Bringing the Mountains Home

Rainworks Challenge: Campus Master Plan
Team M16 / Aggie Village Community Redesign

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Abstract

The proposed Aggie Village Master Plan provides a new vision for the future of family housing on the campus of Utah State University. Currently, Aggie Village is a 34-acre family housing complex belonging to Utah State University's (USU) on-campus housing. This master plan transforms outdated, inefficient, housing stock into a modern community integrating renewable energy, responsive stormwater infrastructure, and adaptive phasing that unites people and water throughout the site by mimicking surrounding natural landscapes. Drawing inspiration from the natural systems, forms, and function of nearby Logan Canyon, we have titled this master plan "Bringing the Mountains Home."

The project's key objectives establish a community that adapts to an increasingly uncertain social and environmental future. From modular buildings to stormwater retention and storage that adapts to future fluctuations in storm intensity, all aspects of the design were established to allow for adaptation. The design focuses on the capture, treatment, storage, and re-use of stormwater runoff, providing a new model of sustainable housing, that unites the natural landscape with modern infrastructure.

The vision for Aggie Village provides an immersive demonstration of how to live within the water cycle, learning by observing natural systems right outside your front door. The new Aggie Village master plan achieves a harmony between natural and constructed environments, providing an example for future sustainable development at USU and other housing developments across the nation.

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Introduction & Objectives

The proposed project is a complete redesign of the 34-acre Aggie Village site in the master plan category. USU Aggie Village is a married and family student housing community constructed in the 1950s to 1970s. Utah State University is in the northern region of Utah, located in Cache Valley in the city of Logan. This project aims to create an adaptable site, mitigate water overuse, reduce water pollution, implement safer structures, and facilitate a growing population.

To meet the project goals, five main objectives were created. First, to have site that was easily adaptable to meet any future needs. Second, to reduce potable water used for landscape irrigation by implementing sustainable green infrastructure. Third, a decrease in annual stormwater pollutant load from existing conditions. Fourth, updating old structures to maximize benefits of impervious building footprints. Last, to meet water supply and demand requirements of Logan's growing population. This design complements efforts to address areas of environmental, economic, and social needs within the community and the broader region of Cache Valley.

Site Background

Since the 1960's, Aggie Village has been a housing option for married couples and families at Utah State University. However, Cache Valley has experienced a growth in population by 20.6% since the year 2000 (U.S. Census Bureau, 2019). There has also been a similar increase to the student population at USU. This has caused a shortage of on campus housing, making it an inconvenience for students, especially married couples, and families in finding affordable housing with a good learning environment.

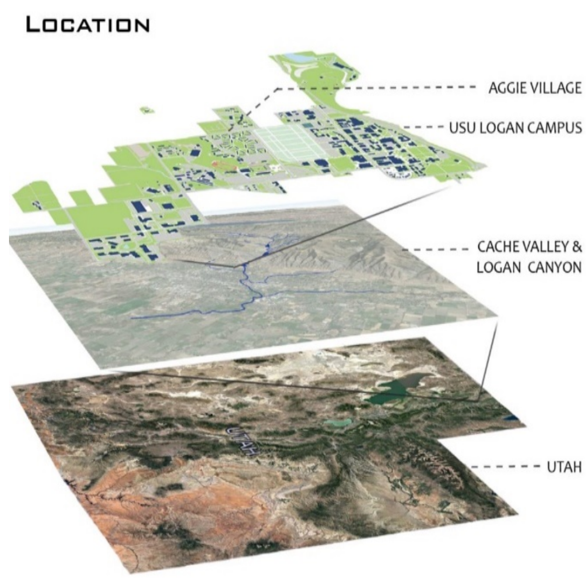


Figure 1. Location Diagram

Currently, Aggie Village does not manage or reuse stormwater. The current method is to collect stormwater through curbs, gutters, and piped storm drains and empty it into a nearby canal (USU SWMP, 2018). This model often overloads structures downstream of the site and causes an extensive need to import culinary water to keep the existing landscape alive.

In addition, Aggie Village needs a redesign due to its current safety, efficiency, and adaptability issues. The age of the buildings means building codes and material requirements are now outdated. The buildings consist of concrete masonry units, making the buildings highly susceptible to failure in the event of an earthquake. This presents a risk to the safety of the residents of Aggie Village. A redesign of Aggie Village will provide a safer housing option with a higher capacity for married couples and families attending USU as students.

