Integrated Pedestrian Underpass with Red Butte Creek at Foothill Drive

Department of
Civil & Environmental Engineering
THE UNIVERSITY OF UTAH

Integrated Pedestrian Underpass with Red Butte Creek at Foothill Drive

Organization: University of Utah
Location: Salt Lake City, Utah
Project #: 4910.23.01.02
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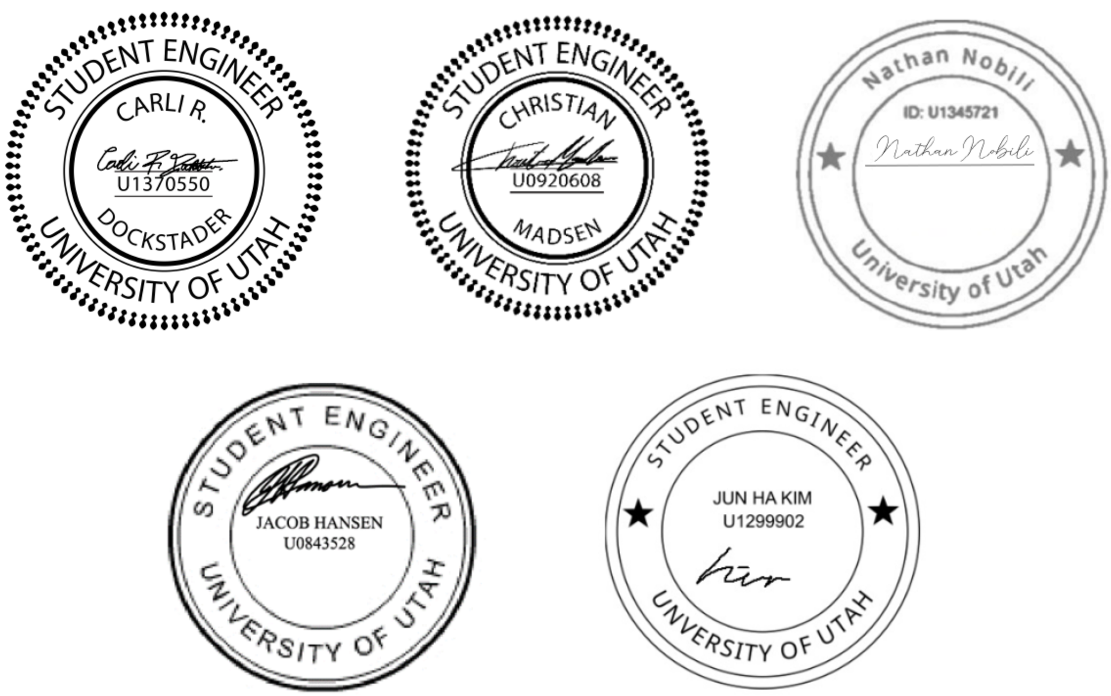

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- David Nordquist, AGEC

Executive Summary

Project 4900.23.01 involves a pedestrian underpass with an integration of Red Butte Creek on Foothill Drive. This will provide a more safe and functional crossing for pedestrian and cyclists along the future and current trails on Red Butte Creek. Major goals include the improved safety, efficiency, and mobility for all modes of transportation in the area. Aspects of the final design of the Pedestrian Underpass on Foothill Drive to meet the goals and needs of the project included structure, aesthetic, and safety.

Structural aspects of the Pedestrian Underpass Final Design:

- Structure to be a prefabricated boxed culvert.
- The pathway is two-way, total of 12 ft (6ft each way).
- Height of clearance to be 11 ft.
- Integration of Creek in channel using a controlled diversion that will prevent flooding inside the underpass.
- Flood Prevention designed for 100-year flood.
- ADA access ramps on both sides.

Aesthetic aspects of the Pedestrian Underpass Final Design:

- Led lighting on each corner to fully illuminate pathway.
- Native rocks and stones to area.
- Murals and artwork on underpass walls.
- Landscaping entrances with retaining walls and native plants.
- Artificial channel with running water through underpass

Safety aspects of the Pedestrian Underpass Final Design:

- Proper lighting and view of tunnel at night.
- Cameras to monitor underpass at VA.
- Safety gate at access to VA.
- Graffiti prevention gloss coating.

After consideration of various options over the past months, the current design provided has been chosen to be the best to fit the needs and goals of the project. Advantages include low cost, limited VA property use, no permanent interference with function of the roadway, utilization of existing flood control systems, and less complicated construction.

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1 Project Summary

This project investigates the installation of a pedestrian underpass on Foothill Drive at Red Butte Creek in Salt Lake City Utah. The underpass is intended to improve the mobility network, safety, and travel. It must also minimize impacts on street width and volume, disruption to traffic and preserving the right of way in the area. This is a crucial step toward pedestrian safety and vehicle efficiency. The following report investigates the project to determine the best possible alternative, as well as predict potential project conflicts. This includes the constructability, location, analysis, constraints, limitations, and scope of work for the project. Finally a full design plan set will be presented.

1.1 Project Needs Statement

Existing pedestrian crossings on Foothill Drive near Red Butte Creek are neither appealing nor safe to use. A recent fatal accident at a nearby intersection has further highlighted the need for upgraded crossings. Salt Lake City Trails has a vision and master plan for trails in the city, with a goal to connect them all. Additionally, future development will increase pedestrian and vehicular traffic along this route, thereby increasing the risk of accidents.

1.1.1 Fatal Pedestrian Accident on Foothill Drive

The combination of the high volume of vehicles and pedestrians can lead to unsafe situations when crossing. Recently, a pedestrian was crossing Foothill Drive on Mario Capecchi when they were struck by a car turning left from Mario Capecchi to Foothill Drive. The accident was fatal, and the pedestrian was killed in the accident. Another fatal auto-pedestrian accident occurred in 2019. This accident happened on Foothill Drive between Wakara Way and Mario Capecchi Drive, which is the proposed location of the underpass.

Pedestrian and bike crossing improvements to the current system should be considered. Crossings are very difficult due to the high volume of vehicle use on Foothill Drive. A new separated grade crossing would improve the safety of the roadway. With the addition of an underpass, it will significantly reduce the likelihood of an auto-pedestrian accident.

Figure 1 *Location of Accident*

1.1.2 West Village Student Housing

The University of Utah is in the process of creating new student housing for Graduate Students in place of the current housing. The West Village contained approximately 660 housing units. The proposed replacement will most likely contain approximately 2000 units. Phase 1 construction is currently scheduled to conclude with 504 new housing units available for Fall 2023.

Figure 2 - *Map of Nearby Student Housing*

1.1.3 Pedestrian & Bicycle Master Plan of SLC

There is a situational need to implement a pedestrian underpass on Foothill Drive near Red Butte Creek to enhance the quality of life for the community. This would create a safer and more efficient means of travel for pedestrians and cyclists for a future vision of what is desired from specific stakeholders. This project will be completed through Salt Lake City and UDOT. Salt Lake City Trails has a vision to connect trails everywhere in the valley, as shown in Figure 3. The location near Red Butte Creek will allow access to existing and future trail systems as well as future bus stops in the area, promoting other transportation options and incorporation of the idea of complete streets in Salt Lake City, Utah. Yellow line in Figure 4 shows University of Utah and Salt Lake City's plan of a shared use pathway along Red Butte Creek from Sunnyside Avenue to Research Park and the Bonneville Shoreline Trail.

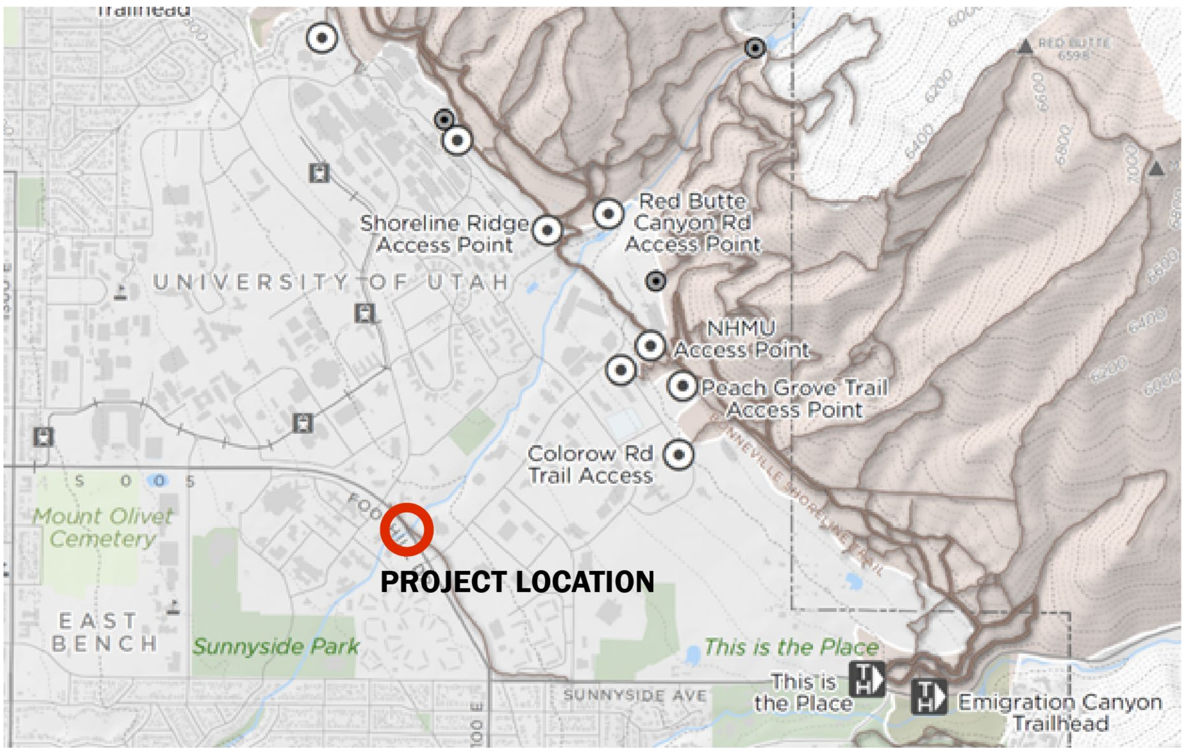


Figure 3 - *SLC Trails Master Plan, Existing trail access points*

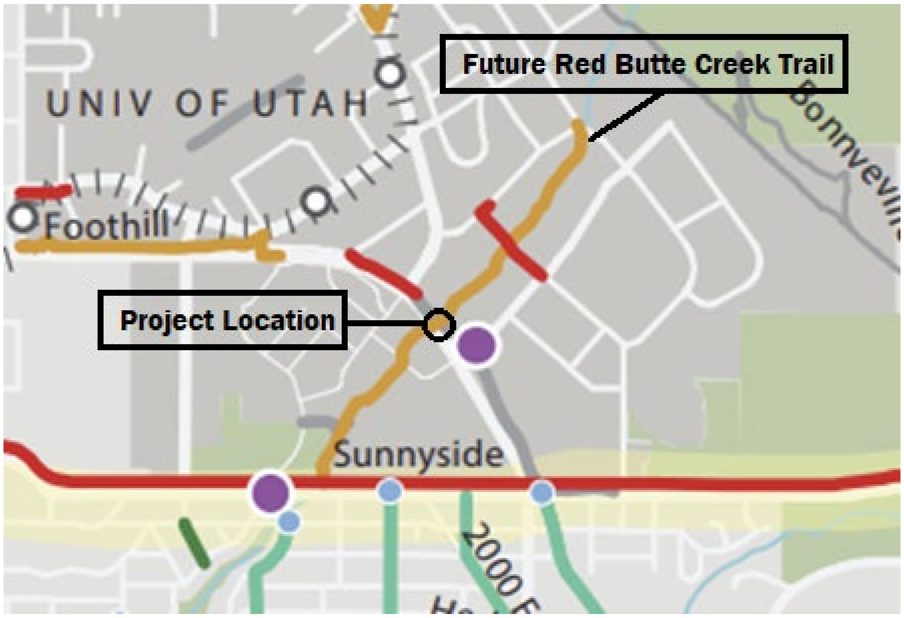


Figure 4 - *Salt Lake City Pedestrian and Bicycle Master Plan*

1.1.4 Foothill Drive Corridor Study

Per UDOT measurements, Foothill Dr. has an Annual Average Daily Traffic volume of 51,000 in 2019 as shown in Figure 5. UDOT has been searching for a solution to the crossing difficulty at Foothill Dr. for years without a viable solution. These are no spaces to widen the road, and their desire is to not infringe upon the traffic with a solution. Many in nearby neighborhood communities commute to and from a popular destination point, the University of Utah. Foothill Drive is a major arterial to the university and downtown Salt Lake City. Existing pedestrian crossings on Wakara Way and Mario Capecchi make it difficult and uncomfortable to cross due to a high volume of vehicles traffic.

