State of the Watershed Report 2019:

Adaptively Managing a Working River in a Recovering Watershed

May 2019

Developed by:

LEFT HAND WATERSHED CENTER
6800 Nimbus Road, Longmont CO 80503 (office)
P.O. Box 1074, Niwot, CO 80544-0210 (mailing)
303.530.4200 | www.watershed.center

Contents

EXECUTIVE SUMMARY....3
Summary of Key Findings 3
....4
Actionable Priorities 4
  Monitoring Priorities 4
  Management Priorities....4
A RECOVERING WATERSHED AND WORKING RIVER....5
Conceptual Model & Conditions Assessment 5
  History 6
  Pre-Flood 6
  Post-Flood....7
  Today and Our Future 7
EVALUATING OUR TRAJECTORY TOWARDS RESILIENCE 8
Monitoring and Assessment....8
2019 Results 9
  Hydrology 9
  Morphology 10
  Habitat Types.... 11
  Riparian Community.... 12
  Water Quality 13
  Biota.... 14
  Key Takeaways.... 15
LEARNING AND ADJUSTING.... 16
  Reframing Restoration Questions 16
  Incorporating the Influence of Stream Evolution Stage 17
  Streamlining Monitoring Protocols 18
  Identifying Future Opportunities.... 18

EXECUTIVE SUMMARY

As Left Hand Watershed recovers from the 2013 floods, Left Hand Watershed Center is monitoring and assessing the state of the watershed using an adaptive management approach. This report describes the state of our recovering watershed one-year after implementing significant restoration projects throughout the watershed and summarizes key lessons learned regarding how to improve our adaptive management plan.

Summary of Key Findings

As expected, our first year of data showed that additional year-to-year comparisons are needed to truly assess our trajectory towards resilience. However, features incorporated in restoration designs to meet resiliency goals were generally functioning as intended. Key findings included:

- Native vegetation abundance was consistently greatest at the creek edge relative to the uplands, supporting the importance of maximizing restoration of lower benches and riparian edges.
- Higher floodplain benches and overflow areas, that were designed to be inundated on a less than annual frequency, were prone to greater non-native species cover. Future projects may benefit from lower occurrence of non-native vegetation by installing lower benches and overflows to increase connectivity to the river and ground water table.
- Though not related to restoration designs, plains reaches continued to show water quality impairment issues, likely due to intermittent flows and the nature of Left Hand Creek as a working river.
- Monitoring and assessment of pools was insufficient to determine whether pools were deep and cool enough to support fish habitat at low flow.

We found that structuring our monitoring and assessment framework by separating key watershed functions limited our ability to assess integrated watershed health due to the inherent interconnectedness of key watershed functions.

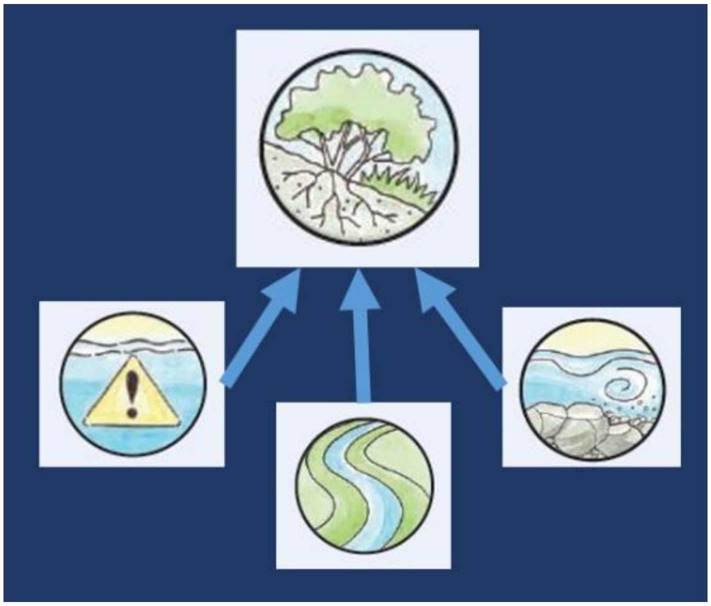


Figure 1. Our updated Monitoring & Assessment Framework assesses ecological parameters as indicators of overall watershed function.

To address this, we've recently updated our adaptive management framework to address flow regime, stream form, and sediment regime as drivers of the ecological community (Figure 1). This will allow us to assess our trajectory towards resilience based on the trajectory of the ecological community, and explain ecological function based on the performance of other key watershed functions.

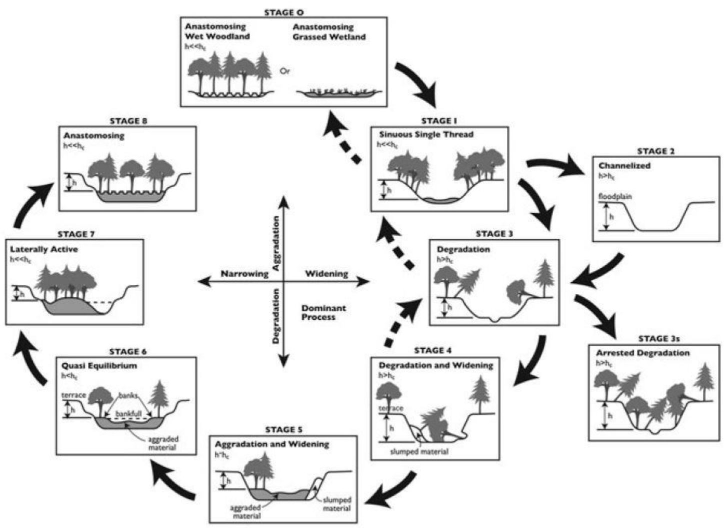


Figure 2. Cluer & Thorne 2013, Stream Evolution Model

While our conceptual model shows desired future conditions for our watershed, it is missing the influence of stream evolution stages (Figure 2). Moving forward, we are considering updating our conceptual model to incorporate the potential ecological benefits associated with stream evolution stages, recognizing that the benefits that we can achieve will vary at different stream evolution stages.

