Howard Creek
Culvert Replacement Design Report

A view upstream to the Howard Creek culverts.

Submitted To:

Ms. Anna Kerr
Lake County Watershed Councils
PO Box 222
Paisley, Oregon 97636

Prepared By:

River Design Group, Inc.
311 SW Jefferson Avenue
Corvallis, Oregon 97333

May 16, 2011

Table of Contents

Tables

Figures

1 Introduction

The Lake County Watershed Councils (LCWC) with funding provided by the Oregon Watershed Enhancement Board, retained River Design Group, Inc. (RDG) to evaluate an existing culvert and prepare a fish passage solution for Howard Creek near Lakeview, Oregon. The existing culvert is a fish passage barrier due to the vertical drop at the culvert outlet. A secondary culvert provides high flow relief, but is also a passage barrier. The proposed design includes replacing the existing culverts with a streambed simulation pipe arch culvert to provide fish passage on Howard Creek.

2 Project Description

The project site is located on Howard Creek near Highway 140 in the Drews Valley east of the Goose Lake Basin's western divide (Figure 2-1). The culvert is located on Forest Road (FR) 790-20 and provides road access between FR 3780 and a secondary road FR 790-50. The fish community inhabiting the Drews Creek drainage (includes Howard Creek) includes endemic species that are naturally found nowhere else (USDA 2006). Obstructions in the drainage include the Drews Reservoir Dam which disconnects the Drews Creek fish community from the greater Goose Lake fish community by eliminating upstream passage from lower Drews Creek into the upper Drews Valley. Addressing fish passage barriers on tributary streams to Drews Creek is important for maintaining fish community persistence in the Drews Valley.

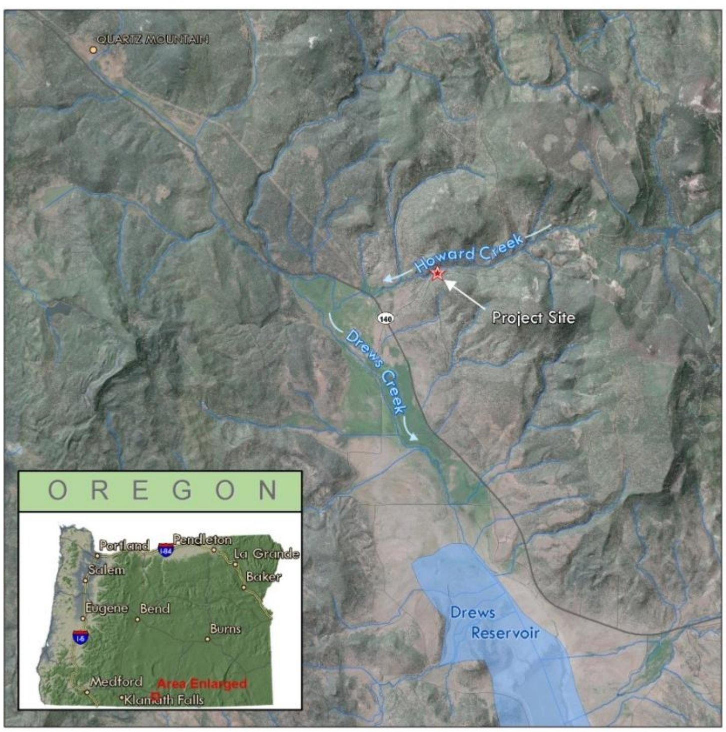

Figure 2-1. The Howard Creek project vicinity map.

2.1 Goals and Objectives

The overall goal of the project is to provide fish passage on Howard Creek. Fish access to the upper watershed is currently eliminated by a perched culvert located at Forest Road 790-20. Channel incision downstream of the culvert is likely the result of past channel clearing and straightening and related upstream headcut propagation. In addition to the incised channel, the culvert's perched condition may also be related to hydraulic scour caused by the culvert's position. The culvert's original installation may have also been inappropriate for ensuring fish passage.

