A River Runs Through It

functional + ecological + educational

Abstract

The south-western U.S. is facing the effects of climate change on a daily basis. 50 year projections show this already harsh desert climate warming as much as 8°F, while simultaneously experiencing a drop in precipitation of 4-8% annually (National Climate Assessment, 105-106). On average Tucson, Arizona receives 11.92" of rainfall annually and has an average high temperature of 83.7°F (Data, US Climate). Based on these projections Tucson could be facing average highs of 90+°F and a decrease in annual precipitation of 0.95". Now more than ever we must work to conserve this precious resource. The integration of water harvesting Green Infrastructure practices into daily life must be coordinated with educational efforts for south-western residents to inform about conserving this resource.

A River Runs Through It intends to recreate the selected site as a functional, ecological, laboratory for the surrounding science buildings, as well as a template for similar areas on campus. The design aims to improve on-site management of water resources, such as storm water and building HVAC condensate through the creation of a dry arroyo bio-swale, which will provide unique gathering spaces for campus users as well as research opportunities for students and faculty. The project also aims to improve connectivity, as well as create a distinct and unique sense of place for the University of Arizona that could be distilled and applied to related sites across the campus. The project seeks to create a functional water harvesting system that educates about desert systems and water conservation practices.

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Table of Contents

Site Selection + Analysis

Situated among seven science buildings, the site serves a broad spectrum of users, including teachers, students, and residents of the University of Arizona (U of A). Surrounded by buildings on all sides with student housing located just off-site, as well as a student union, the site features high traffic volumes as well as high visibility. In addition, the site is close to many transportation hubs, such as a major campus parking garage, multiple bus stops, and the main hub for off campus student housing transportation services. The site is identified as a high priority area within the U of A Surface Water Master Implementation Plan (SWMIP), the main reason being that it has the potential to mitigate downstream flooding problems for buildings that are within the 100 year flood plain. Based on the SWMIP design suggestions, the site would have a storm water harvesting feature that accommodates 7.03-acre feet of storm water, and would be approximately 785' x 65' in dimension (Surface Water Master Implementation Plan, SWMIP-10). A main goal for this project is to meet or exceed the U of A SWMIP metrics for storm water detention, while also creating a feature that improves the aesthetics and human functionality of the site. Currently the site has a time of concentration, for

Figure 1 - Site Context within the University of Arizona campus

Figure 2 - Project site

a 100-year 24-hour storm event of approximately 10 minutes. Based on this metric, another design goal is to retain all water from a 100 year 24-hour storm event on-site, which would alleviate many of the downstream flooding issues. While the project has many other goals, the implementation of only these has the potential to drastically improve ecological function and offers the opportunity to re-work pedestrian, bicycle, and maintenance vehicle circulation.

Currently much of the site is fragmented, with vegetation and paving surfaces changing frequently between buildings. The result is a mish-mash of underused spaces that lack cohesion and have, in some cases, fallen into disrepair. Utilized as a major circulation conduit, both for pedestrians as well as maintenance vehicles, there are numerous conflicts throughout the site when pedestrians and cyclists must avoid cars that are driving seemingly everywhere. What serves as existing maintenance parking is accessible only by traversing across sidewalks and dirt paths, but supplementary parking is located on the street-side of all the buildings. In the event of heavy rain storms, which occur often during Tucson's monsoon season, the central and western portions of the site flood and runoff onto adjacent streets resulting in little to no on-site storm water management.

Through improved design there is the ability to positively impact major functional and circulatory elements that would serve to improve both the site aesthetic and performance, in terms of water harvesting infrastructure and human comfort.

