

# REMEDIATION

A Green Infrastructure Plan for the University of Cincinnati's East Campus



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## PROJECT ABSTRACT

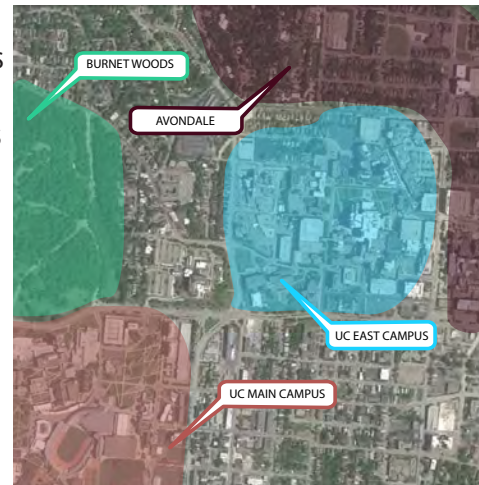
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A team composed of five University of Cincinnati students, with varying academic backgrounds, designed a green infrastructure plan to mitigate stormwater management for the University of Cincinnati's East Campus, called ReMEDiation. ReMEDiation alleviates the frequent flooding and decreases overflows from the combined sewer system which makes its way into the Ohio River. With the endorsement of the University of Cincinnati's Planning+Design+Construction department, ReMEDiation addresses stormwater management needs, fosters community connections, promotes education, provides opportunities for health and healing, and supports long-term sustainability. Through the analysis phase, the team recognized several key issues. One was an abundance of impervious pavement. Secondly, the team identified spaces that could have more functionality built in, through green infrastructure, with minor changes. The team concluded the added value of these stormwater management tactics could add immensely to the character and functionality of East Campus overall. This in-depth analysis used Geographic Information System, the EPA's stormwater calculator, historic context analysis, and a site visit. The proposed plan focuses on a multi-functional green space, called East Commons, and a Healing Garden as two green infrastructure hubs at either end of the campus. A green connection, featuring bioswales and a green facade, link the two areas. ReMEDiation reduces 3,535,761,715 inches of stormwater runoff per year, in addition to numerous social, cultural, health, and biodiversity benefits featured in this report. With ReMEDiation, the University of Cincinnati can strengthen its East Campus and the surrounding community.

## INTRODUCTION TO REMEDIATION

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The University of Cincinnati (UC) is a “Class 1” ranked research university located roughly 2.5 miles from Downtown Cincinnati. UC has two campuses located in the uptown area of Cincinnati: the Main Campus and the East Campus. The East Campus consists of university administrative buildings, as well as health-related academic buildings. Children’s Hospital, UC Health, and a VA hospital are co-located on the campus. 2,356 medical staff, 1,856 faculty, and 2,823 students, in addition to patients, use the urban campus daily. The UC East Campus is located diagonally northeast of the Main Campus. Being somewhat of an annex to the 137 acre Main Campus, the 57 acre East Campus has received less attention regarding planning efforts and does not have a comprehensive plan (UC P+D+C 2009). Surrounding the East Campus is Burnet Woods, a large urban park, and two Cincinnati neighborhoods, Corryville and Avondale.



*Fig. A Location Map*

While the East Campus is a university campus, it is also a campus for the greater-Cincinnati population due to its porous boundaries and diverse building uses (e.g. health, academic, administrative, hotel, etc.). As such, the opportunity to transform the East Campus is also an opportunity to positively affect the greater-community, which is a driving force of ReMEDiation, the green infrastructure plan for the East Campus.

## PLANNING PROCESS

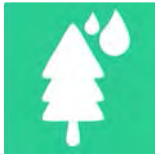
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ReMEDiation was created by a team of students enrolled in a green infrastructure course. The team consists of students with diverse academic and professional backgrounds. The team first analyzed the existing conditions on and surrounding the campus before formulating goals and a plan design. Special emphasis was put on the involvement of stakeholders and the implementation process, critical aspects of any sound plan. The team engaged the UC Planning+Design+Construction (UC P+D+C) office, the office responsible for facilities and planning on the university’s campuses. Additionally, the plan was critiqued by a panel consisting of a landscape architecture professor, urban design and planning professors, UC P+D+C staff, and environmental professionals, ultimately resulting in a plan that is supported by UC P+D+C.

