To: Mike Hoffman  
From: Taylor Batz, Graci Doll, Matt Mueller, Grace Brethel, and Anthony Marazzi  
RE: Storm Water Collection and Reuse at the University of Cincinnati’s Main Campus  
Date: April 20, 2021

Dear Mr. Hoffman,

Storm Delta Engineering Solutions is pleased to present the Storm Water Collection and Reuse at the University of Cincinnati’s Main Campus Proposal. The attached report includes:

- Literature review of historic rainfall data, storage options, and pretreatment options
- Alternative analysis for pretreatment options
- Alternative analysis for storage tank options
- Storage Simulation
- Site Plans
- Economic Analysis

Storm Delta Engineering Solutions is happy to provide design services for the completion of this design proposal and is available to answer any questions as needed. Thank you for your consideration of our proposal.

Respectfully,
Taylor Batz  
Graci Doll  
Matt Mueller  
Grace Brethel  
Anthony Marazzi
Stormwater Reuse at the University of Cincinnati

Main Campus
Executive Summary

Storm Delta Engineering Solutions (SDES) was given the opportunity to work with University of Cincinnati’s Utility Department to help the University mitigate their stormwater runoff through stormwater reuse. Capturing stormwater and reusing it for campus benefit will allow for less water to go into the Metropolitan Sewer District’s combined sewer system, and result in less sewage backups in basements and flooding in areas across campus. Additionally, reusing stormwater will help the University cut down on costs associated with water use on campus.

During the first semester an alternative analysis was performed on pre-treatment and storage options. The result of the alternative analysis was that a hydrodynamic separator would be used as pre-treatment and both the CRC and Fifth Third storage tanks could be used for stormwater collection. Two reuse options were developed. One being to route the reuse water to the utilities plant for water cooling and the other to the new Clifton Court building for toilet water flushing.

During the second semester after discussion and analysis of the options it was decided that the best option would be to use the reuse water for the utilities plant. This is due to the fact that there is already a primary treatment system in place and there was easy access to the routing tunnels for the conveyance of the reuse water. Both of these points would drive down the cost of the project. It was also decided that storm water from both the CRC and Fifth Third tanks would be routed to the utilities plant to maximize the amount of storm water being taken out of the system and reused.

After these decisions were made, routes from the tanks to the utilities plant were developed using Bluebeam Revu, these were approved by the client. Preliminary analyses were carried out to determine the peak flow rates for each storage tank system and to determine how much water could be collected based on historical data. Additionally, a simulation was carried out to show storage changes for dry, average, and wet years. Savings were then calculated by showing how much water would be supplemented to the utilities plant and how much would be taken out of the system. A pump curve was then developed on EPANET. Then different distributors were contacted to budget out the pump, piping, hydrodynamic separator,
screening, and debris baskets costs. An economic analysis was performed to determine the estimated total cost of the project and the breakeven point.

The final designs that were determined for each tank are as follows. The CRC tank will have a hydrodynamic separator as the pre-treatment before the storage tank and a Xylem-Flygt pump after the outlet of the tank. The Fifth Third tank will have debris baskets on each of the three inlets and will also have a dual screen strainer prior to a Xylem-Flygt pump on the outlet of the tank. The stormwater will then go through existing primary treatment at the utility plant. The reuse of water will supplement between 3% and 8% of the utility’s plant total water usage. The reuse will also result in 100% reduction of runoff entering the combined sewer overflow system for both parcels. The total amount saved from reusing the water will be $157,882 per year. The total project cost was $315,462. This results in a payback period of 2 years.
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Introduction

1.1 Scope
The services required for this project were to conduct a review of existing campus stormwater reuse systems and review options for the following: separating existing storm and sanitary sewer collection systems, assessing stormwater storage, determining stormwater treatment for possible reuse for irrigation or toilet use, and reviewing regulatory hurdles for re-using stormwater for the University of Cincinnati campus. The objectives of this project would be to reduce the amount of stormwater runoff going into MSD’s collection system, find a cost-effective way to reuse the storm water runoff using existing storage (this includes pretreatment and primary treatment of water), and assess the action of green infrastructure on campus.

1.2 Background
Located in a combined sewer overflow (CSO) drainage shed, UC’s main campus has some stormwater overflow issues during major storm events. These issues include campus sewers backing up, drains being overwhelmed, and water damage to University buildings, classrooms, and living areas. This has resulted in significant cost to the University. The University of Cincinnati Utilities Department believes that runoff on the main campus can be reused once it is collected into existing detention tanks. This will not only allow runoff to serve a purpose on campus, but also be efficiently mitigated so that it will not enter the CSO drainage shed. In order for the water to be reused it must be treated and conveyed to the proper destination.

1.3 Approach
Storm Delta Engineering researched different technologies and processes for pretreatment, preliminary treatment, and overall reuse projects. Two underground storage tanks that are already in place on campus were analyzed and selected (the CRC and Fifth Third tank.) A preliminary analysis was performed to determine expected stormwater collection for each tank based on historical data, and a simulation was developed to show change in storage over time. An analysis was also performed to determine the peak flow of the system. The stormwater will be collected using existing stormwater sewers going into underground tanks. An outlet control
will be put in place to prevent flow to CSO during storm events (until the capacity of the tank is reached.) This was designed according to an existing plan performed by the Metropolitan Sewer District. Storm Delta then determined the route from the tanks through existing tunnels to the University of Cincinnati’s Utility Plant. A pump curve was developed through EPANET to help determine what pumps were needed. Quotes for the hydrodynamic separator, debris baskets, piping, and pump were then obtained. Site plans were then developed using Bluebeam and Revit. Finally, an economic analysis was performed to determine the breakeven point of the project.

**Alternative Analysis**

This section goes through an alternative analysis for the storage tanks and pre-treatment. For each analysis alternative, every option was rated based on how many options were available with the highest number being the most favorable. Criteria were then weighted based on priorities chosen by Storm Delta Engineering Solutions. These weights were multiplied by each rating and then the sum of the scores were calculated. The final score was used to rank each alternative from the highest score to lowest score.

2.1 Storage Tanks

The four criteria selected for the storage tank analysis were storage capacity, accessibility, drainage potential, and degree of treatment needed. The criteria containing the heaviest weight was drainage potential; this shows how much stormwater runoff will be mitigated and the potential for reuse. The second category was storage capacity. Storage capacity was an important decision factor because there needs to be enough storage to meet the demand requirements of the reuse processes and to store the runoff. The lowest criteria for the analysis was accessibility. Accessibility is something that should be considered but is not seen as a dealbreaker for the project. A comparative analysis for the four criteria is provided in Table 1.
Using data from the comparative analysis in Table 1, an alternative analysis matrix was developed (Table 2).

Table 2: Alternative analysis for storage tank options

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Weight</th>
<th>CRC</th>
<th>Campus Green</th>
<th>5th/3rd</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drainage Potential</td>
<td>3</td>
<td>3 (9)</td>
<td>1 (3)</td>
<td>2 (6)</td>
</tr>
<tr>
<td>Storage Capacity</td>
<td>2</td>
<td>3 (6)</td>
<td>1 (2)</td>
<td>2 (4)</td>
</tr>
<tr>
<td>Accessibility</td>
<td>1</td>
<td>3 (3)</td>
<td>1 (1)</td>
<td>2 (1)</td>
</tr>
<tr>
<td>Unweighted Score (12)</td>
<td>9</td>
<td>3</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Weighted Score (30)</td>
<td></td>
<td>18</td>
<td>6</td>
<td>11</td>
</tr>
</tbody>
</table>

Since the CRC tank and the 5th/3rd tank had the highest weight and unweighted score it was determined that these tanks would be used to hold water for reuse.

2.2 Pre-Treatment
The pre-treatment methods chosen below will only be used for high traffic and larger drainage areas. For lower drainage areas, debris baskets will be used. The four criteria chosen to evaluate the pretreatment options were cost of material and installation, maintenance costs, treatment level, and footprint. The criteria with the biggest weight was chosen to be the treatment level because the total suspended solids (TSS) needs to be reduced as much as possible. Material and installation cost of the system was weighted second because it is
important the system is not too expensive. Maintenance cost was given the third weight because it is important to mitigate recurring cost. Finally, the overall footprint of the system is given the fourth weight. While space needs to be minimized; each alternative could be a possible option when regarding footprint. The estimates for each alternative in Table 3 below. Information for the Ballasted Flocculation material and installation cost were unavailable.

