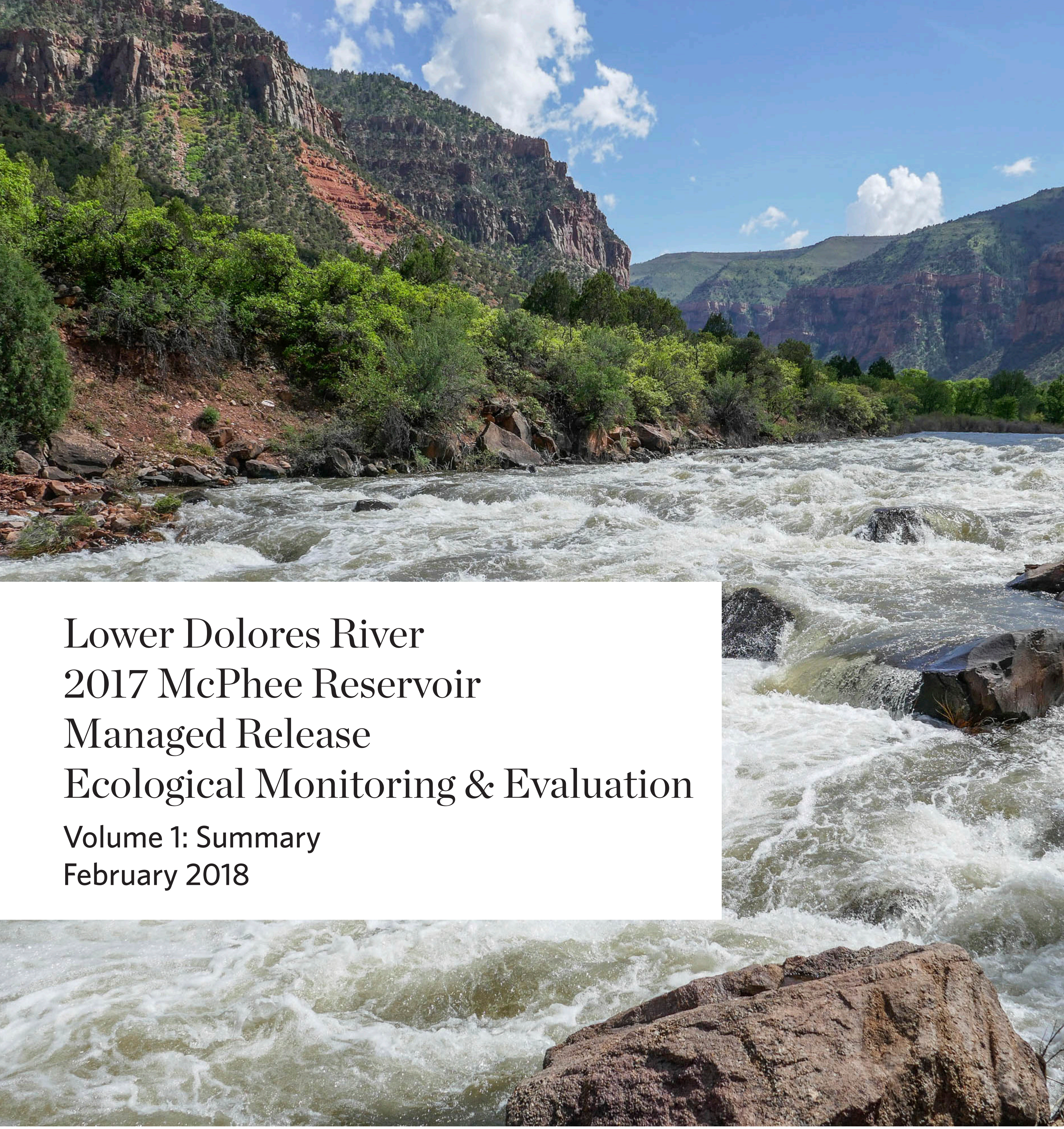


Lower Dolores River 2017 McPhee Reservoir Managed Release Ecological Monitoring & Evaluation

Volume 1: Summary

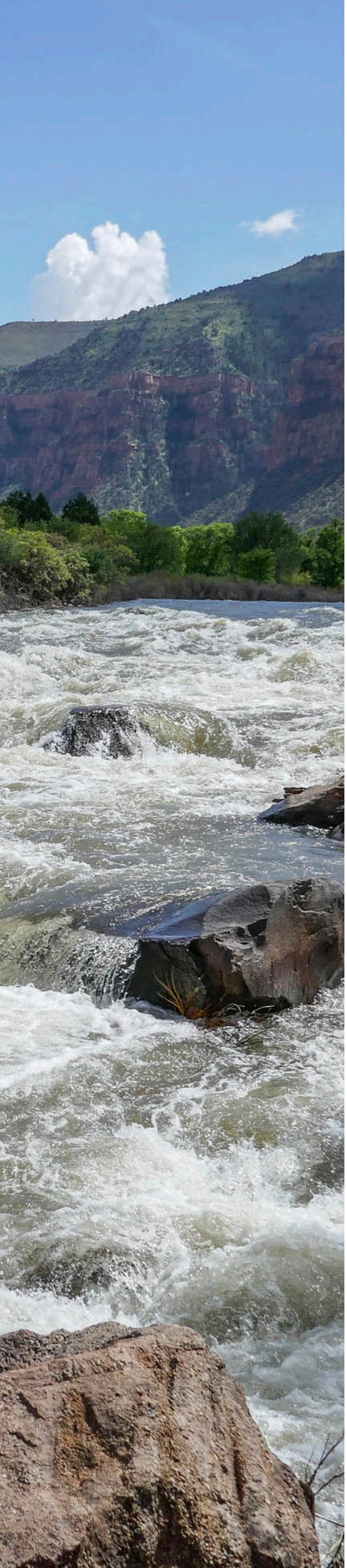
February 2018

Colorado Parks Wildlife

The Nature Conservancy

Colorado Mesa University
Ruth Powell Hutchins Water Center

Fort Lewis College



EXECUTIVE SUMMARY

In 2014, a diverse group of stakeholders working together on the Dolores River finalized the Lower Dolores River Implementation, Monitoring and Evaluation Plan for Native Fish ('2014 Plan'). It was designed to provide specific guidance on monitoring and management actions to improve the status of native fish populations on the Lower Dolores River while respecting existing water rights, water allocations, Dolores Project contracts, and other Project commitments including the tailwater trout fishery and mitigations for whitewater boating. The Dolores River Native Fish Monitoring & Recommendation Team ('M&R Team') was also created to provide guidance and identify opportunities for future 2014 Plan implementation.

Release management, and especially the management of larger releases from McPhee Reservoir, is identified as an important opportunity for native fish in the 2014 Plan. In the winter of 2016/2017, water elevations in McPhee Reservoir, the snowpack in the Dolores River Basin, and forecasting for the 2017 water year all began to point towards the possibility of a large managed release from the reservoir into the Lower Dolores River in the spring of 2017. As such, the Dolores Water Conservancy District (DWCD), Bureau of Reclamation (BOR), and M&R Team began work using the 2014 Plan to identify opportunities for this release to benefit native fish and the associated river ecology below McPhee Reservoir.

The 2014 Plan sets forth specific habitat objectives for native fish (and associated measurable benchmarks) hypothesized to be achievable at four different flow ranges (pp. 29-30), as well as spelling out four native fish assumptions for all managed release scenarios (p. 27). Habitat goals range from flushing of fine sediments and thermal regime management at lower forecasted releases, to habitat maintenance and inducing channel heterogeneity at higher forecasted release volumes. In planning for a potential managed release, reservoir managers determine which flow level(s) might be possible, then researchers plan monitoring efforts to evaluate the success of the managed release in accomplishing habitat objectives associated with those target flow level(s).

Reservoir managers determined it might be possible to achieve all four target flow ranges with the 2017 managed release and aimed to address all four native fish assumptions. The M&R Team developed a plan to evaluate as many measurable benchmarks as possible associated with the habitat objectives for each target flow range. In March 2017, The Nature Conservancy (TNC) and Colorado Parks & Wildlife (CPW) (both members of the M&R Team) launched this monitoring effort with support from Fort Lewis College, Colorado Mesa University, Bureau of Land Management, United States Forest Service, private landowners, and volunteers. Monitoring focused on: (1) sensitive native fish; and (2) assessment of in-channel and riparian habitat. Select pre- and post-release data were collected on five newly established ecological monitoring sites and at multiple other sites.

Dolores River © *John Fielder*

The first strategic reservoir release on the Dolores River to be conducted in association with the 2014 Plan and to address specific ecological targets was managed by the DWCD and BOR, with assistance from the M&R Team, in 2017. It ran for 86 days with an overall total of 208,190 AF released, and downstream releases collectively totaling 63 days at or above 800 cfs, 40 days at or above 1,200 cfs, 11 days at or above 2,000 cfs, and 3 days at 4,000 cfs. Table 1 below shows how the 2017 managed release achieved target flow ranges and native fish assumptions.

Table 1. Summary showing how the 2017 managed release achieved the four target flow ranges and four native fish assumptions.

Target Flow/Native Fish Assumption	How Addressed with 2017 Managed Release
Target - Flushing Flow: 400-800 cfs to scour fine sediment Assumption - Provide flushing flows to prepare spawning bed (~400-800 cfs)	Flushing flows in 400-800 cfs range were achieved during the 2017 release
Target - Flushing Flow: 800-2,000 cfs to initiate mobilization of the median-size particle	Flushing flows in the 800-2,000 cfs range were achieved during the 2017 release.
Target - Habitat Maintenance Flow: 2,000-3,400 cfs for 7+ days (bankfull flows)	Habitat maintenance flows over 2,000 cfs were achieved for more than 7 days.
Target - Habitat Maintenance Flow: Peak flows of >3,400 cfs at frequency of ~7-10 yrs	Peak flows of >3,400 cfs were achieved in early May.
Assumption - Preventing thermal shock: improve ascending spring flows beginning April 1 that ramp sufficiently to minimize pre-release water warm-up that triggers pre-release spawn	Water managers were prepared to make spring releases to prevent thermal shock in 2017, but the early runoff and pre-April 1 start to the release made those thermal regime management releases unnecessary.
Assumption - Attempt to mimic natural pattern of flows during a spill at times most critical to native fish	The 2017 Release was planned and adjusted to mimic a natural pattern of flows under the weather and runoff conditions of 2017.
Assumption - Recession limb of 200 cfs decrease over two days can be used to provide monitoring conditions and assist boaters. This can provide a sufficient three-day period of 400-500 cfs for monitoring.	The ramping criteria were used during the 2017 release to assist boaters and for ecological purposes (including the avoidance of stranding native fish during the recession limb). Water managers worked with CPW to provide appropriate flows for a multiple-day electrofishing survey of Slickrock Canyon (last surveyed in 2007).

Additionally, water managers and the Dolores River Biology Committee worked together to ensure the 2017 managed release was of long enough duration that the Biology Committee could recommend using fish pool water to support a non-native fish removal effort in the Pyramid Reach (also an opportunity identified in the 2014 Plan) after the release ended (in July of 2017).

One challenge of the 2017 monitoring effort was unusually early low-elevation runoff that reduced opportunities to monitor some aspects of instream habitats (riffle dynamics and longitudinal dimensions within the channel). Runoff from the Dolores Rim and the Dolores/Norwood plateau regions elevated flows in the Dolores below McPhee beginning in early March, and peaked at or above 600 cfs during the pre-release sampling period, making it impossible to perform all of the instream assessments envisioned in the plan.

Overview of Major Findings

The status of native fish in the Lower Dolores River has improved over where it was a decade ago, with increases in native fish capture and documented evidence of reproduction. The 2017 managed release benefitted in-channel habitat for native fish. For habitat along the channel, results were mixed. The high flows during the 2017 managed release caused very limited river bank erosion and thinning/removal of riparian vegetation because unnaturally dense vegetation growing along much of the Lower Dolores River has 'armored' the river banks. Despite these armored banks, substantial interaction between the channel and the floodplain occurred, with overbank flooding documented at multiple sites, resulting in noticeable sediment deposition and scour and recharging of the alluvial aquifer.

Key observations of ecological response to the release include:

Sensitive Native Fish

- There was a 95% increase in catch per unit effort (CPUE) over 2007 for all three sensitive native fish species (flannelmouth sucker, bluehead sucker, and roundtail chub). In 2017, 0.43 fish per minute were caught, compared to 0.22 fish per minute in 2007. Despite this improvement, overall density of native fishes is still low.
- All species of sensitive native fish reproduced in 2017. Roundtail chub reproduction was evident at most sites; bluehead sucker and flannelmouth sucker reproduction was also detected, but at low levels. Detection of small new fish is difficult, so surveys in future years will provide a better indication of how much native fish reproduction occurred in 2017.
- Slickrock Canyon is still a stronghold for native species, with the three sensitive native species comprising 88% of the total catch (flannelmouth suckers comprising 53% of the catch, roundtail chub 32%, and bluehead sucker 3%).
- Non-native fish known to prey on native fish have increased. Specifically, smallmouth bass have increased in the Pyramid reach. Other non-native species with small populations that should be monitored are channel catfish, green sunfish, red shiner, and redside shiner.
- One white sucker was found in Slickrock Canyon. This species had not previously been documented below McPhee Dam. White suckers hybridize with native suckers, and are a serious threat to the genetic integrity of native suckers.

In-channel and Riparian Habitat

Through most alluvial ecological monitoring sites, there was evidence of scouring and evacuation of material within surveyed pools, with some evidence of floodplain deposition at a few of these sites, confirming that the release transported sediment and increased pool volume. For example, at the BLM Rec (Big Gypsum) site, mean pool depth increased by more than 3 feet, changing the cross-sectional area from 433 square feet pre-release to 1,226 square feet post-release, increasing pool volume by almost 300%.

- At a low-floodplain location at the Slickrock Downstream site, fine sediments (2 mm particles) were almost completely removed by the release and larger cobbles were moved. Median particle size at this location increased 27%, from 85 mm to 108 mm. This low-floodplain finding suggests that in-channel riffles were at least equally coarsened by the managed release, improving native fish breeding and foraging habitat.

- Except for bank erosion at one site, there was little evidence that the managed release eroded banks and increased channel width, as would be expected during a natural flood. This suggests that the Dolores River is stabilizing within a narrower channel.
- Historic photo comparison confirms that the density of riparian vegetation and consequent 'armoring' of river banks has increased substantially from 2003 to 2017 on multiple sites along the Dolores.
- The configuration of the channel as seen from above (the planform) was little changed.
- Despite armored banks, overbank flooding occurred at multiple sites. This flooding allowed:
    - » Sediment deposition in many areas, up to three feet in some locations.
    - » Flood and water movement through side channels that normally remain dry.
    - » Replenishment of alluvial / floodplain aquifers. At the BLM Rec (Big Gypsum) site groundwater rose to within 2 feet of the ground, providing water to adult cottonwoods.
- The managed release created very few new bare areas where cottonwood seedlings could establish. No new cottonwood seedlings were found on the ecological monitoring sites, likely due to a combination of dense existing vegetation and timing of peak flows that did not correspond with timing of cottonwood seed release.

Summary Table

Table 4 of the 2014 Plan outlines specific native fish habitat objectives to be accomplished through release manipulation, and includes measurable indicators to be monitored in the field to determine progress towards reaching these habitat objectives. The table below (Table 2) organizes the major findings from the 2017 ecological monitoring according to the specific measurable benchmarks/indicators from Table 4 of the 2014 Plan that each of the monitoring efforts targeted and reports the progress achieved towards reaching each of the associated habitat objectives during the 2017 managed release.

Table 2. This modified version of the original Table 4 from the 2014 Plan provides the flow hypotheses, native fish habitat objectives, and measurable benchmarks/indicators from the original table in the first three columns (brown), with the fourth column (blue) reporting the major findings from the 2017 ecological monitoring for the specific measurable benchmarks/indicators they are associated with.

Flow Hypothesis	Habitat Objective	Measurable Benchmark	Overview of 2017 Monitoring Findings
Flushing Flow 400-800 cfs to scour fine Sediment	Maintain quality spawning habitat at times appropriate for spawning to occur	Quantify percentage of fines (<2mm) in spawning beds (cobbles) pre- and post-flow event; percentage of fines measured should be reduced, with specific attention paid to aligning flushing flows relative to the timing of native fish spawning.	Because of early high-flows, we were unable to monitor in-channel cobble habitats. We instead monitored low floodplain locations as surrogates for cobble habitats, and percentage of fines was reduced at these sites. For example, at the Slickrock Downstream site, 2 mm particles were almost completely removed from the site due to the 2017 managed release.
Flushing Flow 800-2,000 cfs to initiate mobilization of the median-size particle	Maintenance of riffle and pool vertical relief	D50 should coarsen in riffles; annual accumulation of fine sediment should be scoured from pools. Pool riffle profile should be maintained.	Several pools deepened (up to 5 feet in spots), and were scoured of fine sediments. Because of early high-flows, we were unable to monitor in-channel cobble habitats. We instead monitored low floodplain locations as surrogates for cobble habitats, and D50 did coarsen. For example, at the Slickrock Downstream site, D50 increased 27%, from 85 mm to 108 mm.
	Maintain benthic macroinvertebrate productivity	Taxa measurements for benthic macro-invertebrate species in riffles (quantitative/ qualitative measures?) should reflect productive instream environment.	Did not monitor in 2017.
Habitat Maintenance Flow 2,000-3,400 cfs for 7+ days (bankfull flows)	Maintain pattern and profile appropriate for the reach	Monitor changes in cross-section and profile dimensions; channel aggradation, degradation or entrenchment should be assessed; over a reach, over time, gradient and pool-riffle spacing should be consistent. Assess plan-view changes, such as stabilization of mid-channel bars or bar extension; vegetative encroachment on point bars; medial bar expansion.	Essentially no change in river plan-view. Photos taken in 2017 that repeat photos from 2003 then 2017 show stabilization of riverbank. Pools sampled in alluvial reaches confirmed scour of up to 5 ft of material, deepening pools and expanding habitat in the pools. Early high flows in 2017 precluded measurements along the length of the channel, so we were unable to assess gradient and other profile dimensions.

Flow Hypothesis	Habitat Objective	Measurable Benchmark	Overview of 2017 Monitoring Findings
Habitat Maintenance Flow 2,000-3,400 cfs for 7+ days (bankfull flows)	Scour pools	Maintenance of pool depth (see above re: pool depths).	Pool depths were increased in alluvial and confined alluvial reaches pre- vs post-release. Scour ranged from 0 to over 5 feet.
	Mobilize majority of riffle materials	Monitor mobile fraction of channel bed in riffle; tracers or direct bedload transport measurements; hydraulic modeling.	Unable to monitor riffle habitat in 2017, and did not measure bedload transport or conduct hydraulic modeling.
	Initiation of significant interaction with floodplains in alluvial reaches.	Cottonwood recruitment (or at least some indication of seed-bed preparation & germination); maintain other riparian indicators (e.g., minimize encroachment of xeric/mesic species onto floodplains). Validate Qbkf hypotheses by reach.	At all cross-sections observed overbank flows and in most cases deposition of fines on floodplains—and scour was observed at most sites—providing some seed-bed preparation. No new cottonwood recruitment observed on ecological monitoring sites. Willow encroachment/ high density likely inhibiting germination.
Habitat Maintenance Flow Peak flows of >3,400 cfs at a frequency of ~7-10 years	Mobilize & re-set riffle habitats; create & maintain instream habitat diversity (pool scour; backwaters; 2° channels)	Document movement of D84 in riffles; assess instream habitat complexity. Assess cross section and longitudinal changes.	Because of early high-flows, we were unable to monitor riffles, thus did not measure movement of D84. Observed pool scour of 0-5 ft. Some normally-dry backwaters and secondary channels flowed during peak release.
	Maintain floodplain exchange and robust riparian vegetative community	Monitor riparian vegetation diversity and density; cottonwood germination and recruitment (NOTE - Riparian monitoring will be an important indicator of whether large flows providing exchange benefits to instream resources).	Vegetative transect comparison 2010 vs 2017 show no increase in willow density. However, comparison of historic photo points show willow density appears to have increased at one site (Big Gypsum) from 2003 to 2017. Overall vegetative diversity appears reduced as willows increasingly dominate.
	Energy and nutrient exchange between channel and floodplains	Validate Qbkf hypotheses by reach. Floodplain inundation depths; measure exchange of material between channel and floodplain (e.g., painted patches; floodplain transect monitoring).	Wildlife cameras captured river stage/flood plain inundation depth. Floodplains showed both scour (Bedrock, Slickrock Downstream) and deposition (BLM Rec [Big Gypsum], Bedrock, Slickrock Downstream). At Slickrock Downstream, 3-D elevation survey showed deposition of sand occurring on floodplain (up to 3 feet), and notable incision (up to 2 feet) occurring in pre-existing side channel.
	Maintenance of alluvial aquifer	Groundwater monitoring in floodplain.	High flows and a long-duration release in 2017 improved groundwater levels at multiple sites; at Big Gypsum site groundwater rose to within 2 feet of the surface, providing needed water to pre-existing adult cottonwoods.

Key Recommendations for Future Monitoring

A section in Volume 2 presents a full and detailed list of recommendations across the full suite of monitoring that has been conducted on the Dolores. Here, we present the core elements of these recommendations based on what was learned in 2017:

- Having historic data from several sites was extremely useful for understanding long-term change. Directing future monitoring at the five new ecological monitoring sites would allow us to build on this understanding.
- The best way to know what is happening with fish populations is to sample fish, so it is essential to continue annual fish surveys at multiple sites below the Dove Creek Pumps.
- Repeat on-the-ground photo point monitoring was very useful for understanding long-term dynamics with riparian vegetation and channel planform.
- Aerial drone imagery collected to capture pre- and post-release planform changes was not particularly revealing this year, but could be useful if repeated every 5-10 years.
- Additional drone-derived photogrammetry (3-D floodplain surveys) may be useful as an important complement to painted patch and erosion stake monitoring; it does not capture data as precisely but the photogrammetry covers much more area.
- Repeating cross-section profiles at established points was useful for understanding specific in-channel sediment dynamics. These should be repeated in the future.
- In future years with release projections and similar pre-/post-release monitoring, it will be important to initiate pre-release monitoring prior to 'low snow' runoff from the Dolores Rim and Glade to complete longitudinal sampling through the ecological monitoring sites, and to ascertain riffle dynamics related to flow magnitude.
- Cottonwood recruitment and survival on the Dolores River is still poorly understood. Groundwater monitoring should be continued, as should efforts to document cottonwood establishment (or lack thereof).
- Continue to repeat historic vegetation transects with future managed release events, and/or at select long-term intervals (e.g. every 5-10 years)
- Since management of water temperature is specifically called out in the 2014 Plan, monitoring of temperature should be continued.

Additional Information and Resources

The Dolores River ecological monitoring in 2017 is presented in two volumes and a set of appendices.

Volume 1 contains an Executive Summary that presents a summary of the release, key findings, and key recommendations. Volume 1 also presents a summary of individual monitoring methods and more detailed findings derived from each method.

Volume 2 contains details methods and findings. It also presents a more comprehensive set of recommendations for future monitoring.

In addition, a set of appendices provide further detail associated with 2017 monitoring efforts conducted on the five new ecological monitoring sites. Many of these appendices are large documents, or a collection of files. As such, all appendices were created as separate documents or folders, and can be obtained through TNC. Any additional data associated with the five new ecological monitoring sites but not contained within these appendices is housed with TNC (aerial imagery, TNC wildlife camera & staff gage data), Fort Lewis College (all other vegetation data), and Colorado Parks and Wildlife (geomorphology & sediment data). Current contacts for this information are Celene Hawkins (TNC), Dr. Cynthia Dott (Fort Lewis College), and David Graf or Ryan Unterreiner (Colorado Parks and Wildlife).

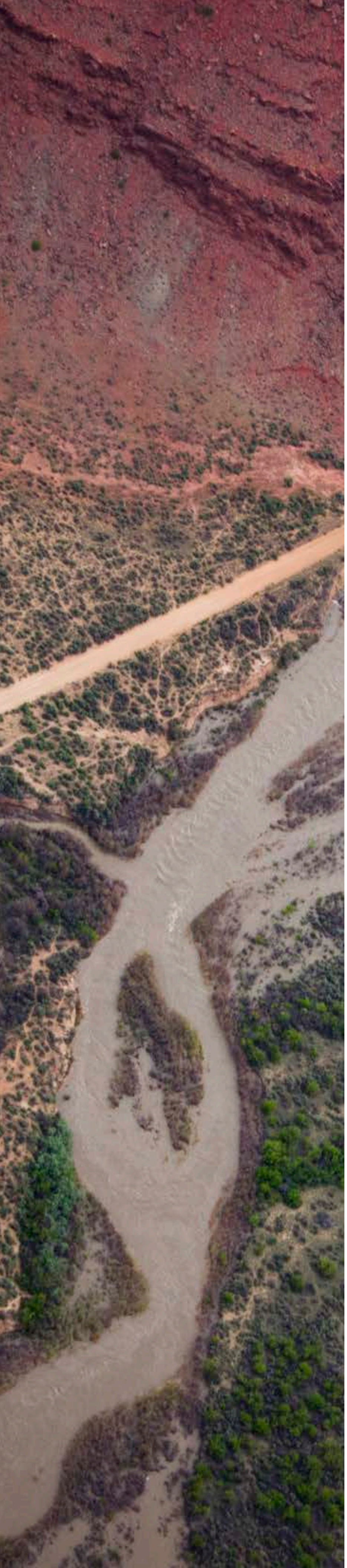
The appendices are:

- Appendix 1. Ecological Monitoring Sites – Site Locations and Descriptions
- Appendix 2. Ecological Monitoring Sites – Photo Point Monitoring Locations & Comparisons
- Appendix 3. Ecological Monitoring Sites – Staff Gage and Wildlife Camera Installation
- Appendix 4. Historic Big Gypsum Photo Point Monitoring Locations & Results
- Appendix 5. New Cottonwood Recruitment Survey Locations & Results
- Appendix 6. Photo Point Summaries of Ecological Monitoring Sites
- Appendix 7. People and Wildlife Summary
- Appendix 8. Sounds of the Dolores River
- Appendix 9. All Ecological Monitoring Site Photos Pre-, Peak-, and Post-Release
- Appendix 10. Ecological Monitoring Preliminary Findings Presentations M&R Team Meeting Oct 2017

Additional Contact Information

Any additional data associated with the five new ecological monitoring sites but not contained within these appendices is housed with TNC (aerial imagery, TNC wildlife camera & staff gage data), Fort Lewis College (all other vegetation data), and Colorado Parks and Wildlife (geomorphology & sediment data). Current contacts for this information are Celene Hawkins (TNC), Dr. Cynthia Dott (Fort Lewis College), and David Graf or Ryan Unterreiner (Colorado Parks and Wildlife).

For more detailed data collection and background information for fisheries, groundwater, and DEM/elevation data collection efforts please contact the following organizations directly: Colorado Parks and Wildlife (Jim White) for fisheries data, and Fort Lewis College for DEM/elevation data (Dr. Jonathan Harvey), and groundwater sensor and other wildlife camera river stage data (Dr. Gary Gianniny).
For more information regarding full details of the managed release itself, see the 2017 McPhee Controlled Release Summary report by Eric Sprague of the DWCD, or contact Eric Sprague or Ken Curtis directly at the DWCD. For more information on recreation boating 2017 monitoring efforts contact American Whitewater (Nathan Fey), Dolores River Boating Advocates (Amber Clark), or Bureau of Land Management (Jeff Christenson).



SUMMARY OF MONITORING METHODS & FINDINGS

The 2017 ecological monitoring efforts focused on two general areas: assessment of sensitive native fish and assessment of in-channel and riparian habitat. This section summarizes methods and findings for individual aspects of the monitoring effort. Volume 2 contains more detailed descriptions of sites, methods, and findings. A set of appendices contains further detail on methods and data collected.

Sensitive Native Fish

Fisheries Monitoring

Fisheries monitoring in 2017 was targeted primarily at improving the understanding of the distribution and abundance of native and non-native fishes in the Lower Dolores River and assessing native and non-native fish reproduction. While monitoring was being conducted, non-native invasive fish known to inhibit native fish populations were removed, and native fishes were marked with passive integrated transponder (PIT) tags to assess movement patterns and population dynamics. Monitoring efforts resulted in 50 miles of the Dolores River being surveyed (including electrofishing the entire 36-mile Slickrock Canyon, all 14 miles of the Pyramid Reach, and 1000 feet at Dove Creek Pumps; and seining low velocity habitats in 3 miles at James Ranch and 2 miles at Big Gypsum). A total of 609 native fish were marked with PIT tags throughout the summer.

Summary of Findings:

- Slickrock Canyon is still a stronghold for native species, with three native species (flannelmouth sucker, bluehead sucker, and roundtail chub) comprising 88% of the total catch out of 591 fish caught. Specifically, flannelmouth suckers comprised 53% of the catch, roundtail chub 32%, and bluehead sucker 3%.
- Overall density of native fishes is still low in Slickrock Canyon, yet a fair number of suckers are still being caught, particularly flannelmouths.
- In Slickrock Canyon, there was a 95% increase in catch per unit effort (CPUE) over 2007 for the three native fish species. In 2017, 0.43 fish per minute were caught, whereas in 2007 only 0.22 fish per minute were caught.
- Roundtail chub reproduction was evident at most sites, including the Dove Creek Pumps reach, James Ranch Reach, and Big Gypsum Reach. Young-of-the-year bluehead and flannelmouth suckers were also detected, but at low levels. Findings about 2017 reproduction are preliminary because detection of young-of-year fish is difficult; population surveys in future years will provide a better indication of how much reproduction of native species occurred this year.
- Few non-natives were found in Slickrock Canyon.
- One white sucker was found in Slickrock Canyon. This species had not previously been documented on the Dolores River below McPhee

Dolores River © *Lauryn Wachs/TNC*

Dam. White suckers hybridize with native suckers and are a serious threat to the genetic integrity of native suckers.

- Smallmouth bass (non-native predator fish that eat native fish) were found to be persistent in the Pyramid Reach, and more frequent removals of these species is recommended. CPUE was 34.6 smallmouth bass/hour in 2017, versus 13.4 in 2007, and 18 in 2011.
- No smallmouth bass were found downstream of Disappointment Creek, including in Slickrock Canyon.
- Removal of non-native fish was only possible because of the combination of the large managed release and the use of approximately 2,800 acre feet of fish pool water.
- More catfish, red shiner, and sand shiner were found in 2017 (versus surveys in 2012, 2013, and 2014), which was troubling. Shiner habitat overlaps with the habitat of young native fish, and shiners eat the natives.
- As in past years, higher trout biomass was sampled with higher discharge.

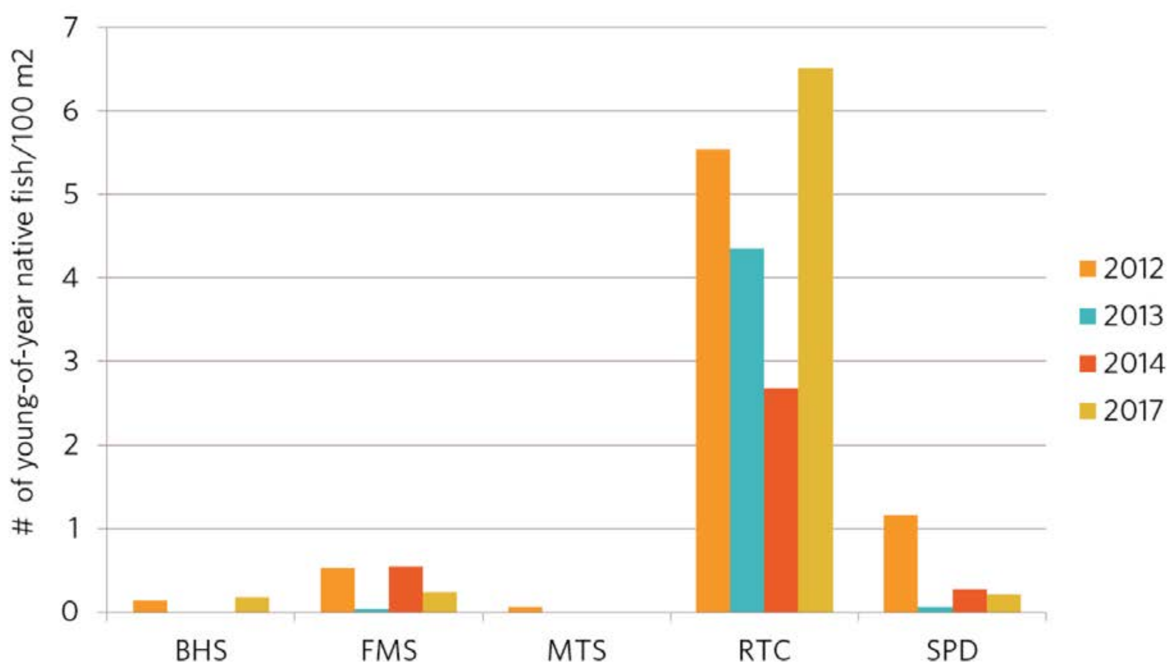


Figure 1. Young-of-year native fish by species caught in reproduction surveys on the Dolores River in 2012 (orange), 2013 (blue), 2014 (red), and 2017 (yellow). CPUE = Catch per unit effort, BHS = bluehead sucker, FMS = flannelmouth sucker, MTS = mottled sculpin, RTC = roundtail chub, and SPD = speckled dace. Reproduction of all three species of sensitive native fish occurred in 2017. Young-of-year flannelmouth suckers and roundtail chubs have been detected in every survey year. Bluehead sucker reproduced in 2017 and 2012, but were not detected in 2013 and 2014.