Actionable Priorities

Below we summarize actionable stream management and monitoring priorities based on year one monitoring and assessment results. Moving forward Left Hand Watershed Center will prioritize these management and monitoring actions to address data gaps and improve Left Hand Watershed's trajectory towards resilience.

Monitoring Priorities

- Conduct additional water quality monitoring using labs with faster processing time than River Watch to understand if water quality is improving from mine drainage issues.
- Conduct additional fish and benthic macroinvertebrate monitoring to understand how these communities are recovering from mine drainage issues.
- Conduct comprehensive assessment of existing mines and related water quality issues.
- Monitor and set up experiments to better understand ecological benefits of different restoration methodologies and stream stages, particularly related to quantifying the relationship between vegetation and floodplain connectivity, as well as resulting resiliency outcomes.
- Collect data on pool depth and pool temperature data in summer months to determine whether pools are deep and cool enough to support fish habitat at low flow.

Management Priorities

- Assess and implement modifications to diversion structures and/or operations in lower reaches to address water quality impairment issues. Discussions with water owners about potential modifications have been initiated and potential options have been identified for nearly all diversions.
- Identify areas with disconnected floodplains and implement restoration projects to reconnect the river to the floodplain where possible. Restoration efforts should first prioritize reaches without water quality impairment issues.
- Identify unconfined reaches or floodplain pockets and implement projects to restore to a stage zero stream where possible.

A RECOVERING WATERSHED AND WORKING RIVER

Like many watersheds throughout the Front Range, Left Hand Creek provides tremendous economic, ecological, and recreational value for our community, and was dramatically altered following the extensive 2013 floods. In this section, we summarize the state of our watershed before and after the floods, and describe steps taken to move our watershed in a trajectory towards resilience.

Conceptual Model & Conditions Assessment

To better understand the context of our watershed and apply scientific understanding to define improved watershed health and resilience, we developed a conceptual model that depicts the evolution of our watershed through time, as related to the 2013 floods.

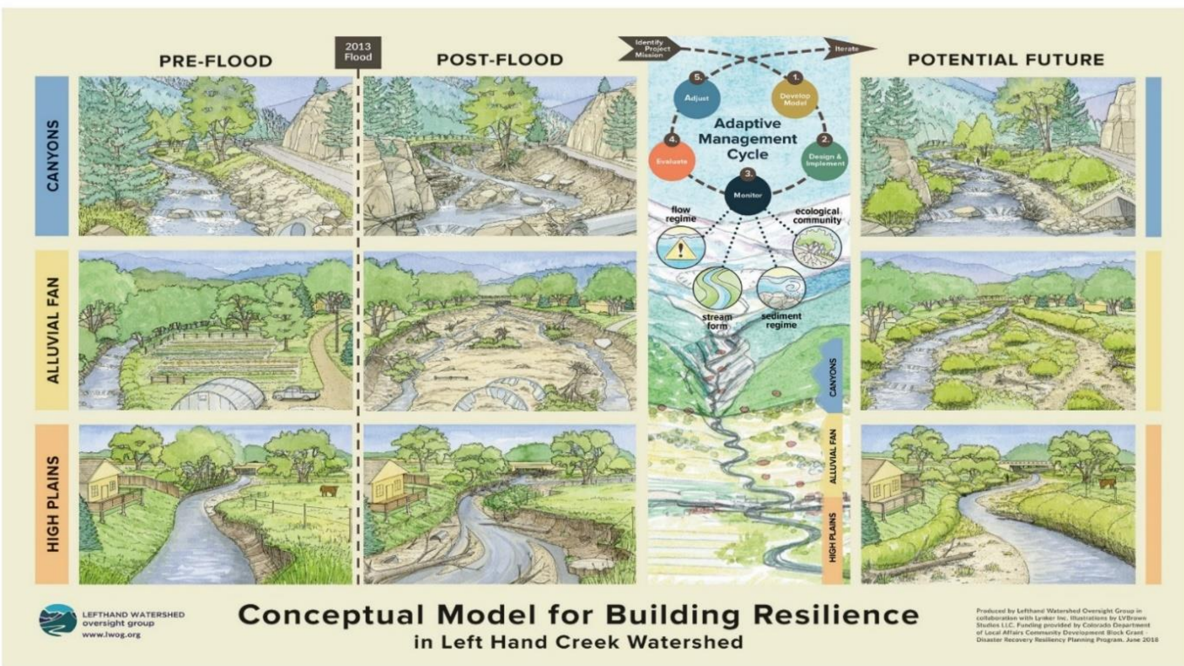
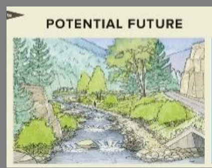


Figure 3. This figure shows the conceptualized status of Left Hand Creek Watershed on nine drawn panels arranged by watershed zone and time. The adaptive management cycle is drawn between the post-flood and potential future scenarios, indicating that adaptive management began after the 2013 flood. Restoration goals are presented in the potential future panels. Key watershed functions tie directly to the monitoring step of the adaptive management cycle, indicating that these parameters are measured to track the trajectory of restoration efforts.

The conceptual model depicts conditions in the watershed as they were directly prior to the flood. However, it is also important to consider how other historical conditions, as far back as pre-settlement and beyond, influenced our watershed. These historical conditions provide important context to what may be possible and desirable in the future. We do not look back at these conditions because we want to restore to some historical point in time, but rather to learn from our history.



While the conceptual model depicts just one potential future condition, we recognize that watersheds are dynamic and that many different future conditions are possible, particularly in the face of processes such as flood, drought, fire, and climate change.

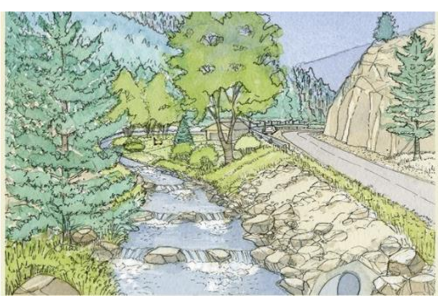
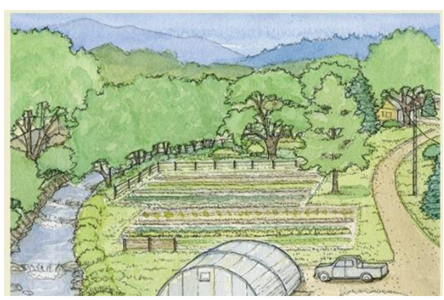
History

Left Hand Creek Watershed carries more water than it would in its natural state thanks to Colorado's historic first inter-basin transfer, the Left Hand Ditch. First dug in 1861, this diversion brings water from South St. Vrain Creek to James Creek, a Left Hand Creek tributary, just west of the town of Ward. Prior to 1861 Left Hand Creek was a flashy seasonal creek or wetland swale which flowed intermittently from the mountains to the plains during wet years and likely dried up in late summer.

