Attachment 10

Determination of Appropriate Ecological and Channel Maintenance Flows for Drift Creek Downstream of the Proposed Dam

Drift Creek Dam Project
Marion County, Oregon

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1.0 Introduction

This report presents results of analyses used to estimate appropriate ecological and channel maintenance flows for the 6.5-mile reach of Drift Creek downstream from East Valley Water District's proposed dam site. Ecological flows refer to those flows that fish and aquatic organisms require to trigger or allow activities such as migration, spawning, off-channel use of flood plain habitat on large rivers, and initiation of different life stages of certain aquatic insects. Channel maintenance flows or flushing flows are those flows that provide conditions conducive to maintaining stream morphology and habitat where the concern is more long-term and intermittent in nature.

At the present time, there is no universally accepted methodology for determining ecological and channel flushing flows. In 2007, Oregon Department of Fish and Wildlife (ODFW) published a white paper entitled "Calculating Channel Maintenance/Elevated Instream Flows When Evaluating Water Right Applications for out of Stream and Storage Water Rights" (Robison, 2007). This paper provides what we believe is an adequate approach for evaluating the ecological and flushing flow requirements on lower Drift Creek. We are aware that additional guidance on determining ecological and flushing flows is being developed by the Oregon Water Resources Department (OWRD) Ecological Flow Technical Advisory Group (EFTAG) and that they have published an interim white paper that provides a summary and overview of the procedures used in other parts of the United States. However, EFTAG has not yet developed any specific guidance for determining ecological or flushing flows for Oregon waters. If EFTAG develops specific guidance in the future that differs significantly from the approach taken in this report, their study guidelines will be reviewed and evaluated relative to the approach and findings reported herein. The determination of whether East Valley Water District would be required to conduct additional analysis under future EFTAG guidelines will likely be determined through consultation with OWRD and ODFW.

2.0 Regulatory Flow Requirements

Oregon House Bill 3369 provided grant and loan programs for agricultural water conservation and development projects. This bill was passed and became ORS 541.600 – 646 in 2009. Language in ORS 541.631 states that the Oregon Water Resources Department (OWRD) "may require that a project protect peak and ecological flows to the extent determined by the State Department of Fish and Wildlife (ODFW)," and that a project only be funded if "there is a reasonable certainty that the project, considered in total, will deliver a measurable net environmental public benefit." ORS 541.646 states that applications for grant funds include, "an analysis of by-pass, optimum peak, flushing and other ecological flows of the affected stream and of the impact of the project on those flows, that conform to standards set by the department in consultation with ODFW and other relevant agencies." The overriding provision of the statute is that a funded project must deliver a "measurable net environmental public benefit."

Regardless of whether the East Valley Water District intends to apply for grant money provided under ORS 541.600, all water right applications must provide for the protection of "instream

values"(OAR 690-410-0070 (2(a))). These instream values are undefined and established by OWRD through consultation with ODFW. ODFW interprets its role broadly in consulting on new water rights with OWRD. Their consultation includes recommending flows to be protective of threatened and endangered species under OAR 690-033-0220 and OAR 690-033-0230. ODFW consultation has also expanded to include specific recommendations for the release of peak flows (e.g Robison, 2007) on evaluating the need for channel maintenance and elevated flows when providing consultation to OWRD on water right/permit applications. What this means in practice is, that as part of the water right application review process, OWRD consults with ODFW to ensure that instream values are protected; to evaluate the need for elevated channel maintenance flows; and to assess potential project impacts on sensitive, threatened or endangered species. ODFW issues instream flow recommendations, which can be adopted by OWRD as conditions of the permit.

3.0 Description of Drift Creek Watershed and Study Area

The Drift Creek Watershed encompasses approximately 25 square miles and is located in the foothills of the western Cascade Mountains east of Salem, Oregon. Drift Creek is a 4th order stream and is a tributary to the upper Pudding River, entering at approximately RM 49.The headwaters of Drift Creek are located primarily on managed forestlands on steep terrain. These headwater streams consolidate into the East and West Forks of Drift Creek, which combine to form mainstem Drift Creek at approximately RM 9.5. There are presently no impoundments or storage diversions in the watershed; however, there are a number of small water rights for active flow diversions during the irrigation season and ODFW has an instream water right for protection of fisheries resources. Most of the irrigation water rights are located downstream of the proposed dam site.

Most of the annual precipitation in the Drift Creek watershed occurs as rain. Some snow accumulation may occur in cool years in the upper watershed but snowmelt contributes very little to the annual runoff pattern. Most of the precipitation and runoff occurs from November through May, with the months of November, December and January usually receiving the highest precipitation.

Streamflow data for Drift Creek are limited. Marion County Soil and Water Conservation District (MCSWCD) established a flow gauging station near the Victor Point Road crossing (RM 6.2) in the fall of 2008 and has data for the period October 2008 through November 2009. East Valley Water District has continued to monitor the flow at the Victor Point Road crossing and has compiled the flow data for two complete water years (i.e., 2008-2009 and 2009-2010) (EES 2011). Flow data are continuing to be collected in 2011. A second gauge monitored by MCSWCD was established earlier in 2008 near the mouth of the creek at Hibbard Road bridge (RM 0.5) and provides comparable flow data to the Victor Point bridge site for the same time period. Based on regional precipitation records, the 2008-2009 water year was a low precipitation year and streamflows were close to historic low flow conditions. The 2009-2010 water year was more typical of average year flow conditions based on comparisons with flows in other nearby streams with longer periods of record.

Figure 1 shows the gradient profile from the headwaters to the mouth of the creek. The highest point in the watershed is at approximately 1,760 feet mean sea level (MSL) and the lowest is

approximately 160 feet MSL. The headwaters of both the East and West Forks of Drift Creek consist of small high gradient 1st and 2nd order streams. As these small streams consolidate into the third order East and West Forks, they reach a plateau were the gradient is low and the land use transitions from forestry to agriculture (mostly Christmas tree farms, grass lands, and cattle pastures). From the first plateau, both streams drop through relatively steep canyons where the stream gradients increase substantially. On the East Fork, there is a large falls and a secondary smaller falls where much of the drop in elevation occurs. On the West Fork there are numerous cascades and steep rapids over primarily boulder and cobble substrates. At the confluence of the East and West Forks the gradient drops again as Drift Creek enters the low gradient valley floor where the proposed storage reservoir would be located. The creek meanders over the valley floor for approximately 3.2 miles. At the proposed dam site the average bankfull width is approximately 35 feet. Below the dam site the gradient increases and remains nearly constant at about 1.5 percent for approximately 6.0 miles as it flows through a mostly forested canyon to the Willamette Valley floor. Substrate in this reach is predominately bedrock, boulders and large cobble. The last 0.5 miles of Drift Creek is a low gradient section winding thorough farmlands until it joins the Pudding River.

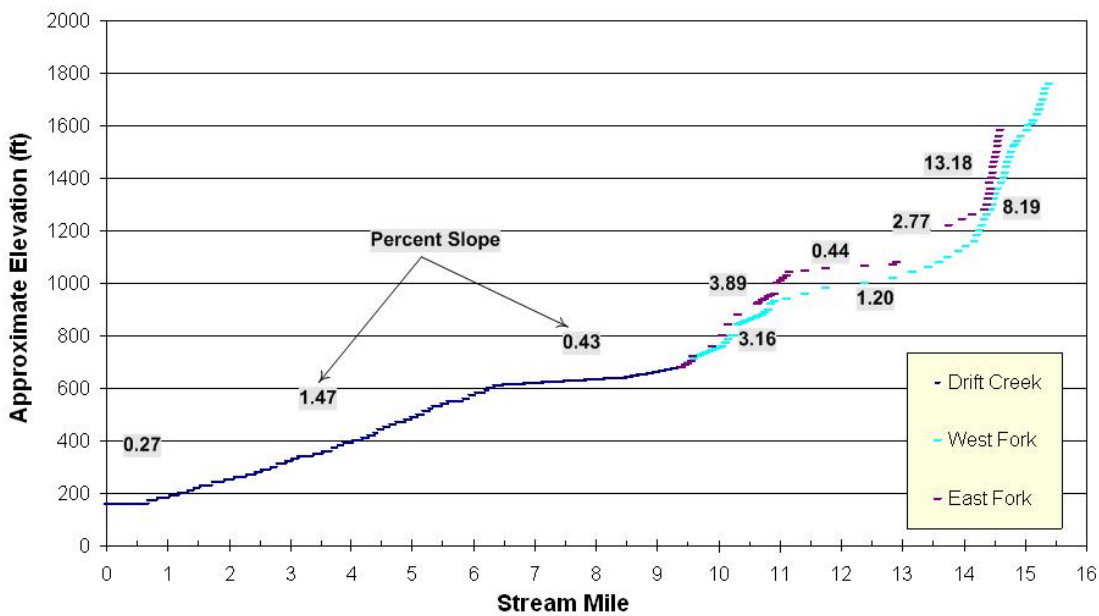

Figure 1. Gradient changes in Drift Creek from headwaters to mouth.

