

GREEN INFRASTRUCTURE CONCEPTUAL PLAN FOR SPELMAN COLLEGE

Written by Sydney Hubbert and Imani Love, Environmental and Health
Sciences Department



NOVEMBER 23, 2015
SPELMAN COLLEGE

Table of Contents

	<u>Page</u>
I. Introduction.....	1
II. Background.....	1
III. Literature Review and Field Work	2
IV. Methodology.....	4
V. Calculations	8
VI. Green Infrastructure Conceptual Plan	13
a. Cisterns.....	14
b. Ephemeral Stream.....	15
c. Floodplains.....	16
d. Spelman Parking Lot.....	17
e. Spelman Lane Berm and Swale	17
VII. Benefits and Experiences.....	18
VIII. References	19

I. Introduction:

This report focuses on Spelman College and its goal of capturing 4.5 million gallons of storm water during a 100-year rain event. This fits into an overall purpose of developing a conceptual plan that will capture 22.4 million gallons of storm water from Atlanta University Consortium campuses including Spelman College, Morehouse School of Medicine, Clark Atlanta University, Morris Brown, and ITC.

II. Background:

Spelman College is a private, liberal arts institution located on 39 acres in the West End neighborhood of Atlanta, GA. Spelman College, as well as the other institutions included in the AUC, was built in the higher elevated areas of West Atlanta. Unfortunately, during heavy rainfall, massive flooding occurs as the rain drains through a combined sewer system into downstream lower elevation areas such as Vine City and English Avenue. The storm water carries pollutants and trash with it that eventually litters the downstream communities. Furthermore, the combined sewer system is overpowered by the rain, which causes water and sewage back-up in many of the lower elevation residential areas in West Atlanta.

Sewage overflows exert physical, chemical and biological effects on the receiving environment. This may result in human health, environmental and aesthetic impacts, which can be both acute and cumulative (American Rivers). Such impacts are dependent on the characteristics of the discharge and receiving environment.

As sewer overflows may contain raw sewage, they can carry pathogens, which are disease-causing organisms. These include bacteria, viruses, protozoa, helminths (intestinal worms), and inhaled molds and fungi. The diseases they may cause range in severity from mild gastroenteritis (causing stomach cramps and diarrhea) to potentially life-threatening ailments

such as cholera, dysentery, infectious hepatitis, and severe gastroenteritis. Human health impacts can be dependent on the duration of exposure to, and the levels of pollutants in the overflow. Humans can be exposed to pathogens through direct contact with overflows into homes and businesses and into public areas such as parks, streets, streams, and tributaries. Downstream Proctor Creek residents have historically used the streams for baptisms, fishing, swimming, and other communing with nature.

Many health problems are associated with back-up sewer systems. Potential human exposure to the pollutants found in sewer overflows can occur through several pathways. According to EPA, the most common pathways include direct contact with waters receiving CSO or SSO discharges, drinking water contaminated by sewer discharges, and consuming or handling contaminated fish or shellfish. However, humans are also at risk of direct exposure to sewer overflows, including sewer backups into residential buildings, city streets, and sidewalks.

The cost of eliminating CSOs and SSOs throughout the nation is staggering. The wastewater systems of the United States are aging and require significant investment in traditional infrastructure and innovative, non-structural infrastructure to prevent the occurrence of sewer overflows. In its most recent Clean Water Needs Survey (2000), EPA estimated the future capital needs to address existing CSOs at \$50.6 billion. In addition, EPA estimated that it would require an additional \$88.5 billion in capital improvements to reduce the frequency of SSOs caused by wet weather and other conditions (e.g., blockages, line breaks, and mechanical/power failures).

III. Literature Review and Field Work:

In the beginning stages, we collected aerial maps of Spelman College that depicted elevation, combined sewer lines, and electrical conduits. Then we interviewed persons working for the facility management, including Art Frazier, Director of Facility Planning and

Management. We also met every Friday and conducted field work by walking around the campus with the maps and taking notes on areas where potential green infrastructure can be constructed. Based on literature review and initial field work, we concluded that floodplains will cost less than cisterns per gallon of storm water detained. We chose to detain 3.0 million gallons of rainwater in floodplains and 1.5 million gallons in cisterns.

At this stage, we considered the following ideas: capturing storm water in a pond centered in the oval, fixing localized puddling problem, and placing a greenhouse in near the Physical Plant building. The oval is located between the older administrative buildings (Rockefeller and Packard Hall) and the residence halls (Abby and Morehouse James) on the east part of campus. It extends from the Science Center (near Chapel Street) down to Giles Hall (near Greensferry Street). We decided that placing a pond in the center of the oval would detract from historical aspects of the oval.

Next, we concluded that localized flooding problems would be solved incidental to our overall 4.5 million gallon rain water detention initiative. Finally, placing a greenhouse above the Physical Plant would be desirable but will not make a significant contribution to our project goal of storm water detention.

