

## **APPENDIX C – GEOLOGY AND GEOMORPHOLOGY**

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# RECLAMATION

*Managing Water in the West*

## GEOLOGY AND GEOMORPHOLOGY REPORT FOR THE CATHERINE CREEK TRIBUTARY ASSESSMENT – GRANDE RONDE RIVER BASIN Tributary Habitat Program, Oregon



U.S. Department of the Interior  
Bureau of Reclamation  
Pacific Northwest Region  
Geology and Fluvial Analysis Group  
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U.S. DEPARTMENT OF THE INTERIOR

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**Cover Photograph:** View looking east (downstream) along Catherine Creek, Reach 2 at river mile 26.0, in the Cove area, Mt. Fanny (upper left) and Phys Point (upper right) can be seen in the background. **Catherine Creek Tributary Assessment-Grande Ronde River Basin-Tributary Habitat Program, Oregon – July 29, 2010.**



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# 1. Summary

The primary objectives of this tributary-scale geomorphic assessment are to:

1. Delineate and describe geomorphic reaches based on differing geomorphology that includes:
  - The natural and artificially induced controls on current morphology.
  - Historic conditions.
  - Current channel form.
2. Discuss the conditions and processes noted above as they relate or contribute to the known limiting factors that impede the reproduction and/or survival of Chinook salmon and steelhead.
3. Discuss initial rehabilitation strategies that address the current conditions and limiting factors that affect the reproduction and/or survival of spring Chinook salmon and steelhead.

Seven geomorphic reaches were identified and grouped into three sections within the Catherine Creek Tributary Assessment area. The primary in-basin limiting factors of water quantity (low summer flows), water quality (elevated summer temperatures), poor habitat quantity/diversity (low abundance of pool habitat and lack of habitat diversity), excess fine sediment, and returning adult passage (NOAA Fisheries 2008) are noted to persist across all of Catherine Creek. In order to address the causes of the limiting factors, both short-term and long-term approaches based on a strategy of prioritizing rehabilitation activities described by Roni et al. (2002) should be considered. The short-term strategy should address the immediate need to increase habitat quality and quantity by increasing complexity in the main channel. The long-term focus of rehabilitation efforts should include multiple strategies that: 1) reconnect isolated habitats, 2) restore long-term processes, and 3) restore short-term habitat.

The Grande Ronde Valley and Catherine Creek are within the Blue Mountain physiographic province in northeast Oregon. The valley is a large structural basin situated along the east flank of the Blue Mountain uplift, bordered by the Blue Mountains to the northwest, the Wallowa Mountains to the east, and the Elkhorn Mountains to the south (Carson 2001). Subsidence of the basin opposite the direction of flows has resulted in a low gradient across the basin and infilling by alternating lacustrine and fluvial depositional conditions along the southern portion of the valley creating what is now a broad, flat plain that Catherine Creek meanders through.

The basin is filled with a thick sequence of interbedded silt, sand, and gravel and poorly sorted alluvial fan deposits (Van Tassell 2001) mark the valley margins. Samples from deep-water wells in the valley show mostly river channel, floodplain, marsh, and shallow

lake sediments, indicating the basin was never a deep water environment (Carson 2001). Both the Grande Ronde River and Catherine Creek carried glacial outwash from adjacent highlands into the Grand Ronde Valley, producing terrace and alluvial fan-delta deposits as sedimentation rates fluctuated during glacial advances and retreats (Ferns et al. 2010). Pleistocene deposits also include air-fall ash from Cascades volcanic eruptions, and wind-blown loess originating from outburst glacial flood deposits near Pendleton (Ferns et al. 2010).

For this report, the assessment area was divided into three distinct geomorphic areas: the Upper Valley Group, the Alluvial Fan, and the Valley Floor Group. Reaches are unconfined in the Valley Floor Group and range from confined to unconfined in the alluvial fan and upper valley reaches. Catherine Creek is characterized by very high sinuosity in the Valley Floor Group and relatively low sinuosity in the alluvial fan and Upper Valley Group. Substrate ranges from boulder cobble and gravel in the alluvial and upper valley reach to fine sand and silt interbedded with clays in the Valley Floor Group. Riparian vegetation ranges from grass and willows to trees. Overall Catherine Creek and the adjacent riparian and floodplain vegetation have been significantly altered for flood control/conveyance and irrigation storage in addition to agricultural and residential development. Alterations include channel shortening, channelization, and levee construction.

## **2. Introduction**

Declining populations of salmon and steelhead in the Columbia Basin have resulted in attempts to improve habitat in spawning tributaries. This geology and geomorphology report is being prepared as part of a “tributary assessment (TA)” of one of those tributaries (Catherine Creek within the Grande Ronde Watershed of the Snake River basin). The TA represents the initial phase of a work process adapted by the Bureau of Reclamation (Reclamation) to help determine the existing conditions as well as the potential to improve the habitat. This study provides technical information to decision makers tasked with implementing rehabilitation projects that will increase the abundance and productivity of Endangered Species Act (ESA) listed steelhead and spring Chinook on Catherine Creek. In doing so, Reclamation will be working toward meeting tributary habitat commitments contained in the 2008 Federal Columbia River Power System (FCRPS) Biological Opinion (BiOp) (NOAA Fisheries 2008).

### **2.1 Purpose of Study**

The primary objectives of the geomorphic assessment are to understand the geomorphic regimes, delineate geomorphic reaches based on differing physical conditions, characterize watershed conditions and large-scale impacts to geomorphic regimes, and



provide information to identify sections that have potential for habitat enhancement and reconnected reach assessments. This report was prepared for the purpose of documenting the results of geologic and geomorphic mapping and field verification work performed during the 2010 field season.

## 2.2 Location

The Catherine Creek TA area focuses on the “valley segment” of Catherine Creek from its confluence with the Grande Ronde River at the State Ditch upstream to near its headwaters at the U.S. Forest Service (USFS) boundary at the confluence of the north and south forks of Catherine Creek. This segment of Catherine Creek is approximately 55-miles long and is located within three distinct geologic regimes: Upper Valley, Alluvial Fan, and Valley Floor. Several tributaries are also of interest within this area, most notably Mill Creek, Ladd Creek, Little Creek, and Pyles Creek. The study area includes the floodplain and Channel Migration Zone of Catherine Creek within this segment as shown in Figure 1.

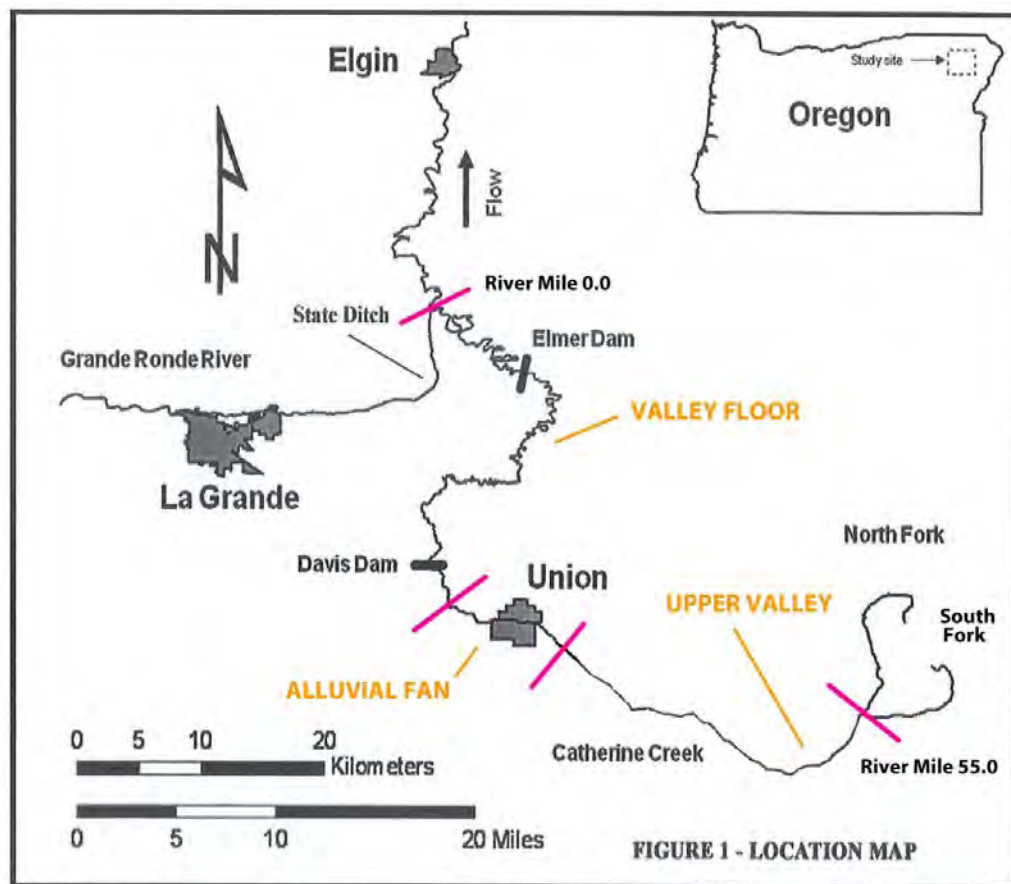


Figure 1. An illustration showing the Grande Ronde Valley and associated features.

## 2.3 Current Investigations

This report was prepared using historical accounts, ground photographs, maps, aerial photography, LiDAR (Light Deflecting Airborne Radar), USGS 30 meter DEM (Digital elevation Model), existing geologic maps and field mapping performed during the summer of 2010. Catherine Creek reaches were delineated based on physical parameters including geologic and geomorphic characteristics. The findings were compiled into a Geographical Information System (GIS) database.

Field investigations included photographic documentation of geologic and anthropogenic features for the 55-mile segment of mainstem Catherine Creek. Geologic features documented include active channel deposits, bank, and floodplain sediments. Human impacts include channel shortening, channel slope increases, reduced channel migration, and altered sediment transport regime due to mechanical channel straightening and manipulation, and bank stabilization. Specific human features include bridges, roads, culverts, diversions, levees, drains, pumps, and bank protection (riprap, etc.). A complete set of photographs with brief descriptive captions are in Attachment A.

Channel bed and bank sediments were sampled at 11 locations along Catherine Creek. Samples were logged visually and submitted for physical properties and gradation analysis. Samples were classified using methods described in Reclamation's 5005 [Earth Manual, Part 2, Third Edition, and the Unified Soil Classification System (USCS)]. The results of the laboratory testing are shown on the summary and gradation analysis sheets in Attachment B.

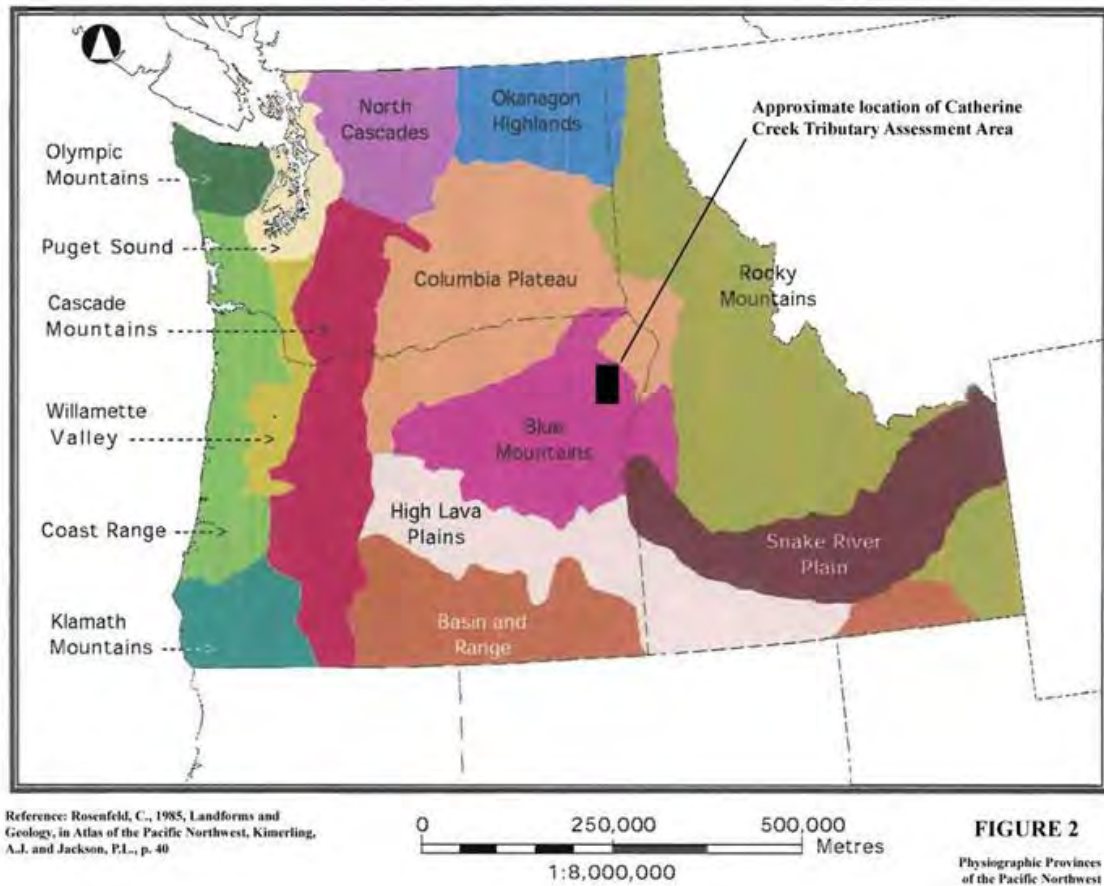
Channel bed and bar sediments were sampled using pebble counts at 17 locations. Pebble counts were performed using systematic sampling at evenly spaced intervals along a measuring tape. In most areas, the spacing was 0.5 feet. Sediment bars that were relatively small in length often required multiple transects to complete a minimum of 100 counts. A gravelometer was used in the measurement of each particle size. Pebble count data sheets and graphic plots are in Attachment C of this appendix.

Channel profiles were surveyed using an electronic distance finder and a standard fiberglass survey rod. Channel profiles and cross sections were prepared and used to identify significant natural and human-placed vertical grade controls, determine wetted width, and calculate the active channel width-to-depth ratios. Channel cross-sectional profiles are in Attachment D.

Channel geometry and flow characteristics were measured and calculated from GIS data and survey profiles. A compilation of the measured attributes is provided in Appendix D.

### 3. Regional Geology

The Grande Ronde Valley and Catherine Creek are within the Blue Mountain physiographic province in northeast Oregon (Figure 2). The modern Grande Ronde Valley is a large structural basin situated along the east flank of the Blue Mountain uplift, bordered by the Blue Mountains to the northwest, the Wallowa Mountains to the east, and the Elkhorn Mountains to the south (Carson 2001).



**Figure 2. Physiographic provinces of the Pacific Northwest.**

Radiometric dating of ash samples from deep wells have been used to determine sediment accumulation and subsidence rates of the Grande Ronde basin. Ash layer dating suggest sediment accumulation began during the Miocene, and that over the last 2.6-million years the southwest margin of the basin has subsided faster than the northeast side of the basin (Carson 2001). Subsidence of the basin opposite the direction of flows has resulted in a low gradient across the basin and infilling by alternating lacustrine and

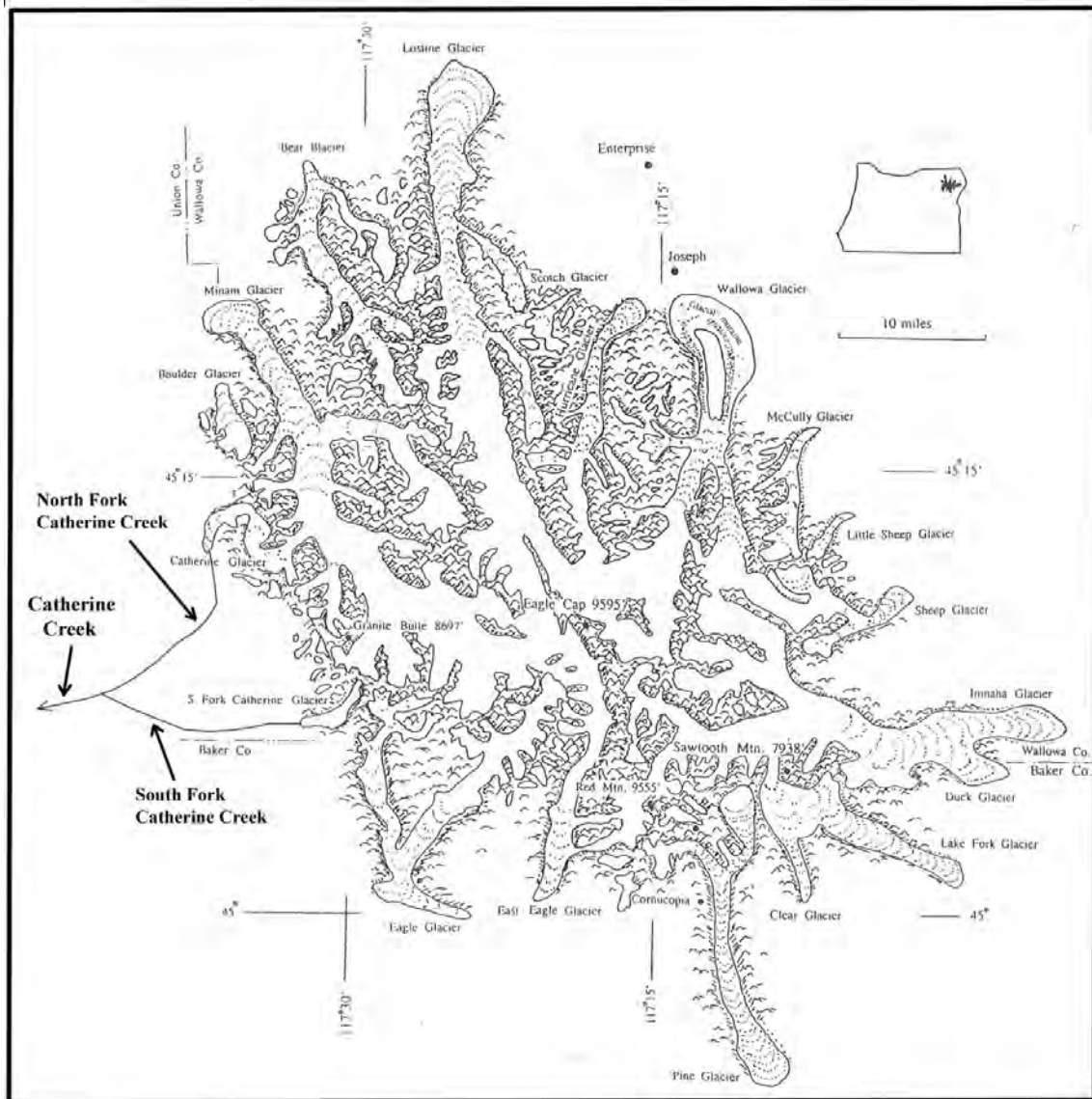
fluvial depositional conditions along the southern portion of the valley creating what is now a broad, flat plain that Catherine Creek meanders through.

The western most out crops of the Wallowa batholith (Cretaceous) are exposed along the upper reaches of Catherine Creek. The unit is composed of medium-grained granodiorite and tonolite, and fine- to medium-grained diorite. Aside from the granitic rocks of the Wallowa Mountains, the mountains surrounding the Grande Ronde Valley are mostly Miocene Columbia River Basalt Group, Grande Ronde Formation, and younger volcanic rocks of the Powder River Volcanic Field.

A thick sedimentary valley-fill sequence overlies the bedrock in the Grande Ronde basin. The most detailed information on the sediments comes from water wells. In one deep well the valley-fill sediments coarsen upward from a thin section of organic clays and silts, into a 1550-foot-thick section of sandy silt interbedded with thin seams of gravel and sand (Van Tassell 2001). Samples from deep water wells in the valley show mostly river channel, floodplain, marsh, and shallow lake sediments, indicating the basin was never a deep water environment (Carson 2001).

Sequences of laterally discontinuous gravel, sandy gravels, and sandy silts, interfingered with valley margin deposits of poorly sorted bouldery conglomerate and alluvial fan debris suggest the basin fill was largely alluvial and fluvial, and the presence of lacustrine sediments indicates intermittent/temporary damming of the outflow and deposition related to tectonic tilting of the basin (Van Tassell 2001). It has been suggested that ephemeral lakes and marshes developed in part due to periodic damming of the Grande Ronde River by landslides from the western flank of Mount Harris, and landslides at Rhinehart Gap at the northern end of the basin (Ferns et al. 2010).

Glaciation in the Wallowa Mountains contributed many depositional and geomorphic changes in the surrounding river basins (Figure 3). The depositional history of the Grande Ronde Valley during the Pleistocene was dominated by three episodes of alpine glaciations in the adjacent highlands of the Elkhorn and Wallowa Mountains (Ferns et al. 2002). Both the Grande Ronde River and Catherine Creek carried glacial outwash into the Grand Ronde Valley, producing terrace and alluvial fan-delta deposits as sedimentation rates fluctuated during glacial advances and retreats (Ferns et al. 2010). Pleistocene deposits also include air-fall ash from Cascades volcanic eruptions, and loess from outburst glacial flood deposits near Pendleton, which were blown into the basin (Fern 2010).



**Figure 3. Extent of Pleistocene glaciers in the Wallowa Mountains (Orr 1992).**

The modern day floor of the Grande Ronde Valley where lower Catherine Creek runs north to the Rhinehart Gap is a broad, flat alluvial plain, ringed by terraces, alluvial fans, and debris flow and landslide deposits (Van Tassell 2001). Large alluvial fan-deltas have formed where major streams, such as Catherine Creek and the Grande Ronde River, have entered the valley. The valley's alluvial plain is traversed by meandering streams and is marked by marshes and shallow lakes in the south, and low-relief, windswept ridges of aeolian sand and silt in the north (Van Tassell 2001).

Agricultural activity has altered the natural drainage patterns of the Grande Ronde River and Catherine Creek in the last hundred years. Numerous irrigation ditches, drainage

canals, and levees have been constructed to control the flow of water. The State Ditch, an 8-mile bypass, was dug around 1870 to aid in the conveyance of flood flows. The ditch evolved to eventually capture all of the Grande Ronde River. As a result, flows in the old Grande Ronde River channel have been significantly reduced and only Catherine Creek now flows through the downstream 22.5 miles. Ladd Marsh and Hot Lake are remnants of a larger lake that occupied the southern end of the Grande Ronde Valley prior to alterations beginning in the 1870s with redirecting of the Grande Ronde by construction of the State Ditch and rerouting of Catherine Creek.

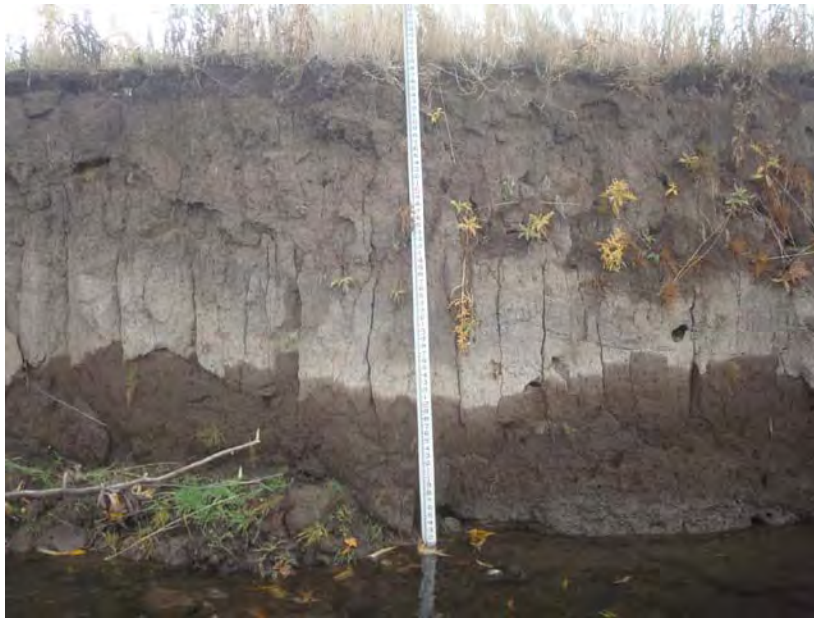
## **4. Site Geology**

The bedrock stratigraphy of the Grande Ronde Valley consists of Tertiary Powder River Volcanic Field and Columbia River Basalt Group (Tb) basalt, andesite and dacite lava flows; Pre-Tertiary meta-sedimentary and intrusive volcanic rocks (Trsv) composed of marine sedimentary rocks (metamorphic limestone); and intrusive volcanic rocks (altered diorite) of the Wallowa Batholith to the east. Surface units consist of a thick valley-fill sequence of alluvium (QTal); valley floor sediments consisting of fine-grained fluviolacustrine sediments (Qal1); alluvial fan-delta (Qfd) and coarse-grained fluvial sediments (glacial outwash) (Qal2); valley margin sediments consisting of landslide deposits (Qls) and colluviums (Qc); and active sediment deposits consisting of loess (L) and active channel alluvium (Qa). The main geologic units are described in general from youngest to oldest in the following sections; on the Geologic Explanation, and shown on cross-sectional profiles in this appendix.

### **4.1 Active Sediments**

Active sediments present in the assessment area include loess (L) and active alluvium (Qa).

Loess (L) consists of homogeneous, non-stratified, slightly indurated deposits consisting primarily of windblown silt with lesser amounts of fine sand, sandy silt and silty sand with some lean clay, including Mazama and older ash-fall deposits. The loess is generally firm, with occasional continuous moderately open vertical parting planes (cracks) forming along the banks of the creek, the loess in these areas tends to become over-steepened, resulting in occasional slab failures when subjected to high stream flows and saturated conditions (Figure 4).



**Figure 4. View of loess (L) exposure on the outside bank of a meander bend along Catherine Creek at river mile (RM) 37.25. Catherine Creek Tributary Assessment-Grande Ronde River Basin-Tributary Habitat Program, Oregon – Bureau of Reclamation – November 10, 2010.**

### **Active Alluvium (Qa)**

The active alluvium (Qa) is surficial sediment subjected to seasonal transport and deposition cycles within the bed of Catherine Creek, side channels, and floodplain. Two general types of active alluvium material; fine-grained sediment (silt and sand bars) that occupy the lower gradient sections of Catherine Creek; and coarse-grained sediment (gravel, cobble, and boulder bars and riffles) within the upper reaches.

The active alluvium (Qa) in the artificial backwater sections of Catherine Creek (behind Elmer and Davis dams) is submerged (Figure 5) and difficult to observe. However, based on samples from the lower banks, the overall soft texture of the submerged bed, and low gradient of the reach, it is likely the active alluvium consists primarily of fines, including silt, elastic silt, fine sand and clay, derived from sorted upland sediments, and reworked and redeposited valley plain fluviolacustrine and loess sediments (Qal1) eroded from the banks.





**Figure 5. View looking upstream at typical section of Catherine Creek, upstream of Elmer Dam at RM 13.60. Catherine Creek Tributary Assessment-Grande Ronde River Basin-Tributary Habitat Program, Oregon – Bureau of Reclamation – July 10, 2010.**

The active alluvium grades in an upstream direction from silt and sand, to sand and fine gravel (Figures 6 and 7).





**Figure 6.** View looking downstream at active alluvium (Qa) deposits in a sand bar along Catherine Creek at RM 30.89. Catherine Creek Tributary Assessment-Grande Ronde River Basin-Tributary Habitat Program, Oregon – Bureau of Reclamation- July 28, 2010.



**Figure 7.** Close up view of active alluvium (Qa) deposit consisting of medium sand (2 mm) sized fragments, Catherine Creek at RM 31.40. Catherine Creek Tributary Assessment-Grande Ronde River Basin-Tributary Habitat Program, Oregon – Bureau of Reclamation - July 28, 2010.

The active alluvium (Qa) in the upper reaches of Catherine Creek consists predominantly of poorly sorted gravel with sand, silt and scattered cobbles, derived from reworked and re-deposited alluvial fan-delta (Qfd), and coarse-grained alluvium deposits (reworked glacial outwash (Qal2) (Figures 8 and 9).



**Figure 8. View looking downstream at active alluvium (Qa) deposit forming riffles along the bed of Catherine Creek at RM 39.10. Catherine Creek Tributary Assessment-Grande Ronde River Basin-Tributary Habitat Program, Oregon – Bureau of Reclamation – August 2, 2010.**



**Figure 9. View looking downstream at active alluvium (Qa) deposit forming a gravel and cobble bar along the bed of Catherine Creek at RM 41.65. Catherine Creek Tributary Assessment-Grande Ronde River Basin-Tributary Habitat Program, Oregon – Bureau of Reclamation – August 16, 2010.**

About 6 miles east of Union the creek is confined to a canyon formed by bedrock and Oregon State Highway (S.H.) 203 to the north, and a large pre-historic landslide to the south (Figure 10). Here the active alluvium is composed primarily of gravel with sand, cobbles, and boulders. The channel in the vicinity of Catherine Creek State Park, in the area of RM 49.0, is less confined, but the active alluvium (Qa) also consists of gravel, sand and cobbles with boulders and occasional blocks (Figure 11).





**Figure 10. View looking upstream at active alluvium (Qa) deposits along the bed of Catherine Creek at RM 46.20. Catherine Creek Tributary Assessment-Grande Ronde River Basin-Tributary Habitat Program, Oregon – Bureau of Reclamation – August 18, 2010.**



**Figure 11. View looking downstream at active alluvium (Qa) deposits along the bed of Catherine Creek at RM 48.45 (near Catherine Creek State Park). Catherine Creek Tributary Assessment-Grande Ronde River Basin-Tributary Habitat Program, Oregon – Bureau of Reclamation – August 17, 2010.**

Catherine Creek upstream of the state park flows through a broad flat valley, referred to locally as Hall Ranch, which is underlain by a thick accumulation of glacial outwash deposited by Catherine and Little Creeks (Carson 2001). The channel is braided and the active alluvium (Qa) is composed of primarily of rounded cobbles with well-sorted (mostly coarse) gravel and sand (Figure 12). The alluvium is derived primarily from reworked glacial outwash (Qg) deposits, and to a lesser extent slopewash and colluvium from the slope on the north side of the valley.



**Figure 12. View looking downstream at active alluvium (Qa) deposits along the bed of Catherine Creek RM 51.40. Catherine Creek Tributary Assessment-Grande Ronde River Basin-Tributary Habitat Program, Oregon – Bureau of Reclamation – August 19, 2010.**

The upper most section of Catherine Creek again flows through a narrow canyon, from the confluence of the North and South Forks of Catherine Creek downstream to the head of the broad Hall Ranch valley. The valley side slopes are rather steep with shallow bedrock surfaces, the active alluvium is composed of cobbles and gravel with sand and occasional boulder size material (Figures 13 and 14). The active alluvium is derived from slopewash and colluvium from the steep side slopes, and reworked glacial till and outwash materials from the upper reaches of the North and South Forks of Catherine Creek.





**Figure 13. View looking from right to left at the active alluvium (Qa) forming the bed of Catherine Creek at RM 52.30. Catherine Creek Tributary Assessment-Grande Ronde River Basin-Tributary Habitat Program, Oregon – Bureau of Reclamation - November 10, 2010.**



**Figure 14. Close up view of active alluvium (Qa) deposit consisting of cobble (3- to 12-inch) size rocks, Catherine Creek at RM 54.86. Catherine Creek Tributary Assessment-Grande Ronde River Basin-Tributary Habitat Program, Oregon – Bureau of Reclamation – November 10, 2010.**

## **Valley Floor Sediments**

Valley Floor sediments present in the assessment area includes Fluviolacustrine Sediments (Qal1), Alluvial Fan-delta Sediments (Qfd), and Fluvial Sediments (Qal2).

### **Fluviolacustrine Sediments (Qal1).**

Alluvial plain lacustrine sediments (Qal1) form the banks (Figure 15) and bed (Figure 16) of Catherine Creek throughout most of lower reaches within the agricultural plain of the Grande Ronde Valley. The deposits are stratified (1 to 3 foot layers) and composed predominantly of soft to hard, silt and silty sand (Figure 17). There are also lenses and layers of diatomaceous silts and clays. These sediments are indicative of marsh, low energy fluvial, and shallow lake conditions at the time of deposition (Ferns et al. 2002). Shallow lake and marsh deposits extending north from Hot Lake dominate the southwest end of the valley. Ladd Marsh is the remnant of an extensive shallow lake that covered more than 30 square miles of the Valley Floor prior to construction of the State Ditch and rerouting of Catherine Creek (Ferns et al. 2002). Water well logs indicate the alluvial plain fluviolacustrine sediments are up to about 50 feet thick.



**Figure 15. View looking upstream at fine-grained fluvio-lacustrine sediments (Qal1) exposed along the left bank of Catherine Creek at RM 21.28. Catherine Creek Tributary Assessment-Grande Ronde River Basin-Tributary Habitat Program, Oregon – Bureau of Reclamation – July 11, 2010.**





**Figure 16. View looking downstream at fine-grained fluviolacustrine sediments (Qal1) forming the bed of Catherine Creek at RM 32.85. Catherine Creek Tributary Assessment-Grande Ronde River Basin-Tributary Habitat Program, Oregon – Bureau of Reclamation – August 1, 2010.**



**Figure 17.** Close up of stratified fine-grained fluviolacustrine sediments (Qal1) exposed on the bank of Catherine Creek at RM 22.70, material consists of brown silty sand (SM) overlain by firm to hard light colored sandy silt and diatomaceous silt. Catherine Creek TA-Grande Ronde River Basin-Tributary Habitat Program, Oregon – Bureau of Reclamation – July 30, 2010.

### **Alluvial Fan-delta Sediments (Qfd)**

The alluvial fan-delta formed where Catherine Creek enters the Grande Ronde Valley near Union. The deposits grade from coarse grained near the mouth of the interfingering with finer grained sediments where the fan merges with the alluvial plain (Ferns et al. 2002). The deposits are composed predominantly of poorly graded gravel with sand, silt, and cobbles, well-graded gravel with sand, silt, and cobbles, and occasional beds of red iron-oxidized silty sand (Figure 18).



**Figure 18. View of alluvial fan-delta deposits (Qfd) exposed along the left bank of Catherine Creek river mile 40.33 (union). Catherine Creek Tributary Assessment-Grande Ronde River Basin-Tributary Habitat Program, Oregon – Bureau of Reclamation - August 2, 2010.**

Based on well logs, the Catherine Creek fan-delta has a greater percentage of fines than the Grande Ronde River fan-delta, the fines are derived from the heavily glaciated highlands upstream of Union, and a large amount of fine glacial flour was washed down onto the fan-delta by high-flow glacial melt water (Ferns et al. 2002). Gravel that underlies the fan-delta has a maximum thickness of approximately 500 feet, and is about 300 feet thick at Union (Carson 2001). Fan-delta deposits are locally overlain by overbank silt and fine sand deposits and cut by active alluvial channels (Ferns et al. 2002).

Trends of modern and abandoned channels on the fan surface indicate progressive northwestward tilting along the southeast section of the Grande Ronde Valley near Union over time (Ferns et al. 2002). The uphill part of the Catherine Creek fan-delta is likely to be more poorly sorted and contain greater amounts of debris flow deposits,



while the distal (downslope) margins become finer where the delta merges with the alluvial plain (Ferns et al. 2002).

### **Fluvial Sediments (Qal2)**

Upstream of Union, Catherine Creek flows northwestward along flat-floored, northwest trending valleys which are underlain by thick accumulations of fluvial sediments (glacial outwash) deposited by Catherine Creek (Ferns et al. 2002). The deposits are derived from glacial till, which are unconsolidated, poorly stratified deposits of silt, coarse gravel, sand and loess, eroded from rocks of the Wallow Batholith, exposed mainly in lateral moraines along the upper reaches of Catherine Creek (Ferns et al. 2010). Glacial outwash, reworked and mixed with fluvial deposits, forms much of the bed and banks of the upper reaches of Catherine Creek. The deposits are composed predominantly of well- to poorly-sorted gravel with sand, silt, and cobbles, with scattered boulders and interbeds of silty sand (Figure 19). The fluvial sediment (glacial outwash) deposits likely interfingered with fan-delta deposits in the middle reaches near Union at the apex of the Catherine Creek fan-delta.



**Figure 19. View of fluvial sediments interbedded with silty sand (Qal2) exposed along the right bank of Catherine Creek at river mile 51.02. Catherine Creek Tributary Assessment-Grande Ronde River Basin-Tributary Habitat Program, Oregon – Bureau of Reclamation - August 19, 2010.**

## Valley Margin Sediments

Valley margin sediments present in the assessment area include landslide deposits (Qls) and colluvium (Qc).

### Landslide Deposits (Qls).

Landslide deposits form the south bank of Catherine Creek throughout the canyon section near Catherine Creek State Park (Figure 20). The deposits are composed of unconsolidated, chaotically mixed masses of rock and soil (Gehrels 1981). Landforms are typically hummocky surfaces marked by closed depressions, springs and wet seeps, scarps, cracks and crevices, the landslides deposits are often traceable upslope to scarps or slip surfaces. In the assessment area, the landslides generally originate along contacts between competent lava flows and underlying tuffaceous units (Ferns et al. 2002). The landslide appears to be inactive now with the exception of small-scale erosion at the toe and soil creep along the relatively steep hillsides above Catherine Creek.



**Figure 20. View looking downstream along a section where the left bank of Catherine Creek is comprised of landslide debris (Qls) near river mile 46.21. Catherine Creek Tributary Assessment-Grande Ronde River Basin-Tributary Habitat Program, Oregon – Bureau of Reclamation - August 18, 2010.**

### Colluvium (Qc)

Colluvium deposits at the mouths of small side canyons, exposed primarily along the south side of the valley and along the south bank of Catherine Creek throughout much of

reach 4 (Figure 21). The deposits grade down slope from coarse grained boulder to gravel to fine to medium-grained gravel, sand and silt deposits near the Valley Floor (Figure 22).



**Figure 21. View looking downstream at colluvium (Qc) forming the left (south) bank of Catherine Creek near river mile 44.00. Catherine Creek Tributary Assessment-Grande Ronde River Basin-Tributary Habitat Program, Oregon – Bureau of Reclamation – September 9, 2011.**





**Figure 22. Close-up view colluvium (Qc) deposits along the left (south) bank of Catherine Creek near RM 44.00. Catherine Creek Tributary Assessment-Grande Ronde River Basin-Tributary Habitat Program, Oregon – Bureau of Reclamation – September 9, 2011.**

### **Quaternary-Tertiary Valley-fill Sediments (QTal)**

The valley-fill is the thickest sedimentary unit in the area, the sediments overlie the bedrock and forms the deep valley deposits in the Grand Ronde basin. The sediments are not well exposed in the study area, but detailed information from water wells indicate the valley-fill sediments coarsen upward from a thin section of organic clays and silts, into a 1,550-foot thick section of sandy silt interbedded with thin seams of gravel and sand (Van Tassell 2001). Samples from deep water wells in the valley show mostly river channel, floodplain, marsh and shallow lake sediments, indicating the basin was never a deep water environment (Carson 2001).

## 4.2 Bedrock Units

Bedrock is exposed along the banks of the upper reaches of Catherine Creek upstream of Union. The bedrock consists of undifferentiated volcanic rocks of the Tertiary Powder River Volcanic Field and Columbia River Basalt Group (Tb) composed of basaltic, basaltic andesite, andesite and dacite lava flows; Pre-Tertiary meta-sedimentary and intrusive volcanic rocks (Trsv) composed of marine sedimentary rocks (metamorphic limestone), and intrusive volcanic rocks of the Wallowa Batholith to the east (Gehrels 1981).

## 5. Geomorphology

### 5.1 Introduction

Various geomorphic (physical) processes are responsible for creating and maintaining riverine habitat for multiple aquatic species. The manipulations to Catherine Creek and its floodplain within the TA area have a cumulative impact on the physical processes and instream functions that sustain salmonid habitat. These impacts, to varying levels, collectively contribute to the known limiting factors that include water quantity (low summer flows), water quality (elevated summer temperatures, low dissolved oxygen levels), poor habitat quantity/diversity (low abundance of pool habitat and lack of habitat diversity), returning adult passage, excess fine sediment and degraded riparian conditions (NOAA Fisheries 2008). Below is a general discussion on causes and interrelations between the known limiting factors.

The limiting factor of water quantity is primarily a result of the combination of water withdrawal combined with seasonal low flow. Water quantity is compromised due to mid-July through the end of September withdrawals that can reduce instream flows by 90 to 95 percent (NOAA Fisheries 2008). Additionally, decreed water rights and permitted withdrawals may exceed the actual flow of Catherine Creek (NOAA Fisheries 2008). Reduction of groundwater recharge is due to multiple factors including reduced floodplain interaction during high flow events and reduction of total floodplain area associated with construction of roads and levees and other impervious surfaces, and the development of the floodplain into agricultural use. Low flow conditions can also contribute to other limiting factor conditions. The water quality parameter of elevated summer water temperatures can be exacerbated by low flow conditions. The reduction in water depth in the main channel can increase the effect of the surface warming due to solar radiation. Low flow conditions can lend to the limiting factor of reduced habitat by reducing the overall depth and wetted width (NOAA Fisheries 2008). This would presumably reduce the depth of pools for holding and resting as well as reducing the near bank-rearing habitat. Low flow conditions can also promote the limiting factor of

passage by creating upstream and downstream passage barriers in the main channel as well as cut-off passage into tributaries or off-channel habitat.

The limiting factor of water quality has two parameters: elevated summer water temperature and low dissolved oxygen (DO). DO is not addressed in this report. Elevated water temperature is directly related to multiple factors, including degraded riparian conditions, water diversion and return, and reduced river and floodplain interaction. When the riparian vegetation that shades the stream has been altered, or is not present, more solar radiation is absorbed by the stream causing the water temperature to rise. Surface water withdrawals can also contribute to increased temperatures in the main channel by reducing the depth of water in the channel as described above. In addition, the water that is diverted off the main channel may absorb greater amounts of solar radiation given the shallow depth and lack of vegetation along most ditches or ponds before returning to the main channel via surface flow. Another contributor to the elevated summer temperatures in the very low stream gradient on the valley floor. The low gradient leads to very low water velocities that can in turn lead to the thermal stratification of the water column. With thermal stratification, the warmest water is at the surface and essentially warms the water that flows through the fish ladders at diversion dams, and may create a thermal barrier. Reduction of groundwater recharge as described above can also promote elevated summer water temperatures. Floodplain interaction at high flow allows water to enter the hyporheic zone via infiltration. This water is “stored” in the ground to return to the main channel as cooler recharge water during times of low flow.

Fish passage is listed as a limiting factor, and is related to or a product of one or more other conditions or manipulations. One of the causal conditions for reduced fish passage is low flow, which is described above. Extreme in-channel low flow can cause a migration barrier to both returning adults as well as smolts attempting to migrate within Catherine Creek (NOAA Fisheries 2008). Elevated summer water temperatures and thermal stratification can also impede passage, as described above. Increased amounts of absorbed solar radiation combined with low flow can elevate summer water temperatures to limit access of returning adults as well as summer rearing (NOAA Fisheries 2008). During high flows, loss of instream habitat complexity from bank hardening, channelization, and reduced large wood in the channel can also result in velocity barriers to certain life stages of Chinook and salmon.

Habitat quantity and diversity is also a limiting factor. The reduction of habitat quantity and diversity likely began with modifications that took place beginning soon after the settlement of the valley by Anglo-European settlers in the mid to late 1800s and continued until as recently as the mid-1970s. Past logging practices have reduced the amount of large wood available from the upland areas. The implementation of agricultural land use practices including the conversion of wetlands, meadows, and multiple channel systems to grazing and crop production has decreased areal extent of

off-channel habitat and reduced diversity of instream habitat. Vegetation removal or conversion from riparian species to agricultural or upland species decreases large wood recruitment for instream complexity and cover, and reduces nutrients and food for aquatic macro-invertebrates that fish feed on. Bank armoring and or channelization reduce the natural rates of channel migration. Channel migration is a product of bank erosion accompanied by bar building on the opposite bank. Erosion of the bank supplies needed sediment and potentially some woody debris to the system. Concurrent bar building through deposition provides low floodplain surfaces for colonizing vegetation (such as cottonwoods) and high-flow refuge for fish. Disturbances to the balance between erosion and deposition often result in a depletion of one or the other. When that occurs, processes that create and maintain diverse habitat types are not able to do so. The result is a decrease of in-channel complexity and habitat diversity. Reduced habitat quantity is further attributed to low flow conditions including velocity barriers, described above.

The limiting factor of excess fine sediment has been well documented (GRWQC 2000; NOAA Fisheries 2008; Nowak 2004). Fine sediment can come from multiple sources. Sections of bank throughout the assessment area that have altered or removed vegetation are more susceptible to localized erosion. Fine sediment can also be incorporated into the system by scour of the floodplain surface during high flow. Another source of fine sediment input can be from upstream/upland sources where logging and subsequent fires have altered the surface runoff characteristics and increased fine sediment input. Increased levels of fine sediment can degrade potential spawning habitat by increasing the level embeddedness of spawning gravels, as well as reduce the survival during the incubation period (NOAA Fisheries 2008). In areas where floodplain interaction has been reduced through levees or channelization, the fine sediment remains in the system rather than being allowed to deposit on the floodplain (NOAA Fisheries 2008).

## **5.2 Purpose and Scope**

The primary objectives of the geomorphic assessment are to:

- Delineate and describe geomorphic reaches based on differing geomorphology that includes:
  - Natural controls on morphology including geology, valley confinement, and valley and channel gradient.
  - Historic conditions
  - Current channel form and process.

Additional objectives include:

- Discuss the conditions and processes noted above as they relate to or contribute to the identified limiting factors that affect the reproduction and/or survival of salmonid species.
- Discuss initial rehabilitation strategies that address the current conditions/limiting factors that are affecting the reproduction and/or survival of salmonid species.

### **5.3 Geomorphic Reach Delineation**

Geomorphic reaches along Catherine Creek were identified based on differences in physical parameters that include channel gradient, surficial geology, physical processes, and valley confinement, and grouped by area (Figure 23). Individual reach boundaries are determined by physically significant differences in these parameters. Seven geomorphic reaches were identified within the TA area on Catherine Creek. These reaches are combined into three groups as noted in Table 1 to facilitate discussion of general physical characteristics.



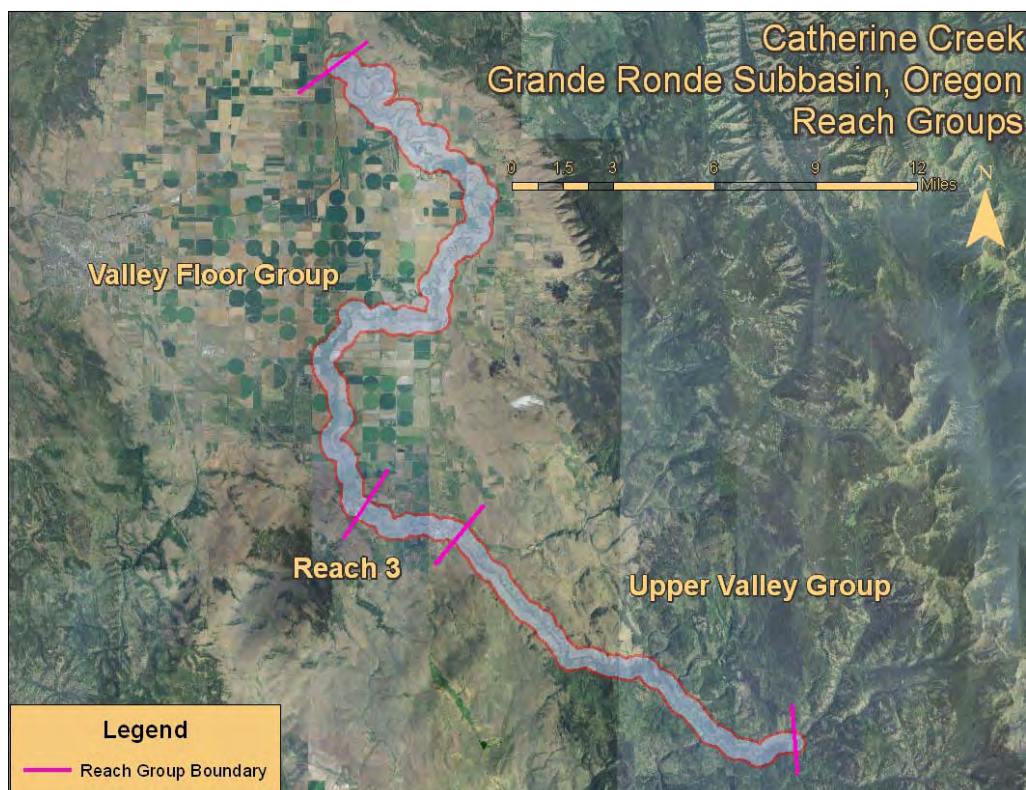


Figure 23. A plan view showing the geomorphic reach groups on Catherine Creek.

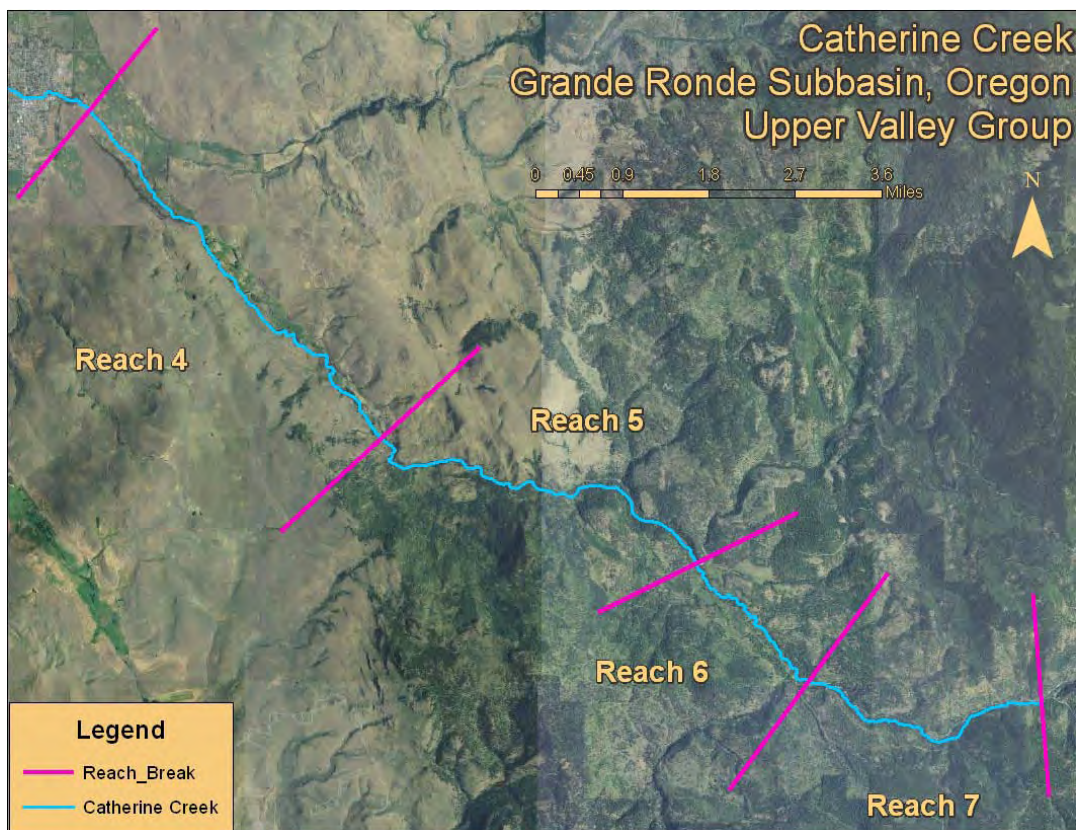
Table 1. Locations, surficial geology, confinement classification, and grouping of geomorphic reaches along Catherine Creek.

| Geomorphic Reach | Location by RM | Surficial Geology    | Confinement Classification | Group              |
|------------------|----------------|----------------------|----------------------------|--------------------|
| 7                | 52.0 – 54.9    | Alluvium/bedrock     | Confined                   | Upper Valley Group |
| 6                | 50.11 – 52.0   | Alluvium             | Unconfined                 | Upper Valley Group |
| 5                | 45.8 – 50.11   | Alluvium/Landslide   | Confined                   | Upper Valley Group |
| 4                | 40.78 – 45.8   | Alluvium/Bedrock     | Unconfined                 | Upper Valley Group |
| 3                | 37.2 – 40.78   | Alluvium (Fan-delta) | Unconfined                 | Alluvial Fan       |
| 2                | 22.5 – 37.2    | Fluvial-Lacustrine   | Unconfined                 | Valley Floor Group |
| 1                | 0.0 – 22.5     | Fluvial-Lacustrine   | Unconfined                 | Valley Floor Group |

### 5.3.1 Upper Valley Group, Reaches 7 through 4

Geomorphic reaches 7 through 4 comprise the Upper Valley Group on Catherine Creek. The group includes the area from the confluence of the North and South Fork of Catherine Creek near RM 54.9 downstream to the valley mouth, just upstream of the town of Union at RM 40.78 (Figure 24). Within the Upper Valley Group, the reaches range from confined to unconfined by bedrock hillslopes that form the valley walls, with the valley floor being comprised of alluvium. The valley walls within the Upper Valley Group are comprised of bedrock that includes dacite and basalt in the lower and mid-

sections of the valley segment, and andesite, basalt, and argillite in the top section (Ferns et al. 2010). Other units mapped by Ferns et al. (2010) include local landslides and a large debris flow/debris avalanche. Channel bed and bank materials were observed to range from boulders to silt-sized material. Natural lateral and vertical control in the Upper Valley Group comes from bedrock and the coarser fraction of alluvium and landslide material that includes boulders, and cobble. The overall channel gradient averages about 1.1 percent within the Upper Valley Group. Banks range from gently sloping with grass, willow, small tree and a few large trees (Figure 25). Large and small trees are defined as 21 to 31.9 inches diameter-at-breast-height (dbh) and 9 to 20.9 inches dbh, respectively (USFS 2008). In reaches 4 and 6, the majority of the floodplain has been altered to agriculture or pasture land. Vegetation along the banks includes willow, aspen, and small cottonwood trees. Small stands of relic cottonwood galleries are present along the banks and in the floodplain. In reach 6, floodplain that had been converted to grass and pasture land is now returning to native floodplain and streambank species. Current use by Chinook salmon and steelhead includes migration, spawning, and rearing (NOAA Fisheries 2008).



**Figure 24.** Location map of the Upper Valley Group on Catherine Creek, with reaches sequentially numbered from upstream to downstream.





**Figure 25. Various bank conditions, vegetation, and substrate in the Upper Valley Group.**

### **Historic Conditions.**

Historically, within the Upper Valley Group, Catherine Creek likely looked similar to the way it looks today. The stream would have alternated between higher energy, confined reaches with lower sinuosity, and unconfined reaches with greater sinuosity and lower stream energy. The general vegetation composition within the Upper Valley Group reaches would have likely consisted of riparian galleries that included cottonwood, aspen, and willow in the unconfined reaches (NOAA Fisheries 2008). Floodplain vegetation likely consisted of grasses and shrubs with wetland vegetation in areas inundated by or connected to beaver complexes. Extensive beaver activity would have created diverse instream and floodplain habitats, with deep pools and strong connections to floodplains in the unconfined reaches (NOAA Fisheries 2008). Large woody debris (LWD) would have been present on the floodplain and instream where it would have added to channel complexity. Catherine Creek likely migrated within its floodplain in unconfined areas, which would have supplied some woody debris to the channel; however, the rate of migration into and through mature stands would have been slow enough that this would not have provided the majority of LWD to the stream.

Instream LWD was likely supplied primarily from upland coniferous forests via debris flows or mass wasting events from excessive rain and/or rain-on-snow events (NOAA Fisheries 2008). Once incorporated, the large wood may have only migrated a short distance downstream during large run-off events due to flatter gradients and depositional processes in the unconfined reaches. In-channel substrate would have been coarser in the confined reaches and finer in the unconfined reaches, similar to present day conditions.

## **Current Conditions**

Conditions including sinuosity, width-to-depth ratios and valley and stream gradient have likely changed as a result of the manipulations that have been applied by humans to the channel, banks, and floodplain of Catherine Creek in the Upper Valley Group. Observed shortening of the channel would have increased the stream gradient by decreasing sinuosity over the same valley length potentially resulting in local changes to the width-to-depth ratio access to the floodplain or the floodplain width. Essentially all of the observed manipulations to the channel and floodplain were completed by the earliest set of complete aerial photographs (1956). However, some change is still detectable through remote analysis of the later aerial photographs. The results of the remote analysis showed that channel sinuosity has slightly increased in reach 4 from 1.05 in 1956 to 1.07 in 2008. In reach 6, there was a slight increase from 1.11 in 1964 to 1.19 in 2008, likely due to the river readjusting to decreased levels of ‘management’. In reach 5, the sinuosity decreased from 1.08 in 1964 to 1.06 in 2008. In reach 7, the sinuosity remained relatively constant from 1956 to 2008. In both cases, where amounts of increase and decrease in sinuosity were noted the amount of change is small and could partially be contributed to parallax, where the edges of the areal image are distorted. In addition, the image quality of the earlier aerial photos made precise mapping and analysis difficult.

Results from field measurements, observations, and remote analysis using GIS software show that the geomorphic conditions differ from reach to reach in the Upper Valley Group (see Attachment A – Photographic Documentation, of reaches 7 through 4). Stream gradients range from 1.57 percent to 0.83 percent, and valley gradients range from 1.64 percent to 0.89 percent. Both steadily decrease in the downstream direction. The average width to depth ratio is 27:1. Reach 5 has the lowest width to depth ratio at 20:1, and reach 6 has the highest at 34:1 (Table 2) (see Attachment D for drawings of cross sections in reaches 7 through 4).

**Table 2. Valley and channel gradients, sinuosity, and width-to-depth ratios of the Upper Valley Group of reaches on Catherine Creek.**

| <b>Geomorphic Reach</b> | <b>Valley Gradient ( percent)</b> | <b>Stream Gradient (percent)</b> | <b>Sinuosity</b> | <b>Average Width:Depth</b> |
|-------------------------|-----------------------------------|----------------------------------|------------------|----------------------------|
| 7                       | 1.64                              | 1.57                             | 1.04             | 28:1                       |
| 6                       | 1.50                              | 1.25                             | 1.19             | 34:1                       |
| 5                       | 1.10                              | 1.00                             | 1.06             | 20:1                       |
| 4                       | 0.89                              | 0.83                             | 1.07             | 25:1                       |

Calculated sinuosity values for each reach within the Upper Valley Group are similar, with the exception of reach 6, an unconfined reach. Within reach 6, the sinuosity has increased, and therefore the channel gradient has decreased. This is due to the stream readjusting to the impacts to the stream that occurred in association with the construction of Highway 203/Medical Springs Highway sometime prior to 1937. Reach 4, the other unconfined reach, has a low sinuosity. Reasons for the lower sinuosity in the reach include sections of more coarse substrate and reduced sediment supply, as well as lateral and vertical control of bedrock. Reaches 7 and 5 are naturally confined; therefore, a low sinuosity value in those reaches is considered normal, and has not likely changed compared with historic conditions.

Pebble counts were conducted in each reach in order to develop grain size distribution curves for substrate in the active channel bottom including the thalweg and bars (see Attachment B for complete set of grain size distribution curves). The dominant substrate of the Upper Valley Group is cobble and gravel; however, boulders, sands, and fine material were also observed. The  $D_{50}$ , (meaning that 50 percent of the material is smaller than that size) measurements for the Upper Valley Group range from 33.5 mm in reach 6 to 70.9 mm in reach 7, with the average  $D_{50}$  for the Upper Valley Group being 56.2 mm (see Table 3 for complete gradation averages).

**Table 3. Average gradation analysis of in-channel substrate within the Upper Valley Group on Catherine Creek.**

| <b>Reach</b> | <b>Average Diameter of Substrate (mm)</b> |                            |                            |                            |                            |
|--------------|-------------------------------------------|----------------------------|----------------------------|----------------------------|----------------------------|
|              | <b><math>D_{15}</math></b>                | <b><math>D_{35}</math></b> | <b><math>D_{50}</math></b> | <b><math>D_{84}</math></b> | <b><math>D_{95}</math></b> |
| 7            | 37.7                                      | 57.1                       | 70.9                       | 119.8                      | 191.2                      |
| 6            | 4.3                                       | 18.9                       | 33.5                       | 93.5                       | 142.3                      |
| 5            | 21.7                                      | 48.1                       | 63.2                       | 120.4                      | 166.6                      |
| 4            | 29.2                                      | 44.8                       | 57.2                       | 111.2                      | 157.1                      |

## **Physical Processes**

Channel migration, sediment transport, and large wood recruitment are the primary physical processes that create and maintain instream salmonid habitat in Catherine Creek. Each is discussed individually below.

### **Migration**

Observed evidence of vertical and lateral migration within the Upper Valley Group area varied from reach to reach as well as within each reach with sections of bank showing signs of local scour and/or undercutting commonly observed in all reaches (see Attachment A – Photographic Documentation). In reaches 7 and 5, overall migration rates are low due to natural conditions/controls such as non-erosive bedrock and coarse-grained bed and bank material, increased confinement, and steeper gradient. In reach 6, observed indications of active lateral migration included vertical bare banks, with associated meander/lateral sediment bar deposition, bifurcation and avulsion of the channel as a result of the high spring flow from 2010. These observations as well as bar formation and growth in reach 6 indicate that the vertical and lateral migration rates are somewhat representative of a stream that is in dynamic equilibrium. In reach 4, areas with low migration rates exist at the bottom and top of the reach, although some local bank erosion is noted to be occurring in the top section. The overall low migration rate in these sections can be attributed to bedrock and coarse alluvial material that act as natural vertical and lateral migration controls. In the mid-section of reach 4 from approximately RM 44.0 upstream to RM 44.95, accelerated rates of migration are noted to be occurring, with rapid migration occurring multiple times, the most recent occurring during the spring high low of June 2010 being the most recent (Dyke 2010; 2011). The accelerated rate is due to a combination of erodible bank materials and altered riparian vegetation.

### **Sediment Transport**

Initial sediment transport calculations utilizing data collected at cross-sections that includes particle sizes of  $D_{50}$  (meaning 50 percent of the material is smaller than) and  $D_{84}$  (meaning 84 percent is smaller than) and general channel geometry (bankfull width and depth) and average channel slope were used to calculate hydraulic radius, shear stress and critical shear stress. The HEC-RAS model was not built for reaches 5, 6 and 7. Shear stresses calculated from cross-sections range from about 1.6 lb/ft<sup>2</sup> in reach 7 to 1.2 lb/ft<sup>2</sup> in reach 5. HEC-RAS model results show a reach average shear stress of around 1.1 lb/ft<sup>2</sup> at a 1.5 year recurrence interval in reach 4 (Appendix D). However, there is a wide range of conditions throughout each reach including slope, estimated bankfull area, wetted perimeter, and sediment size in reach 4. Overall, reach 7 is a sediment transport reach with a steep slope and coarser substrate. Reach 6 is a sediment storage reach as noted by large point bars and local channel avulsions due to sediment



build up. Reach 5 is predominantly a sediment transport reach as it is confined with a narrow floodplain. The top and bottom sections of reach 4 are primarily sediment transport sections. In both sections the channel is somewhat confined with coarser substrate. The mid-section is a sediment storage sections with smaller substrate, numerous point bars, increased lateral migration rates, as well as noted channel evulsion sites.

## **Large Wood**

Observed occurrences of large wood within the active channel were low. Small sections of live large trees were observed growing along the banks and within the floodplain throughout the Upper Valley Group area. Although some wood (cottonwood and Alder) was likely supplied to the stream from the banks on the valley floor by beaver activity, blow down, and mortality, the main source of large wood is likely from mass wasting in upland forests resulting rain-on-snow events or intense rainstorms.

## **Anthropogenic Manipulations**

Although beyond the scope of this effort, impacts to the headwater areas of the subbasin should be noted. Over 11,000 acres of the upland vegetation has been altered by logging practices. Additionally, over 4,000 acres have been burned in forest fires since 1985. The channel, banks, and adjacent floodplain areas within the Upper Valley Group on Catherine Creek have all experienced anthropogenic manipulations to some degree. Manipulations generally include road construction and bridges, bank protection measures, alteration of floodplain and bank vegetation, surface water withdrawal sites, and in some cases, possible channel relocation. The individual reaches exhibit increasing degrees of impacts from past and ongoing manipulation as one moves from the upper most reach (7) downstream.