## STATEMENT OF PURPOSE

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The vision of ReMEDiation is to remediate the current impervious nature of the University of Cincinnati (UC)’s East Campus to address stormwater and climate change concerns, while capitalizing upon the campus’ strengths in location between two communities and its provision of health services. Through implementing ReMEDiation’s green infrastructure projects, UC’s East Campus will become a beacon of health, both of the environment and of the employees and patients, providing ecosystems services that were previously not abundant. ReMEDiation is focused around five guiding themes:



### ENVIRONMENTAL HEALTH

- Reduce stormwater runoff by 25% and improve stormwater infiltration by decreasing impervious surfaces and installing rain gardens and bioswales
- Rehabilitate vegetated space and biodiversity by planting native, habitat strengthening vegetation



### HEALTH & HEALING

- Provide opportunities for outdoor fitness for students, employees, and patients through a system of urban nature trails
- Increase access to fresh fruits and vegetables for students and community organizations by planting edible plants
- Create spaces for reflection and healing by constructing healing gardens



### EDUCATION

- Support the educational legacy of the University of Cincinnati through integrated academic programming
- Promote green infrastructure through instructive signage and outreach to surrounding Cincinnati Public Schools
- Explore education outreach opportunities with Children’s Hospital



### COMMUNITY CONNECTIONS

- Restore site’s connection with the surrounding environment, including the expansive Burnet Woods to the west and the Avondale neighborhood to the east
- Include University of Cincinnati student body and Avondale community organizations in installation, maintenance, and programming of green infrastructure sites



### LONG-TERM SUSTAINABILITY

- Address anticipated climate change threats, such as increased rainfall and temperatures, through adaptive and safe-to-fail green infrastructure
- Ensure long-term commitment from UC Sustainability and UC Planning+Design+Construction

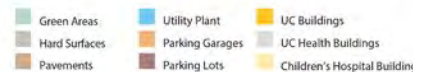
## EXISTING CONDITONS

### CAMPUS & HISTORICAL CONTEXT

Situated on 57 acres, the East Campus is comprised of 28 buildings. The campus includes UC Health, Children’s Hospital, Veterans Affairs Medical Center (VAMC), utility, and Kingsgate Conference Center/Hotel buildings, in addition to several parking lots and garages. The East Campus is situated to have a strong connection with the surrounding community. The plan aims to remediate the campus’ adverse effects to the surrounding community and natural environment. The goals focus to reconnect the campus to the community around it by providing education and health opportunities, and balancing environmental health in an age of rapid growth and expansion.

