United States Department of Agriculture

NRCS

Natural Resources Conservation Service
9173 W. Barnes Dr., Ste. C
Boise, Idaho 83709

Job:	Hellroaring Creek Fish Passage
Authority:	CO-01 Conservation Technical Assistance
Phase:	Preliminary Design
Job Class:	III, Channel Forming Flow Velocity < 8 fps
Date:	June, 2006

This is a preliminary design report on the Hellroaring Creek Fish Passage project. Drawings, specifications and analysis are attached for review.

General

The purpose of this project is to restore fish passage and normal hydraulics to a 500 foot section of Hellroaring Creek in Bonner County, Idaho. This project involves removing a 7 foot high concrete dam, replacing an existing 10 foot wide culvert under Pack River Road with a larger one, and replacing the roughness elements and bedforms in the stream channel.

The fish species of interest is Bull Trout (*Salvelinus confluentus)*. Hydraulic values and passage parameters used were typically those published for Juvenile Salmonids, due to lack of specific information for Bull Trout. Flow duration information was used to provide passage during the median low flow up to approximately 30% of the channel forming flow, or about 98% of the time.

NRCS will create a final design after interagency review is complete. NRCS will perform the construction inspection and final certification. The Bonner Soil Conservation District (SCD) will administer the construction contract.

This job is designed under the following NRCS Practice Standards:
580 – Streambank and Shoreline Protection, 2005
395 – Stream Habitat Improvement and Management, 2004
396 – Fish Passage, 2002
587 – Structure for Water Control, 2004

Location

This project is located in the NW ¼ of the SE ¼ of Section 3 in T 59 N., R 2 W. of the Boise Meridian. It is at about elevation 2,260 feet AMSL. The reference is the Colburn, Idaho Quadrangle. The site was surveyed twice by NRCS personnel. Profiles, Cross-Sections, Field Notes and Photos are contained in the design documentation.

Hydrology

Using USGS mapping and streamflow statistics, a rough analysis indicates the Hellroaring catchment is approximately 11 square miles at the Pack River Road crossing. These flows were also estimated using NRCS Technical Release-20, Hydrology for Project Formulation. The streamflows are:

Q_{50} = 1,400 cfs
Q_{25} = 1,100 cfs

Q_{10} = 800 cfs
Q_2 = 300 cfs
$Q_{1.5}$ = 220 cfs

The low flow month is September and the average monthly flows are 3.4 cfs. Channel forming flows (referred to by some as bankfull) are approximately 200 cfs, as indicated by sedimentary surfaces and hydraulic calculations. A flow duration curve is attached.

Geomorphology
Hellroaring Creek catchment is mostly composed of Precambrian sedimentary rock of the Belt Formation. The upper part of the catchment is in the Kaniksu batholith granites. Both of these rocks are relatively hard and weather to steep slopes and relatively large sediments. Hellroaring Creek at the project site is on its alluvial fan, about 30 feet vertically above its confluence with the Pack River.

The fan is composed of coarse gravel, cobble and fine boulders with glacial erratics up to many feet in diameter. The fan slope is 3.4%. Sediment samples taken from the fluvial deposits indicated a D_{50} of 4 to 5 inches and a D_{84} of 6 to 8 inches. Sediment gradation curves are attached. Current tractive stresses during channel forming flow move rocks greater than 5 inches (2.4 # ft^{-2}). After project tractive stresses will be 1.4 # ft^{-2}. The design storm for stability is a 25 year storm. This has velocities of 7.5 feet per second and a depth of 5 feet. This storm generates tractive stress of 3.8 # ft^{-2}, and moves an 8 inch rock. This is the design rock size for stability.

The proposed channel morphology is a combination step-pool and plane-bed (Montgomery and Buffington, 1993). Channel forming width (W) is 18 feet, and channel forming depth (D) averages 1.35 feet for a W/D ratio of 13. Entrenchment ratio at the 25 year storm is 1.5 to 1.7. Sinuosity of streams on coarse alluvial fans is generally close to 1 (Wohl, 2001). Using a Rosgen typology this channel would be an A3 channel. Proposed planform and dimensions are consistent with surrounding streams in this valley type on fan landforms. The planned channel is entrenched. Although this is normal for these stream types, working around the bridge exacerbates the entrenchment.

Several spatial analogs (sometimes called ‘reference reaches’) were examined upstream and down. Downstream the channel leaves the fan, and therefore is a different stream type. Upstream the gradient steepens rapidly. Accounting for this slope, an analog with a channel forming width of 16 feet was observed. Channel “stability” appears to mostly correlate with coarseness of the bed material and sediment transport capacity rather than any geometry. Given these observations, no further effort was put into spatial analogs, and a rational, analytic approach will be used.

Fish Passage
The ‘design’ fish for this analysis is an adult Bull Trout (*Salvelinus confluentus*), 10 inches long. The minimum low flow depth is 8”. The maximum high flow velocity is taken as 4 fps. The maximum burst swimming velocity is taken as 8 fps. The maximum burst swimming duration is taken as 5 seconds, and burst distance at maximum design conditions is 20 feet.. Much of these data are taken from the State of Oregon Statutes and NOAA Fisheries documents, often for juvenile salmonids. This structure configuration is passable by these standards 85% of the days. References are included at the end of the report.