In the 1860s, farmers started settling on the plains and diverting water for crops in the semi-arid environment, leading to the construction of the Left Hand ditch system and the transformation of Left Hand Creek from a flashy seasonal creek to a working river. Increased flows resulting from the new role of Left Hand Creek as a working river began this transformation of the creek and surrounding riparian community. Left Hand Creek changed from a seasonal creek or wetland complex with an open canopy and occasional cottonwoods to a more defined river corridor and channel, with increasing woody riparian vegetation along channel margins.

At the same time, mining activities were booming in the upper reaches of the watershed and producing millions of dollars in gold and silver. By the early 20th century most mines were abandoned, leading to extensive acid mine drainage and associated leaching of metals into the creek, as well as excess sediment. Despite clean-up efforts, the impacts to water quality from these mine activities are still present in the watershed today.

Pre-Flood


Prior to the 2013 floods Left Hand Creek had spent more than 150 years (following farm settlement) growing and changing as a working river, with an increasing number of people relying on the creek for their livelihood and recreation. Like many rivers in the Front Range, diversions and ditches continued to be used to bring water, habitat, and life to places that would otherwise be dry. From wildlife habitat and fishing, to trails, cycling routes, and historic sites, our Front Range rivers, including their ditches and diversions, continued to enhance our community's quality of life.

Yet, diverting water also resulted in diminished stream flows, posing challenges for wildlife, ecosystem health, and recreation, as well as people who relied upon the creek. Diminished stream flows meant that sections of the creek became too dry to support a healthy and resilient watershed. Non-native vegetation, particularly crack willow (*Salix fragilis*), became prevalent throughout the watershed and encroached into the creek corridor.

Crack willows became especially problematic in reaches that experienced diminished stream flows because the trees track the lowering water table and occupy increasing space within the stream channel. As crack willows grew more abundant along the channel edge they created an armored creek bank that resulted in down-cutting and incision of the channel, disconnecting the river from the floodplain.

As the floodplain became disconnected and inundation events occurred less frequently, land use and cultivation right up to the creek edge became more prevalent. Infrastructure such as buildings, roads, and bridges were common in the floodway and adjacent to the creek. The combination of encroachment from crack willow, land use, and infrastructure resulted in a “locked-in” stream form with limited floodplain access and little natural erosion/deposition processes. Water quality impairment from historical mining activities was still evident and mixed with other surrounding pollution sources, particularly in the plains where runoff from agriculture and urbanization was most prevalent.

Post-Flood

In 2013 extensive flooding due to three plus days of heavy rain caused another dramatic transformation to all Front Range Watersheds, including Left Hand Creek. High peak flow and sediment/debris inputs caused the creek to migrate and experience deposition, erosion, and loss of riparian vegetation and habitat. Debris flows and eroded hillslopes in the upper watershed delivered a substantial quantity of sediment and debris to the alluvial fan and plains areas. This high sediment load quickly plugged crossings, resulting in wide-spread sediment deposition, channel avulsion, and substantial bank erosion. Much of the agriculture, lawns, and infrastructure were damaged or destroyed when high flows reconnected the creek to its floodplain. Invasive crack willow (*Salix fragilis*) encroachment was also reduced in some areas where the high flows felled trees adjacent to the banks. Water quality and aquatic communities declined compared to pre-flood as a result of sediment pulses from mine tailings in the upper watershed, substantial bank and floodplain erosion, and a loss of aquatic and riparian habitat.

Today and Our Future

Today our watershed continues to change and evolve as it recovers from the 2013 floods. We are managing this recovery using an adaptive approach. Our approach is described in detail in our Adaptive Management Guide, available on our website. As part of this process we (1) conceptualized a desired future for our watershed which aims to maximize resilience within the reality of a working river; (2) developed a framework for monitoring our trajectory towards resilience; (3) implemented flood recovery restoration projects throughout the watershed to jumpstart the process of building resiliency and directing watershed functions towards the desired future condition; and (4) evaluated our trajectory towards resilience by monitoring and assessing key watershed functions.

As we conceptualize the resilient future of our watershed, we envision a watershed with a healthy riparian community and robust aquatic habitat created and maintained by good floodplain connectivity and dynamic geomorphic and ecological processes. We also envision room for the creek to move and adjust, in order to allow dynamic river processes to occur and diverse, ever-changing, riparian habitat. Leveraging lessons learned from looking at our history we knew that we must avoid a “locked-in” creek dominated by invasive crack willow (*Salix fragilis*), and that this would likely require on-going maintenance because of a lack of flushing flows. Recognizing that intermittent flows will always be a reality in our working river, we considered solutions to alleviate the impacts of diminished flows on watershed health and looked for multiple benefit opportunities whereby benefits to watershed health also benefit functions of ditches and diversions.

EVALUATING OUR TRAJECTORY TOWARDS RESILIENCE

Starting in 2016 we designed and implemented numerous flood recovery restoration projects to jumpstart our watershed’s trajectory towards the most resilient future possible – eleven projects are complete and eight are ongoing. Projects were generally designed to increase flood resilience, restore long-term stream health and stability, and improve aquatic and riparian habitat. The graphic below summarizes specific restoration features that were incorporated into most projects.