Table 3: Comparative analysis for pretreatment options

<table>
<thead>
<tr>
<th>Comparative Analysis for Pretreatment Alternatives</th>
<th>Ballasted Flocculation</th>
<th>Hydrodynamic Separator</th>
<th>Bioswale</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Alternative</strong></td>
<td><strong>Material Cost</strong></td>
<td><strong>Installation &amp; Shipping</strong></td>
<td><strong>Total Cost</strong></td>
</tr>
<tr>
<td>Ballasted Flocculation</td>
<td>Unavailable</td>
<td>Unavailable</td>
<td>$30,000</td>
</tr>
<tr>
<td>Hydrodynamic Separator</td>
<td>$30,000</td>
<td>included in above</td>
<td>$35,000</td>
</tr>
<tr>
<td>Bioswale</td>
<td>Included in above</td>
<td>Included in above</td>
<td>$35,000</td>
</tr>
<tr>
<td><strong>Treatment Fecal Coliforms</strong></td>
<td>65%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td><strong>Treatment TSS</strong></td>
<td>85%</td>
<td>at least 80%</td>
<td></td>
</tr>
<tr>
<td><strong>Yearly Maintenance Hours</strong></td>
<td>80</td>
<td>8</td>
<td>Once a month or after 1.5 inches of rain</td>
</tr>
<tr>
<td><strong>Yearly Maintenance Cost</strong></td>
<td>$1,600</td>
<td>$160</td>
<td>$1,200.00</td>
</tr>
<tr>
<td><strong>Yearly Pump Cost</strong></td>
<td>$1,000</td>
<td>$1,000</td>
<td>$0</td>
</tr>
<tr>
<td><strong>Total Maintenance Cost per Year</strong></td>
<td>$2,600</td>
<td>$1,160</td>
<td>$1,200</td>
</tr>
<tr>
<td><strong>Footprint Above Ground</strong></td>
<td>N/A</td>
<td>N/A</td>
<td>1000</td>
</tr>
<tr>
<td><strong>Footprint Below Ground</strong></td>
<td>Largest due to Low Flow Required</td>
<td>Compact</td>
<td>Medium (Not a lot of Area on Campus)</td>
</tr>
<tr>
<td><strong>Total Footprint</strong></td>
<td>N/A</td>
<td>N/A</td>
<td>6000 (1000 sqft, 6ft deep)</td>
</tr>
</tbody>
</table>

Based on the information in Table 3, an alternative analysis matrix was developed (Table 4).
Since the hydrodynamic separator had the highest unweighted score, it was determined that this would be used for pretreatment in the high trafficked and large drainage area for CRC. For the Fifth Third tank the pretreatment can be less stringent and there are three different inlets into the tank. Thus, debris baskets will be used to reduce cost. Which is a typical method of “pre-treatment” for areas that need less filtering.

**Preliminary Analysis**

### 3.1 Surface Runoff Analysis

The land area of the University of Cincinnati’s 200 acre main campus consists of a variety of run-off generating surfaces. In order to calculate the amount of run-off generated on main campus, an analysis of these surfaces was required. The campus was divided up by surface types: brick sidewalk, concrete sidewalk, rooftops, and green space. The total area of UC’s main campus was calculated as well as the drainage areas for each of the storage tanks located on campus. The polygon area tool in Bluebeam Revu was used to manufacture precise areas for each surface type on campus (Table 5). The total average runoff coefficient was determined by calculating the percentage of the total area for each respected surface type and multiplying it by the runoff coefficient. These values were then summed together in order to find the overall average coefficient used for the runoff volume (see Appendix A, Equation 1).
In order to determine the runoff coefficient for each drainage area, the same process was followed above, except for smaller areas. This resulted in 0.628 for the CRC tank drainage area and 0.875 for the Fifth Third tank drainage area. It makes sense that CRC would be similar to the whole campus because the drainage area is much larger and contains similar surface types. The runoff coefficients will be used in determining the peak flow in Section 3.3, the recovered runoff volume for both tanks in Section 3.4, and to determine the amount of runoff going into the tanks for the storage simulation in Section 3.5.

### 3.2 Stormwater Collection

In order to collect stormwater for reuse the existing inlet and outlet locations of the storage tanks needed to be determined. Both of the tanks, CRC and Fifth Third, have existing connections. Both the CRC and Fifth Third tanks have a stormwater sewer inlet pipe and an outlet pipe that connects to the surrounding combined sewer overflow (CSO) system. Instead of adding more pipes to the system to collect and route stormwater to the tanks, the inlets already in place will continue to be utilized and the outlets will be controlled. The University of Cincinnati Utilities and MSD currently have a project for outlet control of the CRC tank. A gate will be installed on the 12” low flow outlet that will be controlled through a level sensor in the tank, downstream sensors, and weather forecast information. This gate will be remotely communicated to the MSD SCADA system, which will allow it to take into account the factors mentioned above. By controlling the outlets during storm events, the amount of stormwater being collected will be able to be managed and the amount being reused will be able to be tracked.
3.3 Time of Concentration and Peak Flow Rate

In order to size different preliminary treatment devices, the peak flow needs to be determined. To do this the time of concentration for the drainage area for each of the tanks was determined by creating a path through the drainage area. This path was divided into sheet flow, shallow concentrated flow, and pipe flow. The information for each of these paths was then put into HydroCAD which then calculated the time of concentration. After the time of concentration was determined, the rainfall intensity based on the time of concentration was calculated. The standards equations to calculate the rainfall intensity were found in Hamilton County Code Article 07. Once the rainfall intensity was determined for both watersheds the rational method \( Q = C_i A \) was used to determine the peak flow rate (see Appendix A Equation 2.) The coefficients \( C \) from Section 3.1 were used in the rational method calculation. As stated in Section 3.1, the CRC coefficient is 0.628 and the Fifth Third coefficient is 0.875.

Table 6: Time of Concentration Values

<table>
<thead>
<tr>
<th>Return Periods (years)</th>
<th>Peak Rainfall (in/hr)</th>
<th>Peak Q (cfs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>2.4</td>
<td>14.5</td>
</tr>
<tr>
<td>5</td>
<td>2.8</td>
<td>17.2</td>
</tr>
<tr>
<td>10</td>
<td>3.4</td>
<td>20.5</td>
</tr>
<tr>
<td>25</td>
<td>4.0</td>
<td>24.3</td>
</tr>
<tr>
<td>50</td>
<td>4.6</td>
<td>27.9</td>
</tr>
<tr>
<td>100</td>
<td>5.0</td>
<td>30.1</td>
</tr>
</tbody>
</table>

3.4 Historical Rainfall Analysis

Using the historical rainfall data given by MSD last semester, a historical statistical analysis was completed to determine how much rain can be expected. A total rainfall amount in inches was summed for every month during the 16 year period. Next, a box and whisker plot was created for each month with the sixteen totals, any outliers were identified, and an average rainfall was taken. After having monthly average rainfall data, the runoff coefficients from Section 3.1 were used to determine the estimated runoff recovery of rainfall in each drainage area in inches (see Appendix A Equation 3). The monthly average volume was determined using the estimated...
runoff recovery and the drainage area volumes. Monthly water usage volumes were provided by the utilities plant and the monthly supplemental percentage is outlined in Table 7.

