BYU ENGINEERING
Civil & Construction Engineering

CAPSTONE

ASCE SUSTAINABLE SOLUTIONS COMPETITION
PROJECT ID: CEEN_CPST_007

by

Sustainability Team
Andrew Rodriguez
David Shill
Haley Beckstrand

A Capstone Project Final Report

Submitted to

Jennifer Upmeyer
American Society of Civil Engineers

Department of Civil and Construction Engineering
Brigham Young University

April 17, 2023

EXECUTIVE SUMMARY

PROJECT TITLE: ASCE SUSTAINABLE SOLUTIONS COMPETITION
PROJECT ID: CEEn_CPST_007
PROJECT SPONSOR: American Society of Civil Engineers
TEAM NAME: Sustainability Team

For our Capstone Project, we are participating in the ASCE Sustainable Solutions Competition. The purpose of this competition is to challenge students to develop a stronger understanding of sustainability and learn to incorporate creative sustainable solutions into everyday problems using the resources we have available.

The problem statement for this year's competition was to revitalize one block of a fictional city. The existing buildings would remain on site, but we were to invest our efforts into reimagining the surrounding area to create a cohesive and walkable corridor. In addition, the project needed to include a storm water management system, multimodal transit approach, the construction of an education community center, and a Superior level ENVISION design at minimum. While the city block is technically fictional, we were encouraged to incorporate local codes and regulations to justify decisions.

The deliverables were a technical report, an ENVISION Checklist spreadsheet, a public outreach poster, and a sketch-up model of our design. The technical proposal included an executive summary, documentation on all calculations conducted, a justification report following the ENVISION framework, and a cost estimate of the project. These deliverables were submitted to the ASCE server on March 24th, 2023. At the competition in Reno, Nevada from April 13th to April 15th, we will present our public outreach poster and our project to the judges.

We received the prompt for the competition in September. For Fall semester, we focused on growing our team and completing the ENVISION course to become ENV-SP certified. The beginning of winter semester was dedicated to brainstorming and research. In January we conceptualized different ways we could meet the requirements of the project in creative ways. February was spent refining those ideas and working on our individual responsibilities; namely ENVISION standards, model design, and project calculations. In March, we finished the initial deliverables and submitted our project to the competition. Finally, April was spent preparing our presentation and attending the competition.

TABLE OF CONTENTS

Contents

Executive Summary 2
Table of Contents 3
List of Figures 4
List of Tables 4
Introduction 5
Schedule 7
Assumptions & Limitations 7
Design, Analysis & Results 8
Related Issues 14
Lessons Learned 14
Conclusions 15
Recommendations 15
Appendix A 16

LIST OF FIGURES

[NONE]

LIST OF TABLES

Table 1. C Values for each Land Use 9
Table 2 Composite C Calculation 9
Table 3. Calculation of 100-Year Flow for each Sub-basin 10
Table 4. C Values for each Land Use 10
Table 5. Composite C Calculation 10
Table 6. Calculation of 100-year flow 11
Table 7. Pipe Sizing 11

INTRODUCTION

We were assigned to revive a fictional city block and transform the underutilized area into a gathering place for our community. To achieve this, we adhered to the ENVISION Checklist framework and looked for sustainable solutions to the underlying issue of revitalizing, rebuilding, and expanding our community here in Provo, Utah. The project had specific requirements, including the implementation of a stormwater management system, multimodal transportation approach, construction of an educational community center, and meeting at least a Superior level ENVISION design. Though the city block was not real, we were advised to assume that it was a project based in our own community and to integrate local regulations and codes into our decision-making process.

Throughout the school year, our team had to complete various tasks to meet the March 24th deadline for our project. Upon receiving the prompt in September, our first task was to recruit additional team members. By adding more people, we aimed to gain diverse perspectives and increase problem-solving capacity, which would help us complete the project more efficiently. To this end, we created a presentation outlining the project goals and submitted it to the seminar to invite interested people. We received positive responses and were able to assemble a team comprising Civil and Construction Engineering students. These members brought fresh ideas and insights, which enhanced the final design of our Capstone project, and provided us with opportunities to practice leadership and delegation skills.

The other task for fall semester was receiving our ENV-SP certification via the ENVISION program. This certification was crucial to the sustainability aspect of our project, and we were fortunate to secure funding from BYU to enroll in the ENVISION course. The course provided an in-depth understanding of the importance of the ENVISION framework for sustainable projects and clarified the details of its implementation. Through this course, we gained valuable insights that aided in our decision-making process and helped us start brainstorming for the final design. We learned how to incorporate sustainability and resilience principles into our project design and operation, ensuring that our Capstone project fulfilled the competition’s requirements to contribute positively to the surrounding community and environment. Overall, the ENVISION certification and the course enabled us to approach our project with a clearer perspective, emphasizing the triple approach of economic, social, and environmental sustainability.

The winter semester marked the start of our project's development. Throughout January, we devoted our attention to generating innovative solutions to the problems presented in the prompt. We conducted extensive research on various approaches and held regular meetings to share our discoveries and discuss the most effective course of action. In February, we divided our team into sub-groups to maximize our productivity. We refined our earlier ideas and assigned tasks accordingly. The design team set to work mastering Sketch-up software and creating a detailed 3-D model of our project. Meanwhile, the calculations team analyzed the layout to determine values for stormwater management, parking stall requirements, earth load balance, and more to support our ideas. The ENVISION team conducted extensive research to develop a framework and linked ideas to specific sections to achieve a superior rating. March was a busy month, as we finalized and polished our individual responsibilities and prepared technical statements for the report. We also completed the cost estimation and created a public outreach poster. On March 24th, we submitted all the necessary deliverables through the ASCE server.

As April approached, our focus shifted to making final preparations for the ASCE competition in Reno, Nevada. We printed out our public outreach poster and commenced planning our presentation. To showcase our project in its entirety, we prepared a comprehensive set of slides with a 3-D walkthrough of our model. Additionally, we crafted a script for the presentation and rehearsed our individual parts to ensure that we conveyed the extent of our hard work on this project. The conference is scheduled for April 13th, and we are looking forward to the opportunity to showcase our efforts.

SCHEDULE

Each week we had a meeting with the whole group. Each capstone member had their own team which they are responsible for leading in this weekly meeting. In most cases, meetings occurred every Thursday at 6 pm, but there were some weeks when capstone members were so overwhelmed with extenuating life circumstances or simply did not need to meet for various reasons. Before this meeting each week, members of this capstone group prepared for the meeting by organizing thoughts and tasks into a plan (written or unwritten). Capstone members also met together to coordinate the project each week.

One of the milestones that we were shooting for was, by the end of last semester, to complete ENVISION training, and its writeup and justifications. This important milestone would have ensured that going into the project we had a good idea of the sustainability standards to look for. However, this was a more daunting task than we realized. We were all able to complete some ENVISION training, but most of that burden lay on Haley to complete the justifications, and she was able to do so before the submission deadline.

In January we began designing. Rough ideas became more detailed and some calculations for the design were completed. Our original plan was to finish the "before" calculations in January, but that became untenable as there were more design calculations than we anticipated, and many of them required after data. Thus, the calculations were completed in tandem with ENVISION and design instead of ahead of those two facets of the project. In February we planned on preparing the presentation aspects of the project. However, this was a higher goal than we had anticipated. The design team was, though, able to create posters and modeling before the submission deadline in March.

Our milestones may not have been completed in the predetermined schedule, but everything was completed by the submission deadline, so we are content. In the future, sustainability teams should make a greater effort to solidify ENVISION justifications in December so as to stay on schedule. We think we would have had an easier time with the project had we as an entire team finished the ENVISION justifications first and then split up to work on other aspects of the project. We are, however, very proud of our great accomplishment of finishing this project within the set deadlines despite the fact that too much of the work was done in the weeks leading up to that deadline.

ASSUMPTIONS & LIMITATIONS

According to the prompt from the competition, it was important that we assume that the fictional city block we were revitalizing existed within our own community. This presented an interesting challenge because it was necessary for us to create our design using the appropriate local regulations and codes. While this did technically limit our design, it helped us to be more creative and to look at the project in a more realistic way despite its hypothetical nature.

In addition to complying with regulations in the area, we had to consider the environmental restrictions specific to Provo while designing our storm water system. We considered local rainfall levels and soil types to create a system that could effectively handle the precipitation in Utah. However, during our research, we realized that some of our initial ideas were not practical for the area. To address this issue, we sought the help of professionals in the field and made necessary adjustments. As a result, our design evolved from a general plan to a practical and thriving system that is tailored to the unique environmental conditions of Provo. This level of thought is reflected throughout the project.

DESIGN, ANALYSIS & RESULTS

There were many calculations done to inform the design of this project. Those included:

- *Existing and New Impervious Areas*, to understand both visually and mathematically how much green space we would be adding to the project
- *Existing and New Stormwater Runoff Volume*, to understand by what factor we were reducing runoff volume
- *Existing and New Site Discharge*, to design the stormwater management plan and to ensure that the pipes could handle the 100-year storm event.
- *Earthwork Balance*, to ensure that all cut and fill in the project was balanced and to account for digging an appropriately sized detention pond.
- *Roadway design*, to ensure a good user experience, especially for pedestrians
- *Parking Space Justification*, to ensure there are enough parking spots, and that we can remove parking areas and replaces them with green areas and forest
- *Energy Use Reduction*, to understand the amount of energy we can reduce and to ensure that we have space for enough solar panels for entire operational energy use.
- *Water Use Reduction*, to ensure that the catchment of water at the site is enough for 95% of the water needs of the operation.

All of these calculations and their results are found below:

Existing and New Impervious Areas

Prior to our improvements, we estimate that pervious areas constituted 66.29% of the total area at 767,380 ft² or 17.62 acres. Impervious areas constitute the other 33.71% of the total area at ***390,285 ft²*** or 8.96 acres. In our improvement plan, we estimate that pervious areas will constitute 93% of the total area at 1,079,815 ft² or 24.79 acres. Impervious areas will constitute the other 7% of the total area at ***77,850 ft²*** or 1.79 acres. Thus, improvements decreased impervious areas by 80%.

Existing and New Stormwater Runoff Volume

Existing:

The Soil Conservation Service (SCS) method is a commonly used approach to calculate the runoff volume for a given area. To use this method, the hydrologic soil group needs to be determined, which, in this case, is group C. Additionally, the CN (Curve Number) we will be using for impervious and pervious areas are 98 and 74, respectively. Given that impervious areas make up 66.29% of the area and pervious areas are 33.71%, a composite CN can be calculated by using a weighted average. With this composite CN, the runoff volume can be calculated for a precipitation event of 1 inch. The total area of the region is 26.58 acres, and 1 inch of precipitation is equivalent to 0.0833 feet. The SCS method equation for runoff volume in inches is

$Q = ((P - 0.2S)^2 / (P + 0.8S) * 0.01) * A$

Where Q is the runoff volume, P is the precipitation, S is the maximum potential retention, and A is the area. For hydrological group C and a composite CN of 82.09, S is calculated as follows:

$S = 1000 / CN – 10$

This results in a runoff volume of approximately ***11,166 cubic feet*** or 83,526 gallons.

New:

As part of our strategy, we will be capturing all of the stormwater from the roofs of the buildings and thus that area will be excluded from our area calculations. In addition, all pavement will be replaced with permeable materials with a curve number of 74. Thus our composite CN is 74. Using the same method described before with a new CN and new area, we get a total estimated runoff of ***2,065.31 cubic feet*** or 15,450 gal which represents a reduction of runoff volume of ~80%.

Existing and new site discharge at outfall - Stormwater Management Plan

Existing:

To estimate site discharge at outfall, and also to size our pipe, we will be using the rational method.

