University of Illinois at Urbana-Champaign Campus Stormwater:

An Assessment and Evaluation of Strategies for High-Performance Landscape Design and Management

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Background

The University of Illinois at Urbana-Champaign (UIUC) signed the American College and University Presidents' Climate Commitment, which states that the university will become "carbon-neutral" as soon as possible, but not later than 2050. In order to accomplish this lofty goal, the university developed the Illinois Climate Action Plan (iCAP), in which it states goals and objectives for transforming the university into a carbon-neutral entity.

The iCAP is broken down into several categories, including: Energy Conservation/Building Standards, Energy Generation/Purchasing/ Distribution, Transportation, Water/Stormwater, Purchasing/Waste/Recycling, Agriculture/Land Use/Food/Sequestration, Carbon Offsets, Financing, Curricular Education, Outreach, and Sustainability Research. During the process of preparing the iCAP document, the university created Sustainability Working Advisory Teams (SWATteams) to focus on each category. The SWATeams are made up of representatives from faculty, staff, facilities management, and the student body. Each team aided in the preparation of their section of the iCAP document and the teams are now working towards identifying the best methods to implement the plan.

The water and stormwater SWATeam identified 6 objectives in the 2015 iCAP:

1. Obtain and Publicize Water Data
2. Reduce Cooling Tower Water Use
3. Water Audit to Establish Conservation Targets and Facilities Standards
4. Inventory and Benchmark Existing Landscape Performance
5. Implement Pilot Projects for Water Reuse and/or Non-Potable Water Substitution
6. Stormwater Runoff Pollutant Reduction

The percent capture/reduction of discharge goals listed in Table 1 were identified in the 2015 iCAP plan, beginning with a 25% reduction by the year 2020. However, the iCAP goal does not specifically state if this is a reduction of the total average runoff from the campus or a percentage of a certain average storm intensity. This goal should be clarified before committing to a final course of action as targeting the average rainfall versus a storm of a specific intensity could result in dramatically different capture requirements.

Table 1: Stormwater capture goals (Page 44 of 2015 iCAP).

Year	Percent capture
2020	25%
2025	40%
2030	50%
2040	75%
2050	90%

Table 2: Average monthly precipitation in Urbana-Champaign. Data source: http://www.isws.illinois.edu/atmos/statecli/cuweather/cuaverages.htm

Month	**Average**	**Inches per month based on % capture goals**				
	(inches)	25%	40%	50%	75%	90%
January	*2.05*	0.51	0.82	1.03	1.54	1.85
February	*2.13*	0.53	0.85	1.07	1.60	1.92
March	*2.86*	0.72	1.14	1.43	2.15	2.57
April	*3.68*	0.92	1.47	1.84	2.76	3.31
May	*4.89*	1.22	1.96	2.45	3.67	4.40
June	*4.34*	1.09	1.74	2.17	3.26	3.91
July	*4.70*	1.18	1.88	2.35	3.53	4.23
August	*3.93*	0.98	1.57	1.97	2.95	3.54
September	*3.13*	0.78	1.25	1.57	2.35	2.82
October	*3.26*	0.82	1.30	1.63	2.45	2.93
November	*3.68*	0.92	1.47	1.84	2.76	3.31
December	*2.73*	0.68	1.09	1.37	2.05	2.46
Total	*41.38*	10.35	16.55	20.69	31.04	37.24
Average inches/month:		0.86	1.38	1.72	2.59	3.10

Campus Stormwater

The entire UIUC campus drains to either Boneyard Creek or the Embarras River. Both receiving streams are tributaries that connect to the Wabash River, which flows into the Ohio River, which joins the Mississippi River and eventually flows into the Gulf of Mexico. Therefore, runoff that departs the UIUC campus eventually makes its way into the Gulf of Mexico. The demarcation line between the two watersheds is just north of Kirby Avenue.

This study focuses on the main campus area north of the demarcation line that discharges into Boneyard Creek. The Boneyard Creek watershed was divided into two areas based on their relation to Boneyard Creek, either north or south of the creek. These north and south areas were then subdivided based on the stormwater trunk lines that the areas drain to, all of which discharge directly into Boneyard Creek. Based on this breakdown, there are over 57 sub-drainage areas on the UIUC campus that drain to Boneyard Creek (35 south and 22 north). These sub-drainage areas can be broken down even further by evaluating the areas that drain into each individual pipe or drain inlet.

This study utilizes data collected through analysis of UIUC campus GIS that was provided by the Facilities and Services department (F&S). The data was used to establish quantities of different surface cover on the campus including: buildings, streets, parking/service drives, sidewalks, and unpaved areas. The classification of surface types is important because the surface finishes impact the quantity of stormwater runoff discharged from the area. For example, almost all of the rain water that falls on an impervious surface, such as a building roof or a concrete sidewalk, will run off of the surface. Conversely, landscape areas where the soil is not heavily compacted will allow some of the precipitation that falls on the area to infiltrate down into the ground, which results in a lower amount of runoff. Plants can capture rainwater on their leaves and their structures can act as barriers that slow the flow of water across the surface of the ground, resulting in a reduction in the intensity and amount of the runoff.

Stormwater discharge from impervious surfaces can also result in the introduction of pollutants into the receiving waters. Areas that are used for vehicular traffic, such as streets and parking lots, can introduce oil, anti-freeze, and other chemicals that have dripped off of vehicles into the stormwater runoff. Stormwater runoff from turf areas is another potential source of contaminants, as residual fertilizer, insecticides, and herbicides are often washed into the receiving waters. These introduction of these chemicals into a stream can result in negative impacts to the stream ecosystem. For example, excess fertilizer from central Illinois is contributing to an ecological issue in the Gulf of Mexico known as the dead zone.

