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FOURMILE – MONITORING & ADAPTIVE MANAGEMENT

FINAL REPORT

PREPARED FOR

COLORADO WATERSHED RESTORATION PROGRAM GRANT

ATTN: CHRIS STURM

JUNE 30, 2022

GRANTEE: FOUR MILE FIRE PROTECTION DISTRICT

AKA FOURMILE WATERSHED COALITION/BOULDER WATERSHED COLLECTIVE

GRANT AMOUNT: $64,149

PREPARED BY: CAT PRICE

THE BOULDER WATERSHED COLLECTIVE

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1. Introduction & Background

In September 2013, heavy rains fell on the Front Range of Colorado for five consecutive days, causing catastrophic flooding and significant damage to public and private property and infrastructure. Boulder County was 1 of 18 counties part of the Presidential Disaster Declaration on September 24, 2013.

Under the fiscal responsibility of the Four Mile Fire Protection District, the Fourmile Watershed Coalition (FWC) formed in the wake of the flood to spearhead recovery efforts in the Fourmile Creek Watershed. During that immediate recovery period, FWC brought communities and local stakeholders together; created master plans to identify and prioritize needs; secured federal, state, and local funding to complete flood recovery projects; and implemented nearly 14,000 linear feet of stream and riparian rehabilitation projects within the watershed.

To evaluate whether the Coalition-implemented flood recovery stream restoration projects achieved their stated goals, careful and consistent monitoring was deemed a necessary responsibility. Monitoring efforts helped to determine whether interim actions should be taken to adaptively manage these projects toward meeting their objectives and positively impacting their river corridors. Those aspects, paired with discussions with the Technical Assistance team and industry experts, catalyzed FWC to request funds from the Colorado Watershed Restoration Program grant to develop a watershed wide monitoring and adaptive management framework that could be applied to all Fourmile project sites (map below).

Image 1. Fourmile Monitoring & Adaptive Management 11 Project Sites (Blue Markers)

CLICK HERE TO VIEW GEO-TAGGED MAP

FWC created a scope of work with three tasks: (1) to create a monitoring and adaptive management plan, (2) to execute the monitoring goals there in with site-specific tasks, and (3) complete adaptive management evaluations (and subsequent action(s) if necessary) at Fourmile Creek Watershed flood recovery project locations. In January of 2018, the Colorado Water Conservation Board (CWCB) awarded $64,149 to support monitoring and adaptive management goals.

2. Methods

The development of a robust long-term monitoring and adaptive management plan began by reviewing pre-project monitoring data where available, collaborating with designers and experts, and incorporating existing monitoring plans created for specific projects. The objectives determined during the initial project development phase include:

- Develop a comprehensive Monitoring Plan,
- Develop an Adaptive Management Framework,
- Monitor all Coalition stream restoration sites,
- Collect, analyze, and document data,
- Implement adaptive management strategies as appropriate, and
- Share data, strategies, and learning.

Task 1: Plan Development

The first task was to create the Monitoring Plan and accompanying Adaptive Management framework. From the onset, the primary goals of this plan were:

(1) To monitor the long-term effectiveness of flood recovery projects by tracking changes to stream health factors and key watershed functions over time; and

(2) To inform adaptive management decisions so that if needed, actions can be taken to keep the project area on a trajectory toward watershed health and resilience.

The FWC partnered with the Big Thompson Coalition to hire a consultant to develop the monitoring plan. Alba Watershed Consulting (Alba), uniquely suited due to extensive knowledge about individual project sites in each watershed, was selected to develop the plan following procurement policies and procedures.

Over many months Alba, Big Thompson, and FWC met to discuss goals and objectives, parameters and methods, and other needs to be addressed within the Plan. All participating parties understood that the Big Thompson River and Fourmile Creek were very different streams and thus monitoring and adaptive management needs could vary drastically. The plan was structured to list and describe general monitoring parameters and associated protocols, and then discuss each project to be monitored in the separate watersheds and their specific monitoring suggestions.