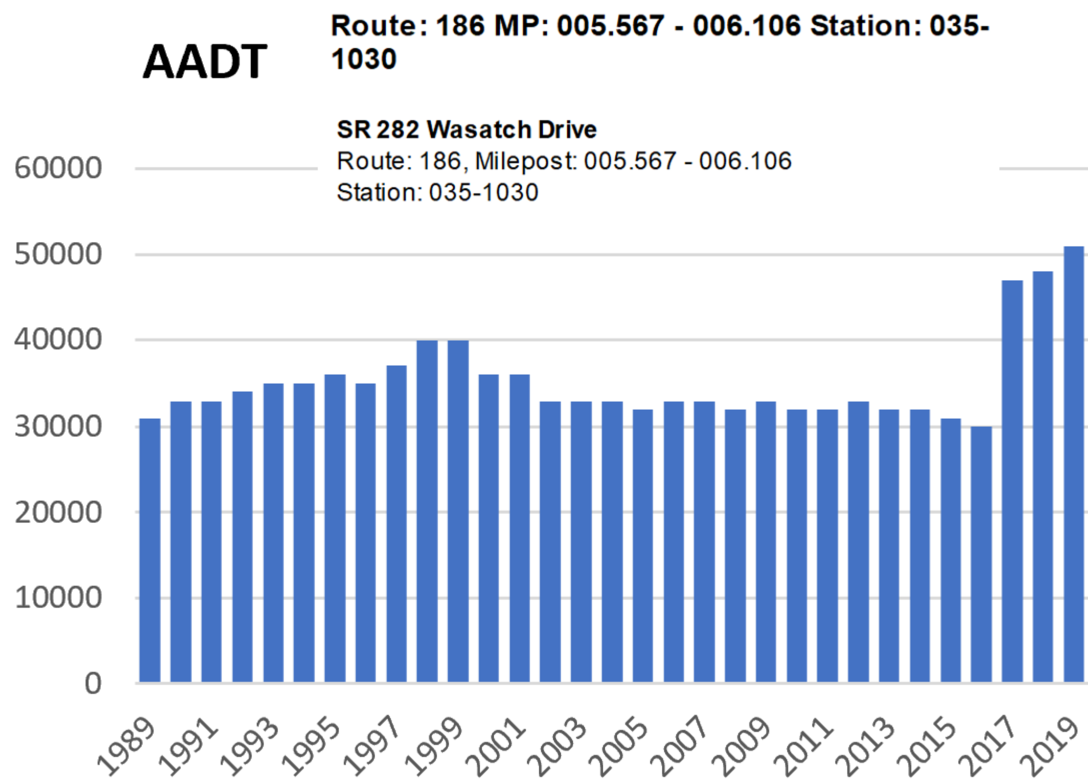


***Figure 5** - UDOT AADT on Foothill Dr.*

1.2 Project Goals and Vision

The overall goal of this underpass project is to provide a safe and functional crossing for users of all ages and abilities within the extents of Wakara Way/Foothill Drive Intersection. For the project's sustainability, it aims to comply with the Envision guidelines. The Envision guidelines that we focused on are improved safety, efficiency, connections, improved mobility, and economy (Appendix A). By providing an underpass, safety of pedestrian and bicycle improve by reducing the use of at grade crossings. If use of sidewalks decreases, it also improves the safety and the efficiency of vehicles on the road. The efficiency and mobility of pedestrian and cyclist traffic also improves without having to wait for the traffic light. The underpass can serve as a connection between the current and future Red Butte Creek Trail. It can also be incorporated with the current bus stops on each side of Foothill Drive.

1.3 Project Participants and Organization

The project site will cross Foothill Drive which is a high-volume arterial road. It is in proximity to Red Butte Creek. It borders the property of the federal government, a university, a growing business center and nearby community. Growing communities nearby and increasing traffic volume on Foothill Drive make safe crossing essential. These different special aspects bring in many interested parties, or stakeholders. While it would prove a challenging task to fulfill the needs of each stakeholder, they should each be recognized and evaluated. Project participants and organization can be subdivided into four categories based on their responsibilities and roles in implementing the project. Further details about the stakeholders in each category will be discussed in the next section.

1.4 Stakeholders

The planning and execution of most projects involve a personal stake from many parties. A stakeholder is an independent party with interest or concern in a project. The project stakeholders for this project vary from the owner of the project to the biking society located in the area. To ensure the success of a project the stakeholders are identified and analyzed so the appropriate measure of communication can be administered. The main objective of this is to identify the major stakeholders to facilitate the project improvements by increasing awareness, and management coordination and guidelines.

1.4.1 Stakeholder Study Methodology

Models have been developed to evaluate external stakeholders for construction project management. This study adopts a systems approach to identify all stakeholders. The methodology adopted for the analysis consists of four major components:

- Stakeholder identification
- Stakeholder needs and concerns.
- Stakeholder impact analysis
- Conclusions and Recommendations

1.4.2 Stakeholder Identification

The project will consist of two major categories of stakeholders. The first is an internal stakeholder. This consists of invested parties that are within the inner project communication circles. Project progression is primarily dependent on the internal stakeholders as they typically generate the project concept and funding. Examples of the internal stakeholders would be the client and project design team. These stakeholders are the primary invested parties and are the first to receive project communications and updates. The second category are called external stakeholders. This consists of all invested parties that while initially they may not generate the project concept or funding, can influence project decisions or even potentially shut down project progression. The twelve stakeholders identified in this study are below:

- Salt Lake City Engineering Department
- Salt Lake City Trails Division
- UDOT
- VA Salt Lake City Regional Office
- US Army Corp of Engineers
- Salt Lake City Ordinance Riparian Corridor Overlay District (RCO)
- Utah Division of Forestry, Fire & State Lanes
- Utah State Engineer's Office
- Salt Lake County Engineering and Flood Control
- Salt Lake County Watershed Planning and Restoration
- University of Utah Students and Faculty
- Utah Division of Drinking Water

1.4.3 Needs and Concerns

Salt Lake City Engineering Department

The City of Salt Lake is the primary client. In other words this is a public sector project and will be managed by the SLC Engineering Department. The SLC Engineering Department will be an internal stakeholder and will be involved in all project news and progression. They will also be the primary stakeholder developing to project concept and design. Their primary project values and goals are to create a crossing that has integrated usage and purpose, improved equity, access, and inclusion, is low maintenance and low construction, poses minimal invasion to existing property, integrates safety measures, has no impact to off-site city infrastructure, minimizes impacts to storm drainage and conveyance systems, minimizes impacts to utilities, preserves and protects riparian corridors, connects to historic heritage, and promotes sustainable design, construction and usage.

Salt Lake Trails Division

The Salt Lake City Trails Division is a recreational group that requires that the crossing accommodate pedestrians and cyclists of all ability levels, minimizes unnecessary elevation changes, connects to future trail points, has a width that accommodates two-way passage, has cross-slopes and centerline profiles that accommodate all mobility levels (ADA compliant), is affordable, and has possible natural walking paths on one side of Red Butte Creek and northeast side of Foothill Drive.

UDOT

The Utah Division of Transportation (UDOT) is a government agency with over 17,000 employees and is responsible for over 48,812 roads in Utah. Their goal is to enhance the quality of life through transportation by encouraging good health, better mobility, strong economies, and connected communities. They are especially invested in this project as Foothill Drive is in their right-of-way and three pedestrian fatalities have taken place within the intersection of Mario Capecchi Drive.

VA Salt Lake City Regional Office

The United States Department of Affairs (VA) regional office is located near the project intersection. In fact, it will likely be the closest building to the south side of the pedestrian crossing. Not only does their building physically limit the project boundaries and constraints but so will also their rules and regulations. The nature of these rules and regulations, will require the VA property to have the ability to completely shut down and secure their project site at all times. This is in preparation to bomb and other potential threats. For this reason, the VA will be a substantial stakeholder in the project as they will require communication and approvals during the design and construction phases.

US Army Corp of Engineers

The United States Army Corp of Engineers is an engineer-based organization that by Section 206 of the 1960 Flood Control Act, has the authority to regulate site specific data and obstructions to flood flows, flood formation and timing; flood depths, stages or floodway velocities; and flood loss potentials before and after the use of flood plain management measurements. This organization will require substantial consideration throughout the design process. Not only will they require permit applications and approvals that extensively discuss the project specifications and boundaries, but they will also require consideration in the design process. The permit applications require that the owner prove substantial need in the area, and thorough alternative analysis proving that the proposed project is in the best interest of the floodway.

Salt Lake City Ordinance Riparian Corridor Overlay District (RCO)

The purpose of the RCO is to minimize erosion and stabilize stream banks, improve water quality, preserve fish and wildlife habitat, moderate stream temperatures, reduce potential for flood damage, preserve the natural aesthetic value of streams and wetland areas of the city. For this reason any project requirements that will result in a change to the riparian corridor of Red Butte Creek will require a RCO permit that meets the rules and regulations of the RCO.

Utah Division of Forestry, Fire & State Lands

The Utah Division of Forestry, Fire, & State Lands is responsible for forest health, responding to wildland fires, and managing sovereign lands in Utah. For fire safety reasons it is extremely important that they maintain the necessary site access at all times. Coordination on their needs for said access will be required and while it may not be extensive, if not properly made they have the authority to shut down the project.

Utah State Engineer's Office

The Utah State Engineer's Office is responsible to ensure that proposed projects are in the best interest of the safety of the general public. They have regulations specifically regarding the alteration of floodways. They will require permit applications and coordination throughout the project.

Salt Lake County Engineering and Flood Control

Like the previous organizations, the SLC County Engineering and Flood Control is invested in the health and integrity of the floodway. The appropriate permitting and coordination will be required but will likely not be extensive.

Salt Lake County Watershed Planning and Restoration

The SLC County Watershed Planning and Restoration is responsible to ensure integrated watershed planning, data collection and analysis, and stream restoration and protection. The appropriate permitting and coordination will be required but will likely not be extensive.

University of Utah Students and Faculty

The proposed project enables pedestrians to cross Foothill Drive. This is specifically significant to the University of Utah Students and Faculty, as it will allow many students and faculty residing in the housing on the north side of the road to safely access campus. Currently many of the student drive to class, and struggle with parking and traffic in the area. The project will not only alleviate both the traffic and parking congestion but will also promote the recreational trail system in the area. Both are a significant advantage to the students and faculty. The project will need to be designed considering this stakeholder, because if not properly implemented they may not feel comfortable using the system, leaving the crossing underutilized.

Utah Division of Drinking Water

The Utah Division of Drinking Water regulates drinking water and water disposal to ensure the safety of the general public. The project will require some coordination, but it will likely not be extensive.