The basic equation for the rational method is

Q = CIA

where:

Q is the peak discharge (in cubic feet per second)

C is the runoff coefficient (dimensionless)

I is the rainfall intensity (in inches per hour)

A is the drainage area (in ft^2)

First we will calculate a composite C. To calculate composite C, the drainage area is divided into sub-basins. We then calculate the land use proportions. We then use a weighted average of the land uses and their areas to calculate a composite C. C values for each land use are found in Table 1. Composite C is calculated in Table 2.

Table 1. C Values for each Land Use

Existing Forest	Grass	Gravel	Pavement / Roofs
0.15	0.25	0.85	0.90

Table 2 Composite C Calculation

Drainage Index	Drainage Area [ft²]					COMPOSITE C
	Forest	Grass	Gravel	Pavement	TOTAL	
A	1076.22	55445.78	0.00	9902.71	66424.71	0.3452828905
B	50840.96	61234.54	41760.69	5965.88	159802.07	0.3992480107
C	141405.53	114978.42	0.00	212751.16	469135.12	0.5146310156
D	0.00	16313.47	0.00	7288.70	23602.16	0.4507295774
E	0.00	16207.17	0.00	4902.65	21109.82	0.4009592776
F	0.00	2636.68	0.00	21030.89	23667.57	0.8275869625
G	0.00	5514.64	0.00	31788.22	37302.85	0.8039077589
H	0.00	13457.51	0.00	62615.01	76072.51	0.7850126192
I	0.00	53595.93	0.00	34039.41	87635.35	0.502473681
J	0.00	192913.00	0.00	0.00	192913.00	0.25

Now that we have a C value and area for each Sub-Basin, we must lastly calculate intensity. To do so, we must measure the drainage lengths and slopes and calculate the time of concentration. Time of concentration is calculated as follows:

T_c = 60*(0.007*(0.016*D)^0.8)/(0.9^0.5*S^0.4)

Where:

T_c = Time of Concentration [min]

D = Drainage Length [ft]

S = Slope [%]

We then use rainfall intensity tabular data for the 100-year storm from The National Oceanic and Atmospheric Administration (NOAA) for Provo, UT. This relates the time of concentration directly to intensity. Now that we have I (intensity) we can multiply our C-values, intensities, and areas to get our 100-year flow for each sub-basin. Calculations for the 100-year storm flow in cfs are found in Table 3.

Table 3. Calculation of 100-Year Flow for each Sub-basin

Drainage Index	Drainage Length [ft]		Street Slope	Hillside Slope	Time of Concentration [min]			100 Year Intensity [in/hr]	100 Year Flow [cfs]
	Road	Hillside			Road	Hillside	Total		
A	202.00	380.00	2.17%	2.63%	5.23	8.04	13.27	4.34	2.30
B	180.00	460.00	2.17%	2.63%	4.77	9.37	14.14	4.17	6.16
C	430.00	630.00	2.78%	2.63%	8.68	12.05	20.73	3.56	19.91
D	230.00	0.00	2.17%	--	5.81	0.00	5.81	6.36	1.57
E	180.00	0.00	2.17%	--	4.77	0.00	4.77	5.14	1.01
F	550.00	0.00	2.78%	--	10.57	0.00	10.57	4.84	2.19
G	445.00	0.00	2.08%	--	10.01	0.00	10.01	4.84	3.36
H	355.00	0.00	2.08%	--	8.36	0.00	8.36	5.45	7.53
I	355.00	0.00	2.08%	--	8.36	0.00	8.36	5.45	5.55
J	0.00	455.00	--	2.67%	0.00	9.24	9.24	5.14	5.74

The sum of all flows from the sub-basins is ~***55 cfs.*** By inspection, the current pipe system is not adequate for this amount of flow.

New:

To calculate the new flows for the updated stormwater management plan, we adjusted the areas of each land use in each sub-basin to reflect the plan. This included adding more forest to Drainages A, B, and C, removing all roof areas (since we will be capturing that water), and removing pavement areas where we have removed parking. All pavement will be replaced with permeable concrete, which is rated to have a runoff coefficient of 0.30 (See Table 4). Using the same method as before, we calculate composite C (see Table 5).

Table 4. C Values for each Land Use

Existing Forest	Grass	Pavement
0.15	0.25	0.30

Table 5. Composite C Calculation

Drainage Area [ft²]				Composite C
Forest	Grass	Pavement	TOTAL	
56522.00	0.00	9902.71	66424.71	0.172
150086.19	0.00	5965.88	156052.07	0.156
153705.53	114978.42	159451.16	428135.12	0.233
0.00	16313.47	7288.70	23602.16	0.265
0.00	16207.17	4902.65	21109.82	0.262
0.00	2636.68	21030.89	23667.57	0.294
13461.69	0.00	23841.16	37302.86	0.246
31883.51	0.00	276390.04	308273.55	0.284
71085.35	0.00	0.00	71085.35	0.150

0.00	192913.00	0.00	192913.00	0.250

Table 6. Calculation of 100-year flow

Table C-6. Calculation of 100-year flow

Drainage Index	Composite C	100 Year Intensity [in/hr]	Drainage Area [ft²]	100 Year Flow [cfs]
A	0.17	4.34	66424.71	1.15
B	0.16	4.17	156052.07	2.34
C	0.23	3.56	428135.12	8.22
D	0.27	6.36	23602.16	0.92
E	0.26	5.14	21109.82	0.66
F	0.29	4.84	23667.57	0.78
G	0.29	4.84	37302.85	1.22
H	0.29	5.45	59522.51	2.17
I	0.26	5.45	71085.35	2.35
J	0.25	5.14	192913.00	5.74

Time of concentration and therefore intensity remains unchanged as slopes, areas, and drainage lengths are the same. Thus, we can use the same information from table 3 to calculate our improved 100-year flow (See Table 6). The sum of flow is ~***26 cfs***, which represents a reduction in outflow by ~53%.

Next, we redesigned the pipe system. We will capture as much of the stormwater as possible, filter it, purify it, and use it in the buildings on site. However, in the case of large storms, we must be prepared to handle full flow as our water reservoirs in the buildings may fill up. Thus we designed the new storm drain pipe system for the full 100-year storm.

Calculations were made using manning's equation:

Q_{max} = (1.49/n)*(3.14159*((p/12)^2)/4)*((p/12)/4)^(2/3)*(s)^0.5

Where:

n = pipe roughness coefficient (0.013 for concrete pipes)

p = pipe size in inches

s = slope in percent

Solving for the flow capacity, we are able to construct table 7 and compare flow required and flow capacity and thus design our pipe sizes and slopes. In green are pipes that will need to be replaced.

Table 7. Pipe Sizing

Drainage Index	Pipe Slope [%]	Pipe Size [in]	Pipe capacity [cfs]	Flow Required [cfs]
D	1.00%	12	3.57	0.92
D+A	1.13%	12	3.80	2.07
E	1.00%	12	3.57	0.66
A+B+D+E	2.00%	15	9.16	5.07
A+B+C+D+E	2.00%	18	14.90	13.29
A+B+C+D+E+F	2.00%	18	14.90	14.07
I	1.46%	12	4.32	2.35

H+I	1.46%	15	7.83	4.52
H+I+G	1.46%	15	7.83	5.74

Earthwork Balance

Cut - ***900,000 cubic feet***

The community center will have a footprint of ~4000 ft² and will have a foundation of ~12 ft = 50,000 cubic feet

The road has an area of ~166,000 ft² and we will be excavating 3 feet to construct the new road = 500,000 cubic feet

We will also be replacing about ~83,000 ft² of parking and excavating 3 feet to put in new pavement = 250,000 cubic feet

We will also be digging a new retention pond which will be ~100,000 cubic feet

Fill- ***900,000 cubic feet***

We will be grading all the material from the cut to obtain well-draining gravel. Based on other surveys of Provo soils, this should be found from around 1 foot down. This gravel will be used for trails and as a subgrade for roadway construction.

The road will have been excavated down 3 feet, and we will then fill it back up with 2 feet of gravel = 332,000 cubic feet

The same will be done to replace parking pavement = 166,000 cubic feet

We will be filling the old retention pond = 38,000 cubic feet

Where we removed parking (83,000 ft²) we will use 1 foot of excavated soil as part of the restoration = 83,000 cubic feet

We will lay 1 foot of soil along the trails which are 10 feet wide and total 4300 ft in length = 43,000 cubic feet

We will use the remaining excavated soil (238,000 cubic feet) to grade the area around the retention basin to make it more suitable as a park. This means we have perfectly balanced earthwork; no material will be imported nor exported from the site.

In sizing our retention pond, we designed for the 100-year storm for the duration of 24 hours. We created a hydrograph to see the max accumulation of storage and thus the minimum detention required to hold 100% of the 100-percentile storm. Storage volume is defined as accumulation volume minus infiltration volume. Accumulation volume is the product of time, intensity, C, and area. Infiltration volume is the product of time and the total infiltration rate, which is calculated by multiplying the infiltration area by the percolation rate of 0.21 inches per hour. We then take the difference between the two volumes (accumulation and infiltration) for each storage hydrograph time and see which is the highest for a 24 hour storm. We determined that the largest accumulated storage occurs at the end of the 24-hour event with an accumulation volume of 107,000 cubic feet, an infiltration volume of 7,000 cubic feet, and thus an accumulated storage of 100,000 cubic feet. The retention pond should therefore be designed to contain 100,000 cubic feet, preferably with a freeboard of ~1 foot. We thus are able to detain ***100% of the 95 percentile storm***.

Proposed roadway design (roadway, sidewalk dimensions, and justifications)

The standard section of the road will have a ***10'*** sidewalk, 2' buffer with hedges and landscaping, 8' multimodal lane, 6' landscape buffer, 10' car lane, 12' bus lane, 6' median with landscaping, 12' bus lane, 10' car lane, 6' landscaping buffer, 8' multimodal lane, 2' buffer with hedges and landscaping, and ***10*** sidewalk. We decided on having such large sidewalks to give space for restaurants and businesses to use and also to accommodate large flows of people. We then have a small safety buffer to give space between the sidewalk and the multimodal lane (bikes, e-scooters, etc). We gave so much room to landscaping so that the trees can grow to their full potential, improve the pedestrian experience, and also reduce noise. Car lanes are quite narrow to signal to drivers that this is a slow area. We have also made the whole road and sidewalks on the same level to be more wheelchair accessible and signal to drivers that this is a pedestrian-owned space.

Parking Space Justification

In assessing the parking requirements for this project, we relied on the urban code for Salt Lake City,, which, in most cases, required 1 parking spot for every 1000 square feet. The art gallery was allowed to have 0.5 parking spots per 1000 square feet. Restaurants were required to have 2 spots per 1000 square feet. Using these codes, we calculated that the multiuse building will require 164 spots, the art gallery will require 22, the government building will require 36, and the community center will require 36. We decided to be conservative and require ***250 parking spots*** on site. There are ~450 existing spots, and thus we are able to get rid of ~200 spots.

Energy - RA2.1, RA2.3, CR1.2

After extensive research, we were able to find the makeup of energy consumption by building use. Restaurants, retail, office, and art galleries all have different energy consumption breakdowns, so we made note of what percent each use (lighting, heating, refrigeration) makes up the total energy bill, and we researched ways that we could reduce each of those uses. By replacing lighting with LED, we were able to reduce the lighting portion of energy consumption by 90%. By replacing heat/cooling systems with SEER 25, we were able to reduce that portion of consumption by 58%. We also found techniques to reduce energy costs related to cooking by 50%. By updating refrigeration systems, we can reduce that portion of consumption by 35%. Computers' portion of energy consumption can be reduced by 75% by automatically turning them off and also updating computers. We then weighted each of these reductions by the percent contribution to total energy consumption to get an overall energy reduction for each type of building use (restaurant, retail, office, and art galleries). We then weighted each of these reductions by the square footage and our total estimated energy reduction was ***50%***.

