COLORADO SCHOOL OF MINES
EARTH • ENERGY • ENVIRONMENT

Final Design Report

for

Beaver Habitat Development

Clear Creek Watershed & Forest Health Partnership

City of Golden

Colorado Watershed Assembly

Pinyon Environmental Inc

Team Members:

Mitchell Awdziejczyk

Nick Forrester

Alyssa Moreland

Emma Nelson

Hannah Snakenberg

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1. Project Review

The challenge tasked to the B.V.R. team was to assess the viability of beaver complexes and other methods as a means of stream restoration in the Clear Creek Watershed. This project was born from a 2020 Clear Creek Pre-Wildfire Planning Study. From the study, three locations along the stream were identified as critical locations for development. These locations may serve as a point of refuge and flood breaks in the case of a wildfire. Stream restoration efforts in the proposed locations will be beneficial for several other reasons as well. The main goal to work towards with our proposed solutions is to repair the floodplain, improve the water quality, and increase water storage. All of these effects will improve the overall quality of the watershed and reduce the effects of wildfires, flooding, and general human activity that has reduced the condition of the stream over time.

The project takes place along the mainstem of Clear Creek in Colorado in a roughly 3.5-mile stretch between Bakerville and Silverplume along the Colorado I-70 expressway. Three zones within this stretch of Clear Creek have been identified in the [Upper Clear Creek Watershed Pre-wildfire Planning Study] completed by Matrix Design, Inc. as critical locations for low-impact stream development. The proposed areas are prone to wildfires and post-wildfire flooding and would benefit from stream restoration efforts. The stream lies in the valley of the Clear Creek watershed and is constrained between two roadways on either side. The creek has significant variability in channel characteristics along the proposed sites, showing higher flow in pinched areas and low flow in wider sections. The most viable site for stream restoration was determined to be the westernmost location (39°41’38.2” N 105°47’08.9” W), SR-2, due to it possessing the necessary room for expansion of the floodplain and its lack of an existing beaver population. The site is well-wooded with aspen which is also necessary for beaver introduction.

Figure 1.1 Map of the three zones of interest as stated by the Upper Clear Creek Watershed Pre-Wildfire Planning Study. The zone on the far left was identified as our working site.

With the needs described above in mind, our goal is to provide a comprehensive report outlining multiple possible solutions. Our main deliverable is the Comprehensive Solution Analysis. We will also provide a formal recommendation based on our analysis. To achieve this, extensive site analysis, flow modeling, and research were completed along with heavy consideration of the thoughts and opinions of a diverse group of experts.

The Clear Creek Watershed and Forest Health Partnership plan to use the Comprehensive Solution Analysis to support their efforts in acquiring funding in order to revitalize this area of the Clear Creek Watershed.

Site Background

The specific location identified along Clear Creek at our site is extremely dynamic. In the nine months that we have been monitoring the area, the landscape, flow patterns, tree coverage, as well as beaver activity have all changed dramatically.

In the initial site visitation, evidence of beaver activity was present, although relatively minor. Beaver fallen trees were few and far between and the stream, while wandering, was fairly narrow in most areas.

Figure 1.2 Beaver Chew Found on Initial Site Visit on March 16, 2023

Figure 1.3 General Landscape Found on Initial Site Visit March 16, 2023

In August of 2023 the site was revisited and it was found that beaver activity in the area had increased dramatically. Heavy rain in the early summer months had changed aspects of the stream's flow patterns; an abundance of beaver fallen trees also impacted the flow dynamics in the area. Beaver activity that was previously half a mile downstream had since moved into the area. Beaver activity within the site boundaries has expanded to two separate dams, a check dam denoted as Colony A Dam Beta ($CL\ A\ Dam$ β) and a main dam denoted as Colony A Dam Alpha ($CL\ A\ Dam$ α) as well as a beaver lodge which are represented in Figure 1.4. The beavers took it into their own small hands, building a roughly 160-foot wide dam, named Colony A Dam α, 500 feet upstream from our initially selected site (SR-2). The dam raises the water almost 8 feet above the existing stream and creates a pond, named Colony A Pond α, that spans more than an acre and averages at least 1 foot deep throughout, in some places getting as deep as 6 feet. Just slightly upstream of Dam α is another, older, structure which we will call Colony A Dam β. According to some local fishermen we spoke with, this dam has been around for about 5 years. However, this dam is much less structurally sound than Dam α, and currently only serves as a check dam of sorts, filtering larger debris from getting into the newly developing Pond α. The entire area of interest and the respective coordinates are outlined in Figure 1.5.

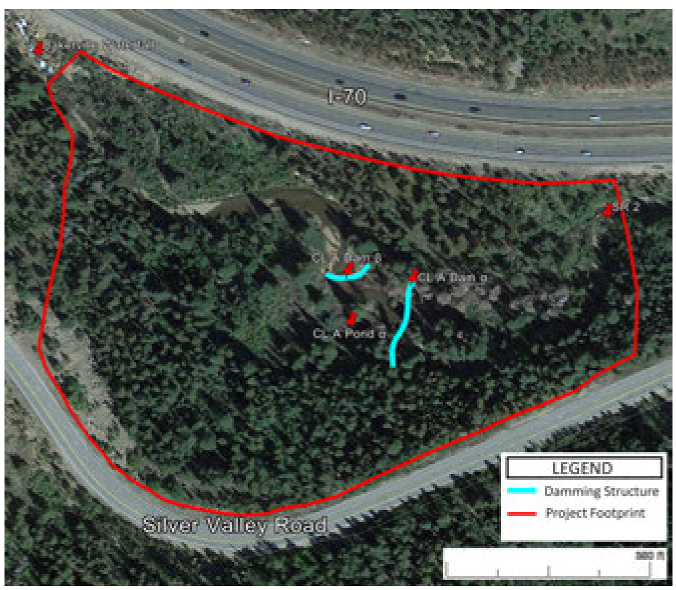

Figure 1.4 Project Footprint, New Dam Outlines, and New Pond

Figure 1.5 Naming Conventions and Coordinates of All Areas of Interest

Figure 1.6 Woody Debris and Beaver Chew October 17, 2023

Figure 1.7 Dam α October 17, 2023

<u>Final Solution</u>

After going on multiple site visits, utilizing our models, comparing costs, and analyzing previous solutions, the final solution was decided to be a combination of a few actions. Throughout the course of our research for this project it became clear that minimizing human interference in this developing ecosystem has to be a top priority.

1. Develop a new path to site, the current one has slopes which are unsuitable for equipment and/or people.
2. Revegetate in the meadow
3. Further investigation into spillway development:
4. Install a BSS above Colony A between:
    a. 39°41’37.96”N 105°47’15.55”W
    b. 39°41’38.48”N 105°47’17.39”W

Beaver populations are expanding rapidly in the immediate area, supporting that development is key to moving forward in a sustainable and effective manner. Increasing vegetation in the area will support beaver habitat development, stabilize the hillside to prevent erosion, increase water infiltration, and reduce risks of stormwater pollution in the area. Furthermore, adding the BSS or developing the spillway will increase the above-ground water storage.

<u>Stakeholder and Expert Engagement</u>

To accomplish our goals, we utilized the knowledge of experts and constantly verified our actions with our stakeholders. This was to ensure that our alternative analysis is quality work and sufficiently meets the clients needs. An overview of the stakeholders goals and objectives is outlined in Figure 1.8.

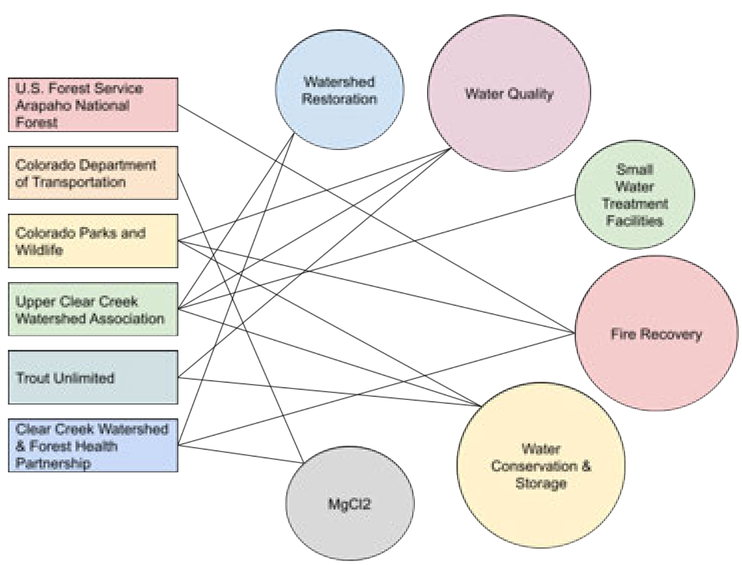

Figure 1.8 Stakeholder Goals Matrix

Having representatives of the values of the Colorado Department of Transportation, Upper Clear Creek Watershed Association, the Clear Creek Watershed and Forest Health Partnership, Pinyon Environmental Services, and the Golden Water Department on our client team allowed us to have a deeper understanding of four key players in this game. Their guidance, direction on resources, and connections in related industries were extremely valuable, and increased the effectiveness and depth of the solution. Our Clients, Ashley Giles, Diane Kielty, and Kerry Major, gave us constant constructive feedback as well as helped us grow as a team and as engineers.

Through our clients, we received supplements from other experts as well. Tammi Renninger, A GIS Technical Consultant who developed highly detailed GIS maps for use in site analysis and flow modeling. Amy Crandall, a Sediment and Debris Analyst for the Colorado Geologic Survey gave us a personal presentation on alluvial fans and how sediment and debris may act in our specific location. Paul Winkle, an Aquatic Biologist for the Colorado Division of Natural Resources went on a site visit with us and talked us through some of the complex relationships of the aquatic and semi aquatic wildlife in the surrounding areas. Joseph Walter, a District Wildlife Manager for Colorado Parks and Wildlife in the Idaho Springs area also accompanied the team on a site visit and gave us his direct testimony as to beaver activity in the area he had witnessed and insight into what we can and cannot do on public lands.

