Evaluating Urban Ecological Infrastructure for Stormwater Management in Phoenix, AZ

Central Arizona-Phoenix Long-Term Ecological Research CAP LTER

Kayla Tarr, Mikhail Chester, Daniel L. Childers, Abigail York

Central Arizona-Phoenix LTER, Arizona State University

LTER NETWORK

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Introduction & Background Information

Urban ecological infrastructure (UEI) is an inclusive term that encapsulates all infrastructure within an urban setting that exhibits ecological structure or function. Because UEI is inherently more resilient and adaptable than traditional gray infrastructure, it is of interest to urban ecologists, city planners, landscape architects, engineers, and other stakeholders involved in designing, implementing, and maintaining urban infrastructure. Enhancing urban resilience is especially important in the face of climate change.

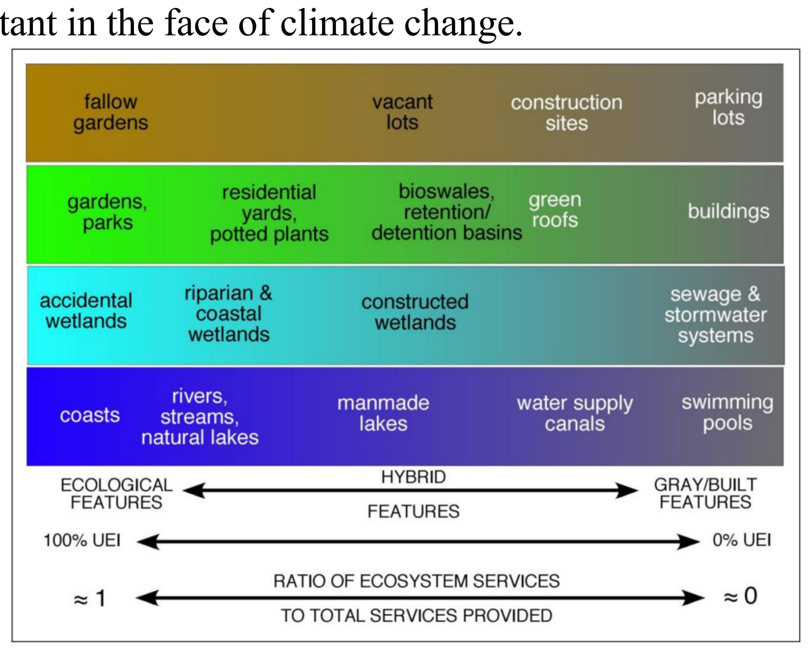

Fig. 1. UEI schematic demonstrating the various types of UEI and how they incorporate ecological and built features. Brown infrastructure represents land features that are not vegetation-based; green infrastructure represents land features that are vegetation-based; turquoise infrastructure represents hybrid land-water features; and blue infrastructure represents water features. The subject of this poster is a series of bioswales on ASU's Tempe campus, which are considered hybrid features (Childers et. al., 2019).

In 2017, ASU redesigned a portion of its Tempe campus, Orange Mall, to include bioretention basins for stormwater management. This UEI provides us the opportunity to understand its ecohydrological impacts on the surrounding areas and the challenges of implementing and maintaining such infrastructure. Additionally, the location of the bioswales in an arid climate presents unique challenges and opportunities. Meeting these challenges requires a transdisciplinary approach, as the infrastructure system classifies as a social-ecological-technological system (SETS). Using a SETS framework can connect multiple research questions to provide a deeper understanding of how various infrastructure designs function and why certain designs are chosen over others. The main question this poster explores is: *What are the ecohydrological characteristics of stormwater UEI that influences its treatment of stormwater?*

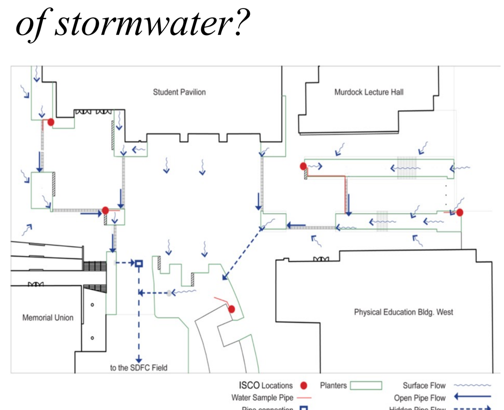

Fig. 2. Aerial map of study site with location of monitoring instruments (Sanchez, 2019)

