelihood of being near the intake during project operation to late August and September when the intake is oxygenated. As for adults, juveniles are vigorous swimmers with both maximum and sustained speeds greater than intake velocities.

The potential for juvenile walleye entrainment during project operation is**minimal**.

4.1.5 Centrarcids

Bass and Crappie-Life History
Bass and crappie tend to occupy littoral habitats. Optimal conditions for largemouth bass are lakes with extensive areas of shallow water (i.e., less than 6 m) to support submerged aquatic vegetation, but deep enough to allow overwintering (Scott and Crossman 1973).

Largemouth bass spawn during the spring in shallow, littoral habitats and remain to guard the young once hatched. Fry remain in shallow, protected habitats such as coves and flooded tributary mouths as the adults return to other shallow lacustrine habitats with abundant vegetation.

Smallmouth bass were originally limited in range to eastern central North America, but have been widely stocked elsewhere (Scott and Crossman 1998). Unlike the warm, weedy lakes and slow moving rivers preferred by the largemouth bass, cooler lakes, streams, and rivers are preferred by smallmouth bass. Lakes that hold populations of smallmouth bass are generally over 100 acres in size, over 30 feet deep and thermally stratified, and have clear water and large areas with rock or gravel substrate (Scott and Crossman 1998).

Smallmouth bass also move toward shore in early spring, but select sites with a clean stone, rock, or gravel substrate for spawning. As for largemouth bass, the smallmouth guard their young after hatching and the young remain in shallow protected areas after the adults leave. During winter, the adults tend to move to deeper water (Langhurst and Schoenike 1990). Smallmouth bass are found almost exclusively in the epilimnion during summer stratification in northeastern Wisconsin and Ontario, but frequent depths up to 12 m in northern New York (NAI 2009).

Lacustrine black crappie habitat can be characterized as the littoral zone of large warmwater reservoirs and lakes, usually with some type of in-water cover such as sunken logs (Scott and Crossman 1973). Spawning occurs primarily in April, typically in coves and shallow embayments, near but just beyond the edge of submerged vegetation (approximately 2 to 5 m deep, ODFW 2012). Although this species does not do well in the main body of large lakes, it can become abundant in shallow areas and bays (Scott and Crossman 1973). Crappie feed on the surface during dawn and dusk. During the winter, crappies often move to deeper water along vertical structure such as pilings or dams (NAI 2009).

In general, optimal temperatures for growth of adult bass range from 24 to 30° C, with very little growth below 15° C. However temperature tolerances differ among species. Lakes and rivers that are clear enough and rocky enough to be suitable for trout, but in which the water temperature is too high for trout, are generally suitable for smallmouth bass. Preferred smallmouth bass temperatures are between 16 EC and 26 E C , although nest building and spawning can occur at lower temperatures. Largemouth bass are considered warmwater species, preferring temperatures between 27 to 30 EC . However, the largemouth bass is intolerant of low dissolved oxygen concentrations and is therefore susceptible to winterkill in its vegetated, high oxygen demand habitat

Optimal temperatures for black crappie are between 22 to 25° C; with no growth below 11° C or above 30°C .

Smallmouth bass require more than 6 ppm DO for optimal growth and largemouth bass more than 8 ppm. Both species can tolerate DO levels as low as 4 ppm, but show distress at these levels. Levels below 2 ppm cause mortality. DO requirements for black crappie are assumed to be above 5 ppm, the general level for warmwater fish.In lacustrine environments, these three species tend to select temperature strata with suitable oxygen levels, although, as noted above, the largemouth bass preference for shallow, high temperature vegetated areas tends to result in late season or winterkill mortality.

Sustained swim speeds for small juvenile largemouth bass range from 1.01 to 1.64 fps within a temperature range of 15 to 30°C (NAI 2009). Swim speeds were higher for larger juveniles and small adults (1.80-2.17 fps). Maximum juvenile or “burst” speeds are estimated at 3.2 to 4.2 fps and higher for adults.

Smallmouth bass sustained swim speeds have been estimated as 1.8 fps for juveniles and 3.9 fps for adults. Maximum speeds of 3.6 to 7.8 fps for juvenile and adults, respectively have been estimated (NAI 2009).

Black crappie swim speeds have not been studied. However, studies of the related white crappie indicate that crappies are quite slow swimmers, with speeds from 0.5 to 0.75 fps at optimal temperatures, and reduced to 0.18 fps in cold water. Maximum speeds have been estimated at 1.0 to 1.5 fps. However, poor orientation to current has also been exhibited (NY Power Authority 2005, NAI 2009).

Swimming speeds of all of the above species is reduced in cold water.

Bass and Crappie-Entrainment Potential
Most regional entrainment studies are focused on salmonids. Entrainment studies over a 2-year period at Fall Creek Reservoir (Downey and Smith 1992) identified that although anadromous salmonids comprised 77.5% of the total fish moving through the reservoir outlet, that black crappie comprised another 21.9% of the entrained fish. Crappie entrainment occurred almost entirely during November and December.

Spawning: All species spawn in shallow water. Largemouth bass tend to spawn in shallow, vegetated or other littoral habitat, which is located more than 1,700 feet from the intake. Black crappie spawn in shallow water (2-5 m deep), which occurs well away from the Mason Dam intake. There is **no** potential for entrainment of spawning largemouth bass or black crappie.

Smallmouth bass spawn along shallow or rocky shorelines. The nearest potential habitat is located 65 to 100 feet north and east, respectively from the Mason Dam intake. Although the intake is relatively close to potential spawning habitat , smallmouth bass would not be spawning at the depth of the Mason Dam intake. There is **minimal** potential for entrainment of spawning smallmouth bass.

Adult: Both adult largemouth bass and black crappie prefer shallow, warm water habitats and not deep, cool open water areas. Largemouth bass, in particular are strongly oriented towards shallow, vegetated habitats limiting any exposure to a deep intake. There is **no** potential for entrainment of adult largemouth bass.

Although generally preferring shallow water, crappie may move to deeper water during the winter. It is possible that during late fall movements they could occur near the intake, as has been observed at the Fall Creek Reservoir. The Mason Dam hydroelectric project would not be operational during this time period. If crappie did occur near the intake, they would likely be entrained, as they are poor swimmers. However, the potential for black crappie to be entrained during project operation would be restricted to late September. As a result, the overall potential for black crappie during project operation would be **minimal to low**, with the greatest likelihood of entrainment occurring during the fall after the project has ceased operation.

Smallmouth bass are cool water species with strong preferences for well-oxygenated water. Although smallmouth bass may overwinter in deep water, the Mason Dam hydroelectric project would not be operational during this time period. DO levels are suitable for smallmouth bass near the intake during the spring, but temperatures are too cold. As described for the salmonids, as temperatures warm near the intake, DO levels drop. This combination results in unsuitable smallmouth bass conditions during most of the project operational period. Smallmouth bass could occur near the intake during September. Because adult smallmouth bass are vigorous swimmers, they would not likely be entrained. The overall risk of adult smallmouth bass entrainment is **minimal**.

Juveniles: Both juvenile largemouth bass and black crappie reside in shallow water. There is **no** potential for entrainment of juvenile largemouth bass or black crappie.

Juvenile smallmouth bass would be vulnerable to entrainment if they occurred within the intake vicinity, but their preference for shallow littoral areas and protected coves limits their exposure to a deep intake. Larger juveniles could move from littoral habitats during the late season and occur within the intake vicinity during September. However, by this time, the larger juveniles would be able to escape the intake approach velocities. The overall risk of juvenile smallmouth bass entrainment is **none** for small juveniles and **minimal** for larger juveniles.

Comment [DG 54]: Please provide references that support this conclusion. It is not clear how entrainment would be higher in the fall when flows and reservoir levels drop. Please provide information that explains why fall periods would have the greatest likelihood of entrainment.

Comment [DG 55]: Smallmouth bass are some of the most tolerant and adaptable warmwater fish species. Because of this, lower DO levels and warmwater temperatures would not be entirely unsuitable to them. Smallmouth bass can spawn in most gravel substrates in depth of 2-20 feet which can also vary in temperature and DO. Males guard the nest for a short time after the fry emerge but leave the nest area in search of prey which makes them more susceptible to entrainment between mid-June and so on. Therefore this conclusion should be changed to show that the overall risk will be at least "minimal." Please provide rationale and references should the determination remains as is.

Comment [DG 56]: Depending on the suction of the intake valve and drawdown effect, fish are susceptible to getting caught in the suction vortex and be entrained regardless of how their swimming ability. Therefore it is recommended this conclusion be changed to show the overall risk as "moderate".Please provide rationale and references should the determination remains as is.

Comment [DG 57]: This finding does not mean they stay in these areas for any length of time. Warmwater fish rely on structure, their spiny rays, and size for protection and defense. Shallow water makes them susceptible to avian and mammal predation which causes them to move around in search of prey, cover, and optimum habitats. The dynamics of a reservoir is ever changing with the rise and fall of storage release which means fish are also required to move and relocate as conditions become unfavorable or resources are depleted. Constant movement of fish for these reasons makes the possibility of entrainment in any life stage possible. It is suggest that language for this determination be revised to a "minimal to moderate" level based on the information provided in this comment. Please provide rationale and references should the determination remains as is.

4.1.6 Cyprinids

Northern Pikeminnow-Life History

The northern pikeminnow is a native fish that prefers lakes and slow-moving water. The species feeds on aquatic invertebrates as juveniles (up to 300 mm), with crayfish and small fish increasing in importance as the fish grows larger (Gadomski et al. 2001). Adults continue to feed on crawfish, molluscs, and other macroinvertbrates as well as fish. Preferred species include salmonids, sculpins and suckers. Although the pikeminnow has been identified as an important salmonid predator, a number of studies have identified crayfish as a key prey item (Zorich 2004).

Northern pikeminnow spawn in the spring when temperatures reach 12 to 18 EC . Once spawning occurs, the adults leave the spawning area without parental care. Spawning habitat includes gravelly areas at tributary inlets, and clean rocky substrate along lakeshores in both shallow and deep littoral areas. Spawning typically occurs in slow-moving water.

Seasonally, the pikeminnow tends to move towards the shoreline areas in the spring and into deeper water later in the season (Martinelli and Shively 1997). Within rivers, they are frequently associated with riprap, rocky outcrops or structures (Zorich 2004).

Northern pikeminnow can tolerate a wide range of temperatures. No specific tolerances were located in the literature, but as a coolwater species, the temperature tolerances were assumed to be similar to that of the smallmouth bass.

The pikeminnow is not a strong swimmer with sustained speeds of 0.74 fps and maximum speeds of 1.6 to 2.7 fps (Mesa and Olsen 1993, Zorich 2004).

Northern Pikeminnow-Entrainment Potential

Spawning: Spawning habitats can include both shallow, gravelly areas in embayments and near tributaries, as well as rocky lakeshores. The nearest embayment/tributary habitat is located 1700 feet west or southwest of the intake. There is no potential for nothern pikeminnow entrainment during spawning in these habitats. The intake is located 65 to 100 feet from a rocky shore that could possibly used for spawning. There is some potential for the pikeminnow to travel near the intake while moving between deepwater and shallower spawning habitats. Overall there is a **minimal** risk of spawning northern pikeminnow entrainment.

Comment [DG 58]: Please provide a map that depicts the location of this embayment. As suggested, there appears to be more cove type habitats and shoreline recesses suitable for pikeminnow spawning and rearing. As suggested in comment 53, Please describe your rationale that indicates no other spawning areas for this species are found or available within 1700 feet of the dam and the site indicated in this statement.

Adult: The combination of seasonal movements from shallow to deep water and the northen53pikeminnow temperature preferences could place fish within portions of the intake vicinity between mid-August and September. The pikeminnow are relatively slow swimmers, and if they occur within the intake vicinity, would likely be entrained. Entrainment might also be high following the September rainbow trout stocking, which occurs near the dam. There is a**moderate potential**of adult northern pikeminnow entrainment during the late summer and early fall.

Juveniles: Juvenile pikeminnow tend to remain in shallow water areas where aquatic invertebrates and small fish are readily available. As the reservoir draws down in September and suitable temperature and DO conditions occur near the intake, juveniles could occur in the intake vicinity. If juveniles occur near the intake they would likely be entrained. Because the overall likelihood of juveniles being near the intake during project operation is low and restricted to the fall, the overall risk of juvenile northern pikeminnow entrainment during project operation is**minimal tolow**.

