Final Grand Ditch Report

Rocky Mountain National Park, CO

Covey Potter and Dr. David Cooper

BACKGROUND

In 2003 the Grand Ditch, located on the east-facing slope of the Never Summer Range within Rocky Mountain National Park, breached in a reach above Lulu Creek; inundating the creek, several km of the Colorado River and its floodplains, and the Lulu City wetland with more than 36,000 m^3 of sediment and debris (RMNP Fact Sheet 2010) (Figure 1 in appendix 3). Sediment deposits from this event have altered stream channels, flood plains, streamside water table, and riparian vegetation. Riparian vegetation is sensitive to alterations in groundwater, limiting the establishment of critical plant species, shifting species composition, affecting ecosystem functions, and causing die back and mortality (Rood and Mahoney 1990, Smith *et al.* 1991, Dixon and Johnson 1999). Riparian vegetation composition is determined in part by available shallow groundwater (Brinson *et al.* 1985, Van Coller *et al.* 2000) that may be linked to stream water (Rood *et al*. 2003, Cooper and Merritt in press).

STUDY AREA

The restoration study site is in western Rocky Mountain National Park along the headwaters of the Colorado River, its tributaries, and adjacent wetlands. The Kawuneeche valley ranges from 2,700 – 3,100 m above sea level and is flanked by two mountain ranges that rise 1,200 m above the valley floor. The Never Summer Mountains to the west were formed by a now-extinct volcanic chain. With most of the volcanic rock eroded away, igneous granitic and metamorphic formations dominate covered by an extensive lateral moraine from Pleistocene glaciations and areas of unstable hydrologically-altered welded tuff. The highly erosive volcanic formations of Specimen Mountain stand to the east (Braddock and Cole 1990). Silt loam and loamy sand textured mineral soils in the valley naturally vary in thickness (Braddock and Cole 1990); however multiple debris events over the past 100 years have artificially thickened this substrate. The study area is a mixture of high and low gradient stream channels, wetlands, and wet meadows. Stream flows are altered by water diversion into the Grand Ditch, resulting in as much as a 60 percent reduction of snowmelt peak flows and summer receding flows (Woods 2001). The sites slated for restoration have been greatly impacted by altered stream flow, aberrant sedimentation, and the resulting shift in riparian vegetation. Reference sites in and out of RMNP provide insight into soil structure, groundwater depths, and vegetation composition on which to base restoration.

Four reference reaches within the Colorado River valley in RMNP and 11 reference reaches outside of the Colorado River valley were studied. The offsite reaches were along Saint Vrain Creek and Big Thompson River on the East side of RMNP, Willow Creek in the Routt National Forest North of Clark, two reaches of Willow Creek in the Arapaho National Forest North of Granby, Elk River in the Routt National Forest Northeast of Clark, Homestake Creek and Eagle River in the White River National Forest South of Redcliff, Cataract Creek in the Dillon Ranger District South of Heeney, and Ranch Creek in the Arapaho National Forest East of Tabernash.

METHODS

Reference Sites: I selected four Colorado River reference reaches comparable to areas affected by the 2003 Grand Ditch breach in June of 2009 using physical site attributes (e.g. elevation, aspect, slope, channel size, valley size, and flow rates) in conjunction with a visual reconnaissance survey (Cooper, Rathburn, and Potter 2009). Reference reaches are along Sawmill Creek, the Colorado River at Shipler Park, Lost Creek, and just below the confluence with Beaver Creek. Reference surveys were conducted onsite (at the headwaters of the Colorado River and tributaries in the Kawuneeche Valley in RMNP) and offsite at selected watersheds elsewhere in the Rocky Mountains of Colorado.

ONSITE

Groundwater Monitoring: In June of 2009, I installed 35 groundwater monitoring wells at the onsite reference reaches (Table 1). 13 at Lost Creek, 8 at Shipler Park, 6 at Sawmill Creek, and 8 below Beaver Creek. Wells were constructed of 1 ½ inch slotted PVC pipe with a perforated bottom cap and solid top cap. Wells were installed along transects perpendicular to the river so as to monitor water table cross sections across the flood plain gradient. Wells were installed by hand using a spade, rock bar, post-hole-digger, and bare hands. Floodplain pits were excavated below the groundwater to the point where the sides of the pit could no longer hold shape. PVC wells were inserted and the hole was backfilled. Each well varied in depth between .5 – 1.5 m. Staff gauges were installed at each reference reach to measure stream height (Figure 2 in appendix 3). 50 wells had been previously installed in the reaches impacted by the breach (Gage 2004) (Figure 3 in appendix 3). Groundwater levels were monitored using the 85 total wells (Figures 4 – 29 in appendix 3). Manual depth to water (DTW) measurements were taken biweekly during June through October using a metal tape measure fitted with a multimeter. Water table depth was logged as the distance from the top of the water column to the western lip of the well and stickup (PVC height above ground surface) was subtracted to give DTW to the nearest 10th of a cm. To corroborate the manual DTW measurements, 8 In-situ Level Troll 100 digital data loggers were installed – 2 at each reference site. The data loggers were suspended by 24 gauge steel galvanized wire attached to a horizontal steel bolt threaded through the top of the well. The stickup to bolt and cable length were measured and recorded for later calibration. The data loggers recorded pressure and temperature every 15 minutes from in July – October 2009 and again June – October 2010. The data was downloaded and corrected using In-situ Baro-merge software and In-situ Barrologger data from the Kawuneeche visitor center in RMNP.

Vegetation Analysis: In August 2009 I analyzed the vegetation in 25 m^2 plots centered around each reference site groundwater monitoring well. All species present were noted and percent canopy cover by species was visually estimated for each plot. Plant species nomenclature follows Weber and Whitman (2001).