4.0 Methods

4.1 Ecological Flow Analyses

As discussed in Robison (2007), fish and other aquatic organisms are known to key certain activities such as migration or spawning to changes in environmental conditions such as water temperature, turbidity, daily sunlight, or flows. Usually these conditions need to occur on a regular basis and need to be provided to enable the survival of the species.

The first step in an ecological flow analysis involves identifying potential target species. Generally target species are gamefish or special status species (e.g., state or federal threatened or endangered species). Fish sampling was conducted within the proposed reservoir footprint and at several downstream locations during 2005, 2006 and 2009 (EES 2005; EES 2006; EES 2010). Cutthroat trout and coho salmon were the only game fish found in these samples. Coho salmon are not native to the Willamette River basin upstream of Willamette falls and are not listed as threatened or endangered. No steelhead or chinook salmon, which are federally listed threatened species, were collected and none have been reported from the Drift Creek watershed in recent history. However, since coho salmon have been observed as far upstream as the upper end of the proposed reservoir, it can be assumed that steelhead trout could potentially access the stream beyond the dam site. Small numbers of lamprey ammocetes were also found within the reservoir footprint and although keys were not available to identify ammocetes to species level, it is reasonable to assume that some of the ammocetes were the migratory Pacific lamprey. The only other migratory fish species collected was largescale sucker, which is known to migrate from rearing areas to spawning areas. Other fish species present included northern pikeminnow, speckled dace, redside shiner and reticulate sculpin. One yellow bullhead and one juvenile largemouth bass were collected near the mouth of the creek. From the list of fish known to occur or which could potentially occur in Drift Creek, the following were selected as potential target species for ecological flow analysis:

- Cutthroat trout
- Coho salmon
- Steelhead trout
- Pacific lamprey
- Largescale sucker

In determining the significance of an ecological triggering flow for the potential target species, Robison (2007) recommends that the following criteria should be included:

1. Is an elevated streamflow actually triggering a life stage or activity that would otherwise likely not occur without the increased streamflow or is elevated streamflow merely enhancing it;
2. Is the life stage activity crucial for survival of the target species;
3. Is the effect of the ecological trigger flow documented by indicating correlation in species abundance with the occurrence of the triggering flow or by studies showing population decline when elevated streamflows are reduced?

Each of these criteria were assessed, where information was available, for each target species. The individual results were then consolidated and recommendations developed.

4.2 Flushing Flow Analysis

The objective of channel maintenance or flushing flows is to provide conditions conducive to creating or maintaining stream morphology and habitat where the concern is more long-term and intermittent in nature. The primary focus of the flushing flow guidance provided in Robison (2007) is on methods for determining streamflows in which bed movement occurs. Bed movement in streams is a function of flow, channel type and streambed composition. Streambed

composition is considered the major determinant of a maintenance flow regime with a) sand bed streams, b) gravel bed streams and c) coarse bed streams needing different flow prescriptions. This is because the discharge level that can move the streambed is directly related to substrate size and characteristics (Knighton, 1998).

4.2.1 Assessing Streambed Conditions

Streambed conditions were determined at the "reach scale". A "reach" is a length of stream that has similar morphology characteristics that can be anywhere from 100 feet to over a mile long. The majority of the stream channel between the proposed dam site and the confluence of Drift Creek with the Pudding River was surveyed during September 2009 and a shorter section was surveyed in late October 2009. Both sections were surveyed under low flow conditions. Two survey methods were utilized (i.e., detailed reach surveys and general observations of habitat conditions while walking the creek bed).

4.2.1.1 Detailed reach surveys

Reach survey methods were based on ODFW habitat survey methods for the aquatic inventory project (ODFW, 2008). The ODFW methods collect data on habitat "reaches." Typically, reaches are delineated by named tributaries, changes in valley and channel form, major changes in vegetation type, or changes in land use or ownership. However, reaches can also be defined simply as the distance surveyed.

Within the survey reaches are individual habitat units. Units are relatively homogeneous lengths of stream that are classified by channel bed form, flow characteristics, and water surface slope. Individual units are formed by the interaction of discharge and sediment load with the channel resistance (roughness characteristics such as bedrock, boulders, and large woody debris). Channel units are defined (in priority order) based on characteristics of (1) bedform, (2) gradient, and (3) substrate. The typical channel morphologies used to describe habitat are riffles, runs (or glides) and pools. However, the ODFW methodology also includes cascades, steps and rapids, and further sub-categorizes each of these morphologies. For instance, within the larger "pool" unit class are: plunge pools, straight scour pools, lateral scour pools, trenched pools, dammed pools and beaver dam pools. In addition to data on stream morphology, information is collected on valley form, channel shade, substrate makeup, LWD, and riparian conditions. A detailed description of the ODFW methodology can be obtained from:
http://www.science.oregonstate.edu/~madsenl/TIESNA2009/Habitat_protocol.pdf.

The ODFW methods were designed to survey an entire stream, from mouth to headwaters. Because collecting data on all units over the entire length of Drift Creek was beyond the scope of this survey, survey reaches were defined *a priori* as segments of stream equal in length to approximately 20 stream widths. The locations of the survey reaches were selected to be representative of different habitats present in Drift Creek: Survey Reach 1 was located in the lower agricultural region, approximately 25 feet upstream of the confluence with the Pudding River and continued upstream for 390 feet; Survey Reach 2 was located outside the flood plain and silt/clay deposits of the Pudding River, where relief in the Drift Creek valley is slightly higher, but land use is still agricultural at approximately RM 1.8, continuing upstream for 650 feet; Reach 3 was located in a steep-sided wooded valley at approximately RM 3.7, continuing upstream for 440 feet; and reach 4 was located in flatter topography above the steep-sided valley

at approximately RM 5.6, continued upstream for 300 feet. Study Reach 1 was considered representative of the conditions from the mouth of Drift Creek upstream to RM 0.4; Reach 2 was representative of conditions from RM 0.4 to RM 2.5; Reach 3 from RM 2.5 to RM 5.4; and Reach 4 from RM 5.4 to the proposed dam site at RM 6.5. Pebble counts were also conducted at each reach and just downstream of the Hibbard Road bridge (RM 0.5) using the methodology described in Bauer and Burton (1993). The pebble count data were compiled and cumulative frequency graphs were constructed (also using the methods described in Bauer and Burton, 1993) to calculate the median particle size (D50) at each sampling station.

4.2.1.2 General Observations of Channel and Substrate Conditions:

Outside of the detailed study reach locations, the creek bed was walked, and notes were taken on the general habitat conditions, including bank erosion, substrate type, condition of the riparian zone, locations of significant large woody debris (LWD), beaver dams, obstructions and other features likely to influence the suitability of Drift Creek as fish habitat. Photographs were taken both within the detailed reaches and throughout the surveyed areas.

4.3 Methods for Estimation of Recurrence Flows

Recurrence flows refer to the frequency of certain levels of flow in a stream channel. Typically, recurrence flows are related to the frequency of flood flow events such as the 2-year, 10-year, 25-year and 100-year flood flows. In streams with substrates consisting of gravel and small cobble, bed movement usually begins at flows approximating the bankfull flow condition (Rosgen 1996). For a data set of mostly larger Pacific Northwest Rivers (Castro and Jackson 2001), recurrence intervals for bankfull flow conditions were found to vary between 1-3 years with a mean of 1.4 years. In streams with coarse bed substrates, bedload movement may not start until flows reach a 2- or 3-year flow event (Robison 2007). Robison (ibid) emphasizes the importance of determining at least the 2-year and bankfull flow conditions in a flushing flow analysis.