To figure out whether or not it will be possible to be net positive in renewable energy production via solar panels, we must estimate energy use for each building use type. Using energy star estimates of energy use intensity (kBtu/ft2/yr) we were able to estimate energy consumption in kWh/year by converting their estimates to kWh and multiplying each factor by the amount of square footage used. After summing up each of these energy estimates, we were able to estimate that we will be using ~9.3 million kWh every year during operation. The total area of roofs of all of the buildings is ~89,000 square feet and thus can fit at least 2000 5kW panels. Given that each panel should produce at least 5400 kWh in a year, we have a total amount produced of 10.8 million kWh, which is a surplus each year of ***1.5 million kWh per year***.

Water - RA3.2

Our goal with water was to go completely off the grid and capture all the water that we would need. Thus, first we needed to estimate water consumption per year. We were able to find estimates of water use intensity from data provided by the EPA and use them to estimate water consumption by square footage of building use. Doing so, we estimated a yearly water consumption use of 3.17 million gallons per year. Using an average annual precipitation in Provo of 20.15 inches, we then calculated the amount we were able to capture from roofs. The total square footage of all the roofs is ~89,000 square feet and multiplying by 20.15 inches of rain per year, we estimate that we will be able to capture 1.55 million gallons of water per year from roofs. We plan to capture this water by sealing the roof in an impermeable layer, purifying it, and funneling the water into rain barrels sized for the 50-year storm that are connected to the buildings' water system. Using the same process (SCS method) we used previously– this time for 20.15 inches instead of 1 inch– we estimate a total runoff volume of 1.47 million gallons. We plan to capture this water by running pipes from stormwater inlets into the basements of the nearest buildings, purifying the water, and funneling it into rain barrels sized for the 50-year storm that are connected to the buildings' water systems. Should we fill these barrels, the water will then be funneled into the stormwater system and eventually the retention basin. With the catchment of water from both roofs and the inlets, we are able to reduce potable water usage by ***95%***.

RELATED ISSUES

To see the impact of our project, please see the technical proposal we submitted for the competition at the end of this document.

LESSONS LEARNED

One of the biggest issues we faced was the many aspects of sustainability that this project encompassed such as transportation, storm water management, and construction methods being just a few items we had to consider. In order to manage our priorities, we divided up responsibilities between the three team captains, overlapping where necessary. These captains dealt with 1) calculations 2) justifications 3) design.

The calculations and justifications took the most time and the design was dependent on those too. In the future, we'd recommend having a majority of the team, 5-6 students, on the justifications team, providing research and recommending solutions with 3-4 on students on the design time helping model. And 2-3 performing calculations. Individuals did and should provide solutions where necessary. Delegating was key to our success this year.

In addition, with 1/3 of the team captains having prior experience with the Sustainable Solutions competition, it was helpful to have someone navigating the experience.

CONCLUSIONS

Our participation in the ASCE Sustainable Solutions Competition gave us valuable insights into sustainability and innovative problem-solving. We revitalized a fictional city block by implementing a stormwater management system, multimodal transportation approach, constructing an educational community center, and achieving a superior level ENVISION design. We grew our team, became ENV-SP certified, brainstormed, researched, refined ideas, and submitted final deliverables to prepare for the conference in April.

To address Utah's long-standing drought, we updated stormwater management strategies by collecting water from rooftops and inlets and directing it to purification systems. We also built a retention basin capable of holding excess water during major storms. To reduce potential runoff, we replaced existing pavement and restored green space with native vegetation. These efforts promote responsible resource use and demonstrate how future projects can help alleviate the burden on Utah's water usage.

Provo's Mayor Kaufusi believes sustainable living is a moral duty and has set sustainability goals for 2023, including promoting cleaner transportation. To support this objective, we provide access to shared bikes, EV stations, and a UVX bus rapid transit line. We reduced parking space and created dedicated lanes for multimodal use, discouraging the use of cars and encouraging the public to explore more sustainable ways of travel.

Our new community center supports marginalized members by offering educational courses and supplies. We designed a program that offers educational courses and much-needed supplies to participants of Provo's homeless outreach program. We plan to partner with local groups to help refugees and small businesses. The center will host volunteer programs, markets, rallies, and panels. It represents the culmination of our aspirations for the project.

Overall, this competition provided us with valuable experiences and lessons. We learned to collaborate with team members, develop leadership and delegation skills, conduct extensive research, refine ideas, and develop detailed and accurate technical reports. We also learned to consider sustainability and resilience principles when designing and operating projects. These skills and experiences will be valuable in our future careers as engineers, and we are grateful for the opportunity to participate in this competition.

RECOMMENDATIONS

For future Sustainable Solutions competitions, we recommend starting justifications earlier and completing the majority of them around Christmas. This will provide ample time to model and receive community and professional feedback regarding the justifications.

We also recommend promoting the competition more and enlisting people’s help earlier. It would be helpful to gain help from someone who understands project management due to the enormity of this project.

In regard to communication, we’d recommend using a group chat of some kind. We used email and it was difficult to ensure our messages were received.

We also recommend considering the continuity of the project for future teams.

APPENDIX

Andy Rodriguez

typicalandy.com (661) 932-3312 andriguez42@gmail.com

EDUCATION

B.S. Civil Engineering, Minor in Music
Brigham Young University, Provo, UT
- December 2023
- GPA 3.52
- MicroStation, AutoCAD, Revit, Bluebeam, Photoshop, Illustrator, CET, MS Office Suite, SketchUp

RELEVANT COURSEWORK

- History of Architecture and Interior Design I & II
- Structural Analysis
- Sustainable Community Development
- Sustainable Infrastructure

EXPERIENCE

Assistant to Interior Designers *April 2021 – Present*
Brigham Young University, Provo, Utah
- Initiate work orders by meeting with clients regarding requests and coordinating with designers
- Render 100+ floorplans of BYU campus on Revit, CET, and AutoCAD
- Create existing floorplans of old Provo High in Revit to prepare for upcoming renovation

Preservation Intern *June 2022 – December 2022*
Preservation Utah, Salt Lake City, Utah
- Inspected 120+ historic properties that hold preservation easements across Utah
- Evaluated structural and aesthetic changes to buildings' conditions and provided recommendations

Team Captain, ASCE Sustainability Solutions Competition *January 2022 – Present*
BYU, American Society of Civil Engineers, Provo, Utah
- Plan a 1.07-acre site plan that follows Envision© Sustainability Guidelines and local building codes
- Render a 3D mock-up of site using Sketchup and AutoCAD, including 10 individual tiny houses and a shared community space
- Won 1st place in Intermountain district regional competition in 2022 and 7th at nationals

Interior Design Lead, *January 2023 – Present*
BYU Solar Decathlon, Provo, Utah
- Design and construct a house with sustainable practices and materials for the U.S. Department of Energy and the Orange County Sustainability Decathlon
- Collaborate with construction and purchasing team to achieve a cohesive design throughout structure
- Ensure architectural documentation meets 90% construction documentation standards
- Prepare home for Utah County Parade of Homes

Networking Coordinator *August 2022 – December 2022*
BYU Architecture Association, Provo, Utah
- Organize field trips and panels with industry professionals
- Create networking resources for BYU students interested in architecture.

Associations & Student Teams

- Institute of Transportation Engineers
- American Society of Civil Engineers
- Institute of Classical Architecture and Art
- Earthquake Engineering Research Institute

Personal Passions

- Crochet / fiber arts
- Collecting vintage Pyrex
- Material culture
- Interviewing role models

Haley Beckstrand
(801) 602-3240 · Beck.haley@gmail.com· www.linkedin.com/in/Haley-Beckstrand

EDUCATION

Brigham Young University Apr 2023
Bachelor of Civil Engineering, Emphasis in Geotechnical Engineering Provo, UT

- GPA 3.32
- Team Co-captain of the Sustainable Solutions team focused on finding sustainable solutions to current engineering dilemmas
- Coursework was focused on Geotechnical studies including Seismology and soil stability

PROJECTS/RESEARCH

Large-Scale Reality Modeling of a University Campus Using Combined UAV and Terrestrial Photogrammetry for Historical Preservation and Practical Use May 2020-Nov 2021
Third author and lead field assistant Provo, Ut

- Photographed the 560 acres that make up Brigham Young University's main campus during the Covid-19 pandemic
- Documented 40 building exteriors using photogrammetry processes to create detailed model grouping
- Researched fundamental historical and cultural preservation using UAV and LIDAR Technology
- Took over 80,000 drone captured and ground images for comprehensive 3D model of campus
- Edited 1,000 photographs of Brigham Young University campus using 3D Modeling software to create accurate and detailed model
- Published findings in special issue of Geoinformatics for the Preservation and Valorization of Cultural Heritage

SKILLS/INTERESTS/ACHIEVEMENTS/ABILITIES

- ContextCapture, Agistoft Metashape, AutoCAD
- Licensed FAA UAS Part 107 Pilot
- Graphic design experience; created logos and mascots for educational purposes
- Third author in the special issue of the journal MDPI entitled Geoinformatics for the Preservation and Valorization of Cultural Heritage, focused on history and preservation of Brigham Young University campus: https://3dbyu.byu.edu

EXPERIENCE

RB&G Engineering May 2021-December 2022
Engineering Intern and Soil Technician Provo, UT

- Conducted over 300 soil classifications in accordance with industry standards which resulted in satisfactory on time results
- Served as primary inspector on a 2-week project by monitoring fill depth and performing density and moisture testing using nuclear gauge
- Performed data entry and analysis for 15 settlement monitoring devices to predict surcharge removal date on the West Davis Corridor for the Utah Department of Transportation
- Presented on findings from settlement data on the West Davis Corridor to 20 engineers and fellow interns
- Acted as lead geologist by classifying and logging more than 30 samples on drill rig

Brigham Young University Drone Research Group Aug 2018- Nov 2021
Pilot and Research Assistant Provo, Ut

- Obtained FAA UAS Part 107 Pilot License to operate UAV and oversee commercial flights
- Completed more than 30 group and solo missions to gather information for 3D modeling
- Participated as ground crew support for government supervised study to gather data for water table effects on erosion related to Starvation Dam, Utah area
- Collaborated on solutions for detailed projects with a team of 20 people to ensure safe and efficient missions

David Shill

(480) 721-6928 - drussellshill@gmail.com

Professional Profile

Resourceful prospective graduate with goals of PE certification and developing new skills. Highly skilled in engineering design, engineering software, and effective communication. I work well in both group and individual settings and value hard work, integrity, and compassion.

I finish my coursework in August of 2023 but am available to work after graduation in April of 2023.

Proficiencies

ArcGIS Pro, AutoCAD, Civil 3D, Revit, Python, CLiq, MS Office, and Adobe Suite

Geotechnical Analysis & Design, Seismic Analysis, Liquefaction, Management

Writing, Nonprofit Management, Social Impact, Event Planning, Public Relations, Legal Analysis

Education

BS Civil Engineering
Minor Intl. Development
Brigham Young University
(2019- 2023) Provo, Utah

Certifications & Achievements

Notary Public
ASCE President
Jeff Green Scholarship
Ralph Rollins Scholarship
ASCE CUB Scholarship

Volunteering

Board of Directors (2022 - present)
Cougar Pride Center – 4 hrs per week

- Manages the Board of Directors to provide support, leadership, and direction to the president and five vice presidents
- Ensures the entity complies with all company policies and relevant laws and bylaws

Founding President (2021 - 2022)
Cougar Pride Center – 7 hrs per week

- Oversaw all operations of the organization including event planning, PR, resource creation, outreach, social impact, and fundraising.
- Managed four teams of six people and each team's projects.
- Administer the founding of the organization by creating bylaws, policies, procedures, and ensuring compliance for 501(c)(3) application.