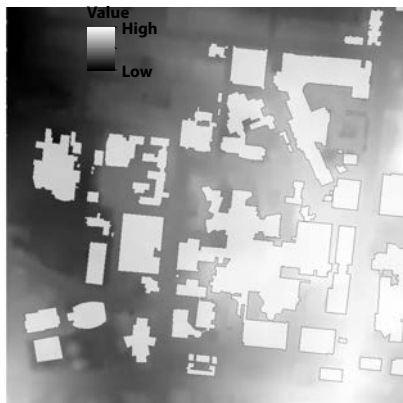


Fig. B Campus Context Map

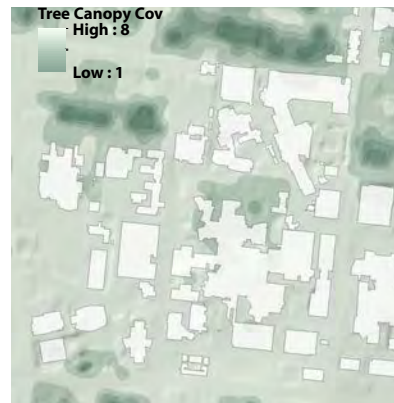


## PHYSICAL ANALYSIS

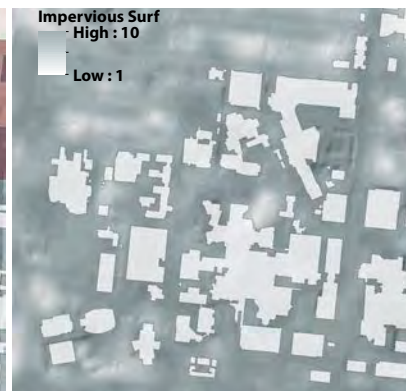
The East Campus is highly urbanized. There are extensive amounts of impervious surfaces with intermittent green space.



**SLOPE** | The East Campus has varied topography with an average slope of 5%. However, there are many steeper areas, both natural and man-made. Generally, the highest elevations are on the eastern edge of the campus and slope toward the west-northwest corner.



**TREE COVER** | The average tree canopy for the East Campus is only 6%.



**SOIL & IMPERVIOUS SURFACE** | There is one major soil complex present in the area, UrB (Urban land-Rossmoyne Complex). This soil is moderately well-drained and is somewhat suitable for vegetation (USDA 1982). It should be noted that UrB is not ideal for buildings with basements (USDA 1982). Though little of the soil is exposed as 70% of the surface area is impervious (Homer et al. 2015).

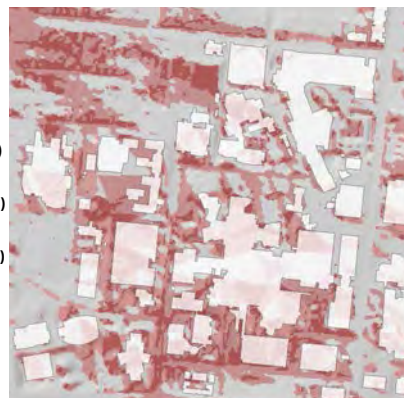


**OWNERSHIP** | The effects of intensive runoff and compaction can already be seen throughout the campus. It is pertinent that the East Campus increases infiltration and addresses climate resilience issues, as any kind of disturbance will negatively affect the entire area. Coordination between different property owners is particularly important. There are several key property owners. The University of Cincinnati and the City of Cincinnati together own 29% of the land, the state of Ohio and the federal government own 30%, and UC Health owns approximately 14%.

## ASPECT

25% of the land is covered by a building. The spacing and height of buildings leave little space for vegetation and non-paved surfaces, as well as blocking sunlight.

- | Aspect                  |
|-------------------------|
| Flat (-1)               |
| North (0-22.5)          |
| Northeast (22.5-67.5)   |
| East (67.5-112.5)       |
| Southeast (112.5-157.5) |
| South (157.5-202.5)     |
| Southwest (202.5-247.5) |
| West (247.5-292.5)      |
| Northwest (292.5-337.5) |
| North (337.5-360)       |



## EXISTING PLANS AND INITIATIVES

ReMEDiation aims to support and supplement existing UC plans and initiatives. The chart below presents the existing plans and how they connect to the goals of ReMEDiation.

EXISTING PLAN	KEY COMPONENTS	REMEDIATION'S SUPPORT
<b>Master Plan</b>	Efficiency projects in energy, transportation, solid waste and refrigerants and other chemicals; mitigation efforts in power distribution, building efficiencies, grounds (hardscapes, landscapes, stormwater), transportation and campus behavior and culture.	ReMEDiation supports efficiency in energy and transportation by creating a vegetative, user-friendly landscape that shades and cools buildings while encouraging pedestrian transportation. The use of green infrastructure reduces hardscapes and mitigates stormwater runoff.
<b>Water Management Plan</b>	Water conservation efforts and the implementation of green roofs aim to reduce stormwater runoff that contributes to Cincinnati's combined sewer overflow.	ReMEDiation features vegetation, rain gardens, bioswales, and reduction of hardscapes which slow runoff and allow it to percolate back into the site's soil instead of contributing to the sewer system.
<b>American College and University Presidents' Climate Commitment (ACUPCC)</b>	Presidents who sign this commitment, vow to work towards a decrease in campus greenhouse gas emissions over a period of time.	The ample vegetation included in ReMEDiation supports the reduction of greenhouse gas emissions by absorbing CO <sub>2</sub> , a major greenhouse gas. The encouragement of pedestrian traffic decreases the need for vehicular transportation, which emits greenhouse gases.
<b>Sustainability Tracking, Assessment &amp; Rating System through Association for the Advancement of Sustainability in Higher Education (AASHE)</b>	STARS is a resource provided to members of AASHE that helps track their current sustainability performance and continuing progress. UC has devised a stormwater master plan that includes the use of green roofs, porous pavement, collection of roof water, and swales.	ReMEDiation aligns with the efforts of UC and their stormwater master plan in that a variety of green infrastructure techniques will be implemented to filter, divert or slow down the release of stormwater runoff so that it no longer contributes to overflow events.