Current Layout

Figure 2 depicts the current layout of Aggie Village, with 39 residential buildings containing 12 apartments each. The housing area has several amenities which include garden boxes for rent, a pavilion with grills, an outdoor basketball court, a sand volleyball court, a children's library, and a community laundromat.

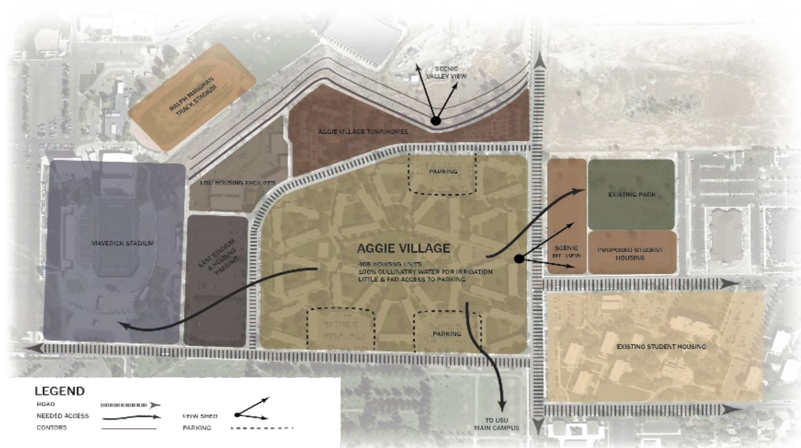


Figure 2. Site Inventory

Geography

Logan, Utah is located in the mountains of the Western United States. This state falls into the category of the mountain plateau region of the United States. Cache Valley also falls into the semiarid belt. The functionality the mountains give in providing water to allow the valley to grow is essential to note and a key characteristic we wanted to give to the site's geography.

Climate

Cache Valley has a distinct climate characteristic with four seasons. The spring and fall months are typically moderate, with average temperatures of 45.7 to 49.9 degrees Fahrenheit. Summer months bring higher temperatures with an average of about 85 degrees Fahrenheit. The afternoons during the summer heat up to peak temperatures but then slowly bleed off at night. The long winter months oppose the summer strongly, with temperatures being cold and dry with an average of 25.3 degrees Fahrenheit (Climate Logan, 2021).

According to the EPA Stormwater Calculator, the average annual precipitation for Logan is 21.09 inches, while the average annual precipitation for the United States is 30.28 inches. Rainfall is greatest during the spring and fall, accounting for a third of the annual precipitation. Summer months typically receive 2-3 inches of rainfall in the form of thunderstorms; however, the largest quantity of precipitation comes during winter in the form of snow. Most precipitation remains stationary in the mountains at higher elevations, and as snow melts, water runoff drains into the valley during the warmer months (EPA, 2019).

Geology

Based off the Natural Resources Conservation Service soil survey data, the soil categories for Aggie Village are B and C, also known as sandy loam and clay loam soil respectively. The sandy loam soil has an area of 27.37 acres and the clay loam soil has an area of 6.63 acres. Soils pertaining to this site formed an alluvium of lake sediments from various kinds of rocks found in flood plains. The soil is near mountains and ancient lake benches which are slightly acidic to neutral soils (Nelson & Eckmann, 1915).

Unconsolidated basin-fill deposits in Cache Valley have sediment sizes ranging from clays and silts to sands, gravels, cobbles, and boulders of the alluvial fan and terrace deposits. The more permeable deposits lie along the east bench where this site is located. More specifically, USU's campus is sitting on a layer of gravel approximately 100 ft., allowing water to permeate the soil easily.

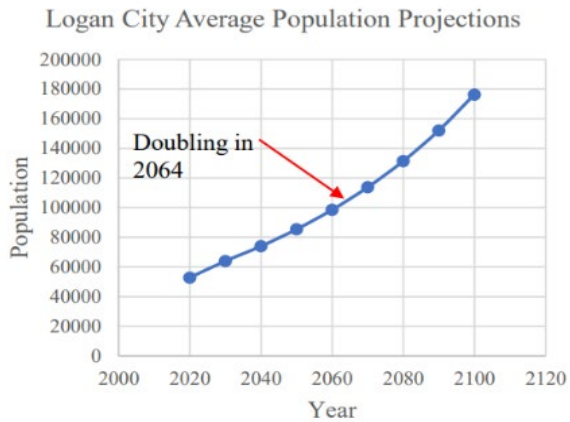
Figure 3. Current Grey Infrastructure

Hydrology
The surface water in Cache Valley originates from outside the valley and flows into the valley from major streams. Groundwater sits in both natural and manmade aquifers consisting of both consolidated and poorly consolidated rocks, as well as in unconsolidated basin-fill deposits. Water recharge to consolidated rock occurs though the filtration of precipitation and seepage from streams. Most recharge occurs in the mountains surrounding the valley (United States Department of Agriculture, 2004).