In 2018 we monitored and assessed key watershed functions throughout the watershed using our adaptive management plan. Each key watershed function was tied to a monitoring parameter, performance standard, management triggers, and monitoring method described within the plan. We implemented this plan at three types of sites throughout the watershed:

- Restored: 11 sites where restoration projects were complete in 2016-2018
- Unrestored: 9 sites where no restoration work was implemented
- Pre-Project: 9 site where no work was implemented but restoration projects will be implemented later in 2019

Monitoring and Assessment

In our first year of monitoring, we assessed the performance of four key watershed functions to help us address the following key restoration questions to evaluate our trajectory toward resilience. We also continued our long-term monitoring of chemical water quality, indicative of acid mine drainage and metals leaching from legacy mining sites. Our annual water quality report can be found on our website.

1. Are floodplains low enough to inundate at appropriate frequencies?
2. Are we seeing evidence of beneficial dynamic fluvial geomorphic processes on floodplains?
3. Are we increasing or maintaining pools year to year?
4. Is native vegetation cover increasing?
5. Is water quality, as indicated by biotic community, improving year to year?

2019 Results

On the following pages we provide a summary of data collected and initial impressions, recognizing that we are limited by just one year of data and additional year-to-year comparisons are needed to assess our trajectory towards resilience. All raw data is available on our website.

Hydrology

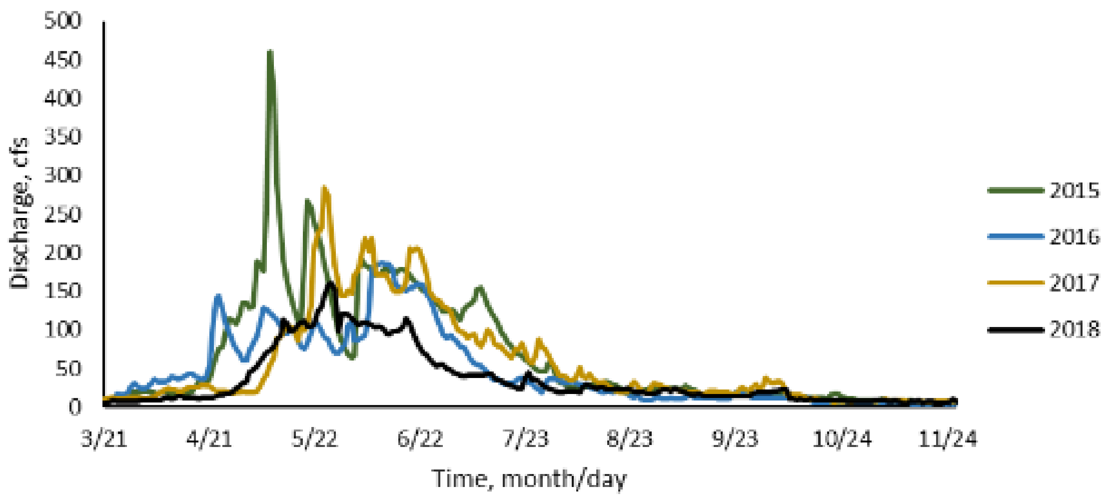


Figure 4. Annual discharge from March through November from 2015-2018 at the Colorado Division of Water Resources LEFTCRECO stream gage on Left Hand Creek, Boulder County, CO. The gage is located upstream of the Allen Lake diversion.

- Like other streams in the Front Range, Left Hand Creek is a snowmelt system with a peak springtime flushing flow associated with snowmelt. In 2018, we did not reach peak flushing flows typical to recent years due to drought conditions.
- After runoff, water downstream of the Allen's Lake diversion is diverted for agriculture and instream flow below the diversion is not reflected in this hydrograph.
- As a result of diverting water, lower flows may not properly transport sediment below diversions or inundate the floodplain or appropriate benches, as desired.
- Drought conditions further impact lower flows in the summer and fall, resulting in dry periods and encroachment of vegetation into the channel.

Morphology

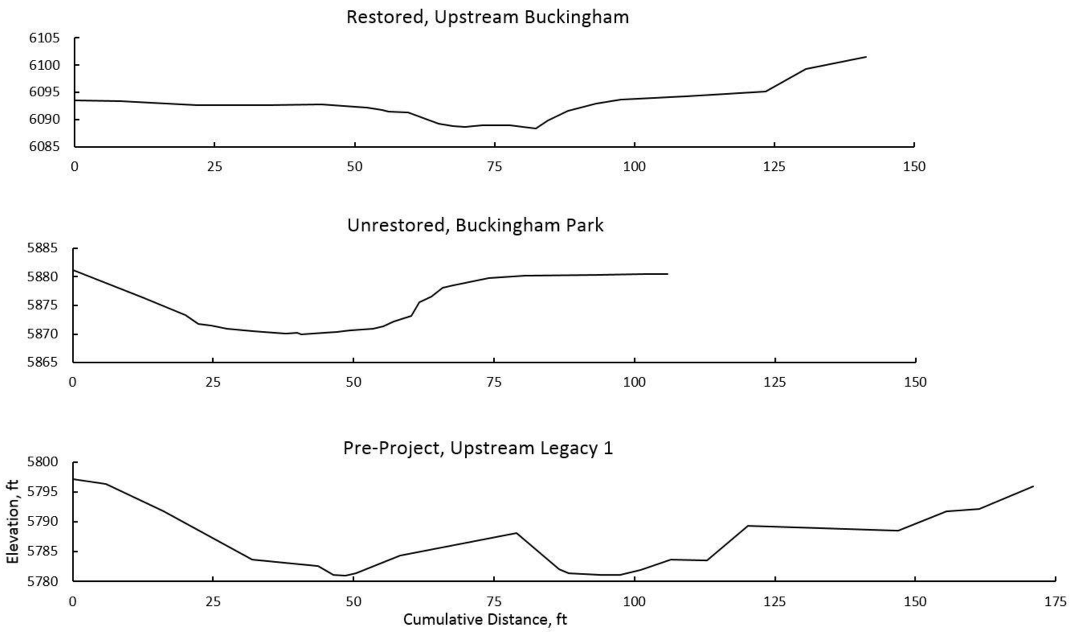


Figure 5. Representative cross sections from 2018 monitoring of a restored, unrestored, and pre-project site in the canyons of Left Hand Creek, Boulder County, Colorado.