4.1.7 Catastomids

Suckers-Life History
Suckers are very abundant throughout the Columbia River drainage (Scott and Crossman 1973). Because of their abundance, they have not been as extensively studied as rarer species, introduced species or predaceous fish (Schmetterling and McFee 2006). Their habitat generally occurs within slow-moving portions of rivers and in lakes. Largescale sucker fry feed on zooplankton, but juveniles and adults feed on benthic invertebrates, diatoms, filamentous algae and other plant material. Little is known about seasonal or daily sucker movements in lakes and reservoirs, but adults seem to be relatively sedentary benthic feeders outside of the spawning period. During the summer, adults have been caught both above and below the thermocline in stratified reservoirs.

Largescale suckers use a wide range of substrates and water depths for spawning and are not generally considered spawning-habitat limited. However, some studies have indicated a preference for sandy or gravelly lake shoals in the Columbia River system (Dauble 1986, Baxter 2002).

The bridgelip sucker occurs in lakes and river backwaters with sandy or muddy substrates. Spawning occurs in the spring shortly after ice-out. Their diet consists of aquatic insects, crustaceans and algae that is scraped off of bottom rocks.

Suckers in general prefer DO levels greater than 3 ppm and can not tolerate DO levels less than 2.4 ppm. There is little documentation on temperature preferences.

Sustained swimming speeds for various species of sucker have been measured at 1.4 to 4.9 fps, with maximum speeds from 4.0 to 7.9 fps (Baxter 2002).

Suckers-Entrainment Potential

Most regional entrainment studies have focused on salmonids. Entrainment studies over a 2-year period at Fall Creek Reservoir (Downey and Smith 1992) identified that anadromous salmonids and black crappie comprised 99.4% of the total fish moving through the reservoir outlet, with other fishes (including suckers) cumulatively totaling less than 1% of the annual entrainment. At the Blue River Reservoir, juvenile suckers comprised 4% and adult suckers 0.5% of the measured entrainment (Downey and Smith 1989). Most of the sucker entrainment occurred between October and December, a time period during which the Mason Dam hydroelectric project would not be operating.

Spawning: Reservoir sucker habitat can be varied but given the depth of the Mason Dam intake during the spring (more than 20 m below the surface), it is not likely that spawning would occur within the vicinity. The nearest likely spawning habitat is located more than 1,000 feet from the intake. The potential for entrainment of spawning suckers is **none to minimal.**

Adult: As benthic feeders, adult suckers could occur within the intake vicinity during much of the time the project is in operation. The exception would be between July and August when the bottom near the intake is anoxic. The sucker feeding behavior could place them in close proximity to the intake in other months. Suckers are relatively strong swimmers and can outswim the approach velocities if aware of the intake. However, because sucker behavior would place them within the intake vicinity most of the time, the overall entrainment potential is rated as **Low to Moderate**.

Juveniles: Juveniles are also benthic feeders that could occur within the Mason Dam intake vicinity during much of the project operation. Details regarding juvenile bridgelip and largescalesuckers movements within reservoirs are sparse. Because of the uncertainty or reservoir movements, the known benthic orientation, and the lower swimming abilities than adults, the overall entrainment potential for juvenile sucker entrainment is rated as **Moderate .**

4.1.8 Entrainment Summary

The fish species most susceptible to entrainment during both the proposed Mason Dam hydroelectric project 4 to 6 month operating period and the 6 to 8 month non-operating period is the yellow perch. Yellow perch behavior and low oxygen tolerance place them frequently within the intake vicinity and their low swimming speeds would likely result in entrainment if they were near the intake. There are an estimated 1,636,575 yellow perch in Philips Reservoir, with a high potential for entrainment, particularly during late summer and fall. Studies in reservoirs with high perch populations have indicated that from 1 to 3 % of the total perch population is entrained annually (see for example, summaries in Kleinschmidt [2011]). Because these studies were conducted in non-stratified, warmwater reservoirs, it is highly likely that the percent of the population entrained at Mason Dam would fall at the lower end of the range (or 1%). This would equate to a existing annual average entrainment rate of 16,000 yellow perch through Mason Dam.

Other species susceptible to entrainment during both the project operational and non-operational periods include the native northern pikeminnow, suckers and black crappie. Although vigorous swimmers, walleye could occasionally be entrained while following their prey into less than optimal dissolved oxygen conditions. Adult suckers are also relatively strong swimmers, but their behavior would place them within the intake vicinity most of the time, potentially resulting in some inadvertent entrainment. Juvenile suckers would have a higher likelihood of being entrained. Black crappie are poor swimmers and any movement within the intake vicinity would likely result in entrainment. Entrainment rates would be highest during the late summer and fall and during dry years.

Bull trout entrainment during the proposed project operating period is highly unlikely due to the bull trout's inability to tolerate the water quality conditions near the intake during most of the project operational period and its very strong swimming ability that would allow it to escape the relatively low intake approach velocities at other times. Likewise, the potential for rainbow trout entrainment would generally be minimal.

Comment [DG 59]: Unless there are supporting studies or literature showing water quality, temperatures and swimming abilities are solid reasons for low entrainment potential, this sentence should be modified to state that bull trout entrainment is minimal to moderate. Because bull trout are pisciverous, they are constantly on the move and will go where the food is even if temperatures exceed their upper limits. As mentioned, depending on the drawdown velocities of the intake valve and vortex conditions, entrainment is possible regardless of swimming ability.

Based on a study by CH2MHill (2007) of 12 other regional reservoirs that both support trout and contain a deep intake, the potential for rainbow trout entrainment would be from 0 to 2.6% of the population on an annual basis. The 2.6% entrainment rate was developed from a reservoir operated strictly for hydropower production and in which the reservoir is routinely drawn down to 12% of its total volume, an operation that only occasionally occurs at Mason Dam. Using the results from the other 11 studies, the range of regional trout entrainment is from 0 to 0.1% of the total population. With an estimated population of 60,000 to 100,000 rainbow trout (the annual stocking rate of 58,200 fish plus an unknown number of additional residents), this would equate to an average of 0 to 100 rainbow trout being entrained over the course of a year, with the majority likely being stocked fish. The exception would be in dry years in which up to 1,500 to 2,500 additional rainbow trout might be entrained, mostly stocked fish and juveniles.

The entrainment potential for other species during the proposed project operating period (smallmouth bass, largemouth bass) is nonexistent or very low. These species tend to be entrained in high numbers within reservoirs with shallow intakes located within littoral zones. Entrainment through a deep intake within a stratified reservoir, such as occurs at Mason Dam, is very unlikely, except in very dry years in which the reservoir is drawn down to a small pool volume.

The preliminary estimate of fish entrainment through Mason Dam was identified as falling within a range of 17,325 to 61,875 fish per year, with these estimates being on the high end as they do not account for the strong summer stratification and low approach velocity (see section 4.1.1). Using species-specific entrainment data and known Philips Reservoir population data (where available), the following fish species would be anticipated to be entrained on an annual basis. An annual basis was identified for those species that would be susceptible to entrainment both during project operation and outside the project operating period, as the existing data does not allow for accurate monthly entrainment estimates.

- 16,000 yellow perch
- 0 to 100 rainbow trout
- Unknown number of black crappie. The population number is unknown but Shrader (2000) identified that the population was in serious decline. With the known very reduced densities, the total number of entrained black crappie would likely be quite low.
- Unknown number of other species, but based on other studies identifying the remaining species as typically comprising 1% or less of total entrainment, from 100 to 200

additional suckers, northern pikeminnow and occasional individuals of other species would likely pass through the outlets.

The following species would not likely be entrained during the proposed project operating period: bull trout, smallmouth bass and largemouth bass. Neither late fall/winter nor annual entrainment estimates were derived for these species.

This would account for a total revised annual entrainment estimate of slightly less than 17,325 fish[1] or the low end of the estimate based on the Fall Creek reservoir data. During very dry years, entrainment could increase by up to 1% of the perch population and by to 2,500 additional fish (rainbow trout and black crappie) as the reservoir volume is drawn down very low, for an upper revised annual estimate of 34,700 fish during very dry years.

As total annual entrainment estimates, these number represent fish entrained both during the time the project is operational (from 33 up to 50% of the year, see Figure 1 in Section 2.0) and when the project is not running (from 50 to 67% of the year). The highest levels of entrainment are expected to occur during the late summer and fall and the project would only be operating within a portion of that time.

Comment [DG 60]: Please provide references that support this conclusion.

[1]Excepting bull trout, smallmouth bass and largemouth bass which are not likely to be entrained during the Mason Dam hydroelectric project operating period and for which late fall/winter entrainment estimates were not derived.

Table 4. Summary of General Habitat Requirements for Fish Species Known to Occur in Philips Reservoir.

Species	Water Quality Requirements				Swimming Speeds (ft/sec)		Reservoir Habitat Preferences
	Preferred		Tolerable		Max	Sustained	
	DO (ppm)	Temp (E C)	DO (ppm)	Temp (E C)			
Salmonids							
Rainbow trout subspecies	∃ 7	12-18	∃ 5	0-25	1.79 juv 4.3+ adult	4.3+ adult	Cool, oxygenated habitat, move within reservoirs based on temp, DO + food sources
Bull trout	> 8	2-15	6-8	0-22	1.79 juv 22.5 adult	15.1 adult	Cold, deep oxygenated water in winter, migrate to tributaries when lakes warm or stratify
Percids							
Yellow perch	∃ 5	17.6-25	<2	4-30	1.77	0.88	Move daily and seasonally between littoral or shoreline areas and deep water
Walleye	> 5	15-18	∃ 3	6-32	6.02-11.2	3.3-4.8	
Centrarchids							
Smallmouth bass	> 6	16-26	∃ 4	0-30	3.6-7.8	1.8 juv 3.9 adult	Rocky shorelines, move to deeper water in winter
Largemouth bass	> 6	27-30	∃ 4.5	? - 30	3.2-4.2	1-1.6 juv 1.8-2.2 adult	Shallow, vegetated habitats
Black crappie	> 5	22-25	∃ 4	? - 30	1-1.5	0.5-0.75	Shallow habitats, move to deeper water in winter
Cyprinids							
Northern pikeminnow	>5	16-26*	>3	0-30*	1.6-2.7	0.74	Seasonal movements between shoreline areas and deep water
Catastomids							
Suckers	>3		>2.4		4.0-7.9	1.3-4.9	Relatively sedentary benthic feeders

* estimated as similar to smallmouth bass, another “coolwater” species.

Table 5. Species Entrainment Potential during the Mason Dam Mid-March to Sept 30 Operating Period.		
Species	**Life Stage**	**Entrainment Potential**
Salmonids		
Bull trout	Spawning	None
	Adult	None to Minimal
	Juvenile	None to Minimal
Rainbow trout subspecies	Spawning	None
	Adult	None to Minimal
	Juvenile	Minimal
	Recently stocked fish	Low to Moderate
Percids		
Yellow perch	Spawning	None
	Adult	High
	Juvenile	High
Walleye	Spawning	Minimal to Low
	Adult	Minimal
	Juvenile	Minimal
Centrarcids		
Smallmouth bass	Spawning	Minimal
	Adult	Minimal
	Juvenile	None to Minimal
Largemouth bass	Spawning	None
	Adult	None
	Juvenile	None
Black crappie	Spawning	None
	Adult	Minimal to Low
	Juvenile	None

Table 5. Continued.		
Cyprinids		
Northern pikeminnow	Spawning	Minimal
	Adult	Moderate
	Juvenile	Minimal to Low
Catastomids		
Suckers	Spawning	None to Minimal
	Adult	Low to Moderate
	Juvenile	Moderate

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APPENDIX A: Entrainment and Mortality Background Summary

Numerous studies have been conducted at reservoirs and hydrolelectric facilities throughout the US and Canada. The results have shown variation in entrainment rates according to fish species composition, reservoir operation type and depth, and intake characteristics. However, some general trends have been observed and summarized in a number of reports (FERC 1995, EPRI 1997, Ch2MHill 2003, NY Power Authority 2005, CH2MHill 2007, NAI 2009, Symbiotics 2009, City of New York 2011):

Fish Species

- Entrainment is relatively low (less than 20 fish/hour) for most resident warmwater/coolwater fish communities. Residents tend to be entrained inadvertently in relation to their use of habitats near the intake. Episodic entrainment events have been noted for anadromous salmon and other obligate downstream migrants, as well as fish species that travel in large schools.