Specific project objectives include:

- Replacing the existing two culverts with a streambed-simulation culvert that provides sufficient capacity to convey the 50-year flood event, debris transport, and fish passage.
- Ensuring stable channel conditions upstream and downstream of the streambed simulation culvert and within the culvert following project construction.
- Cost-effectively complete the culvert replacement and channel stabilization work.

2.2 Project Area and Condition Description

The following sections provide an overview of the Drews Creek watershed and Howard Creek. Most of the information is taken from USDA (2006).

Drews Creek Watershed Summary

Physiography

The Drews Creek watershed encompasses a relatively narrow band of topographical relief. Elevations at the northeastern portion of the watershed are generally the highest, ranging from 6,400 feet to 7,900 feet near Grizzly Peak. Elevations approach 7,000 feet southwest of Drews Reservoir near Dog Mountain. Elevations are lowest (4,200-5,000 feet) immediately adjacent to Drews Reservoir, along Drews Creek downstream of the reservoir, and in the valley adjacent to Goose Lake. Mean elevation in the watershed is 5,420 feet. Slope ranges from 0 percent to 200 percent (0 to 90 degrees), although much of the watershed slopes relatively gently, with the mean slope being 14 percent. Aspects vary widely within the watershed, ranging from 0 to 360 degrees. However, the mean aspect of the Drews Creek watershed is 162 degrees. This corresponds with the generally southeast flowing Drews Creek, which drains into Goose Lake at the southeast end of the watershed. The watershed is generally divided by Drews Creek and Drews Valley. Streams located to the west of this divide flow in an easterly direction, while streams located to the east of the divide generally flow westerly toward the divide.

Climate

The Drews Creek watershed is located in south central Oregon on the eastern side of the Cascade Mountains. The majority of the watershed is located within Oregon Climate Zone 7, with only a small portion near the watershed divide falling within Climate Zone 5. Oregon Climate Zone 7 is characterized as receiving relatively little precipitation, except for the higher mountain locations. Highest monthly precipitation is generally in the winter months; summers are generally quite warm, and winters cold. Oregon Climate Zone 5 experiences relatively cooler temperatures and higher precipitation than the adjacent Zone 7.

Mean monthly precipitation increases with elevation among the subwatersheds. Mean monthly precipitation is lowest in the month of July for all subwatersheds and is greatest in the month of December for all except Quartz Creek subwatershed. The distribution of precipitation is bimodal in all subwatersheds, with a spike in precipitation occurring during the month of March. The reason for relatively high March precipitation values is not clear. Examination of the precipitation records from individual stations in the vicinity show no March spike in precipitation at most stations and only a slight increase over January and February values at the higher elevation stations. The pattern may be due to the disproportionate effect that the higher elevation stations may have in the PRISM model.

Channel Morphology

The principal tributary streams that drain from the eastern side of the watershed (Howard Creek and both Fish Creeks) have generally steeper gradients than those draining from the west (Hay, Dog, and Dent Creeks). This is most likely due to the local tilt in the underlying geologic strata. Weldon et al. (2003) identify the principal fault that parallels Drews Reservoir and Drews Creek above the reservoir as dipping to the northeast. The low-gradient tributaries draining from the west have extensive areas of floodplain development where the floodplain hasn't been lost to down cutting.

Hydrologic Regime

The primary peak flow-generating processes active in Oregon are rainfall, snowmelt, and rain-on-snow (ROS). Rain-on-snow is the common term used to describe wintertime conditions when relatively warm wind and rain combine to produce rapid snowmelt. Spring snowmelt and summertime convective rainstorms are identified as the primary peak flow generating processes within the Drews Creek watershed (WPN 2001). Examination of the hydrograph for the unregulated Cottonwood Creek gage shows a hydrograph typical for a snowmelt-dominated system. Annual instantaneous peak flow events at the gage occur during the spring snowmelt season.