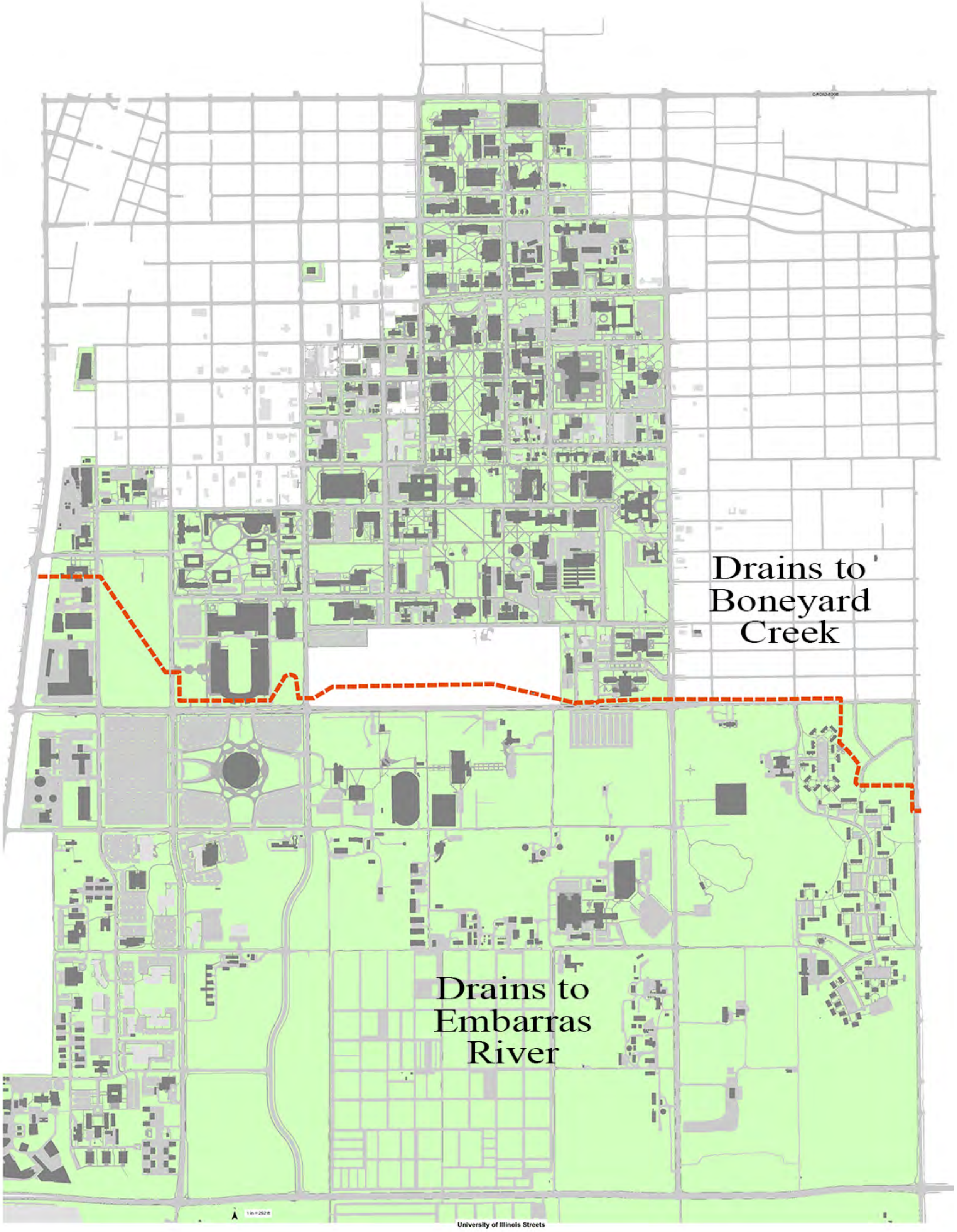


Figure 1: The UIUC campus and the demarcation line between the Boneyard Creek and Embarras River watersheds.

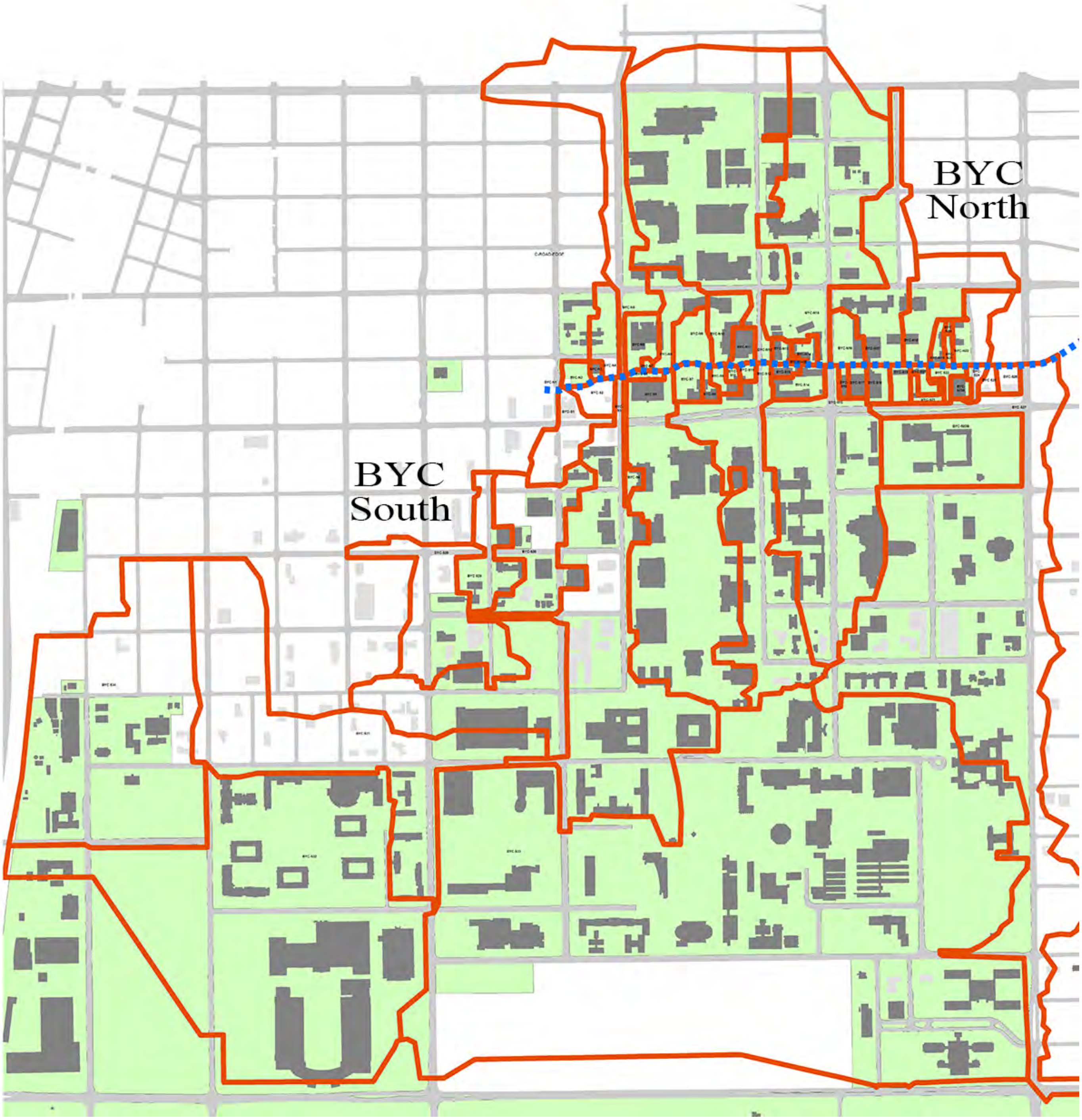


Figure 2: Boneyard Creek catchment areas (Boneyard Creek is represented by the dashed blue line).

Table 3: Quantities of surface coverage for the north and south sides of Boneyard Creek

North of Boneyard Creek			
North	SF	Acres	Percent
Parking	738,989	16.96	15.3%
Service Drive	37,243	0.85	0.8%
Sidewalk	499,948	11.48	10.4%
Building	915,290	21.01	19.0%
Street	482,557	11.08	10.0%
Hardscape	**2,674,026**	**61.39**	**55.5%**
Unpaved	2,141,678	49.17	44.5%
Total area	4,815,704	110.55	Acres

South of Boneyard Creek			
South	SF	Acres	Percent
Parking	3,071,233	70.51	12.1%
Service Drive	395,651	9.08	1.6%
Sidewalk	3,033,395	69.64	12.0%
Building	4,466,537	102.54	17.6%
Street	2,547,340	58.48	10.0%
Hardscape	**13,514,155**	**310.24**	**53.3%**
Unpaved	11,864,212	272.36	46.7%
Total area	25,378,368	582.61	Acres

Table 4: Total Quantities of campus surfaces that drain to Boneyard Creek

Total to Boneyard Creek			
Total	SF	Acres	Percent
Parking	3,810,222	87.47	12.6%
Service Drive	432,893	9.94	1.4%
Sidewalk	3,533,343	81.11	11.7%
Building	5,381,826	123.55	17.8%
Street	3,029,897	69.56	10.0%
Hardscape	**16,188,182**	**371.63**	**53.6%**
Unpaved	14,005,890	321.53	46.4%
Total area	30,194,072	693.16	Acres

Study areas

For the purpose of this study, two catchment areas on the south side of Boneyard Creek were selected for a more detailed evaluation. The areas were selected based on the percentage of impervious cover and their highly visible locations on campus. The first area is identified as BYC_S6 and it is the drainage area that contains the main quad. This catchment area covers a total of 28.9 acres, of which 15.9 acres (55.3%) are impervious surfaces. A detailed breakdown of surface types is included in Table 5.

The second area is identified as BYC_S15 and it is centered on the Goodwin Avenue corridor and contains the west side of the Krannert Center for the Performing Arts. This catchment includes 24.06 acres of land, of which 17.1 acres (70.9%) are impervious surfaces. This area was selected because it contains a major vehicular thoroughfare and because the percentage of impervious is significantly higher than the catchment area that includes the quad. A detailed breakdown of surface types is included in Table 5.

Table 5: Surface coverage, BYC_S6 area section of Goodwin Ave).

BYC_S6		
Cover type	*SF*	*%*
Parking	32253.97	2.6%
Service Drive	0	0.0%
Sidewalk	300135.1	23.9%
Building	347198.3	27.6%
Street	15153.33	1.2%
Hardscape Sub Total	694740.7	55.3%
Landscape	562180.5	44.7%
Total area	1256921	28.9 ac.