After additional fieldwork, we located potential cistern sites as well as identified existing cistern/ storage capacities, and analyzed major flooding areas. Potential cistern sites included a variety of sites on the Spelman Lane side of campus near each building. Spelman College already has a 58,000 gallon cistern located under the driveway between Abby Residential Hall and Morehouse-James Residence Hall. Likewise, an underground water storage space is by Milligan Career Development Building. Major flooding occurs behind Abby Hall and Giles Academic Building, as identified by Michael E. Jackson, Groundskeeper. Finally, the Spelman

parking lot right inside the gates off Westview Drive was identified as a major location for underground water storage due to its large surface area.

On September 10, 2015, Atlanta, Georgia experienced heavy rainfall of 1.89 inches in 2 hours. This rain event describes a 2-year rain event. After this rainfall, we were able to individually identify flooding/puddling areas around the campus. We also met with Art Frazier to distinguish specific buildings with flooding problems due to the heavy rainfall. LLC1 guest room, Abby Hall, Morehouse-James Hall, Science Center basement, and Manley Student Center Lower Level were the buildings that experienced flooding problems because of sewer system piping back-ups. Finally, we recorded the flooded buildings on the map to later consider these problem areas during our solution creation.

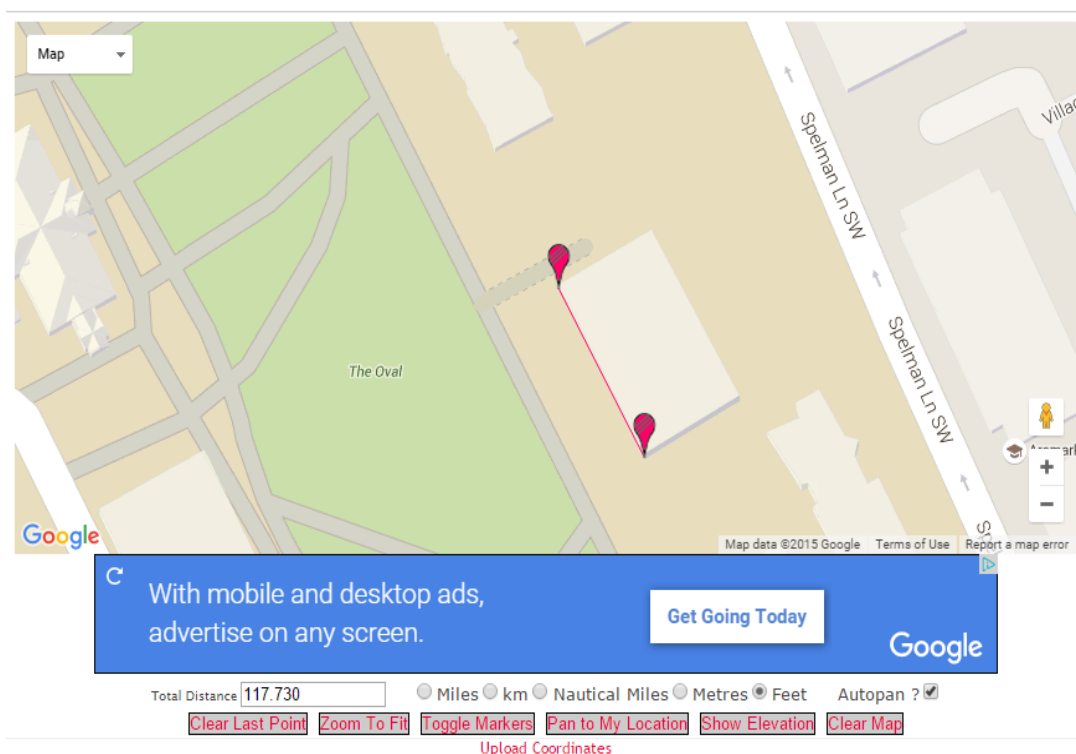
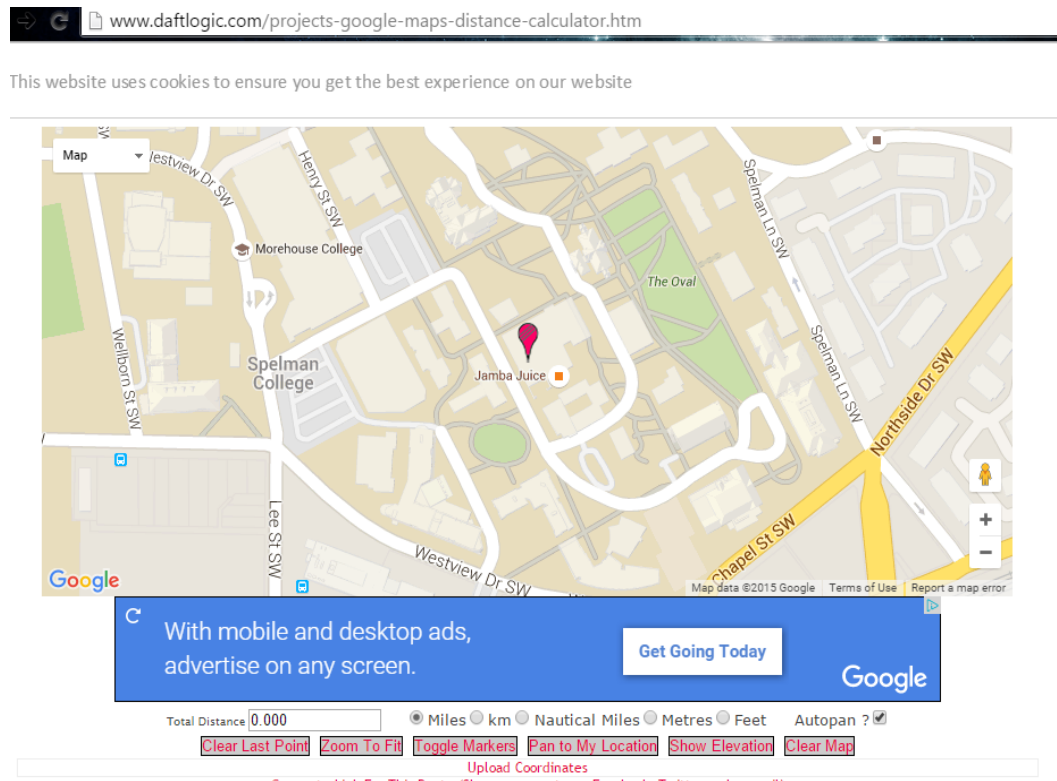
One very important assertion we made is wanting fewer, bigger cisterns, rather than more, smaller cisterns. For reasons such as financial, time, etc., we knew that less was truly more.