- It is important for creeks to have access to floodplains throughout the year to allow for natural occurrence of dynamic fluvial geomorphic processes.
- As demonstrated in the restored and pre-project cross sections, the 2013 floods either cut down channels or deposited excess sediment and debris that detached the creek from its floodplain.
- Restoration projects reconnected floodplains that were designed to be inundated at peak flows throughout the watershed.
- As demonstrated in the restored site cross section, restored sites maintained broader floodplains one year after restoration.

Habitat Types

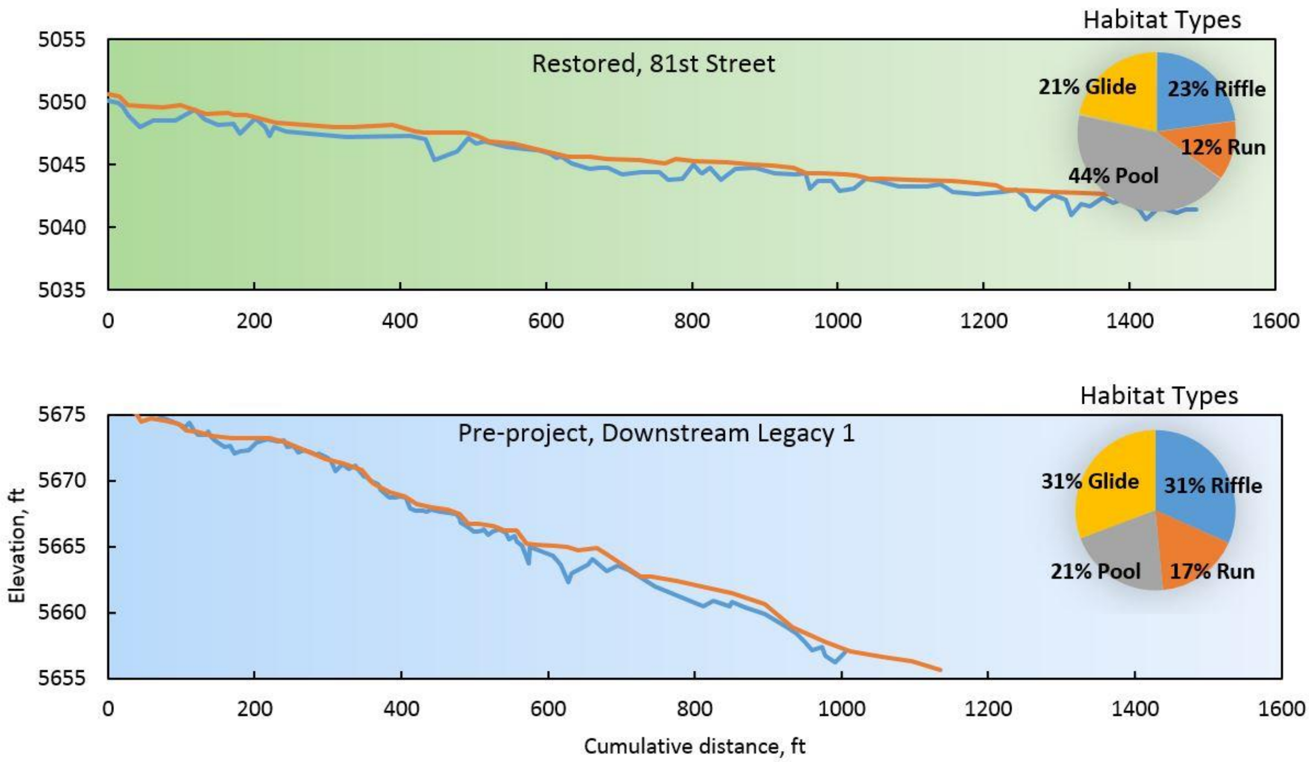


Figure 6. The 2018 longitudinal profile for a representative restored and unrestored reach in Left Hand Creek, Boulder County, Colorado. Water surface and bottom along the thalweg indicated by orance and blue lines, respectively.

- Pool habitat and pool/riffle sequences are important habitat types for fish and invertebrates.
- As demonstrated in the pre-project logitudnal profile, post- flood channels were lined with debris and had fewer pools and embedded riffles.
- Restoration projects removed larger debris and established pools and riffles with appropriately sized substrate.
- As demonstrated in the restored longitudnal profile, pool habitat was greater at restored sites than pre-project sites and pool/riffle sequences were retained at restoration sites one year after restoration.

Riparian Community

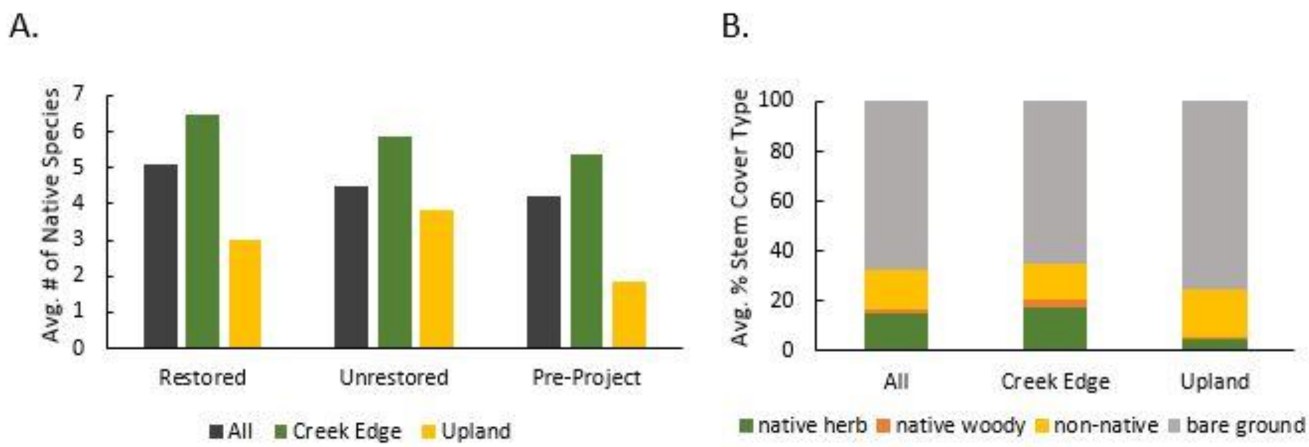


Figure 7. The 2018 riparian vegetation summary for (A.) average native species richness in riparian zones for all restored, unrestored, and pre-project sites and (B.) average percent cover type in riparian zones at all restored sites in Left Hand Creek, Boulder County, Colorado.