### Table 7: Average Monthly Rainfall and Monthly Supplemental Percentage

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>2.856</td>
<td>2.499</td>
<td>1.793</td>
<td>399.09</td>
<td>624.29</td>
<td>14,088</td>
<td>7.26%</td>
</tr>
<tr>
<td>February</td>
<td>3.395</td>
<td>2.971</td>
<td>2.132</td>
<td>474.53</td>
<td>742.31</td>
<td>19,811</td>
<td>6.14%</td>
</tr>
<tr>
<td>March</td>
<td>4.437</td>
<td>3.883</td>
<td>2.787</td>
<td>620.15</td>
<td>970.09</td>
<td>21,916</td>
<td>7.26%</td>
</tr>
<tr>
<td>April</td>
<td>4.815</td>
<td>4.213</td>
<td>3.024</td>
<td>672.96</td>
<td>1052.70</td>
<td>24,561</td>
<td>7.03%</td>
</tr>
<tr>
<td>May</td>
<td>4.185</td>
<td>3.662</td>
<td>2.628</td>
<td>584.82</td>
<td>914.82</td>
<td>26,742</td>
<td>5.61%</td>
</tr>
<tr>
<td>June</td>
<td>4.764</td>
<td>4.169</td>
<td>2.992</td>
<td>665.83</td>
<td>1041.56</td>
<td>27,004</td>
<td>6.32%</td>
</tr>
<tr>
<td>July</td>
<td>4.349</td>
<td>3.805</td>
<td>2.731</td>
<td>607.79</td>
<td>950.75</td>
<td>36,379</td>
<td>4.28%</td>
</tr>
<tr>
<td>August</td>
<td>3.387</td>
<td>2.964</td>
<td>2.127</td>
<td>473.34</td>
<td>740.44</td>
<td>36,889</td>
<td>3.29%</td>
</tr>
<tr>
<td>September</td>
<td>3.704</td>
<td>3.241</td>
<td>2.326</td>
<td>517.62</td>
<td>809.71</td>
<td>35,013</td>
<td>3.79%</td>
</tr>
<tr>
<td>October</td>
<td>3.675</td>
<td>3.216</td>
<td>2.308</td>
<td>513.66</td>
<td>803.52</td>
<td>28,813</td>
<td>4.57%</td>
</tr>
<tr>
<td>November</td>
<td>3.393</td>
<td>2.969</td>
<td>2.131</td>
<td>474.24</td>
<td>741.84</td>
<td>21,137</td>
<td>5.75%</td>
</tr>
<tr>
<td>December</td>
<td>3.729</td>
<td>3.263</td>
<td>2.342</td>
<td>521.20</td>
<td>815.31</td>
<td>16,813</td>
<td>7.95%</td>
</tr>
</tbody>
</table>

### 3.5 Storage Simulation

A storage simulation was created in Microsoft Excel so that the University of Cincinnati can visualize what the storage in the tanks could look like during an average, wet, and dry year. The averages from Table 6 were compared to the rainfall data for each year to determine what years would be used for the simulation. It was decided that 2006 most closely represented an average year, 2014 most closely represented a dry year, and 2011 most closely represented a wet year. In the simulation the rainfall data was summed to become daily amounts of rain over the year. It was then converted to runoff by multiplying it by the runoff coefficient from Section 3.1 for each drainage area and then it was converted to gallons per day (GPD.) The runoff GDP is the inflow for the tank. The outflow was determined by taking the total daily plant demand for that month and subtracting it by the amount the utilities plant would need to receive from GCWW. For the different weather conditions, the amount that the utilities plant would receive...
from GCWW would fluctuate due to there being an increase or decrease of inflow. For the dry year simulation, the utility plant on average would get 7% of their water from the tanks and 93% of their water from GCWW. For the average year simulation, the utility plant on average would get 10% of their water from the tanks and 90% of their water from GCWW. For the wet year simulation, the utility plant on average would get 23% of their water from the tanks and 77% of their water from GCWW. These percentages were determined by stopping the simulation once the storage at any point of the year was below the max amount of combined storage, which is around 1,000,000 gallons. This can be observed in the storage graphs below, where storage equals inflow minus outflow. The graph shows storage in gallons versus time on the bottom x-axis and daily rainfall in inches versus time on the top x-axis.

![Dry Year Storage Simulation](image)

*Figure 1: Dry Year Storage Simulation*
Figure 2: Average Year Storage Simulation

Figure 3: Wet Year Storage Simulation

An example calculation for the simulation can be found in Appendix A, Equation 4. For each simulation there are months that have larger storage peaks. During these months, there is a larger amount of storage due to an increased amount of rainfall. Since there is more water in the tanks, the utilities plant could draw more water and therefore the percent supplemented by
the tanks would be larger than the base percent mentioned above. For instance, during a wet year for April 2011 the utilities plant could pull more water and thus for that month the percent supplemented would be larger 23%. The graphs also have areas where there is zero storage, this means that during those times the amount sent to the utilities plant pulled all the water out of the tank or there was a dry spell. Thus, the percent supplemented would be at the base percent or below it. By looking at the rainfall data on the top axis, it can be observed if there was a dry spell or if all the water was just taken to the utilities plant. All of these graphs never have an instance where the runoff goes above the maximum storage amount. Therefore, it is correct to assume that all runoff from these drainage areas can be collected, stored, and used.

**Design**

**4.1 Hydrodynamic Separator Design (Appendix C - Figure C1)**

The hydrodynamic separator (HDS), Cascade Separator-8, by Contech Engineering Solutions was designed to separate and trap debris, sediment, and hydrocarbons from stormwater runoff before entering the CRC detention tank. The stormwater will enter the HDS through a 20 inch inlet pipe where the water creates a swirling vortex causing floatable debris to be captured in the separation chamber and sediment to settle in an isolated sump. This design allows the Cascade Separator-8 to treat high flow rates with a small environmental footprint. The campus area where the CRC storage tank is located has a large drainage area of 9.59 acres and is a heavily trafficked part of campus. The Cascade Separator-8 will be able to handle the large volumes of runoff and trash that this area of campus will produce. These two factors have determined the Cascade Separator-8 to be installed at manhole D31, about 110 feet from the inlet of the CRC storage tank. See Appendix B, Figures B1 and B2 for placement and Appendix C, Figure C1 for sizing.
4.2 Strainer Design

4.2.1 Debris Basket (Appendix C - Figure C2)

Since the Fifth Third storage tank has a smaller drainage area than that of the CRC detention tank and the storage tank has three inlets, it was decided that a debris basket would be installed rather than a hydrodynamic separator for collection of large solid material. In order to prevent debris from entering the storage tank a B1B trash basket, by Halliday Products, will be placed at the inlets of the Fifth Third storage tank. This provides a cheaper alternative to screen out solids that may damage the pump equipment. The trash basket is placed on rails that work as a hoist to easily raise and lower the basket for cleaning purposes. See Appendix B, Figures B3 and B4 for placement and Appendix C, Figure C2 for sizing.

4.2.2 Duplex Strainer (Appendix C - Figure C3)

A Keckley carbon steel 6 inch duplex strainer will be installed at the outlet of the CRC and Fifth Third storage tanks, prior to the pumping system, to prevent any small solids or sedimentation from passing through the pump, which may cause clogging or pump damage. The duplex strainer will be manufactured with positive sealing bronze diverters in order to safely handle the suction service provided by the water pump. In addition, the two separate basket housings allow for continuous flow, so the system never has to be shut down for cleaning and/or maintenance. Keckley duplex basket strainers are designed with knob type covers for tool free removal of the baskets. Also, the handle to divert the water flow is designed to be over the in-service chamber allowing for easy cleaning and removal of the off-duty chamber basket. The selected duplex strainer will also have flanged rather than threaded ends on both the inlet and outlet pipes for ease of installation. See Appendix B, Figures B1, B2, B3, and B4 for placement and Appendix C, Figure C3 for design.

4.3 Pump Design (Appendix C - Figure C4 & Figure C5)

In order to designate a pump for the system, the total head loss from the tank to the utilities plant needed to be determined. Before determining the head loss, the characteristics of the system must be decided. The flow rate of 150 gallons per minute was specified from the client.
The piping used will be carbon steel with an inside diameter of 6 inches, resulting in a velocity of 1.7 feet per second. The routes from CRC and Fifth Third were drawn (see Figure 6), the number of 45 and 90 degree turns were counted, the lengths were measured, and the elevation changes were determined. Minor losses due to turns, contraction from tank to pipe, and expansion from pipe to the utility’s tank were all included in the equation to ensure better accuracy. Next, the frictional factor was determined using Von Karmen’s equation as an initial guess and iterating using Colebrook’s Equation. Once the frictional factor was obtained, the Darcy Weisbach Equation was used to determine the dynamic head (see Appendix A, Equation 5). The static head is the difference between the elevation of the tank and the utilities plant. The total head of the system in feet is the sum of the static and dynamic head. The total head for each route as well as the horsepower needed for each pump is outlined in Table 8.