<u>The methods/procedures used during this task include:</u>

- Review project/site specific goals and objectives to compile watershed-level objectives
- Review existing data, including any pre-project data available, design reports, etc.
- Interview and collaborate with project design engineers
- Review exiting monitoring and adaptive management methodologies (academics, practitioners, etc.)
- Develop metrics and parameters for assessment
- Assemble a comprehensive monitoring plan and accompanying adaptive management framework that supports goals and objectives

After many reviews and iterations, a final, all-inclusive Monitoring Plan document was completed, put into function, and utilized by FWC staff to begin scheduling the field seasons and gathering multi-year project data.

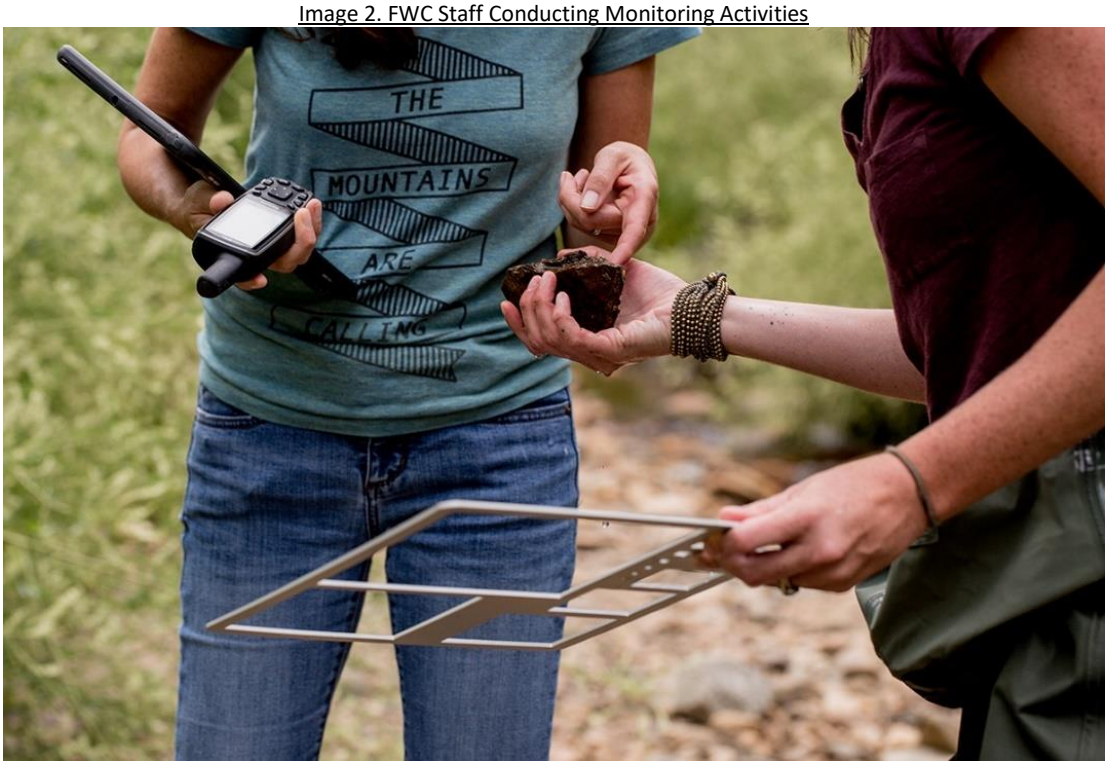
In the same time period, Alba, Big Thompson, and FWC also met with the Lefthand Watershed Center to understand their approach to monitoring and adaptive management. FWC decided to

use the framework as a general guide complimentary to internal decision making for adaptive management needs/considerations. This framework can be found in the shared drive project folder.