We also collaborated with professors at Mines. Alina Handorean, our project advisor aided the team in securing resources, developing good project management techniques, and provided constructive feedback on the work completed throughout the course. Dr. John Spear, one of our technical advisors, gave us a better understanding of the history of beaver in the area, he also provided great insight into water rights, interesting developments and projects happening around the country, and discussed with us the potential for increased water quality. His general understanding of many things included in the scope of this project allowed him to guide us through many of the convoluted intricacies that one must deal with when working in a field like this. Jeffrey Holley, another technical advisor, dedicated much of his time towards helping us understand the data needed to develop the site model in Civil 3D as well as how to properly use that data. Finally, Kate Spangler helped us by assisting with and providing essential equipment to take flow data, a dissolved oxygen sensor, and water waders. The time and effort volunteered by those mentioned above was critical in the completion of this project, their guidance and understanding allowed for us to develop a practical and attainable solution.

2. Application of Design Methodology/Exploration

Over the course of this project, research was consistently a significant part of our problem solving process. There was a lot to learn from previous similar projects and to learn about the environmental impacts of possible designs. It was important to know the existing species in the area, the existing and past conditions of the site, and how the surrounding community may be impacted. Gathering the information helped us hone in on our scope, understand our goals better, and figure out which existing solutions would fit our project best.

Several potential solutions were explored as a means of developing and improving the riparian habitat and watershed health. These consisted of beaver expansion, Beaver Dam Analogs (BDAs), step pools, revegetation, man made dams, as well as anchored and unanchored debris. Beaver expansion in the area was explored as the primary solution, due to the number of beavers already present in the area and their effectiveness at causing change to the stream system. Analog dams and man made dams were explored as a highly effective short term solution. They also act as a potential habitat enticement for beavers, as they may build upon dams and improve them. Other minor solutions were considered as well, such as revegetation, step pools, and woody debris. These potential solutions were considered to be less effective but also less invasive to the site. We narrowed down the solutions by continuing our research and consulting with our technical advisors

Another way we determined our final solution was through modeling and surveying. Going on site visits was an effective way to familiarize ourselves with the existing conditions and get a better grasp on what the needs of the environment are. Through going on site visits, we learned that there was already some pooling and channeling and a lot of beaver activity. This further helped us specialize our solution to accommodate and utilize the existing conditions. On our site visits, we surveyed the area with a total station to get topographic information and collected water samples before, at, and after an existing beaver dam. This was to get existing water storage data and see how beaver dams impact water chemistry. The identified maximum amount of water storage was 68 acre-feet, so getting a baseline of the current storage let us know how much we could expand it. One of the considerations with our project was also to address the magnesium chloride in the water. The water testing data showed how the dam impacts the concentration of magnesium and other constituents in the water (see Appendix B – Calculations for water quality comparisons). Finally, with our survey data, we were able to model the stream and see how adding our proposed solutions would impact flow, retention, water behavior, and storage.

Figure 2.1 *Surveying the site* **Figure 2.2** *Testing at the Golden water lab*

Furthermore, in order to achieve the design goals for this project, our team utilized a method of iterative design which incorporated changing criteria to remain flexible throughout the design process. We followed the Scrum strategy which involved a cycle of introduction - exploration - and reflection. We started by identifying our goals over the course of 2 weeks and what we reasonably could achieve. Over the 2 weeks, we would explore our tasks and work towards our internal, smaller goals. At the end of the 2 weeks, we would come together as a team and with the client and reflect on what went well, if we achieved what we set out to achieve, and what should happen next. This strategy ensured we were constantly getting better; we improved the way we worked together and split up tasks and how we met the clients expectations.

3. Engineering Analysis

In order to gather a better understanding of the layout of our site and the possibilities for development, we conducted several site visits to our selected location. These site visits initially involved only visual inspection and water testing, however, we planned to also start surveying the stream bed above and below our initially selected site (SR-2) in order to create a profile which we could use for flow modeling. The first day we set out to begin surveying SR-2 we came across a newly developed ~163 ft wide dam (CL A Dam α). This changed our plans drastically and we instead began to survey the newly created pond (CL A Pond α) above the dam to try to get a volume of how much water this structure was holding.

Since then, our team has gone on several more surveying and water testing trips focused around this new site of interest. The purpose of these trips has been to both continue surveying the newly developed beaver structures, as well as surveying a nearby area of land, which we have referred to as the meadow. Throughout this area there are several channels both dry and active with water. We surveyed these channels in the hopes that some of, or more specifically one of these channels may be utilized to connect the meadow to Clear Creek and activate this floodplain into a more permanent structure expanding the volume of water stored above Dam α. Once we had sufficient points collected for these channels, our window of good weather and need for more surveying had come to an end.

Figure 3.1 Total Station [1]

Figure 3.2 Prism and Staff [2]

To complete the surveying we utilized a Total Station (Figure 3.1) and Prism (Figure 3.2) to collect the relative locations of points of interest at the site. A Total Station is an electronic instrument used for surveying; It is a device which is capable of acting as a theodolite (measures vertical and horizontal angles) and perform electronic distance measurements (precise distance measurements when shot at a Prism). We set our Total Station up at a location which we staked and tied this staked location into two other staked permanent points creating a relative resection map from which all other points were then based on. The Total Station control point was not precisely located as the nearest Horizontal Control point [1] was roughly 0.34 miles up the road and would have required at least 5 Total Station teardowns and setups, several along an active road with blind corners and high speeds, a risk we were not willing to take. Instead, we located our relative map coordinates based on a rough coordinate from map estimation and aligning our taken points to the LiDAR topography in Civil 3D. For this reason, our Civil 3D models are good estimates, but the precision is not exact.

From there, we have continued our analysis of the site in Civil 3D and HEC-RAS. During the survey, our strategy was to collect points along the existing shoreline, so that the pond could be built in Civil 3D, and a volume could be found. In Civil 3D, we overlaid our survey points collected in the field on top of LiDAR data collected by the Colorado Water Conservation Board via the Colorado Hazard Mapping & Risk MAP Portal [3] to create a surface of our site. From this model, we found a volume for the newly developed Pond α, Pond □, Pond □, and attempted to create a file which could be translated to HEC-RAS for flow modeling.

In addition to surveying our site, we also collected water quality samples to analyze the potential effects of our project on the stream's chemistry. Samples were taken in bottles and delivered to the City of Golden water testing lab. These samples were analyzed for turbidity, hardness, alkalinity, and dissolved metal content. Additionally, equipment borrowed from the Colorado School of Mines included a water flow meter to determine the volume flow rate of the creek upstream of the dam, precise values for pH, and dissolved oxygen. Initially, 3 locations were selected for testing surrounding another existing beaver habitat, Colony B, and at our originally selected site, SR-2, as a test subject to observe any differences caused by beaver damming.

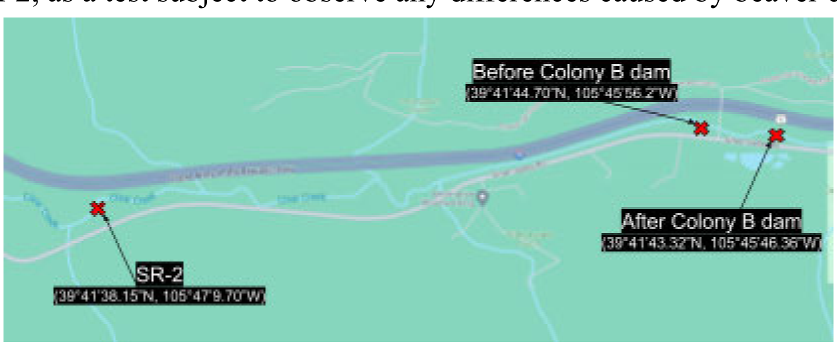

Figure 3.3 Initial Water Test Sites

After returning from summer break we returned to our site to survey and found the newly established CL A Dam α and Pond α which we could now test as its location was much closer to the originally desired location. For our next round of testing, we maintained our 3 original test locations in order to compare with our first round of collection as well as adding two new locations. One in the channel leading up to Pond α and another in Pond α. Our original test site at SR-2 acted as an after dam site being only 500 ft downstream of Dam α.

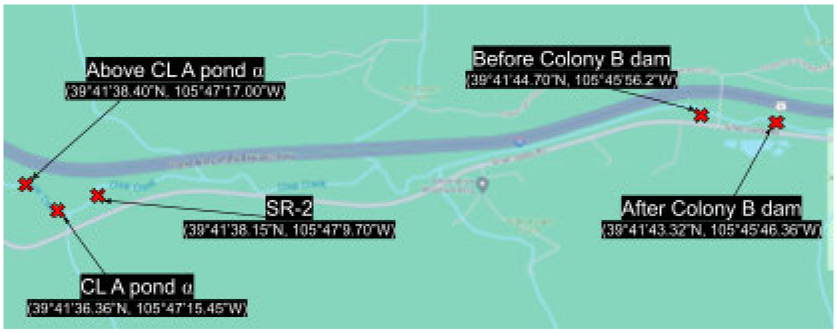

Figure 3.3 Fall 2023 Water Test Sites

4. Final Deliverables

Alternative Analysis and Recommendation and Plan of Action

Introduction

The B.V.R team was tasked with creating an alternative analysis of possible solutions to address the clients needs (See *Stakeholder and Expert Engagement*). The solutions explored include natural expansion and revegetation, adding Beaver Simulated Structures, and adding a human-made large dam. The following are explanations of the solution accompanied by a comprehensive pro and con discussion. The pros and cons are further summarized for each solution for ease of understanding.

When choosing solutions to investigate, we considered the clients needs as well as the impacts on the surrounding environment. The main goal kept in mind was to increase water storage while maintaining the health of the ecosystem. The solutions are discussed by level of human-intervention, natural expansion and revegetation being the lowest level (least human intervention). At the end of the analysis is our formal recommendation and suggested plan of action for the project.