Manipulations to the channel or within the floodplain in reach 7 appear to be minimal, aside from possible alteration to the vegetation from land clearing and grazing. Human features along the banks in reach 7 are limited to a single bridge at the downstream end. A road that traces along the north side of the valley along the transition from the floodplain of Catherine Creek to the adjacent upland slopes for the entire length of the reach (Table 4). The road may slightly alter the timing of runoff and the sediment input to the system, but the impact to channel processes is likely minimal. It should be noted that the entire length of reach 7 was not surveyed due to access issues. If further assessment or project identification and development occur in reach 7, the entire reach should be evaluated.

**Table 4. List of anthropogenic features in reach 7 on Catherine Creek.**

| <b>Reach 7 Anthropogenic Features</b> |                 |                    |
|---------------------------------------|-----------------|--------------------|
| <b>Anthropogenic Feature</b>          | <b>Quantity</b> | <b>Length (ft)</b> |
| Bridge                                | 1               |                    |

Reach 6 has undergone manipulations to the channel and floodplain. The 2009 LiDAR imagery indicates that 26 acres has been disconnected from the main channel by Highway 203/Medical Springs. In addition, vegetation has been cleared or altered and land use includes historical grazing. The area is now the Eastern Oregon Agricultural Research Center. Grazing does take place within the riparian area on an annual basis; however, the amount of time that the grazing is allowed is limited (DelCurto 2011). Human features noted along the stream in reach 6 are small sections of bank protection associated with Highway 203/Medical Springs Highway and a small section of gravel road, both of which are located at the upstream end of the reach. In addition, Highway 203/Medical Springs highway bisects the left floodplain for the entire length of the reach (Table 5).

**Table 5. List of anthropogenic features in reach 6 on Catherine Creek.**

| <b>Reach 6 Anthropogenic Features</b> |                 |                    |
|---------------------------------------|-----------------|--------------------|
| <b>Anthropogenic Feature</b>          | <b>Quantity</b> | <b>Length (ft)</b> |
| Road (paved/Unpaved)                  |                 | 9,697              |
| Bank Protection                       |                 | 334                |

Within reach 5, Catherine Creek runs adjacent to Medical Springs Highway/203 along the right bank for about a quarter of the reach length. Subangular to angular riprap protects the road prism in essentially all instances where the road prism forms the right bank of the stream. Another method of bank protection that was observed within the reach was cabled log bank protection along the left bank, downstream of the bridge near RM 47.6 (Table 6).

**Table 6. List of anthropogenic features in reach 5 on Catherine Creek.**

| <b>Reach 5 Anthropogenic Features</b> |                 |                    |
|---------------------------------------|-----------------|--------------------|
| <b>Anthropogenic Feature</b>          | <b>Quantity</b> | <b>Length (ft)</b> |
| Road (paved/Unpaved)                  |                 | 6,640              |
| Bank Protection                       |                 | 5,693              |
| Bridge                                | 5               |                    |
| Historic Abutment                     | 3               |                    |
| Push-up Diversion                     | 1               |                    |
| Well                                  | 1               |                    |
| Submersible Pump                      | 1               |                    |
| Gauge                                 | 1               |                    |

Reach 4 has potentially been manipulated to the largest degree of all the reaches in the Upper Valley Group. In the downstream end of the reach, the general location of Catherine Creek along the left valley wall is likely controlled by cross-valley sloping caused by the Catherine Creek Fault, which shows displacement down and to the east (Ferns et al. 2010). However, in the areas of RM 41.1 and 41.5 the 2009 LiDAR imagery show evidence of past migration in the form of channel scars. The 1937 aerial imagery shows differences in vegetation that also suggest that the stream could have meandered away from the left valley wall in these two areas prior to the original construction of Highway 203/Medical Springs Highway. Additional sections of channel scars are visible in the LiDAR in the upstream section of the reach. Migration in these locations was likely the result of the channels response to large flow events that delivered significant amounts of bedload and debris from upstream, choked the channel causing some avulsion, and then over time the channel eventually returned to its “original” position controlled by slope/topography and structural geology. Other human features along the banks include multiple bridges, head gates, and both channel spanning concrete as well as pushup type diversions associated with surface water withdrawals, multiple sites of surface water return, and four round concrete vaults of unknown use or purpose (Table 7).

**Table 7. List of anthropogenic features in reach 4 on Catherine Creek.**

| <b>Reach 4 Anthropogenic Features</b> |                 |                    |
|---------------------------------------|-----------------|--------------------|
| <b>Anthropogenic Feature</b>          | <b>Quantity</b> | <b>Length (ft)</b> |
| Road (paved/Unpaved)                  |                 | 5,766              |
| Levee                                 |                 | 866                |
| Bank Protection                       |                 | 2,989              |
| Bridge                                | 3               |                    |
| Headgate                              | 2               |                    |
| Channel-spanning Diversion            | 2               |                    |
| Push-up Diversion                     | 3               |                    |
| Concrete Vault                        | 4               |                    |
| Surface Water Return                  | 5               |                    |

## Impacts

The impacts of past logging practices and fire history in the headwater area of the Catherine Creek subbasin have impacts over the entire length of Catherine Creek. The two collectively can alter the volume and timing of surface run off and sediment input characteristics to the main channel as well as large wood input. Within the assessment area, manipulations to the floodplain, channel cross-section, banks, and planform of the channel within the Upper Valley Group area also collectively have an impact to the physical function of Catherine Creek. These impacts, both directly and indirectly, contribute to the known limiting factors. Cumulatively, this list of impacts and

associated limiting factors affects all life stages of Chinook salmon and steelhead (NOAA Fisheries 2008). The limiting factors and the relationships to each other were previously discussed in the Introduction section of this appendix. Below, each of the limiting factors is discussed as it pertains to the manipulations observed in the Upper Valley Group area.

### ***Water Quantity***

In the Upper Valley Group, the limiting factor of water quantity is likely a culmination of multiple factors. Reduced floodplain interaction during high flow events as a result of levees, channelization, and development of the floodplain into agricultural use predominantly in reach 4 and 6, may contribute slightly to the water quantity limiting factor by reducing the levels of low flow recharge. There are a total of nine surface diversions or pumps in reaches 5 and 6 that take water from the main channel. However, the combination of seasonal low flow and surface water withdrawals likely do not create adverse low flow conditions in the Upper Valley Group. The limiting factor of water quantity is likely a cumulative effect that is more pronounced in the downstream reaches.

### ***Elevated Summer Water Temperature***

In addition to the nine water removal sites discussed above, there are five surface return sites that were observed in reach 4 that likely return warm water to the main channel. Vegetation along the channel and in the floodplain has been altered or removed to the greatest extent in reach 4, followed by reach 6. The alteration or removal of the vegetation allows for an increase in the amount of solar radiation that is absorbed by the water in the main channel. Reaches 5 and 7 also have altered vegetation along the banks and within the floodplain, although to a lesser degree. Reduced floodplain interaction during high flow events as a result of levees, and channelization, and development of the floodplain into agricultural use predominantly in reach 4 and 6 reduces the amount of cool water input during low flow conditions (see Tables 5-7). A flight that recorded water surface temperatures with forward looking infrared (FLIR) was conducted in 2000 by Watershed Sciences, LLC. The results show a steady warming from the confluence of the North and South Forks at the top of reach 7 downstream to the confluence with Little Catherine Creek at the bottom of reach 6. Another section of warming was noted from RM 44.7 near the top of reach 4, downstream to RM 41.6, near the bottom of reach 4.

### ***Habitat Quantity and Diversity***

In unconfined alluvial systems such as reaches 4 and 6, beaver activity is one mechanism that promotes physical processes such as river and floodplain interaction and channel migration that produces and maintains different habitat types within the main channel and floodplain. Conversion of wetlands, meadows, and multiple channel systems to

pasture and cropland in these unconfined reaches also results in decreased areal extent of habitat and reduced diversity of instream habitat. Reduced habitat quantity is also attributed to surface water withdrawals by reducing first the depth and then the wetted width of the channel (NOAA Fisheries 2008). Less water can also contribute to a reduced amount of low energy habitat found along the margins of the stream, as well as overall number and or depth of pools. Another contributing factor to the reduction in quality and diversity of habitat may be a result of channel-spanning diversion dams in reaches 4 and 5. Dams have multiple effects on the stream and physical processes. The dams act as artificial grade control structures that alter sediment transport characteristics and reduce dynamic adjustment to changes in sediment load and hydrology. The backwater area upstream of the dams becomes an artificial depositional zone, filling existing pools with sediment. Pools may not be re-established in the low energy environment that exists upstream of the dam during high-water events that normally would mobilize sediment (during channel forming or greater flow recurrences).

### ***Fish Passage***

Those conditions and contributors that contribute to the overall limiting factor of fish passage include the nine surface withdrawal sites in reaches 4 and 5 and the noted warming trends in the downstream direction within the valley segment. In addition, there are channel-spanning diversion dams; both concrete and push-up type within reach 4. Although all of the concrete dams have fish ladders, fish passage effectiveness at low flow remains unclear, as communicated by local biologists in a 2011 habitat work session. The push-up type diversions may also be migration barriers from a height as well as a velocity standpoint.

### ***Fine Sediment***

The limiting factor of fine sediment has been well documented (GRWQC 2000; NOAA Fisheries 2008; Nowak 2004). Fine sediment can come from also has multiple sources. Banks throughout the Upper Valley Group are comprised of 4 to 12 inches of silt sand and clay overlying gravel and sand with cobble. Sections of bank in all four reaches that have altered or removed vegetation are more susceptible to localized erosion. Fine sediment can also be incorporated into the system by scour of the floodplain surface during high flow. Another source of fine sediment input can be from upstream sources where logging and fires have altered the surface runoff characteristics and increased fine sediment input. As with temperature and water quantity, the effects of fine sediment are likely a cumulative result that increases in the downstream direction. Increased levels of fine sediment can degrade potential spawning habitat by increasing the level embeddedness of spawning gravels, as well as reduce the survival during the incubation period (NOAA Fisheries 2008). In areas where floodplain interaction has been reduced through levees or channelization, the fine sediment remains in the system rather than being allowed to deposit on the floodplain (NOAA Fisheries 2008). Fine sediment that is deposited in the artificial backwater areas upstream of channel spanning diversion



dams is likely flushed during bankfull or channel forming flow, but only after the initial aggradation that would occur as a result of the channel adjusting to the artificial grade control that the structures impose.

### ***Riparian Condition***

Within the Upper Valley Group, riparian vegetation along the banks and within the floodplain has been altered to varying degrees. The alterations contribute to multiple limiting factors including elevated water temperatures, excess fine sediment, and reduced habitat quality and quantity. Effects from habitat modification, increased fine sediment, and increased water temperature could all be improved with the enhancement of vegetation condition (GRWQC 2000). While not the only problem, riparian habitat degradation is a serious problem and addressing this issue will also indirectly address temperature, stability, sediment, other water quality factors and habitat (GRWQC 2000).

### **Conclusions**

Anthropogenic impacts within all four reaches in the Upper Valley Group on Catherine Creek contribute to the identified limiting factors for salmonids. These impacts result from human alterations including channelization, hardened banks, levees, instream diversion dams, water withdrawals, altered riparian and floodplain vegetation, reduced large wood recruitment to the stream, and reduced and hardened floodplain areas.

### **Recommendations**

In order to address the causes of the limiting factors within the Upper Valley Group, an approach that uses a strategy of prioritizing rehabilitation activities based on potential long-term benefit as described by Roni et al. (2002) should be considered. Components of the strategy could address the immediate need to increase habitat quality and quantity by adding complexity and cover in the main channel within the reach group. The addition of wood or other structures in the main channel would increase channel roughness and hydraulic complexity, which would increase habitat quality by adding channel complexity and instream cover for rearing and migrating Chinook salmon and steelhead. Habitat quantity would be improved due to the increased number of scour pools that would potentially form as a result of the stream adjusting to the new hydraulic feature and channel roughness.

The focus of rehabilitation efforts in the Upper Valley Group reaches should include multiple strategies that;

1. Restore long-term processes.
2. Restore short-term habitat.

Restoration of long-term processes include: re-initiating floodplain processes, including floodplain access through increased overbank flow which may alter the energy regime within the channel, allow more diverse bedform development and increased variability of hydraulic conditions within the channel, and provide groundwater recharge to floodplain areas that provide long-term flows to the channel; and increasing channel migration will increase habitat quality and quantity by redistributing sediment and debris, adding woody materials to the channel, and increase length and area of active channel and associated habitat. In addition, when components of the strategy of restoring short-term habitat, such as instream large wood are combined with re-initiation of long-term processes, additional habitat quality is gained. Identifying appropriate strategies and individual projects that would allow floodplain access and channel migration to re-establish in areas of willing landowners should be completed at the reach scale.

### **5.3.2 Alluvial Fan Reach; Reach 3**

Reach 3 extends through the Catherine Creek alluvial fan from the downstream end of reach 4 at RM 40.78 downstream to the toe of the alluvial fan at RM 37.2 (Figure 26). The town of Union is located in the upstream half of the reach.



**Figure 26. Location map of reach 3, which covers the Catherine Creek alluvial fan.**

Reach 3 is developed on an alluvial fan deposit from the Pleistocene and early Holocene (between 25 million and 12,000 years ago) which extends upstream and downstream from Union, Oregon. This reach is naturally a gently sloping fluvial fan-delta that developed through alluvial processes (Ferns et al. 2010). The floodplain functions differently than a typical fluvial floodplain. Being on an alluvial fan, this reach was pre-historically dynamic with multiple high-flow channels. Flooding would have spread out across the sloping fan surface as sheet and distributary flow rather than in a discreet floodplain, and fine sediment would have been dispersed without building a typical depositional floodplain surface. The channel would have been single-threaded following seasonal high flows or sediment transport events, but the channel location may have switched back and forth between multiple channels across the fan surface. The lower third of the reach would have had a more developed floodplain due to lower gradient and finer grained sediment than the upstream two-thirds of the reach. This fan structure and the processes that formed it are remnant from the post-Pleistocene runoff and wetter climates. Present day Catherine Creek is “underfit” in that it is superimposed on the old fan surface and channels without having the sediment load, competency, or capacity to continue the physical processes that built the fan. The stream has adjusted to a different

type of system in this reach. The lower third has developed into an unconfined alluvial channel with fine-grained banks that can be eroded, allowing the channel to develop a meandering planform. The upper third to two-thirds is likely developed within the most recent channel from the alluvial fan processes, without enough flow volume and competency to significantly interact with the banks. Thus, today's "channel forming flow" likely does not do much in the way of channel cross-section development and maintenance and the channel would not be expected to migrate.

Material directly adjacent to the stream has been mapped as alluvium and described as channels locally choked with overbank silt by Ferns et al. (2010). Material in the floodplain has been mapped as fluvial fan-delta deposits (Ferns et al. 2010). Channel bed materials were observed to be predominantly cobble and gravel with boulders present in the upstream section. Bank materials were observed to be inter-bedded sands, gravel and cobbles, indurated fine sand and iron oxidized, moderately cemented gravel and cobble. Natural lateral and vertical control in reach 3 appears to come from a combination of the substrate size and cohesive and/or cemented condition observed. In addition, there is an anthropogenic component to the lateral and vertical control provided by various anthropogenic features including multiple grade control structures, channel spanning concrete diversion dams, and bank protection, including riprap and concrete walls along the edge of the channel. There is also apparent channel straightening with remnant oxbows cut-off from the main channel. Banks range from gently sloping with grass, shrubs, and some mature trees; to banks that are vertical and artificially constructed (Figure 27). Some instances of bank trampling were observed, particularly in the downstream end of the reach. Within the town of Union in the upper section of reach 3, the majority of the current land use practice is commercial and residential. Land use practices include agricultural land beyond the town limits. Results from a cursory channel profile generated in GIS show that the channel gradient ranges from 0.50 to 1 percent at the upstream end of the reach, flattening to 0.01 to 0.05 percent at the downstream end (Table 8). Current use by Chinook salmon includes migration, rearing, and some spawning.



**Figure 27. Various bank conditions, vegetation, and substrate in reach 3.**

**Table 8. Location, surficial geology, and confinement of reach 3 on Catherine Creek.**

| Geomorphic Reach | Location by RM | Surficial Geology  | Confinement Classification |
|------------------|----------------|--------------------|----------------------------|
| 3                | 37.2 – 40.78   | Alluvium/Fan-delta | Unconfined                 |

## Historic Conditions

Traveler’s accounts of historic conditions in the Catherine Creek area collected by Beckham (1995) include descriptions of vegetation describing various grasses in the floodplain, and willows and cottonwoods along the banks of Catherine Creek and the Grande Ronde.

Based on the typical behavior of a stream channel on an alluvial fan and evidence in historic aerial photographs and LiDAR imagery, it can be hypothesized that Catherine Creek had multiple overflow channels running down the remnant alluvial fan that were likely activated during the spring freshet, or during rain on snow events. There may have been multiple main channel paths as well, with activation governed by sediment load and deposition, woody debris from upstream or beaver activity. Flows may have shifted from one channel to another every few years as sediment and debris deposited at the apex or upstream area of the alluvial fan.

## Current Conditions

Conditions including sinuosity, width-to-depth ratios and valley and stream gradient have likely changed as a result of manipulations that have been applied to the channel, banks and floodplain of reach 3. Shortening of the channel by the disconnection of meanders would increase the stream gradient by decreasing the length of active stream over the same valley length.

Conditions of sinuosity and width-to-depth ratios have likely changed as a result of the manipulations that have been applied by humans to the channel, banks, and floodplain of Catherine Creek in the reach 3. Observed shortening of the channel would have increased the stream gradient by decreasing sinuosity over the same valley length potentially resulting in local changes to the width-to-depth ratio and access to the floodplain or the floodplain width. Although a considerable amount of development along the banks of Catherine Creek and within the floodplain had occurred by the earliest set of aerial photos (1937) within reach 3, significant changes to the channel planform can be observed to be occurring in the 1937 aerial photos and completed in the 1964 aerial photos. A comparison of the 1937 aerial photographs and the 2009 NAIP imagery shows local areas of both improvement and degradation in vegetation in reach 3. Overall, the vegetation appears to have successively decreased in reach 3 in the aerial 1937, 1965, 1964, and 1971. A comparison of the 1971 and the 2008 aerial photographs show an overall improvement the riparian vegetation; however, it is believed that there is a considerable departure from natural historic riparian and floodplain vegetation conditions. The results of the remote analysis also indicate that channel sinuosity decreased from 1.45 in 1937 to 1.14 in 2008. In addition, approximately 3,637 linear feet of channel was observed to be partially disconnected in the 1937 aerial photographs. Additional manipulations are further discussed below (see Attachment A for photographic documentation of reach 3).

Results from field measurements, observations, and remote analysis using GIS software show that within reach 3, the stream and valley gradients is less than 1 percent. The channel has relatively low sinuosity, and appears to be slightly entrenched as a result of channelization efforts that include bank hardening and the cutting off of historic meander section, particularly in the downstream end. The average width to depth ratio is 20:1 (Table 9) (see Attachment D for drawings of cross sections in reach 3).

**Table 9. Valley and channel gradients, sinuosity, and width-to-depth ratios of reach 3 on Catherine Creek.**

| <b>Geomorphic Reach</b> | <b>Valley Gradient ( percent)</b> | <b>Stream Gradient (percent)</b> | <b>Sinuosity</b> | <b>Average Width:Depth</b> |
|-------------------------|-----------------------------------|----------------------------------|------------------|----------------------------|
| 3                       | 0.65                              | 0.57                             | 1.14             | 20:1                       |



Pebble counts were conducted in reach 3 in order to develop grain size distribution curves for substrate in the active channel bottom including thalweg and bars (see Attachment B for complete set of grain size distribution curves). The dominant substrate is cobble and gravel; however, sands and fine material were observed. The  $D_{50}$ , (meaning that 50 percent of the material is smaller than that size) measurements for reach 3 range from 42.6 mm to 50.5 mm, with the average  $D_{50}$  for reach 3 being 46.85 mm (Table 10).

**Table 10. Average gradation analysis of in-channel substrate within reach 3 on Catherine Creek.**

| Reach | Average Diameter of Substrate (mm) |          |          |          |          |
|-------|------------------------------------|----------|----------|----------|----------|
|       | $D_{15}$                           | $D_{35}$ | $D_{50}$ | $D_{84}$ | $D_{95}$ |
| 7     | 27.9                               | 38.15    | 46.85    | 86.63    | 127.7    |

## Physical Processes

Channel migration, sediment transport and large wood recruitment are the primary physical processes that create and maintain instream salmonids habitat in Catherine Creek. Each is discussed individually below.

## Migration

Although local sections of vertical bare banks and some undercutting were observed throughout the reach, overall rates of lateral and vertical migration appear to be low. Channelization by the construction of levees, as well the reported ‘raising and revetting’ of banks in 1949 by the U.S. Army Corps of Engineers (USACE) has resulted in conditions that require a flow of greater than the 500 year recurrence interval to overtop the banks at 70 percent of cross-section locations within the reach. In addition to the human manipulations, the natural processes responsible for the construction of the fan have changed. Lower flow volumes and sediment load than those that were active when the fan was actively building exist in the system in the present day. The combination of the two factors, anthropogenic manipulation and a change to the fluvial and geomorphic processes, result in a stream that is underfit for the channel that it resides in anthropogenic causes of the reduction of lateral migration and apparent incision are discussed below in the manipulations sections.

## Sediment Transport

Initial sediment transport calculations utilizing data collected at cross sections that includes particle sizes of  $D_{50}$  (meaning 50 percent of the material is smaller than) and  $D_{84}$  (meaning 84 percent is smaller than) and general channel geometry (bankfull width and depth) and average channel slope were used to calculate hydraulic radius, shear

stress and critical shear stress. HEC-RAS model results show a reach average shear stress of around 1 lb/ft<sup>2</sup> at a 1.5-year recurrence interval (Appendix D). However, there is a wide range of conditions throughout the reach including slope, estimated bank-full area, substrate size, and wetted perimeter. Overall, the upstream half of reach 3 is a sediment transport section, as indicated by a steeper slope and an in-channel substrate that is slightly coarser. The lower half is a sediment storage section, which is evident by the observed increase in developed point bars and finer sediment.

## **Large Wood**

Observed and documented occurrences of large wood within the active channel were low in reach 3 (Kavanagh, Jones, and Stein 2010). Although some wood (cottonwood and alder) were likely supplied to the stream from the banks of the alluvial fan from beaver activity, blow down or simply dying and falling in, the main source of large wood was likely from upland forests upstream. Large wood that was incorporated upstream would have been transported into reach 3 during high water events, such as rain on snow or intense local rainstorms, but likely did not transport much farther than the distal end of the alluvial fan near the bottom of the reach as the stream transitions to a very low-gradient, low energy environment in downstream reaches. The lack of large wood is likely exacerbated by past channel-clearing efforts as well.

## **Manipulations**

In addition to the manipulation of the channel planform and floodplain described above, the active channel and banks within reach 3 on Catherine Creek have experienced a number of significant anthropogenic manipulations. Manipulations generally include road construction and bridges, bank protection measures, alteration to floodplain and bank vegetation, surface water withdrawal sites and sometimes channelization (Table 11). One online document from the USACE indicates that in addition to woody debris removal performed in the mid 1980s, emergency work was performed in 1949 that is described as raising and revetting the banks of Catherine Creek at critical sections through and in the vicinity of Union, Oregon (USACE 2011a). Another document states that emergency work was also accomplished in 1950 and 1951, and describes a project that would provide local flood protection through the construction of levees, channel clearing, straightening, enlargement, and realignment along 27.2 miles of Catherine Creek. The document does state that funds were expended on the project but does not state specific type of work or the location (USACE 2011b). A third document notes that local farmers have in several cases excavated channel cut-offs across narrow reaches of stream meanders, and constructed low earth levees (Appendix D). Several instances of this can be noted in the downstream end of the reach in the 1937 and 1956 aerial photographs.

Human features along the banks in reach 3 include bridges, historic abutments, roads, levees, bank protection, diversions, pumps, wells, and a stream gage. Observed levees

are concentrated in the downstream third of the reach from RM 37.86 to the bottom of the reach at RM 37.2, and are small constructed or push-up type. Although bank protection/manipulations were observed throughout the reach, there is a higher concentration along the banks within the town of Union. Due to the high density of roads in the town of Union, total road lengths were not calculated for the floodplain and along the banks in this reach.

**Table 11. List of anthropogenic features along the bank and within the floodplain in reach 3 on Catherine Creek.**

| <b>Reach 3 Anthropogenic Features</b> |                 |                    |
|---------------------------------------|-----------------|--------------------|
| <b>Anthropogenic Feature</b>          | <b>Quantity</b> | <b>Length (ft)</b> |
| Bridge                                | 5               |                    |
| Concrete/rock spur                    | 13              |                    |
| Diversions                            | 4               |                    |
| Surface water return                  | 7               |                    |
| Pump                                  | 2               |                    |
| Grade control structures              | 8               |                    |
| Plug                                  | 8               |                    |
| levee                                 |                 | 1,903              |
| Bank protection                       |                 | 335                |
| Water wells                           | Unknown         |                    |
| Channel Straightening?                |                 |                    |

## Impacts

Manipulations to the floodplain, channel cross section, banks, and planform within reach 3 collectively have an impact to the physical function of Catherine Creek. These impacts, both directly and indirectly, contribute to the limiting factors affect all life stages of Chinook salmon and steelhead (NOAA Fisheries 2008). The limiting factors and the relationships to each other were previously discussed in the Introduction section of this appendix. Below, each of the limiting factors will be discussed as it pertains to the manipulations observed in reach 3.

The limiting factor of water quantity is primarily a combination of multiple factors. Within reach 3, there are four surface diversions. In addition, there are the surface diversions upstream in reaches 4 and 5 that were previously noted. The cumulative effect of the surface withdrawals in this reach and those upstream, combined with seasonal low flow can create a water quantity limiting factor. The low condition in the reach also contributes to additional limiting factors such as water quality, reduced habitat quantity and quality and fish passage. All of those will be discussed below.

The limiting factor of elevated summer water temperatures is directly related to multiple factors, including water diversion and return, and reduced river and floodplain

interaction, and translocation of existing conditions from upstream. The effects of surface water withdrawals in reach 3 and upstream in reach 4 and 5 combined with seasonal low flow has been described in the water quantity section. The effects of the absorption of solar radiation during low flow have also been previously described. Water that enters the reach from upstream is noted to warm on arrival (Watershed Sciences, LLC. 2000). That condition combined with low flow conditions are the biggest contributors to elevated summer water temperatures. In the downstream third of the reach, reduction of groundwater recharge due to reduced floodplain interaction during high flow events due to levees and the conversion of floodplain to agricultural use also contribute to the higher water temperatures. Floodplain interaction at high flow allows water to enter the hyporheic zone via infiltration. This water is “stored” in the ground to return to the main channel as cooler recharge water during times of low flow.

A reduction in habitat quantity and diversity is a result of the manipulations described above. Channelization by the “revetting” and hardening of bank in the mid and upstream sections increases and levees in the downstream section have the physical structure of the stream channel and floodplain. Hardened banks may alter sediment and streamflow interactions and result in reduction of instream habitat quality in the mid and upstream sections. In the lower third of reach 3, the channelization has reduced channel migration and deposition. Migration is a product of bank erosion accompanied by bar building on the opposite bank. Erosion of the bank supplies needed sediment and potentially some woody debris to the system. Concurrent bar building through deposition provides low floodplain surfaces for colonizing vegetation (such as cottonwoods) and high-flow refuge for fish. Disturbances to the balance between erosion and deposition often result in a depletion of one or the other. When that occurs, processes that create and maintain diverse habitat types are not able to do so. The effects of channelization, and the reduction of channel length that has occurred in the downstream end of reach 3 lends to the diminished habitat quantity and diversity by slowing rates of lateral migration and subsequent deposition. Floodplain access by the river is also reduced, leading to the reduction of high flow, and/or off channel habitat. Reduced habitat quantity is also attributed to low-flow conditions due to the combination of seasonal low flow and surface water withdrawals by reducing first the depth and then the wetted width of the channel (NOAA Fisheries 2008). Another contributing factor to the reduction in quality and diversity of habitat may be a result of the channel-spanning diversion dams. The dams act as artificial grade control structures, limiting the amount of vertical migration, so the process of self adjustment of the stream may be interrupted. The backwater area upstream of the dam becomes an artificial depositional zone, filling existing pools with sediment.

The limiting factor of fish passage is again the product of one or more conditions. One of the related conditions is low flow, which is described above. The low-flow condition can cause a low-flow migration barrier to both returning adults as well as smolts attempting to migrate out of or within Catherine Creek (NOAA Fisheries 2008).

Additional manipulations that may contribute to fish passage issues within reach 3 are the channel spanning diversion dams. Although all of the channel spanning diversions are equipped with fish ladders, the low-flow effectiveness remains unclear, as communicated by local biologists in a 2011 habitat work session. During high flows, loss of complexity within the channel can result in velocity barriers to certain life stages. This loss of complexity is a result of bank hardening, channelization, levees, and clearing of instream woody debris.

The limiting factor of excess fine sediment can have multiple sources as previously described in the Upper Valley Group section. Within the mid and upstream sections of reach 3, fine sediment input is likely low given the overall low rate of migrations. Fine sediment is likely transported into and through the upper two-thirds of the reach during high runoff events. The lower one-third of reach 3 has occurrences of localized fine sediment input from bank erosion noted at RM 37.25 in 2010 and 38.85 in 2011.

The limiting factor of riparian condition within reach 3 is primarily due to altered vegetation within the floodplain in the lower third of the reach where floodplain and wetland areas have been converted to agricultural use. Vegetation is present along the streambank throughout most of the reach. However, the successional stage and composition of the vegetation community itself are impaired with mostly decadent trees and grasses observed.

## **Conclusion**

Anthropogenic impacts within reach 3 on Catherine Creek contribute to the identified limiting factors for salmonids. These impacts result from human alterations including hardened banks, levees, instream diversion dams and water withdrawals, altered riparian and floodplain vegetation, reduced large wood recruitment to the stream, and reduced and hardened floodplain areas.

## **Recommendations**

In order to address the causes of the limiting factors within reach 3, both short-term and long-term approaches that use a strategy of prioritizing rehabilitation activities based on potential long-term benefit as described by Roni et al. (2002) should be considered.

The rehabilitation strategy for reach 3 should address the need to increase habitat quality and quantity by increasing in the main channel in appropriate sections of reach 3. The addition of wood or other structures to the main channel would increase channel roughness and hydraulic complexity, which would increase habitat quality by adding channel complexity and instream cover for rearing and migrating Chinook salmon and steelhead. Habitat quantity would be improved with increased in-channel diversity by increasing the number of scour pools that would form as a result of the stream adjusting to the new hydraulic features.

The focus of rehabilitation efforts in reach 3 should include multiple strategies that:

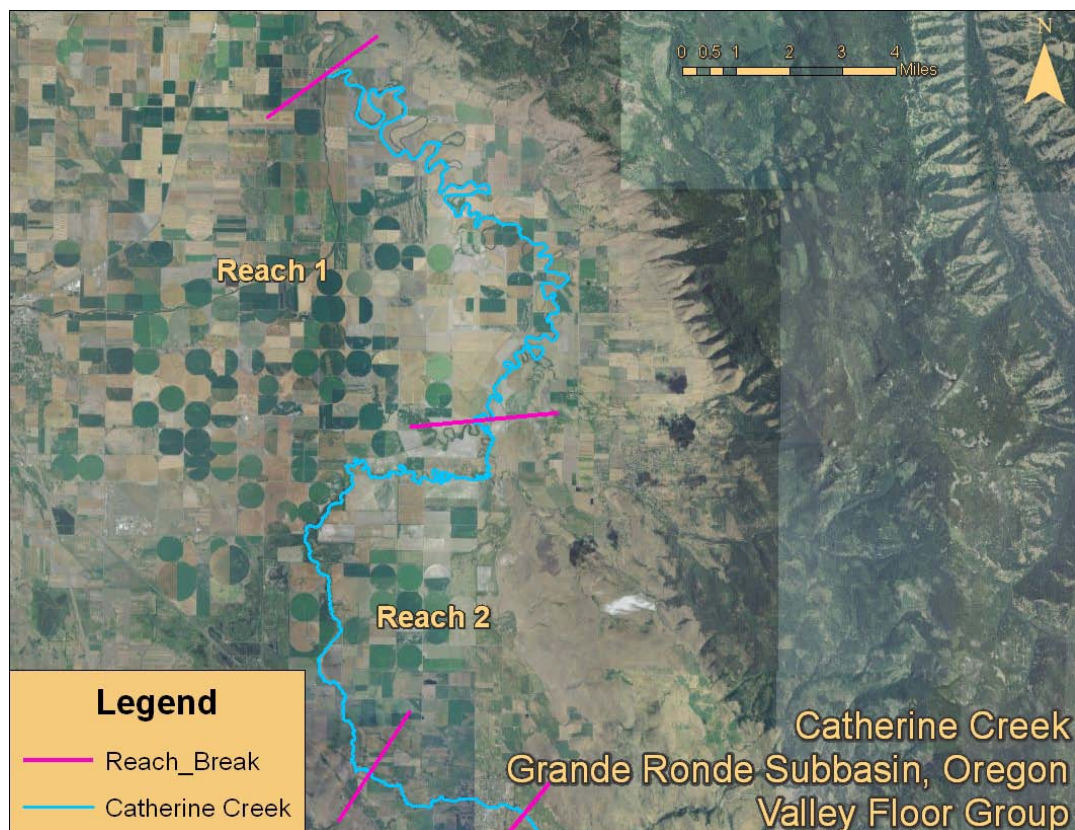
1. Reconnect isolated habitat.
2. Restore long-term processes.
3. Restore short-term habitat.

Reconnection of isolated habitats could involve reconnection of some of the oxbows that have been disconnected since 1937. Reconnection would include reconnecting the main channel and oxbows by appropriate means to allow access while not creating a stranding issue. This action would increase habitat quantity by adding access to remnant existing habitat that is currently not accessible as well as adding additional habitat beyond that which currently exists. Restoring long-term processes by re-initiating floodplain processes, including floodplain interaction through more frequent overbank flows and restoration of appropriate riparian and floodplain vegetation would increase habitat quantity and quality. When components of the strategy of restoring short-term habitat, such as instream large wood are combined with re-initiation of long-term processes, additional habitat quality is gained. Identifying appropriate strategies and individual projects that would allow floodplain interaction and channel migration to re-establish in areas with willing landowners should be completed at the reach scale.

### **5.3.3 Valley Floor Group: Reaches 2 and 1**

Reaches 2 and 1 comprise the Valley Floor Group on Catherine Creek. This group extends from the toe of the Catherine Creek alluvial fan, near RM 37.2 downstream to the confluence of Catherine Creek and the State Ditch at RM 0.0 (Figure 28).





**Figure 28. Location map of the Valley Floor Group on Catherine Creek.**

Within the Valley Floor Group the reaches are unconfined, with very broad, flat floodplains that have developed through vertical accretion processes where sediment is accumulated on the floodplain when water is out of bank. The floodplain materials have previously been mapped as alluvium by Ferns (2010), and described as stream gravels with channels locally choked with over bank silt bound by fluvial lacustrine and alluvial plain materials that include clay and sand (Table 12). The processes of lateral accretion where bars build in response to channel migration within the active channel are occurring at overall low rates in reach 1. However, bar development was observed during low flow conditions due to surface diversions in sections of reach 2 upstream of the Elmer Dam backwater pool (see Attachment A). Within the Valley Floor Group, the channel gradient is very low and the channels are very sinuous. In addition, some sections of the channel in the Valley Floor Group appear to be locally entrenched. Channel bed materials were observed to be loose fine sands and silts, and dense cohesive clayey silts. Bank materials were observed to be inter-bedded cohesive silts, clays, clayey silts and indurated fine sands, and range from gently sloped to vertical (Figure 29). Natural lateral and vertical control appears to be provided by the cohesive material observed in the banks and on the channel bottom where present. There is an anthropogenic component to the vertical control as well in the form of multiple channel

spanning concrete diversion dams. Current use by Chinook salmon and steelhead includes migration in reach 1 and migration and rearing in reach 2 (NOAA Fisheries 2008). The mainstem of Catherine Creek up to the town of Union supports rearing and migration for steelhead as well (NOAA Fisheries 2008).

**Table 12. Location, surficial geology, and confinement classification of the Valley Floor Group on Catherine Creek.**

| Geomorphic Reach | Location by RM | Surficial Geology           | Confinement Classification | Grouping           |
|------------------|----------------|-----------------------------|----------------------------|--------------------|
| 2                | 22.5 – 37.2    | Alluvium/Fluvial-Lacustrine | Unconfined                 | Valley Floor Group |
| 1                | 0.0 – 22.5     | Alluvium/Fluvial-Lacustrine | Unconfined                 | Valley Floor Group |

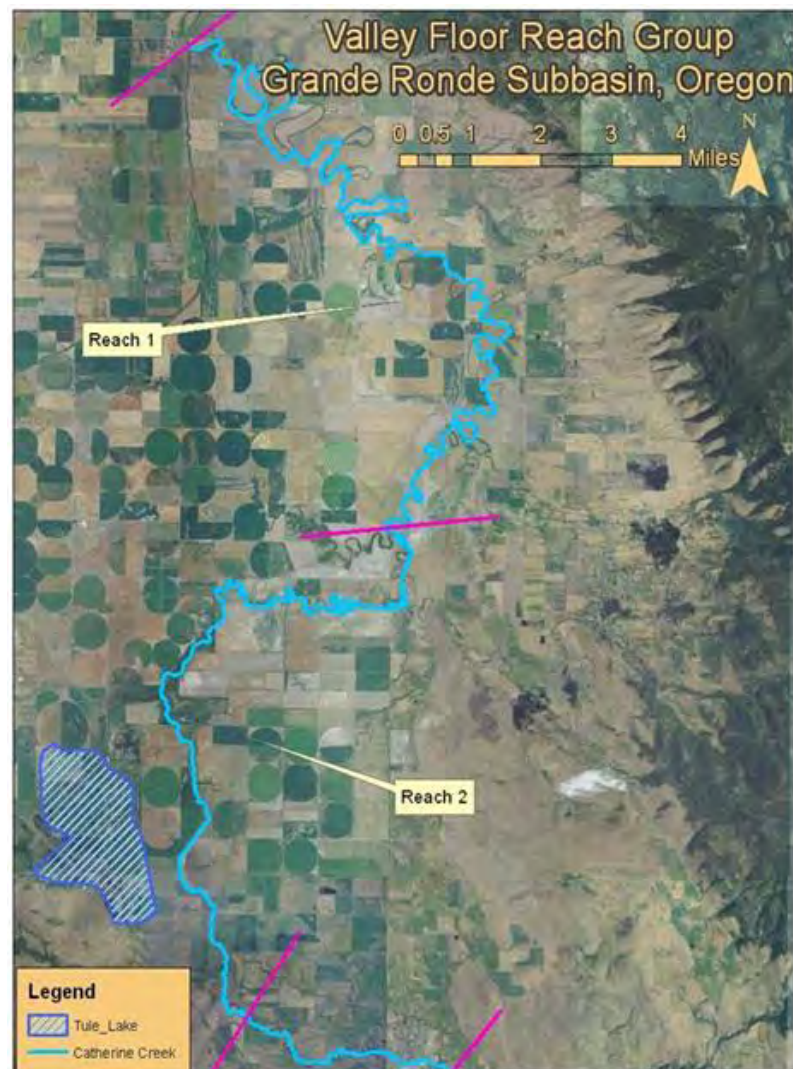


**Figure 29. Various bank conditions, vegetation, and substrate in the Valley Floor Group.**



## Historic Conditions

Historically, the Valley Floor Group area was likely a low energy environment that contained wet meadows, emergent wetlands, and open water complexes (NOAA Fisheries 2008). Historical descriptions compiled from the journals of pioneers describe the valley floor as having numerous small creeks and rivulets running through all parts. Tule Lake existed in the south-central valley floor, and was fed by runoff and overflow from Catherine Creek and the Grande Ronde River, and drained back into both (Duncan 1998) (Figure 30**Error! Reference source not found.**). Catherine Creek historically flowed into the lake at its southeastern end and flowed out on its northeastern side.



**Figure 30. Showing the location of Tule Lake based of General Land Office (GLO) maps. Note the size is significantly smaller than described in historical accounts.**

The reported size of the lake varies from 2,300 acres (Beckham 1995) up to 20,000 acres (Duncan 1998). In addition, Hot Lake was a spring-fed lake in the same area. Historical accounts describe the valley floor conditions as wet and marshy. Duncan (1998) reports that an estimated 72,000 acres in the middle valley were subject to flooding, and that up to 60 percent of the valley floor might be inundated for as long as 5 months. Another historical account described the area from La Grande, across the valley to Union and Cove as big cattail swamps (Duncan 1998). Vegetation on the floodplain was noted to be camas root, red clover, rye grass, and other grasses (Beckham 1995; Duncan 1998). The banks of Catherine Creek (and the Grande Ronde) were noted to be high and muddy, covered with Cottonwoods, willows and other underbrush (Beckham 1995; Duncan 1998). Duncan (1998) noted that the Umatilla Tribe named the Grande Ronde and Catherine Creek valley “cop-copi” for the large, dense black cottonwood trees that lined the riverbanks. Noted wildlife included numerous inhabitants from the otter family, along with deer, raccoon, elk, and beaver (Beckham 1995).

Based on the historical accounts from Beckham (1995) and Duncan (1998), it appears the Valley Floor Group area contained vast wetlands that were inundated for long periods of time beginning during the spring freshet. The channel was likely a single-thread channel with numerous side, overflow channels, and interconnected wetlands that would have been inundated because of high flows and beaver activity.

## Current Conditions

Results from field measurements, observations, and remote analysis using GIS software indicate that the two reaches exhibit similar physical characteristics of width-to-depth ratios and gradient. The largest difference in the two reaches being in the sinuosity (Table 13) (see Attachment A – Photographic Documentation of reaches 2 and 1).

**Table 13. Valley and channel gradients, sinuosity, and average width-to-depth ratios of the Upper Valley Group on Catherine Creek.**

| Reach | Valley Gradient (percent) | Stream Gradient (percent) | Sinuosity | Average Width:Depth |
|-------|---------------------------|---------------------------|-----------|---------------------|
| 1     | 0.03                      | 0.01                      | 2.4       | 10:1                |
| 2     | 0.04                      | 0.03                      | 1.4       | 10:1                |

In the Valley Floor Group, characteristics of valley and stream gradient and width-to-depth ratios likely remain relatively stable given the anthropogenic manipulations. However, sinuosity has changed as a result of the shortening within both reaches in the Valley Floor Group. In reach 2, the channel has been shortened by nearly 12,500 feet, with a resulting decrease in sinuosity from 1.61 in 1937 to 1.40 in 2009. Similarly, the channel length in reach 1 was shortened by approximately 28,800 feet resulting in a

decrease in sinuosity from 3.00 in 1937 to 2.40 in 2009. Due to the naturally low gradient in both reaches, the overall channel gradient in the Valley Floor Group was not impacted a great deal by the reduced channel length.

No pebble counts were conducted in reaches 2 and 1 due to high water depths at the time of data collection, but the observed dominant mobile bed material consisted of medium sand sized material (2 mm or less) silts, clays, and ash.

Bank material was observed to be inter-bedded indurated fine sands, and dense, cohesive silts, clays, and ash. The denser materials may act as an aquatard to some degree and promote lateral movement of the perched water table, rather than allowing continued downward infiltration. The banks range from gently sloping to vertical. In the Valley Floor Group, the channel of Catherine Creek is primarily located within fine-grained alluvial and fluvial lacustrine sediments. However, Catherine Creek does meander into a higher terrace along the left bank from about RM 5.2 to 5.8, along the right bank at RM 13.0 and again at RM 2.9 to 3. At RM 3.7 the creek meanders against the toe of a bajada (geologic feature formed by coalescing or overlapping alluvial fans) that forms the base of the Wallowa Mountains along the right bank. Materials in the banks developed in higher terraces and the bajada consisted of indurated fine sands and cohesive silts and clays similar to the alluvial and fluvio-lacustrine valley fill previously described.

Vegetation, when present on the face of the bank is comprised of grasses, shrubs, and willows, with occasional small dbh trees. Vegetation along the tops of the banks is predominantly grasses and shrubs with willows and sapling trees; however, some mature deciduous trees are present.

The floodplain is generally very wide, with subtle terrace rises. The morphology of the Valley Floor Group is generally indicative of a low energy environment, with surface water ponding within historic oxbows and topographic lows on the floodplain and very low gradient channels. Extensive sections of one or both sides of Catherine Creek in both reaches have been altered with levee construction. There are typically two types of levees; large constructed levees that may be up to 30 feet tall, and smaller levees that may actually be the natural result of out of bank flood processes. Areas behind levees can be marshy. In instances where the levees are set back from the top of the bank, the floodplain area between the bank and the levee toe is typically a flat elongate bench where woody debris and flood deposits accumulate. Materials include flood deposits of silts and fine sands inter-bedded with clay. Within the floodplain area, there are relict channel scars visible in the LiDAR. These relict scars may contain slightly coarser material with higher porosity that interacts with the less permeable layers described above and may provide a conduit to return shallow groundwater back to the current active channel.

## **Physical Processes**

### ***Hydraulics***

It should be noted that the hydraulics within reach 1 are not typical of a mountain stream, which many common geomorphic descriptions are based upon. The hydraulics of the Valley Floor Group are more indicative of an ephemeral lake or estuary. Therefore, typical values of geomorphic properties such as the width-to-depth ratio and bankfull flow values do not apply in reach 1. The physical characteristics of this reach are dominated by backwater effects from the Grande Ronde River that are controlled by Rhinehart Gap and the timing of runoff in the Grande Ronde. This means that processes of sediment and water movement through this reach are dominated by hydrograph timing and magnitude of both Catherine Creek and the Grande Ronde River, not Catherine Creek alone. The steady state HEC-RAS hydraulic model indicated that average in-channel velocities are very low and are typically around 1.3 feet per second at discharges with recurrence intervals between 1.5 and 100 years. Similarly, shear stresses are very low, indicating the potential to only transport fine-grained sediment and little potential to erode the channel or banks under flood conditions. Levees are present along most of the reach, limiting floodplain access. In most locations, levees are overtopped at flows equal to or less than the 10-year discharge. There are four disconnected oxbows (RM 10.2, 14, 16.3, and 17.5) in this reach where the levee is overtopped at less than a 5-year flood. The most notable hydraulic controls in this reach are Elmer Dam at RM 13.1 and the Old Grande Ronde River, which is located in the upstream extent of the reach at RM 22.5. Bridges within the reach, including Booth Lane, Market Lane, and Highway 237, exert local controls at flows exceeding the 100-year discharge but do not appear significant at lower discharges (Appendix D).

Channel migration, sediment transport, and large wood recruitment are the primary physical processes that create and maintain instream habitat in Catherine Creek. Each is discussed below.

### **Migration**

In the Valley Floor Group, banks ranged from gently sloping and vegetated to high, near vertical and often void of vegetation. In reach 2, there were small local sections of bank that showed slumping that was usually associated with removed riparian vegetation, slight erosion of the bank on the outside of meander bends and corresponding lateral accretion in the inside of meander bends was also observed at low flow. In reach 1, bank slumps and bars were also noted although less frequently. In some instances where tall banks were noted, anecdotal evidence in the form of casual discussions noted dozer tracks that still exist in the bottom of the channel suggest in addition to the straightening, the channel may have been artificially deepened to convey more flow, and provide material to construct plugs across oxbow entrances and exists at some locations (Kuchenbecker 2010). Results of a 1937 analysis and 2008 and 2009 aerial photographs



showed little or no natural change in channel planform. Given multiple natural factors, including the overall low gradient and base level provided by the Rhinehart Gap, the lacustrine nature of the valley floor as noted by the dense, consolidated fine grained bank material that includes interbedded sands, silts and clays, lateral and vertical migration rates would be expected to be low. In addition, the stream energy is further reduced in both reaches by the backwater effects of diversion dams in both reaches.

## **Sediment Transport**

Calculations to determine if the D<sub>50</sub> sized material mobilized during channel forming flow discharge were not performed in the Valley Floor Group. In non-backwatered sections, the in-channel substrate was observed to be medium sand (2 mm or less) using the unified soil classification system (USCS). This sand appears to move via saltation at low flows, forming dune-ripple and delta-type bedforms in the wetted channel. Given those observations, it is assumed that the medium sand in-channel substrate is mobilized and transported during channel forming flow. Finer particles (silt and clay) are likely transported as suspended sediment at a wide range of flows.

## **Large Wood**

Large wood recruitment potential is assumed to be low in the Valley Floor Group area based on the very low gradient and lack of large trees in and adjacent to the riparian area along the stream. Oregon Department of Fish and Wildlife (ODFW) staff (2010) observed and documented a low number of pieces of large wood in the channel. Historically, large wood (predominantly cottonwood and alder) was likely supplied to the stream from the banks of the valley floor by beaver activity, blow down, or simply dying and falling in. It is unlikely that large wood was transported into these reaches from upland forests upslope or from upstream reaches. The flat gradient of both the valley and the river channel downstream from the toe of the alluvial fan near the break between geomorphic reaches 2 and 3 combined with the Tule Lake flow-through likely precluded any large wood moving into these reaches from upstream.

## **Manipulations**

Within the Valley Floor Group, alterations to the channel, banks and adjacent floodplain began soon after the arrival of Anglo-European settlers. The extirpation of beaver (Duncan 1998), the initiation of surface water withdrawals, and the conversion of floodplain and wetlands to crop production and pasture followed settlement. Within both reaches of the Valley Floor Group, the channel bed, banks, and adjacent floodplain areas have experienced significant anthropogenic manipulations. Manipulations generally include road construction and bridges, construction of levees along the channel and within the floodplain, alteration to floodplain and bank vegetation, surface water withdrawal and channel relocation. Below is a description of the anthropogenic features in reaches 2 and 1 of the Valley Floor Group.

In reach 2, one of the earliest modifications to the channel planform of Catherine Creek was the draining of Tule Lake in 1870 (Beckham 1995). This action entailed the re-routing and channelization of Catherine Creek around the lake on the east side in a constructed channel. The comparison of the GLO maps (circa 1864-1876) to the current channel alignment in ortho-rectified aerial photographs suggests that the location of the main channel was altered beginning around RM 34.4 and continuing downstream to about RM 31.4. Other stream channel manipulations include the reduction of overall channel length by nearly 3 miles since 1937. This has been accomplished by cutting off individual sections of channel meanders. Some of the meanders that have been disconnected since 1937 now function as off channel storage ponds that are filled by spring melt of valley floor snow as well as overbank inundation from Catherine Creek during high flows. Other historic oxbows have been filled in with soil and converted to agricultural use. The cut off sections are concentrated in the downstream half of reach 2 between RM 23.5 to 30.0 and within a short upstream section from RM 35.8 to 37.8.

Additional manipulations to Catherine Creek in reach 2 include levees, roads, and bridges (Table 14). Levees have been constructed essentially through the entire reach. The levees are generally located along the edges of the meander belt-width. This means that the majority of the reach is enclosed in levees even though the total length in feet of levees in reach 2 is a much lower figure than the total length of channel and banks. Catherine Creek exhibits a high degree of sinuosity within a wide band of area between two relatively straight levees. A numerical analysis that compares the total length of levees to the channel length and total bank length (two times the channel length) indicates that the total length of levee is about 55 percent of the total length of banks.

Included in the levees are nine sections that act as plugs across the entrance and/or exit of historic main and/or side channels. In addition to the levees, 39,262 linear feet of paved highway, gravel, and private (field access) roads that may also act as levees either directly adjacent to Catherine Creek or within the floodplain are present. Bank protection in the form of riprap comprised of concrete blocks, rock cobbles and boulders, and car bodies was noted, but overall covers less than 1 percent of both banks (Table 14). Bank and floodplain vegetation has also been highly modified from those historic conditions described by Beckham (1995) and Duncan (1998). Although some willow and large dbh cottonwood trees exist along the immediate bank, there are likely fewer today than recent historic condition. In the floodplain areas away from the channel bank, multi-story, multi-species, and varied age-class native vegetation has been almost completely replaced by commercial crops and pasture grass.

**Table 14. List of anthropogenic features in reach 2 on Catherine Creek.**

| <b>Reach 2 Anthropogenic Features</b> |                 |                    |
|---------------------------------------|-----------------|--------------------|
| <b>Anthropogenic Feature</b>          | <b>Quantity</b> | <b>Length (ft)</b> |
| Bridge                                | 6               |                    |
| concrete/rock spur                    | 1               |                    |
| Head gate                             | 2               |                    |
| Diversion                             | 2               |                    |
| Pump                                  | 6               |                    |
| Plug                                  | 9               |                    |
| Road (paved/unpaved/private)          |                 | 23,027             |
| Levee                                 |                 | 91,020             |
| Bank Protection                       |                 | 468                |

Within reach 1 one of the earliest known modifications was an indirect action in that it was not implemented on Catherine Creek itself, but certainly resulted in significant impact to Catherine Creek. That action was the original excavation during the 1860s of what would become the State Ditch section on the Grand Ronde River. The original excavation was 6 feet wide and 3 feet deep (Duncan 1998), but eventually captured the entire Grande Ronde River and now re-routes the entire discharge of the Grande Ronde River. When this capture occurred, the confluence of Catherine Creek and the Grande Ronde was shifted several miles downstream and the section of present-day Catherine Creek from RM 22.5 to RM 37.2 now flows in the old Grande Ronde River channel without the input and influence of the main Grande Ronde River. Other manipulations to Catherine Creek within reach 1 include the reduction in channel length of nearly 5.5 miles that has occurred since 1937 through channel straightening accomplished by cutting off large meanders. Most of the meanders disconnected since 1937 now act as irrigation storage areas that are filled during the spring freshet either by the opening of valves or gates or by inundation from overbank flows from Catherine Creek and/or spring melt of valley floor snowpack. The cut-off sections are concentrated in the downstream half of the reach between RM 5.6 and 14.0.

Similar to reach 2, levees have been constructed throughout essentially the entire length of reach 1. The same numerical analysis method described above indicates the total length of levee is about 48 percent of the total length of the banks. Again, this percentage number is deceiving due to the levees generally being located along the edges of the meander belt-width, and the stream having a high sinuosity. The levees types are the same as those observed in reach 2 and previously described. Included in the levees are 19 sections that act as plugs across the entrance and exit of historic main and side channels. In addition to the levees along the banks and within the floodplains, 47,309 linear feet of paved highway, gravel and private (field access) roads may also act as levees either along Catherine Creek or within the floodplain within reach 1. Bank protection in the form of riprap comprised of concrete blocks and rock cobbles and

boulders was noted, but overall covers less than 1 percent of both banks (Table 15). Vegetation has also been highly altered. Although some willow and large dbh cottonwood trees exist along the immediate bank, there are likely fewer today than recent historic conditions. In the floodplain areas away from the channel bank, native vegetation has been almost completely replaced by commercial crops and pasture grass.

**Table 15. List of anthropogenic features in reach 1 on Catherine Creek.**

| <b>Reach 1 Anthropogenic Features</b> |                 |                    |
|---------------------------------------|-----------------|--------------------|
| <b>Anthropogenic Feature</b>          | <b>Quantity</b> | <b>Length (ft)</b> |
| Bridge                                | 6               |                    |
| Historic abutments/piers              | 8               |                    |
| water return/drains                   | 11              |                    |
| Diversion dam                         | 1               |                    |
| Earthen Dam                           | 1               |                    |
| Dock                                  | 1               |                    |
| Pump                                  | 10              |                    |
| Head gate                             | 1               |                    |
| In channel pilings                    | 1               |                    |
| Suspended pipe                        | 2               |                    |
| Levee                                 |                 | 112,126            |
| Roads (paved/gravel/private)          |                 | 47,309             |
| Bank protection                       |                 | 725                |

## Impacts

Manipulations to the floodplain, channel cross section, banks, and planform within the Valley Floor Group collectively have an impact to the physical function of Catherine Creek. These impacts, both directly and indirectly, contribute to the identified limiting factors that affect all life stages of Chinook salmon and steelhead (NOAA Fisheries 2008). The limiting factors and the relationships to each other have been previously discussed in the Introduction section of this appendix. Below, each of the limiting factors will be discussed as it pertains to the manipulations observed in the Valley Floor Group.

The limiting factor of water quantity and its relationship to other limiting factors or conditions has been previously discussed. In the Valley Floor Group, there are 3 head gates, 3 channel spanning diversion dams, and at least 16 pumps. The amount of water withdrawal within the reach group, combined with the withdrawals upstream of the Valley Floor Group can lead to a low-flow condition in the areas beyond the backwater pools of the Davis and Elmer dams, particularly when seasonal low flow is an issue.

The limiting factor of elevated summer water temperatures is likely the product of warm water from upstream as well as conditions within both reaches in the Valley Floor

Group. In the Upper Valley Group, 11 sites of water return and shallow drain sites were observed. In one case, ponded water was being pumped from a historic oxbow back into the main channel. Water returning to the main channel via surface run off, gravity or pumping could have warmed in the historic oxbows or shallow ponds, which could contribute to elevated water temperatures, as well as high nutrients in the main channel. The natural condition of low-stream gradient can also lead to warmer water temperatures, given that low velocity water can thermally stratify. Thermal stratification was observed just below the Davis dams with a maximum temperature of 26.9°C being recorded at RM 9.0, downstream of Elmer Dam (Watershed Sciences, LLC. 2000). Potential implications of the thermal stratification will be discussed below in the fish passage discussion.

The limiting factor of reduced habitat quantity and diversity in the Valley Floor Group is a result of the previously described manipulations to the channel and floodplain. The draining of the original wet meadow, emergent wetlands and open water complexes on the valley floor for the implementation of agricultural land use practices including grazing, combined with extirpation of beaver have resulted in reduced habitat quantity and diversity by simplifying the physical structure of the stream channel and floodplain (NOAA Fisheries 2008). In unconfined wetland systems such as reaches 1 and 2, beaver activity is one mechanism that promotes physical processes such as river and floodplain interaction and in-channel complexity that produce and maintain different habitat types within the main channel and floodplain (NOAA Fisheries 2008). The result is a reduction in the aerial extent of off-channel habitat and diversity of instream habitat. Reduced habitat quantity is also attributed to surface water withdrawals by reducing the depth and wetted width of the channel (NOAA Fisheries 2008). This would presumably reduce the amount of rearing habitat found along the margins of the stream, as well as the depth and overall number of pools in those areas not submerged in the backwater pools of the Upper and Lower Davis dams and Elmer Dam. The diversion dams can act as artificial grade control structures, altering sediment transport processes so the process of self-adjustment of the stream may be interrupted. The backwater area upstream of the diversion dams becomes an artificial depositional zone, filling any previously existing pools with sediment. Pools may not be re-established when the sediment is mobilized and transported during periods of channel forming flow due to lack of instream complexity. Some of the sediment deposited in the backwater pools is likely flushed out during channel forming flow, but only to the elevation imposed by the artificial grade control. Construction of levees along the channel bank or in the floodplain can also reduce habitat quantity and quality by altering hydraulic conditions within the channel.

Fish passage is listed as a limiting factor, and was previously discussed. In the Valley Floor Group, fish stranding in historic oxbows may contribute to the limiting factor of fish passage. The oxbows are filled either by bank overtopping or by the opening of gates during spring runoff. Any fish that enters would be trapped, as there is no fish return mechanism on the oxbows. In addition to low-flow conditions, the thermal

stratification of the water column in low water velocity areas recorded in 2000 during FLIR data collection may form a thermal migration barrier when the heated water at the surface flows through the fish ladders. Fish passage effectiveness at low flow remains unclear, as communicated by local biologists in a 2011 habitat work session. However, both Davis dams were completely reconstructed in 2011 and included new fish ladders for passage.

Within the Valley Floor Group, the limiting factor of excess fine sediment likely has multiple causes. The previously described occasional bank slumping and slight erosion contributes some fine sediment to the system, in addition to fine sediment transported from into the Valley Floor Group from upstream. Given the composition of the banks, that includes silts, fine sands, and clay. Once fine sediment is incorporated into the system, it likely stays suspended in the water column. Uniform channels with little variability and reduced floodplain interaction do not provide adequate sediment storage areas such as near channel wetlands and side channels and instream pools.

The limiting factor of riparian vegetation in the Valley Floor Group is due to the multiple impacts of vegetation alteration and/or removal that were discussed previously. In the Valley Floor Group, a high percentage of the vegetation along the banks has been removed or altered. In much of the Valley Floor Group, floodplain vegetation has almost completely been removed to allow for agricultural development. The effects from habitat modification, increased fine sediment, and increased water temperature could all be improved with the improvement of vegetation condition (GRWQC 2000). While not the only concern, riparian habitat degradation is a serious problem and addressing this issue also indirectly addresses water quality factors such as temperature, stability, sediment, and habitat (GRWQC 2000)

## **Conclusion**

Anthropogenic impacts within the Valley Floor Group on Catherine Creek contribute to the identified limiting factors for salmonids. These impacts result from human alterations including hardened banks, levees, instream diversion dams and water withdrawals, and altered riparian and floodplain vegetation.

## **Recommendations**

In order to address the causes of the limiting factors in a systematic way within the Valley Floor Group, both short-term and long-term approaches that use a strategy of prioritizing rehabilitation activities based on potential benefits as described by Roni et al. (2002) should be considered. The short-term strategy could employ pilot projects to address the immediate need to increase habitat quality and quantity by adding complexity in the main channel in reaches 1 and 2. The addition of wood or other structures in the main channel would increase channel roughness and hydraulic complexity, which would in turn increase habitat quality by adding in-channel



complexity and instream cover for rearing and migrating Chinook salmon and steelhead. Habitat quantity would be provided with increased in channel structure roughness by increasing the number of scour pools that would form as a result of the stream adjusting to the new hydraulic feature.

The long-term focus of rehabilitation efforts in the Valley Floor Group reaches should include multiple strategies that;

1. Reconnect isolated habitats.
2. Restore long-term processes.
3. Restore short-term habitat.

Reconnection of isolated habitats could involve reconnection of some of the oxbows that have been disconnected since 1937 and include reconnecting the main channel and oxbows by appropriate means to allow access but avoid a stranding issue. This action would increase habitat quantity by adding access to remnant existing habitat that is currently not accessible as well as adding additional habitat beyond that which currently exists. Restoring long-term processes by re-initiating floodplain processes, including floodplain interaction through more frequent overbank flows and restoration of appropriate riparian and floodplain vegetation would increase habitat quantity and quality. When components of the strategy of restoring short-term habitat, such as instream large wood are combined with re-initiation of long-term processes, cumulative benefits to habitat quality occur. Identifying appropriate strategies and individual projects that would allow floodplain access and channel migration to re-establish in areas with willing landowners should be completed at the reach scale.