In-channel and Riparian Habitat

Ecological Monitoring Site Photo Point Monitoring

New repeat photo monitoring points were established at each of the five new ecological monitoring sites prior to the 2017 managed release, with photos taken pre-release (March 20-24), peak-release (May 5-7) (if points could be reached during high flows), and post-release (July 6-8) 2017. These new photo points were established to: (1) provide a visual characterization of vegetation changes, sediment scour/ deposition, ground-view river bank erosion, and planform changes that might be observed pre- versus post-release in 2017; (2) establish a visual 'baseline' of the above for comparison in future years; and (3) capture the extent of overbank flooding occurring at each site during the 2017 managed release, thus helping to visually characterize floodplain inundation depth, and the interaction and exchange of material between channel and floodplain.

Summary of Findings:

- Comparison of pre- and post-release photos showed noticeable changes in sediment scour and deposition and captured substantial overbank flooding occurring at peak-release.
- Pre- and post-release photo comparison found limited changes in vegetation, river bank erosion, and planform change. These findings and photos are presented as part of other monitoring efforts in Volume 2 and in several appendices.

Geomorphology and Sediment Monitoring

Pre- and post-release monitoring was conducted by CPW on the five new ecological monitoring sites to determine effects of the 2017 managed release on site geomorphology and sediment movement. Survey efforts included cross-section surveys and Wolman pebble counts, as well as installing erosion stakes, painted patches, and sediment traps. Fort Lewis College researchers also created a topographic map comparing the landscape before and after the 2017 managed release to assess changes in sediment mobilization.

Summary of Findings

- Overall, there was noticeable evidence of scouring and evacuation of sediment within the channel and substantial deposition of this sediment on floodplains in places (up to 3 feet of deposition at the Slickrock Downstream site).
- At most alluvial ecological monitoring sites, there was evidence of scouring and evacuation of material within surveyed pools, with evidence of floodplain deposition at some sites, confirming that the release re-set vertical relief and increased overall pool volume. For example, at the BLM Rec (Big Gypsum) site mean pool depth increased by more than 3 feet, changing the cross-sectional area from 433 square feet pre-release to 1,226 square feet post-release, increasing pool volume by almost 300%.
- Little bank erosion was observed. The exception to this was the substantial bank erosion documented at one monitoring site (just upstream from the Bedrock site, where an estimated 260 tons of material eroded). Otherwise, there was little evidence that the large managed release and big peak flows eroded banks and increased channel width. This suggests that the Lower Dolores River is stabilizing within a narrower, more confined channel.
- At the Slickrock Downstream site, fine sediments (2 mm particles) were almost completely removed from the survey area with the 2017 managed release (Figure 2 below). Though the measurable benchmark associated with fine sediment removal is in reference to in-channel riffle habitats, this result is important because it indicates that higher-energy sites within the active channel were at least equally coarsened by the managed release, which improves breeding and foraging habitat for native fish.

- D50 coarsened from 85mm to 108mm on a high energy, low-floodplain environment at the Slickrock Downstream site, considered the best surrogate for in-channel processes that occurred in riffle habitats.
- At the Slickrock Downstream Site, erosion stakes on a low floodplain, high energy site showed substantial scour (Figure 3). Some cobble movement was observed into and out of the painted patch, indicating that larger particles were also mobilized with the managed release.
- At the Slickrock Downstream site, the 3-D elevation survey conducted by FLC researchers showed minimal lateral bank erosion, but found substantial deposition of sand occurring on the floodplain (up to 3 feet), particularly where river flow was slowed by dense willow, and notable incision (up to 2 feet) occurring in the pre-existing side channel.
- Reactivation of side channels was observed at several sites.

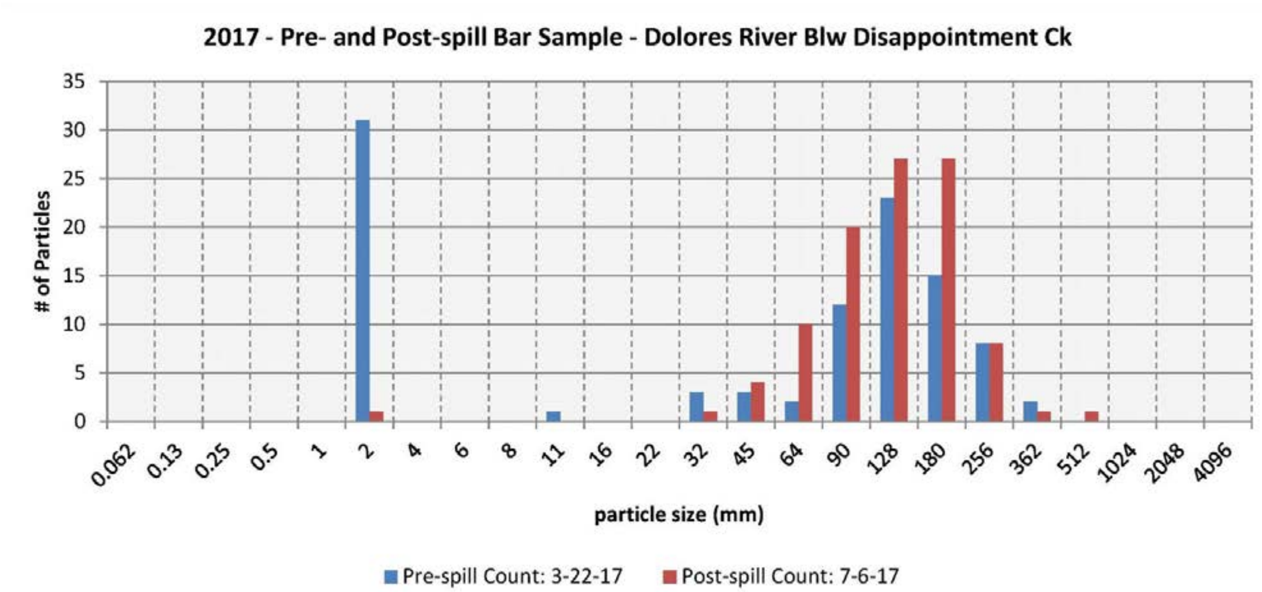


Figure 2. Slickrock Downstream (Below Disappointment Creek) site Wolman pebble count results 2017. These important results show that 2 mm particles were almost completely removed from the site.

Figure 3. Slickrock Downstream sediment trap (yellow circle) and erosion stake (blue circle); pre-release photo on left (3/22/17), and post-release photo on right (7/6/17). Note the scouring of fine material observed with the orange erosion stake between pre- and post-release. It is estimated that the sediment trap was washed away with strong scouring flows during the managed release (absence of sediment trap post-release).

Wildlife Cameras and Staff Gage Monitoring

Wildlife cameras and staff gages were installed between March 20-24, 2017 at each of the five new ecological monitoring sites. Cameras captured images of staff gages at regular intervals showing changes in flow stage height prior to, during, and after the 2017 managed release.

Summary of Findings

- Cameras captured the river rising substantially out of its banks at multiple sites during peak-release, an important benefit of the managed release, resulting in noticeable sediment deposition and scour, and crucial recharging of the alluvial aquifer (see Figure 4 below).
- Images do, however, also show minimal bank erosion, providing further evidence of the substantial 'armoring' of the banks at multiple sites.

Dove Creek

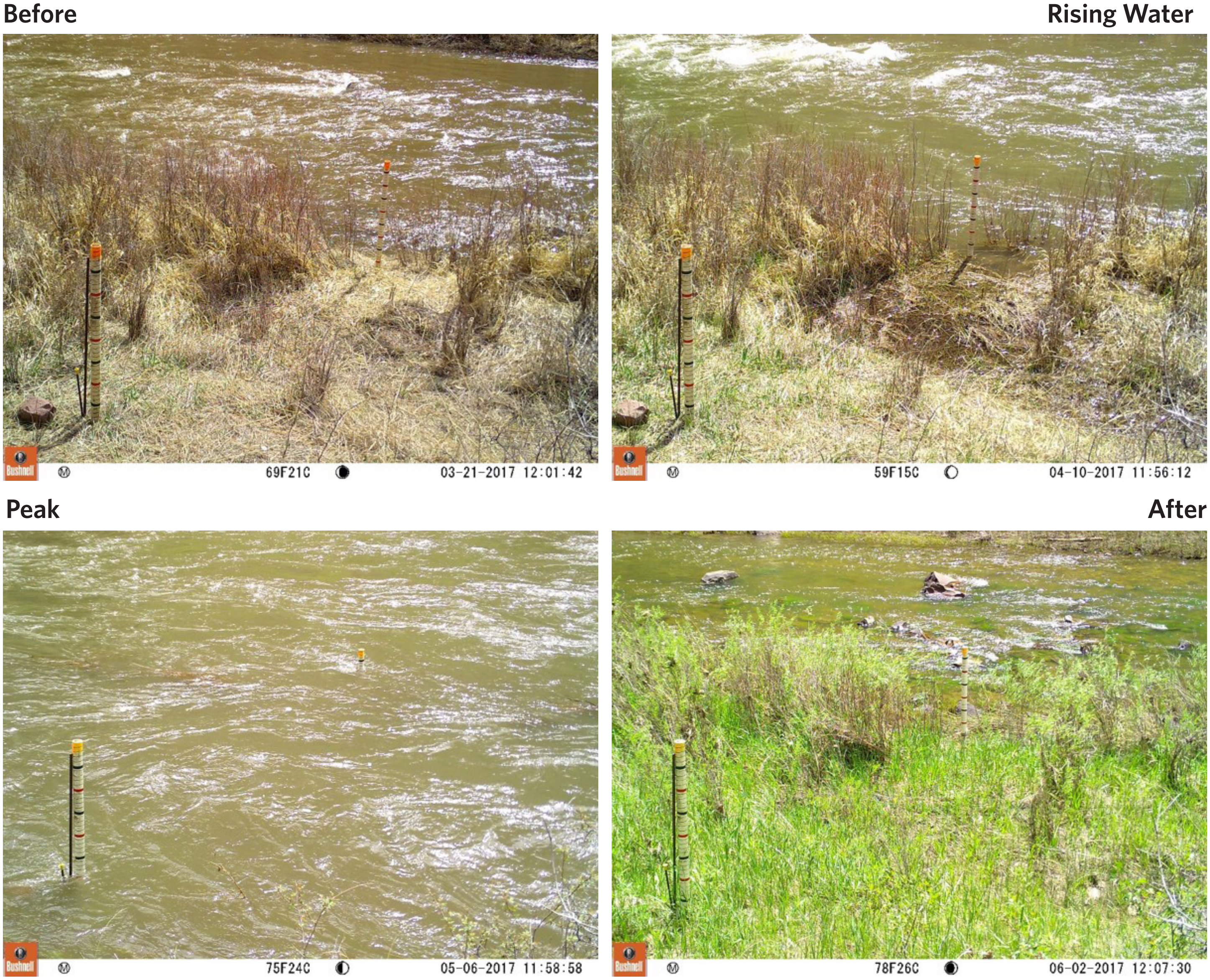


Figure 4. Dove Creek staff gage at pre-release, rising water, peak-release, and post-release. Notice river rising substantially out of its banks at peak-release but with very little change in the amount of woody vegetation.

Groundwater Monitoring

Fort Lewis College researchers measured changes in groundwater depth in response to the 2017 high flow managed release, the 2012 moderate release, and 2011 low flow only or baseflow conditions at two sites along the Lower Dolores River (Lone Dome, Big Gypsum). Three piezometers to measure groundwater depth were installed at each site with increasing distance from rivers edge, with the middle groundwater well (Well #2) installed in the 'cottonwood zone'.

Summary of Findings

- The 2017 peak release (~4,070 cfs) resulted in peak discharge at Slickrock (the closest gage to the Big Gypsum site) of 3,630 cfs, and this resulted in floodplain inundation and groundwater levels above baseflow conditions for 89 days at Lone Dome & 91 days at Big Gypsum.
- The 2011 moderate release (peak release ~1,500 cfs) resulted in groundwater levels above baseflow conditions for 46 Days at Lone Dome & 31 Days at Big Gypsum.

- At the Big Gypsum site, the 2012 baseflow conditions only (no mimic of a snowmelt release) resulted in groundwater levels 4 feet below ground surface for the total duration of the study (117 days), with only the well closest to rivers' edge (Well #1) maintaining any water at all (the other two wells ran dry). The Lone Dome site responded similarly but not as dramatically—no wells ran dry at that site. This noticeable difference in well response to low flows between the two sites is likely a combined result of lower precipitation at Big Gypsum and the increased reliance of groundwater at this site on stream discharge.
- Looking at both sites, years with no peak release resulted in groundwater table depths of approximately 3.8 feet or greater at the Well #2 in the 'young cottonwood zone'.
- High flows and a long-duration release improved water table levels at both sites, with the biggest improvement at Big Gypsum, resulting in groundwater depths of 2 feet or less from the beginning of April through the end of July, providing much needed water for pre-existing adult cottonwoods (Figure 5 below).
- Adult cottonwoods typically need a groundwater depth of less than 1.5m (4.8 ft) to maintain healthy growth (Scott 1999; Shafroth et al. 2000, Rood et al. 2011)
- Both moderate (e.g., 2011) and large (e.g., 2017) releases are valuable for maintaining cottonwood.

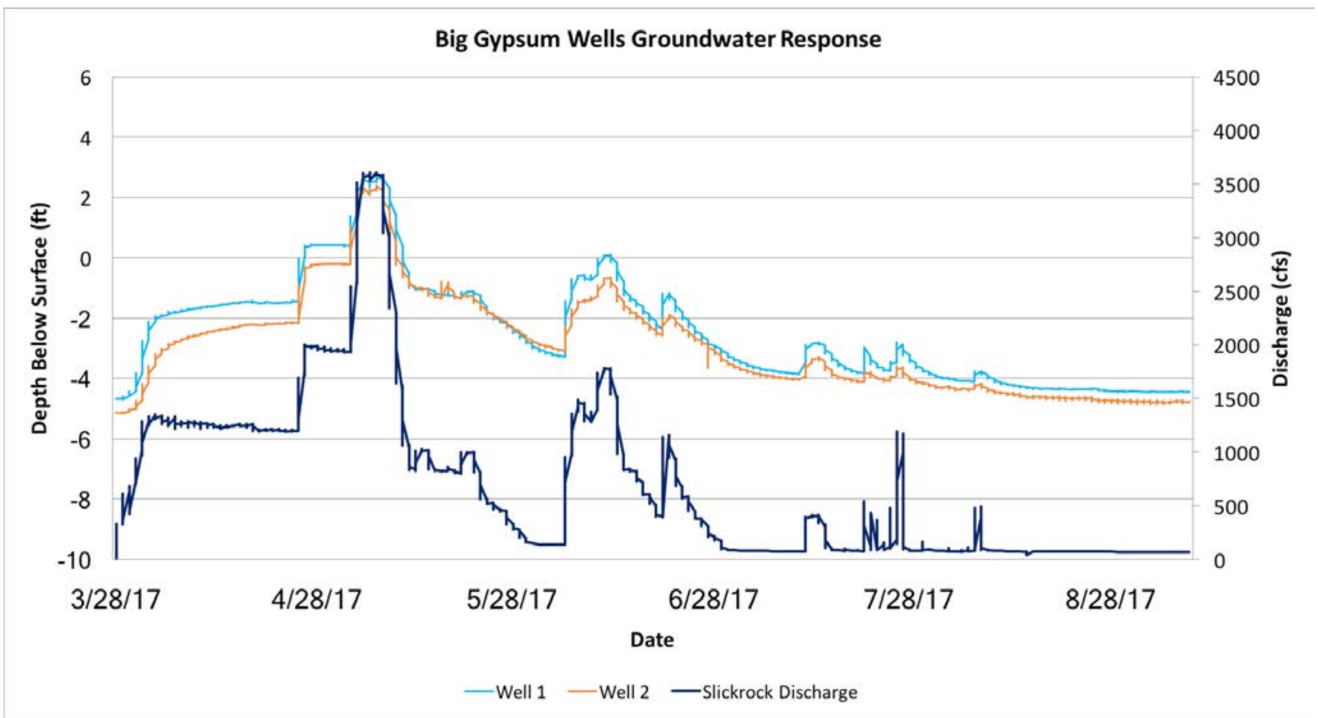


Figure 5. Big Gypsum site in 2017, showing Slickrock Discharge and groundwater well data for a high-flow release. Note that both Well #1 and Well #2 show groundwater depths of 2 feet or less from the beginning of April through the end of July.

Riparian Vegetation Monitoring

Riparian vegetation monitoring in 2017 consisted of: (1) repetition of historic (2003) photo points at select points along the river; (2) establishment and repetition of new photo points at the five new ecological monitoring sites pre-, peak-, and post-release 2017; (3) conducting new cottonwood recruitment surveys post-release on the new ecological monitoring sites; and (4) repetition of historic (2010) vegetation transect monitoring at select points along the river.

Summary of Findings

- Comparison of historic repeat photos confirm noticeable willow encroachment on point bars and river banks from 2003 to 2017, and appear to also have increased in density from 2003 to 2017 along the river bank at the Big Gypsum site (See Figure 6 below).
- However, new ecological monitoring site photo points do show evidence of floodplain scouring and movement of sediment resulting in deposition, creating some new small bare areas.
- The configuration of the channel as seen from above (the planform) was also overall little changed.
- The density of riparian vegetation (mostly willow) and consequent 'armoring' of river banks resulted in very little bank erosion or thinning/removal of riparian vegetation, creating few new bare areas where cottonwood seedlings could establish.
- No new cottonwood seedlings were found on ecological monitoring sites. The most common non-cottonwood seedlings found were willow, occurring at multiple survey areas. Possible reasons for no cottonwood seedlings being found include: (1) cottonwood seed release did not appear to occur until after peak-release; (2) managed release draw down rates appeared to be faster than that that required for successful seedling establishment; and (3) potential high accumulation of salts at some sites.
- Comparison of historic vegetation transects found average willow stem density did not change between 2010 and 2017, indicating the managed release did not reduce willow density. Willows are serving to 'armor' the river banks, resulting in channel narrowing, and represent one of the biggest changes in recent times on the Lower Dolores.
- Percent bare ground was over 40% at the Big Gypsum site, resulting in some seed germination on new seedbeds, but seedlings here were also found to be predominantly willow.

Figure 6 (a-d). Historic Big Gypsum Photo Point #2 (top photos) and Photo Point #6 (bottom photos) taken in 2003 (6/17/03) (photos on left) and 2017 (6/26/17) (photos on right). The photos show how, between these years, riparian vegetation increased in size, cover and density, and bare ground between plants decreased.

Aerial Imagery Monitoring

TNC collected both pre- and post-release drone imagery in 2017 at three of the new ecological monitoring sites (Slickrock Upstream, Slickrock Downstream, and BLM Rec [Big Gypsum]).

Summary of findings

- Pre- versus post-release drone imagery in 2017 revealed virtually no change in river planform (See Figure 7).

Slickrock Downstream (Below Disappointment Creek)

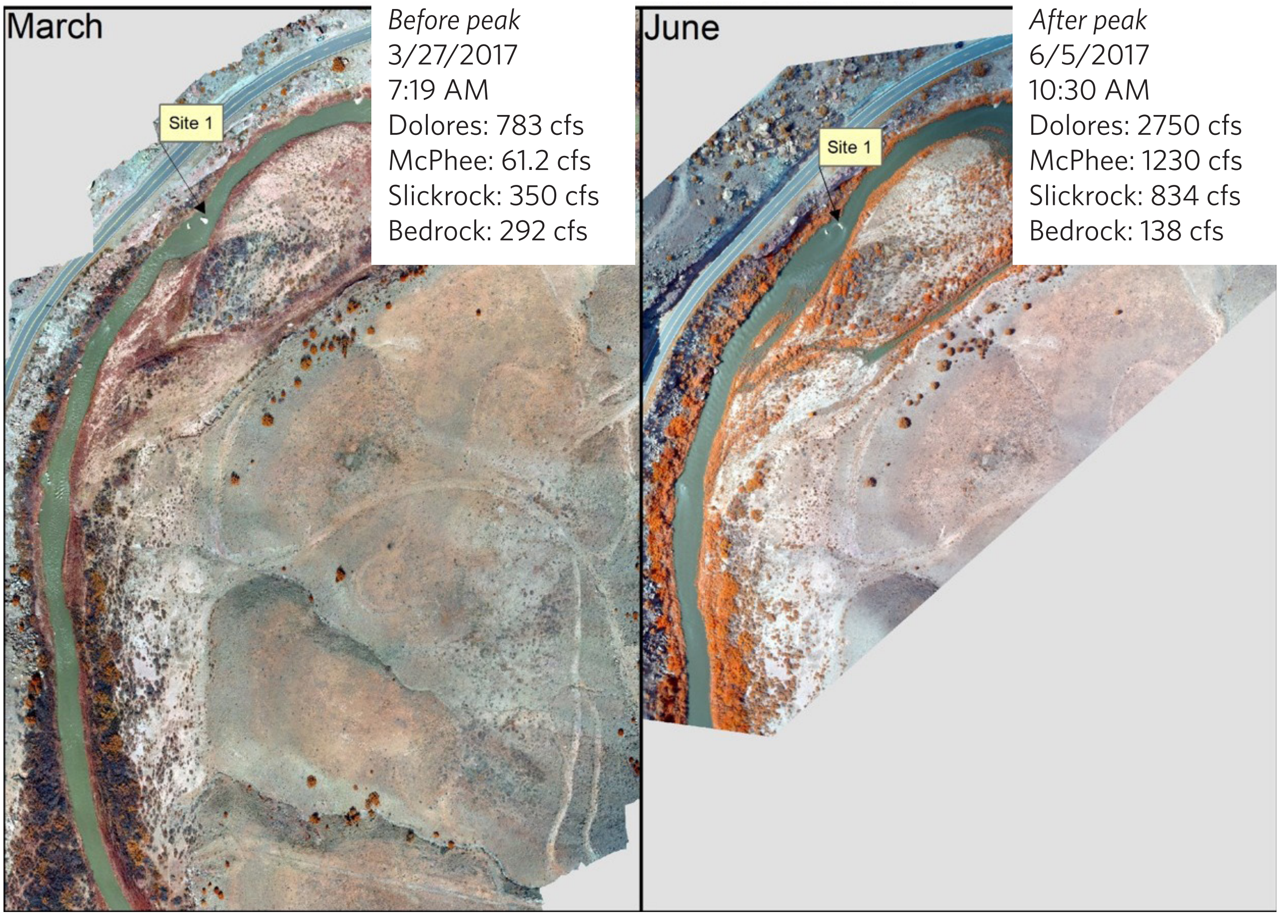
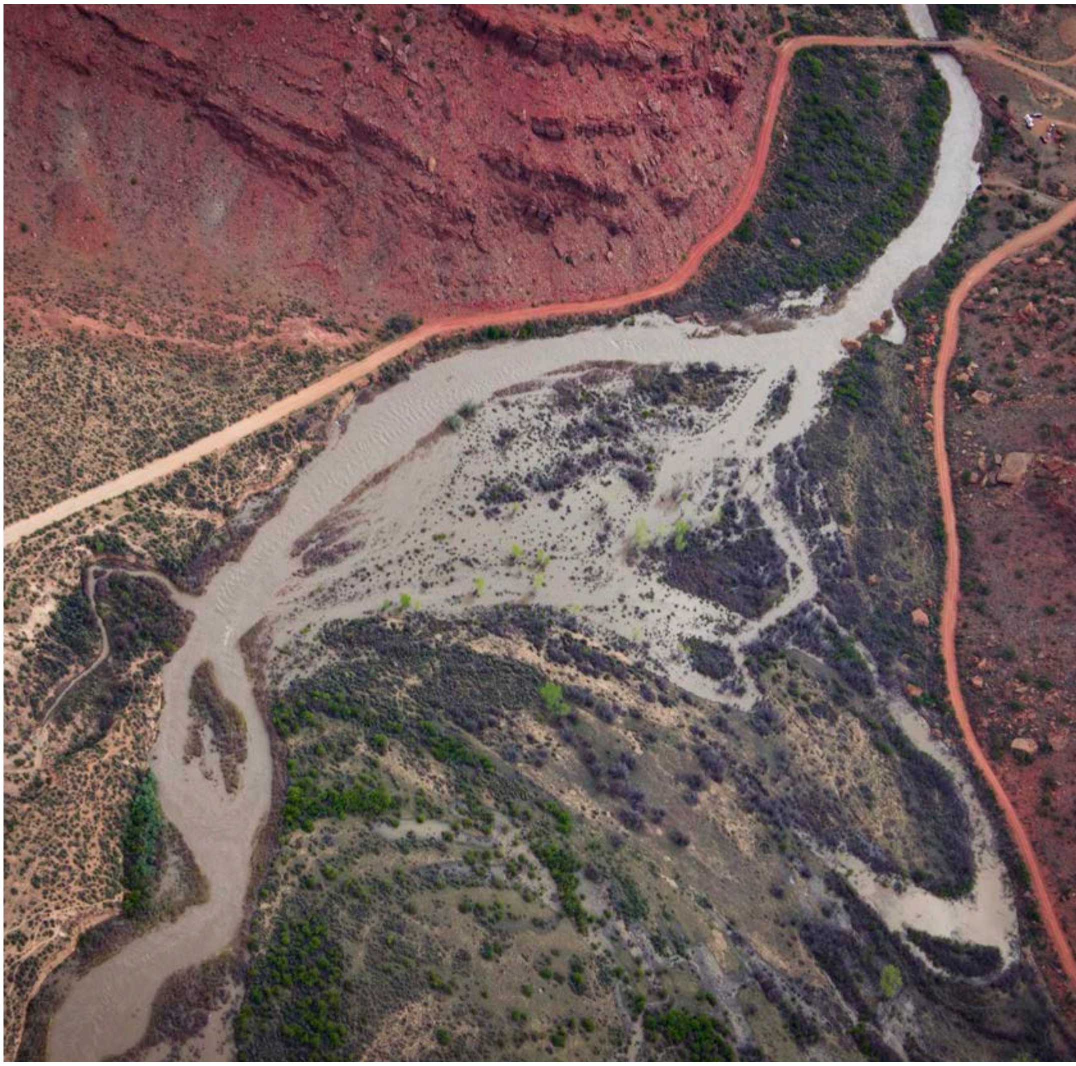


Figure 7. Drone imagery comparison March versus June 2017 at the Slickrock Downstream site. There is very little difference in planform pre- versus post-release. Most of the differences observed is because of higher water levels in June photos. Higher flow caused side-channel flow here, and floodplains stand out as a whiter color because of sand deposits.

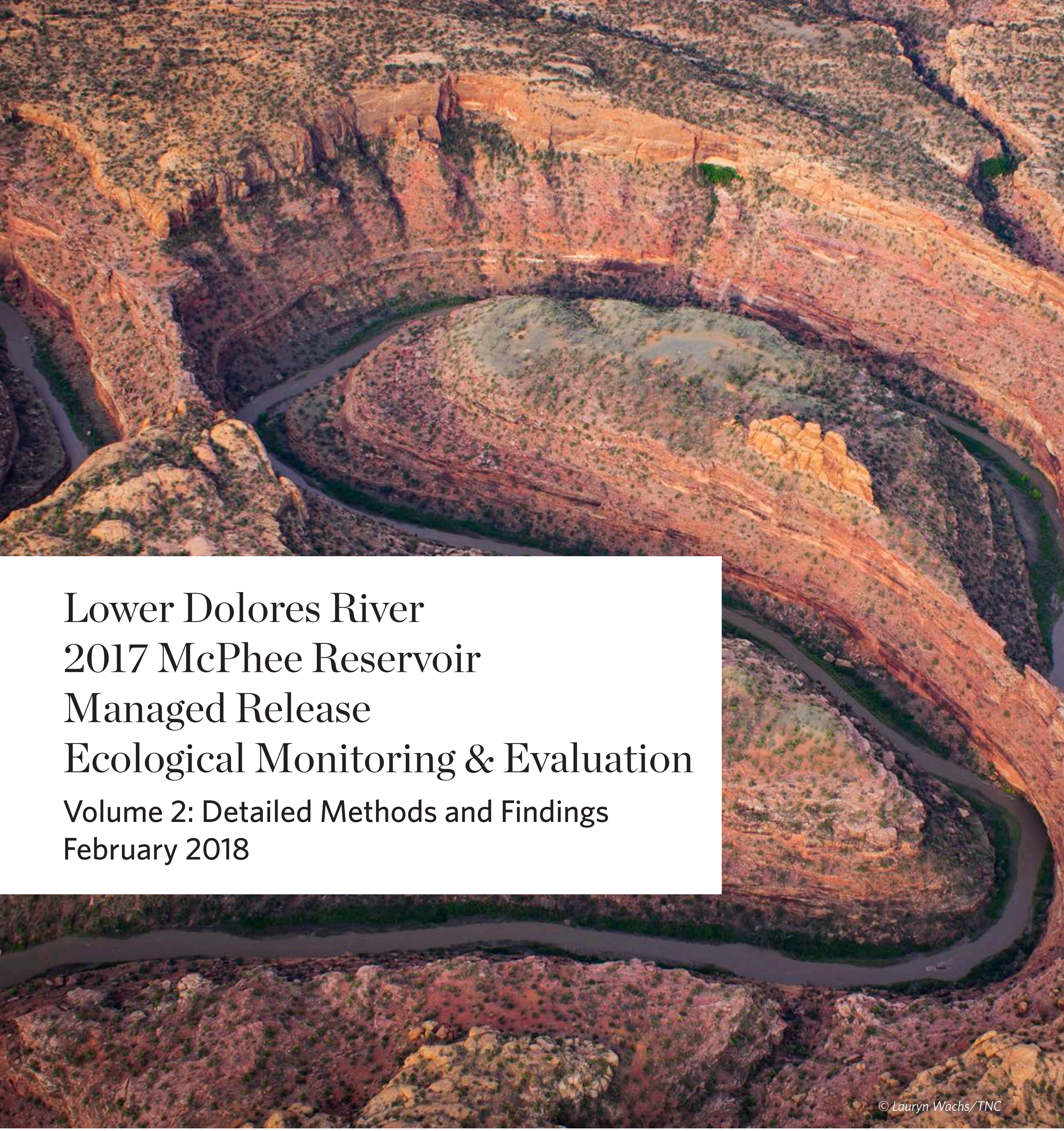
TNC is also preparing to conduct analyses comparing 2015 versus 2017 National Agriculture Imagery Program (NAIP) imagery of the Lower Dolores River—specifically comparing change in the channel, vegetated surfaces, and bare ground along the river from McPhee Reservoir to the Colorado/Utah state border.







Clockwise from top left: CPW staff hold a bluehead sucker during a fish survey © *Jim White/CPW*, Dolores River © *John Fielder*, Fish surveying in a tributary © *Celene Hawkins/TNC*, Aerial view of peak release time on the river © *Lauryn Wachs/TNC*, Kayaking on the Dolores © *Lauryn Wachs/TNC*



Lower Dolores River 2017 McPhee Reservoir Managed Release Ecological Monitoring & Evaluation

Volume 2: Detailed Methods and Findings

February 2018

Colorado Parks & Wildlife
The Nature Conservancy
Colorado Mesa University
Ruth Powell Hutchins Water Center
Fort Lewis College

TABLE OF CONTENTS

INTRODUCTION

This Volume 2 presents detailed information on methods, data collected, and key findings from monitoring of ecological effects of the 2017 McPhee Reservoir managed release. For an overview of the release and a summary of results, see Volume 1. For further detail on specific aspects of the monitoring, see the appendices.