Site Design Strategy

As proposed in the Storm Water Master Implementation Plan (SWMIP) this site would be able to detain 7.03-acre feet of storm water, which would enter the site from the

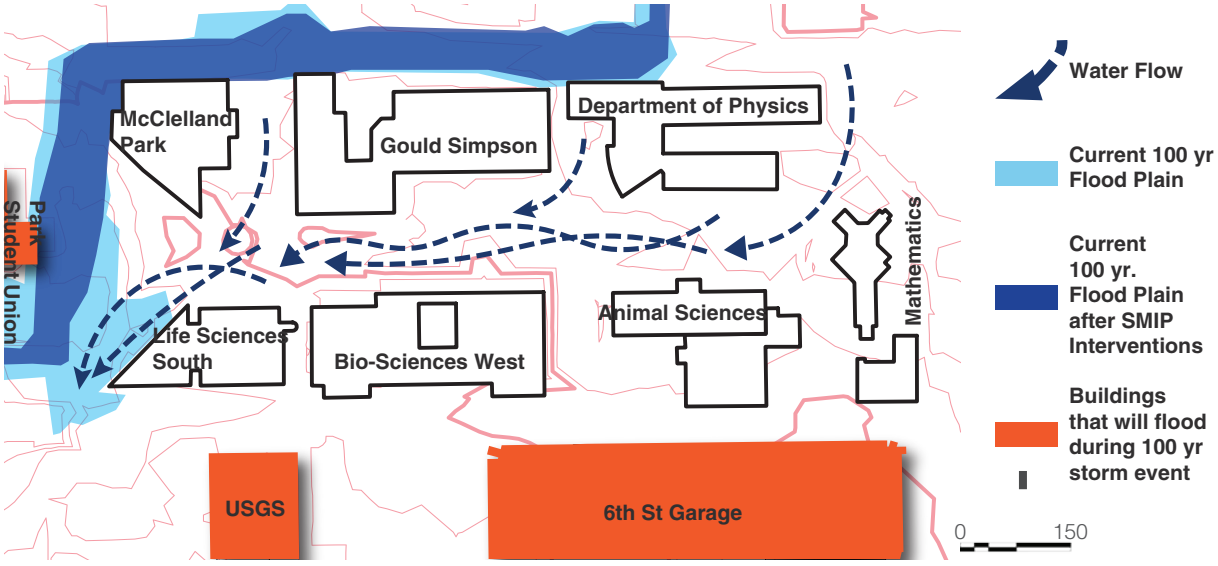

Figure 3 - Site water flow & issues

northeast corner from 4th street. The University of Arizona plan calls for a combination of active and passive mitigation strategies such as: subsurface cisterns, storage tanks, etc. as well as bio-swales, detention and retention basins (Surface Water Master Implementation Plan, 4-6, Figure 17). The proposed design, *A River Runs Through It*, is able to capture and detain a greater amount of a water with significantly less subsurface treatments while also treating the water harvesting and detention system as a functional amenity with educational components throughout. Additionally, numerous environmental improvements are folded into the functional and beautiful design.