President (2021)
BYU Student Chapter of ASCE – 6 hrs per week

- Oversaw all operations of the chapter including event planning, networking, coordination with ASCE national and ISW conference, fundraising and budgeting.
- Managed seminar each week

Experience

Geotechnical Research Assistant
Brigham Young University (2021 – present)
Kyle Rollins (801) 422-6334

- Participate in writing of two academic journal articles about concrete pile engineering and liquefaction.
- Gather, arrange, and correct research data to create representative graphs and charts highlighting results for presentations.
- Perform statistical, qualitative, and quantitative analysis.

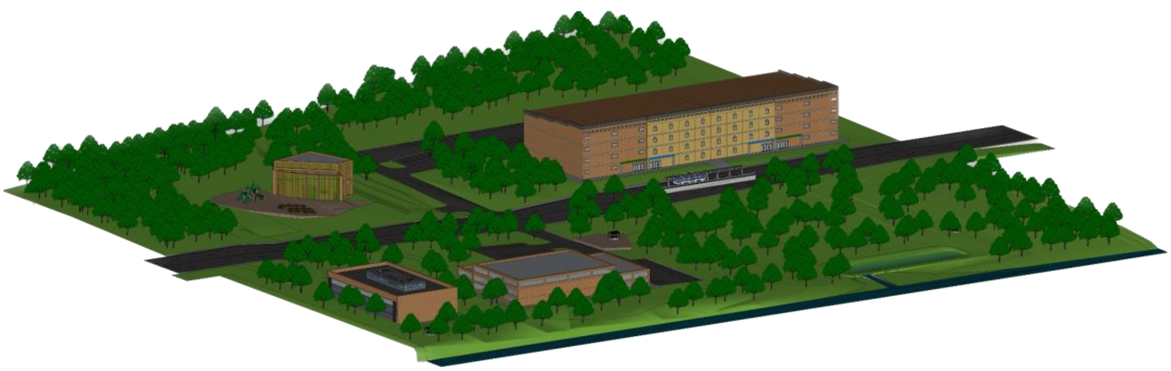
Instructional Assistant
Brigham Young University (2019 – 2022)
Dan Ames (801) 422-3620

- Instructed the lab section of CCE 214 (Geomatics – Surveying & GIS)
- Guided over 250 students one-on-one in troubleshooting and performing geoprocesses with ArcGIS Pro.
- Prepare curriculum and lessons

Escrow / Legal Assistant
McCarty Perry Attorneys at Law (2019-2021)

- Provided clerical services such as filling out paperwork, taking phone calls, and assisting clients with complex legal and property issues.
- Opened files and coordinated with all parties involved, drafted legal paperwork, and closing documents, and facilitated closings of the purchase or sale of both commercial and residential property
- Managed all accounting for a variety of accounts, ensuring that they all abide by lawful practices
- procedures.

ASCE Sustainable Solutions 2023 – Technical Design Proposal



Team members:
Andy Rodriguez
Haley Beckstrand
David Shill

Executive Summary

Recovery after the COVID-19 pandemic has taken various forms. While there have been many efforts to address the health consequences of that time, we are just starting to understand other impacts. During the quarantine period, a technological boom emerged as people tried to maintain their eroding sense of community. Researchers from across the globe, including Tyler J. VanderWeele Ph.D. from the Human Flourishing Program at Harvard, studied the effects of our separation after the end of strict quarantine guidelines. Professor VanderWeele commented that as we look to the future, "it is important to consider how we will rebuild - how we will recreate - community.[1]" We were assigned to revive a fictional city block and transform the underutilized area into a gathering place for our community. To achieve this, we adhered to the ENVISION Checklist framework and looked for sustainable solutions to the underlying issue of revitalizing, rebuilding, and expanding our community here in Provo, Utah.

Our efforts began with a focus on updating stormwater management strategies. Utah has been experiencing drought conditions for over twenty years, so it was important to us to utilize stormwater in our design. We decided on a system of collecting water from rooftops and through inlets and directing it to purification systems to reduce the impact our project would have on water usage. In the event of a major storm, we created a system with resized storm piping and a retention basin capable of holding excess water. To improve the beautification of the area and reduce potential runoff, we removed existing parking and pavement and restored green space with native vegetation. We hope our efforts will encourage more responsible use of resources and demonstrate how future projects can help reduce the burden on Utah's water usage.

Provo's Mayor Kaufusi declared in a statement that "Sustainable living is a moral duty.[2]" She outlined Provo's sustainability goals for 2023, which include a push for more multimodal transportation. One of our objectives for this project was to promote cleaner transportation and connect our city block to Provo's rapidly expanding public transportation network. To achieve this goal, we provide access to shared bikes and EV stations, create dedicated lanes for multimodal use, reduce space for parking, and construct a UVX bus rapid transit line within the revitalized city block. Our efforts discourage the use of cars and the pollution they cause while encouraging the public to explore more sustainable ways of travel.

Our work culminates in the construction of a new community center, dedicated to supporting marginalized members of our society and providing a space for community members to volunteer and learn about creating a better world. The Provo city government recently launched a homeless outreach program committed to finding lasting solutions as a community[3]. To further these efforts, we designed a program that offers educational courses and much-needed supplies to program participants. We also plan to partner with local organizations dedicated to supporting refugees and helping them grow businesses in their new community. Meeting spaces within the center will be utilized for organizing volunteer programs and drives, hosting markets for local small businesses, holding rallies and panels for educating the public, and much more. The community center represents the culmination of all our aspirations for this project.

Our project was designed with the ultimate goal of building a better future for our community. Our efforts and commitment to sustainability are outlined in the rest of this report. As we look forward to the future, we hope that our work will inspire others to think about how they can rebuild their communities in a sustainable and inclusive way, ensuring a better quality of life for all.

Team Organization Chart

Andy Rodriguez
Design Team Lead
Senior
2nd Year with Sustainable Solutions

Team:
Kenny
David

Haley Beckstrand
Envision Team Lead
Senior
1st Year with Sustainable Solutions

Team:
Abbie
Mahina
Josh

David Shill
Calculations Team Lead
Senior
1st Year with Sustainable Solutions

Team:
Mara

Design Calculations

Existing and New Impervious Areas

Prior to our improvements, we estimate that pervious areas constituted 66.29% of the total area at 767,380 ft^2 or 17.62 acres. Impervious areas constitute the other 33.71% of the total area at 390,285 ft^2 or 8.96 acres. (See Figure C-1) In our improvement plan, we estimate that pervious areas will constitute 93% of the total area at 1,079,815 ft^2 or 24.79 acres. Impervious areas will constitute the other 7% of the total area at 77,850 ft^2 or 1.79 acres. (See Figure C-2) Thus, improvements decreased impervious areas by 80%.

Figure C-1. Pre-improved Pervious and Impervious Areas

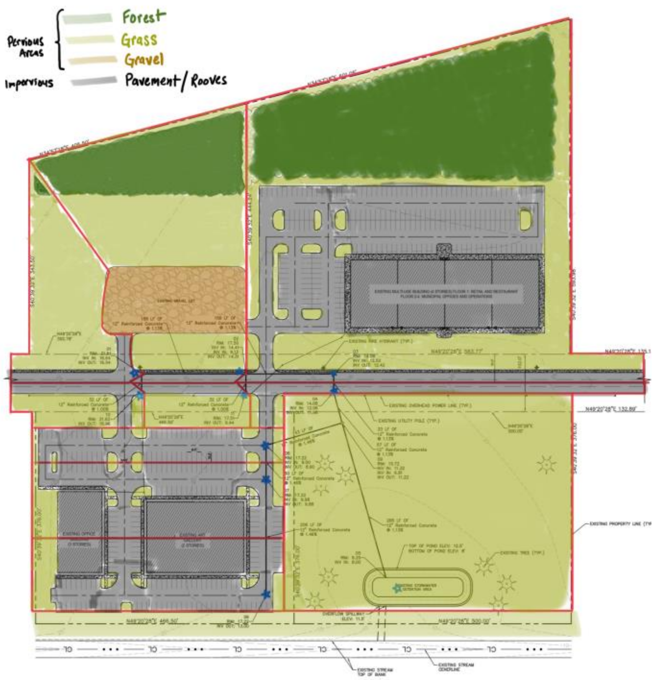
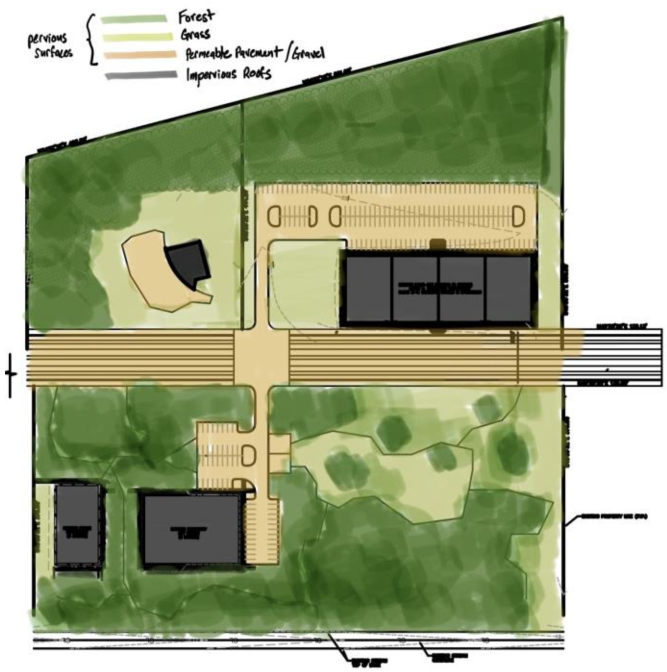


Figure C-2. Improved Pervious and Impervious Areas



Existing and New Stormwater Runoff Volume

Existing:

The Soil Conservation Service (SCS) method is a commonly used approach to calculate the runoff volume for a given area. To use this method, the hydrologic soil group needs to be determined, which, in this case, is group C. Additionally, the CN (Curve Number) we will be using for impervious and pervious areas are 98 and 74, respectively. Given that impervious areas make up 66.29% of the area and pervious areas are 33.71%, a composite CN can be calculated as follows:

$$CN = (CN\_impervious * \%\ impervious\ area) + (CN\_pervious * \%\ pervious\ area) = 82.09$$

With this composite CN, the runoff volume can be calculated for a precipitation event of 1 inch. The total area of the region is 26.58 acres, and 1 inch of precipitation is equivalent to 0.0833 feet. The SCS method equation for runoff volume in inches is

$$Q = ((P - 0.2S)^2 / (P + 0.8S) * 0.01) * A$$

Where Q is the runoff volume, P is the precipitation, S is the maximum potential retention, and A is the area. For hydrological group C and a composite CN of 82.09, S is calculated as follows:

$$S = 1000 / CN - 10$$

Thus, S = 1000/ 82.09 - 10 = 2.18 inches
Substituting the values, we get
q = ((1 - 0.2(2.18))^2 / (1 + 0.8(2.18))) = 0.115 inches = 0.00965 feet
Q = qA = 0.00965 ft * 1157665.17 ft^2
This results in a runoff volume of approximately 11,166 cubic feet or 83,526 gallons.

New:
As part of our strategy, we will be capturing all of the stormwater from the roofs of the buildings and thus that area will be excluded from our area calculations. In addition, all pavement will be replaced with permeable materials with a curve number of 74. Thus our composite CN is 74. Using the same method described before with a new CN and new area, we get a total estimated runoff of 2,065.31 cubic feet or 15,450 gal which represents a reduction of runoff volume of ~80%.

Existing and new site discharge at outfall - Stormwater Management Plan

Existing:
To estimate site discharge at outfall, and also to size our pipe, we will be using the rational method.