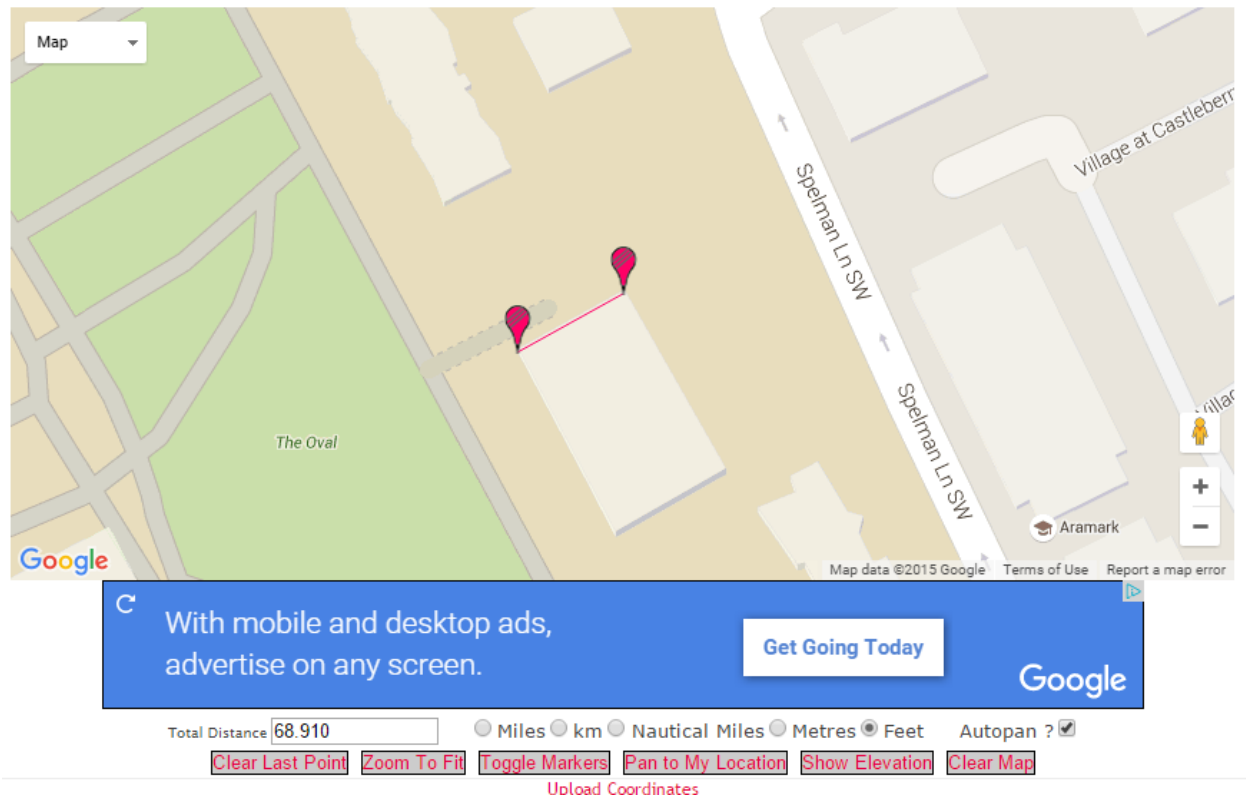
Towards the end of our field work and research, we concluded the following solutions for storm water capturing: **three major cisterns, an ephemeral stream, a terraced floodplain, and an underground detention vault for detaining excess water.**