Natural Expansion and Revegetation

Riparian revegetation consists of planting sturdy, long-rooted bushes/trees/other native plants near or on a stream embankment in order to increase stream channel stability and decrease flood risk [5]. While the main purpose of revegetation is to increase stability, it has a lot of positive impacts on the stream environment including increasing diversity, restoring habitats, and improving water quality [6]. They require careful planning to ensure that they will be successful [7]. Based on B

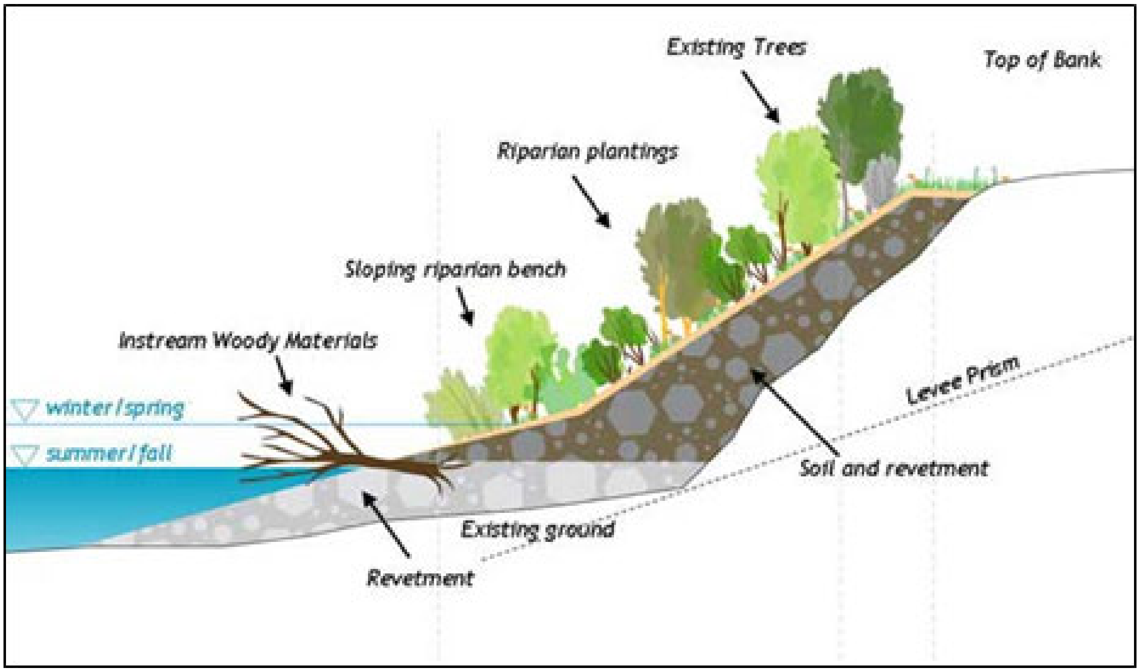

Figure 4.1 Example Riparian Revegetation Plan

Revegetation can lead to many improvements in the water and habitat quality of an area. It can also encourage beaver activity by providing food and materials for them. It also may increase flood resistance and decrease erosion as the plants will absorb more water and reinforce the soil. If done right, a single revegetation effort can help an area thrive on its own for years. It can also be used in conjunction with other solutions, should those be explored in the future. For example, revegetation can be used if there is any solution used that requires construction as a way to mitigate impacts to the environment.

At our sites, we have noticed significant amounts of beaver activity. They have already developed a substantial dam and seem to be continuing to grow it. This leads us to believe that, should their environment continue to be conducive to their needs (the water continues to flow and they still have sufficient food and materials), the population will continue to grow and more dams will be built. As more dams are built, the water storage will increase and the water quality could improve more as the retention times increase.

According to a revegetation guide created by the Colorado Parks and Wildlife (CPW), " In the montane zone, willow carrs occur adjacent to meandering streams on broad floodplains often inundated by beaver dams. Tall willows, in various combinations, often dominate these communities. Typical tall willow species include Drummond's willow, Geyer's willow, planeleaf willow, shining willow, and mountain willow. Barren ground willow, Wolf's willow and bog birch may be present, but more commonly occur at higher elevations. Water sedge, beaked sedge, and bluejoint reedgrass are common in the understory along with a variety of forbs." [8]. Based on this, these will be the best vegetation options to include, these are also great options because beavers like to eat willows and birch.

Figure 4.2 Wolf Willow

Figure 4.3 Bog Birch

Due to the nature of revegetation, the lifetime of the plants must be considered and it is important to remember that the positive impacts of this method may take years to develop. That being said, there are many pros to revegetation. This is a long-term solution which requires very little human intervention. This means that there will be minimal disturbance to the environment and is very hands off after the initial planting. Pros specific to the impacts of revegetation are extensive. Plant roots act as binders which help hold the soil together. This will improve channel slope stability by decreasing risk of erosion. Along with this, the plants will increase infiltration. The roots of the plants act as little pockets to increase the water infiltration, this increase of water infiltration will also decrease flood risks as the water levels will not get as high. Furthermore, these plants are specifically picked because they help repair riparian habitats and/or serve as food for animals who typically live in riparian habitats, thus improving the habitat to help the ecosystem thrive.

There are also some cons to revegetation. Primarily, the long timeline associated with it in order to see the benefits. It could take years, or even decades, to get significant results (depending on the plants). Furthermore, flood levels at the revegetated site may not be decreased as they will downstream because it takes time for the infiltration to occur. Finally, it does not directly increase above-ground storage as it does not increase any volumes.

Table 4.1 Pros and Cons of Revegetation [9]

Pros	Cons
Improve channel stability	Long timeline – depends on what is planted
Riparian habitat improvement	Flood levels may increase in the vicinity of the rehabilitated riparian zone
Improved water quality	On its own, does not increase above-ground storage capacity significantly
Flood risk decreases downstream	
Long-term, very little human involvement, often only a single-action required	
Increase infiltration (underground storage)	

Beaver-Simulated Structures (BSS)

These are a manmade structure designed to mimic beaver activity. They utilize woody debris in order to pond the flow and act as a dam. This will encourage beaver activity near these dams. Beavers will often continue to build upon BSSs, reinforcing with more wood and mud, increasing their seal and improving functionality. These structures are often catalysts for habitat expansion and complex development. BSSs tend to be cost-effective compared to other stream restoration techniques. Installment costs range around $2,000-$5,000. This is a direct result of promoting increased beaver activity and allowing nature to complete the work for us.

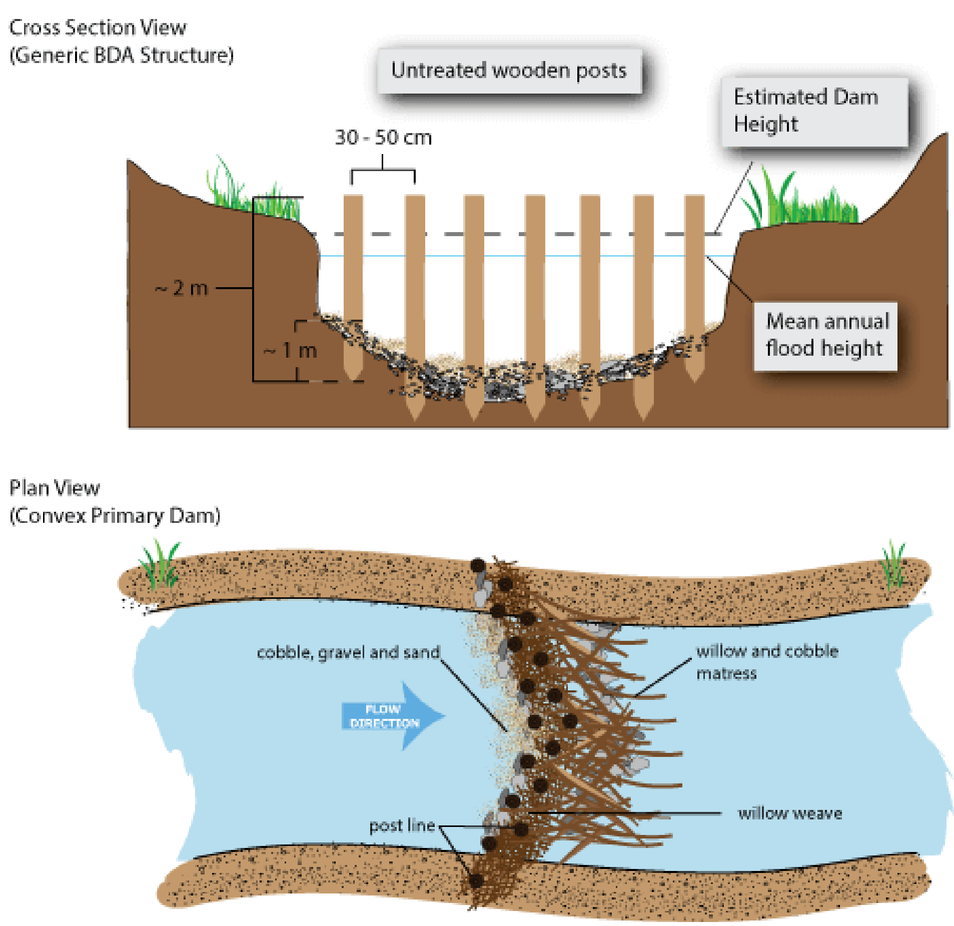

Figure 4.4 BSS Cross Section and Plan View

We tested two different possible spots to add a BSS. The first being at SR-2. When calculating the volume retained from adding a BSS, we found that there would be no significant increase of water storage at this location. This is because the slope from Colony A, Dam α to SR-2 changes rapidly, requiring an outrageously wide dam to keep water from going around it and negating any actual effects of the damming structure.The second spot was above the Colony A Dam β. It also did not cause significant increases in water storage for the same reasons as the first spot. It would have to be extremely wide (beyond the width of the creek) to account for the water channelizing in the meadow adjacent to it.

Stream restoration through BSS introduction is not an overnight process and will slowly change the profile of a stream over the course of several years. Positive benefits of installation can be seen relatively quickly however, within 1 to 3 years of installation beaver can be fairly established and stream flow will begin to change and adapt.