The remaining gages are all subject to flow regulation and do not represent natural flow conditions. Median daily flows at the Dog Creek gage (located downstream of Dog Lake) are at or close to zero from July through February. The low flows during the late fall and winter are probably in response to reservoir filling. The hydrograph for the Drews Creek gage, located downstream of Drews Reservoir, exhibits low flows well into the late winter and early spring months (probably in response to reservoir filling), and high flows during the late spring and summer during the period of reservoir release. Much of the released water is captured by the North and South Drews Canals and is distributed to areas in lower Drews Creek, Antelope Creek, and adjacent watersheds. The pattern of annual peak flows at the Drews Creek gage is similar to the unregulated Cottonwood Creek gage, with the majority of peak flows occurring during the spring melt season (when the reservoir is presumably full and storm waters are transmitted downstream).

Aquatic Species

Both the history of the Drews Creek watershed and its current ecological condition are important for understanding the characteristics of the aquatic species living there today, their habitats, and the factors that may limit their success. Many fish species in the Goose Lake Basin are endemic, meaning they are found naturally nowhere else, as the Goose Lake Basin became geographically isolated when the large Pleistocene lakes of eastern Oregon dried. Because of this geographic isolation, fishes of Goose Lake Basin are morphologically and genetically distinct, reflecting adaptations for life in its rich, alkaline, and muddy waters and survival in remnant habitats during periods of drought (Moyle 2002). Tui chub and Sacramento sucker have been described as subspecies, and the two most distinctive fishes are the undescribed Goose Lake lamprey and the Goose Lake redband trout (Moyle 2002). Two additional, distinctive species are the federally listed Modoc sucker (endangered) and Pit roach (species of concern).

Historically, the hydrologic cycle in the basin involved a complex system of streams, marshes, and lakes, with periodic droughts during which fishes were able to find refuge. Currently, the watershed and the larger basin are characterized by a fragmented system of streams, lakes, and reservoirs, across which the fishes are scattered with varying abundance and, often, limited distribution. This fragmentation is associated with channel degradation and accelerated lake desiccation. It is due primarily to human impacts on the landscape over the last 150 years, such as irrigation diversions, livestock grazing, and loss of natural water storage areas (e.g., wet meadows) (ODFW 1995).

Fish species that reside in the Drews Creek watershed and may potentially use Howard Creek to complete their life history are included in Table 2-1.

Table 2-1. Fish species, their distribution, likelihood of use, and classification for Howard Creek.

Species	Distribution	Likelihood of Howard Creek Use	Classification
Goose Lake redband trout	Seven closed basins in Oregon	High	State Sensitive-Vulnerable
Goose Lake chub	Endemic to Goose Lake Basin	Moderate	State Naturally Rare
Goose Lake sucker	Endemic to Goose Lake Basin	High	Federal Species of Concern
Modoc sucker	Goose Lake Basin and Pit River Basin	Low	Federal Endangered Species
Goose Lake lamprey	Endemic to Goose Lake Basin	High	Federal Species of Concern
Pit roach	Only population in Oregon	Low	Federal Species of Concern

3 Fish Passage Design

The following sections outline RDG's design parameters used in developing fish passage alternatives for the project under consideration.

3.1 Fish Passage Criteria

The Oregon Department of Fish and Wildlife (ODFW) publishes design flow requirements for fish passage in Oregon Administrative Rule (OAR) 635 Division 412 - Fish Passage. There are requirements for fish passage at road-stream crossings and specific criteria for passage using a "streambed simulation" approach. This approach strives to duplicate streambed geometry of the nearby channel reach within the new culvert, resulting in a streambed surrogate that is passable by being geometrically and hydraulically similar to the surrounding channel. The streambed simulation approach was used to design the replacement culvert and a summary of ODFW criteria for design of streambed simulation culverts is shown in Table 3-1.

Table 3-1. OAR fish passage criteria for streambed simulation culverts.