- Entrainment rates vary by species and are not necessarily related to the relative composition of a water body. Yellow perch, northern pike and smallmouth bass are species that are particularly susceptible to entrainment. Species less susceptible to entrainment include rainbow trout and some sucker species.

- Species entrainment rates vary both diurnally and seasonally according to species behavior.

- Young-of-year (YOY) and juvenile fish are more susceptible to entrainment than adult fish.

Reservoir Characteristics

- Entrainment rates are much higher for shallow reservoirs than deeper reservoirs, with up to twice as many fish entrained in reservoirs with dams less than 50 feet high (15 meters) than those greater than 50 feet.

- Reservoirs that are operated to be drawn down over the winter and allow for spring storage can increase winter entrainment rates as more fish are placed in closer proximity to the intake.

Intake Characteristics

- Intakes adjacent to shorelines tend to entrain more fish than those located away from the shoreline as many fish species tend to follow shorelines or orient to the physical structure associated with shorelines.

- The littoral zone is the most productive area within a reservoir and many species spawn and rear there. Intakes in littoral zones entrain more species than deeper intakes.

- Poor water quality near the intake can form a barrier and reduce fish susceptibility to entrainment. This is particularly true if there is low dissolved oxygen in the hypolimnion.

Fish swim speeds in relation to velocities at the intake can also affect entrainment potential. The ability to avoid entrainment depends on both the fish's swimming speed, and its ability to detect and respond quickly to a change in velocity. Detection can be comprised by darkness, turbidity or cold temperatures. If a fish does not respond to a velocity acceleration until it can only maintain position in the flow, it would find itself quite close to the intake and may not have enough time or strength to scape. Detection for strong swimming fish is generally only an issue for river intakes or where approach velocities are greater than or equal to 5 ft/sec. Swimming performance can be decreased by as much as 50% when temperatures fall outside a species' preferred range (Bell 1997). This latter item most often occurs as winter approaches and temperatures cool.

Of all the factors examined by studies of reservoirs with deep intakes, the intake depth and the water quality near the intake tend to be the most important factors affecting fish entrainment. This is because the DO, temperature and depth in relation to other habitat features affect the fishes' potential to occur in the intake vicinity. The reservoir size is not as important.

Once entrained, a separate set of factors affects whether or not the fish survives. Fish mortality from entrainment is generally related to two factors: (1) sudden differences in pressure from being entrained underwater to being suddenly ejected into atmospheric conditions, and (2) physical damage as a result of being thrown about at high velocities (Battelle Research Laboratory 1997). Also important is the type of intake. Valve outlets appear to cause more mortality to fish than gate-controlled flow regulators, perhaps because of increased shear stress around the valve cone. Mortality rates associated with spillways are variable, influenced by velocity and head height, but tend to be lower than those of regulating structures. Multi-intake tower mortality rates are also variable as they draw water from different depths of the reservoir.

Other factors influencing fish mortality during entrainment includes fish species and size, and reservoir operation (e.g., type of operation, hydraulic head, discharge, water velocity). General mortality trends include:

- Young fish are more likely to be entrained and survive than mature fish; conversely mature fish are less likely to be entrained but if they are, their survival rate is lower. According to EPRI (1997), more than 90% of the fish entrained at hydroelectric projects are less than 4-8 inches (approximately 100 to 200 mm), and their high survival rate tends to reduce the overall entrainment impact on fish populations.

- Mortality tends to be positively correlated with both discharge and reservoir head. The higher the discharge and the higher the hydraulic head, the greater mortality will be.

- Mortality rates via pressure change vary by species, with perch, crappie and bass more susceptible to mortality than salmonids and minnows. Survival of percids tends to be very low, 0 to 10%, with large differences in pressure.

- Mortality due to pressure changes is reduced as the reservoir lowers.

- Mortality is relatively low in spillways with water velocities less than 50 fps, but increases sharply at velocities greater than that, with 100% mortality observed at velocities more than 80 fps.

Page 15: [1] Comment [DG 51] **Gonzalez, Daniel -FS** **11/13/2012 3:57:00 PM**

Emigration of juvenile trout from natal streams back to reservoir systems have been known to occur between April through May. Their presence and life history needs while in the reservoir will increase the chance of entrainment particularly when discharge from the reservoir peaks at the same time juvenile are entering the reservoir. Please include the rationale used to verify this determination or consider adjusting the call to a 'moderate' possibility given the information in this comment. Please use the following as references to assist with a revised determination: Russell F. Thurow[a], Danny C. Lee[a]&Bruce E. Rieman.1997.Distribution and Status of Seven Native Salmonids in the Interior Columbia River Basin and Portions of the Klamath River and GreatBasins **DOI.**

russell f. thurow* and bruce e. rieman, danny c. lee, philip j. howellraymond d. perkinson. 2007. Distribution and Status of Redband Trout in the Interior Columbia River Basinand Portions of the Klamath River and Great Basins. U.S. Department of Agriculture-Forest Service

Page 15: [2] Comment [DG 52] **Gonzalez, Daniel -FS** **11/13/2012 3:39:00 PM**

Experience shows that stocked fish tend to stay in the general vicinity of their release point for at least 7-10 days if not lnoger. Hatchery fish endure a high level of stress, disorientation, gas saturation, and crowding from the time they are taken from the hatchery and loaded into trucks. Then, to add more stress and complications, when they are released, there is a short period of shock and awe they go through when their bodies have to adjust to their new environments. Here in eastern Oregon, it's generally poorer water quality conditions and the fact that they no longer have a human hand feeding them. The likelihood of entrainment, especially if fish are released near the dam is very high. Please provide references that supports the conclusions made here.

RE: Fish Entrainment and Mortality Study

DADOLY John to: jyencopal@bakercounty.org 10/22/2012 08:52 AM

Cc: DADOLY John

Jason, thanks for the update on your project. I looked through the updated report and I do not see any major water quality issues that were not covered by DEQ's previous comments that were sent to you in May 2010. I don't think I need to participate in the Fish Entrainment and Mortality Study work session proposed for next month.

I will continue to review information and participate as needed. The presence of Bull Trout in the Powder river below the dam is the only potential issue I can see at this time. If Bull trout were confirmed to be present below the dam DEQ would have to modify its comments regarding temperature and dissolved oxygen levels.

Thanks
John Dadoly
DEQ Water Quality Program

From: jyencopal@bakercounty.org [mailto:jyencopal@bakercounty.org]
Sent: Thursday, October 18, 2012 2:56 PM
To: Audie Huber; Carolyn Templeton; Carl Stiff; FAGAN Colleen E; GRIFFIN Dennis; Fred Warner; Gary Miller; Kenneth Hogan; GRAINEY Mary S; Randy Joseph; KIRK Steve; Quentin Lawson; LUSK Rick M; Robert Ross; Shawn Steinmetz; Susan Rosebrough; STAHL Thomas; Timothy Welch; Joseph Hassell; Carl Merkle; lgecy@ecowest-inc.com; ted@tsorenson.net; gsense@cableone.net; HOMOLKA Ken; Jeff Tomac; Rick Rieber; DADOLY John; OSIERMOATS Elizabeth A
Subject: Fish Entrainment and Mortality Study

Dear, Stakeholders,

I would like to start by thanking all of you for your contributions to this updated draft fish entrainment and mortality report. As you will read we focused on the entrainment issues first and would like your feedback before updating the mortality portion of the report. This way we can ensure we are on the right track as we move forward.

As a work in progress, we hope that you would be willing to provide feedback in an informal fashion within a work session to be scheduled in mid-November. If you would like, you could also send informal written comments at anytime. Those that we receive early we will try and respond to prior to the meeting to keep the discussion going. We are particularly interested in any information you feel pertinent that we may have missed or any conclusions that you feel need additional clarification. You will find that we have added additional baseline and proposed project details that are pertinent to both the potential for entrainment and mortality and tried to compare data from those Pacific Northwest projects that are most similar, suing ODFW and Tribal/BOR project data. We would also like to have feedback on whether or not we missed any key studies that you have access to and that should be reviewed.

We would like to schedule a work session prior to Thanksgiving if at all possible to keep things moving. Please let me know your availability for November 12th through the 21st.

Thank you for your time and continued help with this project.

Jason Yencopal
Community Development Director
1995 Third Street
Baker City, OR 97814
541.523.9669 Office
541.523.8201 Fax
jyencopal@bakercounty.org

Re: Mason Dam fish
Leslie Gecy to: Ken Homolka 07/16/2012 01:50 PM
Cc: Colleen Fagan, Elizabeth A OsierMoats, Timothy Bailey, jyencopal, DGonzalez

Hi Ken,

Thank you for all the reports you sent. I had to put the Mason Dam project aside during the spring field season and am now back on it. I have reviewed the Fall River information you sent me and had a couple of quick questions.

1. I am trying to compare mortality rates among appropriate PNW projects according to both the type and depth of outlet, as well as the velocities within the outlet.

A couple of items I noted from the material you sent me was a study identifying a correlation between mortality rates and water velocities, and of course your data on how mortality changed with flow and pool depth. It also seemed that once gates were open full at Fall River (4-6 ft), the mortality dropped to very low rates, well different from the other data. I am wondering if there was a velocity threshold here that was relieved with full gate opening.

The reason I see the velocities being another key part is that the Mason Dam water velocities are 127 fps or above at full operation. The older study showed that in spillways, velocities more than 80 fps led to 100% mortality and velocities less than 50 fps resulted in 100% survival, with a sharp curve in between the two.

Do you know either the outlet pipe size or the pipe velocities? With the internal pipe size, I can calculate in-pipe velocities. (For comparison the maximum opening on Mason Dam is 4.6 feet, but the outlet then split into 2 33" pipes where the velocities really accelerate). That would be great if you knew that or could provide a contact to get the information.

2. The number of crappie entrained was surprising for such a deep intake. Do you know the % remaining pool volume during the fall crappie entrainment or the low water level over the intake?

Leslie

Leslie Gecy
Senior Plant/Wildlife Biologist
Certified Wetland Professional #000455
EcoWest Consulting, Inc
13740 Red Fox
Baker City, OR 97814
541-403-1163

----- "Ken Homolka" <ken.homolka@state.or.us> wrote:
> Sure,
>
> Attached are two reports for Fall Creek. I need to have the Cougar and Blue River reports scanned to a PDF which will take at least through tomorrow.
> Ken
>
>
>
> Ken Homolka
>
> Oregon Department of Fish and Wildlife
>
> Hydropower Program Leader
>
> 3406 Cherry Ave
>
> Salem, Or 97303
>
> 503-947-6090 (Office)
>
> 503-871-0135 (Cell)
>
>
>
> From: Colleen Fagan [mailto:colleen.e.fagan@state.or.us]
> Sent: Monday, May 07, 2012 11:27 AM
> To: Ken Homolka
> Cc: Elizabeth A OsierMoats; Timothy Bailey
> Subject: FW: Mason Dam fish
>
>
>
> Ken:

>
>
>
> Could you provide these reports or a link to these reports to Leslie?
>
>
>
> Colleen
>
>
>
> From: Leslie Gecy [mailto:lgecy@ecowest-inc.com]
> Sent: Thursday, May 03, 2012 6:01 PM
> To: Colleen Fagan; Timothy Bailey
> Cc: jyencopal
> Subject: Mason Dam fish
>
>
>
> Colleen and Tim,
>
> We briefly discussed the fact that I was working on adding species-specific data to the Mason Dam Entrainment and Mortality report. I am also trying to develop a simple database of regional studies with deep intakes to compare Mason Dam. There are 12 reservoirs that I have identified with similar deep intakes, and with other potentially similar characteristics. Three of these reservoirs appear to be ones on which ODFW conducted the entrainment and mortality studies: Fall Creek, Cougar, and Blue River. All three of these reservoirs have slide gates, with intakes varying from deeper than Mason Dam (Fall Creek, Blue River) to similar depths as Mason Dam (Cougar). It appears than Ken was the lead investigator on these studies. I have not been able to locate any technical reports online and wonder if you can direct me to the proper report links or email copies of ODFW reports pertaining to these three reservoirs.
>
> If you need clarification regarding this request, please email or call at 541-403-1163.
>
> Thanks. I do have one jar of pepper jelly left to share during our fish discussions.
>
> Leslie
>
> Leslie Gecy
> Senior Plant/Wildlife Biologist
> Certified Wetland professional #000455
> EcoWest Consulting, Inc
> 13740 Red Fox