## 6. References

| <b>Parenthetical Reference</b> | <b>Bibliographic Citation</b>                                                                                                                                                                          |
|--------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Beckham 1995                   | Beckham, Stephen D. 1995. Grande Ronde River, Oregon: River Widths, Vegetative Environment, and conditions shaping its condition, Imbler Vicinity to Headwaters.                                       |
| Carson 2001                    | Carson, R.J., 2001. "Where the Rockies meet the Columbia Plateau: Geologic field trip from the Walla Walla Valley to the Wallowa Mountains, Oregon." Oregon Geology, Volume 63, Number 1, Winter 2001. |
| DelCurto 2011                  | DelCurto, T. 2011. Director Eastern Oregon Agricultural Research Center. Personal communication.                                                                                                       |

**Parenthetical  
Reference**

**Bibliographic Citation**

|                                 |                                                                                                                                                                                                                                                                                                                                                                                   |
|---------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Duncan 1998                     | Duncan, A. 1998. History Science, the Law and Watershed Recovery in the Grande Ronde, A case Study,                                                                                                                                                                                                                                                                               |
| Dyke 2010                       | Dyke, D. 2010. Reclamation Subbasin Liaison. Personal communication. Spring 2010                                                                                                                                                                                                                                                                                                  |
| Dyke 2011                       | Dyke, D. 2011. Reclamation Subbasin Liaison. Personal communication. Spring 2011.                                                                                                                                                                                                                                                                                                 |
| Ferns et al. 2002               | Ferns, M.L., I. Madin, P. McConnell, and J.J. Johnson. 2010. "Geology of the Upper Grande Ronde River basin, Union County, Oregon." Oregon Department of Geology and Mineral Industries Bulletin 107 scale 1:100,000, 65 p                                                                                                                                                        |
| Ferns et al. 2010               | Ferns, M.L., V.S. McConnell, I.P. Madin, and J.J. Johnson. 2010. "Geology of the Upper Grande Ronde River Basin, Union County, Oregon." Oregon Department of Geology and Mineral Industries Bulletin 107, scale 1:100,000, 65 p.                                                                                                                                                  |
| Gehrels 1981                    | Gehrels, G., 1981. "The Geology of the Western Half of the La Grande Basin, Northeastern Oregon." M.S., University of Southern California, abstract published in Oregon Geology, Vol. 45, No. 1, January 1983.                                                                                                                                                                    |
| GRWQC 2000                      | Grande Ronde Water Quality Committee. 2000. <i>Upper Grande Ronde River Subbasin Water Quality Management Plan</i> . Oregon.                                                                                                                                                                                                                                                      |
| Kavanagh, Jones, and Stein 2010 | Kavanagh P., K. Jones, and S. Stein. 2010. <i>Fish Habitat assessment in Catherine Creek, Grande Ronde River Basin</i> ; Oregon Department of Fish and Wildlife                                                                                                                                                                                                                   |
| Kuckenbecker 2010               | Kuckenbecker, L. 2010. Grande Ronde Model Watershed. Personal communication.                                                                                                                                                                                                                                                                                                      |
| NOAA Fisheries 2008             | NOAA Fisheries Service. 2008. Consultation on Remand for Operation of the Federal Columbia River Power System, 11 Bureau of Reclamation Projects in the Columbia Basin and ESA Section 10(a)(1)(A) Permit for Juvenile Fish Transportation Program (Revised and reissued pursuant to court order, NWF v. NMFS, Civ. No. CV 01-640-RE (D. Oregon)), May 5, 2008, F/PNR/2005/05883. |

| Parenthetical Reference       | Bibliographic Citation                                                                                                                                                                                                                                                                                     |
|-------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Nowak 2004                    | Nowak, M. 2004. <i>Grande Ronde Subbasin Plan</i> . Prepared for Northwest Power and Conservation Council.<br><a href="http://www.nwcouncil.or/fw/subbasinplanning/granderonde/plan">www.nwcouncil.or/fw/subbasinplanning/granderonde/plan</a>                                                             |
| Roni et al. 2002              | Roni, P., T. Beechie, R. Bilby, F. Leonetti, M. Pollock, and G. Pess. 2002. "A review of stream restoration techniques and a hierarchical strategy for prioritizing restoration in Pacific Northwest Watersheds." <i>North American Journal of Fisheries Management</i> , 22:1-20.                         |
| USACE 2011a                   | U.S. Army Corps of Engineers. 2011a. Walla Walla District Digital Project Notebook. Catherine Creek, Union, Oregon. Accessed online August 2, 2011 at<br><a href="http://www.nwww.usace.army.mil/dpn/dpn_project.asp?project_id=24">http://www.nwww.usace.army.mil/dpn/dpn_project.asp?project_id=24</a>   |
| USACE 2011b                   | U.S. Army Corps of Engineers. 2011b. Walla Walla District Digital Project Notebook. Catherine Creek, Union, Oregon. Accessed online August 2, 2011 at<br><a href="http://www.nwww.usace.army.mil/dpn/dpn_project.asp?project_id=220">http://www.nwww.usace.army.mil/dpn/dpn_project.asp?project_id=220</a> |
| USFS 2008                     | U.S. Forest Service. 2008. <i>Stream Inventory Handbook</i> , Level I & II, V 2.8.                                                                                                                                                                                                                         |
| Van Tassell 2001              | Van Tassell, J. 2001. "The mid-Pliocene Imbler fish fossils, Grande Ronde Valley, Union County, Oregon, and the connection between Lake Idaho and the Columbia River." <i>Oregon Geology</i> , Volume 63, Number 3, Summer 2001.                                                                           |
| Watershed Sciences, LLC. 2000 | Watershed Sciences, LLC. 2000. Remote Surveying of the Grande Ronde River Basin, Thermal Infrared and Color Videography.                                                                                                                                                                                   |



## **ATTACHMENT A – PHOTOGRAPHIC DOCUMENTATION**

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## **Reach 1 – Valley Floor Group**

## Reach 1



**Photograph 1. View looking upstream at the dam at the mouth of the (former) Grande Ronde River, Catherine Creek in foreground near river mile 22.50. Reach 1 – Catherine Creek, Grand Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 11, 2010.**



**Photograph 2. View looking upstream at the dam and screened outlet/inlet at the mouth of the (former) Grande Ronde River, Catherine Creek in foreground near river mile 22.50. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 11, 2010.**



**Photograph 3. View from the crest of the embankment dam looking upstream at the (former) Grande Ronde River near river mile 22.50. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 11, 2010.**



**Photograph 4. View looking downstream at the dam and spillway channel, the (former) Grande Ronde River is in the lower right corner of photo, Catherine Creek is at top center of photo near river mile 22.50. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 11, 2010.**



**Photograph 5. View looking from the right bank toward the left bank (east to west) at profile location near the intersection with the (former) Grande Ronde River near river mile 22.42. Reach 1 –Catherine Creek, Grande Ronde, Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 11, 2010.**





**Photograph 6. View of fine-grained alluvium, sloughing and tree debris on the right (east) bank of Catherine Creek near river mile 22.00. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 11, 2010.**



**Photograph 7. View of fine-grained alluvium exposed on the right (east) bank of Catherine Creek near river mile 21.90. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 11, 2010.**



**Photograph 8. View looking downstream at Catherine Creek channel near river mile 21.40. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 11, 2010.**



**Photograph 9. View looking upstream at the Oregon State Highway 237 (Cove Highway) Bridge near river mile 21.29. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 11, 2010.**





**Photograph 10. View looking downstream at the Oregon State Highway 237 (Cove Highway) Bridge near river mile 21.29. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 11, 2010.**



**Photograph 11. View of fine-grained alluvium exposed on the right (east) bank of Catherine Creek immediately downstream of Oregon State Highway 237 (Cove Highway) bridge near river mile 21.28. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 11, 2010.**



**Photograph 12. View looking downstream at irrigation pipe crossing Catherine Creek near river mile 20.81. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 11, 2010.**



**Photograph 13. View of fine-grained alluvium exposed on the right (east) bank of Catherine Creek near river mile 20.65. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 11, 2010.**



**Photograph 14. View looking upstream at left (west) bank of Catherine Creek, note erosion of bank materials downstream of shrubs near river mile 20.25. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 11, 2010.**



**Photograph 15. View from the left bank looking downstream at mostly bare banks near river mile 20.12. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 29, 2010.**





**Photograph 16. View looking at alfalfa grass and undercut right bank of Catherine Creek near river mile 20.10. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 11, 2010.**



**Photograph 17. View looking downstream at tree branch erosion protection on right (east) bank of Catherine Creek adjacent to grain field near river mile 19.97. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 11, 2010.**



**Photograph 18. View looking downstream at Catherine Creek channel near river mile 19.50.  
Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation  
Photograph by D. Stelma, July 11, 2010.**



**Photograph 19. View looking downstream at Catherine Creek channel near river mile 19.20.  
Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation  
Photograph by D. Stelma, July 11, 2010.**



**Photograph 20. View looking east toward the mouth of Warm Creek with Catherine Creek in the foreground near river mile 19.02. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 10, 2010.**



**Photograph 21. View looking from the left bank toward the right bank (west to east) at profile location at the mouth of Warm Creek near river mile 19.02. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 10, 2010.**





**Photograph 22. View looking upstream at Catherine Creek channel near river mile 18.25.  
Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation  
Photograph by D. Stelma, July 10, 2010.**



**Photograph 23. View looking upstream at Catherine Creek channel near river mile 17.50.  
Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation  
Photograph by D. Stelma, July 10, 2010.**



**Photograph 24. View looking downstream at discharge pipe with one-way flapper valve on left bank of Catherine Creek near river mile 17.33. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 10, 2010.**



**Photograph 25. View looking at erosion and truck-mounted pump (abandoned?) on left (west) bank of Catherine Creek near river mile 17.10. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 10, 2010.**



**Photograph 26. View looking downstream at discharge pipe with one-way flapper valve on right bank of Catherine Creek near river mile 16.93. Reach 1 – Catherine Creek, Grand Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 10, 2010.**



**Photograph 27. View looking downstream at wood dock structure on the right (east) bank of Catherine Creek channel near river mile 16.70. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 10, 2010.**





**Photograph 28. View looking upstream at exposed fine-grained alluvium on right (east) bank of Catherine Creek near river mile 16.53. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 10, 2010.**



**Photograph 29. View looking upstream at Catherine Creek channel near river mile 16.20. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 10, 2010.**



**Photograph 30. View looking upstream at small diameter pipe crossing Catherine Creek near river mile 16.06. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 10, 2010.**



**Photograph 31. View looking upstream at Catherine Creek channel near river mile 15.90. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 10, 2010.**



**Photograph 32. Crushed culvert at discharge of man-made drainage ditch, Catherine Creek in foreground near river mile 15.77. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 10, 2010.**



**Photograph 33. View looking upstream at Catherine Creek channel (alfalfa grass) near river mile 15.70. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 10, 2010.**





**Photograph 34. Oxbow lake discharge pipe with one-way flapper valve on right (east) bank of Catherine Creek near river mile 15.67. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 10, 2010.**



**Photograph 35. Small remnant of oxbow in field east of Catherine Creek near river mile 15.67. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 10, 2010.**



**Photograph 36. Oxbow lake discharge pipe with one-way flapper valve on right (east) bank of Catherine Creek near river mile 15.55. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 10, 2010.**



**Photograph 37. Dock on right (east) bank of Catherine Creek upstream of Booth Road bridge near river mile 15.45. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 10, 2010.**



**Photograph 38. View looking upstream at Booth Road Bridge near river mile 15.30. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 10, 2010.**



**Photograph 39. Pumping plant on left (west) bank of Catherine Creek upstream of Booth Road bridge near river mile 15.30. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 10, 2010.**





**Photograph 40. Pumping plant on left (west) bank of Catherine Creek, upstream of Elmer Dam near river mile 15.13. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 10, 2010.**



**Photograph 41. Bench at fishing hole on left (east) bank of Catherine Creek at partially opened inlet to an abandoned meander near river mile 14.84. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 10, 2010.**



**Photograph 42. View looking from the left bank toward right of Catherine Creek at profile site near river mile 14.50. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 10, 2010.**



**Photograph 43. View looking upstream at Catherine Creek channel upstream of Elmer Dam near river mile 14.40. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 10, 2010.**



**Photograph 44. View of steel pump intake pipe, Elmer Reservoir, on right bank of Catherine Creek near river mile 14.30. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 10, 2010.**





**Photograph 45. View looking west (left bank) at partially opened inlet to an abandoned meander near river mile 14.10. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 10, 2010.**



**Photograph 46. View of CMP drain pipe with one-way flapper-valve on the right bank of Catherine Creek near river mile 14.06. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 10, 2010.**



**Photograph 47. View looking west at wooden piers (pilings) exposed at oxbow lake and Catherine Creek intersection near river mile 13.90. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 10, 2010.**



**Photograph 48. View looking west at discharge pipe from oxbow lake (cut-off meander), Catherine Creek in foreground near river mile 13.75. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 10, 2010.**



**Photograph 49. View looking downstream at fine-grained alluvium exposed along the left (west) bank of Catherine Creek (artificial cut) near river mile 13.68. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 10, 2010.**



**Photograph 50. Close-up of fine-grained alluvium (firm to hard sandy silt) exposed along the left (west) bank of Catherine Creek (artificial cut) near river mile 13.68. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 10, 2010.**





**Photograph 51. View looking west at algae covered oxbow lake (cut-off meander) near river mile 13.62. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 10, 2010.**



**Photograph 52. Pump house on west side of Catherine Creek near river mile 13.62. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 10, 2010.**



**Photograph 53. View looking upstream at Catherine Creek channel near river mile 13.60. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 10, 2010.**



**Photograph 54. View looking downstream at abandoned bridge piers exposed in the Catherine Creek channel upstream of Elmer Dam near river mile 13.24. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 10, 2010.**





**Photograph 55. View looking upstream at Elmer Dam near river mile 13.13. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 9, 2010.**



**Photograph 56. View looking upstream at observation deck on east bank of Catherine Creek downstream of Elmer Dam near river mile 13.13. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 9, 2010.**



**Photograph 57. View looking upstream at farm access road bridge across Catherin Creek downstream of Elmer Dam near river mile 12.95. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 9, 2010.**



**Photograph 58. View looking upstream at Catherine Creek channel near river mile 12.65. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 9, 2010.**



**Photograph 59. View looking upstream at left bank, exposed fine-grained alluvium along an under-cut stream bank near river mile 12.55. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 9, 2010.**



**Photograph 60. View looking upstream toward the left bank at CMP drain pipe with slide-gate near river mile 12.50. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 9, 2010.**





**Photograph 61. View looking upstream at Catherine Creek channel near river mile 12.30. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 9, 2010.**



**Photograph 62. View looking downstream at vegetation (European Willow) and fine-grained alluvium exposed on the left bank of Catherine Creek near river mile 11.90. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 9, 2010.**





**Photograph 63. View looking upstream at Catherine Creek channel near river mile 11.80. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 9, 2010.**



**Photograph 64. View looking upstream at farm access road bridge crossing Catherine Creek near river mile 11.30. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 9, 2010.**



**Photograph 65. View looking east at wetland area behind levee on the inside curve of Catherine Creek oxbow (Mt. Fanny in background) near river mile 11.05. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 9, 2010.**



**Photograph 66. View looking from the right bank toward the left bank at profile site near river mile 10.50. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 9, 2010.**



**Photograph 67. View looking east (upstream) at man-made drainage ditch near river mile 10.19. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 9, 2010.**





**Photograph 68. View looking at bridge and discharge pipe at mouth of man-made drainage ditch, Catherine Creek is on the other side of the road near river mile 10.19. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 9, 2010.**



**Photograph 69. View looking downstream at Catherine Creek channel near river mile 9.55. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 9, 2010.**





**Photograph 70. View looking southeastward (upstream) at abandoned bridge piers within the Catherine Creek channel near river mile 9.03. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 9, 2010.**



**Photograph 71. View looking of Catherine Creek water sample, note less discoloration of sample than appears in stream near river mile 8.89. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 9, 2010.**



**Photograph 72. View looking northeastward (downstream) at left bank of Catherine Creek through artificial channel area between oxbows near river mile 8.49. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 9, 2010.**



**Photograph 73. View looking east at oxbow lake (cutoff meander), note weed-covered levee in foreground near river mile 8.45. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 9, 2010.**



**Photograph 74. View looking northeastward (downstream) at levee (left) and oxbow lake (right) near river mile 8.45. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 9, 2010.**



**Photograph 75. View looking of flooded area between oxbow lake lakes near river mile 8.45. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 9, 2010.**





**Photograph 76. View looking east at oxbow lake (cutoff meander), note grass-covered levee in foreground near river mile 7.80. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 9, 2010.**



**Photograph 77. View looking west at oxbow lake discharge headgate and Catherine Creek in background near river mile 7.80. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 9, 2010.**



**Photograph 78. View looking across Catherine Creek from the left (west) bank toward the right (east) bank at profile site near river mile 7.75. Note the rope across creek which was used to support boat for surveying work. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 9, 2010.**





**Photograph 79. View looking downstream at abandoned bridge piers near river mile 7.60. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 9, 2010.**



**Photograph 80. View looking upstream at abandoned concrete bridge abutment near river mile 7.60. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 7, 2010.**



**Photograph 81. View looking downstream toward the left bank of Catherine Creek in burned forest area near river mile 7.20. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 9, 2010.**



**Photograph 82. View looking upstream and west at pumping plant on the east bank of Catherine Creek, intake is submerged in creek bed near river mile 7.20. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 7, 2010.**



**Photograph 83. View of fine-grained (silt and clay) sediments along the bank of Catherine Creek with a mix of willows and hay-grass near river mile 6.90. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 7, 2010.**



**Photograph 84. View of cutoff meander (oxbow lake) and gravity drainage pipe to Catherine Creek near river mile 6.60. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 7, 2010.**





**Photograph 85. View looking upstream at Market Lane Bridge near river mile 6.50. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 7, 2010.**



**Photograph 86. Looking northeastward at cutoff meander pond and discharge pump near river mile 5.70. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 7, 2010.**





**Photograph 87. View of meander pond discharge pipe and rock erosion protection with Catherine Creek in background near river mile 5.70. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 7, 2010.**



**Photograph 88. Looking upstream at high left (west) bank of Catherine Creek near river mile 5.60. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 7, 2010.**



**Photograph 89. Remnants of bridge supports, Catherine Creek near river mile 5.30. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 7, 2010.**



**Photograph 90. Duck blind located on the left bank of Catherine Creek near river mile 4.70. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 7, 2010.**



**Photograph 91. View looking at grass covered levee and fine-grained alluvial soil (Qal2) along the right bank of Catherine Creek near river mile 4.40. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 7, 2010.**





**Photograph 92. View looking upstream at fine-grained alluvium (Qal1) surface in background and grass covered levee (L) in foreground, Catherine Creek is immediately to the left of the willow trees on the left side of the photograph near river mile 3.95. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 7, 2010.**



**Photograph 93. View of standing water (swamp) beyond the right bank of Catherine Creek near river mile 3.60. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 7, 2010.**



**Photograph 94. View looking upstream at Catherine Creek channel, note dense vegetation on both banks near river mile 3.50. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 7, 2010.**



**Photograph 95. View of slumping fine-grained alluvial soil (Qal2) on the outer side a meander on the left bank of Catherine Creek near river mile 3.15. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 7, 2010.**





**Photograph 96. View looking at fine-grained alluvial soil (Qal1), scattered riprap, horses and a corral on the outer side of a meander on the right bank of Catherine Creek near river mile 2.95. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 7, 2010.**



**Photograph 97. View looking southeast the crest of a levee and standing water behind levee along the left bank of Catherine Creek near river mile 2.25. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 7, 2010.**



**Photograph 98. View looking downstream at Catherine Creek channel, note dense vegetation on both banks near river mile 2.25. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 7, 2010.**



**Photograph 99. View looking downstream at Catherine Creek channel, note dense vegetation on both banks near river mile 1.80. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 7, 2010.**



**Photograph 100. View of Catherine Creek from the right (east) bank looking toward the left (west) bank near river mile 1.80. Note the rope across creek which was used to support boat for surveying work. Reach 1 – Catherine Creek, Grand Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 8, 2010.**



**Photograph 101. View looking at grass covered levee in background, and slumping fine-grained alluvial soil (Qal2) along the left bank of Catherine Creek near river mile 1.09. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 7, 2010.**





**Photograph 102. View looking downstream at fine-grained alluvium (Qal2) surface in background and grass covered levee in foreground, Catherine Creek is in upper left with Mount Emily on the horizon near river mile 1.00. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 7, 2010.**



**Photograph 103. View looking downstream at fine-grained alluvial soil (Qal1) exposed along the inner bank of a meander on the right bank of Catherine Creek near river mile 0.75. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 7, 2010.**



**Photograph 104. View looking upstream at field/levee drain discharge pipe on right (east) bank of Catherine Creek (foreground) near river mile 0.47. Reach 1 – Catherine Creek, Grand Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 8, 2010.**



**Photograph 105. View looking downstream at fabricated-barrel discharge pipe used to drain water from behind a levee along the right bank of Catherine Creek near river mile 0.47. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 7, 2010.**





**Photograph 106. View looking upstream from the crest of the levee at fabricated-barrel discharge pipe used to drain water from behind the levee, Catherine Creek in the background near river mile 0.47. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 7, 2010.**



**Photograph 107. View looking at pumping station on the right bank of Catherine Creek near river mile 0.40. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 7, 2010.**



**Photograph 108. View looking from the right bank toward the left bank at profile location near river mile 0.10. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 8, 2010.**



**Photograph 109. View looking downstream at grass covered levee, and slumping fine-grained alluvial soil (Qal2) along the left bank of Catherine Creek near river mile 0.03. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 7, 2010.**



**Photograph 110. View from Alicel Bridge (RM 0.0) looking upstream at the Catherine Creek channel (middle) and the mouth of the State Ditch (right) near river mile 0.0. Reach 1 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 7, 2010.**

## **Reach 2 – Valley Floor Group**



## Reach 2



**Photograph 1. View looking downstream over-steepened right bank of Catherine Creek, note vertical cracks in silt deposits near river mile 37.20. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, November 10, 2010.**





**Photograph 2. View looking downstream at wood debris on the left bank of Catherine Creek near river mile 37.14. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 3, 2010.**



**Photograph 3. View looking at under-cut and exposed tree roots on the right bank of Catherine Creek near river mile 37.14. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 3, 2010.**



**Photograph 4. View looking at fine-grained sediments exposed on the left bank of Catherine Creek near river mile 37.10. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 3, 2010.**



**Photograph 5. View looking at partially buried garbage exposed in the right bank of Catherine Creek near river mile 37.05. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 3, 2010.**





**Photograph 6. View looking downstream at the Catherine Creek channel near river mile 37.04. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 3, 2010.**



**Photograph 7. View looking upstream at Catherine Creek channel at the mouth of Pyles Creek near river mile 36.89. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 3, 2010.**



**Photograph 8. Pyles Creek discharge from culvert near the confluence with Catherine Creek near river mile 36.89. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 3, 2010.**



**Photograph 9. View looking downstream at culvert and farm road crossing Pyles Creek near the confluence with Catherine Creek near river mile 36.89. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 3, 2010.**



**Photograph 10. View looking upstream at the Pyles Creek channel from the farm access road near river mile 36.89. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 3, 2010.**





**Photograph 11. View looking downstream at Miller Lane Bridge at river mile 36.48. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 31, 2010.**



**Photograph 12. Left abutment of Miller Lane Bridge near river mile 36.48. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 31, 2010.**



**Photograph 13. View looking downstream at a section of the left bank that is nearly vertical near river mile 36.35. Note the predominantly grass vegetation along the top of the bank. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 31, 2010.**



**Photograph 14. View looking downstream at a section of the left bank that is nearly vertical near river mile 36.25. Note the predominantly grass vegetation. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 31, 2010.**



**Photograph 15. View looking downstream at a section of the left bank that is nearly vertical near river mile 36.04. Note the predominantly grass vegetation. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 31, 2010.**



**Photograph 16. View from the right to left at the site of profile P-R2-7, at river mile 35.91. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 31, 2010.**





**Photograph 17. View from Catherine Creek looking at the entrance of Little Creek from the east, along the right bank near river mile 35.87. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 31, 2010.**



**Photograph 18. View of topsoil exposed on the right (east) bank of Catherine Creek near river mile 35.80. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 31, 2010.**



**Photograph 19. View of looking downstream at Catherine Creek channel upstream of Upper Davis Dam near river mile 35.80. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 31, 2010.**



**Photograph 20. View looking at old barn on the left (west) bank of Catherine Creek near river mile 35.47. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 31, 2010.**





**Photograph 21. View from the left bank to the right at location of profile P-R2-8 at river mile 35.31. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 31, 2010.**



**Photograph 22. View looking downstream at the Oregon State Highway 203 Bridge near river mile 35.30. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 31, 2010.**



**Photograph 23. View looking downstream at the Catherine Creek channel upstream of Upper Davis Dam near river mile 35.15. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 31, 2010.**



**Photograph 24. View of a diversion headgate along the right bank of Catherine Creek near river mile 35.02, upstream of Upper Davis Dam. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 31, 2010.**



**Photograph 25. View looking downstream at the upstream side of Upper Davis Dam, note (lower) Davis Dam tail water in background near river mile 34.99. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 31, 2010.**



**Photograph 26. View looking from right to left at the upstream side of Upper Davis Dam near river mile 34.98. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 1, 2010.**





**Photograph 27. View of water backed up at Upper Davis Dam at river mile 34.98. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, August 1, 2010.**



**Photograph 28. View from the left bank of the checked-up water level upstream of Upper Davis Dam near river mile 34.98. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 27, 2010.**



**Photograph 29. View looking from right to left at the downstream side of Upper Davis Dam, note (lower) Davis Dam tail water level approximately 2- to 3-feet below gates near river mile 34.98. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 1, 2010.**



**Photograph 30. View looking downstream from the crest of Upper Davis Dam near river mile 34.98, note (lower) Davis Dam tail water in background. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 1, 2010.**





**Photograph 31. View looking downstream from Upper Davis Dam at the riprap across the bottom of the channel and along the right bank near river mile 34.98. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 27, 2010.**



**Photograph 32. View looking downstream from Upper Davis Dam at the riprap across the bottom of the channel and along the left bank near river mile 34.98. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 27, 2010.**



**Photograph 33. View looking downstream from Upper Davis Dam at the riprap across the bottom of the channel and along the right bank near river mile 34.98. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 27, 2010.**



**Photograph 34. View looking downstream from Upper Davis Dam at sand deposition along the right bank and a crude rock structures along the left bank and in the channel near river mile 34.98. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 27, 2010.**



**Photograph 35. View of water backed by Lower Davis Dam on the down-stream side of Upper Davis Dam near river mile 34.97. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, August 1, 2010.**



**Photograph 36. View looking upstream at rip rap and sandbar deposits downstream of Davis Dam (in background). Near river mile 34.49. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 27, 2010.**





**Photograph 37. View looking downstream from the crest of Davis Dam at ODFW biologist electro-shocking and capturing fish in tailrace during brief water shut-off for dam repair work near river mile 34.40. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 27, 2010.**



**Photograph 38. View from right to left at the upstream side of Davis Dam, fish ladder in foreground near river mile 34.40. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 27, 2010.**



**Photograph 39. View looking upstream from the crest of Davis Dam near river mile 34.40. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon– Bureau of Reclamation Photograph by D. Stelma, July 27, 2010.**



**Photograph 40. View from the right bank looking downstream at 8-to-12 inch placed riprap directly downstream of Lower Davis Dam at river mile 34.40. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 27, 2010.**





**Photograph 41. View from the right bank looking upstream at a plunge pool located on the downstream side of Lower Davis Dam near river mile 34.40. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 27 2010.**



**Photograph 42. View from the right bank looking downstream at low flow conditions near river mile 34.39. Note the sand substrate and the meander thalweg. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 27 2010.**



**Photograph 43. View from the left bank looking downstream at grass vegetation along the top and toe of the right bank near river mile 34.33. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 27 2010.**



**Photograph 44. View of a very firm indurated silty sand comprising the channel bottom and acting as grade control near river mile 34.31. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 27 2010.**





**Photograph 45. View of a very firm, indurated silty sand that comprises the channel bottom and bank toe near river mile 34.26. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 27 2010.**



**Photograph 46. A close-up view of the firm indurated silty sand that comprises the channel bottom and bank toe and acts as local vertical control and lateral migration control near river mile 34.26. Note the brown oxidation layer and the gray core. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation photograph by R. McAfee, July 27, 2010.**



**Photograph 47. A view to the northeast showing the backside of a levee placed along the left bank of Catherine Creek near river mile 34.26. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 27, 2010.**



**Photograph 48. A view showing one of the few pieces of woody debris in reach 2, located near river mile 34.20. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 27, 2010.**





**Photograph 49** View looking downstream at Catherine Creek near the upper end of the artificial straight section near river mile 34.20. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 27, 2010.



**Photograph 50.** View of a very firm, indurated silty sand that comprises the channel bottom and bank toe near river mile 34.15. Note the basalt gravels that overly the material. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 27, 2010.



**Photograph 51. View of relatively clean sands with cross bedding features interbedded with silts and clays along the left bank near river mile 34.05. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 27, 2010.**

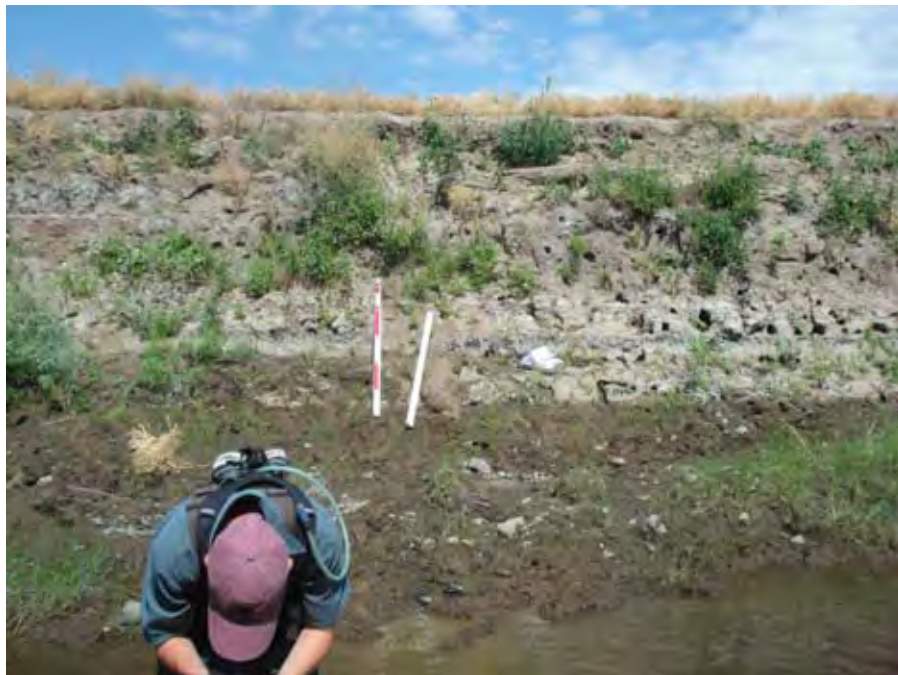


**Photograph 52. View of interbedded silty sands and clays with gravels along the left bank near river mile 34.05. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 27, 2010.**





**Photograph 53. View from the left bank to the right at location of profile P-R2-1, located near river mile 34.05. Note the grass, willow, shrub-sapling and small diameter vegetation. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 27, 2010.**



**Photograph 54. View of the left bank at location of profile P-R2-1, located near river mile 34.05. Note the lack of vegetation. Reach 2 – Bureau of Reclamation Photograph by R. McAfee, July 27, 2010.**



**Photograph 55. View looking downstream at a section with very low water velocities and mixed vegetation along both banks near river mile 33.98. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 27, 2010.**



**Photograph 56. View looking downstream at Catherine Creek channel near river mile 33.95. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 27, 2010.**





**Photograph 57. View of small brush debris and the resulting sand deposition directly downstream near river mile 33.91. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 27, 2010.**



**Photograph 58. View of a small brush and wood debris and the resulting sand deposition directly downstream near river mile 33.89. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 27, 2010.**



**Photograph 59. View of a small brush along the left bank with local scour downstream near river mile 33.89. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 27, 2010.**



**Photograph 60. View from left bank to the right showing local scour in the channel bottom and a 'diving board' along the right bank near river mile 33.89. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 27, 2010.**





**Photograph 61. View from left bank looking downstream at the Woodruff Lane Bridge near river mile 33.85. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 27, 2010.**



**Photograph 62. View from the top of the left bank looking downstream at a floodwater pump and return upstream the Woodruff Lane Bridge near river mile 33.85. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 27, 2010.**



**Photograph 63. View from Woodruff Lane looking down a levee along the right bank near river mile 33.84. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 27, 2010.**



**Photograph 64. View looking downstream at the first occurrence of small alternating lateral sand bars as a result of local scour at the Woodruff Lane Bridge near river mile 33.84. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 27, 2010.**





**Photograph 65. View looking downstream at the Woodruff Lane Bridge near river mile 33.84. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation  
Photograph by D. Stelma, July 27, 2010.**



**Photograph 66. View looking downstream at Catherine Creek through the long straight artificial channel section, note silty sand and sand silt bed deposits near river mile 33.80. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation  
Photograph by D. Stelma, July 27, 2010.**



**Photograph 67. View looking downstream at a small section of riprap along the right bank near river mile 33.78. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 27, 2010.**



**Photograph 68. View of an example of how small roughness elements can promote local deposition near river mile 33.78. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 27, 2010.**





**Photograph 69. View from the right bank of a local area of deposition, with a low-flow riffle and small bars in the wetted width near river mile 33.70. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 27, 2010.**



**Photograph 70. View looking downstream of woody debris along the banks and a large lateral bar along the left bank with vegetation beginning to establish near river mile 33.65. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 27, 2010.**



**Photograph 71. View looking downstream along an eroding section of the right bank. The bank has about 6 feet of vertical face that is contributing sand, silt and clay sized material near river mile 33.65. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 27, 2010.**



**Photograph 72. A close-up view of the left bank material comprised of silt and clay inter-bedded with sand near river mile 33.65. Note the plastic cup lid to the left of the pen. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 27, 2010.**





**Photograph 73. A close-up view of the left bank material comprised of silt and clay interbedded with sand near river mile 33.65. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 27, 2010.**



**Photograph 74. View looking downstream at the Catherine Creek channel and ODFW biological survey crew near river mile 33.63. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 27, 2010.**



**Photograph 75. View looking downstream at Catherine Creek channel near river mile 33.63, note sloughing off right bank. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 27, 2010.**



**Photograph 76. A view looking to the north of the back side of a levee that runs along the left bank near river mile 33.59. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 27, 2010.**



**Photograph 77. View looking to the north of the right floodplain, and a section of erosion along the right bank near river mile 33.50. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 27, 2010.**



**Photograph 78. View to the south, looking upstream at an eroding grass-covered right bank on the outside of a meander bend near river mile 33.50. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 27, 2010.**





**Photograph 79. View looking downstream at Catherine Creek channel near river mile 33.28. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 27, 2010.**

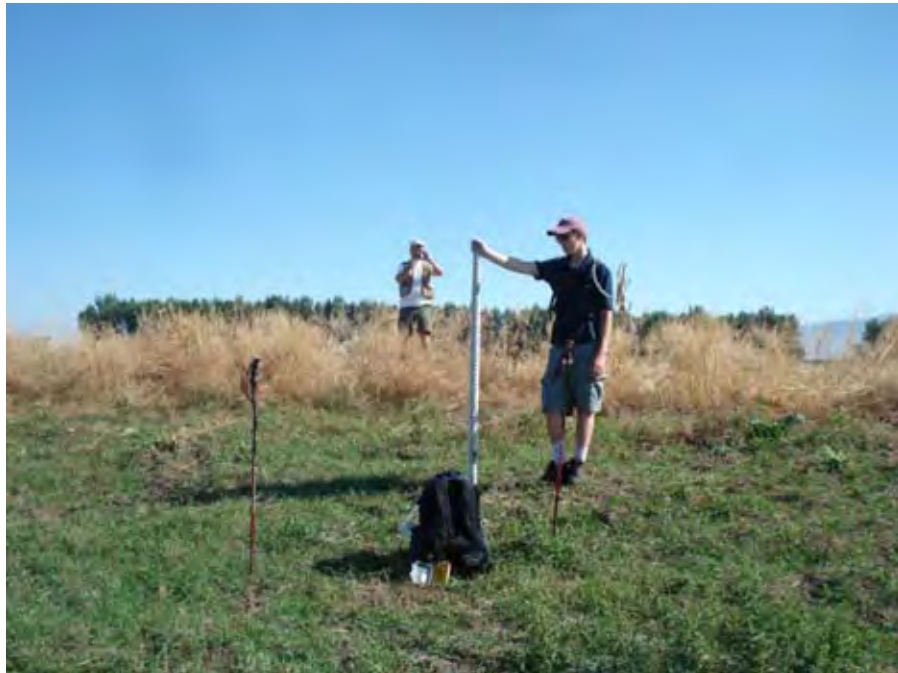


**Photograph 80. View looking downstream at the Catherine Creek channel and profile location, note fine-grained alluvium (tan dense silt) forming the bed and lower banks of the creek near river mile 33.22. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 1, 2010.**





**Photograph 81. View looking at the left bank and levee in the back ground at the location of profile P-R2-9 at river mile 33.22. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, August 1, 2010.**



**Photograph 82. View looking at the right bank and levee in the back ground at the location of profile P-R2-9 at river mile 33.22. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, August 1, 2010.**



**Photograph 83. View looking from right to left across the Catherine Creek channel, profile location near river mile 33.22. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 1, 2010.**



**Photograph 84. View looking upstream of banks that show signs of trampling near river mile 33.20. Note the mostly grassy vegetation along the banks. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, August 1, 2010.**



**Photograph 85. View looking downstream at alternating bar formation, evidence of trampling along both banks and a dense firm sedimentary layer at the water edge along the right bank at river mile 33.20. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, August 1, 2010.**





**Photograph 86. View from the left bank looking downstream at a point sand bar that acts as a hydraulic control near river mile 33.18. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 27, 2010.**



**Photograph 87. View looking downstream at large sandbar on the right bank (inside bend) of Catherine Creek near river mile 33.18. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 1, 2010.**





**Photograph 88. View looking downstream at large sandbar on the right bank (inside bend) of Catherine Creek near river mile 33.18. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 1, 2010.**



**Photograph 89. View looking downstream at a large bar along the right bank in the foreground near river mile 33.18. The right bank exhibits slumping and becomes vertical in the back ground. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, August 1, 2010.**



**Photograph 90. View looking downstream at the Catherine Creek channel, note fine-grained alluvium (tan dense silt) forming the bed of the creek near river mile 33.14. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 1, 2010.**



**Photograph 91. A close up view of the firm silty material that is erosion resistant, and visible along the toe of the right bank near river mile 33.03. Note the karst-type topography resulting from local ball milling by gravels visible in the lower left of the photograph. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, August 1, 2010.**



**Photograph 92. View looking downstream at the Catherine Creek channel near river mile 33.00, note fine-grained alluvium (tan dense silt) forming the bed of the creek. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 1, 2010.**





**Photograph 93. View looking downstream of sand along the left bank and the firm silty material that is erosion resistant in the channel bottom and along the toe of the right bank near river mile 32.96. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, August 1, 2010.**



**Photograph 94. View of a section of the right bank that is near vertical, with banks slumps at the toe near river mile 32.90. Note the firm, silty material that is erosion resistant in the channel. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, August 1, 2010.**





**Photograph 95. View of a pump with an excavated sump on the outside of a levee set back from the right bank near river mile 32.88. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, August 1, 2010.**



**Photograph 96. View of a pump discharge on the inside of a levee set back from the right bank near river mile 32.88. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, August 1, 2010.**



**Photograph 97. View from the right bank looking across the channel to the left at location of profile P-R2-10, near river mile 32.85 material that is erosion resistant in the channel. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, August 1, 2010.**



**Photograph 98. View from the right bank looking across the channel to the left at location of profile P-R2-10, near river mile 32.85 material that is erosion resistant in the channel. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, August 1, 2010.**



**Photograph 99. View from the right bank looking to the east of a levee in the right floodplain at material that is erosion resistant in the channel near river mile 32.85. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, August 1, 2010.**





**Photograph 100. View looking downstream at the Catherine Creek channel and profile location near river mile 32.85, note fine-grained alluvium (tan dense silt) forming the bed of the creek. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 1, 2010.**





**Photograph 101. View looking downstream at the Catherine Creek channel near river mile 32.84, note fine-grained alluvium (tan dense silt) forming the bed of the creek. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 1, 2010.**



**Photograph 102. View looking upstream at the Catherine Creek channel near river mile 32.83, note fine-grained alluvium (tan dense silt) forming the bed of the creek. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 1, 2010.**



**Photograph 103. View of the firm, silty material that is erosion resistant in the channel bottom and along the toe of the right bank near river mile 32.81. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, August 1, 2010.**



**Photograph 104. A close up view of ripple marks in the surface of the firm, silty material that is erosion resistant in the channel bottom and along the toe of the right bank near river mile 32.81. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, August 1, 2010.**





**Photograph 105. View from the right bank looking across the channel to the left at location of deposition of sand-sized material and 'braided flow' near river mile 32.75. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, August 1, 2010.**



**Photograph 106. View from the right bank looking across the channel to the left at location of deposition of sand-sized material and 'braided flow' near river mile 32.75. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, August 1, 2010.**



**Photograph 107. View looking downstream at gently sloped to vertical (left) banks, sand sized bed material and a dense, light tan erosion resistant material along the left bank toe near river mile 32.54. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, August 1, 2010.**



**Photograph 108. View looking downstream at the Catherine Creek channel near river mile 32.53, note cattle in stream. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 1, 2010.**





**Photograph 109. View along the right bank showing active bank erosion and the firm, silty material that is erosion resistant in the channel bottom and along the toe of the right bank near river mile 32.50. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, August 1, 2010.**



**Photograph 110. View looking downstream at an over-flow site along the right bank near river mile 32.30. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, August 1, 2010.**



**Photograph 111. View looking downstream at the Catherine Creek channel near river mile 32.30, note cattle in stream. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 1, 2010.**



**Photograph 112. View looking downstream at the Catherine Creek channel near river mile 32.30, note cattle on stream bank. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 1, 2010.**





**Photograph 113. View from the right bank looking downstream at scour along the left bank associated with wood accumulation along the right bank near river mile RM 32.30. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, August 1, 2010.**



**Photograph 114. View from the right bank looking at a section of deposition of sand sized material near river mile 32.14. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, August 1, 2010.**



**Photograph 115. View from the right bank looking downstream at sandbar with vegetation along the toe of both banks near river mile 32.10. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, August 1, 2010.**



**Photograph 116. View looking downstream at the Catherine Creek channel near river mile 32.10, note sandy bed deposits. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 1, 2010**





**Photograph 117. View from the right bank looking downstream at sandbar development along the toe of both banks near river mile 32.00. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, August 1, 2010.**



**Photograph 118. View from the right bank looking upstream at sandbar development along the toe of both banks near river mile 32.00. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, August 1, 2010.**



**Photograph 119. View looking downstream at the Wilkinson Lane Bridge near river mile 32.00. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 1, 2010.**



**Photograph 120. View from the Wilkinson Lane Bridge looking downstream at the Catherine Creek channel near river mile 31.95. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 28, 2010.**





**Photograph 121. View of Catherine Creek from the Wilkinson Lane Bridge near river mile 31.95. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 28, 2010.**



**Photograph 122. View looking downstream from Wilkinson Bridge of grass/shrub vegetation along the left bank, and sapling-pole vegetation and random riprap along the right bank near river mile 31.95. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 28, 2010.**



**Photograph 123. A view looking downstream from Wilkinson Bridge at debris collecting in front of the sapling-pole vegetation along the right bank near river mile 31.95. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 28, 2010.**



**Photograph 124. View looking downstream from the left bank to the right at random concrete blocks along the toe of the right bank near river mile 31.94. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 28, 2010.**





**Photograph 125. View from the right bank looking upstream at an overflow channel in the right floodplain near river mile 31.89. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 28, 2010.**



**Photograph 126. View from the right bank looking downstream an overflow channel in the right floodplain at river mile 31.89. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 28, 2010.**



**Photograph 127. View looking downstream from the left bank at predominantly grass vegetation along the top of the left bank, willow and small tree vegetation along the right, and alternating sand bar deposits in the channel near river mile 31.88. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 28, 2010.**



**Photograph 128. A view from the right bank looking downstream at slumping along a predominantly grass vegetated right bank and sand bed-load in the main channel near river mile 31.87. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 28, 2010.**





**Photograph 129. View looking downstream from the left bank at predominantly grass vegetation along the top of the left bank, willow and small tree vegetation along the right, and recently deposited sand bar along the toe of the left bank near river mile 31.85. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 28, 2010.**



**Photograph 130. View looking downstream at a low flow riffle to pool sequence near river mile 31.80. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 28, 2010.**



**Photograph 131. View of sandy bed material in Catherine Creek channel near river mile 31.80. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 28, 2010.**





**Photograph 132. View looking downstream at Catherine Creek Channel near river mile 31.79. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 28, 2010.**



**Photograph 133. View looking downstream at a hard, indurated fine grained material that is erosion resistant along the toe of the left bank near river mile 31.69. The channel has incised through this material. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 28, 2010.**



**Photograph 134. View from the top of the left bank looking to the northwest of grass vegetation and a levee near river mile 31.68. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 28, 2010.**



**Photograph 135. View from the top of the left bank to the right bank. The vegetation is grass/shrub and willow near river mile 31.66. Note the exposed soil sections that are a source of fine sediment. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 28, 2010.**



**Photograph 136. Wood debris on upper left bank near river mile 31.65, Catherine Creek visible through willows on the right side of the photo. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 28, 2010.**





**Photograph 137. View from the top of the left bank to the right bank at location of profile P-R2-2 at river mile 31.63. The vegetation is grass/shrub and willow. Note the exposed soil sections and visible slumping indicating fine sediment input. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 28, 2010.**



**Photograph 138. View from the top of the left bank to a levee set back to the northwest at the location of profile P-R2-2 at river mile 31.63. The vegetation is grass/shrub and willow. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 28, 2010.**





**Photograph 139. View looking downstream at Catherine Creek Channel near river mile 31.52. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 28, 2010.**



**Photograph 140. View from the top of the left bank looking downstream at grass/shrub with patches of small to medium tree vegetation along the right bank and bare bank, grass shrub on the left near river mile 31.51. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 28, 2010.**



**Photograph 141. View from the top of the left bank looking to the right bank at an exposure of the hard, firm fine grained material at river mile 31.50. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 28, 2010.**



**Photograph 142. View of fine-grained alluvium (tan dense silt) exposed on the right bank of Catherine Creek near river mile 31.50. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 28, 2010.**



**Photograph 143. View from the top of the left bank looking downstream of small tree vegetation along the right bank and grass/shrub along the left near river mile 31.42. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 28, 2010.**





**Photograph 144. View looking upstream at small tree vegetation along the right bank and grass/shrub along the left at the Ladd Marsh input at river mile 31.40. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 28, 2010.**



**Photograph 145. View looking downstream at sandbars along the right bank of Catherine Creek, directly downstream of the Ladd marsh input at river mile 31.40. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 28, 2010.**





**Photograph 146. View of a fence across the Ladd Marsh input 100 feet off of the main channel of Catherine Creek near river mile 31.40. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 28, 2010.**



**Photograph 147. A close-up view of the coarse-to-fine sand that comprises the bars in Catherine Creek, at the Ladd marsh input at river mile 31.40. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 28, 2010.**



**Photograph 148. Close-up of sandbar deposits at the mouth of Ladd Creek near river mile 31.40. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 28, 2010.**



**Photograph 149. View looking westward at Ladd Creek entering Catherine Creek near river mile 31.39. Note beaver dam in Ladd Creek channel (background). Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 28, 2010.**





**Photograph 150. View looking downstream at a section with very slow velocity, 2' of depth and predominantly grass/shrub vegetation along both banks, at river mile 31.29. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 28, 2010.**



**Photograph 151. View from the left bank looking downstream at a section with very slow velocity, 2' of depth and predominantly grass/shrub vegetation along both banks, at river mile 31.27. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 28, 2010.**





**Photograph 152. View looking at drain slide-gate on the left bank of Catherine Creek near river mile 31.18. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 28, 2010.**



**Photograph 153. View looking downstream from the top of the right bank near river mile 31.14. The channel bottom is comprised of a dense, firm silty material that is erosion resistant, and visible along the toe of the right bank. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, August 1, 2010.**



**Photograph 154. View from the left bank to the right at location of profile P-R2-3 at river mile 31.09. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 28, 2010.**



**Photograph 155. View from the edge of the left bank to the back to a small terrace in the left flood plain at location of profile P-R2-3 at river mile 31.09. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 28, 2010.**





**Photograph 156. A view of the fine sand-sized material along the right bank near river mile 31.08. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 28, 2010.**



**Photograph 157. A view from the right bank to left showing an exposure of the hard, firm fine grained material that is erosion resistant at the toe of the left bank, and fine sand bed load in the active channel near river mile 31.08. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 28, 2010.**



**Photograph 158. A view from the right bank looking downstream at an exposure of the hard, firm fine grained material that is erosion resistant at the toe of the right bank on the outside of a meander bend at river mile 31.00, and bank slumping just downstream. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 28, 2010.**



**Photograph 159. View looking downstream at sandbar (medium sand) on the right (east) side of Catherine Creek near river mile 30.89. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 28, 2010.**





**Photograph 160. View from the right bank looking upstream at slumping along the predominantly grass vegetated left bank, hard fine grained material at the toe of the bank and sand bed-load in the main channel near river mile 30.88. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 28, 2010.**



**Photograph 161. View from the right bank looking downstream at predominantly grass vegetated banks and sand bed-load in the main channel that forms small point bars at lower flow conditions near river mile 30.86. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 28, 2010.**



**Photograph 162. View from the top of the right bank looking downstream at an overflow channel return in the right floodplain at river mile 30.64. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 28, 2010.**



**Photograph 163. View from the top of the right bank looking upstream at a grass vegetated left bank at river mile 30.64. Slumping and exposed sediment/soil indicates local fine sediment input. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 28, 2010.**





**Photograph 164. View from the top of the right bank looking upstream at an overflow channel in the right floodplain at river mile 30.61. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 28, 2010.**



**Photograph 165. View from the top of the right bank looking downstream at woody debris accumulation in an overflow channel in the right floodplain at river mile 30.61. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 28, 2010.**



**Photograph 166. View from the top of the right bank looking downstream at a grass vegetated bank with slumping at river mile 30.60. Bed load is comprised of sand sized sediment that is visible in a delta-like pulse. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 28, 2010.**



**Photograph 167. View looking downstream at Catherine Creek Channel, over-grown levee at right of photo near river mile 30.52. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 28, 2010.**





**Photograph 168. View from the right bank to the left at a grass vegetated bank with slumping at river mile 30.49. Exposed sediment/soil indicates local fine sediment input. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 28, 2010.**



**Photograph 169. View from the right bank looking slightly upstream at a grass-vegetated left bank with an overflow channel return near river mile 30.43. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 28, 2010.**



**Photograph 170. View from the right bank looking a debris accumulation on the surface near river mile 30.43. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 28, 2010.**



**Photograph 171. View from the right bank looking downstream at mostly denuded banks and a debris accumulation along the right bank near river mile 30.43. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 28, 2010.**



**Photograph 172. View from the right bank looking upstream at debris accumulation along the right bank near river mile 30.43. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 28, 2010.**





**Photograph 173. View of wood debris on upper right bank of Catherine Creek channel near river mile 30.42. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 28, 2010.**





**Photograph 174. View looking from right to left at wood debris accumulation in the Catherine Creek channel near river mile 30.40. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 28, 2010.**



**Photograph 175. View looking downstream at wood debris on upper right bank of Catherine Creek near river mile 30.40. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 28, 2010.**



**Photograph 176. View from the right bank to the left at location of profile P-R2-5, at river mile 30.36. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 28, 2010.**



**Photograph 177. View from the right bank looking to the break in slope along the right floodplain at location of profile P-R2-5, at river mile 30.36. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 28, 2010.**





**Photograph 178. View of a buried log and riprap structures along the left bank at river mile 30.30. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 28, 2010.**



**Photograph 179. A close-up view of a buried log and riprap structure along the left bank at river mile 30.30. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 28, 2010.**



**Photograph 180. View looking downstream at fence and wood strand line along left bank of Catherine Creek near river mile 30.28, note creek channel at upper right of photo. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 28, 2010.**



**Photograph 181. View looking downstream at the right bank. The light strip near the water surface is a hard, fine grained material that is resistant to erosion near river mile 30.25. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 28, 2010.**





**Photograph 182. View looking downstream at the right bank. This section of the bank is grass vegetated, and the lighter material at the toe of the bank is a hard, fine-grained material that is resistant to erosion. Note the woody debris accumulation along the left bank near river mile 30.24. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 28, 2010.**



**Photograph 183. View looking at the woody debris accumulation along the left bank at river mile 30.22. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 28, 2010.**



**Photograph 184. View looking downstream at Catherine Creek channel near river mile 30.15. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 28, 2010.**



**Photograph 185. Heron nesting area near river mile 30.13. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 28, 2010.**



**Photograph 186. View looking downstream at Catherine Creek channel near river mile 30.13. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation  
Photograph by D. Stelma, July 28, 2010.**



**Photograph 187. View of the sand-sized material comprising the in-channel substrate near river mile 30.11. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation  
Photograph by R. McAfee, July 28, 2010.**





**Photograph 188. View of the sand-sized material comprising the bed-load river mile 30.11. Lighter gravel-sized material is pieces of the hard fine- grained material that have been input into the system. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 28, 2010.**



**Photograph 189. View from the right bank looking downstream at a section of concrete slab armoring along the left bank and a point bar comprised of sand-sized material along the right bank river mile 30.11. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 28, 2010.**





**Photograph 190. View from the left bank to the right at location of profile P-R2-4 at river mile 30.09. Note the predominantly grass/shrub vegetation and sand sized sediment along the bank. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 28, 2010.**



**Photograph 191. View looking from right to left at fence across Catherine Creek near river mile 30.00. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 28, 2010.**



**Photograph 192. View looking downstream at debris scattered along stream bank near river mile 30.00. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 28, 2010.**



**Photograph 193. View looking upstream at fallen tree and wood debris within the Catherine Creek channel near river mile 29.98. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 28, 2010.**





**Photograph 194. View from the right bank looking downstream at a wide, flat active channel with sand-sized material comprising the bed load near river mile 29.81. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 28, 2010.**



**Photograph 195. View looking downstream at sandbars (medium sand) on the right (east) side of Catherine Creek near river mile 29.66. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 28, 2010.**



**Photograph 196. View of the sand-sized material that comprises the bed-load and point-bars near river mile 29.65. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 28, 2010.**



**Photograph 197. View looking downstream at semi-vegetated point bars comprised of sand sized material along the right bank near river mile 29.65. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 28, 2010.**





**Photograph 198. View looking upstream at the Catherine Creek channel near river mile 29.60. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 28, 2010.**



**Photograph 199. View from the right bank looking downstream at 2 feet of silty-sand (topsoil) over lying about 8 feet if the hard, fine grained material near river mile 29.59. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 28, 2010.**



**Photograph 200. View looking north at the mouth McAlister Slough, Catherine Creek in foreground near river mile 29.38. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 28, 2010.**



**Photograph 201. View looking downstream at fine-grained alluvial sediments exposed along the left (north) bank of Catherine Creek near river mile 29.37. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 28, 2010.**



**Photograph 202.** View from the right bank looking slightly downstream at an inlet to an irrigation/stock pond along the left bank at river mile 29.37. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 28, 2010.



**Photograph 203.** View from the right bank looking slightly downstream at the exposed stratigraphic sequence consists of clayey-silty-sand overlain by about 10 feet of hard fine-grained material and then 2 feet of topsoil near river mile 29.36. Note the grass vegetation along both banks. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 28, 2010.





**Photograph 204. View from the right bank looking downstream at the exposed stratigraphic sequence consists of clayey-silty-sand overlain by hard fine-grained material and then topsoil near river mile 29.15. Note the predominantly grass vegetation along both banks. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 28, 2010.**



**Photograph 205. View looking downstream at fine-grained alluvial sediments exposed along the right (east) bank of Catherine Creek (Mt Harris at upper right of photo) near river mile 29.15. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 28, 2010.**





**Photograph 206. View from the right bank looking across to the subtle overflow inlet on the left bank at river mile 29.05. The inlet fills the storage pond that was the historic Grande Ronde river channel. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 28, 2010.**



**Photograph 207. View looking downstream at fine-grained alluvial sediments exposed along the right (south) bank of Catherine Creek (Phys Point at upper right of photo) near river mile 28.70. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 28, 2010.**



**Photograph 208. View from the right bank looking downstream at a levee along the right bank that is failing near river mile 28.40. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 28, 2010.**



**Photograph 209. View looking downstream at fine-grained alluvial sediments exposed along the right (south) bank of Catherine Creek near river mile 28.39. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 28, 2010.**



**Photograph 210. View looking downstream at fine-grained alluvial sediments exposed along the right (south) bank of Catherine Creek near river mile 27.98. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 29, 2010.**



**Photograph 211. View looking upstream at fine-grained alluvial sediments exposed along the left (north) bank of Catherine Creek near river mile 27.98. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 29, 2010.**





**Photograph 212. View looking north from high southern bank at profile location near river mile 27.98. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 29, 2010.**





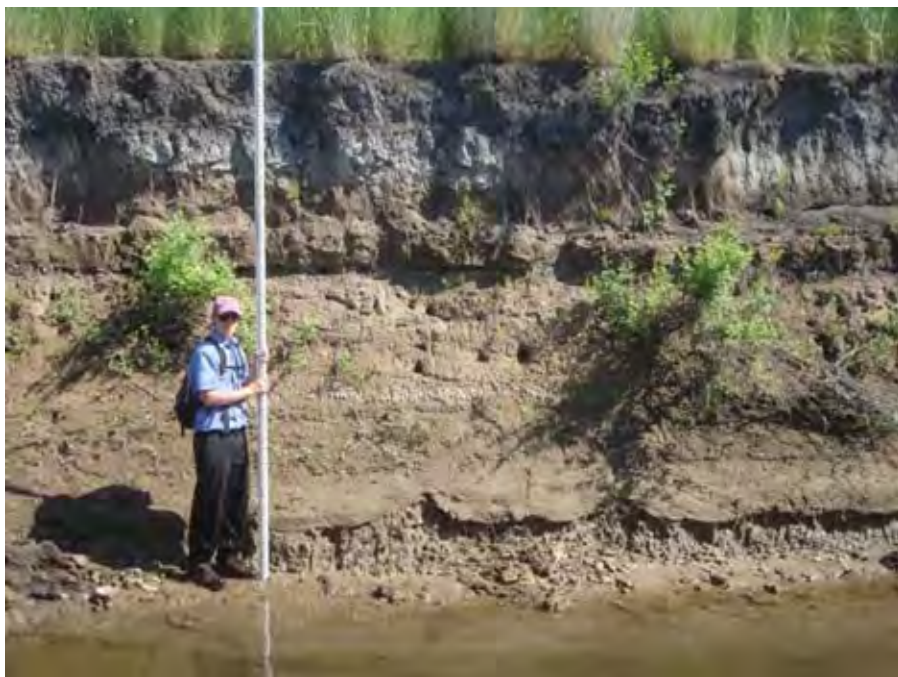
**Photograph 213. View from the right bank looking downstream at a grass/willow vegetated banks, and a thinly bedded clayey-silty sand material along the toe of the right bank and in the wetted channel at river mile 27.94. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 29, 2010.**



**Photograph 214. A close-up view of the thinly bedded clayey-silty sand, material along the toe of the right bank and in the wetted channel at river mile 27.94 . Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 29, 2010.**



**Photograph 215. View from the right bank to the left showing a vertical denuded face and the typical stratigraphy comprised of topsoil over hard, indurated fine-grained material and well-to-poorly indurated silty-clayey sands near river mile 27.86. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 29, 2010.**



**Photograph 216. View looking at fine-grained fluvial lacustrine sediments exposed along the left (north) bank of Catherine Creek near river mile 27.85. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 29, 2010.**



**Photograph 217. View looking upstream at fine-grained alluvial sediments exposed along the left (north) bank of Catherine Creek near river mile 27.85. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 29, 2010.**





**Photograph 218. Cattle at creek side near river mile 27.78. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 29, 2010.**



**Photograph 219. Views looking south at side drainage channel discharge gate and ditch near river mile 27.72. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 29, 2010.**





**Photograph 220. Views looking north at side drainage channel discharge, and pumps on north side of Catherine Creek near river mile 27.72. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 29, 2010.**



**Photograph 221. View from the right bank of riprap hardened points along both banks at river mile 27.72. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 29, 2010.**



**Photograph 222. View from the right bank looking downstream at another exposure of thinly bedded clayey-silty sand material near river mile 27.59. The vertical and/or undercut ledge just beneath the water surface is up to 2 feet tall. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 29, 2010.**



**Photograph 223. Cattle at creek side near river mile 27.30. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 29, 2010.**





**Photograph 224. View from the right bank to the left or a pump on top of the left bank with the 30-inch intake just below the water level at the toe of the left bank and riprap protection along the bank toe near river mile 27.30. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 29, 2010.**



**Photograph 225. View of an irrigation return constructed of concrete with a metal drum gate along the right bank near river mile 27.30. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 29, 2010.**



**Photograph 226. View of a pump along the top of the right bank with the intake situated off the main channel, in the return channel noted in photograph 236 near river mile 27.30. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon- Bureau of Reclamation Photograph by R. McAfee, July 29, 2010.**



**Photograph 227. View from the right bank looking to the left bank at another exposure of thinly bedded clayey-silty sand material at river mile 27.26. The vertical and/or undercut ledges just beneath the water surface can be greater than 2 feet tall. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 29, 2010.**





**Photograph 228. View from the right bank looking to the southwest at standing water in an historic channel swale near river mile 27.00. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon - Bureau of Reclamation Photograph by R. McAfee, July 29, 2010.**



**Photograph 229. View from the right bank looking downstream at Godley Lane Bridge at river mile 26.70. Note the small section of riprap on the left bank underneath the bush at the water's edge. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 29, 2010.**



**Photograph 230. View from the right bank to the left of an overflow oxbow entrance. There is a large area of bank seep in this location at river mile 26.70. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 29, 2010.**



**Photograph 231. View looking south at the downstream side of the Godley Lane Bridge near river mile 26.70. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 29, 2010.**





**Photograph 232. View from the right bank looking downstream at grass, shrub and small tree vegetation along both banks near river mile 26.44. This section is very low velocity due to the back water effect of Elmer Dam. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 29, 2010.**



**Photograph 233. Views looking downstream at Catherine Creek channel (Phys Point at upper right of photo) near river mile 26.35. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 29, 2010.**



**Photograph 234. View from the right bank looking downstream at grass vegetated right bank and a grass/small tree vegetated right bank near river mile 26.34. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 29, 2010.**



**Photograph 235. View from the left bank looking downstream at the top of grass vegetated left bank and a grass/small tree vegetated right bank near river mile 26.00. Note nearly vertical denuded left bank face and the hard indurated silty sand at the toe. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 29, 2010.**



**Photograph 236. View looking downstream fine-grained alluvial sediments exposed along the left (north) bank of Catherine Creek near river mile 25.98. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 29, 2010.**





**Photograph 237. View looking downstream fine-grained alluvial sediments exposed along the left (north) bank of Catherine Creek (Phys Point at upper right of photo) near river mile 25.48. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 29, 2010.**



**Photograph 238. View from the left bank looking upstream at grass and willow dominated vegetation near river mile 25.45. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 29, 2010.**





**Photograph 239. View from the left bank looking downstream at grass and willow dominated vegetation near river mile 25.45. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 29, 2010.**



**Photograph 240. View from the left bank looking at a sand pulse in the channel at river mile 25.36. The pulse is lobe-shaped with secondary ripples along the length. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 29, 2010.**



**Photograph 241. View looking downstream fine-grained alluvial sediments exposed along the left (north) bank of Catherine Creek (Phys Point at upper right of photo) near river mile 25.10. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 29, 2010.**



**Photograph 242. View from the left bank looking downstream of grass and small tree vegetation along the banks, with a firm, indurated sand in the bottom of the wetted channel near river mile 24.96. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 29, 2010.**





**Photograph 243. View from the left bank looking upstream of grass and small tree vegetation along the banks, with a firm, indurated sand in the bottom of the wetted channel near river mile 24.96. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 29, 2010.**



**Photograph 244. View from the top of the left bank looking at a historic oxbow in the left (north) floodplain near river mile 24.88. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 29, 2010.**





**Photograph 245. View looking at cut-off meander channels (plowed over) north of present Catherine Creek (Phys Point at lower right of photo) near river mile 24.80. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 29, 2010.**



**Photograph 246. View of fine-grained fluvial lacustrine sediments exposed on the right (south) bank of Catherine Creek (near east end of artificial channel) near river mile 24.65. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 29, 2010.**



**Photograph 247. View from the left bank looking downstream at bank slumps and denudation of the bank indicates, which can indicate local fine sediment input at this site at river mile 24.54. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 29, 2010.**



**Photograph 248. View from the top of the left bank looking down at a bank seep along the toe at river mile 24.54. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 29, 2010.**





**Photograph 249. View of fine-grained fluvial lacustrine sediments exposed on the left (west) bank of Catherine Creek (Phys Point in background) near river mile 24.30. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 29, 2010.**



**Photograph 250. View right bank looking up into Mill Creek near river mile 24.11. Note the amount of apparent incision on Mill Creek. Catherine Creek reflects the same amount of incision. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 30, 2010.**





**Photograph 251. View looking at exposed sedimentary sequence along the right bank near river mile 24.09. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 30, 2010.**



**Photograph 252. View looking at block-sized bank slumps along the right bank near river 23.92. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 30, 2010.**



**Photograph 253. View looking downstream at predominantly grass covered banks, and the Gekeler Lane Bridge across the main channel near river mile 23.70. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 30, 2010.**



**Photograph 254. View looking upstream at the Gekler Lane Bridge near river mile 23.68. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 30, 2010.**



**Photograph 255. View looking downstream at Catherine Creek channel near river mile 23.40. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 30, 2010.**



**Photograph 256. View looking at the sediment sequence exposed in the right bank near river mile 23.40. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 30, 2010.**





**Photograph 257. View looking at the sediment sequence exposed in the right bank near river mile 22.95. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by R. McAfee, July 30, 2010.**



**Photograph 258. View of fine-grained alluvial sediments exposed on the left (west) bank of Catherine Creek near river mile 22.91. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 30, 2010.**



**Photograph 259. View of fine-grained alluvial sediments (tan dense silt) exposed on the left (west) bank of Catherine Creek near river mile 22.72. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, July 30, 2010.**

## **Reach 3 – Alluvial Fan**



### Reach 3



**Photograph 1. View looking downstream at the Oregon State (Medical Springs) Highway 203 Bridge over Catherine Creek at Union, OR near river mile 40.65, note return flow from CMP on left side of channel. Reach 3 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 16, 2010.**