Criteria	Requirement
Min. Water Depth	Same as Adjacent Stream
Min. Culvert Width	Same as Adjacent Stream
Length	No Limit
Embedment Depth	Greater of 12" or 20% Structure Height
Structural Integrity	100-yr Return Interval Storm

3.2 Fish Passage Flows

Fish passage flows are defined in OAR 635.412 as the range of flows bound by the 95% and 5% exceedance flows. The lowest flow considered for fish passage is the 95% exceedance flow, which is the average daily discharge that is exceeded 95% of the time that native migratory fish are present. The high fish passage flow is the 5% exceedance flow, or the average daily discharge that is exceeded 5% of the time during the period of fish use. Because fish may be distributed in Howard Creek throughout the year, the yearly period of record was used to determine fish passage flows. This also results in a more robust passage design because it includes a greater range of flows.

The contributing drainage area at the project site is predominately forested. The average basin elevation is 6,230 feet NGVD. The project area is located between 5250 and 5280 feet NGVD with a drainage area of 3.5 square miles. In order to develop project specific flow data, a hydrologic analysis was completed for the contributing area. The best data for stream flows is developed from active stream gages with long periods of record; however, Howard Creek does not have an active stream gage so other methods were utilized to estimate flow characteristics. The two methods were area-weighting relationships to nearby gaged sites with similar climatic and physiographic conditions and estimates based on regional regression equations developed for this region (Cooper 2005).

There are three stream gages with historical data near the project area and within the Goose Lake Basin and Summer Lake Basin. These gages have similar watershed characteristics such as topography, cover, soils, and climatic patterns as the project site. A summary of each of the gages is shown in Table 3-2. The nearby stream gages have larger drainage areas than the project site and were proportionally scaled based on drainage area to yield flow data for the project site. For comparison purposes, the channel elevation of Howard Creek is 5,262 ft with a drainage area of 3.5 square miles.

Table 3-2. Summary of historical stream gages near the project site.

Characteristics	Honey Creek near Plush	Cottonwood Creek above Reservoir	Cottonwood Creek below Reservoir
Gage Elevation (ft NGVD)	4550	5200	4949
Period of Record (years)	99	29	73
Drainage Area (sq. miles)	168	23	33

Cottonwood Creek and is the adjacent basin north of the project site. The Cottonwood Creek above Cottonwood Reservoir gage has a larger drainage area, similar elevation, and relatively long period of record. Therefore, the Cottonwood Creek above Cottonwood Reservoir gage was used as the basis for the flow duration curve completed to calculate fish passage exceedence flows corrected for the Howard Creek project site's smaller drainage area (3.5

square miles vs. 23 square miles for the gage). Table 3-2 includes the 5% and 95% exceedance flows for the Howard Creek project site.

Table 3-3. Project site predicted flows based on area-weighting from gage data.

Characteristics	Discharge (cfs)
5% Exceedance Flow	15
95% Exceedance Flow	0.2

Project site peak flows for use in design were determined using regional regression equations applicable to the project area. The Oregon Water Resource Department (OWRD) Peak Flow Web Mapping program was used to perform peak flow hydrologic calculations. OWRD Web Mapping is a web-based geographic information system (GIS) program that locates physical and climatic basin characteristics, delineates watershed areas based on digital elevation models (DEM), and predicts flood flows based on regionalized flood-frequency regression equations. Flows for selected return intervals are summarized in Table 3-4.

Table 3-4. The predicted flood frequency for the Howard Creek project site.

		95% Confidence	
Frequency (recurrence interval)	Peak Flow (cfs)	Lower Limit (cfs)	Upper Limit (cfs)
2-yr	41	15	117
5-yr	66	29	152
10-yr	87	40	187
25-yr	116	54	247
50-yr	139	65	301
100-yr	164	74	367

3.3 Howard Creek Culvert Design

The design culvert is an oversized pipe arch with a simulated streambed. The designed 150 inch by 96 inch pipe arch is a 32 ft long aluminized, 10 gauge corrugated metal arch.

The U.S. Forest Service (USFS) and the Washington Department of Fish and Wildlife (WDFW) have published detailed guidelines on simulated streambed culvert design (Bates et al. 2003), and this effort followed the design approach from those guidelines. The design also satisfies regulatory requirements for fish passage as outlined by ODFW.