IV. Methodology:

The methodology of this project was directed at capturing storm water. To determine the amount of storm water we wanted to capture, we calculated the surface area of each building and some select ground spaces. Using *DaftLogic.com*, we were able to pull up Spelman College on *Google Maps* and place “pins” to find the lengths and widths of each space. Then, we created a table of each space, noting the dimensions, calculating the surface areas, and figuring the storage for each rain-event (2, 5, 10, 25, 50, and 100- year).

To illustrate, *DaftLogic.com* was used to find the dimensions of each building and greenspace on campus. The following images display how Daft Logic can be used:





Once we had surface area calculations and reviewed topography, campus restraints, historical land use, and aesthetics, we were able to identify the type of green infrastructure we wanted to implement at specific locations relative to the amount of water that needed to be captured. We tabulated the dimensions and area of each building along with the dimensions of some parking lots, tennis courts, and green spaces.

Table 1: Dimensions of Buildings, Parking Spaces and Green Spaces at Spelman College

BUILDING	DIMENSION (ft)	AREA (sq ft)
Packard Hall	(50 x118)+(32 x 68)+2(16 x24)	8,844
Giles Hall	(173*52) + (53*42)	11,222
Rockefeller Hall	(78 x 132)	10,296
Reyond's Cottage	(82 x 46)+(27 x 55)	5,257
Manley Center	(161 x 138)+(120 x 80)	31,818
Science Center	(188 x 106)+(63 x 116)+(136 x 77) +(103 x 35)	33,893
Tapley Hall	(135 x 53)	7,155
Sisters Chapel	(153 x 80)	12,240
Read Hall		42,000
Milligan	(135x233)+(32x45)	32,895
Dr.Camille Cosby	(140x75)+(110x90)	20,400
Fine Arts	(70x40)+(125x125)+(70x40)	21,225
MacVicar	(100x55)+(35x92)+(68x45)+(90x45)	15,935
Mail Center/Bookstore		3,780
Physical Plant		3,048
The BDT Suites	(35x60)+(32x114)+(70x60)+(40x45)+(65x140)	20,848
LLC1	(61 x 89)+(80x82)+(63x82)	17,155
LLC2	(54x107)+(100x82)+(115x45)+(99+95)	28,558
Bessie Strong	(44 x 82)	3,608
Laura Spelman	(70 x 118)	8,260
Morehouse James	(40 x 170)	3,500
Abby	(141 x 43) + (48 x 35)	7,743
H.H.	(154x45)+(107x31)	10,247
Manley Hall	(150x45)+(40x40)	8,350
McAlpin	(130x50)+(50x55)	9,250
Cosby Parking Lot	185*220	40,700
Bessie Strong parking lot	(135*150)*1/2	10,125
Tennis Courts	(105*123)+(110*115)	25,565
Spelman Parking Deck	(185*250)	46,250

V. Calculations:

The following calculations were used to find the surface areas of each space: (length x width) = area in square feet. To calculate the gallons for each area, we converted the area of square feet to acres to use the following equation:

$$\frac{\text{calculated sq ft}}{43,560 \frac{\text{sq ft}}{\text{acre}}} = \text{acres}$$
$$\left(\frac{\text{acres} \times \text{rain water event (inches)}}{12 \frac{\text{inches}}{\text{ft}}} \right)$$
$$= \text{acre feet (1 inch deep with stormwater runoff)}$$
$$\text{acre feet} \times 325,000 \frac{\text{gals}}{\text{acre} \times \text{ft}} = \text{gallons}$$

To calculate the amount of rainfall that occurs for each rain event, we spoke with Dr. Nirajan Dhakal, an Assistant Professor of Environmental and Health Sciences Program at Spelman College. The rain gauge that calculated the following constants is located in Newnan, Georgia since 1891. He gave us the following constants for each rain event:

Rain Event (years)	Precipitation (inches)
2	3.15
5	4.15
10	4.81
25	5.65
50	6.26
100	6.87

Source: USHCN (United States Historical Climatological Network)

From there, we calculated the capabilities by distinguishing which buildings' run-off would go to each cistern and then computing the necessary storage for each cistern:

Oval:

An 8,494 sq. ft. cistern with the height of 6 feet will have the capacity to store 380,831 gallons of storm water under the Oval. The storm water will be collected from Packard Hall, Giles Hall, Rockefeller Hall, Reynold's Cottage, Manley Science Center and Tapley Hall, Sisters Chapel, Laura Spelman Residential Hall, Morehouse James Residential Hall, and Abby Residential Hall. The following chart illustrates the amount of storm water run-off for each building during the 25-year rain event:

Oval Cistern	25 year rain event
Packard Hall	31,068
Giles Hall	39,421
Rockefeller Hall	36,169
Reyond's Cottage	18,467
Science Center	119,062
Tapley Hall	25,135
Sisters Chapel	42,998
Laura Spelman	29,016
Morehouse James	12,295
Abby	27,200
TOTAL	380,831

To determine the dimensions of the cistern, the total amount of gallons of storm water from each building running into the Oval cistern was divided by the conversion of gallons per acre feet. Then, we choose 6 feet as the height of the cistern to compute the amount of acres for 6 feet. Finally, we converted the amount to sq feet:

$$\frac{380,831 \text{ gallons}}{325,000 \frac{\text{gallons}}{\text{acre ft}}} = 1.17 \text{ acre ft}$$

$$\frac{1.17 \text{ acre ft}}{6 \text{ ft height of cistern}} = 0.195 \text{ acres at 6 ft deep with storm water}$$

$$0.195 \text{ acres} \times 43,560 \frac{\text{sqft}}{\text{acre}} = \mathbf{8,494 \text{ sq ft}}$$

Tennis Courts:

An 11,238 sq. ft. cistern with the height of 6 feet will have the capacity to store 502,151 gallons of storm water under the tennis courts located next to Read Hall. The storm water will be collected from Read Hall, MacVicar Hall, Life and Learning Center I (LLC1) and LLCII Residential Halls, Bessie Strong Residential Hall, Bessie Strong Parking Lot, and the tennis courts themselves. The following chart illustrates the amount of storm water run-off for each building during the 25-year rain event:

Tennis Courts Cistern	25 year rain event
Read Hall	147,541
MacVicar	55,978
LLC1	60,263
LLC2	100,321
Bessie Strong	12,674
Bessie Strong parking lot	35,568
Tennis Courts	89,807
TOTAL	502,151

Similar, to the cistern under the oval, to determine the dimensions of the cistern, the total amount of gallons of storm water from each building running into the tennis courts cistern was divided by the conversion of gallons per acre feet. Then, we choose 6 feet as the height of the cistern to compute the amount of acres for 6 feet. Finally, we converted the amount to sq feet:

$$\frac{502,151 \text{ gallons}}{325,000 \frac{\text{gallons}}{\text{acre ft}}} = 1.55 \text{ acre ft}$$

$$\frac{1.55 \text{ acre ft}}{6 \text{ ft height of cistern}} = 0.258 \text{ acres at 6 ft deep with storm water}$$

$$0.258 \text{ acres of 6ft} \times 43,560 \frac{\text{sqft}}{\text{acre}} = \mathbf{11,238 \text{ sq ft}}$$

Cosby Parking Lot:

An 11,435 sq. ft. cistern with the height of 6 feet will have the capacity to store 512,072 gallons of storm water under the tennis courts located next to Read Hall. The storm water will be collected from Manley Student Center, Dr. Camille Cosby Academic Building, the Fine Arts Building, Howard-Herald Residential Hall, Manley Residential Hall, Maclin Residential Hall, the Bookstore/ Mail Center, and the Cosby Parking Lot. The following chart illustrates the amount of storm water run-off for each building during the 25-year rain event:

Cosby Parking Lot Cistern	25 year rain event
Manley Center	111,773
Cosby	71,663
Fine Arts	74,561
Mail Center/Bookstor	13,279
H.H.	35,996
Manley Hall	29,333
McAlpin	32,494
Cosby Parking Lot	142,974
TOTAL	512,072

Similar, to the cistern under the oval, to determine the dimensions of this cistern, the total amount of gallons of storm water from each building running into the Cosby Parking Lot cistern was divided by the conversion of gallons per acre feet. Then, we choose 6 feet as the height of the cistern to compute the amount of acres for 6 feet. Finally, we converted the amount to sq feet:

$$\frac{512,072 \text{ gallons}}{325,000 \frac{\text{gallons}}{\text{acre ft}}} = 1.58 \text{ acre ft}$$

$$\frac{1.58 \text{ acre ft}}{6 \text{ ft height of cistern}} = 0.263 \text{ acre at 6 ft deep with storm water}$$

$$0.263 \text{ acre at 6 ft} \times 43,560 \frac{\text{sqft}}{\text{acre}} = \mathbf{11,435 \text{ sq ft}}$$

Spelman Creek ephemeral stream:

Dr. Nirajan Dhakal calculated the Spelman Creek ephemeral stream to be about 3 inches deep (Computation was done using excel solver function):

Data source used to compute 100-yr and 25-yr rainfall depth: United States Historical Climatology Network (USHCN)

***VI:** Volume of runoff from pervious area (in³)*

***V2:** Volume of runoff from impervious area (in³)*

***Q:** Total inflow runoff/discharge to creek (ft³/s)*

***Vs:** Average flow velocity in creek/stream (ft. /s)*

Equation used to compute Vs

Manning equation:

$$V = \frac{k}{n} R_h^{2/3} S^{1/2}$$

Where, V = Velocity, (ft. /s)

*n = Manning's Roughness Coefficient (**n= 0.013 for brick lining**)*

R_h = Hydraulic Radius, (ft.)