The basic equation for the rational method is
Q = CIA

where:
Q is the peak discharge (in cubic feet per second)
C is the runoff coefficient (dimensionless)
I is the rainfall intensity (in inches per hour)
A is the drainage area (in ft^2)

First we will calculate a composite C. To calculate composite C, the drainage area is divided into sub-basins (See Figure C-3). We then calculate the land use proportions. We then use a weighted average of the land uses and their areas to calculate a composite C. C values for each land use are found in Table C-1. Composite C is calculated in Table C-2.

Figure C-3. Delineation and Indexing of Drainage Sub-basins

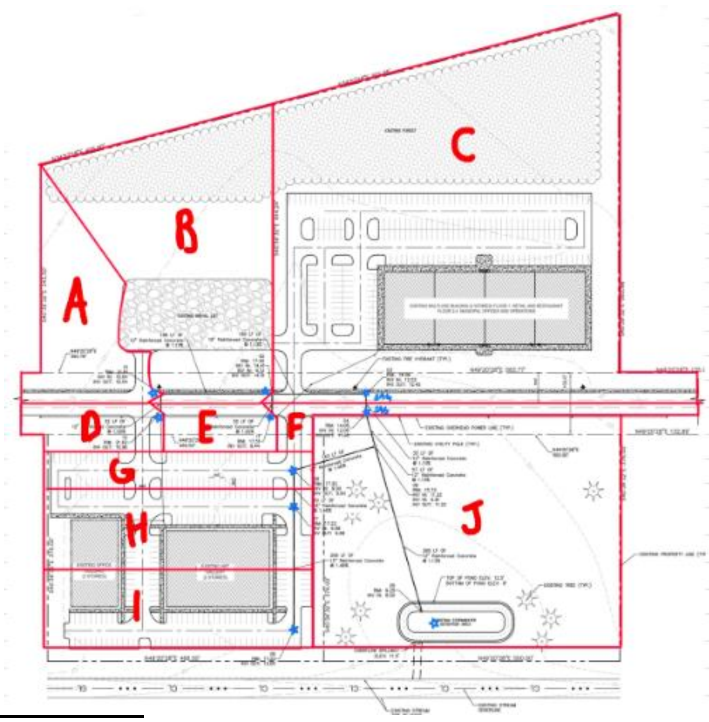


Table C-1. C Values for each Land Use

Existing Forest	Grass	Gravel	Pavement / Roofs
0.15	0.25	0.85	0.90

Table C-2. Composite C Calculation

Drainage Index	Drainage Area [ft^2]					COMPOSITE C
	Forest	Grass	Gravel	Pavement	TOTAL	
A	1076.22	55445.78	0.00	9902.71	66424.71	0.3452828905
B	50840.96	61234.54	41760.69	5965.88	159802.07	0.3992480107
C	141405.53	114978.42	0.00	212751.16	469135.12	0.5146310156
D	0.00	16313.47	0.00	7288.70	23602.16	0.4507295774
E	0.00	16207.17	0.00	4902.65	21109.82	0.4009592776
F	0.00	2636.68	0.00	21030.89	23667.57	0.8275869625
G	0.00	5514.64	0.00	31788.22	37302.85	0.8039077589
H	0.00	13457.51	0.00	62615.01	76072.51	0.7850126192
I	0.00	53595.93	0.00	34039.41	87635.35	0.502473681

J	0.00	192913.00	0.00	0.00	192913.00	0.25

Now that we have a C value and area for each Sub-Basin, we must lastly calculate intensity. To do so, we must measure the drainage lengths and slopes and calculate the time of concentration. Time of concentration is calculated as follows:

Tc = 60*(0.007*(0.016*D)^0.8)/(0.9^0.5*S^0.4)

Where:
Tc = Time of Concentration [min]
D = Drainage Length [ft]
S = Slope [%]

We then use rainfall intensity tabular data for the 100-year storm from The National Oceanic and Atmospheric Administration (NOAA) for Provo, UT. This relates the time of concentration directly to intensity. Now that we have I (intensity) we can multiply our C-values, intensities, and areas to get our 100-year flow for each sub-basin. Calculations for the 100-year storm flow in cfs are found in Table C-3.

Table C-3. Calculation of 100-Year Flow for each Sub-basin

Drainage Index	Drainage Length [ft]		Street Slope	Hillside Slope	Time of Concentration [min]			100 Year Intensity [in/hr]	100 Year Flow [cfs]
	Road	Hillside			Road	Hillside	Total		
A	202.00	380.00	2.17%	2.63%	5.23	8.04	13.27	4.34	2.30
B	180.00	460.00	2.17%	2.63%	4.77	9.37	14.14	4.17	6.16
C	430.00	630.00	2.78%	2.63%	8.68	12.05	20.73	3.56	19.91
D	230.00	0.00	2.17%	--	5.81	0.00	5.81	6.36	1.57
E	180.00	0.00	2.17%	--	4.77	0.00	4.77	5.14	1.01
F	550.00	0.00	2.78%	--	10.57	0.00	10.57	4.84	2.19
G	445.00	0.00	2.08%	--	10.01	0.00	10.01	4.84	3.36
H	355.00	0.00	2.08%	--	8.36	0.00	8.36	5.45	7.53
I	355.00	0.00	2.08%	--	8.36	0.00	8.36	5.45	5.55
J	0.00	455.00	--	2.67%	0.00	9.24	9.24	5.14	5.74

The sum of all flows from the sub-basins is ~55 cfs. By inspection, the current pipe system is not adequate for this amount of flow.

New:
To calculate the new flows for the updated stormwater management plan, we adjusted the areas of each land use in each sub-basin to reflect the plan. This included adding more forest to Drainages A, B, and C, removing all roof areas (since we will be capturing that water), and removing pavement areas where we have removed parking. All pavement will be replaced with permeable concrete, which is rated to have a runoff coefficient of 0.30 (See Table C-4). Using the same method as before, we calculate composite C (see Table C-5).

Table C-4. C Values for each Land Use

Existing Forest	Grass	Pavement
0.15	0.25	0.30

Table C-5. Composite C Calculation

Drainage Index	Drainage Area [ft²]				Composite C
	Forest	Grass	Pavement	TOTAL	
A	56522.00	0.00	9902.71	66424.71	0.172
B	150086.19	0.00	5965.88	156052.07	0.156
C	153705.53	114978.42	159451.16	428135.12	0.233
D	0.00	16313.47	7288.70	23602.16	0.265
E	0.00	16207.17	4902.65	21109.82	0.262
F	0.00	2636.68	21030.89	23667.57	0.294
G	13461.69	0.00	23841.16	37302.86	0.246
H	31883.51	0.00	276390.04	308273.55	0.284
I	71085.35	0.00	0.00	71085.35	0.150
J	0.00	192913.00	0.00	192913.00	0.250

Table C-6. Calculation of 100-year flow

Drainage Index	Composite C	100 Year Intensity [in/hr]	Drainage Area [ft²]	100 Year Flow [cfs]
A	0.17	4.34	66424.71	1.15
B	0.16	4.17	156052.07	2.34
C	0.23	3.56	428135.12	8.22
D	0.27	6.36	23602.16	0.92
E	0.26	5.14	21109.82	0.66
F	0.29	4.84	23667.57	0.78
G	0.29	4.84	37302.85	1.22
H	0.29	5.45	59522.51	2.17
I	0.26	5.45	71085.35	2.35
J	0.25	5.14	192913.00	5.74

Time of concentration and therefore intensity remains unchanged as slopes, areas, and drainage lengths are the same. Thus, we can use the same information from table C-3 to calculate our improved 100-year flow (See Table C-6). The sum of flow is ~26 cfs, which represents a reduction in outflow by ~53%.

Next, we redesigned the pipe system. We will capture as much of the stormwater as possible, filter it, purify it, and use it in the buildings on site. However, in the case of large storms, we must be prepared to handle full flow as our water reservoirs in the buildings may fill up. Thus we designed the new storm drain pipe system for the full 100-year storm. Calculations were made using manning's equation:

Qmax = (1.49/n)*(3.14159*((p/12)^2)/4)*((p/12)/4)^(2/3)*(s)^0.5

Where:

n = pipe roughness coefficient (0.013 for concrete pipes)

p = pipe size in inches

s = slope in percent

Solving for the flow capacity, we are able to construct table C-7 and compare flow required and flow capacity and thus design our pipe sizes and slopes. In green are pipes that will need to be replaced.

Table C-7. Pipe Sizing

Drainage Index	Pipe Slope [%]	Pipe Size [in]	Pipe capacity [cfs]	Flow Required [cfs]
D	1.00%	12	3.57	0.92
D+A	1.13%	12	3.80	2.07
E	1.00%	12	3.57	0.66
A+B+D+E	2.00%	15	9.16	5.07
A+B+C+D+E	2.00%	18	14.90	13.29
A+B+C+D+E+F	2.00%	18	14.90	14.07
I	1.46%	12	4.32	2.35
H+I	1.46%	15	7.83	4.52
H+I+G	1.46%	15	7.83	5.74

Earthwork Balance

Cut - 900,000 cubic feet

The community center will have a footprint of ~4000 ft^2 and will have a foundation of ~12 ft = 50,000 cubic feet
The road has an area of ~166,000 ft^2 and we will be excavating 3 feet to construct the new road = 500,000 cubic feet
We will also be replacing about ~83,000 ft^2 of parking and excavating 3 feet to put in new pavement = 250,000 cubic feet
We will also be digging a new retention pond which will be ~100,000 cubic feet

Fill- 900,000 cubic feet

We will be grading all the material from the cut to obtain well-draining gravel. Based on other surveys of Provo soils, this should be found from around 1 foot down. This gravel will be used for trails and as a subgrade for roadway construction.
The road will have been excavated down 3 feet, and we will then fill it back up with 2 feet of gravel = 332,000 cubic feet
The same will be done to replace parking pavement = 166,000 cubic feet
We will be filling the old retention pond = 38,000 cubic feet
Where we removed parking (83,000 ft^2) we will use 1 foot of excavated soil as part of the restoration = 83,000 cubic feet
We will lay 1 foot of soil along the trails which are 10 feet wide and total 4300 ft in length = 43,000 cubic feet
We will use the remaining excavated soil (238,000 cubic feet) to grade the area around the retention basin to make it more suitable as a park. This means we have perfectly balanced earthwork; no material will be imported nor exported from the site.

In sizing our retention pond, we designed for the 100-year storm for the duration of 24 hours. We created a hydrograph to see the max accumulation of storage and thus the minimum detention required to hold 100% of the 100-percentile storm. Storage volume is defined as accumulation volume minus infiltration volume. Accumulation volume is the product of time, intensity, C, and area. Infiltration volume is the product of time and the total infiltration rate, which is calculated by multiplying the infiltration area by the percolation rate of 0.21 inches per hour. We then take the difference between the two volumes (accumulation and infiltration) for each storage hydrograph time and see which is the highest for a 24 hour storm. We determined that the largest accumulated storage occurs at the end of the 24-hour event with an accumulation volume of 107,000 cubic feet, an infiltration volume of 7,000 cubic feet, and thus an accumulated storage of 100,000 cubic feet. The retention pond should therefore be designed to contain 100,000 cubic feet, preferably with a freeboard of ~1 foot. We thus are able to detain 100% of the 95 percentile storm.