Monitoring efforts focused on two general areas: (1) assessment of sensitive native fish; and (2) assessment of in-channel and riparian habitat. Fish sampling was conducted across many sites located throughout the Lower Dolores River established by CPW. In-channel habitat and riparian habitat assessment efforts were conducted predominantly at five ecological monitoring sites, as well as at several additional sites established by Fort Lewis College (FLC sites) and Colorado Mesa University (CMU sites). The bulk of this volume is comprehensive descriptions of the ecological monitoring efforts, organized as follows:

Sensitive Native Fish

- Fish Monitoring

In-channel and Riparian Habitat

- Ecological Monitoring Site - Photo Point Monitoring
- Geomorphology and Sediment Monitoring
- Wildlife Cameras and Staff Gage Monitoring
- Groundwater Monitoring
- Riparian Vegetation Monitoring
- Aerial Imagery Analysis

Additional information about monitoring is provided in ten appendixes that are stand-alone documents:

Appendix 1. Ecological Monitoring Sites – Site Locations and Descriptions
Appendix 2. Ecological Monitoring Sites – Photo Point Monitoring
Appendix 3. Ecological Monitoring Sites – Staff Gage & Wildlife Camera Installation
Appendix 4. Historic Big Gypsum Photo Point Monitoring Locations & Results
Appendix 5. New Cottonwood Recruitment Survey Locations & Results
Appendix 6. Photo Point Summaries of Five Ecological Monitoring Sites
Appendix 7. People and Wildlife Summary
Appendix 8. Sounds of the Dolores River
Appendix 9. All Ecological Monitoring Site Photos Pre-, Peak-, and Post-Release
Appendix 10. Ecological Monitoring Preliminary Findings Presentations M&R Team Meeting Oct 2017

Five New Ecological Monitoring Sites

Five new ecological monitoring sites were established on the Lower Dolores River in March 2017, between McPhee Reservoir and the confluence with the San Miguel River (Figure 1). The five sites are (from upstream to most downstream): Dove Creek Pumps, Slickrock Upstream (Above Disappointment Creek), Slickrock Downstream (Below Disappointment Creek), BLM Rec (Big Gypsum), and Bedrock. The Slickrock Upstream and Slickrock Downstream sites were located near each other to compare changes above and below a sediment-heavy tributary (Disappointment Creek). For more information on the five newly established ecological monitoring sites see *Appendix 1. Ecological Monitoring Sites – Site Locations and Descriptions.*

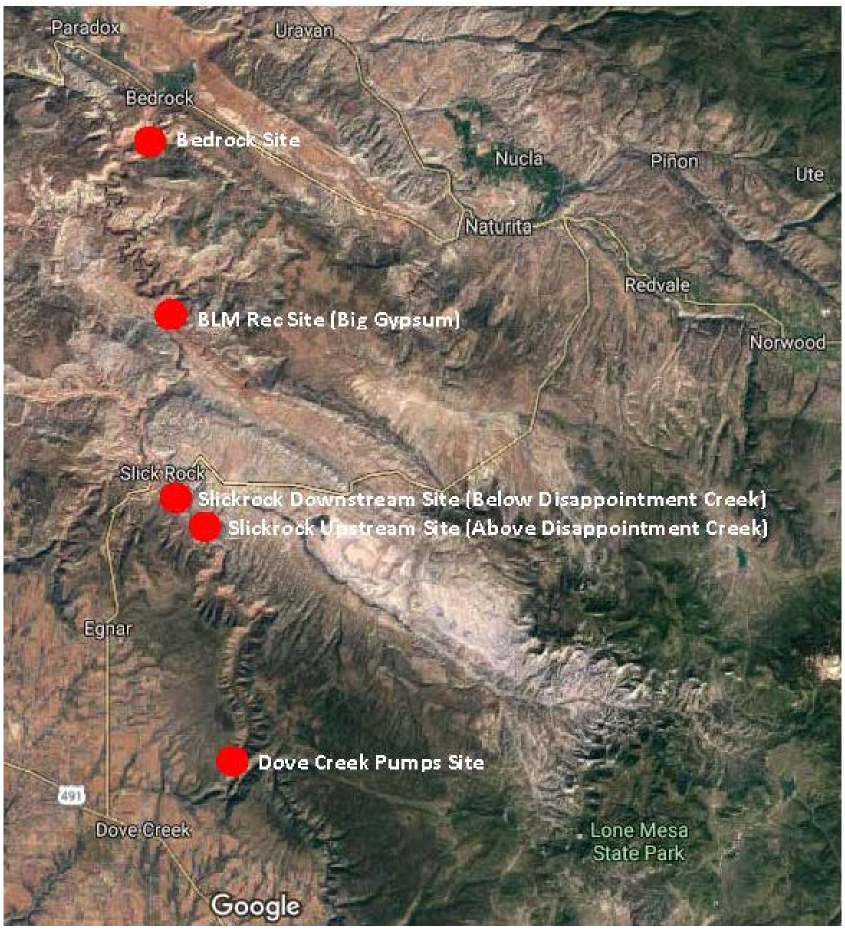


Figure 1. Five new ecological monitoring sites established in 2017 along the Lower Dolores River to evaluate the effect of the 2017 managed release on sensitive native fish and in-channel and riparian habitat, in line with the measurable benchmarks in Table 4 of the 2014 Plan.

Overview of Ecological Monitoring Efforts

Pre- and post-release riparian vegetation, geomorphology, groundwater, streamflow, and sediment data were collected on these new ecological monitoring sites through a host of methods. Table 1 provides an overview of the 2017 monitoring efforts organized by topic and including measurable benchmarks assessed (as per the original Table 4, 2014 Plan), monitoring methods used, and organization responsible for data collection and assessment.

Table 1. Overview of all 2017 ecological monitoring efforts, including measurable benchmarks assessed (as per the original Table 4, 2014 Plan), monitoring methods used, and organization responsible for data collection and assessment.

Data Category	Overview of Data Collection Efforts	Measurable Benchmark being assessed	Methods Used	Frequency	Location of Data Collection	Monitoring Organization
Fisheries	Longitudinal surveys, invasive removal, reproduction surveys, PIT tag marking natives, repeat annual historic surveys	NA – Table 4 of 2014 Plan only addresses habitat objectives	Electro-fishing, seining, angling	Spill (Longitudinal); Post-spill (Invasive removal and reproduction surveys)	CPW sites throughout Lower Dolores River	Colorado Parks and Wildlife
Vegetation	Repeat of historic vegetation transects (density/cover); repeat of historic vegetation photo points; establishment of new Ecological Monitoring Site photo points, and repetition of photos pre-, peak-, and post-release; cottonwood recruitment surveys	Vegetation diversity and density; changes in vegetative encroachment; cottonwood germination and recruitment; assess plan-view changes.	Transects, photos, quick surveys	New photo points pre- and post-release; historic photo points post-release; all other vegetation data collected post-release	New photo point estab. and cottonwood recruitment surveys conducted at new ecological monitoring sites; historic photo points at CMU sites; historic veg transects at FLC sites (Big Gypsum, Lone Dome)	Fort Lewis College, TNC
Geomorphology/ Sediment	Conducted cross-section surveys and Wolman pebble counts pre- and post-release; installed erosion stakes, painted patches and sediment traps for post-release monitoring. Also conducted pre- and post-release elevation surveys of floodplains.	Quantify percentage of fines; assess D50 coarsening in riffles; monitor changes in cross-section and profile dimensions; assess channel aggradation, degradation or entrenchment; assess plan-view changes; assess maintenance of pool depth; measure exchange of material between channel and floodplain changes.	Cross-sections, erosion stakes, painted patches, sediment traps, Wolman pebble count by CPW; FLC drone-derived photogrammetry (3-D floodplain survey)	Pre- and post-release	Some CPW data collection at all five new ecological monitoring sites; and FLC drone elevation data collected pre-release Big Gypsum; pre- & post-release at Slickrock Downstream site, and at additional FLC Slickrock site just upstream from Slickrock Downstream site.	Colorado Parks and Wildlife; Fort Lewis College

Table 1. (continued)

Data Category	Overview of Data Collection Efforts	Measurable Benchmark being assessed	Methods Used	Frequency	Location of Data Collection	Monitoring Organization
Groundwater	Recording groundwater levels with changes in river stage; recording changes in river stage with cameras	Floodplain inundation depths; groundwater monitoring in floodplain	Groundwater sensors, wildlife cameras	Continuous data collection every 30 minutes May-Sep 2017	FLC sites (Big Gypsum, Lone Dome)	Fort Lewis College
Hydrology/Flow data	Installation of staff gages and recording changes in river stage level with wildlife cameras	Floodplain inundation depths.	Staff gages, wildlife cameras	Continuous data collection pre- to post-release*	Some data collection at all five new ecological monitoring sites	TNC
Aerial imagery	Drone imagery pre- and post-release 2017; future analyses of 2015 vs 2017 NAIP imagery planned	Assess plan-view changes.	Drones, aircraft (NAIP)	TNC Drone = Pre-release, post-release; Aircraft (NAIP) = 2015, 2017	Drone at new ecological monitoring sites: Pre-release Bedrock; pre & post-release Slickrock Upstream and Downstream, BLM Rec (Big Gypsum)	TNC
Repeat photo point monitoring	Photo points pre, peak, and post-release	Vegetation diversity/ density, encroachment; cottonwood germination/ recruitment; assess plan-view changes; floodplain inundation depths.	Photos	Pre-release, peak-release, post-release	All five new ecological monitoring sites	TNC

*Some wildlife cameras were flooded or lost during peak-release. All remaining TNC wildlife cameras were removed approximately July 2017.

SENSITIVE NATIVE FISH

Fish Monitoring

This report is a synopsis of a presentation given by Jim White, an aquatic biologist with Colorado Parks and Wildlife, summarizing their 2017 monitoring efforts. The presentation was given on 10/27/17 at the Monitoring and Recommendation Team Meeting in Cortez, Colorado. This report was made possible by the excellent note taking of Gail Binkly this meeting.

Fisheries monitoring in 2017 was targeted primarily at improving the understanding of the distribution and abundance of native and non-native fishes in the Dolores River, and assessing native and non-native fish reproduction. While monitoring was being conducted, non-native invasive fish known to inhibit native fish populations were removed, and native fishes were marked with passive integrated transponder (PIT) tags to assess movement patterns and population dynamics.

The following provides an overview of the methods and results of the different specific fisheries monitoring activities conducted in 2017 including: (1) a longitudinal survey in Slickrock Canyon; (2) removal of warm and coldwater invasive fish in native fish habitat; (3) assessment of native and non-native fish reproduction; (4) marking native fishes with PIT tags for assessment of movement patterns; and (5) conducting annual monitoring surveys for coldwater sportfish and warmwater natives at historic stations along the Dolores River.

Longitudinal Survey in Slickrock Canyon

The longitudinal survey was conducted May 15-17 in Slickrock Canyon and consisted of a 36-mile long survey at 800 cfs requiring 2 electro-fishing rafts, 3 support boats, and a crew of 10 for four days. The survey found that three native species comprised 88% of the total catch (with 591 fish being caught in total). Flannelmouth suckers (FMS) made up the largest component of the catch at 53%, followed by roundtail chubs (RTC) at 32%, and bluehead suckers (BHS) at 3%. Non-natives found included black bullhead (5%), and brown trout and sand shiner (less than 1% each). No smallmouth bass (SMB) were found although the water was warm enough that bass would have been active. One white sucker (WHS) was found, which was troubling to researchers, because they had not previously documented white suckers below McPhee Dam. White suckers hybridize with native suckers, and are a serious threat to the genetic integrity of the native suckers.

The last time this longitudinal survey was conducted was in 2007. There was a 95% increase in catch per unit effort (CPUE) over 2007 for all three native fish species. In 2017 they caught 0.43 fish per minute, whereas in 2007 they were only catching 0.22 fish per minute. In 2007 they were catching an average of 16 fish per mile.

In a comparison of the roundtail chubs found at Slickrock versus the Dove Creek Pumps area, the Slickrock fishes were found to be larger (see Figure 2 below). The reason is unclear, although it may be a result of larger more productive pool habitats, and/or potentially older fish occupying downstream reaches.

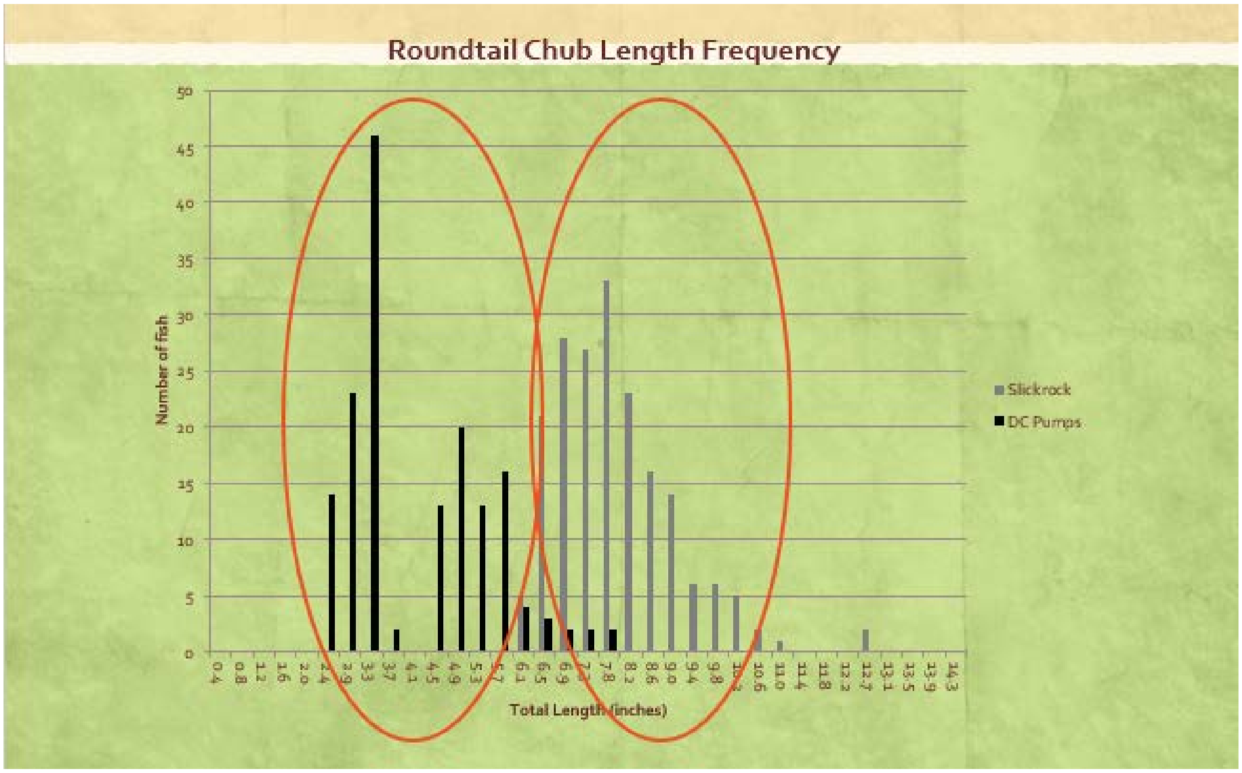


Figure 2. Length of roundtail chub found on Dolores River in 2017.

Removal of Invasive Fish

Removal efforts were conducted July 11-13 with a crew of 7 using 2 electro-fishing rafts and 2 support boats at 450 cfs (Figure 3). These efforts were possible because of the large managed release plus use of fish pool water to create boatable flows (~2,800-acre feet [AF] of water).

Figure 3. Non-native fish removal efforts on the Dolores River in 2017.

The total fish catch during this monitoring effort was 670, with 65% of the catch being smallmouth bass (436 bass were removed). Overall, 86% of the fish caught were non-native, and 14% native. All three of the native fishes were present. One white sucker was caught. Channel catfish made up 7% of the catch, more than was observed in previous surveys (Figure 4). Also see smallmouth bass demographics observed (Figure 5).

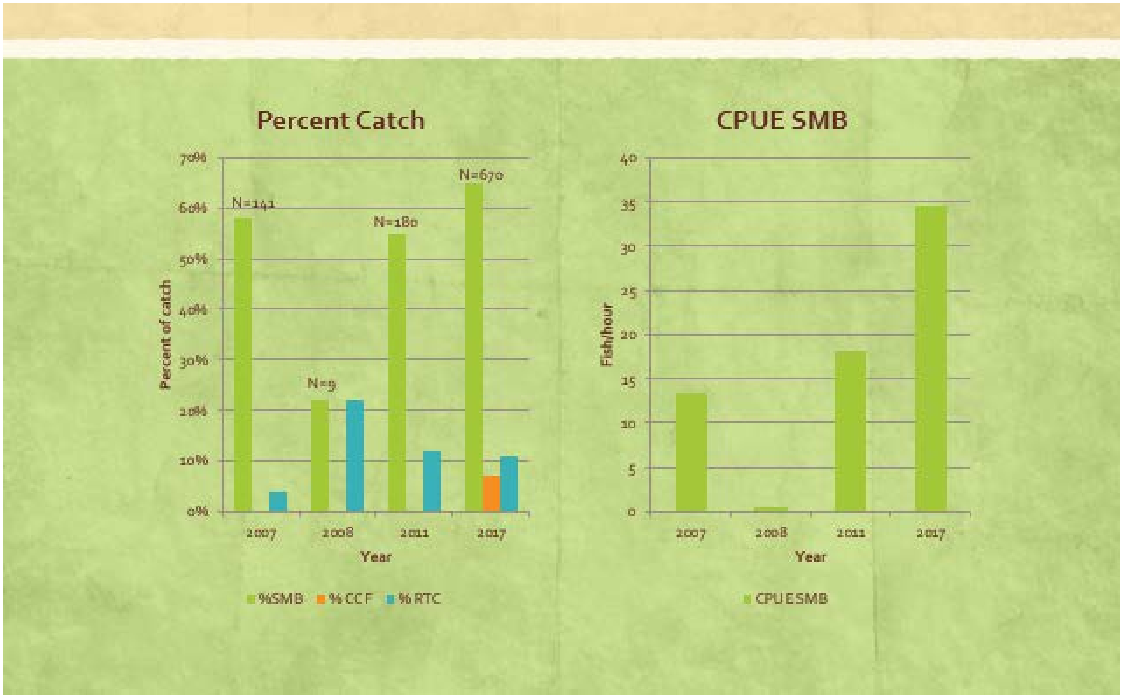


Figure 4. Comparison of survey catch on the Dolores River. SMB = smallmouth bass, CCF = channel catfish, RTC = roundtail chub, and CPUE = catch per unit effort. Data collected in the Pyramid reach only (14 miles of river starting just below Snaggletooth rapid to Disappointment Creek).

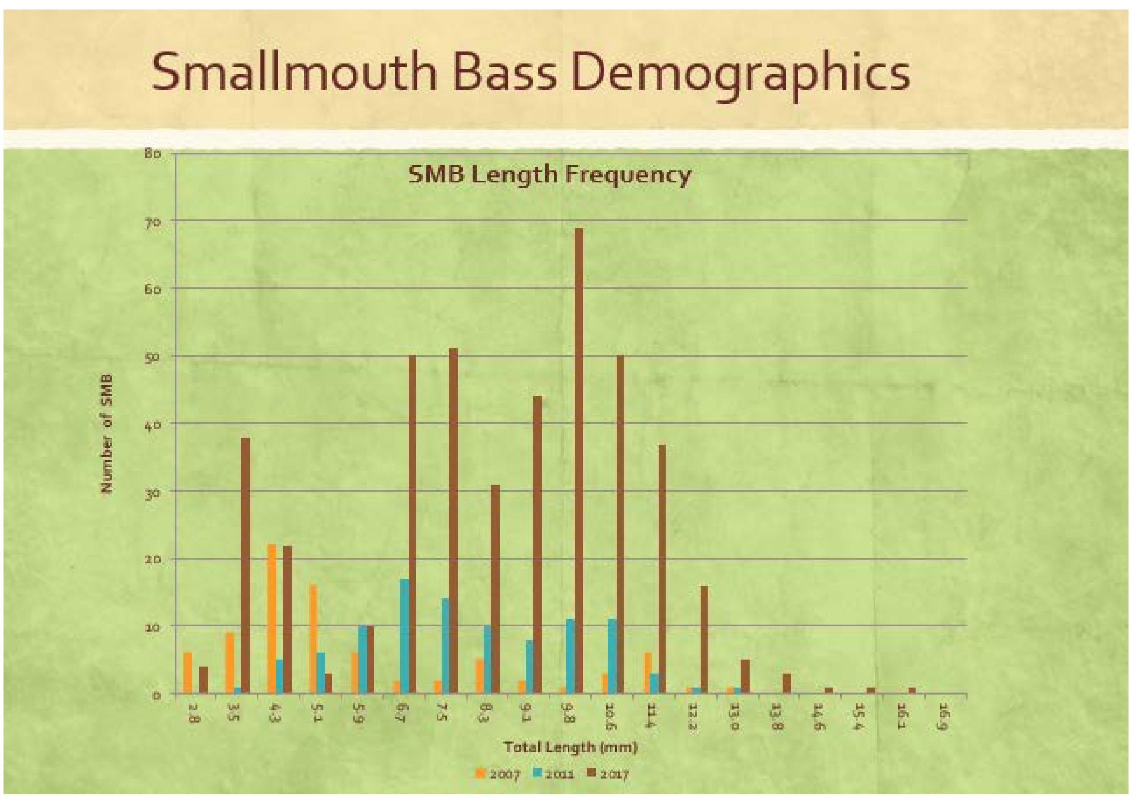


Figure 5. Comparison of smallmouth bass (SMB) demographics on the Dolores River.

Assessment of Native and Non-native Fish Reproduction

Assessment of fish reproduction was conducted August 21-24 through seining (Figure 6), electro-fishing, and angling. A crew of 12 was used at 3 locations (Dove Creek Pumps, Big Gypsum, and James Ranch). A total of 1,053 fish were captured. Forty-two percent of the fish were native, consisting of bluehead sucker, flannelmouth sucker, roundtail chub, and speckled dace. Red and sand shiners comprised 44% of the catch. Twenty-five smallmouth bass were also captured, which comprised 2% of the catch. These results are aggregated across all sites (Figures 7 and 8).

Figure 6. Fish sampling on Dolores River.

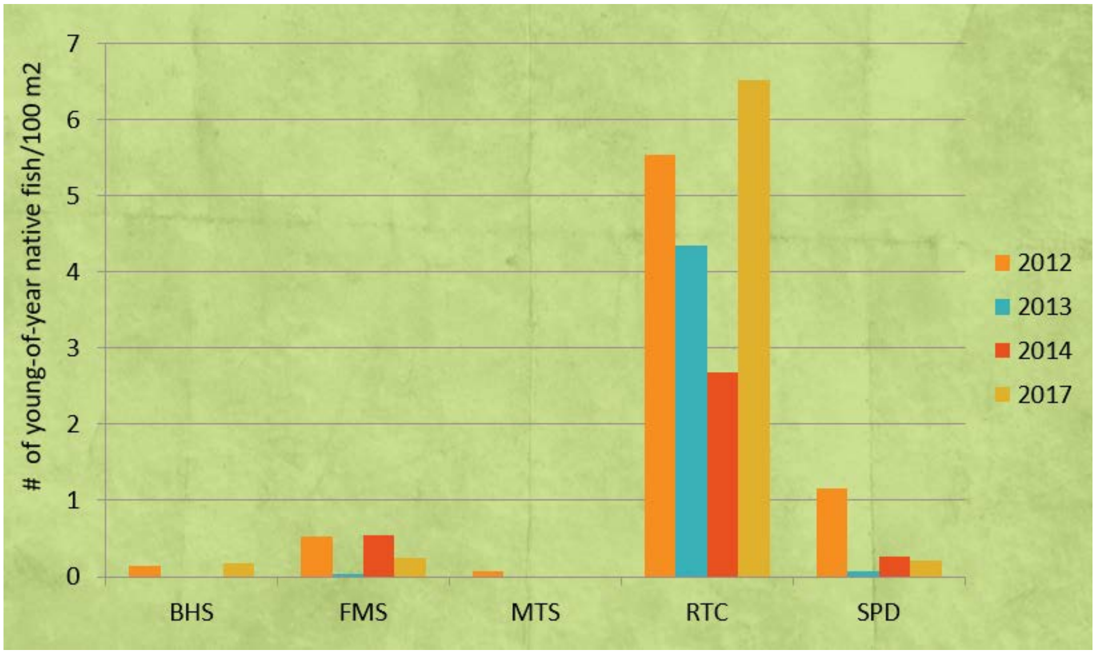


Figure 7. Young-of-year native fish by species caught in reproduction surveys on the Dolores River in 2012 (orange), 2013 (blue), 2014 (red), and 2017 (yellow). CPUE = Catch per unit effort, BHS = bluehead sucker, FMS = flannelmouth sucker, MTS = mottled sculpin, RTC = roundtail chub, and SPD = speckled dace. Reproduction of all three species of sensitive native fish occurred in 2017. Young-of-year flannelmouth suckers and roundtail chubs have been detected in every survey year. Bluehead sucker reproduced in 2017 and 2012, but were not detected in 2013 and 2014.

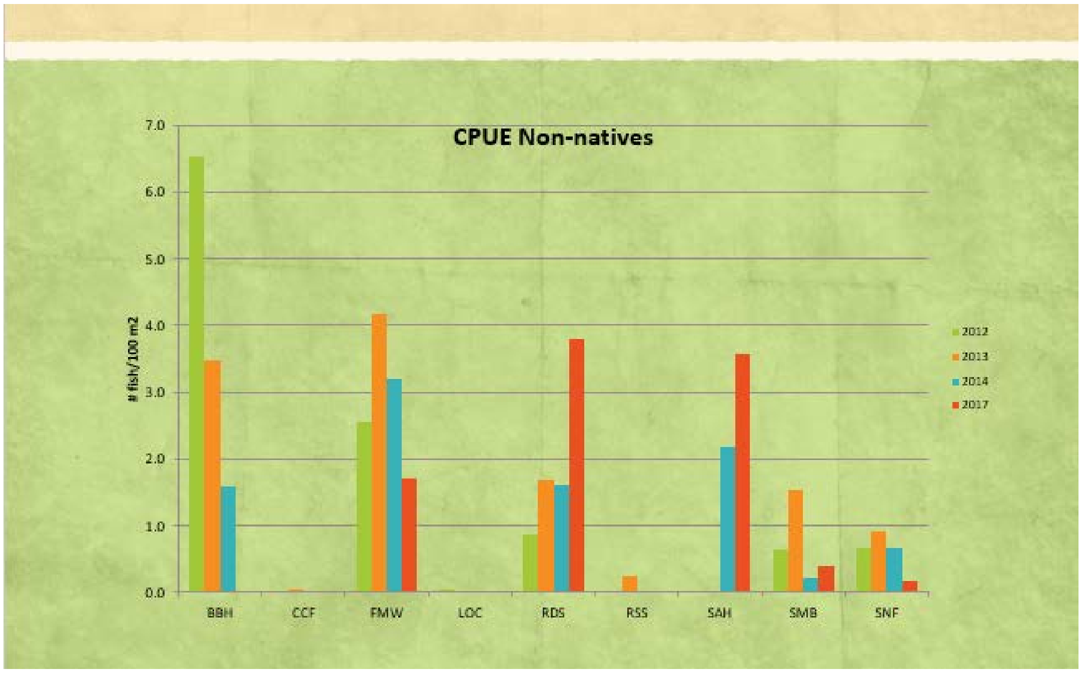


Figure 8. Non-native fish caught in fish reproduction surveys on the Dolores River in 2012 (green), 2013 (orange), 2014 (blue), and 2017 (red). BBH = black bullhead, CCF = channel catfish, FMW = fathead minnow, LOC = brown trout, RDS = red shiner, RSS = redside shiner, SAH = sand shiner, SMB = smallmouth bass, SNF = green sunfish.

Marking Native Fishes with PIT Tags and Assessing Movement Patterns

A total of 609 fish were marked with passive integrated transponder (PIT) tags over the summer of 2017. This included bluehead suckers, flannelmouth suckers, and roundtail chub (Figure 9).

	Slickrock	Pyramid	YOY	DC Pumps	Total
BHS	12	3	0	1	16
FMS	297	15	0	0	312
RTC	176	73	22	10	281
Total	485	91	22	11	609

Figure 9. Bluehead suckers, flannelmouth suckers, and roundtail chub PIT tagged on the Dolores River in 2017.

Monitoring Coldwater Sportfish and Warmwater Natives

The annual coldwater survey (Figure 10) has been running since 1989. In 2017, four sites were surveyed at 40 cfs, using a crew of 10 over 2 days. The survey found close to 30 pounds/acre of trout in the first 12 miles of the river below the dam, with the amount of water having a positive influence on biomass (Figure 11). At the habitat improvement site in Lone Dome, the trout biomass increased to over 30 pounds/acre.

Figure 10. Annual coldwater survey on the Dolores River.

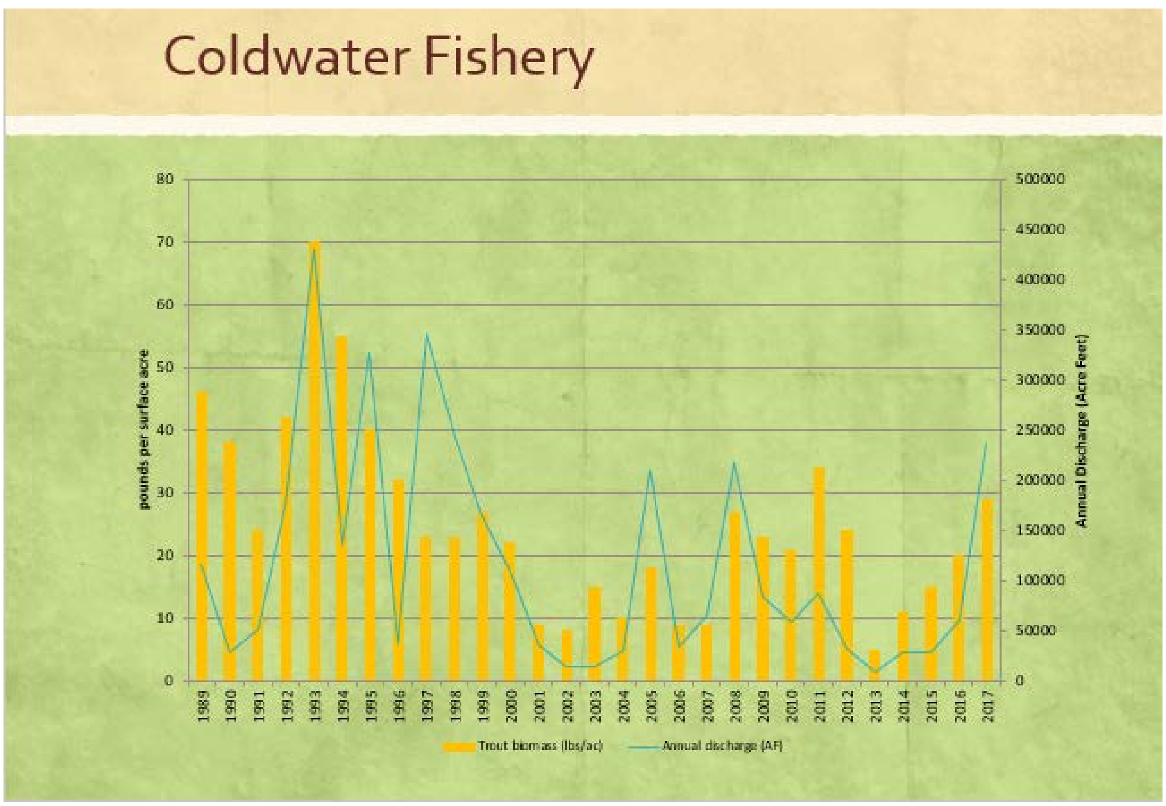


Figure 11. Graph showing impact of discharge (blue) on trout biomass (yellow) from 1989 to 2017.

For the warmwater native fish survey, the Dove Creek Pumps survey found 95% native fish with a total number of fish caught of 170. Ninety-four percent of the fish caught were roundtail chub (See trends in number of roundtail chub caught in Figure 12 below). One adult bluehead sucker was captured and tagged. No smallmouth bass were found. A few green sunfish were caught, and there was a small increase in brown trout caught (4% of the catch.)