> Baker City, OR 97814
> 541-403-1163
>

>
>

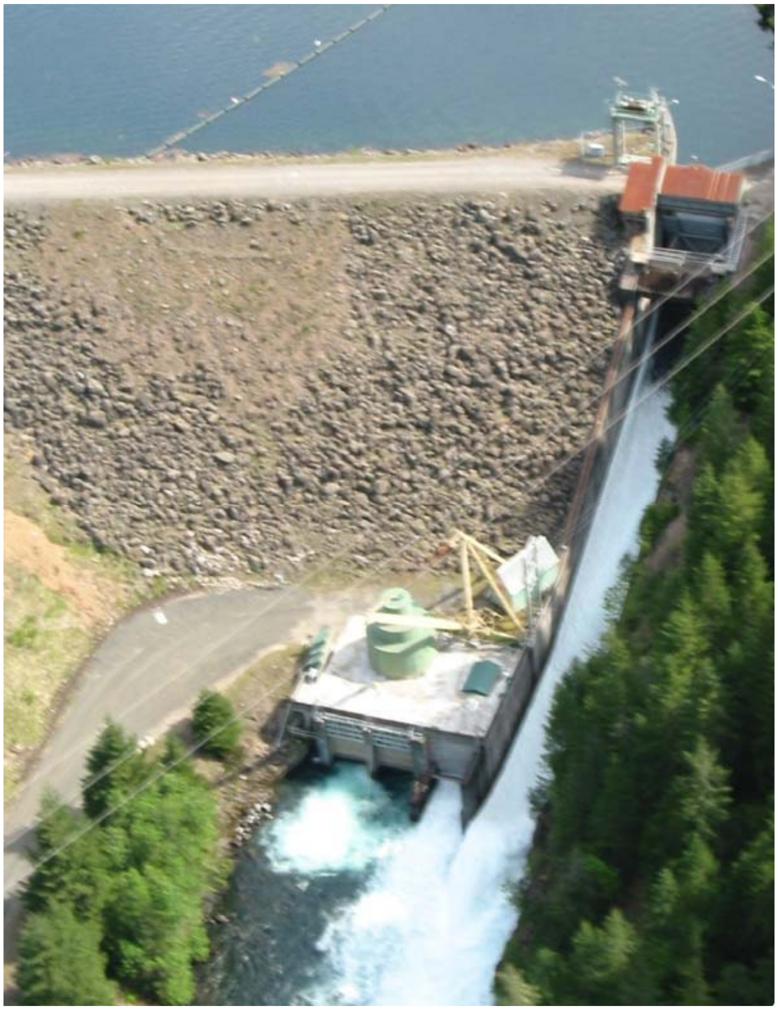
Fish Entrainment Study
Gonzalez, Daniel -FS to: jyencopal@bakercounty.org 05/02/2012 09:47 AM
History: This message has been forwarded.

Jason:

Good to see you at our last meeting. Attached is a study I thought would be helpful to you and Lesley, unfortunately my emails don't always work when I try and contact her. Please forward this to her when you can. Thanks and stay in touch. DG

Daniel Gonzalez
Forestry and Range Sciences Lab
1401 Gekler Lane
La Grande, OR 97850
Office: 541-962-6533

 Carmen_Smith Fish Entrainment regarding the Project under P_2242 Jan 06.pdf



Fish Entrainment at the Carmen-Smith Hydroelectric Project, Upper McKenzie River Basin, Oregon

Final Report

Prepared for
Eugene Water & Electric Board
Eugene, Oregon

Prepared by
Stillwater Sciences
Arcata, California

January 2006

Stillwater Sciences

November 15, 2011 Mason Dam work session

Jason A Yencopal to: Audie Huber, Carolyn Templeton, Carl Stiff, Colleen Fagan, GRIFFIN Dennis, Emily Carter, Fred Warner, Gary Miller, 02/17/2012 03:12 PM

Cc: Jason A Yencopal, hmartin

Dear Stakeholders,

Attached are the November 15, 2011stakeholder work session minutes.

From this meeting some action items were discussed and listed below.

-Baker County will provide ODF&W references of the bull trout study (on Baker County Website)

-BOR will provide additional water quality data. (on Baker County Website)

-FS (Dan) will help provide information on bull trout data from Beulah and Wickiup

-ODFW will provide the summary reports regarding the perch netting efforts and their current estimates of Perch in Phillips Reservoir

-ODFW to provide information on their Phillips fish tagging operation

-Baker County will review the options stated at the end of the minutes and pick one to move forward with the project.

In order that Baker County can make this decision, we would like to gather your thoughts on monitoring and potential mitigation as discussed during the meeting.

There were also some other studies that were mentioned that if you have access to would be helpful. (in addition to Buelah and Wickiup, Fall Creek and Cougar reservoirs)

In addition, I had to have my e-mail rebuilt and make a new stakeholder contact list. If you are receiving this and would not like to please let me know and I will fix the list again. If you notice anyone that should be receiving this and is not please let me know and I will add them.

Thank you,
Jason

November 15 Meeting Minutes with tables attached.pdf

November 15, 2011

Mason Dam Work Session

Attendees,

Mike Hall USFS
Gary Miller USF&W
Colleen Fagan ODFW
Mike Gerdes USFS
Nick Myat ODFW
Dan Gonzales USFS
Jeff Tomac USFS
Leslie Gecy Eco West Consulting
Tim Kerns Baker County Commissioner
John Deloly ODEQ
Jason Yencopal Baker County

Rick Reiber BOR
Bob Ross BOR
Mary Grainey OWRD
John Unger OWRD
Ken Homolka ODFW
Ken Hogan FERC
Elizabeth OsierMoats ODFW

Update

Baker County has submitted the Draft Biological Assessment and Preliminary License Proposal. Since that time work has continued in forming the License Application and Draft Final Biological Assessment. Through the perch netting done in Phillips Reservoir two bull trout were discovered and the County is making sure to address this issue in the two above documents.

Bull Trout

Baker County has started to do some additional analysis of the data with the finding of the bull trout. Leslie presented the following update.

One of the things discussed in the DBA was the water quality and the effects on the bull trout particularly the stratification that occurs in Phillips Reservoir. Water quality monitoring was done near the Mason Dam intake. The data was looked at and compared to the life stages of bull trout, juvenile versus adult. Tracking studies that were also looked at which included: Flathead Reservoir, Beulah Reservoir, Lake Billy Chinook, and a couple others to look at the seasonal bull trout movement and how that compares to Phillips Reservoir. The question that we asked ourselves were, how would these movements correlate to the risk of entrainment in Phillips Reservoir? The project is not going to change the risk of entrainment but what will happen to the bull trout once entrained. In looking at the handouts provided (and included at the end of these minutes) Table 5-3 is a new water quality table that is different than the previous tables provided because the previous tables showed the bottom elevation of the intake and not the top. The new tables show the range of condition of temperature and DO from the top to the bottom of the intake. Beginning in the summer, DO conditions are outside bull trout survival limits. The DO data is not broke into adult or juvenile numbers like the temperature columns, instead any DO below 6.5 would not be suitable for bull trout.

Colleen asked about how close were these measurements to the intake. Jason replied that the water samples were taken near the intake but a little to the Southwest of the intake so that the measurements could be taken of the full water column down to the old river channel which would be the deepest part of the reservoir. Colleen's concern was the horizontal distance of the samples to the intake as the DO could change.

Leslie continued, that in the other reservoir studies that if the reservoir stratifies, or not, because some of the reservoirs don't stratify as much and some of them do, come June the bull trout are moving. The moving starts based on temperature and photoperiod. Even when the reservoir does not stratify the bull trout start to move out of the deep area. There are two things occurring in all of the studies she has seen. One is that there is a pattern of bull trout life history moving out of deep water and the second is the water quality issue. So we are looking at the water quality of the intake and the assumption was made that the water samples are representative of the water at the intake. Figure 5-1 is a graphical representation of table 5-3 DO column and figure 5-2 is a graphical representation of temperature.

Mike G asked what is the irrigation season? Leslie replied May 1st to September 30th but releases may increase due to flood control concerns. Mike added that this would mirror the generation, in which Leslie asked everyone to look at the last figure of the packet. This figure looks at the frequency of operation. The water is shut down to minimum flow on September 30th and this graph shows the number of times the flow exceeded 100 cfs from 2000-2009. This data was looked at to assess the risk of entrainment during operation for bull trout being mid April to mid June when the project could be running, the water quality is suitable, and the life history shows they could or would be within the deeper part of the reservoir. Through this data we are trying to identify the risks of entrainment and tie them into the operation and water quality to show us the highest risk of entrainment.

Colleen asked about the studies that showed the bull trout moving out of the reservoirs, what was the temperature of those? Leslie stated that from the Beulah study that the bull trout migrate in mid April to mid May and that the reservoir rarely exceeds 15 degrees Celsius. Dan stated that most of the adults or sub adults start migrating or staging in April and he wondered what the concern or risk was if it was primarily with juveniles or fry that may stay in the reservoir for a year. By April most of the fish of concern would be already starting to migrate to the headwaters. Leslie replied that the concern is the entrainment of any bull trout. Colleen was wondering if there is a temperature trigger that causes the movement into the tributary streams not just the life history. She also added that in Hells Canyon, they see movement from April into June, so she was looking to see if there is a temperature correlation that we can look at to compare with Phillips Reservoir. Leslie will provide the references she used so that Colleen can review this information. Dan discussed the Beulah study, where some juveniles were entrained in May and then entrained again. They stayed in the reservoir for a while regardless of the temperature showing there is some life history that keeps them there. Leslie added that Beulah is also a cooler reservoir. Rick from BOR added that Reclamation did some extensive water quality monitoring and found that if any bull trout if they were to stay in the reservoir regardless of the contents would not survive. Inhabitable conditions started to occur in mid to late June or the first of July even if there was a substantial amount of water left. However between mixing and wind events the data showed basically the same thing as shown in the Phillips Reservoir data as far as DO and temperature. Reclamation collects water quality data near the dam and that a request can be made to obtain this data. Leslie added that the data was collected during a dry year. Since stratification occurs from the top down you would expect in a wet year that you would get a strong if not stronger stratification. You may also see cooler temperatures but you would have a longer anoxic condition near the bottom.

Discussion about the operation of Phillips occurred. Phillips is used for flood control and irrigation. Water is stored during the winter and released during the summer. Phillips is unique in that when it reaches 100% it still has additional room for flood surcharge which other projects do not have this capability. Depending upon inflows, releases could match inflows and be made at anytime for flood control operations. Reclamation will discuss how often Phillips uses this surcharge area in their Biological Assessment that they will be working on. Phillips does have a dead pool and cannot be drained 100 percent.

The max outflow is 875 cfs with a max velocity of around 2.0. Velocity equals cfs/area. Velocities at the intake will be reviewed to determine the velocity range and how that could affect different fish species. Dan asked if Phillips is able to pass flows both through the outlet and spillway? Phillips is designed in such a way that is can only release flows through the outlet gates until the reservoir reaches its maximum level and then water will go through the spillway. Rick added that at Beulah Reservoir, releases flows through both the spillway at certain depths and the outlet works. It was found that entrainment of bull trout occurred more often when releases were made through the spillway. When releases were changed to the outlet works entrainment decreased to near zero probably because the conditions were perhaps inhospitable and this will be reviewed in the BA for Phillips. Also at Arrowrock they found that entrainment has lessened with releases made through the new clam shell gates that are lower in the reservoir than the releases that used to be made near mid reservoir levels, so lower releases are better in terms of entrainment. Gary asked if that was for all species or just for bull trout. (We had some technical issues and Rick with BOR answered this question later.)

Leslie asked about the report that Timothy Bailey with ODF&W was working on about the perch netting process done in Phillips Reservoir. Nick Myatt will get back to the group after discussing this with Timothy when that could be expected. (Nick received correspondence from Timothy during the meeting that indicated that the summary report for last year is available and that the 2011 summary will be available in about a week. The report of all three years will not be available until early next year).

Rick addressed a question that was raised earlier about if other fish species were affected or just bull trout by having the water withdrawn from a lower level. From Beulah when BOR switched from spillway releases to outlet releases not only was there a substantial reduction in bull trout entrainment but also rainbow and red band trout as well.

