"Keeping up with the thyme"

Team M2

Elizabeth Diaz-Gunning (Team Lead) | Civil Engineering Major
Melissa Hamling | Civil Engineering Major
Bryson Tamaye | Civil Engineering Major
Sean Yoshishige | Civil Engineering Major
Charline Hendrickx Vandenbosch | Civil Engineering Major

Jordy Wolfand, Ph.D. | Academic Department Advisor
Cara Poor, Ph.D. | Academic Department Advisor
Jennie Cambier | Associate VP for Land Use and Planning

ABSTRACT

The University of Portland (UP) campus is in the North region of Portland, located on a bluff overlooking the Willamette River. The school has implemented green infrastructure on campus, such as green roofs and bioretention cells, but they are not currently operating at maximum efficiency. The foundation of "**Green UP"** lies in addressing the existing stormwater management challenges while considering faculty, staff, and student engagement in future projects. Currently, UP uses over a million gallons of clean water for landscaping purposes. Instead of keeping the luscious green lawn year-round, we propose replacing approximately 88,000 square feet of lawn with purple thyme that is less water consumptive and provides the same level of usability for the community. In addition to utilizing alternative lawn cover, we propose implementing a rainwater cistern facility on campus that collects and reuses runoff for landscaping purposes and pumps the water to the desired location via existing irrigation lines. While proposing new green infrastructure ideas is important for **"keeping up with the thyme,"** it is equally important to retrofit and repair the existing green infrastructure on campus. We propose a starting point of fixing the bioretention cell curb cutouts in the Chiles parking lot. We also plan on introducing new green infrastructure to campus such as living walls and demonstrating small scale versions in our proposed Mental Health Haven. This will more efficiently capture, infiltrate, and use stormwater runoff while keeping the original intention of creating a greener campus and educating students on the importance of it.

I. BACKGROUND

The city of Portland, Oregon is well known for the rain, receiving a range of 24 inches to 62 inches annually over the past twelve years (USGS 2021). In addition, Portland ranks third on the list of urban areas that have the rainiest days in the country with 164 rainy days a year. This precipitation is, however, subject to seasonal variability with dry summer months and wet winter seasons. In that sense, climate change models predict that rainfall variability will grow more extreme in the coming decades, resulting in hotter, drier summers and even wetter winters (May et al. 2018). Portland Water Bureau expects shifts in rain patterns resulting in more severe droughts, floods, landslides, and even wildfires (City of Portland 2019). Additionally, the reduction of snowpack in the Pacific Northwest's mountains will eventually lead to water shortage and treatment challenges as the overall temperature of water increases. The accumulation of challenges illustrates the importance of maximizing the use of local precipitation while designing pertinent landscape and architectural features to account for the changing rainfall patterns and excessive runoff. The UP campus was established in 1901, located within the University Park neighborhood of North Portland (Figure 1) is home to 3,393 students, who either live on campus or near campus in the residential neighborhood that surrounds the university. This urban campus stretches over 170 acres both on the bluff and below, on the riverfront, which is a remediated Superfund site based on past industrial uses in the early 1900s (Ramirez 2021). The UP campus stands out as a beautiful green area in aerial views of Portland. More than 40% of the campus's total surface is composed of lawns, sports fields, flowerbeds, and centuries-old trees. The campus features unique spaces such as the bluff on the edges, with a panoramic view of the Willamette River, Swan Island, and Mount Hood. Given the challenges cited, UP is gradually implementing more environmentally conscious features, considering both sustainability aspects and community engagement as founding elements.

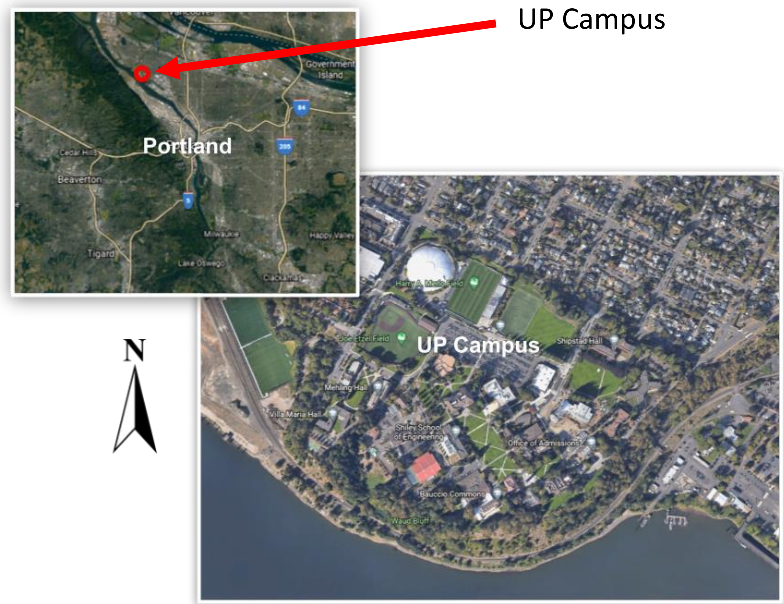

Figure 1. University of Portland Campus [ArcMap]

Despite the apparent attention given to landscape design and a recent interest in implementing green infrastructure on campus, UP faces many of the same stormwater management challenges inherent at any urban site. The current runoff associated with the existing impervious surfaces and grey infrastructure causes pooling and degradation of the asphalt cover in several areas of campus. In turn, while the irrigation system uses over a million gallons of water a year, no rainfall is collected and reused, thus opening an opportunity for our design intervention.