1.4.4 Stakeholder Impact Analysis

Based on the needs of each stakeholder discussed in the section above, the stakeholders can be classified as a high, medium, or low impact stakeholder (Table 1). The high impact stakeholders will likely require extensive coordination through all phases of development. The medium stakeholders will require some coordination and the project may need to implement their rules and regulations, but extensive communication is not necessary. The low impact stakeholders are the parties involved that may impact design and development but will not require communication.

Table 1 - *Stakeholder Impact Analysis and Prioritization Level*

Stakeholder	Impact	Prioritization
SLC Engineering Department	High	1
SLC Trails Division	Low	11
UDOT	High	2
VA Salt Lake City Regional Office	High	3
US Army Corp of Engineers	Medium	4
SLC Riparian Corridor Overlay District (RCO)	Medium	7
Utah Divisiton of Forestry, Fire & State Lanes	Low	10
Utah State Engineer's Office	Medium	5
SLC Engineering and Flood Control	Medium	6
SLC Watershed Planning and Restoration	Low	9
University of Utah Students and Faculty	Medium	8
Utah Division of Drinking Water	Low	12

1.4.5 Stakeholder Conclusions and Recommendations

Based on the Impact Analysis above, a figure was generated each stakeholder by their influence, and power over the project Figure 6.

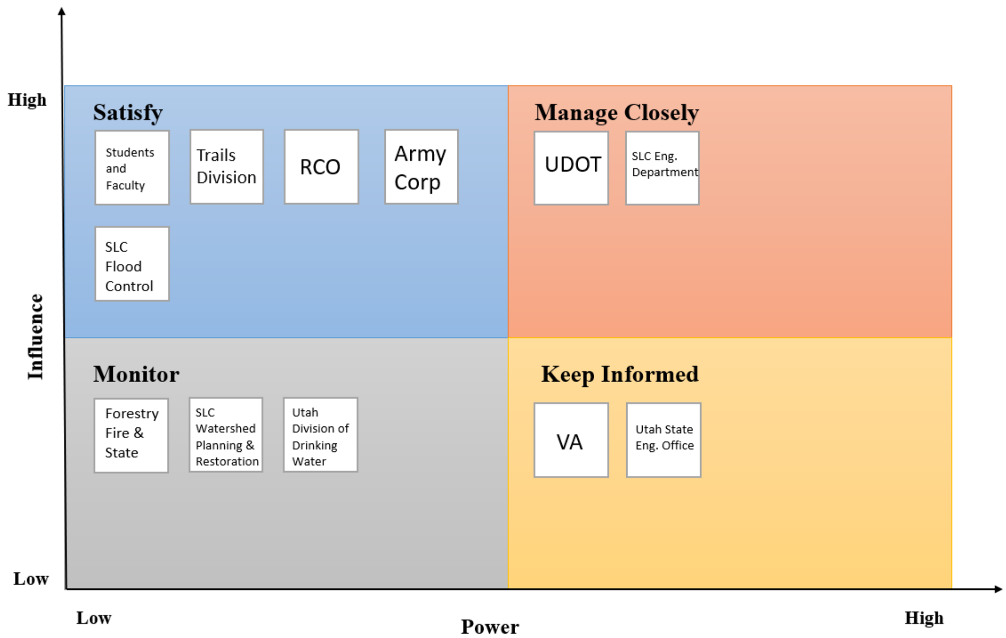


Figure 6 - *Stakeholder Recommendation of Action*

In summary, the major stakeholders for the project will be UDOT, SLC Engineering Department, and the Veterans Administration. While the others will require some coordination and satisfaction, they will not require coordination on a daily basis. Considering the number of stakeholders invested in the integrity of the flood corridor, the project should prioritize this in the design process. If done correctly there will be less conflict in receiving the necessary permitting and approvals.

2 Site Description and Analysis

Prior to generating a design, the site conditions were thoroughly investigated. First, the site was analyzed from an arial perspective which allowed the design team to predict and prevent potential areas of conflict. Then an in-depth geotechnical analysis was performed by AGEC. This was followed up with a hydraulic analysis of the area that identified the flood plain and the areas of impact for the project. Finally, a topographic analysis was performed by the design team utilizing advanced surface technologies and comparing them with site characteristics discovered during site visits conducted by the professional practice class. A detailed summary of each of the investigations performed is given in the sections below.

2.1 Location and General Usage

The proposed project is located on Foothill Drive near Red Butte Creek. The approximate location has a latitude of 40°45'21.74"N and a longitude of 111°50'5.37"W. This is approximately 350 feet southeast of the intersection of Mario Capecchi Drive and Foothill Drive. The general project location is shown relative to the university in Figure 7.

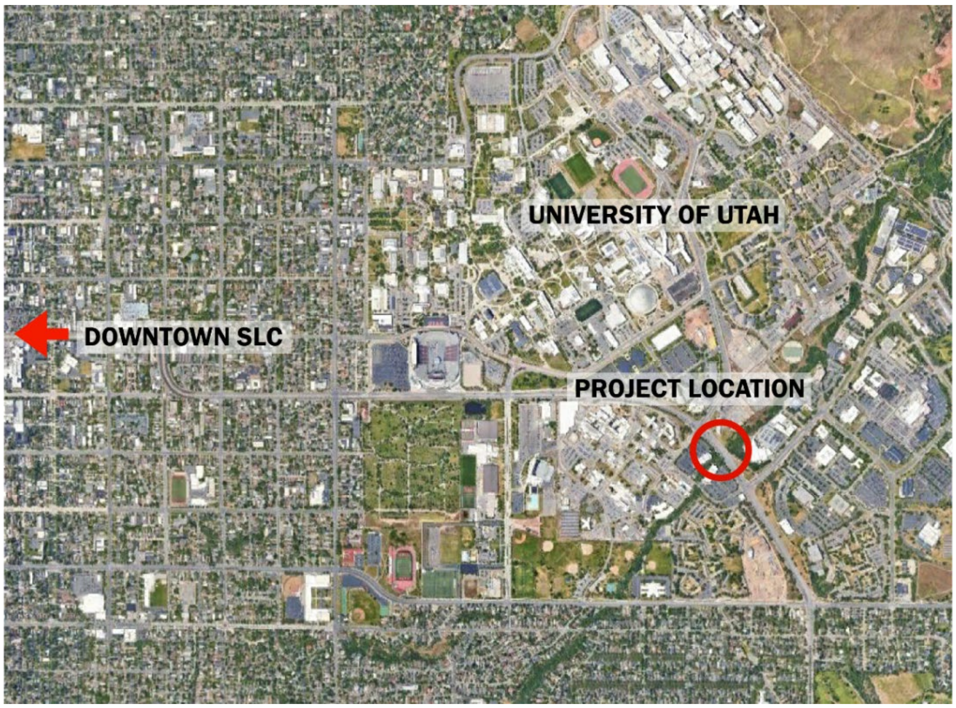


***Figure** 7 - Overall Project Location Provided by Google Earth*

As seen in the figure, the proposed project is located within the University of Utah campus. The intent of the project is to generate a "hot spot" crossing for the areas nearby. Short term, the crossing would provide connection from the University of Utah Orthopedic Center to student housing. The current pedestrian accommodations are complicated and pose considerable risk as discussed in the accident history discussion above. The City of Salt Lake Engineering Department expects that the crossing would resolve the previous conflicts and encourage students who live on the North side of Foothill Drive to walk/bike to campus. These areas are delineated in the figure below, specifically the crossing would connect the East Village with the West Village. Long term, the crossing would accommodate the future trail system along Red Butte Creek. The trail system is currently in the early project stages and would connect the current trail system with the Bonneville shoreline trail. The crossing would be considered a first installment for the advanced trail system with a tentative build date of 2027-2032.

2.2 Geologic and Geotechnical Analysis

An onsite geotechnical analysis was performed. The analysis included a review of available soil literature, conducting onsite exploration, mapping/logging and sampling, laboratory testing of field samples, and location and surface conditions. The investigation was conducted by AGEC on December 13, 2022. The purpose of the site investigation was to determine the feasibility of the project considering soil conditions. Included below are both a soil map of the project area (Figure 8) and the major findings from the laboratory testing (Table 2).

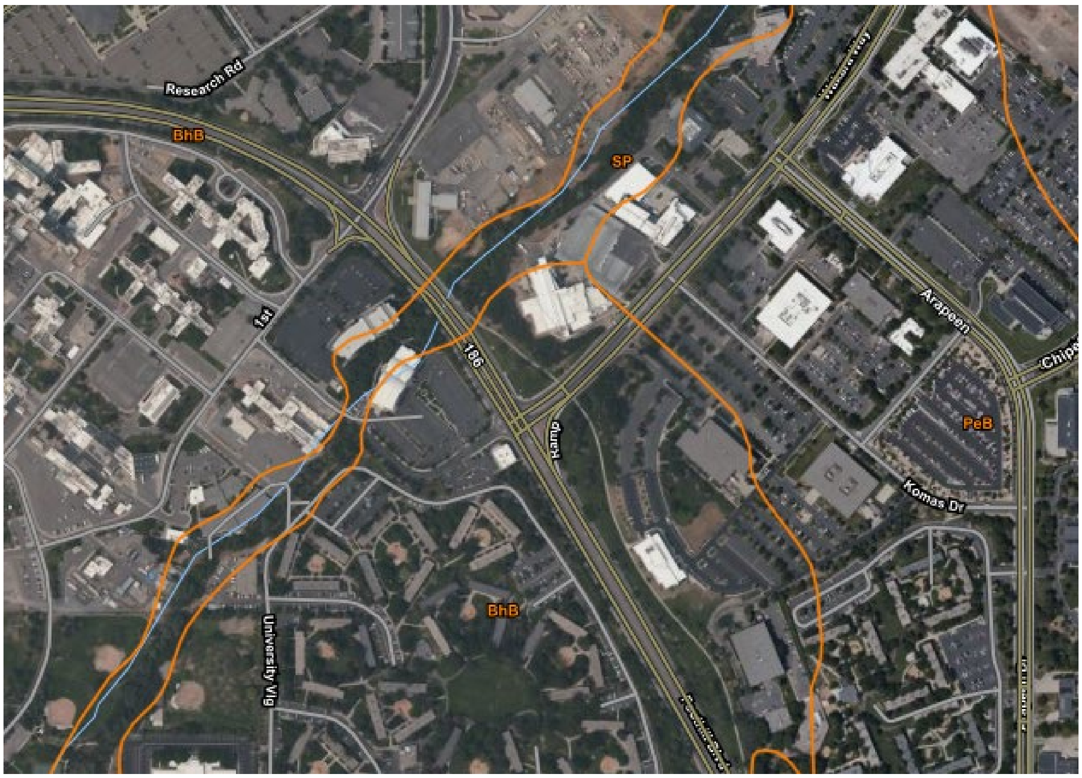


***Figure 8 -** Project Site Soil Map (USGS)*

***Table 2** - AGEC Soil Lab Results*

Initial Density			**Initial Moisture**		
Volume	0.001693	cu.ft	Wet Weight	82.54	g
Wet Weight	82.54	g	Dry Weight	69.33	g
Dry Density	90.28	pcf	Water Weight	13.21	g
Bulk Density	107.48	pcf	Moisture Content	19.05	%
Final Density			**Final Moisture**		
Volume	0.001693	cu.ft	Wet Weight	91.73	g
Wet Weight	95.62	g	Dry Weight	76	g
Dry Density	101.49	pcf	Water Weight	15.73	g
Bulk Density	---	pcf	Moisture Content	22.69	%

The report also includes a detailed sieve analysis with a total dry mass of sample ranging from 250-390 grams. These values were used to derive an estimated shrinkage factor for excavation, as well as generate the preliminary compaction results for the soil. The excavation values are reported as part of the cost estimate.

2.2.1 Floodplain Identification and Permitting

Site development requires storm water investigations and preparations. The floodplain was identified and is shown in Figure 9.