Since Drift Creek has very little gauged flow information, estimation of bankfull and 2-year flow levels could not be based on a hydrologic record. For this un-gauged watershed, two different methods were employed to estimate peak flow recurrence intervals. The first method was the use of a general prediction equation available on-line from Oregon Water Resources Department for Western Interior Watersheds with elevations <2,875 feet. Their prediction equation takes the form:

Q(T) = (10.0^CO (T))*(CHR1^(T))*…CHRn^Cn(T))

Where:

Q(T) = Peak Discharge for Return Period T
Cx(T) = Coefficient of x for Return Period T
CHR1 = The First Watershed Characteristic
CHRn = The nth Watershed Characteristic

Note: * = multiplication, ^ = exponentiation

For western interior watersheds with mean elevations below 2,875 feet, peak flows are estimated using the prediction equations for western interior watersheds below 3,000 feet. The prediction equation for interior watersheds < 3,000 feet is as follows:

Q(T) = (10.0^CO(T)) * (X1^C1(T)) * (X2^C2(T) *(X3^C3(T)) * (X4^C4(T)) *(X5C5(T))

Where:

Q(T) = Peak Discharge for Return Period T
Cx(T) = Coefficient x for Return Period T
X1 = Drainage area (square miles)
X2 = Mean watershed Slope (degrees)
X3 = 2-year 24-hour precipitation intensity (inches)
X4 = NA
X5 = NA

Note: * = multiplication, ^ = exponentiation, NA = not applicable

Prediction equation coefficients used in the equation were:

Return Period T	CO (T)	C1(T)	C2(T)	C3(T)	C4(T)	C5(T)
2	9.607E-01	9.004E-01	4.695E-01	8.481E-01		
5	1.162E+00	9.042E-01	4.73E5-01	7.355E-01		
10	1.267E+00	9.064E-01	4.688E-01	6.937E-01		
20	1.351E+00	9.081E-01	4.633E-01	6.651E-01		
25	1.375E+00	9.086E-01	4.615E-01	6.578E-01		
50	1.443E+00	9.101E-01	4.559E-01	6.390E-01		
100	1.503E+00	9.114E-01	4.501E-01	6.252E-01		
500	1.620E+00	9.141E-01	4.365E-01	6.059E-01		

The drainage area upstream from the proposed dam site (square miles) = 15.5 .miles
Mean watershed slope (degrees) = 7.87
2-year 24-hour precipitation intensity (inches) = 2.560

Bankfull flow conditions for Drift Creek near the proposed dam site and near the creek mouth were estimated using methods outlined in Robison (2007). Three cross sections were surveyed: one just upstream of Victor Point Road (xsec 1) near the proposed dam site; one in Habitat Survey Reach 4 (xsec 2) about 1 mile downstream from the dam site; and one downstream of Hibbard Road (xsec 3) about 0.5 miles upstream from the creek mouth. Survey methods followed those outlined in Harrelson et al. (1994). Head stakes and tailpins were installed and surveyed to an arbitrary benchmark at each transect. A tape was strung across the river and the cross-section profile was surveyed with an engineer's rod and level. Bankfull stage was determined using methods outlined in Rosgen (1996). A low-water surface gradient was measured by determining the distance and elevation difference from the upper to lower ends of the habitat unit containing the cross section (in all cases a run with riffles at the upper and lower end). A high-water gradient was obtained by determining the distance and elevation difference between the bankfull stage at the farthest points visible along the bank without moving the level. In each case, the distance from the upstream to downstream measurements for the highwater stage was between 11 and 15 bankful widths. Gauge readings were obtained from the MCSWCD gauges at Victor Point and Hibbard Roads. Flows for the upper two transects were

estimated based on the Victor Point Road gauge and flow for the lower transect was based on the Hibbard Road gauge.

The cross section and gradient data were input to WinXSPRO, obtained from the Stream Systems Technology Center (http://www.stream.fs.fed.us/publications/winxspro.html). WinXSPRO is a model that estimates bankfull flow conditions. User supplied Manning's n was used as the analysis option. The Manning's n values were adjusted for the "low flow" discharge (discharge at the time of field data collection) to achieve the flow indicated by the Marion County SWCD gauges. Manning's n values were decreased for the high flow discharges based on typical Manning's n values for similar substrates supplied in the WinXSPRO manual (Hardy et al., 2005).

5.0 Results

5.1 Ecological Flows

The East Valley Water District will probably seek a fish passage waiver from the Oregon Department of Fish and Wildlife (ODFW) for the proposed dam. Preliminary discussions regarding the fish passage waiver option have been conducted with ODFW staff and it appears likely that a passage waiver would be the preferred option due to passage facility limitations associated with summer low flows and reservoir water surface elevation fluctuations. Therefore, for the ecological flow assessment, it was assumed that fish migration would be blocked at the dam site and that the assessment would focus on the reach of stream between the dam site and the mouth of Drift Creek.

Use of the reach of Drift Creek downstream of the dam site by each of the target species is described below based on fish sampling conducted in 2006 and 2009 and on known habitat requirements and life histories of the various species. Also, for each species a discussion is presented relative to the following three criteria:

1. Is an elevated streamflow actually triggering a life stage or activity that would otherwise likely not occur without the increased streamflow or is elevated streamflow merely enhancing it;
2. Is the life stage activity crucial for survival of the target species;
3. Is the effect of the ecological trigger flow documented by indicating correlation in species abundance with the occurrence of the triggering flow or by studies showing population decline when elevated streamflows are reduced?

5.1.1 Upper Willamette River Steelhead (threatened)

For Upper Willamette River Steelhead trout, we examined the role of elevated flows on adult upstream migration and juvenile downstream migration. No other life stages or activities were identified that potentially could require specific elevated flows.

Upper Willamette River Steelhead trout are winter run steelhead, which move upstream over Willamette Falls after February 15. ODFW biologists estimate that adult winter steelhead migration in the Pudding River extends through May (2003).

Despite scattered historical reports of steelhead presence, and known use of Pudding River tributaries such as Abiqua Creek, Butte Creek and Silver Falls Creek, there have been no recent observations of steelhead use of Drift Creek (PWA 2005). None were captured during the fish sampling conducted by Ellis Ecological Services, Inc in 2005, 2006 or 2009 at various sampling locations within Drift Creek. However, because coho salmon have been observed to spawn and rear in Drift Creek upstream of the dam site, it is considered possible that steelhead also could access available spawning habitat.

Winter steelhead preferred spawning substrates are the alluvial deposits and gravel substrates found in unconstrained channels with gradients ranging from one to five percent (Steel et al., 2004). Suitable spawning gravel ranges from 1.3 cm to 11.4 cm diameter in water velocities of approximately 76.2 cm/sec (Pauley et al 1986). Very little substrate in this size range was found during habitat surveys conducted in 2009 between the dam site and the mouth of Drift Creek.

The three criteria used to determine the need for ecological flows for winter steelhead trout are discussed below relative to available information.

Criterion #1 *- Is an elevated streamflow actually triggering a life stage or activity that would otherwise likely not occur without the increased streamflow or is elevated streamflow merely enhancing it?*

Adult winter steelhead in the Pudding River watershed move upstream to spawning areas over an extended period of time (ODFW 2003). In many streams, upstream movement of adult steelhead is often highest during declining flows following high flow events (Karp et al. 2005). However, winter steelhead will move upstream during stable flow conditions as long as there are appropriate depth and water velocity conditions (Bjornn et al. 2003). For example, daily adult steelhead returns reported by PGE (2009) in the Clackamas River compared to daily mean flows for the same period illustrate that steelhead migrate upstream over a wide range of flow regimes (Figure 2). When flows are very low and there are numerous areas of very shallow water, movement will stop (McEwen and Jackson 1996). It appears therefore, that with the exception of streams that have extended periods of very low flows during the spawning migration period, elevated flows enhance upstream migration but are not essential for this activity.

It has been reported that seven inches of water across 25 percent of the channel is the minimum depth required for successful migration of adult steelhead (Thompson 1972 as cited in Barnhart 1986). We measured depth across two representative channel transects near the dam site during flow conditions of about 30 cfs and one transect near the mouth of the creek at about 38 cfs in February 2010. At these flows, much of the wetted channel was over one foot in depth. A walking survey from the dam site to the mouth, conducted as part of the habitat survey, indicated that the conditions measured at the three cross sections in February 2010 were representative of conditions throughout the reach and that there did not appear to be extensive areas of very shallow riffle habitat or barriers, which could represent a significant obstacle to adult upstream movement.

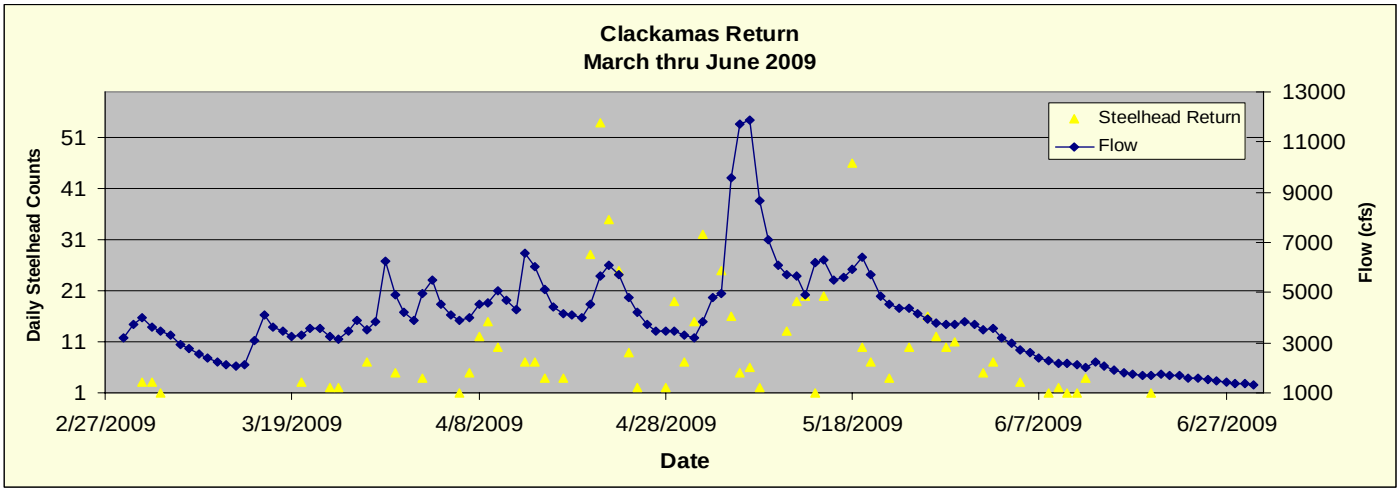

FIGURE 2. Daily fish counts at the North Fork Dam trap on the Clackamas River versus mean daily flow.