Table 8: Total Head and Total Horsepower Needed for Each Route

<table>
<thead>
<tr>
<th>Route</th>
<th>Head (ft)</th>
<th>Horsepower</th>
</tr>
</thead>
<tbody>
<tr>
<td>CRC to Utilities</td>
<td>192</td>
<td>7.27</td>
</tr>
<tr>
<td>5th/3rd to Utilities</td>
<td>157</td>
<td>5.94</td>
</tr>
</tbody>
</table>

Once the total head for each tank was determined, the one point method in EPANET was used to obtain pump curves. The total head in feet and the desired flow rate of 150 gallons per minute were inputted to obtain adequate pump curves. After the pump curves were developed, a salesperson at BL Anderson Company was consulted. It was determined that Xylem-Flygt pumps with an NZ configuration would best fit this application. The pumps will be contained in a pump house directly next to the tank, with the dimensions of twenty-three feet tall, twelve feet long, and six feet wide, with walls one foot thick. This will make it accessible from ground level and provides plenty of room for the pump to be maintained.
4.4 Conveyance Design

In order to convey the stormwater collected in the CRC and Fifth Third tanks to the Utility Plant, 0.83 miles (4,382.4 feet) of carbon steel pipe is to be installed. This length was measured from routes proposed by Storm Delta Engineering Solutions and approved by the client; routes shown in Figure 6. These routes were based off the existing university tunnel system and are the shortest distances possible with the least amount of excavation needed. For the material of the pipe, originally SDE considered PVC piping due to it being inexpensive. However, PVC has a low melting point and the pipes could come in contact with high temperatures in the university tunnel system. To account for the heat in the tunnel system SDE decided that carbon steel would be the best material for the conveyance system due to being durable and heat resistant.
Figure 6: Conveyance Routes to Utilities Plant

For both the CRC tank and the Fifth Third tank an outlet pipe will need to be installed and connected to the university tunnel system. As previously mentioned, the outlet pipe will be 6” carbon steel and connected to a duplex strainer then a Xylem-Flygt pump. The height of this outlet pipe will be about 2’ above the bottom of the tank. This height was decided so that the maximum amount of stormwater can exit the tank without bringing extra debris that has settled to the bottom of the stormwater collection tanks. See appendix B, Figures B1-B4 for corresponding site plans of conveyance layout to tanks.

Economic Review

5.1 Savings

Using the historical rainfall analysis in Section 3.2, the monthly and annual cost of water savings were calculated. The City of Cincinnati charges commercial institutions $2.25 per gallon for every gallon used after 600 CCF of water. In order to get the cost amount saved on water usage, the gallons supplemented from the stormwater was multiplied by $2.25.
Table 8: Monthly and Annual Savings on Water Usage at the Utilities Plant

<table>
<thead>
<tr>
<th>Month</th>
<th>Utility Avg Usage (CCF)</th>
<th>Water Supplemented (CCF)</th>
<th>Cost Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>14,088</td>
<td>1,083.56</td>
<td>$2,438.01</td>
</tr>
<tr>
<td>March</td>
<td>21,916</td>
<td>1,683.74</td>
<td>$3,788.42</td>
</tr>
<tr>
<td>April</td>
<td>24,561</td>
<td>1,827.12</td>
<td>$4,111.02</td>
</tr>
<tr>
<td>May</td>
<td>26,742</td>
<td>1,587.82</td>
<td>$3,572.60</td>
</tr>
<tr>
<td>June</td>
<td>27,004</td>
<td>1,807.78</td>
<td>$4,067.51</td>
</tr>
<tr>
<td>July</td>
<td>36,379</td>
<td>1,650.18</td>
<td>$3,712.91</td>
</tr>
<tr>
<td>August</td>
<td>36,889</td>
<td>1,285.14</td>
<td>$2,891.57</td>
</tr>
<tr>
<td>September</td>
<td>35,013</td>
<td>1,405.37</td>
<td>$3,162.08</td>
</tr>
<tr>
<td>October</td>
<td>28,813</td>
<td>1,394.63</td>
<td>$3,137.92</td>
</tr>
<tr>
<td>November</td>
<td>21,137</td>
<td>1,287.58</td>
<td>$2,897.06</td>
</tr>
<tr>
<td>December</td>
<td>16,813</td>
<td>1,415.09</td>
<td>$3,183.95</td>
</tr>
<tr>
<td><strong>Total per year</strong></td>
<td><strong>289,355</strong></td>
<td><strong>16,428.01</strong></td>
<td><strong>$36,963.02</strong></td>
</tr>
</tbody>
</table>

In addition, the University will save money from a reduction in stormwater charge on both areas of campus. The Fifth Third “watershed” has a current monthly stormwater cost of $3,129. It is estimated the utilities plant will capture and reuse 100% of the stormwater from this parcel, saving the University $37,554 per year. The CRC “watershed” has a current monthly stormwater cost of $6,947. The estimated capture and reuse percentage is 100%, which saves the University $83,365 per year. The total savings from water usage and stormwater cost reduction is $157,882 per year.

5.2 Project Cost

Various quotes from businesses were used to estimate the projected costs of the project (Appendix D). The total material cost estimate is $242,663, while the total project cost is
estimated to be $315,462. The construction and project management costs are estimated to be 30% of the total material costs. The construction costs would include the installation of the piping, debris baskets, pumps, hydrodynamic separator, new tank outlets, and construction of pump houses. The estimate of 30% is conservative due to the fact that the University employs plumbers, engineers, and other maintenance workers who may be able to assist the project at a lower cost than a contractor. A breakdown of the project costs can be seen in Table 8.

### Table 8: Overall Project Costs

<table>
<thead>
<tr>
<th>Description</th>
<th>Quantity</th>
<th>Units</th>
<th>Cost per Unit</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trash Basket (5th/3rd)</td>
<td>3</td>
<td>EA</td>
<td>$775</td>
<td>$2,325</td>
</tr>
<tr>
<td>Strainer 6 inches (5th/3rd and CRC outlets)</td>
<td>2</td>
<td>EA</td>
<td>$23,012</td>
<td>$46,024</td>
</tr>
<tr>
<td>Hydrodynamic Separator (CRC)</td>
<td>1</td>
<td>EA</td>
<td>$30,000</td>
<td>$30,000</td>
</tr>
<tr>
<td>Pipe from 5th/3rd to Utilities</td>
<td>2112</td>
<td>LF</td>
<td>$12</td>
<td>$25,344</td>
</tr>
<tr>
<td>Pipe from CRC to Utilities</td>
<td>2112</td>
<td>LF</td>
<td>$12</td>
<td>$25,344</td>
</tr>
<tr>
<td>Pipe Delivery Cost</td>
<td>2</td>
<td>EA</td>
<td>$2,800</td>
<td>$5,600</td>
</tr>
<tr>
<td>Excavation/Backfill from Tank to Tunnel</td>
<td>2</td>
<td>LS</td>
<td>$2,400</td>
<td>$4,800</td>
</tr>
<tr>
<td>New Tank Outlet</td>
<td>2</td>
<td>EA</td>
<td>$1,150</td>
<td>$2,300</td>
</tr>
<tr>
<td>Pump House</td>
<td>2</td>
<td>LS</td>
<td>$6,000</td>
<td>$12,000</td>
</tr>
<tr>
<td>Pumps and Controls</td>
<td>2</td>
<td>LS</td>
<td>-</td>
<td>$88,926</td>
</tr>
<tr>
<td>Construction and PM contingency</td>
<td>30%</td>
<td>LS</td>
<td>-</td>
<td>$72,799</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>$315,462</strong></td>
</tr>
</tbody>
</table>

### 5.3 Payback Period

The payback period was determined by taking the total project costs divided by the yearly saving. With yearly savings of $157,882, the project will take only 2 years to pay for itself in savings. Because the payback period is so short, interest and inflation are not considered in the calculation.
Conclusion

The final designs that were determined for each tank are as follows. The CRC tank will have a hydrodynamic separator as the pre-treatment before the storage tank, dual screen strainer prior to the pump and Xylem-Flygt pump after the outlet of the tank. The Fifth Third tank will have debris baskets on each of the three inlets and will also have a dual screen strainer prior to a Xylem-Flygt pump on the outlet of the tank. The stormwater will then go through existing primary treatment at the utility plant. The reuse of water will supplement between 3% and 8% of the utility’s plant total water usage. The reuse will also result in 100% reduction of runoff entering into the combined sewer overflow system for both parcels. The total amount saved from reusing the water will be $157,882 per year. The total project cost was $315,462. This results in a payback period of 2 years.
References


Vision Statement

Company: Storm Delta Engineering Solutions

Vision Statement: Offering stormwater management solutions rooted in professional, ethical and sustainable practices.
Personal Statements

Taylor Batz (Data Analyst)

Taylor is a fifth year environmental engineering student at the University of Cincinnati. She has co-op experience with the Ohio Department of Transportation, Terracon Consulting, and Scwhan’s Food Company. Taylor spent her first co-op working in the construction management and project engineering field, followed by two co-ops working in environmental consulting consisting mostly of Phase I and II and OEPA compliance fieldwork and reports. Finally, she finished her final co-op working as a Quality Engineer remotely for Schwan’s.