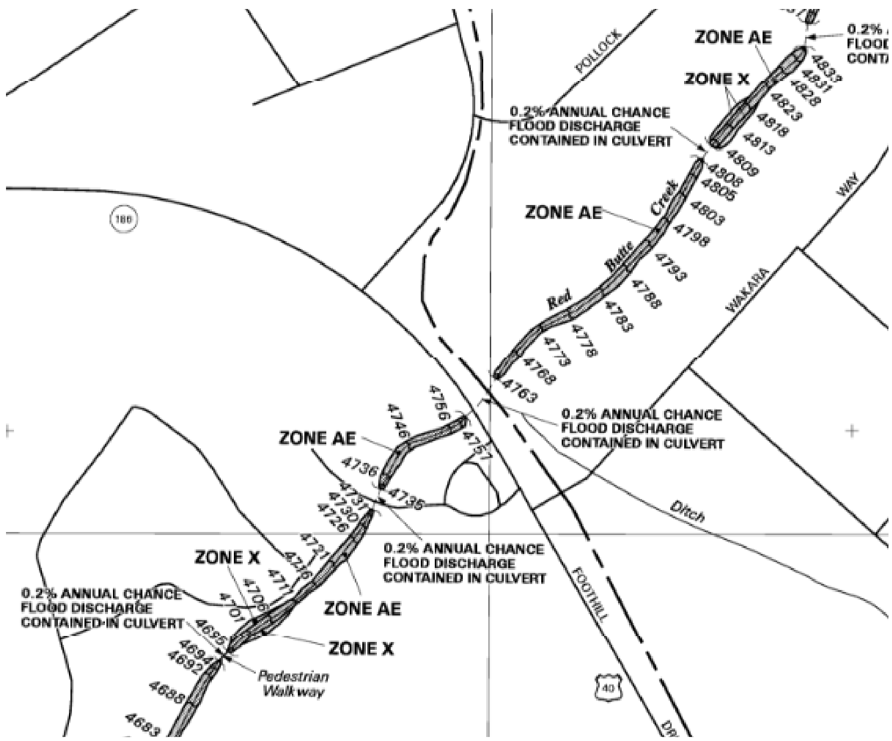


Figure 9 - *Floodplain Identification (provided by National Flood Insurance Program)*

In addition to the floodplain identification, the elevations for the floodplain were analyzed using the FEMA profile view of the floodplain. This is shown in Figure 10.

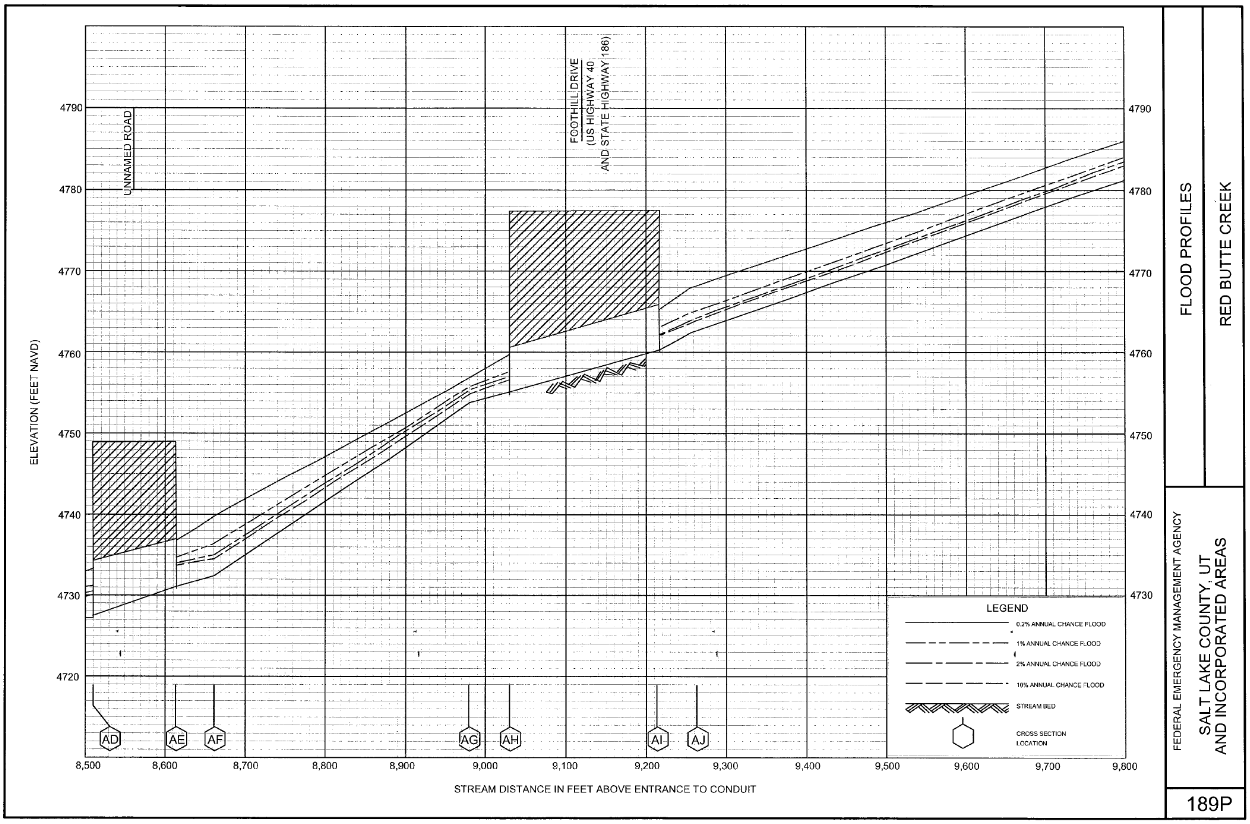


Figure 10 - *Red Butte Creek Flood Elevations (FEMA)*

Due to the proximity of the project to the 100-year floodplain, the project will require permitting on state, city, and nationwide basis. The permits required for the project are:

- Floodplain Development Permit
- Riparian Corridor Permit
- Stream Alteration Permit
- Salt Lake County Flood Control Permit

2.2.2 Hydrologic Analysis

To better understand the hydrologic conditions near the site, a report was generated via the USGS StreamStats software. The basin delineated for the site is shown in Figure 11. The entire report generated can be found in Appendix BLANK. The major finding that was utilized in the project design was an estimated flow rate of 1 cfs. This value was later used in the artificial channel calculations that can be found in Appendix B.

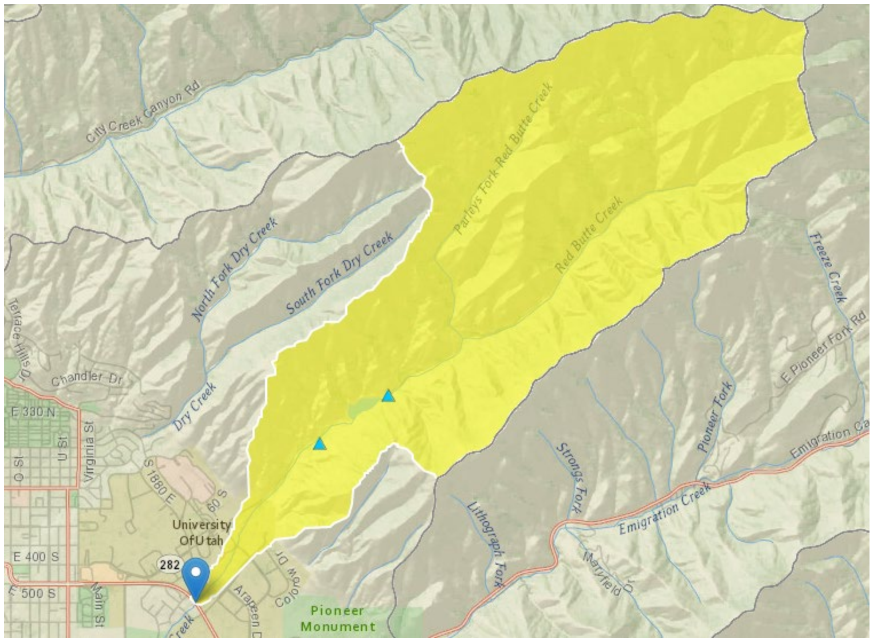


Figure 11 - *Site Basin Characteristics (StreamStats)*

2.3 Topographic

The terrain near the site posed many design conflicts. Specifically, the proposed ramp system on the southwest side of the crossing required several loops to accommodate for the elevation increase over the narrow area available. Note that all design values utilized were based on a lidar surface obtained by Open Topography. The values for elevation should therefore be verified onsite prior to construction. The surface derived from Open Topography is depicted in Figure 12.

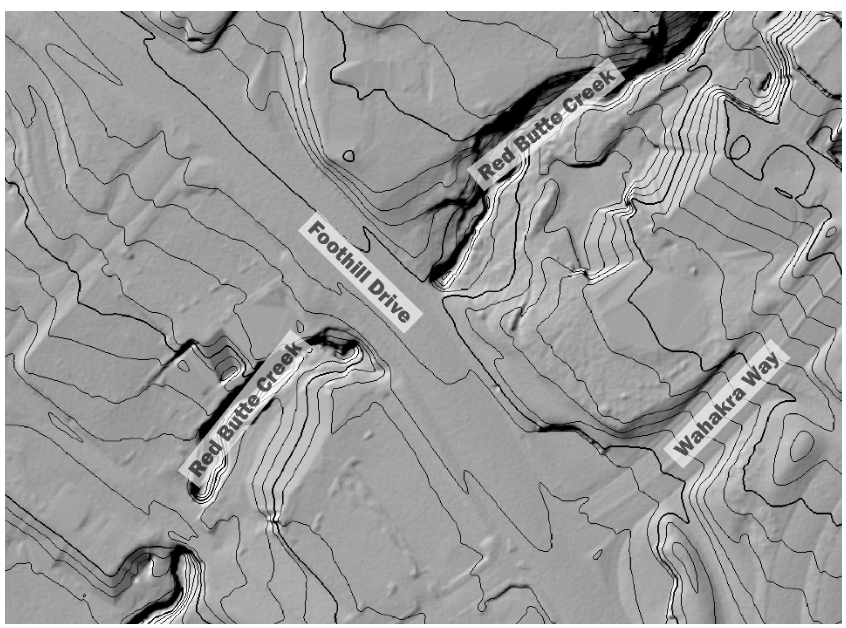


Figure 12 - *Project Topography (OpenTopography.com)*

3 Summary of Criteria

For the purpose of uniform analysis, a set of criteria was determined to meet the goals and objectives of the project. That criteria and the process to develop it are described in the following section.

3.1 Project Criteria

The goal of the pedestrian underpass is to provide a safer and more effective crossing on Foothill Drive than the existing at-grade crossings. A separated grade crossing will allow pedestrians and bicycles to cross the roadway without impacting the high volume of vehicle traffic to and from the University of Utah.

Outlining goals used to create an underpass with an effective design and considered throughout the final design process:

- Increased safety compared to at-grade crossing.
- Increased efficiency compared existing at-grade crossing.
- Accessibility to both pedestrians and cyclists.
- Compliant to minimum ADA standards.
- Maintenance of traffic through foothill drive during construction.
- Maintenance of existing flood control measures.

Other desirable goals that were considered that can improve the success of the project:

- Minimize construction process and time.
- Increase the natural beauty of the area.
- Incorporate natural and artificial lighting.

Limitations of design throughout the design process to meet goals and needs of the project are detailed in Table 3.