ODFW has an instream flow water right of 40 cfs at the mouth of Drift Creek from November through April and a 30 cfs water right for the month of May. Because of the ODFW water right, the proposed storage facility would be required to pass natural flows until the water right was exceeded. Based on a runoff yield analysis for Drift Creek prepared by Dr. Tanovan (see "Runoff Yield Analysis" Technical Report) and Drift Creek reservoir modeling conducted by Portland State University (see "Drift Creek Reservoir Model: Model Development and Scenarios Report" Technical Report), it is predicted that in most years the reservoir will be full by January 1. This assumes an irrigation withdrawal of 8,000 acre-feet, which East Valley Water District believes is a reasonable estimate of their foreseeable irrigation needs. Filling could take somewhat longer if the maximum irrigation demand of approximately 11,000 acre - feet is used. In either case, natural flow conditions will exist during most of the period when steelhead could potentially be migrating upstream into Drift Creek.

Flows during February through May often exceed 40 cfs at the dam site. Therefore, there should be substantial periods when flows of 40 cfs or more could be maintained at the creek mouth. Maintenance of the natural flow regime and compliance with ODFW's water right for 40 cfs at the mouth through April and 30 cfs at the mouth through May should allow unimpeded upstream migration throughout the reach below the dam. However, under existing conditions, there is little reason for steelhead to migrate to this reach of the creek since spawning habitat is generally lacking.

Downstream migration of juvenile steelhead also occurs over an extended period of time in the Pudding River watershed, with peak outmigation occurring in April and May. Water temperature as well as elevated flows have been reported as possibly influencing downstream movement of steelhead smolts in other streams (Bergrenn 1993). However, outmigration does occur under relatively stable flow conditions (Bjornn 1971). Therefore, we conclude that elevated flows may enhance out-migration but are not essential for this activity.

Criterion #2 *- Is the life stage or activity crucial for survival of the target species?*

Upstream migration to spawning habitat is crucial for survival of the winter steelhead. Downstream migration of juvenile steelhead is also crucial for survival of the population.

Criterion #3 *- Is the effect of the ecological trigger flow documented by indicating correlation in species abundance with the occurrence of the triggering flow or by studies showing population decline when elevated streamflows are reduced?*

With the exception of streams that typically experience very low flow conditions during the spawning period, no evidence was found to indicate that elevated flows during the spawning migration were correlated with species abundance or that declines in populations occurred when elevated streamflows were reduced during the spawning migration as long as flow levels were sufficient to allow upstream movement.

Likewise, we found no evidence to indicate that elevated flows during the juvenile out-migration period were correlated with species abundance or that declines in populations occurred when elevated streamflows were reduced during the outmigration period. Given the existing instream flow water rights on Drift Creek, more than adequate flows should be available for successful out-migration of smolts.

5.1.2 Migratory Cutthroat Trout

For cutthroat trout, we examined the ecological flow requirements for adult migration and for juvenile migration in the affected reach of Drift Creek below the dam site. It is generally believed that a component of the cutthroat trout population in the Pudding River watershed exhibits seasonal migratory movements from small headwater streams where they spawn to rearing habitat in larger streams or rivers and then back again to the small headwater streams(Nichols 1978, Kavenaugh 2006). This migration pattern is referred to as potamodromous or river-migrating. Cutthroat trout adult migration through the Pudding River tributaries primarily occurs from mid-October through the end of January, however some movement occurs through the end of March (ODFW 2003). Juvenile migration probably occurs year round (ibid) in areas where water temperatures are suitable.

ODFW timing tables for Drift Creek report potential spawning from January through May. Preferred cutthroat spawning habitat occurs in waters 3.5 to 11.8 inches deep with velocities ranging from 6.2 to 23.6 in/s. Suitable substrate is silt free gravel less than 3.4 inches in diameter (Matchtinger and Boyle, 2007). Very little suitable spawning substrate for cutthroat trout was found in the reach below the dam site.

Cutthroat alevins emerge as fry between March and June, with peak emergence in mid-April (Giger 1972, Scott and Crossman 1973). At emergence, fry quickly migrate to channel margins and backwaters with low stream gradients, where they remain throughout the summer (Edie 1975, Glova and Mason 1976).

In the absence of other species, cutthroat trout prefer to rear in pools (Giger 1972), but when coho salmon are present, the cutthroat juveniles move to less preferred, low gradient riffle areas, where they remain until displaced by winter flows (Glova and Mason 1977, Glova 1987). In

winter, the cutthroat trout go to pools near log jams or overhanging banks (Bustard and Narver 1975).

The three criteria used to determine the need for ecological flows for cutthroat trout are discussed below relative to available information.

Criterion #1 *- Is an elevated streamflow actually triggering a life stage or activity that would otherwise likely not occur without the increased streamflow or is elevated streamflow merely enhancing it?*

Timing of adult movements likely reflects responses to changes in discharge and water temperature (Hildebrand and Kershner 2000). Within Oregon streams, population scale movements generally increase with increasing discharge. A study of cutthroat trout in western Oregon using over 800 PIT and radio tagged cutthroat found that seasonal cutthroat trout movements decreased from August through October during low flows (0.02 m^3/s), increased moderately from October through February as discharge increased and peaked in April as temperatures rose above 8 °C (Gresswell and Hendricks, 2007). These observations suggest that increasing flows during the fall and early winter are important for triggering upstream adult movements.

After emergence from redds, cutthroat trout juveniles generally remain in upper tributaries until they are 1 year of age, when they may begin extensive movement up and down streams. Directed downstream movement by parr usually begins with the first spring rains (Giger 1972) but has been documented in every month of the year (Sumner 1962, 1972; Giger 1972; Moring and Lantz 1975; Johnston and Mercer 1976; Johnston 1981). In Oregon, upstream movement of juveniles from mainstem to tributaries begins with the onset of winter freshets during November, December, and January (Giger 1972, Moring and Lantz 1975). At this time, these 1-year and older juvenile fish average less than 200 mm in length.

From these reviews of migratory behavior, it appears that increasing flows during the late fall and early winter are important triggers for both adult and juvenile cutthroat trout. Downstream movements of adult and juvenile cutthroat trout may increase with higher flows but high flows do not appear to be critical for downstream movements in that the literature indicates such movements can occur throughout most of the year.

The existing ODFW instream water right for fish flows in Drift Creek increases from 3.0 cfs to 5.26 cfs on October 16 then increases to 20.0 cfs November 1 and to 40.0 cfs on November 16. The proposed project would be required to bypass water until these flow requirements were met at the creek mouth. Therefore, it is anticipated that during the fall and early winter, flow conditions downstream of the dam would follow much the same pattern as they do under present conditions. This flow pattern should provide more than sufficient change in flow to stimulate upstream migration of returning adults and juveniles in the fall and early winter months. Note that the runoff yield analysis prepared by Dr. Tanovon, indicates that under heavy runoff conditions during November and December the flow released from the dam could be less that 1 cfs and still meet the 40 cfs fish flow requirements at the mouth of the stream. This means that there would be a gradual diminution of flow moving upstream toward the dam. At some point

near the dam, flow could drop to levels that would interfere with upstream migration of adult cutthroat trout. These conditions are not expected to persist for extended periods of time and would not be expected to affect any areas suitable for cutthroat trout spawning.

Temperature of the water discharged from the reservoir during the winter and early spring months would be expected to be similar to the existing ambient water temperatures since the reservoir would be completely mixed. Therefore no additional flow releases beyond those required by the existing ODFW instream water right would be required to ensure that water temperatures for adult and juvenile cutthroat trout upstream or downstream migration are in the temperature appropriate range.