II. SITE SELECTION

SITE SELECTION

The 55-acre site (Figure 2) was selected for the following reasons:

- Selecting the area that feature **drainage issues** and **excessive runoff.**
- Focusing on areas that are of concern for the **UP community** based on the input from various community stakeholders (students, staff, and faculty).
- Avoiding cutting **utility lines** (water, sewer, irrigation).
- Including the main campus and **academic quad** as it represents a central point for community building and engagement.
- Keeping in mind two key aspects of the project: **educate** the community on rainwater management and its challenges and promote **mental health**.

SOILS

The UP campus is built on a combination of Sandy Silt and Sand that are underlain by gravel. Based on geotechnical borings performed in 2018 at various locations in and surrounding the academic quad, the gravel is typically more than 100 feet below the ground surface (BGS) (Reed et al. 2018). Per recommendations, all constructed floor slabs shall be underlain by at least 8-inches of free-draining, clean, angular rock. Observations from geotechnical professionals and a review of a recent survey map indicate the academic quad, North, and Southeast of the site is relatively flat and typically varies from approximate elevation 168 to 174 feet (City of Portland Datum) (Reed et al. 2018).

Noticeable slopes are however observed on the Southwest part of the site. The geotechnical report from 2019 (Paveglio et al. 2019) indicates that this part of campus is located within a former ravine that was partially filled between 1956 and 1964 with additional fill placement in the 1980s. The fill at the site predominately consists of loose, silty sand with zones of soft to medium stiff till.

The slopes within the site, the types of pervious surfaces, and the location of impervious surfaces were therefore considered in the design process.

HYDROLOGY

Although groundwater was not encountered in the borings at the time of drilling, the moisture-sensitive nature of the near-surface soils should be addressed in the design and construction processes of any project on campus. Based on groundwater mapping in the area,

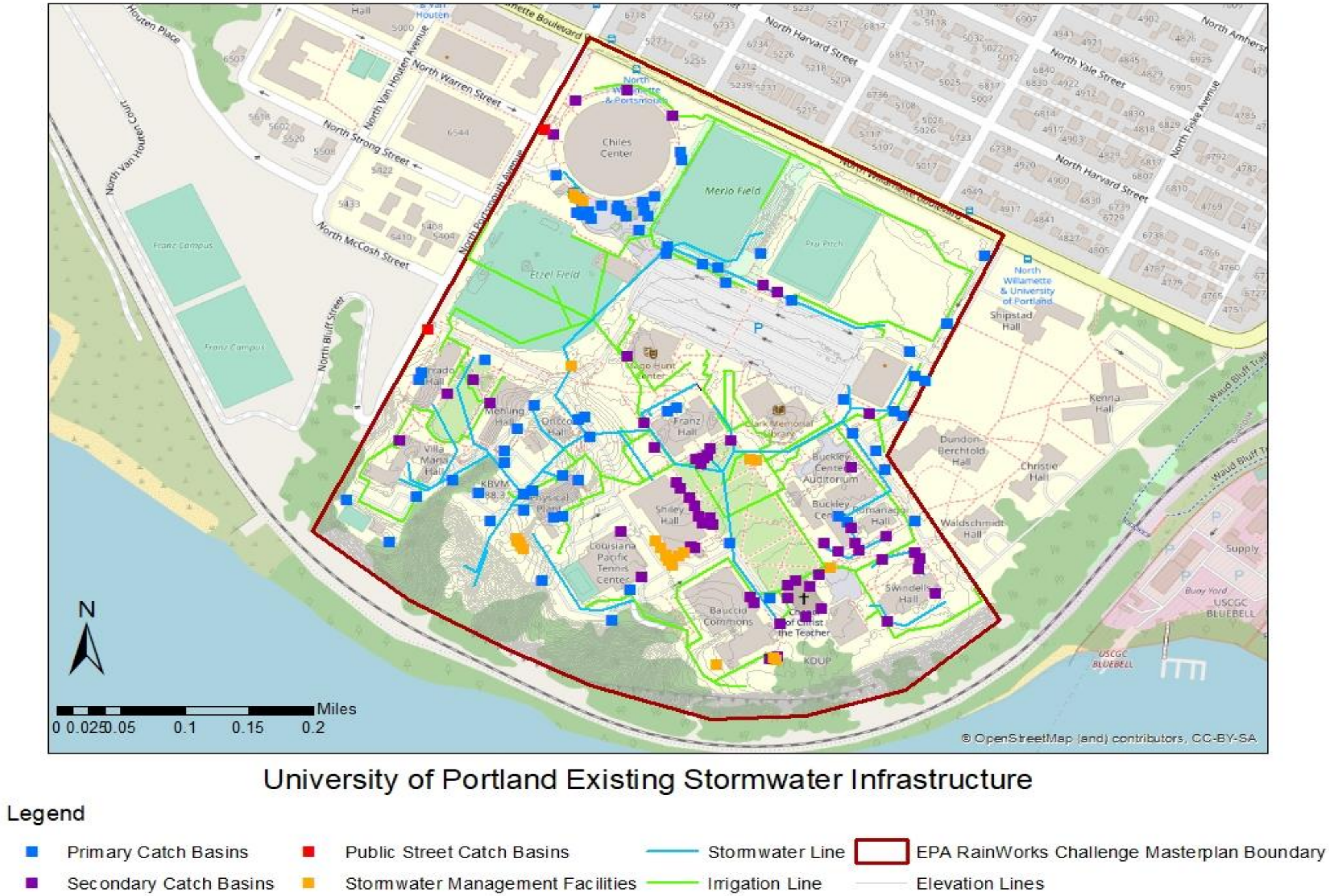

Figure 2: Map illustrating outline of the 55-acre site and existing green infrastructure on the UP campus. Orange markers show areas with existing stormwater management facilities including green infrastructure such as green roofs and rain gardens.

groundwater is likely to vary between 80 to 100 feet BGS. Perched water could also be presented above the static water table in the wet season and within the fill (Paveglio et al. 2019).