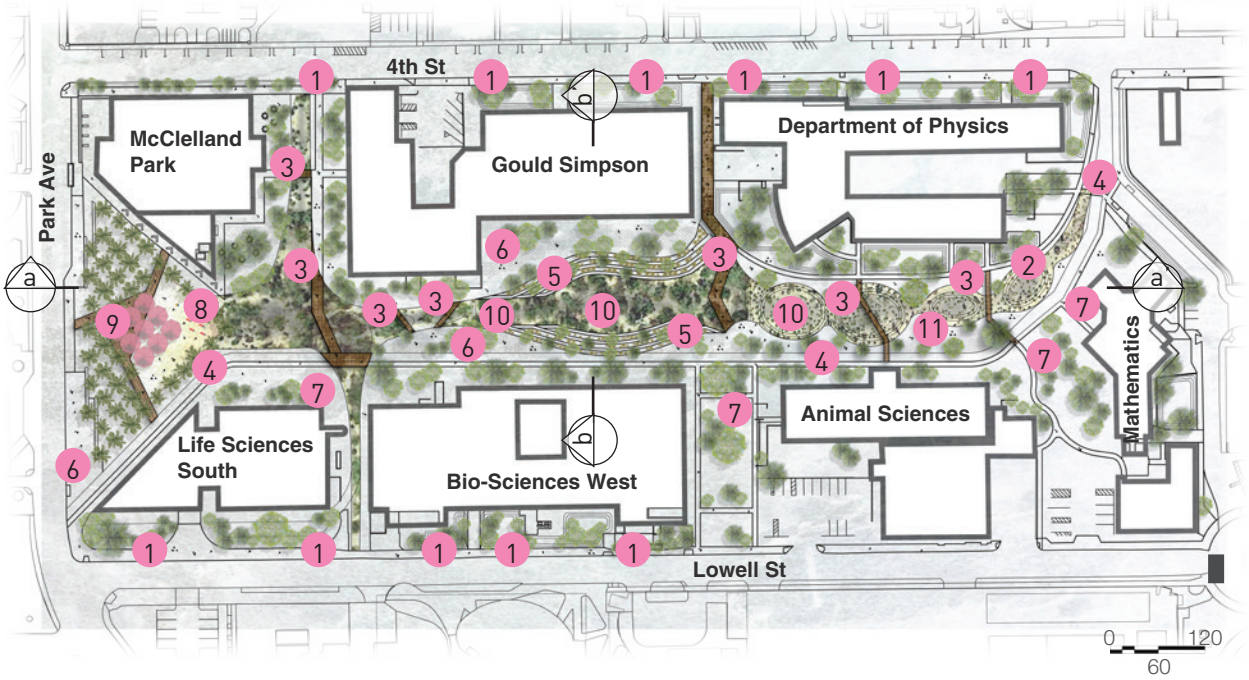

Figure 4 - *A River Runs Through It* design solution

Design Solution

The main goals of the project are to: retain 100% of storm water runoff from a 100-year 24-hour storm event, to meet or exceed the SWMIP target detention volume for storm water of 7.03 acre feet, and to mitigate downstream flooding issues for major campus buildings. *A River Runs Through It* seeks to take the functional aspects of water harvesting infrastructure and integrate them with educational and activity amenities throughout the site to better educate users as to the importance of water in

the southwest. It also seeks to improve the site ecology by utilizing native and near native plant palettes, increasing the vegetative cover, and utilizing building heating, ventilation, and air conditioning (HVAC) condensate for supplemental irrigation. The ecological aspects serve a dual purpose by creating outdoor learning environments and comfortable places to spend time. The implementation of educational signage to inform about water harvesting, as well as desert ecosystems and biotic communities, also helps to educate visitors to the Green Infrastructure systems around them.

In total, the design has the capacity to handle 8.47 acre feet of storage. This is primarily achieved through passive systems, detention and retention basins, and some active water harvesting systems, which are subsurface storage tanks. Within *A River Runs Through It,* the central conceptual and organizing feature is a dry arroyo. Through the arroyo, in combination with street-scape bio-swales, and three underground storage tanks, the design is able to exceed the University of Arizona Surface Water Master Implementation Plan target storage of 7.03 acre feet by 1.44 acre feet. The design integrates green infrastructure techniques, storm water management practices, ecological planting design, and amenities for campus users. In addition to