- Diverse native species composition provides resilience and habitat for fish and wildlife.
- Restoration projects seeded riparian areas from creek edge to upland zones with native species.
- In 2018, restored sites had greater average native species richness (A.) compared to unrestored and pre-project sites. The greatest average native richness for all sites was found at creek edge.
- Similarly, average percent native cover (B.) at restored sites was greatest along creek edge compared to upland zones.

Water Quality

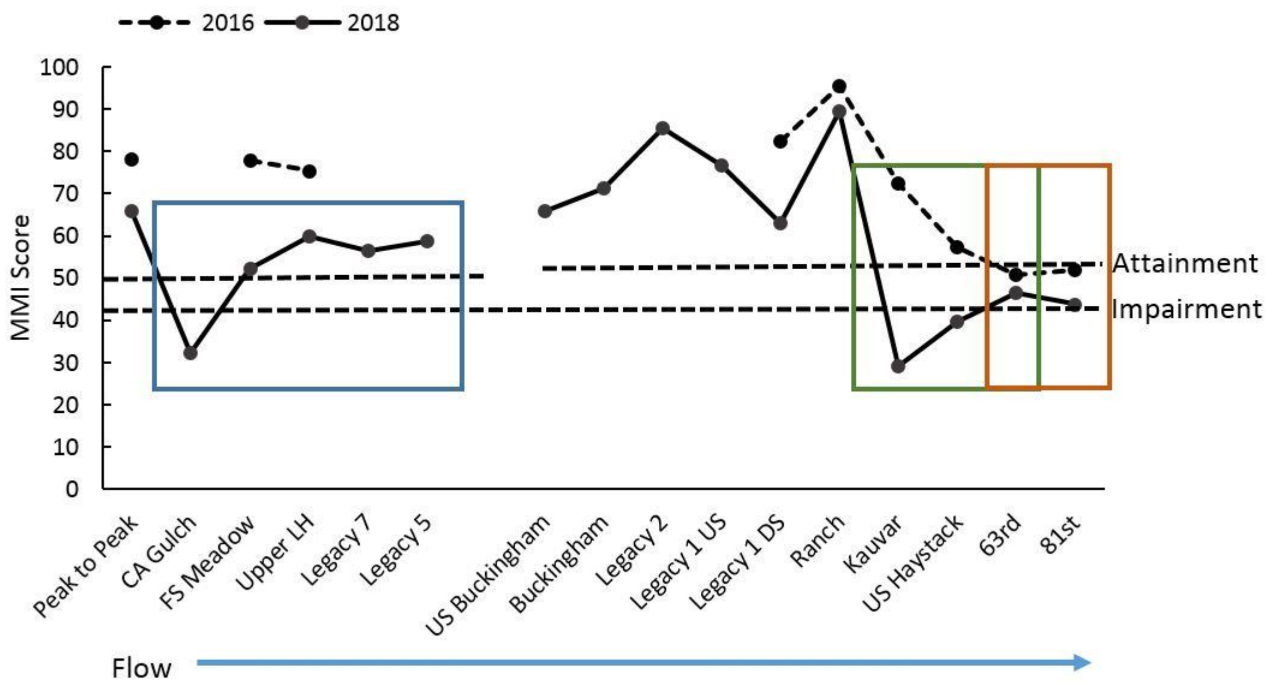


Figure 8. The 2016 and 2018 Colorado Streams Multi-Metric Index (MMI) values for sites in Left Hand Creek, Boulder County, Colorado. MMI water quality thresholds for attainment and impairment, designated by horizontal dashed lines, are based on habitat biotypes: Mountains and Transition. Potential drivers behind water quality impairments are illustrated in blue (mine drainage), green (dry conditions) and orange (return flows). Sites are arranged upstream to downstream.

- Water quality is important for drinking and agricultural use and for fish and wildlife.
- Indices derived from benthic macroinvertebrate (BMI) community present in the stream can indicate water quality.
- Interpretations of year-to-year comparisons (2016 vs. 2018) are limited due to annual variation in sampling conditions.
- As noted in the figure, Left Hand Creek may have reoccurring or discrete impairments to water quality impairment depending on location in the watershed
    - Mine drainage: Upper reaches; In 2018, the Captain Jack Mine's Big Five Tunnel released acidic water laden with metals prior to sampling BMI.
    - Dry conditions: Lower reaches; Reduced flows and a lesser amount of suitable habitat.
    - Return flows: Lower reaches; Above and below ground return flows may carry excess nutrients and insecticides.

Fish Kill: In fall of 2018, Left Hand Creek experienced a fish kill resulting from a discrete mine-related discharge from the Captain Jack Mine's Big Five Tunnel. Left Hand Watershed Center closely tracked the issue and will continue to be involved in water quality sampling, remediation discussion, and reporting information to the community as we learn more.