Part of the UP campus is situated within the historic floodplain of the Willamette River. The upper campus within our site is on a slight topographic variation that increases to a 6% slope to the Southwest part of campus, near the Physical Plant building, which houses the staff that manages campus facilities, and Orrico Hall (see Figure 2). The runoff from the academic quad thus drains to the inlets on the Southwest corner of the quad, behind the Shiley School of Engineering building and down to Orrico Hall on the edge of the site. This water then goes to the detention pond behind the Physical Plant building and to the Willamette River via storm drain. The roofs of most buildings on site are currently drained by a series of downspouts off the front, back, and side facades. The Shiley School of Engineering features a green roof on the East side; conversations with the Physical Plant staff gave us insights on the maintenance of this green infrastructure.

The site includes the largest parking facility on campus that is used for student parking, event parking, etc. All runoff from this parking lot drains into bioretention cells before draining to the inlets in the Chiles Center direction.

The existing vegetation constitutes an important part of the campus green stormwater solutions. Bioretention cells with native plants in the parking lot as well as the various planters and mature trees around the site contribute to the infiltration of rainwater and the slowing down of runoff. The numerous lush green lawns that characterize the UP campus contribute considerably to the overall runoff infiltration and stormwater management.

Overall, the primary catch basins, drains, and drainage areas are dispersed around campus and most of the secondary catch basins, which are smaller square catch basins that capture runoff from smaller areas, are located around the academic quad in the Southeast part of our site. Most of the infiltration basins that are located on campus are in the Southeast corner of the Shiley School of Engineering building and behind the Tennis Center.

Currently, the Grounds Department at Physical Plant manages both stormwater and irrigation lines on campus. It involves all phases from installation to maintenance, adjustments, and repairs. The irrigation for the main campus comes from a private well; no city water is used for maintaining the various lawns and green infrastructure on that part of campus. This supplies all irrigation water for campus and athletics, watering all lawns and plants from one source. This water is also used in cooling systems for heating, ventilation, and air conditioning (HVAC) in the most recent buildings on campus (Dundon-Berchtold), which is not part of our site of study. Therefore, estimating the water consumption for irrigation on the main campus is difficult to pinpoint. Based on conversations and meetings with the input of the Grounds Department staff, **irrigation water demand is typically approximately one million gallons per year.**

COMMUNITY CONCERNS & COMMON PROBLEMS

With the input of Physical Plant staff, faculty, and other students we identified three main community concerns and three common problems. From the Physical Plant staff, we learned that they are concerned about the maintenance of the new green infrastructure we will implement. They explained to us that they wanted something that was low maintenance and to see improvements to the existing green infrastructure on campus. The concerns we got from students were that they wanted a more environmentally friendly campus, to maintain the usability of campus open spaces, and green infrastructure that can serve multiple purposes such as providing reflection space. **The most common problem we noticed and heard about from our stakeholders is that our campus has a lot of good green infrastructure, but it either wasn't implemented correctly or isn't maintained properly**. The prime example of this is the bioretention cells in the Chiles Parking lot that have curb cutouts in the wrong locations, so the runoff pools on the surrounding pavement as a result.

This ongoing pandemic has taken a toll on everyone in our world. With the new societal push to prioritize mental health, this is an area that UP currently lacks resources in. Our campus has designated locations for academic and physical health success. Having a place outside of the health and counseling center that allows people to focus on their mental health would serve our community and prioritize the idea of having balance in life. We believe that creating a space that incorporates the benefits of the rainy Portland culture through the soothing sounds that come with rain catchments and a glass rainwall, as well as incorporating small scale living walls, all of which will help our community cultivate more appreciation for the wet season and have a better mental relationship with the darker months of the year.

PRIORITIES

Our design focuses to address three main areas:

- Reduce the excessive use of water on campus
- Revamp some of the current green infrastructure we already have to improve efficiently
- Create more space for students to focus on mental health through connectivity with nature/natural resources

These three aspects are most important to us because they all address the main concerns of the community while still creating a positive impact on the environment.

III. ANALYSIS OF DESIGN

ALTERNATIVES ANALYSIS

The two main components of our design are focused on stormwater management (i.e., runoff reduction) and reduction of water use for irrigation. Design options were considered using a decision-matrix approach. Each design alternative was considered by weighing them against five controlling factors, based on initial stakeholder feedback: maintenance, environmental impacts, desirability/aesthetics, feasibility, and cost (Table 1 and 2). Maintenance was slotted as the most important factor based on stakeholder feedback and the design performance being dependent on the upkeep provided by the Physical Plant team. Environmental impacts were weighted as the second most important factor because the overall goal of this design is to limit UP's carbon dioxide emissions while adapting the campus into a greener space. Desirability/aesthetics were considered the third most important factor because new additions to campus need to match UP's 16th-century brick gothic aesthetic, as well as following the administration and student preferences, such as leaving the academic quad a completely open space. The feasibility of the design alternatives was the fourth most important factor because the project is focused on new, innovative ideas that might not currently exist. The cost was designated as the least most important factor based on stakeholder feedback that reinforced that with enough community and financial support from donors, anything is possible.