Task 2: Monitoring

The field monitoring methods utilized during the Task 2 efforts of this project were driven by the parameters and objectives developed in Task 1 and the full description of each field monitoring method can be found in the accompanying Monitoring Plan found in the shared drive project folder. Qualitative and quantitative data was collected and used to measure project outcomes and guide adaptive management strategies.

Image 2. FWC Staff Conducting Monitoring Activities



Logan Mill, Monitoring Activity: Pebble Count, Early Fall 2019

The general methods/procedures used to fulfill this task as a grant deliverable include:

- Acquire necessary equipment/supplies
- Train staff to implement technical monitoring procedures
- Schedule monitoring activities
- Collect data (staff, consultants, volunteers, interns, etc.)
- Analyze data (consultants)
- Incorporate data findings into FWC plans and processes
- Maintain equipment and store data

Image 3. FWC Staff Conducting Monitoring Activities

Some parameters incorporated into the plan and monitored each year include substrate surveys (pebble counts and point bar surveys), water quality sampling, in-stream feature surveys (pools, habitat, thalweg), vegetation monitoring, flow measurements, fish population, benthic macroinvertebrate studies, and photo point documentation. A full list of parameters, methods, and procedures can be found in the Monitoring Plan in the shared drive project folder. Due to the large file size and robust data sets from three years of collection, the comprehensive data files are not included in this report and are kept separately in the shared drive project folder.

Image 4. FWC Staff & CPW Conducting Fish Population Monitoring Activity

Upper Fourmile, Monitoring Activity: Fish Population, June 2019

Task 3: Adaptive Management

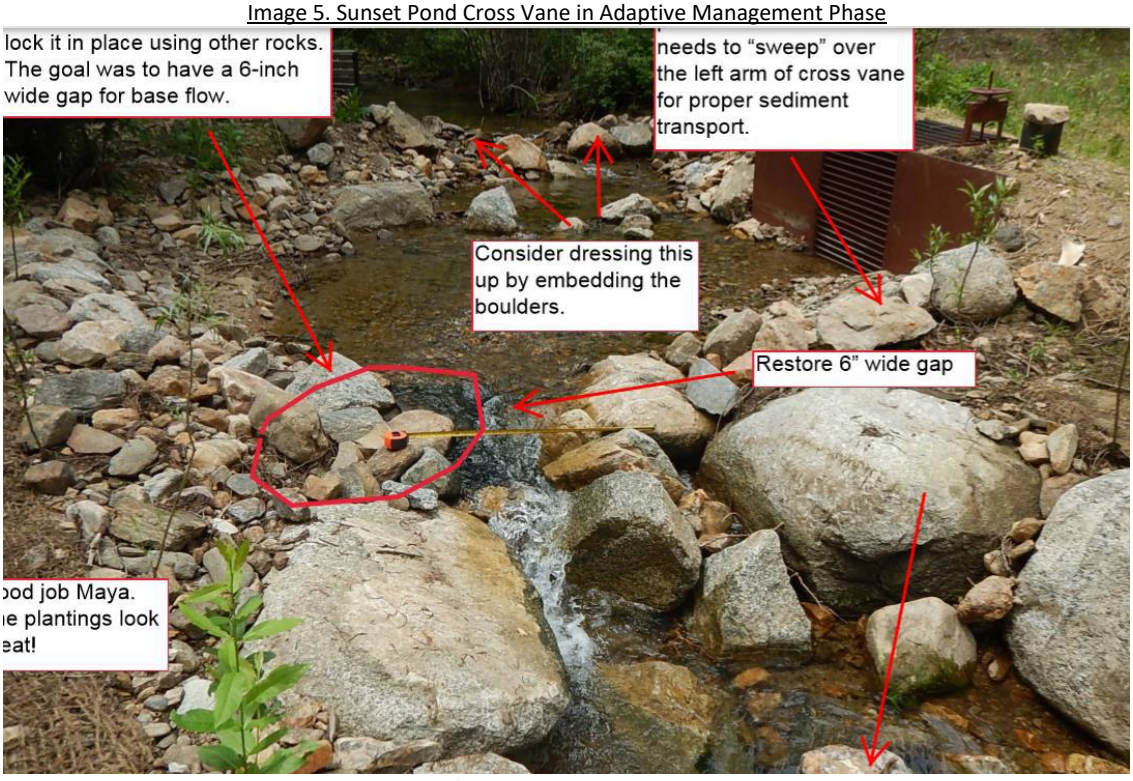
As project life advances, project outcomes are likely to change and revisions to project operations, monitoring, and maintenance procedures become necessary.