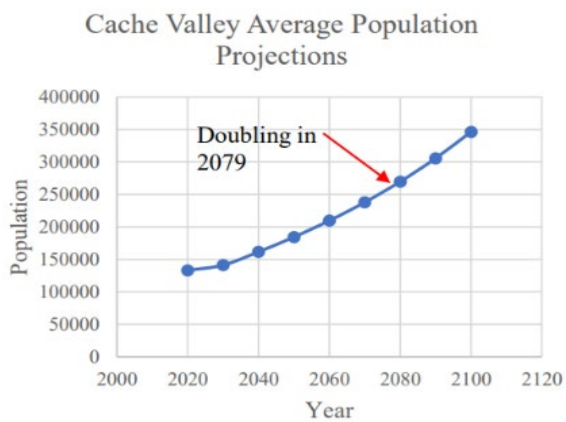
Existing Stormwater Systems
The current stormwater system for Aggie Village does not reuse any water throughout the site. This mitigates beneficial rain events for this site, as infiltration and reuse systems are absent. Water collects in grey infrastructure and drains into the Logan city pipe system. The stormwater line currently runs along 1000 North to enter a canal.

Additionally, a large water retention unit sits underneath the west parking lot, but no stormwater drains into this basin, nor is stored water used to irrigate the site. The dry wells for Aggie Village also have no pollution removal features. According to USU's on site landscape architect, the water used to irrigate this property is the only place on USU's campus that uses 100% treated, drinking water quality culinary water.

Capacity
As stated, before the city of Logan is growing rapidly at a rate of 6.9% from 2010 to 2020. Data shows Logan has grown 20.6% in population since the year 2000. This means that when compared to similarly sized cities, Logan is growing 64% faster. Between the years 1990 and 2000, the city grew 23% in population. In total, within the past 30 years Logan has had a population increase of 43.6% (U.S. Census Bureau, 2019).



Logan City	Population	% Increase	Multiplier
2020	52778	-	-
2030	63911	21%	1.21
2040	73927	40%	1.40
2050	85364	62%	1.62
2060	98512	87%	1.87
2070	113718	115%	2.15
2080	131403	149%	2.49
2090	152070	188%	2.88
2100	176327	234%	3.34



Cache County	Population	% Increase	Multiplier
2020	133154	-	-
2030	141077	6%	1.06
2040	161624	21%	1.21
2050	184334	38%	1.38
2060	209588	57%	1.57
2070	237837	79%	1.79
2080	269611	102%	2.02
2090	305535	129%	2.29
2100	346343	160%	2.60

Figure 4: Average Population Projection for a. Logan City, b. Cache Valley.

The state of Utah has grown 16% in population within the past 10 years alone, leading the nation in population increase this past census (U.S. Census Bureau, 2019). As the state's population grows exponentially, we estimated the city of Logan's would follow the same growth pattern. Housing needs provided by the university should accommodate the same growth rate of the past 30 years at a minimum.

Figure 4 shows our future population estimations based on past growth. As the population is projected to double before 2080, this increase will lead to additional competition for student families further exacerbating the housing crisis for students attending Utah State University if additional housing units are not built before this occurs. By redesigning Aggie Village, we can meet the student housing demand and incorporate essential environmentally friendly facilities.

Vehicle Transportation

Vehicle transportation is also an essential factor in thinking about future population and technology growth. Based on data collected within the past five years, 48% of college students currently own a car. As fuel prices rise and the availability of fossil fuels drops, electric vehicles and their benefits have skyrocketed over recent years in the US. Electric vehicles are proving to be more efficient, better for the environment, and the optimal way to power future transportation.

Autonomous vehicles are also a rising mode of transportation due to the increased safety of passengers by removing the factor of human error.

Design Development and Guidelines

The criteria used to develop this project include metrics regarding environmental concerns, adaptability, capacity, community interests, and stakeholder inputs. The metrics chosen to develop this site will help cultivate new, innovative ideas. Factoring with the highest weight is impact on the environment. Environmental criteria include the managed design storm, included green infrastructure, and green infrastructure placement.