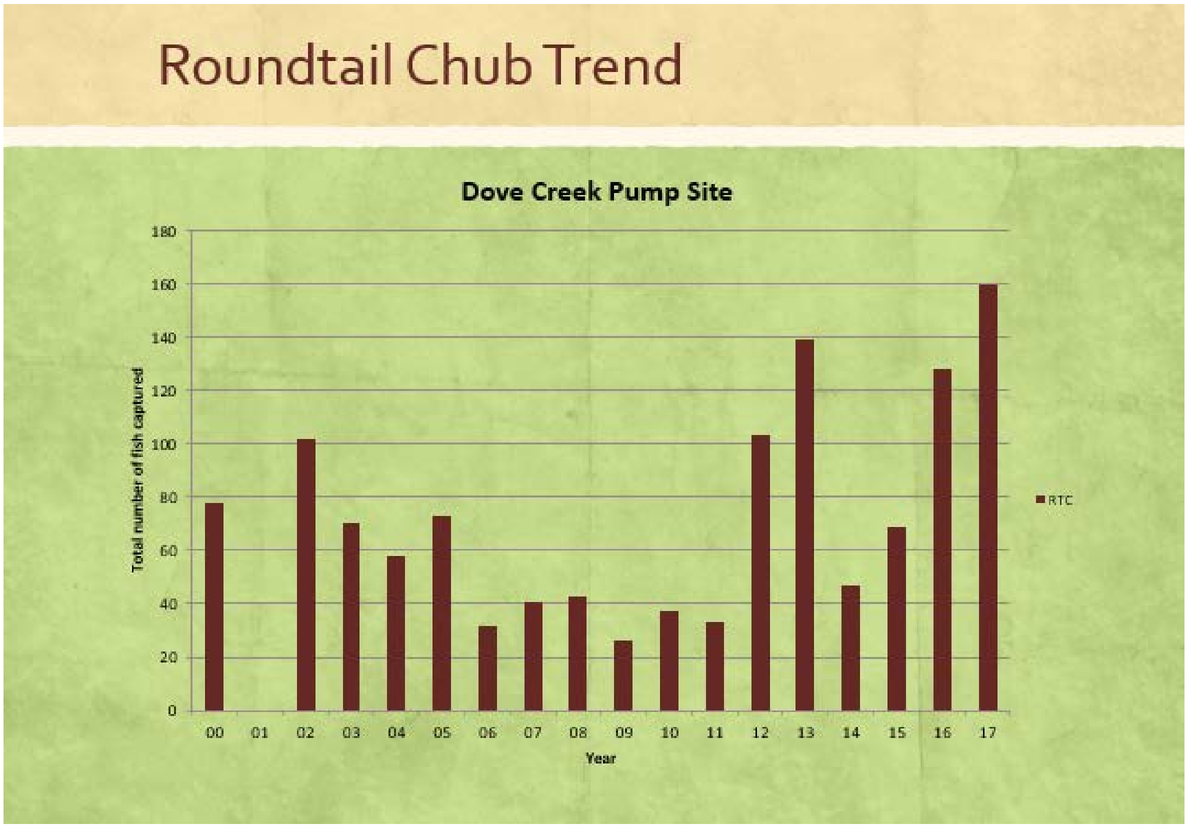


Figure 12. Trend in number of roundtail chub caught on the Dolores River over time in fish surveys.

Summary of Findings: Fish Monitoring

Monitoring efforts resulted in 50 miles of the Dolores River being surveyed (including electrofishing the entire 36-mile Slickrock Canyon, all 14 miles of the Pyramid Reach, and 1000 feet at Dove Creek Pumps; and seining low velocity habitats in 3 miles at James Ranch and 2 miles at Big Gypsum). A total of 609 fish were marked with passive integrated transponder (PIT) tags over the summer.

- Slickrock Canyon is still a stronghold for native species with few non-natives found. Three native species (flannelmouth sucker, bluehead sucker, and roundtail chub) comprised 88% of the total catch out of 591 fish caught; flannelmouth suckers comprised 53% of the catch, roundtail chub 32%, and bluehead sucker 3%.

- While overall density of native fishes is low in Slickrock Canyon, the relatively large number of native suckers caught should be noted (particularly flannelmouth suckers).
- In Slickrock Canyon, there was a 95% increase in catch per unit effort (CPUE) over 2007 for the three native fish species. In 2017, 0.43 fish per minute were caught, whereas in 2007 only 0.22 fish per minute were caught.
- One white sucker was found in Slickrock Canyon. This species had not previously been documented below McPhee Dam. White suckers hybridize with native suckers, and are a serious threat to the genetic integrity of native suckers.
- Smallmouth bass (predator fish that eat native fish) were found to be persistent in the Pyramid Reach, and more frequent removals of these species is recommended. CPUE was 34.6 smallmouth bass/hour in 2017, versus 13.4 in 2007, and 18 in 2011.
- No smallmouth bass were found downstream of Disappointment Creek, including in Slickrock Canyon.
- Removal of non-native fish was only possible because of the combination of the large managed release, and the use of fish pool water (used approximately 2800 AF of water)
- Roundtail chub reproduction was evident at most sites, including the Dove Creek Pumps reach, James Ranch Reach, and Big Gypsum Reach. Young-of-the-year bluehead and flannelmouth suckers were also detected, but at low levels. Findings about 2017 reproduction are preliminary because detection of young-of-year fish is difficult; population surveys in future years will provide a better indication of how much reproduction of native species occurred this year.
- The rise in catfish, red shiner, and sand shiner found in 2017 (versus surveys in 2012, 2013, and 2014) was troubling. Shiner habitat overlaps with the habitat of young native fish, and shiners eat the natives).
- An increase in trout biomass was found with increasing discharge.

IN-CHANNEL AND RIPARIAN HABITAT

<u>Ecological Monitoring Site - Photo Point Monitoring</u>

Repeat photo monitoring points were established at each of the five new ecological monitoring sites prior to the 2017 managed release, with photos taken pre-, peak, and post-release. As it was impossible to know where noticeable change might occur at each site, and to ensure a thorough characterization of pre-release conditions at each site for future comparison, approximately five repeat photo point locations were established at each site, with a large quantity of additional photos taken throughout each site pre-release March 20-24, 2017. During the peak-release time-frame, relevant photo points were repeated (May 5-7) when possible (some photo points were completely submerged at peak-release and impossible to repeat at that time). Post-release, relevant photo points were then repeated again (July 6-8). For most photo point locations, a series of photos were taken from each photo point.

These new photo points were established to: (1) provide a visual characterization of vegetation changes, sediment scour/deposition, ground-view river bank erosion, and planform changes that might be observed pre- versus post-release in 2017; (2) establish a visual 'baseline' of the above for comparison in future years; and (3) capture the extent of overbank flooding occurring at each site during the 2017 managed release, thus helping to visually characterize floodplain inundation depth, and the interaction and exchange of material between channel and floodplain.

Comparison of pre- and post-release photos found noticeable changes in sediment scour and deposition, and captured substantial overbank flooding occurring at peak-release. Pre- and post-release photo comparison found limited changes in vegetation, river bank erosion, and planform change. These findings and photos are presented as part of other monitoring reports included in this document, and in several Appendices.

For all additional detailed photo point descriptions, GPS coordinates, and other relevant information for the final repeat photo point locations selected for each site, please see *Appendix 2: Ecological Monitoring Sites – Photo Point Monitoring Locations and Comparisons.* Summaries of select photo points were also compiled for each Ecological Monitoring Site and can be found in *Appendix 6. Photo Point Summaries of Five Ecological Monitoring Sites*.

Summary of Findings: Ecological Monitoring Site Photo Point Monitoring

New repeat photo monitoring points were established at each of the five new ecological monitoring sites prior to the 2017 managed release, with photos taken pre-release (March 20-24), peak-release (May 5-7) (if points could be reached during high flows), and post-release (July 6-8) 2017. Photo points were established to (1) provide a visual characterization of vegetation changes, sediment scour/deposition, ground-view river bank erosion, and planform changes that might be observed pre- versus post-release in 2017, (2) establish a visual 'baseline' of the above for comparison in future years, and (3) capture the extent of overbank flooding occurring at each site during the 2017 managed release, thus helping to visually characterize floodplain inundation depth, and the interaction and exchange of material between channel and floodplain.

- Comparison of pre- and post-release photos found noticeable changes in sediment scour and deposition, and captured substantial overbank flooding occurring at peak-release.
- Pre- and post-release photo comparison found limited changes in vegetation, river bank erosion, and planform change.
- These findings and photos are presented as part of other monitoring reports included in this document, and in several Appendices.

<u>Geomorphology and Sediment Monitoring</u>

This report is a synopsis of: (1) a presentation given by David Graf, Water Resource Specialist, and Ryan Unterreiner, Southwestern Region Water Resource Specialist, of Colorado Parks and

Wildlife summarizing their 2017 monitoring efforts; and (2) additional 2017 monitoring efforts conducted by Dr. Jonathan Harvey and undergraduate student Dominique Shore of Fort Lewis College. The Graf and Unterreiner presentation was given on 10/27/17 at the Monitoring and Recommendation Team Meeting in Cortez, Colorado. A summarization of their presentation in this report is made possible by the excellent note taking of Gail Binkly at the Cortez meeting.

New Ecological Monitoring Sites

Pre- and post-release monitoring efforts were conducted in 2017 on the five new ecological monitoring sites to determine effects of the managed release on site geomorphology and sediment movement. Survey efforts included conducting cross-section surveys and Wolman pebble counts, as well as installing erosion stakes, painted patches, and sediment traps. Table 2 below shows the monitoring efforts conducted at each of the five sites.

Table 2. Monitoring conducted at each of the five new ecological monitoring sites for determining effects of the managed release on geomorphology and sediment movement.

	Cross Section Type	Scour/Erosion Stakes?	Painted Patches/ Frame?	Wolman Pebble Count?	Sediment Traps?
Dove Creek Pumps	Riffle, Pool	No	No	No	No
Slickrock Upstream	Pool	No	No	No	No
Slickrock Downstream	Pool	Yes	Yes	Yes	Yes
BLM Rec (Big Gypsum)	Pool	Yes	No	No	No
Bedrock	Pool	Yes	No	No	Yes

Previous research conducted near the BLM Rec (Big Gypsum) site in the Big Gypsum Valley by Dr. Gigi Richard of Colorado Mesa University found that at river flows of 3,400 cfs, most of the floodplain surface was flooded in this location. As such, researchers wanted to determine what peak flows greater than 3400 cfs could accomplish (see Figure 13 for 2017 hydrographs).

It is important to note that while the flow hypotheses in Table 4 of the 2014 Plan state that at a given flow level certain ecological outcomes should be achieved, a release of (for example) 4000 cfs at McPhee Reservoir does not necessarily mean that a given site downstream will experience a flow rate of 4000 cfs. A 4,000 cfs release such as was observed in 2017 on the Dolores resulted in substantial overbank flooding. When overbank flooding occurs, the river is now flowing in a much wider channel, resulting in a loss of velocity. As well, as water flows downstream it is lost to saturation into the ground and storage in the alluvial aquifer; significant loss from plant evapotranspiration can also occur. All of this means that it may not be realistic to expect 4,000 cfs ecological outcomes on a given site, knowing that there are inevitable losses occurring along the way. Figure 13 below shows the actual flows and the timing of these flows occurring in the river as a result of these 2017 releases from the reservoir, utilizing data from select river gage stations. Note that the peak flow at Slick Rock was approximately 500 cfs less than the amount released from McPhee Reservoir.

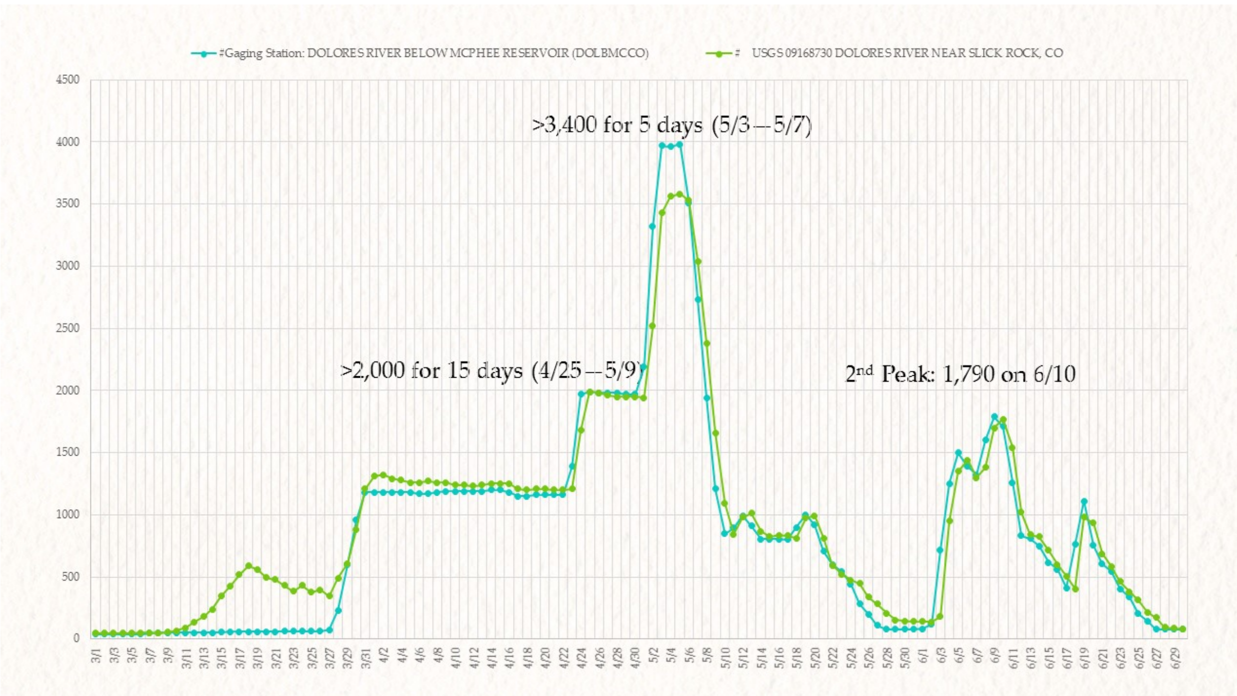


Figure 13. Hydrograph from two different gaging stations along the Dolores River from March 1 to June 30, 2017; just below McPhee reservoir, and near Slick Rock. Note the peak flow at Slick Rock (green line) was nearly 500 cfs less than the amount released from McPhee Reservoir (blue line), resulting in a reduced amount of power in the river, and a reduction in the habitat maintenance work that the water could accomplish.

Dove Creek Pumps Site Characteristics

The Dove Creek Pumps site (Figure 14) is a confined, colluvial U-shaped valley type, with relatively stable, moderate side slopes, and a moderate valley slope. Located within a portion of the Dolores with steep canyon walls and a very narrow riparian corridor, there is a relatively low sediment supply, but areas of high sediment supply can occur. There is also large, woody debris here.

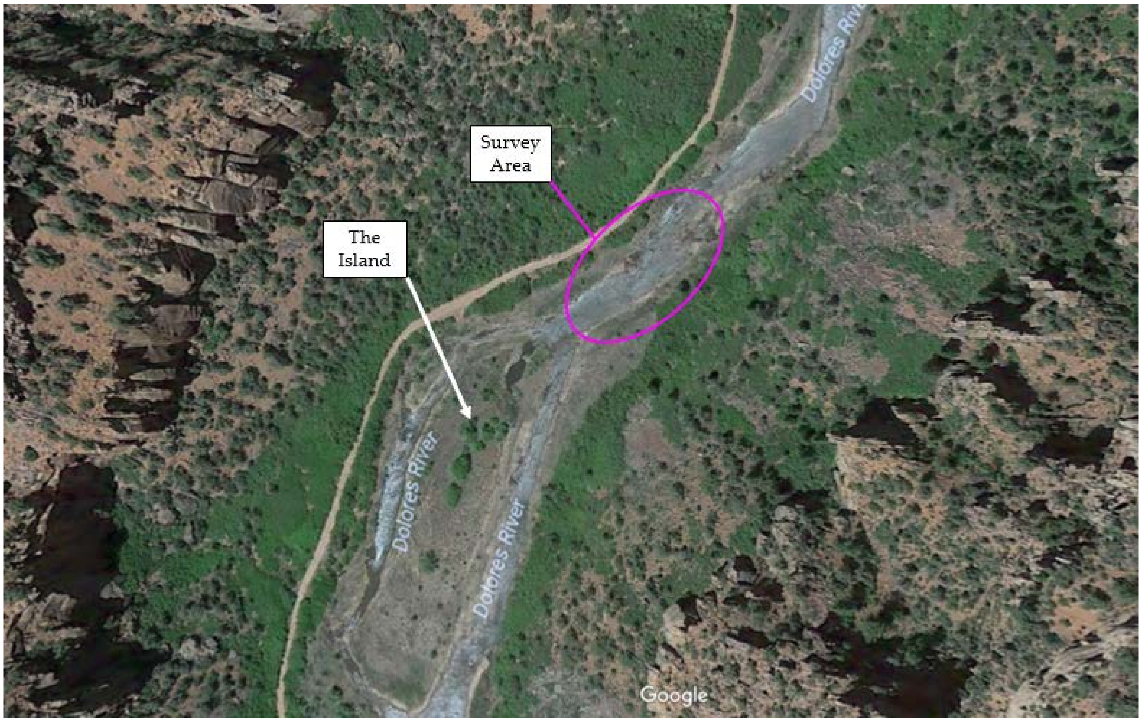


Figure 14. Dove Creek Pumps site overview, showing the location of the survey area circled in purple.

Riffle (Figure 15) and pool cross-sections were conducted at this site. This was the only site that a riffle cross-section could be completed - monitoring of riffle habitat was planned for 2017 at all ecological monitoring sites but higher than anticipated flows in March prevented most of the riffle monitoring.

Pre- and post-release 2017 cross-section comparisons for the riffle at this site show little change (Figure 16); the Dove Creek Pumps site almost represents a control reach, as it is a very stable, narrow riparian corridor. There was also not much change observed in the cross-sections when compared to 2004 (Figure 17). The pool cross-section also showed little change (Figures 18 and 19)

Figure 15. Dove Creek Pumps Site, upstream riffle cross-section. This is a pre-release photo of the riffle (March 2017).

Morphological Parameters

	March 20	July 6	Change
Maximum Depth	4.4	4.6	0.2
Bankfull Width	82	81.5	(0.5)
Mean Bankfull Depth	2.9	3.0	0.1
Width/Depth Ratio	28.4	26.9	(1.49)
Cross-Sectional Area	236.8	246.9	10.1

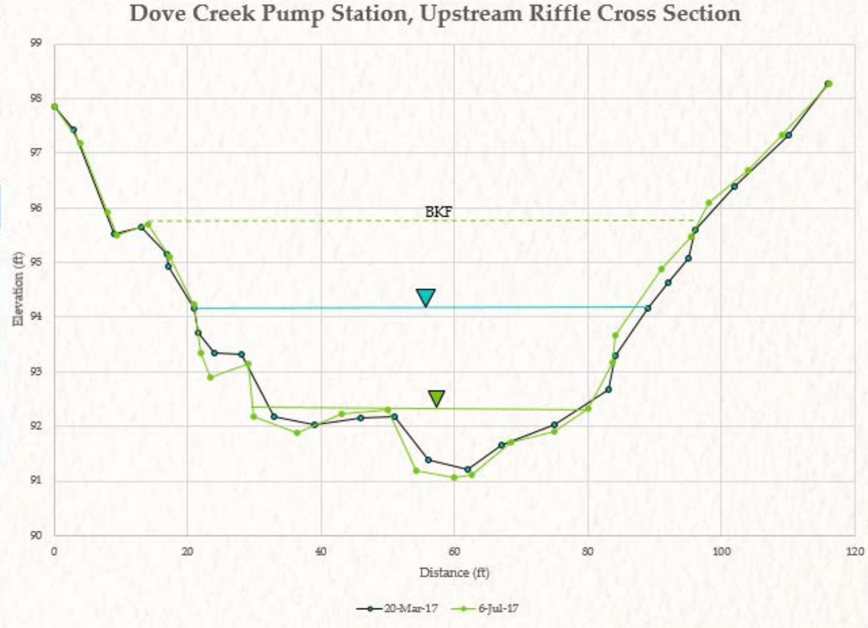


Figure 16. Dove Creek Pumps 2017 upstream riffle cross-sections. Little change was observed between the pre-release cross-section conducted March 20 (blue) and the post-release cross-section conducted July 6 (green).

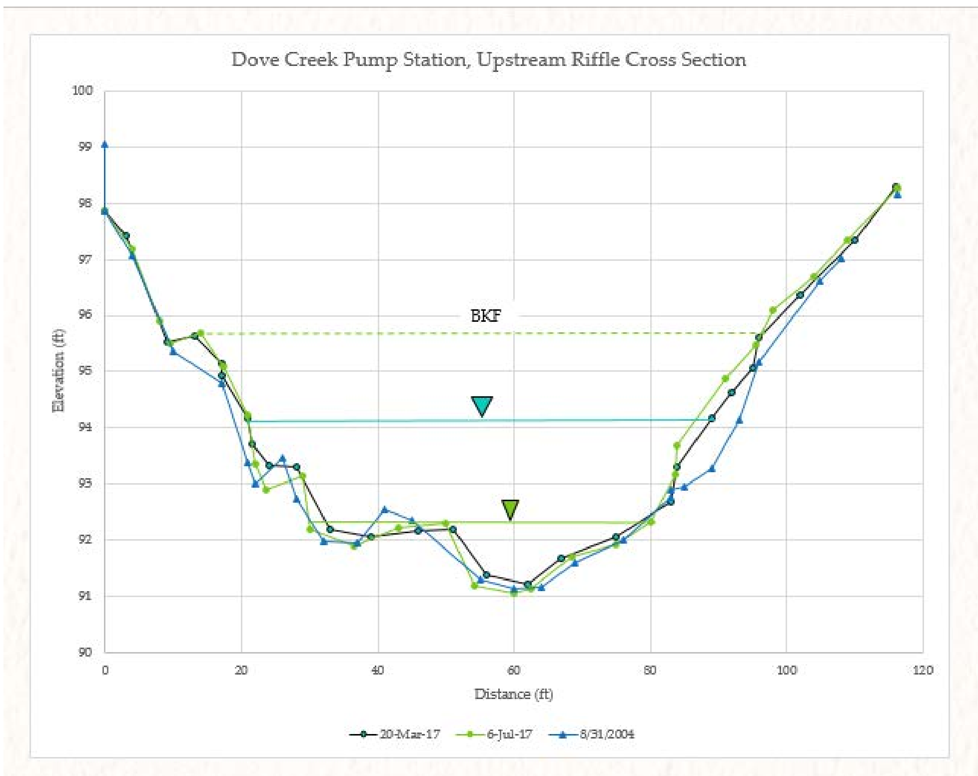
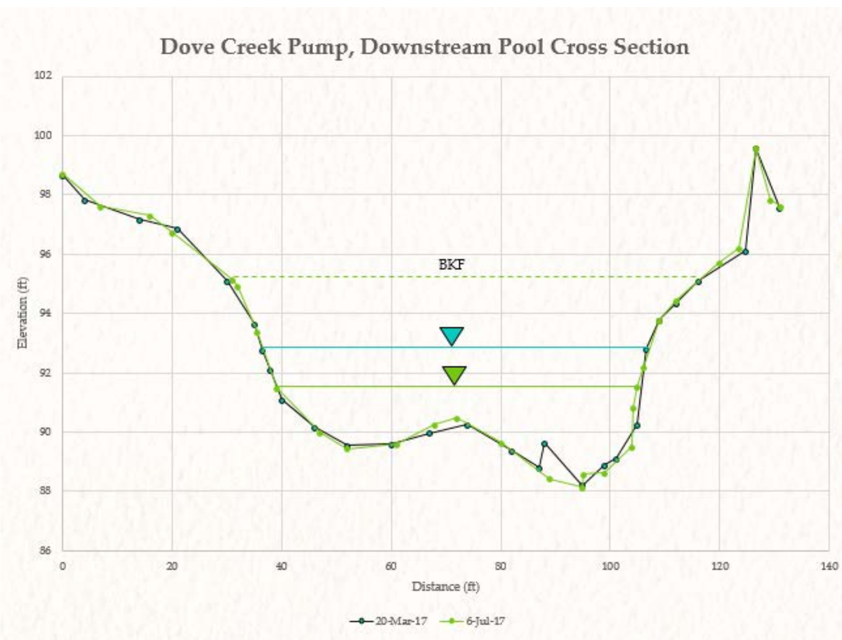


Figure 17. Dove Creek Pumps 2017 upstream riffle cross-sections on March 20 (black) and July 6 (green), compared to 2004 cross-section conducted August 31 (blue); with little change observed.

Figure 18. Dove Creek Pumps Site, pool cross-section, shown for 2017 pre-release (March 20) and post-release (July 8).



Morphological Parameters

	March 20	July 6	Change
Maximum Depth	6.3	6.8	0.5
Bankfull Width	86	89	3
Mean Bankfull Depth	4.5	4.4	(0.1)
Width/Depth Ratio	19.1	20.1	1.0
Cross-Sectional Area	387.6	393.7	6.1

Figure 19. Dove Creek Pumps 2017 downstream pool cross-sections; little change was observed between the pre-release cross-section conducted March 20 (black) and the post-release cross-section conducted July 6 (green).

Slickrock Upstream (Above Disappointment Creek) Site Characteristics

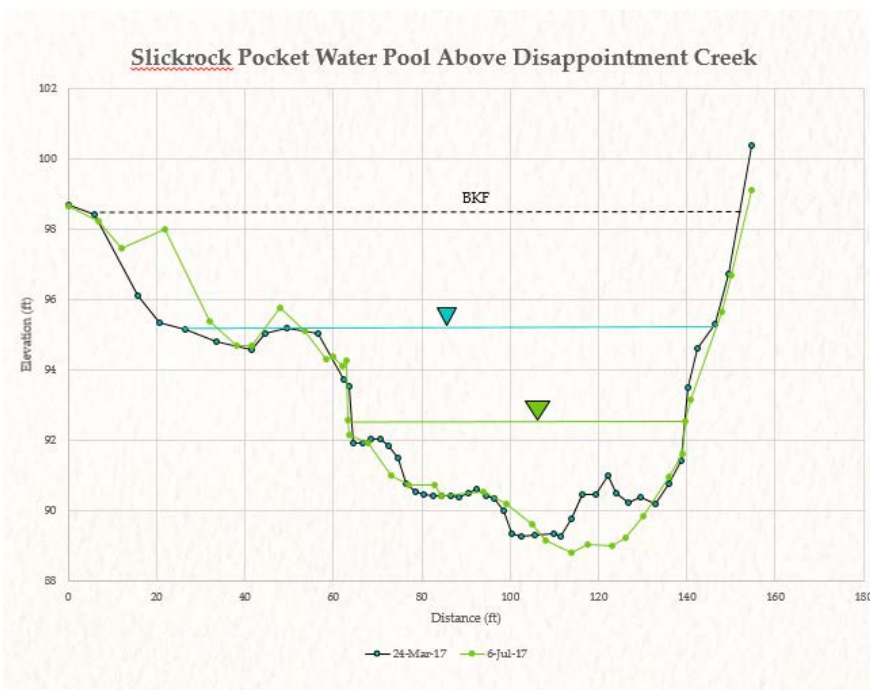
The Slickrock Upstream site is a semi-confined, alluvial valley type, with alluvial deposition and a narrow floodplain. It has a meandering riffle-pool system, with streambank erosional processes and a productive riparian community; there is not a lot of sinuosity in the stream (Figures 20-22).

Figure 20. Slickrock Upstream Site Overview. Circle in blue shows the survey area.
This is a post-release photo (8/6/17).

Figure 21. Slickrock Upstream Site, downstream pool. Photos of the pool are, from left to right, pre-release (3/24/17), peak-release (5/6/17), and post-release (7/6/17).

Figure 22. Slickrock Upstream Site, pool viewed from above. The red circle indicates location of staff gage. Surveyed pool is located in photos in general area between red circle and large white rocks. Photos are taken post-release (7/6/17), with right side of photos downstream end.

This reach also did not show a sizeable amount of change, but there were some subtle differences (See Figure 23 below).



Morphological Parameters

	March 20	July 6	Change
Maximum Depth	9.18	9.45	0.27
Bankfull Width	146.20	146.00	(0.20)
Mean Bankfull Depth	5.58	5.34	(0.24)
Width/Depth Ratio	26.20	27.33	1.13
Cross-Sectional Area	815.79	780.06	(35.73)

Figure 23. Slickrock Upstream Site, pool cross-sections 2017, pre-release March 24 (black) and post-release July 6 (green). Some deposition has occurred, contributing to a narrowing of the channel, and the inner berm feature has more definition.

Slickrock Downstream (Below Disappointment Creek) Site Characteristics

The Slickrock Downstream site is also a semi-confined, alluvial valley type, with alluvial deposition and a narrow floodplain (Figure 24). It has a meandering riffle-pool system, with streambank erosional processes and a productive riparian community.

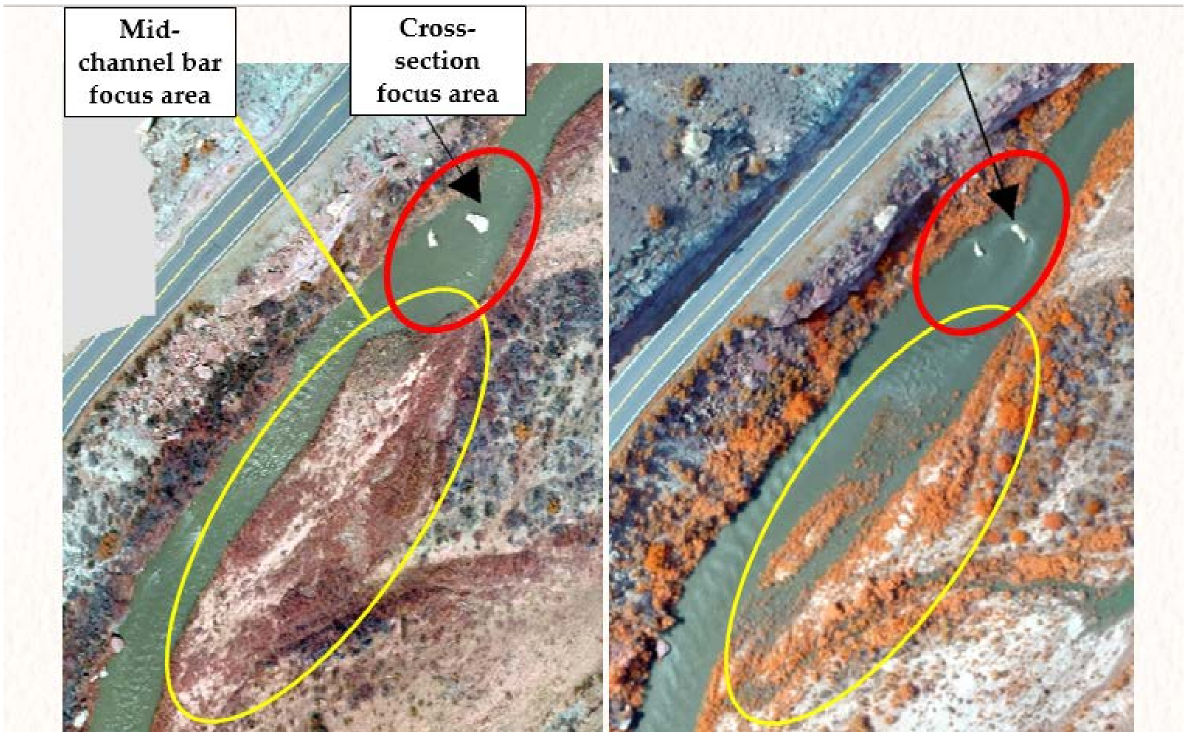


Figure 24. Slickrock Downstream Site. Drone imagery from late March (left) and early June (right) 2017. The red circle indicates the cross-section focus area. Water is higher in June. Bottom of photos indicate downstream end.

A pre- and post-release pool cross-section was conducted in 2017; comparison of the results show this site experienced fairly good scouring and decent evacuation of material with the 2017 managed release, and some depth was added overall (Figure 25). Specifically, there was a 127 square foot increase in the cross-sectional area, and 3 feet of depth was added. It should also be noted that deposition on the floodplain of approximately one foot on the left bank also occurred at this site.