The methods/procedures used during this task include:

- Utilize adaptive management framework and monitoring data derived from previous tasks to inform evaluation and decision-making process
- Implement adaptive management strategy
- Document findings and actions as appropriate
- Share lessons learned and best management practices

Most stream restoration project sites did not require extensive Adaptive Management strategies to structural features, except for one cross-vane nearest a diversion structure at the Sunset Pond site. Construction completed in 2017 and the following year's runoff (2018) caused multiple boulders to shift and dislodge. After discussing options with the designer and contractor, the decision was made to repair the cross-vane to protect the diversion. Originally round, locally sourced boulders had been installed; the contractor repaired the cross vane with more angular boulders for reinstallation.

Image 5. Sunset Pond Cross Vane in Adaptive Management Phase



Sunset Pond, Upper Cross Vane, Summer 2018

Image 6. Sunset Pond Cross Vane in Post Adaptive Management

Sunset Pond, Upper Cross Vane, August 2021

The most common adaptive management activities that occurred were weed management, re-seeding and planting. At most sites, one or two seasons of re-seeding and/or weed management occurred before the native species outcompeted the weeds and no additional management was necessary. FWC typically used mechanical weed management with volunteers but did hire contractors for herbicide use where there were larger invasive species issues. The following sites received seeding and weed management: Sunset Pond, Wall Street, Logan Mill, Lower Fourmile Bank Protection locations, Ingram Gulch and Black Swan. Overall, each year displayed a healthy and diverse riparian zone moving farther up slope, while weeds and invasives were seen moving out of the system.

Image 7. Teens Inc Youth Core Weeding - Adaptive Management

Ingram Gulch, Cheat Grass & Weed Management, July 2019

Reseeding and container plant installations were two other adaptive management strategies FWC utilized for the Sunset Pond, Wall Street, Logan Mill, and Ingram Gulch sites. While the invasive species management was effective, these sites benefitted from additional container plantings in order to help foster a strong establishment in the riparian zone.

The Logan Mill site required attention for multiple seasons, since it struggled with both the weed spreading as well as unsuccessful seed and container growth in the upper zones. Soil samples were collected in winter of 2018 to provide directive on adaptive management actions. This soil analysis showed, among other things, sandy soil, low organic matter, and a pH of 8.1. One theory for the lack of grass growth was that the wood straw had been applied too thick and did not allow adequate sunlight to hit the soil, so a layer of the wood straw was removed prior to applying a soil amendment recommended by an ecologist. The site was responsive to these efforts and demonstrated successful seed growth by spring of 2019.

Image 8. Logan Mill Post Adaptive Management Soil Amendments

Logan Mill, Established Vegetation After Soil Amendments & Reseeding, August 2021