The first design matrix focuses on analyzing the following three alternatives for stormwater management practices (Table 1): green roofs, green streets, and living walls. Each alternative was ranked from 1 (not desirable) to 3 (desirable). The results are summarized below:

Table 1. Design Matrix for Stormwater Management Alternatives

	Maintenance (5 = most important)	Environmental Impacts (4 = very important)	Desirability/ Aesthetics (3 = important)	Feasibility (2 = somewhat important)	Cost (1 = not as important)	Total
Green Roofs	(2*5) = 10 Medium	(2*4) = 8 Medium	(1*3) = 3 Low	(1*2) = 2 Low	(2*1) = 2 Medium	25
Green Streets	(1*5) = 5 Low	(2*4) = 8 Medium	(2*3) = 6 Medium	(3*2) = 6 High	(2*1) = 2 Medium	27
Living Walls	(3*5) = 15 High	(2*4) = 8 Medium	(2*3) = 6 Medium	(3*2) = 6 High	(3*1) = 3 High	38

Green Roofs: advantages include providing shade, removing heat from the air, and reducing temperatures on the building (EPA, 2011). Based on stakeholder feedback from the Physical Plant Team, the existing green roofs on campus require more care than Physical Plant can provide to keep them functioning at high efficiency. They also explained that it is not feasible to implement more green roofs on campus. Since UP has old infrastructure, there would be additional cost for structural analysis of the buildings to ensure the roofs could support the extra weight. Due to the green roofs needing to be properly maintained to be fully effective, this would not be a feasible option for our campus.

Green Streets: advantages include removing up to 90% of pollutants, replenishing groundwater supplies, absorbing carbon, improving air quality and neighborhood aesthetics, and improving pedestrian and bike safety (EPA, 2021). Based on stakeholder feedback from the Physical Plant team, green streets can be easily maintained depending on the type of vegetation utilized in the planters. Due to the existing vegetation curb areas and the layout of the campus, the desirability of green streets is not high. There is limited additional curb area available to implement, meaning additional demolition is required to make space. As a result, green streets will cost more and produce more environmental pollution if added to the UP campus; thus this would not be a feasible option.

Living Walls: advantages include reducing building energy consumption, collecting rainwater, reducing heat island effects, and providing a nice aesthetic to the buildings. Based on research about implementation and care of living walls, the maintenance would be minimal because they need to be pruned annually and will receive water during the rainy season. During the dry season the living walls will need to be watered in order to keep them strong. Through research about efficiency and usability, the environmental impacts of living walls address another area of environmental concern (heat and building energy) than other aspects of our design. Although living walls would take multiple years to reach maximum efficiency, they would still maintain UP's 1900s brick gothic aesthetic while also reducing the energy consumption of the buildings. **Living walls were the recommended alternative because of the low maintenance requirements and the high environmental impacts, such as reducing the energy consumption of buildings.**

The second design matrix focuses on reducing the water usage throughout campus by comparing three lawn cover alternatives (Table 2): Grass, Thyme, and Permeable Pavement. Each alternative was ranked from 1 (being not desirable) to 3 (being desirable). The results are summarized below:

Table 2. Design Matrix for Water Usage Reduction

	Maintenance (5 = most important)	Environmental Impacts (4 = very important)	Desirability/ Aesthetics (3 = important)	Feasibility (2 = somewhat important)	Cost (1 = not as important)	Total
Grass	(1*5) = 5 Low	(1*4) = 4 Low	(3*3) = 9 High	(3*2) = 6 High	(1*1) = 1 Low	25
Thyme Lawn	(2*5) = 10 Medium	(2*4) = 8 Medium	(2*3) = 6 Medium	(3*2) = 6 High	(2*1) = 2 Medium	32
Permeable Pavement	(3*5) = 15 High	(2*4) = 8 Medium	(1*3) = 3 Low	(1*2) = 2 Low	(1*1) = 1 Low	29

Grass: advantages include providing space for activities to be held, looking nice (when green) throughout the whole year, and being already implemented. Based on mowing and water requirements, the existing lawn must be mowed at least once a week and watered every day, which may not be sustainable given changing climate. By mowing the lawns at least once a week and using leaf blowers to clean up excess cuttings, unnecessary carbon emissions are produced. Furthermore, the lawns at UP at kept green year-round, which requires a lot of water, especially in the dry season (May–October). Based on stakeholder feedback from the student community and the Physical Plant team, the grass is highly desirable because of its usability for activities (such as frisbee) and the fact that it is already planted in the necessary areas. To appease the community, our goal was to find a more sustainable lawn cover that provides the same usability, since grass is not a sustainable lawn cover.

Thyme: advantages include providing space for activities to be held, looking nice throughout the whole year, being more infiltrative than grass, and requiring little water. Based on research about implementation and care, the maintenance of a thyme lawn is minimal because there is no mowing and, if properly seeded, no weeding is required. Thyme lawns are drought resistant (minimal water in the summer) and very infiltrative. A purple thyme lawn matches UP's school pride and provides visual aesthetics. This would be very feasible because it provides the same level of usage as a grass lawn but has lower maintenance and water requirements (Vinje, 2019).

Permeable Pavement: advantages include durability and sustainability of material, as well as very little maintenance yet full infiltration of runoff. The construction of permeable pavement does release carbon emissions but there aren't many environmental impacts once it is implemented. Based on stakeholder feedback from the UP student community, the desirability of permeable pavement is low because there would be 88,000 square feet of pavement covering the academic quad, which does not fully support activities, such as frisbee.

Thyme Lawns were the recommended alternative based on researched maintenance, environmental impacts, and the UP campus aesthetics.