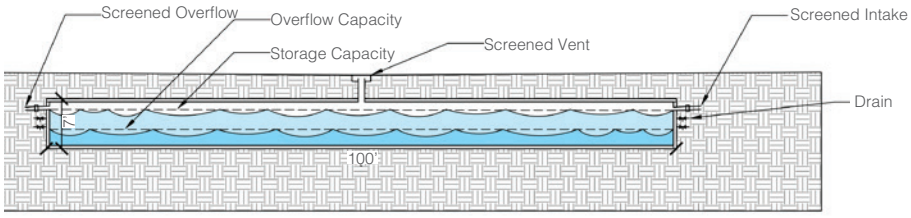

Figure 5 - Drawing illustrating the storage tank concept

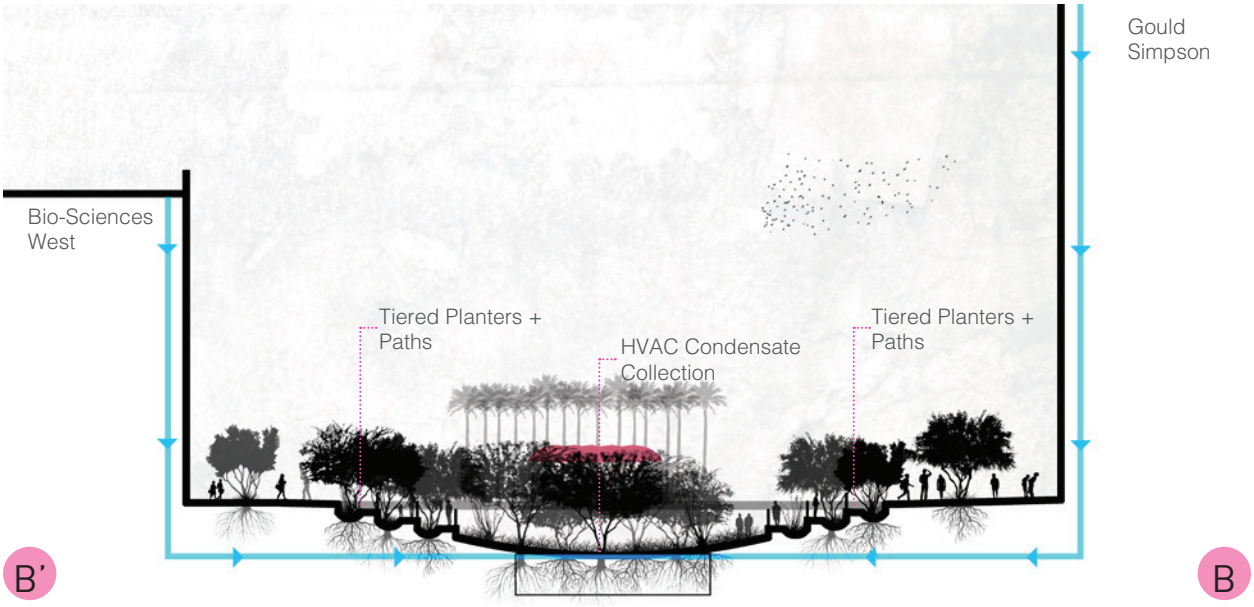

Figure 6 - Section showcasing the central basin as well as the concept of utilizing HVAC condensate for irrigation

the main arroyo feature, the site also has a campus beach, which offers opportunity for playful recreation. The beach uses the existing palm tree grid, enhances the area with a board-walk, and creates connections to the Park Student Union across the street with a sandy beach where students can sun bath, throw a frisbee, or enjoy their lunch. This design creates a beautiful, functional, educational, and playful space in an underutilized portion of campus.

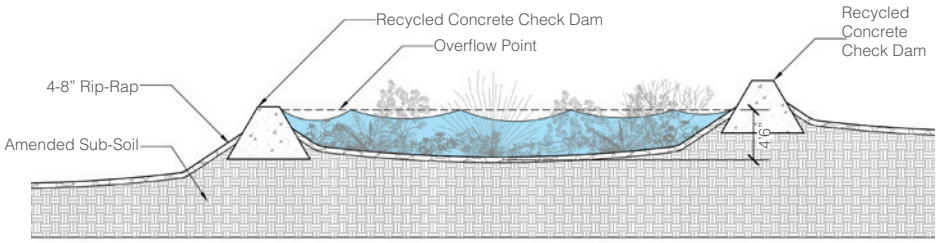

Figure 8 - Drawing illustrating check dam & vegetated basins concept

The design solution incorporates a variety of green infrastructure and low impact design strategies, some of which include: bio-retention/detention basins throughout the site, permeable paving surfaces, and reducing the amount of hardscape on-site. Additionally, the dry arroyo functions as the main storm water harvesting element, while also serving as habitat for pollinators and creating shade and a pleasant environment for human users. In addition to the arroyo, there are three subsurface tanks located at major points within the design, these tanks offer the ability to capture, store, and utilize the water for irrigation or other purposes. Educational elements and outdoor classrooms are integrated throughout to take advantage of opportunities presented throughout the site.