Morphological Parameters

	March 22	July 6	Change
Maximum Depth	9.76	12.78	3.02
Bankfull Width	74.2	69.6	(4.60)
Mean Bankfull Depth	6.76	9.03	2.27
Width/Depth Ratio	10.98	7.71	(3.27)
Cross-Sectional Area	501.41	628.47	127.06

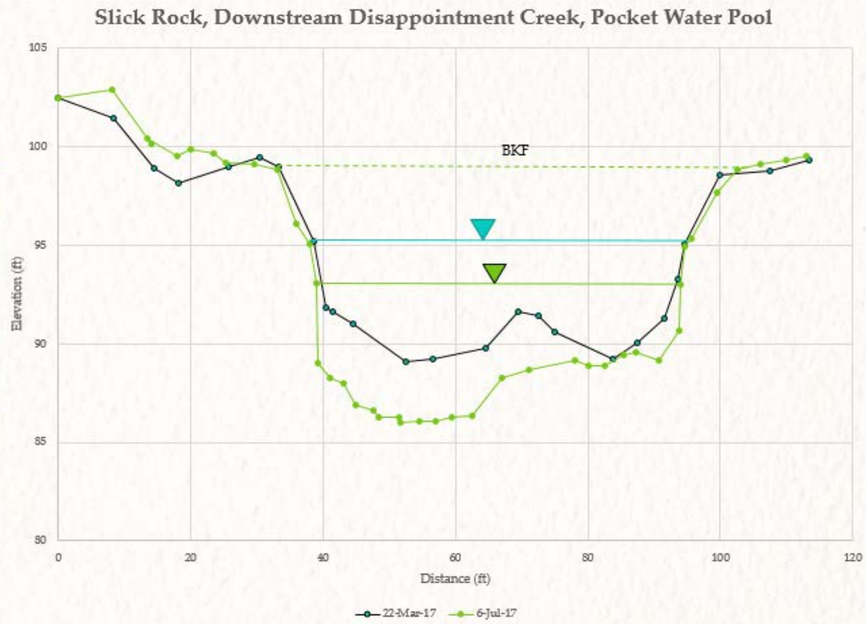


Figure 25. Slickrock Downstream Site, pool cross-sections, pre-release (3/22/17) and post-release (7/6/17). Fairly good scouring occurred, with a decent evacuation of material. Some overall depth was also added. Note the additional deposition on the bank as well.

Three erosion/scour stakes were installed at this site in the survey area, and all showed floodplain scour from 0.2 to 0.5 feet (Figure 26 and Figure 27). Scour consisted of removing fines, and mobilizing smaller cobbles from this low-floodplain environment. Sediment traps were installed using 6-inch PVC cut and dug into the floodplain in an attempt to document materials transported across the floodplain, but all traps were scoured from the floodplain so no data were acquired. Comparisons of painted patches/frames (0.5-meter square) pre- and post-release showed cobble movement in and out of the frames (Figure 28), and visually support the particle size analyses showing coarsening of the floodplain as fines were removed. Because the survey was conducted in a low-floodplain area, it was subjected to relatively high energy and is the best surrogate for processes that occurred in active in-channel sites. In that sense, these data support the objective of cleaning fines from cobbles to enhance spawning conditions for native fish. Wolman pebble counts at the Slickrock Downstream Site (Figure 29 and Figure 30) illustrate the coarsening of sediments, i.e., the removal of sand, silt, and clay.

Figure 26. Slickrock Downstream sediment trap and erosion stake; pre-release photo on left (3/22/17), and post-release photo on right (7/6/17). Note the scouring of fine material observed with the orange erosion stake circled in blue between pre- and post-release. It appears that strong flows ripped out sediment trap pre- versus post-release.

Figure 27. Post-release scour on low floodplain at Slickrock Downstream site. Stake painted to depth installed pre-release (3/22/17). Approximately 0.5 feet of material was scoured from this location.

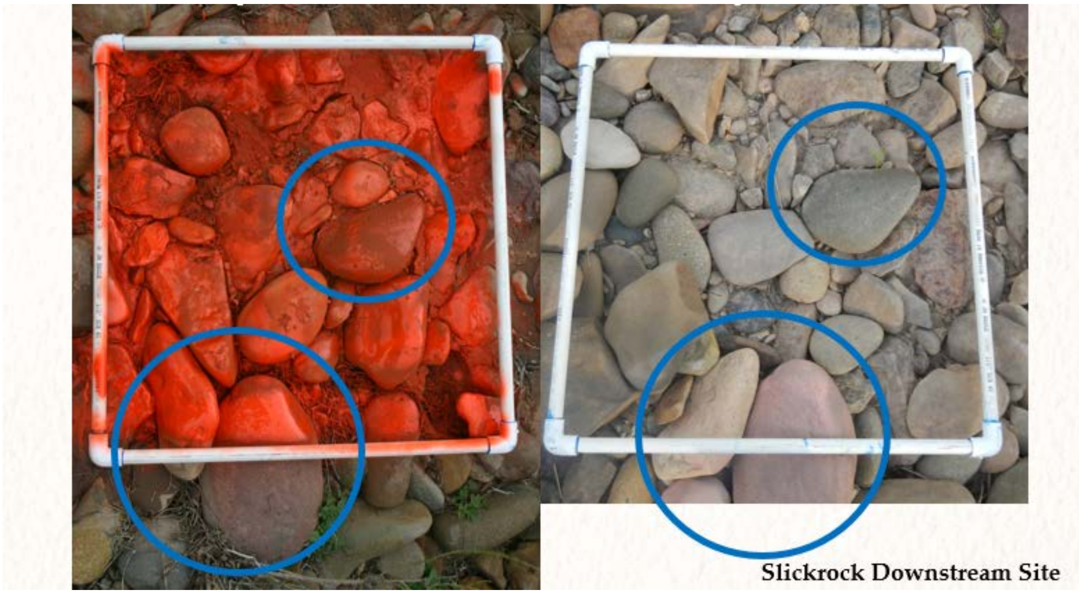


Figure 28. Slickrock Downstream painted patch. Note the fine sediment (clay, silt, and sand) between cobles pre-release (3/22/17; on left) and their absence (7/6/17; on right). Also, note how the cobbles have shifted positions and, in some cases, been moved entirely out of the frame. Rocks circled in blue serve as reference points.

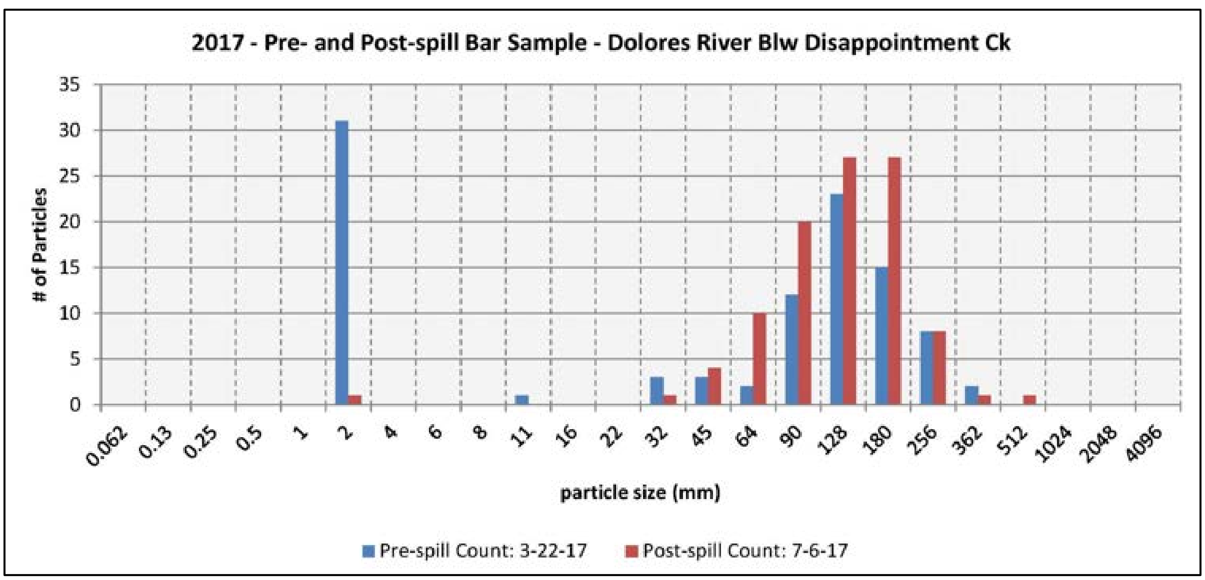


Figure 29. Slickrock Downstream (Below Disappointment Creek) pebble count results 2017. These important results show that 2 mm particles were almost completely removed from the site.

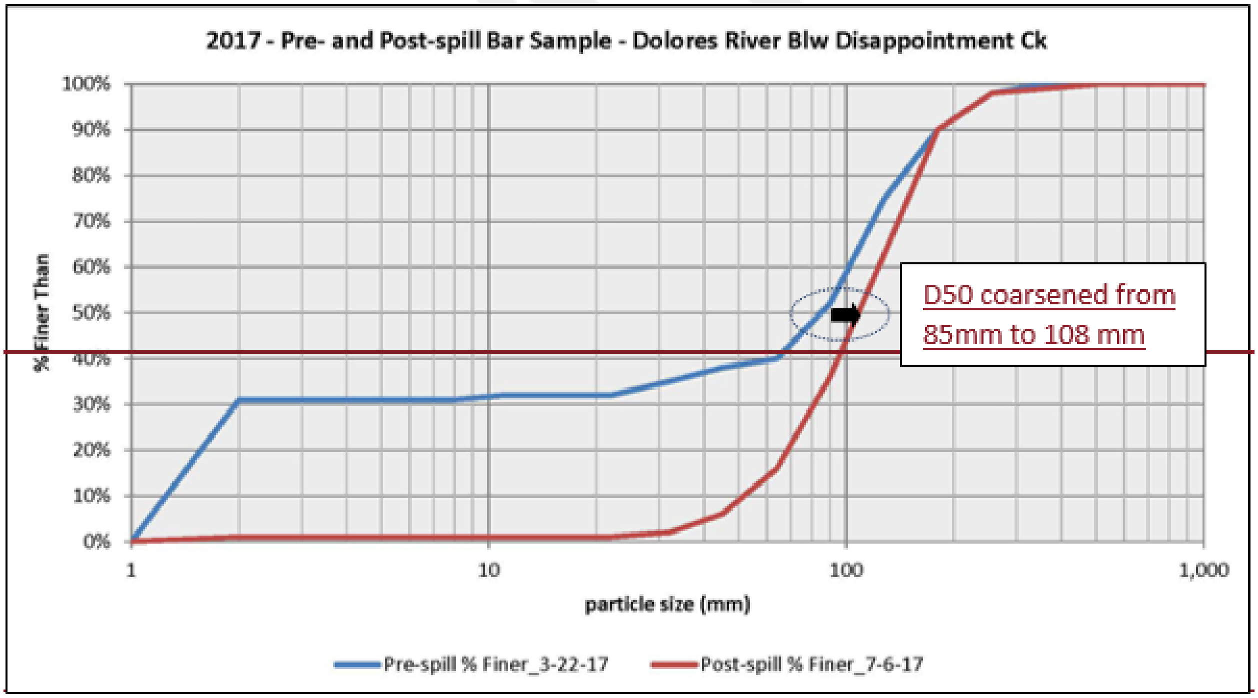


Figure 30. Additional Slickrock Downstream (Below Disappointment Creek) pebble count from low floodplain environment.

BLM Rec (Big Gypsum) Site Characteristics

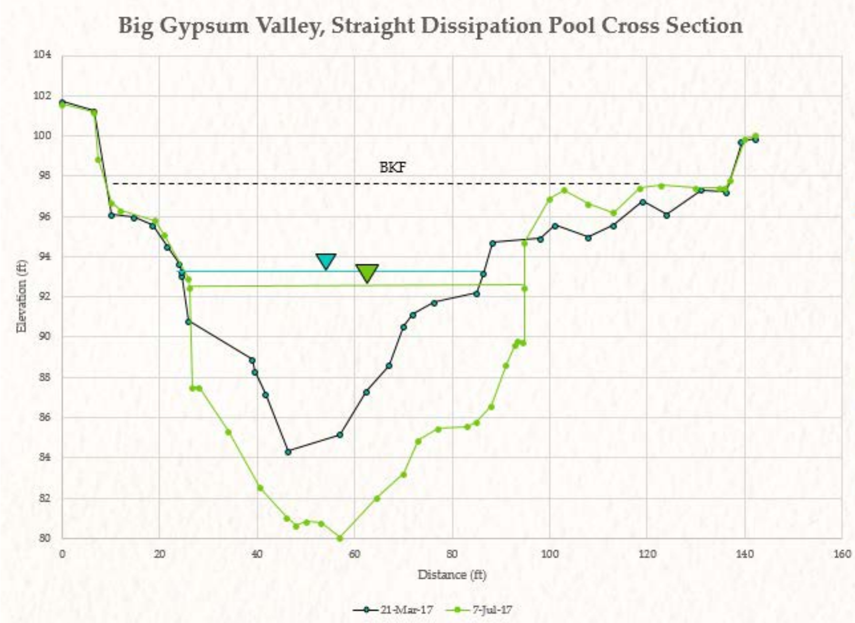
The BLM Rec (Big Gypsum) Site is a semi-confined, alluvial valley type, with alluvial deposition and a narrow floodplain (Figure 32). It has a meandering riffle-pool system, streambank erosional processes, and a productive riparian community.

Figure 31. Overview of BLM Rec (Big Gypsum) site post-release July 8, 2017.

Figure 32. BLM Rec (Big Gypsum) Site, showing area of cross-section survey pre-release in March (top), and post-release in June (bottom) 2017.

At the BLM Rec (Big Gypsum) Site, a major evacuation of material was observed. At the BLM Rec (Big Gypsum) site, mean depth increased by over 3 feet, and the cross-sectional area of the pool changed from 433 square feet pre-release to 1226 square feet post-release, resulting in almost 300% more pool volume post-release when extrapolated across the length of the pool (Figure 34).

Figure 33. BLM Rec (Big Gypsum) Site, showing cross-section line pre-release (3/21/17; on left), and estimated line trajectory if it had been run at peak-release (5/5/17; on right), 2017.



Morphological Parameters

	March 23	July 7	Change
Maximum Depth	12.99	17.36	4.37
Bankfull Width	120.8	108.5	(12.30)
Mean Bankfull Depth	5.30	8.50	3.20
Width/Depth Ratio	22.78	12.76	(10.02)
Cross-Sectional Area	640.59	922.36	281.77

Figure 34. BLM Rec (Big Gypsum) pool cross-sections 2017, Mar 21 pre-release (black) and July 7 post-release (green). At this site, a major evacuation of material was observed, with mean depth increasing by over 3 feet, and the cross-sectional area of the pool changing from 433 square feet pre-release to 1226 square feet post-release, resulting in almost 300% more pool volume post-release when extrapolated across the length of the pool.

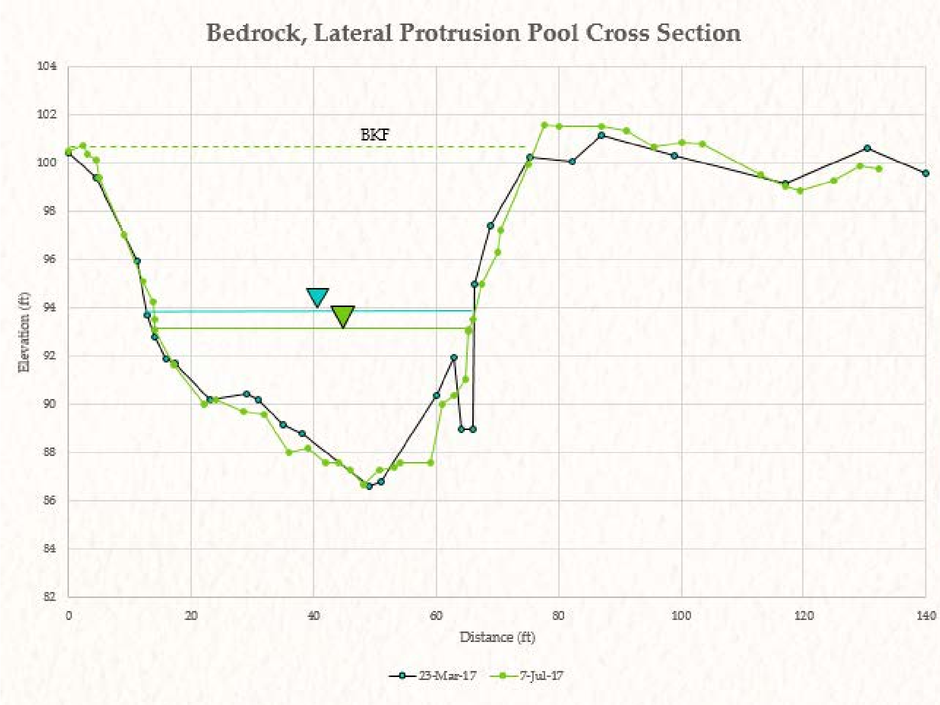
Bedrock Site Characteristics

The Bedrock Site is a semi-confined, alluvial valley type, with alluvial deposition and a narrow floodplain. It is a meandering, riffle-pool system, with streambank erosional processes, and a productive riparian community (Figure 35).

Figure 35. Overview of Bedrock site pre-release (3/23/17; top), peak-release (5/6/17; middle), and post-release (7/7/17; bottom).

Figure 36. Bedrock Site, showing area of cross-section survey in March (top), and in July 2017 (right).

At the Bedrock site there was not much change in the channel but some scour did occur (Figure 37 and 38). Deposition of material occurred on the right bank (Figure 39). An estimated 260 tons of material at this site was eroded and released into the river (based on bank loss calculations). There was good mobilization of material. Riffle habitat was reset, and water accessed the floodplain (Figure 40).



Morphological Parameters

	March 23	July 7	Change
Maximum Depth	13.68	13.11	(0.57)
Bankfull Width	75.2	70.5	(4.70)
Mean Bankfull Depth	8.30	8.99	0.69
Width/Depth Ratio	9.06	7.84	(1.22)
Cross-Sectional Area	624.16	634.03	9.87

Figure 37. Bedrock pool cross-sections 2017, Mar 23 pre-release (black) and July 7 post-release (green); not a lot of change in the channel but some scour did occur. Note deposition of up to one foot of new sediment on the right bank, as well as minor scouring of overbank secondary channel occurring on far-right bank.

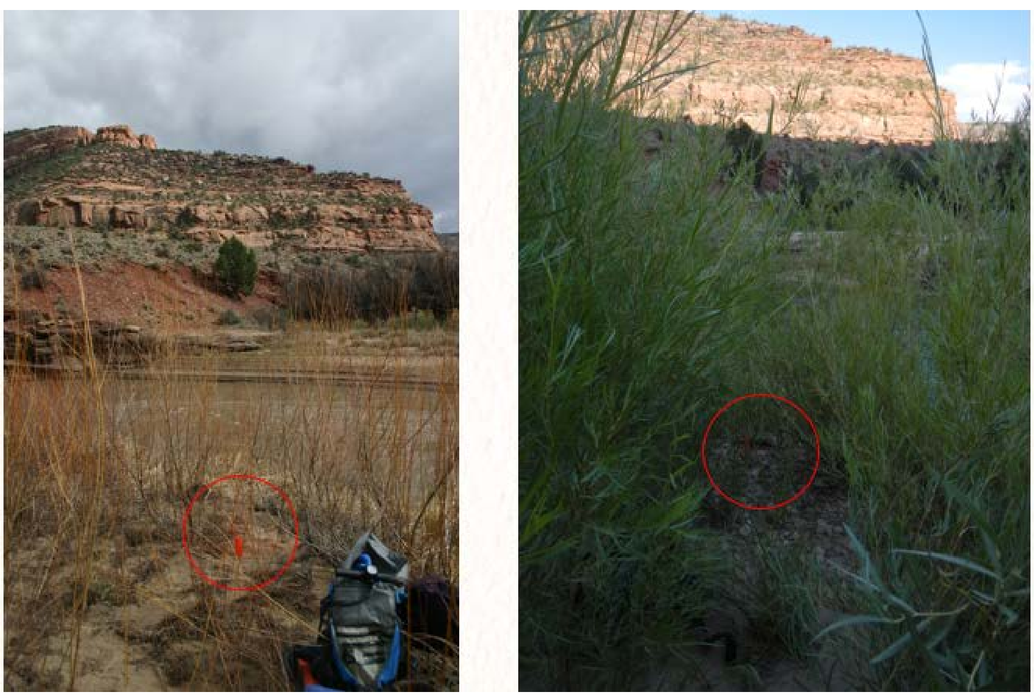


Figure 38. Bedrock erosion stake monitoring, Stake #1 (closest to the water) pre-release (3/23/17, left) and post-release (7/8/17; right). Note scour of sediment.

Figure 39. Bedrock erosion stake monitoring, a close-up view of stake #1 post-release. The bare wood below the blaze orange is the depth of scour.

Figure 40. Separate monitoring site just upstream from the main Bedrock monitoring site. This additional monitoring site was established to capture additional scour and depositional information, as well as to more fully characterize potential bank loss with the installation of additional erosion stakes.

FLC Slickrock Site and Slickrock Downstream Ecological Monitoring Site

During the 2017 managed release, Dr. Jonathan Harvey and Dominique Shore of Fort Lewis College conducted some complementary data collection efforts to CPW, in that they conducted a set of three channel cross-sections pre- and post-release at an FLC Slickrock site established approximately 0.3 miles upstream from the Slickrock Downstream site (but still downstream of Disappointment Creek). Results from this site were consistent with cross-section results at the Slickrock Downstream site, although they did not document as much scour as seen at that site. Results at the FLC Slickrock site showed 1-2 feet of scour in the pool cross-section, and almost no change in the riffle or mid-channel island cross-sections.

Additionally, the researchers conducted drone-derived photogrammetry (3-D floodplain surveys) pre- and post-release at both the FLC Slickrock site, and at the Slickrock Downstream site (one of the five newly established ecological monitoring sites). A pre-release 3-D floodplain survey was also conducted at the BLM Rec (Big Gypsum) Site, but a post-release survey has not yet been conducted at this site (researchers could not collect data post-release during the 2017 growing season extensive vegetative cover at this site was predicted to significantly reduce the clarity of elevation data collection efforts). Using the data collected at the FLC Slickrock site and the Slickrock Downstream site, they created 3-D elevation models for these two sites to compare how the broader floodplain and stream-marginal environments changed as a result of overbank flows, including assessing scour and deposition on stream-marginal floodplains, emergent in-channel bars, and side channels. At the Slickrock Downstream site, comparison of pre- and post-release elevation models showed minimal lateral bank erosion, but up to 2 feet of incision in a pre-existing side channel. It also revealed deposition of up to 3 feet of sand on the floodplain, with the greatest deposition in a bar proximal to the channel amongst the willows.

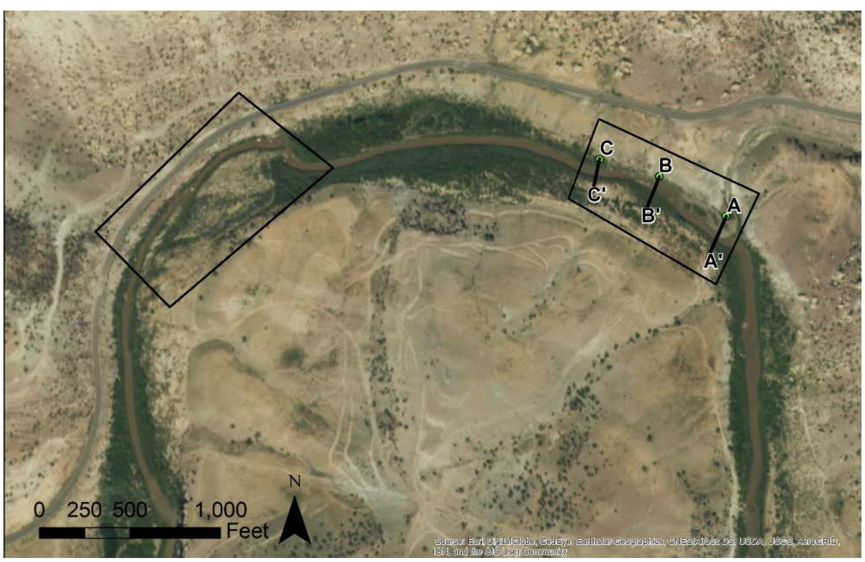
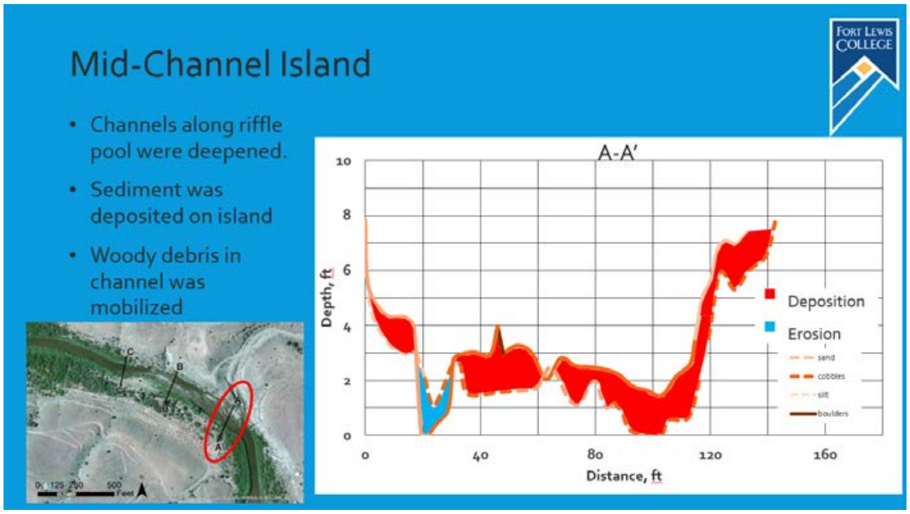
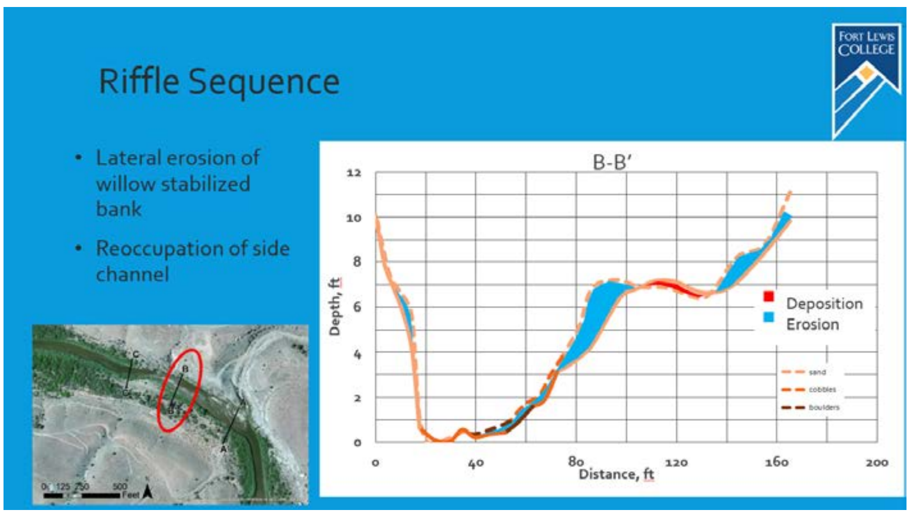


Figure 41. The Slickrock Downstream site (left) and the Fort Lewis College site farther upstream showing cross-sections analyzed with structure from motion technology.





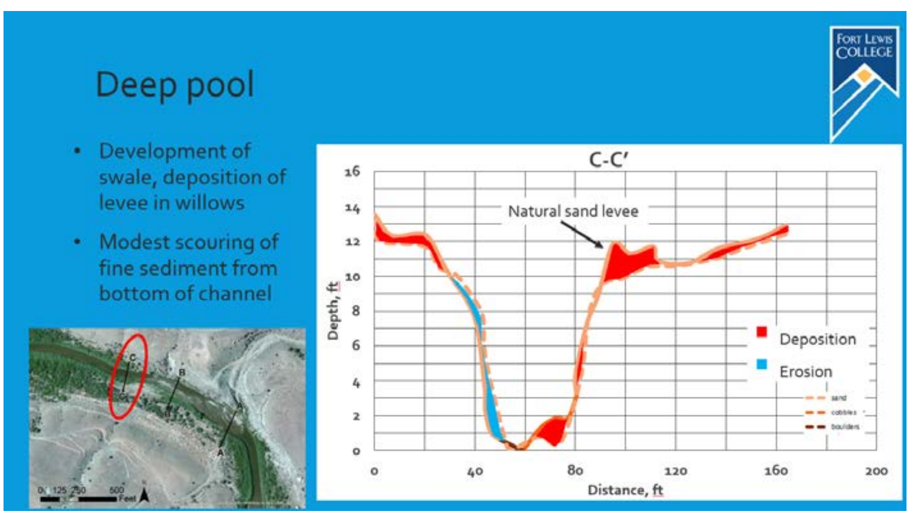


Figure 42. Deposition and erosion at cross-sections A-A' (top), B-B' (middle), and C-C' (bottom), derived from structure-from-motion data.

Summary of Findings: Geomorphology and Sediment Monitoring

Pre- and post-release monitoring was conducted on the five new ecological monitoring sites by CPW to determine effects of the 2017 managed release on site geomorphology and sediment movement. Survey efforts included conducting cross-section surveys through pools, Wolman pebble counts on one low-floodplain high energy site, and installing erosion stakes, painted patches, and sediment traps. Though some of the measurable benchmarks reference in-channel objectives, the high flows during the pre-release surveys for the most part precluded surveying anything but the pool cross sections. Therefore, data comparison was limited predominantly to examining pre- versus post-release changes to pool cross sections, and examining the limited work done on floodplains at the five ecological monitoring sites.

Fort Lewis College researchers conducted drone-derived photogrammetry on two sites and created 3-D elevation models to assess scour and deposition on stream-marginal floodplains, emergent in-channel bars, and side channels.

Measurable Benchmark: Quantify percentage of fines

- At the Slickrock Downstream site, 2 mm particles were almost completely removed from the site due to the 2017 managed release. Though the benchmark is in reference to in-channel riffle habitats, this result is important because it indicates that higher-energy sites within the active channel were at least equally coarsened by the managed release, which improves breeding and foraging habitat for native fish.

Measurable Benchmark: Assess D50 – it should coarsen in riffles

- D50 coarsened from 85mm to 108 mm on a high energy, low-floodplain environment at the Slickrock Downstream site, considered the best surrogate for in-channel processes that occurred in riffle habitats.

Measurable Benchmark: Monitor changes in cross-section and profile dimensions; Assess channel aggradation, degradation or entrenchment; Assess plan-view changes; Assess maintenance of pool depth

- Except for the bank erosion being monitored at a site just upstream from the official Bedrock ecological monitoring site (where an estimated 260 tons of material eroded from that bank just upstream of the surveyed cross section), there was little evidence that the large managed release and big peak flows were able to erode banks and increase channel width. This suggests that the Dolores River is stabilizing within a narrower, more confined channel.
- The Dove Creek Pump site represents a colluvial dominated, confined canyon/valley reach. It is very stable, and data going back to 2004 suggest that planform and vertical relief will not be responsive to flow events.

- Through most alluvial ecological monitoring sites, there was evidence of scouring and evacuation of material within surveyed pools, with some evidence of floodplain deposition at a few of these sites, confirming that the release was able to re-set vertical relief and increase overall pool volume. For example, at the BLM Rec (Big Gypsum) site mean pool depth increased by more than 3 feet, changing the cross-sectional area from 433 square feet pre-release to 1,226 square feet post-release, increasing pool volume by almost 300%.
- The Slickrock Upstream (Above Disappointment Creek) site showed both evacuation of pool sediments and deposition on what could become a low floodplain environment. Future monitoring of this site may show how narrowing of the channel occurs.
- Fairly good scouring and decent evacuation of material occurred at the Slickrock Downstream (Below Disappointment Creek) site, with some depth added overall. Deposition of sediment on the floodplain indicates how the in-channel and floodplain habitats become increasingly disconnected at lower peak flows.
- At the Slickrock Downstream Site, erosion stakes on a low floodplain, high energy site showed significant scour. Some cobble movement was observed into and out of the painted patch, indicating that larger particles were also mobilized with the managed release.
- At the Slickrock Downstream site, the 3-D elevation survey conducted by FLC researchers showed minimal lateral bank erosion, but found significant deposition of sand occurring on the floodplain (up to 3 feet), particularly where river flow was slowed by dense willow, and notable incision (up to 2 feet) occurring in the pre-existing side channel.
- Reactivation of side channels was observed at several sites by FLC researchers.

Measurable Benchmark: Measure exchange of material between channel and floodplain

- Evidence of floodplain deposition and scour of material occurred at nearly all alluvial or confined alluvial sites, indicating that significant interactions between the channel and floodplains did occur during the 2017 managed release. As indicated by the scour stakes at multiple sites (Below Disappointment Creek, BLM Rec [Big Gypsum], and Bedrock), river water accessed the floodplain with enough energy to erode or deposit floodplain materials. Future monitoring should discern how these interactions change as peak flows are reduced below 3400 cfs under different managed release scenarios.