Proposed roadway design (roadway, sidewalk dimensions, and justifications)

The standard section of the road will have a 10' sidewalk, 2' buffer with hedges and landscaping, 8' multimodal lane, 6' landscape buffer, 10' car lane, 12' bus lane, 6' median with landscaping, 12' bus lane, 10' car lane, 6' landscaping buffer, 8' multimodal lane, 2' buffer with hedges and landscaping, and 10' sidewalk. We decided on having such large sidewalks to give space for restaurants and businesses to use and also to accommodate large flows of people. We then have a small safety buffer to give space between the sidewalk and the multimodal lane (bikes, e-scooters, etc). We gave so much room to landscaping so that the trees can grow to their full potential, improve the pedestrian experience, and also reduce noise. Car lanes are quite narrow to signal to drivers that this is a slow area. We have also made the whole road and sidewalks on the same level to be more wheelchair accessible and signal to drivers that this is a pedestrian-owned space.

Parking space justification

In assessing the parking requirements for this project, we relied on the urban code for Salt Lake City, which, in most cases, required 1 parking spot for every 1000 square feet. The art gallery was allowed to have 0.5 parking spots per 1000 square feet. Restaurants were required to have 2 spots per 1000 square feet. Using these codes, we calculated that the multiuse building will require 164 spots, the art gallery will require 22, the government building will require 36, and the community center will require 36. We decided to be conservative and require 250 parking spots on site. There are ~450 existing spots, and thus we are able to get rid of ~200 spots.

Energy - RA2.1, RA2.3, CR1.2

After extensive research, we were able to find the makeup of energy consumption by building use. Restaurants, retail, office, and art galleries all have different energy consumption breakdowns, so we made note of what percent each use (lighting, heating, refrigeration) makes up the total energy bill, and we researched ways that we could reduce each of those uses. By replacing lighting with LED, we were able to reduce the lighting portion of energy consumption by 90%. By replacing heat/cooling systems with SEER 25, we were able to reduce that portion of consumption by 58%. We also found techniques to reduce energy costs related to cooking by 50%. By updating refrigeration systems, we can reduce that portion of consumption by 35%. Computers' portion of energy consumption can be reduced by 75% by automatically turning them off and also updating computers. We then weighted each of these reductions by the percent contribution to total energy consumption to get an overall energy reduction for each type of building use (restaurant, retail, office, and art galleries). We then weighted each of these reductions by the square footage and our total estimated energy reduction was 50%.

To figure out whether or not it will be possible to be net positive in renewable energy production via solar panels, we must estimate energy use for each building use type. Using energy star estimates of energy use intensity (kBtu/ft2/yr) we were able to estimate energy consumption in kWh/year by converting their estimates to kWh and multiplying each factor by the amount of square footage used. After summing up each of these energy estimates, we were able to estimate that we will be using ~9.3 million kWh every year during operation. The total area of roofs of all of the buildings is ~89,000 square feet and thus can fit at least 2000 5kW panels. Given that each panel should produce at least 5400 kWh in a year, we have a total amount produced of 10.8 million kWh, which is a surplus each year of 1.5 million kWh per year.

Water - RA3.2

Our goal with water was to go completely off the grid and capture all the water that we would need. Thus, first we needed to estimate water consumption per year. We were able to find estimates of water use intensity from data provided by the EPA and use them to estimate water consumption by square footage of building use. Doing so, we estimated a yearly water consumption use of 3.17 million gallons per year. Using an average annual precipitation in Provo of 20.15 inches, we then calculated the amount we were able to capture from roofs. The total square footage of all the roofs is ~89,000 square feet and multiplying by 20.15 inches of rain per year, we estimate that we will be able to capture 1.55 million gallons of water per year from roofs. We plan to capture this water by sealing the roof in an impermeable layer, purifying it, and funneling the water into rain barrels sized for the 50-year storm that are connected to the buildings' water system. Using the same process (SCS method) we used previously– this time for 20.15 inches instead of 1 inch– we estimate a total runoff volume of 1.47 million gallons. We plan to capture this water by running pipes from stormwater inlets into the basements of the nearest buildings, purifying the water, and funneling it into rain barrels sized for the 50-year storm that are connected to the buildings' water systems. Should we fill these barrels, the water will then be funneled into the stormwater system and eventually the retention basin. With the catchment of water from both roofs and the inlets, we are able to reduce potable water usage by 95%.

Cost Estimation

COMMUNITY CENTER

Building Construction	Quantity of Units	Cost per Unit	$ 5,168,000	Source
Recycled Brick [$1.90 per brick]	500,000	$ 1.90	$ 950,000	Source
Glass [$7 per sq ft]	54,000	$ 7.00	$ 378,000	Source
Recycled Concrete [$165 per yard]	3,000	$ 165.00	$ 495,000	Source
Building structure and framing - labor [$17 per hour]	90,000	$ 17.00	$ 1,530,000	Source
Interior finishes (paint, flooring, etc.) [$100 per sqft]	15,000	$ 100.00	$ 1,500,000	Source
HVAC system [$6 per sqft]	15,000	$ 6.00	$ 90,000	Source
Plumbing system [$15 per sqft]	15,000	$ 15.00	$ 225,000	Source
Electric system [$12 per sqft]	15,000	$ 12.00	$ 180,000	Source
Site Preparation			$ 262,000	
Earthwork and grading [$2 per sq ft]	6,000	$ 2.00	$ 12,000	Source
Excavation and foundation work [$5793 per cubic yard]	1,777	$ 5,793.00	$ 230,000	Source
Utility connections	1	$ 20,000.00	$ 20,000	Source
Permits and fees			$ 1,205,131	
Building permits and impact fees [2%]			$ 109,557	Source
Environmental permits and studies [5%]			$ 273,893	Source
Design and engineering fees [15%]			$ 821,680	Source
Contingency and other costs			$ 1,791,899	
Contingency reserve [10% of whole project]			$ 663,513	Source
Inspection and testing [10% of building construction]			$ 516,800	Source
Project management and administration [11%]			$ 611,585	Source
Site Improvements			$ 129,868	
Community garden	1	$ 7,500.00	$ 7,500	Source
ADA Playground	1	$ 57,164.00	$ 57,164	Source
Water monitoring system (all buildings)	4	$ 16,301.00	$ 65,204	Source
Energy Monitoring system (all buildings	42	$ 1,800.00	$ 75,600	Source
Total			$ 8,556,898	

ROADWAY DESIGN

Building Construction	Quantity of Units	Cost per Unit	$ 15,113,578	Source
Building Materials (permeable concrete) [$165per yard]	55,466	$ 165.00	$ 9,151,890	Source
Landscaping (trees, hedges, native plants) [$30 per sq ft]	33,000	$ 30.00	$ 990,000	Source
Road and sidewalk heating system [$21 per sq ft]	100,000	$ 12.00	$ 1,200,000	Source
Paving / concrete work [$17 per hour]	221,864	$ 17.00	$ 3,771,688	Source
Site Preparation			$ 1,702,000	

Site demolition and clearing (remove existing pavement) [$6 per sq ft]	128,000	$ 6.00	$ 768,000	Source
Earthwork and grading [$2 per sq ft]	184,000	$ 2.00	$ 368,000	Source
Utility connections [$335 per linear foot]	1,600	$ 335.00	$ 536,000	Source
Replacing stormwater pipes [$100 per linear foot]	300	$ 100.00	$ 30,000	Source
Permits and fees			$ 3,724,841	
Building permits and impact fees [2%]			$ 338,622	Source
Environmental permits and studies [5%]			$ 846,555	Source
Design and engineering fees [15%]			$ 2,539,664	Source
Contingency and other costs			$ 5,849,104	
Contingency reserve [10% of whole project]			$ 2,065,593	Source
Inspection and testing [10% of building construction]			$ 1,511,358	Source
Project management and administration [11%]			$ 2,272,153	Source
Site Improvements			$ 115,516	
EV Stations [$2690 per station]	10	$ 2,690.00	$ 26,900	Source
Bike Sharing Hub [$38308 per station]	2	$ 38,308.00	$ 76,616	Source
UVX bus station	1	$ 12,000.00	$ 12,000	Source
Total			$ 26,505,039	

FOREST AND PARK RESTORATION

Building Construction	Quantity of Units	Cost per Unit	$ 1,756,020	Source
Landscaping Materials (tree, hedges, native plants) [$4 per sqft]	431,480	$ 4.00	$ 1,725,920	Source
Trails [$7 per foot]	4,300	$ 7	$ 30,100	Source
Site Preparation			$ 1,792,440	
Site demolition and clearing (remove pavement) [$6 per sq ft]	83,000	$ 6.00	$ 498,000	Source
Earthwork and grading [$4 per sq ft]	431,480	$ 3.00	$ 1,294,440	Source
Permits and fees			$ 780,661	
Building permits and impact fees [2%]			$ 70,969	Source
Environmental permits and studies [5%]			$ 177,423	Source
Design and engineering fees [15%]			$ 532,269	Source
Contingency and other costs			$ 1,084,717	
Contingency reserve [10% of whole project]			$ 432,912	Source
Inspection and testing [10% of building construction]			$ 175,602	Source
Project management and administration [11%]			$ 476,203	Source
Total			$ 5,413,839	

Total Project Cost: $40,475,774

ENVISION Criteria Justifications

QL1.1 – Improve Community Quality of Life (20/26)
To identify and address community needs, goals, and issues, we consulted Provo Mayor Michelle Kaufusi's statement "Provo's Sustainable Efforts in Action.[2]" The statement emphasizes that "Sustainable living is a moral duty" and highlights various programs aimed at increasing community sustainability[2]. Our design draws inspiration from these goals and incorporates them in areas of beautification, air quality, transportation, recycling, composting, water conservation, and more. We elaborate on these ideas in later justifications. Furthermore, by referencing the Provo City General Plan, which was developed with public input, we were able to enhance our final concept by addressing concerns related to potential negative social, environmental, and economic impacts[4]. Our efforts have culminated in a design that can transform this downtown block into a sustainable gathering place, aligned with Provo's city mission statement of "Exceptional care for an exceptional community.[5]"

QL1.2 – Enhance Public Health and Safety (20/20)
To confirm that our project meets all health and safety regulations and laws for operations, we referenced Provo City Code. We have exceeded minimum requirements by exceeding regulations set in Title 9 of the code, Public Peace and Safety[6]. To improve public safety, we have implemented a curbless street system and continuous walkways in which pedestrians, micro mobility users, and motor vehicles share the same space and are at the same level. A report published in 2018 by the Delaware Valley Regional Planning Commission found that the design of curbless streets encourages decreased speeds and increased awareness from vehicle operators by prioritizing pedestrians[7]. It also brings pedestrians who are crossing intersections closer to the level of those in a vehicle, making them more visible. This is especially important for youth and wheelchair users who can be more difficult to see in taller vehicles. Other elements of the project also improve safety efforts for others in the disabled community in Provo by providing systems that comply with and exceed the ADA accessibility standards, such as handicap parking and audible crosswalks. We also widen the sidewalks to 10 ft, providing more room for wheelchair users to navigate the city block. The community center will include These systems ensure that those with disabilities do not face disproportionate levels of risk and are equally cared for. We also increased lighting at night so that those walking or waiting for public transit will feel safe while doing so.

QL1.3 – Improve Construction Safety (14/14)
The project owner and contractor have made commitments to improving health and safety. The project will be conducted by companies with proven commitment to safety and programs in place to protect workers health and well being. All construction workers involved in this project will be OSHA 30 certified, and regular inspections will be conducted to ensure that all health and safety regulations are being met. Project meetings will also include time to discuss safety measures and take feedback from construction workers.

QL 1.4 – Minimize Noise and Vibration (6/12)
Revitalizing this fictional block and constructing a new community center will increase the noise and vibrations experienced by the immediate community both during construction and after its completion. To reduce construction noise, we will implement noise reduction barriers and provide hearing protection for all workers on site. To reduce operational noise, trees will be planted along roads throughout the city block. The Salt Lake City Public Lands department recommends the Rocky Mountain Juniper because it is drought resistant, provides good noise buffering, and is native to Utah[8]. Our project will meet Provo code limits for continuous or intermittent noises for commercial areas, which is 85 dBA during daytime hours and 65 dBA for nighttime hours[9]. Through a survey, impacted stakeholders were engaged and approved the noise reduction plan.