**Photograph 2. View looking upstream at the Oregon State (Medical Springs) Highway 203 Bridge over Catherine Creek at Union, OR near river mile 40.65. Reach 3 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 16, 2010.**

**Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 16, 2010.**



**Photograph 3. View looking downstream at Schwackhammer diversion dam near river mile 40.60. Reach 3 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 2, 2010.**



**Photograph 4. View looking upstream at Schwackhammer diversion dam near river mile 40.60. Reach 3 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 2, 2010.**





**Photograph 5. View looking downstream at the Catherine Creek channel below Schwackhammer diversion dam near river mile 40.56, note abundance of gravel and cobble size material in bars on both sides of the creek. Reach 3 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 2, 2010.**





**Photograph 6. View looking from left to right across Catherine Creek at profile location immediately downstream from Schwackhammer diversion dam near river mile 40.55. Reach 3 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 2, 2010.**



**Photograph 7. View looking downstream at the Catherine Creek channel in Union, OR near river mile 40.53, note rip rap erosion protection on both banks, Oregon State (Medical Springs) Highway 203 is near the left side of the photo. Reach 3 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 2, 2010.**



**Photograph 8. View looking downstream at the Catherine Creek channel in Union, OR near river mile 40.50, note log placed along banks to deflect flows. Reach 3 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 2, 2010.**





**Photograph 9. View looking at log flow deflectors on the left bank of Catherine Creek in Union, OR near river mile 40.50. Reach 3 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 2, 2010.**



**Photograph 10. View looking downstream at Catherine Creek channel in Union, OR near river mile 40.39. Reach 3 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 2, 2010.**





**Photograph 11. View looking at coarse-grained alluvium and/or fan-delta deposits exposed along the left bank of Catherine Creek in Union, OR near river mile 40.33. Reach 3 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 2, 2010.**



**Photograph 12. View looking downstream at rock weir (energy dissipater) structure on Catherine Creek in Union, OR near river mile 40.33. Reach 3 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 2, 2010.**



**Photograph 13. View looking from right to left across the Catherine Creek in Union, OR at a rock weir (energy dissipater) structure near river mile 40.33. Reach 3 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 2, 2010.**



**Photograph 14. View looking at coarse-grained alluvium and/or fan-delta deposits exposed along the left bank of Catherine Creek in Union, OR near river mile 40.29. Reach 3 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 2, 2010.**





**Photograph 15. View looking downstream at the Catherine Creek channel in Union, OR near river mile 40.28, note rip rap erosion protection on right bank and bed. Reach 3 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 2, 2010.**



**Photograph 16. View looking from left to right across the Catherine Creek in Union, OR at a rock weir (energy dissipater) structure near river mile 40.27. Reach 3 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 2, 2010.**



**Photograph 17. View looking downstream at the Catherine Creek channel in Union, OR near river mile 40.25. Reach 3 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 2, 2010.**



**Photograph 18. View looking downstream at the Catherine Creek channel in Union, OR near river mile 40.20. Reach 3 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 2, 2010.**





**Photograph 19. View looking downstream at the North Bellwood Street Bridge over Catherine Creek in Union, OR near river mile 40.11. Reach 3 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 2, 2010.**



**Photograph 20. View looking downstream at the Catherine Creek channel between the North Bellwood Street and North Main Street bridges in Union, OR near river mile 40.10. Reach 3 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 2, 2010.**





**Photograph 21. View looking downstream at the North Main Street Bridge over Catherine Creek in Union, OR near river mile 40.01. Reach 3 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 2, 2010.**



**Photograph 22. View looking downstream at diversion dam on Catherine Creek in Union, OR near river mile 39.98. Reach 3 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 2, 2010.**



**Photograph 23. View looking toward the left abutment of the diversion dam, note irrigation intake structure and slide gate, Catherine Creek channel in Union, OR near river mile 39.98. Reach 3 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 2, 2010.**



**Photograph 24. View looking downstream at the diversion dam on Catherine Creek in Union, OR near river mile 39.98. Reach 3 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 2, 2010.**





**Photograph 25. View looking downstream at Catherine Creek channel in Union, OR near river mile 39.95. Reach 3 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 2, 2010.**



**Photograph 26. View looking upstream at excavator being used to repair or modify small diversion dam on Catherine Creek in Union, OR near river mile 39.84. Reach 3 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 2, 2010.**





**Photograph 27. View looking upstream at diversion dam work on Catherine Creek in Union, OR near river mile 39.84. Reach 3 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 2, 2010.**



**Photograph 28. View looking downstream at the North 5<sup>th</sup> Street Bridge over Catherine Creek in Union, OR near river mile 39.72. Reach 3 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 2, 2010.**



**Photograph 29. View looking upstream at the Catherine Creek channel and concrete diversion dam within the city of Union, OR near river mile 39.63. Reach 3 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 2, 2010.**



**Photograph 30. View looking downstream at the Catherine Creek channel and concrete diversion dam within the city of Union, OR near river mile 39.63. Reach 3 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 2, 2010.**





**Photograph 31. View looking downstream at the Catherine Creek channel and concrete diversion dam within the city of Union, OR near river mile 39.63, note ditch/canal intake on the upstream right side of the structure. Reach 3 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 2, 2010.**





**Photograph 32. View looking from left to right across Catherine Creek at profile location immediately upstream from concrete diversion dam near river mile 39.63. Reach 3 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 2, 2010.**



**Photograph 33. View looking downstream at the Catherine Creek channel below the concrete diversion dam within the city of Union, OR near river mile 39.60. Reach 3 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 2, 2010.**



**Photograph 34. View looking from left to right across Catherine Creek at profile location immediately downstream from concrete diversion dam near river mile 39.60. Reach 3 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 2, 2010.**





**Photograph 35. View looking downstream at the North 10<sup>th</sup> Street Bridge over Catherine Creek in Union, OR near river mile 39.46, note river flow gage station (with solar panel) near the right abutment of the bridge. Reach 3 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 2, 2010.**



**Photograph 36. View looking downstream at the Catherine Creek channel near the west edge of the city of Union, OR near river mile 39.45. Reach 3 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 2, 2010.**





**Photograph 37. View looking downstream at the Catherine Creek channel near the west edge of the city of Union, OR near river mile 39.35. Reach 3 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 2, 2010.**



**Photograph 38. View looking downstream at the Catherine Creek channel near the west edge of the city of Union, OR near river mile 39.26. Reach 3 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 2, 2010.**



**Photograph 39. View looking downstream at the Catherine Creek channel near the waste water treatment plant (buildings in background) near river mile 39.12. Reach 3 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 2, 2010.**



**Photograph 40. View looking downstream at the Catherine Creek channel near the waste water treatment plant near river mile 39.10. Reach 3 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 3, 2010.**





**Photograph 41. View looking toward the left bank of Catherine Creek at a concrete encased discharge pipe at waste water treatment plant near river mile 39.00. Reach 3 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 3, 2010.**



**Photograph 42. View looking downstream at the Catherine Creek channel near the waste water treatment plant near river mile 39.00, note concrete encased discharge pipe entering the channel from the left. Reach 3 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 3, 2010.**





**Photograph 43. View looking downstream at Catherine Creek channel near the waste water treatment plant near river mile 38.99, note rock weir and logs placed for erosion protection. Reach 3 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 3, 2010.**



**Photograph 44. View looking downstream at Catherine Creek channel near waste water treatment plant near river mile 38.90, note rip rap erosion protection along left bank. Reach 3 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 3, 2010.**



**Photograph 45. View looking downstream at Catherine Creek channel near river mile 38.77, note pipeline crossing from the waste water treatment plant in background. Reach 3 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 3, 2010.**

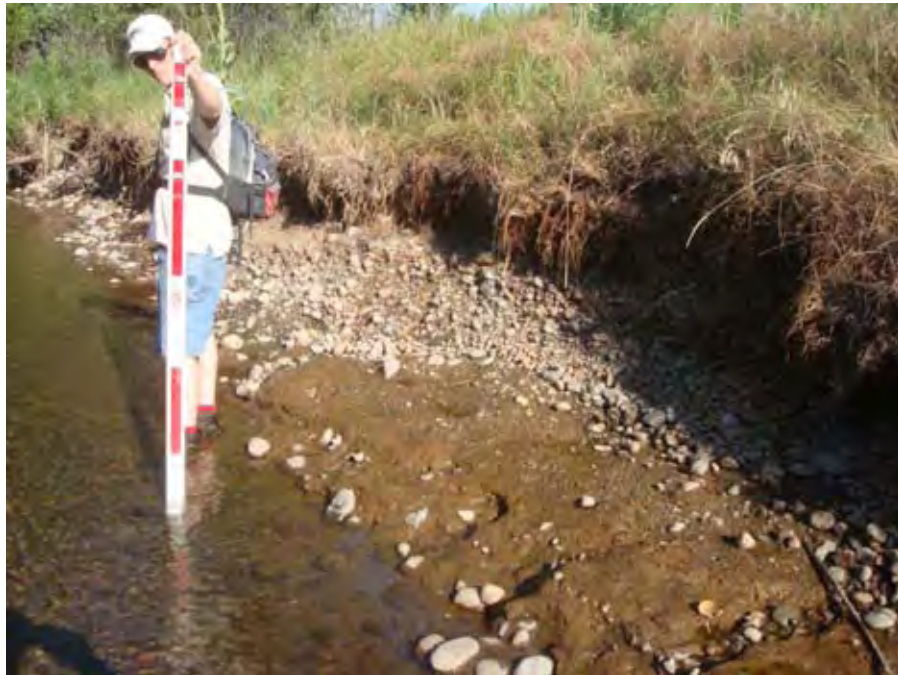


**Photograph 46. View looking downstream at Catherine Creek channel near river mile 38.71. Reach 3 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 3, 2010.**





**Photograph 47. View looking downstream at Catherine Creek channel near river mile 38.70, note gravel bar and riffles. Reach 3 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 3, 2010.**



**Photograph 48. View looking at right bank of Catherine Creek near river mile 38.66, note coarse-grained alluvium overlying fine-grained sediments (dense silt). Reach 3 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 3, 2010.**





**Photograph 49. View looking downstream at Catherine Creek channel near river mile 38.44, note gravel bar and riffle along left side of channel. Reach 3 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 3, 2010.**



**Photograph 50. View looking downstream at Catherine Creek channel near river mile 38.25, note gravel bar and ponderosa pine log for erosion protection on left. Reach 3 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 3, 2010.**



**Photograph 51. View looking downstream at Catherine Creek channel near river mile 38.24, note gravel bar on right and log jam in background. Reach 3 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 3, 2010.**



**Photograph 52. View looking downstream at Catherine Creek channel near river mile 38.19. Reach 3 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 3, 2010.**





**Photograph 53. View looking downstream at log jam and rip rap within the Catherine Creek channel near river mile 38.19. Reach 3 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 3, 2010.**



**Photograph 54. View looking downstream at the Catherine Creek channel near river mile 38.14. Reach 3 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 3, 2010.**

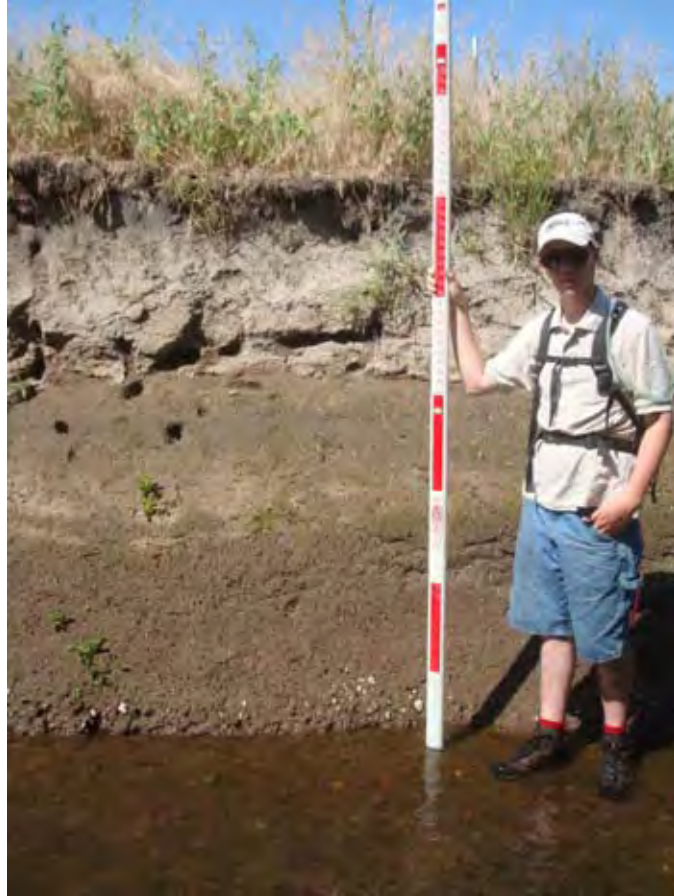




**Photograph 55. View looking downstream at the Catherine Creek channel near river mile 38.10. Reach 3 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 3, 2010.**



**Photograph 56. View looking downstream at Catherine Creek channel near river mile 37.95. Reach 3 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 3, 2010.**



**Photograph 57. Close-up of left bank fine-grained sediments mixed with sandy silt and gravelly sediments at transition zone between Reaches 2 and 3 near river mile 37.95. Reach 3 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 3, 2010.**



**Photograph 58. View looking downstream at Catherine Creek channel, note fine-grained deposits (fill or topsoil) over gravelly alluvium in left bank exposure near river mile 37.77. Reach 3 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 3, 2010.**





**Photograph 59. View looking downstream at the left bank of Catherine Creek, note fine-grained deposits (fill or topsoil) over gravelly alluvium; this is an area where material may have been placed to artificially cut-off a stream meander in order to straighten the creek near river mile 37.77. Reach 3 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 3, 2010.**



**Photograph 60. View looking downstream at farm access bridge across Catherine Creek on the Yeargain property near river mile 37.64. Reach 3 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 3, 2010.**



**Photograph 61. Rock-filled drums used for erosion protection on the left bank of Catherine Creek near river mile 37.63. Reach 3 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 3, 2010.**



**Photograph 62. View looking toward left bank of Catherine Creek near river mile 37.63, note cattle on stream bank. Reach 3 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 3, 2010.**



**Photograph 63. View looking downstream at gravel and cobble bar on the left side of the Catherine Creek channel near river mile 37.55. Reach 3 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 3, 2010.**





**Photograph 64. View looking west at the trace of a former meander bend, the current Catherine Creek channel is to the right of the photo near river mile 37.44. Reach 3 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, November 9, 2010.**



**Photograph 65. View looking downstream at Catherine Creek channel, note gravel bar deposits on bed of stream near river mile 37.40. Reach 3 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 3, 2010.**



**Photograph 66. View looking downstream Catherine Creek channel; note gravel bar and wood debris accumulation under large tree branch near river mile 37.30. Reach 3 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, November 9, 2010.**



**Photograph 67. View looking downstream at slough entering Catherine Creek from the north near river mile 37.30. Reach 3 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, November 9, 2010.**





**Photograph 68. View looking east at an abandoned meander bend located north of the current Catherine Creek channel; accumulated water forms slough that eventually drains into Catherine Creek (see previous photo) near river mile 37.30. Reach 3 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, November 9, 2010.**



**Photograph 69. View looking downstream Catherine Creek channel and head-cut area, not rock-filled automobile for erosion protection on the left bank near river mile 37.26. Reach 3 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, November 9, 2010.**





**Photograph 70. View looking upstream Catherine Creek channel and head-cut area, not rock-filled automobile for erosion protection on the left bank near river mile 37.26. Reach 3 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, November 9, 2010.**



**Photograph 71. Rock-filled automobile used for erosion protection on the left bank of Catherine Creek near river mile 37.26. Reach – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 3, 2010.**



**Photograph 72. View looking downstream at concrete blocks and wood debris on the banks of Catherine Creek near river mile 37.20. Reach 2 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 3, 2010.**

## **Reach 4 – Upper Valley Group**



#### Reach 4



**Photograph 1. View looking downstream at access bridge (rail road car frame) across Catherine Creek near river mile 45.65. Reach 4 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 18, 2010.**



**Photograph 2. View looking at coarse-grained alluvium mixed with soil and colluvium along the right bank of Catherine Creek near transition between Reaches 4 and 5 near river mile 45.60. Reach 4 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 18, 2010.**



**Photograph 3. View looking downstream at Catherine Creek channel near river mile 45.52.  
Reach 4 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation  
Photograph by D. Stelma, August 18, 2010.**



**Photograph 4. View looking downstream at Catherine Creek channel near river mile 45.40.  
Reach 4 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation  
Photograph by D. Stelma, August 18, 2010.**





**Photograph 5. View looking downstream at Catherine Creek channel near river mile 45.30.  
Reach 4 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation  
Photograph by D. Stelma, August 18, 2010.**



**Photograph 6. View looking downstream at Catherine Creek channel near river mile 45.25.  
Reach 4 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation  
Photograph by D. Stelma, August 18, 2010.**



**Photograph 7. View looking downstream at Catherine Creek channel near river mile 44.98, note small diversion structure and head gate on right bank. Reach 4 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 18, 2010.**



**Photograph 8. Close-up of diversion and head gate on right bank of Catherine Creek near river mile 44.98. Reach 4 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 18, 2010.**





**Photograph 9. View looking downstream at Catherine Creek channel near river mile 44.92. Reach 4 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 18, 2010.**



**Photograph 10. View looking downstream at gravel bar and log jam on the left bank of Catherine Creek near river mile 44.91. Reach 4 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 18, 2010.**





**Photograph 11. View looking downstream from the right bank at Catherine Creek channel near river mile 44.91. Reach 4 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 18, 2010.**



**Photograph 12. View looking from right to left across Catherine Creek at profile location near river mile 44.90. Reach 4 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 18, 2010.**

**NOTE: Section of Catherine Creek between approximately River Miles 43.27 and 44.90 not mapped or photographed due to right-of-way issues.**





**Photograph 13. View looking downstream at the Catherine Creek channel near river mile 43.27. Reach 4 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 19, 2010.**



**Photograph 14. View looking downstream at the Catherine Creek channel near river mile 43.26. Reach 4 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 19, 2010.**



**Photograph 15. View looking from right to left across Catherine Creek at profile location near river mile 43.25. Reach 4 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 19, 2010.**



**Photograph 16. View downstream at the Catherine Creek channel near river mile 43.15. Reach 4 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 19, 2010.**



**Photograph 17. View looking downstream at the Catherine Creek channel near river mile 43.10. Reach 4 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 19, 2010.**





**Photograph 18. View looking south at small pond (abandoned channel) on the right bank of Catherine Creek (in background at upper right of photo) near river mile 43.01. Reach 4 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 19, 2010.**



**Photograph 19. View looking downstream at the Catherine Creek channel near river mile 43.00, note large wood debris on right bank. Reach 4 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 19, 2010.**



**Photograph 20. View looking downstream at Catherine Creek channel near river mile 42.96, note left bank erosion. Reach 4 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 19, 2010.**



**Photograph 21. View looking downstream at the Catherine Creek channel near river mile 42.90, note foot bridge in background. Reach 4 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 19, 2010.**





**Photograph 22. View looking downstream at Catherine Creek channel near river mile 42.89. Reach 4 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 19, 2010.**



**Photograph 23. View looking toward left bank (north) at small push-up diversion dam and head gate structure near river mile 42.80. Reach 4 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 19, 2010.**





**Photograph 24. View looking downstream at gravel bar, riffle and wood debris along the Catherine Creek channel near river mile 42.75. Reach 4 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 19, 2010.**



**Photograph 25. View looking downstream at Catherine Creek channel near river mile 42.70. Reach 4 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 19, 2010.**



**Photograph 26. View looking downstream at woody debris along the left bank of Catherine Creek near river mile 42.62. Reach 4 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 19, 2010.**



**Photograph 27. View looking from left to right across Catherine Creek at manhole structure near river mile 42.57. Reach 4 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 19, 2010.**





**Photograph 28. View looking downstream at Catherine Creek channel near river mile 42.55. Reach 4 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 19, 2010.**



**Photograph 29. View looking downstream at the fish trap holding pond intake structure and slide gate on the right bank of Catherine near river mile 42.54. Reach 4 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 19, 2010.**



**Photograph 30. View looking downstream at the fish trap structure and Catherine Creek channel near river mile 42.50. Reach 4 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 16, 2010.**



**Photograph 31. View looking downstream at the fish trap structure and Catherine Creek channel near river mile 42.50. Reach 4 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 16, 2010.**





**Photograph 32. View looking downstream at fish trap structure and Catherine Creek channel near river mile 42.50. Reach 4 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 16, 2010.**



**Photograph 33. Sediment excavated from the bed of Catherine Creek upstream and within the concrete fish trap structure, stockpiled on right bank downstream of the fish trap near river mile 42.49. Reach 4 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 16, 2010.**





**Photograph 34. Sediment excavated from the bed of Catherine Creek upstream and within the concrete fish trap structure near river mile 42.49. Reach 4 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 16, 2010.**



**Photograph 35. View looking downstream at Catherine Creek channel below the fish trap structure near river mile 42.48. Reach 4 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 16, 2010.**



**Photograph 36. View looking north at fish trap return flow entering Catherine Creek on the right bank near river mile 42.40. Reach 4 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 16, 2010.**



**Photograph 37. View looking from right to left across Catherine Creek at profile location near river mile 42.36. Reach 4 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 16, 2010.**





**Photograph 38. View looking downstream at the Catherine Creek channel near river mile 42.35, note steep hill side and bedrock outcrop forming left bank. Reach 4 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 16, 2010.**



**Photograph 39. View looking downstream at the Catherine Creek channel near river mile 42.34, note steep hill side and bedrock outcrop forming left bank. Reach 4 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 16, 2010.**





**Photograph 40. View looking downstream at farm access bridge across Catherine Creek near river mile 42.25. Reach 4 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 16, 2010.**



**Photograph 41. View looking downstream at Catherine Creek channel near river mile 42.24, note concrete blocks and automobile for erosion protection on left side creek. Reach 4 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 16, 2010.**



**Photograph 42. View looking downstream at the Catherine Creek channel near river mile 42.09, note steep hill side and bedrock outcrop forming left bank. Reach 4 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 16, 2010.**



**Photograph 43. View looking south at bedrock exposed along the left bank of Catherine Creek near river mile 42.09. Reach 4 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 16, 2010.**





**Photograph 44. View looking downstream at the Catherine Creek channel near river mile 41.95, note steep hill side and bedrock outcrop forming left bank. Reach 4 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 16, 2010.**



**Photograph 45. View looking downstream at the Catherine Creek channel near river mile 41.86. Reach 4 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 16, 2010.**





**Photograph 46. View looking downstream at the Catherine Creek channel near river mile 41.82, note steep hill side and bedrock exposures along left bank. Reach 4 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 16, 2010.**



**Photograph 47. View looking downstream at the Catherine Creek channel near river mile 41.69, note steep hill side and bedrock exposures along left bank. Reach 4 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 16, 2010.**



**Photograph 48. View looking downstream at gravel and cobble deposits along the left side of the Catherine Creek channel near river mile 41.65. Reach 4 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 16, 2010.**





**Photograph 49. View looking downstream at gravel and cobble deposits around block/boulders along the bed of Catherine Creek near river mile 41.65. Reach 4 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 16, 2010.**



**Photograph 50. View looking downstream at the Catherine Creek channel near river mile 41.54. Reach 4 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 16, 2010.**



**Photograph 51. View looking from right to left across Catherine Creek channel at profile location near river mile 41.53, note Oregon State (Medical Springs) Highway 203 in foreground. Reach 4 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 16, 2010.**



**Photograph 52. Coarse-grained alluvium deposits on bed of Catherine Creek near river mile 41.53. Reach 4 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 16, 2010.**





**Photograph 53. View looking downstream at the Catherine Creek channel near river mile 41.46, note person standing on boulder/block or in-place bedrock. Reach 4 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 16, 2010.**



**Photograph 54. View looking downstream at the Catherine Creek channel near river mile 41.35, note Oregon State (Medical Springs) Highway 203 forms the right bank, bank material consists primarily of road fill and rip rap. Reach 4 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 16, 2010.**



**Photograph 55. View looking downstream at the Catherine Creek channel near river mile 41.30, note boulders scattered along creek bed derived from road construction, and from the steep hillside to the south. Reach 4 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 16, 2010.**



**Photograph 56. View looking toward the right bank of Catherine Creek near river mile 41.26, note Oregon State (Medical Springs) Highway 203 in background, bank material consists primarily of road fill and rip rap. Reach 4 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 16, 2010.**





**Photograph 57. View looking downstream at concrete diversion dam on Catherine Creek near river mile 41.19, structure diverts water north to Little Creek. Reach 4 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 16, 2010.**



**Photograph 58. Fish ladder near river mile 41.19. Reach 4 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 16, 2010.**





**Photograph 59. View looking downstream at irrigation intake structure on the left side of the channel near river mile 41.19. Reach 4 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 16, 2010.**



**Photograph 60. View looking from the right abutment toward the left abutment at concrete diversion dam on Catherine Creek, irrigation diversion intake structure in background (left side) near river mile 41.19. Reach 4 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 16, 2010.**



**Photograph 61. Irrigation canal intake with fish screens near river mile 41.19. Reach 4 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 16, 2010.**



**Photograph 62. View looking upstream at intake structure, farm access road and culverts near river mile 41.19. Reach 4 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 16, 2010.**





**Photograph 63. View looking downstream at the Catherine Creek channel adjacent to Oregon State (Medical Springs) Highway 203, located to the right, near river mile 41.05, note rip rap erosion protection on right bank. Reach 4 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 16, 2010.**



**Photograph 64. View looking toward the right bank of Catherine Creek near river mile 40.97, note Oregon State (Medical Springs) Highway 203 in background, bank material consists primarily of road fill and rip rap. Reach 4 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 16, 2010.**



**Photograph 65. View of diversion structure and slide-gate on the left bank of Catherine Creek at the rock push-up dam near river mile 40.80. Reach 4 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 16, 2010.**



**Photograph 66. View looking downstream at the Catherine Creek channel immediately upstream from the Oregon State (Medical Springs) Highway 203 Bridge near river mile 40.80, note small rock push-up dam and diversion on left side of creek. Reach 4 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 16, 2010.**



## **Reach 5 – Upper Valley Group**

## Reach 5



**Photograph 1. View looking downstream at Catherine Creek channel near river mile 50.10. Reach 5 - Catherine Creek, Grande Ronde Subbasin, Oregon - Bureau of Reclamation Photograph by D. Stelma, August 17, 2010.**



**Photograph 2. View looking downstream at Catherine Creek channel near river mile 50.00, Oregon State Highway (Medical Spring) 203 fill and rip rap erosion protection forms the left bank of the creek in this section. Reach 5 - Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 17, 2010.**



**Photograph 3. View looking downstream at Catherine Creek channel and the Oregon State Highway (Medical Spring) 203 Bridge near river mile 49.90. Reach 5 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 17, 2010.**



**Photograph 4. View looking downstream at Catherine Creek channel near river mile 49.78. Reach 5 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 17, 2010.**





**Photograph 5. View looking from the right bank toward the left bank at the Catherine Creek channel and profile location near river mile 49.65. Reach 5 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 17, 2010.**



**Photograph 6. View looking downstream at Catherine Creek channel near river mile 49.60. Reach 5 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 17, 2010.**



**Photograph 7. View looking downstream at over bank gravel and cobbles deposits along the right side of Catherine Creek near river mile 49.55. Reach 5 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 17, 2010.**





**Photograph 8. Concrete footings and foundations on upper right bank of Catherine Creek, upstream from Catherine Creek State Park near river mile 49.50. Reach 5 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 17, 2010.**



**Photograph 9. View looking downstream at Catherine Creek channel near river mile 49.45. Reach 5 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 17, 2010.**





**Photograph 10. View looking downstream at Catherine Creek channel near river mile 49.36. Reach 5 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 17, 2010.**



**Photograph 11. View looking at pump intake along right bank of Catherine Creek channel and foot-bridge, immediately upstream from Catherine Creek State Park near river mile 49.28. Reach 5 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 17, 2010.**



**Photograph 12. View looking downstream at Catherine Creek channel, Catherine Creek State Park near river mile 49.19. Reach 5 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 17, 2010.**



**Photograph 13. View looking downstream at Catherine Creek channel and foot-bridge, Catherine Creek State Park near river mile 49.00. Reach 5 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 17, 2010.**





**Photograph 14. View looking downstream at rock weir and pool, Catherine Creek State Park near river mile 48.99. Reach 5 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 17, 2010.**



**Photograph 15. View looking downstream at bedrock, blocks, boulders, and gravel and cobble deposits in the Catherine Creek, Catherine Creek State Park near river mile 48.98. Reach 5 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 17, 2010.**





**Photograph 16. View looking downstream at gravel and cobble deposits in the Catherine Creek, Catherine Creek State Park near river mile 48.85. Reach 5 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 17, 2010.**



**Photograph 17. View looking at right bank exposure along Catherine Creek within Catherine Creek State Park near river mile 48.74, note gravel and cobble deposits overlain by thin soil horizon. Reach 5 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 17, 2010.**



**Photograph 18. View looking north at Catherine Creek side channel within Catherine Creek State Park near river mile 48.70, sand and gravel deposits observed immediately downstream from the confluence of this side channel and the main channel. Reach 5 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 17, 2010.**



**Photograph 19. View looking downstream at sand and gravel deposits in the Catherine Creek near the confluence with the side channel from the north near river mile 48.70, note block on the left side of the channel. Reach 5 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 17, 2010.**





**Photograph 20. View looking upstream at sand and gravel deposit in the Catherine Creek channel within Catherine Creek State Park near river mile 48.64. Reach 5 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 17, 2010.**



**Photograph 21. View looking downstream at Catherine Creek within Catherine Creek State Park near river mile 48.63. Reach 5 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 17, 2010.**



**Photograph 22. View looking downstream at wood debris along the left bed and bank of Catherine Creek within Catherine Creek State Park near river mile 48.63, note left abutment of foot-bridge at upper right side of photo. Reach 5 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 17, 2010.**



**Photograph 23. View looking upstream at boulders, blocks and pools along the bed of Catherine Creek within Catherine Creek State Park near river mile 48.60, note foot-bridge in background. Reach 5 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 17, 2010.**





**Photograph 24. View looking downstream at Catherine Creek channel at the west edge of Catherine Creek State Park near river mile 48.50. Reach 5 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 17, 2010.**



**Photograph 25. View looking downstream at boulders and blocks within the Catherine Creek channel near river mile 48.45. Reach 5 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 17, 2010. .**





**Photograph 26. View looking downstream at gravel and cobble deposits within the Catherine Creek channel near river mile 48.35. Reach 5 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 17, 2010.**



**Photograph 27. View looking downstream at eroded left bank of Catherine Creek near river mile 48.31. Reach 5 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 17, 2010.**



**Photograph 28. View looking at downstream at gravel and cobble deposits along the bed of the Catherine Creek channel near river mile 48.24. Reach 5 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 17, 2010.**



**Photograph 29. View looking from the right bank toward the left bank across Catherine Creek at profile location near river mile 48.24. Reach 5 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 17, 2010.**





**Photograph 30. View looking at downstream at the Catherine Creek channel near river mile 48.20. Reach 5 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 17, 2010.**



**Photograph 31. View looking at downstream at gravel and cobble deposits along the bed of the Catherine Creek channel near river mile 47.96. Reach 5 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 17, 2010.**



**Photograph 32. View looking at top soil overlying alluvium along the left bank of Catherine Creek near river mile 47.93. Reach 5 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 17, 2010.**





**Photograph 33. View looking downstream at gravel and cobble bar on the right side of the Catherine Creek near the mouth of a side canyon from the north near river mile 47.92. Reach 5 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 17, 2010.**



**Photograph 34. View looking downstream at Catherine Creek channel parallel to Oregon State (Medical Springs) Highway 203 (on right side of photo) near river mile 47.80. Reach 5 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 17, 2010.**





**Photograph 35. View looking downstream at gravel bar on the right side of the Catherine Creek upstream of residential access road bridge near river mile 47.60. Reach 5 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 17, 2010.**



**Photograph 36. View looking downstream at large log anchored to the left bank of Catherine Creek downstream of residential access road bridge near river mile 47.58. Reach 5 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 18, 2010.**



**Photograph 37. View looking downstream at Catherine Creek channel, Oregon State (Medical Springs) Highway 203 in background near river mile 47.51, note rip rap erosion protection along road embankment. Reach 5 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 18, 2010.**



**Photograph 38. View looking downstream at Catherine Creek channel near river mile 47.38. Reach 5 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 18, 2010.**



**Photograph 39. View looking at 2-inch pump intake on the right bank of Catherine Creek near river mile 47.31. Reach 5 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 18, 2010.**





**Photograph 40. Spring or surface water flow entering Catherine Creek from the left bank near river mile 47.25. Reach 5 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 18, 2010.**



**Photograph 41. View looking downstream at Catherine Creek channel near river mile 47.16. Reach 5 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 18, 2010.**



**Photograph 42. View looking from the right bank toward the left bank at typical boulder and pool along the bed of Catherine Creek near river mile 47.16. Reach 5 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 18, 2010.**





**Photograph 43. View looking downstream at residential access bridge across Catherine Creek near river mile 47.15. Reach 5 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 18, 2010.**



**Photograph 44. View looking downstream at Catherine Creek channel near river mile 47.14, Oregon State (Medical Springs) Highway 203 in background. Reach 5 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 18, 2010.**

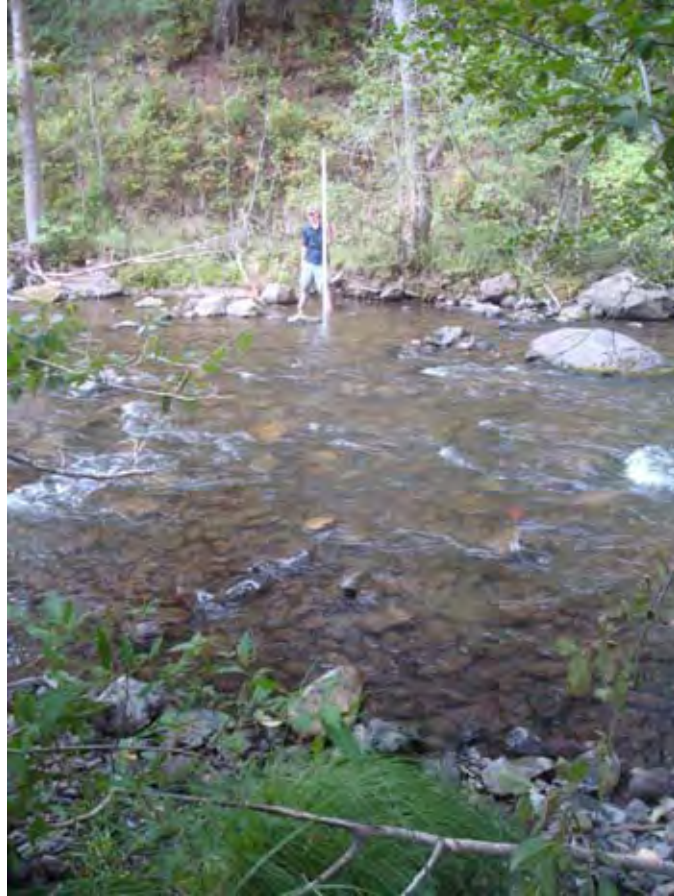




**Photograph 45. View looking from the right bank toward the left bank at log buried in the bed of Catherine Creek near river mile 47.03. Reach 5 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 18, 2010.**



**Photograph 46. View looking downstream at Catherine Creek channel near river mile 47.02.  
Reach 5 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation  
Photograph by D. Stelma, August 18, 2010.**



**Photograph 47. View looking from the right bank toward the left bank across Catherine Creek at profile location near river mile 46.93. Reach 5 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 18, 2010.**





**Photograph 48. View looking downstream at Catherine Creek channel near river mile 46.92. Reach 5 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 18, 2010.**



**Photograph 49. View looking downstream at Catherine Creek channel, photo taken from Oregon State (Medical Springs) Highway 203 near river mile 46.90. Reach 5 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 18, 2010.**



**Photograph 50. View looking downstream at Catherine Creek channel near river mile 46.85, note recently fallen tree across creek. Reach 5 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 18, 2010.**



**Photograph 51. View looking downstream at Catherine Creek channel near river mile 46.75. Reach 5 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 18, 2010.**



**Photograph 52. View looking downstream at Catherine Creek channel near river mile 46.70, note river gage station on right bank. Reach 5 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 18, 2010.**





**Photograph 53. View looking toward right bank at river gage station on Catherine Creek, note Oregon State (Medical Springs) Highway 203 behind building near river mile 46.70. Reach 5 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation  
Photograph by D. Stelma, August 18, 2010.**



**Photograph 54. View looking downstream at Catherine Creek channel near river mile 46.64. Reach 5 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation  
Photograph by D. Stelma, August 18, 2010.**



**Photograph 55. Spring or surface water flow entering Catherine Creek from the left bank near river mile 46.60. Reach 5 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 18, 2010.**





**Photograph 56. Remnant of bridge abutment on the left bank of Catherine Creek near river mile 46.57. Reach 5 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 18, 2010.**



**Photograph 57. View looking downstream at residential access bridge across Catherine Creek near river mile 46.53. Reach 5 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 18, 2010.**



**Photograph 58. View looking downstream at Catherine Creek channel, Oregon State (Medical Springs) Highway 203 (upper center in photo) near river mile 46.45. Reach 5 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 18, 2010.**



**Photograph 59. View looking downstream at Catherine Creek channel near river mile 46.35. Reach 5 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 18, 2010.**





**Photograph 60. View looking toward left bank of Catherine Creek near river mile 46.34, note coarse-grained alluvium overlain by soil. Reach 5 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 18, 2010.**



**Photograph 61. View looking downstream at Catherine Creek channel near river mile 46.31. Reach 5 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 18, 2010.**





**Photograph 62. View looking downstream at Catherine Creek channel in the canyon section, Oregon State (Medical Springs) Highway 203 is to the right near river mile 46.22, note abundance of boulders derived from landslide debris (left bank) and road construction (right bank). Reach 5 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 18, 2010.**



**Photograph 63. View looking downstream at Catherine Creek channel in the canyon section near river mile 46.21, note under-cut bank and fallen trees on the left side of the channel. Reach 5 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 18, 2010.**



**Photograph 64. View looking toward left bank of Catherine Creek from Oregon State (Medical Springs) Highway 203 in the canyon section near river mile 46.21, note under-cut bank and fallen trees. Reach 5 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 18, 2010.**



**Photograph 65. View looking upstream at Catherine Creek channel within the canyon section near river mile 46.20, note abundance of large boulders along the bed of the creek. Reach 5 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 18, 2010.**





**Photograph 66. View looking downstream at log jam within the Catherine Creek channel near river mile 46.09. Reach 5 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 18, 2010.**



**Photograph 67. View looking downstream at Catherine Creek channel near river mile 46.09, note downstream- end of log jam on right. Reach 5 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 18, 2010.**



**Photograph 68. View looking from the right bank toward the left bank at profile location near river mile 46.09. Reach 5 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 18, 2010.**



**Photograph 69. View looking downstream at Catherine Creek channel near river mile 46.07. Reach 5 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 18, 2010.**



**Photograph 70. View looking downstream at Catherine Creek channel adjacent to Oregon State (Medical Springs) Highway 203 (upper right in photo) near river mile 45.99, note rip rap erosion protection on right bank. Reach 5 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 18, 2010.**





**Photograph 71. View looking downstream at Catherine Creek channel near river mile 45.95.  
Reach 5 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation  
Photograph by D. Stelma, August 18, 2010.**



**Photograph 72. View looking downstream at small rock (partial) diversion dam on the left bank of Catherine Creek near river mile 45.85, note pump intake in creek and pump house on upper left bank. Reach 5 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 18, 2010.**



**Photograph 73. View looking downstream at small rock (partial) diversion dam on the left bank of Catherine Creek near river mile 45.85. Reach 5 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 18, 2010.**



## **Reach 6 – Upper Valley Group**

## Reach 6



**Photograph 1. View looking upstream at Catherine Creek channel near river mile 52.00, note failed concrete blocks along U.S.F.S. Road 7785 in background. Reach 6 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 19, 2010.**



**Photograph 2. View looking downstream at Catherine Creek channel near river mile 52.00, note failed concrete blocks along U.S.F.S. Road 7785 in on left side of creek. Reach 6 –**

**Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 19, 2010.**



**Photograph 3. View looking downstream at Catherine Creek channel near river mile 52.00, note repaired erosion protection (concrete blocks, rip rap and log) along U.S.F.S. Road 7785 in background. Reach 6 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, November 10, 2010.**



**Photograph 4. View looking downstream at Catherine Creek channel near river mile 51.98. Reach 6 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 19, 2010.**





**Photograph 5. View looking downstream at treed island within the Catherine Creek channel near river mile 51.92. Reach 6 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 19, 2010.**



**Photograph 6. View looking downstream at cobble deposits exposed along the right edge (north) of island within the Catherine Creek channel near river mile 51.91. Reach 6 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 19, 2010.**



**Photograph 7. View looking downstream at cobble deposits along the bed of Catherine Creek near river mile 51.90. Reach 6 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 19, 2010.**



**Photograph 8. View looking downstream at Catherine Creek channel near river mile 51.88. Reach 6 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 19, 2010.**





**Photograph 9. View looking downstream at Catherine Creek channel near river mile 51.82.  
Reach 6 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation  
Photograph by D. Stelma, August 19, 2010.**



**Photograph 10. View looking downstream at Catherine Creek channel near river mile 51.75.  
Reach 6 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation  
Photograph by D. Stelma, August 19, 2010.**



**Photograph 11. View looking from the right bank toward the left bank across Catherine Creek at profile location near river mile 51.72. Reach 6 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 19, 2010.**



**Photograph 12. View looking from the left bank toward the right bank across Catherine Creek at profile location near river mile 51.72. Reach 6 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 19, 2010.**





**Photograph 13. View looking downstream at Catherine Creek channel near river mile 51.71.  
Reach 6 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation  
Photograph by D. Stelma, August 19, 2010.**



**Photograph 14. View looking downstream at Catherine Creek channel near river mile 51.65.  
Reach 6 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation  
Photograph by D. Stelma, August 19, 2010.**



**Photograph 15. View looking downstream at Catherine Creek channel near river mile 51.60. Reach 6 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 19, 2010.**



**Photograph 16. View looking downstream at Catherine Creek channel, photo taken at downstream end of island near river mile 51.51, note white survey (aerial) marker in foreground. Reach 6 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 19, 2010.**





**Photograph 17. View looking downstream at Catherine Creek channel, photo taken at downstream end of island near river mile 51.51, note water flowing from right and left side of island. Reach 6 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 19, 2010.**



**Photograph 18. View looking downstream at Catherine Creek channel near river mile 51.47, note alluvium and glacial outwash deposits on left bank. Reach 6 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 19, 2010.**





**Photograph 19. View looking toward the left bank of Catherine Creek at inter-bedded alluvium, glacial outwash and soil deposits (fining-upward sequence) near river mile 51.46. Reach 6 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation  
Photograph by D. Stelma, August 19, 2010.**



**Photograph 20. View looking downstream at Catherine Creek channel near river mile 51.40.  
Reach 6 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation  
Photograph by D. Stelma, August 19, 2010.**



**Photograph 21. View looking downstream at Catherine Creek channel near river mile 51.40, note boulders in bed of creek. Reach 6 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 19, 2010.**





**Photograph 22. View looking north toward the right bank of Catherine Creek near river mile 51.40, note boulders on slope, and in creek bed. Reach 6 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 19, 2010.**



**Photograph 23. View looking downstream at Catherine Creek channel near river mile 51.31.  
Reach 6 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation  
Photograph by D. Stelma, August 19, 2010.**



**Photograph 24. View looking downstream at Catherine Creek channel near river mile 51.20.  
Reach 6 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation  
Photograph by D. Stelma, August 19, 2010.**





**Photograph 25. View looking downstream at Catherine Creek channel near river mile 51.13. Reach 6 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation  
Photograph by D. Stelma, August 19, 2010.**



**Photograph 26. View looking downstream at Catherine Creek channel near river mile 51.10. Reach 6 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation  
Photograph by D. Stelma, August 19, 2010.**





**Photograph 27. View looking downstream at Catherine Creek channel near river mile 51.05. Reach 6 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 19, 2010.**



**Photograph 28. View looking toward the right bank of Catherine Creek at inter-bedded alluvium, glacial outwash and soil deposits near river mile 51.02. Reach 6 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 19, 2010.**



**Photograph 29. View looking downstream at Catherine Creek channel near river mile 51.00.  
Reach 6 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation  
Photograph by D. Stelma, August 19, 2010.**



**Photograph 30. View looking downstream at Catherine Creek channel near river mile 50.90.  
Reach 6 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation  
Photograph by D. Stelma, August 19, 2010.**





**Photograph 31. View looking downstream at Catherine Creek channel near river mile 50.84.  
Reach 6 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation  
Photograph by D. Stelma, August 19, 2010.**



**Photograph 32. View looking downstream at Catherine Creek channel near river mile 50.84.  
Reach 6 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation  
Photograph by D. Stelma, August 19, 2010.**





**Photograph 33. View looking downstream at Catherine Creek channel near river mile 50.70.  
Reach 6 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation  
Photograph by D. Stelma, August 19, 2010.**



**Photograph 34. View looking downstream at Catherine Creek channel near river mile 50.61.  
Reach 6 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation  
Photograph by D. Stelma, August 19, 2010.**



**Photograph 35. View looking downstream at Catherine Creek channel near river mile 50.55.  
Reach 6 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation  
Photograph by D. Stelma, August 19, 2010.**



**Photograph 36. View looking downstream at Catherine Creek channel near river mile 50.45.  
Reach 6 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation  
Photograph by D. Stelma, August 19, 2010.**





**Photograph 37. View looking at alluvium and glacial outwash deposits overlain by soil exposed along the right bank of Catherine Creek near river mile 50.45. Reach 6 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 19, 2010.**



**Photograph 38. View looking downstream at Catherine Creek channel near river mile 50.32. Reach 6 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 19, 2010.**





**Photograph 39. View looking downstream at Catherine Creek channel near river mile 50.26.  
Reach 6 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation  
Photograph by D. Stelma, August 19, 2010.**



**Photograph 40. View looking downstream at Catherine Creek channel near river mile 50.21.  
Reach 6 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation  
Photograph by D. Stelma, August 19, 2010.**



**Photograph 41. View looking downstream at Catherine Creek channel near river mile 50.15. Reach 6 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 19, 2010.**



**Photograph 42. View looking upstream at the mouth of Little Catherine Creek near river mile 50.12, Catherine Creek channel in foreground. Reach 6 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 19, 2010.**





**Photograph 43. View looking from the right bank toward the left bank at Catherine Creek pebble count location near river mile 50.12. Reach 6 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, August 19, 2010.**



## **Reach 7 – Upper Valley Group**

## Reach 7



**Photograph 1. View looking downstream at the Catherine Creek channel from the U.S.F.S. Road 7785 Bridge near river mile 54.90. Reach 7 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, November 10, 2010.**



**Photograph 2. View looking east at the confluence of the South (background) and North Forks (foreground) of Catherine Creek near river mile 54.86. Reach 7 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, November 10, 2010.**



**Photograph 3. View looking downstream at the Catherine Creek channel near river mile 54.86, U.S.F.S. Road 7785 can be seen in the background. Reach 7 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, November 10, 2010.**



**Photograph 4. Close-up of bed deposits near the confluence of the South (background) and North Forks (foreground) of Catherine Creek near river mile 54.86. Reach 7 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, November 10, 2010.**





**Photograph 5. View looking downstream at the Catherine Creek channel profile site near river mile 54.70, U.S.F.S. Road 7785 can be seen at upper right of photo. Reach 7 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, November 10, 2010.**



**Photograph 6. View looking from the right bank toward the left bank across Catherine Creek at profile site near river mile 54.70. Reach 7 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, November 10, 2010.**



**Photograph 7. View looking downstream at Catherine Creek from the U.S.F.S. Road 7785 Bridge near river mile 52.30. Reach 7 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation Photograph by D. Stelma, November 10, 2010.**



**Photograph 8. View looking from the right bank toward the left bank across Catherine Creek at profile site immediately upstream from U.S.F.S. Road 7785 Bridge near river mile 52.30. Reach 7 – Catherine Creek, Grande Ronde Subbasin, Oregon – Bureau of Reclamation  
Photograph by D. Stelma, November 10, 2010.**



# **ATTACHMENT B – SUMMARY AND GRADATION ANALYSIS SHEETS**

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# United States Department of the Interior

BUREAU OF RECLAMATION  
MP CONSTRUCTION OFFICE  
1140 West Wood Street  
P.O. Box 988  
WILLOWS, CALIFORNIA 95988-0988

IN REPLY  
REFER TO:

MPCO-350  
RES-2.00

SEP 29 2010



## MEMORANDUM

To: Pacific Northwest Region  
Bend Field Office, Bend, OR  
Attention: BFO-3230 (DStelma)

*R. A. Welsh*  
From: Richard A. Welsh  
Construction Engineer

Subject: Physical Properties and Gradation Analyses -Catherine Creek Tributary Assessment-  
Grande Ronde River Basin, Oregon

Attached are the final laboratory physical properties and gradation analyses for the Catherine Creek Tributary Assessment samples 1 through 11.

If you have any questions with regard to the above, please contact Mr. Richard Kuntz of our office at 530-934-5887 or 530-308-9855.

Attachments

cc: Construction Engineer, Willows, CA  
MPCO-305 (w/o atts)



## SUMMARY OF PHYSICAL PROPERTIES TEST RESULTS

|        |                 |         |                                      |         |                          |       |                    |    |   |
|--------|-----------------|---------|--------------------------------------|---------|--------------------------|-------|--------------------|----|---|
| Hole   |                 |         |                                      |         |                          | DATE  | September 27, 2010 |    |   |
| Number | Samples 1 to 11 | PROJECT | Catherine Creek Tributary Assessment | FEATURE | Grande Ronde River Basin | SHEET | 1                  | OF | 1 |

[illegible]

|                                                      |                   |                                           |                                          |                                |                                            |                                                                               |                   |
|------------------------------------------------------|-------------------|-------------------------------------------|------------------------------------------|--------------------------------|--------------------------------------------|-------------------------------------------------------------------------------|-------------------|
| 7-1451 (9-86)<br>Bureau of Reclamation<br><b>613</b> |                   | <b>GRADATION ANALYSIS</b>                 |                                          |                                |                                            | Designation USBR 5325 -<br>Designation USBR 5330 -<br>Designation USBR 5335 - |                   |
| SAMPLE NO. CC-1-1                                    |                   | PROJECT Grande Ronde River Basin          |                                          | FEATURE Catherine Creek        |                                            |                                                                               |                   |
| RIVER MILE RM 01.80                                  |                   | EXC. NO.                                  |                                          | LOCATION WIDE SECTION OF CREEK |                                            |                                                                               |                   |
| <b>GRADATION OF GRAVEL SIZES</b>                     |                   |                                           |                                          |                                |                                            |                                                                               |                   |
| TESTED AND COMPUTED BY Hill                          |                   | DATE 9/24/2010                            |                                          | % MOISTURE CONTENT OF + NO. 4  |                                            | WET MASS OF TOTAL SPECIMEN                                                    |                   |
| CHECKED BY Wazid                                     |                   | DATE 9/27/2010                            |                                          | % MOISTURE CONTENT OF - NO. 4  |                                            | TOTAL DRY MASS OF SPECIMEN <b>228.30</b>                                      |                   |
| <b>SIEVE SIZE</b>                                    |                   | 3" (75 mm)                                |                                          | 1-1/2" (37.5 mm)               |                                            | 3/4" (19.0 mm)                                                                |                   |
|                                                      |                   | 3/8" (9.5 mm)                             |                                          | NO. 4 (4.75 mm)                |                                            | PAN                                                                           |                   |
| MASS OF CONTAINER AND RETAINED MATERIAL              |                   |                                           |                                          |                                |                                            |                                                                               |                   |
| MASS OF CONTAINER                                    |                   |                                           |                                          |                                |                                            |                                                                               |                   |
| WET MASS RETAINED                                    |                   |                                           |                                          |                                |                                            |                                                                               |                   |
| DRY MASS RETAINED                                    |                   |                                           |                                          |                                |                                            | 0.00                                                                          |                   |
| DRY MASS PASSING                                     |                   |                                           |                                          |                                |                                            | 228.30                                                                        |                   |
| % OF TOTAL PASSING                                   |                   |                                           |                                          |                                |                                            | 100.0                                                                         |                   |
| <b>GRADATION OF SAND SIZES</b>                       |                   |                                           |                                          |                                |                                            |                                                                               |                   |
| DRY MASS OF SPECIMEN <b>59.6</b> g                   |                   | FACTOR =                                  |                                          | % TOTAL PASSING NO. 4          |                                            | 100.0                                                                         |                   |
| DISH NO. <b>82</b>                                   |                   | DRY MASS OF SPECIMEN (SIEVED)             |                                          | 59.6                           |                                            | 1.6779                                                                        |                   |
| SIEVING TIME 15 Min.                                 |                   | DATE                                      |                                          |                                |                                            |                                                                               |                   |
| SIEVE NO.                                            | MASS RETAINED (g) | MASS PASSING (g)                          | FACTOR X MASS PASSING % OF TOTAL PASSING | % OF TOTAL PASSING             | PARTICLE DIAMETER                          | REMARKS                                                                       |                   |
| 8                                                    | 0.0               | 59.6                                      |                                          | 100.0                          | 2.36 mm                                    | COBBLE %                                                                      | OVERSIZE %        |
| 16                                                   | 0.1               | 59.5                                      |                                          | 99.8                           | 1.18 mm                                    | GRAVEL %                                                                      | 0.0 LL = 66.9     |
| 30                                                   | 0.2               | 59.4                                      |                                          | 99.7                           | 600 µm                                     | SAND %                                                                        | 1.8 PL = 38.5     |
| 50                                                   | 0.4               | 59.2                                      |                                          | 99.3                           | 300 µm                                     | FINES %                                                                       | 98.2 PI = 28.4    |
| 100                                                  | 0.6               | 59.0                                      |                                          | 99.0                           | 150 µm                                     | Classification of Fines: MH                                                   |                   |
| 200                                                  | 1.1               | 58.5                                      |                                          | 98.2                           | 75 µm                                      | MOISTURE % 45.2                                                               |                   |
| PAN                                                  | 1.2               |                                           |                                          |                                |                                            |                                                                               |                   |
| TOTAL                                                |                   |                                           |                                          |                                |                                            |                                                                               |                   |
| TESTED AND COMPUTED BY Hill                          |                   | DATE 9/27/2010                            |                                          | CHECKED BY Wazid               |                                            | DATE                                                                          |                   |
| <b>HYDROMETER ANALYSIS</b>                           |                   |                                           |                                          |                                |                                            |                                                                               |                   |
| HYDROMETER NO. 1350                                  |                   | DISPERSING AGENT SODIUM HEXAMETAPHOSPHATE |                                          |                                |                                            |                                                                               |                   |
| STARTING TIME                                        |                   | DATE                                      |                                          | AMOUNT 125 mL                  |                                            |                                                                               |                   |
| TIME                                                 | TEMP °C           | HYD READ                                  | HYD CORR                                 | CORR READ                      | FACTOR X CORRECT READ = % OF TOTAL PASSING | % OF TOTAL PASSING                                                            | PARTICLE DIAMETER |
| 1 min                                                | 23.5              | 55                                        | 4.5                                      | 50.5                           |                                            | 84.7                                                                          | 50 µm             |
| 4 min                                                | 23.5              | 51                                        | 4.5                                      | 46.5                           |                                            | 78.0                                                                          | 37 µm             |
| 19 min                                               | 23.0              | 42                                        | 4.5                                      | 37.5                           |                                            | 62.9                                                                          | 19 µm             |
| 60 min                                               | 23.0              | 34                                        | 4.5                                      | 29.5                           |                                            | 49.5                                                                          | 9 µm              |
| 7h 15 min                                            | 24.0              | 23                                        | 4.0                                      | 19.0                           |                                            | 31.9                                                                          | 5 µm              |
| 25 h 45 min                                          | 24.0              | 18                                        | 4.0                                      | 14.0                           |                                            | 23.5                                                                          | 2 µm              |
|                                                      |                   |                                           |                                          |                                |                                            |                                                                               | 1 µm              |
| TESTED AND COMPUTED BY Hill                          |                   | DATE 9/25/10                              |                                          | CHECKED BY Wazid               |                                            | DATE 09/27/10                                                                 |                   |

**Gradation Test**

U.S. Standard Sieve Sizes



|                                                      |                   |                                           |                                          |                                     |                                            |                                                                               |                   |  |
|------------------------------------------------------|-------------------|-------------------------------------------|------------------------------------------|-------------------------------------|--------------------------------------------|-------------------------------------------------------------------------------|-------------------|--|
| 7-1451 (9-86)<br>Bureau of Reclamation<br><b>639</b> |                   | <b>GRADATION ANALYSIS</b>                 |                                          |                                     |                                            | Designation USBR 5325 -<br>Designation USBR 5330 -<br>Designation USBR 5335 - |                   |  |
| SAMPLE NO. CC-1-2                                    |                   | PROJECT Grande Ronde River Basin          |                                          | FEATURE Catherine Creek             |                                            |                                                                               |                   |  |
| RIVER MILE RM 22.72                                  |                   | EXC. NO.                                  |                                          | LOCATION LEFT BANK OF CREEK-LAYER 1 |                                            |                                                                               |                   |  |
| <b>GRADATION OF GRAVEL SIZES</b>                     |                   |                                           |                                          |                                     |                                            |                                                                               |                   |  |
| TESTED AND COMPUTED BY Hill                          |                   | DATE 9/24/2010                            |                                          | % MOISTURE CONTENT OF + NO. 4       |                                            | WET MASS OF TOTAL SPECIMEN                                                    |                   |  |
| CHECKED BY Wazid                                     |                   | DATE 9/27/2010                            |                                          | % MOISTURE CONTENT OF - NO. 4       |                                            | TOTAL DRY MASS OF SPECIMEN <b>341.60</b>                                      |                   |  |
| <b>SIEVE SIZE</b>                                    |                   | 3" (75 mm)                                |                                          | 1-1/2" (37.5 mm)                    |                                            | 3/4" (19.0 mm)                                                                |                   |  |
|                                                      |                   | 3/8" (9.5 mm)                             |                                          | NO. 4 (4.75 mm)                     |                                            | PAN                                                                           |                   |  |
| MASS OF CONTAINER AND RETAINED MATERIAL              |                   |                                           |                                          |                                     |                                            |                                                                               |                   |  |
| MASS OF CONTAINER                                    |                   |                                           |                                          |                                     |                                            |                                                                               |                   |  |
| WET MASS RETAINED                                    |                   |                                           |                                          |                                     |                                            |                                                                               |                   |  |
| DRY MASS RETAINED                                    |                   |                                           |                                          |                                     |                                            | 0.00                                                                          |                   |  |
| DRY MASS PASSING                                     |                   |                                           |                                          |                                     |                                            | 341.60                                                                        |                   |  |
| % OF TOTAL PASSING                                   |                   |                                           |                                          |                                     |                                            | 100.0                                                                         |                   |  |
| <b>GRADATION OF SAND SIZES</b>                       |                   |                                           |                                          |                                     |                                            |                                                                               |                   |  |
| DRY MASS OF SPECIMEN <b>88.4</b> g                   |                   | FACTOR =                                  |                                          | % TOTAL PASSING NO. 4               |                                            | 100.0                                                                         |                   |  |
|                                                      |                   |                                           |                                          | DRY MASS OF SPECIMEN                |                                            | 88.4                                                                          |                   |  |
| DISH NO. <b>11A</b>                                  |                   | DRY MASS OF SPECIMEN (SIEVED)             |                                          |                                     |                                            | <b>1.1312</b>                                                                 |                   |  |
| SIEVING TIME 15 Min.                                 |                   | DATE                                      |                                          |                                     |                                            |                                                                               |                   |  |
| SIEVE NO.                                            | MASS RETAINED (g) | MASS PASSING (g)                          | FACTOR X MASS PASSING % OF TOTAL PASSING | % OF TOTAL PASSING                  | PARTICLE DIAMETER                          | REMARKS                                                                       |                   |  |
| 8                                                    | 0.0               | 88.4                                      |                                          | 100.0                               | 2.36 mm                                    | COBBLE %                                                                      | OVERSIZE %        |  |
| 16                                                   | 0.00              | 88.4                                      |                                          | 100.0                               | 1.18 mm                                    | GRAVEL %                                                                      | 0.0 LL = 0        |  |
| 30                                                   | 0.1               | 88.3                                      |                                          | 99.9                                | 600 µm                                     | SAND %                                                                        | 14.9 PL = 0       |  |
| 50                                                   | 0.2               | 88.2                                      |                                          | 99.8                                | 300 µm                                     | FINES %                                                                       | 85.1 PI = 0       |  |
| 100                                                  | 3.8               | 84.6                                      |                                          | 95.7                                | 150 µm                                     | Classification of Fines: ML                                                   |                   |  |
| 200                                                  | 13.2              | 75.2                                      |                                          | 85.1                                | 75 µm                                      | MOISTURE % 40.4                                                               |                   |  |
| PAN                                                  | 15.4              |                                           |                                          |                                     |                                            |                                                                               |                   |  |
| TOTAL                                                |                   |                                           |                                          |                                     |                                            |                                                                               |                   |  |
| TESTED AND COMPUTED BY Hill                          |                   | DATE 9/27/2010                            |                                          | CHECKED BY Wazid                    |                                            | DATE 9/27/2010                                                                |                   |  |
| <b>HYDROMETER ANALYSIS</b>                           |                   |                                           |                                          |                                     |                                            |                                                                               |                   |  |
| HYDROMETER NO. 1350                                  |                   | DISPERSING AGENT SODIUM HEXAMETAPHOSPHATE |                                          |                                     |                                            |                                                                               |                   |  |
| STARTING TIME 813                                    |                   | DATE                                      |                                          | AMOUNT 125 mL                       |                                            |                                                                               |                   |  |
| TIME                                                 | TEMP °C           | HYD READ                                  | HYD CORR                                 | CORR READ                           | FACTOR X CORRECT READ = % OF TOTAL PASSING | % OF TOTAL PASSING                                                            | PARTICLE DIAMETER |  |
| 1 min                                                | 23.5              | 60                                        | 4.5                                      | 55.5                                |                                            | 62.8                                                                          | 50 µm             |  |
| 4 min                                                | 23.5              | 50                                        | 4.5                                      | 45.5                                |                                            | 51.5                                                                          | 37 µm             |  |
| 19 min                                               | 23.0              | 30                                        | 4.5                                      | 25.5                                |                                            | 28.8                                                                          | 19 µm             |  |
| 60 min                                               | 23.0              | 19                                        | 4.5                                      | 14.5                                |                                            | 16.4                                                                          | 9 µm              |  |
| 7h 15 min                                            |                   |                                           |                                          |                                     |                                            |                                                                               | 5 µm              |  |
| 25 h 45 min                                          |                   |                                           |                                          |                                     |                                            |                                                                               | 2 µm              |  |
|                                                      |                   |                                           |                                          |                                     |                                            |                                                                               | 1 µm              |  |
| TESTED AND COMPUTED BY Hill                          |                   | DATE 9/25/10                              |                                          | CHECKED BY Wazid                    |                                            | DATE 09/27/10                                                                 |                   |  |