Table 6: Surface coverage, BYC_S15 area (Includes (Includes the main quad).

BYC_S15		
Cover type	*SF*	*%*
Parking	116837.1	11.1%
Service Drive	8649.368	0.8%
Sidewalk	193447	18.5%
Building	262013	25.0%
Street	162294.1	15.5%
Hardscape Sub Total	743240.1	70.9%
Landscape	304633.3	29.1%
Total area	1047873	24.06 ac.

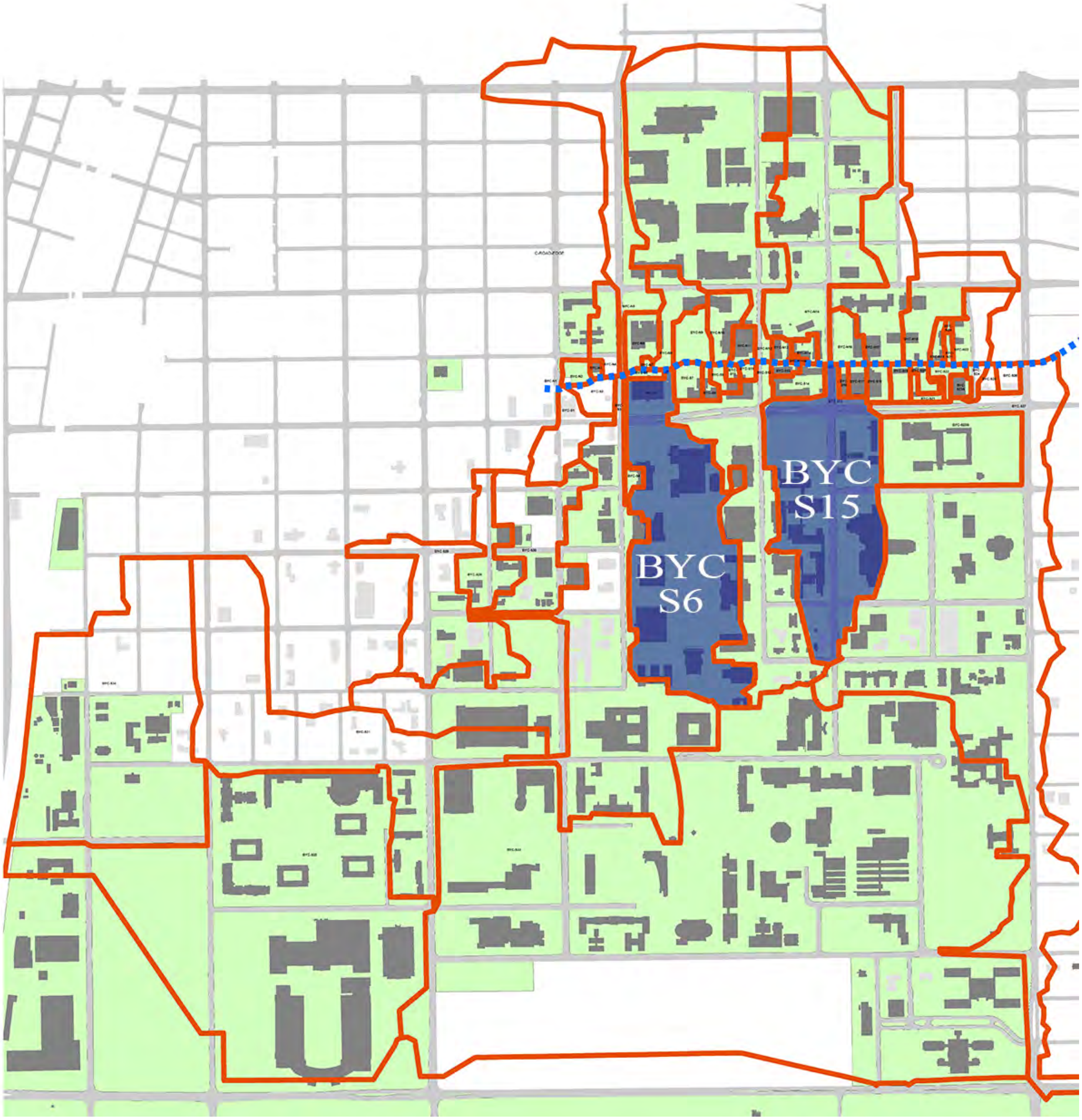


Figure 3: Study area locations.

Figure 4: BYC_S6 catchment area that includes the main quad.

Figure 5: BYC_S16 catchment area, contains a portion of Goodwin Avenue (the central north/south road).

AREAS OF CONCERN ON THE UIUC CAMPUS

Turf

At first glance, many people see lawn areas as a beneficial, “green” parts of campus. These lawn areas, such as the quad area, provide a classic aesthetic quality to the campus and social benefits that can be seen on any warm, sunny day when classes are in session. However, these large expanses of turf come with several negative side effects including highly compacted soil and intensive maintenance requirements. The soil compaction develops over time due to pedestrian use and being driven on with maintenance equipment. These compacted soils resist water infiltration, resulting in higher storm water runoff rates.

The maintenance of lawn areas represents a significant use of labor as they require frequent mowing during the growing season. The maintenance equipment, currently a collection of gasoline powered mowers, string trimmers, and blowers, release emissions and are a significant source of sound pollution on campus. The non-native plant species used in these lawn areas require fertilizer and chemical applications to look their best. The chemicals used to maintain turf areas, including fertilizers, insecticides, and herbicides, can be washed downstream, creating negative impacts on the downstream ecosystems.

While the university has reduced the use of chemicals on lawn areas in recent years, the result of that reduction is that many turf areas are in poor condition. The turf areas are becoming over-run with dandelions and other invasive weed species. As these weeds are allowed to “go to seed” across campus, the problem increases exponentially. This increase in weeds reduces the visual quality of the campus and has the potential of presenting a less than favorable first impression to visitors. Everyone doesn’t view a sea of dandelions as a “badge of honor” for reduced chemical usage.

Mulch beds

The UIUC grounds, especially areas around buildings, feature large, expansive mulch beds which are only planted with trees. Without understory plantings of shrubs, grasses, or perennial plants, there is little resistance to stormwater runoff from the beds. The lack of under-plantings also reduces the habitat potential for birds and other small wildlife in these areas.

Figure 6: Dandelions are multiplying and taking over many campus turf areas.

Figure 7: Large mulch beds that lack understory plantings.

Rooftops

Currently, most stormwater from university building rooftops is piped directly from the down spouts to the underground storm water pipe network. This direct connection to the stormwater network eliminates any opportunity for this water to infiltrate into the ground.

Figure 8: Typical downspout connection to storm drainage piping.

Parking lots and service drives

A substantial percentage of the university campus (87.4 acres that drain to Boneyard Creek) is allocated for parking, resulting in large expenses of impervious pavements such as asphalt parking lots. The stormwater discharge from these parking lots is often times contaminated with oil, anti-freeze, and other chemicals that drip off of vehicles. Those chemicals are washed downstream where they negatively impact the stream ecology. Many of the parking lots on campus also appear to be underutilized, which results in having more impervious surface than may be necessary.

Figure 9: Example of a typical campus parking lot.

Sidewalks

The many acres of sidewalks and bicycle parking areas throughout campus represent a significant swath of impervious surfaces on campus (81.1 acres that drain to Boneyard Creek) and these paved surfaces result in large volumes of stormwater runoff. Additionally, the campus sidewalks are often treated with deicing chemicals during the winter months. These chemicals are washed off the paved surfaces by melting snow/ice and are flushed into the surrounding landscape and the stormwater drainage system. Deicing chemicals typically contain high quantities of salt, which can negatively impact the surrounding landscape and the streams that the stormwater system discharges into.

Overall stormwater performance

While some of the more recently constructed campus facilities, such as the engineering quad and Ikenberry Commons, have included stormwater detention, the majority of the campus releases stormwater directly into the stormwater drainage network. The drainage network then discharges directly into the receiving waters without any identifiable control measures. Because of the minimal amount of existing stormwater control features, reaching the goal of 90%+ capture for reuse and infiltration will be a substantial, and expensive, undertaking. The UIUC campus is essentially starting from zero and has a long way to go to reach the 90% goal.