IV. CONCEPT AND MASTER PLAN

The foundation of the **"Green UP"** design concept is based on retrofitting and repairing existing green infrastructure on the UP campus while integrating new, innovative ideas. This design is centered around **"keeping up with the thyme"** in terms of social movements (such as prioritizing mental health) and environmental awareness (such as using non-potable water for non-recreational purposes). **The goal is to start a conversation about combatting the wicked problem of climate change, specifically within a college setting, while introducing both immediate and long-term plans to feasibly create a greener future at UP.**

Figure 3 displays the approximate locations of existing green infrastructure, as well as all proposed additions within our site.

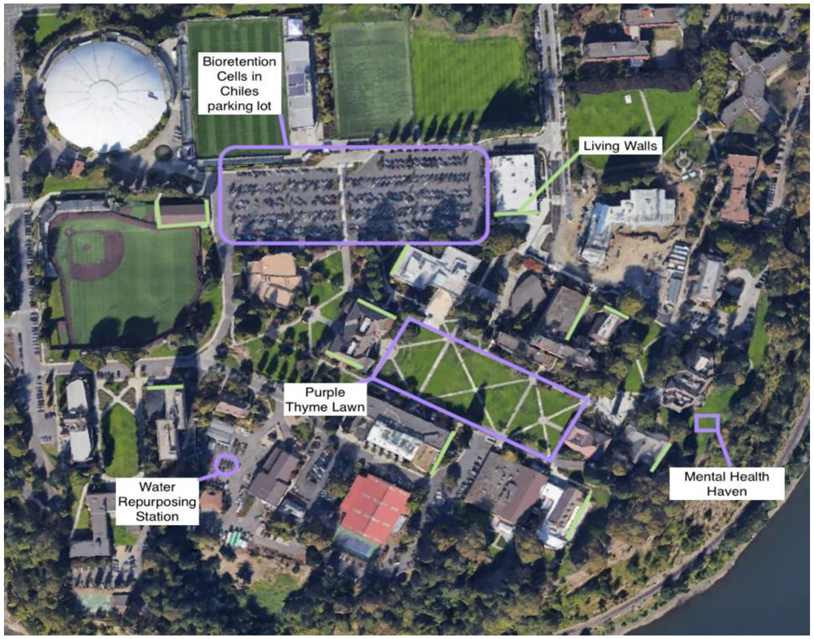

Figure 3. Spatial location off all proposed green infrastructure additions on campus

WATER REPURPOSING FACILITY

The area of the UP campus within our 55-acre site drains to a singular catch basin located in the Southwest region near Oracle Hall (Figure 2) and is transported via storm drain to the Willamette River. **We propose the addition of a water repurposing facility on campus, which consists of a cistern, Ultraviolet (UV) disinfection station, and a 50-horsepower centrifugal pump.** The cistern would be located above ground (Figure 4), just south of where all the stormwater lines combine to efficiently maximize the amount of water collected.

Figure 4. Above ground cistern that would store treated stormwater runoff. The brick exterior matches the UP building aesthetic.

The cistern was sized by calculating the average annual precipitation rate in Portland and the UP water requirements for landscaping purposes. Using United States Geological Survey (USGS) station number 193, we computed that the UP campus receives approximately 37 inches of rain annually. Accounting for potential losses from infiltration and spill as the runoff travels from the impervious surfaces to the stormwater lines, the UP campus could harvest 14,973,037 gallons of rainwater annually, which is 14 times the amount of water currently used.

Taking into account the approximate amount of water that can be harvested in conjunction with the catchment areas within our site, which were calculated from AutoCAD drawings provided by Jennie Cambier, the Associate VP of Land Use and Planning at UP, we determined that a 20,000-gallon cistern was the most efficient size based on economic feasibility. There is a six-inch pipe located one foot below the roof of the cistern for overflow protection. The pump was selected based on the elevation change between the location of the cistern and the highest point of our site, as well as the anticipated pressure required to pump the water throughout the irrigation system. Due to the great environmental benefits this would provide, this would be part of the short-term plan for our design.

RETROFITTING & REPAIRING

UP has approximately 29 bioretention cells located in the Chiles parking lot to capture and treat stormwater runoff. The intended function of this green infrastructure was to guide the runoff towards the two to three curb cutouts located on each bioretention cell. Due to the incorrect placement of the curb cutouts, there is short-circuiting in most bioretention cells (Figure 5A) and ponding on the impervious surfaces surrounding the bioretention cells (Figure 5B).

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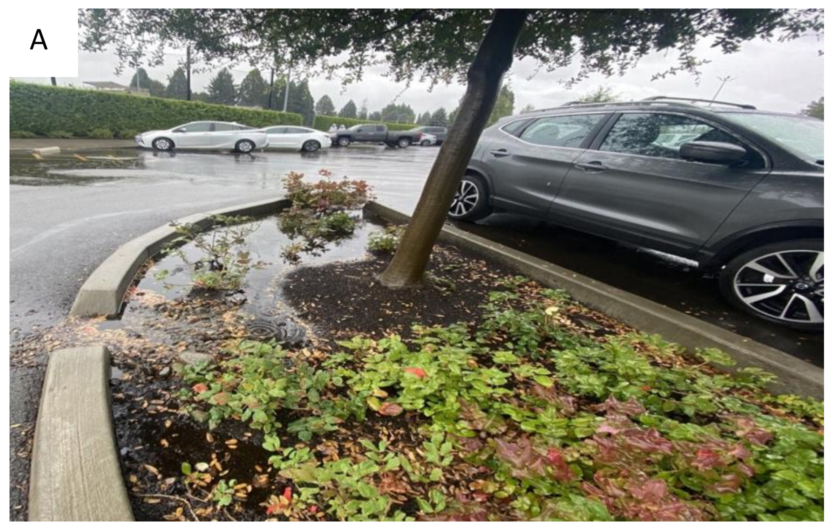

Figure 5. Current bioretention cell curb cutouts located in the Chiles parking lot create ponding and runoff; (A) Bio-cells short-circuiting; and (B) Stormwater runoff ponding outside of the bioretention cell.