## SITE SELECTION

A s-shaped site was identified using a GIS-based site selection analysis. This model is based on Tetra Tech's GI BMP site selection methodology (Tetra Tech 2015). Data was collected from several sources including Natural Resource Conservation Service (NRCS), Cincinnati Area Geographic Information Service (CAGIS), and National Land Cover Data (NLCD). This data was formatted for a raster analysis.

It was determined that areas with higher tree canopy cover need less intervention than areas with no cover. The opposite is true

of areas with high impervious surfaces and slope. The higher the percentage the more intervention need. Interventions need to be concentrated on University of Cincinnati land or the City of Cincinnati, with whom the University already works closely. Lastly, to slow down or reduce runoff into sewers, proximity to manhole covers was included. Interventions within 100 ft of manhole covers are preferable because the intent is to reduce water entering the combined stormwater system. The table below shows all indicators and their rankings.

INDICATOR	NAME	RANKING
1	Tree Canopy Cover	1-10, where 1 represents 66% cover and 10 represents 0%
2	Impervious Surface	1-10, where 1 represents 2% cover and 10 represents 100%
3	Slope	1-10, where 1 represents % slope < 1 and 10 represents % slope > 30
4	Proximity to Manhole	+5 if within 100 ft of manhole cover
5	Property Ownership	+5 if within property owned by UC or City of Cincinnati

Fig. C Suitability Ranking

The composite analysis map on the board shows the final analysis output. The areas of darker maroon represent a higher final ranking or more suitable locations for green infrastructure interventions.

Team members visited the site to identify areas that either needed intervention or held potential for a better use. The site visit also helped to ground truth the analysis and identify other potential sites. The site areas was expanded in the northern portion to accommodate these observations. The key issues were erosion along sidewalks and paved areas and an abundance of paved surfaces.



Fig. D Site visit photographs and identification of problems

## DESIGN PLAN

The ReMEDiation plan is focused around the “S-shaped” green connector which runs along the primary campus travel route. The green connector links the East Commons with the Healing Garden through a system of pocket rain gardens, green facades, and bioswales. The overall site plan is featured on the board. Below is the concept plan with featured interventions.

Permeable pavement creates an “S” shaped **CONNECTION** from the community of Avondale to the urban forest of Burnet Woods, branching off into parking lots along the way. Rain gardens flourishing with native species add visual interest along sidewalks and allow stormwater to slowly infiltrate back into the soil. Green facades adorn the sides of parking structures to absorb heat and soften the built environment. Fitness trail markings along the footpath provide a sense of direction and encourage an active lifestyle.

The **HEALING GARDEN** illustrates the importance of mental, emotional and physical well-being, along with their connection to nature. The garden is inclusive, providing access and safety features for users of all ages and abilities. A shaded tree canopy and green boundary enclose the space to suggest feelings of comfort and safety. A bridge and walking trail offer space for outdoor rehabilitation exercises or a leisurely stroll. Educational signage is scattered throughout the garden to note the textures, fragrances, visual characteristics and medicinal uses of specific plant species.