3. Results

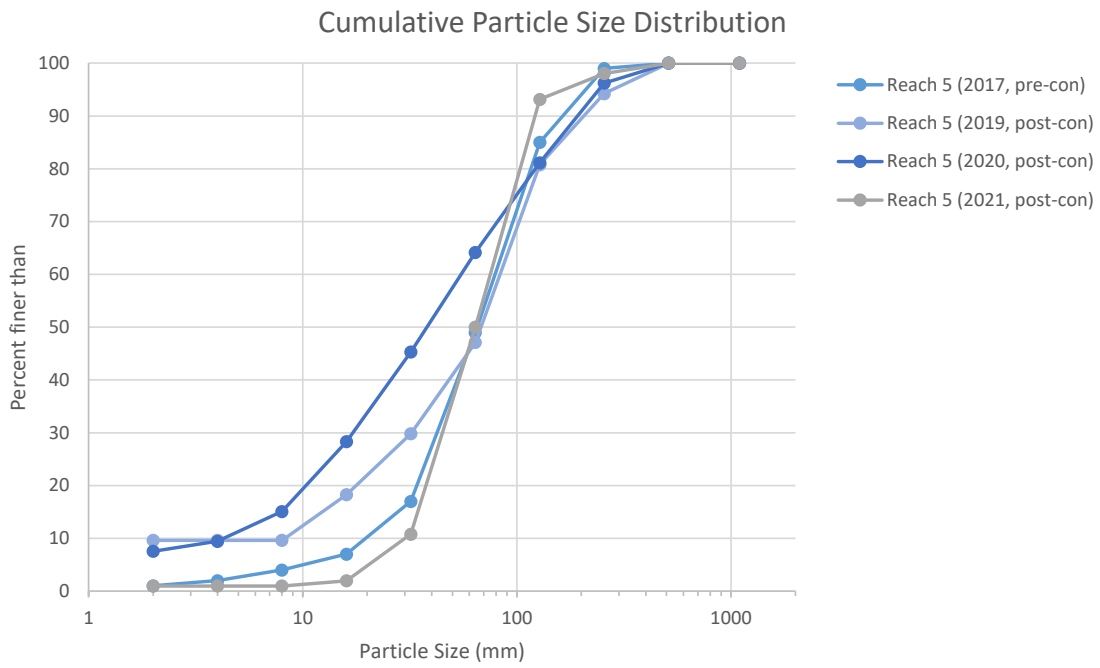
Comprehensive results from our Monitoring and Adaptive Management efforts are stored and can be found in the Data Summary Report and data files in the shared drive project folder. This Data Summary Report (DSR) presents data collected in 2019-2021 (and earlier years for some parameters) to support the Monitoring Plan's (BTWC/FWC 2019) goals of assessing areas of improvement and ecological lift within the Fourmile watershed. It describes data collection efforts for a suite of parameters measured at the project sites and a couple of reference sites. While it is still early to draw significant conclusions about geomorphic and ecological changes in

the watershed, this DSR serves as a starting point for presenting the results of data collection efforts and will be a living document with which to update and adjust as site objectives evolve.

Some representative results are displayed on the following pages.

Representative Results Example 1: Cumulative Particle Size – Wall Street – 2017-2021

Figure 1. Cumulative Particle Size Distribution – Wall Street – 2017-2021



Comparison of pre-construction (2017) to post-construction (2021) grain-size distributions indicates that fine sediments that may have accumulated in the interim years (late 2017 through 2020) due to construction activities or inadequate flushing flows have been significantly reduced by 2021. The D50 and D84 particle sizes of 77 and 128, respectively, in 2021 indicate that cobbles and coarse gravels comprise most of the stream bed substrate.

Representative Results Example 2:

Figure 2. Aquatic Habitat Types at Project Locations on Fourmile Creek - 2019-2021

In general, pool habitat dominates the Sunset and Black Swan project sites, and riffle habitat is more common in the Wall Street and Logan Mill sites. Runs and glides are much more uncommon at all locations. The dominance of pool habitat at the Sunset and Black Swan sites is likely related to the steepness of these reaches (4-6 percent grade), where step-pool systems are expected, rather than their position in the watershed or the impacts of restoration treatments. The grade at the Sunset project site is approximately 4 percent, and the average grade through the inventoried section of the Black Swan project site is 5.3 percent. The average grade at the Logan Mill project site is 3.3 percent, and the average grade through the inventoried section of the Wall Street project site is 2.8 percent. Plane-bed and pool-riffle systems are much more typical at these more moderate slopes, and these stream types generally exhibit a wider range of aquatic habitat types.