Figure 10: Typical concrete campus sidewalk.

PRECEDENT STUDIES

In his Master of Environmental Studies Capstone Project at the University of Pennsylvania, Steven Gillard interviewed representatives from 9 universities regarding their stormwater management efforts. The universities interviewed included: the University of Delaware, Georgia Tech, Harvard, Johns Hopkins, the University of Maryland – Baltimore County, the University of Michigan, Princeton, Villanova, and Yale. His study states that the most commonly implemented green infrastructure elements are retention ponds, rain gardens, and bioswales. He also identified downspout disconnects as the “low-hanging fruit” that 5 of the 9 universities targeted. 8 of the 9 universities were pursuing stormwater reductions due to either regulatory rules or campus sustainability goals. 8 of the 9 schools identified high financial costs as a major barrier to implementing these projects (Gillard, 2011).

Many university campuses are working to reduce their environmental footprint and stormwater management is an important part of each program. After reviewing stormwater reports and masterplans for 10 universities across the country, the most commonly suggested and implemented stormwater treatment methods include:

1. Disconnecting downspouts from storm drain systems
2. Bio-retention areas/rain gardens/bioswales
3. Turf conversion
4. Green roof retrofits and required on new construction
5. Cistern (above and below grade)
6. Porous pavers

More specifically, Iowa State University has implemented a variety of green infrastructure throughout their campus and have published a map of the feature locations (Figure 11). Iowa State has implemented several greenroof projects, including simple sedum based plantings and more intensive plantings that feature a variety of native plants. The university has also installed many porous paving projects featuring a variety of permeable pavements including pervious concrete, porous asphalt, and permeable pavers. While the pavements all allow for stormwater infiltration, the incorporation of a variety of materials creates a beneficial learning environment for design students, as they can experience the different pavements in person. Iowa State has also implemented a variety of bio-retention areas and rain gardens, with several of these features constructed near surface parking lots. While none of the Iowa State programs stand out as extremely cutting edge, the large quantity of implementations across the campus sets a strong example for UIUC to follow.

Loyola University Chicago’s Lake Shore Campus is an example of a campus that has made tremendous progress in the implementation of a campus-wide stormwater management plan. While the campus is only 29.09 acres, the university has removed over 195,686 square feet (4.49 acres) of impervious surfaces through the removal of streets, parking lots, and impervious sidewalks. That area has been replaced with 80,000 square feet of permeable paver sidewalks and green spaces. Those green spaces cover a collection of water storage tanks and infiltration beds that retain 22% of the campus's stormwater discharge. Additional stormwater is filtered on-site and discharged directly into Lake Michigan, further reducing the campus's contribution to the City of Chicago's combined sewer system.

The Loyola campus has also improved its landscape through the integration of 24 native plant species into the campus plant palette. These native plants have been mixed with non-native ornamental plants and planted in large swaths of single species. The visual effect is more "traditional" and it avoids the "wild" appearance that intensely mixed native plantings feature. These broad swaths of plants could be more acceptable to the UIUC staff and alumni who have complained about highly mixed native plantings when they have been implemented on campus. While the Loyola campus does benefit from a highly permeable sandy soil, it provides a strong example of what a university can do when it fully commits to changing its stormwater discharge.

The University of Michigan has an extensive stormwater management plan that includes a turf management plan that divides turf areas into 3 classes based on usage and location. Priority 1 lawns are high profile, high use areas and are highly maintained. Priority level 3 lawns are at the other end of the spectrum and these turf areas are mowed less and they receive no chemical treatments. Michigan's Best Management Practices focuses on promoting infiltration through the promotion of overland flow in vegetated swales, reduced impervious surfaces, the incorporation of bio-retention areas, and filter chambers to clean stormwater discharge. Michigan is also implementing soil restoration efforts where compacted soils are improved through deep tilling (20") and the addition of soil amendments. These efforts can increase the ability of the soil to retain moisture and better support plant growth. The University of Illinois could incorporate many of the University of Michigan's Best Management Practices and develop a similar turf rating system that identifies turf areas that could be converted to native grasses.

Figure 11: Map of green infrastructure projects on the Iowa State University campus. Image source: http://www.fpm.iastate.edu/planning/masterplan/Stormwater%20Poster%20Feb%202012.pdf

SUGGESTED FUTURE STUDIES FOR THE UIUC CAMPUS

Several additional studies are recommended in order to aid the university in establishing a successful stormwater management and reuse program. The results from these studies will provide the data necessary to determine the optimum stormwater management solutions.

Parking lot utilization:

Study of parking lot utilization to identify which lots are under-utilized during the school day. Suggested responsible department: Parking Services. This study may be able to utilize data collected by the parking department's new license plate reader system that is being used to identify parking violators (If the system can provide vehicle counts for parking lots over the course of a typical day/week).

Parking lot surface condition:

Inventory of parking lot pavement condition to identify lots in need of resurfacing that could be retrofitted with pervious paving applications when they are resurfaced. This study should be combined with the parking lot utilization study (above) to determine which lots should be retained for parking and retrofitted with pervious paving and which lots could be decommissioned. Suggested responsible department: Facilities and Services (F&S).

Soil testing:

Campus soils should be tested for both infiltration rates and compaction density. The inventory of soil infiltration rates across campus will aid in determining which areas on campus are prime location for infiltration basins. The infiltration rate will determine how quickly water can drain and will have significant influence on the performance of the stormwater management system. Soils should also be tested for compaction and those areas that are heavily compacted should be identified for future soil restoration work. Suggested responsible departments: Engineering department and F&S.

Water demand study:

Inventory of building water usage and irrigation water usage across the campus. This inventory will identify the demand volumes for reuse water. The demand volumes can then be used to determine storage requirements for reuse water. This study should also examine the feasibility of retrofitting all existing buildings for greywater usage. The identification of zones of high demand for greywater can then inform the planning of implementation of stormwater storage, both in volume and location. If the highest demand for greywater is around the horticulture department on south campus, then the storage of reuse water should be located as close to the demand point as possible, which reduces pumping requirements and infrastructure installation. Suggested responsible departments: Engineering department and F&S.

Turf area analysis:

Inventory and analysis of existing turf areas to determine usage by students, faculty, and staff. This study should be completed during the spring and fall semesters to identify usage during a typical school day and special events such as football Saturdays and graduation day. This could include a grading scheme similar to the system implemented by the University of Michigan. Suggested responsible departments: Landscape Architecture department and F&S.

Deicing alternatives:

The chemicals that are used for deicing sidewalks often have a high salt content, which can damage landscaping and the streams that the campus stormwater is discharged into. The university should explore other deicing chemicals and the potential reduction in icing that permeable paving provides. This could be incorporated into student/class research projects and tested on the campus grounds. Suggested responsible departments: Engineering department and F&S.

PROPOSED TREATMENT PROGRAMS:

In order to take control of the stormwater discharge from the UIUC campus, it is recommended that the university focus on 3 stormwater factors:

1. Quantity of discharge: First and foremost, the university should focus on reducing the amount of stormwater that is discharged from the campus.
2. Quality of discharge: When/where the university must release stormwater, it should work to improving the quality of the water discharged from the campus. Increasing the quality

of campus discharge will require a reduction of waterborne pollutants, including: debris, suspended solids, nutrients, and other chemicals.

3. Velocity of discharge: When/where the university must release stormwater, it should reduce the speed at which stormwater is discharged. Water that flows at high rates is more likely to cause erosion and create problems for downstream neighbors. Velocity can be reduced by temporarily storing stormwater and releasing it over a greater period of time.

In order to meet these three factors and move towards the goals identified in the iCAP, the university should work towards implementing the following treatment programs.

	Quantity Reduction	Quality Improvement	Velocity Reduction
Disconnect			
Downspouts	■	■	■
Curb cuts	■	■	■
Landscape			
Turf zone inventory			
Turf conversion	■	■	■
Regrade turf zones	■		
Understory planting	■	■	■
Underground storage			
Reuse	■		
Infiltration	■		
Pavement conversion			
Sidewalks			
Conversion to permeable pavement	■		
Parking lot			
Reduction in area	■	■	■
Conversion to permeable pavement	■		
Filtration			
In-line filtration system		■	

Figure 12: Suggested treatments and their impacts on stormwater.