Grace Brethel (Bluebeam Coordinator)

Grace is a fifth year Environmental Engineering Student at the University of Cincinnati. She completed three co-op rotations with AECOM as a Wastewater co-op working on stormwater system design, one rotation with Turner working on a jobsite as an assistant engineer, and one rotation as a BIM Operator with Mid-City Electric working on clash detection and design of electrical systems. Through these co-ops she has gained significant experience using ArcGIS, Revit, AutoCAD Civil 3D, PC SWMM, and Bluebeam. Her area of interest includes sustainable stormwater management practices and implementation of Green Infrastructure in urban areas.
Graci Doll (PM)

Graci is a fifth year environmental engineering student at the University of Cincinnati. She has previous co-op experience at Fishbeck, Greater Cincinnati Metropolitan Sewer District, and Strand Associates. Graci’s first three co-ops were at Fishbeck in the Water and Wastewater Department. Two of those co-ops she was contracted to MSD in the Remote Monitoring Department. Her final co-op was at Strand Associates in the Municipalities department. In all the co-ops she worked on different water and wastewater design and analysis projects. Her most recent co-op however, focused on stormwater management design and analysis. Through these experiences she has gained skills in AutoCad 3D, XP SWMM, HydroCAD, and ArcGIS.

Anthony Marazzi (Project Engineer)

Anthony is currently in his fifth year of environmental engineering at the University of Cincinnati. He has completed his five co-op rotations at Valeo Climate Control and the Ohio Department of Transportation. The first three rotations were with Valeo Climate Control where he worked in the quality lab assisting with quality control and the creation of part tolerances using Calypso CMM software. The second rotation with the Ohio Department of Transportation was spent within the environmental planning department. Anthony assisted with the GIS mapping for new construction projects and worked as a NEPA process coordinator.
Matt Mueller (Project Engineer)

Matt is currently in his fifth year of environmental engineering at the University of Cincinnati, where he has completed five co-op rotations at New Line Structures, KBD Technic, and Helix Electric. The first rotation was with NLS in which he assisted the project engineers and managers with daily site inspections in order to ensure development of the project site. Matt worked two semesters with KBD Technic, an engineering and consulting firm specializing in air system testing, where he assisted with site visits and completing client reports. In his most recent co-op, he aided Helix Electric project managers with submittals, RFIs, MOPs, and takeoffs for his respected projects.
Taylor Batz

School Address 2720 Glendorn Ave, Apt. 3  Permanent Address 918 James Rd.
Cincinnati Ohio, 45219  Lancaster Ohio, 43130  batzt@mail.uc.edu

EDUCATION

University of Cincinnati, Cincinnati, Ohio  Expected 2021
  • Environmental Engineering  GPA 3.56/4.0
  • Cincinnati Scholar

University of Cincinnati, Cincinnati, Ohio  Expected 2021
  • ACCEND, Master of Business Administration  GPA 3.89/4.0
  • Attending MBA classes simultaneously to undergraduate classes

Lancaster High School, Lancaster, Ohio  May 2016
  • Graduate of Marketing and Business Education Program, 2015-2016  GPA 3.8/4.0

EXPERIENCE

Global Supply Chain Engineering Intern – Sehwan’s Company, Minneapolis, Minnesota  June 2020- August 2020
  • Created an experimental design process for a manufacturing plant
  • Wrote Food Defense and Food Safety plans needed for SFQ Audit for multiple manufacturing plants
  • Worked with plant managers to organize audit documentation into centralized database

Engineering Technician Intern – Terracon Consultants Inc., Cincinnati, Ohio  August 2018-March 2020
  • Complete different types of inspections and environmental field testing
  • Made recommendations to clients based on laboratory data analyzed in excel
  • Wrote Phase I Environmental Site Assessment reports
  • Led office in a company-wide safety training initiative
  • Worked part time (20 hours per week) during school semester to help finish projects

College Intern – Ohio Department of Transportation, Hamilton County, Ohio  January 2018- August 2018
  • Collaborated with supervisor and crew to quickly come up with solutions for problems encountered on the job
  • Managed work crew on day-to-day operations
  • Organized and filed all necessary documentation for completion of job
  • Worked part time (15 hours per week) during school semester to help finish projects

ACTIVITIES

Bearcat Buddies  January 2020-present
  • Tutored elementary Cincinnati Public School students weekly in multiple subjects

Women in Leadership  January 2018-present
  • Attend monthly meetings and networking events for women pursuing their master’s degree

Kappa Delta Sorority  January 2018-September 2019
  • Contributed on various committees and attended volunteer-oriented events

Society of Environmental Engineers  January 2017-September 2018
  • President and coordinator of the project planning committee

SKILLS

• Microsoft Office
• MATLAB
• ArcGIS
• Asbestos Hazard Evaluation Specialist in the state of Ohio
• Asbestos Inspector in the state of Indiana
Grace Brethel  
brethegm@mail.uc.edu / (614) 623-0848

EDUCATION
University of Cincinnati, Cincinnati, Ohio  
Bachelor of Science in Environmental Engineering  
Class of 2021

Upper Arlington High School, Upper Arlington, Ohio  
Class of 2016

EXPERIENCE
BIM Operator Intern, Mid-City Electric, Columbus, OH  
May 2020-August 2020
• Developed documents to track project completion across multiple departments
• Generated drawing sheets in Revit for large data centers, high-rise hotel, and library building
• Utilized Revit Dynamo to streamline workflow
• Created families in AutoCAD to be utilized in Revit for use by multiple BIM Operators

Engineering Assistant, Turner Construction, Cincinnati, OH  
January 2020-May 2020
• Prepared and monitored asset management document for the owner
• Facilitated communication between subcontractors and the owner for requests for information
• Reviewed and tracked subcontractor submittals for compliance with specifications for project close-out
• Actively participated in field coordination meetings and assisted in preparation of meeting minutes

Water/Wastewater Intern, AECOM, Columbus, OH  
May 2019-August 2019

Water/Wastewater Intern, AECOM, Cincinnati, OH  
August 2018-December 2018

Water/Wastewater Intern, AECOM, Columbus, OH  
January 2018-April 2018
• Modeled water mains, storm sewer lines, and structures, in PCSWMM, AutoCAD, and ArcGIS
• Mapped existing waterlines for replacement associated with the Water and Sewage Department of Detroit
• Created and edited maps for incorporation into product submittals to display project plan
• Generated maps of Green Infrastructure using ArcGIS to facilitate data collection
• Created and modified Access Databases to track status of required work to meet clients’ needs

SKILLS
MATLAB, Microsoft Office (Word, Excel, PowerPoint, Access), ArcGIS, AutoCAD Civil3D, PCSWMM, Revit, Navisworks, Trimble Sysque, Revit Dynamo, Certified SCUBA diver

ACTIVITIES AND INVOLVEMENT
College/Community:
Tapped Member, Rho Lambda Honorary  
October 2019-Present
• Collaborate with a diverse group of leaders on campus

Roar Guide, University of Cincinnati  
November 2017-Present
• Lead weekly campus tours for 10-30 prospective students and family members
• Effectively communicate facts and statistics for a two-hour tour
• Recruit current students to join ROAR

Vice President Standards, Kappa Kappa Gamma Sorority  
November 2016-May 2020
• Managed the standing and academic achievements of a chapter of 150 women
• Led a seven-member committee to prepare morale boosting and educational events with a $2000 budget
• Conducted individual meetings with members who are not maintaining chapter standards
• Assisted chapter members in creating a recovery plan to achieve chapter standards