***Table 3 -** Design Constraints*

Design Constraints	
Location	Must not infringe on VA on west side of Foothill Drive
	Must not infringe on Fort Douglas Property on east side of Foothill Drive
Elevation Change	Maximum 1:20 grade change on paths to remain ADA compliant
	Existing elevation changes from east to west of Foothill Drive, the existing culvert, and Red Butte Creek's flow line
Utilities	Stormwater Drainage pipe needs to maintain function
Constructability	Pre-cast concrete features to speed construction time and minimize road closures during the construction phase
	Maintenance of traffic
Incorporation of Creek	Must incorporate the flow of the creek into an artificial channel within the underpass
Existing Culvert	Existing culvert must stay in place for creek flow and maintain 500-year flood design

3.2 Basis of Design

The Basis of Design provides a framework for the proposed crossing of Foothill Drive at Red Butte Creek. Functioning as a roadmap and a reference for the next stages of design. To accomplish this, a list of future tasks and a summary of stakeholder concerns have been constructed. Also, a concise summary of the project's concerns and needs has been included.

3.2.1 Integration of Stakeholder Priorities and Values

The major project stakeholders are listed below:

- Salt Lake City Engineering
- Salt Lake City Trails
- Sunnyside Neighborhood Community
- US Army Corp of Engineers
- SLC Ordinance Riparian Corridor Overlay District (RCO)
- Utah Division of Forestry, Fire & State Lands
- Utah State Engineer's Office
- SLC Engineering and Flood Control
- SLC Watershed Planning and Restoration
- US Federal Government

Previous research indicated that the primary project stakeholders are the SLC Engineering Department, and UDOT. SLC Engineering Departments primary project objectives are to create a pedestrian crossing that has integrated usage and purpose, improves the equity access and inclusion, is low maintenance and low construction, poses minimal invasion to the existing property, is safe for pedestrian use, poses no impact to off-site city infrastructure, minimizes the impacts to storm drainage and conveyance systems, minimizes the impacts to existing utilities, preserves the riparian corridor, connects to historic heritage, and promotes sustainable design.

The primary project objectives as provided by previous research for UDOT is to create a pedestrian crossing that is not at grade due to the proximity of the adjacent crossings, does not change the existing street width and volume, poses minimal disruption to traffic congestion, and preserves their right-of-way. Additional stakeholder objectives and goals were identified and classified. However, in the interest of keeping the report brief, the summaries are not included.

3.2.2 Integration of Sustainability

Red Butte Creek is a protected waterway and various permits will be required before development or alterations to the creek. Red Butte Creek Strategic Vision includes light preservation but promotes service and accessibility to the creek.

Underpass Environmental Requirements

- Priority for wildlife
- Proper stormwater drainage
- Access through structure
    - Water
    - People
    - Animals

Environmental limitations on development are in ordinance with the SLC Riparian Corridor along the creek. This is separated into areas A, B and C. Each area has restrictive measures on construction. Area A, 25 ft from edge, is a no disturbance. Area B, 25 to 50 ft from edge, is where structure limit can occur. Area C, 50 to 100 ft from edge, is a buffer transition area that allows development. The project falls within Area B, which is where structures are limited.

3.2.3 Integration of Equity, Diversity, Inclusion, Access

With any project it is necessary to include the integration of quality-of-life aspects of the community that will be impacted directly and indirectly. The importance of equity, diversity, inclusion, and access were analyzed based on a series of questions. Answers to the following questions were used to analyze the impact of the project:

- Does the project improve health and safety for the broader community?
- Does the project preserve and enhance cultural resources?
- Does the project meet the needs and goals of the community?
- Does the project minimize negative impact on the surrounding community?
- Does the project follow fair, equitable, and inclusive development?
- Is the project located near public transportation?

The project has a great opportunity to improve the pedestrian experience in the area, concurrently encouraging the use public transportation and bike paths/lanes. It will also encourage residents to participate in the nearby businesses without driving and struggling with parking. It will also be a huge improvement for the biking community as it will encourage the bike trail along Red Butte Creek which is a huge recreational opportunity.

Overall, our goal of the project is to create a safer pedestrian experience along Foothill Drive. Features included to enhance the quality of life for the community:

- ADA accessibility minimum requirements
- Lighting features
- Multi-use width
- Resting/seating area
- Connection to trail systems

The project aims to improve the quality of life for the broader community by improving the pedestrian experience. Currently the pedestrian crossing does not meet the community standards, and several fatalities have occurred in the area. Long term, the crossing is part of a much larger biking trail that would increase the recreational activities in the area. This increases the community's overall sustainability, increasing the quality of life, and increasing recreational activities.

3.3 Decision Criteria

The decision criteria to analyze our alternatives was the Envision Estimate provided in Appendix A classified the project using five major categories:

- Quality of life
- Leadership
- Resource allocation
- Natural world
- Climate and resilience

Each of these categories can be evaluated in terms of the sustainability for the project. Sustainability is defined as a community's ability to meet their needs without compromising the ability of future generations to meet their own needs.

To achieve this, the project design will keep in mind the regulations regarding the project location. The necessary research will also be conducted to prove that the project does not pose a danger to the surrounding area.

4 Summary of Process for Alternative Development, Analysis, and Selection

The alternative development's purpose is to make an informed decision on the best design approach. Alternatives in design were based upon feasibility and the desires of the clients. The location is a constant, but the means is open to the selection process.

4.1 Alternative Analysis

Limitations of design throughout the design process to meet goals and needs of the project included location, elevation change, utilities, constructability, integration of creek, and keeping the existing culvert. These constraints were used to develop alternatives for consideration.

Beyond constraints of the project, the following considerations were used to evaluate potential alternatives:

- Minimize the impact of the design on all surrounding facilities, neighborhoods, and communities.
- Increase user utilization by the proper use of vertical alignment, visibility, and site lines or waypoints.
- Incorporate access for all ages and skill levels of pedestrians (walkers, runners and strollers) and cyclists.
- Maintain the safety, and sustainability of the project at all times.
- Include landscaping/beautification in the project design.
- Identify and minimize impacts to existing utilities and roadway infrastructure.
- Identify and minimize potential construction issues and concerns.
- Identify and minimize impacts to existing storm water and sanitary services.
- Provide construction alternatives that allow for phased construction and future revisions to design that minimize the impacts to constructed facilities.

Many design aspects were considered while analyzing potential alternatives, however some were not included in the final design. Underpass alternative options included below.

Structural elements of underpass:

- Corrugated steel
- Buried bridge
- Boxed culvert
- Angled tunnel
- L-tunnel

Alternative options of underpass:

- Incorporation of creek
- Bike rail on stairs
- Small elevator
- Bike ramp
- Covered entrance
- Murals on the inside
- Retaining walls
- Switch backs for slope
- Skylight

Above are various underpass alternative options addressed to improve the project's constraints. For example, some alternatives did not make the final design. A bike rail and stair combination could reduce the amount of space by removing the ramp into the tunnel, a small elevator can be included for ease of access, and a covered entrance can be incorporated with the existing bus stop to improve public transportation in the area. Although these options would be beneficial, they did not meet the final design of the project after further analysis.

Location was a major limitation and analyzed heavily to determine a final location. There were two locations that were considered, both with the incorporation of Red Butte Creek. One location over the creek and another offset about … feet from the creek. The first location would replace the existing culvert and incorporate a full-sized channel for the Creek. This was not ideal due to the large size of the culvert and construction would face many challenges in closing roadways to remove the culvert. The second location was … feet from the existing culvert that would remain fully functional. Only a partial diversion would be incorporated in the design of the new underpass. This was the most ideal design after analysis.

4.2 Technical Scope of Work

The technical scope of work focusses on sizing of primary members, location (vertical and horizontal alignment), aesthetic design, and a preliminary engineer’s cost estimate. This includes the following features:

- 20’ wide x 10’ tall precast boxed culvert (12’ x 10’ underpass path clearance)
- 12’ wide path at < 5% grade on either side of the underpass to provide accessibility for pedestrians and cyclists of all abilities.
- Locations and preliminary sizing of concrete and block retaining walls
- Sizing of cobblestone-lined artificial channel to be installed within the precast boxed culvert (see drawing C-300)
- 8” diversion pipe with suggested location
- Stormwater drain relocation.

Aspects outside of the technical scope of work considered in this design are:

- Design of the diversion pipe and diversion structure
- Construction-grade plan set
- Detailed calculations for retaining walls (typical sizes used)

5 Design Development Summary

Once the analysis of alternatives had been performed, the design progressed towards the status of an engineering drawing set. The level of detail of this set was greater than a TSL (Type-Size-Location) drawing set, but not to the level of construction-ready documents. Details on the design are listed in the following sections.

5.1 Process

The design process timeline was marked by 2 primary deadlines. At each deadline, a set of drawings attached to a design summary was submitted to the client (Salt Lake City Corporation). After each of those deadlines, feedback was evaluated and then applied to the drawing set alongside continued progress and increased level of detail. The following sections will summarize the feedback that was received at each deadline, and how a resolution was approached (Table 4, Table 5).

5.1.1 Deadline 1

Table 4 - *February 6 Feedback*

Feedback	Resolution
Graffiti removal and prevention needs to be considered	Cost of anti-graffiti coating included in estimation
Lighting needs to be sufficient to feel like the underpass is full of natural light	Bright LED lights, and exterior lighting included in drawings
Measures need to be taken to ensure that the underpass feels welcoming and safe	Emphasis on the size of underpass, and inclusion of artificial channel emphasized
Engineers preliminary cost estimation needs to be provided	To be included
Details on what happens when Red Butte Creek floods needs to be provided	To be included in design

5.1.2 Deadline 2

Table 5 - *March 3 Feedback*

Feedback	Response
Maintenance of traffic plan needs to be included	To be included
Specific reasoning for the 20’ wide box culvert needs to be included	Will be explained with artificial channel and need for attractive underpass
CPTED issues need to be addressed	Existing CPTED measures emphasized

5.2 Design Data and Specification Summary

Table 6 - *Design Data and Specifications*

Path Width	12’
Path Elevation (NE Tunnel Entrance)	4760.7’
Path Elevation (SW Tunnel Entrance)	4756.8’
Path Elevation (NE Sidewalk Connection)	4773.8’
Path Elevation (SW Sidewalk Connection)	4770.2’
Max Path Grade	5.0 %
Path Thickness	4”
Box Culvert Interior Dimensions	20’ x 10’
Box Culvert Wall Thickness	1’

5.3 Operations and Maintenance Summary

Operation and maintenance will be required for the following features:

- Lighting
- Graffiti Removal / Graffiti Prevention
- Flood control inspection / Post-Flood Clearing
- Landscaping Maintenance

The project will utilize an anti-graffiti coating, native plant landscaping, and durable LED lighting to reduce operations and maintenance as much as possible. However, yearly inspections will be required to ensure that all systems are functioning properly. Since the flood control inspection and landscaping are time dependent, it would be wise to include inspections of the other systems concurrently. The timing of this inspection should occur after the spike in creek flow known as spring runoff.

***Table** 7 - Operations and Maintenance*

Concern	Operations / Maintenance
Lighting	Replacement of LED bulbs approximately every 5 years, with inspections occurring yearly.
Graffiti Removal and Prevention	Initial anti-graffiti coating on walls, graffiti removal at each incident.
Flood Control and Debris Clearing	Yearly inspection and clearing of the flow diversion structure to be performed after spring runoff. Debris cleaning after any flood classified as a 100YR flood or greater.
Landscaping	Yearly spring maintenance and inspection of landscaping.

5.4 Construction Needs and Phasing Summary

The construction will take place in two primary phases that will allow for traffic flow on half of Foothill Drive at any given time. Construction will begin near the VA building, until it is time to excavate the existing culvert. At that point the SW half of Foothill Drive will be closed off for excavation and installation of the new culvert (Figure 13). The next phase will involve closing off the NE half of Foothill Drive to excavate and install the new box culvert (Figure 14). Finally, that excavation will be filled, and the area on the NE side of Foothill Drive will be excavated so that the approach ramp can be installed. Additionally, after each phase of the road excavation has been completed, foothill drive will be re-paved and sidewalks will be re-poured. Herein lies potential for integration with the long-term complete streets plan for Foothill Drive.