**BIOSWALES** are substituted for paved medians, capturing runoff and naturally filtering pollutants from parking lots.

**BIOSWALES**

**GREEN CONNECTIONS**

**HEALING GARDEN**

**EAST COMMONS**

**EAST COMMONS** was designed as a dynamic, multi-use space for students and faculty. Plenty of comfortable seating areas allow for intimate gatherings under a shaded canopy or picnics out on the lawn. A grouping of edible trees and shrubs provide a nutritious food forest for visitors, while rain gardens frame the space and increase the health of the environment. A large open-air theater offers space for outdoor lectures and entertainment. Fitness trails spill into the commons from Eden Avenue, encouraging outdoor activity and enjoyment.



## EXPECTED BENEFITS & OUTCOMES

### EXPECTED OUTCOMES

EXPECTED OUTCOME	AMOUNT
Reduction in impervious area (acres) <sup>1</sup>	1.22
Reduction in runoff depth from existing and/or natural condition (in/year) <sup>2</sup>	3,535,761,715
Change in Maximum Rainfall Retained (in) <sup>2</sup>	0.39
Annual groundwater recharge (gallons/year) <sup>2</sup>	15,306,328
Area of protected soils (acres) <sup>1</sup>	8.92
Area of restored soils (acres) <sup>1</sup>	1.02
Area of restored native plant communities (acres) <sup>1</sup>	8.50
New trees planted	120
Increase in canopy cover (10 years after installation) (% of site area) <sup>1</sup>	12%
Increase in hardscape area (roads, sidewalks, parking lots, courtyards) shaded by vegetation (% of hardscape area) <sup>1</sup>	2.89
Air pollutant removal by trees, also known as dry deposition (lbs/yr) <sup>3</sup>	169
Carbon dioxide (CO2) sequestered by new trees (lbs/year) <sup>4</sup>	324
Reduced air pollutants by new trees (\$/year) <sup>5</sup>	\$21.72
Carbon dioxide (CO2) sequestered by new trees (\$/year) <sup>5</sup>	\$14.40
Groundwater Recharge (from removed impervious surface only, \$/year) <sup>5</sup>	\$380.96
1. Calculated from Team's GIS Work 2. EPA Stormwater Calculator 3. Nowak, 2002 4. US DOE, 1998 5. Green Values, 2013	

### STORMWATER BENEFITS

The proposed interventions are expected to reduce runoff from current levels by approximately 9%. This is based on a 20 year projection using a median climate change model. Additionally, infiltration is projected to increase 11%. New design reduces stormwater runoff

	NO INTERVENTION	REMEDICATION PLAN	DIFFERENCE
<b>RUN OFF</b>	60%	51%	-9%
<b>INFILTRATION</b>	29%	40%	+11%
<b>EVAPORATION</b>	11%	9%	-2%

depth from existing site, 4"/yr. The site receives approximately 43" of precipitation per year, so the runoff depth is reduced about 10%. In the future, under warmer and wetter climate projections, rainfall would increase 3"/year. Evaporation is reduced due to increased absorption of rainwater into the ground. The interventions suggested in this plan are a first phase. To achieve the goal of 20% reduction in stormwater runoff more interventions are needed. Cisterns or other rain harvesting techniques could be used on the site. While the plan suggests white roofs to reduce energy use, more green roofs could be installed throughout the site as well in later stages. Additionally, water from roof tops and that condenses from air conditioning equipment could be used to water the proposed landscape improvements.

## CLIMATE CHANGE & RESILIENCY BENEFITS

Climate change threats, including increased rainfall (both in severity and frequency) and increased temperatures, will have an effect on Cincinnati (Union of Concerned Scientists 2009). ReMEDiation aims to

	WHITE ROOFS	BIO-SWALES	GREEN CONNECTIONS	RAIN GARDENS	GREEN FACADES	PERMEABLE PAVEMENT
INCREASED SUMMER HEAT WAVES	X	X	X	X	X	
WETTER FALL & WINTER SEASONS		X	X	X	X	X

Fig. F Climate change effects and proposed interventions

address these climate change threats and build campus and community resiliency. The chart above shows which aspects of the ReMEDiation plan will help the campus community build resiliency to the future climate change impacts (indicated by an "X").