Alumni Council Member, Central Ohio Leadership Academy  
July 2015-Present
• Facilitate small group meetings
• Present on alumni panels throughout the year

AWARDS
Gloria S Goering Giving Forward Award-Scholarship  
October 2018
Graci Doll
5585 Lucenna Dr.
Cincinnati, OH 45238

(513)-638-2479
dollgm@mail.uc.edu

Skills
AutoCAD 2019 with Civil 3D • Matlab • Microsoft Office • ArcGIS • XPSWMM • Technical Writing • Communication

Education

University of Cincinnati | Cincinnati, Ohio
Carl H. Lindner College of Business
Master of Business Administration
- ACCEND Program
Spring 2019 – Spring 2021
4.0 / 4.0

University of Cincinnati | Cincinnati, Ohio
College of Engineering and Applied Science
Bachelor of Science, Environmental Engineering
- Recipient of Dean’s List for the years of 2017, 2018, and 2019
Fall 2016 – Spring 2021
3.7 / 4.0

Experience

Strand Associates, Inc. | Cincinnati, Ohio
Municipal Engineering Co-op
Summer 2020
- Developed modeling skills to assist with three different stormwater and water projects by using XPSWMM, HydroCAD, and WaterGEM
- Assisted with a community capability assessment for an upcoming municipal project
- Performed an alternative cost analysis for disinfection systems for a wastewater treatment plant project.
- Strengthened project management skills by assisting with project research, budgeting, and organization tasks

University of Cincinnati
Research Position
Fall 2019 - Present
- Researching an innovative and cost-effective solution for removal of Perfluorooctanoic acid (PFOA) and Perfluorooctanesulfonic acid (PFOS) families from water
- Run experiments in a lab to determine ways to functionalize sawdust that will remove PFOA and PFOS from water

Fishbeck | Cincinnati, Ohio
Engineering Co-op – Contracted to Greater Cincinnati MSD
Fall 2018 and Summer 2019
- Developed problem solving skills to troubleshoot issues for over 100 telemetry and flow monitor devices
- Analyzed flow monitor data using Ayyeka to configure remote monitoring devices for over 200 project sites
- Drafted drawings and existing utility design for three municipal projects using AutoCAD Civil 3D
- Assisted in field work such as surveying and water sampling
- Applied research skills to find information on permitting for multiple municipal project
- Wrote 30 procedures on different tasks done at MSD by utilizing technical writing and communication skills

- Wrote 30 procedures on different tasks done at MSD by utilizing technical writing and communication skills

- Assisted in drafting drawings for watermain, sewer, and pump station project plans for four different municipal projects using AutoCAD Civil 3D
- Created 24 utility letters to inform municipal utilities of project areas
- Enhanced organizational skills by working in Excel sheets to calculate flow data and create graphics for presentation for various projects
- Collaborated with three coworkers to collect flow monitor data through flow monitor installs

Spring 2018
EDUCATION

University of Cincinnati
Class Of 2021
Major: Environmental Engineering
Current GPA: 2.9

EXPERIENCE

Quality Engineer Co-op, Valeo Climate Control (Cincinnati, OH)
May 2018 – August 2019
- Full-Time
- Wrote new processes for testing methods
- Presented results to quality team including international visitors
- Maintained historical data to determine part tolerances
- Examined deficiencies on parts sent into the Validation Lab

Environmental Engineer, Ohio Department of Transportation (Cincinnati, OH)
January 2020 – August 2020
- Full-Time
- Coordinated NEPA process for upcoming projects
- Created mapping using ArcGIS for project proposals
- Consulted with the public to satisfy NEPA public involvement requirement

Crew Leader, Bellaire Puritas Development Corporation (Cleveland, OH)
May 2014 - August 2017
- Full-Time
- Managed a team of seven to provide housing services to seniors
- Managed customer needs with appropriate resources
- Revitalized neighborhoods through work

Stagehand Union Hand, Local 27 (Cleveland, OH)
Jan 2016 - May 2017
- Used teamwork and problem solving to set up and remove stages in a time stressed environment

TRAINING
- Microsoft Office
- MatLab
- AutoCAD
- CALYPSO Measurement Software
Matthew P. Mueller  
muellemp@mail.uc.edu / 216-630-0845

EDUCATION  
University of Cincinnati, College of Engineering & Applied Science, Cincinnati, Ohio  
Class of 2021  
• Bachelor of Science: Environmental Engineering  
GPA 3.1/4.0

EXPERIENCE

Intern  
January 2020 – August 2020  
Helix Electric, San Diego, California  
• Attended weekly site meetings at the California State University of Los Angeles project to participate in a site walk-through  
• Assisted Project Managers with submittals, RFIs, MOPs, and takeoffs for the CSULA and PMRF projects

Intern  
August 2018 – December 2018; May 2019 – August 2019  
KBD Technic, Cincinnati, Ohio  
• Participated in meetings with project team to plan and prioritize weekly goals  
• Assisted Project Engineers with airflow measurements during site visits and participated in meetings with clients  
• Completed client reports, which included calculations, measurements, and drawings from site visits

Intern  
February 2018 – May 2018  
New Line Structures, New York, New York  
• Assisted Project Engineers at the NLS’s Hallett’s Point project site  
• Attended daily inspections of the project site to ensure development of the project site  
• Participated in meetings with contractors to communicate the progress of Hallett’s Point  
• Managed the organizational program that communicated daily updates to all individuals/teams involved in the Hallett’s Point project

Scholar Program  
June 2016 – December 2017  
Cintas, Solon, Ohio  
• Interacted with the business department to develop customer service skills  
• Maintained the factory bay area; organized incoming shipments and assisted various departments

ACTIVITIES

Member, Engineering & Applied Science Tribunal  
September 2016 – Present  
• Provide input and feedback regarding policies and curriculum to the College of Engineering and Applied Science  
• Assist in the development of professional, social, and leadership contacts for students

Member, EWeek Committee  
January 2017 – February 2017  
• Participated in the organization of Engineers’ Week’s interactive events for the College of Engineering and Applied Science

SKILLS

Technical  
• Microsoft Office Suite, Bluebeam Software, BIM360, ASITE, AutoCad

Seeking a full-time position after graduation in May 2021
Appendices

Appendix A: Calculations

Equation 1: Total Average Runoff Coefficient

Total Average Runoff Coefficient = (Brick RC * % of Brick Total Area) + (Concrete RC * % of Concrete Total Area) + (Rooftop RC * % of Rooftop Total Area) + (Green Space RC * % of Green Space Total Area)

Example calculation to solve for the total average runoff coefficient (Use Table 1 - Section 3.1: Surface Runoff Analysis for runoff coefficients and area type percentages)

Total Average Runoff Coefficient =

\[(0.775 \times 0.0999) + (0.875 \times 0.02868) + (0.850 \times 0.5527) + (0.175 \times 0.3187)\]

Total Average Runoff Coefficient = 0.6281

Equation 2: Rational Method (Peak Runoff)

\[Q = A \times I \times C\]

\(Q\) = Runoff Volume (ft³/sec)

\(A\) = Total Basin Surface Area (acres)

\(I\) = Peak Rainfall (in/hr)

\(C\) = Total Average Runoff Coefficient (unitless)

Example calculation to determine the runoff volume for the 100-year storm and \(Tc = 27\):

\(A = 9.59\) acres, \(I = 5\) in/hr, \(C = 0.6281\)

Plug values into Equation 2 above to solve for \(Q\) (ft³/sec)

\(Q = (9.59 \text{ acres}) \times (5 \text{ in/hr}) \times (0.6281)\)

\(Q = 30.1\) ft³/sec
Equation 3: Runoff Recovery Calculation

\[ Q = \frac{(A \times AP \times C)}{100} \]

- \( Q \) = Runoff Volume (centennial cubic feet)
- \( A \) = Total Basin Surface Area (ft\(^3\))
- \( AP \) = Average Precipitation (ft)
- \( C \) = Total Average Runoff Coefficient (unitless)

Example calculation to determine recovery volume for January to the Fifth Third tank:

\[
Q = \frac{[(191,664 \text{ ft}^3) \times (0.238 \text{ ft}) \times (0.875)]}{100}
Q = 399.09 \text{ CCF}
\]