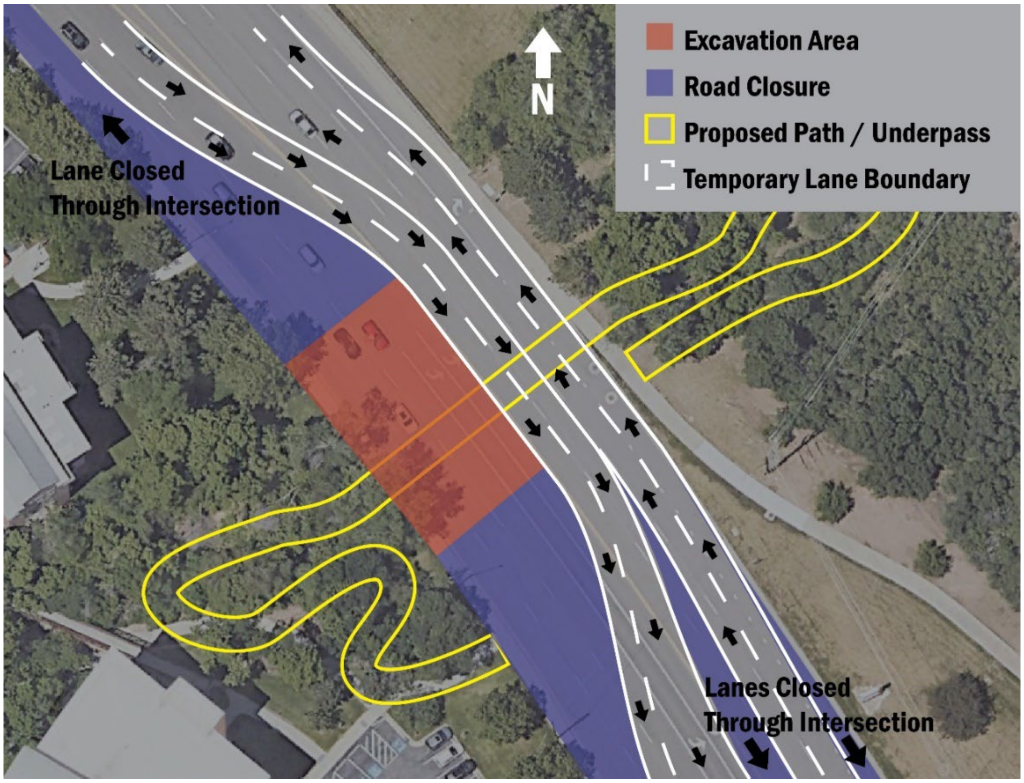


Figure 13 - *MOT Phase 1 Diagram*

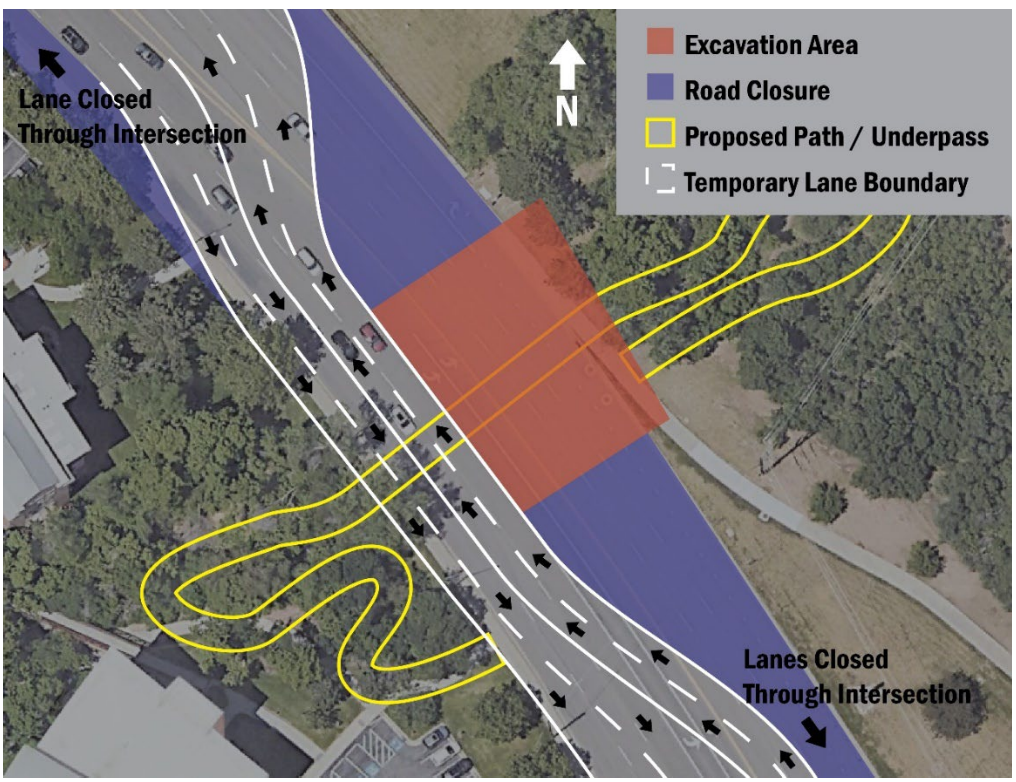


Figure 14 - *MOT Phase 2 Diagram*

Depending on VA cooperation, construction staging for the SW half of excavation may occur in the corner of the VA parking lot, or in the areas of road closure adjacent to the excavation area in Figure 13. For the NE side, construction staging will likely occur on U of U property NE of Foothill Drive and SE of Red Butte Creek. Additional area for construction staging will be available within the road closure next to the excavation area marked in Figure 14.

Foothill Dr must be kept open at all times. This is because the Hospital needs constant access to the community, and Foothill is a major arterial to the Hospitals on the hill. Due to the University schedule of semesters, the only viable time to perform the installation of the culvert will be during the lowest demand on the roads. The optimum time to perform the installation would likely be in the time period between June and early July to begin the project. August through May of any given year would be unfeasible with higher demand from students and faculty. The installation would preferably need to be completed by August 1, to allow for error in the construction if there is a delay without interfering with the semester timeline.

6 Design Summary Effectiveness

The Pedestrian Underpass provides a safer and more effective crossing on Foothill Drive. A separated grade crossing will allow pedestrians and bicycles to cross the roadway without impacting the high volume of vehicle traffic to and from the University of Utah. The goals outlined above were used to develop the proposed design.

Highlighted features and functions of the design include:

- Controlled diversion of Red Butte Creek to produce an artificial creek running through the underpass.
- Earthen berm barrier to guide floodwaters into the existing boxed culvert, maintaining existing flood control measures.
- Stackable block retaining walls to reduce cost and increase ease of construction.
- Artificial lighting inside and outside of the underpass to maintain safety.

Table 8 below addresses each individual design criteria and presents the solutions utilized in the design. It should be noted that many of the criteria were selected based on the stakeholder presenting the criteria. However, each criteria regardless of the stakeholder level of impact on the project was addressed and the solution selected.

Table 8 - *Project needs and design summary*

Project Criteria	Design Solution
Alternative to at-grade crossing	Underpass at 14’ below grade with connections to sidewalks.
Safe and attractive crossing	Appropriate lighting to match the feel of natural lighting. 20’ underpass width for roomy, natural feel. Murals included throughout tunnel and entrance
Accommodate to all ages / abilities	12’ path width with 5% maximum grade
Connect to current and future trail system	Marked locations for future trail connection. 12’ path to accommodate biking on trial connection. Incorporation of artificial channel into underpass Native plant landscaping.
Incorporation of Red Butte Creek	Partial diversion of Red Butte Creek into a small channel using pipe or dam.
Plants and vegetation	Use of native plants, grasses, flowers, bushes, shrubs, and stone to be incorporated in design entrance and surrounding landscaping
Maintenance of Traffic	2 phase road excavation and use of pre-cast structures to reduce total road closures.
Flood Control	Utilization of existing flood control measures. Earthen berm to separate floodplain from proposed culvert. Controlled diversion of flow for artificial channel to prevent flooding.
CPTED	Crime Prevention Through Environmental Design using natural access, sufficient lighting, and surveillance near VA property.

To better understand the final design and how the project needs, goals, and criteria were met throughout this project, please refer to the attached design drawings. Included in the Pedestrian Underpass Integrated with Red Butte Creek final design drawings are:

- Site plan
- Grading plan
- Profile views
    - East entrance
    - Underpass
    - West entrance
- Cross sections
    - East entrance
    - West entrance
- Details
    - Gravity wall sections
    - Retaining walls along trail
- Landscaping plan

7 Cost Summary

A preliminary engineer's cost estimate has been provided in Appendix C. The total price, which includes a 15% contingency and a 15% construction design cost, is $6.5 million. This cost estimation is finalized and would change as construction-grade drawings and design are developed.

Appendix C contains the details of the cost estimation process and quantities. Unit cost for the estimates were obtained from the best available sources, including online databases, and many lump-sum costs were obtained from projects of similar size. The most influential factor in the cost of the design is the pre-cast boxed culvert. The total of which comes to $4.5 million. This was based on a volumetric unit cost provided by an engineering consultant of $500/cubic foot.

Features and items excluded from the cost estimate:

- Final grading and fill
- Benches
- In-depth landscaping details and allocated costs.

While there are items not included in the cost estimate, the magnitude of the boxed culvert cost compared to the rest of the estimate indicates it may be overestimated. Considering both these aspects of the estimate, future refining is likely to result in a cost estimate of the $7-9 million range.

8 Work Summary

The results of the work performed for this project have been described and displayed in this report. This section will outline the specific progress and limits of that work performed. This progress can be summarized into 3 primary checkpoints of design which will be detailed below:

- Basis of Design
- Alternatives Analysis
- Final Design Development

Basis of Design

Upon introduction to the project, relevant master plans, stakeholders, and landowners were considered. Additionally, the site was observed from satellite imagery and topographic information. These investigations allowed for an effective list of objectives to be developed for a site visit. At the site visit, photos, rough measurements, utility locations, landmarks, and general observations were noted and referenced to a map. After this point, the practical restrictions of the site and needs of the project were developed. To synthesize the practical restrictions and project, the team met with many experts that were relevant to the project. All of this information was then combined to produce a Basis of Design for the project.

Alternatives Analysis

With the Basis of Design completed, work began on developing alternatives sketches for the project. 6 separate concepts were divided between 6 teams. Within each team, multiple alternatives for that concept were developed. After several rounds of presentation, critique, and review, a specific concept was chosen. At this time the 6 concepts were then altered at request of the client, and again alternatives were developed. It was at this point that the final concept of an underpass at Red Butte Creek, with an incorporated channel was settled on.

Final Design Development

At this point, calculations, specifications, and TSL (type, size, location) level drawings were developed. Aspects of the design determined by the team are listed below.

- Sizing, grade, and alignment of the underpass.
- Sizing, grade, and alignment of the path connecting the underpass to the sidewalk as well as future and existing trails.
- Underpass finishes, lighting, and artificial channel sizing.
- Landscaping and exterior features (lighting, retaining walls, benches)
- Utility relocation.
- Suggest construction phasing and MOT plan.

Appendix A – Referenced Envision Analysis

Date: 3/2/2023
Quality of Life Does the project: 1. Improve health and safety for the broader community?+1 2. Preserve and enhance cultural resources?+1 3. Meet the needs and goals of the community?+1 4. Minimize negative impact on the surrounding community?+1 5. Follow a fair, equitable, and inclusive development process?+1 6. Is the project located near public transportation? +2 Discuss: The project is a great opportunity to improve the pedestrian experience in the area which will encourage public transportation and utilize walking and biking in the area. The surrounding community is expected to experience population expansion, and yet the space for increased vehicular traffic is limited. This project will allow for increased pedestrian pathways on either side of Foothill Drive to connect through the underpass, and maintain a positive pedestrian experience. For each question, speculate as to: +0 not applicable or no opportunity +1 basic opportunity +2 chance to go above and beyond for little cost SCORE:7/12
Leadership 1. Are there sustainability commitments from the project developers?+1 2. Is there a sustainability management plan in place?+2 3. Are stakeholders engaged?+1 4. Will the project stimulate economic development?+2 5. Are local residents employed on the project?+0 6. Is the project located near public transportation? +2 Discuss: The project will undergo significant regulations because changes are being proposed in a floodway. The regulations will require substantial research and evidence that the proposed project does not negatively impact the environment in the area. However, currently there

are major stakeholders like the VA that are not engaged, and local residents have not yet been involved due to the early stage of planning the project is currently at.