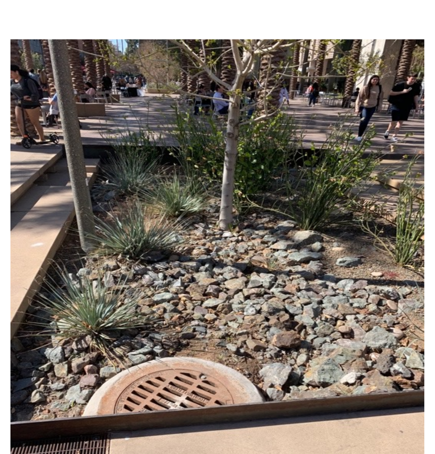

Fig. 3. Example of Orange Mall bioswale

Methods & Results

This project utilizes the following monitoring instruments:

- ISCO 6712 automated pump samplers
- Onset HOBO U20L water loggers
- Onset HOBO 10HS soil moisture probes

There are five ISCO samplers throughout the study site that are set to automatically collect stormwater samples when at least 3 cm of water is detected in the basins (see Fig. 2). These samples are collected within 24 hours and are analyzed for the following constituents:

- Total nitrogen and phosphorus (TN & TP)
- Ammonium (NH_4^+)
- Cations
- Anions
- Dissolved organic carbon (DOC)

Precipitation data are obtained from public access sources. Data collected from the water loggers, and data collected from the soil moisture probes are used to determine how much water is retained by the basins and how much is leaving the site. Monitoring of the site began in September 2018 and is ongoing. Data have been collected for 30 storm events so far. Summary statistics for each instrument can be found in Tables 1 and 2. Preliminary results for TN & TP for a storm event on July 14, 2021, collected from Instrument B (outflow for West Basin), are shown in Fig. 4.

Instrument	Number of Events	Mean	Median
A	21	-6.4602277	-13.533835
B	28	-44.717933	-52.356032
C	12	-6.8168197	-6.063921
D	3	-3.7823528	-9.3959732
E	25	-15.572496	-42.888283

Table 1. Number of events for which data on total nitrogen was collected for each instrument, along with mean and median total percent change in total nitrogen concentration from the first sample collected to the last sample collected.

Instrument	Number of Events	Mean	Median
A	21	-23.480249	-20.41383
B	27	-30.865531	-52.040816
C	12	14.1304348	14.1304348
D	3	-76.917056	-83.452211
E	24	-23.093099	-50.307107

Table 2. Number of events for which data on total phosphorus was collected for each instrument, along with mean and median total percent change in total phosphorus concentration from the first sample collected to the last sample collected.

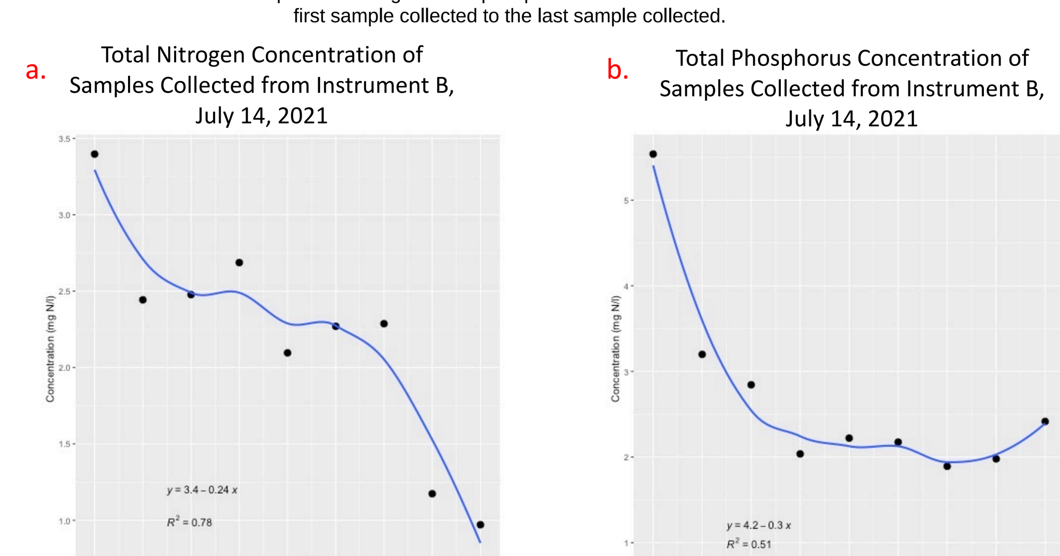

Fig. 4. Graphs demonstrating how TN & TP in stormwater samples changed over the course of a storm event on July 14, 2021, for Instrument B. Instrument B collects water samples at the outflow of the West Basin (see Fig. 2). Although nutrient concentrations fluctuate throughout the storm, there is an overall decrease in both total nitrogen and total phosphorus concentrations as the storm progresses.