Measurable Benchmark: Validate Q_{bkf} - bankfull discharge at monitoring sites

- Evidence that 3400 cfs (or other flow) is flow that inundates majority of floodplain surfaces was determined through use of wildlife cameras and drone imagery, and further confirmed by erosion/deposition on floodplain surfaces. Further inquiry needs to assess whether a lower bankfull discharge will be adequate to inundate newer, 'low floodplain' surfaces, and begin to define the range of flows that provide similar exchange functions, as well as to define which surfaces should no longer be considered 'active floodplain' within the valley bottom of the river (i.e., when does an 'old' or 'high' floodplain become a terrace, more conducive to propagation of upland rather than riparian vegetation).

Wildlife Cameras and Staff Gage Monitoring

Wildlife cameras and staff gages were installed at each of the five new ecological monitoring sites between March 20-24, 2017 to capture important changes in river flow stage height prior to, during, and after the 2017 McPhee Reservoir managed release (see Figure 43 for example). One Bushnell wildlife camera and one staff gage were installed at each site, with the exception of the Dove Creek site, where two staff gages were installed. Wildlife cameras were attached to stable objects or installed posts to capture images at regular intervals of the staff gages. Staff gages were typically installed across the river (on the opposite river bank) from the location of the wildlife cameras, with one exception (Dove Creek Pumps). All staff gage locations were benchmarked to the local datum, so that data could be correlated with other flow and survey data. For detailed information on locations and installation information of the wildlife cameras and staff gages, see *Appendix 3: Ecological Monitoring Sites – Staff Gage and Wildlife Camera Installation.*

Figure 43. Installation of staff gage and wildlife camera at the Slickrock Upstream site in March 2017. From left to right: installed camera, shot from camera at time of installation (staff gage circled in red), and staff gage close-up (post-release).

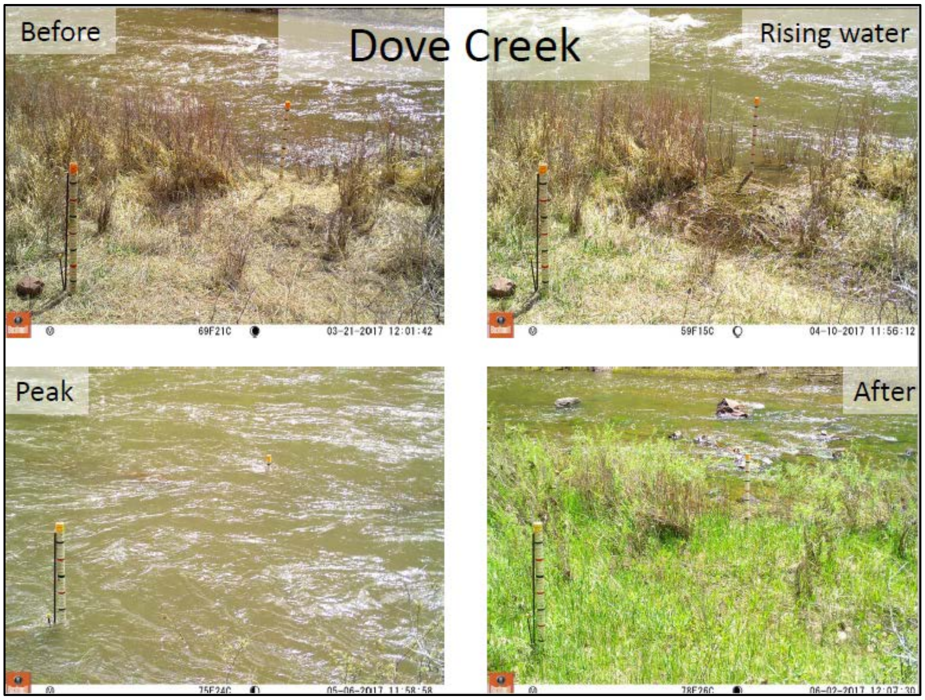


Figure 44. Dove Creek staff gage at pre-release, rising water, peak-release, and post-release. Notice river rising substantially out of its banks at peak-release but with very little change in the amount of woody vegetation.

Figure 45. Slickrock Downstream staff gage at pre-release, rising water, peak-release, and post-release.

Figure 46. BLM Rec (Big Gypsum) staff gage at pre-release, rising water, and peak-release.

Figure 47. Bedrock staff gage at pre-release, rising water, and peak-release.

Summary of Findings: Wildlife Cameras and Staff Gage Monitoring

Bushnell wildlife cameras, and staff gages, were installed between March 20-24, 2017 at each of the five new ecological monitoring sites. Cameras captured images of staff gages at regular intervals showing important changes in flow stage height prior to, during, and after the 2017 McPhee Reservoir managed release. Several cameras were flooded and one was stolen, but majority of critical imagery captured or retrieved for each site.

Measurable Benchmark: Assess floodplain inundation depths

- Images show minimal bank erosion, capturing further evidence of the substantial "armoring" of the banks at multiple sites
- Images also show the river rising substantially out of its banks at multiple sites, particularly important as mentioned previously for sediment scour and deposition, nutrient transfer, and recharging the alluvial aquifer.

Groundwater Monitoring

This report is a synopsis of a combination of presentations given by Dr. Gary Gianniny, professor and chair of the Department of Geosciences at Fort Lewis College, and Amanda Webb, an undergraduate student at Fort Lewis College, summarizing their 2017 monitoring efforts. These presentations were given on 10/27/17 at the Monitoring and Recommendation Team Meeting in Cortez, Colorado. A summarization of their presentations in this report is made possible by the excellent note taking of Gail Binkly at the Cortez meeting.

Fort Lewis College conducted groundwater monitoring, where they compared the groundwater recharge of riparian aquifers at two separate sites along the Dolores River. The goal of the monitoring efforts was to compare the differences in groundwater recharge at these two sites between (1) 2017 High-flow release, (2) 2011 Moderate release, and (3) 2012 Low flow only release. The two sites monitored along the river included a site at Lone Dome approximately 8 miles below the dam, and a site in the Big Gypsum Valley just downstream of the new ecological monitoring site of BLM Rec (Big Gypsum). Researchers were interested in the effects of groundwater levels on the riparian community, particularly cottonwoods.

Three piezometers were installed at each site in a transect line to record groundwater levels, with groundwater levels increasing as discharge increased (see Figure 48 below). Drive point piezometers and slotted PVC piezometers were used, and each well was installed ~ 2-3 meters below land surface. Submersible pressure transducers logged the data, with measurements being taken every 30 minutes from May - September 2017. In order to quantify the concurrent levels of flood inundation above-ground, field observation of flood debris was used, as well as installation of Bushnell wildlife cameras to capture floodplain inundation from April through July 2017. The wells were established to monitor groundwater in different vegetation zones: Well #1 is closest to the river and in willows, and Well #3 is furthest from the rivers' edge and in mature cottonwood if present (or in the case of Big Gypsum, in the tamarisk zone). Well #2 is in between and in young cottonwood (where present).

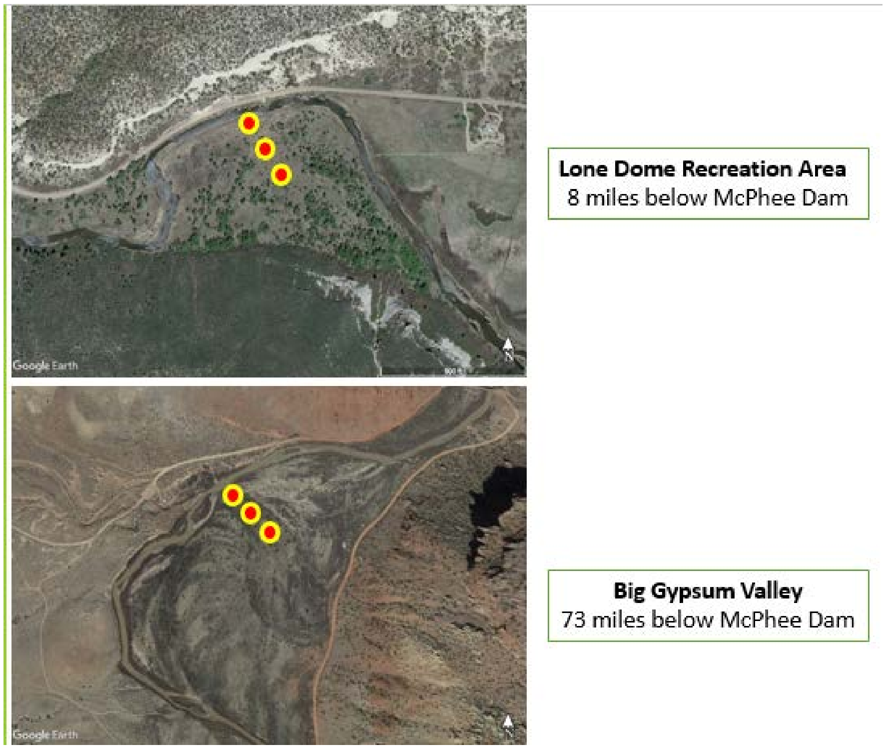


Figure 48. Transect lines of 3 piezometers each installed at the FLC Lone Dome and Big Gypsum sites. Well #1 is closest to the river and in willows, and Well #3 is furthest from the rivers' edge and in mature cottonwood if present (or in the case of Big Gypsum, in the tamarisk zone). Well #2 is in between and in young cottonwood (where present).

Growth of newly establishing young cottonwood seedlings may require groundwater to be within 1-2 meters of the establishment surface (McBride and Strahan 1984, Mahoney and Rood 1992, Segelquist et al. 1993, Stromberg et al. 1996), with first year seedlings considered to survive best where groundwater depth < 1 m (Mahoney & Rood 1992, Stromberg et al. 1996). The ideal drawdown rate of a managed release or flood event for cottonwood establishment is 2.5 cm (1") per day (Mahoney & Rood 1998, Amlin & Rood 2002, Rood et al. 2005).

Mature adult cottonwoods in riparian settings are typically found at groundwater levels of ≤ 3.5 meters (Scott et al. 1997, Stromberg et al. 1997). When the groundwater table is > 3 meters deep, it is believed that up to 50% of roots are found in the upper 1 meter of soil, and that groundwater declines of > 1m cause severe stress and canopy dieback of cottonwoods (Dott et al. 2016, Rood et al. 2011, Scott et al. 1999).

Scott et al (1999) demonstrated the importance of depth to groundwater changes for cottonwood health, and Rood et al (2011) documented that most *Populus deltoides* and *Populus angustifolia* have their median large root zones at 0.8-0.9 meters. Dott et al (2016) demonstrated significant cover value declines in cottonwood canopy cover values for sites where the depth to groundwater was below 1.5 meters in low spill or no spill years. Based on this information, it was determined that adult cottonwoods typically need a groundwater depth of less than 1.5 meters (4.8 ft) to maintain healthy growth. Researchers at FLC thus developed a cut-off of 4 feet (when depth to groundwater is greater than 1-1.5 meters) as a higher stress zone for cottonwoods to use for their groundwater data analyses. This 4-foot cut-off is shallower than Dott et al (2016) suggests, but significantly deeper than Rood et al (2011) suggests).

Groundwater monitoring results of the 2017 multi-peak release had a peak discharge of approximately 4,070 cfs and resulted in floodplain inundation and groundwater levels above baseflow conditions for 89 days at Lone Dome & 91 days at Big Gypsum, with groundwater levels still receding back to baseflow levels at end of data collection period. Baseflow conditions are defined as no managed release to mimic snowmelt conditions. The 2011 moderate release had a peak discharge of approximately 1,500 cfs and resulted in groundwater levels above baseflow conditions for 46 Days at Lone Dome & 31 Days at Big Gypsum. The 2012 baseflow conditions only scenario resulted in groundwater levels 4 feet below ground surface for total duration of study (117 days), with only the well closest to rivers' edge maintaining water levels (the other two wells ran dry). Researchers stated that they do not know the specific number of days with adequate groundwater necessary to keep cottonwoods viable at these sites. However, when there are multiple drought years, mortality has been observed (Dott et al. 2016).

The following sections provide details regarding the responses of the groundwater wells to the different discharge scenarios at the Lone Dome and Big Gypsum sites, respectively, in 2017, 2012, and 2011.

Lone Dome Site Results

The following figures provide an overview of the results found at the Lone Dome site. Figure 49 shows the location of Well #1 in relation to water levels at low flow in 2015, and moderate flow in 2017. Figure 50 shows the hydrograph for the 2017 managed release, and Figure 51 shows the changes in depth to groundwater at the three wells installed at the Lone Dome site in response to the 2017 managed release, with Well #1 closest to the rivers' edge and Well #3 the furthest. All three wells showed groundwater in the cottonwood root zone in 2017. Conversely, a low-flow only release from McPhee Reservoir results in groundwater in the cottonwood stress zone in two out of three wells (Figure 52).

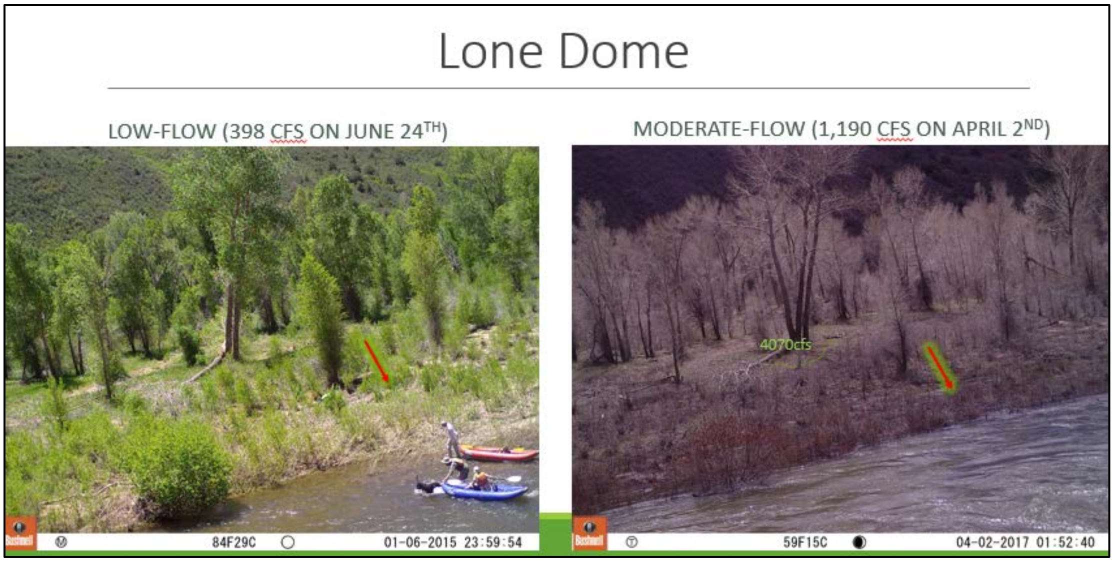


Figure 49. Lone Dome site at low flow on June 24, 2017, and moderate flow on April 2, 2017. The red arrow indicates the location of Well #1, closest to rivers edge in the willow zone.

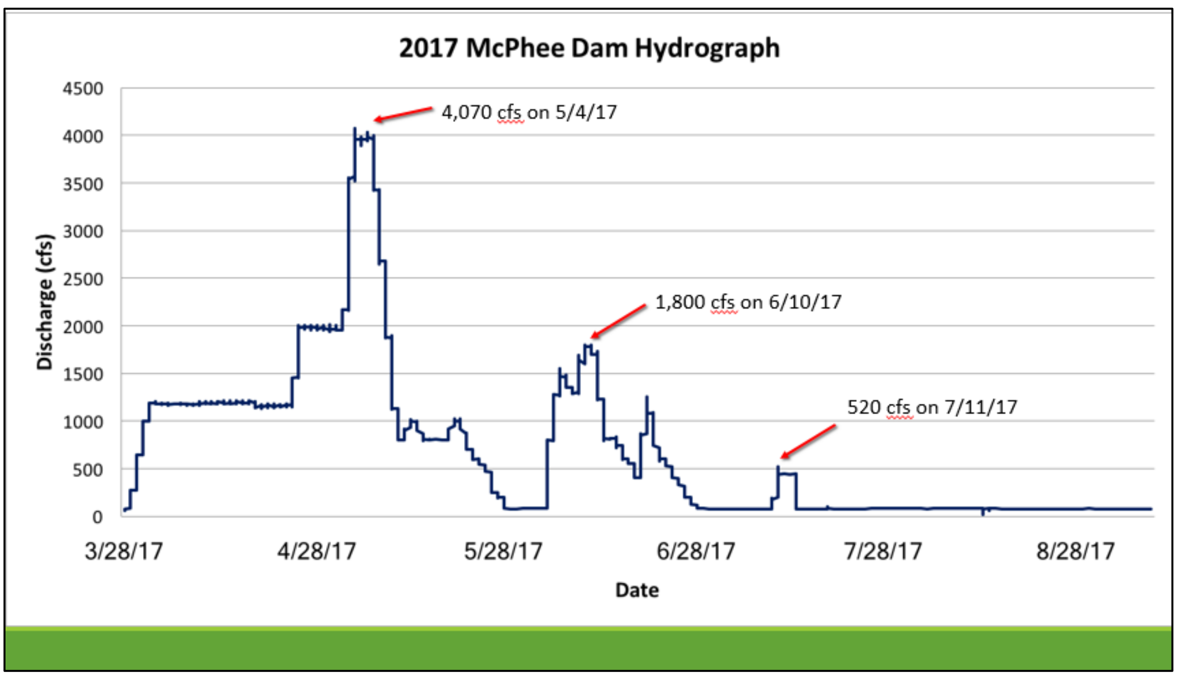


Figure 50. The hydrograph for the 2017 managed release, from late March to early September.

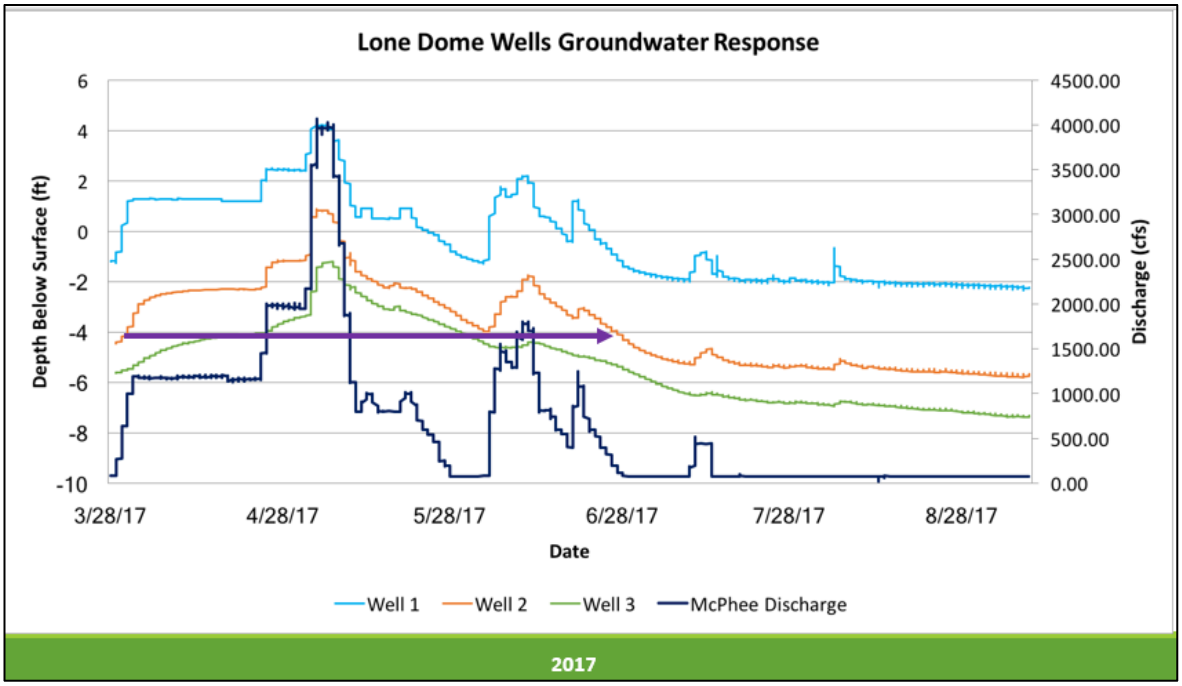


Figure 51. Lone Dome site in 2017, showing McPhee Discharge and corresponding groundwater well data for a high-flow release. Well #1 is closest to rivers edge in the willow zone. Note the close correlation of Well #1 to changes in flow, with its close proximity to rivers' edge. The purple arrow indicates the window of time when groundwater depth is less than four feet from the end of March until the end of June in two out of the three wells (Well #1 and 2), although even Well #3 experiences groundwater depths less than four feet throughout much of the month of May. Well #2 is considered to be in the 'cottonwood zone'.

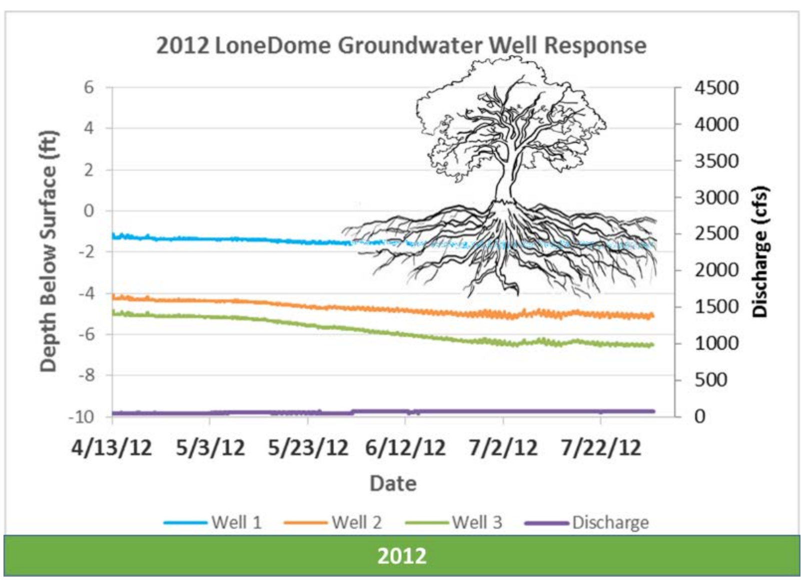


Figure 52. Lone Dome site in 2012, showing McPhee discharge and groundwater well data for a low flow only release. Groundwater levels in well 2 remained in the cottonwood stress zone, deeper than 4 feet below the surface, for the entire growing season.

In general, when the water table drops below approximately 4 feet this causes cottonwood stress, but during a low flow only release such as at Lone Dome (2012), when there are no peaks to bring the water table above four feet for any length of time this is particularly stressful on the trees as there is no groundwater recharge (See Figure 50).

Big Gypsum Site Results

At Big Gypsum we see some similar results as that observed at Lone Dome, with some distinctions. Figure 53 shows the location of Well #1 for this site, as indicated by the red arrow. Figure 54 shows the response of two different groundwater wells to the high-flow release in 2017. Groundwater levels were noticeably increased by this release.

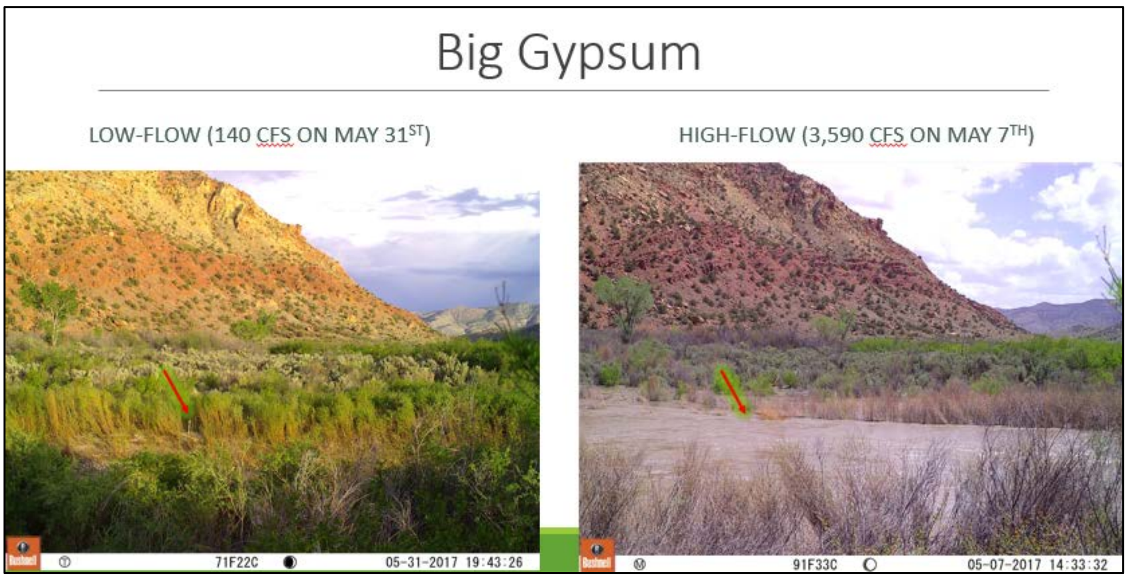


Figure 53. Big Gypsum site at low flow on May 31, 2017, and moderate flow on May 7, 2017. The red arrow indicates the location of Well #1, closest to rivers edge.

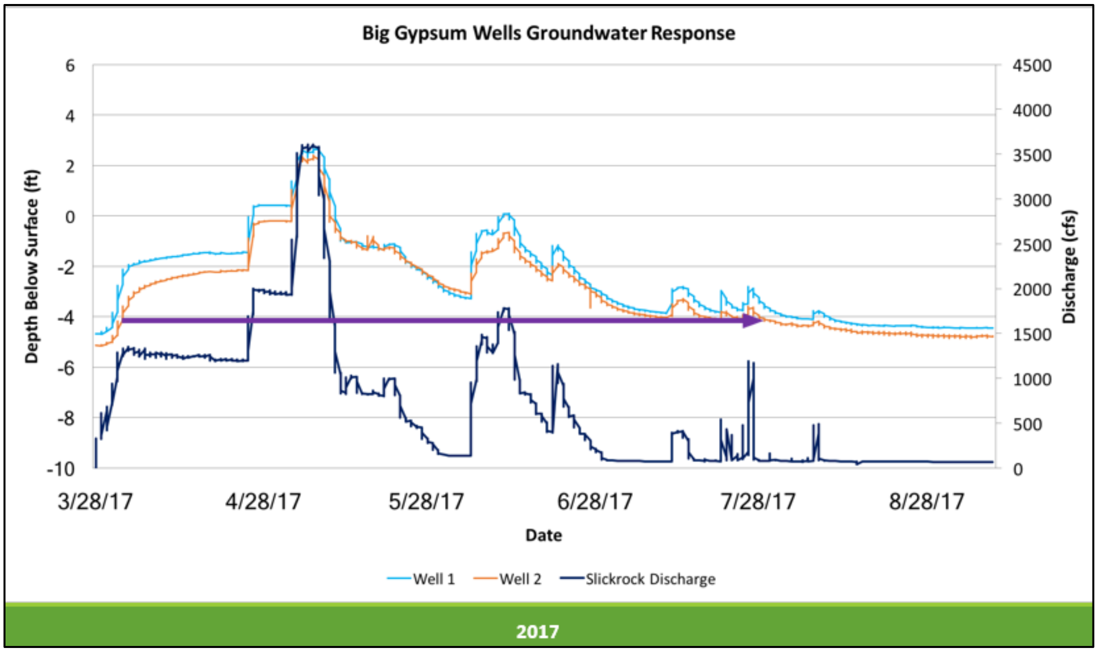


Figure 54. Big Gypsum site in 2017, showing Slickrock Discharge and groundwater well data for a high-flow release. Note that both Well #1 and Well #2 show groundwater depths of 2 feet or less from the beginning of April through the end of July.

Figure 555 shows what a moderate managed release from McPhee Reservoir looks like at the Big Gypsum site (2011), and the associated changes in groundwater depth. Note that groundwater depths of less than four feet are still achieved for much of the month of June to support cottonwood growth, a similar result as that observed at Lone Dome, but with a slightly shorter window of shallower groundwater relative to the results seen at the Lone Dome site.

During a low flow only release at Big Gypsum (2012), groundwater dropped significantly deeper than that observed at the Lone Dome site, and resulted in dry wells for Well #2 (in the ‘cottonwood zone’) and Well #3 for much of the growing season (Figure 56). This noticeable difference in well response to low flows between the two sites is likely a combined result of lower precipitation at Big Gypsum and the increased reliance of groundwater at this site on stream discharge.

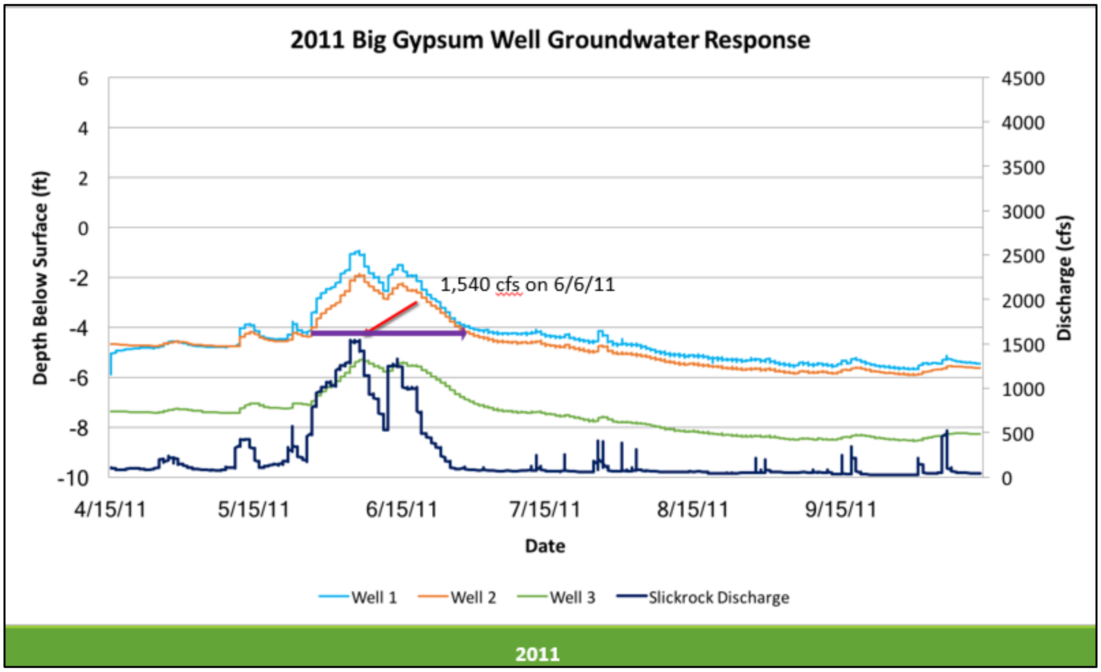


Figure 55. Big Gypsum site in 2011, showing Slickrock Discharge and groundwater well data for a moderate release. The purple arrow indicates groundwater depth shallower than four feet for much of the month of June in Well #1 and Well #2.

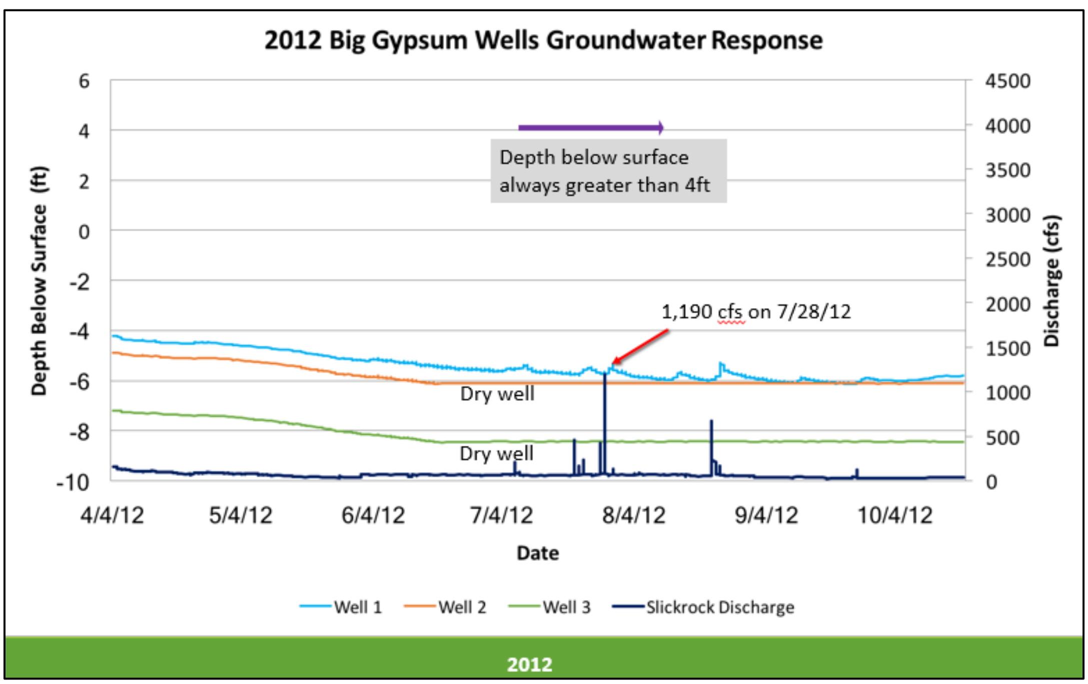


Figure 56. Big Gypsum site in 2012, showing Slickrock Discharge and groundwater well data for a low flow only release. Note that two of the three wells run dry at baseflows only, including Well #2 in the cottonwood zone. Note that the monsoon discharge peaks only influence the well directly adjacent to the channel (Well #1).