To ensure maximum efficiency of the existing green infrastructure on campus, we propose to relocate these cutouts to the appropriate location allowing the runoff to be properly captured and treated. Since this is a quick fix to the existing green infrastructure, this would be part of the short-term plan for our design.

THYME LAWNS

Per stakeholder feedback from the UP Physical Plant Senior Grounds Manager, Nathan Hale, the University uses over one million gallons of water per year. The proposed solution to reduce the landscaping water requirement is replacing the approximate 88,000 square feet of lawn located in the academic quad with purple thyme (Vinje, 2014). Figure 6 shows a rendering of the new proposed planting.

Figure 6. Rendering of the preferred proposed land cover alternative, Purple Thyme, in the UP academic quad.

Thyme is a drought-resistant groundcover that provides the same usability as grass, requires no mowing (reduction in carbon emissions), and uses a minimal amount of fertilizer compared to grass (reduction in chemical pollution). The advantages of implementing purple thyme include a reduction in landscaping water requirements, reduction in maintenance, full usability, increase in areas for bee pollination, and a purple aesthetic that matches UP's purple pride. In order to further quantify these benefits, we compared the monthly water demands of purple thyme to grass. To cover the lawn with one inch of water each time, purple thyme requires approximately 109,648 gallons, whereas grass requires 219,296 gallons, which is double the volume. This is due to purple thyme having an average watering period of about 14 days and grass every 5-7 days (Vinje 2019). Since this would lower the water usage and minimize power consumption, but still provide the same or more benefits and usability, purple thyme is a great substitute for our site. Due to the nature of properly seeding thyme to minimize weeds and maximize infiltration, this design feature would take multiple years to fully cover the intended area; as a result, this would be considered a part of the long-term plan for our design.

LIVING WALLS

A majority of UP's infrastructure was built in the 1900s with a 16th-century brick gothic aesthetic, which is considered a less damaging manufactured material than concrete and steel (Williams, 2020). However, bricks consume approximately 3,000 Mega-Joules of energy per ton due to heating/cooling effects (HABITAT, 1991). **To combat this, we believe it would be beneficial to implement living walls on thirteen campus buildings** (Figure 7).

The advantages of implementing living walls throughout the UP campus include additional reduction of runoff, reduction in building heating/cooling requirements, removal of gaseous pollutants from the air, and reduction of urban heat island effect (Malslog-Levis 2014). A study conducted in Shiraz, Iran concluded that living wall systems can reduce the ambient air temperature by up to 8.7 °C; furthermore, during the hours of solar radiation, the simulation experienced an average drop of 2.59 °C (Shafiee 2020).

The main drawbacks of this design are the cost of installation and the maintenance associated with vegetation trailing a multi-story building. To keep this design feature as low maintenance as possible, we would work in conjunction with the UP Physical Plant team, who would perform the upkeep, to select appropriate walls that allow for easy accessibility and maximum reduction in energy consumption.

The proposed living walls would be constructed with wall planters to house the vegetation and irrigation troughs mounted on the buildings to lower maintenance requirements. It takes one person approximately four hours to install 86 square feet of living wall as well as a full year for the vegetation to mature and reach maximum efficiency (Leishman, 2018). Due to economic feasibility, we propose implementing 13, 500 square feet of living walls on campus over a span of multiple years, which causes this to be categorized as a part of the long-term plan for our design.

Figure 7. Rendering of a living wall on the UP Bookstore

MENTAL HEALTH HAVEN

As college students adapting to a new way of life post-COVID, we have the unique opportunity to advocate and implement a mental health haven as a key part of our design. **We were driven to innovate a space that would serve the community, while simultaneously educating the community about green infrastructure and the large potable water usage on campus.** UP uses over a million gallons of potable water annually for activities such as landscaping and flushing toilets; however, stormwater can be captured, treated, and used instead.

The metal health haven is a small structure with three double pane glass walls, with each layer of glass spaced about two feet apart to act as a storage space for the collected stormwater runoff and has multiple windows for natural lighting (Figure 8).

Figure 8. Planview of the interior of the Mental Health Haven showing rain collection walls and activities for destressing that utilize natural resources.

This building would be constructed on the Northeast side of campus that overlooks the bluff; a location that provides both a quiet and private space. The inside of this haven houses couches, an electric fireplace for the wintertime, a fountain that runs off the collected rainfall, and artwork portraying different types of green infrastructure.

The idea behind the rainfall-powered fountain is to visually illustrate the amount of precipitation Portland receives. The glass walls have an additional exterior piece of glass that acts as a container to store the stormwater. The roof is sloped to create a direct path for the stormwater to drain into the space between the glass walls and ensure the maximum amount of runoff is captured and reused. The runoff will be stored in the space between the glass walls and be transported to the rainfall-powered fountain when there is enough supply. The fountain will be dry when there is not enough stored rainwater to power it.

The artwork included in the Mental Health Haven will portray the different types of green infrastructure that exists around campus and ideas that are proposed as a part of our design; specifically, we want to showcase green roofs, downspout disconnections, bioswales, the urban tree canopy, and the purple thyme lawn. The idea behind including this artwork in the Mental Health Haven is for the community to become more familiar with green infrastructure. To promote inclusivity and engagement, all artwork will be commissioned from within the UP community.

An additional design component of the mental health haven is demonstration-scale green infrastructure located throughout the exterior of the building to more intimately introduce the community to the benefits. We propose to have a small living wall on the front side of this building (Figure 9) next to a plaque that is used to explain the purpose and intention of this green infrastructure.