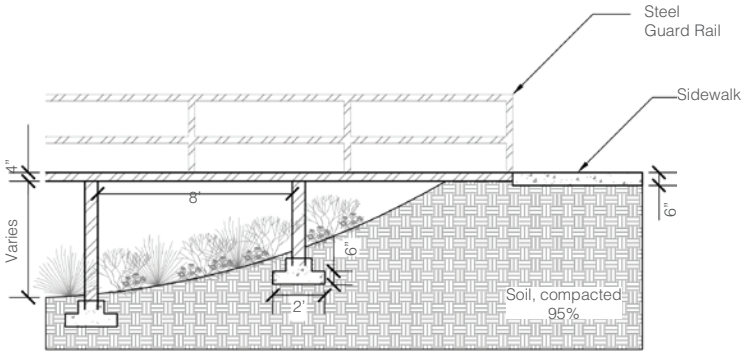

Figure 9 - Drawing illustrating the elevated walkway over the vegetated basins

Planting Plan

The planting plan is divided into three main groups which correspond to irrigation needs, hydro zones, and climate resiliency. The three native plant communities, Arizona Upland, Xeroriparian Woodland, and Lower Colorado River Valley, were chosen to transition vegetation between arid, low water plants, where there is little programmed use, to lush and riparian plant species where the most active spaces are located.