Equation 4: Simulation Example Calculation

Rainfall = 0.483 inches
CRC Tank: \( C = 0.628 \)
Fifth Third Tank: \( C = 0.875 \)

Total Runoff CRC = \( \frac{(0.628 \times 0.483 \text{ in})}{12 \text{ in}} \times (8.59 \text{ acres} \times 43,560 \text{ ft}^2/\text{acre}) \times 7.48 \text{ gallons/ft}^3 = 78,983 \text{ gallons} \)

Total Runoff Fifth Third = \( \frac{(0.875 \times 0.483 \text{ in})}{12 \text{ in}} \times (4.4 \text{ acres} \times 43,560 \text{ ft}^2/\text{acre}) \times 7.48 \text{ gallons/ft}^3 = 50,491 \text{ gallons} \)

Total Inflow = 78,983 gallons + 50,491 gallons = 129,474 gallons

Total Plant Demand = 340,000 gallons
Plant Demand From GCWW = 0.90 * 340,000 gallons = 261,800 gallons
Outflow of Tank = 340,000 gallons - 261,800 gallons = 76,200 gallons

**Net Supply** = 129,747 gallons - 76,200 gallons = 51,247 gallons

**For the simulation a running sum of the net supply was taken for each day, with negative values being set to zero.**
Equation 5: Total Head Equation

\[ H = f\left(\frac{L}{D}\right)\left(\frac{v^2}{2g}\right) + (z_2 - z_1) + c\cdot n\cdot \left(\frac{v^2}{2g}\right) \]

**H** = total head loss (ft)

**f** = friction factor coefficient (unitless)

**L** = length of pipe (ft)

**D** = diameter of pipe (ft)

**v** = velocity (ft/sec)

**g** = gravitational force (ft/sec^2)

**z_i** = elevation at point i (ft)

**c** = various coefficients for pipe turns, expansion, and contraction

**n** = number of occurrences (unitless)

Example Calculation for total head loss of CRC tank:

\[ H = 0.0304\cdot\left(\frac{2112\text{ft}}{0.5\text{ft}}\right)\cdot\left[\left(\frac{1.703\text{ft/sec}}{2(32.2\text{ft/sec}^2)}\right)\right] + (880\text{ft} - 780\text{ft}) + (0.75\cdot 7\cdot\left[\left(\frac{1.703\text{ft/sec}}{2(32.2\text{ft/sec}^2)}\right)\right]) + (0.35\cdot 5\cdot\left[\left(\frac{1.703\text{ft/sec}}{2(32.2\text{ft/sec}^2)}\right)\right]) + (0.5\cdot 1\cdot\left[\left(\frac{1.703\text{ft/sec}}{2(32.2\text{ft/sec}^2)}\right)\right]) + (1\cdot 1\cdot\left[\left(\frac{1.703\text{ft/sec}}{2(32.2\text{ft/sec}^2)}\right)\right]) \]

\[ H = 192 \text{ ft} \]
Appendix B: Site Plans

Figure B1: CRC Tank Top View

Figure B2: CRC Tank Side View
Figure B3: Fifth Third Tank Top View

Figure B4: Fifth Third Tank Side View
Appendix C: Product Data

Figure C1: Hydrodynamic Separator Product Data
SERIES B1B TRASH BASKET

STANDARD FEATURES:
- ALL ALUMINUM BASKET AND RAILS
- SOLID ALUMINUM WHEELS AND STAINLESS STEEL AXLES
- HEAVY DUTY LADDER/GUIDERAIL COMBINATION
- 1 3/8" TYPE "D" RUNG WITH FLAT SLIP RESISTANT SURFACE
- BAR SCREEN STYLE BASKET
- AVAILABLE W/O LADDER RUNGS (GUIDE RAILS ONLY)
- MODEL B4B STAINLESS STEEL BASKET AVAILABLE
- STAINLESS STEEL CHANNEL RAIL SYSTEM AVAILABLE
- 3 YEAR GUARANTEE
- OTHER SIZES AVAILABLE

REQUIRED INFORMATION:
- BASIN DIAMETER
- RAIL LENGTH
- STANDOFF LENGTH (7" [178 MM] MIN. FOR LADDER COMBO)

Figure C2: Debris Basket Product Data
### Product Details for 62RFD-CS-SDPXF

**Category:** Style SDPXF Flanged

**Print this page**

#### Figure C3: Duplex Strainer Product Data

<table>
<thead>
<tr>
<th>Attributes</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size (in)</td>
<td>6</td>
</tr>
<tr>
<td>Pressure Class (lb)</td>
<td>150</td>
</tr>
<tr>
<td>A (in)</td>
<td>18 5/8</td>
</tr>
<tr>
<td>B (in)</td>
<td>10 9/16</td>
</tr>
<tr>
<td>C (in)</td>
<td>13.000000</td>
</tr>
<tr>
<td>D (in)</td>
<td>23 1/2</td>
</tr>
<tr>
<td>E (in)</td>
<td>16</td>
</tr>
<tr>
<td>F (in)</td>
<td>15</td>
</tr>
<tr>
<td>G (in)</td>
<td>22 5/8</td>
</tr>
<tr>
<td>H (in)</td>
<td>1/2</td>
</tr>
<tr>
<td>Weight (lbs)</td>
<td>373.0</td>
</tr>
<tr>
<td>Screen Perforation (stainless) (in)</td>
<td>1/8</td>
</tr>
<tr>
<td>Open Area (stainless)</td>
<td>0.43</td>
</tr>
<tr>
<td>Screen Perforation (liquid) (in)</td>
<td>1/8</td>
</tr>
<tr>
<td>Open Area (liquid)</td>
<td>0.43</td>
</tr>
<tr>
<td>Flange Dia. (in)</td>
<td>11</td>
</tr>
<tr>
<td>Bolt Circle Dia. (in)</td>
<td>3 1/2</td>
</tr>
<tr>
<td>Flange Thk. (in)</td>
<td>1</td>
</tr>
<tr>
<td>Raised Face Dia. (in)</td>
<td>8 1/2</td>
</tr>
<tr>
<td>No. Bolts</td>
<td>8</td>
</tr>
<tr>
<td>Bolt Dia. (in)</td>
<td>3/4</td>
</tr>
<tr>
<td>Bolt Length (in)</td>
<td>3 1/4</td>
</tr>
<tr>
<td>Stud Length (in)</td>
<td>4</td>
</tr>
</tbody>
</table>
Figure C4: CRC Tank Pump Product Data
Figure C5: Fifth Third Tank Pump Product Data
Appendix D: Product Quotes

RE: [EXTERNAL] Re: UC Capstone Project - Hydrodynamic Separator

Dana Hinaman <Dana.Hinaman@ContechLLC.com>
Wed 2/24/2021 3:49 PM
To: Mueller, Matt <muellemp@mail.uc.edu>
Cc: Doll, Graci <dollgm@mail.uc.edu>; Brethei, Grace <brethegm@mail.uc.edu>; Batz, Taylor <batzta@mail.uc.edu>; Marazzi, Anthony <marazzal@mail.uc.edu>

2 attachments (439 KB)
CS-8-DTL.pdf; OH - Water Quality Flow Calculator.pdf;

Matt,

Thanks for the information! I ran a quick WQf calculation to determine the ‘first flush’ that would be coming from your drainage area. This is how I generally size the HDS. That being said, it looks like you need a CS-8 to treat the WQf. Assuming we do the internal bypass, the CS-8 can easily bypass your 100yr storm-event. And if memory serves me correct, this would be outletting to your detention/storage. If you want to fully treat your water quality, you’d need to take the WQf you calculated into account for your total detention storage. But I think I remember you saying all this was for reuse anyway, so it may not be necessary since the water would be treated again during the reclamation process.

Average price for a CS-8 is about $30,000.

Please let me know if you have any additional questions or comments.

Thanks!