Figure 9. The exterior of the front side of the Mental Health Haven is located on the Northeast side of the bluff with a small-scale living wall, permeable pathway, and small bioretention planters.

Furthermore, leading up to the entrance of the outdoor seating area we designed a permeable path that has small bioretention planters on either side. These designs intend to introduce the community to the idea of rainwater harvesting, and best practices for stormwater management.

SOCIAL ANALYSIS

At the core of our proposal was the idea of human-centered design, specifically for the community on campus which includes students and faculty. One concern voiced by the student community was the usability of the academic quad. Replacing the 88,000 square feet of lawn with purple thyme would allow the students to utilize the space in the same manner, but with a more colorful and environmentally friendly landscape, which might invite more people to spend time outside between classes.

The Mental Health Haven is another design aspect that prioritizes the well-being of the environment and our community. Through the glass walls of the building, students can observe the rain over the Bluff in the wet months and the sun rays in the dry months. In addition to reconnecting our community with the environment, the glass rain wall in this building provides an educational component for the community to learn about the effects of climate change on precipitation in Portland and the innovative practices in rainwater harvesting through a rainfall-powered fountain.

To create a better relationship with the rain, we propose hosting an annual Rain Festival. This would be an event that is held during the first rain of each new water year. In addition to introducing the community to how important precipitation is for the environment; we hope the community will embrace the rainy Portland culture and appreciate all the benefits it provides.

The other educational component of our design is the water repurposing facility, which includes a 20,000-gallon cistern, a pumping station, and a water treatment station. The purpose of the design element is to introduce our community to the idea of rainwater harvesting on a larger scale than what is shown in the Mental Health Haven. Our community has voiced concern about the UP campus landscaping watering requirements, which can be proficiently satisfied with this water repurposing facility on campus. Not only will UP more sustainably meet the campus water demands, but the community will become educated on the specifications about water repurposing.

The living walls on campus would add a more aesthetically pleasing environment in the academic quad and boost the community's connection to nature. This aspect also shows initiative that UP recognizes climate change, and is working towards minimizing the campus impact, specifically in reducing the effect of heat islands on our campus.

ECONOMIC ANALYSIS

Our proposed masterplan is estimated to cost approximately $1,555,877 (Table 3). To feasibly integrate new, innovative green infrastructure on campus, we recommend utilizing three phases.

Table 3. Overview of Masterplan Capital Costs

Mental Health Haven	$382,722.00
Purple Thyme	$4,400.00
Living Walls	$1,134,900.00
Water Repurposing Station	$33,854.00
Parking Lot Curb Cutouts	$11,310.00
Total	$1,555,877.00

The first phase is focused on fixing the bioretention cell curb cutouts in the Chiles parking lot and replacing the lawn in the academic quad with purple thyme; the intended outcome is to fix the existing green infrastructure on campus and start a conversation about lowering the landscaping watering requirements. Retrofitting the 29 bioretention cells is estimated to cost approximately $11,310, which includes the cost of filling the incorrect cutouts with concrete and demolition of concrete for new, correct cutouts. Implementing 88,000 square feet of purple thyme in the academic quad is projected to cost approximately $4,400, which does not include labor fees.

The second phase is focused on reducing UP climate impact by introducing the water repurposing facility on campus. In the preliminary phase, the 20,000-gallon cistern, pumping station, and UV treatment station are estimated to cost approximately $33,855. In 2012, the UP campus water bill was approximately $175,647 (Oregonian 2013), and between the years 2008-2016, the annual price escalated at an average rate of 6.82% (FEMP 2017). For the 2021 calendar year thus far, UP has an estimated water bill of $622,879.88, which will increase until the new year. Based on this information, a water repurposing station would pay itself back within one year of use. In addition to being a beneficial financial investment, the water repurposing station would educate the community on the process and advantages of water repurposing.

The third phase is focused on introducing new, innovative human-centered designs on campus through implementing living walls on older infrastructure and constructing a green infrastructure demonstration mental health haven on the Northeast side of campus. In total, this phase is estimated to cost approximately $1,517,600. Our masterplan proposes adding thirteen living walls on older buildings throughout our 55-acre site, which is projected to cost $1,134,9000 in total, or

$87,300 per wall. This includes fees for structural frames, irrigation systems, and vegetation. More advanced structural calculations are required before constructing the living walls to ensure the buildings can support the additional load. Since the mental health haven is a new structural addition to campus, the estimated cost is about $383,000, which only accounts for the materials of the building, and not labor or additional testing, such as geotechnical reports. While constructing a mental health haven on campus is a financial investment, it prioritizes the well-being of the community, while simultaneously reconnecting people with nature and introducing them to the idea of rainwater harvesting.

PROJECT TIMELINE

Our proposed design was created to be implemented over various time horizons, with the flexibility to adapt to changing circumstances. We have proposed milestones based on a 1-year (Figure 10), 2-year (Figure 11), and 5-year (Figure 12) mark.

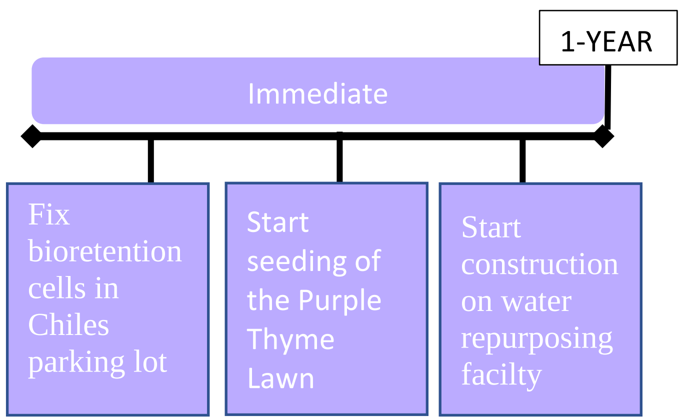

Figure 10. Timeline for tasks to be completed within the first-year.