Rick felt that typically in the spring that bull trout are seeking prey in the shallow areas that are starting to warm up a little bit. He also found it interesting that ODF&W were able to catch these two bull trout with Merwin traps that only fish about 2 meters below the surface. They have tried to use these in Arrowrock and have not had as much success.

Jason asked that does the finding of two bull trout in Phillips Reservoir change the process as we move forward with the licensing of the Mason Dam Hydroelectric project? Gary does not see where it changes the process but the analysis of the information does change.

Rick bought up a point that may need to be addressed and that would be the addition of the tiger trout which have been introduced into Phillips and tiger musky which has been considered but not introduced at this time. USF&W has had some discussion with ODF&W concerning the tiger musky but at this time there has been no consultation.

Entrainment and Mortality Study

Mike G. asked for an update on the entrainment study with the comments that were received in February. Jason replied that Baker County feels that the project will not change the entrainment through operation of a hydroelectric project because we are not changing the intake. The report looked at other projects to determine the possible entrainment rate. Rick added that Beulah and Arrowrock currently had terms and conditions that have them trap and haul bull trout entrained with success at both projects. The issue he sees is that it would be difficult to trap and haul bull trout that might be injured through the turbines if there is an issue with bull trout at Phillips Reservoir. Bob added that the issue is that the impacts to fish will change with a Francis turbine versus a slide gate (it was difficult to hear Bob, for some reason the phone connection was in and out.)

Dan asked Rick about the outcomes from the studies on the Columbia River with strobe lights and hydro acoustics in deterring fish from intakes? Rick did not believe the outcome of those studies have proven very successful.

Dan also asked if the state is willing to give a waiver from fish passage. Colleen added that a waiver is possible if you go before the Fish and Wildlife Commission and can show a net benefit over what they would expect with passage or with a screen in place. Both are an option but Baker County would need to prepare a proposal and present it to the Fish and Wildlife Commission. Dan asked if this has been done and if both options are being considered. Baker County's standpoint is that the project would not be feasible if fish passage would have to be done and so we will look at some sort of benefit likely through some type of mitigation and working through the waiver process. Rick added that in lieu of a fish ladder an option could be "trap and haul" that would only occur in certain years and for short durations when they are spilling water or releasing a large amount of water. Bob added Reclamation's stand on screening is based on safety that if the screen gets clogged and cannot pass flood or irrigation flows that they would not allow anything to be put in the entrance that would prevent this. Other than a separate intake that would probably not be a starter for Baker County, Reclamation would not entertain any motions that include screens on the intake. Ken Homolka asked what is the issue with the screens? Bob added that Reclamation has a mandate to deliver irrigation water under all conditions and there is also a safety issue and if you cannot control the water through the valves the water could go over the spillway and you would not have any control at that point. What about breakaway panels asked Ken with ODF&W. Bob stated he could look at it but he feels that the cost to do it would probably be expensive. Baker County did look at screening options with the engineers and all the options became economically unfeasible.

Gary added that basically, the comments received are mute because Baker County feels that nothing is changing with the current intake so whatever entrainment there is now is not going to be any different with the project. Baker County took those comments and will make some changes to the study but Baker County feels that the entrainment rate would not increase or decrease with project operation but what will change is the mortality which was also looked at in the report.

Mike G. feels that where we will end up is that in the summary from the entrainment report, it states that 74,000 – 250,000 fish could be entrained per year. Colleen added that there is no information on perch, rainbow, red band, or what size these fish are that are entrained and this could affect the mitigation. Leslie asked if anyone had taken the perch data and come up with any population analysis. Nick stated that he feels there have been some estimates made on perch but is unaware of those made on other species. Colleen asked if Leslie had seen last year's perch report and if not would send it to Jason for distribution to the entire group. Jason's understanding was that Timothy was going to compile the last two years findings from the perch netting process into one report. Mike Hall had an understanding that they have been tagging some of the fish that were caught and releasing them back into Phillips Reservoir so that if they caught all of those fish or a certain number they could determine the percentage of fish they are catching. Nick thought they had been marking every year but will check with Timothy. Colleen added that ODF&W has not been out doing surveys on population numbers. They try and use the available data to do some of this, however they do know the numbers of stocked fish.

Mike G. asked about the trap and haul method used and how they monitor what is caught? Rick replied that they try and get as many bull trout as possible but found that short gill net sets have been the best way to capture those fish entrained.

Colleen asked Rick how successful have you been with the gill nets for bull trout? Rick explained that it depends upon the runoff, in some years they may only be out there for two weeks and may only get 12-15 bull trout in good water years. In other years where they only spill for a day or two they may only get a bull trout or two. As he mentioned earlier since BOR has started to discharge from lower in the reservoir that the numbers entrained is less and that their requirements to trap and haul have been less and less because they have been able to pass that water through the valves that otherwise would have gone over the spillway.

Colleen asked that if the Reclamation's cue to trap is based on when the dams are spilling? That is what are found in the terms and conditions for when they spill, if they do not spill they go out every other year stated Rick. Rick recalled that the last time they went out to trap and haul that they only caught about 1-2 bull trout. Mike G. asked if that was done with the gill nets? Rick replied that the gill nets were the method used. Rick added that from his memory he does not believe they have had any mortality using this method. He was not sure if a gill net could be used in the tail race of Mason Dam. Dan was curious about a rotary screw trap. Rick thought that it might work but they have not used one. Jason asked about the depth needed to use one of these traps. Colleen said that there are some that work at 5 to 8 feet deep and Dan added that they can be set fairly shallow. Rick commented that Symbiotics used two traps below Wickiup dam and ran them 24-7 and caught lots of fish. Dan also added that the mortality rate is very low but they need to be checked often.
Rick stated that one thing missing from this conversation is that, Reclamation as it is works on the BA, will need to step back and discuss bull trout in general from Phillips Reservoir and upstream. There was some decent run off this last spring. Could these bull trout have been flushed down? Did they stay in the reservoir for a little while and then started to move back up to the tributaries. Reclamation consulted with USF&W on the lower Umatilla and in certain years you would see bull trout showing up depending upon run off conditions. Typically these fish would start to work their way back up the tributaries but if they waited too long they could encounter a thermal barrier. From his understanding he does not believe there have been any recent surveys of the upper Powder River basin so it is hard to know if there is a migratory component in this system or larger bull trout that are typically migratory versus the resident bull trout that are smaller. There are some considerations that should be looked at from a Fish and Wildlife standpoint of do we now have a growing population that is starting to migrate or was this occurrence due to runoff, what is going on in the basin?

Gary is not familiar with when the last surveys that was done in the upper Powder River Basin.

Rick continued that at Beulah they were enough bull trout available that they were able to radio tag a few so they could look at entrainment. At Phillips Lake it may be a different scenario and he would be interested with what happens this spring depending upon the runoff but if they are found again. If so it could mean that there is more of a migratory population or are there enough fish in the head waters to radio tag. However, if the numbers are low you probably would not want to harass them and since it has been sometime since they have been monitored, you would have to put that into perspective as well.

Leslie asked of each agency should Baker County need to do some mitigation in lieu of the screen what their positions are for studies as part of the mitigation? For USF&W, typically studies or research information is not considered mitigation. ODF&W also added that typically the answer would be no, because you really would not see a net benefit to the species in lieu of screening or passage. Ken Homolka added that they would be looking for something that provided no net loss or provide a net benefit as far as habitat or the number of species affected. Colleen added that the passage and screening issue should not be limited to just bull trout but all native migratory species such as red band.

Dan asked that couldn't research be a caveat to management to use this information to form the actions? Colleen stated that her understanding is that the studies that have been conducted as part of the licensing should be giving us the information needed to license the project and what mitigation is needed. Dan added that with Beulah, the information that was received from the studies provided information that was used to adjust the management based on what was found and that it was good mitigation just to get the information that changed the operations and saved a lot of fish. These operations are not changing said Colleen. Ken Hogan brought up the Commission's position as he understands it, is that generally they would not support studies in lieu of mitigation but studies to inform mitigation steps are a different approach and may be considered.

Mike G. suggested that some type of tiered approach for monitoring could be useful over the life of the license, if more information is needed in this case bull trout, then if some type of pre work is needed to inform what the mitigation would be then the Forest Service would include that. Ken Hogan mentioned that FERC could do something similar with an adaptive management approach where you go out and do some study, monitor the effects, evaluate, and make a decision from that point. Where Mike G was going with his questions about the numbers of entrained fish going through Mason Dam, is that we don't know what the composition of the fish are and from the report of 74,000-250,000, he was trying to get an idea of monitoring methods that might inform them on the compositions of the fish entrained. Then based on the information found, some type of mitigation could be done, in addition to tributary work, then these two pieces of information could lead to some better form of mitigation.

Rick added that putting a rotary screw trap below Mason Dam could be a permanent condition for either Reclamation or the County. At this point he is not certain because there needs to be a better handle on the current population.

For an entrainment study ODF&W requested that the actual fish entrained be found by using a rotary screw trap below the dam and in lieu of the study the screen was proposed and in lieu of the screen a literature report was conducted on entrainment. ODF&W would like to have this information before setting mitigation. Are you saying that mitigation would be determining what species and numbers are coming out of the project asked Colleen? No, what Mike G is suggesting that without this information in hand today is that in part of the mitigation package for this project to move forward that we develop a very tiered approach starting with monitoring to figure out what the entrainment is. Based on that move forward with adaptive management, looking at species composition, rate, mortality, using a rotary screw trap below the project, and looking at the composition of the population above the project. Colleen was wondering that if Baker County is seeking a waiver how could the Fish and Wildlife Commission could approve a waiver that is dependent upon information that is yet to be received because there is not the information to determine if this would provide a net benefit.

From Ken Hogan's perspective with an adaptive management approach it would have to have very specific triggers and steps that would have to be defined that would include step by step instructions for what is found and what the outcome would then be. With these triggers and steps being so defined it may help with the Fish and Wildlife Commission. Ken Homolka thinks that this would potentially work but the timing of this sounds like it would be done after the project has been constructed which may still work with this being very specific. The County will look into this, understanding that it will need to gather a lot of information and get back with the agencies with additional questions if needed. Ken Hogan added that if the County so chooses to go this route that additional information should be obtained, gathering more details from the agencies of what they are thinking about for monitoring and potential mitigation to inform your decision.

Mike Hall recapped the discussion in that after the project is implemented there may be some mitigation that the County would be responsible for that we don't know yet based on the monitoring such as that if A = B then C would be done. These could become quite costly for the County.

The County understands this and will have to take all of these measures into consideration when it makes it decision.

Ken Hogan was curious about if Reclamation was starting a BA of Mason Dam. Rick responded that they are currently in the process of drafting a BA. Ken Hogan continued, so regarding all of this recent information we have been talking about, entrainment, how are you addressing this for your biological assessment and why would this be any different for Mason Dam or the hydroelectric project?

If Reclamation is issued a condition to trap and haul bull trout that are entrained, it can be very difficult to trap and haul injured bull trout that have gone through a turbine. We don't know if there would be mortality with the turbines versus the existing outlet works and they may never know that with such low numbers of bull trout. There may need to be a post project study such as a balloon tag study to see what level of mortality there is on whatever fish you release stated Rick.

Ken Hogan was wondering what studies BOR are currently doing for current conditions to assess the reservoir population of entrainment data that the current project is affecting.

BOR has not done anything in Phillips Reservoir because there is not a Biological Opinion that requires them to do anything and there is no funding to do so currently. However, that could change when an opinion is issued but up until that time the best scientific information will be gathered and incorporated into the BA.

Ken Hogan was wondering what scientific information you are collecting for your BA?

BOR would start with the information that was identified during the designation of the critical habitat and there is not a lot of that information out there. The bull trout information from this spring and previous ODF&W and FS studies will be used to form the BA.

Ken Hogan pointed out that then the BOR will be using existing data and not conducting any field studies, which Rick confirmed.

Rick added that in some cases there is more information when there is a bull trout fishery but for Phillips there was no information until this spring, there was nothing on the reservoir fishery. One of the biggest concerns is the abundance of yellow perch and the effect they would have on any salmonid and or bull trout in the reservoir. It is having an effect on the prey base of everything. This will be an issue identified in the BOR BA.

Ken Hogan wanted to make sure that everyone understood that there is a distinct line between the effects of Phillips Reservoir and BOR operations versus the incremental affect of adding a turbine. It is important so you can assess project related effects versus the effects of the entire Phillips Reservoir complex.