*S = Channel Slope, (ft. /ft.) (**S = 3.2 % for our case**)*

*K is a conversion factor (**k=1.49 for English units**)*

Spelman Lot Detainment Vault:

*Culvert box Dimensions: 4ft wide x 6 feet tall x 8 feet long = 192ft³
Spelman College Milligan Parking Lot: 250 feet long*

Each culvert has an inflow pipe of 6 inches and a drain pipe of 2 inches.

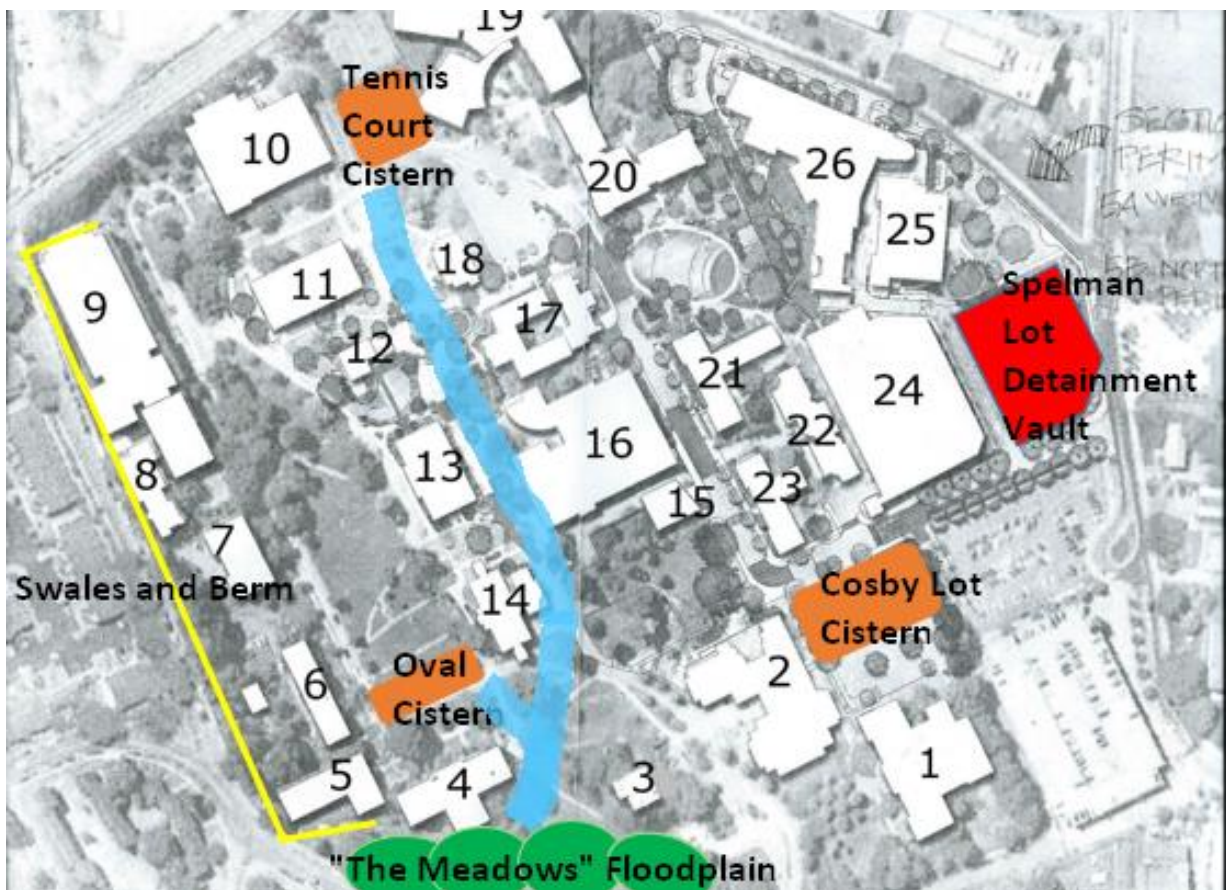
*192 ft³ x 7.48 = 1436.2 gallons being caught in each box
30 x 1436.2 = 43, 084 gallons caught in total area per 240 feet.*

Need to catch a total of 1.5 million gallons:

1.5 million/ 43,086 = 34.8 = 35 lines

4 feet wide x 35 lines = 140 feet area

VI. Spelman College Green Infrastructure Conceptual Plan:

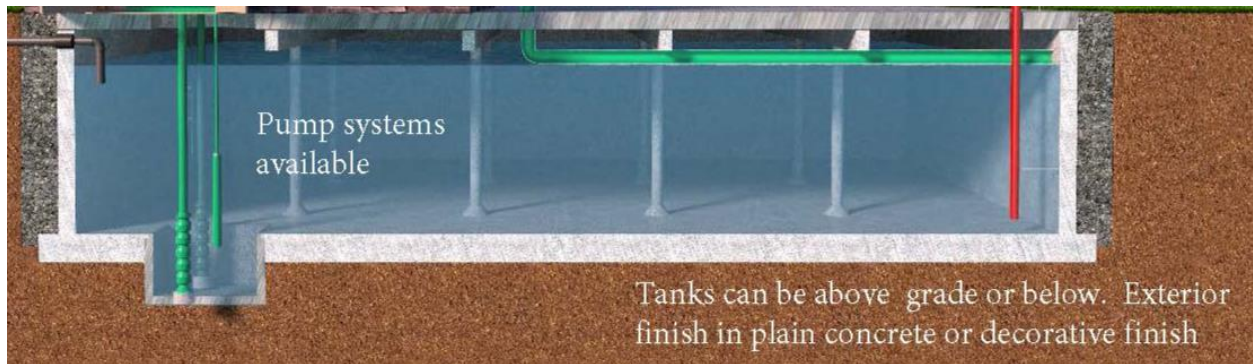


Academic/ Administrative Buildings	Number
Bookstore/ Mail Center	15
Camille Cosby	2
Fine Arts	1
Giles Hall	4
MacVicar	17
Milligan	25
Packard	14
Parking Deck	24
Read Hal	10
Reynold's Cottage	12
Rockefeller Hall	13
Sisters Chapel	11
Science Center	9
Tapley Hall	8

Residential Halls	Number
Abby	5
Bessie Strong	18
BDT Suites	26
Howald-Herrald (HH)	21
Laura Spelman	7
LLC I	20
LLC II	19
Manley	23
McAlpin	22
Morehouse-James	6

Type of Green Infrastructure	
Cistern	Orange
Spelman Vault	Red
Floodplains	Green
Ephemeral Stream	Blue
Spelman Lane Berm & Swale	Yellow

a. *Cisterns*



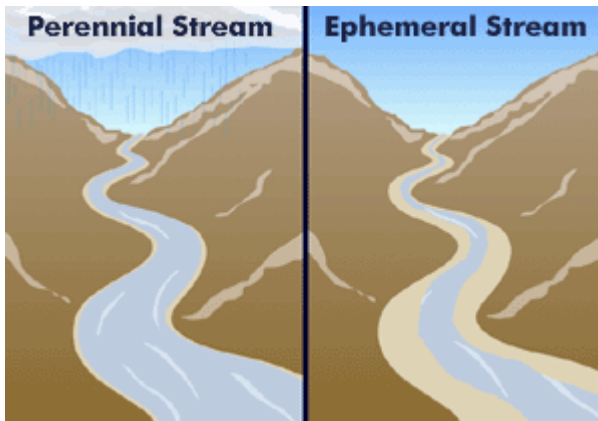
Above is an example of a cistern. Cisterns are underground tanks that store water. Three cisterns are covered in this report.

The Oval Cistern will hold 380,831 gallons of storm water and will be similar in footprint to the size of Packard Hall. Furthermore, the cistern will easily fit in any location under the oval. The depth below the ground elevation will be determined. Excess rain will flow into Spelman Creek ephemeral stream and eventually to the Meadows Floodplain.

The Tennis Courts Cistern will hold 502,151 gallons of storm water and will be similar in footprint to Giles Hall. Any excess water of the 25-year rain event will flow into the Spelman Creek Ephemeral stream and eventually flow into the Meadows Floodplain.

The Cosby Parking Lot Cistern will hold 512,072 gallons of storm water, will be less than 1/3 the size of the Cosby parking lot and is best located at the lowest elevation of the parking lot. The depth below ground will be determined at a later date. The cistern has a relative size footprint of Giles Hall, which is about 11,000 sq ft. Cistern overflow from rain events in excess of the 25-year rain event will be discharged into the Spelman Lot Detainment Vault through a culvert under the entrance driveway.

b. Ephemeral Stream – “Spelman Creek”