During the site survey, a long profile along the channel thalweg was taken extending nearly 10 bankfull widths upstream and downstream of the culverts. The long profile was sufficiently detailed to show channel bedforms on either side of the existing culverts and can be used to estimate future potential elevations of the streambed within a range of observed bedform depths. These points represent the range of anticipated thalweg positions over time, and were used to determine the replacement culvert profile. The replacement culvert profile was set within the anticipated range of potential channel thalweg positions to assure function over a range of future scenarios in stream channel adjustment as shown on the drawing set.

The channel width was also measured throughout the long profile survey. Pipe sizes were selected to exceed the bankfull channel width. WDFW currently recommends selecting structure widths to be 125% of the active channel width, and this guideline was balanced with the need for structure economy when selecting a culvert size.

A low-profile pipe arch was selected because of the small amount of headroom available between the design thalweg and the road surface. This measurement is already limited by the cover over the existing pipe. Utilizing a standard shape culvert, which is taller, would require either excavating deeper or raising the road surface to fit a larger pipe within this space. Therefore, only low profile pipe designs were evaluated for this site to minimize excavation depth and imported fill requirements.

The streambed material was sized for structural integrity at the 100-yr flow as specified in OAR 412. Therefore, the streambed within the culvert contains larger substrates than in the adjacent reaches to create a stable interlocking matrix of cobbles, gravels, and fines. In addition to fulfilling the structural integrity requirements of OAR 412, this also provides important channel grade control functions and minimizes potential scour.

4 Permitting Information

Removal-Fill permits are required from the Oregon Division of State Lands (DSL) and Army Corps of Engineers (ACOE) whenever working within the ordinary high water (OHW) and conditions for project exemptions are not met. Since OHW is a jurisdictional boundary, the state of Oregon defines it in ORS 274.005. In summary, it states that OHW is an elevation on the bank to which the high water ordinarily rises each year and is the limit to which upland vegetation ceases. OHW is generally recognizable by a visible change or break in the soil and vegetation.

To help determine the OHW for the site, a determination of OHW based on channel morphological indicators and vegetation was made during the field survey. The drawing set includes a designation of OHW for use in permitting.

A recommendation for work area isolation for working below OWH has also been provided on the drawing set. Isolating the in-water work area is meant to protect water quality and instream organisms during construction.

The ACOE also recognizes “Nationwide Permits” (NW) for certain projects within jurisdictional boundaries. Nationwide permits exist to efficiently regulate commonly occurring projects. Because this project addresses maintenance on existing transportation infrastructure and also addresses fish passage, the project likely fits under either NW-03 (Maintenance), NW-14 (Linear Transportation Projects), or NW-27 (Aquatic Habitat Restoration, Establishment, and Enhancement Activities). The applicability of general authorizations is determined by the ACOE during review and does not alter the permit application process.

A general authorization for “Fish Habitat Enhancement” is recognized by the Oregon DSL for projects that meet specific criteria to enhance fish habitat or provide fish passage. This project likely falls under the General Authorization for Fish Habitat Enhancement. To apply for a general authorization, a supplementary form is submitted along with the permit application.

Removal and fill quantities below OHW are summarized in Table 9. There is a net removal of material below OHW because the proposed culverts are much larger than the culverts they replace. However, overall cut and fill volumes balance more closely because the replacement pipes would be installed with the manufacturer’s recommended cover, which is greater than the amount of soil cover over the existing culvert pipes.

Table 4-1. The removal and fill quantities below OHW.

	Below OHW		Project Total	
Project Element	Removal (cubic yards)	Fill (cubic yards)	Removal (cubic yards)	Fill (cubic yards)
Culvert Inlet and Outlet Scour Protection	-	30	-	50
Streambed Simulation Matrix Material	-	45	-	45
Streambed Simulation Rock Band Material	-	24	-	24
Culvert Backfill for Roadbed	50	50	100	450
Culvert Bedding Material	-	8	-	8
Upstream Channel Grading	30	-	30	-
Total	80	178	130	577

A joint permit application will be necessary for this project.

5 References

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