### Gradation Test

U.S. Standard Sieve Sizes

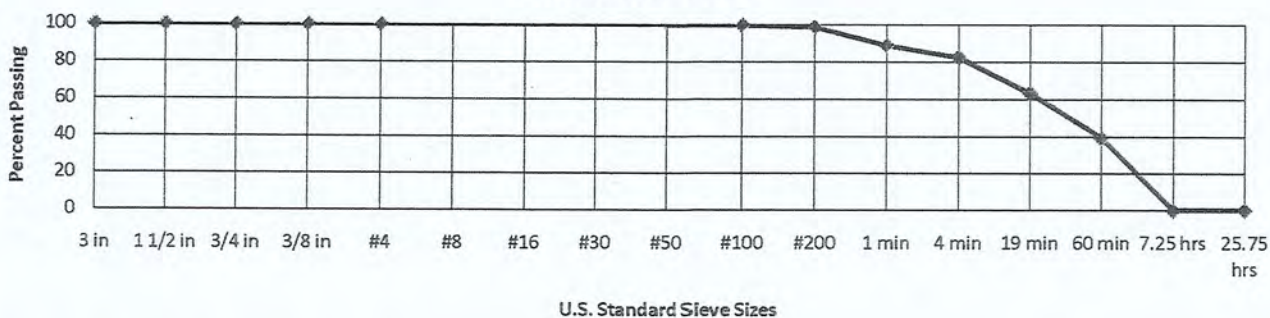






|                                                      |                   |                                                                               |                                          |                                            |                                             |                                                                               |                        |
|------------------------------------------------------|-------------------|-------------------------------------------------------------------------------|------------------------------------------|--------------------------------------------|---------------------------------------------|-------------------------------------------------------------------------------|------------------------|
| 7-1451 (9-86)<br>Bureau of Reclamation<br><b>662</b> |                   | <b>GRADATION ANALYSIS</b>                                                     |                                          |                                            |                                             | Designation USBR 5325 -<br>Designation USBR 5330 -<br>Designation USBR 5335 - |                        |
| SAMPLE NO. <b>CC-1-4</b>                             |                   | PROJECT <b>Grande Ronde River Basin</b>                                       |                                          | FEATURE <b>Catherine Creek</b>             |                                             |                                                                               |                        |
| RIVER MILE <b>RM 22.72</b>                           |                   | EXC. NO.                                                                      |                                          | LOCATION <b>LEFT BANK OF CREEK-LAYER 3</b> |                                             |                                                                               |                        |
| <b>GRADATION OF GRAVEL SIZES</b>                     |                   |                                                                               |                                          |                                            |                                             |                                                                               |                        |
| TESTED AND COMPUTED BY<br><b>Hill</b>                |                   | DATE<br><b>9/24/2010</b>                                                      | % MOISTURE CONTENT OF + NO. 4            |                                            | WET MASS OF TOTAL SPECIMEN                  |                                                                               |                        |
| CHECKED BY<br><b>Wazid</b>                           |                   | DATE<br><b>9/27/2010</b>                                                      | % MOISTURE CONTENT OF - NO. 4            |                                            | TOTAL DRY MASS OF SPECIMEN<br><b>139.20</b> |                                                                               |                        |
| <b>SIEVE SIZE</b>                                    |                   | <b>3" (75 mm)</b>                                                             |                                          | <b>1-1/2" (37.5 mm)</b>                    | <b>3/4" (19.0 mm)</b>                       | <b>3/8" (9.5 mm)</b>                                                          | <b>NO. 4 (4.75 mm)</b> |
| MASS OF CONTAINER AND RETAINED MATERIAL              |                   |                                                                               |                                          |                                            |                                             |                                                                               | PAN                    |
| MASS OF CONTAINER                                    |                   |                                                                               |                                          |                                            |                                             |                                                                               |                        |
| WET MASS RETAINED                                    |                   |                                                                               |                                          |                                            |                                             |                                                                               |                        |
| DRY MASS RETAINED                                    |                   |                                                                               |                                          |                                            |                                             | 0.00                                                                          |                        |
| DRY MASS PASSING                                     |                   |                                                                               |                                          |                                            |                                             | 139.20                                                                        |                        |
| % OF TOTAL PASSING                                   |                   |                                                                               |                                          |                                            |                                             | 100.0                                                                         | Units in:              |
| <b>GRADATION OF SAND SIZES</b>                       |                   |                                                                               |                                          |                                            |                                             |                                                                               |                        |
| DRY MASS OF SPECIMEN <b>62.4</b> g                   |                   | FACTOR = $\frac{\% \text{ TOTAL PASSING NO. 4}}{\text{DRY MASS OF SPECIMEN}}$ |                                          | $\frac{100.0}{62.4} =$                     |                                             | <b>1.6026</b>                                                                 |                        |
| DISH NO. <b>1A</b>                                   |                   | DRY MASS OF SPECIMEN (SIEVED)                                                 |                                          |                                            |                                             |                                                                               |                        |
| SIEVING TIME<br><b>15 Min.</b>                       |                   | DATE                                                                          |                                          |                                            |                                             |                                                                               |                        |
| SIEVE NO.                                            | MASS RETAINED (g) | MASS PASSING (g)                                                              | FACTOR X MASS PASSING % OF TOTAL PASSING | % OF TOTAL PASSING                         | PARTICLE DIAMETER                           | REMARKS                                                                       |                        |
| 8                                                    | 0.0               | 62.4                                                                          |                                          | 100.0                                      | 2.36 mm                                     | COBBLE %                                                                      | OVERSIZE %             |
| 16                                                   | 0.00              | 62.4                                                                          |                                          | 100.0                                      | 1.18 mm                                     | GRAVEL %                                                                      | <b>0.0</b> LL = 0      |
| 30                                                   | 0.00              | 62.4                                                                          |                                          | 100.0                                      | 600 µm                                      | SAND %                                                                        | <b>1.1</b> PL = 0      |
| 50                                                   | 0.00              | 62.4                                                                          |                                          | 100.0                                      | 300 µm                                      | FINES %                                                                       | <b>98.9</b> PI = 0     |
| 100                                                  | 0.1               | 62.3                                                                          |                                          | 99.8                                       | 150 µm                                      | Classification of Fines: ML                                                   |                        |
| 200                                                  | 0.7               | 61.7                                                                          |                                          | 98.9                                       | 75 µm                                       |                                                                               |                        |
| PAN                                                  | 0.8               |                                                                               |                                          |                                            |                                             |                                                                               |                        |
| TOTAL                                                |                   |                                                                               |                                          |                                            |                                             | MOISTURE %                                                                    | <b>33.6</b>            |
| TESTED AND COMPUTED BY<br><b>Hill</b>                |                   | DATE<br><b>9/27/2010</b>                                                      |                                          | CHECKED BY<br><b>Wazid</b>                 |                                             | DATE<br><b>9/27/2010</b>                                                      |                        |
| <b>HYDROMETER ANALYSIS</b>                           |                   |                                                                               |                                          |                                            |                                             |                                                                               |                        |
| HYDROMETER NO. <b>1350</b>                           |                   | DISPERSING AGENT <b>SODIUM HEXAMETAPHOSPHATE</b>                              |                                          |                                            |                                             |                                                                               |                        |
| STARTING TIME <b>819</b>                             |                   | DATE                                                                          |                                          | AMOUNT <b>125 mL</b>                       |                                             |                                                                               |                        |
| TIME                                                 | TEMP °C           | HYD READ                                                                      | HYD CORR                                 | CORR READ                                  | FACTOR X CORRECT READ = % OF TOTAL PASSING  | % OF TOTAL PASSING                                                            | PARTICLE DIAMETER      |
|                                                      |                   |                                                                               |                                          |                                            |                                             |                                                                               |                        |
| 1 min                                                | 23.5              | 60                                                                            | 4.5                                      | 55.5                                       |                                             | 88.9                                                                          | 50 µm                  |
| 4 min                                                | 23.5              | 56                                                                            | 4.5                                      | 51.5                                       |                                             | 82.5                                                                          | 37 µm                  |
| 19 min                                               | 23.0              | 44                                                                            | 4.5                                      | 39.5                                       |                                             | 63.3                                                                          | 19 µm                  |
| 60 min                                               | 23.0              | 29                                                                            | 4.5                                      | 24.5                                       |                                             | 39.3                                                                          | 9 µm                   |
| 7h 15 min                                            |                   |                                                                               |                                          |                                            |                                             |                                                                               | 5 µm                   |
| 25 h 45 min                                          |                   |                                                                               |                                          |                                            |                                             |                                                                               | 2 µm                   |
| TESTED AND COMPUTED BY<br><b>Hill</b>                |                   | DATE<br><b>9/25/10</b>                                                        |                                          | CHECKED BY<br><b>Wazid</b>                 |                                             | DATE<br><b>09/27/10</b>                                                       |                        |

### Gradation Test





|                                                      |                   |                                           |                                          |                                     |                                            |                                                                               |                   |
|------------------------------------------------------|-------------------|-------------------------------------------|------------------------------------------|-------------------------------------|--------------------------------------------|-------------------------------------------------------------------------------|-------------------|
| 7-1451 (9-86)<br>Bureau of Reclamation<br><b>602</b> |                   | <b>GRADATION ANALYSIS</b>                 |                                          |                                     |                                            | Designation USBR 5325 -<br>Designation USBR 5330 -<br>Designation USBR 5335 - |                   |
| SAMPLE NO. CC-1-5                                    |                   | PROJECT Grande Ronde River Basin          |                                          | FEATURE Catherine Creek             |                                            |                                                                               |                   |
| RIVER MILE RM 22.72                                  |                   | EXC. NO.                                  |                                          | LOCATION LEFT BANK OF CREEK-LAYER 4 |                                            |                                                                               |                   |
| <b>GRADATION OF GRAVEL SIZES</b>                     |                   |                                           |                                          |                                     |                                            |                                                                               |                   |
| TESTED AND COMPUTED BY Hill                          |                   | DATE 9/24/2010                            |                                          | % MOISTURE CONTENT OF + NO. 4       |                                            | WET MASS OF TOTAL SPECIMEN                                                    |                   |
| CHECKED BY Wazid                                     |                   | DATE 9/27/2010                            |                                          | % MOISTURE CONTENT OF - NO. 4       |                                            | TOTAL DRY MASS OF SPECIMEN <b>170.50</b>                                      |                   |
| <b>SIEVE SIZE</b>                                    |                   | 3" (75 mm)                                |                                          | 1-1/2" (37.5 mm)                    |                                            | 3/4" (19.0 mm)                                                                |                   |
|                                                      |                   | 3/8" (9.5 mm)                             |                                          | NO. 4 (4.75 mm)                     |                                            | PAN                                                                           |                   |
| MASS OF CONTAINER AND RETAINED MATERIAL              |                   |                                           |                                          |                                     |                                            |                                                                               |                   |
| MASS OF CONTAINER                                    |                   |                                           |                                          |                                     |                                            |                                                                               |                   |
| WET MASS RETAINED                                    |                   |                                           |                                          |                                     |                                            |                                                                               |                   |
| DRY MASS RETAINED                                    |                   |                                           |                                          |                                     |                                            | 0.00                                                                          |                   |
| DRY MASS PASSING                                     |                   |                                           |                                          |                                     |                                            | 170.50                                                                        |                   |
| % OF TOTAL PASSING                                   |                   |                                           |                                          |                                     |                                            | 100.0                                                                         |                   |
| <b>GRADATION OF SAND SIZES</b>                       |                   |                                           |                                          |                                     |                                            |                                                                               |                   |
| DRY MASS OF SPECIMEN <b>98.0</b> g                   |                   | FACTOR =                                  |                                          | % TOTAL PASSING NO. 4               |                                            | 100.0                                                                         |                   |
|                                                      |                   |                                           |                                          | DRY MASS OF SPECIMEN                |                                            | 98                                                                            |                   |
| DISH NO. <b>9A</b>                                   |                   | DRY MASS OF SPECIMEN (SIEVED)             |                                          |                                     |                                            | <b>1.0204</b>                                                                 |                   |
| SIEVING TIME 15 Min.                                 |                   | DATE                                      |                                          |                                     |                                            |                                                                               |                   |
| SIEVE NO.                                            | MASS RETAINED (g) | MASS PASSING (g)                          | FACTOR X MASS PASSING % OF TOTAL PASSING | % OF TOTAL PASSING                  | PARTICLE DIAMETER                          | REMARKS                                                                       |                   |
| 8                                                    | 0.1               | 97.9                                      |                                          | 99.9                                | 2.36 mm                                    | COBBLE %                                                                      | OVERSIZE %        |
| 16                                                   | 0.4               | 97.6                                      |                                          | 99.6                                | 1.18 mm                                    | GRAVEL %                                                                      | 0.0 LL = 0        |
| 30                                                   | 4.0               | 94.0                                      |                                          | 95.9                                | 600 µm                                     | SAND %                                                                        | 68.1 PL = 0       |
| 50                                                   | 14.6              | 83.4                                      |                                          | 85.1                                | 300 µm                                     | FINES %                                                                       | 31.9 PI = 0       |
| 100                                                  | 49.4              | 48.6                                      |                                          | 49.6                                | 150 µm                                     | Classification of Fines: ML                                                   |                   |
| 200                                                  | 66.7              | 31.3                                      |                                          | 31.9                                | 75 µm                                      | MOISTURE % 21.8                                                               |                   |
| PAN                                                  | 68.4              |                                           |                                          |                                     |                                            |                                                                               |                   |
| TOTAL                                                |                   |                                           |                                          |                                     |                                            |                                                                               |                   |
| TESTED AND COMPUTED BY Hill                          |                   | DATE 9/27/2010                            |                                          | CHECKED BY Wazid                    |                                            | DATE 9/27/2010                                                                |                   |
| <b>HYDROMETER ANALYSIS</b>                           |                   |                                           |                                          |                                     |                                            |                                                                               |                   |
| HYDROMETER NO. 1350                                  |                   | DISPERSING AGENT SODIUM HEXAMETAPHOSPHATE |                                          |                                     |                                            |                                                                               |                   |
| STARTING TIME 822                                    |                   | DATE                                      |                                          | AMOUNT 125 mL                       |                                            |                                                                               |                   |
| TIME                                                 | TEMP °C           | HYD READ                                  | HYD CORR                                 | CORR READ                           | FACTOR X CORRECT READ = % OF TOTAL PASSING | % OF TOTAL PASSING                                                            | PARTICLE DIAMETER |
|                                                      |                   |                                           |                                          |                                     |                                            |                                                                               |                   |
| 1 min                                                | 23.5              | 28                                        | 4.5                                      | 23.5                                |                                            | 24.0                                                                          | 50 µm             |
| 4 min                                                | 23.5              | 22                                        | 4.5                                      | 17.5                                |                                            | 17.9                                                                          | 37 µm             |
| 19 min                                               | 23.0              | 17                                        | 4.5                                      | 12.5                                |                                            | 12.8                                                                          | 19 µm             |
| 60 min                                               | 23.0              | 13                                        | 4.5                                      | 8.5                                 |                                            | 8.7                                                                           | 9 µm              |
| 7h 15 min                                            |                   |                                           |                                          |                                     |                                            |                                                                               | 5 µm              |
| 25 h 45 min                                          |                   |                                           |                                          |                                     |                                            |                                                                               | 2 µm              |
|                                                      |                   |                                           |                                          |                                     |                                            |                                                                               | 1 µm              |
|                                                      |                   |                                           |                                          |                                     |                                            |                                                                               |                   |
| TESTED AND COMPUTED BY Hill                          |                   | DATE 9/25/10                              |                                          | CHECKED BY Wazid                    |                                            | DATE 09/27/10                                                                 |                   |

### Gradation Test

| Sieve Size | Percent Passing |
|------------|-----------------|
| 3 in       | 100             |
| 1 1/2 in   | 100             |
| 3/4 in     | 100             |
| 3/8 in     | 100             |
| #4         | 100             |
| #8         | 100             |
| #16        | 100             |
| #30        | 95              |
| #50        | 85              |
| #100       | 45              |
| #200       | 25              |
| 1 min      | 15              |
| 4 min      | 10              |
| 19 min     | 5               |
| 60 min     | 2               |
| 7.25 hrs   | 1               |
| 25.75 hrs  | 0               |

U.S. Standard Sieve Sizes



|                                         |                   |                                                                                                  |                                             |                                           |                                            |                                                                               |                                  |  |
|-----------------------------------------|-------------------|--------------------------------------------------------------------------------------------------|---------------------------------------------|-------------------------------------------|--------------------------------------------|-------------------------------------------------------------------------------|----------------------------------|--|
| 7-1451 (9-86)<br>Bureau of Reclamation  |                   | <b>GRADATION ANALYSIS</b>                                                                        |                                             |                                           |                                            | Designation USBR 5325 -<br>Designation USBR 5330 -<br>Designation USBR 5335 - |                                  |  |
| <b>603</b>                              |                   | SAMPLE NO. CC-1-6                                                                                |                                             | PROJECT Grande Ronde River Basin          | FEATURE Catherine Creek                    |                                                                               |                                  |  |
| RIVER MILE RM 22.95                     |                   | EXC. NO.                                                                                         |                                             | LOCATION LEFT BANK OF CREEK               |                                            |                                                                               |                                  |  |
| <b>GRADATION OF GRAVEL SIZES</b>        |                   |                                                                                                  |                                             |                                           |                                            |                                                                               |                                  |  |
| TESTED AND COMPUTED BY Hill             |                   | DATE 9/24/2010                                                                                   | % MOISTURE CONTENT OF + NO. 4               |                                           | WET MASS OF TOTAL SPECIMEN                 |                                                                               |                                  |  |
| CHECKED BY Wazid                        |                   | DATE 9/27/2010                                                                                   | % MOISTURE CONTENT OF - NO. 4               |                                           | TOTAL DRY MASS OF SPECIMEN <b>315.80</b>   |                                                                               |                                  |  |
| <b>SIEVE SIZE</b>                       |                   | 3" (75 mm)                                                                                       | 1-1/2" (37.5 mm)                            | 3/4" (19.0 mm)                            | 3/8" (9.5 mm)                              | NO. 4 (4.75 mm)                                                               | PAN<br><br><br><br><br>Units in: |  |
| MASS OF CONTAINER AND RETAINED MATERIAL |                   |                                                                                                  |                                             |                                           |                                            |                                                                               |                                  |  |
| MASS OF CONTAINER                       |                   |                                                                                                  |                                             |                                           |                                            |                                                                               |                                  |  |
| WET MASS RETAINED                       |                   |                                                                                                  |                                             |                                           |                                            |                                                                               |                                  |  |
| DRY MASS RETAINED                       |                   |                                                                                                  |                                             |                                           |                                            | 0.00                                                                          |                                  |  |
| DRY MASS PASSING                        |                   |                                                                                                  |                                             |                                           |                                            | 315.80                                                                        |                                  |  |
| % OF TOTAL PASSING                      |                   |                                                                                                  |                                             |                                           |                                            | 100.0                                                                         |                                  |  |
| <b>GRADATION OF SAND SIZES</b>          |                   |                                                                                                  |                                             |                                           |                                            |                                                                               |                                  |  |
| DRY MASS OF SPECIMEN <b>93.0</b> g      |                   | FACTOR = $\frac{\% \text{ TOTAL PASSING NO. 4}}{\text{DRY MASS OF SPECIMEN}} = \frac{100.0}{93}$ |                                             | = <b>1.0753</b>                           |                                            |                                                                               |                                  |  |
| DISH NO. <b>21A</b>                     |                   | DRY MASS OF SPECIMEN (SIEVED)                                                                    |                                             |                                           |                                            |                                                                               |                                  |  |
| SIEVING TIME 15 Min.                    |                   |                                                                                                  |                                             | DATE                                      |                                            |                                                                               |                                  |  |
| SIEVE NO.                               | MASS RETAINED (g) | MASS PASSING (g)                                                                                 | FACTOR X MASS PASSING %<br>OF TOTAL PASSING | % OF TOTAL PASSING                        | PARTICLE DIAMETER                          | REMARKS                                                                       |                                  |  |
| 8                                       | 0.0               | 93.0                                                                                             |                                             | 100.0                                     | 2.36 mm                                    | COBBLE %                                                                      | OVERSIZE %                       |  |
| 16                                      | 0.00              | 93.0                                                                                             |                                             | 100.0                                     | 1.18 mm                                    | GRAVEL %                                                                      | LL = 0                           |  |
| 30                                      | 0.1               | 92.9                                                                                             |                                             | 99.9                                      | 600 µm                                     | SAND %                                                                        | PL = 0                           |  |
| 50                                      | 0.1               | 92.9                                                                                             |                                             | 99.9                                      | 300 µm                                     | FINES %                                                                       | PI = 0                           |  |
| 100                                     | 0.7               | 92.3                                                                                             |                                             | 99.3                                      | 150 µm                                     | Classification of Fines: ML                                                   |                                  |  |
| 200                                     | 5.2               | 87.8                                                                                             |                                             | 94.4                                      | 75 µm                                      |                                                                               |                                  |  |
| PAN                                     | 6.7               |                                                                                                  |                                             |                                           |                                            | MOISTURE %                                                                    | 41.4                             |  |
| TOTAL                                   |                   |                                                                                                  |                                             |                                           |                                            |                                                                               |                                  |  |
| TESTED AND COMPUTED BY Hill             |                   | DATE 9/27/2010                                                                                   |                                             | CHECKED BY Wazid                          |                                            | DATE 9/27/2010                                                                |                                  |  |
| <b>HYDROMETER ANALYSIS</b>              |                   |                                                                                                  |                                             |                                           |                                            |                                                                               |                                  |  |
| HYDROMETER NO. 1350                     |                   |                                                                                                  |                                             | DISPERSING AGENT SODIUM HEXAMETAPHOSPHATE |                                            |                                                                               |                                  |  |
| STARTING TIME 825                       |                   |                                                                                                  |                                             | DATE                                      |                                            | AMOUNT 125 mL                                                                 |                                  |  |
| TIME                                    | TEMP °C           | HYD READ                                                                                         | HYD CORR                                    | CORR READ                                 | FACTOR X CORRECT READ = % OF TOTAL PASSING | % OF TOTAL PASSING                                                            | PARTICLE DIAMETER                |  |
| 1 min                                   | 23.5              | 60                                                                                               | 4.5                                         | 55.5                                      |                                            | 59.7                                                                          | 50 µm                            |  |
| 4 min                                   | 23.0              | 50                                                                                               | 4.5                                         | 45.5                                      |                                            | 48.9                                                                          | 37 µm                            |  |
| 19 min                                  | 23.0              | 28                                                                                               | 4.5                                         | 23.5                                      |                                            | 25.3                                                                          | 19 µm                            |  |
| 60 min                                  | 23.0              | 17                                                                                               | 4.5                                         | 12.5                                      |                                            | 13.4                                                                          | 9 µm                             |  |
| 7h 15 min                               |                   |                                                                                                  |                                             |                                           |                                            |                                                                               | 5 µm                             |  |
| 25 h 45 min                             |                   |                                                                                                  |                                             |                                           |                                            |                                                                               | 2 µm                             |  |
|                                         |                   |                                                                                                  |                                             |                                           |                                            |                                                                               | 1 µm                             |  |
| TESTED AND COMPUTED BY Hill             |                   | DATE 9/25/10                                                                                     | CHECKED BY Wazid                            |                                           |                                            | DATE 09/27/10                                                                 |                                  |  |

### Gradation Test

| Sieve Size | Percent Passing |
|------------|-----------------|
| 3 in       | 100             |
| 1 1/2 in   | 100             |
| 3/4 in     | 100             |
| 3/8 in     | 100             |
| #4         | 100             |
| #8         | 100             |
| #16        | 100             |
| #30        | 100             |
| #50        | 100             |
| #100       | 100             |
| #200       | 59.7            |
| 1 min      | 48.9            |
| 4 min      | 25.3            |
| 19 min     | 13.4            |
| 60 min     | 5.2             |
| 7.25 hrs   | 0               |
| 25.75 hrs  | 0               |

U.S. Standard Sieve Sizes



|                                                      |                   |                                           |                                          |                               |                                            |                                                                               |                    |
|------------------------------------------------------|-------------------|-------------------------------------------|------------------------------------------|-------------------------------|--------------------------------------------|-------------------------------------------------------------------------------|--------------------|
| 7-1451 (9-86)<br>Bureau of Reclamation<br><b>604</b> |                   | <b>GRADATION ANALYSIS</b>                 |                                          |                               |                                            | Designation USBR 5325 -<br>Designation USBR 5330 -<br>Designation USBR 5335 - |                    |
| SAMPLE NO. CC-1-7                                    |                   | PROJECT Grande Ronde River Basin          |                                          | FEATURE Catherine Creek       |                                            |                                                                               |                    |
| RIVER MILE RM 31.85                                  |                   | EXC. NO.                                  |                                          | LOCATION BED OF CREEK         |                                            |                                                                               |                    |
| <b>GRADATION OF GRAVEL SIZES</b>                     |                   |                                           |                                          |                               |                                            |                                                                               |                    |
| TESTED AND COMPUTED BY Hill                          |                   | DATE 9/24/2010                            |                                          | % MOISTURE CONTENT OF + NO. 4 |                                            | WET MASS OF TOTAL SPECIMEN                                                    |                    |
| CHECKED BY Wazid                                     |                   | DATE 9/27/2010                            |                                          | % MOISTURE CONTENT OF - NO. 4 |                                            | TOTAL DRY MASS OF SPECIMEN <b>90.00</b>                                       |                    |
| <b>SIEVE SIZE</b>                                    |                   | 3" (75 mm)                                |                                          | 1-1/2" (37.5 mm)              |                                            | 3/4" (19.0 mm)                                                                |                    |
|                                                      |                   | 3/8" (9.5 mm)                             |                                          | NO. 4 (4.75 mm)               |                                            | PAN                                                                           |                    |
| MASS OF CONTAINER AND RETAINED MATERIAL              |                   |                                           |                                          |                               |                                            |                                                                               |                    |
| MASS OF CONTAINER                                    |                   |                                           |                                          |                               |                                            |                                                                               |                    |
| WET MASS RETAINED                                    |                   |                                           |                                          |                               |                                            |                                                                               |                    |
| DRY MASS RETAINED                                    |                   |                                           |                                          |                               |                                            | 0.00                                                                          |                    |
| DRY MASS PASSING                                     |                   |                                           |                                          |                               |                                            | 90.00                                                                         |                    |
| % OF TOTAL PASSING                                   |                   |                                           |                                          |                               |                                            | 100.0                                                                         |                    |
| <b>GRADATION OF SAND SIZES</b>                       |                   |                                           |                                          |                               |                                            |                                                                               |                    |
| DRY MASS OF SPECIMEN <b>43.4</b> g                   |                   | FACTOR =                                  |                                          | % TOTAL PASSING NO. 4         |                                            | <b>100.0</b>                                                                  |                    |
| DISH NO. <b>1</b>                                    |                   | DRY MASS OF SPECIMEN (SIEVED)             |                                          | DRY MASS OF SPECIMEN          |                                            | <b>43.4</b>                                                                   |                    |
| SIEVING TIME 15 Min.                                 |                   | DATE                                      |                                          |                               |                                            |                                                                               |                    |
| SIEVE NO.                                            | MASS RETAINED (g) | MASS PASSING (g)                          | FACTOR X MASS PASSING % OF TOTAL PASSING | % OF TOTAL PASSING            | PARTICLE DIAMETER                          | REMARKS                                                                       |                    |
| 8                                                    | 0.2               | 43.2                                      |                                          | 99.5                          | 2.36 mm                                    | COBBLE %                                                                      | OVERSIZE %         |
| 16                                                   | 0.6               | 42.8                                      |                                          | 98.6                          | 1.18 mm                                    | GRAVEL %                                                                      | <b>0.0</b> LL = 0  |
| 30                                                   | 0.7               | 42.7                                      |                                          | 98.4                          | 600 µm                                     | SAND %                                                                        | <b>4.1</b> PL = 0  |
| 50                                                   | 0.9               | 42.5                                      |                                          | 97.9                          | 300 µm                                     | FINES %                                                                       | <b>95.9</b> PI = 0 |
| 100                                                  | 1.3               | 42.1                                      |                                          | 97.0                          | 150 µm                                     | Classification of Fines: ML                                                   |                    |
| 200                                                  | 1.8               | 41.6                                      |                                          | 95.9                          | 75 µm                                      | MOISTURE % <b>48.9</b>                                                        |                    |
| PAN                                                  | 1.8               |                                           |                                          |                               |                                            |                                                                               |                    |
| TOTAL                                                |                   |                                           |                                          |                               |                                            |                                                                               |                    |
| TESTED AND COMPUTED BY Hill                          |                   | DATE 9/27/2010                            |                                          | CHECKED BY Wazid              |                                            | DATE 9/27/2010                                                                |                    |
| <b>HYDROMETER ANALYSIS</b>                           |                   |                                           |                                          |                               |                                            |                                                                               |                    |
| HYDROMETER NO. 1350                                  |                   | DISPERSING AGENT SODIUM HEXAMETAPHOSPHATE |                                          |                               |                                            |                                                                               |                    |
| STARTING TIME 828                                    |                   | DATE                                      |                                          | AMOUNT 125 mL                 |                                            |                                                                               |                    |
| TIME                                                 | TEMP °C           | HYD READ                                  | HYD CORR                                 | CORR READ                     | FACTOR X CORRECT READ = % OF TOTAL PASSING | % OF TOTAL PASSING                                                            | PARTICLE DIAMETER  |
| 1 min                                                | 23.0              | 43                                        | 4.5                                      | 38.5                          |                                            | 88.7                                                                          | 50 µm              |
| 4 min                                                | 23.0              | 40                                        | 4.5                                      | 35.5                          |                                            | 81.8                                                                          | 37 µm              |
| 19 min                                               | 23.0              | 35                                        | 4.5                                      | 30.5                          |                                            | 70.3                                                                          | 19 µm              |
| 60 min                                               | 23.0              | 26                                        | 4.5                                      | 21.5                          |                                            | 49.5                                                                          | 9 µm               |
| 7h 15 min                                            | 24.0              | 12                                        | 4.0                                      | 8.0                           |                                            | 18.4                                                                          | 5 µm               |
| 25 h 45 min                                          | 24.0              | 7                                         | 4.0                                      | 3.0                           |                                            | 6.9                                                                           | 2 µm               |
|                                                      |                   |                                           |                                          |                               |                                            |                                                                               | 1 µm               |
| TESTED AND COMPUTED BY Hill                          |                   | DATE 9/25/10                              |                                          | CHECKED BY Wazid              |                                            | DATE 09/27/10                                                                 |                    |

**Gradation Test**

| Sieve Size | Percent Passing |
|------------|-----------------|
| 3 in       | 100             |
| 1 1/2 in   | 100             |
| 3/4 in     | 100             |
| 3/8 in     | 100             |
| #4         | 100             |
| #8         | 100             |
| #16        | 100             |
| #30        | 100             |
| #50        | 100             |
| #100       | 100             |
| #200       | 95.9            |
| 1 min      | 88.7            |
| 4 min      | 81.8            |
| 19 min     | 70.3            |
| 60 min     | 49.5            |
| 7.25 hrs   | 18.4            |
| 25.75 hrs  | 6.9             |



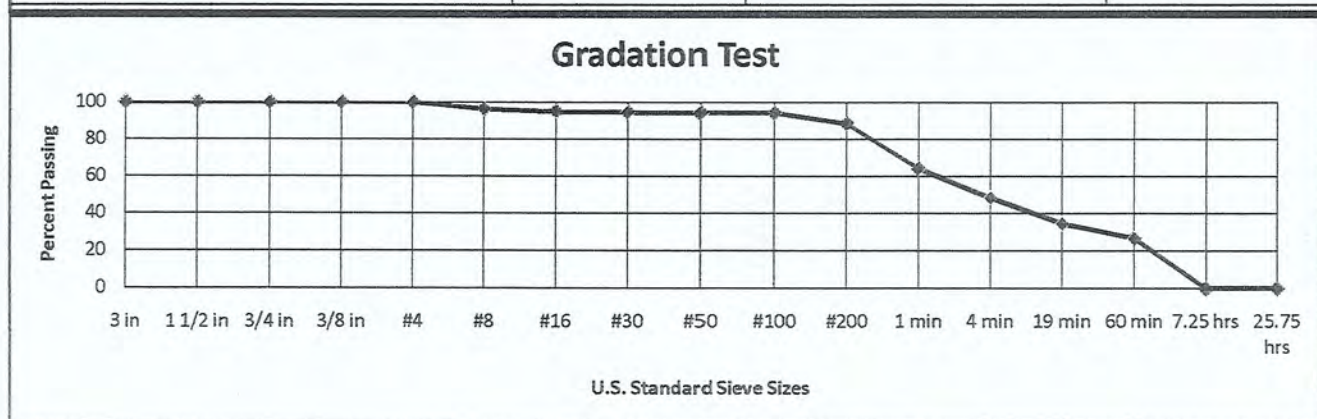
|                                                      |                   |                                           |                                          |                                                       |                                                                               |                                          |
|------------------------------------------------------|-------------------|-------------------------------------------|------------------------------------------|-------------------------------------------------------|-------------------------------------------------------------------------------|------------------------------------------|
| 7-1451 (9-86)<br>Bureau of Reclamation<br><b>663</b> |                   | <b>GRADATION ANALYSIS</b>                 |                                          |                                                       | Designation USBR 5325 -<br>Designation USBR 5330 -<br>Designation USBR 5335 - |                                          |
| SAMPLE NO. CC-1-8                                    |                   | PROJECT Grande Ronde River Basin          |                                          | FEATURE Catherine Creek                               |                                                                               |                                          |
| RIVER MILE RM 33.66                                  |                   | EXC. NO.                                  |                                          | LOCATION BED OF CREEK                                 |                                                                               |                                          |
| <b>GRADATION OF GRAVEL SIZES</b>                     |                   |                                           |                                          |                                                       |                                                                               |                                          |
| TESTED AND COMPUTED BY Hill                          |                   | DATE 9/24/2010                            |                                          | % MOISTURE CONTENT OF + NO. 4                         |                                                                               | WET MASS OF TOTAL SPECIMEN               |
| CHECKED BY Wazid                                     |                   | DATE 9/27/2010                            |                                          | % MOISTURE CONTENT OF - NO. 4                         |                                                                               | TOTAL DRY MASS OF SPECIMEN <b>217.50</b> |
| <b>SIEVE SIZE</b>                                    |                   | 3" (75 mm)                                |                                          | 1-1/2" (37.5 mm)                                      | 3/4" (19.0 mm)                                                                | 3/8" (9.5 mm)                            |
|                                                      |                   |                                           |                                          | NO. 4 (4.75 mm)                                       | PAN                                                                           |                                          |
| MASS OF CONTAINER AND RETAINED MATERIAL              |                   |                                           |                                          |                                                       |                                                                               |                                          |
| MASS OF CONTAINER                                    |                   |                                           |                                          |                                                       |                                                                               |                                          |
| WET MASS RETAINED                                    |                   |                                           |                                          |                                                       |                                                                               |                                          |
| DRY MASS RETAINED                                    |                   |                                           |                                          |                                                       |                                                                               | 0.00                                     |
| DRY MASS PASSING                                     |                   |                                           |                                          |                                                       |                                                                               | 217.50                                   |
| % OF TOTAL PASSING                                   |                   |                                           |                                          |                                                       |                                                                               | 100.0                                    |
| <b>GRADATION OF SAND SIZES</b>                       |                   |                                           |                                          |                                                       |                                                                               |                                          |
| DRY MASS OF SPECIMEN <b>99.0</b> g                   |                   | FACTOR =                                  |                                          | % TOTAL PASSING NO. 4                                 |                                                                               | <b>1.0101</b>                            |
| DISH NO. <b>25</b>                                   |                   | DRY MASS OF SPECIMEN (SIEVED)             |                                          | 99                                                    |                                                                               |                                          |
| SIEVING TIME 15 Min.                                 |                   | DATE                                      |                                          |                                                       |                                                                               |                                          |
| SIEVE NO.                                            | MASS RETAINED (g) | MASS PASSING (g)                          | FACTOR X MASS PASSING % OF TOTAL PASSING | % OF TOTAL PASSING                                    | PARTICLE DIAMETER                                                             | REMARKS                                  |
| 8                                                    | 1.8               | 97.2                                      |                                          | 98.2                                                  | 2.36 mm                                                                       | COBBLE %                                 |
| 16                                                   | 8.7               | 90.3                                      |                                          | 91.2                                                  | 1.18 mm                                                                       | GRAVEL %                                 |
| 30                                                   | 28.1              | 70.9                                      |                                          | 71.6                                                  | 600 µm                                                                        | SAND %                                   |
| 50                                                   | 71.6              | 27.4                                      |                                          | 27.7                                                  | 300 µm                                                                        | FINES %                                  |
| 100                                                  | 89.3              | 9.7                                       |                                          | 9.8                                                   | 150 µm                                                                        |                                          |
| 200                                                  | 91.2              | 7.8                                       |                                          | 7.9                                                   | 75 µm                                                                         |                                          |
| PAN                                                  | 91.4              |                                           |                                          |                                                       |                                                                               |                                          |
| TOTAL                                                |                   |                                           |                                          |                                                       |                                                                               |                                          |
|                                                      |                   |                                           |                                          | Classification of Fines: ML<br>MOISTURE % <b>23.8</b> |                                                                               |                                          |
| TESTED AND COMPUTED BY Hill                          |                   | DATE 9/27/2010                            |                                          | CHECKED BY Wazid                                      |                                                                               | DATE 9/27/2010                           |
| <b>HYDROMETER ANALYSIS</b>                           |                   |                                           |                                          |                                                       |                                                                               |                                          |
| HYDROMETER NO. 1350                                  |                   | DISPERSING AGENT SODIUM HEXAMETAPHOSPHATE |                                          |                                                       |                                                                               |                                          |
| STARTING TIME 831                                    |                   | DATE                                      |                                          | AMOUNT 125 mL                                         |                                                                               |                                          |
| TIME                                                 | TEMP °C           | HYD READ                                  | HYD CORR                                 | CORR READ                                             | FACTOR X CORRECT READ = % OF TOTAL PASSING                                    | % OF TOTAL PASSING                       |
|                                                      |                   |                                           |                                          |                                                       |                                                                               | PARTICLE DIAMETER                        |
| 1 min                                                | 23.0              | 11                                        | 4.5                                      | 6.5                                                   |                                                                               | 50 µm                                    |
| 4 min                                                | 23.0              | 9                                         | 4.5                                      | 4.5                                                   |                                                                               | 37 µm                                    |
| 19 min                                               | 23.0              | 8                                         | 4.5                                      | 3.5                                                   |                                                                               | 19 µm                                    |
| 60 min                                               | 23.0              | 6                                         | 4.5                                      | 1.5                                                   |                                                                               | 9 µm                                     |
| 7h 15 min                                            |                   |                                           |                                          |                                                       |                                                                               | 5 µm                                     |
| 25 h 45 min                                          |                   |                                           |                                          |                                                       |                                                                               | 2 µm                                     |
|                                                      |                   |                                           |                                          | 1 µm                                                  |                                                                               |                                          |
|                                                      |                   |                                           |                                          | Poorly graded sand with silt (SP-SM)                  |                                                                               |                                          |
| TESTED AND COMPUTED BY Hill                          |                   | DATE 9/25/10                              |                                          | CHECKED BY Wazid                                      |                                                                               | DATE 09/27/10                            |

**Gradation Test**

| Sieve Size | Percent Passing |
|------------|-----------------|
| 3 in       | 100             |
| 1 1/2 in   | 100             |
| 3/4 in     | 90              |
| 3/8 in     | 70              |
| #4         | 60              |
| #8         | 50              |
| #16        | 40              |
| #30        | 25              |
| #50        | 10              |
| #100       | 5               |
| #200       | 2               |
| 1 min      | 1               |
| 4 min      | 0.5             |
| 19 min     | 0.2             |
| 60 min     | 0.1             |
| 7.25 hrs   | 0.05            |
| 25.75 hrs  | 0.02            |



|                                         |  |                                            |  |                                  |  |                                                                                                                         |  |
|-----------------------------------------|--|--------------------------------------------|--|----------------------------------|--|-------------------------------------------------------------------------------------------------------------------------|--|
| 7-1451 (9-86)<br>Bureau of Reclamation  |  | <b>GRADATION ANALYSIS</b>                  |  |                                  |  | Designation USBR 5325 - <u>      </u><br>Designation USBR 5330 - <u>      </u><br>Designation USBR 5335 - <u>      </u> |  |
| <b>816</b>                              |  | SAMPLE NO. CC-1-9                          |  | PROJECT Grande Ronde River Basin |  | FEATURE Catherine Creek                                                                                                 |  |
| RIVER MILE RM 34.30                     |  | EXC. NO.                                   |  | LOCATION BED OF CREEK            |  |                                                                                                                         |  |
| <b>GRADATION OF GRAVEL SIZES</b>        |  |                                            |  |                                  |  |                                                                                                                         |  |
| TESTED AND COMPUTED BY Hill             |  | DATE 9/24/2010                             |  | % MOISTURE CONTENT OF + NO. 4    |  | WET MASS OF TOTAL SPECIMEN                                                                                              |  |
| CHECKED BY Wazid                        |  | DATE 9/27/2010                             |  | % MOISTURE CONTENT OF - NO. 4    |  | TOTAL DRY MASS OF SPECIMEN <b>53.10</b>                                                                                 |  |
| <b>SIEVE SIZE</b>                       |  | 3" (75 mm)                                 |  | 1-1/2" (37.5 mm)                 |  | 3/4" (19.0 mm)                                                                                                          |  |
|                                         |  | 3/8" (9.5 mm)                              |  | NO. 4 (4.75 mm)                  |  | PAN                                                                                                                     |  |
| MASS OF CONTAINER AND RETAINED MATERIAL |  |                                            |  |                                  |  |                                                                                                                         |  |
| MASS OF CONTAINER                       |  |                                            |  |                                  |  |                                                                                                                         |  |
| WET MASS RETAINED                       |  |                                            |  |                                  |  |                                                                                                                         |  |
| DRY MASS RETAINED                       |  |                                            |  |                                  |  | 0.00                                                                                                                    |  |
| DRY MASS PASSING                        |  |                                            |  |                                  |  | 53.10                                                                                                                   |  |
| % OF TOTAL PASSING                      |  |                                            |  |                                  |  | 100.0                                                                                                                   |  |
| <b>GRADATION OF SAND SIZES</b>          |  |                                            |  |                                  |  |                                                                                                                         |  |
| DRY MASS OF SPECIMEN <b>50.7</b> g      |  | FACTOR =                                   |  | % TOTAL PASSING NO. 4            |  | 100.0                                                                                                                   |  |
| DISH NO. <b>20A</b>                     |  | DRY MASS OF SPECIMEN (SIEVED)              |  | 50.7                             |  | 1.9724                                                                                                                  |  |
| SIEVING TIME 15 Min.                    |  | DATE                                       |  |                                  |  |                                                                                                                         |  |
| SIEVE NO.                               |  | MASS RETAINED (g)                          |  | MASS PASSING (g)                 |  | REMARKS                                                                                                                 |  |
| 8                                       |  | 1.8                                        |  | 48.9                             |  | 96.5 2.36 mm COBBLE %                                                                                                   |  |
| 16                                      |  | 2.5                                        |  | 48.2                             |  | 95.1 1.18 mm GRAVEL %                                                                                                   |  |
| 30                                      |  | 2.7                                        |  | 48.0                             |  | 94.7 600 µm SAND %                                                                                                      |  |
| 50                                      |  | 2.9                                        |  | 47.8                             |  | 94.3 300 µm FINES %                                                                                                     |  |
| 100                                     |  | 3.0                                        |  | 47.7                             |  | 94.1 150 µm                                                                                                             |  |
| 200                                     |  | 5.9                                        |  | 44.8                             |  | 88.4 75 µm                                                                                                              |  |
| PAN                                     |  | 7.0                                        |  |                                  |  | Classification of Fines: ML                                                                                             |  |
| TOTAL                                   |  |                                            |  |                                  |  | MOISTURE % 40.5                                                                                                         |  |
| TESTED AND COMPUTED BY Hill             |  | DATE 9/27/2010                             |  | CHECKED BY Wazid                 |  | DATE 9/27/2010                                                                                                          |  |
| <b>HYDROMETER ANALYSIS</b>              |  |                                            |  |                                  |  |                                                                                                                         |  |
| HYDROMETER NO. 1350                     |  | DISPERSING AGENT SODIUM HEXAMETAPHOSPHATE  |  |                                  |  |                                                                                                                         |  |
| STARTING TIME 834                       |  | DATE                                       |  | AMOUNT 125 mL                    |  |                                                                                                                         |  |
| TIME                                    |  | TEMP °C                                    |  | HYD READ                         |  | HYD CORR                                                                                                                |  |
| CORR READ                               |  | FACTOR X CORRECT READ = % OF TOTAL PASSING |  | % OF TOTAL PASSING               |  | PARTICLE DIAMETER                                                                                                       |  |
| 1 min                                   |  | 23.0                                       |  | 37                               |  | 4.5                                                                                                                     |  |
| 4 min                                   |  | 23.0                                       |  | 29                               |  | 4.5                                                                                                                     |  |
| 19 min                                  |  | 23.0                                       |  | 22                               |  | 4.5                                                                                                                     |  |
| 60 min                                  |  | 23.0                                       |  | 18                               |  | 4.5                                                                                                                     |  |
| 7h 15 min                               |  |                                            |  |                                  |  |                                                                                                                         |  |
| 25 h 45 min                             |  |                                            |  |                                  |  |                                                                                                                         |  |
| TESTED AND COMPUTED BY Hill             |  | DATE 9/25/10                               |  | CHECKED BY Wazid                 |  | DATE 09/27/10                                                                                                           |  |





|                                                                                                         |                   |                                  |                                          |                                           |                                            |                                                                               |                   |
|---------------------------------------------------------------------------------------------------------|-------------------|----------------------------------|------------------------------------------|-------------------------------------------|--------------------------------------------|-------------------------------------------------------------------------------|-------------------|
| 7-1451 (9-86)<br>Bureau of Reclamation<br><div style="text-align: center; font-weight: bold;">212</div> |                   | GRADATION ANALYSIS               |                                          |                                           |                                            | Designation USBR 5325 -<br>Designation USBR 5330 -<br>Designation USBR 5335 - |                   |
| SAMPLE NO. CC-1-10                                                                                      |                   | PROJECT Grande Ronde River Basin |                                          | FEATURE Catherine Creek                   |                                            |                                                                               |                   |
| RIVER MILE RM 37.84                                                                                     |                   | EXC. NO.                         |                                          | LOCATION RIGHT BANK OF CREEK              |                                            |                                                                               |                   |
| GRADATION OF GRAVEL SIZES                                                                               |                   |                                  |                                          |                                           |                                            |                                                                               |                   |
| TESTED AND COMPUTED BY Hill                                                                             |                   | DATE 9/24/2010                   |                                          | % MOISTURE CONTENT OF + NO. 4             |                                            | WET MASS OF TOTAL SPECIMEN                                                    |                   |
| CHECKED BY Wazid                                                                                        |                   | DATE 9/27/2010                   |                                          | % MOISTURE CONTENT OF - NO. 4             |                                            | TOTAL DRY MASS OF SPECIMEN 2221.60                                            |                   |
| SIEVE SIZE                                                                                              |                   | 3" (75 mm)                       |                                          | 1-1/2" (37.5 mm)                          |                                            | 3/4" (19.0 mm)                                                                |                   |
|                                                                                                         |                   | 3/8" (9.5 mm)                    |                                          | NO. 4 (4.75 mm)                           |                                            | PAN                                                                           |                   |
| MASS OF CONTAINER AND RETAINED MATERIAL                                                                 |                   |                                  |                                          |                                           |                                            |                                                                               |                   |
| MASS OF CONTAINER                                                                                       |                   |                                  |                                          |                                           |                                            |                                                                               |                   |
| WET MASS RETAINED                                                                                       |                   |                                  |                                          |                                           |                                            |                                                                               |                   |
| DRY MASS RETAINED                                                                                       |                   | 0.0                              |                                          | 549.6                                     |                                            | 1026.1                                                                        |                   |
| DRY MASS PASSING                                                                                        |                   | 2221.60                          |                                          | 1672.00                                   |                                            | 1195.50                                                                       |                   |
| % OF TOTAL PASSING                                                                                      |                   | 100.0                            |                                          | 75.3                                      |                                            | 53.8                                                                          |                   |
|                                                                                                         |                   |                                  |                                          | 40.4                                      |                                            | 32.9                                                                          |                   |
| GRADATION OF SAND SIZES                                                                                 |                   |                                  |                                          |                                           |                                            |                                                                               |                   |
| DRY MASS OF SPECIMEN 164.4 g                                                                            |                   | FACTOR =                         |                                          | % TOTAL PASSING NO. 4                     |                                            | 32.9                                                                          |                   |
| DISH NO. S-3                                                                                            |                   | DRY MASS OF SPECIMEN (SIEVED)    |                                          | 164.4                                     |                                            | 0.2004                                                                        |                   |
| SIEVING TIME 15 Min.                                                                                    |                   | DATE                             |                                          |                                           |                                            |                                                                               |                   |
| SIEVE NO.                                                                                               | MASS RETAINED (g) | MASS PASSING (g)                 | FACTOR X MASS PASSING % OF TOTAL PASSING | % OF TOTAL PASSING                        | PARTICLE DIAMETER                          | REMARKS                                                                       |                   |
| 8                                                                                                       | 20.7              | 143.7                            |                                          | 28.8                                      | 2.36 mm                                    | COBBLE %                                                                      | Cu =              |
| 16                                                                                                      | 44.0              | 120.4                            |                                          | 24.1                                      | 1.18 mm                                    | GRAVEL %                                                                      | Cc =              |
| 30                                                                                                      | 86.5              | 77.9                             |                                          | 15.6                                      | 600 µm                                     | SAND %                                                                        | LL =              |
| 50                                                                                                      | 110.7             | 53.7                             |                                          | 10.8                                      | 300 µm                                     | FINES %                                                                       | PL =              |
| 100                                                                                                     | 119.3             | 45.1                             |                                          | 9.0                                       | 150 µm                                     | Classification of Fines:                                                      |                   |
| 200                                                                                                     | 126.0             | 38.4                             |                                          | 7.7                                       | 75 µm                                      |                                                                               |                   |
| PAN                                                                                                     | 126.7             |                                  |                                          |                                           |                                            | MOISTURE %                                                                    | 7.7               |
| TOTAL                                                                                                   |                   |                                  |                                          |                                           |                                            |                                                                               |                   |
| TESTED AND COMPUTED BY Hill                                                                             |                   | DATE 9/24/2010                   |                                          | CHECKED BY Wazid                          |                                            | DATE 9/27/2010                                                                |                   |
| HYDROMETER ANALYSIS                                                                                     |                   |                                  |                                          |                                           |                                            |                                                                               |                   |
| HYDROMETER NO.                                                                                          |                   |                                  |                                          | DISPERSING AGENT SODIUM HEXAMETAPHOSPHATE |                                            |                                                                               |                   |
| STARTING TIME                                                                                           |                   |                                  |                                          | DATE                                      |                                            | AMOUNT 125 mL                                                                 |                   |
| TIME                                                                                                    | TEMP °C           | HYD READ                         | HYD CORR                                 | CORR READ                                 | FACTOR X CORRECT READ = % OF TOTAL PASSING | % OF TOTAL PASSING                                                            | PARTICLE DIAMETER |
| 1 min                                                                                                   |                   |                                  |                                          |                                           |                                            |                                                                               | 50 µm             |
| 4 min                                                                                                   |                   |                                  |                                          |                                           |                                            |                                                                               | 37 µm             |
| 19 min                                                                                                  |                   |                                  |                                          |                                           |                                            |                                                                               | 19 µm             |
| 60 min                                                                                                  |                   |                                  |                                          |                                           |                                            |                                                                               | 9 µm              |
| 7h 15 min                                                                                               |                   |                                  |                                          |                                           |                                            |                                                                               | 5 µm              |
| 25 h 45 min                                                                                             |                   |                                  |                                          |                                           |                                            |                                                                               | 2 µm              |
|                                                                                                         |                   |                                  |                                          |                                           |                                            |                                                                               | 1 µm              |
| TESTED AND COMPUTED BY                                                                                  |                   |                                  |                                          | DATE                                      |                                            | CHECKED BY                                                                    |                   |
|                                                                                                         |                   |                                  |                                          |                                           |                                            | DATE                                                                          |                   |

Gradation Test

| Sieve Size | Percent Passing |
|------------|-----------------|
| 3 in       | 100             |
| 1 1/2 in   | 75.3            |
| 3/4 in     | 53.8            |
| 3/8 in     | 40.4            |
| #4         | 32.9            |
| #8         | 28.8            |
| #16        | 24.1            |
| #30        | 15.6            |
| #50        | 10.8            |
| #100       | 9.0             |
| #200       | 7.7             |
| 1 min      | 7.7             |
| 4 min      | 7.7             |
| 19 min     | 7.7             |
| 60 min     | 7.7             |
| 7.25 hrs   | 7.7             |
| 25.75 hrs  | 7.7             |







## **ATTACHMENT C – PEBBLE COUNT DATA**

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**Pebble Count Workbook**

STREAM NAME: Catherine Creek  
SITE: PC-R7-2 (RM 54.70)

DATE: 11/10/2010  
CREW: McAfee

STREAM NAME: Catherine Creek  
SITE: PC-R7-1 (RM 52.30-Dry)

DATE: 11/10/2010  
CREW: McAfee

STREAM NAME: Catherine Creek  
SITE: PC-R7-1 (RM 52.30-Wet)

DATE: 11/10/2010  
CREW: McAfee

STREAM NAME: Catherine Creek  
SITE: PC-R6-1 (RM 51.72)

DATE: 8/19/2010  
CREW: McAfee

STREAM NAME: Catherine Creek  
SITE: PC-R6-2 (RM 51.30)

DATE: 8/19/2010  
CREW: McAfee

STREAM NAME: Catherine Creek  
SITE: PC-R5-4 (RM 49.65)

DATE: 8/17/2010  
CREW: McAfee

STREAM NAME: Catherine Creek  
SITE: PC-R5-3 (RM 48.24)

DATE: 8/17/2010  
CREW: McAfee

STREAM NAME: Catherine Creek  
SITE: PC-R5-2 (RM 46.93)

DATE: 8/18/2010  
CREW: McAfee

STREAM NAME: Catherine Creek  
SITE: PC-R5-1 (RM 46.09)

DATE: 8/18/2010  
CREW: McAfee

STREAM NAME: Catherine Creek  
SITE: PC-R4-4 (RM 44.90)

DATE: 8/18/2010  
CREW: McAfee

STREAM NAME: Catherine Creek  
SITE: PC-R4-3 (RM 43.25)

DATE: 8/19/2010  
CREW: McAfee

STREAM NAME: Catherine Creek  
SITE: PC-R4-2 (RM 42.36)

DATE: 8/16/2010  
CREW: McAfee

STREAM NAME: Catherine Creek  
SITE: PC-R4-1 (RM 41.53)

DATE: 8/16/2010  
CREW: McAfee

STREAM NAME: Catherine Creek  
SITE: PC-R3-5 (RM 40.58)

DATE: 8/2/2010  
CREW: McAfee

STREAM NAME: Catherine Creek  
SITE: PC-R3-4 (RM 39.63)

DATE: 8/2/2010  
CREW: McAfee

STREAM NAME: Catherine Creek

DATE: 8/2/2010



SITE: PC-R3-3 (RM 39.60)  
STREAM NAME: Catherine Creek  
SITE: PC-R3-2 (RM 38.20)

CREW: McAfee  
DATE: 8/3/2010  
CREW: McAfee

STREAM NAME: Catherine Creek  
SITE: PC-R3-1 (RM 37.50)

DATE: 8/3/2010  
CREW: McAfee

# Pebble Count Workbook

STREAM NAME:  
SITE:

Catherine Creek  
PC-R7-2 (RM 54.70)

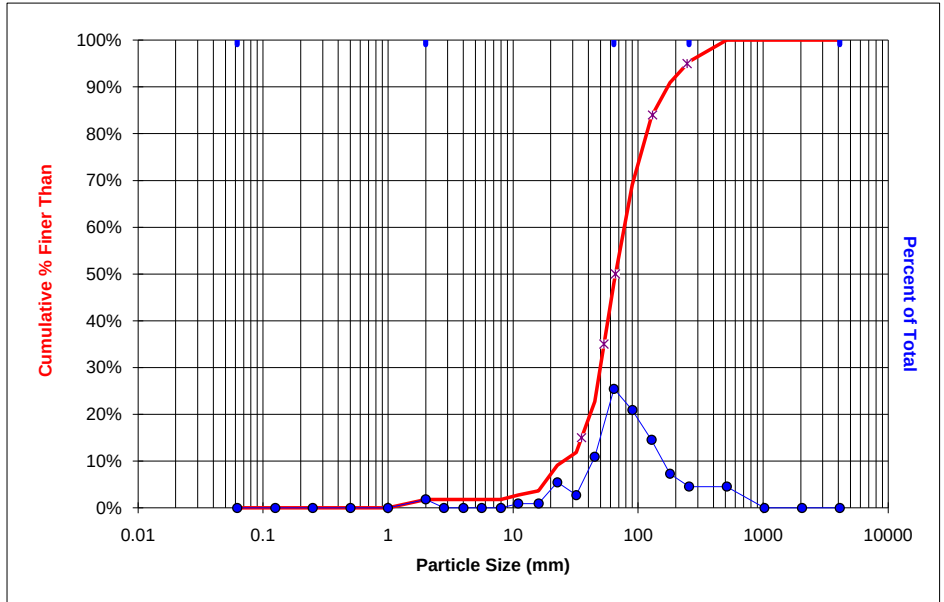
DATE: 11/10/2010  
CREW: McAfee

## Pebble Count Worksheet

| Gravelometer (mm) | Particle Size (mm) | % finer than | Total Count |
|-------------------|--------------------|--------------|-------------|
| 0.062             | <0.062             | 0%           | 0           |
| 0.125             | 0.062 - 0.125      | 0%           | 0           |
| 0.25              | 0.125 - 0.25       | 0%           | 0           |
| 0.5               | 0.25 - 0.5         | 0%           | 0           |
| 1                 | 0.5 - 1.0          | 0%           | 0           |
| 2                 | 1 - 2              | 2%           | 2           |
| 2.8               | 2 - 2.8            | 2%           | 0           |
| 4                 | 2.8 - 4            | 2%           | 0           |
| 5.6               | 4 - 5.6            | 2%           | 0           |
| 8                 | 5.6 - 8            | 2%           | 0           |
| 11                | 8 - 11             | 3%           | 1           |
| 16                | 11 - 16            | 4%           | 1           |
| 22.6              | 16 - 22.6          | 9%           | 6           |
| 32                | 22.6 - 32          | 12%          | 3           |
| 45                | 32 - 45            | 23%          | 12          |
| 64                | 45 - 64            | 48%          | 28          |
| 90                | 64 - 90            | 69%          | 23          |
| 128               | 90 - 128           | 84%          | 16          |
| 180               | 128 - 180          | 91%          | 8           |
| 256               | 180 - 256          | 95%          | 5           |
| 512               | 256 - 512          | 100%         | 5           |
| 1024              | 512 - 1024         | 100%         | 0           |
| 2048              | 1024 - 2048        | 100%         | 0           |
| 4096              | 2048 - 4096        | 100%         | 0           |

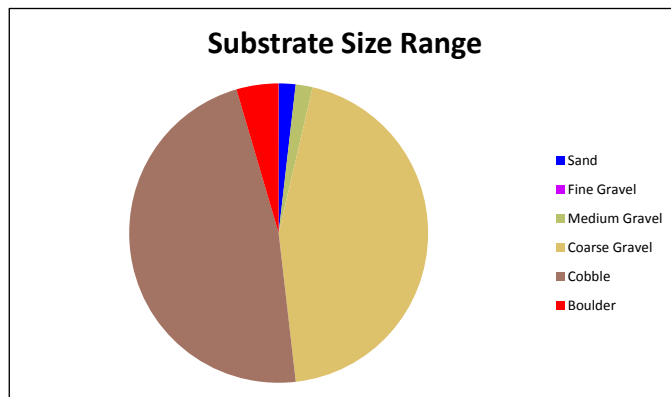
Particle Size  
Distribution (mm)

| D15  | D35  | D50  | D84   | D95   |
|------|------|------|-------|-------|
| 35.3 | 53.3 | 65.9 | 130.2 | 247.1 |



## Size Range Worksheet

| Size Range (mm) | Classification | Total Count |
|-----------------|----------------|-------------|
| 0.062 - 2.0     | Sand           | 2           |
| 2 - 8           | Fine Gravel    | 0           |
| 8 - 16          | Medium Gravel  | 2           |
| 16 - 64         | Coarse Gravel  | 49          |
| 64 - 256        | Cobble         | 52          |
| 256 - 4096      | Boulder        | 5           |



# Pebble Count Workbook

STREAM NAME: Catherine Creek  
SITE: PC-R7-1 (RM 52.30 - Dry)

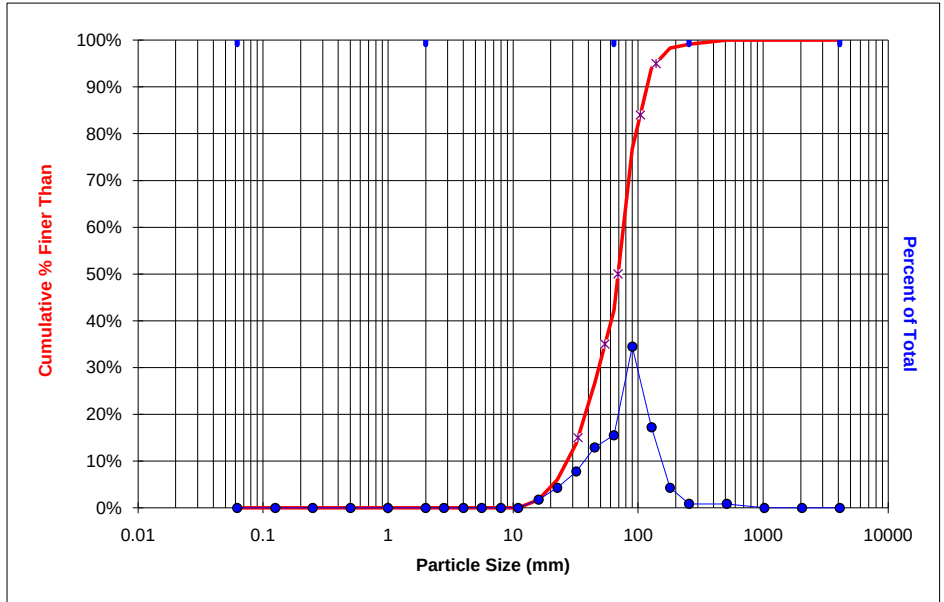
DATE: 11/10/2010  
CREW: McAfee

## Pebble Count Worksheet

| Gravelometer (mm) | Particle Size (mm) | % finer than | Total Count |
|-------------------|--------------------|--------------|-------------|
| 0.062             | <0.062             | 0%           | 0           |
| 0.125             | 0.062 - 0.125      | 0%           | 0           |
| 0.25              | 0.125 - 0.25       | 0%           | 0           |
| 0.5               | 0.25 - 0.5         | 0%           | 0           |
| 1                 | 0.5 - 1.0          | 0%           | 0           |
| 2                 | 1 - 2              | 0%           | 0           |
| 2.8               | 2 - 2.8            | 0%           | 0           |
| 4                 | 2.8 - 4            | 0%           | 0           |
| 5.6               | 4 - 5.6            | 0%           | 0           |
| 8                 | 5.6 - 8            | 0%           | 0           |
| 11                | 8 - 11             | 0%           | 0           |
| 16                | 11 - 16            | 2%           | 2           |
| 22.6              | 16 - 22.6          | 6%           | 5           |
| 32                | 22.6 - 32          | 14%          | 9           |
| 45                | 32 - 45            | 27%          | 15          |
| 64                | 45 - 64            | 42%          | 18          |
| 90                | 64 - 90            | 77%          | 40          |
| 128               | 90 - 128           | 94%          | 20          |
| 180               | 128 - 180          | 98%          | 5           |
| 256               | 180 - 256          | 99%          | 1           |
| 512               | 256 - 512          | 100%         | 1           |
| 1024              | 512 - 1024         | 100%         | 0           |
| 2048              | 1024 - 2048        | 100%         | 0           |
| 4096              | 2048 - 4096        | 100%         | 0           |

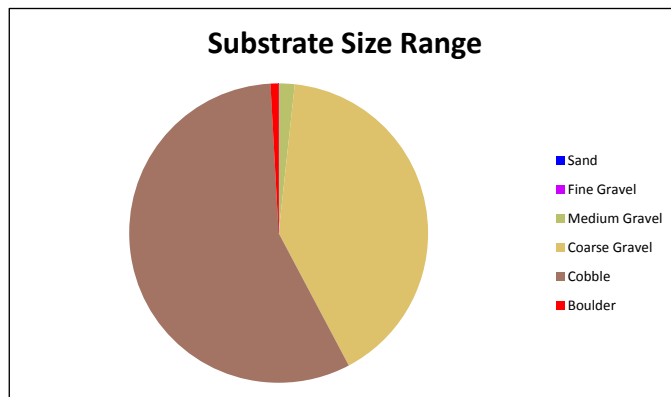
Particle Size Distribution (mm)

| D15  | D35  | D50  | D84   | D95   |
|------|------|------|-------|-------|
| 33.0 | 54.3 | 69.1 | 104.4 | 138.9 |



## Size Range Worksheet

| Size Range (mm) | Classification | Total Count |
|-----------------|----------------|-------------|
| 0.062 - 2.0     | Sand           | 0           |
| 2 - 8           | Fine Gravel    | 0           |
| 8 - 16          | Medium Gravel  | 2           |
| 16 - 64         | Coarse Gravel  | 47          |
| 64 - 256        | Cobble         | 66          |
| 256 - 4096      | Boulder        | 1           |





# Pebble Count Workbook

STREAM NAME:  
SITE:

Catherine Creek  
PC-R7-1 (RM 52.30 - Wet)