To better understand how beaver dams and how they impact water chemistry, on field visits we took multiple water tests. The findings of these tests will be discussed in Appendix B, Table B.1 and B.2 for the original comparison data.

Water quality testing conducted on 4/20/23 was taken before and after colony dam B as well as SR-2 and data was compared across all variations of sites. Most significant changes were found in the parameters Aluminium, Iron, Manganese, Zinc, Nitrate, Nitrite, Turbidity, as well as total Nitrogen. Aluminum increased by 75% before and after the Colony A and Colony B dam, which could be attributed to runoff from I-70. Deicing roads has shown a correlation to an increase in Aluminum caused by leaching from road fills. Results from later testing on 10/17/23 showed an increase in Aluminum by 185% before and after the largest dam, potentially caused by runoff from the roads. Other measurements before and after the dam that increased due to runoff from I-70 or industrial discharges include Iron and Manganese. During this same round of testing, Nitrate showed a significant decrease in measured values by 72.8% for the same locations. High Nitrate values in water indicate the presence of runoff from fertilizers, wastewater, or urban drainage. The reduction in this parameter pre and post dam could potentially be caused by microbial heterotrophic and autotrophic processes that occur in the pond due to the increased residence time.Turbidity showed an increase before and after the dam, which contradicts the teams prediction that it would decrease the amount of suspended solids. This could require further iterative testing in order to understand if beaver dams have a positive or negative effect on turbidity. Other measured parameters before and after the dam were not as significant in their differences.

Water quality testing as a whole helped to evaluate what constituents were most concerning in the stream system. Beaver dams prove to have an effect on some of the measured parameters but the team found there was a need for continued monitoring to prove any correlations. Inconsistencies in data based on measurements taken at different times of the year also indicates the need for additional year round testing if desired.

Other benefits include a direct increase in water storage capacity. BSS's will act the same as normal beaver dams and will cause ponding. The other pros are very similar to revegetation; it will improve water quality (as discussed above) by increasing retention time (thus increasing the time for constituents to adsorb to the surfaces), as well as decrease flood risk downstream by holding back more water before it gets downstream.

The cons for BSS are mostly associated with construction. The path down to the site of interest is very steep. It may be challenging to get equipment and people down to work on the BSS. Furthermore, this construction will disturb the surrounding environment and the existing beaver habitat. BBSs are also not 100% fail proof. If there is a major flood event, the dam could break and increase risks of flood damage down stream. Finally, it may require maintenance if beavers do not adopt it and continue to work on it.

Table 4.2 Pros and Cons of BSS

Pros	Cons
More water storage and sediment depositing than simply revegetating	Construction equipment will need to be brought down to the site. This will be challenging because of the steep grade to reach the site from Silver Valley rd, which has grades up to 40%
Fast timeline (1-3 years to see results)	Construction activity could possibly disturb the existing beaver habitat
Improved water quality as retention allows for natural chemical activity	Increased storage increases downstream risks from potential dam failure
Flood risks decrease downstream	Costs more than simply revegetating
Support existing beaver activity	Not self-sustaining and may require maintenance

Human-Made Large Dam

The pre wildfire planning study proposed a man made, concrete dam in place of the recently developed beaver dam that now exists on our site. The study proposed an 18ft high dam across the stream cross section that would reach nearly up to the elevation of Interstate 70. This dam would allow for the absolute maximum water storage for our project site at about 21 acre ft of volume, with 4.41 acres of area available to work with. This is by far the most extreme measure proposed as an alternative to revegetation and leaving the beavers to do the work. At the very least, an access road would need to be built from Silver Valley Rd down to the stream in order to bring heavy equipment to the site. Additionally, flooding risks would be extremely high; the water level of the pond would be very close to running off onto I-70, and the downstream risks from a dam failure would be far more considerable and destructive.

Figure 4.5 Example of Existing Concrete Human-Made Dam [11]

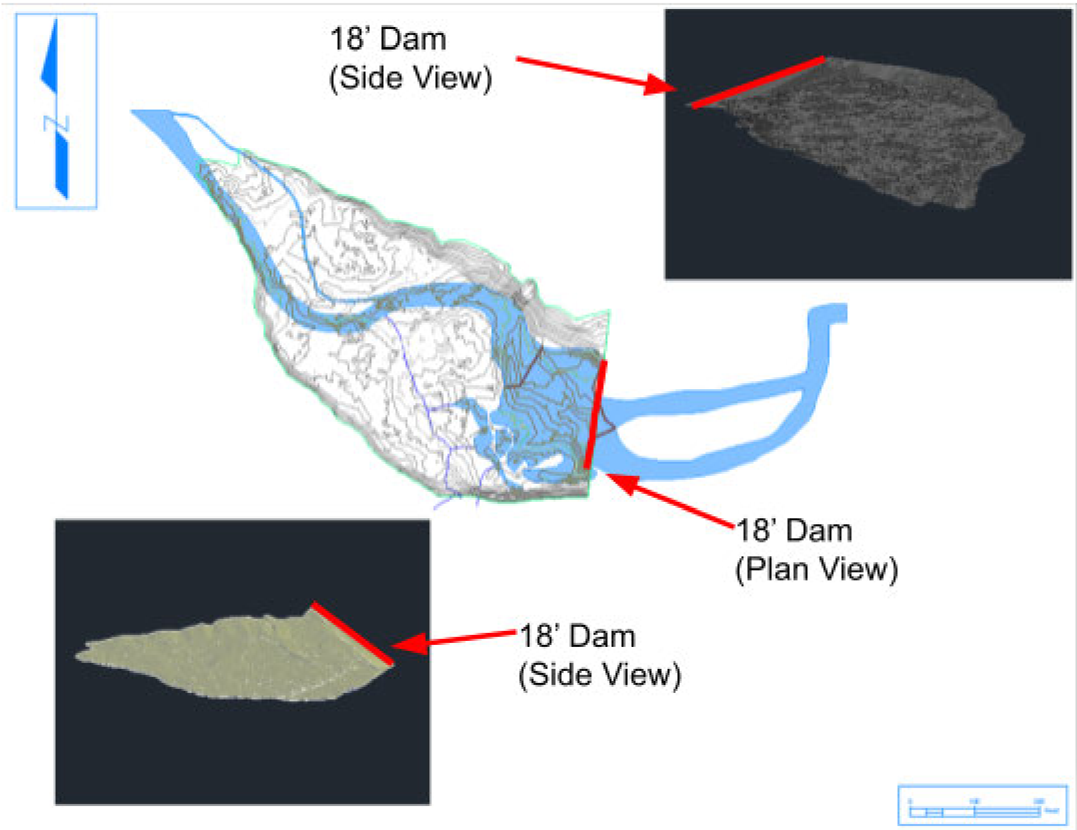

Figure 4.6 Civil 3D rendered Surface of Potential Human-Made Dam

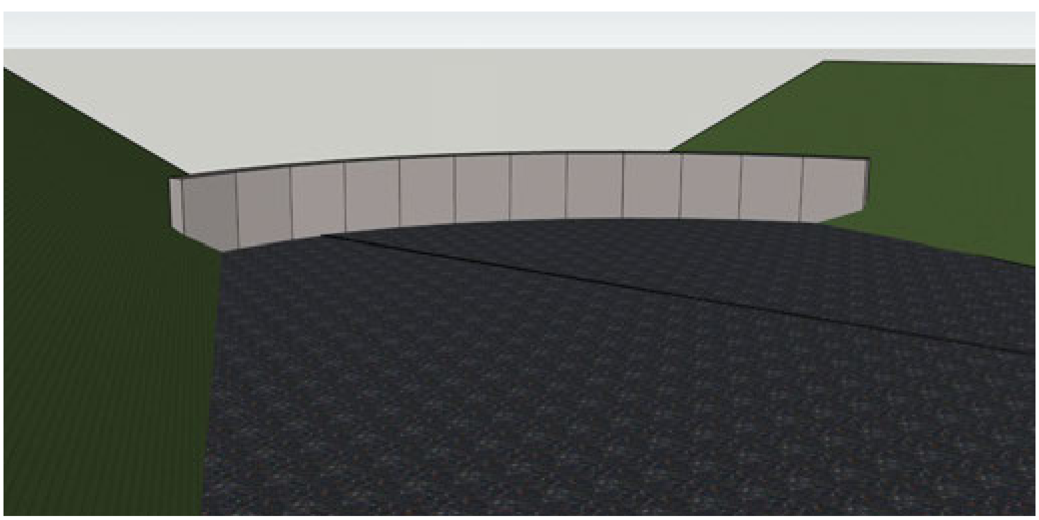

Figure 4.7 CAD Rendered Potential Human-Made Dam

Table 4.3 Pros and Cons of Human-Made Large Dam

Pros	Cons
Very high water storage in comparison to other alternatives at ~21 ac ft	Highly destructive to existing beaver habitat - current beaver dam and colony would need to be removed
Highly increased ground infiltration in the creek valley	High risk from potential floods
Improved water quality from natural chemical reactions from increased retention time	Equipment would be difficult to get to the site, an access road would need to be constructed with cut and fill
	Would highly alter the existing environment, as current habitat would be flooded over
	Cost would by far be the highest of any alternative
	Extensive permitting would need to be acquired

As the final project deliverable became clearer focusing on things such as base level estimates and base level schedules have been developed, specifics of those schedules and budgets cannot be fully determined until a solution plan is selected, this of course is dependent on the funding acquired by the Colorado Watershed and Forest Health Partnership. As such, a conservative estimate considering the most expensive selections as well as the longest project term. The man hour estimate is based on a five week project. The first two weeks are heavy on project management, resource securement, and detail planning. It is estimated that this will take 320 man hours, or a team of four engineers two weeks to complete. In the construction phase there is ideally a crew of 8 guys working on the project over the span of 3 weeks. This estimate includes mobilization of equipment as well as the site reclamation after construction efforts have finished. For post construction Site Monitoring it would ideally include 3 engineers to analyze the water quality, development of localized ecosystems, and soil and hydraulic changes four times a year over the course of four years. This three phase plan is detailed in Appendix C.