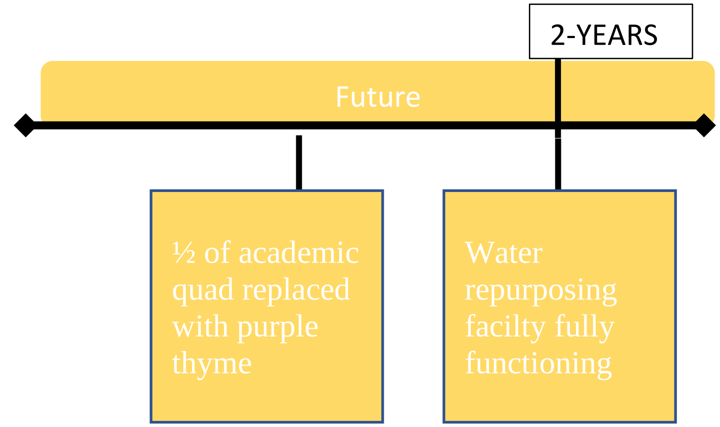

Figure 11. Timeline for tasks to be completed within the second year.

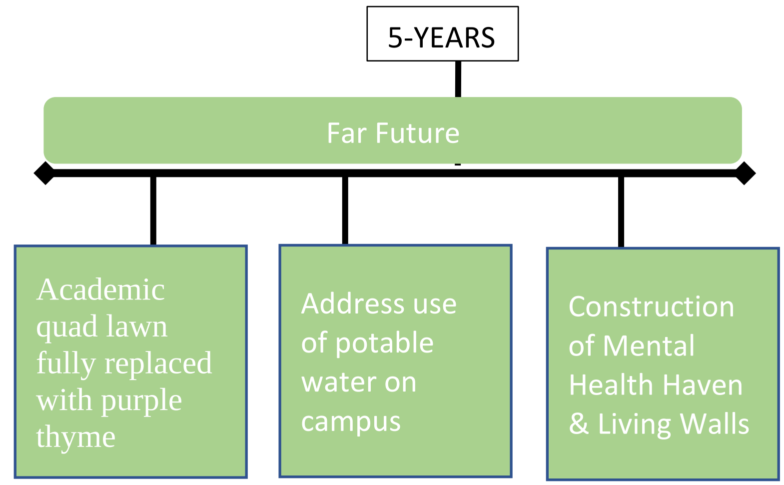

Figure 12. Timeline for tasks to be completed within the fifth year.

To determine reasonable implementation time frames, we considered cost, seasonal dependency, community feedback, and compared short-term versus long-term benefits.

The construction of the Mental Health Haven and the living walls is outside of the 5-year timeline because there are factors that could cause this to happen at a shorter or longer time frame. The 5-year timeline includes an idea about addressing the use of potable water on campus because our proposed design only focuses on the landscaping watering requirements. In conjunction with the City of Portland to ensure all design aspects are within regulation, UP has the ability to only use recycled water to fulfill all campus watering requirements. As UP begins to cultivate a greener environment on campus, we believe implementing more facilities for water repurposing, following the Portland SWMM specifications, will be necessary.

SUSTAINABILITY ANALYSIS

Although environmental impacts are one of the primary factors considered throughout all the stages of our design, it is crucial to examine the immediate and long-term sustainability of the design. The goal is indeed to optimize the processes as best as we can in every step of the project to limit energy and material use, thus better controlling the costs and greenhouse gases emissions. In that respect, the materials and construction methods required for our proposed designs described in previous sections should be carefully discussed.

In that sense, a life cycle analysis of the new designs should be conducted to estimate the sustainability and carbon impact, as well as evaluate the reuse potential of the older infrastructures. The objective is to gradually tend towards circular processes in the construction steps, encouraging deconstruction over demolishing to enhance and prioritize reuse possibilities. Ultimately, the design should drive the following principles: eliminate waste and pollution, circulate materials, and regenerate nature. As part of the masterplan proposes to implement more circular practices on campus by reusing stormwater, the built design should also encompass circular aspects through the choice and/or reuse of materials. In practical terms, enabling the deconstruction and reuse of material on new designs can be easily done by fostering the use of natural building materials, while limiting concrete and more traditional building methods, that rarely account for repurposing materials.

V. CONCLUSION

With the addition of new green infrastructure and retrofitting existing green infrastructure on the UP campus, the objective of our proposed design remains the same: create a more environmentally aware campus that focuses on implementing green practices through educational components to prioritize community involvement. While most of our ideas focus on the betterment of stormwater management practices on campus, we also wanted to address rising climate and social movements to encompass how diverse green infrastructure can be utilized. Retrofitting the Chiles parking lot curb cutouts, replacing the lawn in the academic quad with purple thyme, and implementing a water repurposing station on campus are all feasible and realistic design options that support more efficient stormwater management practices. Implementing living walls on older buildings throughout our 55-acre site focuses on reducing energy production and heat island effects, which as a result minimizes greenhouse gas emissions. Constructing a mental health haven focuses on prioritizing community well-being in conjunction with establishing relationships between people and nature. As a civil engineering group, our dedication to creating a greener space on campus is for our community. The entire foundation of our proposal was committed to sustainable human-centered design.

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