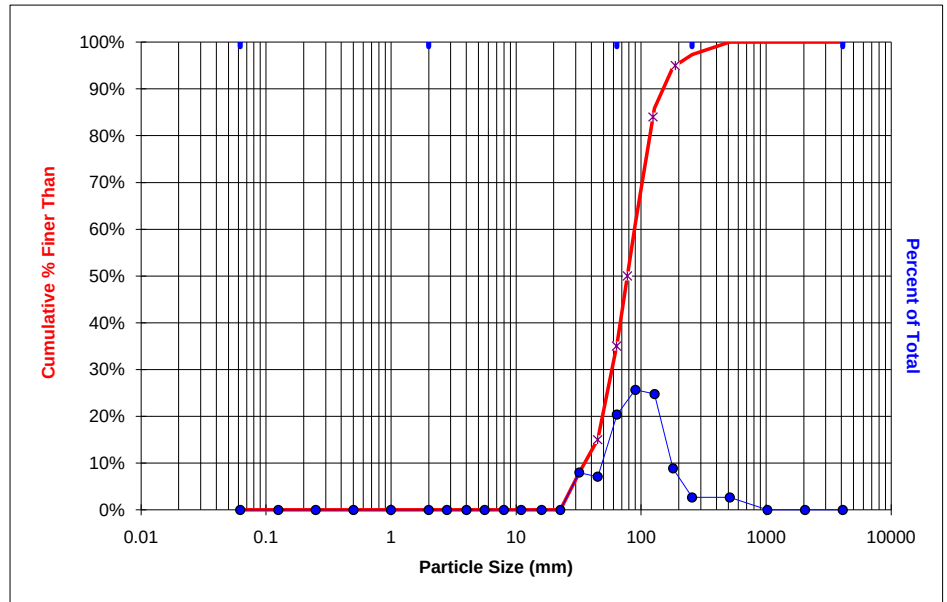
DATE: 11/10/2010  
CREW: McAfee

## Pebble Count Worksheet

| Gravelometer (mm) | Particle Size (mm) | % finer than | Total Count |
|-------------------|--------------------|--------------|-------------|
| 0.062             | <0.062             | 0%           | 0           |
| 0.125             | 0.062 - 0.125      | 0%           | 0           |
| 0.25              | 0.125 - 0.25       | 0%           | 0           |
| 0.5               | 0.25 - 0.5         | 0%           | 0           |
| 1                 | 0.5 - 1.0          | 0%           | 0           |
| 2                 | 1 - 2              | 0%           | 0           |
| 2.8               | 2 - 2.8            | 0%           | 0           |
| 4                 | 2.8 - 4            | 0%           | 0           |
| 5.6               | 4 - 5.6            | 0%           | 0           |
| 8                 | 5.6 - 8            | 0%           | 0           |
| 11                | 8 - 11             | 0%           | 0           |
| 16                | 11 - 16            | 0%           | 0           |
| 22.6              | 16 - 22.6          | 0%           | 0           |
| 32                | 22.6 - 32          | 8%           | 9           |
| 45                | 32 - 45            | 15%          | 8           |
| 64                | 45 - 64            | 35%          | 23          |
| 90                | 64 - 90            | 61%          | 29          |
| 128               | 90 - 128           | 86%          | 28          |
| 180               | 128 - 180          | 95%          | 10          |
| 256               | 180 - 256          | 97%          | 3           |
| 512               | 256 - 512          | 100%         | 3           |
| 1024              | 512 - 1024         | 100%         | 0           |
| 2048              | 1024 - 2048        | 100%         | 0           |
| 4096              | 2048 - 4096        | 100%         | 0           |

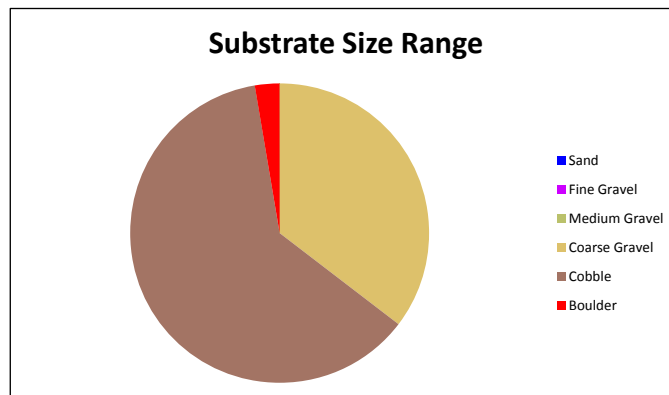
Particle Size  
Distribution (mm)

| D15  | D35  | D50  | D84   | D95   |
|------|------|------|-------|-------|
| 44.9 | 63.6 | 77.7 | 124.7 | 187.6 |



## Size Range Worksheet

| Size Range (mm) | Classification | Total Count |
|-----------------|----------------|-------------|
| 0.062 - 2.0     | Sand           | 0           |
| 2 - 8           | Fine Gravel    | 0           |
| 8 - 16          | Medium Gravel  | 0           |
| 16 - 64         | Coarse Gravel  | 40          |
| 64 - 256        | Cobble         | 70          |
| 256 - 4096      | Boulder        | 3           |



# Pebble Count Workbook

STREAM NAME:  
SITE:

Catherine Creek  
PC-R6-1 (RM 51.72)

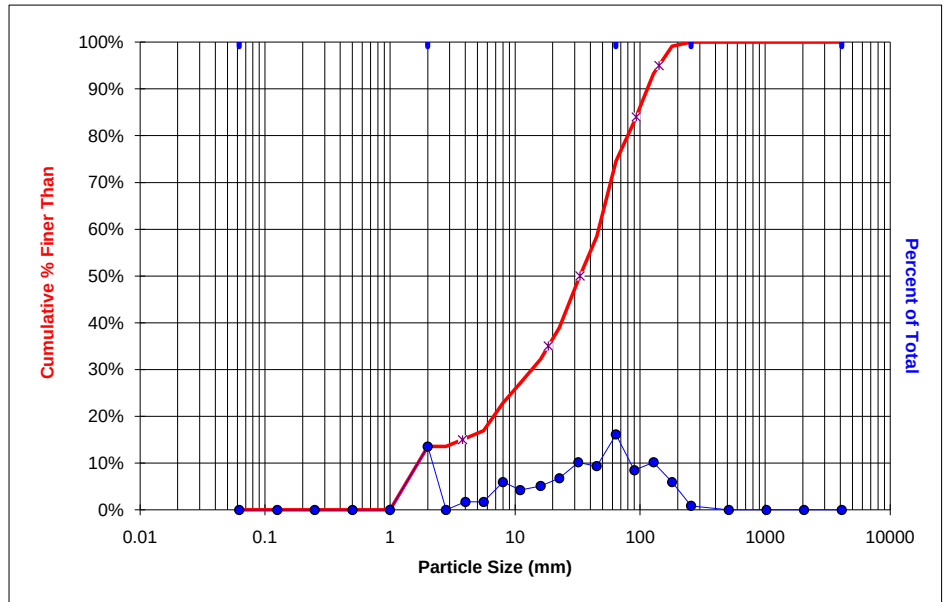
DATE: 8/19/2010  
CREW: McAffee

## Pebble Count Worksheet

| Gravelometer (mm) | Particle Size (mm) | % finer than | Total Count |
|-------------------|--------------------|--------------|-------------|
| 0.062             | <0.062             | 0%           | 0           |
| 0.125             | 0.062 - 0.125      | 0%           | 0           |
| 0.25              | 0.125 - 0.25       | 0%           | 0           |
| 0.5               | 0.25 - 0.5         | 0%           | 0           |
| 1                 | 0.5 - 1.0          | 0%           | 0           |
| 2                 | 1 - 2              | 14%          | 16          |
| 2.8               | 2 - 2.8            | 14%          | 0           |
| 4                 | 2.8 - 4            | 15%          | 2           |
| 5.6               | 4 - 5.6            | 17%          | 2           |
| 8                 | 5.6 - 8            | 23%          | 7           |
| 11                | 8 - 11             | 27%          | 5           |
| 16                | 11 - 16            | 32%          | 6           |
| 22.6              | 16 - 22.6          | 39%          | 8           |
| 32                | 22.6 - 32          | 49%          | 12          |
| 45                | 32 - 45            | 58%          | 11          |
| 64                | 45 - 64            | 75%          | 19          |
| 90                | 64 - 90            | 83%          | 10          |
| 128               | 90 - 128           | 93%          | 12          |
| 180               | 128 - 180          | 99%          | 7           |
| 256               | 180 - 256          | 100%         | 1           |
| 512               | 256 - 512          | 100%         | 0           |
| 1024              | 512 - 1024         | 100%         | 0           |
| 2048              | 1024 - 2048        | 100%         | 0           |
| 4096              | 2048 - 4096        | 100%         | 0           |

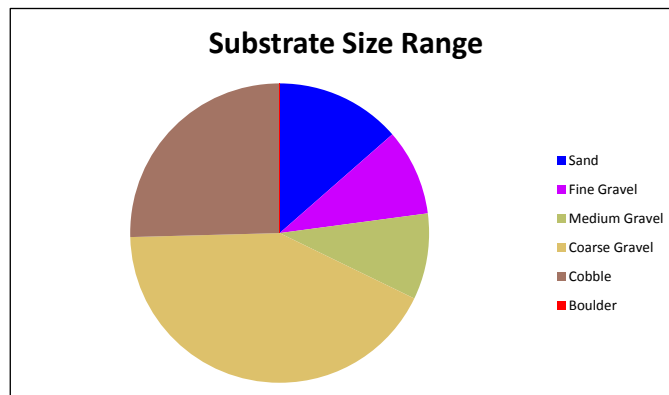
Particle Size  
Distribution (mm)

| D15 | D35  | D50  | D84  | D95   |
|-----|------|------|------|-------|
| 3.8 | 18.4 | 33.0 | 93.0 | 141.8 |



## Size Range Worksheet

| Size Range (mm) | Classification | Total Count |
|-----------------|----------------|-------------|
| 0.062 - 2.0     | Sand           | 16          |
| 2 - 8           | Fine Gravel    | 11          |
| 8 - 16          | Medium Gravel  | 11          |
| 16 - 64         | Coarse Gravel  | 50          |
| 64 - 256        | Cobble         | 30          |
| 256 - 4096      | Boulder        | 0           |



# Pebble Count Workbook

STREAM NAME:  
SITE:

Catherine Creek  
PC-R6-2 (RM 51.30)

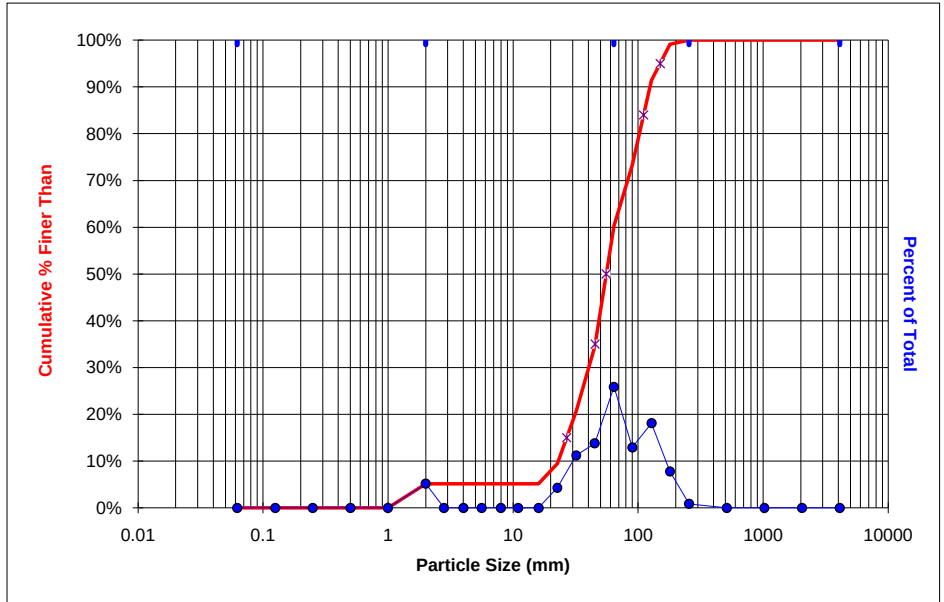
DATE: 8/19/2010  
CREW: McAfee

## Pebble Count Worksheet

| Gravelometer (mm) | Particle Size (mm) | % finer than | Total Count |
|-------------------|--------------------|--------------|-------------|
| 0.062             | <0.062             | 0%           | 0           |
| 0.125             | 0.062 - 0.125      | 0%           | 0           |
| 0.25              | 0.125 - 0.25       | 0%           | 0           |
| 0.5               | 0.25 - 0.5         | 0%           | 0           |
| 1                 | 0.5 - 1.0          | 0%           | 0           |
| 2                 | 1 - 2              | 5%           | 6           |
| 2.8               | 2 - 2.8            | 5%           | 0           |
| 4                 | 2.8 - 4            | 5%           | 0           |
| 5.6               | 4 - 5.6            | 5%           | 0           |
| 8                 | 5.6 - 8            | 5%           | 0           |
| 11                | 8 - 11             | 5%           | 0           |
| 16                | 11 - 16            | 5%           | 0           |
| 22.6              | 16 - 22.6          | 9%           | 5           |
| 32                | 22.6 - 32          | 21%          | 13          |
| 45                | 32 - 45            | 34%          | 16          |
| 64                | 45 - 64            | 60%          | 30          |
| 90                | 64 - 90            | 73%          | 15          |
| 128               | 90 - 128           | 91%          | 21          |
| 180               | 128 - 180          | 99%          | 9           |
| 256               | 180 - 256          | 100%         | 1           |
| 512               | 256 - 512          | 100%         | 0           |
| 1024              | 512 - 1024         | 100%         | 0           |
| 2048              | 1024 - 2048        | 100%         | 0           |
| 4096              | 2048 - 4096        | 100%         | 0           |

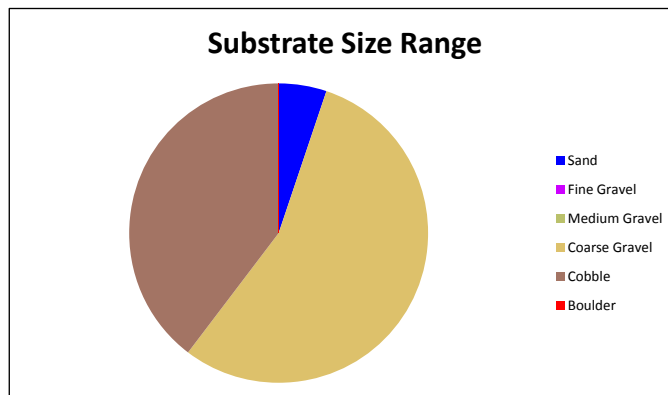
Particle Size  
Distribution (mm)

| D15  | D35  | D50  | D84   | D95   |
|------|------|------|-------|-------|
| 26.8 | 45.3 | 55.6 | 110.9 | 150.1 |



## Size Range Worksheet

| Size Range (mm) | Classification | Total Count |
|-----------------|----------------|-------------|
| 0.062 - 2.0     | Sand           | 6           |
| 2 - 8           | Fine Gravel    | 0           |
| 8 - 16          | Medium Gravel  | 0           |
| 16 - 64         | Coarse Gravel  | 64          |
| 64 - 256        | Cobble         | 46          |
| 256 - 4096      | Boulder        | 0           |





# Pebble Count Workbook

STREAM NAME:  
SITE:

Catherine Creek  
PC-R5-4 (RM 49.65)

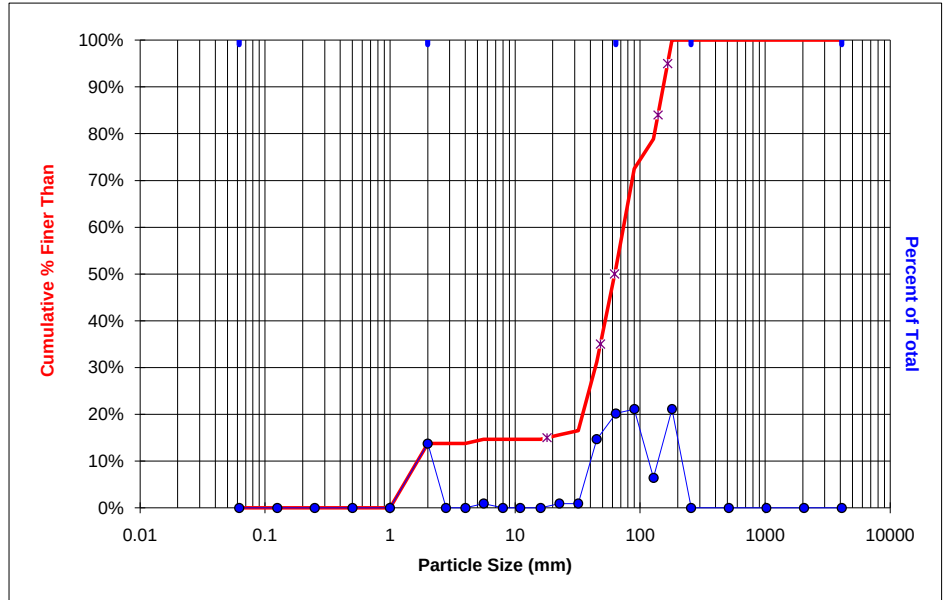
DATE: 8/17/2010  
CREW: McAfee

## Pebble Count Worksheet

| Gravelometer (mm) | Particle Size (mm) | % finer than | Total Count |
|-------------------|--------------------|--------------|-------------|
| 0.062             | <0.062             | 0%           | 0           |
| 0.125             | 0.062 - 0.125      | 0%           | 0           |
| 0.25              | 0.125 - 0.25       | 0%           | 0           |
| 0.5               | 0.25 - 0.5         | 0%           | 0           |
| 1                 | 0.5 - 1.0          | 0%           | 0           |
| 2                 | 1 - 2              | 14%          | 15          |
| 2.8               | 2 - 2.8            | 14%          | 0           |
| 4                 | 2.8 - 4            | 14%          | 0           |
| 5.6               | 4 - 5.6            | 15%          | 1           |
| 8                 | 5.6 - 8            | 15%          | 0           |
| 11                | 8 - 11             | 15%          | 0           |
| 16                | 11 - 16            | 15%          | 0           |
| 22.6              | 16 - 22.6          | 16%          | 1           |
| 32                | 22.6 - 32          | 17%          | 1           |
| 45                | 32 - 45            | 31%          | 16          |
| 64                | 45 - 64            | 51%          | 22          |
| 90                | 64 - 90            | 72%          | 23          |
| 128               | 90 - 128           | 79%          | 7           |
| 180               | 128 - 180          | 100%         | 23          |
| 256               | 180 - 256          | 100%         | 0           |
| 512               | 256 - 512          | 100%         | 0           |
| 1024              | 512 - 1024         | 100%         | 0           |
| 2048              | 1024 - 2048        | 100%         | 0           |
| 4096              | 2048 - 4096        | 100%         | 0           |

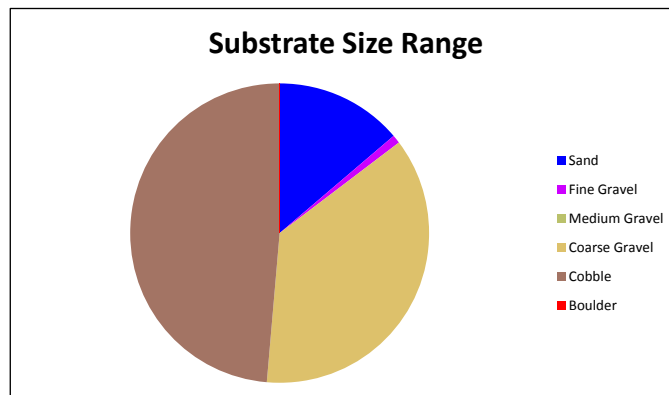
Particle Size  
Distribution (mm)

| D15  | D35  | D50  | D84   | D95   |
|------|------|------|-------|-------|
| 18.1 | 48.1 | 62.5 | 139.0 | 166.0 |



## Size Range Worksheet

| Size Range (mm) | Classification | Total Count |
|-----------------|----------------|-------------|
| 0.062 - 2.0     | Sand           | 15          |
| 2 - 8           | Fine Gravel    | 1           |
| 8 - 16          | Medium Gravel  | 0           |
| 16 - 64         | Coarse Gravel  | 40          |
| 64 - 256        | Cobble         | 53          |
| 256 - 4096      | Boulder        | 0           |



# Pebble Count Workbook

STREAM NAME:  
SITE:

Catherine Creek  
PC-R5-3 (RM 48.24)

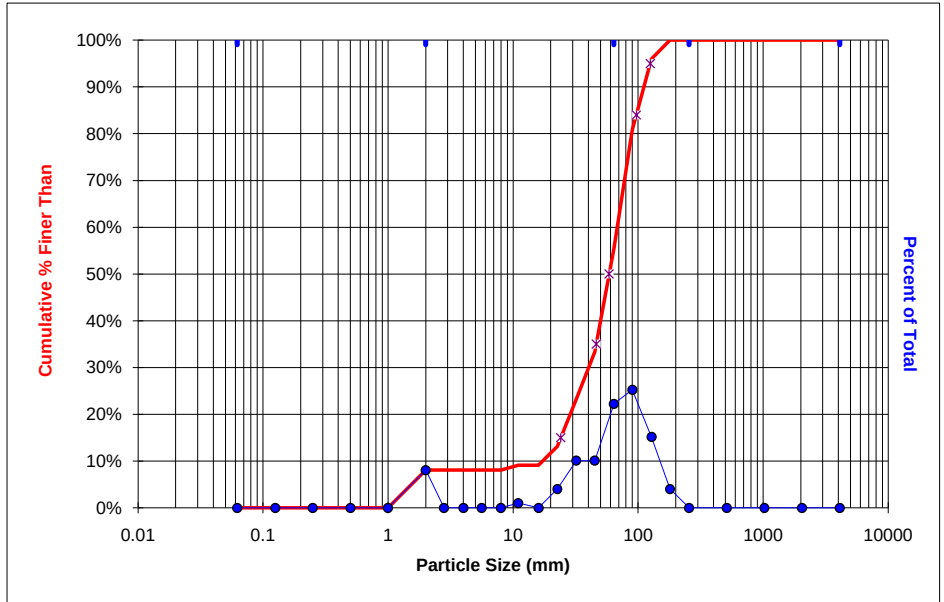
DATE: 8/17/2010  
CREW: McAfee

## Pebble Count Worksheet

| Gravelometer (mm) | Particle Size (mm) | % finer than | Total Count |
|-------------------|--------------------|--------------|-------------|
| 0.062             | <0.062             | 0%           | 0           |
| 0.125             | 0.062 - 0.125      | 0%           | 0           |
| 0.25              | 0.125 - 0.25       | 0%           | 0           |
| 0.5               | 0.25 - 0.5         | 0%           | 0           |
| 1                 | 0.5 - 1.0          | 0%           | 0           |
| 2                 | 1 - 2              | 8%           | 8           |
| 2.8               | 2 - 2.8            | 8%           | 0           |
| 4                 | 2.8 - 4            | 8%           | 0           |
| 5.6               | 4 - 5.6            | 8%           | 0           |
| 8                 | 5.6 - 8            | 8%           | 0           |
| 11                | 8 - 11             | 9%           | 1           |
| 16                | 11 - 16            | 9%           | 0           |
| 22.6              | 16 - 22.6          | 13%          | 4           |
| 32                | 22.6 - 32          | 23%          | 10          |
| 45                | 32 - 45            | 33%          | 10          |
| 64                | 45 - 64            | 56%          | 22          |
| 90                | 64 - 90            | 81%          | 25          |
| 128               | 90 - 128           | 96%          | 15          |
| 180               | 128 - 180          | 100%         | 4           |
| 256               | 180 - 256          | 100%         | 0           |
| 512               | 256 - 512          | 100%         | 0           |
| 1024              | 512 - 1024         | 100%         | 0           |
| 2048              | 1024 - 2048        | 100%         | 0           |
| 4096              | 2048 - 4096        | 100%         | 0           |

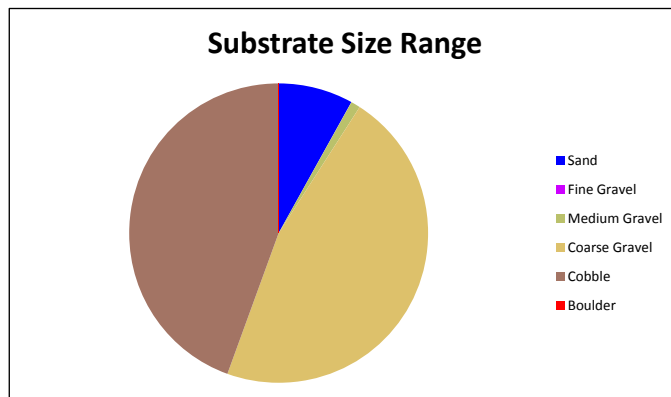
Particle Size  
Distribution (mm)

| D15  | D35  | D50  | D84  | D95   |
|------|------|------|------|-------|
| 24.1 | 46.2 | 58.6 | 96.9 | 125.2 |



## Size Range Worksheet

| Size Range (mm) | Classification | Total Count |
|-----------------|----------------|-------------|
| 0.062 - 2.0     | Sand           | 8           |
| 2 - 8           | Fine Gravel    | 0           |
| 8 - 16          | Medium Gravel  | 1           |
| 16 - 64         | Coarse Gravel  | 46          |
| 64 - 256        | Cobble         | 44          |
| 256 - 4096      | Boulder        | 0           |



# Pebble Count Workbook

STREAM NAME:  
SITE:

Catherine Creek  
PC-R5-2 (RM 46.93)

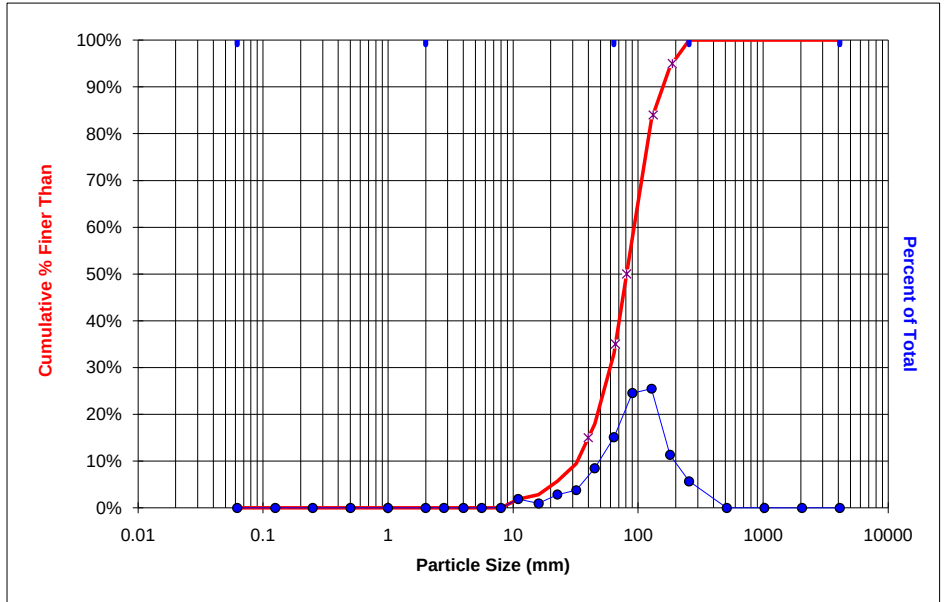
DATE: 8/18/2010  
CREW: McAfee

## Pebble Count Worksheet

| Gravelometer (mm) | Particle Size (mm) | % finer than | Total Count |
|-------------------|--------------------|--------------|-------------|
| 0.062             | <0.062             | 0%           | 0           |
| 0.125             | 0.062 - 0.125      | 0%           | 0           |
| 0.25              | 0.125 - 0.25       | 0%           | 0           |
| 0.5               | 0.25 - 0.5         | 0%           | 0           |
| 1                 | 0.5 - 1.0          | 0%           | 0           |
| 2                 | 1 - 2              | 0%           | 0           |
| 2.8               | 2 - 2.8            | 0%           | 0           |
| 4                 | 2.8 - 4            | 0%           | 0           |
| 5.6               | 4 - 5.6            | 0%           | 0           |
| 8                 | 5.6 - 8            | 0%           | 0           |
| 11                | 8 - 11             | 2%           | 2           |
| 16                | 11 - 16            | 3%           | 1           |
| 22.6              | 16 - 22.6          | 6%           | 3           |
| 32                | 22.6 - 32          | 9%           | 4           |
| 45                | 32 - 45            | 18%          | 9           |
| 64                | 45 - 64            | 33%          | 16          |
| 90                | 64 - 90            | 58%          | 26          |
| 128               | 90 - 128           | 83%          | 27          |
| 180               | 128 - 180          | 94%          | 12          |
| 256               | 180 - 256          | 100%         | 6           |
| 512               | 256 - 512          | 100%         | 0           |
| 1024              | 512 - 1024         | 100%         | 0           |
| 2048              | 1024 - 2048        | 100%         | 0           |
| 4096              | 2048 - 4096        | 100%         | 0           |

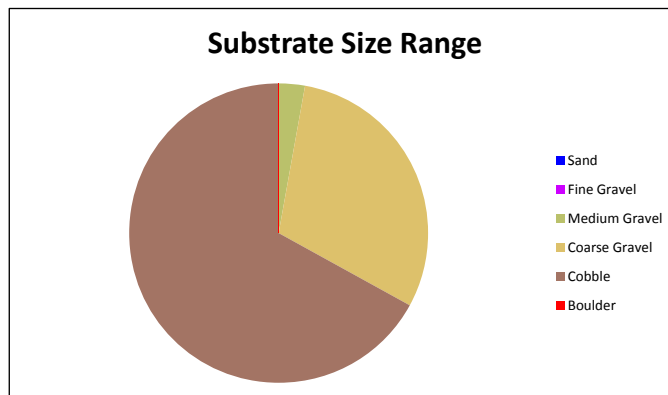
Particle Size  
Distribution (mm)

| D15  | D35  | D50  | D84   | D95   |
|------|------|------|-------|-------|
| 40.0 | 65.8 | 81.0 | 131.8 | 187.6 |



## Size Range Worksheet

| Size Range (mm) | Classification | Total Count |
|-----------------|----------------|-------------|
| 0.062 - 2.0     | Sand           | 0           |
| 2 - 8           | Fine Gravel    | 0           |
| 8 - 16          | Medium Gravel  | 3           |
| 16 - 64         | Coarse Gravel  | 32          |
| 64 - 256        | Cobble         | 71          |
| 256 - 4096      | Boulder        | 0           |





# Pebble Count Workbook

STREAM NAME:  
SITE:

Catherine Creek  
PC-R5-1 (RM 46.09)

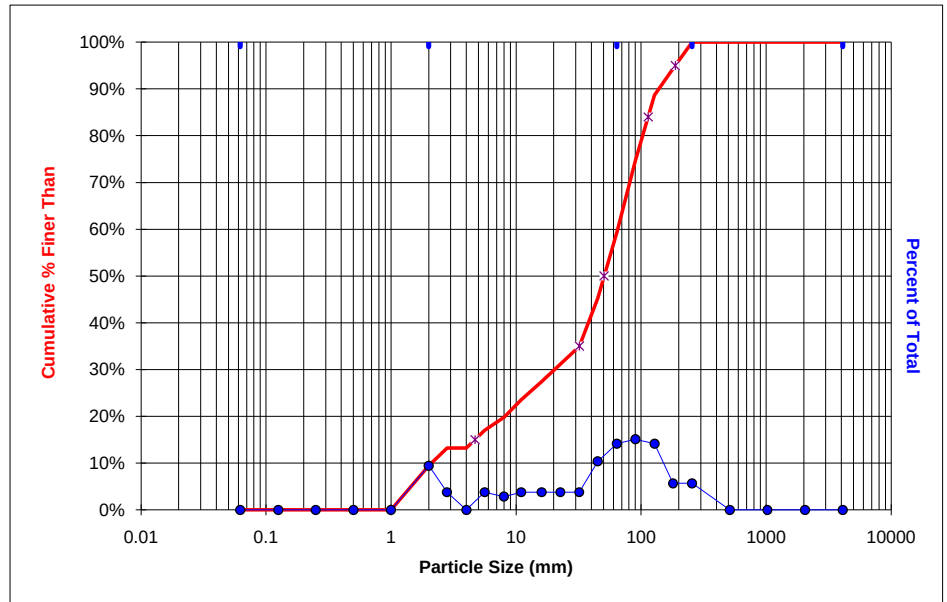
DATE: 8/18/2010  
CREW: McAfee

## Pebble Count Worksheet

| Gravelometer (mm) | Particle Size (mm) | % finer than | Total Count |
|-------------------|--------------------|--------------|-------------|
| 0.062             | <0.062             | 0%           | 0           |
| 0.125             | 0.062 - 0.125      | 0%           | 0           |
| 0.25              | 0.125 - 0.25       | 0%           | 0           |
| 0.5               | 0.25 - 0.5         | 0%           | 0           |
| 1                 | 0.5 - 1.0          | 0%           | 0           |
| 2                 | 1 - 2              | 9%           | 10          |
| 2.8               | 2 - 2.8            | 13%          | 4           |
| 4                 | 2.8 - 4            | 13%          | 0           |
| 5.6               | 4 - 5.6            | 17%          | 4           |
| 8                 | 5.6 - 8            | 20%          | 3           |
| 11                | 8 - 11             | 24%          | 4           |
| 16                | 11 - 16            | 27%          | 4           |
| 22.6              | 16 - 22.6          | 31%          | 4           |
| 32                | 22.6 - 32          | 35%          | 4           |
| 45                | 32 - 45            | 45%          | 11          |
| 64                | 45 - 64            | 59%          | 15          |
| 90                | 64 - 90            | 75%          | 16          |
| 128               | 90 - 128           | 89%          | 15          |
| 180               | 128 - 180          | 94%          | 6           |
| 256               | 180 - 256          | 100%         | 6           |
| 512               | 256 - 512          | 100%         | 0           |
| 1024              | 512 - 1024         | 100%         | 0           |
| 2048              | 1024 - 2048        | 100%         | 0           |
| 4096              | 2048 - 4096        | 100%         | 0           |

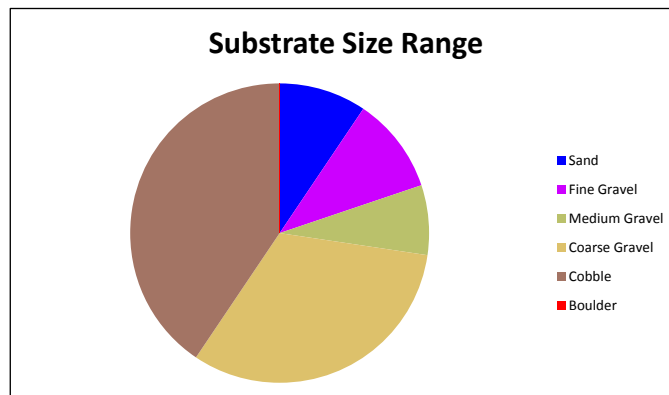
Particle Size  
Distribution (mm)

| D15 | D35  | D50  | D84   | D95   |
|-----|------|------|-------|-------|
| 4.7 | 32.1 | 50.6 | 113.9 | 187.6 |



## Size Range Worksheet

| Size Range (mm) | Classification | Total Count |
|-----------------|----------------|-------------|
| 0.062 - 2.0     | Sand           | 10          |
| 2 - 8           | Fine Gravel    | 11          |
| 8 - 16          | Medium Gravel  | 8           |
| 16 - 64         | Coarse Gravel  | 34          |
| 64 - 256        | Cobble         | 43          |
| 256 - 4096      | Boulder        | 0           |



# Pebble Count Workbook

STREAM NAME:  
SITE:

Catherine Creek  
PC-R4-4 (RM 44.90)

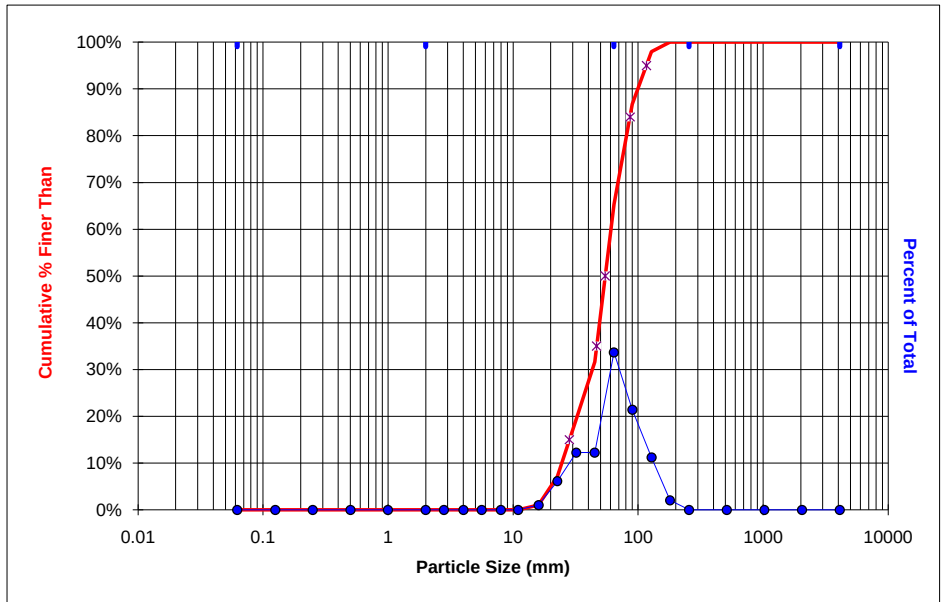
DATE: 8/18/2010  
CREW: McAffee

## Pebble Count Worksheet

| Gravelometer (mm) | Particle Size (mm) | % finer than | Total Count |
|-------------------|--------------------|--------------|-------------|
| 0.062             | <0.062             | 0%           | 0           |
| 0.125             | 0.062 - 0.125      | 0%           | 0           |
| 0.25              | 0.125 - 0.25       | 0%           | 0           |
| 0.5               | 0.25 - 0.5         | 0%           | 0           |
| 1                 | 0.5 - 1.0          | 0%           | 0           |
| 2                 | 1 - 2              | 0%           | 0           |
| 2.8               | 2 - 2.8            | 0%           | 0           |
| 4                 | 2.8 - 4            | 0%           | 0           |
| 5.6               | 4 - 5.6            | 0%           | 0           |
| 8                 | 5.6 - 8            | 0%           | 0           |
| 11                | 8 - 11             | 0%           | 0           |
| 16                | 11 - 16            | 1%           | 1           |
| 22.6              | 16 - 22.6          | 7%           | 6           |
| 32                | 22.6 - 32          | 19%          | 12          |
| 45                | 32 - 45            | 32%          | 12          |
| 64                | 45 - 64            | 65%          | 33          |
| 90                | 64 - 90            | 87%          | 21          |
| 128               | 90 - 128           | 98%          | 11          |
| 180               | 128 - 180          | 100%         | 2           |
| 256               | 180 - 256          | 100%         | 0           |
| 512               | 256 - 512          | 100%         | 0           |
| 1024              | 512 - 1024         | 100%         | 0           |
| 2048              | 1024 - 2048        | 100%         | 0           |
| 4096              | 2048 - 4096        | 100%         | 0           |

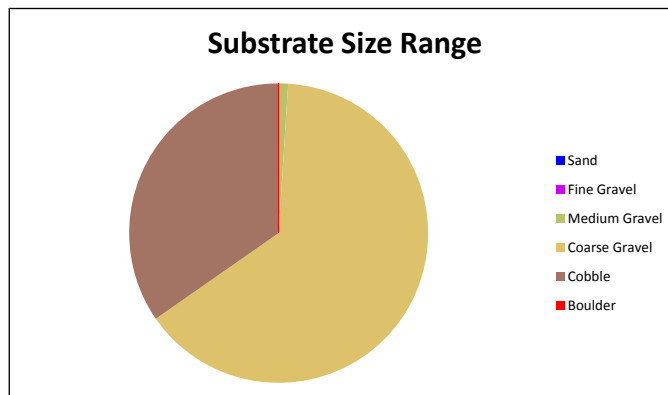
Particle Size  
Distribution (mm)

| D15  | D35  | D50  | D84  | D95   |
|------|------|------|------|-------|
| 28.3 | 46.6 | 54.5 | 86.2 | 116.6 |



## Size Range Worksheet

| Size Range (mm) | Classification | Total Count |
|-----------------|----------------|-------------|
| 0.062 - 2.0     | Sand           | 0           |
| 2 - 8           | Fine Gravel    | 0           |
| 8 - 16          | Medium Gravel  | 1           |
| 16 - 64         | Coarse Gravel  | 63          |
| 64 - 256        | Cobble         | 34          |
| 256 - 4096      | Boulder        | 0           |



# Pebble Count Workbook

STREAM NAME:  
SITE:

Catherine Creek  
PC-R4-3 (RM 43.25)

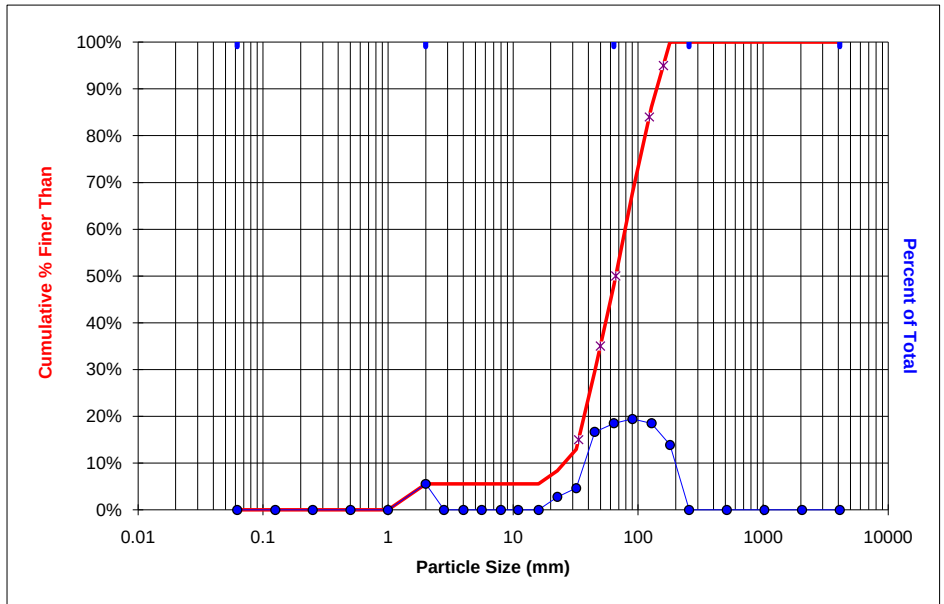
DATE: 8/19/2010  
CREW: McAfee

## Pebble Count Worksheet

| Gravelometer (mm) | Particle Size (mm) | % finer than | Total Count |
|-------------------|--------------------|--------------|-------------|
| 0.062             | <0.062             | 0%           | 0           |
| 0.125             | 0.062 - 0.125      | 0%           | 0           |
| 0.25              | 0.125 - 0.25       | 0%           | 0           |
| 0.5               | 0.25 - 0.5         | 0%           | 0           |
| 1                 | 0.5 - 1.0          | 0%           | 0           |
| 2                 | 1 - 2              | 6%           | 6           |
| 2.8               | 2 - 2.8            | 6%           | 0           |
| 4                 | 2.8 - 4            | 6%           | 0           |
| 5.6               | 4 - 5.6            | 6%           | 0           |
| 8                 | 5.6 - 8            | 6%           | 0           |
| 11                | 8 - 11             | 6%           | 0           |
| 16                | 11 - 16            | 6%           | 0           |
| 22.6              | 16 - 22.6          | 8%           | 3           |
| 32                | 22.6 - 32          | 13%          | 5           |
| 45                | 32 - 45            | 30%          | 18          |
| 64                | 45 - 64            | 48%          | 20          |
| 90                | 64 - 90            | 68%          | 21          |
| 128               | 90 - 128           | 86%          | 20          |
| 180               | 128 - 180          | 100%         | 15          |
| 256               | 180 - 256          | 100%         | 0           |
| 512               | 256 - 512          | 100%         | 0           |
| 1024              | 512 - 1024         | 100%         | 0           |
| 2048              | 1024 - 2048        | 100%         | 0           |
| 4096              | 2048 - 4096        | 100%         | 0           |

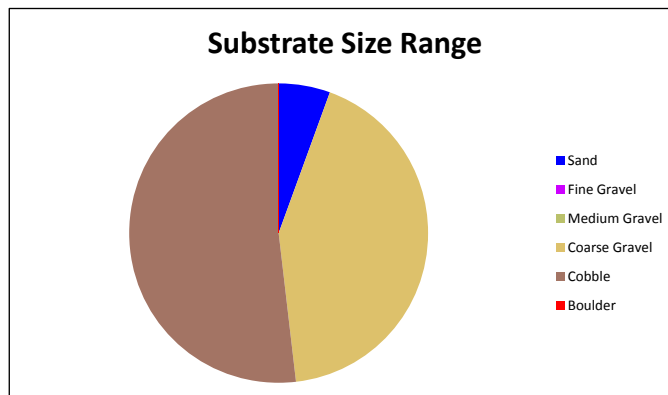
Particle Size  
Distribution (mm)

| D15  | D35  | D50  | D84   | D95   |
|------|------|------|-------|-------|
| 33.4 | 49.8 | 66.1 | 123.0 | 159.2 |



## Size Range Worksheet

| Size Range (mm) | Classification | Total Count |
|-----------------|----------------|-------------|
| 0.062 - 2.0     | Sand           | 6           |
| 2 - 8           | Fine Gravel    | 0           |
| 8 - 16          | Medium Gravel  | 0           |
| 16 - 64         | Coarse Gravel  | 46          |
| 64 - 256        | Cobble         | 56          |
| 256 - 4096      | Boulder        | 0           |





# Pebble Count Workbook

STREAM NAME:  
SITE:

Catherine Creek  
PC-R4-2 (RM 42.36)

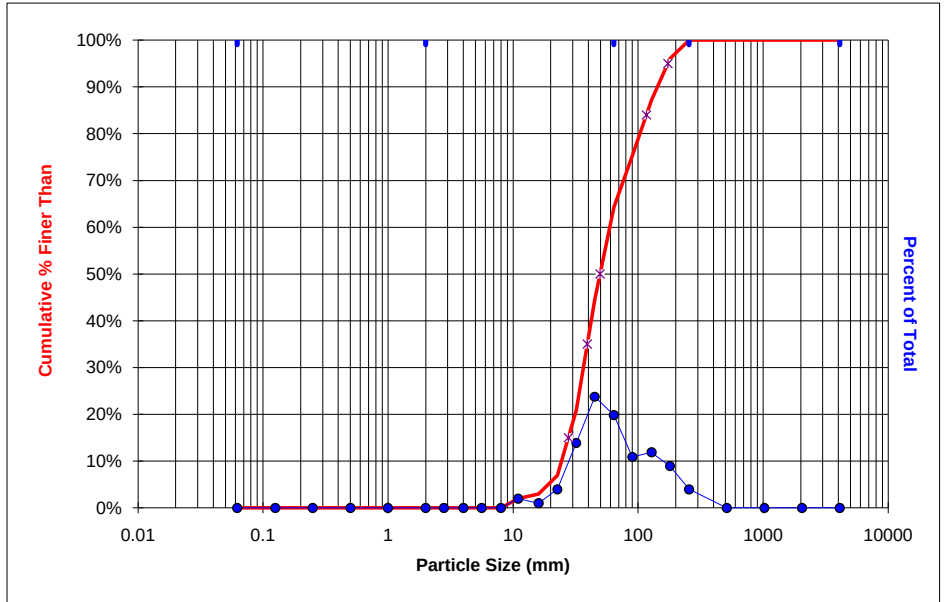
DATE: 8/16/2010  
CREW: McAfee

## Pebble Count Worksheet

| Gravelometer (mm) | Particle Size (mm) | % finer than | Total Count |
|-------------------|--------------------|--------------|-------------|
| 0.062             | <0.062             | 0%           | 0           |
| 0.125             | 0.062 - 0.125      | 0%           | 0           |
| 0.25              | 0.125 - 0.25       | 0%           | 0           |
| 0.5               | 0.25 - 0.5         | 0%           | 0           |
| 1                 | 0.5 - 1.0          | 0%           | 0           |
| 2                 | 1 - 2              | 0%           | 0           |
| 2.8               | 2 - 2.8            | 0%           | 0           |
| 4                 | 2.8 - 4            | 0%           | 0           |
| 5.6               | 4 - 5.6            | 0%           | 0           |
| 8                 | 5.6 - 8            | 0%           | 0           |
| 11                | 8 - 11             | 2%           | 2           |
| 16                | 11 - 16            | 3%           | 1           |
| 22.6              | 16 - 22.6          | 7%           | 4           |
| 32                | 22.6 - 32          | 21%          | 14          |
| 45                | 32 - 45            | 45%          | 24          |
| 64                | 45 - 64            | 64%          | 20          |
| 90                | 64 - 90            | 75%          | 11          |
| 128               | 90 - 128           | 87%          | 12          |
| 180               | 128 - 180          | 96%          | 9           |
| 256               | 180 - 256          | 100%         | 4           |
| 512               | 256 - 512          | 100%         | 0           |
| 1024              | 512 - 1024         | 100%         | 0           |
| 2048              | 1024 - 2048        | 100%         | 0           |
| 4096              | 2048 - 4096        | 100%         | 0           |

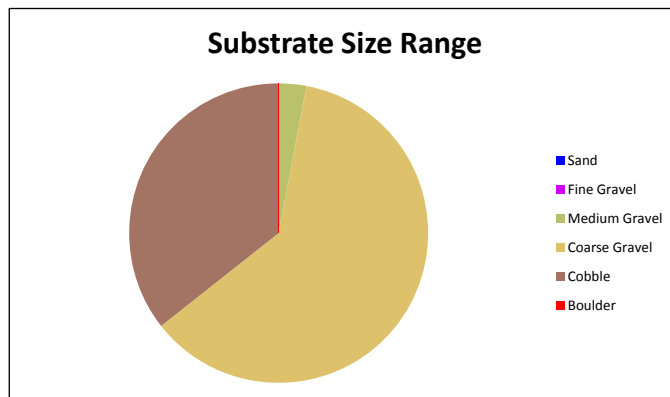
Particle Size  
Distribution (mm)

| D15  | D35  | D50  | D84   | D95   |
|------|------|------|-------|-------|
| 27.7 | 39.2 | 49.6 | 116.7 | 173.0 |



## Size Range Worksheet

| Size Range (mm) | Classification | Total Count |
|-----------------|----------------|-------------|
| 0.062 - 2.0     | Sand           | 0           |
| 2 - 8           | Fine Gravel    | 0           |
| 8 - 16          | Medium Gravel  | 3           |
| 16 - 64         | Coarse Gravel  | 62          |
| 64 - 256        | Cobble         | 36          |
| 256 - 4096      | Boulder        | 0           |



# Pebble Count Workbook

STREAM NAME:  
SITE:

Catherine Creek  
PC-R4-1 (RM 41.53)

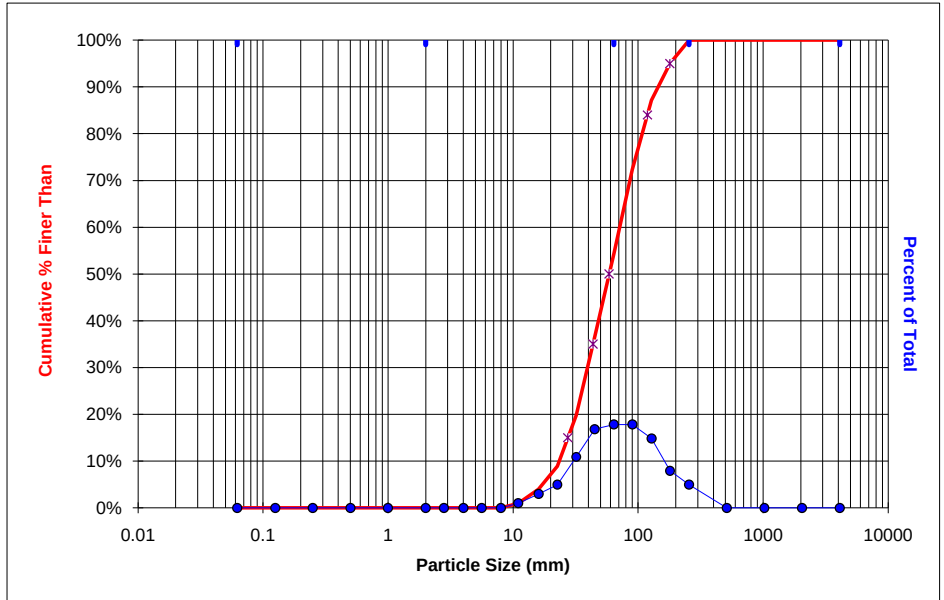
DATE: 8/16/2010  
CREW: McAfee

## Pebble Count Worksheet

| Gravelometer (mm) | Particle Size (mm) | % finer than | Total Count |
|-------------------|--------------------|--------------|-------------|
| 0.062             | <0.062             | 0%           | 0           |
| 0.125             | 0.062 - 0.125      | 0%           | 0           |
| 0.25              | 0.125 - 0.25       | 0%           | 0           |
| 0.5               | 0.25 - 0.5         | 0%           | 0           |
| 1                 | 0.5 - 1.0          | 0%           | 0           |
| 2                 | 1 - 2              | 0%           | 0           |
| 2.8               | 2 - 2.8            | 0%           | 0           |
| 4                 | 2.8 - 4            | 0%           | 0           |
| 5.6               | 4 - 5.6            | 0%           | 0           |
| 8                 | 5.6 - 8            | 0%           | 0           |
| 11                | 8 - 11             | 1%           | 1           |
| 16                | 11 - 16            | 4%           | 3           |
| 22.6              | 16 - 22.6          | 9%           | 5           |
| 32                | 22.6 - 32          | 20%          | 11          |
| 45                | 32 - 45            | 37%          | 17          |
| 64                | 45 - 64            | 54%          | 18          |
| 90                | 64 - 90            | 72%          | 18          |
| 128               | 90 - 128           | 87%          | 15          |
| 180               | 128 - 180          | 95%          | 8           |
| 256               | 180 - 256          | 100%         | 5           |
| 512               | 256 - 512          | 100%         | 0           |
| 1024              | 512 - 1024         | 100%         | 0           |
| 2048              | 1024 - 2048        | 100%         | 0           |
| 4096              | 2048 - 4096        | 100%         | 0           |

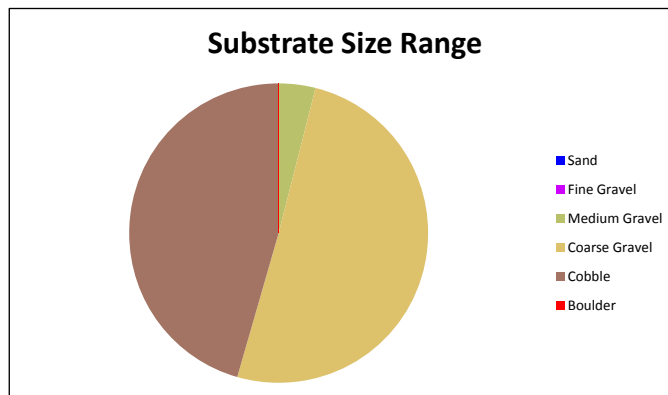
Particle Size  
Distribution (mm)

| D15  | D35  | D50  | D84   | D95   |
|------|------|------|-------|-------|
| 27.5 | 43.5 | 58.6 | 118.8 | 179.6 |



## Size Range Worksheet

| Size Range (mm) | Classification | Total Count |
|-----------------|----------------|-------------|
| 0.062 - 2.0     | Sand           | 0           |
| 2 - 8           | Fine Gravel    | 0           |
| 8 - 16          | Medium Gravel  | 4           |
| 16 - 64         | Coarse Gravel  | 51          |
| 64 - 256        | Cobble         | 46          |
| 256 - 4096      | Boulder        | 0           |



# Pebble Count Workbook

STREAM NAME:  
SITE:

Catherine Creek  
PC-R3-5 (RM 40.58)

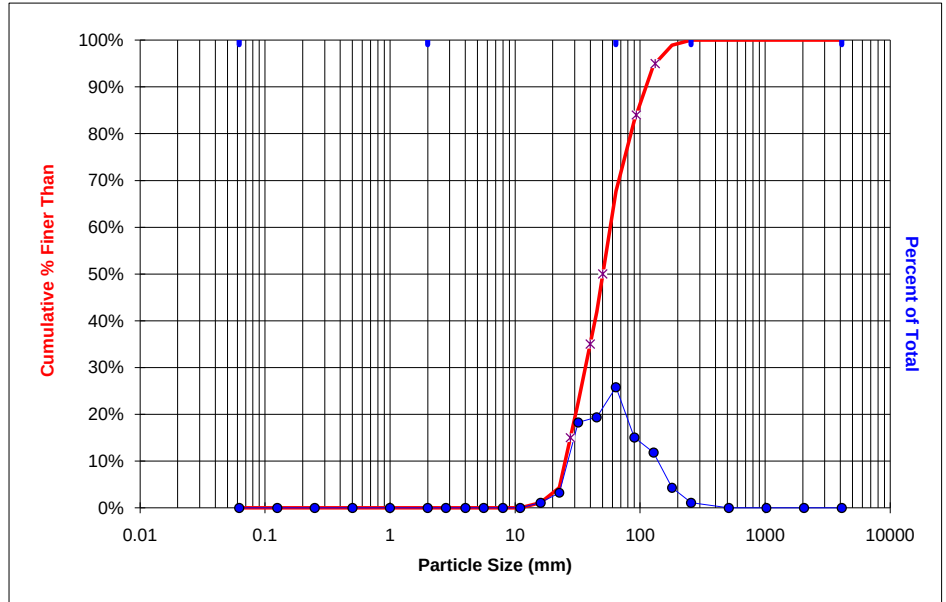
DATE: 8/2/2010  
CREW: McAfee

## Pebble Count Worksheet

| Gravelometer (mm) | Particle Size (mm) | % finer than | Total Count |
|-------------------|--------------------|--------------|-------------|
| 0.062             | <0.062             | 0%           | 0           |
| 0.125             | 0.062 - 0.125      | 0%           | 0           |
| 0.25              | 0.125 - 0.25       | 0%           | 0           |
| 0.5               | 0.25 - 0.5         | 0%           | 0           |
| 1                 | 0.5 - 1.0          | 0%           | 0           |
| 2                 | 1 - 2              | 0%           | 0           |
| 2.8               | 2 - 2.8            | 0%           | 0           |
| 4                 | 2.8 - 4            | 0%           | 0           |
| 5.6               | 4 - 5.6            | 0%           | 0           |
| 8                 | 5.6 - 8            | 0%           | 0           |
| 11                | 8 - 11             | 0%           | 0           |
| 16                | 11 - 16            | 1%           | 1           |
| 22.6              | 16 - 22.6          | 4%           | 3           |
| 32                | 22.6 - 32          | 23%          | 17          |
| 45                | 32 - 45            | 42%          | 18          |
| 64                | 45 - 64            | 68%          | 24          |
| 90                | 64 - 90            | 83%          | 14          |
| 128               | 90 - 128           | 95%          | 11          |
| 180               | 128 - 180          | 99%          | 4           |
| 256               | 180 - 256          | 100%         | 1           |
| 512               | 256 - 512          | 100%         | 0           |
| 1024              | 512 - 1024         | 100%         | 0           |
| 2048              | 1024 - 2048        | 100%         | 0           |
| 4096              | 2048 - 4096        | 100%         | 0           |

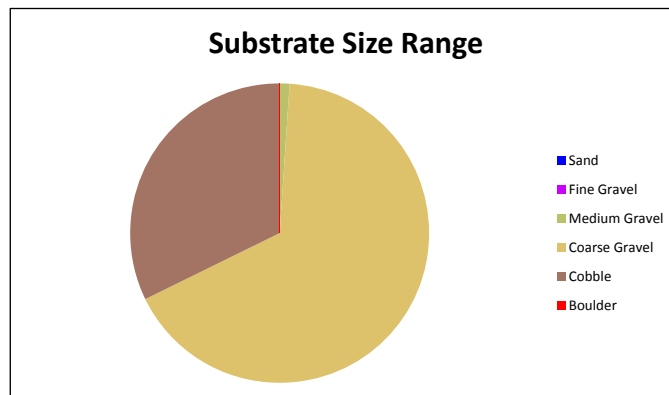
Particle Size  
Distribution (mm)

| D15  | D35  | D50  | D84  | D95   |
|------|------|------|------|-------|
| 27.7 | 39.8 | 50.2 | 93.3 | 131.9 |



## Size Range Worksheet

| Size Range (mm) | Classification | Total Count |
|-----------------|----------------|-------------|
| 0.062 - 2.0     | Sand           | 0           |
| 2 - 8           | Fine Gravel    | 0           |
| 8 - 16          | Medium Gravel  | 1           |
| 16 - 64         | Coarse Gravel  | 62          |
| 64 - 256        | Cobble         | 30          |
| 256 - 4096      | Boulder        | 0           |





# Pebble Count Workbook

STREAM NAME:  
SITE:

Catherine Creek  
PC-R3-4 (RM 39.63)

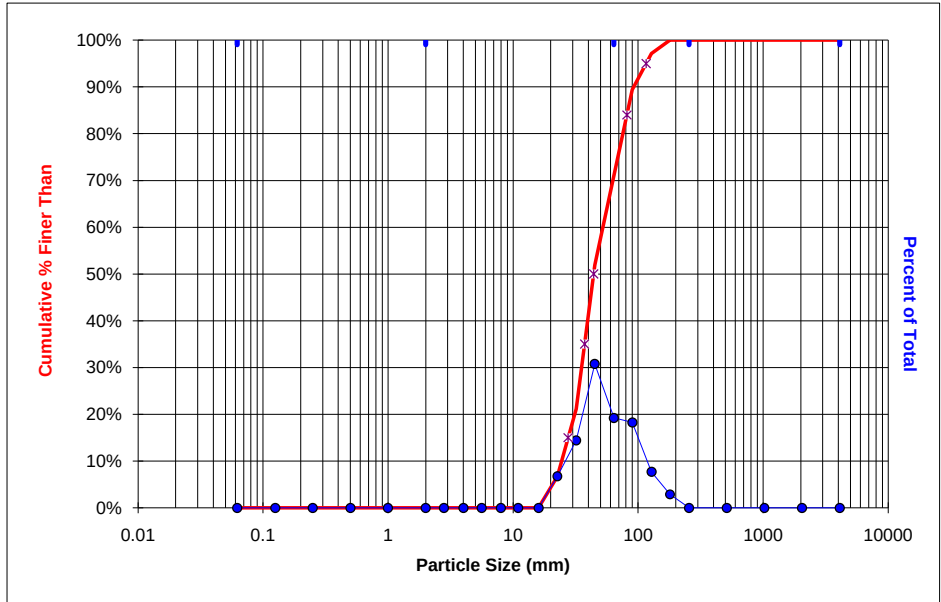
DATE: 8/2/2010  
CREW: McAfee

## Pebble Count Worksheet

| Gravelometer (mm) | Particle Size (mm) | % finer than | Total Count |
|-------------------|--------------------|--------------|-------------|
| 0.062             | <0.062             | 0%           | 0           |
| 0.125             | 0.062 - 0.125      | 0%           | 0           |
| 0.25              | 0.125 - 0.25       | 0%           | 0           |
| 0.5               | 0.25 - 0.5         | 0%           | 0           |
| 1                 | 0.5 - 1.0          | 0%           | 0           |
| 2                 | 1 - 2              | 0%           | 0           |
| 2.8               | 2 - 2.8            | 0%           | 0           |
| 4                 | 2.8 - 4            | 0%           | 0           |
| 5.6               | 4 - 5.6            | 0%           | 0           |
| 8                 | 5.6 - 8            | 0%           | 0           |
| 11                | 8 - 11             | 0%           | 0           |
| 16                | 11 - 16            | 0%           | 0           |
| 22.6              | 16 - 22.6          | 7%           | 7           |
| 32                | 22.6 - 32          | 21%          | 15          |
| 45                | 32 - 45            | 52%          | 32          |
| 64                | 45 - 64            | 71%          | 20          |
| 90                | 64 - 90            | 89%          | 19          |
| 128               | 90 - 128           | 97%          | 8           |
| 180               | 128 - 180          | 100%         | 3           |
| 256               | 180 - 256          | 100%         | 0           |
| 512               | 256 - 512          | 100%         | 0           |
| 1024              | 512 - 1024         | 100%         | 0           |
| 2048              | 1024 - 2048        | 100%         | 0           |
| 4096              | 2048 - 4096        | 100%         | 0           |