Biota

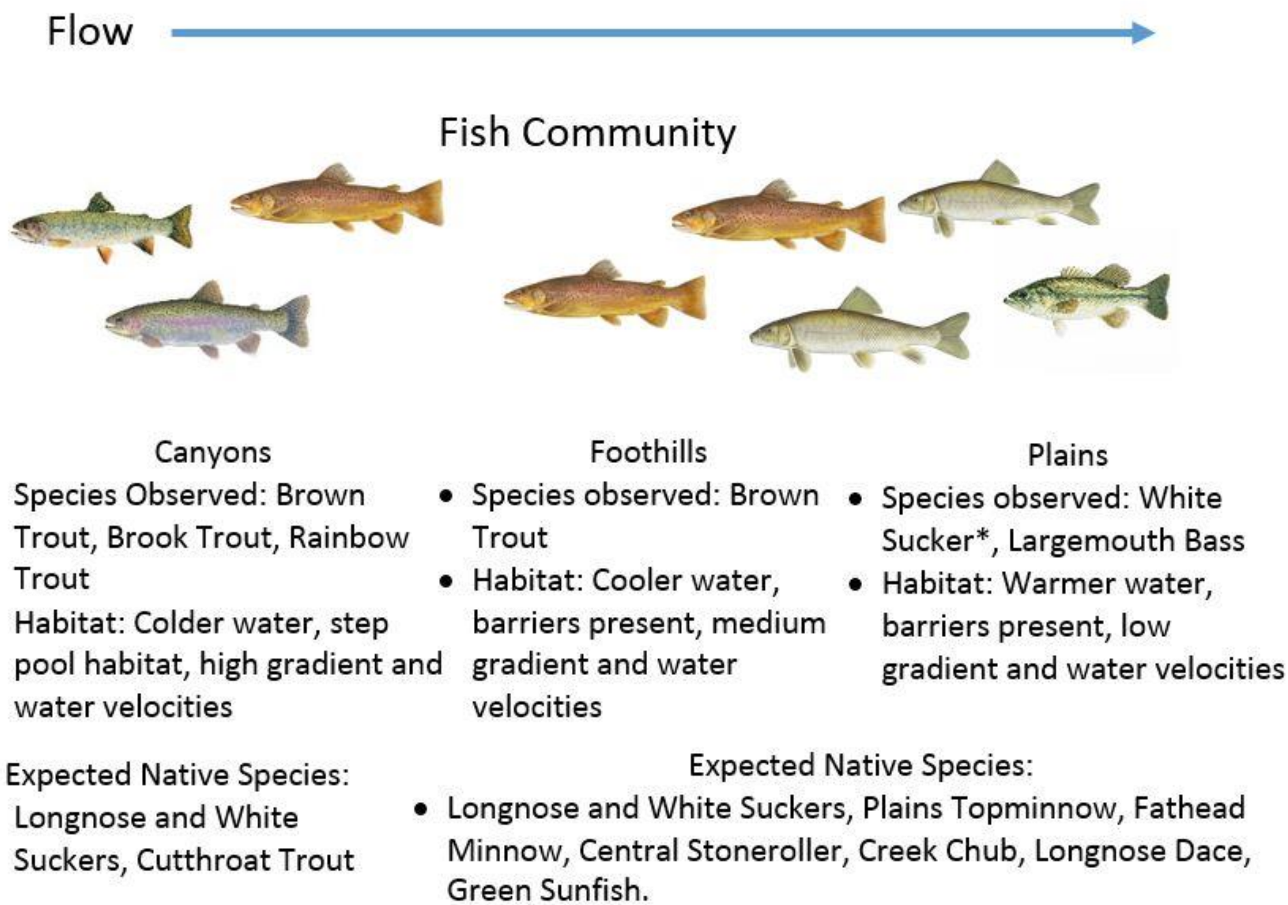


Figure 9. The 2018 fish community observations made visually and by electrofishing in Left Hand Creek, Boulder County, CO. Species and habitat descriptions grouped by watershed area (Canyons, Foothills, Plains) from upstream to downstream. Native species are denoted with an asterisk (*).

- Instream biota are important indicators of watershed health and our trajectory towards resilience.
- The 2018 BMI community was more diverse and made up of more sensitive species in the absence of water quality impairments due to mine drainage, dry conditions, and return flows. These conditions occurred in the upstream reaches of the watershed, but below the Captain Jack Mine. The less diverse communities downstream were made up of species with high tolerance to impairments.
- The 2018 observed and sampled fish community is mostly non-native species, except for observed White Sucker. Fish species observations were reflective of watershed zone and abiotic conditions including water temperature and velocity, as well as channel gradient. Barriers to movement and non-native species competition may prevent native species from reaching historic ranges.

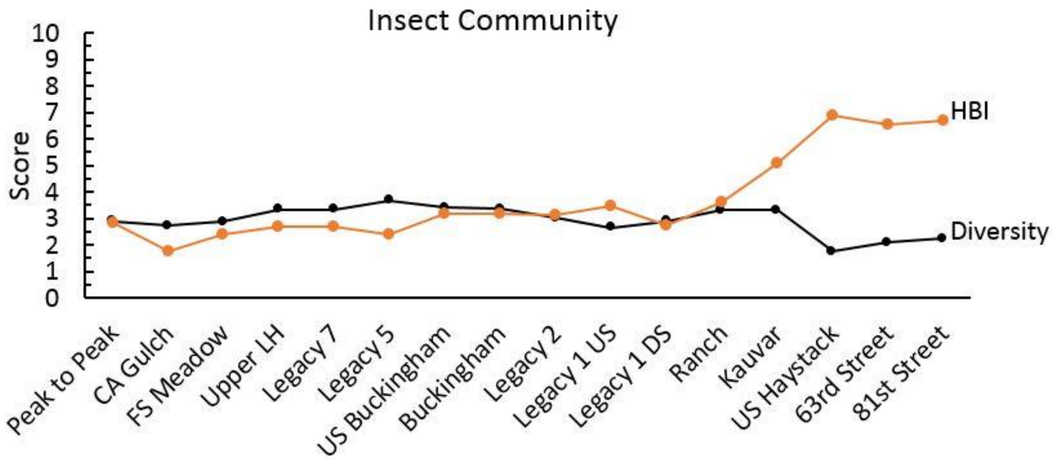


Figure 10. The Shannon Diversity and Hilsenhoff Biotic Index (HBI) for 2018 BMI community samples in Left Hand Creek, Boulder County, Colorado. The greater the diversity score, the more diverse the community, the greater the HBI score, the more tolerant the community is to water quality impairments. Sites are arranged upstream to downstream.

Key Takeaways

Summarized below are key takeaways following year one of monitoring and assessment.

1. In 2018, Left Hand Creek did not reach typical high flows or flushing flows and experienced a discrete mine drainage event confirming the importance of continued long-term monitoring because watershed conditions vary from year-to- year.
2. Restored locations had broader and more accessible floodplains and more pool habitat than unrestored and pre-project sites demonstrating that project goals to restore floodplain connectivity and increase pool habitat were met in the first year following restoration.
3. All sites had greater average native vegetation richness along the creek edge compared to upland zones, and restored locations had greater average percent native cover along the creek edge. The results demonstrated the importance of maximizing lower benches to attain greater levels of vegetation cover and richness.
4. As expected in a working river, the biological community, including fish and invertebrates, is impacted by water quality impairments and habitat connectivity. This impairment varies depending on location in the watershed (e.g. relative to mine, diversion, land-use, etc.) and presents an opportunity to identify which management actions may be most beneficial for improving watershed health.