Based on approximate per hour wages of 80 dollars per hour for crew members and 100 dollars per hour for engineers, the phases of the plan have costs as follows.

Engineering & Design	$36,000
Construction	$105,000
Post Construction Site Monitoring	$54,400

Table 4.4 – Project Cost Estimate

Using a conservative estimating style and having direct labor be approximately 40% of the overall cost, materials and equipment will cost $293,000 and the total cost for the project will be $490,000. Carson DeVinney a Senior Construction Engineer for Granite Construction was consulted in order to determine these values.

Clear Creek Revitalisation Plan

Cost Estimate

*PERT = (Opt + 4*Best + Pess)/6*

Level 1	Level 2	- item	Level 3	- item	Descriptions	Summations 1	2	3	4	Man-Hours Perf	Opt	Best	Pess	Worst	PERT
1	0	0	0	0	**Office Building**	**2,176.0**	**2,176.0**	2,176.0							
	2	1	0	0	**Engineering & Design**	*17%*	362.7								
		3	1	1	Project Management			90.7			64	80	160		90.7
		3	1	2	Bid Documents			90.7			64	80	160		90.7
		3	1	3	Revegitation Plan			45.3			32	40	80		45.3
		3	1	4	Structural Drawings			90.7			64	80	160		90.7
		3	1	5	Flow Management			45.3			32	40	80		45.3
	2	2	0	0	**Construction**	*58%*	1,269.3								
		3	2	1	Project Management			170.0			120	150	300		170.0
		3	2	2	Mobilize			45.3			32	40	80		45.3
		3	2	3	Excavation			22.7			16	20	40		22.7
		3	2	4	Concrete Dam			566.7			400	500	1,000		566.7
		3	2	5	Rip Rap			102.0			72	90	180		102.0
		3	2	6	Revegitation			102.0			72	90	180		102.0
		3	2	7	BDA			170.0			120	150	300		170.0
		3	2	8	Site Reclamation - Demobilization			90.7			64	80	160		90.7
	2	3			**Post Construction Site Monitoring**	*25%*	544.0								
		3	3	1	Environmental Monitoring			544.0			384	480	960		544.0
						100%	2,176.0				**1,472**	**1,840**	**3,680**		**2,085.3**
									50/50						2,085.3
									Contingency			245.3			

Figure 4.8 - Man Hour Estimate

Recommendation and Plan of Action

Based on our analysis of the possible alternatives and considering the costs to benefit analysis of each, we recommend the revegetation plan of action and opening the meadow by adding a BSS above Colony A. A revegetation plan created by Pitkin County in Colorado is the plan that we recommend following as it outlines a detailed plan for riparian revegetation. Building a BSS above Colony A would increase water storage by about 0.13 AF, help with sediment depositing, and increase water quality (Refer to Appendix B). All of this while still incentivizing the beavers to build the area. Further, it also has minimal human impact on the environment.

The original goal of our project was to incentivize beaver activity in our project area. This past summer, however, the beavers established a large dam on their own in the exact area that we wanted to. Because of this, we do not want to interfere much with their habitat and let them continue their dam building activity that will increase water storage throughout the stream, collect sediment and debris, and improve water quality. We also do not want to have anything constructed if not necessary so that the habitats are not disturbed and heavy costs can be saved. To encourage the beavers to keep building in the area, we propose that revegetating the area with their preferred trees and plants that will provide them with building material and food.

To achieve this, a team will be sent to the site to plant throughout the relatively flat meadows that surround the stream. We do not think it is necessary to plant up the steep hills, as there is already plenty of existing material that the beavers have been chewing and leaving. This will be done in the spring to allow seeds and/or saplings the best opportunity to grow. If needed, the site can be revisited in future years to be continually revegetated and continue supplying the beavers to keep them building dams in the desired area.

The current path down to the sites of interest are very steep and difficult to navigate. Moving forward, based on our site visits, we have provided a recommendation of where to excavate paths and how. This is for ease of access and also to set up a framework for future transportation needs (i.e. if another solution is explored and construction equipment is necessary). Figure 4.7 outlines these paths. It is designed to accommodate (width and slope of path) a bobcat. It is also important to note that these actions will require permitting and permissions from government organizations. A permit matrix is outlined in Table 4.4.

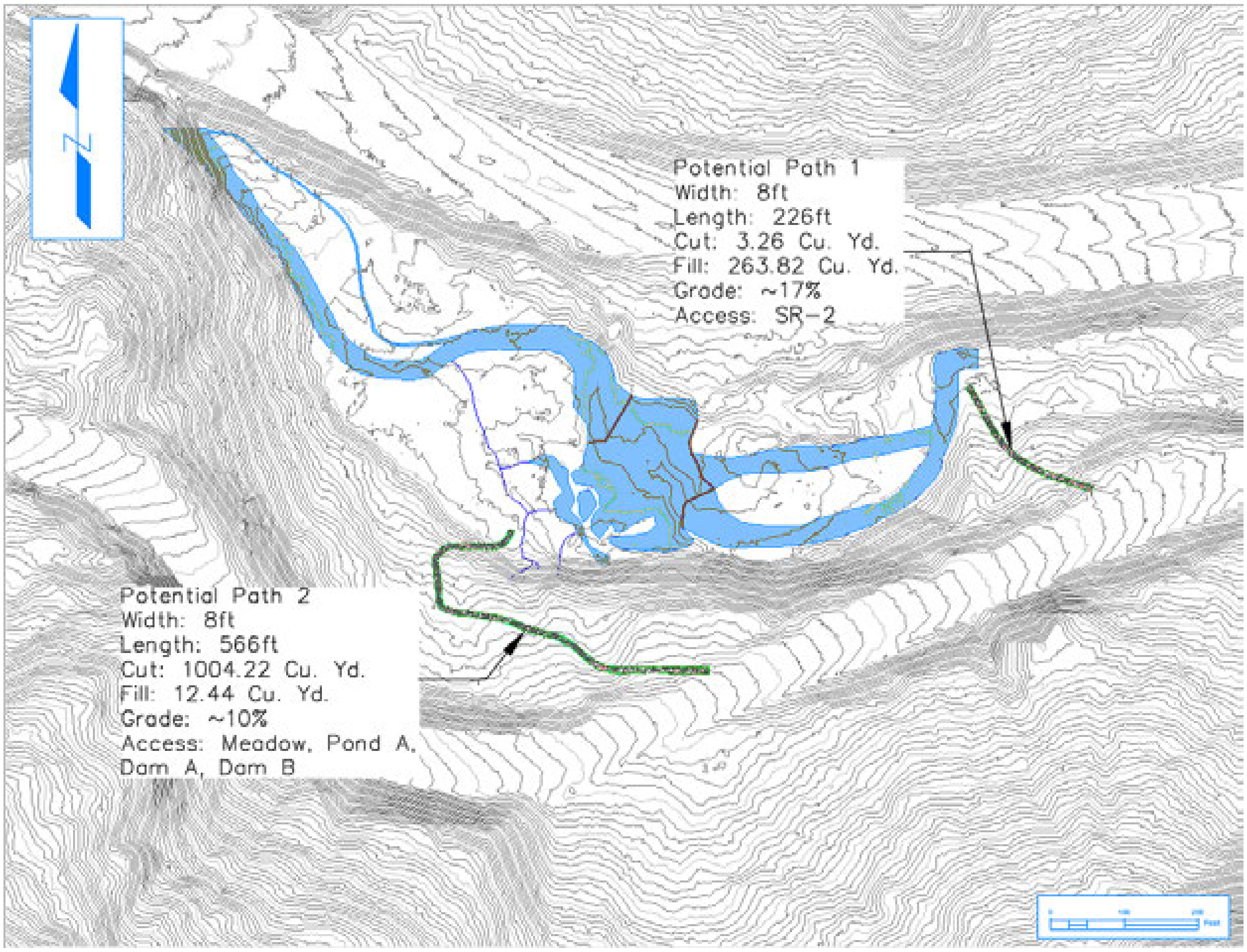

Figure 4.8 Recommended Paths to Sites

The access paths designed for this final solution were designed to accommodate a bobcat. They are 8ft wide and have grades varying between 1-20%. Bobcats can traverse grades up to 40%, however, for ease of access for people, a maximum grade of 20% was chosen. The current terrain to the sites are very steep (<40% grade), and this was the most cost effective maximum grade.

Table 4.4 Permit Matrix for Recommended Design

Permit	Requirements	Timeline
1041 Regulations https://www.clearcreekcounty.us/DocumentCenter/View/219/Printable_1041_Regulations?bidId=	- Pre-application conference - Finding of No Significant Impact (FONSI) a. Includes a fee, permit authority hearing, and public notice - Application describing the development, alternatives, schedule, need, other permits, technical/financial feasibility, socioeconomic impacts, environmental impacts, and many other considerations	30-90 days
Management and protection of Wetlands Section 404 Permit Clean Water Act https://files.nc.gov/ncdeq/Environmental%20Assistance%20and%20Customer%20Service/Permit%20Handbook%20Documents/2016_Revisions/Other-Section-404-Permit.pdf	A section 404 Permit is required when waters of the US including wetlands are affected by the discharge of dredged or fill material into the water of the US. - Application fee ($10-$100) - Contact local field office for permit application	45-120 days
U.S. Army Corps of Engineers Nationwide Permit 27 Aquatic Habitat Restoration, Enhancement, and Establishment Activities https://www.swt.usace.army.mil/Portals/41/docs/missions/regulatory/2021%20NWP/NWP-27.pdf?ver=2Lce-C9I_3zKSuZfgv-lw%3D%3D	- Pre-construction notification - Describe existing conditions - Identify existing impairments - Hydraulic/hydrologic evaluations - Compliance with general conditions - Project Drawings - Rationale - Estimation of the volume of material filled/cut - Monitoring plan	~45 days
Water and Land Use Permits – Dams https://portal.ct.gov/DEEP/Permits-and-Licenses/Factsheets-Inland-Water/Dam-Construction-Fact-Sheet	- Dam safety, hazard, and general permits - Technical documents (engineering design and environmental reports, plans, etc.) required - Publishing of a Notice of Application to the public	~120 days

The permit matrix details the necessary permissions required for all of the proposed solutions. It includes a link to the application, a description of necessary documents, and approximate timeline for approval. Moving forward, if other solutions are explored, more permits may be required.