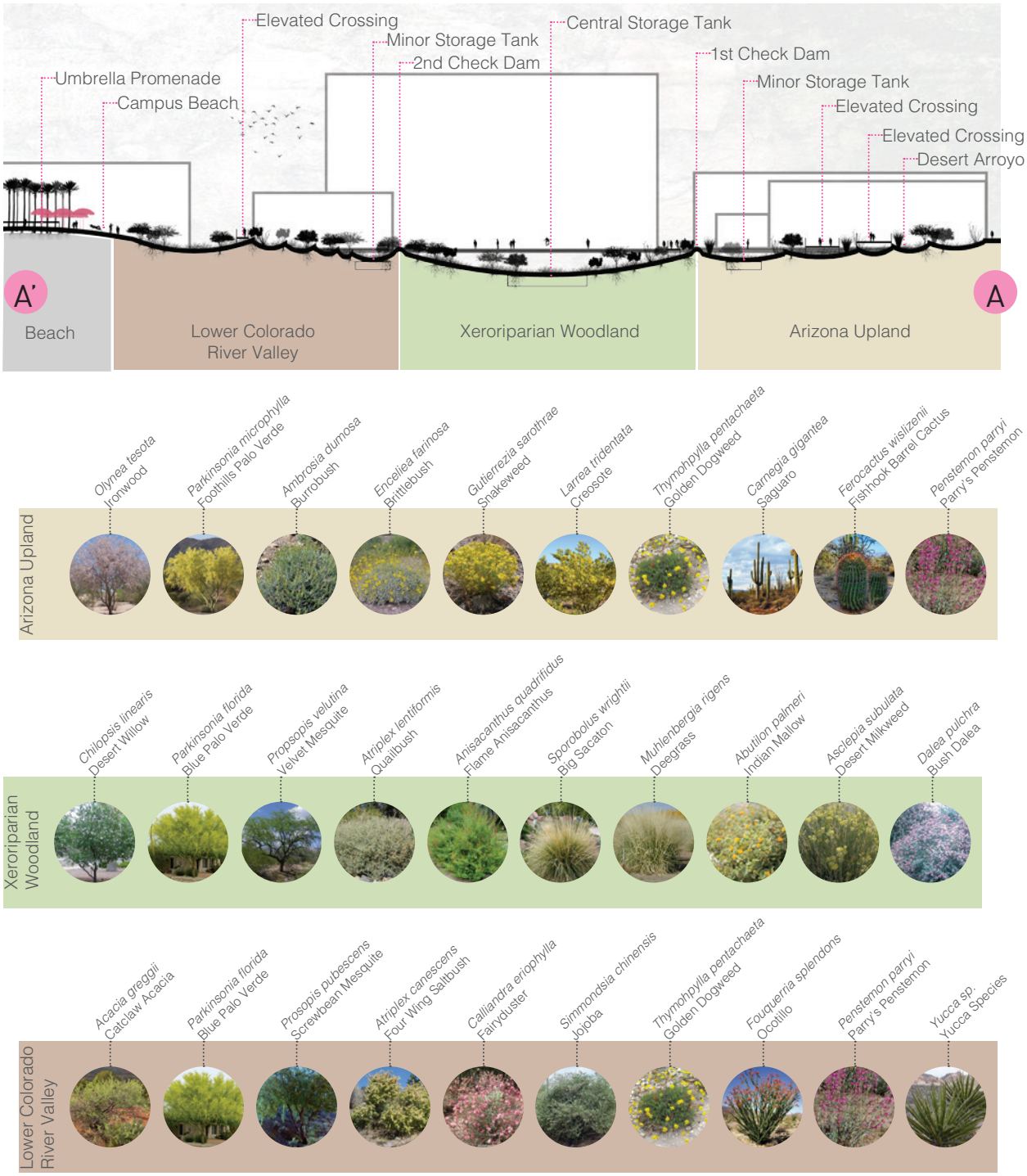

Figure 7 - Section illustrating the three biotic communities & hydro zones associated, additionally, the native & near native planting palette

Modeling & Analysis

The design utilizes two main strategies for storm water harvesting. The central storm water features are passive water harvesting retention and detention basins. The dry arroyo functions as a large passive system with many smaller subsystems making up

its functional pieces. 12 basins and check dams serve to slow water as it enters the site from the northeast. As water makes its way towards the central and largest basin, it moves through five small vegetated basins which slow storm water and offer the opportunity for infiltration and phytoremediation. From the west the site has been re-graded such that rather storm water drains back towards the central basin rather than draining toward Park Avenue and exacerbating downstream flooding issues.

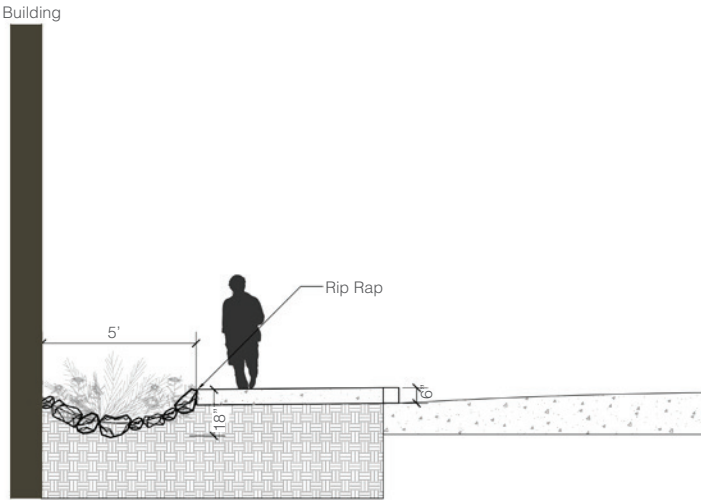

Figure 10 - Drawing illustrating the street-scape bio-retention basin concept along 4th St

The other strategy is active water harvesting in the form of three storage tanks placed at the three main overflow points in the design. The central storage tank is located below the main harvesting basin in the center of the site. Additional minor tanks are located below the basins to the east and west of the central basin. The active water harvesting within the design serves as a safety valve for the passive systems. In the case of a 500+ year storm, the active systems would be able to handle the overflow. The minor tanks serve to ensure that the system has a safe amount of redundancy built into it and ensures that the system can accommodate greater than a 500-year 24-hour storm event. The central tank serves the dual purposes of being a safety feature in the event of a system failure or a massive storm event that inundates the system, as well as storage for HVAC condensate. The seven buildings produce an average of 3,190,600 gallons of water each year that can be utilized to supplement landscape irrigation. The active systems coupled with the passive ones allow the design to capture a greater volume of water than the SWMIP calls for by 1.44-acre feet as well as being able to handle greater than a 500-year

Figure 11 - Example of interpretive educational signage that would be emulated in the ecological laboratory

Figure 12 - Example of educational opportunities in the educational laboratory

24-hour storm event, which would produce 5.83 acre feet of storm water.