<u>Disconnect</u>

Downspout disconnect:

Rooftops are significant sources of stormwater runoff that currently discharge directly into the stormwater drainage system. The downspouts can be disconnected and the water that is discharged from building rooftops can be collected and stored for reuse purposes. Those reuse purposes including toilet flushing and irrigation use. If filtered properly, runoff from rooftops could also be used for potable uses.

Alternatively, roof water can be directed into to infiltration areas where the water can seep into the ground and recharge the aquifer from which drinking water is currently extracted. These infiltration areas can be constructed as underground storage areas or at grade bio-retention ponds/rain gardens. The incorporation of at-grade stormwater management systems would introduce a new aesthetic to the campus and would raise the student body's awareness of the campus's stormwater discharge. The plants within the retention areas would aid in cleaning the water and removing nutrients from the water. These areas can also collect surface runoff from surrounding areas, further reducing the stormwater discharge from the campus.

Curb cuts:

Similar to building downspout systems, the current configuration of the curbs along campus roadways direct stormwater straight into the underground stormwater pipe system. In order to provide an opportunity for infiltration, the curbing can be strategically cut prior to the drain inlets to allow stormwater to flow into nearby rain gardens for infiltration. When the storage capacity of these rain gardens is exceeded during large storm events, the water flow will back up and continue to flow into the existing storm inlets as it currently does. The implementation of curb cuts provides multiple benefits including an ability to capture the "first flush" of stormwater, which typically contains the most pollutants and it provides an opportunity to infiltrate more stormwater into the groundwater system. Furthermore, smaller storm events would be fully contained by the infiltration areas, which reduces the demand on the stormwater system and reduces the volume of water discharged into the receiving waters.

Since sidewalks are typically running parallel to the roadways along the outside of the curb, trench drains would have to be installed across the sidewalk. These trench drains would allow the water to flow from the curb into the rain garden areas, while making it safe for pedestrians and cyclists to cross. These trench drains could feature ornamental grates that allow pedestrians an opportunity to view the water flowing from the curb into the rain gardens, which would help to raise awareness of stormwater and its management. This could also provide a visual indication of the intensity of the storm, as observers would be able to see when the storm maxes out the storage area and begins to flow towards the drain inlet.

Landscape

Turf conversion:

Like many other historic campuses, the UIUC campus features several quad spaces that feature expansive turf lawns bordered by trees and sidewalks. These lawn areas provide a distinct visual aesthetic and, when weather permits, they become a hub of student activity. These aesthetic and social benefits of the quad lawns are important and they underscore why these lawn areas should be maintained. However, the university grounds feature many acres of turf areas that do not offer the same aesthetic benefits or social purposes. As mentioned above, these turf areas are planted with non-native plant species that require intensive maintenance regimes. Reducing the acreage of turf on campus will help to reduce stormwater runoff, reduce maintenance efforts, reduce emissions by maintenance equipment, and reduce the potential for excess nutrients and chemicals in stormwater discharge.

Turf areas, should be evaluated through a turf area analysis and those areas that are not heavily utilized by students and/or are not required to meet specific aesthetic needs should be converted to mulch bed plantings or native grasses and perennials. While the “prairie style” of planting has been met with concerns from staff and donors, native plants can be incorporated into simplified large plant masses that are more structured and that appear less “wild.” While turf areas are often times seen as the cheapest option to install, the long term maintenance requirements and potential for polluting nearby waterbodies raise the long-term cost of turf.

Regrade turf areas:

Most turf areas are currently graded to shed water, which, when combined with the compacted soil, results in significant stormwater runoff. Large turf areas, like those in the quad areas, can be regraded to accept and hold water for infiltration, resulting in a reduction of stormwater runoff. While turf species cannot withstand long-term submersion in water, regraded turf areas can collect stormwater and infiltrate it down through the soil and into underground storage basins where it can be held for long-term storage for infiltration.

Understory planting:

In order to increase the infiltration rates of the existing mulch beds and to slow the discharge of stormwater from these areas, the mulch beds should be planted with a variety of native shrubs, grasses, and perennials. By fully planting these beds, the plants will aid in the slowing of stormwater runoff and provide opportunities for water absorption by their root systems. These plantings could be designed by students in the Landscape Architecture and Horticulture Departments as a part of planting design classes. Furthermore, the university can capitalize on its expansive horticulture department as a resource for the propagation of the native plants for the campus. These plants would be utilized to infill the existing mulch beds that are currently planted with trees.

Underground storage

Stormwater discharge can be directed to underground storage tanks, where it can be held for multiple purposes. Large expanses of open space, such as the turf areas in the quads provide significant opportunities for underground storage. That underground storage can take many forms, including: the void spaces between stones in a gravel filled pit, concrete holding tanks, or large diameter pipes that are capped off to become storage tanks.

For example, the main quad could easily provide space for 112,500 square feet of storage. If that storage area was filled with gravel (39% void space), the void spaces between stones could hold over 329,000 gallons of water per one foot of storage depth. If manufactured storage units were installed and 80% of the area was available for water storage, it could hold over 673,000 gallons per foot of storage depth. This represents a significant volume of water storage that is underground and not impacting the tradition use of the quad area.

Reuse:

Stormwater can be reused in buildings for toilet flushing and can also be used outdoors for irrigation of lawn areas or crops. At the time that this report was prepared, only 1 building on campus is set up to use greywater for toilet flushing (The College of Business Instructional

Facility). In order to justify the cost for implementing a stormwater reuse program, all new buildings on campus should be required to be plumbed for greywater usage.

Infiltration:

Underground storage tanks can also be constructed to store water and allow for infiltration into the groundwater system. While infiltrating water does not offset the cost of water as reuse does, it does reduce the surface discharge of stormwater and it aids in recharging the aquifer that serves as the university's potable water source.

Pavement conversion

Sidewalk surface conversion:

The university campus features many acres of pedestrian sidewalks, all of which are impervious surfaces. The conversion of these sidewalks to permeable materials would result in a significant reduction in stormwater discharge. The university can implement a phased replacement policy that requires that damaged sidewalks are replaced with permeable materials. Furthermore, all new construction on campus should be required to use permeable materials. The university can identify a palette of approved permeable surfaces that creates a unified aesthetic and visual identity for the campus. The university should also specify minimum depths of gravel storage areas under the paving systems to ensure adequate storage area for infiltrated water.

Parking lot area reduction:

Many parking lots across the UIUC campus appear to be 1/3 to 1/2 empty throughout a typical school day. If the parking lot utilization study identifies parking lots that are underutilized, then parking lot users can be consolidated into fewer lots and the unneeded lots can be removed and converted to green space. Parking lots within the interior of the campus should be targeted for removal in order to reduce the number of vehicles that are travelling through the campus, which reduces emissions on campus and increases pedestrian and cyclist safety. These lots can be converted to open spaces that focus on stormwater infiltration of stormwater from adjacent rooftops while also providing students, faculty, and staff with access to outdoor areas for studying, eating, and socializing.

Parking lot surface conversion:

Where parking lots are to remain on campus, the paving surface should be converted from an impervious surface to a porous paving system. Porous paving systems include permeable asphalt, permeable concrete, and permeable pavers. These porous surfaces allow water to flow down through the paving and into the open pores within underlying aggregate fill. With adequate aggregate thickness, these paving systems can store the stormwater runoff from the parking lots, and runoff from adjacent buildings, for infiltration or reuse.

Informational signage program:

As new stormwater management treatments are implemented across the campus, these areas and their function should be highlighted with informational signage. The design and creation of this signage can provide an opportunity to include artistic students from the graphic design program who might not typically be involved in campus stormwater projects. Suggested responsible departments: Landscape Architecture, Graphic Design Program, and F&S

Filtration

The insertion of in-line stormwater filtration systems into the existing stormwater drainage network would aid in a reduction of trash, suspended solids, and oils from stormwater discharge. In-line filters with membranes, such as the Contech Jellyfish can also remove nutrients and metals from runoff. These systems could be installed at points along the existing stormwater drainage system as an initial step towards improving the quality of the campus stormwater discharge with minimal impact on the overall system.