Summary of Findings: Groundwater Monitoring

Researchers measured changes in groundwater depth in response to the 2017 high flow managed release, the 2012 moderate release, and 2011 low flow only or baseflow conditions at two sites along the Lower Dolores River (Lone Dome, Big Gypsum).

Measurable Benchmarks: Conduct groundwater monitoring in floodplain; assess floodplain inundation depth

- The 2017 multi-peak release (peak discharge ~4,070 cfs) resulted in floodplain inundation and groundwater levels above baseflow conditions for 89 days at Lone Dome & 91 days at Big Gypsum, with groundwater levels still receding back to baseflow levels at end of data collection period.
- The 2011 moderate release (peak discharge ~1,500 cfs) resulted in groundwater levels above baseflow conditions for 46 Days at Lone Dome & 31 Days at Big Gypsum
- At the Big Gypsum site, the 2012 baseflow conditions only (no mimic of a snowmelt release) resulted in groundwater levels 4 feet below ground surface for the total duration of the study (117 days), with only the well closest to rivers' edge (Well #1) maintaining any water at all (the other two wells ran dry). The Lone Dome site responded similarly but not as dramatically – no wells ran dry at that site. This noticeable difference in well response to low flows between the two sites is likely a combined result of lower precipitation at Big Gypsum and the increased reliance of groundwater at this site on stream discharge.
- Looking at both sites, years with no peak release resulted in groundwater table depths of approximately 3.8 feet or greater at the Well #2 in the 'young cottonwood zone'.
- High flows and a long-duration release improved water table levels at both sites but Big Gypsum in particular, resulting in groundwater depths of 2 feet or less from the beginning of April through the end of July, providing much needed water for pre-existing adult cottonwoods.
- Adult cottonwoods typically need a groundwater depth of less than 1.5m (4.8 ft) to maintain healthy growth (Scott 1999, Shafroth et al. 2000, Rood et al. 2011)
- Both moderate (e.g., 2011) and large (e.g., 2017) releases are valuable for maintaining cottonwood.
- Substantial interaction with the floodplain occurred - overbank flooding was documented at multiple sites and resulting in crucial recharging of the alluvial aquifer

<u>Overview of Riparian Vegetation Monitoring</u>

The following introduction for the riparian vegetation section draws heavily from and provides a highly condensed summary of key components of two previously created documents addressing Dolores River riparian vegetation - the 'Dolores River Dialogue Riparian Vegetation Analysis' section of the <u>Core Science Report for the Dolores River Dialogue</u> (2005) and 'Appendix H. Evaluation of Proposed Reservoir Release Guidelines Dolores River Below McPhee Dam – Emphasis, Big Gypsum Valley Reach' of the 2014 Plan.

Recent discussion around riparian vegetation in the Dolores River valley below McPhee Reservoir has focused on three species in particular – cottonwood, willow, and tamarisk. Extensive groves of cottonwood historically documented along the Dolores River are now in decline or have disappeared, and new cottonwood regeneration appears to be infrequent in these and other areas. Many river banks and floodplains that were once highly active and scoured by high energy spring flows are now heavily 'armored' by both native (willow) and non-native invasive (tamarisk) vegetation, resulting in a feedback loop of ongoing downcutting of the river and dropping water tables favoring willow along the rivers' edge and tamarisk and other drier species on the floodplain, to the detriment of the diversity of other 'wetter' native species that once thrived in these floodplains (including cottonwood).

One point of discussion around McPhee Reservoir release management has focused on the potential to mimic natural river processes while not compromising storage and delivery obligations. For example, establishment of new cottonwood seedlings are dependent on high spring flows occurring at the right *magnitude* (e.g. high enough and powerful enough to overflow and scour the river banks and floodplains to create new open surfaces for seedling establishment), at the right *time* (e.g. when cottonwood seed release is occurring), at the right *rate of change* (e.g. a drawdown slow enough that newly established cottonwood root growth can keep up, following the water down (ideal drawdown rate for cottonwood establishment is considered to be 2.5 cm (1 inch) per day)), and at the right *frequency and duration* (e.g. often enough and long enough to replenish the floodplain water tables and keep newly established cottonwoods alive). These same flow conditions needed for cottonwood seedling establishment also serve to scour away/reduce the density of populations of species such as willow and tamarisk on a regular basis and discourage the troubling feedback loop described above. Prior to reservoir installation, the river provided all of these conditions naturally. Now we must be more innovative in river management in order to conserve and restore river health, while also ensuring water delivery to human populations dependent on it.

As mentioned previously, the 2014 Plan was developed to provide support for the decision-making and implementation of flow adjustments necessary to best advantage native fish and overall riparian ecosystem health, including benefits for native riparian vegetation. In particular, *Appendix H. Evaluation of Proposed Reservoir Release Guidelines Dolores River Below McPhee Dam – Emphasis, Big Gypsum Valley Reach* of that document provides more detail on flow adjustments most beneficial for riparian vegetation, with Table 4 of the 2014 Plan stating the specific habitat objectives and measurable benchmarks to be tracked when flow adjustments are made to determine their effect on riparian vegetation health specifically.

In 2017, riparian vegetation health was monitored in four ways: (1) the repeating of photos at select points along the river previously taken in 2003; (2) the establishment of new permanent photo points at the five new ecological monitoring sites, and repetition of those photos before and after peak release in 2017; (3) conducting quick surveys for new cottonwood recruitment on the new ecological monitoring sites; and (4) repeating historic vegetation transect monitoring at select points along the river previously established in 2010.

This vegetation monitoring was conducted to capture changes in vegetation that might occur pre- versus post-release 2017, changes in vegetation that might have occurred over a longer time frame (comparisons to historic data), and to establish a baseline or 'before' picture for longer term vegetation comparison into the future. Data collection (through repeat photos, surveys, and transects) focused on addressing the riparian vegetation-related

Measurable Benchmarks: (1) Assess changes in vegetative encroachment on point bars; (2) Provide evidence of cottonwood germination/recruitment (or at least some indication of seed-bed preparation and germination); (3) Provide evidence of the maintenance of other riparian indicators (e.g., minimized encroachment of xeric/mesic species onto floodplains); (4) Monitor riparian vegetation diversity and density; and (5) Assess plan-view changes (*associated with the vegetative 'armoring' of the river banks*). The following provides a summary of the methods and findings of this vegetation monitoring in 2017.

Historic Riparian Vegetation Photo Points

This is a summary of the full report. For the full report and location details associated with the Historic Big Gypsum Photo Point Monitoring, see Appendix 4. Historic Big Gypsum Photo Point Monitoring Locations and Results.

Repeat photos were taken at six historic vegetation photo point locations along the Dolores in the Big Gypsum Valley on June 26, 2017 by Dr. Cynthia Dott and Dr. Julie Knudson. Original photo points were established June 17, 2003 by Dr. Gigi Richard, Rick Anderson, John Groves.

The following figures show two of the 2003 versus 2017 historic vegetation photo point comparisons. To view all six comparisons, see Appendix 4. The most obvious change in both photo sets shown below is the extensive willow growth that has overtaken the river banks.

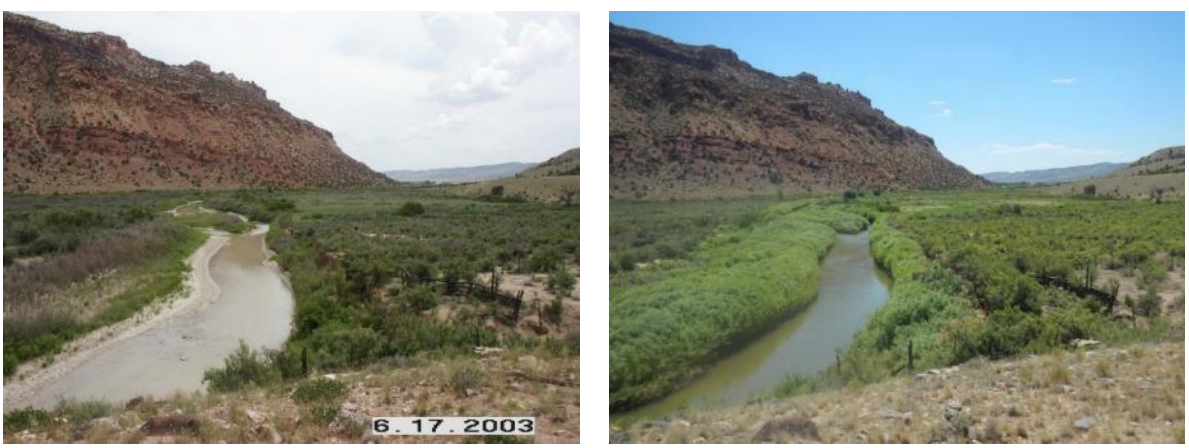


Figure 57. Historic Big Gypsum Photo Point #2 taken in 2003 (6/17/03; top) and 2017 (6/26/17; bottom). Note substantial increase in willow along bank. It should be noted that flows are higher in 2017, so some difference in photos is due to this.

Figure 58. Historic Big Gypsum Photo Point #6 taken in 2003 (6/17/03; top) and 2017 (6/26/17; bottom). Notice how willow has filled in the bank over time. As above, it is important to note that flows are higher in 2017, so some of the observed difference is due to this.

Summary of Findings: Historic Riparian Vegetation Photo Points

The comparison of the historic Big Gypsum repeat photos from 2003 versus 2017 resulted in the following findings. To be clear, these are findings from comparing historical photos to photos taken in 2017, not pre- versus post-release 2017 photos.

Measurable Benchmark: Assess changes in vegetative encroachment on point bars

- Willows have noticeably encroached on point bars and river banks

Measurable Benchmark: Monitor riparian vegetation diversity and density

- Willows appear to be increasing in density along river bank
- Overall vegetative diversity appears to be reduced as willows increasingly dominate

Measurable Benchmark: Provide evidence of cottonwood germination/recruitment (or at least some indication of seed-bed preparation and germination)

- The implication of the above findings is that there are minimal new opportunities for cottonwood seedling recruitment due to very high willow densities; and that even with flows of 4,000 cfs in 2017 showing a minimal amount of scour/vegetation removal.

<u>**Ecological Monitoring Site Photo Points**</u>

As mentioned previously, new permanent photo points were established at the five new ecological monitoring sites in 2017. These photo points were established to capture changes that might result from the 2017 peak release, as well as to establish a baseline or 'before' picture for longer term comparison into the future. Photo points specific to tracking changes in riparian vegetation over time focused on addressing the five riparian-vegetation-related Measurable Benchmarks described above. Photos were taken at photo points prior to peak release (March 20-24, 2017), during the peak release time-frame (May 5-7, 2017), and post release (July 6-8, 2017). Photos were taken by Dr. Julie Knudson. See *Appendix 2: Ecological Monitoring Sites – Photo Point Monitoring Locations & Comparisons* for more site photo point comparisons, and complete details and GPS coordinates for relocating these points.

The following provides a comparison of select pre- and post-release riparian vegetation-related repeat photos from the new ecological monitoring sites organized in terms of measurable benchmarks, followed by a summary of findings based on photo comparison.

Measurable Benchmark: Provide evidence of cottonwood germination/recruitment (or at least some indication of seed-bed preparation and germination)

The following two sections focus on photo point evidence of seedbed preparation including: (1) Evidence of scour of river banks/floodplains; and (2) Evidence of sediment deposition.

(1) Evidence of scour of river banks/floodplains

Tracking noticeable scour of river banks/floodplains through photo points was of interest for its potential to result in new bare areas potentially conducive to establishment of desirable species such as cottonwood, either through removal of sediment/debris less conducive for cottonwood establishment, or through removal of other vegetation currently occupying potential germination sites. The 2017 managed release did provide some scouring of river banks/floodplains. These areas were subsequently surveyed for cottonwood recruitment; see results below in sub-section 'Riparian Vegetation: Quick Surveys for Cottonwood Recruitment', or see the full report in *Appendix 5: New Cottonwood Recruitment Survey Locations and Results.*

At the Slickrock Downstream Site, we observed noticeable evidence of scour in the survey area (Figure 59). We also observed evidence of scour at the Bedrock Site (Figure 60).

Figure 59. Erosion stakes at Slickrock Downstream (Below Disappointment Creek) Site; close-up of sediment scouring (taken from river left, standing on bar), pre-release 3/22/17 on left, post-release 7/6/17 on right. Note the scouring that has taken place pre- versus post-release.

Figure 60. Point bar at Bedrock Site, close-up of sediment scouring (Erosion stake #1, river left), pre-release 3/23/17 on left, and post-release 7/8/17 on right.

Figure 61. Point bar at Bedrock Site, upstream view of some bank/sediment scouring in same general area as above photo set (taken from river left). Photo at top pre-release (3/23/17; #5561); photo at bottom post-release (7/7/17; #1501).

(2) Evidence of sediment deposition

The purpose of tracking sizeable sediment deposition was to determine if the high water created bare areas on which desirable species such as cottonwood might be able to establish. While the 2017 managed release did appear to move sizeable amounts of sediment, much of the sediment deposition observed was deposited too high (i.e. too dry) on the floodplain/river bank to support successful seedling establishment (see photos below).

In other areas where new sediment was deposited to create new bare areas lower on the river bank/floodplain (closer to rivers' edge), both willow and Phragmites (*Phragmites australis*) were observed to quickly colonize (or re-colonize) these bare areas. See Figure 63 below for an example of young willow colonization at the BLM Rec (Big Gypsum) Site. Also see the next sub-section for evidence of Phragmites colonization of newly bare areas (resulting both from scour, and from new sediment deposition).

Figure 62. New sediment accumulation at main Bedrock Site, high on river bank Photos taken from river left, looking downstream, at pre-release (3/23/17), peak-release (5/6/17), and post-release (7/7/17).

Figure 63. Young willow quickly colonizing recently bare ground at the BLM Rec (Big Gypsum) site post-release, indicated by blue arrow. Photos taken pre-release (3/21/17; top) and post-release (7/7/17; bottom) from river left, looking downstream.

Measurable Benchmark: Assess plan-view changes

This section focuses on capturing evidence of the removal or thinning of 'armoring' river bank vegetation (such as tamarisk and willow) to thus interrupt the troubling feedback loop described above. The comparison of 2017 photo points pre- and post-release showed no change in 'armoring' river bank vegetation at some sites, but did show a very small amount of success in removal of 'armoring' river bank vegetation at other sites.

On a related note, several pre-existing riverbank Phragmites populations are also being tracked through photo points; a small amount of Phragmites removal was observed at one pre-existing location. Additionally, several new (or recolonizing) populations of Phragmites are being tracked through photo points in areas where new sediment deposition or bank erosion occurred.

At the main Bedrock Site, photo comparison appeared to show very little removal of willow with 2017 flooding in one area, but some willow removal was obvious in another area (see figures below). In general, however, very little noticeable willow removal was observed at the five new ecological monitoring sites.

Figure 64. Thick willow armoring bank at main Bedrock Site, with photo series appearing to show little noticeable change in willow density with flooding. Photos taken from river left pre-release (3/23/17; top), peak-release (5/6/17; middle), and post-release (7/7/17; bottom).

Figure 65. Close-up of upstream portion of above photo series at main Bedrock Site, appearing to show little noticeable change in willow density with flooding (taken from river left). Pre-release on left (3/23/17), post-release on right (7/7/17).

Figure 66. Point bar at Bedrock Site, upstream view of area that saw a small amount of removal of willow with flooding (taken from river left).

Figure 67. Close-up of point bar at Bedrock Site that saw some removal of willow with flooding (taken standing on bar). However, it appears that regrowth of willow is occurring from remaining willow stumps. 12/29/17, #1972

Just upstream of the main Bedrock Site, however, a separate monitoring site was established. At this site, some limited loss of 'armoring' vegetation (tamarisk) along the river bank was observed (see below photos).

Figure 68. At site just upstream from main Bedrock site; tamarisk loss with bank erosion. Photos taken from river left, post-release (7/7/17).

As mentioned above, another species of interest along the river corridor is that of Phragmites. While there is a native (*Phragmites australis* subsp. *americanus*) and non-native (*Phragmites australis* subsp. *australis*) version of this grass, it is currently believed that Phragmites populations growing along the Dolores River are predominantly native, although this is not yet officially confirmed (Colorado Department of Agriculture is currently conducting a study of Phragmites populations across the state of Colorado, and has sampled Phragmites populations from the Dolores River as part of the study to determine whether sampled populations are native or non-native [personal communication by author with Patty York, Colorado Department of Agriculture, 2018]). However, even the native version of this grass can grow relatively quickly and spread somewhat aggressively, and since it can establish a new population from seed or vegetatively (e.g. by pieces of root fragment washing downstream), it is possible that newly scoured bare ground or new sediment deposits along the rivers' edge that might otherwise be suitable for future cottonwood seedling establishment could relatively quickly be colonized and dominated by a population of Phragmites. And in the absence of substantial flood events that might otherwise remove or thin the young population, once Phragmites has established, the population may continue to spread and potentially 'lock-up' these new germination sites.

As such, it was of interest to establish several photo points that would capture (1) potential changes in existing Phragmites infestations as a result of flooding in 2017 and over time, and (2) potential establishment of or changes in new infestations of Phragmites over time in areas of new sediment deposition or bank scour/erosion.

An existing Phragmites population (mixed with willow) at the Dove Creek site did not appear to change noticeably in photos taken pre- versus post-release 2017; or if some Phragmites was removed willow may have filled in the above ground gaps (Figure 69).

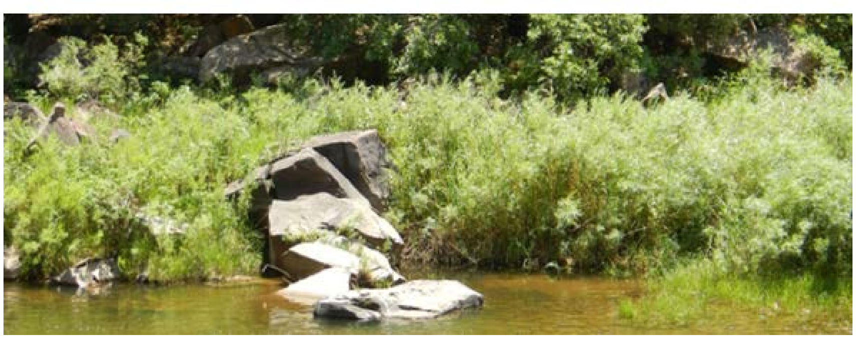


Figure 69. Phragmites population (mixed with willow) at the Dove Creek site, pre- versus post-release 2017 (taken from river left). Pre-release at top (3/20/17), post-release at bottom (7/8/17).

Photos of a Phragmites population at the BLM Rec (Big Gypsum) site (Figure 70) showed some impact from 2017 spring flooding, with a small amount of noticeable scouring/loss of vegetation pre- versus post-release. However, because of the ability of Phragmites to regenerate vegetatively, this small impact may be short-lived as much of the population remained intact.

Figure 70. Phragmites population (mixed with willow) at the BLM Rec (Big Gypsum) site, pre-release (3/21/17) versus post-release (7/7/17), taken from river left.

In several areas where new bare ground was created along the river banks as a result of new sediment deposition and bank scour/erosion from 2017 flooding, Phragmites was indeed observed quickly colonizing, or re-colonizing, these sites (see photos below).

Figure 71. New sediment accumulation at main Bedrock Site, with partially buried Phragmites quickly sending out new runner (stolon) to recolonize new bare area (photo taken from/on river left bank). Post-release 7/7/17, #1536.

Figure 72. Bank erosion at monitoring site just upstream from main Bedrock Site, with Phragmites runners quickly climbing the bank to recolonize new bare area (photo taken from/on river left bank). Post-release 7/7/17, #1559.

Measurable Benchmark: Assess changes in vegetative encroachment on point bars

Photo points established in 2017 for addressing this benchmark focused on establishing a baseline or 'before' picture for tracking changes in vegetative encroachment on point bars over time, as well as to capture potential pre- versus post-release changes that might be observed in 2017.

An example of a site where it will be interesting to track these changes over time is at the Bedrock Site. This point bar received both noticeable scouring and deposition in 2017 with the peak release. The point bar at the BLM Rec (Big Gypsum) site will also be interesting to watch. The only cottonwoods on the point bar are estimated to have established in 2005 (based on size only; actual establishment date was not determined), with the last substantial managed release from the reservoir (the maximum release that year was 4,250 cfs on May 25). Other dominant vegetation on the bar ranges from riparian to mesic. The entire point bar was covered with water during the 2017 peak release, but the majority of the point bar did not appear to receive much obvious scouring or deposition.

Measurable Benchmark: Provide evidence of the maintenance of other riparian indicators (e.g., minimized encroachment of xeric/mesic species onto floodplains)

Photo points established in 2017 for addressing this benchmark focused on establishing a baseline or ‘before’ picture for tracking changes in encroachment of xeric/mesic species onto floodplains over time, as well as to capture potential pre- versus post-release changes that might be observed in 2017.

One site where it will be interesting to track changes over time is at the Dove Creek site. A large island just upstream of the main site is covered with willow, some cottonwood, and a combination of other riparian to mesic vegetation. In 2017, the island was mostly flooded during peak release (Figure 73).

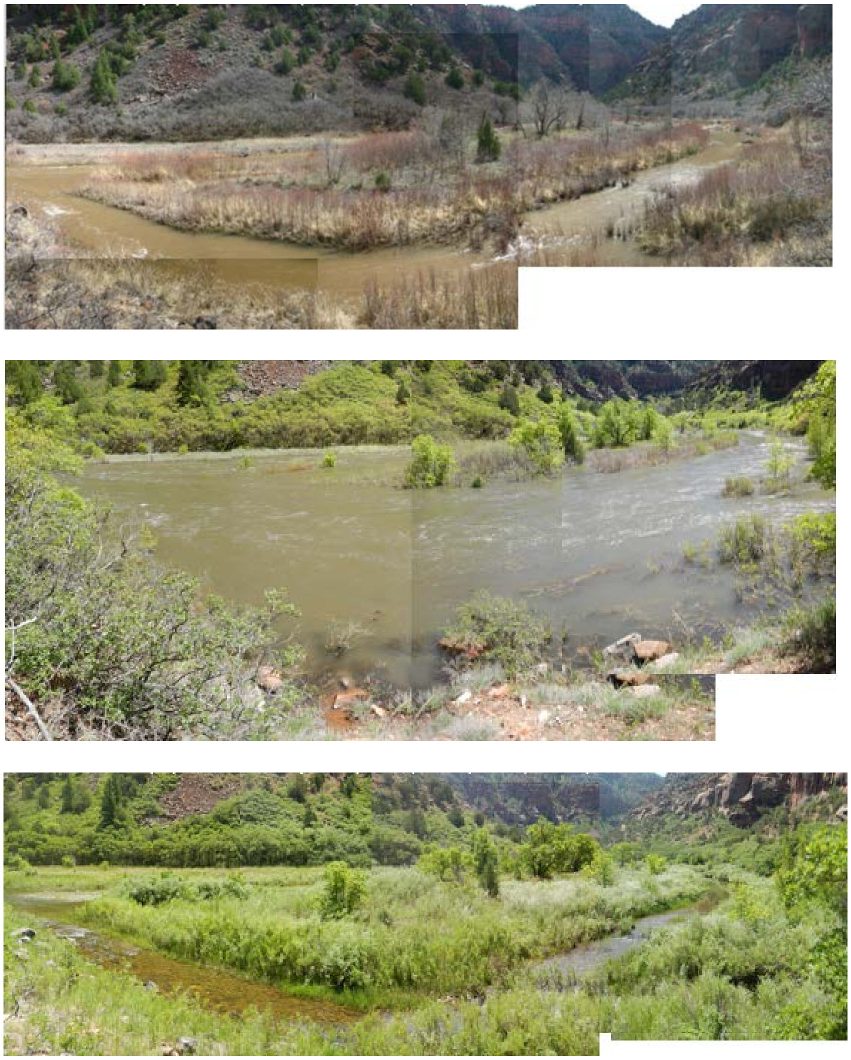


Figure 73. 2017 pre (3/20/17), peak (5/5/17), and post-release (7/8/17) photo series of island just upstream of Dove Creek site (taken from river left).

A large point bar at the BLM Rec (Big Gypsum) site also appears to be currently maintaining primarily riparian and mesic species (Figure 74). The point bar was mostly flooded at peak release in 2017.

Another site where it will be interesting to track the changes over time is at the Slickrock Downstream (Below Disappointment Creek) site, where rubber rabbitbrush and other mesic species currently dominate much of what was once an active mid-channel bar. Much of this area was flooded in 2017, but based on photo comparison, there does not appear to be a noticeable reduction in this vegetation because of flooding (Figure 75).

Figure 74. 2017 pre-release (3/21/17, top) and post-release (7/7/17, bottom) photo series of point bar at the BLM Rec (Big Gypsum) site.

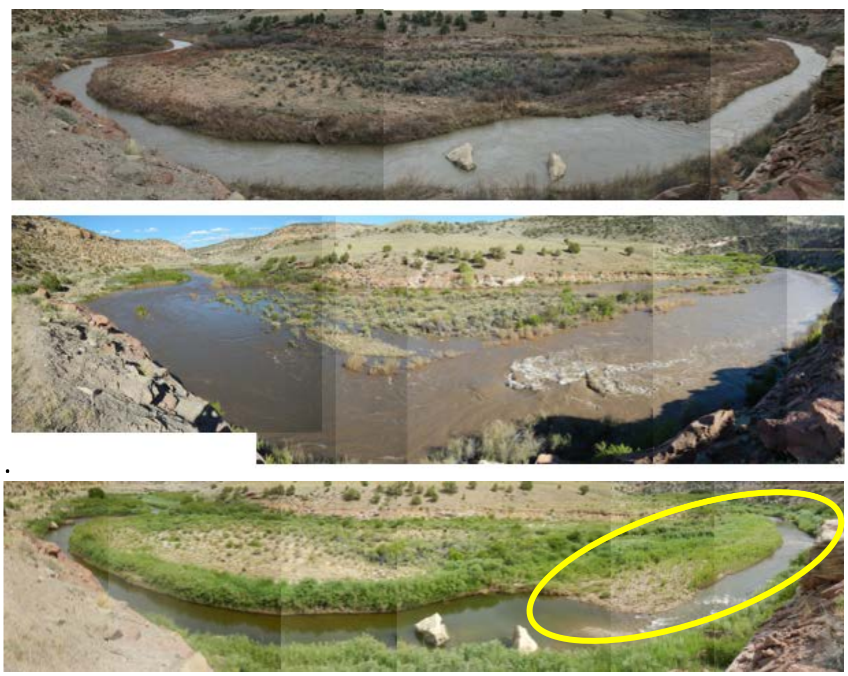


Figure 75. Slickrock Downstream (Below Disappointment Creek) Site pre-release (3/22/17), peak-release (5/5/17), and post-release (7/6/17). Photos taken from river right.

It will also be interesting to watch the focus area of our data collection at this site (circled in yellow above in Figure 75). This area is currently dominated by willow and more riparian species, and we are not currently seeing encroachment of more mesic/xeric species (also see photo series below). However, this area likely sees more regular flooding currently, even without release manipulation.

Figure 76. Close-up of survey area at Slickrock Downstream (Below Disappointment Creek) Site taken from river right, pre-release (3/22/17; top) and post-release (7/6/17; bottom).

Figure 77. Close-up of survey area at Slickrock Downstream (Below Disappointment Creek) Site, taken from river left standing at edge of survey area, pre-release (3/22/17; top) and post-release (7/6/17).

Measurable Benchmark: Monitor riparian vegetation diversity and density

Photo points established in 2017 for addressing this benchmark focused on establishing a baseline or 'before' picture for tracking noticeable changes in riparian vegetation diversity and density over time, as well as to capture potential pre- versus post-release changes that might be observed in 2017.

Some evidence of the lack of noticeable change in density of willow pre- versus post-release 2017 was shown in the above section '*Measurable Benchmark:* Assess plan-view changes' (associated with the vegetative 'armoring' of the river banks).

Summary of Findings: Ecological Monitoring Site Photo Points

Measurable Benchmark: Provide evidence of cottonwood germination/recruitment (or at least some indication of seed-bed preparation and germination)

Evidence of scour of river banks/floodplains (indications of seedbed preparation)

- The 2017 managed release resulted in some scouring of river banks/floodplains

Evidence of sediment deposition (indications of seedbed preparation)

- The 2017 managed release moved noticeable amounts of sediment resulting in deposition on sites

Provide evidence of cottonwood germination/recruitment

  - The potentially suitable new bare areas documented above were then surveyed for cottonwood recruitment in 2017 (see Cottonwood Recruitment Survey section for more details).
  - Photo points were established in 2017 to establish a baseline or 'before' picture for tracking noticeable changes in cottonwood recruitment and establishment over time

Measurable Benchmark: Assess plan-view changes (associated with the vegetative 'armoring' of the river banks)

Removal or thinning of 'armoring' river bank vegetation

- The 2017 managed release showed very little removal of 'armoring' river bank vegetation.
- In general, very little removal of willow occurred (with only a very small amount of noticeable removal occurring at one site).
- A small amount of removal of mature tamarisk was observed at the Bedrock site.
- Another species of interest along the river corridor is Phragmites, as it can also grow relatively quick and spread somewhat aggressively. Several pre-existing riverbank Phragmites populations and several new (or newly re-colonizing) populations of Phragmites

where new sediment deposition or bank erosion occurred with the managed release are being tracked using photo points.
  - A very small amount of noticeable loss of vegetation occurred at one pre-existing Phragmites site.
  - In several areas where new bare ground was created as a result of new sediment deposition and/or bank scour/erosion, Phragmites was observed quickly colonizing, or re-colonizing, these areas.

Measurable Benchmark: Assess changes in vegetative encroachment on point bars

- Photo points were established in 2017 to establish a baseline or 'before' picture for tracking noticeable changes in vegetative encroachment on point bars over time, as well as to capture potential pre- versus post-release changes that might be observed in 2017.
- Several areas where it will be interesting to track these changes over time in particular include the Bedrock and BLM Rec (Big Gypsum) Sites.

Measurable Benchmark: Provide evidence of the maintenance of other riparian indicators (e.g., minimized encroachment of xeric/mesic species onto floodplains)

- Photo points were established in 2017 to establish a baseline or 'before' picture for tracking noticeable changes in encroachment of xeric/mesic species onto floodplains over time, as well as to capture potential pre- versus post-release changes that might be observed in 2017.
- Sites that will be particularly interesting to watch include 'the island' at the Dove Creek site, a large point bar at the BLM Rec (Big Gypsum) site, and the active survey area at the Slickrock Downstream (Below Disappointment Creek) site.

Measurable Benchmark: Monitor riparian vegetation diversity and density

- Photo points were established in 2017 to establish a baseline or 'before' picture for tracking noticeable changes in riparian vegetation diversity and density over time, as well as to capture potential pre- versus post-release changes that might be observed in 2017.
- Photo points found a lack of noticeable change in density of willow pre- versus post-release 2017.

<u>Cottonwood Recruitment Surveys</u>

For the full report and location details associated with the Quick Surveys for New Cottonwood Recruitment, see <u>Appendix 5. New Cottonwood Recruitment Survey Locations & Results.</u>

The new cottonwood recruitment surveys were conducted at four of the five new ecological monitoring sites in 2017 (excluding Dove Creek Pumps site). Survey locations were selected by comparing pre- versus post-release photos from each site; any areas in the photos demonstrating noticeable scouring (of vegetation or sediment) or sediment deposition as a result of the managed release were determined to be potential cottonwood recruitment sites, as long as the resulting new bare areas were estimated to have some access to moisture to support seedling survival/establishment (e.g. close to rivers' edge, or in low lying floodplain area). As the focus of the survey was to quantify successful new cottonwood recruitment (e.g. seedlings that had germinated and survived in 2017 [not just germinated and then quickly died from lack of access to moisture]), surveys were conducted later in the year after the end of the growing season (December 2017).