Changes over time were evident at all project sites, but it is unclear whether these are true transformations of bedforms or due to changes in surveyor, start and end locations, or other field monitoring disparities. At Sunset Pond, the proportions of aquatic habitat types remained

very consistent over time, which is expected due to the large size and quantity of rock used to create the step pools at that location.

Representative Results Example 3

Photo point documentation is arguably one of the most valuable tools available for long-term monitoring. Photo points provide a qualitative record of changes to stream and riparian parameters and can also be used to verify mapped parameters and make quantitative measurements (Beardsley and Johnson 2018). BWC utilizes photos points for overall landscape site monitoring, as well as specific site point documentation. Photo point documentation has allowed BWC to track not only construction and environmental progress, but also landowner use of the land and how best to interact with and educate those stewards. Examples can be seen below and more are stored in the BWC shared drive project folder.

Images 9 – 12: Logan Mill – Landscape Photo Point Documentation

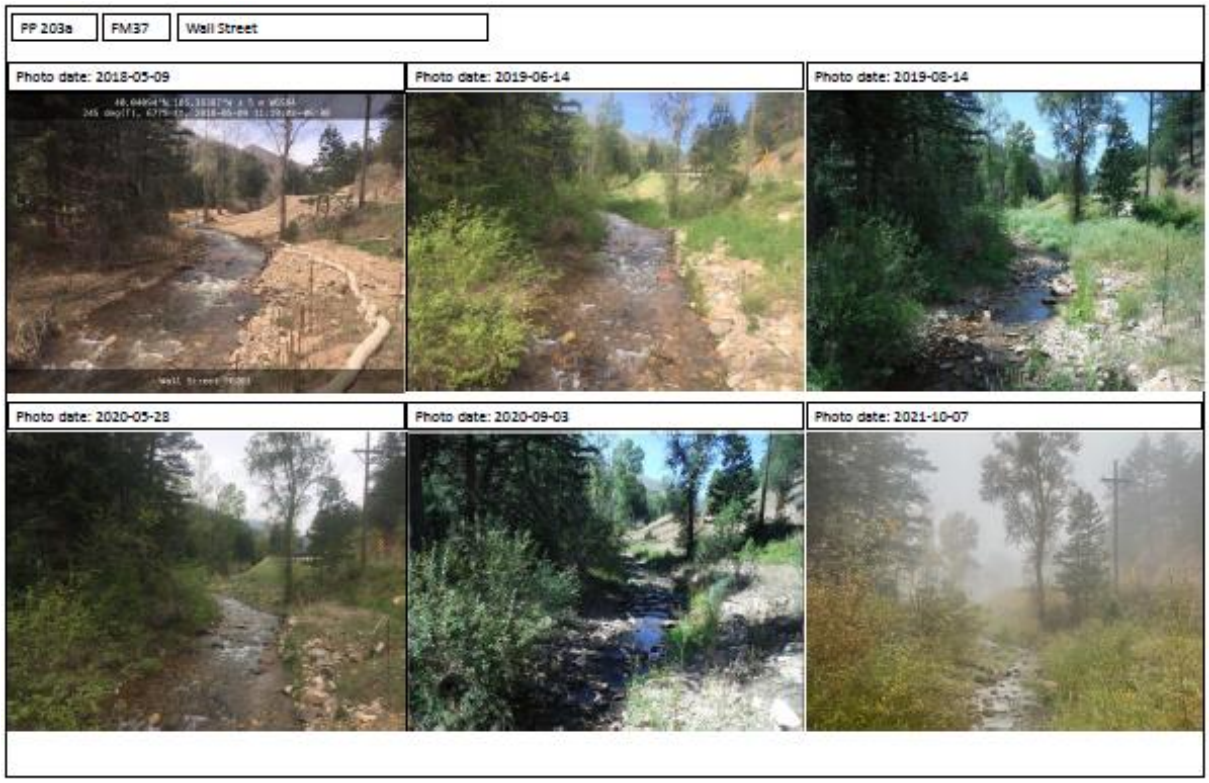
Pre-Construction 2016

Post-Construction 2017

(Early) April 2020

(Late) April 2021

Image 13: Wall Street – Example of Site-Specific Photo Point Documentation



4. Conclusions and Discussions

The objectives were met for this project. We have a robust monitoring plan with protocols which can be used at future sites, as well as significant experience collecting field data. This project helped us closely evaluate our project sites and really understand how they were progressing, identify problem areas and watch the trajectory of restoration unfold. Ultimately, this project helped us become more skilled with the full spectrum of stream restoration and more capable of assisting other flood affected communities in the future.

Challenges associated with this project primarily related to the lack of capacity a small agency must focus significant time collecting and analyzing data. At the beginning of the project, we wanted to create monitoring protocols which were not overly technical and could be completed in-house. For example, Alpine-Eco adapted a vegetation monitoring protocol which could be implemented by non-ecologists. It became evident over the years that a better approach might be to budget for hiring ecologists to collect and analyze the vegetation data. Outsourcing technical projects is more efficient for overall organizational management.