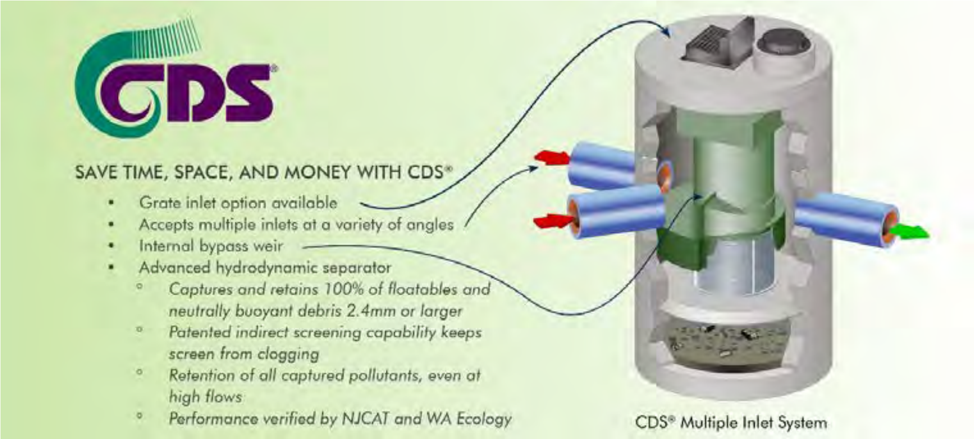


Figure 13: Contech CDS illustration, an example of an in-line filter that could be retrofitted into the existing stormwater system. Image source: http://www.conteches.com/products/stormwater-management/treatment/cds

APPLICATION OF TREATMENTS TO STUDY AREA

BYC_S6 (The main quad area)

This catchment area contains the UIUC's main quad, which features an extensive lawn area that is bordered and crossed by concrete sidewalks. The quad's perimeter is edged by a collection of historic buildings that house classrooms, offices, and the student union. In a 1" storm event, this site produces an estimated 75477 cubic feet (1.73 acre feet) of stormwater runoff. That is equivalent to 564,564 gallons of water. During a 100 year storm event, it is estimated that this study area discharges 213 cubic feet of water per second. In order to contain a 100 year storm event, it is estimated that 162,516 cubic feet (3.73 acre feet) of stormwater would have to be detained.

There is a large quantity of underutilized turf areas along the outside edge of the main sidewalks that border the quad. In order to reduce the runoff from this study area, these turf areas should be combined with nearby mulch bed areas and converted into planted areas and/or rain gardens. The rain gardens could capture and filter/infiltrate runoff from the adjacent building rooftops and sidewalks. While these rain gardens would dramatically change the zone between the buildings and the sidewalks, the stormwater benefits would also be dramatic. Incorporating these treatments along the edge of the high-profile main lawn would also draw significant attention to the university's commitment to improving its environmental footprint.

When directing rooftop water to the rain gardens, a variety of options are available for routing the stormwater. Water from small rooftop areas can be directed into vegetated swales, where native plants stabilize the slope and protect the swale from erosion. When downspouts have higher discharge volumes, the water should be directed into a swale that is more heavily defended against erosion. These swales could be decorative concrete chutes or rock lined swales. Either design would draw attention to the stormwater and would activate spaces during rain events. Students would be able to observe the water flow and gain a sense of the intensity of the storm event. The two proposed rain gardens (Figure 15) in front of Davenport Hall could contain a maximum of 22,400 cubic feet of water. If similarly sized ponds were distributed around the quad, the university could successfully contain a 1" rain event with rain gardens around the quad.

There are 6.9 acres of sidewalks in this study area and these paved areas make a significant contribution to the stormwater discharge volume. Some of these sidewalks appear redundant and could be consolidated to reduce the total square footage of sidewalk coverage. In order to further reduce the potential for runoff from the quad area, the consolidated sidewalks should be converted to a pervious pavement, either porous concrete or permeable pavers. This conversion would reduce the impervious surface area and could provide storage area for infiltration underneath the sidewalks.

As mentioned earlier, the main lawn also presents a massive opportunity for underground stormwater storage. There is room for an 112,500 square foot underground storage area underneath the main lawn. If this storage area is constructed at a depth of 3-5 feet, it can provide a significant amount of storage capacity for either infiltration or reuse. A storage area under the quad could be sized to fully contain a 100 year storm event. However, reuse is only a viable option if some of the surrounding buildings can be converted to use greywater for toilet flushing. Due to the historic nature of the buildings, that conversion might be difficult or too expensive to implement. If the stored water cannot be reused in nearby buildings, it might not make logistical sense to store a large volume of water in this area and have to pump it to buildings in other areas for reuse. However, the underground storage area could still be utilized to support infiltration and recharge the aquifer.

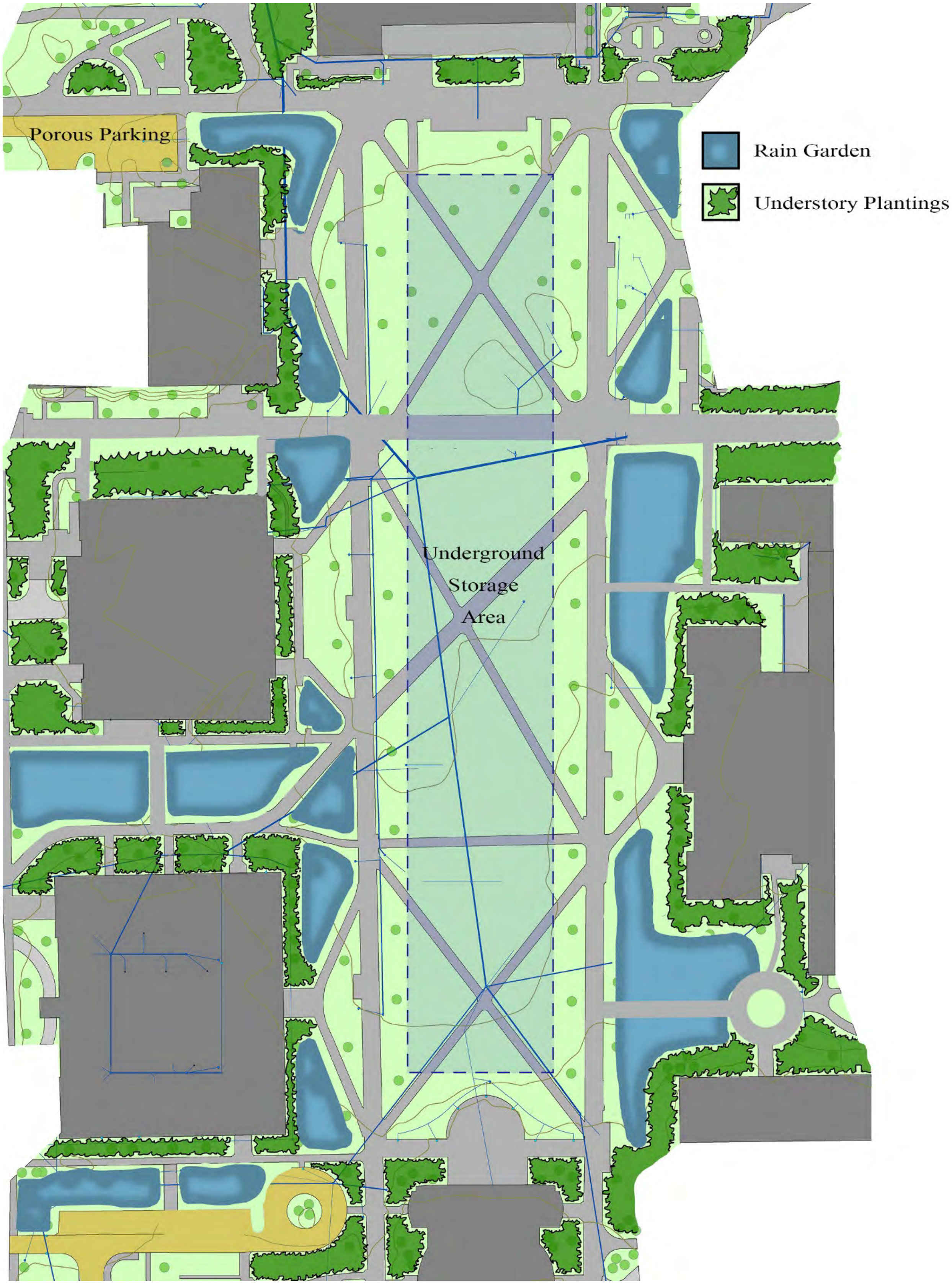


Figure 14: Possible locations of rain gardens, underground storage, and understory plantings around the quad.