The next 50 to 75 years are unprecedented in many aspects, making adaptability another important metric for this redesign. Within this design's lifespan, the future contains uncertainty that will challenge traditional grey infrastructure specifications. Needs for infrastructure continue to shift, motivated by recent changes in environmental, economic, social aspects. Recent and unforeseen health related accommodations allow people to work and learn from home. Even unforeseen events like COVID-19 require a design to be adaptable for the needs of the community.

Additionally, capacity is a criterion to account for requirements of increasing university, city, and state populations. Due to previous population estimates, the design must be able to handle twice the current population of students.

Another metric for design was social factors to create a strong community atmosphere. With this being a family housing development, encouraging community between neighbors provides a safe environment to raise young children in. Features to promote a social community include special amenities, site layout, and building shape.

Finally, the team forged partnerships with stakeholders to help foster this redesign. The stakeholders offered creative input for feasibility and proposed ideas to align the project with local stormwater management requirements. Jim Huppi, USU Landscape Architect stated, "This project represents an exciting example of students and faculty working with Facilities to push the boundaries of planning and design beyond their current state for campus projects." Input from University Architects, Housing staff, and professors influenced the criteria used.

Design Guidelines

The design guidelines are a combination of those created by the team and current engineering codes. The guidelines created by the team this project follows closest are those detailing the best stormwater management features, promoting sustainability, and implementing adaptability. The guidelines from engineering codes follow the ASCE 7 code manual and Logan City's stormwater design guide. While engineering and designing the team worked to restrict creative ideas as little as possible to reach the best outcomes. ASCE 7 codes guided the redesign to be sufficient for the next 50 years over the outdated engineering of the current development.

These guidelines help create a sustainable site to utilize natural resources effectively. Designing this project with adaptability in mind will prove to be beneficial in meeting future economic and environmental factors. Different areas within the site can be adapted throughout time. This will not only save the university money, but also save the environment from pollutants in multiple aspects.

This design will save the environment from unnecessary pollution by following project guidelines. This design will maximize storm events by following project guidelines. This design will capitalize on natural resources of sunlight and precipitation by following project guidelines. This design will celebrate the gift of water by following project guidelines. This design will allow residents to learn the water cycle throughout the site's educational features per project guidelines. This design will instill a higher respect for water and nature in residents as following design guidelines.

Design Strategy

Before the team began designing the master plan for the site, each member researched a topic related to the project. For example, team members collected data on annual climate information, site dimensions, and population growth. In the research phase the team frequently met with Utah State University faculty to build a deeper understanding of the site. The information gathered from faculty included future site plans, design requirements, and current state of the site.

Using this guidance of university faculty, the team began an iterative process of working together to create a draft plan. This process included calculating future populations, demand, and runoff, among other factors. Along with set constraints for the future master plan, the team developed a theme for the project, "Bringing the Mountains Home."

The primary functional themes that guided the design process were adaptability and sustainability. The use of pavers in the parking lots will help to increase the adaptability of the site. This allows for easy removal of parking lots, allowing new structures or green space to replace them. Infiltration and re-use of stormwater in the design will give the site necessary sustainability. The team worked together with the above themes in mind to create a final design and phasing plan. These designs were presented to faculty advisors and other students to gather feedback. Based on the feedback, we adjusted the design to address concerns.

Design Concept & Diagrams

This section shows our team's design concepts of the layout and building footprints. The site layout includes designated parking areas, roadways, building structures, sidewalks, and green infrastructure features. The layout mimics the natural flow of water in nature. Features of green infrastructure incorporated through the entire site maximize water reuse opportunities. The building design increases capacity and quality of living for residents. The site's layout facilitates safety for the children while cultivating a positive social atmosphere.

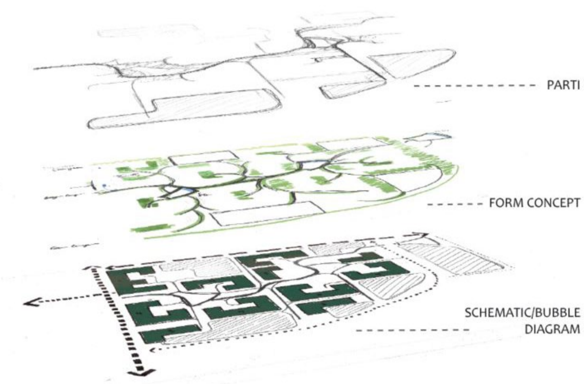


Figure 5. Design Concepts

Master Plan Performance

The final design's primary focus was to use green infrastructure to manage stormwater in an efficient and environmentally friendly way. Safety is emphasized to protect residents and provide a strong sense of community. Educational features placed in the design to capitalize on the opportunity to teach as this is a family development. Capacity doubles with accordance with the growing city, community, and university population. Vehicle accommodation plans to fit the needs of autonomous, shared, and electric vehicles as predicted in the design's lifetime.