Rick added that the effects may not be known until after the project has been approved. At Arrowrock they met several times to discuss the what ifs. At Phillips this will be very difficult because there is not the same bull trout fishery there or at least he does not think so.

With the timing of the BOR BA, BOR would not be collecting any baseline data pre licensing, but post licensing, with Baker County having to do it all with the affects of the current project and the incremental affects of the hydro to determine the mitigation and that is a concern stated Ken Hogan.

Rick understood this and added that on the Arrowrock Project the Boise Board of Control had the license well before the project was constructed and so they did a lot of work post project and the onus was not all on the power plant operator. BOR was informed by the USF&W service that they would be responsible for some of the bull trout monitoring studies.

Bob added that from the Arrowrock project BOR knew that there were existing mitigation measures and there was a take statement so that when they added the hydro what they were really looking for is the mortality through the turbine versus the valves. An understanding of the overall goals is needed to see if the hydro is negatively effecting the overall population. With Arrowrock they are still working on this understanding and if there is a negative effect then the Boise Board of Control would share in the cost in the overall mitigation which could be enhancements. Is the population of bull trout is two or is it a fluke due to the runoff, BOR would like to look at how to move this project forward. Bob encouraged the group to look at the effects of the populations, if they are changing, if the plan is overall affecting the population then what should be done? With a little more water quality analysis done it might confirm what Leslie stated earlier, then bull trout entrainment might be next to nothing as they have seen at other projects.

Because there are so many unknowns with bull trout in the Reservoir he could see some preliminary conditions being; analyze water quality further, perhaps work with the FS to get a more current estimate on population, distribution, and abundance, then go back and re-consult was suggested by Rick.

Gary stated that right now he feels everything is on the table in looking at these things.

Colleen stated that in the entrainment report we are looking at 74000-250000 fish per year. Comments were received from ODF&W and FS with the comments from ODF&W being how can we get information on what species and size of fish are thought to entrained. Could these numbers come from this report to where mitigation could be developed? Colleen also asked for FERC's thoughts and if the study was sufficient?

Ken Hogan replied that as for the study it is still be debated and that if there is an approach that comes out of this discussion that is acceptable to the agencies and the County then that could inform FERC's decision. FERC has been waiting for agency comments and this discussion to figure out if further entrainment studies are needed or if the current report is sufficient to inform the Commission to decide what needs to be done for mitigation. We are not there yet and would like to continue with these discussions.

Gary added that it definitely seems clear that based on all the information we have that the biggest impact with potential entrainment is not with bull trout but with the other species, in which Ken Hogan agreed.

In Rick's opinion the issue with the perch supersedes everything that is going on right now. Until that population is controlled and with the introduction of a predatory fish species, he was unfamiliar with the effects with juvenile bull trout and then the consideration of the tiger musky basically it is almost as if the goal is to clean out Phillips and start from scratch. He felt that this is somewhat a radical move but realistically that is probably what it is going to take to control the yellow perch population. In a you tube video of the netting operations it was amazing to see all the perch in those nets. (There are five short videos that can be found by searching for "Phillips Perch"). Until the perch population is addressed in the reservoir Rick suggested that we should look at what is happening in the tributaries and then comeback and re-consult.

ODF&W's goal is not the elimination of the perch in the reservoir. The goal is to decrease the numbers and one of their concerns is the entraining perch down in the river below the project and native red band trout as well as rainbow trout stocked for sport fishing so it is not just the biological opinion but also the licensing of the project.

Rick asked if there had been much information collected on the fishery below Mason Dam and if it was good, fair, or poor for trout. Colleen stated that she did not know with Ken Hogan adding that he would consider it great with dozens of fish per hour though they are not big. Leslie asked the question if the entrainment study included information similar to the bull trout information that is going in the BA but included red band, rainbow and yellow perch, would that satisfy the questions about the entrainment study?

"No, I think that information needs to be included in the study and that is some of the information that we are looking for but we would need to see what the final product is." stated Colleen. Baker County could talk with Nadine and Timothy about what fish may be found near the intake seasonally. How the species and the sizes correlate to the 74,000-250,000 thousand fish per year and can we get there from the report.

Those are the key questions added Mike G. What is the percent of mortality of the species entrained and with that figure we could get to what type of or amount of mitigation we would be looking at. Without these numbers we are looking at the larger numbers and trying to figure out how we can get to some mitigation.

Dan was not sure how you would get to mortality because the fish don't die necessarily because they are entrained.

Not necessarily but given the type of configuration of what Mason Dam has and the proposal of the Francis turbine there is going to be a high percentage of mortality. You would collect the fish somewhere below the project either dead or alive and that would give us an estimate of mortality or escapement in percentage of species composition stated Mike G. As for as differentiating between BOR and the project as it exists today with what is being proposed it looks like you could, if we go to post construction monitoring, that you could select through the bifurcation valve where the water would be released so you could have a BOR result and with project to see what the difference.

Would this be baseline data then asked Dan, yes it would replied Mike G.

Bob added that when they did the studies on Arrowrock they were able to do an apples to apples comparison by running water through the clamshell valves/gates and then through the turbines for mortality. The other thing you can expect or ask yourself is why a Kaplan has a higher survival rate than a Francis and that is because the clearances are smaller. However, the larger the turbine the better the survival rate and it also depends on the size of the fish entrained through the turbine.

Baker County tried to look for examples that were close but there are no other dams that are exactly like Mason Dam so it is difficult to compare sometimes. In the study the results were to try and show that from the gate valve to the turbine that there should be less mortality. What Baker County is hearing is that the report did not capture the information to show this drop in mortality? Yes, it did not get what we were really looking for which was the specific impact from the proposed project and for us to move forward with some sort of direct mitigation we would need the direct impact. That is Mike G. is proposing the plan discussed above so we can move forward and then identify that. What we may have done during the study phase could take place post project and if we have built in the triggers correctly. Then it would give the state information for the waiver but also Baker County what this is going to cost in the long run which is a very important question and if we do our work correctly then everyone would have a clear expectations of all the agencies and Baker County. Absent of that if we don't want to go with that then we need to install a new study right now to get an idea of entrainment so we have a better understanding of what mitigation is to move forward stated Mike G.

Regarding the ILP process and the licensing process there are three approaches to finalize the study. 1) Finalize the study addressing the agency comments with maybe some additional analysis and file it and the commission will review the data and either approve it or require an additional study. 2) Let FERC know that we are going to do additional studies, develop a study plan and get approval. 3) Do option 1 and propose the adaptive management approach as a PM&E.

Baker County will meet internally and discuss the options that were brought up.

We appreciate everyone's involvement and continuing to work with Baker County.

Table 5.3. Water Quality Conditions Within the Range of Mason Dam Intake Elevations During 2007.						
Date	**Intake Elevation (m below surface)**		**DO (ppm)**		**Temperature (° C)**	
	Top	**Bottom**	**Top**	**Bottom**	**Top**	**Bottom**
11-May	21.9	18.0	8.6	8.6	11.1	11.1
17-May	21.4	17.5	8.1	7.6	9.1	8.9
25-May	21.0	17.1	7.6	7.3	10.8	10.2
1-Jun	20.6	16.7	6.7	5.9	10.1	10.0
9-Jun	20.1	16.2	7.4	6	12.9	10.8
15-Jun	19.5	15.6	6.6	6.6	13.0	13.5
22-Jun	19.5	15.6	5.8	4.2	12.9	11.3
28-Jun	18.9	15.0	5.2	4.8	14.5	14.2
6-Jul	18.1	14.2	3.5	3.5	12.7	12.7
17-Jul	16.8	12.9	2.6	0.9	14.9	12.0
24-Jul	15.7	11.8	1.8	1	15.0	13.5
7-Aug	13.2	9.3	6.0	0.1	20.7	14.8
14-Aug	11.8	7.9	5.2	0.1	20.1	17.0
21-Aug	10.2	6.3	6.2	2.3	19.5	18.9
13-Sep	7.7	3.8	9.6	7.4	17.7	16.9
21-Sep	7.3	3.4	5.8	7.7	15.4	17.0
28-Sep	7.0	3.1	6.0	5.7	13.4	15.4
5-Oct	6.8	2.9	6.2	6.2	No data	No data
12-Oct	6.6	2.7	6.5	6.5	10.8	10.8

The lightly shaded cells identify dates on which conditions would not be suitable for juvenile bull trout (temperatures greater than 8 **° C)**. The darker cells indicates dates on which conditions would not be suitable for either juvenile or adult bull trout (temperatures 15 ° C or greater, DO less than 6.5 ppm).

Figure 5-1. Dissolved Oxygen Levels at the Range of Mason Dam Intake Elevations. Based on 2007 Data.