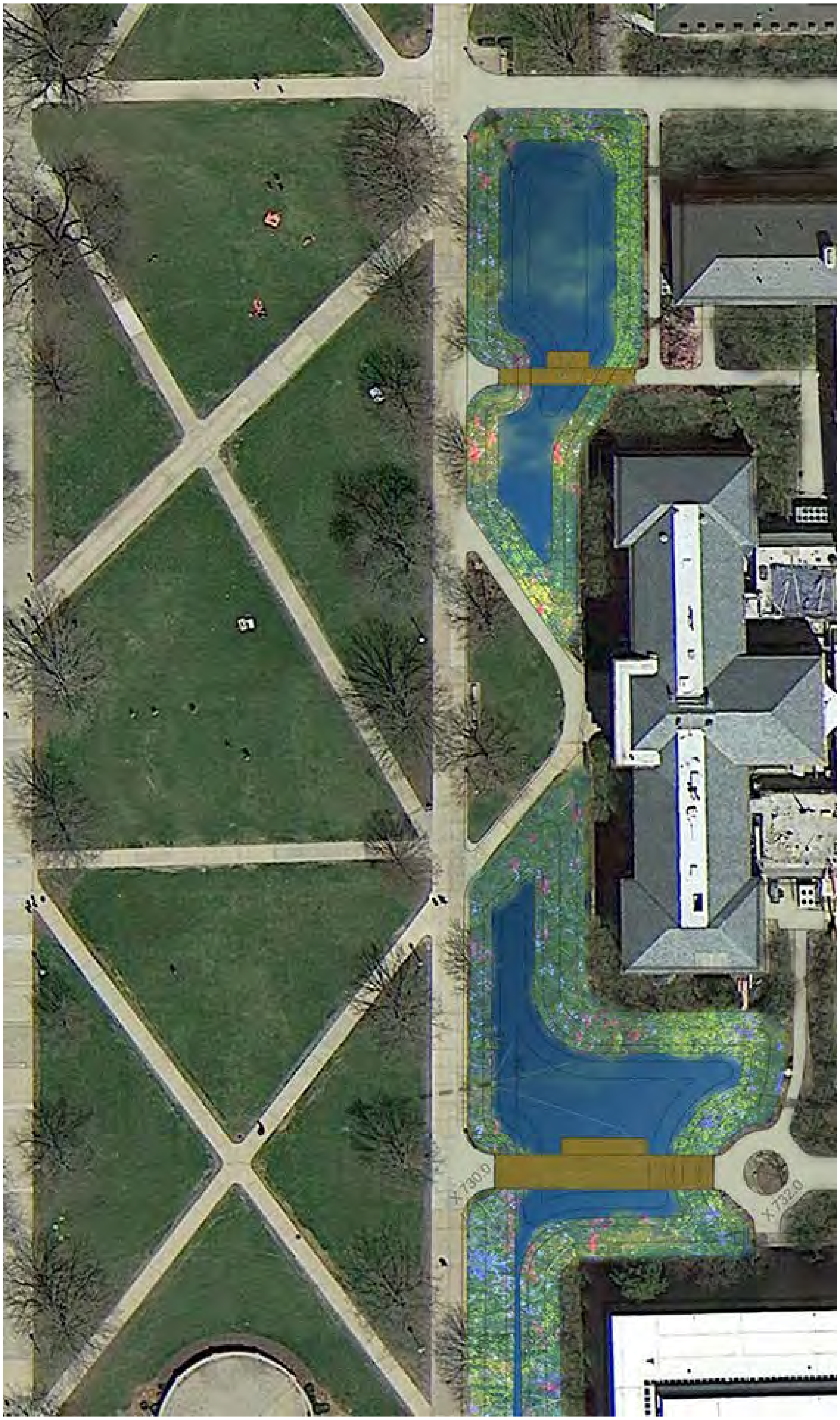
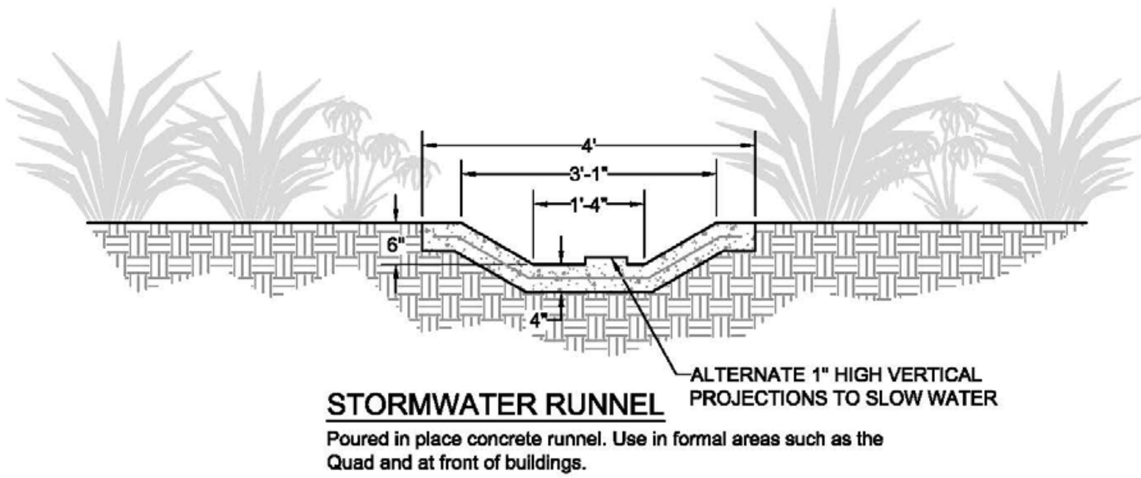


Figure 15: Bio-retention areas around the main quad, in front of Davenport Hall. Bridges across the water would introduce a new pedestrian experience to the campus.



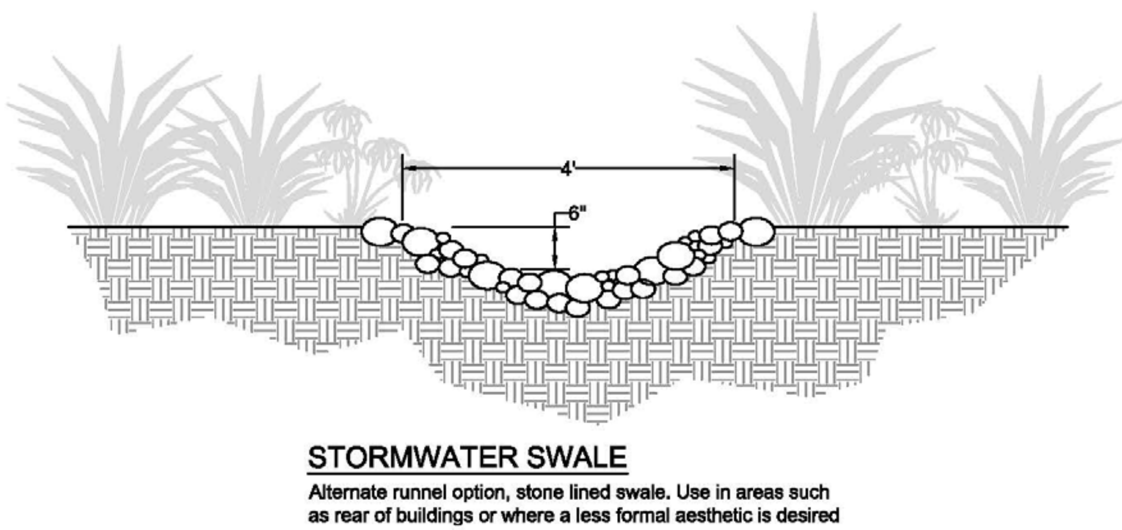


Figure 16: Examples of swales for connecting downspouts to bio-retention areas.