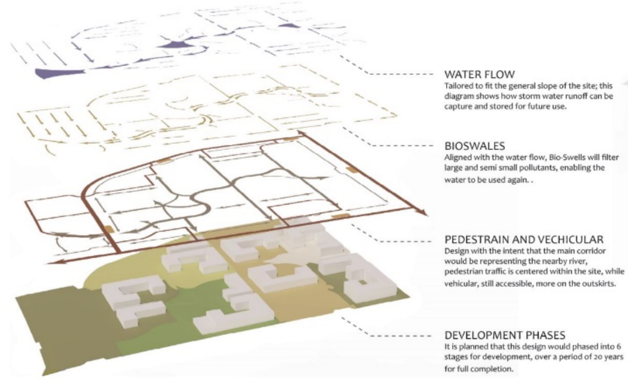


Figure 6. System Movement & Phasing

Figure 7. Final Design Layout

Green Infrastructure

Included green infrastructure features elements are planned primarily for stormwater control, but also exhibit social, economic, and environmental benefits. Incorporating these natural and engineered systems will harvest, reuse, store, and filter 100% of the precipitation this site will receive. Green Infrastructure within the property's design include:

- Bioswales in parking lots
- Bioswales along sidewalks throughout the design
- Detention Ponds
- Underground Aquifers
- Native plant species

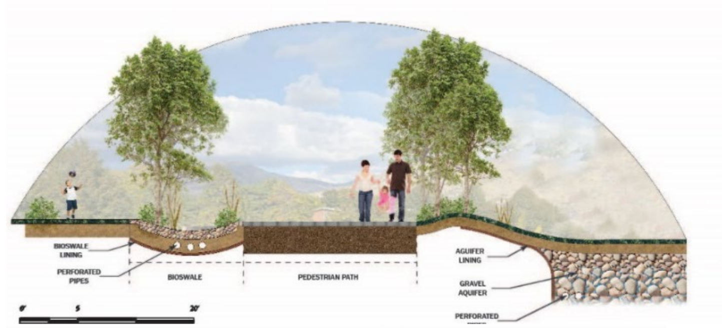
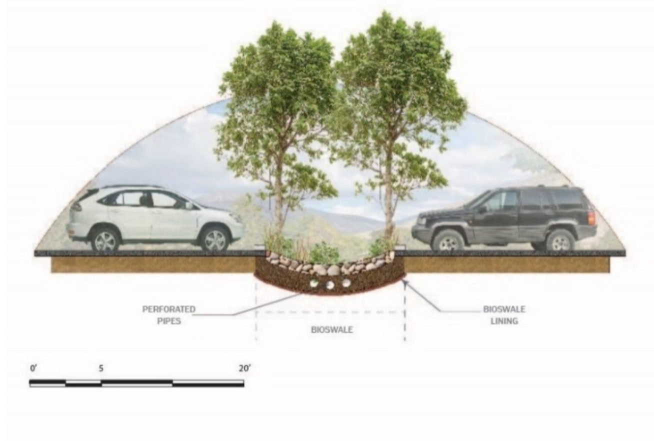


Figure 9. Cross-sections



Stormwater Management

This design features a layout which mirrors the natural flow of Logan Canyon by using three detention basins to act as facsimiles to the three dams in the canyon. Runoff collects in these basins to allow for infiltration and the recharge of underground aquifers. There will also be bioswales along all major pedestrian pathways and within each parking lot.

The stormwater management system of the new design allows the site to sustain its own water needs by capturing and reusing the 100-year, 24-hour design storm. For the 100-year, 24-hour storm, the rainfall depth is 3.22 in., taken from precipitation frequency estimates provided by the National and Atmospheric Administration. The total volume of rainwater expected to fall on this site during a 100-year storm is 9.12 acre-ft of water.