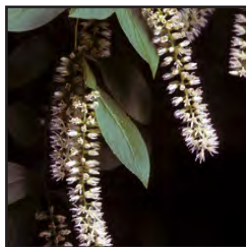
## SOCIAL & CULTURAL BENEFITS

Medical campuses can be emotionally and physically stressful environments. ReMEDiation provides students, doctors, and visitors with a calming social space to balance this burden. Recently, top performing hospitals have discovered the value in green infrastructure's healing properties. The team saw this as an opportunity to incorporate practical stormwater management techniques into an institution founded on bettering overall health. By strategically choosing stormwater management-appropriate plants with healing properties, the plan creates spaces for patients and community members in which to relax. The team chose plants based on their ability to thrive and their calming aesthetic and fragrance. ReMEDiation will further its social value by integrating Avondale's schools and the University of Cincinnati's environmental programs.

### Rain Garden Plants



Agastache foeniculum | Anise Hyssop



Itea virginica | Virginia Sweetspire



Baptisia australis | Blue False Indigo



Rhus aromatica | Fragrant Sumac



Taxodium distichum var. distichum | Bald Cypress

### Trees & Shrubs



Acercis canadensis | Redbud



Ribes odoratum | Clove currant



Amelanchier arborea | Serviceberry



Aesculus glabra | Ohio Buckeye



Corylus americana | American Hazelnut

Fig. G Plants focused on increasing biodiversity and contributing to social and cultural benefits; Sources: Lady Bird Johnson Wildflower Center, Missouri Botanical Garden; Penn State Extension. For Healing Garden plants, please see the board.

## BIODIVERSITY BENEFITS

A carefully selected list of plants was chosen based on plant hardiness, nativeness, and a long list of benefits for the environment and humans. Lush tree canopy provides shelter and shade, cooling off the heat previously radiated from paved

surfaces. A wide variety of wildlife and pollinators is welcomed by flowering perennials and fruiting shrubs. Soils are held in place by deep roots and enriched by nitrogen fixing plants. Green Connections create a successful network of green space and minimizing barriers to dispersal.

## IMPLEMENTATION

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### PHASING

There will be 4 major phases to ReMEDIation over the course of 5 years:

#### Phase I (Year 1): Planning & Partnerships

To ensure the proper implementation and success of the project, the first year of the plan will include creating integral relationships and partnerships with community and institutional stakeholders (see “Community Engagement” for a list of stakeholders). Through meetings with stakeholders, the existing plan will be evaluated and their feedback will be incorporated into the plan.

#### Phase II (Year 2 to 4): Construction

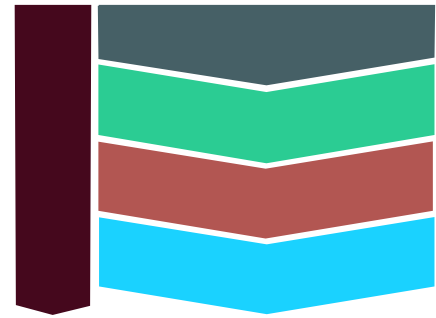
This plan recommends that the Healing Garden and East Commons are constructed before the green connection. These two green infrastructure hubs will anchor the southwest and northeast of campus. Construction and installation of the new green infrastructure park spaces should be done in tandem with any previously scheduled maintenance or upgrading.

#### Phase III (Year 3 to 4): Connection

Towards the end of the East Commons and Healing Garden installation, the green connection should be installed. This involved streetscape upgrades to include bioswales and a green facade on the Eden Avenue garage. This connection will help bridge the two ends of campus and connect it more seamlessly with the UC and Avondale community.

#### Phase IV (Year 4 to 5): Education & Health Promotion

After the installation of the green infrastructure interventions, the last year should focus on the promotion of these spaces and associated educational programming. The active use and awareness of these spaces addresses the guiding themes of education, community connections, and health and healing.