Hydraulics
The step pool configuration was taken from stable stream patterns observed in the literature, and on similar landscapes. The selected pattern was a primary step, followed by a constructed scour pool and a secondary step. The step height (primary step to primary step) was selected to be 8 inches. The difference

between the secondary step and primary step was selected to be 6 inches. The step length was selected to be 18 feet.

Minimum swimming depth at low flow given this configuration is 8". Low flow was taken to be 3 cfs and this occurs at the 4^{th} percentile of the flow duration curve. Residual pool depth at low flow is one foot. Minimum jump pool depth is 1.8 feet and average pool velocity is <2 fps at 90 cfs. Overall velocity at 90 cfs (about ½ of the Q_{CFF}) is 2.2 fps. Velocity at the 2 year storm is still under 4 fps, indicating passable conditions may persist towards the tail (about the 90^{th} percentile) of the flow duration curve. Water surface profiles and calculations are attached.

The Froude number generated by the step geometry given above is 2.4. This is a weak submerged jump bordering on an oscillating jump. This should provide excellent recirculation (upstream velocity) with velocity ratios (fastest/slowest) of greater than 5, while providing very good energy dissipation.

The culvert is designed to pass 1,400 cfs in a debris-free condition.

Structural and Elevations
All of the selected elevations that generate the hydraulics show above are compatible with the existing roadway elevation. The culvert will be on footings that generate a bearing load of 1,500 psf at H25 loading. There will be 2 feet of fill minimum over the culvert.

The culvert will have wingwalls and headwalls. Footings and walls are designed to be below the maximum scour depth of 2 feet. Head- and wingwalls will be made of either concrete or corrugated metal.

3 step-pool structures, consisting of 2 to 4 steps each are proposed for a total of 9 steps. The structures are designed to be immobile, but continue to transport the introduced sediments. Existing material will be used to the extent possible. Whole trees will be incorporated into the middle and lower structures to form the top step.

Each structure will require 10 to 12 stones 2.5 to 3 feet in diameter for the primary step, and 12 to 14 stones 1.5 to 2 feet in diameter for the secondary step. These rocks amount to about 44 cubic yards of material, per step. An additional 25 cubic yards of 4 to 12" rounded material will be required per structure. All total for 9 steps will require 220 cubic yards of large stone for the steps and 225 cubic yards of residual material. Much of this can come from the culvert and channel excavation if it is collected carefully.

The channel will be regarded through the drop where the weir is being removed. This will involve relocating about 480 cubic yards of channel material. Overall, there will be about 480 cubic yards of excavation below high water mark in the channel, and about 700 cubic yards of fill (220 of imported stones and 480 of channel material). Be cause of the culvert replacement and obstruction removal, flood elevations will remain similar to pre-project conditions downstream of the culvert. Upstream of the culvert, flood elevations (25 year storm and above) will go down almost 2 feet.

The bed is designed to be non-mobile. The hydraulics generated by the step-pool at about 200 cfs should transport a 3 to 4" particle through the road crossing. This is consistent with the D_{50} being transported today.

The upstream step in the middle and lowest structure will be formed using whole trees. Trees are designed according Idaho Engineering Technical Note #15, Incorporation of Large Wood into Engineered

Structures. Trees have a factor of safety from momentum of 2.5 and a factor of safety from floating of 1.4 at a 25 year flow.

Construction Considerations and Sequencing
Hellroaring Creek will be diverted above the project into an 18 inch plastic pipe. This pipe will be run through a new 3 foot diameter culvert under the road. The water will then go in a ditch, and back to the Creek below the project. This will allow the entire project to be constructed in the dry. A small dewatering pump may be required.

NRCS will need assistance in staging the dewatering to assure the fewest number of fish are stranded.

Traffic will be diverted around the project upstream of the existing bridge on a one-lane bypass. The old bridge and weir will then be removed. The 300 cubic yards of channel material will then be moved from upstream to down.

The bottomless box culvert will be installed on poured concrete footings while the downstream and middle structures are being simultaneously constructed.

After the bottomless arch is backfilled, the temporary bypass will be removed and traffic will be directed over the new culvert.

The upstream step structure will then be constructed.

The channel bottom in the bottomless box culvert will be composed of native stones 6 to 18 inches in diameter, and will have a 1 foot deep low flow depression.

Sand and fine gravel will need to be pressure washed into the completed structures to ‘seal’ the rocks and prevent the stream from running underneath the rocks. This will take about 50 to 100 cubic yards of fine material.

Careful elevation control will be required when setting the step rocks. NRCS personnel will be present with a surveying instrument to assist. The relative elevations are very important to creating passable hydraulics.

The road will be paved and seedings for revegetation and erosion control will be completed.

Environmental Considerations
A Biologic Opinion will be required to determine if this project will negatively impact Bull Trout. All instream work will be completed during the work window described in the Opinion.

A fill and removal/stream alteration joint permit will be required from the US Army Corps of Engineers and Idaho Department of Lands.

Construction will be completed following the attached specification #5, Pollution Control. The contractor will need to file a notice of intent with EPA regarding a Stormwater Pollution Prevention Plan. The designers see no significant pollution control requirements other than standard practice.

Submitted: ______________________________________ Date: _________________

Approved: ____ Date: _________________
Robert W. Sampson, PE

Literature Reviewed and Employed

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