During the summer low flow period, use of the lower portion of the reach below the dam site is probably restricted due to high water temperature. Water temperature data collected at two locations downstream from the dam site indicated that temperatures reach levels during the summer months that are considered harmful to cold water fish species such as cutthroat trout. The dam would allow the release of cool water from below the hypolimnion during the summer months and is expected to substantially improve temperature conditions throughout the reach (see Drift Creek Reservoir Model: Model Development and Scenarios Report). Improvement of water temperature conditions would expand the period in which both juvenile and adult cutthroat could move freely within the reach. However, low flow conditions could restrict movements if water depth between holding areas becomes limiting, as is probably the case in dry years under existing conditions.

Criterion #2 *- Is the life stage or activity crucial for survival of the target species?*

Short-term interference with adult cutthroat trout migration would probably not be crucial for survival of the migratory component of the population since the adults that remain in the stream as residents could become migratory at some point and some of the resident adults would be expected to carry the migratory trait and pass it on to their offspring. Long-term interference with adult movements potentially could eliminate the migratory component of the population and reduce the population's ability to respond to changing conditions.

The ability of juvenile cutthroat trout to move within the channel is important for their survival if summer water temperature in parts of the reach attain levels that cause mortality. The ability of juveniles to migrate to cooler areas in the reach would therefore, be important for their survival. Often juveniles and adults move to deep, stratified-pool habitat to avoid high water temperatures. Unfortunately, the reach below the dam has very little deep pool habitat. As noted above, the proposed dam is expected to reduce summer water temperature throughout the reach and remove the need for juveniles to find cool water refuges during the summer months.

Criterion #3 *- Is the effect of the ecological trigger flow documented by indicating correlation in species abundance with the occurrence of the triggering flow or by studies showing population decline when elevated streamflows are reduced?*

Most of the literature on effects of flow on cutthroat trout deals with effects of flow reduction or on severe flow fluctuation. We found no studies that showed a direct correlation in abundance of

cutthroat trout and the occurrence of triggering flows. It can probably be inferred that if flows did not increase in the fall and winter and remained at low summer flow conditions upstream migration of adults and juveniles to headwater reaches would be reduced or eliminated. Such an interference with migration could result in reduction in abundance within the affected stream.

In Drift Creek, fish sampling did not indicate the presence of a migratory component of the population and very few cutthroat trout were captured downstream of the dam site. Therefore, the provision of triggering flows beyond that provided by the required instream water right does not appear to be required to maintain the cutthroat trout population in the watershed. It is likely that with the reservoir present, some of the adult and juvenile cutthroat trout in the East and West Branches of Drift Creek will move downstream and rear in the reservoir during part of the year and then move back upstream to spawn and/or rear as flows increase in these tributaries during late fall.

5.1.3 Coho Salmon

Coho salmon migrate upstream through the Pudding River tributaries September through December, with peak travel times occurring mid-September through mid-November (ODFW 2003). Out migration of juveniles occurs from mid-February through mid-July, with a peak(s) usually occurring from mid-March through mid-June (ibid).

Coho salmon usually spawn in gravel (13 to 102 mm in diameter) in small streams with velocities of 0.3 to 0.5 m/seconds (Laufle, 1986). Redds are often found in the downstream end of pools that flow directly into riffles. Suitable substrate for coho spawning is very limited in the reach below the proposed dam site.

Under present conditions, the only documented spawning of coho salmon occurred in Fox Creek a small tributary located upstream of the proposed dam site. Construction of the dam would block access to this habitat. Therefore, provision of ecological trigger flows for coho salmon may be a moot point unless suitable spawning habitat becomes available downstream from the dam site.

The three criteria used to determine the need for ecological flows for coho salmon are discussed below relative to available information.

Criterion #1 *- Is an elevated streamflow actually triggering a life stage or activity that would otherwise likely not occur without the increased streamflow or is elevated streamflow merely enhancing it?*

In the Columbia River system, many adult coho salmon move upstream in the Columbia and larger tributaries such as the Willamette River during late August, September and October when smaller tributary streams such as those in the Pudding River watershed are experiencing low flow conditions. Usually, adults will mill around the mouths of the smaller streams until the first significant freshet occurs. The flows produced by a freshet provide the depth and water quality conditions that allow free upstream movement of the adults. Clearly, if flows were to remain so low that the adults could not reach their spawning grounds there could be a significant loss of production.

The 2009 coho spawning run to western Oregon streams was one of the largest in recent history and a number of spawners were observed in Fox Creek, a small tributary to Drift Creek located in the footprint of the proposed storage reservoir. The spawners were observed by a landowner during the last week in November. Stream flow data collected at Victor Point Road near the dam site, indicated that flows from November 17 through 25 ranged from about 55 to 85 cfs at the proposed dam site. Prior to this, flows were in the 10 to 20 cfs range. Therefore, it appears that upstream movement in 2009 was triggered by flows in the 55 to 85 cfs range in mid to late November at the proposed dam site.

As discussed above for steelhead, ODFW's instream water rights would require that all flows less than 40 cfs be bypassed after mid-November. Flows in the 40 cfs range at the mouth of the creek provide more than sufficient depth to allow adult coho to move upstream. It is likely that provision of natural flows up to 40 cfs during the October through November time frame would be sufficient to stimulate upstream movement of adults.

As discussed above for adult cutthroat trout, there could be conditions during periods of heavy runoff when flow release requirements at the dam could be minimal. Thus, upstream migration of adult coho could be held up by low flow conditions at some point below the dam. This is probably not of much concern under present conditions since there is no suitable spawning habitat for coho below the dam. However, if in the future, habitat improvements were made through gravel introductions and large woody debris placements, coho spawning and rearing could probably be developed in the mid-portion of the 6.5-mile stream reach below the dam. The presence of the dam could facilitate such habitat improvements through flow control and provision of better summer water temperature conditions for juvenile rearing.

ODFW's instream water right should also provide assurance that adequate flows for juvenile out migration are present during the spring out migration period. Generally, the outmigration period coincides with the period (April and May) when the reservoir will be full and natural flow conditions will prevail.

Criterion #2 *- Is the life stage or activity crucial for survival of the target species?*

Upstream migration to spawning habitat is crucial for survival of the coho salmon. Downstream migration of juvenile coho salmon is also crucial for survival.

Criterion #3 *- Is the effect of the ecological trigger flow documented by indicating correlation in species abundance with the occurrence of the triggering flow or by studies showing population decline when elevated streamflows are reduced?*

With the exception of streams that typically experience very low flow conditions during the spawning period, no evidence was found to indicate that elevated flows during the spawning migration were correlated with species abundance or that declines in populations occurred when elevated streamflows were reduced during the spawning migration as long as flow levels were sufficient to allow upstream movement.

Likewise, we found no evidence to indicate that elevated flows during the juvenile out-migration period were correlated with species abundance or that declines in populations occurred when elevated streamflows were reduced during the outmigration period. Given the existing instream flow water rights on Drift Creek, more than adequate flows should be available for successful out-migration of smolts.

5.1.4 Largescale sucker

Movements of adult largescale sucker within river systems have been documented and are generally thought to represent migration to and from spawning areas (Dauble 1986). Spawning occurs over a wide range of spawning substrates, water depths and water velocities (McCart and Aspinwall 1970).

The three criteria used to determine the need for ecological flows for largescale sucker are discussed below relative to available information.

Criterion #1 *- Is an elevated streamflow actually triggering a life stage or activity that would otherwise likely not occur without the increased streamflow or is elevated streamflow merely enhancing it?*

Available information on the life history and flow requirements of largescale sucker provides limited information relative to the importance of flow in triggering spawning migrations. A study detailing the life history and ecology of largescale suckers in the Hanford Reach of the Columbia River noted that peak upstream migration (as measured at the Priest Rapids fish ladder) occurred in June (Dauble 1986). The author was uncertain if this was a spawning or food migration however, he did note that spawning in the Hanford reach, which began as early as April, peaked in May and June as water temperatures reached 12-15°C and snow melt runoff increased. Spawning is generally reported to occur in spring as water temps increase to 6-12 °C and discharge increases from snowmelt runoff (Schmetterling 2006). From this limited information, it appears that water temperature is probably the primary key to spawning activity and that increases in flow are a secondary and probably not essential trigger.

Fish sampling below the proposed dam on Drift Creek by Ellis Ecological Services, Inc. in 2006 and 2009 indicated that the reach supported very low densities of largescale sucker and those that were collected were juveniles. Largescale sucker were found in greater abundance in the deeper slow-moving water within the proposed reservoir footprint, which is more typical habitat for this species.

Criterion #2 *- Is the life stage or activity crucial for survival of the target species?*

Migration of adult largescale sucker to spawning grounds is probably crucial for survival. However, the apparently wide range of suitable substrates and water depths used for spawning probably give this species an advantage in being able to utilize a range of spawning areas.

Criterion #3 *- Is the effect of the ecological trigger flow documented by indicating correlation in species abundance with the occurrence of the triggering flow or by studies showing population decline when elevated streamflows are reduced?*

No information was found that demonstrated correlation in largescale sucker abundance and the occurrence of triggering flows or studies showing decline in abundance when elevated streamflows are reduced.