For each question, speculate as to:
+0 not applicable or no opportunity
+1 basic opportunity
+2 chance to go above and beyond for little cost

SCORE: 9/12

Resource Allocation

1. Is the project constructed from sustainable materials?+1
2. Does the project manage construction and operational waste?+1
3. Does the project reduce energy consumption and source renewable energy?+0
4. Does the project reduce water consumption and protect water resources?+0
5. Does the project monitor energy and water use? +0

Discuss:
As the project has not gone past the preliminary design stages not very many steps have been made to manage the sustainable materials onsite. The nature of the project will not have a large impact to energy or water resources. Careful construction technique and waste management may reduce the impact of resources used.

For each question, speculate as to:
+0 not applicable or no opportunity
+1 basic opportunity
+2 chance to go above and beyond for little cost

SCORE: 2/10

Natural World
Does the project:

1. Avoid sites of high ecological value?+2
2. Protect wetland and surface water quality?+2
3. Maintain hydrological functions?+2
4. Manage storm water?+2
5. Protect soil health?+2
6. Manage or eliminate invasive species? +0

Discuss:
It is a huge priority in the project to prioritize the floodway health and development. When impacting a floodway there are many federal, state and city regulations that must be

complied with in the project. These will be done by installing best management practices on the site and will be submitted as part of all the permitting processes.

For each question, speculate as to:
+0 not applicable or no opportunity
+1 basic opportunity
+2 chance to go above and beyond for little cost

SCORE:10/12

Climate and Resilience
Does or is the project:

1. Reduce greenhouse gas emissions?+2
2. Reduce air pollutant emissions?+1
3. Avoid unsuitable sites?+0
4. Reduce climate change vulnerability?+1
5. Resilient and adaptable?+1

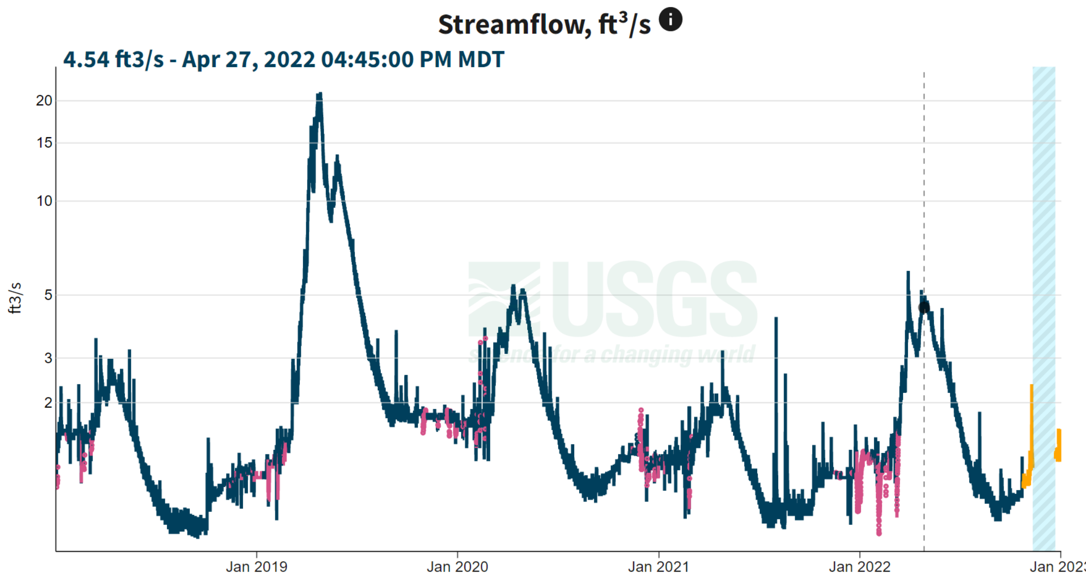
Discuss:
The project will decrease greenhouse gas emissions in the long term by providing attractive transportation options other than personal vehicles. This includes pedestrian, cyclist, and public transportation. However, in the short term many of the construction materials can be toxic and emit a substantial amount of pollutants. For these reasons they did not score a +2.

For each question, speculate as to:
+0 not applicable or no opportunity
+1 basic opportunity
+2 chance to go above and beyond for little cost

SCORE:4/10

Appendix B – Flow Calculations

To determine the size of the pipe that would divert flow from the stream, 2 sets of data were considered. The first set is the typical streamflow data for Red Butte Creek. This dataset shows that in many years, the streamflow is below 1 ft/s for much of the year. This led to the decision to size a small artificial channel that would not appear awkward with minimal flow. Then, the max normal flow of that channel was determined to be 4 ft^3/s. Using that flow rate, and a typical max velocity of 10 ft/s, it was determined that the pipe inner diameter be 8 inches.



Max Pipe Flow			
d (in)	A (ft^2)	v (ft/s)	Q (ft^3/s)
8	0.349066	5	1.745329
8	0.349066	8	2.792527
8	0.349066	10	3.490659

Manning's Equation for Normal Flow (ft^3/s)								
y (ft) depth	n	z (ft/ft)	b (ft) width	A (ft2)	P (ft)	R (ft)	S (ft/ft)	Q (ft3/s)
0.1	0.03	1	1.5	0.16	1.7828	0.0897	0.0083	0.1454
0.2	0.03	1	1.5	0.34	2.0657	0.1646	0.0083	0.463
0.3	0.03	1	1.5	0.54	2.3485	0.2299	0.0083	0.9189
0.4	0.03	1	1.5	0.76	2.6314	0.2888	0.0083	1.5056
0.5	0.03	1	1.5	1	2.9142	0.3431	0.0083	2.2223
0.6	0.03	1	1.5	1.26	3.1971	0.3941	0.0083	3.0708
0.7	0.03	1	1.5	1.54	3.4799	0.4425	0.0083	4.0548

Appendix C – Preliminary Engineer's Cost Estimate

Preliminary Engineers Estimate

PROJECT: Foothill Drive Pedestrian Underpass
PREPARED BY: Professional Practice Group 2
PROJECT NO.: 4910.23.1.2
LOCATION: Foothill Drive @ Red Butte Creek
DATE: February 23, 2023

ITEM	DESCRIPTION	Quantity	Units	Unit Price	EXTENDED PRICE
1	General Condition/Mobilization	1	LS	$30,000.00	$30,000.00
2	Dust Control	1	LS	$7,500.00	$7,500.00
3	Traffic Control (Road)	1	LS	$4,000.00	$4,000.00
4	Clear & Grub	1	LS	$3,500.00	$3,500.00
5	Pre-Construction Condition/SWPPP Documentation	1	LS	$5,000.00	$5,000.00
6	Signage	1	LS	$3,500.00	$3,500.00
7	Landscaping (Trees, Bushes, & Mulch)	1	LS	$20,000.00	$20,000.00
8	Trail Safety Rail	1	LS	$15,000.00	$15,000.00
9	Security System	1	LS	$5,000.00	$5,000.00
10	Concrete Retaining Wall	360	SQ.FT.	$40.00	$14,400.00
11	UDOT Coordination & Encroachment Permits	1	LS	$3,000.00	$3,000.00
12	Additional Permitting Applications	1	LS	$5,000.00	$5,000.00
13	Modular Block Retaining Wall	1,420	SQ.FT.	$25.00	$35,500.00
14	Storm Drain Relocation	1	LS	$20,000.00	$20,000.00
15	Cut/Fill Material	1,200	CU.YD.	$35.00	$42,000.00
16	Excavation, Common 1,000 CY (Culvert)	5,553	CU.YD.	$10.00	$55,530.00
17	Remove & Reinstall Existing Rip-Rap (Approximatly 3000 sq.ft.)	1	LS	$5,000.00	$5,000.00
18	Rip-Rap Rock 24" D50 with Filter Fabric (Basalt Rock)	3,000	SQ.FT.	$8.50	$25,500.00
19	Anti-Graffiti Coating	2,800	SQ.FT.	$1.50	$4,200.00
20	Pillips Luminaire LED lighting	20	EACH	$500.00	$10,000.00
21	Diversion Outlet Structure	1	EACH	$500.00	$500.00
22	RCP 8"	100	FT	$60.00	$6,000.00
23	Diversion Inlet Structure w/ Grate	1	EACH	$4,500.00	$4,500.00
24	22' Wide x 14' Tall Box Culvert with Base	140	LNFT	$32,000.00	$4,480,000.00
25	6" Wide x 18" Tall Parapet Wall	4	CU.YD.	$1,120.00	$4,480.00
26	2.5" Thick Asphalt(Voidless Asphalt Mix)	7,230	SQ.FT.	$2.35	$16,990.50
27	Slurry Overlay	7,230	SQ.FT.	$0.35	$2,530.50
28	6" Thick Concrete Trail Flatwork	19,944	SQ.FT.	$8.50	$169,524.00
29	6" Thick Type II Gravel Roadbase (Trail)	19,944	SQ.FT.	$0.80	$15,955.20
30	Concrete Stairs	84	SQ.FT.	$17.00	$1,428.00
31	6" Thick Cobblestone Artificial Channel Finish (using concrete trail cost)	430	SQ.FT.	$8.50	$3,655.00
32	Trail Pavement Markings Phase 1	1	LS	$625.00	$625.00
33	Asphalt and Base Removal	7,230	SQ.FT.	$1.00	$7,230.00
34	Revegetation of Trail Areas and Pole Plantings	1	LS	$5,000.00	$5,000.00
				Total	**$5,032,048.20**
				Grand Total	**$5,032,048.20**
				Contingency 15%	**$754,807.23**
				Construction Design & Engineering 15%	**$754,807.23**
				Grand Total	**$6,541,662.66**

Appendix D – AGEC Soil Tests & Boring Log

Applied Geotechnical Engineering Consultants, Inc.

Project Number: 1220771
Project Name: U of U Red Butte Crossing
Engineer: DJN

LABORATORY TESTING PROGRAM

Date: Dec. 13, 2022
Date Needed:
Date Completed:

BORING	DEPTH	MOISTURE	MOISTURE/DENSITY	GRADATION	-200 ONLY	HYDROMETER	ATTERBERG	SPECIFIC GRAVITY	CONSOLIDATION	UNCONFINED	DIRECT SHEAR	TRIAXIAL SHEAR	TRIAXIAL PERM.	PERMEABILITY	GRADIENT RATIO	STD. PROCTOR	MOD. PROCTOR	RELATIVE DENSITY	CBR	SULFATES	RESISTIVITY	PH					REMARKS
B-1	2'		X	X																							
B-1	6'		X	X																							
B-1	10'		X	X																							
B-1	14'		X	X			X		X											X							2 liners can be used
B-1	19'		X	X																							
B-1	24'		X	X																							
B-1	29'		X		X		X																				
B-2	2'		X	X																							
B-2	8'		X	X																							
B-2	16		X	X																							
B-2	28		X	X																							
B-2	30		X	X																							

Applied Geotechnical Engineering Consultants, Inc.