BYC_S15 (Goodwin Ave. and west side of the Krannert Performing Arts Center)

This study area is dramatically different than the quad area because it is a street corridor and it features more hardscape coverage (70.9% versus 55.3%). That additional hardscape coverage, a combination of buildings, parking lots, streets, and sidewalks results in more runoff per acre. In a 1" rain event, this area would generate an estimated 70,852 cubic feet (1.62 acre feet) of stormwater runoff. That is the equivalent of 529,976 gallons of water. During a 100 year storm event, it is estimated that this study area discharges 177.6 cubic feet per second. In order to contain a 100 year storm event, it is estimated that 160,443 cubic feet (3.68 acre feet) of stormwater would have to be detained.

The street corridor provides an opportunity to integrate curb cuts that direct runoff from the street into rain gardens prior to releasing stormwater into the existing storm drains. The proposed rain gardens would be installed along the perimeter of the Krannert Performing Arts Center and could also accept water from the Krannert's rooftop plaza area. These rain gardens, estimated to hold a maximum of 18,800 cubic feet of stormwater, provide an opportunity for filtration and infiltration instead of direct discharge into the stormwater system. During the many small rain events that occur during the year, these rain gardens could capture all of the runoff from the area.

This study area also features several parking areas that total 2.7 acres of impervious surface. These parking lots should be evaluated for their utilization rate in order to verify that they are being used to their greatest extent. If the parking lot study verifies that these lots should remain, they should be converted to porous paving. Converting parking areas to porous paving would aid in reducing runoff from this area and provide an opportunity for additional underground stormwater storage for infiltration. This additional storage would be located in a structure under the paving and it could accept water from the surrounding building rooftops. There is also a significant amount of sidewalk paving in this study area, most of which could be converted to porous paving in order to further reduce the volume of stormwater discharge. Finally, many of the small turf areas could be planted with native vegetation to reduce runoff and maintenance demands.

Figure 17: Possible locations of rain gardens, understory plantings, and porous paving around the study area.

Figure 18: Rain gardens along Goodwin Ave provide opportunity for infiltration.

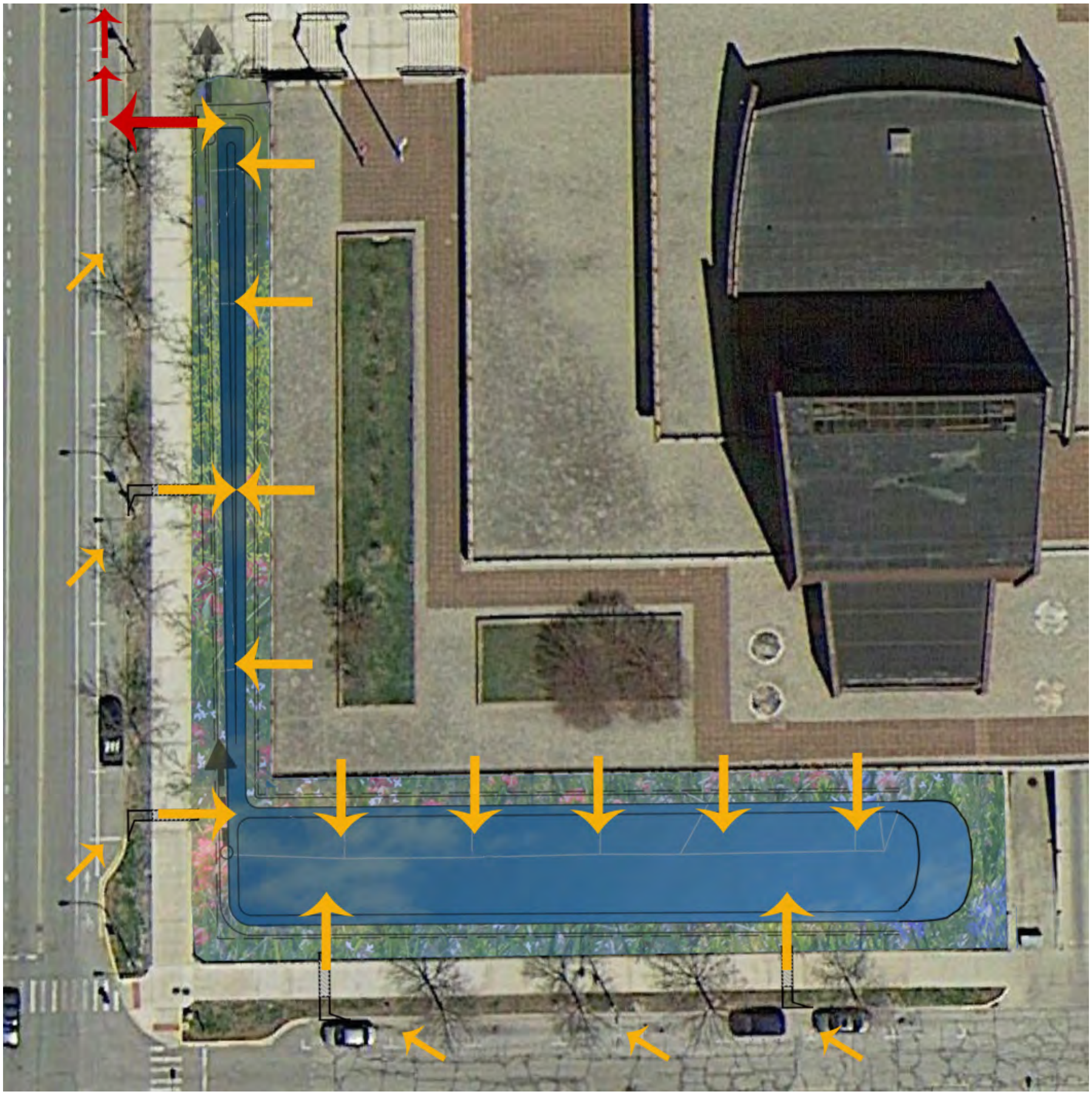


Figure 19: Curb cut diagram.

As shown in Figure 16, curb cuts allow runoff from the street to flow into rain garden areas prior to reaching existing storm inlets. The runoff runs through grate covered runnels that bisect the sidewalk area. These runnels draw attention to the water movement and, when combined with informational signage, aid in educating the general public about the importance of stormwater management. During large storm events, the rain garden would reach their full capacity and excess water would be redirected to the curb and into the existing storm drainage network (red arrows). Additional overflow structures in the rain gardens ensure that large storm events do not result in large releases of water into the street.

Figure 20: Example of stormwater runnel through a sidewalk. Image source: https://ruskinkhartley.com/tag/water-quality/#jp-carousel-1976

In Summary, gaining control of the stormwater from the UIUC campus will be a significant and challenging project. Achieving these goals will require a dramatic changes in the campus, both in aesthetics and how the campus infrastructure operates. In order to meet the 25% - 90% capture and reuse goals, the university will have to implement a variety of strategies that are substantially different than current management practices. With these changes, a re-education of staff will be necessary, as these new programs will require new maintenance techniques. This is an exciting time for the university, as the enactment of these changes will allow the university grounds to become an example of research, engineering, and environmental awareness.

Web Resources:

Embarras River watershed: http://biogeochemistry.nres.illinois.edu/Embarras/map.html

Gillard, Steven. Comprehensive Stormwater Management Plans on University Campuses: Challenges and Opportunities. 2011, May 1. Retrieved from: http://repository.upenn.edu/mes_capstones/44/

Iowa State University: http://www.livegreen.iastate.edu/ and http://www.fpm.iastate.edu/planning/masterplan/

Loyola University: http://www.luc.edu/sustainability/campus/focus_areas/stormwatermanagement/

Gulf of Mexico dead zone: http://serc.carleton.edu/microbelife/topics/deadzone/index.html

University of Michigan stormwater: http://www.oseh.umich.edu/environment/storm.shtml