Although the dam would block upstream movement of adult largescale sucker, it would provide new habitat for adult and juvenile rearing in the reservoir. Spawning could still take place upstream of the reservoir in the East or West Forks. With the exception of the very short section of Drift Creek upstream from its confluence with the Pudding River, habitat below the dam site is very poor for largescale sucker. Therefore, no ecological flows are recommended for this species.

5.1.5 Pacific Lamprey

Adult upstream spawning migration and newly metamorphosed adult downstream migration flow requirements were examined for Pacific lamprey.

The three criteria used to determine the need for ecological flows for Pacific lamprey are discussed below relative to available information.

Criterion #1 *- Is an elevated streamflow actually triggering a life stage or activity that would otherwise likely not occur without the increased streamflow or is elevated streamflow merely enhancing it?*

Adult Pacific lamprey leave the ocean and initiate freshwater upstream migration from March to mid-October; however migratory movement has been observed as late as January and February (Beamish 1980; Moyle 2002). Adults overwinter in freshwater and spawn the following spring (Beamish 1980). Upstream migration occurs over and extended period of time and specific high flow events have not been identified as a triggering requirement for upstream migration.

Spawning usually occurs in May and June, beginning when water temperatures reach 10-15°C (Close, 2002) in gravel bottomed streams, at the upstream end of riffle habitat, typically above suitable ammocoete larvae habitat (Moyle 2002). The young hatch in 2-3 weeks and swim to backwater or eddy areas of low stream velocity where sediments are soft and rich in dead plant materials. They quickly burrow into the muddy bottom where they filter the mud and water, eating microscopic plants (mostly diatoms) and animals. The juvenile lamprey will stay burrowed in the mud for 4 to 6 years, moving only rarely to new areas. High flow events which scour-out silty areas can result in ammocetes being displaced to downstream areas where they seek out suitable substrate and reburrow. This flow-related redistribution of ammocoetes does not appear to be essential for survival of the population. After a two-month metamorphosis, triggered by unknown factors, the ammocoetes emerge as adults, averaging 4.5 inches long. Then during high water periods, in late winter or early spring the new adults migrate to the ocean. Migration during normal spring high flows is probably an adaptation to increase the downstream rate of movement to the estuarine and oceanic environments where food availability is higher.

Criterion #2 *- Is the life stage or activity crucial for survival of the target species?*

Adult upstream migration to spawning grounds is crucial for survival of Pacific lamprey. Downstream migration of newly metamorphosed adults is also critical for completion of the anadromous life cycle.

Criterion #3 *- Is the effect of the ecological trigger flow documented by indicating correlation in species abundance with the occurrence of the triggering flow or by studies showing population decline when elevated streamflows are reduced?*

No studies were found that have correlated ecological triggering flows with the abundance of Pacific lamprey. In addition no studies showing population decline when elevated streamflow are reduced were found.

It should be noted that the habitat survey conducted in 2009 by EES, indicated that habitat suitable for lamprey ammocoetes was very limited downstream from the dam site. Only one or two ammocoetes (unknown species) were observed during electrofishing below the dam site and these were taken in the lower 0.5 miles of the reach. We conclude from review of the available information and the general lack of suitable habitat for Pacific lamprey downstream of the dam site that ecological flow releases are not required for this species at this location.

5.2 Flushing Flow Analysis

5.2.1 Substrate Characterization:

The lower 6.5 miles of Drift Creek downstream from the proposed dam site has very little recruitment of gravel or cobble substrate due to two primary causes. First, the 3.2 miles of very low gradient stream channel immediately upstream of the dam site acts as a settling-out reach for gravel and cobble washed downstream from the steeper parts of the watershed. Gravel and cobble deposits are apparent near the confluence of the East and West Forks of Drift Creek but little gravel or cobble is found in the meandering channel through the low gradient reach above the dam site. Therefore, the unique topography of the creek is an important controlling factor for gravel recruitment downstream of the dam. Second, there is very little gravel or cobble in the banks of the creek. In the slow meandering section of the creek upstream of the dam, the banks cut down through soil containing relatively little rock material. Downstream from the dam site very little exposed bank was found with gravel deposits that could erode into the stream channel. A short section of stream near the Hibbard Road crossing (RM 0.45) was the only area in the entire reach with exposed gravel banks.

The habitat survey conducted by EES in September and October 2009 under low flow conditions documented substrate conditions throughout the 6.5-mile reach of Drift Creek downstream from the dam. Details of the survey methods and the survey results are presented in the Habitat Assessment Technical Report. As indicated in Figure 1, the stream gradient for the first six miles downstream of the dam site is approximately 1.47 percent with little variation through the section. In the upper 5.7 miles of this section, substrate is predominately bedrock, large cobble and boulders. Plates 1 through 5 show typical conditions observed in this reach. In the lower 0.3 miles of this section, the substrate in predominately large cobble and boulder with relatively little exposed bedrock (Plates 6 and 7). Very little fine, medium or coarse gravel was found in the entire 6-mile section.

Pebble counts were taken at several locations within this section to describe typical substrate characteristics. The median particle size for gravel bed streams ranges from about 0.1 (2.5 mm) to about 2.5 inches (63.5 mm) anything over 2.5 inches (63.5 mm) is considered a coarse bed stream. Reach 2 unit 5 at approximately RM 1.2 was the only surveyed area that fell within the gravel bed category and that was at the very upper end of the coarse gravel category. All of the other samples fell within the coarse bed category. From our visual observations, coarse bed conditions should apply to all but the lower 0.5 miles of the survey reach.

The stream gradient decreases at about RM 0.5 near the Hibbard Road Bridge (Figure1). There is a short section where gravel and cobble washed downstream from the steeper gradient portion of the reach deposits on the streambed. This is also the section where gravel and cobble are exposed along the stream bank. A pebble count across a typical cross section in this area yielded a median particle size of 70 mm, which placed it in the coarse bed category.

Plate 1. Boulder/bedrock in mid-section of 6-mile section below dam site.

Plate 2. Large boulder substrate in mid-section of 6-mile section below dam site.

Plate 3. Patch of cobble substrate in upper part of 6- mile section downstream from dam site.

Plate 4. Typical boulder dominated substrate just downstream of Victor Point Road bridge in upper section of 6-mile section below the dam site.

Plate 5. Typical bedrock cascade found throughout upper and middle areas of the 6-mile section below the dam site.

Plate 6. Typical boulder/cobble substrate in lower 0.3 miles of 6-mile section below the dam site.

Plate 7. More boulder/cobble substrate typical of the lower 0.3-miles of 6-mile section below the dam site.

From approximately 400 feet downstream of the Hibbard Road bridge to the creek mouth, the steambed consists of a silty clay hardpan. The hardpan is resistant to erosion. Because there were no pebbles to count in this section, no pebble counts were conducted.

In summary, the 6.5 mile reach of Drift Creek below the dam site is largely a coarse bed stream channel. There is a very short section in the vicinity of the Hibbard Road bridge (RM 0.45) where some coarse gravel and small cobble are present that potentially could represent spawning substrate for steelhead trout. However, this area is near the lower end of the reach and suffers from high water temperature during the late spring when embryo development would be occurring. Therefore, it is unlikely that successful incubation of embryos would be possible in most years if spawning was to occur at this location. The remainder of the stream to the mouth is predominately a hardpan of silt/clay mixture and is resistant to flow-induced movement. We conclude therefore, that the flushing flows for the reach below the dam site should be based on requirements to move a coarse bed stream channel.

5.2.2 Estimation of Appropriate Flushing Flow for Coarse Bed Stream Channel:

The recommended flow to move substrate in a coarse bed stream channel is at least a two-year flood event (Robison 2007). The estimated 2-year peak recurrence flow for Drift Creek at the proposed dam site is 630 cfs with a 95 percent confidence limit of 336 cfs lower limit and 1180 cfs upper limit, based on the OWRD predictive equations.

As a secondary check on the OWRD 2-year peak flow estimate, we collected cross section data at three locations below the dam site and calculated bank full flow conditions using the WinXPro model. Each of the cross sections was plotted to an arbitrary benchmark (elevation 100), and the bankfull stage and stage at the time of the site visit were plotted (Figures 3 through 5). Adjusting the Manning's n values had the effect of approximating the low-flow discharge at the time of field data collection. With the given Manning's n values, velocities estimated for the known discharge were near those observed by EES staff during the data collection effort conducted to field verify the Marion County Soil and Water Conservation District Gage. Based on the slopes, cross-section profile, and given Manning's n values, the bankful discharge was estimated at 575 cfs for X-Sec 1; 536 cfs for X-Sec 2; and 753 cfs for X-Sec 3. Robison (2007) states that bankflow discharge in western Oregon typically has a recurrence interval of 1.4 to 1.6 years. A curve constructed from the two, five, ten, 20, 25 and 50-year return flows supplied by the ODWR calculator has the equation of the line:

$$\text{Recurrence interval} = 0.2206e^{0.0034*\text{discharge}}$$

Given this relationship, a discharge of 575 cfs has a recurrence interval of 1.56 years. A flow with recurrence interval of 1.4 years is 543 cfs. This indicates that the calculated bankful discharge is well within the expected range and that the 630 cfs estimate for a 2-yr peak flow event is a reasonable value.