MOISTURE/DENSITY WORKSHEET

Project Number 1220771
Project Name U of U Red Butte Crossing

Sheet prepared by__Date 12/13/22
Sheet calculated by____Sheet___of___

IDENTIFICATION		TEST RESULTS		SAMPLE DESCRIPTION	DENSITY DETERMINATION					MOISTURE DETERMINATION				
Boring	Depth, Feet	% Moisture	Dry Density (pcf)		Sample Length	Sample Diameter	Set Soil & Tare Wt.	Tare Weight	Wet Soil Weight	Dish Name	Wet Soil & Dish Wt.	Dry Soil & Dish Wt.	Dish Weight	Run By
B-1	2	4.76%	119.04		4.00	1.93	496.38	113.32	383.06		537.33	520.02	156.24	
B-1	6	6.26%	117.65		4.00	1.93	498.17	114.15	384.02		538.91	516.37	156.19	
B-1	10	2.32%	108.20		4.00	1.93	460.34	120.28	340.06		495.67	487.96	155.72	
B-1	14A	4.19%	97.53		4.00	1.93	426.22	114.07	312.15		464.22	451.70	153.11	
B-1	14B	4.19%	92.82		4.00	1.93	417.21	120.15	297.06		464.22	451.70	153.11	
B-1	19	3.23%	104.61		3.87	1.93	439.48	118.53	320.95		474.38	464.34	153.86	
B-1	24	1.39%	106.56		3.83	1.93	435.42	117.64	317.78		469.13	464.78	151.58	
B-1	29	2.10%	121.46		4.00	1.93	505.01	124.09	380.92		300.33	297.25	150.53	
B-2	2	3.34%	109.58		4.00	1.93	473.60	125.77	347.83		498.82	487.59	151.42	
B-2	8	5.49%	115.77		4.00	1.93	489.30	114.16	375.14		526.57	507.05	151.43	
B-2	16	18.23%	81.59		4.00	1.93	413.90	117.59	296.31		448.05	402.44	152.28	
B-2	28	4.98%	102.00		4.00	1.93	443.95	115.02	328.93		480.58	464.98	151.64	
B-2	30	5.56%	126.51		3.96	1.93	526.90	120.81	406.09		564.91	543.57	159.53	

Applied Geotechnical Engineering Consultants, Inc.

Project Number 1220771 SOLUBLE SULFATES Sheet prepared by______Date__________

Project Name U of U Red Butte Crossing WORKSHEET Sheet calculated by_____Sheet____of____

Boring @ Depth	B-1 @ 14		
Dilution (Standard is 30ml/100ml)	None	15ml/100ml	10ml/100ml
Dilution Factor	1	2	3
Turbidity - Soil/Water with $BaCL_2$	29.6		
Turbidity - Soil/Water without BaCL2	2.1		
Turbidity Difference	27.5		
Sulfate, mg from Chart	0.25		
Sulfate, ppm (Chart*100*Dilution Factor)	25	0	0
Sulfate, percent (ppm/10000)	0.0025	0	0

Boring @ Depth			
Dilution (Standard is 30ml/100ml)	None	15ml/100ml	10ml/100ml
Dilution Factor	1	2	3
Turbidity - Soil/Water with $BaCL_2$			
Turbidity - Soil/Water without BaCL2			
Turbidity Difference			
Sulfate, mg from Chart			
Sulfate, ppm (Chart*100*Dilution Factor)	0	0	0
Sulfate, percent (ppm/10000)	0	0	0

Boring @ Depth	@		
Dilution (Standard is 30ml/100ml)	None	15ml/100ml	10ml/100ml
Dilution Factor	1	2	3
Turbidity - Soil/Water with $BaCL_2$			
Turbidity - Soil/Water without BaCL2			
Turbidity Difference			
Sulfate, mg from Chart			
Sulfate, ppm (Chart*100*Dilution Factor)	0	0	0
Sulfate, percent (ppm/10000)	0	0	0

Boring @ Depth	@		
Dilution (Standard is 30ml/100ml)	None	15ml/100ml	10ml/100ml
Dilution Factor	1	2	3
Turbidity - Soil/Water with $BaCL_2$			
Turbidity - Soil/Water without BaCL2			
Turbidity Difference			
Sulfate, mg from Chart			
Sulfate, ppm (Chart*100*Dilution Factor)	0	0	0
Sulfate, percent (ppm/10000)	0	0	0

Boring @ Depth	@		
Dilution (Standard is 30ml/100ml)	None	15ml/100ml	10ml/100ml
Dilution Factor	1	2	3
Turbidity - Soil/Water with $BaCL_2$			
Turbidity - Soil/Water without BaCL2			
Turbidity Difference			
Sulfate, mg from Chart			
Sulfate, ppm (Chart*100*Dilution Factor)	0	0	0
Sulfate, percent (ppm/10000)	0	0	0

Boring @ Depth	@		
Dilution (Standard is 30ml/100ml)	None	15ml/100ml	10ml/100ml
Dilution Factor	1	2	3
Turbidity - Soil/Water with $BaCL_2$			
Turbidity - Soil/Water without BaCL2			
Turbidity Difference			
Sulfate, mg from Chart			
Sulfate, ppm (Chart*100*Dilution Factor)	0	0	0
Sulfate, percent (ppm/10000)	0	0	0

Consolidation Analysis

Project Number:	1220771
Project Name:	U of U Red Butte Crossing
Sample Location:	B-1
Sample Depth:	14.00 ft
Sample Length:	1.00 in
Sample Diameter:	1.93 in

Sample Mold Condition?	Liner
Pounded, Pressed or Natural?	Natural
Use Moisture Correction?	No
Actual Percent of Proctor	#####
Actual Moisture Content:	%
Proctor Target	
OMC	

Initial Density

Volume:	0.001693 ft^3
Wet Weight & Ring:	324.23 g
Ring Weight:	241.69 g
Wet Weight:	82.54 g
Dry Density:	90.28 pcf
Bulk Density:	107.48 pcf

Initial Moisture

Wet Weight:	82.54 g
Dry Weight:	69.33 g
Water Weight:	13.21 g
Moisture Content:	19.05 %

Final Density

Length:	1.0000 in
Volume:	0.001693 ft^3
Wet Weight & Ring:	337.31 g
Ring Weight:	241.69 g
Wet Weight:	95.62 g
Dry Density:	101.49 pcf

Final Moisture

Dish & Wet Weight:	91.73 g
Dish & Dry Weight:	76.00 g
Dish Weight:	6.67 g
Water Weight:	15.73 g
Dry Soil Weight:	69.33 g
Moisture Content:	22.69 %

Dial Readings

Dial Type: Decreases with consolidation

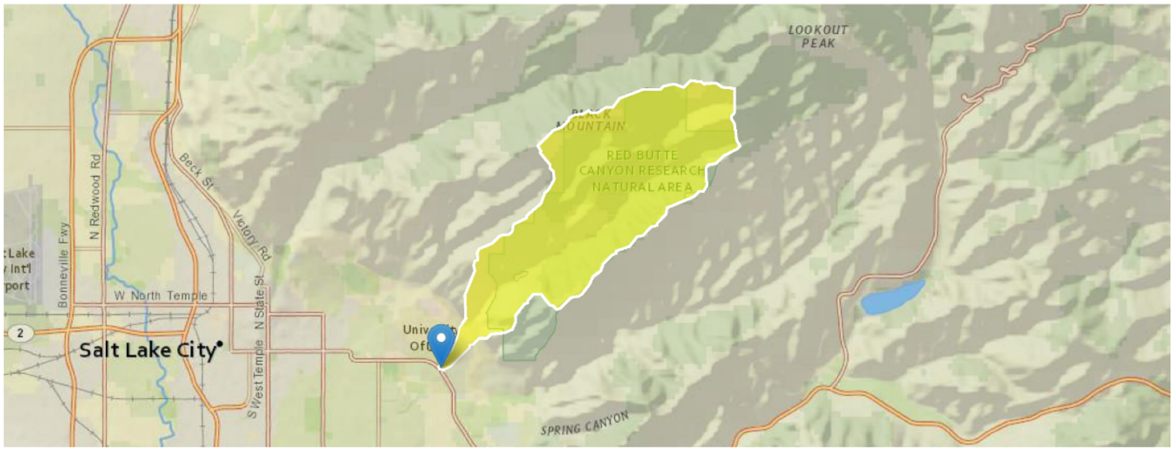
Load (ksf)	Dial Reading	Dial Change	Strain	Pressure (ksf)
0	0.5257	0.0000	0.00	100
1	0.5109	0.0148	1.48	1,000
W	0.4896	0.0361	3.61	1,000
2	0.4831	0.0426	4.26	2,000
4	0.4686	0.0571	5.71	4,000
8			#N/A	8,000
16			#N/A	16,000
4			#N/A	4,000
1			#N/A	1,000

Length Change:	0.0571 in
Collapse:	2.13 %

Appendix E – Stream Stats Report

StreamStats Report

Region ID: UT
Workspace ID: UT20230118031023808000
Clicked Point (Latitude, Longitude): 40.75652, -111.83466
Time: 2023-01-17 20:10:43 -0700



Collapse All

Basin Characteristics

Parameter Code	Parameter Description	Value	Unit
DRNAREA	Area that drains to a point on a stream	8.8	square miles
PRECIP	Mean Annual Precipitation	33.9	inches

Peak-Flow Statistics

Peak-Flow Statistics Parameters [Region 2]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	8.8	square miles	2.14	84.1
PRECIP	Mean Annual Precipitation	33.9	inches	16.5	53.7

Peak-Flow Statistics Flow Report [Region 2]

PII: Prediction Interval-Lower, Plu: Prediction Interval-Upper, ASEp: Average Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	SE	ASEp	Equiv. Yrs.
50-percent AEP flood	41.5	ft^3/s	71	71	0.9
20-percent AEP flood	71.4	ft^3/s	58	58	1.6
10-percent AEP flood	94.8	ft^3/s	53	53	2.5
4-percent AEP flood	118	ft^3/s	51	51	3.7
2-percent AEP flood	149	ft^3/s	50	50	4.6
1-percent AEP flood	172	ft^3/s	50	50	5.4
0.5-percent AEP flood	196	ft^3/s	51	51	6.1
0.2-percent AEP flood	239	ft^3/s	52	52	6.8

Peak-Flow Statistics Citations

Kenney, T.A., Wilkowske, C.D., and Wright, S.J.,2007, Methods for Estimating Magnitude and Frequency of Peak Flows for Natural Streams in Utah: U.S. Geological Survey Scientific Investigations Report 2007-5158, 28 p. (http://pubs.usgs.gov/sir/2007/5158/)

Annual Flow Statistics

Annual Flow Statistics Parameters [Mean Flow SIR08 5230 Region 2]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	8.8	square miles	2.14	70.1
PRECIP	Mean Annual Precipitation	33.9	inches	22.3	49.5

Annual Flow Statistics Flow Report [Mean Flow SIR08 5230 Region 2]

PIl: Prediction Interval-Lower, Piu: Prediction Interval-Upper, ASEp: Average Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	ASEp
Mean Annual Flow	6.54	ft^3/s	63.1

Annual Flow Statistics Citations

Wilkowske, C.D., Kenney, T.A., and Wright, S.J.,2009, Methods for Estimating Monthly and Annual Streamflow Statistics at Ungaged Sites in Utah: U.S. Geological Survey Scientific Investigations Report 2008-5230, 62 p. (http://pubs.usgs.gov/sir/2008/5230/)

Application Version: 4.12.0
StreamStats Services Version: 1.2.22
NSS Services Version: 2.2.1

Appendix F – Drawing Set Sequence and Description

The drawings discussed within this report have been included in a separate PDF. The sequence of pages included in the drawing set are as follows:

C-000 Title Sheet
C-001 General Notes
C-100 Demolition Plan
C-200 Site Plan
C-300 Grading and Drainage Plan
C-400 Landscaping Plan
PP-1 Plan and Profile (1)
PP-2 Plan and Profile (2)
PP-3 Plan and Profile (3)
C-500 Detail Sheet (Typical Cross Sections)