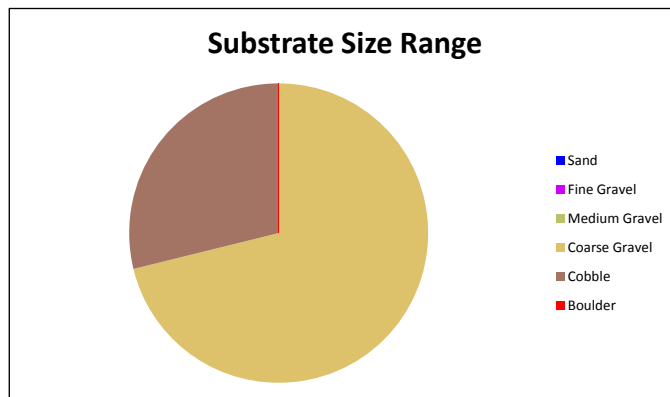
Particle Size  
Distribution (mm)

| D15  | D35  | D50  | D84  | D95   |
|------|------|------|------|-------|
| 27.6 | 37.3 | 44.1 | 81.3 | 116.2 |



## Size Range Worksheet

| Size Range (mm) | Classification | Total Count |
|-----------------|----------------|-------------|
| 0.062 - 2.0     | Sand           | 0           |
| 2 - 8           | Fine Gravel    | 0           |
| 8 - 16          | Medium Gravel  | 0           |
| 16 - 64         | Coarse Gravel  | 74          |
| 64 - 256        | Cobble         | 30          |
| 256 - 4096      | Boulder        | 0           |



# Pebble Count Workbook

STREAM NAME:  
SITE:

Catherine Creek  
PC-R3-3 (RM 39.60)

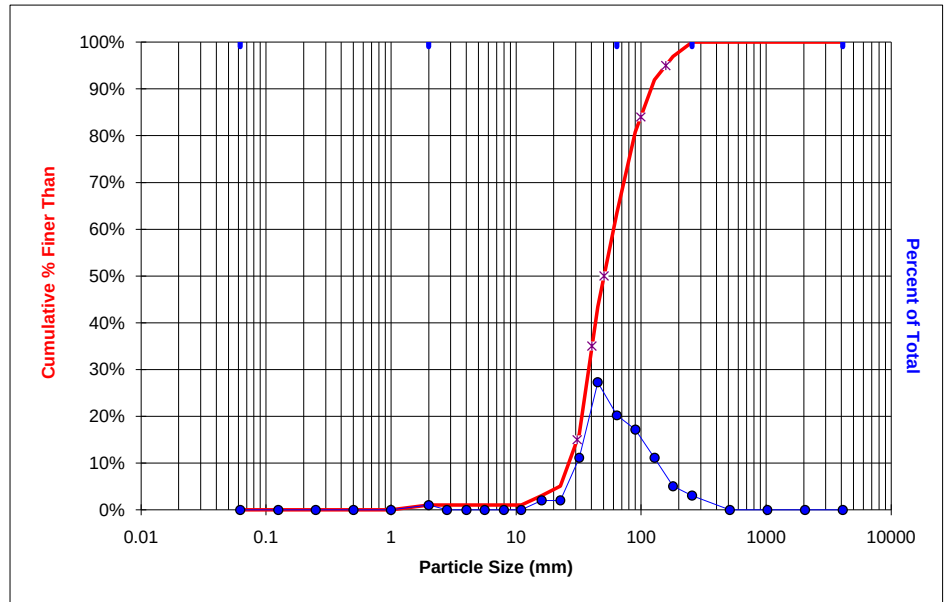
DATE: 8/2/2010  
CREW: McAfee

## Pebble Count Worksheet

| Gravelometer (mm) | Particle Size (mm) | % finer than | Total Count |
|-------------------|--------------------|--------------|-------------|
| 0.062             | <0.062             | 0%           | 0           |
| 0.125             | 0.062 - 0.125      | 0%           | 0           |
| 0.25              | 0.125 - 0.25       | 0%           | 0           |
| 0.5               | 0.25 - 0.5         | 0%           | 0           |
| 1                 | 0.5 - 1.0          | 0%           | 0           |
| 2                 | 1 - 2              | 1%           | 1           |
| 2.8               | 2 - 2.8            | 1%           | 0           |
| 4                 | 2.8 - 4            | 1%           | 0           |
| 5.6               | 4 - 5.6            | 1%           | 0           |
| 8                 | 5.6 - 8            | 1%           | 0           |
| 11                | 8 - 11             | 1%           | 0           |
| 16                | 11 - 16            | 3%           | 2           |
| 22.6              | 16 - 22.6          | 5%           | 2           |
| 32                | 22.6 - 32          | 16%          | 11          |
| 45                | 32 - 45            | 43%          | 27          |
| 64                | 45 - 64            | 64%          | 20          |
| 90                | 64 - 90            | 81%          | 17          |
| 128               | 90 - 128           | 92%          | 11          |
| 180               | 128 - 180          | 97%          | 5           |
| 256               | 180 - 256          | 100%         | 3           |
| 512               | 256 - 512          | 100%         | 0           |
| 1024              | 512 - 1024         | 100%         | 0           |
| 2048              | 1024 - 2048        | 100%         | 0           |
| 4096              | 2048 - 4096        | 100%         | 0           |

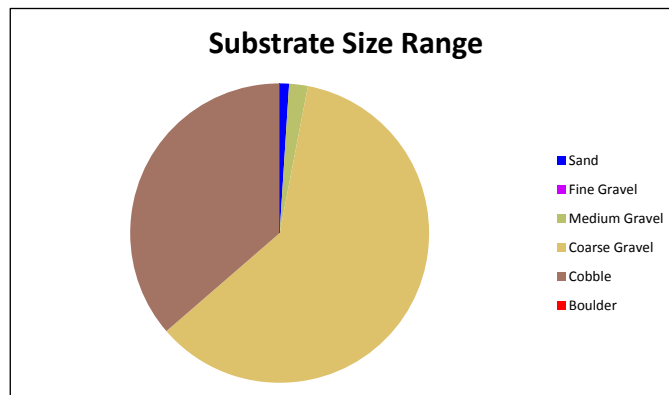
Particle Size  
Distribution (mm)

| D15  | D35  | D50  | D84  | D95   |
|------|------|------|------|-------|
| 30.9 | 40.5 | 50.5 | 99.6 | 157.6 |



## Size Range Worksheet

| Size Range (mm) | Classification | Total Count |
|-----------------|----------------|-------------|
| 0.062 - 2.0     | Sand           | 1           |
| 2 - 8           | Fine Gravel    | 0           |
| 8 - 16          | Medium Gravel  | 2           |
| 16 - 64         | Coarse Gravel  | 60          |
| 64 - 256        | Cobble         | 36          |
| 256 - 4096      | Boulder        | 0           |



# Pebble Count Workbook

STREAM NAME:  
SITE:

Catherine Creek  
PC-R3-2 (RM 38.20)

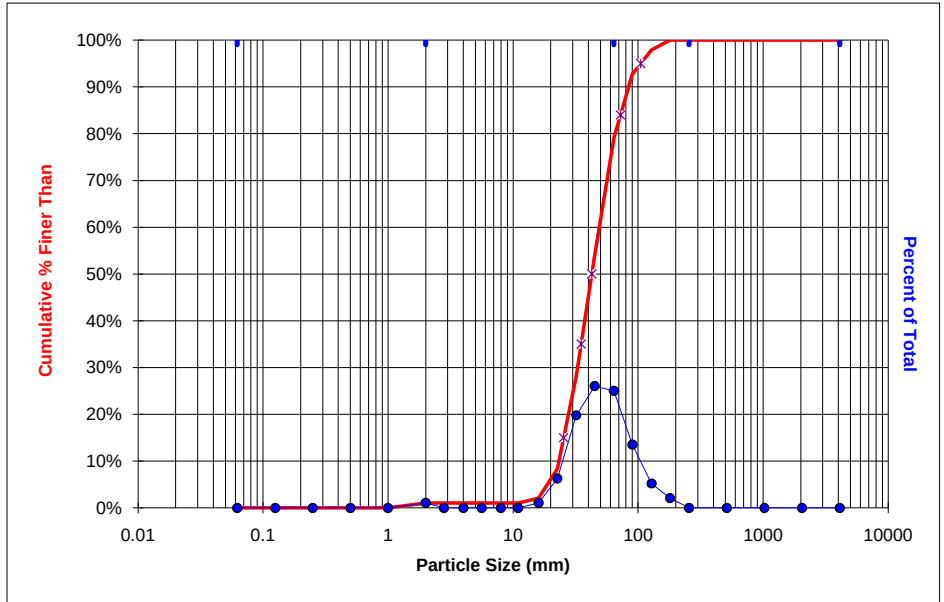
DATE: 8/3/2010  
CREW: McAffee

## Pebble Count Worksheet

| Gravelometer (mm) | Particle Size (mm) | % finer than | Total Count |
|-------------------|--------------------|--------------|-------------|
| 0.062             | <0.062             | 0%           | 0           |
| 0.125             | 0.062 - 0.125      | 0%           | 0           |
| 0.25              | 0.125 - 0.25       | 0%           | 0           |
| 0.5               | 0.25 - 0.5         | 0%           | 0           |
| 1                 | 0.5 - 1.0          | 0%           | 0           |
| 2                 | 1 - 2              | 1%           | 1           |
| 2.8               | 2 - 2.8            | 1%           | 0           |
| 4                 | 2.8 - 4            | 1%           | 0           |
| 5.6               | 4 - 5.6            | 1%           | 0           |
| 8                 | 5.6 - 8            | 1%           | 0           |
| 11                | 8 - 11             | 1%           | 0           |
| 16                | 11 - 16            | 2%           | 1           |
| 22.6              | 16 - 22.6          | 8%           | 6           |
| 32                | 22.6 - 32          | 28%          | 19          |
| 45                | 32 - 45            | 54%          | 25          |
| 64                | 45 - 64            | 79%          | 24          |
| 90                | 64 - 90            | 93%          | 13          |
| 128               | 90 - 128           | 98%          | 5           |
| 180               | 128 - 180          | 100%         | 2           |
| 256               | 180 - 256          | 100%         | 0           |
| 512               | 256 - 512          | 100%         | 0           |
| 1024              | 512 - 1024         | 100%         | 0           |
| 2048              | 1024 - 2048        | 100%         | 0           |
| 4096              | 2048 - 4096        | 100%         | 0           |

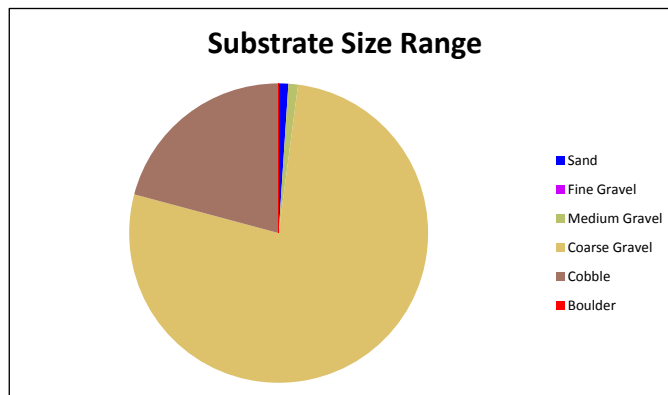
Particle Size  
Distribution (mm)

| D15  | D35  | D50  | D84  | D95   |
|------|------|------|------|-------|
| 25.4 | 35.0 | 42.6 | 72.3 | 105.1 |



## Size Range Worksheet

| Size Range (mm) | Classification | Total Count |
|-----------------|----------------|-------------|
| 0.062 - 2.0     | Sand           | 1           |
| 2 - 8           | Fine Gravel    | 0           |
| 8 - 16          | Medium Gravel  | 1           |
| 16 - 64         | Coarse Gravel  | 74          |
| 64 - 256        | Cobble         | 20          |
| 256 - 4096      | Boulder        | 0           |





# Pebble Count Workbook

STREAM NAME:  
SITE:

Catherine Creek  
PC-R3-1 (RM 37.5)

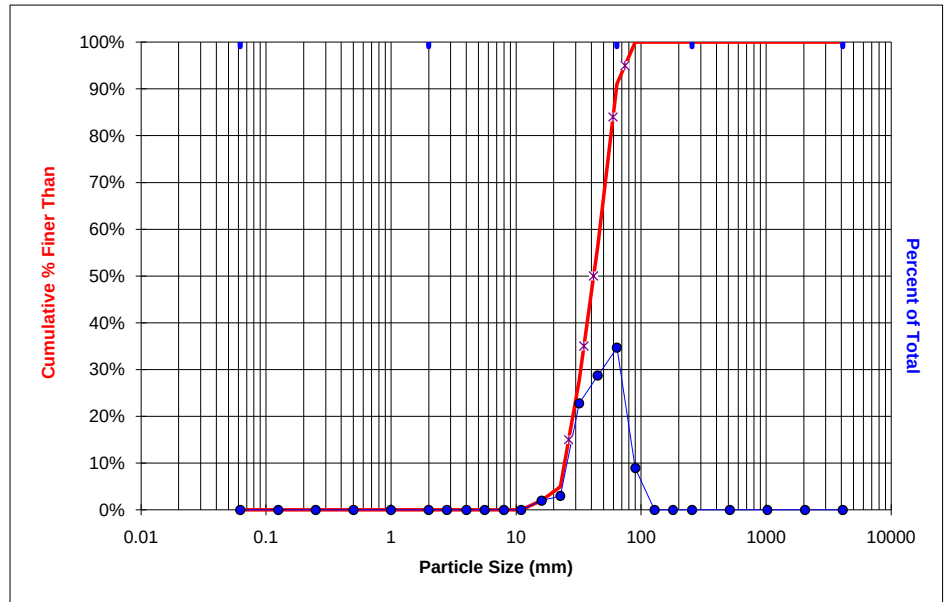
DATE: 8/3/2010  
CREW: McAfee

## Pebble Count Worksheet

| Gravelometer (mm) | Particle Size (mm) | % finer than | Total Count |
|-------------------|--------------------|--------------|-------------|
| 0.062             | <0.062             | 0%           | 0           |
| 0.125             | 0.062 - 0.125      | 0%           | 0           |
| 0.25              | 0.125 - 0.25       | 0%           | 0           |
| 0.5               | 0.25 - 0.5         | 0%           | 0           |
| 1                 | 0.5 - 1.0          | 0%           | 0           |
| 2                 | 1 - 2              | 0%           | 0           |
| 2.8               | 2 - 2.8            | 0%           | 0           |
| 4                 | 2.8 - 4            | 0%           | 0           |
| 5.6               | 4 - 5.6            | 0%           | 0           |
| 8                 | 5.6 - 8            | 0%           | 0           |
| 11                | 8 - 11             | 0%           | 0           |
| 16                | 11 - 16            | 2%           | 2           |
| 22.6              | 16 - 22.6          | 5%           | 3           |
| 32                | 22.6 - 32          | 28%          | 23          |
| 45                | 32 - 45            | 56%          | 29          |
| 64                | 45 - 64            | 91%          | 35          |
| 90                | 64 - 90            | 100%         | 9           |
| 128               | 90 - 128           | 100%         | 0           |
| 180               | 128 - 180          | 100%         | 0           |
| 256               | 180 - 256          | 100%         | 0           |
| 512               | 256 - 512          | 100%         | 0           |
| 1024              | 512 - 1024         | 100%         | 0           |
| 2048              | 1024 - 2048        | 100%         | 0           |
| 4096              | 2048 - 4096        | 100%         | 0           |

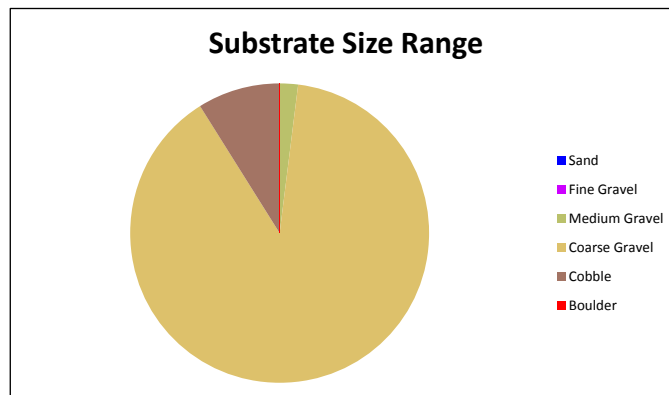
Particle Size  
Distribution (mm)

| D15  | D35  | D50  | D84  | D95  |
|------|------|------|------|------|
| 26.3 | 34.9 | 41.7 | 59.6 | 74.3 |



## Size Range Worksheet

| Size Range (mm) | Classification | Total Count |
|-----------------|----------------|-------------|
| 0.062 - 2.0     | Sand           | 0           |
| 2 - 8           | Fine Gravel    | 0           |
| 8 - 16          | Medium Gravel  | 2           |
| 16 - 64         | Coarse Gravel  | 90          |
| 64 - 256        | Cobble         | 9           |
| 256 - 4096      | Boulder        | 0           |



# **ATTACHMENT D – CHANNEL CROSS SECTIONAL PROFILES**

---





GEOLOGIC LEGEND

Surface Units

Qa

Active Alluvium (Qa).

The active alluvium consists of surface sediments subjected to season transportation and depositional cycles within the bed of Catherine Creek (and side channel/splays). There are two basic types of active alluvium material; fine-grained (silt and sand bars) sediments that predominantly occupy the lower gradient sections of Catherine Creek (Reaches 1 and 2); and coarse-grained (gravel, cobble and boulder bars and riffles) within the upper reaches (Reaches 3 thru 7). Laboratory soil classification of fine-grained active alluvium classified as mostly as silt with lesser amounts of silty sand and poorly graded sand with silt from sand bars. The active alluvium within Reaches 3 thru 7 are variable but consist primarily of well-graded (poorly sorted) gravel with sand and silt with scattered cobbles (3- to 12-inch diameter), derived largely from re-worked and re-deposited alluvial fan-delta, and coarse-grained alluvium (re-worked glacial outwash) deposits.

Qal1

Fluvio-lacustrine Sediments (Qal1).

The alluvial plain lacustrine sediments form the upper surfaces of the Grande Ronde valley floor and bed and banks of Catherine Creek throughout most of Reaches 1 and 2 and the lower section of Reach 3. The deposits are stratified (1 to 3 foot layers) and composed predominantly of firm to hard, silt, silty sand and clay. There are also lenses and layers of organic and diatomite rich silts and clays. The alluvial plain sediments are indicative of marsh, low energy fluvial and shallow lake conditions at the time of deposition.

Qfd

Fan Delta Sediments (Qfd).

The fan delta deposits form the bed and banks of Catherine Creek throughout most of Reach 3 and were deposited as an alluvial fan delta where Catherine Creek enters the Grande Ronde valley near Union. The Catherine Creek fan-delta materials were derived from the heavily glaciated highlands upstream of Union. The deposits grade from course grained near the mouth of the canyon to finer grained material where the delta merges with the alluvial plain. The fan delta materials are composed predominantly of poorly graded gravel with sand, silt and cobbles, well graded gravel with sand, silt and cobbles, and occasional beds of red iron oxidized silty sand.

Qal2

Fluvial Sediments (Qal2).

Upstream of Union, Catherine Creek flows northwestward along flat-floored, northwest trending valleys which are underlain by coarse-grained alluvium derived largely from re-worked glacial till and and glacial outwash. The course-grained alluvial deposits form much of the bed and banks of Catherine Creek throughout Reaches 4 thru 7 and are interfingured with fan-delta deposits in upper section of Reach 3. The deposits are composed predominantly of poorly graded gravel with sand, silt and cobbles, with well graded gravel with sand, silt and cobbles, with scattered beds of red iron oxidized silty sand.

Qla

Quaternary (Holocene and Pleistocene) Landslide Deposits (Qls).

Landslide deposits form the south bank of Catherine Creek throughout most of Reach 5. The deposits are composed of unconsolidated, chaotically mixed masses of rock and soil. Landforms are typically hummocky surfaces marked by closed depressions, springs and wet seeps, scarps, cracks and crevices. The landslides deposits are often traceable upslope to scarps or slip surfaces, and in the assessment area the landslides generally originate along contacts between competent lava flow and underlying tuffaceous units.

Bedrock Units

Tb

Bedrock is not well exposed along the banks of Catherine Creek, but occurs in isolated sections within Reaches 4, 5 and 7. The bedrock consists of undifferentiated volcanic rocks of the Tertiary Powder River Volcanic Field and Columbia River Basalt Group (Tb) composed of basaltic, basaltic andesite, andesite and dacite lava flows; and Pre-Tertiary Meta- Sedimentary and Intrusive Volcanic Rocks (Trsv) composed of marine sedimentary rocks (metamorphic limestone), and intrusive volcanic rocks (altered diorite) of the Wallowa Batholith.

Trsv

Notes:

Topsoil mantles the alluvial and bedrock surfaces throughout most of the Catherine Creek area, the thickest accumulations are in the agricultural areas along Reaches 1, 2 and 3 where the unit is composed mostly of silt, sandy silt, and silty sand with some lean clay and fat clay. The topsoil is generally firm, with occasional continuous moderately open vertical (desiccation) cracks forming along the banks of the creek, the topsoil in these areas tends to become over-steepened, resulting in slab failures when subjected to higher stream flow and saturated conditions.

GEOLOGIC SYMBOLS

Geologic contact. Dashed where approximate, queried where inferred.



Geologic unit. Designation based on existing geologic information and mapping performed during the 2010 summer field season.

Qal2

Channel-forming flow. Approximate creek level that is greater than low flow and typically coincides with the spring run off on about two (2) year intervals. Identified based on vegetation line.

CHANNEL-FORMING FLOW

GEOLOGIC NOTES

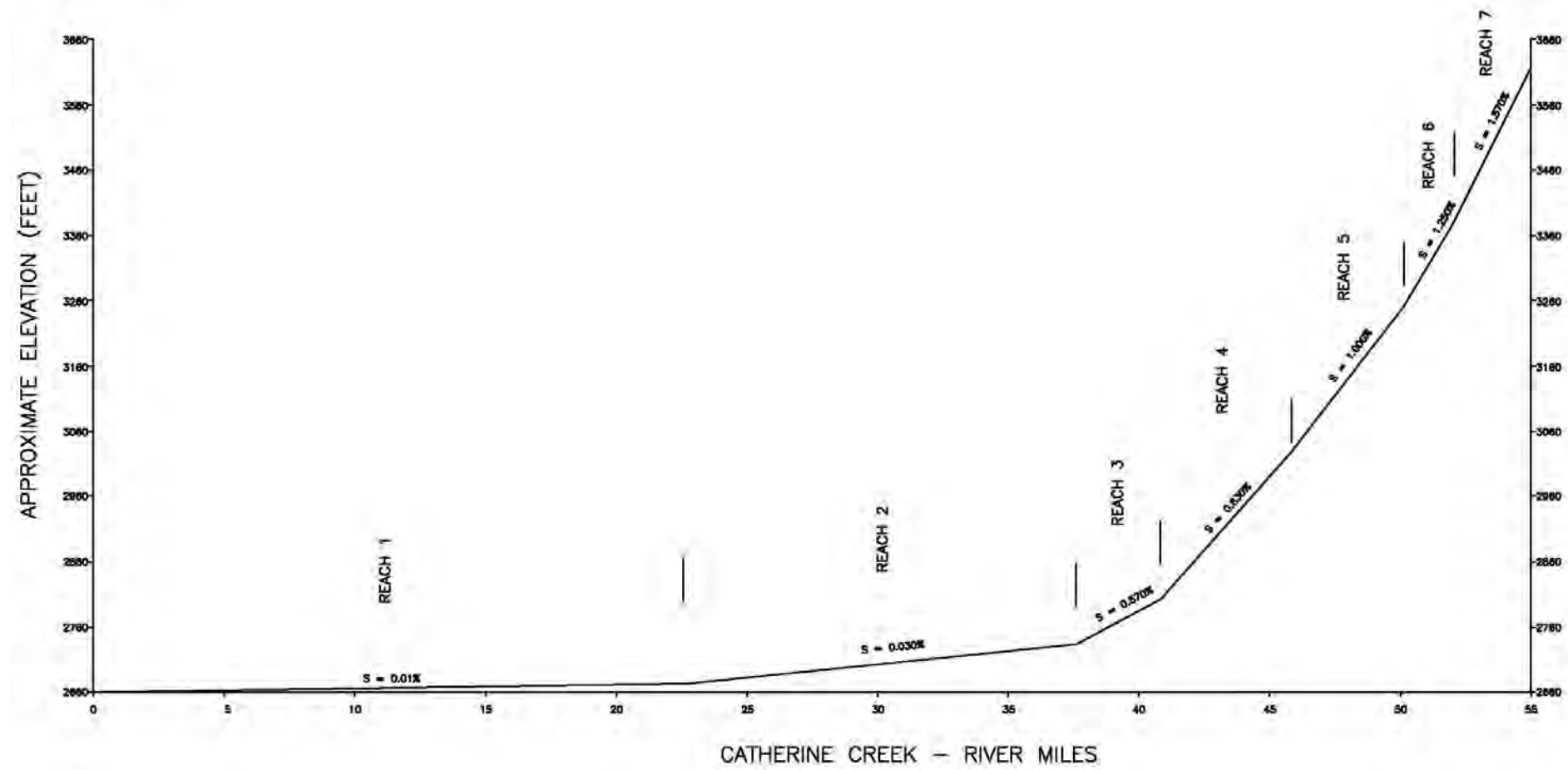
3) Geologic explanation to accompany following list of drawings:

| Drawing                  | Reach | Drawing                  | Reach |
|--------------------------|-------|--------------------------|-------|
| Profile River Mile 0.10  | 1     | Profile River Mile 1.80  | 1     |
| Profile River Mile 7.75  | 1     | Profile River Mile 10.50 | 1     |
| Profile River Mile 14.50 | 1     | Profile River Mile 19.02 | 1     |
| Profile River Mile 22.42 | 1     | Profile River Mile 27.98 | 2     |
| Profile River Mile 30.36 | 2     | Profile River Mile 31.09 | 2     |
| Profile River Mile 31.39 | 2     | Profile River Mile 31.63 | 2     |
| Profile River Mile 32.85 | 2     | Profile River Mile 33.22 | 2     |
| Profile River Mile 34.05 | 2     | Profile River Mile 35.31 | 2     |
| Profile River Mile 35.91 | 2     | Profile River Mile 37.50 | 3     |
| Profile River Mile 38.20 | 3     | Profile River Mile 39.60 | 3     |
| Profile River Mile 39.63 | 3     | Profile River Mile 40.58 | 3     |
| Profile River Mile 41.53 | 4     | Profile River Mile 42.36 | 4     |
| Profile River Mile 43.25 | 4     | Profile River Mile 44.90 | 4     |
| Profile River Mile 46.09 | 5     | Profile River Mile 46.93 | 5     |
| Profile River Mile 48.24 | 5     | Profile River Mile 49.65 | 5     |
| Profile River Mile 51.72 | 6     | Profile River Mile 51.30 | 6     |
| Profile River Mile 52.30 | 7     | Profile River Mile 54.70 | 7     |

|                                                                                                                                                                                                           |             |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|
| ⊕ ALWAYS THINK SAFETY                                                                                                                                                                                     |             |
| UNITED STATES<br>DEPARTMENT OF THE INTERIOR<br>BUREAU OF RECLAMATION<br>TRIBUTARY HABITAT PROGRAM -- OREGON<br>CATHERINE CREEK<br>TRIBUTARY ASSESSMENT<br>GENERAL GEOLOGIC LEGEND, EXPLANATION, AND NOTES |             |
| DESIGNED BY <u>R. McCaffrey, D. Baker</u>                                                                                                                                                                 | SUBMITTED   |
| DRAWN                                                                                                                                                                                                     | RECOMMENDED |
| CHECKED                                                                                                                                                                                                   | APPROVED    |
| RICH, OREGON JANUARY 2011                                                                                                                                                                                 |             |
| Geo. Explanation                                                                                                                                                                                          |             |

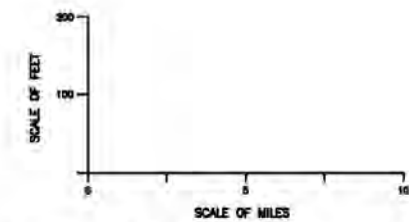
DOWNSTREAM

UPSTREAM



Notes:

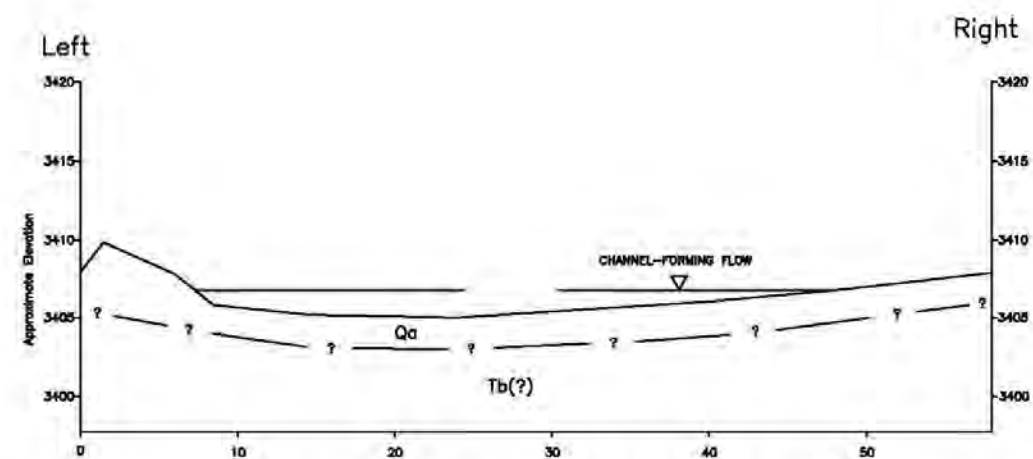
1. Elevations (NAVD29) shown on are from U.S.G.S. 7.5 minute quadrangles.
2. River Mile = distance in river miles from the confluence of Catherine Creek and the State Ditch near the Alicel Bridge.



|                                                                                                            |                   |
|------------------------------------------------------------------------------------------------------------|-------------------|
| ALWAYS THINK SAFETY                                                                                        |                   |
| UNITED STATES<br>DEPARTMENT OF THE INTERIOR<br>BUREAU OF RECLAMATION<br>TRIBUTARY HABITAT PROJECT - OREGON |                   |
| CATHERINE CREEK<br>TRIBUTARY ASSESSMENT<br>STREAM GRADIENTS - REACHES 1 THRU 7                             |                   |
| DESIGNED BY: <u>Matthew Stine</u>                                                                          | CHECKED: _____    |
| DRAWN: _____                                                                                               | TECH. APPR: _____ |
| APPROVED: _____                                                                                            |                   |
| DATE: 08/08/2011                                                                                           | BY: 08/08/2011    |
| Stream Gradients                                                                                           |                   |



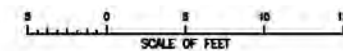




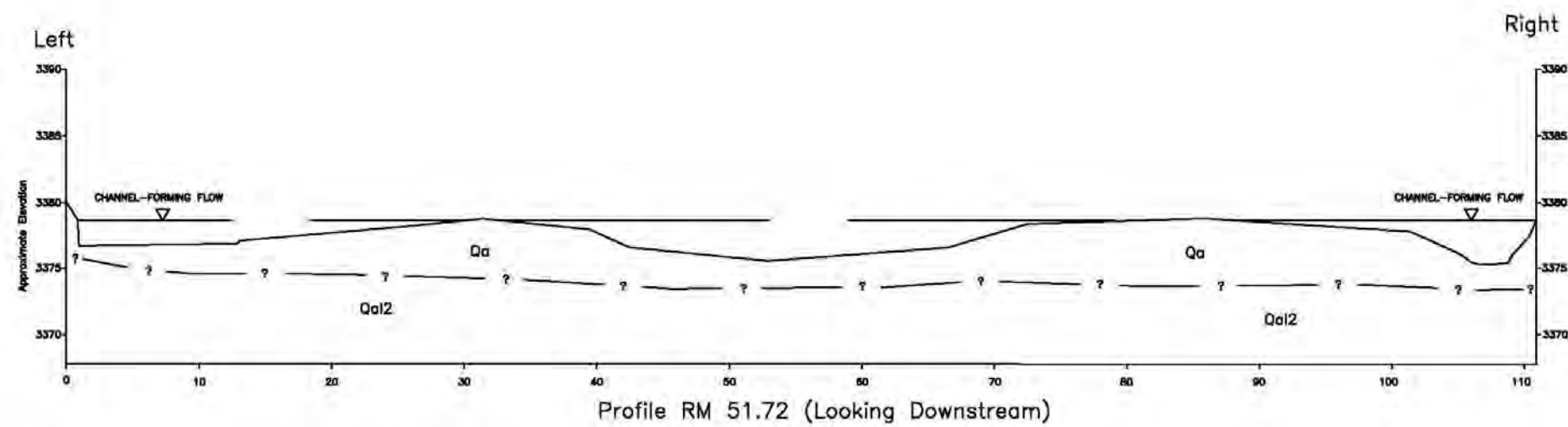
Profile RM 52.30 (Looking Downstream)  
(Upstream of U.S.F.S. Road 7785 Bridge  
Near Intersection with U.S.F.S. Road 2036)

Notes:

1. Elevations (NAVD29) shown on profiles are from the U.S.G.S. 7.5 minute Medical Springs, Oregon Quadrangle.
2. R.M. = distance in river miles from the mouth of the river at the State Ditch.
3. For descriptions of geologic units and symbols refer to the Geologic Explanation.

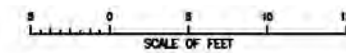


|                                                                                                                                                                                                                                |              |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|
| <p>ALWAYS THINK SAFETY</p> <p>UNITED STATES<br/>DEPARTMENT OF THE INTERIOR<br/>BUREAU OF RECLAMATION<br/>TRIBUTARY HABITAT PROJECT - OREGON</p> <p>CATHERINE CREEK<br/>TRIBUTARY ASSESSMENT<br/>PROFILE RM 52.30 - REACH 7</p> |              |
| DESIGNED BY                                                                                                                                                                                                                    | CHECKED BY   |
| DRAWN BY                                                                                                                                                                                                                       | JOEY APPAL   |
| APPROVED BY                                                                                                                                                                                                                    |              |
| END SYSTEM ACQUISITION                                                                                                                                                                                                         | JANUARY 2011 |
| DRAWING RM 52.30                                                                                                                                                                                                               |              |

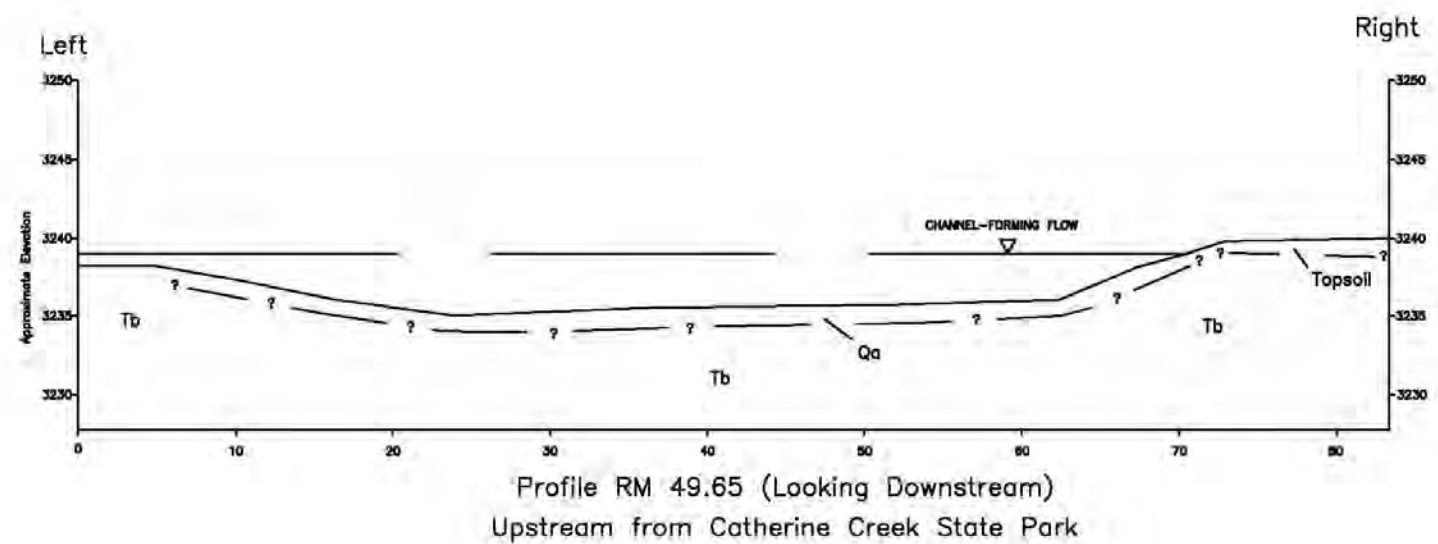


Notes:

1. Elevations (NAVD29) shown on profiles are from the U.S.G.S. 7.5 minute Little Catherine Creek and Medical Springs, Oregon Quadrangles.
2. R.M. = distance in river miles from the mouth of the river at the State Ditch.
3. For description of geologic units and symbols refer to the Geologic Explanation.

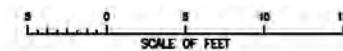


|                                                                                                            |                              |
|------------------------------------------------------------------------------------------------------------|------------------------------|
| ALWAYS THINK SAFETY                                                                                        |                              |
| UNITED STATES<br>DEPARTMENT OF THE INTERIOR<br>BUREAU OF RECLAMATION<br>TRIBUTARY HABITAT PROJECT - OREGON |                              |
| CATHERINE CREEK<br>TRIBUTARY ASSESSMENT<br>PROFILE RM 51.72 - REACH 6                                      |                              |
| DRAWN BY: <u>Matthew Cherry</u>                                                                            | CHECKED BY: <u>JACK AYER</u> |
| APPROVED BY: <u>Paul Smith - District Engineer</u>                                                         |                              |
| END SYSTEM ACQUISITION<br>BETH OREGON                                                                      | JANUARY 2011                 |
| DRAWING RM 51.72                                                                                           |                              |



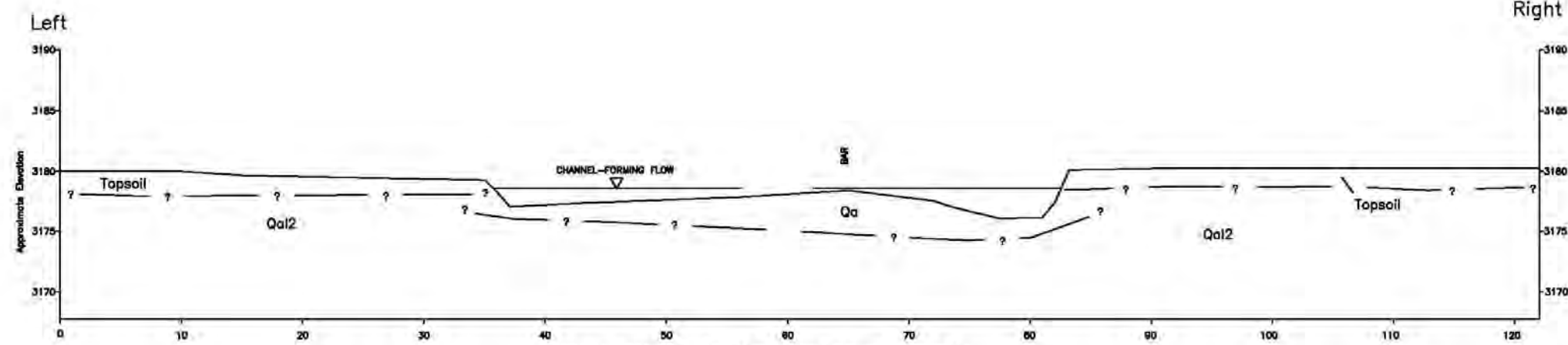
Notes:

1. Elevations (NAVD29) shown on profiles are from the U.S.G.S. 7.5 minute Little Catherine Creek, Oregon Quadrangle.
2. R.M. = distance in river miles from the mouth of the river at the State Ditch.
3. For descriptions of geologic units and symbols refer to the Geologic Explanation.



|                                                                                                            |                                 |
|------------------------------------------------------------------------------------------------------------|---------------------------------|
| ALWAYS THINK SAFETY                                                                                        |                                 |
| UNITED STATES<br>DEPARTMENT OF THE INTERIOR<br>BUREAU OF RECLAMATION<br>TRIBUTARY HABITAT PROJECT - OREGON |                                 |
| CATHERINE CREEK<br>TRIBUTARY ASSESSMENT<br>PROFILE RM 49.65 - REACH 5                                      |                                 |
| DESIGNED BY: <u>Michael C. Smith</u>                                                                       | CHECKED BY: <u>JACK A. PYLE</u> |
| APPROVED BY: <u>PER ORDER - JENNIFER M. HARRIS</u>                                                         |                                 |
| END SYSTEM ACQUISITION<br>BUREAU OF RECLAMATION                                                            | JANUARY 2011                    |
| DRAWING RM 49.65                                                                                           |                                 |

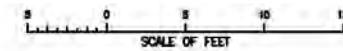




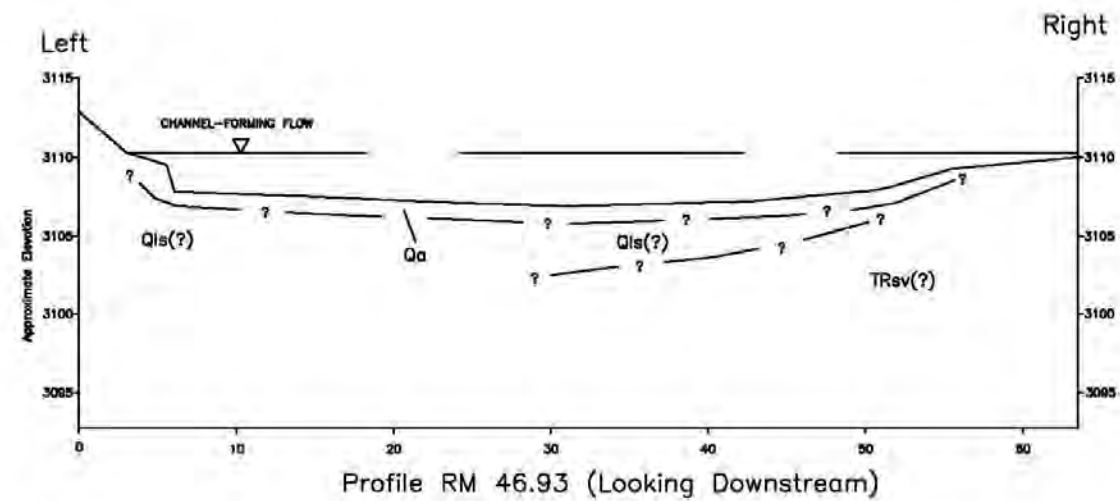
Profile RM 48.24 (Looking Downstream)  
Downstream from Catherine Creek State Park

Notes:

1. Elevations (NAVD29) shown on profiles are from the U.S.G.S. 7.5 minute Little Catherine Creek, Oregon Quadrangle.
2. R.M. = distance in river miles from the mouth of the river at the State Ditch.
3. For descriptions of geologic units and symbols refer to the Geologic Explanation.

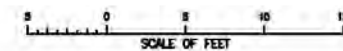


|                                                                                                            |                                |
|------------------------------------------------------------------------------------------------------------|--------------------------------|
| ALWAYS THINK SAFETY                                                                                        |                                |
| UNITED STATES<br>DEPARTMENT OF THE INTERIOR<br>BUREAU OF RECLAMATION<br>TRIBUTARY HABITAT PROJECT - OREGON |                                |
| CATHERINE CREEK<br>TRIBUTARY ASSESSMENT<br>PROFILE RM 48.24 - REACH 5                                      |                                |
| DESIGNED BY: <u>Michael C. Smith</u>                                                                       | CHECKED BY: <u>JOCKA APPEL</u> |
| APPROVED BY: <u>PER ORDER - JENNIFER GILBERT</u>                                                           |                                |
| END SYSTEM ACQUISITION<br>BUREAU OF RECLAMATION                                                            | JANUARY 2011                   |
| DRAWING RM 48.24                                                                                           |                                |

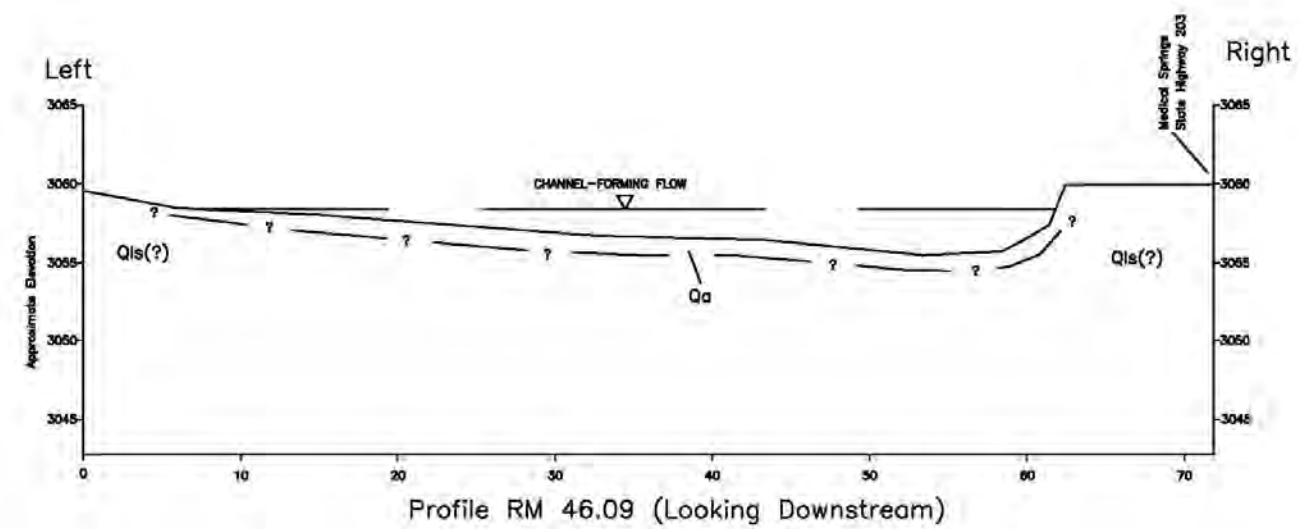


Notes:

1. Elevations (NAVD29) shown on profiles are from the U.S.G.S. 7.5 minute Union, Oregon Quadrangle.
2. R.M. = distance in river miles from the mouth of the river at the State Ditch.
3. For descriptions of geologic units and symbols refer to the Geologic Explanation.

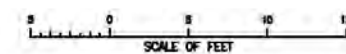


|                                                                                                                                                                                                                                |              |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|
| <p>ALWAYS THINK SAFETY</p> <p>UNITED STATES<br/>DEPARTMENT OF THE INTERIOR<br/>BUREAU OF RECLAMATION<br/>TRIBUTARY HABITAT PROJECT - OREGON</p> <p>CATHERINE CREEK<br/>TRIBUTARY ASSESSMENT<br/>PROFILE RM 46.93 - REACH 5</p> |              |
| DESIGNED BY                                                                                                                                                                                                                    | CHECKED BY   |
| DRAWN BY                                                                                                                                                                                                                       | JOCKA APPR.  |
| APPROVED BY                                                                                                                                                                                                                    |              |
| END SYSTEM ACQUISITION                                                                                                                                                                                                         | JANUARY 2011 |
| DRAWING RM 46.93                                                                                                                                                                                                               |              |



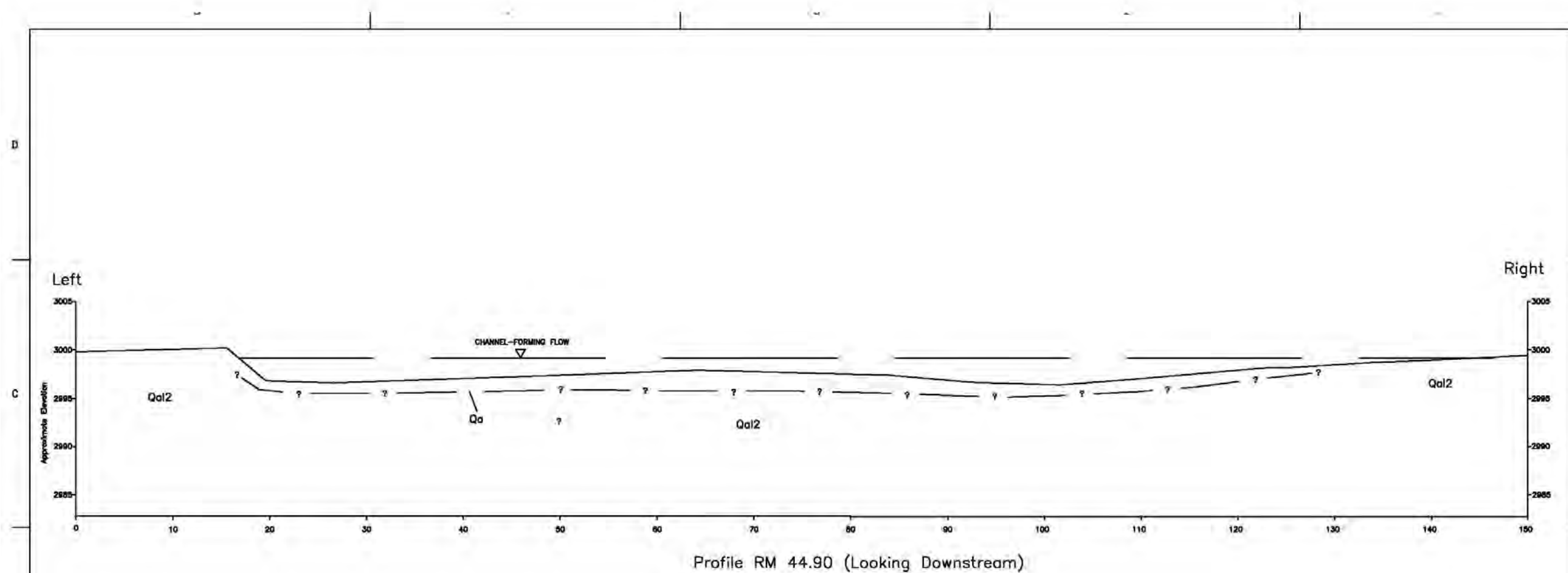
Notes:

1. Elevations (NAVD29) shown on profiles are from the U.S.G.S. 7.5 minute Union, Oregon Quadrangle.
2. R.M. = distance in river miles from the mouth of the river at the State Ditch.
3. For descriptions of geologic units and symbols refer to the Geologic Explanation.



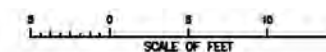
|                                                                                                                                                                                                                                |              |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|
| <p>ALWAYS THINK SAFETY</p> <p>UNITED STATES<br/>DEPARTMENT OF THE INTERIOR<br/>BUREAU OF RECLAMATION<br/>TRIBUTARY HABITAT PROJECT - OREGON</p> <p>CATHERINE CREEK<br/>TRIBUTARY ASSESSMENT<br/>PROFILE RM 46.09 - REACH 5</p> |              |
| DESIGNED BY                                                                                                                                                                                                                    | CHECKED BY   |
| DRAWN BY                                                                                                                                                                                                                       | JOEY APPR.   |
| APPROVED BY                                                                                                                                                                                                                    |              |
| END SYSTEM ACQUISITION                                                                                                                                                                                                         | JANUARY 2011 |
| DRAWING RM 46.09                                                                                                                                                                                                               |              |



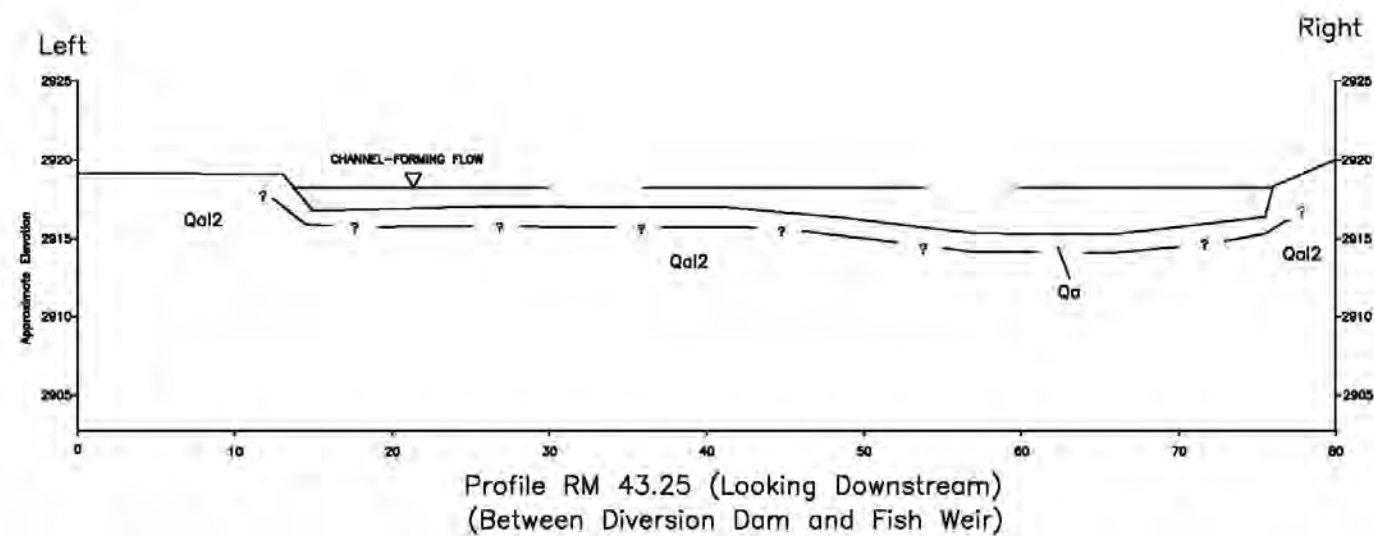


Notes;

1. Elevations (NAVD29) shown on profiles are from the U.S.G.S. 7.5 minute Union, Oregon Quadrangle.
2. R.M. = distance in river miles from the mouth of the river at the State Ditch.
3. For descriptions of geologic units and symbols refer to the Geologic Explanation.

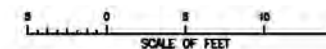


|                                                                                                                                                                                                                                |              |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|
| <p>ALWAYS THINK SAFETY</p> <p>UNITED STATES<br/>DEPARTMENT OF THE INTERIOR<br/>BUREAU OF RECLAMATION<br/>TRIBUTARY HABITAT PROJECT - OREGON</p> <p>CATHERINE CREEK<br/>TRIBUTARY ASSESSMENT<br/>PROFILE RM 44.90 - REACH 4</p> |              |
| DESIGNED BY                                                                                                                                                                                                                    | CHECKED BY   |
| DRAWN BY                                                                                                                                                                                                                       | JOCKA APPR.  |
| APPROVED BY                                                                                                                                                                                                                    |              |
| END SYSTEM ACQUISITION                                                                                                                                                                                                         | JANUARY 2011 |
| DRAWING RM 44.90                                                                                                                                                                                                               |              |

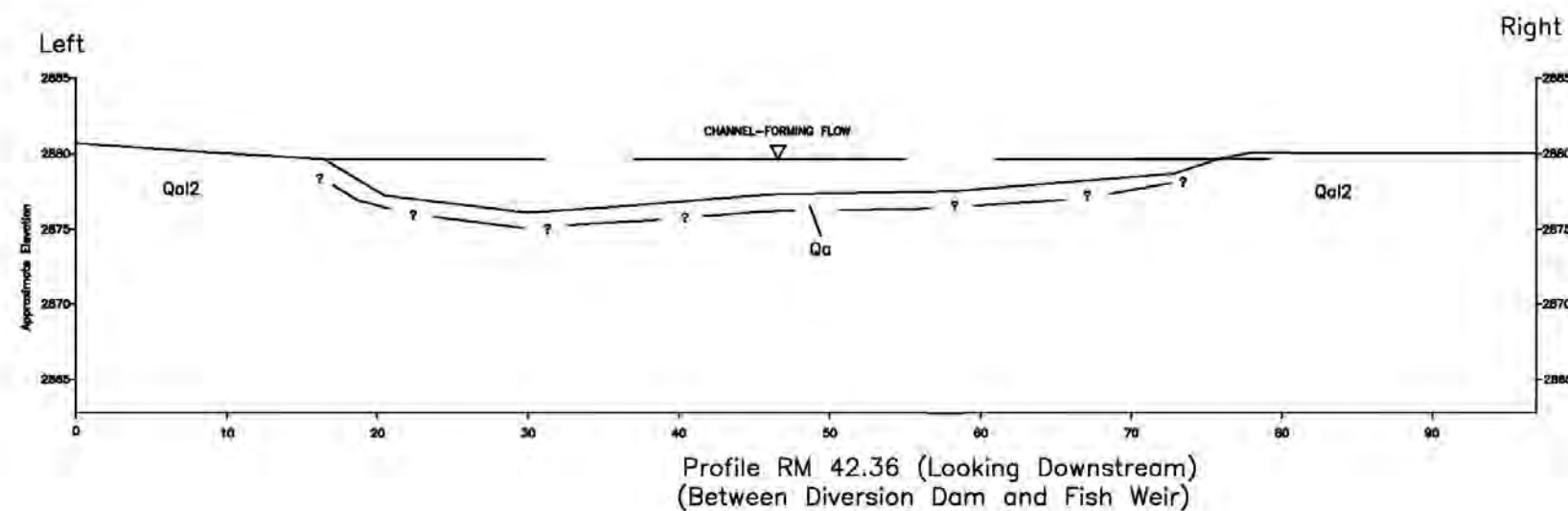


Notes:

1. Elevations (NAVD29) shown on profiles are from the U.S.G.S. 7.5 minute Union, Oregon Quadrangle.
2. R.M. = distance in river miles from the mouth of the river at the State Ditch.
3. For descriptions of geologic units and symbols refer to the Geologic Explanation.

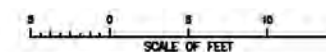


|                                                                                                            |                              |
|------------------------------------------------------------------------------------------------------------|------------------------------|
| ALWAYS THINK SAFETY                                                                                        |                              |
| UNITED STATES<br>DEPARTMENT OF THE INTERIOR<br>BUREAU OF RECLAMATION<br>TRIBUTARY HABITAT PROJECT - OREGON |                              |
| CATHERINE CREEK<br>TRIBUTARY ASSESSMENT<br>PROFILE RM 43.25 - REACH 4                                      |                              |
| DRAWN BY: <u>Matthew Chappin</u>                                                                           | CHECKED BY: <u>JACK AYER</u> |
| APPROVED BY: <u>PER ORDER - JENNIFER TAYLOR</u>                                                            |                              |
| END SYSTEM ACQUISITION<br>BUREAU OF RECLAMATION                                                            | JANUARY 2011                 |
| DRAWING RM 43.25                                                                                           |                              |



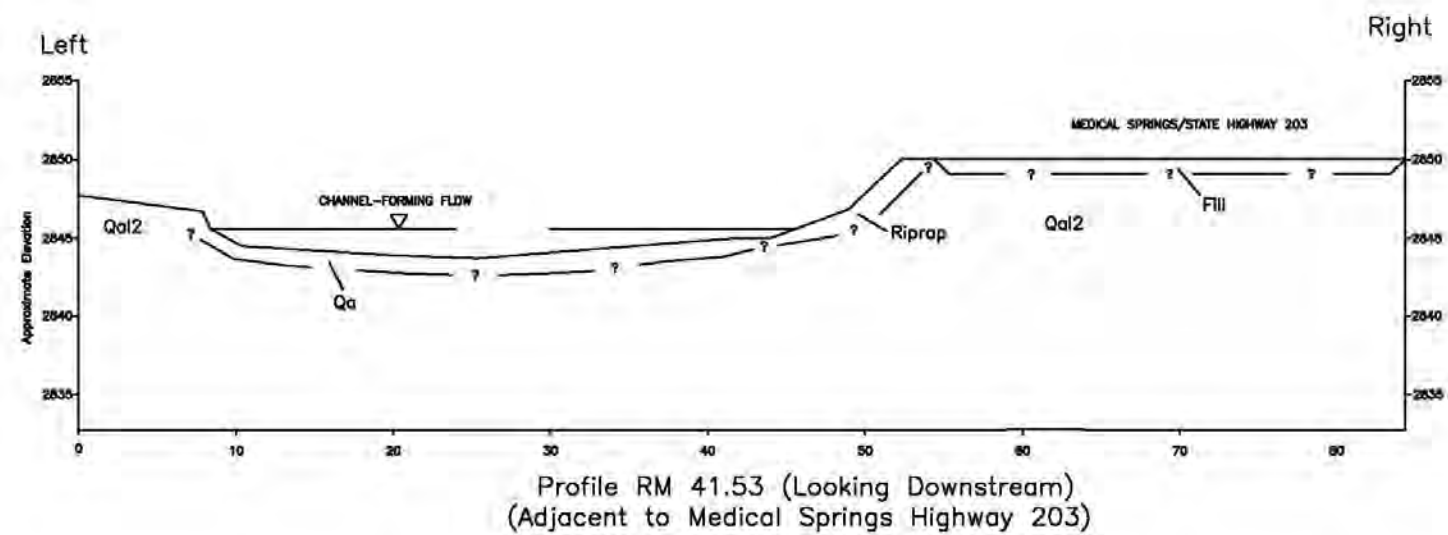
Notes:

1. Elevations (NAVD29) shown on profiles are from the U.S.G.S. 7.5 minute Union, Oregon Quadrangle.
2. R.M. = distance in river miles from the mouth of the river at the State Ditch.
3. For description of geologic units and symbols refer to the Geologic Explanation.



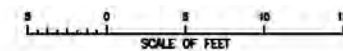
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| ALWAYS THINK SAFETY                                                                                        |                              |
| UNITED STATES<br>DEPARTMENT OF THE INTERIOR<br>BUREAU OF RECLAMATION<br>TRIBUTARY HABITAT PROJECT - OREGON |                              |
| CATHERINE CREEK<br>TRIBUTARY ASSESSMENT<br>PROFILE RM 42.36 - REACH 4                                      |                              |
| DRAWN BY: <u>Matthew Cherry</u>                                                                            | CHECKED BY: <u>JACK AYER</u> |
| APPROVED BY: <u>PER ORDER - JENNIFER GILLES</u>                                                            |                              |
| END SYSTEM ACQUISITION<br>BUREAU OF RECLAMATION                                                            | JANUARY 2011                 |
| DRAWING RM 42.36                                                                                           |                              |



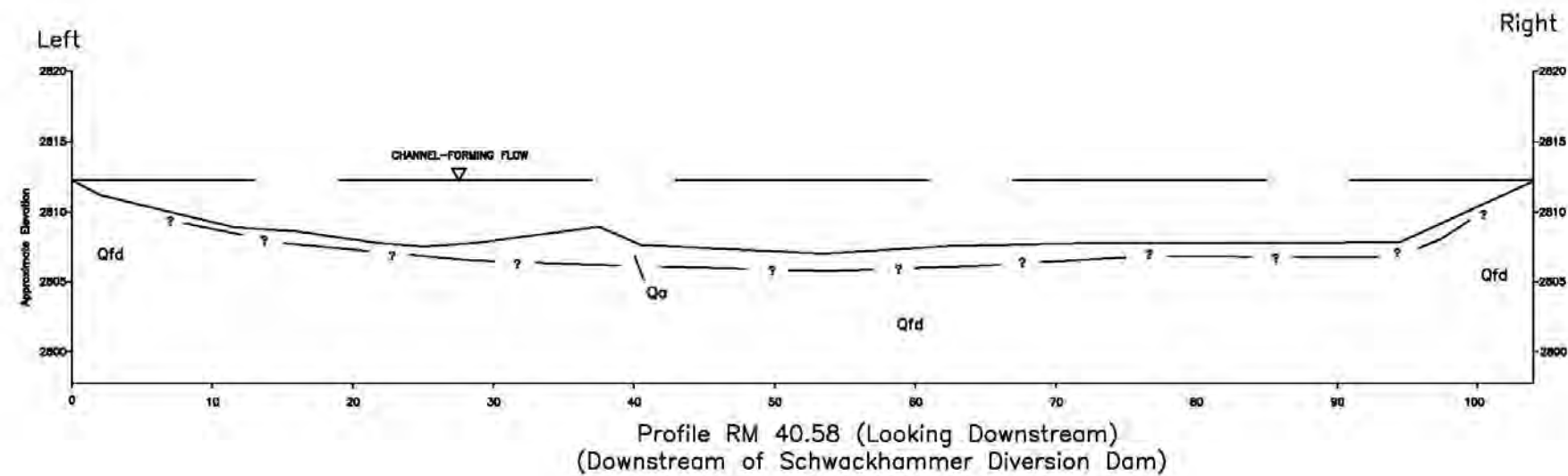


#### Notes:

1. Elevations (NAVD29) shown on profiles are from the U.S.G.S. 7.5 minute Union, Oregon Quadrangle.
2. R.M. = distance in river miles from the mouth of the river at the State Ditch.
3. For descriptions of geologic units and symbols refer to the Geologic Explanation.