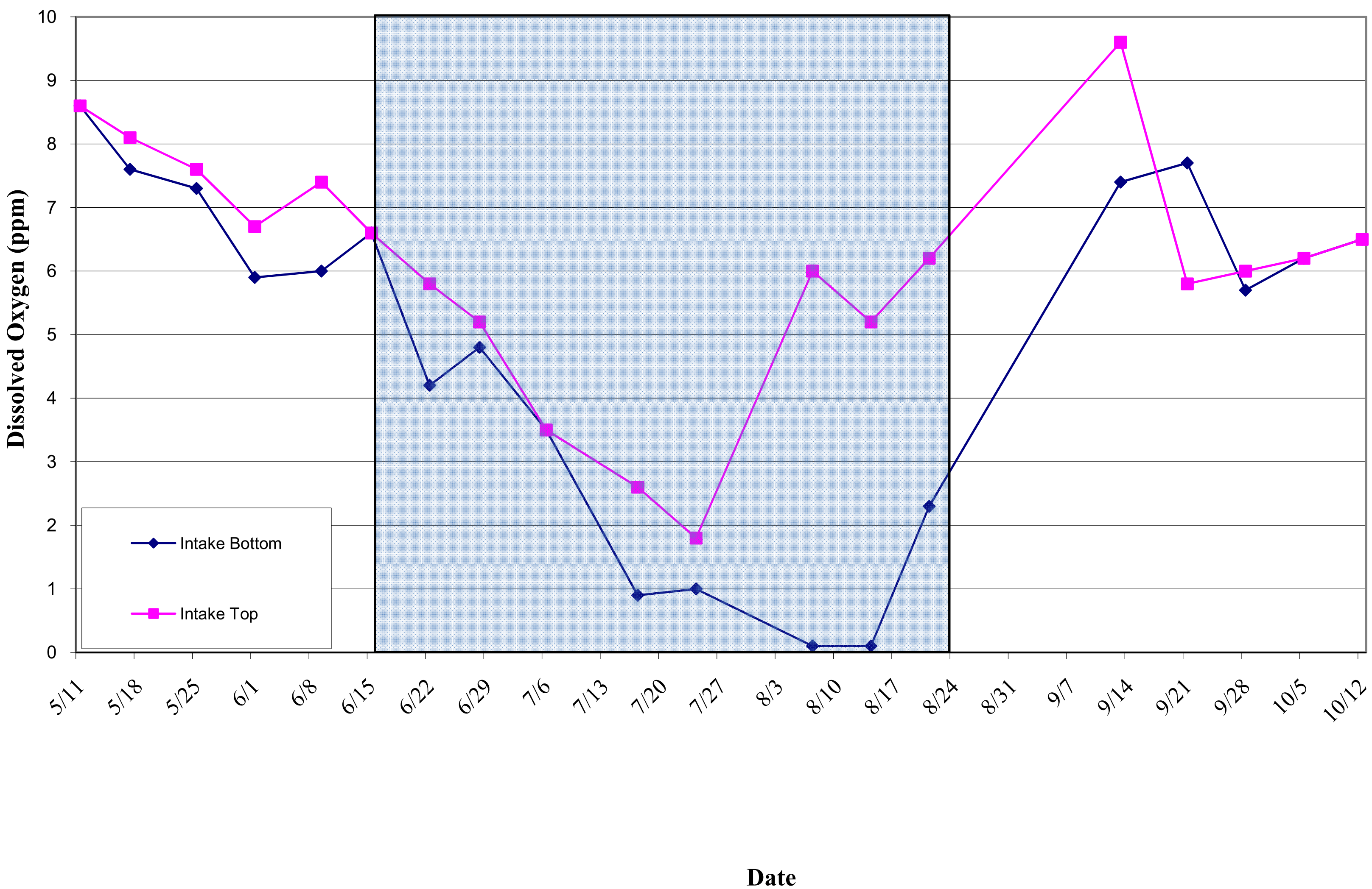
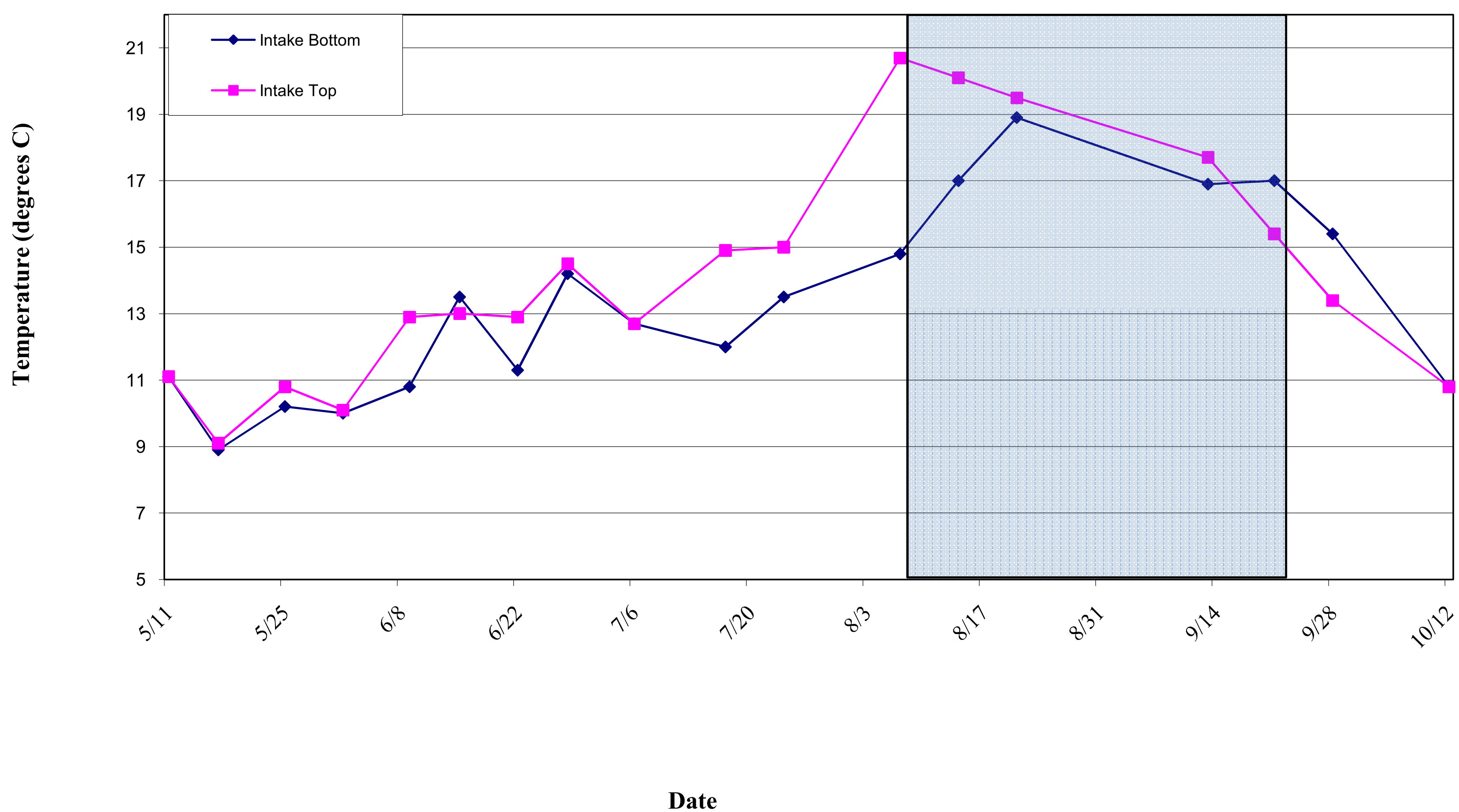
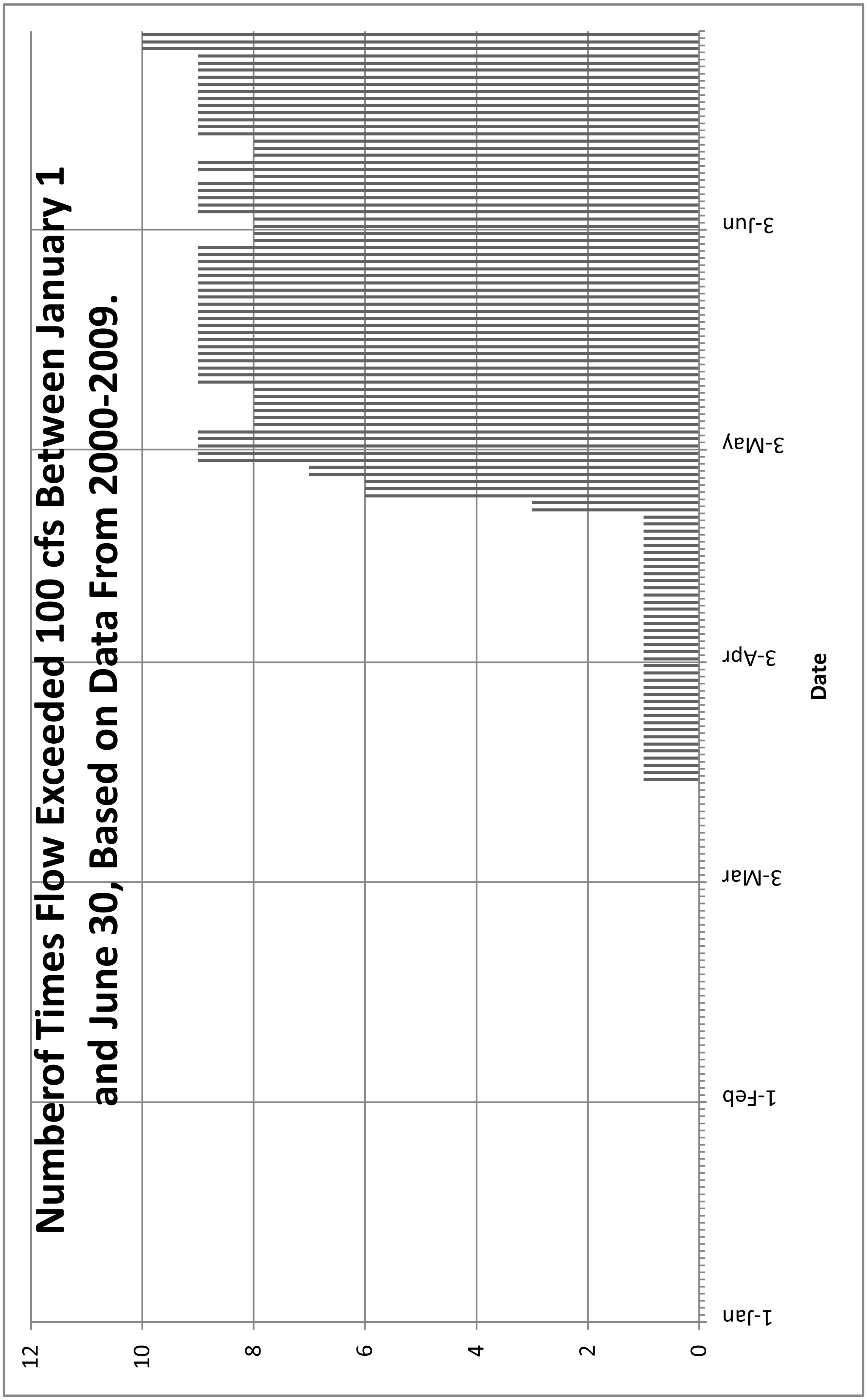


Figure 5-2. Temperatures at the Range of Mason Dam Intake Elevations. Based on 2007 Data.




Numberof Times Flow Exceeded 100 cfs Between January 1 and June 30, Based on Data From 2000-2009.
0
2
4
6
8
10
12
1-Jan
1-Feb
3-Mar
3-Apr
3-May
3-Jun
Date

Phillips Reservoir Water Quality Data
Rieber, Richard W to: Lay, Clyde H. 11/15/2011 01:09 PM
Cc: "Stroud, Bill L", "jyencopal@bakercounty.org"

From: "Rieber, Richard W" <RRieber@usbr.gov>
To: "Lay, Clyde H." <CLay@usbr.gov>
Cc: "Stroud, Bill L" <BStroud@usbr.gov>, "jyencopal@bakercounty.org" <jyencopal@bakercounty.org>

Clyde/Norbert- There was a conference call today on Phillips Reservoir and the progress Baker County is making towards obtaining a license for hydropower at Mason Dam. During the call, they requested any water quality data that Reclamation has for Phillips Reservoir. I have cc'd Jason who is working for Baker County and who requested this information. Please send any information we have to Jason and myself.

Jason- This information will likely be in spreadsheet form and has yet to be summarized. However, it should provide you with additional years of data similar to what Leslie presented during today's call.

I'm going to be out of the office until Nov. 22. If you have any questions once you receive the information, please let me know and we can discuss.

Thank you

rick

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Fw: Mason Dam Work Session

Jason Yencopal to: Audie Huber, Carolyn Templeton, Carl Stiff, Colleen Fagan, GRIFFIN Dennis, Emily Carter, Fred Warner, Gary Miller, Ken 11/15/2011 09:45 AM

Cc: jyencopal

From: Jason Yencopal/Baker County

To: "Audie Huber" <Audiehuber@ctuir.com>, "Carolyn Templeton" <Carolyn.Templeton@ferc.gov>, "Carl Stiff" <cbstiff@wildblue.net>, "Colleen Fagan" <Colleen.E.Fagan@state.or.us>, "GRIFFIN Dennis" <Dennis.Griffin@state.or.us>, "Emily

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----- Forwarded by Jason Yencopal/Baker County on 11/15/2011 09:35 AM -----

From: Jason Yencopal/Baker County
To: Carl Stiff/Baker County@Baker County, undefined, Fred Warner/Baker County@Baker County, "Mike Hall" <mhall02@fs.fed.us>, "Leslie Gecy" <lgecy@ecowest-inc.com>, "Ted Sorenson" <ted@tsorenson.net>, "Nick Josten" <gsense@cableone.net>
Date: 11/14/2011 10:00 PM
Subject: Mason Dam Work Session

Dear Stakeholders,

I decided to include a little agenda and some charts and tables we will discuss .

Agenda

-Welcome

-Brief Project Update

-Bull Trout Discussion
    Baker County's Bull Trout additional analysis
    Any changes to the process from the finding and designation?
    Additional discussion

-Fish Entrainment & Mortality Study
    (Report can be found at the following page http://www.bakercounty.org/mason_dam/home.html under the additional study reports folder)
    Discussion

-Other Comments

-Adjourn

If you have any problems with the conference call please let me know by calling my cell phone at 541.519.0599.

Thank you,

Jason

Nov_15_2011 worksession data.pdf

Table 5.3. Water Quality Conditions Within the Range of Mason Dam Intake Elevations During 2007.						
Date	**Intake Elevation (m below surface)**		**DO (ppm)**		**Temperature (° C)**	
	Top	**Bottom**	**Top**	**Bottom**	**Top**	**Bottom**
11-May	21.9	18.0	8.6	8.6	11.1	11.1
17-May	21.4	17.5	8.1	7.6	9.1	8.9
25-May	21.0	17.1	7.6	7.3	10.8	10.2
1-Jun	20.6	16.7	6.7	5.9	10.1	10.0
9-Jun	20.1	16.2	7.4	6	12.9	10.8
15-Jun	19.5	15.6	6.6	6.6	13.0	13.5
22-Jun	19.5	15.6	5.8	4.2	12.9	11.3
28-Jun	18.9	15.0	5.2	4.8	14.5	14.2
6-Jul	18.1	14.2	3.5	3.5	12.7	12.7
17-Jul	16.8	12.9	2.6	0.9	14.9	12.0
24-Jul	15.7	11.8	1.8	1	15.0	13.5
7-Aug	13.2	9.3	6.0	0.1	20.7	14.8
14-Aug	11.8	7.9	5.2	0.1	20.1	17.0
21-Aug	10.2	6.3	6.2	2.3	19.5	18.9
13-Sep	7.7	3.8	9.6	7.4	17.7	16.9
21-Sep	7.3	3.4	5.8	7.7	15.4	17.0
28-Sep	7.0	3.1	6.0	5.7	13.4	15.4
5-Oct	6.8	2.9	6.2	6.2	No data	No data
12-Oct	6.6	2.7	6.5	6.5	10.8	10.8

The lightly shaded cells identify dates on which conditions would not be suitable for juvenile bull trout (temperatures greater than 8 **° C)**. The darker cells indicates dates on which conditions would not be suitable for either juvenile or adult bull trout (temperatures 15 ° C or greater, DO less than 6.5 ppm).