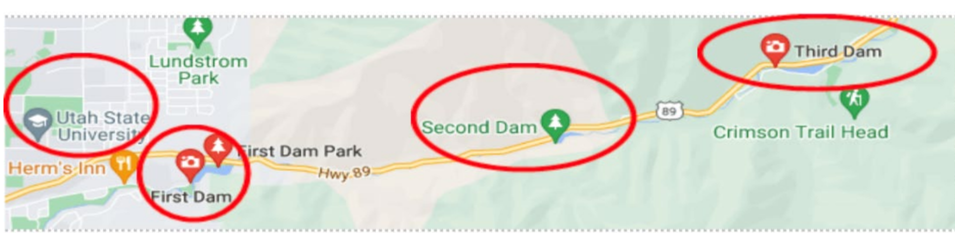


Figure 10. Map of Logan Canyon and Three Dams (Google Maps)

In total this site's design can retain the 9.12 acre-ft of runoff caused by a 100-year storm over a 24-hour period. The three detention ponds will store up to 2.9 acre-feet of rainfall above ground for a 72-hour period as the water drains into the underground aquifers. Aquifer sizes will meet the code for gravel fill to water volume of a 3 to 1 ratio. The aquifers will be constructed beneath each detention pond and all major pathways with bioswales of the site. The aquifers will be constructed with a depth of 6 ft over an area equal to 145,000 sq ft. These dimensions will allow the underground aquifer to store up to 6.6 acre-feet of water. In each detention pond, an overflow piping system will be constructed. This overflow pipe system will allow for excess water within the pond area to drain directly into the underground aquifer.

Safety

This property increases safety in the Aggie Village Property. This housing development is for married students and families with young children, so design should reflect features that appeal to young couples. Courtyard's semi enclosed the proposed structures offer a backyard atmosphere. This also instills a stronger sense of community within neighbors. Studies have indicated that the higher sense of community, the safer the neighborhood and development deterring crime rates within the communities and buildings. Another aspect to improve safety is the layout of the buildings. The buildings and their respective courtyards are all faced towards each other. This encourages central congregation and reduces the risk of kids wandering into streets.

Educational Opportunities

The new Aggie Village design includes multiple features to educate the families and the community, in the site layout. The new design involves incorporating natural landform features of Cache Valley. Natural water systems in this site show the water cycle as it flows from mountain peaks into valleys. Representative water features of reservoirs and rivers will show the travel path of as elevations change.

Capacity

The other main measurement for success of this site is the population increase that will be allowed. A population increase is expected to be accounted for, with room for additional floors to be added to structures to allow for more students to live on site. Varying on interior design layouts, the minimum number of units in this site doubles from that of the original 468 units to 936 units. The layouts in each building can be designed for one, two, and three bedrooms to accommodate for discontinuity in family sizes. The varying size of units within buildings will allow for preference and economic variation. The success of quality of life is projected to be above satisfactory for family residents.

Economics

This project will necessitate the inclusion of several economic opportunities. This will include the creation of jobs for engineers, architects, and construction workers to build the designed site. The buildings, parking lots, and green infrastructure will also require workers for maintenance.

Table 1. Estimated Costs

Description	Quantity	Unit	Cost	Total Cost
Detention Ponds	124,146	CF	$1	$124,146
Green Roof	261,360	SF	$25	$6,534,000
Bioswales	6,000	LF	$32	$192,000
14 Buildings	1,653,600	SF	$225.00	$372,060,000
2-story office building	14,400	SF	$225.00	$3,240,000
Subsurface Utilities	1	LS	7.5% Building Cost	$28,147,500
Parking Lots	291,852	LF	$4.50	$1,313,334
Total Costs	-	-	-	$411,610,980
Inflation: 4%, 20 Years, Compounded Yearly	1	Cost	-	$901,890,344

Source of Funding

Funding for this project will come from several different sources including grants and private donations. Possible sources of funding include the Environmental Education Grant, Blue Goes Green Student Sustainability Grant, and through Section 319 Grant of the Clean Water Act. With respect to the Senate Bipartisan Infrastructure Bill passed in congress, Holly Daines, the mayor of Logan City, spoke on one such funding source. "This bill makes valuable investments not just in roads, bridges, transit and airports, but also much need water infrastructure and specifically western drought resilience for agriculture and communities, something we desperately need right now."

Vehicle & Pedestrian Accommodation

The combination of the five parking lots of varying size will provide a balanced parking layout within the general area. The amount of stalls needed was met while maintaining optimal parking locations and facilitating adaptability. Parking needs may decrease during the life of the buildings as autonomous vehicles grow in popularity. In the future, if the parking lots were no longer needed for Aggie Village, these areas may be transformed into green spaces. The parking lots could also potentially be retrofitted to serve as more housing units, offices, or stores. These options provide a higher income rate for USU.