In addition to the storm water that moves through the site, another source of downstream flooding is water moving west down 4th Street, directly to the north of the site. This flow is an average of 225 cubic feet per second (Surface Water Master Implementation Plan, 4-6, Figure 17). To mitigate this flow street basins were designed along 4th Street to capture that water and to re-mediate flooding issues that it causes.

Education & Engagement

Storm water retention and flood mitigation is a priority for the University of Arizona and thus has high probability of implementation. A River Runs Through It project intends to recreate the space as a functional ecological laboratory to enhance campus sustainability while promoting education and research within the natural environment. Phytoremediation, the water cleaning and filtering function of the plants, creates an integrated system of storm water usage and sanitation. The native plants in and around the basins have unique structures and create shade for campus users as well as serve an important ecological function. Users can enjoy respite from the intense heat in summer and take a rest in this backyard style space after a busy day of classes or work. This project is located between science buildings, where students are learning about biology, ecology, chemistry and other sciences. The central Sonoran Desert Rain Garden will provide educational opportunities for these students. There are a number of informal outdoor classroom spaces, and opportunities for professors and students to run experiments within the site. The campus beach is located on the west side of the site and provides amenities such as sand and tropical palm trees. Users can read interpretive education signage, located throughout the site,

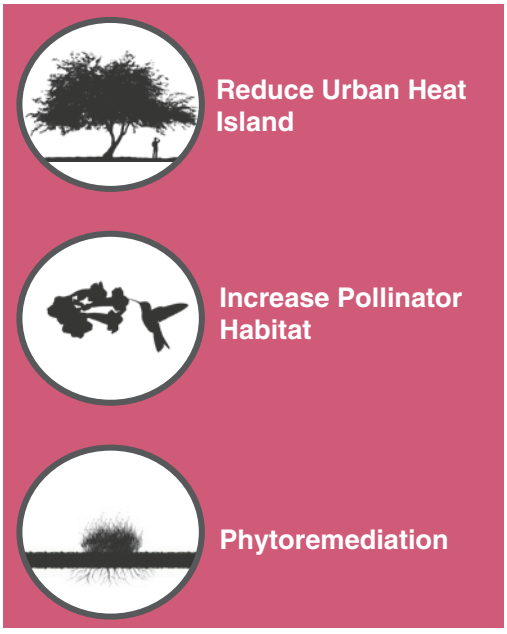

Figure 13 - Graphic illustrating benefits of increased vegetation

about green infrastructure strategies, climate resiliency, plant communities, and treating storm water as a resource. *A River Runs Through It* provides opportunities to increase awareness about the importance of green infrastructure and sustainable landscape practices, while also created inviting spaces that users will enjoy.

Climate Resiliency

The proposed site design serves as a demonstration project which educates the campus on the benefits and strategies of green infrastructure, including water harvesting techniques, climate change mitigation, and the natural biologic communities of the desert southwest. Tucson is a city of perennial heat and long drought. The temperature reaches extreme highs and is very dry for extended periods of time. However, during the summer monsoon season and winter rain, Tucson experiences significant flooding. These shifts place extreme stress on existing water supplies, such that effective management is integral to mitigating the harsh pressures placed on systems within the changing climate. *A River Runs Through It* integrates water management through storage, infiltration, and reuse. Native vegetation improves infiltration and promotes phytoremediation, which helps to restore the natural pre-construction hydro-logic regime on campus. The five basins on the east as well as the

Figure 16 - Global perspective of *A River Runs Through It* looking to the west side of the site

six basins on the west, help to mitigate the pressures of flooding during a heavy rain event and they also create more permeable surface to plant native vegetation. The native plants can help to reduce the high temperature in summer, creating a comfortable place to campus users to take a rest and enjoy a natural setting instead of holing up in an air-conditioned room. The garden and beach in the center and west provide large spaces for gathering. The conversion of turf grass lawn on the beach to sand decreases irrigation water demand and increases resiliency to drought, while reducing maintenance.