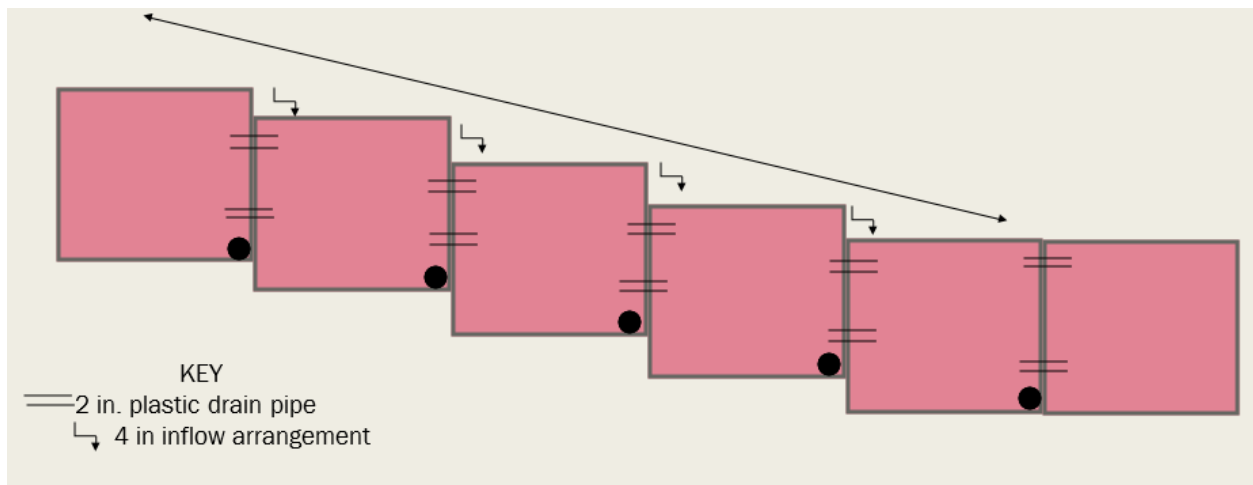
Spelman Creek Ephemeral Stream will run through the campus from South to North, from the tennis courts to the terraced floodplains. Spelman Creek will seldom look different from the way it does today. The word ‘ephemeral’ means the areas will only be filled with water during an intense rainfall, such as the 100-year rain event. Only during rain events exceeding the 25-year rain event will the ephemeral Spelman Creek carry excess storm water. Only for the 100-year rain event will the stream conceive a depth of 2 inches. Its purpose is to allow excess storm water to flow from the tennis courts to the south end of Rockefeller Hall (a low spot behind Sisters Chapel and Reynolds Cottage). The water can flow in a stream constructed near the surface or in a culvert that empties into the stream. Then it will flow to the floodplain. Calculations dealt with 100-year rain event runoff from a 10 acre area, which is more than necessary to stay cautious and include an element of safety.

c. *Terraced Floodplain “The Meadow”*



The Meadow will be located in the green space by Giles Hall and will hold 1.3 million gallons of storm water. It will have four sections that cascade down into a pond, where excess water may flow from the ephemeral stream. It will also be surrounded by berms with a water pipe to allow water to flow into each section

d. Spelman Parking Lot Detainment Vault



The Spelman Parking Lot Detainment Vault will hold 1.8 million gallons of storm water and will be used as a containment area for excess water from the Cosby Parking Lot.

e. Spelman Lane Berm and Swales



The purpose of the Spelman Lane Berm and Swale is to prevent storm water from flowing downhill from behind the east side of campus (behind the Science Center, Laura Spelman, Morehouse-James, and Abby Residential Halls) to Spelman Lane, the street outside of the campus. Because the campus is at a higher elevation from the street, storm water easily flows from the campus and floods into the street.

Table 2: Storm Water Retention and Detention Summary

The following table outlines the amount of gallons each green infrastructure method will capture and the total amount of gallons to be captured once implemented.

Type of Green Infrastructure	Amount of stormwater captures (gallons-based on 25-year rain event)
Spelman College Oval Cistern	380,831
Tennis Court Cistern	502,151
Cosby Parking Lot Cistern	512,072
Terraced Floodplain (Spelman Meadows)	1,343,000
Spelman Parking Lot Underground Detention Vault	1,851,263
Total	~4.6 million gallons of water

VII. Benefits to AUC Community and Students' Learning Experiences:

The purpose of this research is to develop capacity relief for sewer systems and in order to mediate the negative health impacts associated with flooding. Some long-term benefits include system resiliency, capacity enhancement, improved community livability, cleaner air and water, providing water for reuse and for drought, and to lessen the impact of climate change.

We recommend these conceptual plans will be considered over time to not only to improve the community livability in the AUC, but also to ensure improved living conditions for all affected downstream communities. It is our moral responsibility to take action that will help to prevent and reduce impact of flooding on public health.

As students who have been engaged with this project, we have gained an increased understanding of green infrastructure and its application in capturing storm water, engineering concepts, design process, and the importance of moral responsibility.

VIII. References:

- Katherine Baer, “Health Risks of Sewage” American Rivers, Washington D.C.