Physical Model

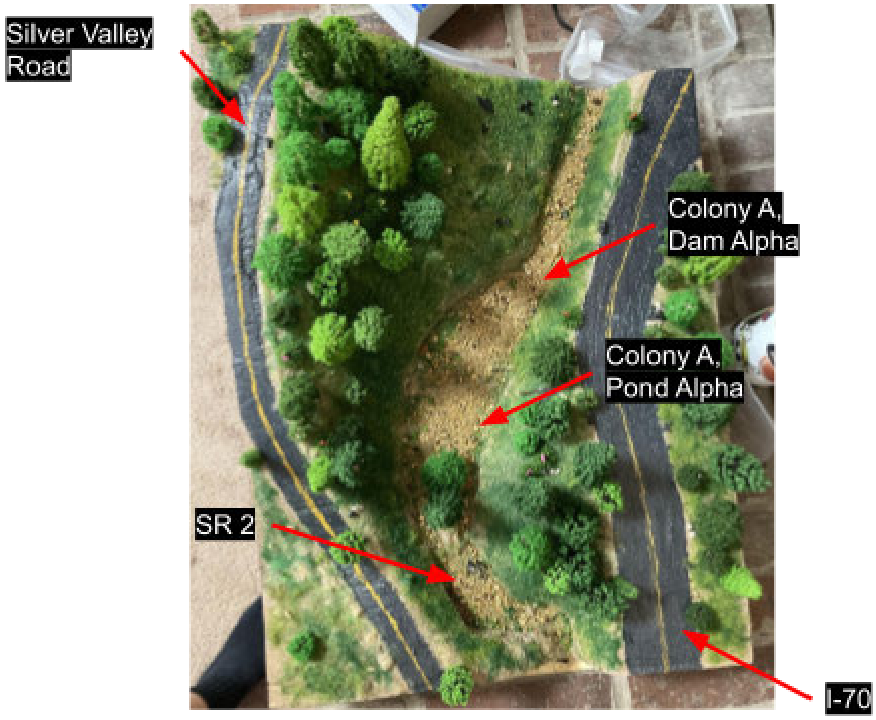

Figure 5.1: Top View of Model, With Labels

Figure 5.2: Side View of Model - From SR 2

This is a 1:600 horizontal, 1:120 vertical scaled model of SR2, Colony A Pond α, and Colony A Dam α. A pump will be attached to the west side of the model to similar water flow. Two dams have been created (not shown), one made of sticks to simulate a beaver dam and one made of cardboard to simulate a human made structure.

5. Project Management

An updated Project Schedule can be found in Appendix C. Identification steps, analysis steps, and reflection steps have been completed, all that is left is the final conclusions to be consolidated into the Comprehensive Solution Analysis.

An updated version of the Project Work Breakdown Structure can be found in Appendix B. A major shift from the original work breakdown to the current is the movement from only itemizing preliminary research to also including steps like modeling and analysis that are used then in the final construction pieces.

The budget for our supplies and site visits has been updated to include all of our most recent purchases and should be finalized for the remainder of the project. This budget can be found in Appendix E. Total project costs fall below the total allocated budget for this course by a significant margin. This was achieved undoubtedly through the assistance of the City of Golden with free water testing, which otherwise would have imposed a serious toll on our budget.

6. Lessons Learned

Over the course of the year, the team learned a lot about how to adapt to a system that was changing over time. Beaver activity in the area caused the formation of additional dams that changed the direction of the project. The design goals changed with these alterations, making a "good design" an ever changing goal. At the start of the project, the team saw a good design as being one that solved the problem and had low impact to the system. This included BDAs, step pools, and revegetation efforts. Now the team believes the most valuable solution is one that protects the environment and existing conditions while also fulfilling the needs of the client. This changed because the team saw the viability of completely natural restoration methods such as beavers and their effectiveness at fulfilling the clients needs.

The team did not make decisions or promises at the beginning of the project that changed over time. We kept our expectations and goals of the project very open from the start and have continued to do the same over time. We recognized the importance of keeping our minds open in the beginning which helped to keep our expectations consistent throughout the course of the project.

The team learned that having a great group dynamic is important, especially outside of the class. We were able to work together in a highly effective and trustworthy manner because of good communication, occasional breakfasts, and friendship. Being close with each other made our project more effective because we had a strong basis to work from for improvement.
At the beginning, the team thought it was easy to implement a single solution to the problem. But over time, we learned that an accumulation of a variety of potential solutions was the best way to go. This proved to be difficult for the team because we weren't able to focus solely on a single result and rather had to approach the problem in an open manner.

7. Works Cited

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Appendix A – Technical Drawings

Figure A.1: Civil3D Rendered Surface of Pond α, Side Profile

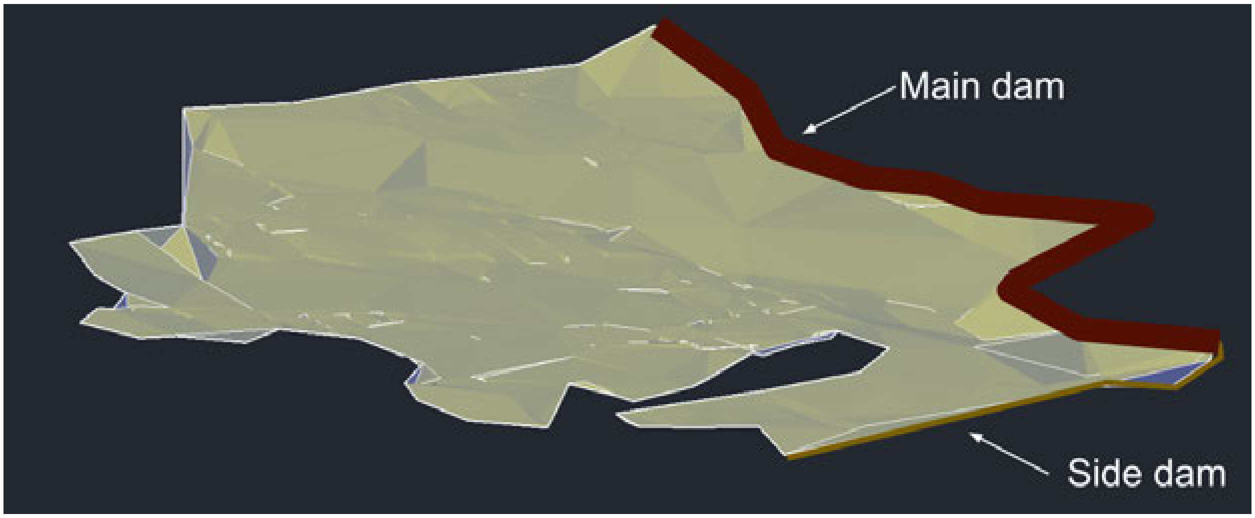
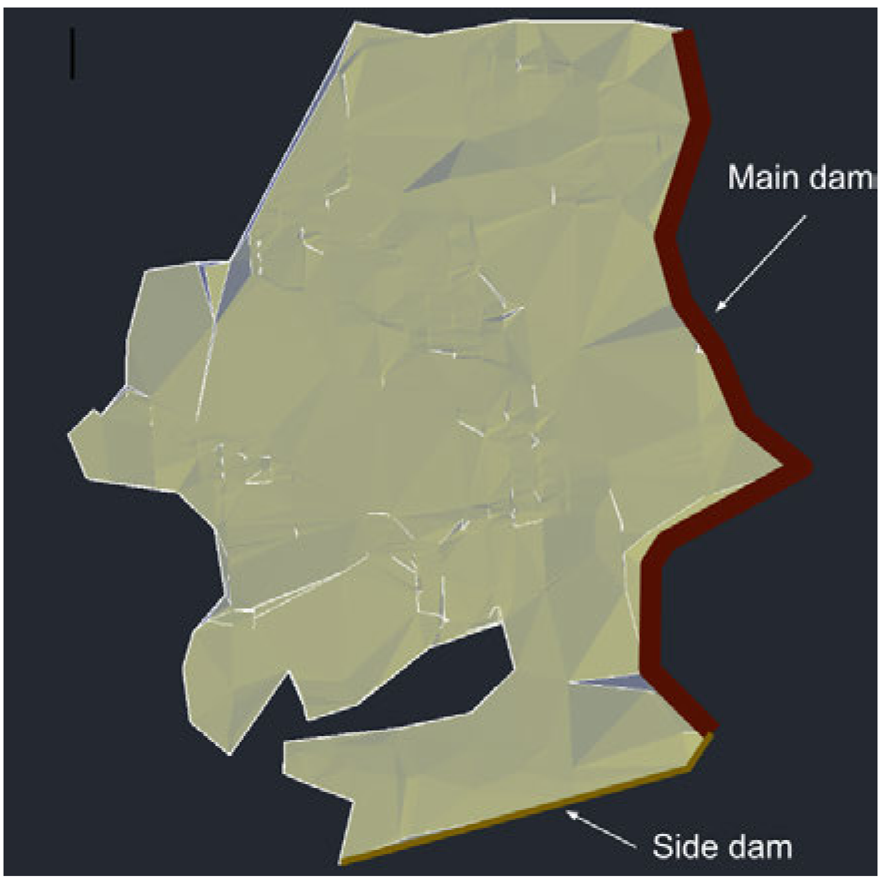