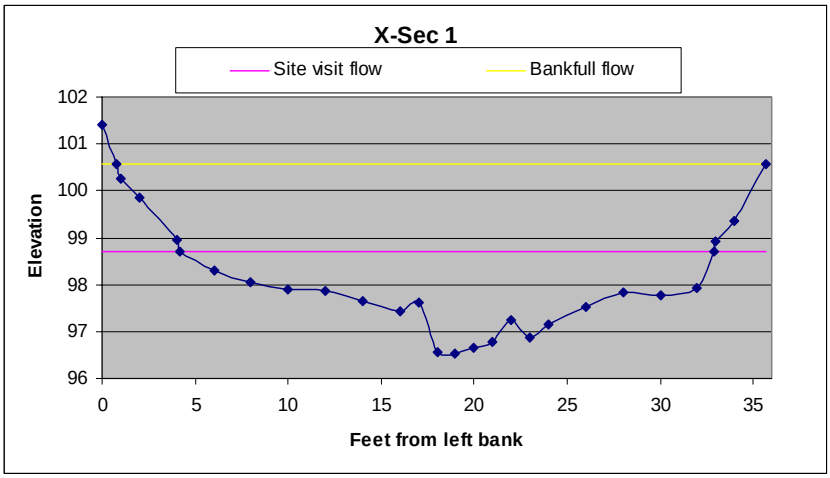

Figure 3. Cross section 1 profile.

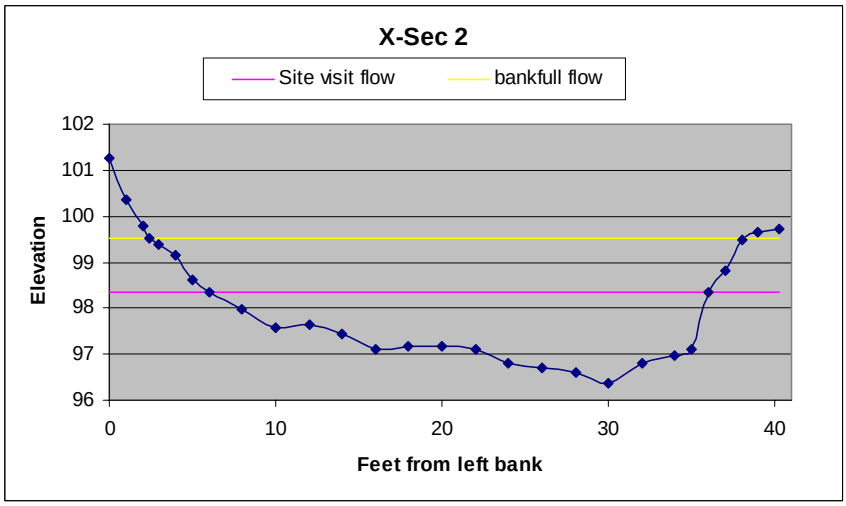

Figure 4. Cross section 2 profile.

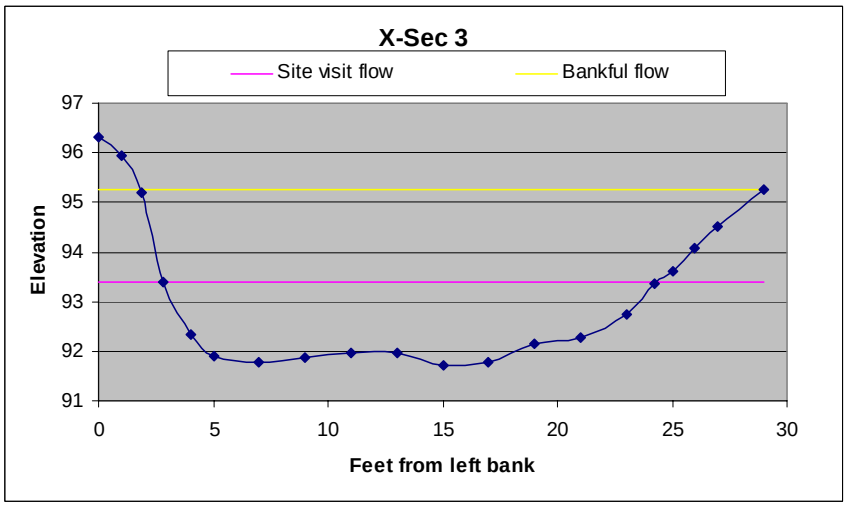

Figure 5. Cross section 3 profile.

6.0 Summary

6.1 Ecological Flow Analyses

The ecological flow analysis for the five target species revealed that habitat conditions in the reach of stream below the dam site is generally poor for both spawning and rearing of all five species. Cutthroat trout and coho salmon may require trigger flows during the late fall or early winter time frame to initiate upstream migrations. However, their spawning habitat upstream of the dam site would be blocked off unless fish passage was provided at the dam. There may be a few pockets of gravel where cutthroat trout could spawn downstream of the dam but coho spawning habitat is very limited. Therefore, provision of triggering flows for these species would not be expected to yield significant biological benefits. Also, there probably would be no reason for the dam to release additional flows to trigger upstream migration for these species since the dam would have to bypass all flows sufficient to provide ODFW's instream flow water right at the stream mouth. ODFW's instream flow water right increases incrementally from about 3 cfs in September to 40 cfs by mid-November. This degree of increase in the fall should be adequate to trigger upstream migration and provide sufficient water depths for migration through the reach. No other trigger flow requirements were identified in the analyses.

There is a possibility that EVWD will want to do some habitat enhancement downstream of the dam site as part of the mitigation requirements for a fish passage waiver. If spawning and rearing habitat for cutthroat trout, coho salmon and steelhead trout were improved in this reach, more than sufficient flow should be available through ODFW's instream flow water right to allow access to such habitat improvements.

6.2 Flushing Flow Analysis

The flushing flow analysis indicated that the majority of the substrate in the streambed downstream from the dam site falls within the coarse bed size category. A small reach of gravel/cobble substrate was identified near the Hibbard Road bridge but pebble counts on this area indicated that it also fell within the coarse bed size category. The short section of stream between the mouth and the lower end of the gavel/cobble section is predominately a silt/clay hardpan that is resistant to scouring. Flushing flows needed to move coarse bed streams are usually provided by a 2-3 year flood event. Based on WRD equations for estimating flood recurrence intervals at the proposed dam site and on modeling of bankfull flows, it appears that the 2-year flood event would be approximately 630 cfs. A 2-year flood event could occur during the period of reservoir filling or during the period when the reservoir was full. Presently, guidance with respect to release of a 2-year flood event during filling of the reservoir is not available from the resource agencies. If the 2-year flood event occurred during filling, it would be difficult for the outlets to discharge 630 cfs due to the high, potentially damaging water velocities that would occur under such conditions. Therefore, unless much larger discharge pipes were installed than those proposed, it would be infeasible to discharge a 2-year flood event during reservoir filling. If the 2-year event occurred after the reservoir was full, some supplemental discharge from the outlet pipes would be required since the reservoir would cause some buffering of the spillway discharge. Such details in managing the 2-year or greater flood releases will need to be worked out during final design of the dam and its controls.

7.0 References

Barnhart, R.A. 1986. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (Pacific southwest) -- steelhead. United States Fish and Wildlife Service, Biological Report 82(11.60). United States Army Corps of Engineers, TR EL-82-4. 21 pp.

Bauer, S.B., and T.A. Burton. 1993. Monitoring protocols to evaluate water quality effects of grazing management on western rangeland streams. U.S. Environmental Protection Agency, Region 10. Seattle, WA. EPA-910/R-93-017.

Beamish, R. J. 1980. Adult biology of the river lamprey (*Lampetra ayersi*) and the Pacific lamprey (*Lampetra tridentata*) from the Pacific coast of Canada. Canadian Journal of Fisheries and Aquatic Sciences 37:1906- 1923.

Berggren, T.J.. and Margaret Filardo. 1993. An Analysis of Variables Influencing the Migration of Juvenile Salmonids in the Columbia River Basin. North American Journal of Fisheries Management 13:48-63, 1993.

Bjornn, T.C. 1971. Trout and Salmon Movements in Two Idaho Streams as Related to Temperature, Food, Stream Flow, Cover and Population Density. Transactions of the American Fisheries Society, Vol. 100, No 3. July, 1971.