Based on these factors and the uncertainty of the transportation industry's future, the proposed redesign accounts for 1.5 parking stalls per unit. It is well known that advances in the transportation world are growing exponentially, and past transportation modes may become outdated as time passes. Our design looks at the present and future possibilities as the site must provide adequate parking as needed within the community while personal cars are still in demand. However, due to advances in technology, a decrease in parking spaces is acceptable new standards are set over time.

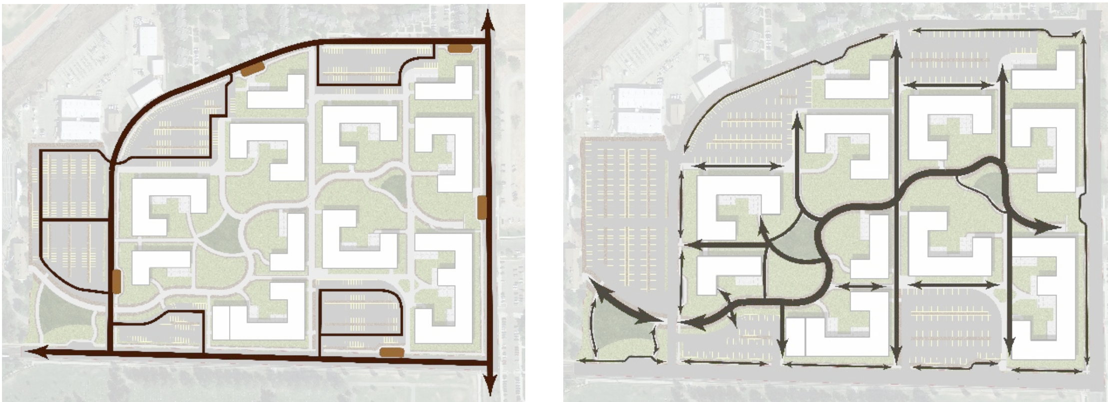


Figure 11. Vehicular and Pedestrian Routes

Modeled Outcome and Performance

To measure the outcome and performance of this design both qualitative and quantitative aspects will be considered. In the modeled outcome, the rigid structure of the building's styles, heights, and models accompanied by the natural flow of green water features provides a unique living environment. Families and children should enjoy their living environment. The water reservoir features and river patterns will bring a beautiful presence of flourishing life and peace to the design.

A key goal to this team was placing each feature to promote the maximum satisfaction and educational opportunities for residents. The parking lots, roads, public transportation, courtyards, amenities, and buildings are designed to satisfy and exceed the basic needs of the residents. The design alternative suggested exceeds the goals and objectives that may be required for a housing development master plan.
The other main measurement for success of this site is the population increase that will be allowed. A population increase is expected to be accounted for, with room for additional floors to be added to structures to allow for more students to live on site. To measure success in acquiring the rising population needs in the university's community this design doubles capacity at a minimum. Varying on interior design layouts, the minimum number of units in this site doubles from that of the original to 936 units. The layouts in each building can be designed for one, two, and three bedrooms to accommodate for discontinuity in family sizes. The varying size of units within buildings will allow for preference and economic variation. The success of quality of life is projected to be above satisfactory for family residents.

Figure 12. Bioswales and Water Flow Diagrams

Implementation and Timeline of Project

This section will outline the phases of construction to implement the engineered redesign of Aggie Village and further recommendations by the team. Recommendations will include the long-term operational maintenance of the site and its features.