Figure A.2: Civil3D Rendered Surface of Pond α, Top View



Appendix B – Calculations

Table B.1: % Differences* – Water Testing 4/20/23			
Parameter Name	*Before Colony Dam B-After Colony Dam B*	*Before Colony Dam B-At SR-2*	*At SR-2-After Colony Dam B*
Alkalinity	-2.22%	2.22%	-4.55%
Alkalinity Phenolphthalein	0.00%	0.00%	0.00%
Aluminum-Total	**74.92%**	**73.62%**	**4.96%**
Antimony-Total	ND	ND	ND
Arsenic-Total	0.00%	0.00%	ND
Barium-Total	1.96%	5.88%	-4.17%
Beryllium-Total	ND	ND	ND
Cadmium-Total	ND	ND	ND
Chromium-Total	ND	ND	ND
Cobalt-Total	ND	ND	ND
Copper-Total	ND	ND	ND
Iron-Total	**37.98%**	**27.90%**	**13.99%**
Lead-Total	ND	ND	ND
Manganese-Total	**30.00%**	**-2.16%**	**31.48%**
Nickel-Total	ND	ND	ND
Thallium-Total	ND	ND	ND
Molybdenum-Total	0.00%	0.00%	0.00%
Selenium-Total	0.00%	0.00%	0.00%
Silver-Total	ND	ND	ND
Uranium-Total	2.16%	2.47%	-0.32%
Vanadium-Total	ND	ND	ND
Zinc-Total	**26.70%**	**40.29%**	**-22.76%**
Thorium-Total	ND	ND	ND
Nitrate + Nitrite as N	**12.90%**	**6.45%**	**6.90%**
Ammonia as N	ND	ND	ND
Phosphorus, Total	ND	ND	ND
Total Organic Carbon	-1.23%	-2.05%	0.80%
Total Kjeldahl Nitrogen	ND	ND	ND
Turbidity	**57.04%**	**46.13%**	**20.26%**
pH	0.00%	8.82%	-9.68%
Nitrate as N	ND	ND	ND
Nitrite as N	ND	ND	ND
Total Nitrogen	**12.90%**	**6.45%**	**6.90%**
Hardness	0.54%	0.54%	0.00%

Table B.2: % Differences* – Water testing 10/17/23					
Parameter Name	**New Comparisons**		**Old Comparisons**		
	Above Colony A, pond α- At SR-2	*Above Colony A, pond α-After Colony B dam*	*Before Colony Dam B-After Colony Dam B*	*Before Colony Dam B-At SR-2*	*At SR-2-After Colony Dam B*
Alkalinity	**-22.03%**	**-23.73%**	**7.14%**	**9.52%**	**-2.17%**
Alkalinity Phenolphthalein	0.00%	0.00%	0.00%	0.00%	0.00%
Calcium	1.68%	0.56%	0.56%	1.68%	-1.10%
Magnesium	0.49%	1.79%	0.32%	-0.96%	1.29%
Potassium	**14.29%**	**14.29%**	0.00%	0.00%	0.00%
Sodium	NT	NT	NT	NT	NT
Chloride	-5.28%	-0.81%	0.83%	-3.72%	4.72%
Fluoride	**0.00%**	**6.67%**	**3.23%**	**-3.23%**	**6.67%**
Sulfate	NT	NT	NT	NT	NT
Aluminum-Total	**151.34%**	**184.76%**	**110.89%**	**86.14%**	**13.30%**
Antimony-Total	ND	ND	ND	ND	ND
Arsenic-Total	ND	ND	ND	ND	ND
Barium-Total	1.57%	6.86%	0.74%	-4.25%	5.21%
Beryllium-Total	ND	ND	ND	ND	ND
Cadmium-Total	ND	ND	ND	ND	ND
Chromium-Total	ND	ND	ND	ND	ND
Cobalt-Total	ND	ND	ND	ND	ND
Copper-Total	ND	ND	ND	ND	ND
Iron-Total	**-4.88%**	**15.24%**	**45.38%**	**20.00%**	**21.15%**
Lead-Total	0.00%	0.00%	0.00%	0.00%	0.00%
Manganese-Total	**37.50%**	**25.63%**	**44.60%**	**58.27%**	**-8.64%**
Nickel-Total	ND	ND	ND	ND	ND
Thallium-Total	ND	ND	ND	ND	ND
Molybdenum-Total	0.00%	0.00%	0.00%	0.00%	0.00%
Selenium-Total	ND	ND	ND	ND	ND
Silver-Total	ND	ND	ND	ND	ND
Uranium-Total	-5.94%	-8.42%	-1.07%	1.60%	-2.63%
Vanadium-Total	ND	ND	ND	ND	ND
Zinc-Total	**8.67%**	**-3.47%**	**1.83%**	**14.63%**	**-11.17%**
Thorium-Total	ND	ND	ND	ND	ND
Nitrate as N	**-75.74%**	**-72.78%**	**64.29%**	**46.43%**	**12.20%**

Table B.2: % Differences* – Water testing 10/17/23					
Parameter Name	**New Comparisons**		**Old Comparisons**		
	Above Colony A, pond α- At SR-2	*Above Colony A, pond α-After Colony B dam*	*Before Colony Dam B-After Colony Dam B*	*Before Colony Dam B-At SR-2*	*At SR-2-After Colony Dam B*
Nitrate + Nitrite as N	**75.74%**	**-72.78%**	**64.29%**	**46.43%**	**12.20%**
Nitrite as N	ND	ND	ND	ND	ND
Ammonia as N	ND	ND	ND	ND	ND
pH	**-9.09%**	**-9.09%**	**-23.08%**	**-23.08%**	**0.00%**
Phosphorus, Total	ND	ND	ND	ND	ND
Hardness	**7.04%**	**12.68%**	**11.11%**	**5.56%**	**5.26%**
Total Kjeldahl Nitrogen	ND	ND	ND	ND	ND
Total Nitrogen	**-69.82%**	**-72.78%**	**64.29%**	**82.14%**	**-9.80%**
Turbidity	**33.33%**	**12.50%**	**1.89%**	**20.75%**	**-15.63%**
Total Organic Carbon	**9.09%**	**10.91%**	**8.93%**	**7.14%**	**1.67%**

*The percent differences were found by taking the second stated site data and subtracting the first stated site data and then dividing by the first stated site data. Finally, that number is multiplied by 100 to get a percentage. This means that if a number is negative, there was a decrease from the first stated site to the second. For example, Before Colony Dam B-At SR-2 would be: $\frac{At\ SR-2\ Data - Colony\ Dam\ B\ Data}{Colony\ Dam\ B\ Data} * 100$ and a negative value means that at SR-2, that value decreased compared to at Before Colony Dam B.

Table B.3: Volume Calculations			
Elevation (ft)	**Area** (ft^2)	**Basic Volume** (ft^3)	**Prismoidal Volume** (ft^3)
		(A1+A2)/2 * Δh	1/3(A1+A2+Sqrt(A1*A2))
9605	0.00	6.57	4.38
9606	13.13	564.84	416.92
9607	1,116.54	2,310.27	2,199.50
9608	3,503.99	5,454.79	5,334.54
9609	7,405.59	9,569.35	9,486.74
9610	11,733.11	13,512.16	13,472.95
9611	15,291.20	17,365.63	17,324.18
9612	19,440.05		
	Sum (ft^3)	48,783.59	48,239.19
	Sum (acre-ft)	1.12	1.11

Table B.4: Mean Flows by Month [3]

Month	Estimated Mean Flows (cfs)
Jan.	7.6
Feb.	7.03
March	7.95
April	18.7
May	103
June	179
July	67.4
Aug.	27.5
Sep.	17.6
Oct.	14.8
Nov.	11.0
Dec.	8.41

Table B.5: Annual Exceedance Probability Flow Measurements [3]

% AEP Flood	Flow (cfs)
50	374
20	512
10	600
4	695
2	819
1	895
0.5	959
0.2	1100

Reference B.1: USGS Data [3]

Average annual precipitation- 30.57 inches.

Drainage area- 36.9 $mi.^2$

Mean annual flow- 40.6 $ft.^3/s$

Channel width- 26.9 ft.

Channel depth- 2.11 ft.

Channel cross-sectional area- 49.6 $ft.^2$

Mean basin slope- 45%

Mean basin elevation- 11664 ft.

Table B.6: Stage Storage for 18-ft Human-Made Dam

STAGE STORAGE TABLE						
ELEV	AREA (sq. ft.)	DEPTH (ft)	AVG END INC. VOL. (cu. ft.)	AVG END TOTAL VOL. (cu. ft.)	CONIC INC. VOL. (cu. ft.)	CONIC TOTAL VOL. (cu. ft.)
9,605.00	0.30	1.00	0.00	0.00	0.00	0.00
9,606.00	1,528.55	1.00	0.16	0.16	0.13	0.13
9,607.00	4,475.92	1.00	764.89	765.05	524.32	524.46
9,608.00	9,283.93	1.00	2238.02	3003.07	1499.97	2024.43
9,609.00	14,849.28	1.00	4642.29	7645.36	3120.97	5145.39
9,610.00	21,191.96	1.00	7424.81	15070.18	4973.58	10118.97
9,611.00	30,482.21	1.00	10605.43	25675.61	7281.29	17400.26
9,612.00	43,859.14	1.00	15241.68	40917.29	10223.51	27623.77
9,613.00	56,640.66	1.00	21929.61	62846.90	14639.76	42263.53
9,614.00	68,918.20	1.00	28320.85	91167.75	18961.72	61225.25
9,615.00	82,852.09	1.00	34459.84	125627.60	23079.91	84305.16
9,616.00	97,188.86	1.00	41426.12	167053.72	27655.52	111960.68
9,617.00	113,119.24	1.00	48595.50	215649.21	32548.64	144509.32
9,618.00	133,584.71	1.00	56561.39	272210.60	37918.64	182427.96
9,619.00	149,351.72	1.00	66792.54	339003.14	44601.58	227029.54
9,620.00	160,803.77	1.00	74677.41	413680.55	50011.57	277041.11
9,621.00	168,221.41	1.00	80404.09	494084.64	53883.43	330924.54
9,622.00	174,952.85	1.00	84112.34	578196.98	56321.70	387246.24
9,623.00	181,032.85	1.00	87477.59	665674.57	58531.20	445777.43
9,624.00	186,780.60	1.00	183906.73	849581.30	183899.24	629676.68
9,625.00	66,696.43	1.00	93391.08	942972.38	62440.59	692117.27