QL 1.5 – Minimize Light Pollution (12/12)

For our project, we needed a lighting solution that reduces light pollution and energy consumption while increasing safety. For these purposes, all outdoor lighting will be upgraded to meet these needs. Following suggestions made by the International Dark-Sky Association, we will use warmer toned LED light bulbs in all outdoor fixtures[10]. These bulbs not only reduce light pollution, but also reduce energy use. All outdoor lights will also have shields that focus the light and direct it downwards, making the overall use more efficient and less wasteful. All lighting planned meets the requirements of the Provo Code: Chapter 15.2 Outdoor Lighting Regulations[11]. The lighting zone for the city block will be LZ2: Moderate ambient light. Luminaires will keep light emissions to backlight low by reducing them to 30°. Backlight, Uplight, and glare requirements will be met for an LZ2 zone[12].

QL – 1.6 Minimize Construction Impacts (8/8)

Our project will implement a construction management plan to address construction impacts on the community. Noise reduction barriers will be constructed and noise levels will be monitored throughout the construction phase. The area where the community center is being constructed will be fenced off and labeled as an active construction site to protect the public from entering potentially dangerous areas. Barriers will be constructed between existing sidewalks and any road work. While work is being done on walkways, alternate routes will be provided with appropriate signage. All lighting for the site at night will be planned and directed to reduce its impact on the immediate community while keeping workers safe. A special QR Code will be posted at all sites of construction that will provide answers to commonly asked questions, a map detailing open walkways and directions to locations within the city block, as well as a place to provide feedback and have concerns addressed. This will help resolve inconveniences from the construction and help the community feel heard.

QL 2.1 – Improve Community Mobility and Access (7/14)

In Provo's Vision 2030 General plan, the city government has committed to expanding transportation options and effectiveness while also seeking to use cleaner methods[13]. Our project's design helps support these commitments by broadening the reach of existing transportation and providing more environmentally friendly options. We based our designs off of the public input from Provo's General plan to be sure that our designs met the needs of Provo locals. With the addition of a UTX Bus Rapid Transit Line stop in the center of the city block, this area will be more easily accessible to the public. We will also have a dedicated micro mobility lane that will include shared bikes and e-scooters to encourage the use of these public transit systems. Providing and expanding these public transportation options for the community will help to cut down the necessity for personal vehicles and reduce accidents and congestion on the roads.

QL 2.2 – Encourage Sustainable Transportation (16/16)

In recent years Provo has invested in improving its public transportation options. The UVX bus system that serves Orem and Provo averaged 14,600 boardings in 2019[14]. This number was reduced during the COVID-19 pandemic, but the Utah Transit Authority has reported that ridership has started to return and has been increasing each month. A bus stop connected to the UVX Bus Rapid Transit Line will be installed in a central location of the city block, providing visitors access to the extended UTA public transit options, like the commuter rail system FrontRunner that serves fifteen stations across several counties. Shared bike hubs and E-scooters will also be available for the public to use and located within the city block to encourage use. There will also be a designated lane for micro mobility users between a pedestrian walkway and a tree barrier that separates both paths from the road. The pedestrian lane will have a distinct coloring to its paving to clearly mark the two paths as separate lanes along with a 2 foot wide strip or barrier. This project contributes to Provo's larger integrated active, shared, and mass transportation goals set forth by Mayor Michelle Kaufusi's statement on making Provo more sustainable in 2023 that was mentioned in QL1.1[2].

QL 3.1 – Advance Equity and Social Justice (14/18)

In Provo, efforts are being made to advance equity and social justice causes. To inform the design of our new community center, we researched several organizations in and around Provo and gauged community members' participation and interest in such organizations. The center aims to be a gathering place for advancing equity and social justice in the community and will partner with existing organizations such as the Spice Kitchen Incubator program and the No More A Stranger Foundation to focus on immigrants in the area. The 2020 census found that Utah's immigrant population accounted for 11.6% of the state's total population and this number is expected to grow[15]. The Utah Compact, which was reaffirmed in 2019, aims to adjust the tone of discussions on immigration and offer support to leaders[16]. The Spice Kitchen Incubator, based in Salt Lake City, is a business incubator that brings together refugees and other disadvantaged community members interested in starting a full or part-time food business[17]. The community center will have a spice kitchen available for this program to start a branch in Provo. The No More A Stranger Foundation, based in Orem, offers legal representation in green card, citizenship, and asylum applications[18]. By connecting these programs and providing a space for immigrants in the Provo area, the community center can aid in their transition and help engage the community on social issues.

LD 1.1 – Provide Effective Leadership and Commitment (18/18)

In order to demonstrate commitment to sustainability, our project owners have created a statement that expresses their written commitment to the social, environmental, and economic needs of the project. There is also a set sustainability management policy in place that takes into account the specific needs of this project. These written contracts exist to ensure the accountability of project owners in keeping true to their word and their goals for the project. Completion of this project is no small feat, so, taking into account the amount of time required to finish the project, we have committed to holding quarterly meetings to assess several aspects of the project, including progress, sustainability commitments, and stakeholder approval. We have ensured that key members of the project team are aligned with our personal project goals by making our values very clear and only choosing to work with those who respect and are willing to uphold these values. These key stakeholders will participate in our quarterly meetings so that every constituent of the project is on the same page.

LD 1.2 – Foster Collaboration and Teamwork (12/18)

As mentioned in LD 1.1, our defined sustainability goals for the project were initially formed in an interdisciplinary meeting at the project's commencement. For items that our team members were lacking knowledge or experience of, we consulted various stakeholders and got insight from them as to what goals we should put in place to make our project more sustainable while also benefiting the affected community. Several different ideas were included in our project because of intersectional thinking. One example of this includes raising the road to the sidewalk level. Not only does this make the road and sidewalk more accessible for those with disabilities, but it also makes our community less car-centric and more focused on pedestrians and public transportation. In addition to these social benefits, the planned material for the road is more permeable, which contributes to our sustainability goals for this project. This is just one example of how this project has been enhanced by our interdisciplinary efforts, but we have tried to apply this thinking into every single aspect of our project. Moving forward, we plan on having regular interdisciplinary meetings throughout the entirety of the project to ensure that our current sustainability goals are being met as well as to create new goals as we see fit.

LD 1.3- Provide for Stakeholder Involvement (9/18)

We have created a list of stakeholders and prioritized them in terms of who is going to be most impacted by the project both in the short term and in the long term. For the sake of this project, we defined primary stakeholders as those who will be most affected by this project in the long term, such as local community, pedestrians, women, children, the homeless, and ect. Secondary stakeholders are defined as those who are affected by the project, but not indefinitely. Defining our stakeholders and mapping out our area of influence has had a great impact in creating our goals for this project. In order to encourage community and stakeholder engagement and communication with this project, we are going to have a community forum held approximately every three months where project leaders can attend and answer questions from the local community. For more consistent use and ease of access, we will also set up an email for people to ask questions or voice concerns about the project throughout its duration, which will be sent directly to a member of the project team. This email will be easy to access with the QR codes that are going to be put up at the construction sites mentioned in section QL 1.6. It will also be accessible in the community center. The anticipated needs of our stakeholders have influenced several of our project designs. We've used brighter street lights to make it safer for people traveling at night. We've raised the height and changed the material of the road to be more accessible for people with disabilities and to encourage this area as a walking-focused block. These are just a few examples, but almost any major decision we made was done so with one or more specific stakeholders in mind.

LD 3.1 – Stimulate Economic Prosperity and Development (20/20)

This project is going to employ many workers in its beginning stages, promoting economic growth. Several of our plans require design, construction, and installation, including our curbless roads, EV stations, walking trails, and active transportation infrastructure. Our use of multi-purpose buildings makes a better use of the space, leading to increased capacity and functionality. The operating capacity for the public, quality of infrastructure, and ease of access has been increased by our changes to make this street block more accessible and friendly to multiple modes of transportation. The updates that we plan to make will make everything more appealing especially for business and the public. Our infrastructure changes make this space more attractive to the public, which in turn brings in more business, boosting the local economy. The hope in transforming this space is that the benefits will be lasting and continue to stimulate economic prosperity.

LD 3.2 – Develop Local Skills and Capabilities (4/16)

Our project provides several opportunities for local skill development. We intend to create a community garden. As part of the terms for the garden, people with need, particularly the homeless, may help with caring for the garden and take home some of the produce in exchange. We also will develop volunteer programs, which provide character and skill building opportunities. The community center will provide additional opportunities for skill development. Free classes, open to the public, may be held there in topics such as personal finance, health and wellness, computer skills, and other things. These training programs are designed to continue long after the project delivery is complete.

RA1.1 – Support Sustainable Procurement Practices (12/12)

As consumers of materials we understand that we are responsible for the production of said materials and therefore have implemented a sustainable procurement policy. This policy sets the expectation of our suppliers to provide sustainably sourced and manufactured materials. Inspections will be done throughout the project by qualified individuals to ensure that the practices and materials used are up to par. We expect that at least 50% of all project materials, supplies, and equipment will meet our sustainable procurement policy.

RA1.2 – Use Recycled Materials (16/16)

Provo was once home to several brick manufacturing companies who furnished bricks for projects like the Old Utah County Courthouse and many of the earlier homes in the area[19]. As these older structures are deconstructed or revitalized, brick can be harvested for reuse in new projects, like our community center. Recycled brick is a sustainable choice because of its long lifecycle and energy efficiency. It also holds meaning and familiarity for the community in Provo. By using this historic brick, the new community center will blend beautifully with the existing infrastructure and connect the project to Provo's roots. Recycled brick is often available as older structures are rebuilt to meet existing earthquake and safety codes. Our project intends to partner with Brigham Young University to obtain bricks for recycling, as they have several such projects in action and planned for the future. We also will be recycling concrete from the demolition of the existing pavement to be reused in the construction of the community center. With recycled brick and concrete each making up 30% of the materials used, at least 50% by volume will be recycled materials.

RA1.3 – Reduce Operational Waste (10/14)

According to the EPA, 75% of the municipal solid waste (MSW) produced yearly in the U.S. can be traced back to five categories: paper waste (23.1%), food waste (21.6%), and plastics (12.2%), yard trimmings (12.1%), and wood (6%)[20]. Assuming our site produces roughly equivalent percentages of MSW we have planned to divert 100% of waste from the aforementioned five categories. Provo has a weekly curbside recycling program to encourage the public to reduce individual waste and has made recycling one of their sustainability goals for 2023[2]. Our project will include designated recycling containers alongside other waste bins that will be collected into Provo's existing recycling system. The Recycling Coalition of Utah has a list of acceptable recyclable material labeled "The Super Six," in poster form which includes paper and plastic waste[21]. To help educate people on recycling and to discourage the contamination of recyclable materials, these posters will be printed on our recycling bins. Another way we are reducing waste is encouraging cyclic use of food waste. Restaurants located in the multi use buildings will be incentivised to save food scraps. These food scraps will then be composted on site and used in the community center garden to grow new produce. This produce will be distributed to three different branches. First, some will be distributed to the homeless and low income volunteers who maintain the garden. Second, it will provide ingredients for a spice kitchen operating out of the community center. Thirdly, it will be sold back to the restaurants at a reduced price to incentivise them to continue saving food scraps. Any yard or garden trimmings will be used in composting or recycled through the city's system.

RA1.5 – Balance Earthwork On Site (8/8)

While designing our project, we planned accordingly to balance cut and fill and eliminate the need for excavated material off site. 900,000 cubic ft of cut material is mainly taken from excavating land for the parking garage under the community center and from the addition of the retention basin. After the material is removed, we will sort it by grain size to extract well draining gravel for the base layer of the road. The fill will also then be used to make the sidewalks and roads level for the curbless street system and continuous walkways. The old retention pond will also be filled, and 1 foot of soil will be used to reclaim the green spaces that are replacing the parking lots. All additional fill will be used to create walking trails through the green space. This produces a perfect balance of earthwork on site.