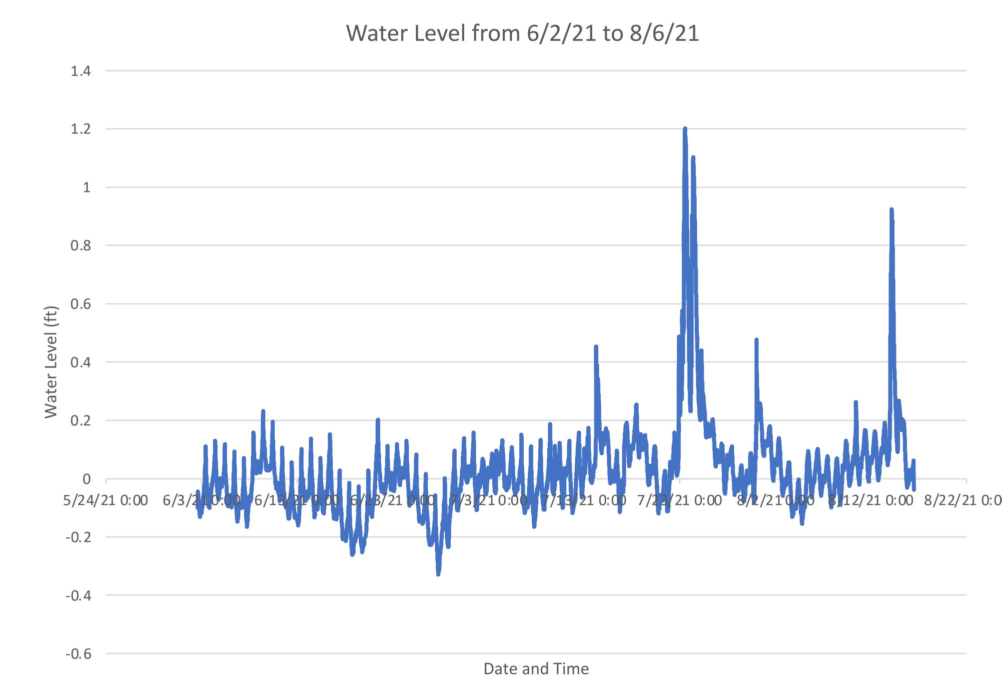

Fig. 6. Water level detected in a basin from June 6, 2021, to August 6, 2021. The spikes in the data correspond to large storm events that occurred July 14, July 23-24, July 31, and August 14. These values will be used to calculate the water volume leaving the site during storm events via V-notched weirs.

In addition to collecting data, we have also noted some important observations about the design of the bioswales and how they contribute to various ecosystem services. While we have not yet collected data on these observations, they nonetheless serve as important starting points for further development of the lead author's Ph.D. research as well as potential avenues for other researchers. The most notable observation we have made is the capacity of various basins, especially in the event of particularly heavy and/or persistent precipitation. One specific basin – located adjacent to the Student Pavilion on the west side – has overflowed on multiple occasions (see **Fig. 5** below). Further, although the bioswales break up the impervious surfaces on Orange Mall, the area is still paved. Puddles of water can be noted in the area after a storm event. The area and the bioswales do not have to be designed to withstand any amount of precipitation, but these observations do raise questions about if the design is effective.

Fig. 6. a) Overflowing basin after heavy precipitation events from July 24-26, 2021. b) Example of water accumulating on impervious surfaces in Orange Mall.

Future Work

Data collection and analysis for the Orange Mall bioswales are ongoing to understand their eco-hydrological impacts. As the analysis advances, we will be able to identify trends and draw conclusions about the effectiveness of the bioswales. These data will be compared to similar data collected from the Indian Bend Wash Greenbelt, another stormwater UEI site in the Phoenix area for which ecohydrological data has been collected since 2008. Eventually, we plan to use these conclusions to provide recommendations for stormwater UEI design in arid regions. In addition to the question of eco-hydrological impacts, the lead author's research also addresses two other questions:

- What are other examples of using UEI for stormwater management in the Phoenix metropolitan area, and what have been the drivers behind their development?
- How do traditional engineering education/continuing education and training/ retaining impact the planning, design, and construction of UEI? How can UEI be implemented into these curricula?

Answering these questions alongside the question addressed in this poster will provide a more holistic view of various stormwater infrastructure designs, their ecological impacts, and the social institutions that oversee them – allowing for a comprehensive SETS perspective.

References

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Acknowledgments

We thank Julia Hernandez, Dax Mackay, Luke Ramsey, and Chris Sanchez for their help with instrument maintenance, data collection, and laboratory assistance. Special thanks to the Goldwater Environmental Laboratory for performing data analysis.

For further information

Please contact *ktarr1@asu.edu*. More information on this and related projects can be obtained at *http://weel.asu.edu/* and https://sustainability-innovation.asu.edu/caplter/.