TOTAL CALCULATED VOLUME	
BASIC VOLUME CALC (ACRE–FT)	CONICAL VOLUME CALC (ACRE–FT)
21.647699	15.888850

Table B.7: Stage Storage for BDA Near SR-2

STAGE STORAGE TABLE						
ELEV	AREA (sq. ft.)	DEPTH (ft)	AVG END INC. VOL. (cu. ft.)	AVG END TOTAL VOL. (cu. ft.)	CONIC INC. VOL. (cu. ft.)	CONIC TOTAL VOL. (cu. ft.)
9,594.00	92.91	1.00	46.45	46.45	46.41	46.41
9,595.00	221.92	1.00	110.96	157.42	74.47	120.88
9,596.00	1,335.62	1.00	667.81	825.22	485.35	606.23
9,597.00	2,493.91	1.00	1244.05	2069.27	835.67	1441.90
9,598.00	4,179.85	1.00	2085.85	4155.11	1566.35	3008.25
9,598.00	4,732.24	0.00	0.00	4155.11	0.00	3008.25

TOTAL CALCULATED VOLUME	
BASIC VOLUME CALC (ACRE–FT)	CONICAL VOLUME CALC (ACRE–FT)
0.095388	0.069060

Table B.8: Stage Storage for BDA Above Colony A

STAGE STORAGE TABLE						
ELEV	AREA (sq. ft.)	DEPTH (ft)	AVG END INC. VOL. (cu. ft.)	AVG END TOTAL VOL. (cu. ft.)	CONIC INC. VOL. (cu. ft.)	CONIC TOTAL VOL. (cu. ft.)
9,610.00	497.31	0.00	0.00	0.00	0.00	0.00
9,612.00	5,189.13	0.00	0.00	503.63	0.00	379.67
9,614.00	14,876.51	0.00	0.00	5693.44	0.00	4048.02

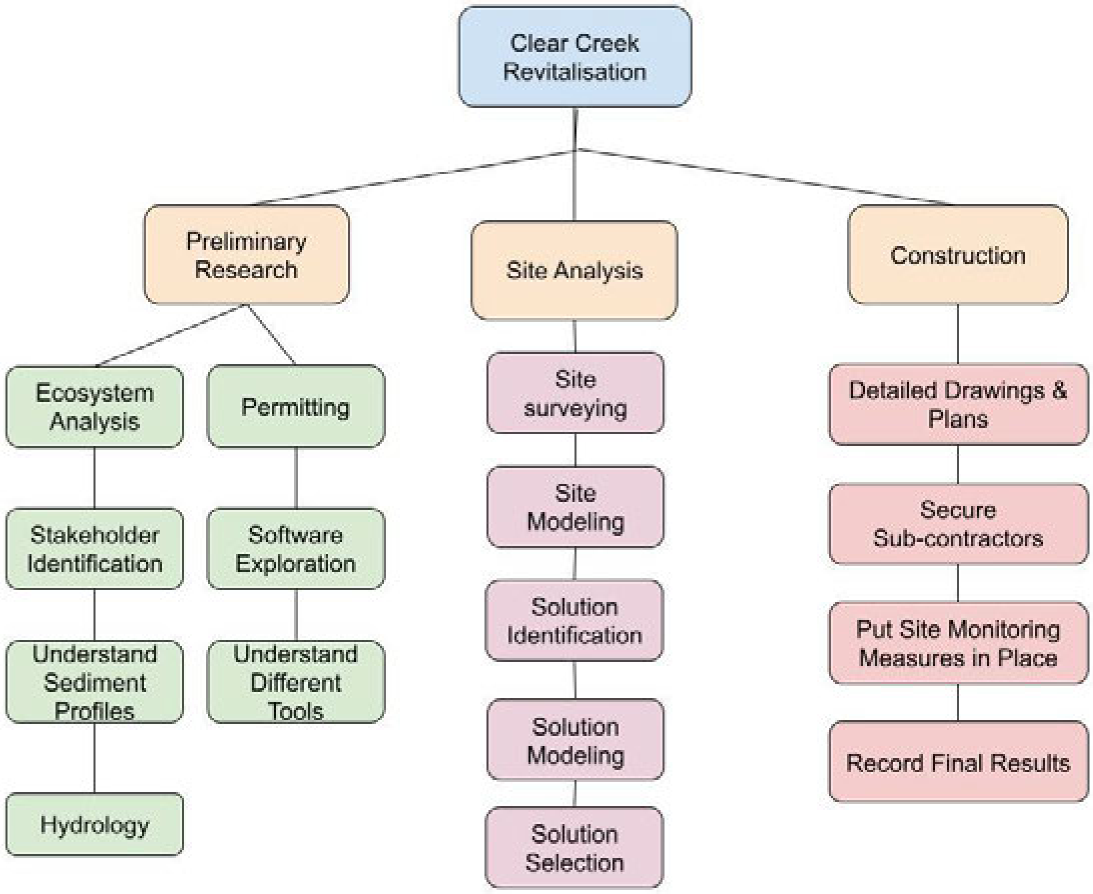
TOTAL CALCULATED VOLUME	
AVG END TOTAL VOL. (ACRE–FT)	CONIC TOTAL VOL. (ACRE–FT)
0.1307035923	0.092929890

Appendix C – Project Schedule

Project	Status	Main Goal	Notes
Sprint 1	Completed	Stakeholder Identification & Preliminary Research	Feb 16, 2023
Sprint 2	Completed	Scope of Work	Mar 2, 2023
Sprint 3	Completed	Solution Analysis and Requirements Matrix Scorecard Identification and requirements matrix	Mar 16, 2023
Sprint 4	Completed	Permit Matrix of all possible permits and requirements	Apr 6, 2023
Sprint 5	Completed	Next Steps & Finalized Criteria for the Iterative Design Process	Apr 20, 2023
Sprint 6	Completed	Identification	Aug 24, 2023
Sprint 7	Completed	Identification	Sep 7, 2023
Sprint 8	Completed	Analysis / Calculations	Sep 21, 2023
Sprint 9	Completed	Analysis /Calculations	Oct 5, 2023
Sprint 10	Completed	Reflection / Modeling	Oct 24, 2023
Sprint 11	Completed	Reflection / Modeling	Nov 7, 2023
Sprint 12	Completed	Conclusions	Nov 21, 2023

Appendix D - Updated Work Breakdown Structure

COLORADO SCHOOL OF MINES
EARTH • ENERGY • ENVIRONMENT



Appendix E - Bill of Materials

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MINES
Capstone Design

Financial Summary	
Fall 2023/Spring 2024	
Date	11/12/2023

Team Number	S23-30
Team Name	B.V.R Engineering
CFO Name	Mitch Awdziejczyk
CFO e-mail	mawdziejczyk@mines.edu
PA Name	Alina Handorean

Starting Budget	Source	Date	Total
Additional funds	Capstone	9/1/2023	$600.00
Additional funds			
Additional funds			
	Total Budget		$600.00
	Total Capstone Spend		$295.29
	Total Refunds		$0.00
	Capstone Balance		$304.71

Total Client Spend	$ -

Instructions:
Enter date, vendor, items, select purchase method, item cost, and if needed return date and refund amount; formulas will populate other cells
Purchases: enter each receipt as one purchase line item (can include multiple items)
Reimbursement: each line should contain the items & total for each reimbursement submission, this can include multiple receipts from multiple vendors
Update all costs to match receipts
Use Client Purchased when your client provides any materials, enter the estimated cost
You will be sent an invitation to upload your monthly financial statement to a form at the end of every month
If you need more rows insert rows as needed within the given month, add pull the formula down

Date	Vendor	Items	Purchase Method	Item cost	Client Charges	Capstone Charges	Return Date	Refund Amount	Notes:
September									
9/3/2023	Site Visit	86 Miles	Reimbursment	$ 48.16		$ 48.16			Nick Drove
9/20/2023	denuodianqiyouxiangongsi	PVC Tubic 3/4", 5'	Amazon Shopping List	$ 11.89	$ -	$ 11.89			
9/20/2023	Amazon.com	Heavy Duty Washing Box	Amazon Shopping List	$ 17.69	$ -	$ 17.69			
9/20/2023	SilverlakeLLC	Craft Foam Block (2x)	Amazon Shopping List	$ 22.99	$ -	$ 22.99			
9/20/2023	FREESA	Aquarium Pump	Amazon Shopping List	$ 17.99	$ -	$ 17.99			
9/20/2023	Starbond	Modeling Glue	Amazon Shopping List	$ 20.49	$ -	$ 20.49			
9/20/2023	ABAB SkyCooool BABA	60 piece Model Trees	Amazon Shopping List	$ 14.99	$ -	$ 14.99			
9/20/2023	WWScenics	Terrain Landscape	Amazon Shopping List	$ 23.99	$ -	$ 23.99			
9/20/2023	David Deng	Grass Texture Paper	Amazon Shopping List	$ 14.30	$ -	$ 14.30			
9/20/2023	Callart	Paint brushes	Amazon Shopping List	$ 25.99	$ -	$ 25.99			
9/20/2023	YuuAnti	Model Vegetation	Amazon Shopping List	$ 16.79	$ -	$ 16.79			
			September Total Spend:		$ -	$ 187.11	September Refunds:	$0.00	
October									
10/17/2023	Site Visit	86 miles	Reimbursment	$ 48.16	$ -	$ 48.16			Hannah Drove
10/26/2023	Hobby Lobby	Styrofoam Wire Cutter	Reimbursment	$ 29.99		$ 29.99			
10/26/2023	Home Depot	1/4 2X2 BCX Plywood	Reimbursment	$ 9.18	$ -	$ 9.18			
10/27/2023	Home Depot	Edge Protect Sponge 180 Grit 1PK	Reimbursment	$ 5.98	$ -	$ 5.98			
			October Total Spend:		$ -	$ 93.31	October Refunds:	$0.00	
November									
11/1/2023	Walmart	FlexSeal Clear	Reimbursment	$ 14.87	$ -	$ 14.87			
					$ -				
					$ -				
					$ -				
			November Total Spend:		$ -	$ 14.87	November Refunds:	$0.00	