LEARNING AND ADJUSTING

As expected, one year of post restoration was generally insufficient to help us answer our key questions. However, we gained valuable insight into the strengths and weaknesses of our adaptive management plan, and how we can improve it in the future to help address our key restoration questions and evaluate our trajectory toward resilience.

Reframing Restoration Questions

Our original restoration questions were developed based on key watershed functions. However, we found that this approach did not carry over well to data evaluation because key watershed functions are influenced by complex interrelationships among all other functions. Generally, we found that answering research questions related to flow, form, or sediment independent of ecology limited data interpretation. As illustrated in the future conditions of our conceptual model, we desire an ecologically resilient system that can withstand stressors and shocks, with improved or maintained ecological conditions and function. Given this goal, we have simplified our restoration questions to one key question, relative to ecological community and habitat, with flow, form, and sediment as drivers of ecosystem health.

UPDATED KEY QUESTION: Is the ecological condition of our watershed improving, declining, or remaining the same each year, and which stream segments have the greatest ecological resilience during drought or flood conditions?

Table 1. Project Goals, Related Ecological Parameters, and Drivers

Goal	Ecological Parameter	Potential Driver
1. Maintain or improve floodplain and channel connectivity;	Floodplain and instream physical habitat.	Flow Regime, Sediment Regime
2. Maintain or improve channel morphology and physical habitat;	Pool habitat quantity and quality and riffle habitat quality.	Flow Regime, Sediment Regime
3. Maintain or improve riparian condition and native plant community;	Riparian condition and community.	Flow Regime, Stream Form
4. Maintain or improve benthic macroinvertebrate community;	Benthic macroinvertebrate community diversity and tolerance indices.	Flow Regime, Sediment Regime
5. Maintain or improve water quality;	Benthic macroinvertebrate community Multimeric Index.	Overall Watershed Function
6. Maintain or improve fish community and condition;	Fish community and condition.	Overall Watershed Function
7. Reduce hazards and increase flood safety for residence living along the creek.	N/A but related to parameters in Goal 1 above.	Flow Regime, Sediment Regime

Incorporating the Influence of Stream Evolution Stage

Part of any adaptive management plan is re-conceptualizing based on what we learn. Our current conceptual model was developed based on space (Canyon, Alluvial Fan, Plains) and time (Pre-Flood, Post-Flood, Future). Moving forward we plan to update our conceptual model to incorporate stage-related resiliency potential based on Cluer and Thorn's 2013 Stream Evolution Model (SEM) (Figure 2). Cluer and Thorn's SEM illustrates how a river evolves in response to disturbances such as channelization or alterations of sediment and water inputs (see figure). Different stages demonstrate stream responses to changing conditions (e.g., degradation, widening, and aggradation). Expanding on previous SEM models, they propose that many unaltered streams were originally at a stage zero, meaning that they were physically complex, with multiple channels. Cluer and Thorne link different stages of stream evolution to habitat and ecosystem benefits, arguing that channels with greater physical complexity better support river ecosystems and have greater resiliency.

Glaciers: Interestingly, the headwaters of Left Hand Creek extend only a few miles west of the Peak to Peak Highway, and were not glaciated during the Ice Age. This differs is in comparison to the headwaters of other Front Range creeks such as Boulder and St. Vrain, which extend to the Continental Divide and were extensively glaciated. As a result, Left Hand did not experience the river carving, channel forming post-glacial processes that were experienced by the other creeks.

We can think about our monitoring sites as reflecting different stages of stream evolution, depending on history of use, adjacent infrastructure, land use, and hydromodification. Of key importance is acknowledging that given the time-scale of these processes and the need for understanding the history of the river system, we may only experience a glimpse into the stream's evolution, and this limits our ability to identify specific stages. For example, the geologic history of our watershed, which was unglaciated during the last ice age, still impacts our channel stages and resiliency potential today. However, assessing stream evolution stage and thinking about physical complexity provides important context for evaluating the trajectory toward resilience of unique project sites and we plan to incorporate this into our conceptual model.

Restoring to the Future: Cluer and Thorne's SEM also describes that optimal ecosystem benefits will be achieved in depositional reaches with a dynamic multi-thread stage zero channel with a broad floodplain and complex habitats to support long-term resiliency. Based on this recommendation, we are using this approach at one of our 2019 restoration projects and setting up an adaptive restoration experiment to quantify the ecosystem benefits of a stage zero channel. Above, the rendering on the left shows a stage zero restoration one year after project completion. The rendering on the right shows just one (of many possible) potential futures for a stage zero site multiple years after restoration.

Streamlining Monitoring Protocols

Opportunities to improve protocols was a key lesson learned during our first year of comprehensive data collection. In particular, we identified areas where the performance of multiple functions could be monitored with one streamlined protocol, rather than several function-specific protocols. For example, in 2019 we measured pool depth at one pool per site and long-profiles for habitat complexity at all sites. This approach provided limited information about habitat quality. Moving forward we plan to use a biotypes protocol to assess both habitat complexity and quality. Using this approach, we will measure pool depth and length as low flows, as well as proportions of riffles, runs, pools and glide. All updated protocols associated with our adaptive management plan will be available on our website (www.watershed.center).

Identifying Future Opportunities

Water quality data collected in 2019 reflected both inherent limitations of restoration in a working river and opportunities for future adaptive management. Water quality consistently declined in the plains, despite restoration efforts to improve riparian community and habitat. As with the SEM stages, this ties back to the importance of site-specific goals about what ecological outcomes are possible in the context of working rivers. However, restoration also provides unique opportunities for future adaptive management to improve flow conditions. Close partnerships developed with water owners during restoration projects have led to a shared interest in improving steam connectivity, where possible, through operational changes without impacting water rights. Adaptive management of these reaches will provide future opportunities to quantify ecosystem benefits of improving flows in a working river.