Bjornn, T. C., P.J. Keniry, K. R. Tolotti, J. P. Hunt, R. R. Ringe, C. T. Boggs, T. B. Horton, and C. A. Peery. Migration of Adult Steelhead Past Dams and Through Reservoirs in the Lower Snake River and into the Tributaries, 1991-1995. Idaho Cooperative Fish and Wildlife Research Unit, University of Idaho, Moscow, ID

Bustard, D. R., and D. W. Narver. 1975. Aspects of the winter ecology of juvenile coho salmon (*Oncorhynchus kisutch*) and steelhead trout (*Salmo gairdneri*). J. Fish. Res. Board Can. 32:667-680.

Castro, J.M., and P.L. Jackson. 2001. Bankfull discharge recurrence intervals and regional hydraulic geometry relationships: Patterns in the Pacific Northwest, USA. Journal of American Water Resources Association 37(5):1249-1262.

Dauble, D. D. 1986. Life history and ecology of the largescalesucker (Catostomus macrocheilus) in the Columbia River. American Midland Naturalist 116(2):356-367.

Edie, B. G. 1975. A census of juvenile salmonids of the Clearwater River basin, Jefferson County, Washington in relation to logging. M.S. Thesis, Univ. Washington, Seattle, 86 p.

Ellis Ecological Services, Inc. (EES). 2005. 2005 Drift Creek fish sampling report. Technical Report submitted to East Valley Water District, October, 2005.

Ellis Ecological Services, Inc (EES). 2006. 2006 Drift Creek fish sampling report. Technical Report submitted to East Valley Water District, October, 2006.

Ellis Ecological Services, Inc. (EES). 2010. 2009 Drift Creek sampling report. Technical Report submitted to East Valley Water District, December 2009.

Ellis Ecological Services, Inc. (EES). 2011. Flow and water temperature data summaries for water years 2008-2009 and 2009-2010, Victor Point Road and Hibbard Road gauging stations, Drift Creek, Marion County, Oregon. Data summary report submitted to East Valley Water District June 2011.

Giger, R. D. 1972. Ecology and management of coastal cutthroat trout in Oregon. Oregon State Game Commission, Fishery Research Rep. 6, 61 p.

Glova, G. J. 1987. Comparison of allopatric cutthroat trout stocks with coho salmon and sculpins in small streams. Environ. Biol. Fishes 20:275- 284.

Glova, G. J., and J. C. Mason. 1976. Interactive ecology of juvenile salmon and trout in streams. Fish. Res. Board Can., Manuscr. Rep. Ser. 1391, 24 p.

Glova, G. J., and J. C. Mason. 1977. Interactions for food and space between sympatric populations of underyearling coho salmon and coastal cutthroat trout in a stream simulator during spring. Fish. Res. Board Can., Manuscr. Rep. Ser. 1428, 36 p.

Gresswell, Robert and Steven Hendricks. 2007. Population-Scale Movemenet of Coastal Cutthroat Trout in a Naturally Isolated Stream Network. Trnasactions of the American Fisheries Society 136:238-253

Hardy, T., P. Panja, and D. Mathias. 2005. WinXSPRO, A Channel Cross Section Analyzer, user's Manual, Version 3.0. United States Department of Agriculture, Rocky Mountain Research Station, CO.

Harrelson, C.C., J.P. Potyondy, C.L. Rawlins,. 1994. Stream Channel Reference Sites: An Illustrated Guide to Field Technique. General Technical Report RM-245. United Staes Department of Agriculture, Forest Service, Fort Collins, CO.

Hildebrand, R. H. and J. L. Kershner,. 2000. Conserving inland cutthroat trout in small stream: How much is enough? North American Journal of Fisheries Mangement 20:513-520.

Johnston, J. M. 1981. Life histories of anadromous cutthroat with emphasis on migratory behavior. In E. L. Brannon, and E. O. Salo (editors), Proceedings of the Salmon and Trout Migratory Behavior Symposium, p. 123-127. School of Fisheries, Univ. Washington, Seattle.

Johnston, J. M., and S. P. Mercer. 1976. Sea-run cutthroat in seawater pens-- broodstock development and extended juvenile rearing (with life history compendium). Washington Dep. Game, Fishery Research Rep., Olympia, WA, 26 p.

Karp, C.; W. Larrick; M Johnson and T. Dick. 2005. Steelhead movements in the upper Yakima Basin winter 2003/2004. U.S. Department of Interior, Bureau of Reclamation, Technical Memorandum 8290-05201.

Kavenaugh, P., S. Charlie, and K. Jones. 2006. Fish Habitat Assessment in the Oregon Department of Forestry North Cascade Study Area. Oregon Department of Fish And Wildlife, Aquatic Inventories Project, Corvallis, OR.

Knighton, D. 1998. Fluvial forms and Processes: A New Perspective. Oxford University Press N.Y.N.Y. 383 p.

Laufle, J.C., G.B. Pauley, and M.F. Shepard. 1986. Species p r o f i l e s : l i f eh i s t o r i e s and environmental requirements of coastal fishes and invertebrates(P a c i f i c Northwest)--coho salmon. U.S. Fish W i l d l . Serv. Biol. Rep. 82(11.48).U.S. Army Corps of Engineers, TR EL-82-4. 18 pp.

Machtinger, Erika and Kathyrn Boyer. 2007. Cutthroat Trout Oncorhynchus clarki. Natural Resources Conservation Service ish and Wildlife Habitat Management Leaflet Number 47.

McCart, P., and N. Aspinwall.1970. Spawning habits of the largescale sucker,Catostomus macrocheilus, at Stave Lake, British Columbia. Journal of FisheriesResearch Board of Canada. 27:1154-1158.

McEwan D and T.A. Jackson. 1996.Steelhead Restoration and Management Plan for California. California Department of Fish and Game, Inland Fisheries Division, Sacramento, CA.

Moring, J. R., and R. L. Lantz. 1975. Cutthroat trout. The Alsea watershed study: Effects of logging on the aquatic resources of three headwater streams of the Alsea River, Oregon. Part 1-Biological Studies, Oregon Dep. Fish Wildlife, Project AFS-58, Final Rep., Corvallis, OR, 7 p.

Moyle, P.B. 2002. Inland fishes of California. University of California Press, Berkeley, California. 502 pp.

Nicholas, Jay. 1978. A Review of Literature and Unpublished Information on Cutthroat Trout (Salmo clarki clarki) of the Willamette Watershed. Oregon Department of Fish and Wildlife, Portland OR.

ODFW. See Oregon Department of Fisheries and Wildlife.

Oregon Department of Fish and Wildlife. 2003. ODFW Timing Tables. Contributed by: K.Braun.June 2003. http://rainbow.dfw.state.or.us/nrimp/information/timing/index.htm.

Oregon Department of Fisheries and Wildlife.2008. Methods for Stream Habitat Surveys Aquatic Inventories Project Conservation and Recovery Program: Oregon Department of Fish and Wildlife.

Pauley, Gilbert B., Bruce M. Bortz, and Michael F. Shepartd. 1986. Species Profiles: Life Histories and Environmental Requuiremtns of Coastal Fishes and Invertbrates Pacific Northwest. United States Fish and Wildlife Service and the Unites States Army Corps of Engineers Biological Report 82 (11.62) August 1986.

PWA. See Pudding Watershed Assessment.

Pudding Watershed Assessment Review Draft, May 2005.

Robison, George. 2007. Calculating Channel Maintenance/elevated Instream Flows when Evaluation Water Right Applicatoins fo Out of Stream and Storage WaterRights. Oregon Department of Fish and Wildlife. Salem, OR, 36p.

Rosgen, D. (1996). Applied river morphology. Wildlife Hydrology, Pagosa Springs, CO.

Schmetterling, David A and James A mcFee. 2006.Migrations by fluvial Largescale Suckers after Transport upstream of Milltown Dam, Montana. Northwest Science, Vol. 80 No. 1, 2006.

Scott, W.B. and E.J. Crossman. 1973. Freshwater fishes of Canada. Fisheries Research Board of Canada Bulletin 184.

Steel, E. Ashley, Blake E. Feist, David W. Jensen, George R. Pess, Mindi B. Sheer, Jody B. Brauner, and Robet E. Bilby. 2004. Landscape models to understand steelhead distribution and help prioritize barrier removals in the Willamette basin, Oregon, USA. Canadian Journal of Fisheries and Aquatic Science. 61: 999-1011 (2004).

Sumner, F. H. 1962. Migration and growth of the coastal cutthroat trout in Tillamook County, Oregon. Trans. Am. Fish Soc. 91(1):77-83.

Sumner, F. H. 1972. A contribution to the life history of the cutthroat trout in Oregon. Oregon State Game Commission, Corvallis, OR, 142 p.

Thompson, K. 1972. Determining stream flows for fish life. Proceedings instream flow requirement workshop. Pacific Northwest River Basin Comm., Vancouver, Washington.