RA2.1 – Reduce Operational Energy Consumption (18/26)

Calculations were conducted to estimate the annual energy consumption of the revitalized city block during its operation. As demonstrated in the calculations portion of our report, we researched each of the building type's energy use based on the ENERGY STAR Report of Median EUIs in the United States[22]. We also accounted for each building's square footage and number of floors. We calculated that the estimated total annual energy consumption of the project would be approximately 9.3 million kilowatt hours per year. To reduce our energy usage, we analyzed several possible solutions. The Department of Energy states that LED lights use 90% less energy than traditional incandescent bulbs and last 25 times longer[23]. Notable heating and cooling systems like the SEER 25 claim to improve energy efficiency by 58%[24]. Restaurants and kitchens on property will be fitted with ENERGY STAR certified commercial food service equipment[25]. All computers will also be replaced with ENERGY STAR certified models which can improve energy efficiency by 75%[26]. These changes together will reduce the operational energy use of our project by at least 50%. More detail is provided in the calculation section of this report.

RA2.3 – Use Renewable Energy (24/24)

Provo is a big proponent of solar energy, so we wanted to incorporate that into our design. We plan to install 2,000 solar panels across the roofs of our buildings, with each panel able to generate 5,400 kilowatt hours of energy. This will generate around 10.8 million kilowatt hours of energy annually. We initially calculated our annual energy consumption at 9.3 million kilowatt hours, so the addition and use of these solar panels will generate a net positive amount of renewable energy. More detail is provided in the calculation section of this report.

RA2.4 – Commission and Monitor Energy Systems (12/14)

Our project will conduct an in-house initial commissioning of energy systems accounting for at least 90% of the total energy consumption/generation. The commissioners will be selected outside of the planning and design personnel for the project and are qualified to observe the energy systems and compose a log of issues. We will employ Vutility, a Utah based company that won the Frost & Sullivan IoT Energy Monitoring Award in 2021 for their monitoring system, called PulseDrop[27]. This system will provide real time data to inform decisions on prioritizing sustainability and reducing energy consumption along with water and natural gas usage. The Vutility system is capable of monitoring the primary functions and accounting for at least 90% of energy use/consumption across the project. The initial team of commissioners will be brought in yearly for commissioning of the energy systems.

RA3.2 – Reduce Operational Water Consumption (17/22)

To reduce our overall water consumption and utilize recycled water, we planned and designed a water reclamation and purification system. Using the Water Use Intensity table from the EPA as a guide, we were able to estimate our annual water consumption at 3.17 million gallons per year[28]. To offset our use, we will first collect water from the rooftops. We calculated the captured water using the combined rooftop area and Provo's annual precipitation of 20.15 inches, totaling 1.55 million gallons per year. Stormwater will also be collected from the remaining area through inlets into the nearest purification system. This will account for an additional 1.47 million gallons per year. All gathered water will be purified and reclaimed for use throughout the city block, totalling 3.02 million gallons. Because all the accumulated water will be purified, we expect to reduce our potable water use by 95% and and our total water use by over 50%. More detail is provided in the calculation section of this report.

RA3.4 Monitor Water Systems (12/12)

To monitor our water systems, we will once again employ Vutility, the company we used for monitoring our energy systems. Their PulseDrop allows for minute-by-minute real time water monitoring to inform sustainability decisions. The system can connect to existing meters, making it capable of monitoring all primary project functions. According to their website, PulseDrop also has a multi-mile outdoor transmission distance and can last up to 10 years on battery power[27]. Using Vutility's system will allow us to account for at least 95% of water use on the project. Having both energy and water systems monitored by the same technology will simplify the monitoring process and increase our ability to make sustainable decisions for the project in the future.

NW1.1 – Preserve Sites of High Ecological Value (22/22)

In the northwest section of the site there is an area of existing forest. After talking to a professor at our college who specializes in Utah's plant and wildlife, we determined that this forest would most likely be made up of pinyon pines and juniper trees. Pinyon-juniper forests are the dominant forest type in Utah and are home to 450 species of vascular plants and 150 vertebrate species including elk, mule deer, bears, rodents, and a variety of birds[29]. Both the Grand Canyon Trust and National Geographic have reported on the proposed destruction of these forests by those who wish to reduce fire risk and to make more room for private cattle grazing operations[30,31]. These proposals will upset the delicate ecosystems of the forests and put their inhabitants at risk while also opening the opportunity for non-native plant growth. Our project is dedicated to protecting this ecologically valuable space and to stop the proposed destruction of these forests across Utah. In order to connect with the public, there will be a donation box in the community center with a dedicated plaque describing the deforestation issue and encouraging patrons to donate to protect natural beauty. These donations will be given in their entirety to organizations fighting these deforestation efforts. We have also chosen to leave the existing forest untouched in our design and to leave a buffer zone between this area and our revitalization efforts. Local experts will be advised on ways to prevent disruption to the forest and its occupants during construction. We will also be planting more native trees along the forest line and throughout the green spaces planned in the project to reclaim the previously developed spaces.

NW1.4 – Preserve Undeveloped Land (24/24)

When planning the revitalization of the city block and the location of the community center, preserving undeveloped land was a crucial consideration for our team. Therefore, we made sure that the developed area of the project is entirely located on previously developed land. We also aimed to create a more natural open space in the area. To achieve this, we plan to remove 200 parking spaces and replace them with native vegetation. This will create more green space for the community to gather, relax and enjoy the natural beauty of Utah. The transformed block will offer more recreational spaces, and we hope that it will inspire others to continue the work of preserving and enhancing natural spaces in our community.

NW3.1 – Enhance Functional Habitats (9/18)

The Salt Lake Tribune recently reported that Utah has lost more than 700 square miles of natural and agricultural open space between 1982 and 2017[32]. Understanding the rapid development of natural land, we sought to preserve and restore as much habitat as possible. While planning the site for the community center, we chose a location as far from the original forested area without removing any other green space, ensuring that no existing habitats are disturbed or damaged. We have also committed around several acres to planting more native Rocky Mountain Juniper and Pinyon Pine to expand the existing forest. We are also increasing green space by removing extra parking spaces and pavement and planting natural vegetation.

NW3.4 – Control Invasive Species (12/12)

Invasive species are easily spread through the transportation of materials. To prevent introducing new invasive species to Utah County, all materials used in the project will be obtained from the surrounding area. Any timber used will be inspected for familiar markings of invasive diseases. A site assessment conducted by the appropriate agencies will also take place before construction to check for any invasive species. Greenspaces will be inspected for signs of noxious weeds such as knapweed and black henbane. The forest area will also be inspected for diseased trees that need to be removed prior to the project's completion. Construction workers will receive a brief training on invasive plant and insect species and inspect their equipment before it is brought on site to reduce the possibility of transporting invasive breeds. Utah Division of Wildlife Resources will be asked to coordinate with local agencies if minor infestations on site are discovered before and throughout construction to remove the infestations promptly with herbicides or pesticides. The project guards against future major and minor infestations by supporting the establishment of native plant species. Local agencies, in their annual visits to the site over the course of at least three years, will ensure that the greenspaces and forested area are not being displaced by invasive species.Any invasive species will be removed or killed according to regulation by the local agencies.

CR1.2 – Reduce Greenhouse Gas Emissions (22/26)

As mentioned in RA2.3, we will be employing solar panels to power the revitalized city block. Our calculated annual energy consumption according to ENERGY STAR will be around 9.3 million kilowatt hours. Our panels will generate 10.8 million kilowatt hours of energy per year, so we will have a net positive energy generation for the project. In our efforts to reduce our energy consumption, we also updated appliances onsite to electric models, as mentioned in RA 2.1. These efforts will reduce greenhouse gas emissions by 100% during its operational life compared to the baseline. This makes our calculated annual greenhouse gas emission equal to 0.

CR2.1 – Avoid Unsuitable Development (12/16)

The Provo area is susceptible to several environmental hazards that our project considered when selecting a site. The Utah Department of Natural Resources has classified Provo as a high risk area for earthquakes due to the Wasatch Fault at the base of the Wasatch Front[33]. This same mountain range also has hazardous rockfalls and a history of landslides that could cause issues for sites near their base. According to Utah's DNR, Provo is also susceptible to liquefaction "because of susceptible soils, shallow groundwater, and a relatively high probability of moderate to large earthquakes.[33]" When selecting the site for our community center, we considered several sites on the property with these hazards in mind. The location needed to have some distance from both the Wasatch Front and wetter soil of Utah Lake. In the end, we chose the upper left hand gravel lot for the community center because that location helped reduce the severity of any potential hazards. We also designed the new community center to meet the specifications of the Seismic Codes set by FEMA[34] and the soil was assessed for potential liquefaction issues and compacted for extra measure. Taking into account all of these factors, the chosen area provided the lowest exposure to site hazards but still met the requirements for size as set by the project.

1 https://www.psychologytoday.com/us/blog/human-flourishing/202112/how-we-can-rebuild-communities-after-the-pandemic
2 https://www.mayorkaufusi.com/post/provo-s-sustainable-efforts-in-action
3 https://www.mayorkaufusi.com/post/emergency-hotel-voucher-program-offers-shelter
4 https://www.provo.org/departments/development/planning/general-plan
5 https://www.mayorkaufusi.com/post/new-provo-city-mission-statement
6 https://www.provo.org/departments/development/planning/general-plan
7 https://www.dvrpc.org/reports/16044.pdf
8 https://www.slc.gov/parks/urban-forestry/urban-forestry-utah-native-trees/
9 https://provo.municipal.codes/Code/9.06.030
10 https://www.darksky.org/our-work/lighting/lighting-for-citizens/lighting-basics/
11 https://provo.municipal.codes/Code/15.21
12 https://www.darksky.org/our-work/lighting/public-policy/model-lighting-laws-policy/lighting-zones/
13 https://provo.municipal.codes/Vision2030/12
14 https://www.sltrib.com/news/politics/2019/10/07/new-provo-orem-bus-rapid/
15 https://www.americanimmigrationcouncil.org/sites/default/files/research/new_americans_in_utah.pdf
16 https://theutahcompact.com
17 https://spicekitchenincubator.org
18 https://www.nomaslegal.org
19 https://jacobbarlow.com/2017/10/04/several-brick-manufacturing-companies-once-operated-in-provo/
20 https://www.epa.gov/facts-and-figures-about-materials-waste-and-recycling/national-overview-facts-and-figures-materials
21 https://utahrecycles.org/super-6/
22 https://www.energystar.gov/buildings/benchmark/understand_metrics/what_eui
23 https://www.energy.gov/energysaver/led-lighting
24 https://www.professionalservicestoday.com/how-much-more-energy-efficient-new-air-conditioners
25 https://www.energystar.gov/products/commercial_food_service_equipment
26 https://www.energystar.gov/products/computers
27 https://vutility.com/pulsedrop
28 https://www.epa.gov/sustainability/lean-water-toolkit-appendix-c
29 https://www.upr.org/show/wild-about-utah/2022-03-11/wild-about-utah-pinyon-juniper-forests
30 https://www.grandcanyontrust.org/advocatemag/spring-summer-2020/pinyon-juniper-forests
31 https://www.nationalgeographic.com/environment/article/pinyon-pine-juniper-forests-utah-torn-out-why
32 https://www.sltrib.com/news/2022/04/22/its-earth-day-so-how-much/
33 https://geology.utah.gov/hazards/info/publications/
34 https://www.fema.gov/emergency-managers/risk-management/earthquake/seismic-building-codes