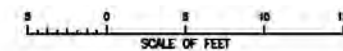


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| ALWAYS THINK SAFETY                                                                                        |                                   |
| UNITED STATES<br>DEPARTMENT OF THE INTERIOR<br>BUREAU OF RECLAMATION<br>TRIBUTARY HABITAT PROJECT - OREGON |                                   |
| CATHERINE CREEK<br>TRIBUTARY ASSESSMENT<br>PROFILE RM 41.53 - REACH 4                                      |                                   |
| DESIGNED BY: <u>Michael C. Smith</u>                                                                       | CHECKED BY: <u>JACK A. PYLE</u>   |
| DRAWN BY: <u>JACK A. PYLE</u>                                                                              | APPROVED BY: <u>JOHN W. BROWN</u> |
| END SYSTEM ACQUISITION<br>BUREAU OF RECLAMATION                                                            | JANUARY 2011                      |
| DRAWING RM 41.53                                                                                           |                                   |



Notes:

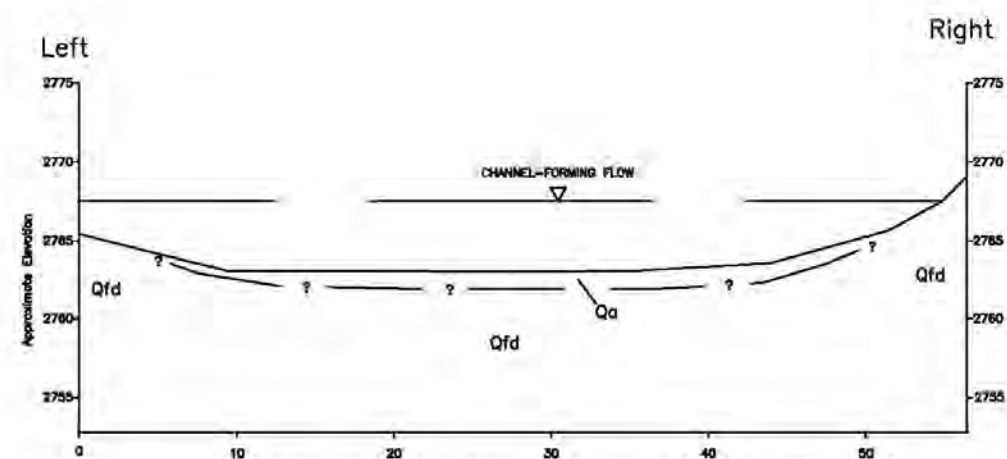
1. Elevations (NAVD29) shown on profiles are from the U.S.G.S. 7.5 minute Union, Oregon Quadrangle.
2. R.M. = distance in river miles from the mouth of the river at the State Ditch.
3. For descriptions of geologic units and symbols refer to the Geologic Explanation.



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| ALWAYS THINK SAFETY                                                                                        |                                 |
| UNITED STATES<br>DEPARTMENT OF THE INTERIOR<br>BUREAU OF RECLAMATION<br>TRIBUTARY HABITAT PROJECT - OREGON |                                 |
| CATHERINE CREEK<br>TRIBUTARY ASSESSMENT<br>PROFILE RM 40.58 - REACH 3                                      |                                 |
| DESIGNED BY: <u>Michael C. Smith</u>                                                                       | CHECKED BY: <u>JACK A. PYLE</u> |
| APPROVED BY: <u>John Smith - District Engineer</u>                                                         |                                 |
| END SYSTEM ACQUISITION<br>BUREAU OF RECLAMATION                                                            | JANUARY 2011                    |
| DRAWING RM 40.58                                                                                           |                                 |



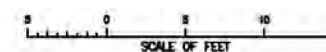




Profile RM 39.60 (Looking Downstream)  
(Downstream of Diversion Dam)

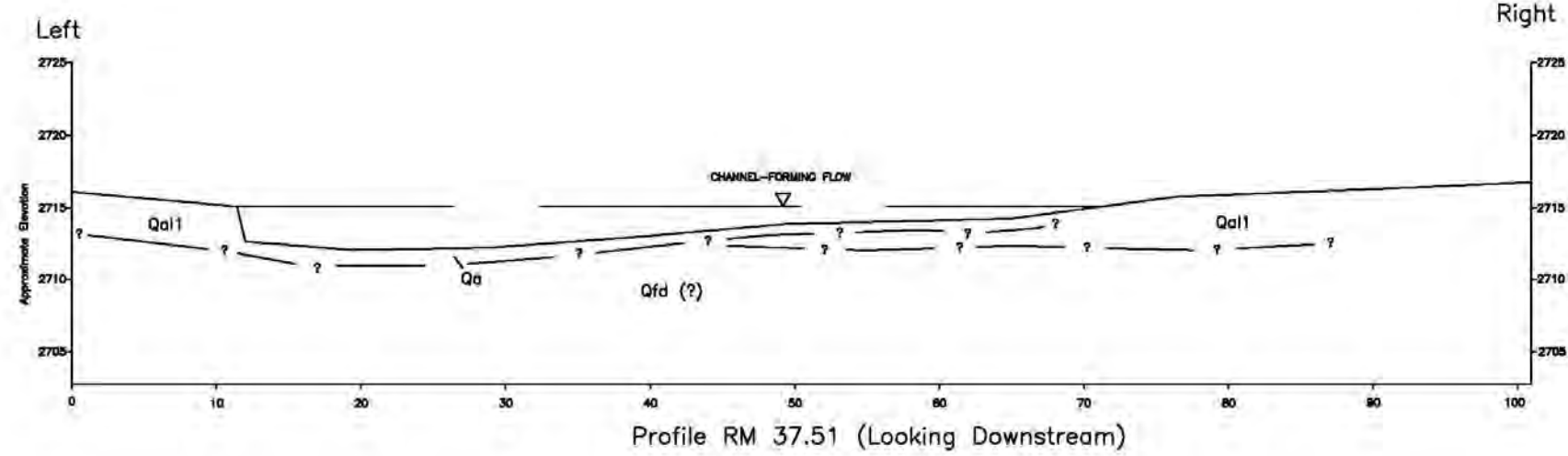
Notes:

1. Elevations (NAVD29) shown on profiles are from the U.S.G.S. 7.5 minute Union, Oregon Quadrangle.
2. R.M. = distance in river miles from the mouth of the river at the State Ditch.
3. For descriptions of geologic units and symbols refer to the Geologic Explanation.



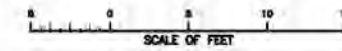
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| ALWAYS THINK SAFETY<br>UNITED STATES<br>DEPARTMENT OF THE INTERIOR<br>BUREAU OF RECLAMATION<br>TRIBUTARY HABITAT PROJECT - OREGON<br>CATHERINE CREEK<br>TRIBUTARY ASSESSMENT<br>PROFILE RM 39.60 - REACH 3 |              |
| DESIGNED BY                                                                                                                                                                                                | CHECKED BY   |
| DRAWN BY                                                                                                                                                                                                   | JOCKA APPR.  |
| APPROVED BY                                                                                                                                                                                                |              |
| END SYSTEM ACQUISITION                                                                                                                                                                                     | JANUARY 2011 |
| DRAWING RM 39.60                                                                                                                                                                                           |              |





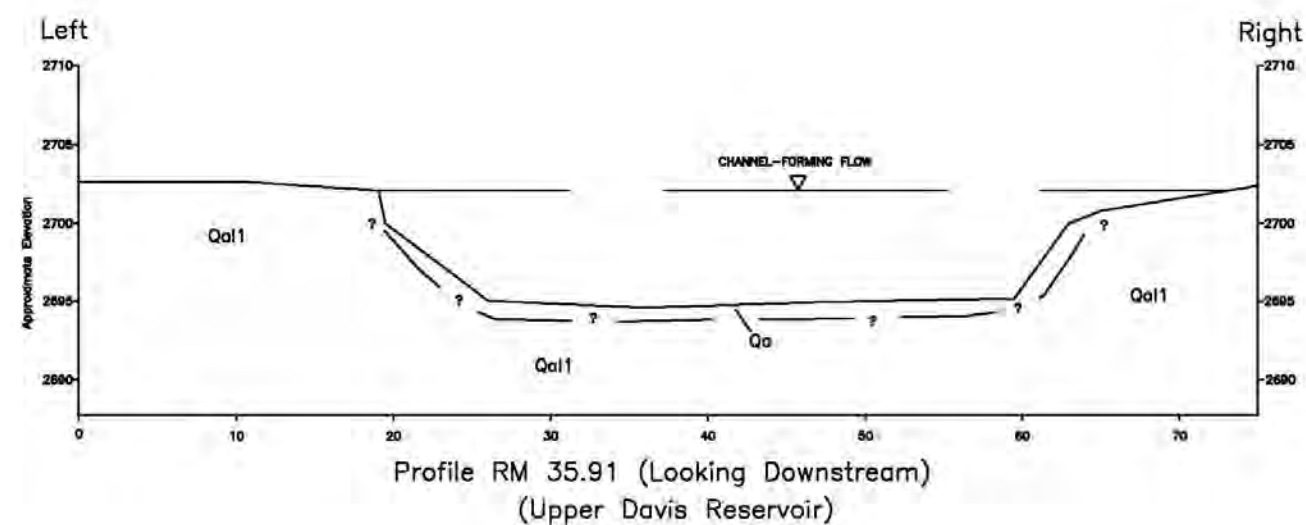
Notes:

1. Elevations (NAVD29) shown on profiles are from the U.S.G.S. 7.5 minute Craig Mountain, Oregon Quadrangle.
2. R.M. = distance in river miles from the mouth of the river at the State Ditch.
3. For descriptions of geologic units and symbols refer to the Geologic Explanation.



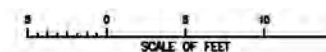
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| ALWAYS THINK SAFETY                                                                                          |                                 |
| UNITED STATES<br>DEPARTMENT OF THE INTERIOR<br>BUREAU OF RECLAMATION<br>TRIBUTARY TREATMENT PROJECT - OREGON |                                 |
| CATHERINE CREEK<br>TRIBUTARY ASSESSMENT<br>PROFILE RM 37.51 - REACH 3                                        |                                 |
| DESIGNED BY: <u>MAY/10/2011</u>                                                                              | CHECKED BY: <u>JECH. APPL.</u>  |
| DRAWN BY: <u>JECH. APPL.</u>                                                                                 | APPROVED BY: <u>JECH. APPL.</u> |
| CAD SYSTEM: <u>ACAD 2000</u>                                                                                 | DATE: <u>JANUARY 2011</u>       |
| REVISION: <u>0000</u>                                                                                        | DRAWING RM 37.51                |



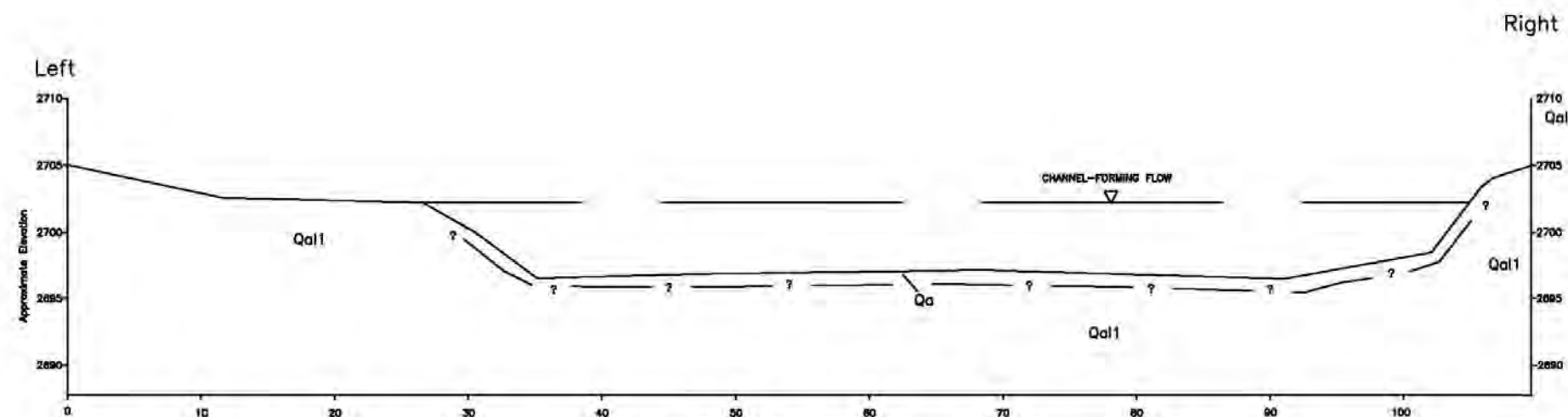


Notes:

1. Elevations (NAVD29) shown on profiles are from the U.S.G.S. 7.5 minute Craig Mountain, Oregon Quadrangle.
2. R.M. = distance in river miles from the mouth of the river at the State Ditch.
3. For descriptions of geologic units and symbols refer to the Geologic Explanation.



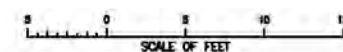
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| <p>ALWAYS THINK SAFETY</p> <p>UNITED STATES<br/>DEPARTMENT OF THE INTERIOR<br/>BUREAU OF RECLAMATION<br/>TRIBUTARY HABITAT PROJECT - OREGON</p> <p>CATHERINE CREEK<br/>TRIBUTARY ASSESSMENT<br/>PROFILE RM 35.91 - REACH 2</p> |              |
| DESIGNED BY                                                                                                                                                                                                                    | CHECKED BY   |
| DRAWN BY                                                                                                                                                                                                                       | JOCKA APPR.  |
| APPROVED BY                                                                                                                                                                                                                    |              |
| FOR REVIEW - BUREAU OF RECLAMATION                                                                                                                                                                                             |              |
| END SYSTEM ACQUISITION                                                                                                                                                                                                         | JANUARY 2011 |
| DRAWING RM 35.91                                                                                                                                                                                                               |              |



Profile RM 35.31 (Looking Downstream)  
(Upper Davis Reservoir at Highway 203)

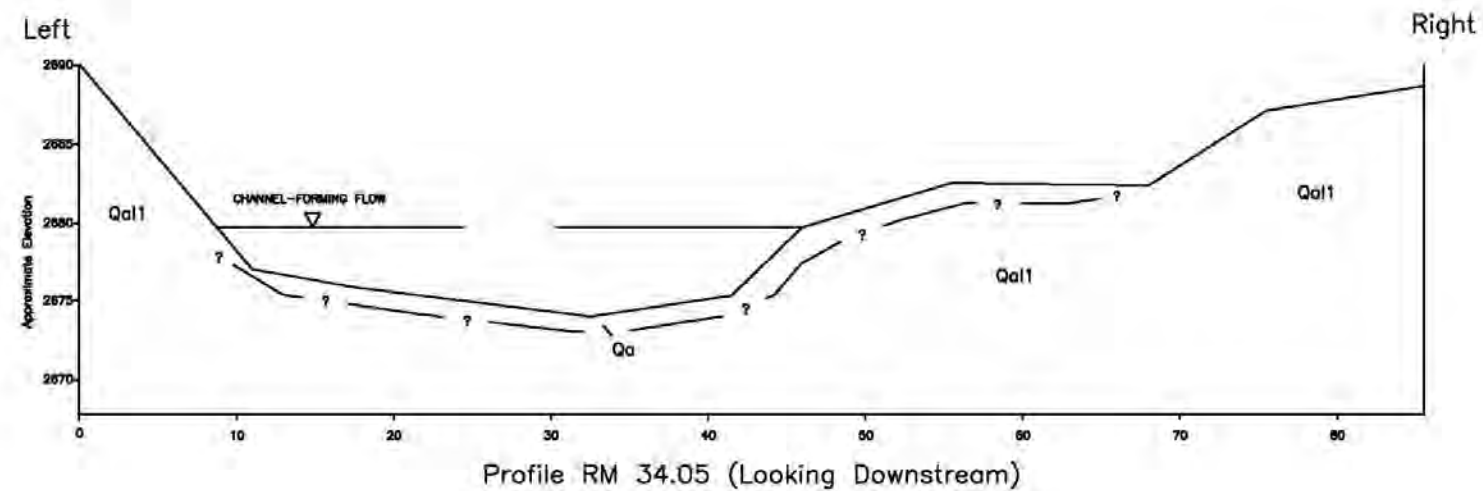
Notes:

1. Elevations (NAVD29) shown on profiles are from the U.S.G.S. 7.5 minute Craig Mountain, Oregon Quadrangle.
2. R.M. = distance in river miles from the mouth of the river at the State Ditch.
3. For descriptions of geologic units and symbols refer to the Geologic Explanation.



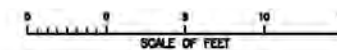
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| ALWAYS THINK SAFETY                                                                                        |                              |
| UNITED STATES<br>DEPARTMENT OF THE INTERIOR<br>BUREAU OF RECLAMATION<br>TRIBUTARY HABITAT PROJECT - OREGON |                              |
| CATHERINE CREEK<br>TRIBUTARY ASSESSMENT<br>PROFILE RM 35.31 - REACH 2                                      |                              |
| DRAWN BY: <u>Michael C. Smith</u>                                                                          | CHECKED BY: <u>JACK AYER</u> |
| APPROVED BY: <u>PER ORDER - JENNIFER TAYLOR</u>                                                            |                              |
| END SYSTEM ACQUISITION<br>BUREAU OF RECLAMATION                                                            | JANUARY 2011                 |

DRAWING RM 35.31



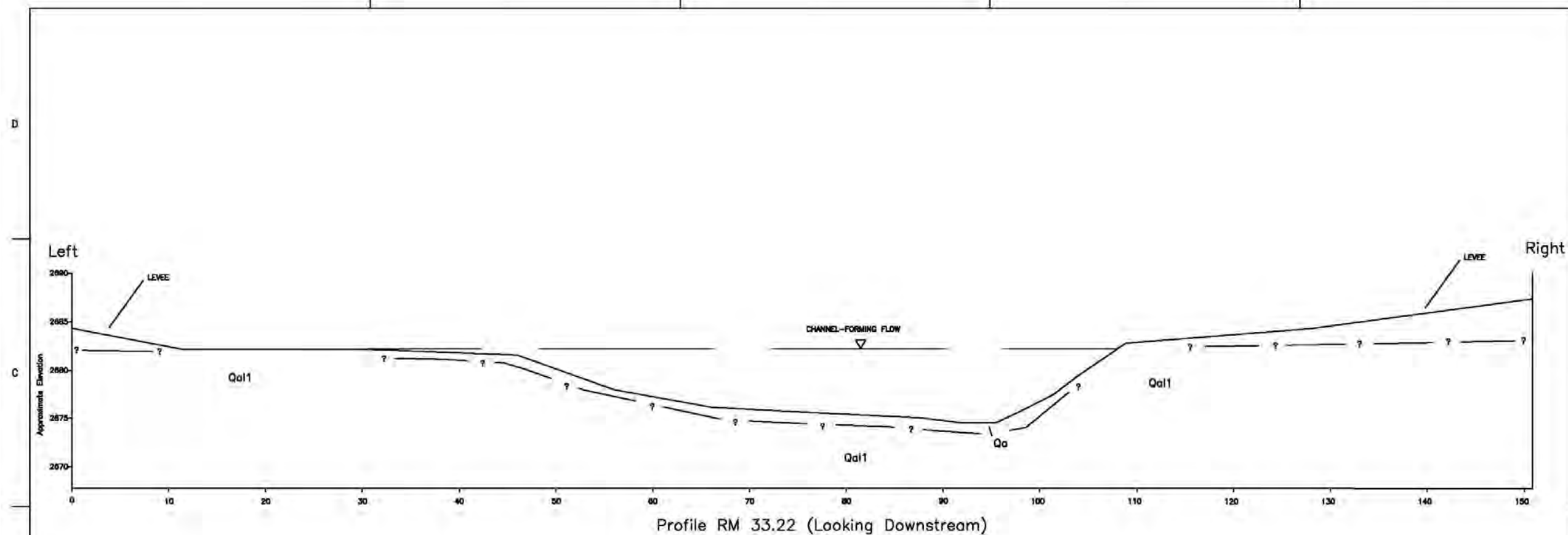
Notes:

1. Elevations (NAVD29) shown on profiles are from the U.S.G.S. 7.5 minute Conley, Oregon Quadrangle.
2. R.M. = distance in river miles from the mouth of the river at the State Ditch.
3. For descriptions of geologic units and symbols refer to the Geologic Explanation.



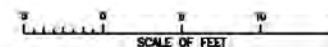
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| ALWAYS THINK SAFETY                                                                                        |                              |
| UNITED STATES<br>DEPARTMENT OF THE INTERIOR<br>BUREAU OF RECLAMATION<br>TRIBUTARY HABITAT PROJECT - OREGON |                              |
| CATHERINE CREEK<br>TRIBUTARY ASSESSMENT<br>PROFILE RM 34.05 - REACH 2                                      |                              |
| DRAWN BY: <u>Michael C. Smith</u>                                                                          | CHECKED BY: <u>JACK AYER</u> |
| APPROVED BY: <u>PER ORDER - JENNIFER GILBERT</u>                                                           |                              |
| END SYSTEM ACQUISITION<br>BUREAU OF RECLAMATION                                                            | JANUARY 2011                 |
| DRAWING RM 34.05                                                                                           |                              |



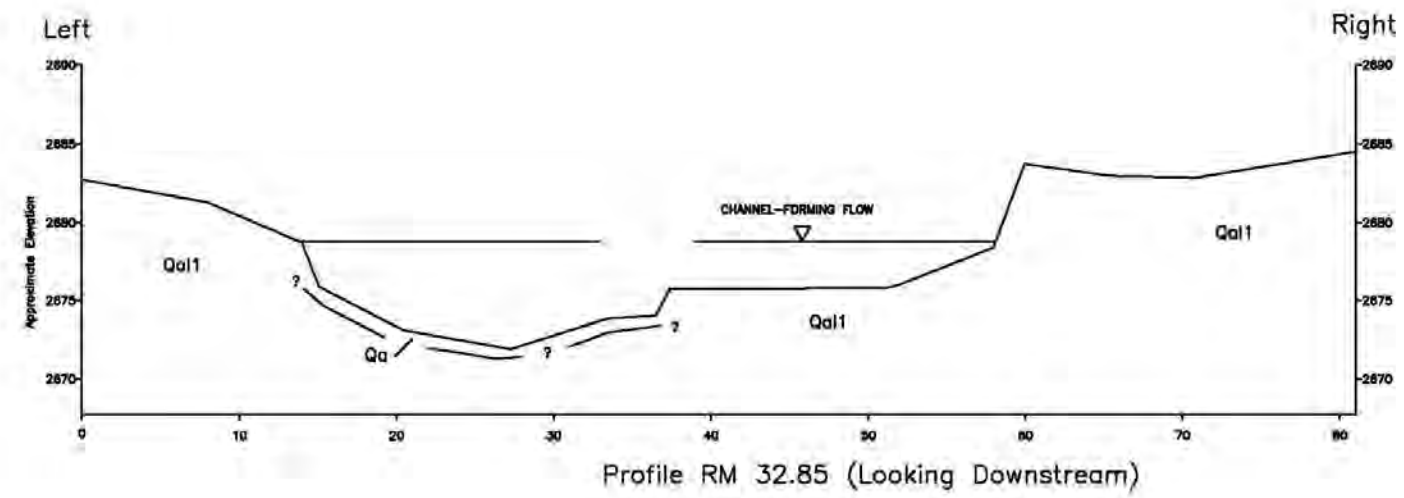


#### Notes:

1. Elevations (NAVD29) shown on profiles are from the U.S.G.S. 7.5 minute Conley, Oregon Quadrangle.
2. R.M. = distance in river miles from the mouth of the river at the State Ditch.
3. For descriptions of geologic units and symbols refer to the Geologic Explanation.

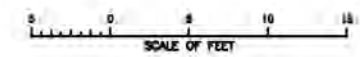


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| ALWAYS THINK SAFETY                                                                                        |                                 |
| UNITED STATES<br>DEPARTMENT OF THE INTERIOR<br>BUREAU OF RECLAMATION<br>TRIBUTARY HABITAT PROJECT - OREGON |                                 |
| CATHERINE CREEK<br>TRIBUTARY ASSESSMENT<br>PROFILE RM 33.22 - REACH 2                                      |                                 |
| DRAWN BY: <u>Michael C. Smith</u>                                                                          | CHECKED BY: <u>JACK A. PYLE</u> |
| APPROVED BY: <u>PER ORDER - JENNIFER GILBERT</u>                                                           |                                 |
| END SYSTEM ACQUISITION<br>BUREAU OF RECLAMATION                                                            | JANUARY 2011                    |
| DRAWING RM 33.22                                                                                           |                                 |

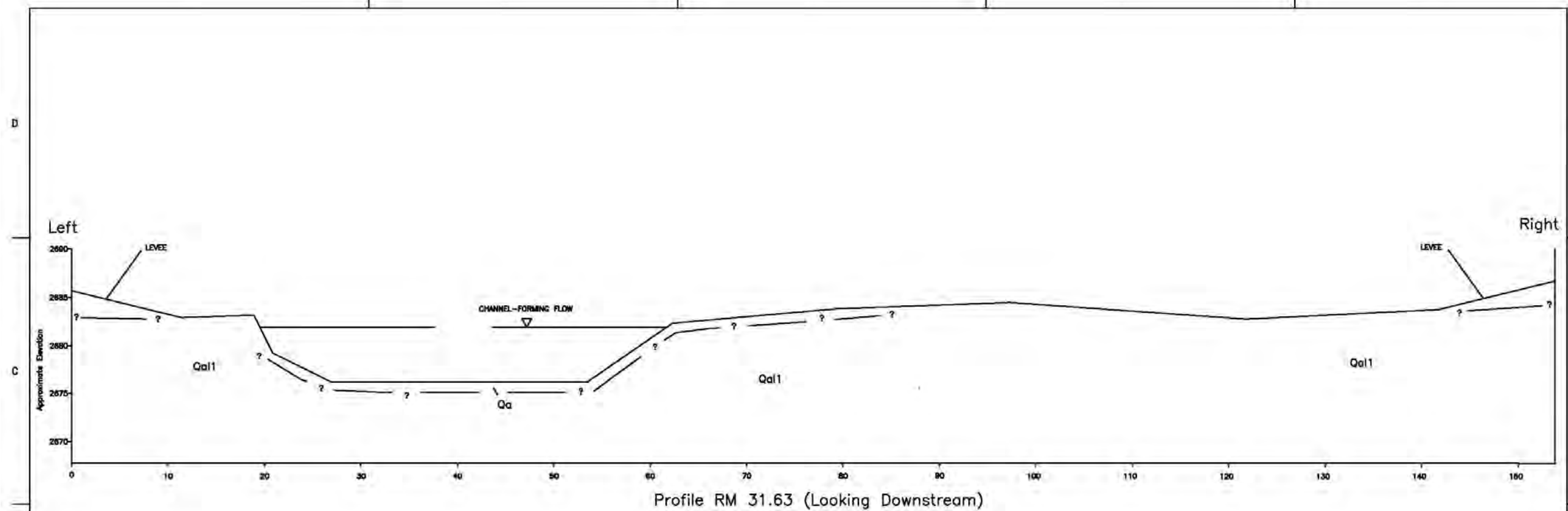


Notes:

1. Elevations (NAVD29) shown on profiles are from the U.S.G.S. 7.5 minute Conley, Oregon Quadrangle.
2. R.M. = distance in river miles from the mouth of the river at the State Ditch.
3. For descriptions of geologic units and symbols refer to the Geologic Explanation.

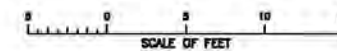


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| <p>ALWAYS THINK SAFETY</p> <p>UNITED STATES<br/>DEPARTMENT OF THE INTERIOR<br/>BUREAU OF RECLAMATION<br/>TRIBUTARY HABITAT PROJECT - OREGON</p> <p>CATHERINE CREEK<br/>TRIBUTARY ASSESSMENT<br/>PROFILE RM 32.85 - REACH 2</p> |               |
| DESIGNED BY                                                                                                                                                                                                                    | CHECKED BY    |
| DRAWN BY                                                                                                                                                                                                                       | JOCKA APPROV. |
| APPROVED BY                                                                                                                                                                                                                    |               |
| END SYSTEM ACQUISITION                                                                                                                                                                                                         | JANUARY 2011  |
| DRAWING RM 32.85                                                                                                                                                                                                               |               |



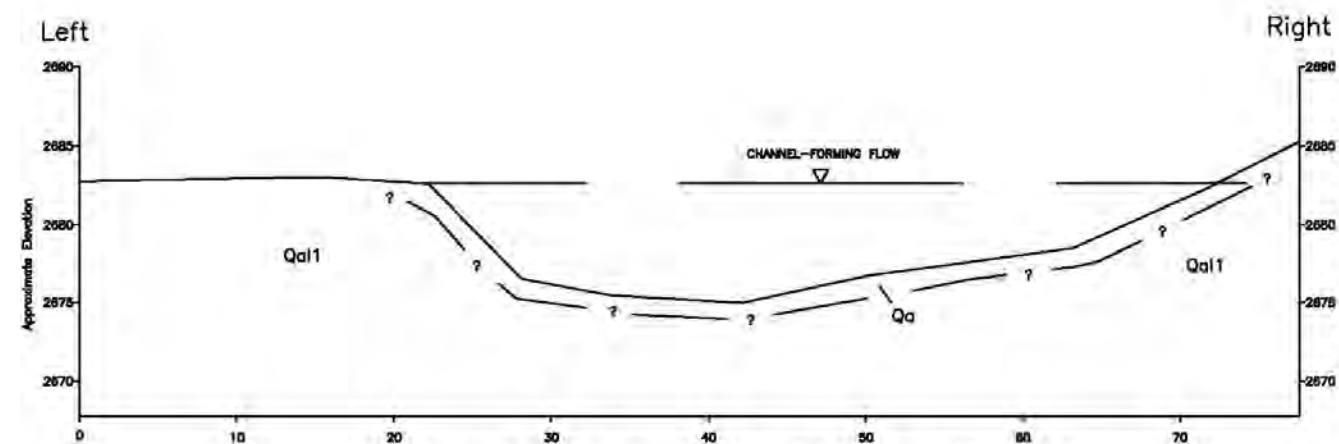
Notes:

1. Elevations (NAVD29) shown on profiles are from the U.S.G.S. 7.5 minute Conley, Oregon Quadrangle.
2. R.M. = distance in river miles from the mouth of the river at the State Ditch.
3. For description of geologic units and symbols refer to the Geologic Explanation.



|                                                                                                            |                                  |
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| ALWAYS THINK SAFETY                                                                                        |                                  |
| UNITED STATES<br>DEPARTMENT OF THE INTERIOR<br>BUREAU OF RECLAMATION<br>TRIBUTARY HABITAT PROJECT - OREGON |                                  |
| CATHERINE CREEK<br>TRIBUTARY ASSESSMENT<br>PROFILE RM 31.63 - REACH 2                                      |                                  |
| DRAWN BY: <u>Matthew Chappell</u>                                                                          | CHECKED BY: <u>JACK AYERS</u>    |
| APPROVED BY: <u>KEVIN WILSON</u>                                                                           |                                  |
| CAD SYSTEM ACAD 2000<br>BUREAU OF RECLAMATION                                                              | JANUARY 2011<br>DRAWING RM 31.63 |





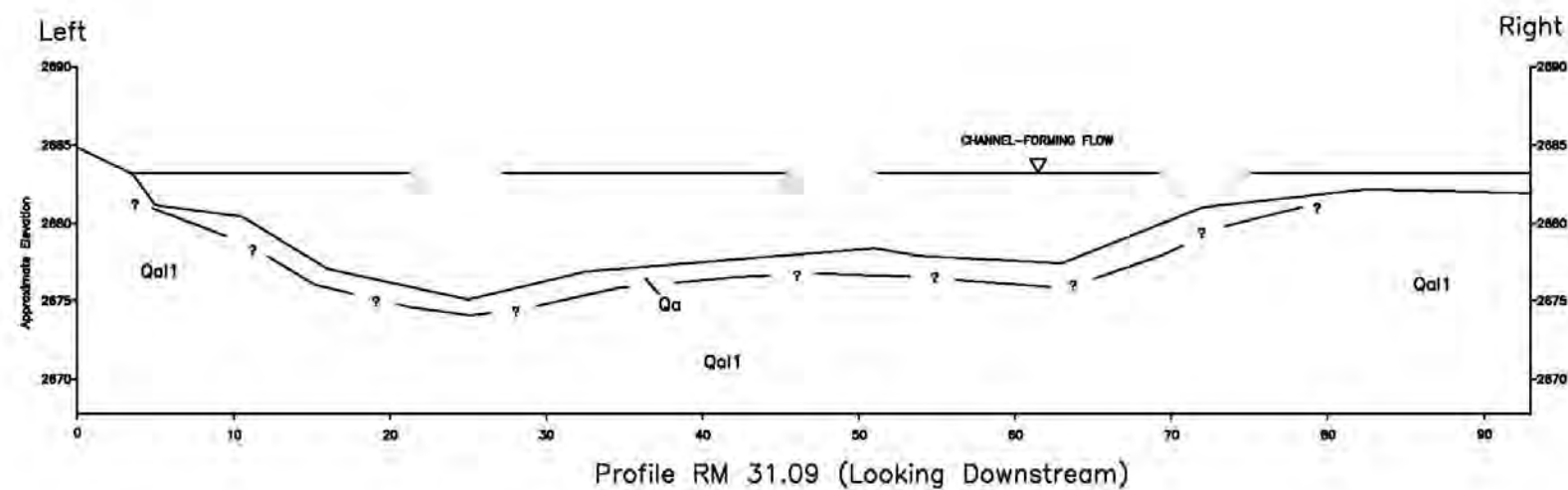
Profile RM 31.39 (Looking Downstream)  
(Near confluence with Ladd Creek)

Notes:

1. Elevations (NAVD29) shown on profiles are from the U.S.G.S. 7.5 minute Conley, Oregon Quadrangle.
2. R.M. = distance in river miles from the mouth of the river at the State Ditch.
3. For descriptions of geologic units and symbols refer to the Geologic Explanation.

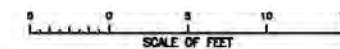


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| ALWAYS THINK SAFETY<br>UNITED STATES<br>DEPARTMENT OF THE INTERIOR<br>BUREAU OF RECLAMATION<br>TRIBUTARY HABITAT PROJECT - OREGON<br>CATHERINE CREEK<br>TRIBUTARY ASSESSMENT<br>PROFILE RM 31.39 - REACH 2 |              |
| DESIGNED BY                                                                                                                                                                                                | CHECKED BY   |
| DRAWN BY                                                                                                                                                                                                   | JOCKA APPR.  |
| APPROVED BY                                                                                                                                                                                                |              |
| END SYSTEM ACQUISITION                                                                                                                                                                                     | JANUARY 2011 |
| DRAWING RM 31.39                                                                                                                                                                                           |              |

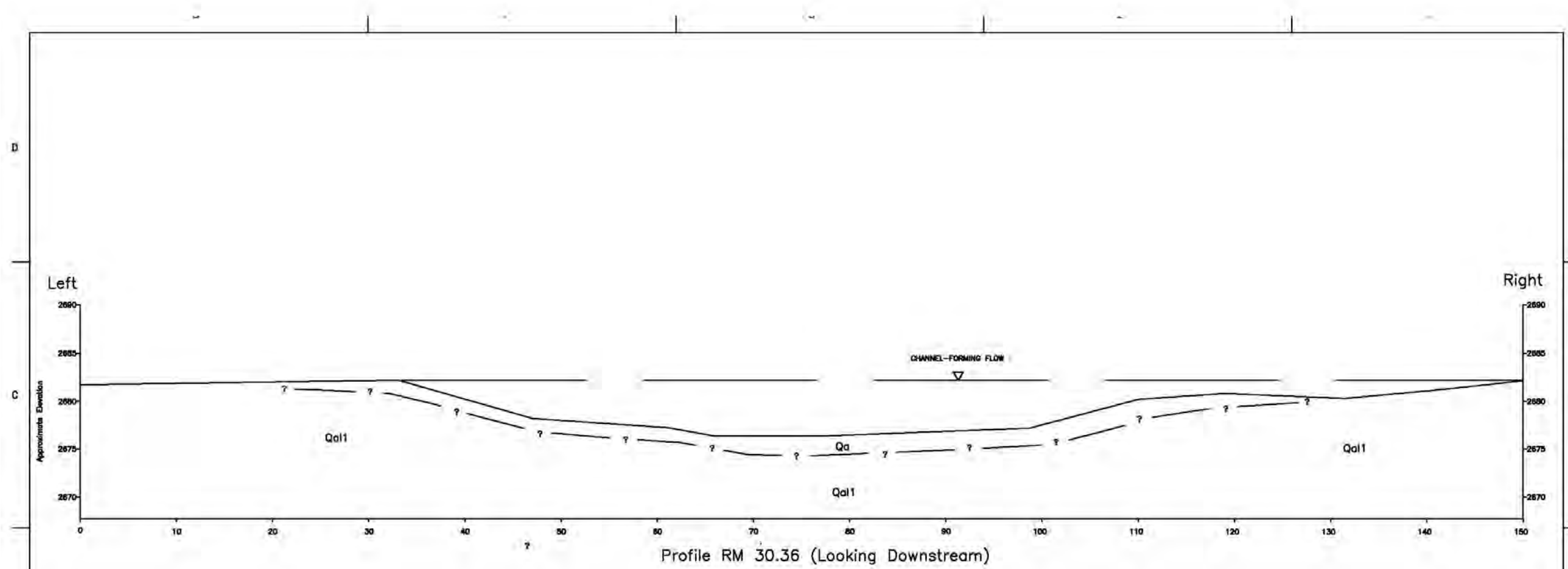


#### Notes:

1. Elevations (NAVD29) shown on profiles are based on water surface measurements relative to Elmer Reservoir (App. El. 2679) and an estimated creek gradient of app. .0001 slope (App. 0.5' per mile); and from the U.S.G.S. 7.5 minute Conley, Oregon Quadrangle.
2. R.M. = distance in river miles from the mouth of the river at the State Ditch.
3. For descriptions of geologic units and symbols refer to the Geologic Explanation.

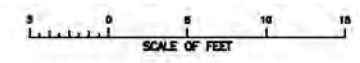


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| ALWAYS THINK SAFETY                                                                                        |                                 |
| UNITED STATES<br>DEPARTMENT OF THE INTERIOR<br>BUREAU OF RECLAMATION<br>TRIBUTARY HABITAT PROJECT - OREGON |                                 |
| CATHERINE CREEK<br>TRIBUTARY ASSESSMENT<br>PROFILE RM 31.09 - REACH 2                                      |                                 |
| DRAWN BY: <u>Michael C. Smith</u>                                                                          | CHECKED BY: <u>JACK A. PYLE</u> |
| APPROVED BY: <u>FOR REVIEW - JENNIFER GILBERT</u>                                                          |                                 |
| CAD SYSTEM ACAD 2000<br>DATE: 08/08/2011                                                                   | DRAWING RM 31.09                |



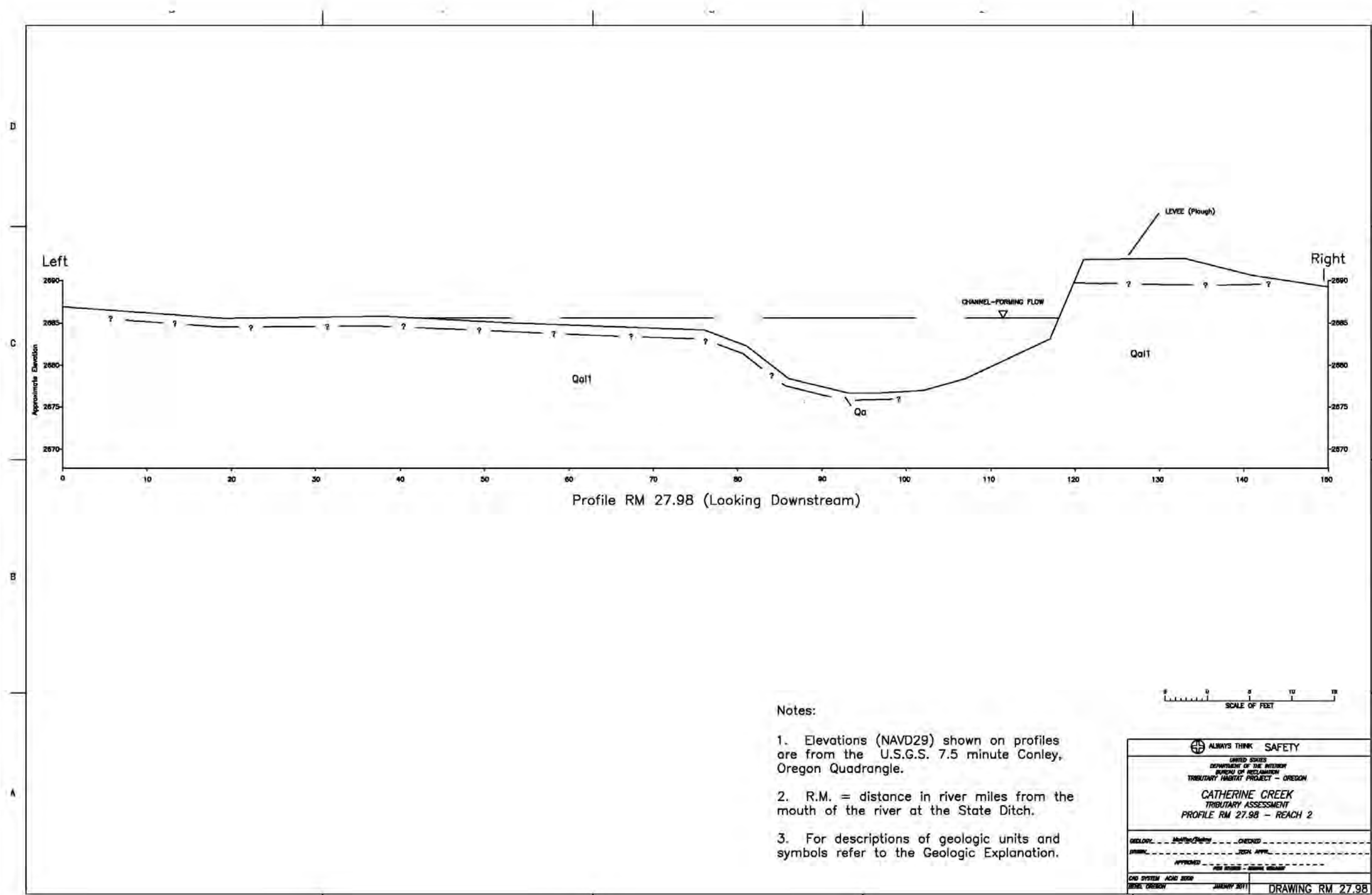
Notes:

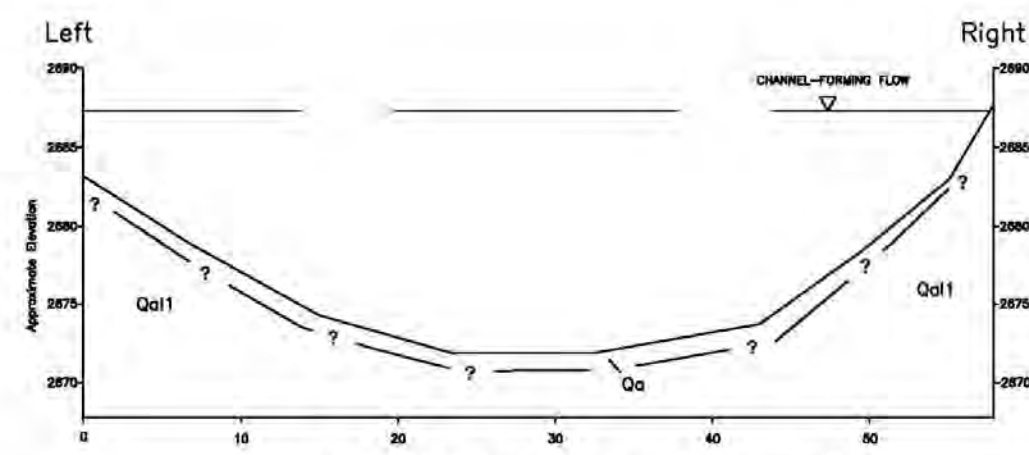
1. Elevations (NAVD29) shown on profiles are from the U.S.G.S. 7.5 minute Conley, Oregon Quadrangle.
2. R.M. = distance in river miles from the mouth of the river at the State Ditch.
3. For descriptions of geologic units and symbols refer to the Geologic Explanation.



|                                                                                                                                                                                                            |              |
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| ALWAYS THINK SAFETY<br>UNITED STATES<br>DEPARTMENT OF THE INTERIOR<br>BUREAU OF RECLAMATION<br>TRIBUTARY HABITAT PROJECT - OREGON<br>CATHERINE CREEK<br>TRIBUTARY ASSESSMENT<br>PROFILE RM 30.36 - REACH 2 |              |
| DESIGNED BY                                                                                                                                                                                                | CHECKED BY   |
| DRAWN BY                                                                                                                                                                                                   | JOCKA APPR.  |
| APPROVED BY                                                                                                                                                                                                |              |
| END SYSTEM ACQUISITION                                                                                                                                                                                     | JANUARY 2011 |
| DRAWING RM 30.36                                                                                                                                                                                           |              |



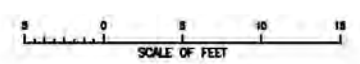




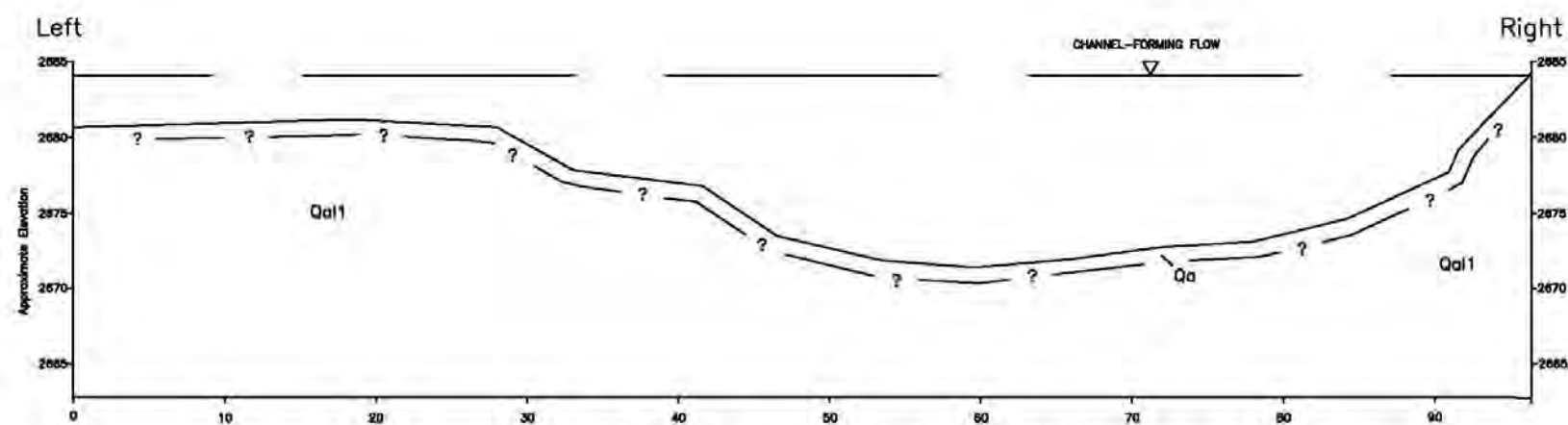
Profile RM 22.42 (Looking Downstream)  
(Elmer Reservoir at Historic confluence of Grande Ronde River)

Notes:

1. Elevations (NAVD29) shown on profiles are from the U.S.G.S. 7.5 minute Cove, Oregon Quadrangle.
2. R.M. = distance in river miles from the mouth of the river at the State Ditch.
3. For descriptions of geologic units and symbols refer to the Geologic Explanation.



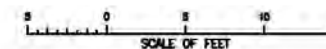
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| ALWAYS THINK SAFETY<br>UNITED STATES<br>DEPARTMENT OF THE INTERIOR<br>BUREAU OF RECLAMATION<br>TRIBUTARY HABITAT PROJECT - OREGON<br>CATHERINE CREEK<br>TRIBUTARY ASSESSMENT<br>PROFILE RM 22.42 - REACH 1 |                  |
| DESIGNED BY                                                                                                                                                                                                | CHECKED BY       |
| DRAWN BY                                                                                                                                                                                                   | JOEY APPAL       |
| APPROVED BY                                                                                                                                                                                                | JOEY APPAL       |
| END SYSTEM ACQUISITION                                                                                                                                                                                     | JANUARY 2011     |
| DATE: OREGON                                                                                                                                                                                               | DRAWING RM 22.42 |



Profile RM 19.02 (Looking Downstream)  
(Elmer Reservoir at Warm Creek)

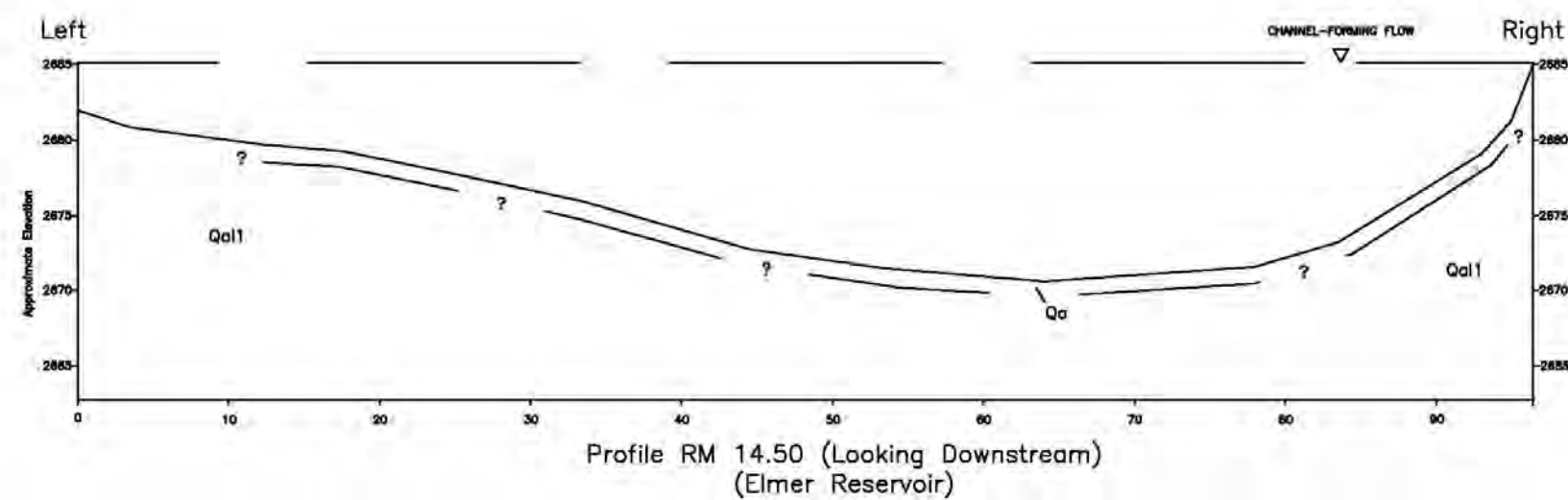
Notes:

1. Elevations (NAVD29) shown on profiles are from the U.S.G.S. 7.5 minute Cove, Oregon Quadrangle.
2. R.M. = distance in river miles from the mouth of the river at the State Ditch.
3. For descriptions of geologic units and symbols refer to the Geologic Explanation.



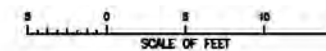
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| ALWAYS THINK SAFETY                                                                                        |                                 |
| UNITED STATES<br>DEPARTMENT OF THE INTERIOR<br>BUREAU OF RECLAMATION<br>TRIBUTARY HABITAT PROJECT - OREGON |                                 |
| CATHERINE CREEK<br>TRIBUTARY ASSESSMENT<br>PROFILE RM 19.02 - REACH 1                                      |                                 |
| DESIGNED BY: <u>Michael C. Smith</u>                                                                       | CHECKED BY: <u>JACK A. PYLE</u> |
| APPROVED BY: <u>John Smith</u>                                                                             |                                 |
| END SYSTEM ACQUISITION<br>BUREAU OF RECLAMATION                                                            | JANUARY 2011                    |
| DRAWING RM 19.02                                                                                           |                                 |





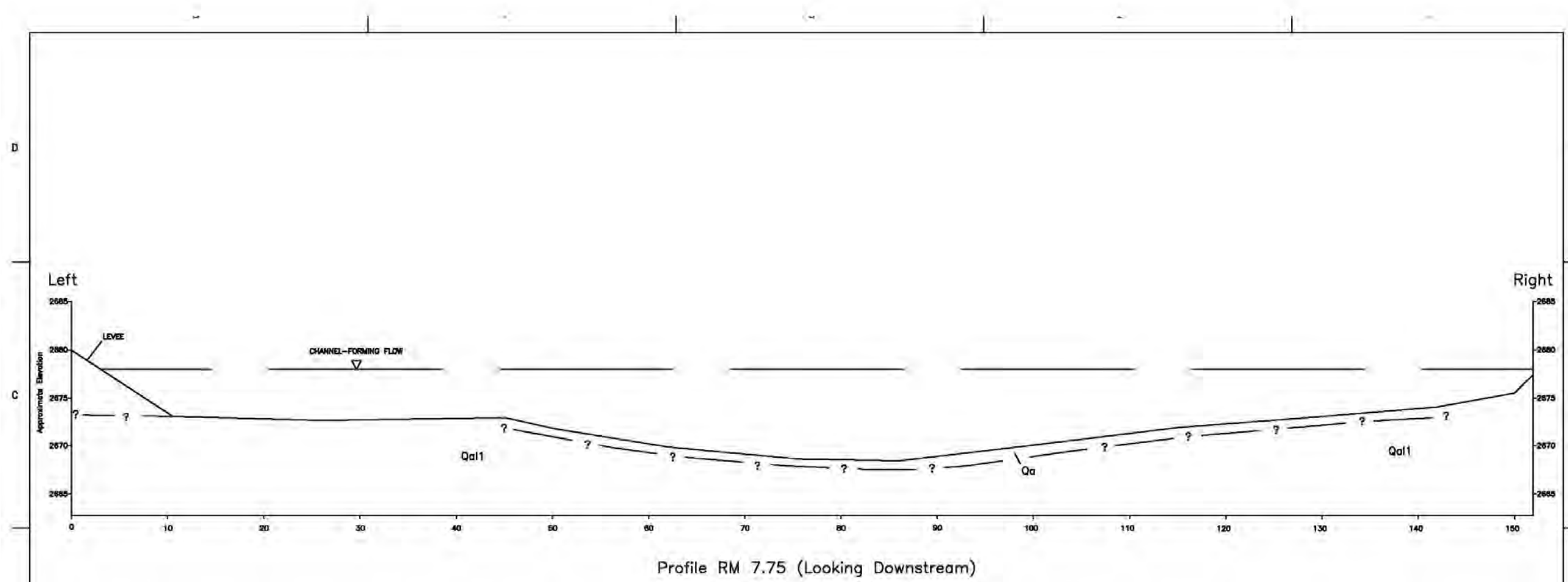
Notes:

1. Elevations (NAVD29) shown on profiles are from the U.S.G.S. 7.5 minute Gasset Bluff and Cove, Oregon Quadrangles.
2. R.M. = distance in river miles from the mouth of the river at the State Ditch.
3. For descriptions of geologic units and symbols refer to Geologic Explanation.



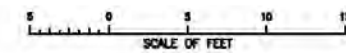
|                                                                                                            |                              |
|------------------------------------------------------------------------------------------------------------|------------------------------|
| ALWAYS THINK SAFETY                                                                                        |                              |
| UNITED STATES<br>DEPARTMENT OF THE INTERIOR<br>BUREAU OF RECLAMATION<br>TRIBUTARY HABITAT PROJECT - OREGON |                              |
| CATHERINE CREEK<br>TRIBUTARY ASSESSMENT<br>PROFILE RM 14.50 - REACH 1                                      |                              |
| DRAWN BY: <u>Michael Cherry</u>                                                                            | CHECKED BY: <u>JACK AYER</u> |
| APPROVED BY: <u>PER ORDER - JENNIFER GILBERT</u>                                                           |                              |
| CAD SYSTEM ACAD 2000<br>BETH OREGON                                                                        | JANUARY 2011                 |
| DRAWING RM 14.50                                                                                           |                              |





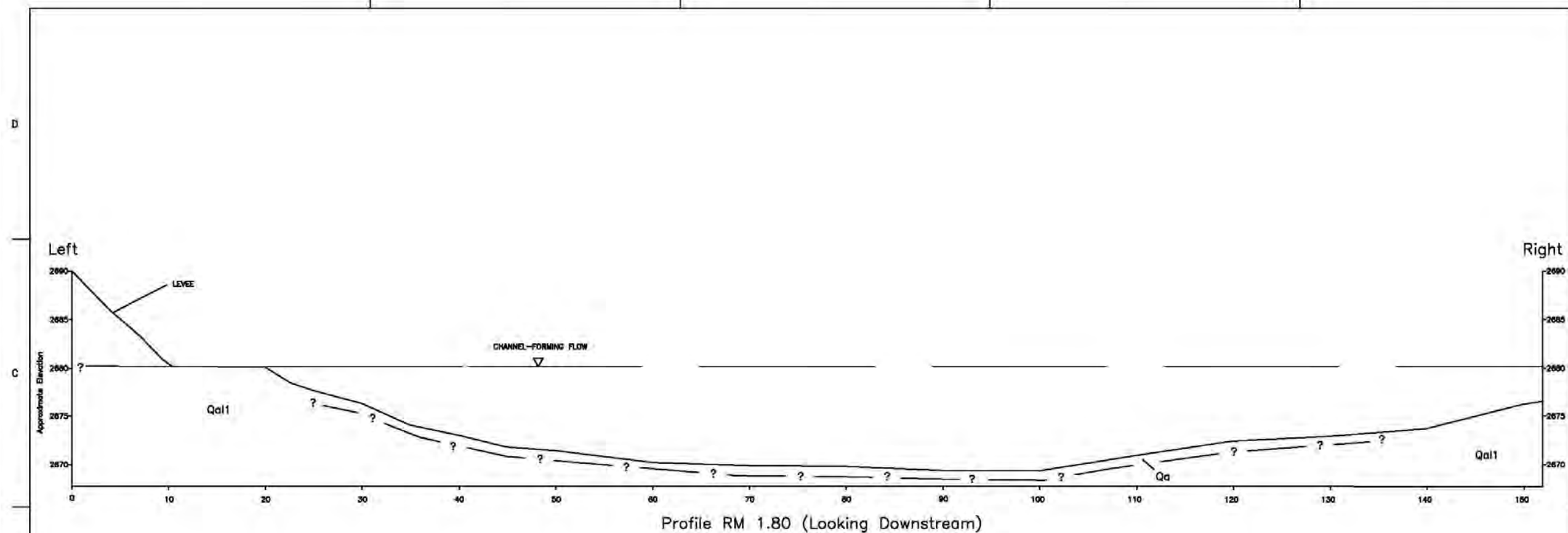
Notes:

1. Elevations (NAVD29) shown on profiles are from the U.S.G.S. 7.5 minute Imbler, Oregon Quadrangle.
2. R.M. = distance in river miles from the mouth of the river at the State Ditch.
3. For descriptions of geologic units and symbols refer to the Geologic Explanation.



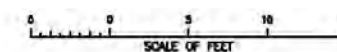
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| ALWAYS THINK SAFETY                                                                                        |                              |
| UNITED STATES<br>DEPARTMENT OF THE INTERIOR<br>BUREAU OF RECLAMATION<br>TRIBUTARY HABITAT PROJECT - OREGON |                              |
| CATHERINE CREEK<br>TRIBUTARY ASSESSMENT<br>PROFILE RM 07.75 - REACH 1                                      |                              |
| DRAWN BY: <u>Matthew Chappin</u>                                                                           | CHECKED BY: <u>JACK AYER</u> |
| APPROVED BY: <u>PER ORDER - DEAN TOLSON</u>                                                                |                              |
| END SYSTEM ACQUISITION<br>BUREAU OF RECLAMATION                                                            | JANUARY 2011                 |
| DRAWING RM 07.75                                                                                           |                              |



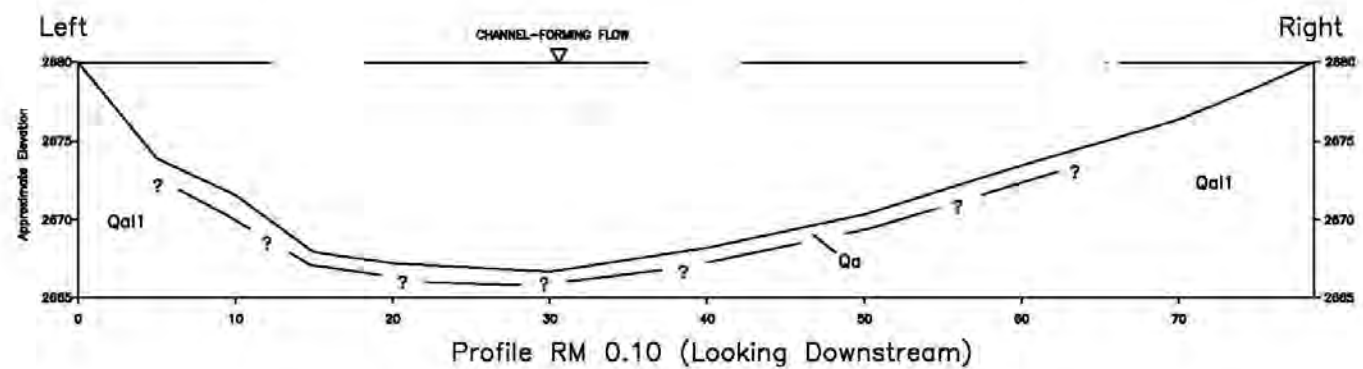


#### Notes:

1. Elevations (NAVD29) shown on profiles are from the U.S.G.S. 7.5 minute Imbler, Oregon Quadrangle.
2. R.M. = distance in river miles from the mouth of the river at the State Ditch.
3. For descriptions of geologic units and symbols refer to Geologic Explanation.

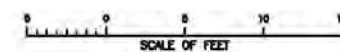


|                                                                                                            |                  |
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| ALWAYS THINK SAFETY                                                                                        |                  |
| UNITED STATES<br>DEPARTMENT OF THE INTERIOR<br>BUREAU OF RECLAMATION<br>TRIBUTARY HABITAT PROJECT - OREGON |                  |
| CATHERINE CREEK<br>TRIBUTARY ASSESSMENT<br>PROFILE RM 1.80 - REACH 1                                       |                  |
| DESIGNED BY                                                                                                | CHECKED BY       |
| DRAWN BY                                                                                                   | JOCKA APPR.      |
| APPROVED                                                                                                   |                  |
| FOR REVIEW - BUREAU CHIEF                                                                                  |                  |
| END SYSTEM ACQUISITION                                                                                     | JANUARY 2011     |
| DATE: OREGON                                                                                               | DRAWING RM 01.80 |



Notes:

1. Elevations (NAVD29) shown on profiles are from the U.S.G.S. 7.5 minute Imbler, Oregon Quadrangle.
2. R.M. = distance in river miles from the mouth of the river at the State Ditch.
3. For descriptions of geologic units and symbols refer to the Geologic Explanation.



|                                                                                                                                                                                                                               |                  |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------|
| <p>ALWAYS THINK SAFETY</p> <p>UNITED STATES<br/>DEPARTMENT OF THE INTERIOR<br/>BUREAU OF RECLAMATION<br/>TRIBUTARY HABITAT PROJECT - OREGON</p> <p>CATHERINE CREEK<br/>TRIBUTARY ASSESSMENT<br/>PROFILE RM 0.10 - REACH 1</p> |                  |
| DESIGNED BY                                                                                                                                                                                                                   | CHECKED BY       |
| DRAWN BY                                                                                                                                                                                                                      | IN CHARGE        |
| APPROVED BY                                                                                                                                                                                                                   |                  |
| END SYSTEM ACQUISITION                                                                                                                                                                                                        | DATE             |
| DATE                                                                                                                                                                                                                          | DRAWING RM 00.10 |