Surveys consisted of visiting each selected area, scanning for new cottonwood seedlings, and taking one or more photos to document the status of each area. It was intended to conduct counts of cottonwood seedlings found in these areas; unfortunately, no cottonwood seedlings were found on survey sites. Presence of new non-cottonwood seedlings in survey areas was documented through photographs and/or descriptive data collection when seedlings could be identified. Two areas were surveyed at the Slickrock Upstream (Above Disappointment Creek) Site, four areas were surveyed at the Slickrock Downstream (Below Disappointment Creek) site, four areas at the BLM Rec (Big Gypsum) Site, and three areas were surveyed at the Bedrock Site. The following provides an overview of findings in the survey areas.

Figure 78. Two cottonwood recruitment survey areas at Slickrock Upstream Site (circled below). Photo from post-release, 7/6/17, #1190.

Figure 79. Closeup of new small depositional survey area at Slickrock Upstream Site (circled in red above). 12/29/17, #1897

a. Seedlings observed at Slickrock Upstream site, 12/29/17, #1899. Photo is a close-up.

12/29/17, #1901

b. and c. Additional seedlings at Slickrock Upstream site. 12/29/17, #1900, and #1901

Figure 80 (a-c). Closeups of some of the young seedlings found on new small depositional survey area at Slickrock Upstream Site.

Figure 81. Another closeup of young seedlings found in this Slickrock Upstream survey area. Note numerous willow seedlings. 12/29/17, #1902

Figure 82. Scoured Phragmites bank survey area at BLM Rec (Big Gypsum) Site, 7/7/17, #1366.

Figure 83. Closeup of scoured Phragmites bank survey area at BLM Rec (Big Gypsum) Site, 12/29/17, #1920. No young seedlings found; only vegetatively spreading Phragmites.

Figure 84. ‘The Island’ survey area at BLM Rec (Big Gypsum) Site, 7/7/17, #1355-1365 various photos merged.

Figure 85. Closeup of willow spreading vegetatively in this area, 12/29/17, #1927.

a. One new native seedling in foreground, 12/29/17, #1970

b. Closeup of native seedling, 12/29/17, #1970

c. Regrowth from willow stumps 12/29/17, #1972

Figure 86 (a-c). Closeup of newly scoured open area (survey area #2) at Bedrock Site.

Figure 87 (a-d). Examples of willow and grass spreading into newly scoured/depositional bare areas. Upper right and left photos: willows resprouting at Bedrock Site, 12/29/17, #1978,1979. Lower left: Slickrock Upstream Site diagonal bar post-release, 7/6/17, #1204. Lower right: Slickrock Upstream Site diagonal bar at the end of the growing season, 12/29/17, #1887

Summary of Findings: Cottonwood Recruitment Surveys

As mentioned above, new repeat photo points documented the creation of potential new seed-beds at four of the five new ecological monitoring sites (excluding Dove Creek Pumps) - either through scour or deposition - and these areas were surveyed for cottonwood recruitment.

The cottonwood recruitment surveys resulted in the following findings, in terms of the measurable benchmark associated with this effort.

Measurable Benchmark: Provide evidence of cottonwood germination/recruitment (or at least some indication of seed-bed preparation and germination

- No cottonwood seedlings were found in any of the survey areas at any of the sites.

- Surveyed areas fell into three general categories: those found to still be completely bare after 2017 scouring or deposition, those found to have a small amount of non-cottonwood seedlings, and those that appeared to be in the process of being quickly (re) colonized by pre-existing willow and grass species.
- The most common non-cottonwood seedlings found were willow, occurring at multiple survey areas. Some tamarisk seedlings were found, but only in one area at one site.
- In particular, more mature willow appeared to be actively vegetatively sprouting and recolonizing multiple surveyed areas.
- While there may be many reasons why no cottonwood seedlings were found, several possible reasons for this may be:
  - Cottonwood seed release did not appear to occur until sometime after peak-release
  - Managed release draw down rates appeared to be faster than that that is required for successful seedling establishment. The ideal drawdown rate for cottonwood establishment is 2.5 cm (1") per day (Mahoney & Rood 1998, Amlin & Rood 2002, Rood et al. 2005), as their roots cannot grow much faster than this to follow the water table down as the new seedling is establishing. On the Dolores River, a stage decline of 1"/day has been estimated as roughly equivalent to a discharge drop of ~100 cfs/day. (Wilcox & Merritt 2005).
  - Some sites appear to have a high accumulation of salts in/on the surface of the soils, and cottonwoods are not highly tolerant to saline conditions. For revegetation practices, Fremont cottonwoods in general are known to have a threshold salinity tolerance of 8 mmhos/cm, and a maximum salinity tolerance of 15 mmhos/cm. Threshold salinity tolerance is the level of soil salt concentration at which plant performance begins to be observably or measurably reduced. Maximum salinity tolerance is that level at which plant viability, growth and/or performance are severely or permanently curtailed (Sher et al. 2010). The photo below shows evidence of salt accumulation on the Slickrock Downstream site. Soil salinity levels on these monitoring sites have not been tested (See Figure 88).

Figure 88. Accumulation of salts (white substance) on soil surface at the Slickrock Downstream site.

Historic Vegetation Transect

This portion of the riparian vegetation section of the report is a synopsis of part of a presentation given by Dr. Cynthia Dott, a riparian ecologist and professor and co-chair of the Biology Department at Fort Lewis College, summarizing their 2017 monitoring efforts. The presentation was given on 10/27/17 at the Monitoring and Recommendation Team Meeting in Cortez, Colorado. This report was made possible by the excellent note taking of Gail Binkly at this meeting.

In 2010, vegetation transect monitoring occurred at select Slick Rock and Big Gypsum Valley sites along the Dolores River. Select transects were then re-sampled post-release in 2017. Willow stem density was determined in 1-square meter plots evenly spaced along transect lines by conducting counts of willow stems. Percent cover of bare ground versus vegetation litter was also determined.

Figure 89. A willow transect along the Dolores River.

Willow Stem Density

Analyses of the monitoring of the willow transects found no significant difference in the average willow stem density between 2010 and 2017, indicating that the managed release did not significantly reduce willow stems. There was also no significant difference between sites (Slickrock versus Big Gypsum sites).

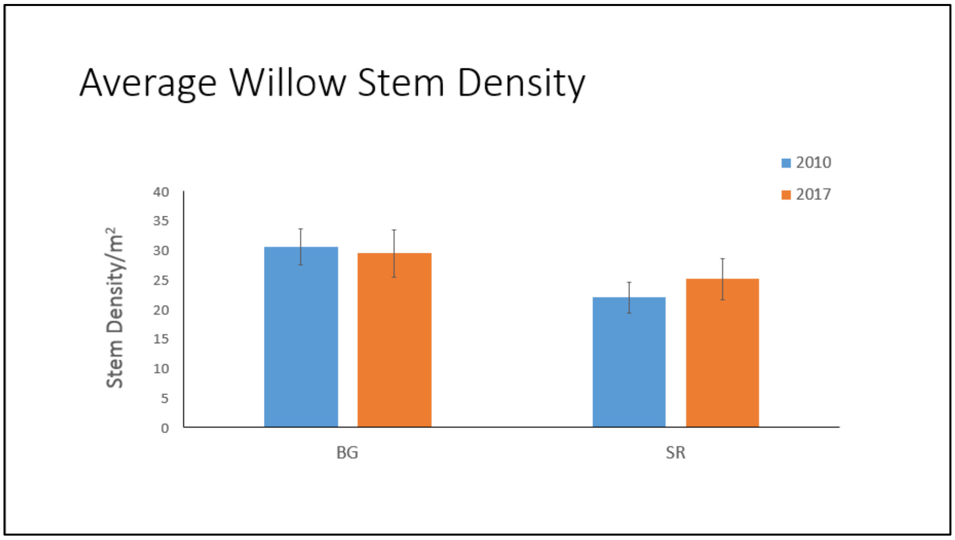


Figure 90. Average willow stem density at Slickrock (SR) versus Big Gypsum (BG) sites for 2010 vs 2017. Note no significant change in density from 2010 to 2017 at either site.

Changes in availability of potential seed beds (bare ground versus vegetation 'litter')

The presence of leaf litter on the soil surface can impede cottonwood seed germination, as can dense willow stands in the overstory. Cottonwood germination is ideal on bare ground, and in open sunny areas not shaded by a dense overstory.

Figure 91. Areas of bare ground encountered during vegetation surveys, 2017.

In 2017, a lot of sediment moved up into the willow zone along the river bank with the managed release, resulting in a noticeable increase in bare ground. The percent of bare ground was over 40% at Big Gypsum in 2017, and there was significantly less leaf litter (Figures 92 and 93 below). Some seed germination was observed on new seedbeds, but was predominantly willows, not cottonwood. Again, it is believed that cottonwood seed release occurred after the managed release. She believes that the cottonwood trees usually drop their seeds in early June.

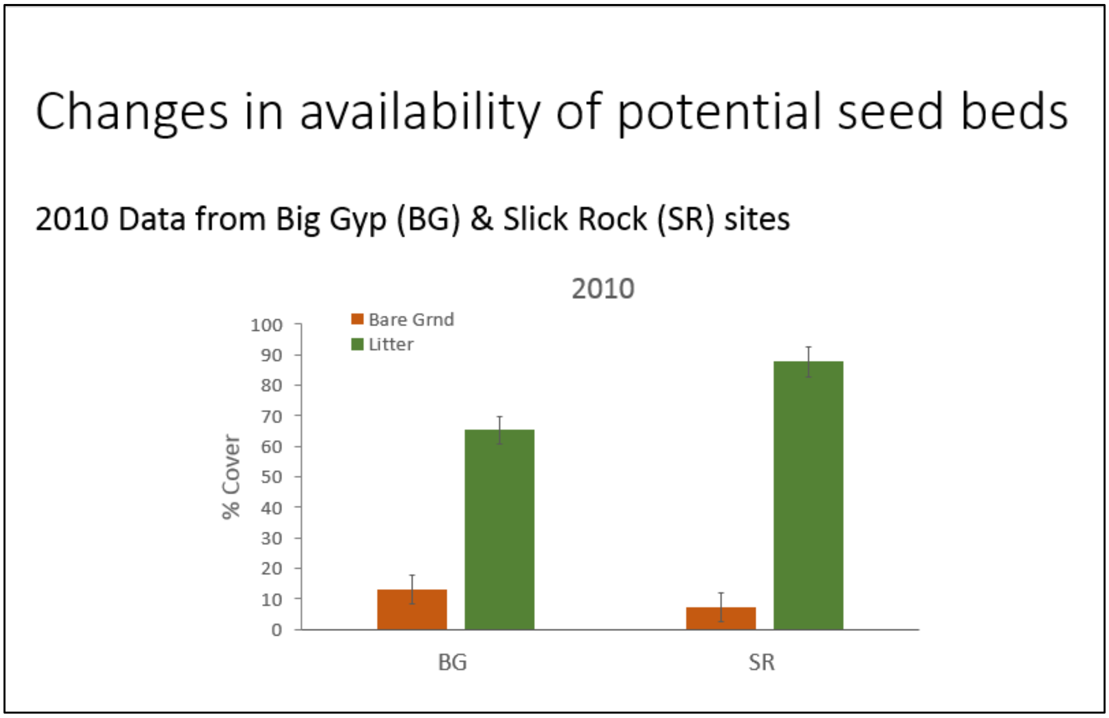


Figure 92. Bare ground (brown) versus vegetation litter (green) at Slickrock (SR) versus Big Gypsum (BG) sites in 2010. Note significantly higher amount of litter on sites versus bare ground in 2010.

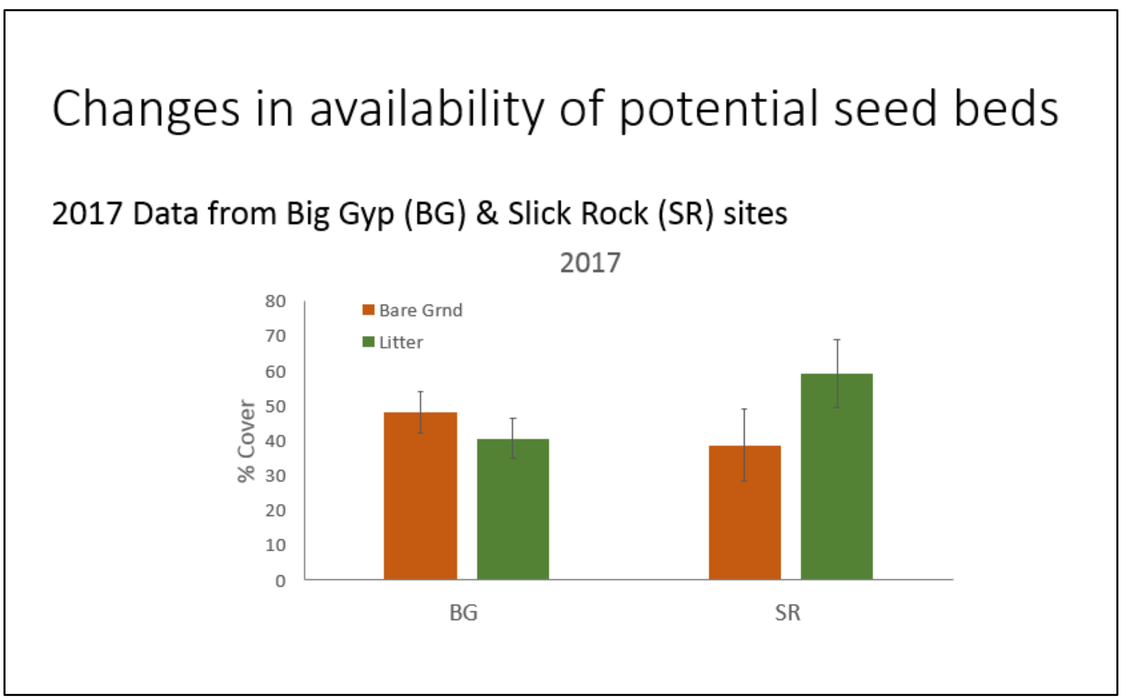


Figure 93. Bare ground (brown) versus vegetation litter (green) at Slickrock (SR) versus Big Gypsum (BG) sites in 2017. Note higher amounts of bare ground for both sites in 2017, while litter makes up less of the cover.

In regard to the potential for new cottonwood establishment, the data implies that new opportunities for cottonwoods have not really been established, because of willow density. Even at 4000 cfs, bank scouring and new sediment deposition were minimal, meaning that active management of willows might be necessary. However, floodplain inundation and groundwater recharge were important benefits of the 2017 managed release, and perhaps some cottonwoods may establish in secondary channels as a result. Riparian tree establishment is possible for box elder (more shade tolerant than cottonwood) and other species.

Summary of Findings: Historic Vegetation Transects

In 2010, vegetation transect monitoring occurred at select Slick Rock and Big Gypsum Valley sites along the Dolores River. Select transects were then re-sampled post-release in 2017. Willow stem density, and percent cover of bare ground versus vegetation litter was determined. The comparison of the historic vegetation transects from 2010 versus 2017 resulted in the following findings.

Measurable Benchmark: Monitor riparian vegetation diversity and density

- No significant difference in average willow stem density between 2010 and 2017, indicating that the managed release did not significantly reduce willow stems
- Willows are serving to 'armor' the banks resulting in channel narrowing, and represent one of the biggest changes in recent times on the Lower Dolores River.
- Overall vegetative diversity appears to be reduced as willows increasingly dominate

Measurable Benchmark: Provide evidence of cottonwood germination/recruitment (or at least some indication of seed-bed preparation and germination

- Percent bare ground was over 40% at Big Gypsum, with significantly less leaf litter, resulting in some seed germination on new seedbeds, but seedlings were predominantly willow.
- Potential for cottonwood establishment:
    - It is believed that cottonwood seed release occurred after the managed release. She believes that cottonwoods in this area usually drop their seeds in early June. It is also believed that cottonwood seed release occurred after the managed release. A release needs to occur closer to the general window of cottonwood seed release in order for cottonwood seeds to be able to take advantage of the wet bare ground created by the managed release for germination and establishment.
    - Data implies new opportunities for cottonwoods limited, because of high willow density.
    - Even with flows at 4000 cfs, bank scouring and new sediment deposition were minimal, resulting in limited creation of new bare areas for cottonwood germination
    - Active management of willows may be necessary.
    - However, floodplain inundation and groundwater recharge resulting from the managed release was a really important benefit.

    - Researchers need to monitor not just cottonwood establishment but survival over the next five years.
- Other riparian tree establishment is possible for box elder and other species.

<u>Aerial Imagery Analysis</u>

This report is a synopsis of a presentation given by Celene Hawkins, Western Colorado Water Project Director with The Nature Conservancy, summarizing their 2017 monitoring efforts. The presentation was given on 10/27/17 at the Monitoring and Recommendation Team Meeting in Cortez, Colorado. This report was made possible by the excellent note taking of Gail Binkly at this meeting.

The Nature Conservancy collected pre- and post-release drone imagery in 2017 at the new ecological monitoring sites. Pre-release drone imagery was collected at the Bedrock Site, and pre- and post-release drone imagery was collected at the Slickrock Upstream Site, Slickrock Downstream Site, and the BLM Rec (Big Gypsum) Site. No drone imagery was collected at the Dove Creek Pumps Site.

Drone imagery includes red, green, blue, and near infrared (NIR). The spatial resolution is approximately 2 inches, meaning this is the size of a pixel in the imagery. The smallest object that can be differentiated/identified is larger than this resolution, probably at least 6x6 inches. Based on this imagery, there was very little difference in planform pre- and post-release 2017.

Most of the differences observed between the two photo sets at the two sites below is because of the higher water levels in the June photos. At the Slickrock Downstream site, higher flow caused side-channel flow. The floodplains also stand out as slightly whiter at this site in these images because of sand deposits (see Figures 94 and 95 below).

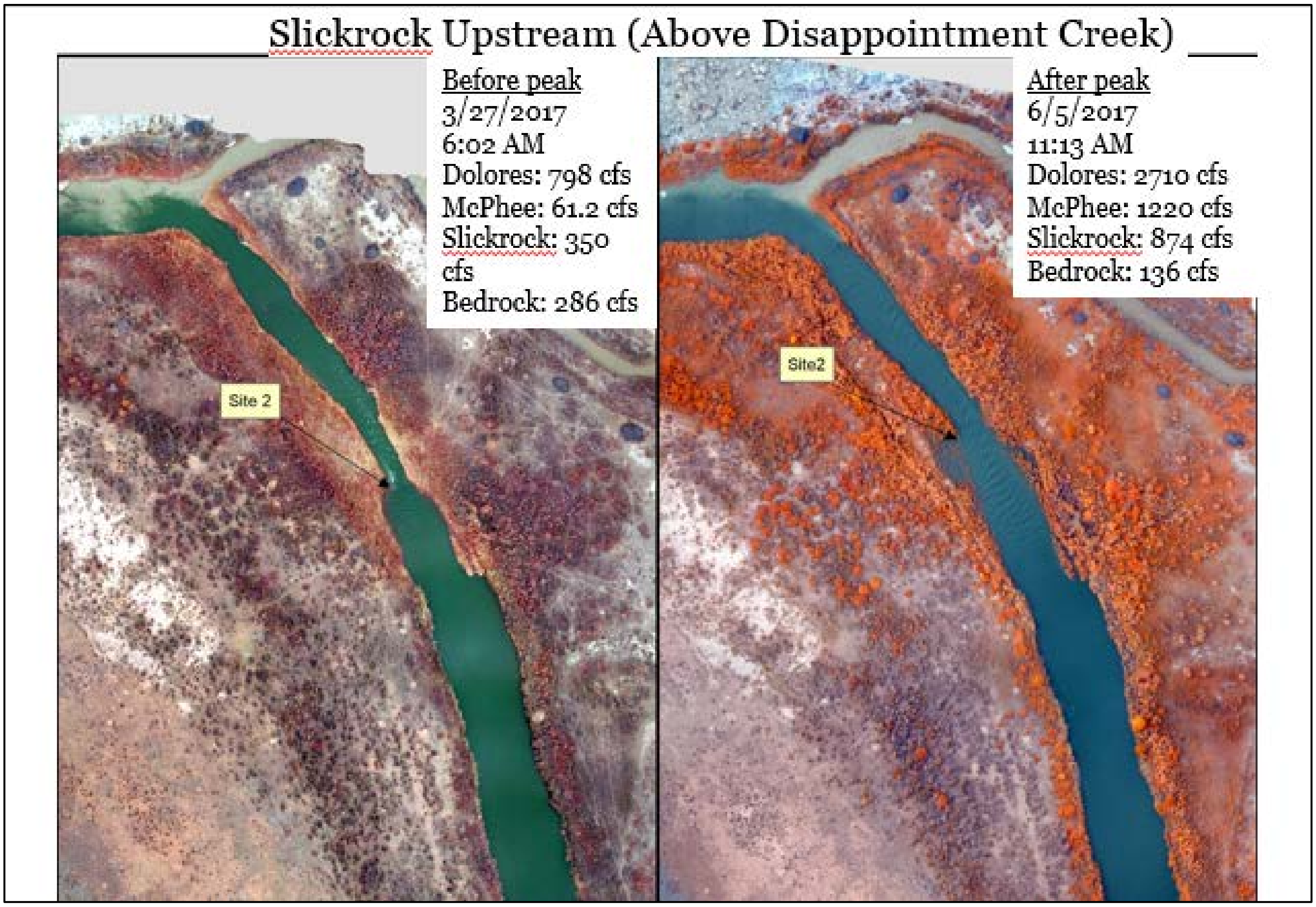


Figure 94. Example of drone imagery from March versus June 2017 at the Slickrock Upstream site. There is very little difference in planform pre- versus post-release. As noted above, most of the differences observed is because of higher water levels in June photo.

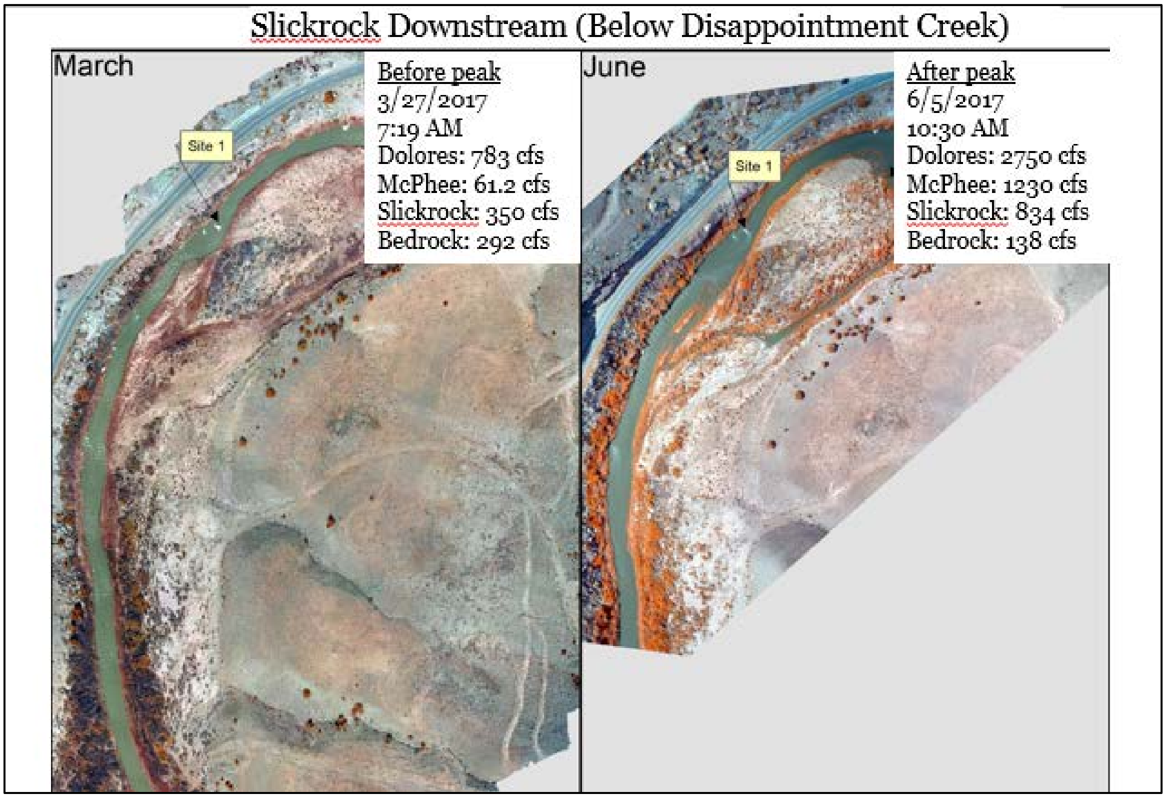


Figure 95. Drone imagery comparison March versus June 2017 at the Slickrock Downstream site. There is very little difference in planform pre- versus post-release. As noted above, most of the differences observed is because of higher water levels in June photo. Higher flow caused side-channel flow here, and floodplains stand out as a whiter color because of sand deposits.

Once 2017 imagery becomes available, TNC is also preparing to conduct analyses comparing 2015 versus 2017 National Agriculture Imagery Program (NAIP) imagery of the Lower Dolores River system. NAIP imagery includes red, green, blue, and near infrared (NIR) bands with a spatial resolution of 1 m. Planned analyses includes a comparison of change in the channel, vegetated surfaces, and bare ground along the Dolores River from McPhee to the Colorado/Utah state border.

Summary of Findings: Aerial Imagery

TNC collected both pre- and post-release drone imagery in 2017 at three of the new ecological monitoring sites (Slickrock Upstream, Slickrock Downstream, and BLM Rec (Big Gypsum). TNC is also preparing to conduct analyses comparing 2015 versus 2017 National Agriculture Imagery Program (NAIP) imagery of the Lower Dolores River system (once 2017 imagery becomes available). Specifically, the plan is to compare change in the channel, vegetated surfaces, and bare ground along the Dolores River from McPhee to the Colorado/Utah state border. Both drone imagery and NAIP imagery includes red, green, blue, and near infrared (NIR) bands, but have different spatial resolutions; drone imagery is approximately 2-inch resolution, while NAIP imagery is 1-meter resolution.

Measurable Benchmark: Assess plan-view changes

- Differences in drone imagery at the new ecological monitoring sites were found to be modest between pre- and post-release 2017.

RECOMMENDATIONS FOR FUTURE MONITORING

The following provides a summary of suggested future monitoring efforts to be conducted in direct association with the 2014 Plan. These monitoring efforts will either continue to build on efforts conducted in 2017 or address new key monitoring activities needed to ensure a comprehensive assessment of progress towards meeting the habitat objectives and measurable benchmarks outlined in Table 4 of the 2014 Plan.

Having historic data from several sites was extremely useful for understanding long-term change. Directing future monitoring at the five new ecological monitoring sites would allow us to build on this understanding.

Fish Monitoring

- It is critical to continue monitoring fish populations as recommended in the 2014 Plan, in order to understand response of fish populations to ongoing implementation of management actions.
- Monitoring (plus associated removal) of small-mouth bass requires several consecutive days of boatable flows in July, so to the extent that this is possible it will significantly enhance monitoring (and removal) efforts. Only under rare and infrequent circumstances can fish pool water be used for this effort.

Photo Point Monitoring at Ecological Monitoring Sites

- Continue repeat on-the-ground photo point monitoring with future managed release events, and/or at select long-term intervals (e.g. every 5-10 years); these are very useful for understanding long-term dynamics with riparian vegetation and channel planform.
- A ‘panorama’ camera or similar wide-angle camera will be useful in the future for repeat photo points, so that multiple photos do not need to be taken and stitched together for different photo series.

Geomorphology and Sediment Monitoring

- Cross-section profiles at established points should be repeated in the future as they are particularly useful for understanding specific in-channel sediment dynamics. These should be repeated in the future.
- In future years with release projections and similar pre-/post-release monitoring, it will be important to initiate pre-release monitoring well prior to 'low snow' runoff from Dolores Rim and Glade in order to complete longitudinal sampling through the ecological monitoring sites, and to ascertain riffle dynamics related to flow magnitude.
- It will be important to track changes in the amount of active depositional surfaces over time (as currently there is very little point bar development or meander migration at monitoring sites visited). This has implications for channel complexity, fish habitat, and carrying capacity.
- As such, additional drone-derived photogrammetry (3-D floodplain surveys) may be useful as an important complement to painted patch and erosion stake monitoring; it does not capture data as precisely but the photogrammetry provides scour and deposition results over a much broader spatial extent.
- Additional measurable benchmarks not monitored in 2017 to be addressed in future:
    - Quantify percentage of fines (<2mm) in riffle habitat, including spawning beds (cobbles) pre- and post-flow event; percentage of fines measured should be reduced, with specific attention paid to aligning flushing flows relative to the timing of native fish spawning.
    - D50 should coarsen in riffles; annual accumulation of fine sediment should be scoured from pools. Pool riffle profile should be maintained.
    - Monitor mobile fraction of channel bed in riffle; tracers or direct bedload transport measurements; hydraulic modeling.
    - Document movement of D84 in riffles; assess instream habitat complexity. Assess cross section and longitudinal changes.
    - Monitor changes in cross-section and profile dimensions; channel aggradation, degradation or entrenchment should be assessed; over a reach, over time, gradient and pool-riffle spacing should be consistent.

Wildlife Cameras and Staff Gage Monitoring

- This monitoring was not very useful in 2017. Not recommended for future monitoring unless there is a specific question identified that could be answered with staff gages.

Groundwater Monitoring

- Continue groundwater monitoring as conducted in 2017

Riparian Vegetation Monitoring

- Historic Vegetation Photo Points

    - Continue repeat photo point monitoring with future managed release events, and/or at select long-term intervals (e.g. every 5-10 years).
    - Collaborate with Bureau of Reclamation researchers to gain better understanding of water and habitat management approaches to bank armoring (for example, see work that has been done on the San Juan River to address a similar problem).
- Ecological Monitoring Site Photo Points
    - Continue repeat photo point monitoring with future managed release events, and/or at select long-term intervals (e.g. every 5-10 years). This will assist in tracking vegetative encroachment on point bars, and encroachment of xeric/mesic species onto floodplains.
    - A 'panorama' camera or similar wide-angle camera will be useful in the future for repeat photo points, so that multiple photos do not need to be taken and stitched together for different photo series.
- Cottonwood Recruitment Surveys
    - Cottonwood recruitment and survival on the Dolores River is still poorly understood. In addition to continuing to monitor groundwater to better understand cottonwood needs, additional monitoring should include:
        - Continue to monitor cottonwood (and other key species) recruitment with future managed release events, including closely tracking draw-down rates and timing of cottonwood release as key contributing factors. As noted above, the ideal drawdown rate for cottonwood seedling establishment (2.5 cm [1"] per day).
        - Consult with local botanists then conduct additional monitoring if possible over multiple years to better determine the approximate window within which cottonwood seed release typically occurs in the area so that, given the opportunity, planning for a managed release could take this into consideration.
        - Cottonwood recruitment surveys conducted in association with managed releases should also be followed up with additional surveys in future years to track not only initial recruitment rates but also survival rates over time.
- Historic Vegetation Transect Monitoring
    - Continue to repeat historic vegetation transects with future managed release events, and/or at select long-term intervals (e.g. every 5-10 years). It will be important to understand how willow dynamics and channel encroachment change over time.

Aerial Imagery Monitoring

- Potentially conduct additional drone imagery collection every 5-10 years to enable comparison of long-term changes at the new ecological monitoring sites. It will be important to conduct pre- and post-release drone surveys in the future at the same discharge level for best comparison of planforms.
- Continue securing NAIP imagery and conducting associated analyses

Benthic Macroinvertebrate Productivity

- Not monitored in 2017. Measurements for benthic macro-invertebrate species in riffles would be useful and is advised.

Water Temperature Monitoring

- Ensure that water temperature monitoring is continued and new monitoring sites instituted as needed just below McPhee Reservoir and at select additional sites downstream. Although water temperature is not a measurable benchmark in Table 4 of 2014 Plan, it is a critical piece directly associated with one of the four native fish assumptions to be aimed for under all managed release scenarios, that of *(1) Preventing thermal shock: improve ascending spring flows beginning April 1 that ramp sufficiently to minimize pre-release water warm-up that triggers pre-release spawn* (see 2014 Plan for more details). This data could help inform future managed releases to best support native fish reproduction.

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