Figure 5-1. Dissolved Oxygen Levels at the Range of Mason Dam Intake Elevations. Based on 2007 Data.

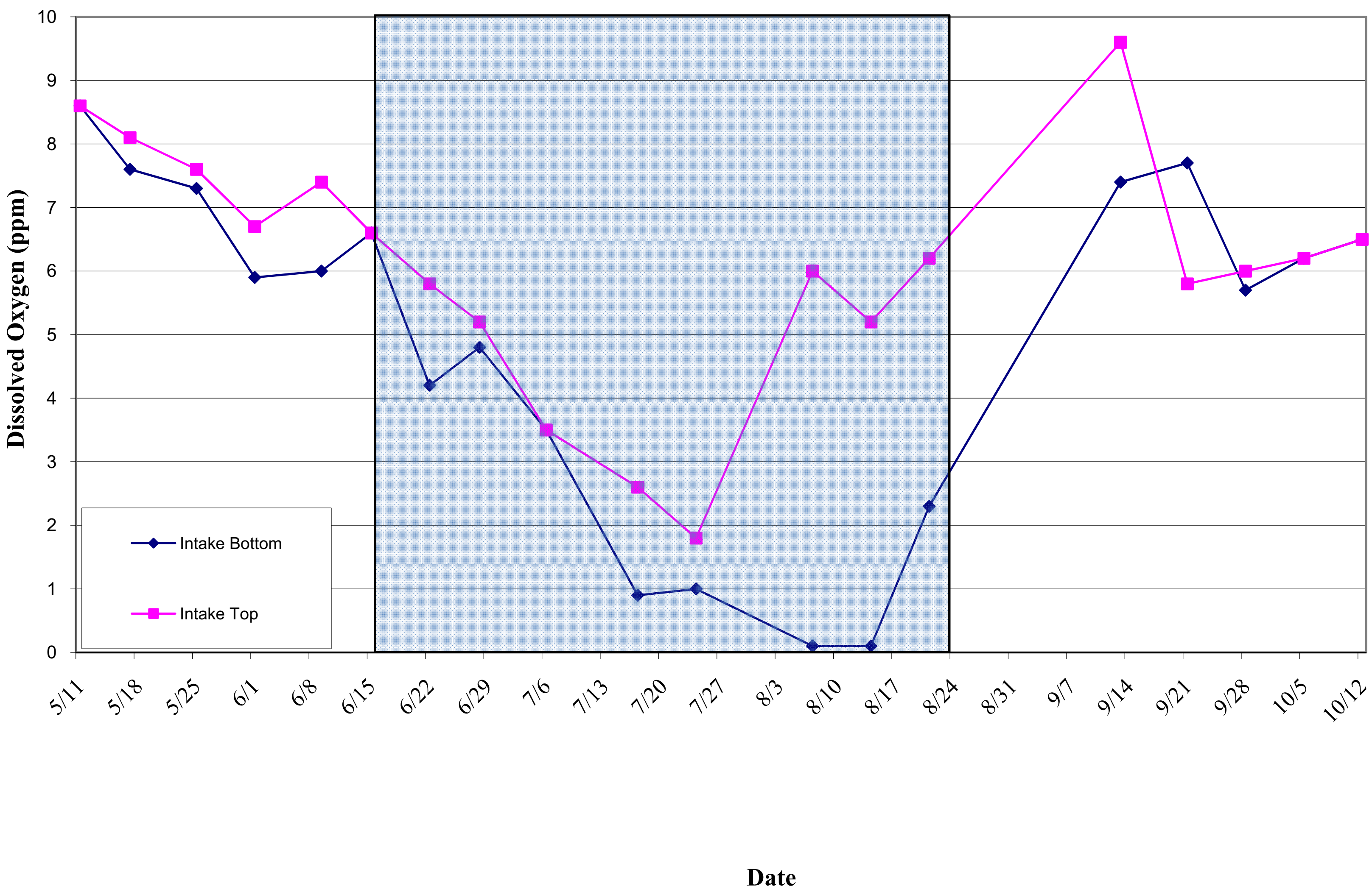
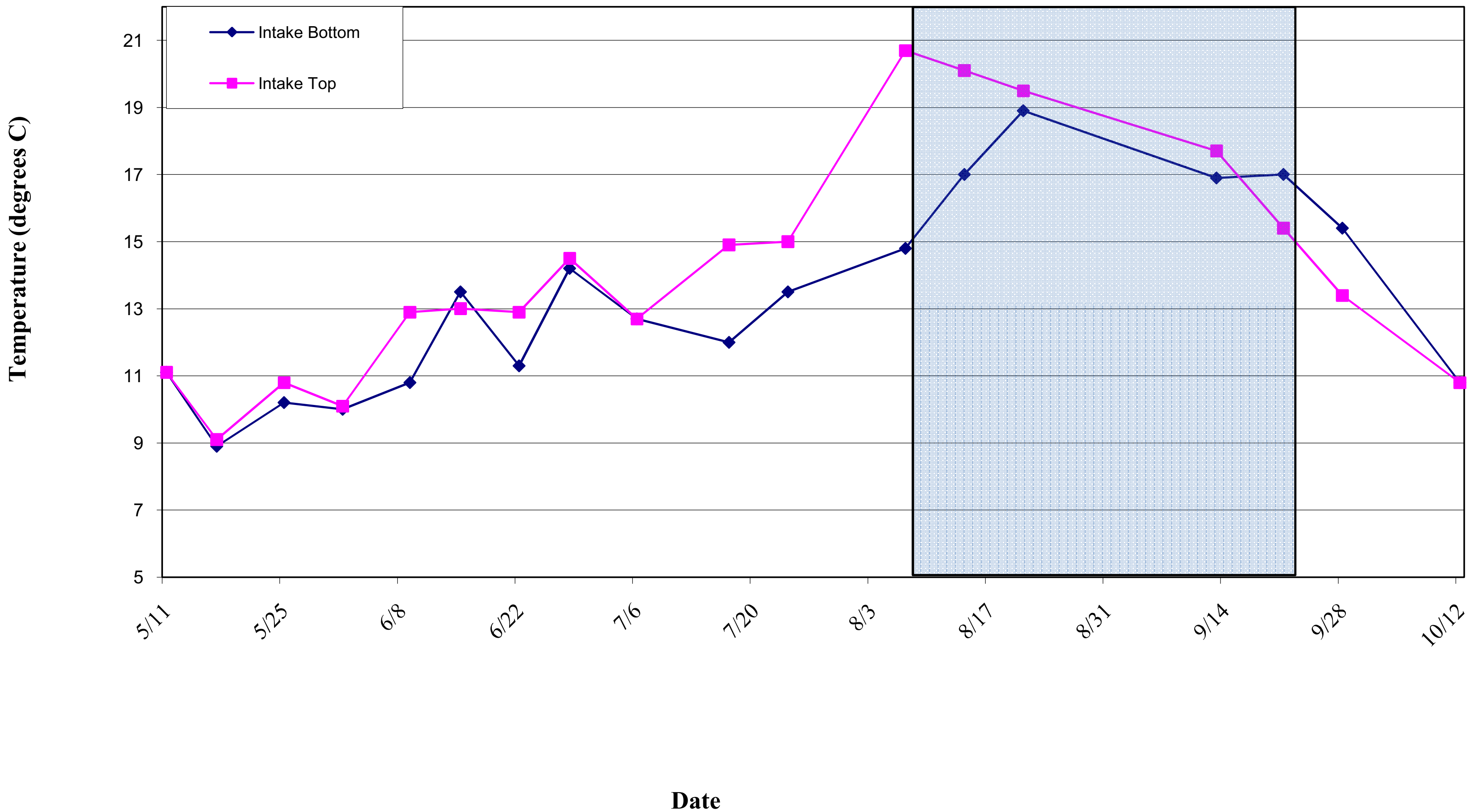
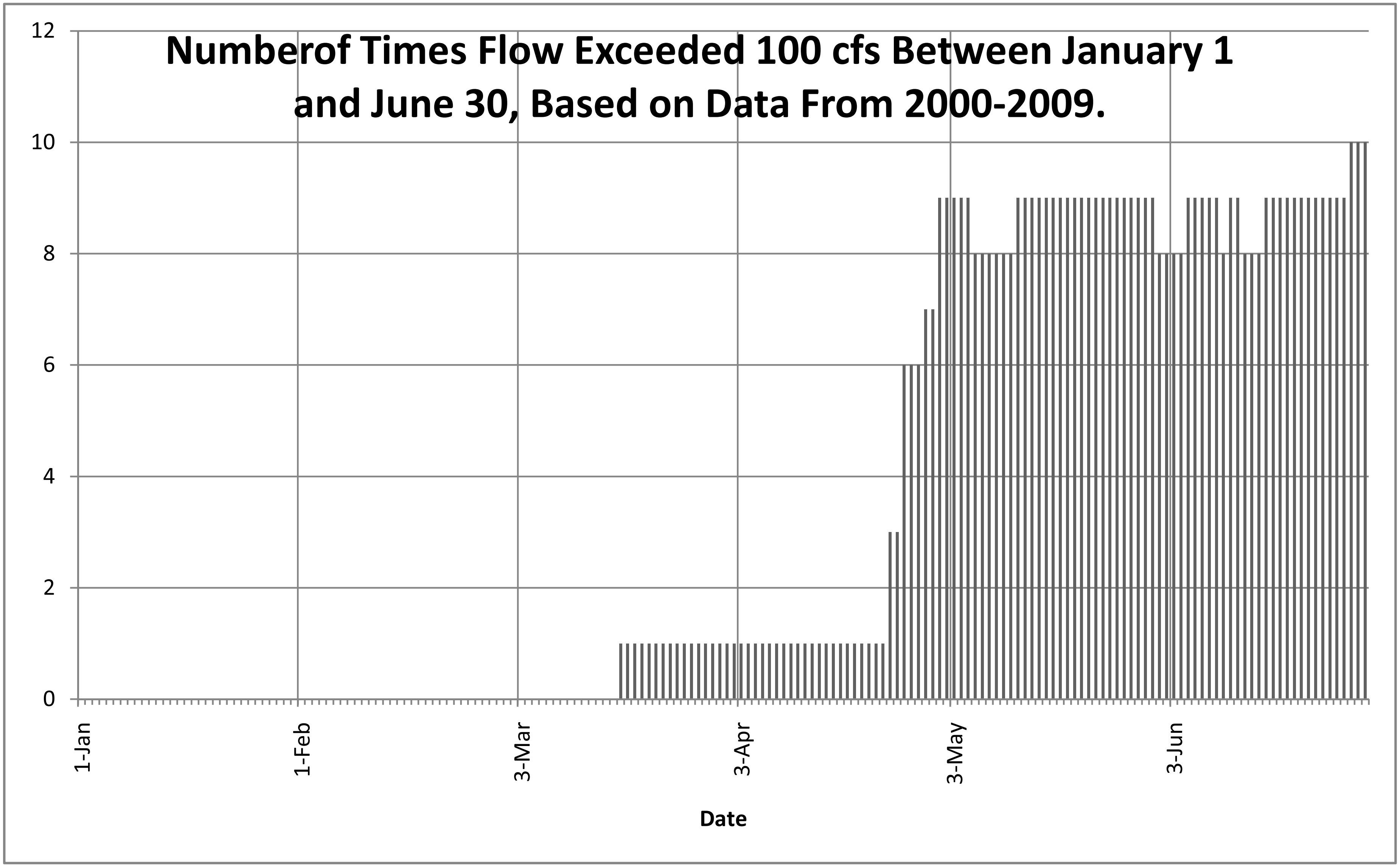


Figure 5-2. Temperatures at the Range of Mason Dam Intake Elevations. Based on 2007 Data.




Numberof Times Flow Exceeded 100 cfs Between January 1 and June 30, Based on Data From 2000-2009.
12
10
8
6
4
2
0
1-Jan
1-Feb
3-Mar
3-Apr
3-May
3-Jun
Date