*Fig. G Phasing of project*

**Throughout:** It is imperative that there is continual monitoring and evaluation throughout the planning process.

Understanding the challenges and successes of different phases of the project will aid in informing next steps and create a more effective project in the long-term.

### MAINTENANCE

Maintenance is critical to the success of ReMEDIation’s objectives. Without proper watering of the bioswales and green facade during droughts, the plants will be unable to absorb water when it does rain, causing them to die. Bioswales and green facades also require regular pruning. To avoid unnecessary accidents, tree limbs should have a fifteen foot clearance over the street and eight foot clearance over the sidewalk. To maintain its social value, the healing garden should be well maintained and not ever be allowed to become overgrown. Campus landscaping staff will be responsible for this maintenance of the healing garden, which should preserve the original design. A team of six trained student worker positions will maintain the bioswales along the green way. These employees will be trained to check soil quality once a month, check the bioswales’ status after large storms, prepare them for winter months, planting in the spring, watering during dry, hot months, and measuring the impact of the bioswales on the stormwater management of the East Campus. These employees will also be trained to prune and water the green facade on an as-needed basis. The team of students will present their findings at the end of each semester to relevant environmental engineering, horticulture, and landscape architecture classes.

## COMMUNITY ENGAGEMENT

ReMEDiation is grounded in community participation and engagement. The plan will engage the community through partnerships with institutions and community groups, as well as through a widespread community outreach campaign. After ReMEDiation is implemented, the team will survey a random sample of employees, students, community members, and long-term patients in the hospital concerning their perception of ReMEDiation's green infrastructure projects and their interaction with the projects.

### Institutional Partnerships

- *Cincinnati Zoo*: The Cincinnati Zoo, the greenest zoo in the nation, can partner with the University of Cincinnati facilities employees to provide best practices and training on how to care for green infrastructure.
- *Cincinnati Public Schools*: Engage students in learning about biodiversity and environmental health through educational programming and activities at the East Commons and Healing Garden.
- *Cincinnati Children's Hospital*: Encourage Cincinnati Children's Hospital to use the Healing Garden and explore ideas for future expansion of therapeutic garden space that also addresses stormwater management needs on the hospital's campus.
- *University of Cincinnati*: Encourage UC Sustainability to host student programming, such as outdoor movie nights, guest speakers, and more, at the East Commons. Partner with UC professors in biology, planning, horticulture, engineering, and more to integrate the ReMEDiation plan into their courses. The UC East Campus can be used as an outdoor laboratory and lecture hall.

### Community Partnerships

- *Avondale Comprehensive Development Corporation*: Health and Wellness is one of Avondale Comprehensive Development Corporation's five priority areas. In partnering with the Avondale CDC on education events and programming, the benefits of the ReMEDiation plan will improve community members' quality of life (Avondale Comprehensive Development Corporation 2016).
- *Avondale Community Council*: The Avondale Community Council supports activities to promote the Avondale Vision Plan of 2005 which includes creating a healthy and safe community. Involving the community council in the planning and programming of the ReMEDiation plan will create a collaborative atmosphere, promoting community connections (Avondale Community Council 2005).

### Public Outreach

- *Community events*: In order to attract people to use the East Commons and the Healing Garden, a series of events will be planned for the student, employee, and community body, such as outdoor movie nights, pop-up markets, concerts, etc.
- *Social media campaign*: Use social media to advertise and educate the public about the newly created green infrastructure on the East Campus.

## CONCLUSION

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ReMEDiation decreases 3,535,761,715 inches per year of stormwater runoff on the University of Cincinnati's East Campus through, primarily Ohio-native, green infrastructure; adding immense social, ecological, and economic benefits to the campus. This plan is true to its name, aiming to not only remediate the environmental effects of the campus, but also strengthening its connections to surrounding communities and the health of all campus users. The team would like to thank the RainWorks Challenge staff for their time and consideration, as it has been a great learning experience and pleasure to critically consider the current stormwater management strategies and design for a greener future. The team would like to acknowledge Dr. Leah Hollstein and the University of Cincinnati Planning+Design+Construction department for providing feedback, data, and their time during this plan making process.

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