Phasing Plan

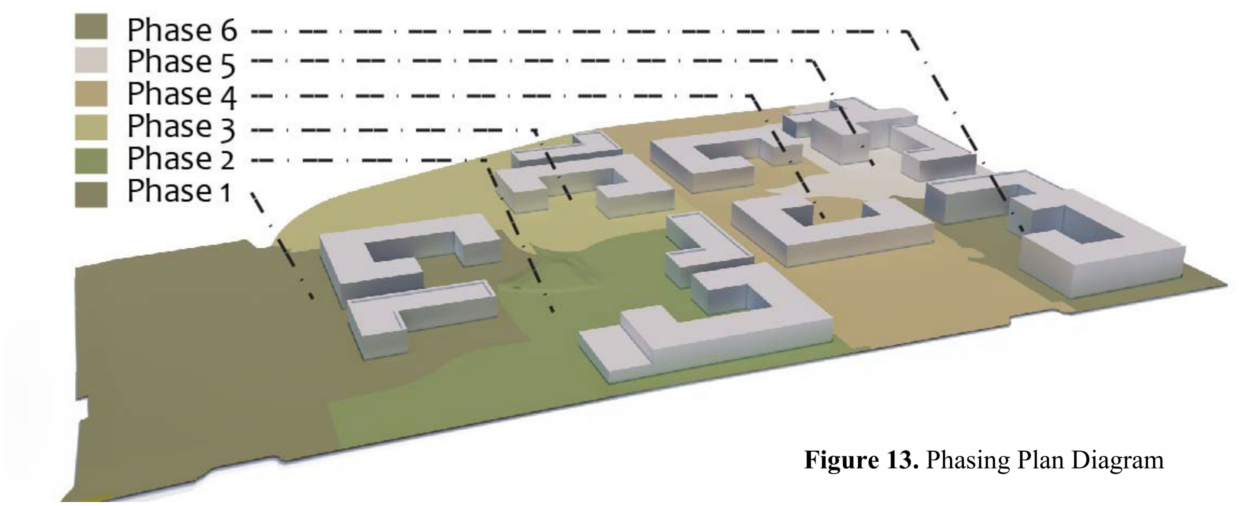


Figure 13. Phasing Plan Diagram

Phase 1: *3 Years*
First detention basin built along with an underground aquifer. Large parking lot repaved with new bioswales installed. Two apartment buildings added with natural vegetation and a single green roof.

Phase 2: *3 Years*
Housing office and two apartment complexes built next to a new parking lot. Bioswales installed in lot and along sidewalks, with the second detention basin and aquifer placed near large green areas.

Phase 3: *3 Years*
Two additional structures built with natural vegetation around the sides. A second parking lot with bioswales constructed on the North side.

Phase 4: *4 Years*
Final two parking lots with bioswales placed on North and South sides of the site. Another two apartment complexes built with green lawn between the two.

Phase 5: *3 Years*
Final detention basin and aquifer built between the buildings from Phase 4. Two more apartment complexes built on North side of site.

Phase 6: *4 Years*
Final structure built with natural vegetation and bioswales surrounding it.

Long Term Operation and Maintenance Plan
The expected lifespan of this project is 75 to 100 years, depending on when each phase is built. USU Housing will handle operations and management over the lifetime of the project.

The water channels on site will be kept clear of debris so that any stormwater can pass through safely. The buildup of debris would cause water to run off site where it would not be available to reuse on site. The underground reservoir is designed to recycle water back into the irrigation system for future water use after storms. Trimming of the natural vegetation would happen seasonally to clear out the absorbed pollutants. This vegetation would then be disposed of with the green waste at the local landfill.

Design and construction accommodate adaptability. More floors can be constructed on the new buildings to allow for more residents if populations grow enough. Parking lots are able to be replaced with either additional structures or new green spaces if autonomous vehicles become the standard for transportation.

Conclusion

Overall, it is obvious that Aggie Village is nearing its lifetime use as it was built in the 1960s and is full of old cinderblock apartments with large amounts of unused grassy areas. In addition, this site was never designed with the intent to be environmentally friendly. The precipitation for the area is 21.09 inches per year, but none of this water is retained on site for later use. Due to climate change and increase of population, water resources have become limited and now is the time to rethink and reform how we sustain our water resources. The redesign of the Aggie Village is proposed to integrate green infrastructure with sustainable buildings to influence the future growth of the USU campus and the surrounding Cache Valley.

The site's success will be measured by the amount of stormwater able to be retained and treated on site. The design storm is at the minimum the 100- year 24-hour storm. The other measure of success is the increase of apartment units for student residents. With the new layout, the capacity of the site has doubled from 468 units to 936 units at a minimum. To fit adaptability guidelines more units and buildings may be added as needed.

Four main criteria were used to develop the final design for the site: resident safety, educational opportunities, a growing population, and transportation options. These criteria were considered thoroughly to develop the design. Stormwater use was then maximized using current strategies to capture water onsite instead of downstream. The building designs are integrated with natural landscapes to harmonize with the stormwater systems, and create a facsimile of Logan Canyon, a familiar natural landscape in the area.

Figure 14. Master Plan Perspective Imagery

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- Michael Young, Environmental Engineering

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- Richard Workman, Assistant Director of Residence Life for Utah State University Housing

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