Maintenance & Operation

Figure 15 - Construction & Maintenance Plan

The project will be implemented in one phase to reduce the impact on campus users and academic functions. This was determined in consultation with the campus

landscape architect, who also provided estimates for the length of construction as approximately one and a half years.

Budget & Funding Sources

The University of Arizona has studied the Science Commons and ear marked 2.5 million dollars to mitigate identified on site issues. Using the Water Environment and Reuse Foundation Low Impact Development Whole Life Cost Tools is estimated that *A River Runs Through It* could be implemented at a cost of approximately 2,474,200 dollars, which is below the Universities ear marked budget (Advanced Solutions International). The underground storage tanks will be the most costly item within the design, estimated to cost $1,346,825. Permeable paving, which covers approximately 69,500 square feet is estimated to cost $917,400. The excavation and grading of the Dry Arroyo is estimated to cost $209,975.

Funding for this project will consist of a mixture of funding sources, including the University of Arizona infrastructure funds, as well as contributions from the City of Tucson and Pima County as these mitigation solutions will reduce downstream flooding issues on public roads. Grant funding may also be available through Environmental Protection Agency and Federal Emergency Management Agency programs.

Conclusion

A River Runs Through It will change the status quo of green infrastructure on the University of Arizona Campus. Through the mitigation of storm-water issues this design will positively impact students, faculty, campus users, and the greater Tucson community. As a model for sustainable climate resilient design, this project can serve as a precedent that can be repeated across campus and the southwest.

Figure 16 - Aerial view of existing site conditions

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Calculations

Existing Conditions		Area (sq/ ft)	% of Total	Post Design Conditions		Area (sq/ ft)	% of Total
Buildings				Buildings			
	McClelland Park	29,138			McClelland Park	29,138	
	Gould-Simpson	44,984			Gould-Simpson	44,984	
	Physics	39,054			Physics	39,054	
	Mathematics & Teaching Laboratory	11,228			Mathematics & Teaching Laboratory	11,228	
	Life Sciences South	16,804			Life Sciences South	16,804	
	Bio Sciences West	48,024			Bio Sciences West	48,024	
	Animal 7 Comparative Biomedical Sciences	22,160			Animal 7 Comparative Biomedical Sciences	22,160	
	Total Building Area	226,368	38.9%		Total Building Area	211,392	38.9%
Gravel		141,745	24.4%	Gravel		29,489	5.1%
Parking		58,096	10.0%	Parking		12,895	2.2%
Lawn		66,241	11.4%	Lawn		Removed	0%
Vegetative Cover		25,986	4.5%	Permeable Sidewalks		87,464	15.1%
Other Impervious		62,288	10.7%	Bioretention Areas		88,845	15.3%
				Dry Arroyo		135,673	23.36%
Total Area		580,724		Total Area		580,724	

<u>Total Site Runoff 100 year 24 hour storm event</u>

Rainfall from storm event = 3.8 inches

Site Area = 580,724 square feet

Volume = Area x Depth

Volume = 83,624,256 (area in square inches) x 3.8

Volume = 317,772,172 cubic inches OR 4.22 acre feet of runoff

<u>Volume of Dry Arroyo</u>

Area = 135,673 sq ft

Average Depth = 7’

Volume = Area x Depth

Volume = 949,711 / 3

949,711 / 3 [to account for side slopes]

Total Storage 316,570 cubic feet OR 7.01 acre feet

<u>% of Irrigation from HVAC condensate</u> (University of California, 2017)

3,190,600 gallons of HVAC available

Total gallons of irrigation required = ET x PF x LA x 0.623

ET = real-time evapotranspiration: 111.07 (Arizona Department of Water Resources)

PF = Plant Factor: 0.7 trees, shrubs, groundcovers, bedding plants

LA = surface area covered by plant canopy (assumes 805 coverage)

255,519 sq ft

0.623 = inches to gallons conversion factor

Total gallons = 111.07 x 0.7 x 255,519 x 0.623

Total gallons = 10,608,629

3,190,600 / 10,608,629 = 0.3007 OR 30.07% from HVAC condensate