Soil Stratigraphy: In September of 2009 using a small Bobcat with an excavator attachment 51 pits were dug in zones 3 and 4 (Figure 30 in appendix 3) and 7 PVC groundwater monitoring wells were installed. Pits were less than 2 meters in depth due to the length of the excavator arm and varied in width depending on erodibility of soil particles. The pits filled rapidly with subsurface water and required continuous bailing by a diesel-powered pump. Soil stratigraphy interpretations revealed thickness of post breach sediment layers and uncovered buried vegetation (Figures 31-82 in appendix 3).

Stream Flow: Daily flows from June – September for the Colorado River were compiled using the USGS Baker Gulch gage in RMNP. To remove inflow variables from tributaries below the reference reaches and above the gage, I subtracted hand sampled 2009 and 2010 upper Colorado River flow rates (Rubin 2010, Henke and Grimsley 2010) from the same date Baker Gulch gage data to determine an average monthly adjustment variable.

OFFSITE

In the spring of 2010, I selected 11 offsite reference reaches in 6 watersheds in northern Colorado (Figures 83-86 in appendix 3). Reference sites were selected on National Forest lands using the United States Forest Service Valley Bottom Classification (VBC) (Carlson 2010). The VBC organizes river reaches by basin, valley width, channel width, stream volume, gradient, and elevation in ArcMap. Utilizing the physical site attributes of the RMNP reaches affected by the breach, The VBC selected several hundred random sites comparable to the Colorado River headwaters and tributaries; I further rectified the VBC selection using United States Geological Survey (USGS) Seamless server orthophotos in ArcMap to analyze standardized elevation, aspect, and gradient conditions. I used Google Earth to determine land ownership and proximity of potential sites to roads. On the ground field observations were the last step in the selection process, looking for the least disturbed, most pristine reference conditions. I selected 10 reference sites in 6 watersheds, a 1 km reach within each site, and 10 homogenous riparian vegetation survey plots per reach; for a total of 100 survey plots. 10 reference surveys per reference condition are desirable to provide adequate comparison within each watershed (Barbour *et al.* 1999).

Offsite reference site surveys were conducted over a two week period in July 2010. Each survey plot was 25 m^2. For each reference survey I measured stream gradient, depth to groundwater, soil characteristics, and vegetation composition. I used USGS stream gage data to determine flows at each survey location.

Groundwater Monitoring: Pits were excavated at the center of each 25 m^2 survey plot to measure DTW. Each pit was excavated using a 10 cm diameter bucket auger. Pits remained open for approximately 24 hours to allow groundwater levels to stabilize before DTW was measured.

Soil samples: A 10x30 cm^3 soil core was collected from each groundwater pit and placed into a 1 gallon zipper-lock bag. Immediately upon return from the field I measured soil moisture content by weighing approximately 10 grams of wet soil from each survey plot, placing samples in the drying oven at 105^o c for 72 hours, before reweighing. I conducted a soil particle size analysis using the hydrometer method (Carter 2008) to determine soil type and percentage of sand, silt, and clay.

Vegetation Analysis: Homogenous stands of riparian vegetation were identified using orthophotos and onsite inspections. Survey plots were 25 m^2 and ranged from directly adjacent to the stream channel to higher on the flood plain. Only riparian communities were surveyed. All species present were noted and percent canopy cover by species was visually estimated for each plot. Plant species nomenclature follows Weber and Whitman (2001).

Stream Flow: Long term stream discharge data were compiled from the closest USGS stream gaging stations to each reference site. A daily flow hydrograph was created for each site for the 2009-2010 water year.

Results

Soil stratigraphy interpretations of the excavated pits exposed variable sediment thicknesses across Lulu City Wetland (Zone 4). Sediment thickness varied according to least resistant flow path and the magnitude and intensity of the event. I developed sediment thickness representational maps for both the solitary 2003 debris event deposition (Figure 1 in appendix 1) and total sedimentation (Figure 2 in appendix 1). At 3 pit excavation locations in zones 3 and 4 we extracted trees (Figure 3 in appendix 1). An unknown willow species, Narrowleaf Cottonwood, and Lodgepole Pine were removed from the pits and taken to the CSU lab where I found the point-of-germination pith and developed an approximate germination date for each specimen (Table 1 in appendix 1). All three trees germinated on bare streamside sediments deposited by historic debris events. These germination dates give us a better perspective into the dates and impacts of historic ditch-related sedimentation and explain the various even aged stands of trees along the elevated floodplain of the Colorado River.

Preliminary top 12 desired vegetation species for restoration were compiled using PC-Ord software (Table 2 in appendix 3). Their approximate requisite DTW and soil texture requirements are included. PC-Ord clusters individual species by environmental characteristics providing average DTW and soil texture requirements for each species at all 114 reference site plots. A more detailed and expansive vegetation list and environmental characteristic report will be filed next year after a second season of reference site data is collected in 2011.

Preliminary ground surface models developed from sediment pit excavations reveal a desired ground surface in Lulu City Wetland significantly below the current ground surface (Figure 1 – 4 in appendix 2).

Discussion

Groundwater monitoring wells were read less often during the 2010 season than in previous years due to the 30-40 year flood event and offsite reference site data collection. The deep snowpack, rain on snow events, and the resulting swift flood waters prohibited safe Colorado River crossing limiting groundwater well monitoring. In addition, until the peak stage had subsided, most stream side groundwater monitoring wells were flooded. Offsite data collection commenced between July 20 and August 6, 2010 limiting onsite DTW collection along the Colorado River.

This is a final report for the 2009-2010 task agreement; however, the data collected under this agreement is part of a larger continuous data set. Further analyses and results will be forthcoming as part of the 2011-2012 task agreement.

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