This plan began as a project with the Fourmile Watershed Coalition. In late 2020, the organization rebranded as the Boulder Watershed Collective (BWC) and expanded its geographic scope into the larger Boulder Creek watershed. This change will influence decisions about future

monitoring efforts. BWC intends to build upon this DSR in future years, eventually aiming to draw preliminary conclusions about the long-term effectiveness of flood recovery projects, the realization of specific project goals, and the Fourmile watershed's trajectory toward health and resilience. The past three years of monitoring have served as a learning tool and have created a foundation from which to adapt the Monitoring Plan to focus on high-priority locations within the larger Boulder Creek watershed while utilizing Fourmile sites as and representative reaches in the greater system.

5. Actual Expense Budget

Task	Description	CWCB Funds Requested/Received
1	Plan Development	$5,795.00
2	Monitoring	$46,799.53
3	Adaptive Management	$11,554.24
	TOTAL	**$64,148.77**

Match

Year	Agency	Amount	Cash/In-Kind	Task
2018	Teens Inc.	$12,293	In-kind	weeding, planting, pebble counts
2018	Western Native Seed	$593	Cash	Logan Mill seed
2018	Four Mile FPD	$5,000	Cash	Staffing
2018	TU/DRMS	$4,829	Cash	Water quality monitoring
2018	DOLA, CDBG-DR (Black Swan)	$15,850	Cash	Invasive species management
2019	Teens Inc.	$9,494	In-kind	weeding, planting
2019	CDPHE	$1,870	In-kind	Macro-invertebrate collection training
2019	One Tree Planted	$675	In-kind	Sunset Pond planting
2019	TU/DRMS	$4,959	Cash	Water quality monitoring
2019	DOLA, CDBG-DR (Glitter Gulch)	$1,000	Cash	Alba- monitoring
2019	DOLA, CDBG-DR (Ingram Gulch)	$35,000	Cash	Vegetation maintenance, irrigation/watering
2020	DOLA, CDBG-DR (Ingram Gulch)	$5,550	Cash	Invasive species management
2020	CPW	$4,000	In-Kind	Electro- fishing
	ALS Labs	$639	Cash	Water quality sampling
2020	TU/DRMS	$4,762	Cash	Water quality sampling
TOTAL		**$106,514**		

6. Appendix

The Monitoring Plan and the Data Summary Reports can be found in the in the shared drive project folder.

7. References

All references for attachments and accompanying documentation are listed in the appropriate appendices, reports, and documents and can be found in the shared drive project folder.