Dana Hinaman
Stormwater Consultant – OH, KY

Contech Engineered Solutions, LLC
1103 Schrock Road | Suite 105 | Columbus, OH 43229
Mobile: (513) 314-4781
Dana.Hinaman@ContechLLC.com
linkedin.com/in/danahinaman

From: Mueller, Matt <muellemp@mail.uc.edu>
Sent: Wednesday, February 24, 2021 2:29 PM
To: Dana Hinaman <Dana.Hinaman@ContechLLC.com>
Cc: Doll, Graci <dollgm@mail.uc.edu>; Brethei, Grace <brethegm@mail.uc.edu>; Batz, Taylor <batzta@mail.uc.edu>; Marazzi, Anthony <marazzal@mail.uc.edu>
Subject: [EXTERNAL] Re: UC Capstone Project - Hydrodynamic Separator

Hi Dana,

https://outlook.office.com/mail/searchId/AAokADUyyY3/MTE3LW8YYm1NDINIlzjdlIWdWExYWZmQwMGlzRZQAjALTy2w5g5ZdFQFpuawK89y7eE%3D

Figure D1: Hydrodynamic Separator Quote

44
Halliday Products, Inc.  
6401 Edgewater Dr  
Orlando, FL 32810  
P: 407-298-4470  F: 407-298-4534  
Sales@HallidayProducts.com

Price Quotation Number  
Q20655  
Date: 04/06/2021  
PRICING VALID FOR 90 DAYS

Customer: UNIVERSITY OF CINCINNATI  

US  
Quoted: ANTHONY MARAZZI  
Phone: (216) 280-7642  
Email: MARAZZAL@MAIL.UC.EDU

Payment Terms:  
NET 30 W/APPROVAL  
Note: A 3.5% Service Fee is  
Applied to all Credit Card  
Payments

Ship Method:  
FEDEX GROUND

HP Salesperson:  
JARROD FLEMING

Production Time:  
2 TO 3 WEEKS ARO

<table>
<thead>
<tr>
<th>Qty</th>
<th>Item Number</th>
<th>Description</th>
<th>Unit Price</th>
<th>Net Price</th>
</tr>
</thead>
</table>
| 1   | B18 TRASH BSKT | FAABB22M18A20G06AA  
The above aluminum barscreen basket to have 1/4" x 2"  
flat bars w/2" clearance between bars. Basket to be 22  
3/4" wide x 18" high x 20 3/8" deep. Basket sides and back  
will be solid 1/4" plate. | 645.00 | 645.00 |

*Any and all prior or subsequent negotiations, documents and agreements between  
the parties hereto are superseded by the terms set forth in this Price Quotation.*

Subtotal | 645.00
(FL - ONLY) EXEMPT | 0.00
Estimated Freight | 130.00

TOTAL | $775.00

Please see www.HallidayProducts.com for O & M Manuals and Limited Product Warranties

Figure D2: Debris Basket Quote
Bid No: 8931895  
Bid Date: 04/01/21  
Quoted By: TJS  
Customer: UC MAINT.  
1  
UNIVERSITY OF CINCINNATI, OH  
Cust PO#: TBD  
Job Name: UC PROJECT  
Cust Phone: TERMS: CASH ON DEMAND  
Ship To: UC MAINT.  
1  
UNIVERSITY OF CINCINNATI, OH

Item | Description | Quantity | Net Price | UM | Total |
--- | --- | --- | --- | --- | --- |
SP-6150SDPXSTRAIN | 6 150# RF DUPLEX KECKLEY STRAINER 6 CLASS 150 RF STYLE SDPX CARBON STEEL DUPLEX STRAINER POSITIVE SEALING BRONZE DIVERTER FOR SUCTION SERVICE W/18 PERFORATED 304 SS BASKET VAXITON O-RING W/NOZZLE COVER | 1 | 23012.00 | EA | 23012.00 |

Net Total: $23012.00  
Tax: $0.00  
Freight: $0.00  
Total: $23012.00

Quoted prices are based upon receipt of the total quantity for immediate shipment (48 hours). SHIPMENTS BEYOND 48 HOURS SHALL BE AT THE PRICE IN EFFECT AT TIME OF SHIPMENT UNLESS NOTED OTHERWISE. QUOTES FOR PRODUCTS SHIPPED FOR RESALE ARE NOT FIRM UNLESS NOTED OTHERWISE.

CONTACT YOUR SALES REPRESENTATIVE IMMEDIATELY FOR ASSISTANCE WITH DBE/MBE/WBE/SMALL BUSINESS REQUIREMENTS.

Seller not responsible for delays, lack of product or increase of pricing due to causes beyond our control, and/or based upon Local, State and Federal laws governing type of products that can be sold or put into commerce. This Quote is offered contingent upon the Buyer's acceptance of Seller's terms and conditions, which are incorporated by reference and found either following this document, or on the web at https://www.ferguson.com/content/website-infomeetings/contest/ 

Govt Buyers: All items are open market unless noted otherwise.

LEAD LAW WARNING: It is illegal to install products that are not "lead free" in accordance with US Federal or other applicable law in potable water systems anticipated for human consumption. Products with "NP" in the description are NOT lead free and can only be installed in non-potable applications. Buyer is solely responsible for product selection.

HOW ARE WE DOING? WE WANT YOUR FEEDBACK!  
Scan the QR code or use the link below to complete a survey about your bids:  
https://survey.medallia.com/?bidorder&fc=541&on=41530

Figure D3: Duplex Strainer Quote
<table>
<thead>
<tr>
<th>Pump / Part</th>
<th>List Price</th>
<th>Quantity</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>NZ 3171 SH3 277</td>
<td>$30,529</td>
<td>2</td>
<td>$61,058</td>
</tr>
<tr>
<td>FM</td>
<td>$0</td>
<td>2</td>
<td>$0</td>
</tr>
<tr>
<td><strong>Standard Accessories</strong></td>
<td>$2,836</td>
<td>2</td>
<td>$5,672</td>
</tr>
<tr>
<td>Intermediate Guide Bar</td>
<td>$0</td>
<td>0</td>
<td>$0</td>
</tr>
<tr>
<td>NZ Pump Stand</td>
<td>$3,604</td>
<td>2</td>
<td>$7,208</td>
</tr>
<tr>
<td>Kellum Grips</td>
<td>$30</td>
<td>2</td>
<td>$60</td>
</tr>
<tr>
<td>Cable holder</td>
<td>$153</td>
<td>2</td>
<td>$306</td>
</tr>
<tr>
<td>Mini-Cas</td>
<td>$504</td>
<td>2</td>
<td>$1,008</td>
</tr>
<tr>
<td>Socket, 11 pin</td>
<td>$48</td>
<td>2</td>
<td>$96</td>
</tr>
<tr>
<td>Start up</td>
<td>$1,800</td>
<td>2</td>
<td>$3,600</td>
</tr>
<tr>
<td>Freight</td>
<td>$805</td>
<td>2</td>
<td>$1,610</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td></td>
<td>$80,618</td>
</tr>
</tbody>
</table>

**Testing**
- Hydraulic
- Hydrostatic

**Testing Total**

**Project Total**  

$80,618

**Standard Accessories**
- Discharge connection
- Hardware Kit
- Disconnect hardware
- Upper Guide Bar
- Safety Hook
- Chain - 3/6" 316 SS 20 ft

Figure D4: Pump Quote
Job/Configuration Name: UC - Stormwater Pumps Well #1
Model Number below based on your selections in configurator:

ACC-D-463-ST-ID-N45-FDN-2A-00-5AH-6C-6K-6N-00-10G-10K-26E-508-PX

- Duplex Pump Control Panel
- 3 Phase Power @ 460 VAC. Panel Includes Control Transformer with Primary Fuses and Control/Alarm Circuit Breaker
- NEMA 4X 304 Stainless Steel Enclosure, Pad-Lockable
- 22mm Lights and Switches Mounted on Aluminum Inner Door
- NEMA Rated Starting Device(s)
- 15 – 45 FLA NEMA Starter Size 2
- Float Control, Using DPC-4F (simplex or duplex) or TPC-4F (triplex). Floats not included, must be ordered separately.
- Pump Down (Emptying) Application
- Full Alarm Package on a Separate Incoming Power Feed, Including Amber Flashing Beacon, Audible Alarm, and Test/Silence Switches, Auxiliary Contact
- Seal Failure/Thermal Cutout Module for CLS or FLS Leakage Sensors. Auto/Manual Thermal Cutout Switch
- Pump Run Auxiliary Contact(s)
- Pump Fail Auxiliary Contact(s)
- Power Fail Auxiliary Contact(s)
- Elapsed Time Meter(s)
- 3 Phase Lightning Arrester
- Anti-Condensation Heater w/Adjustable Thermostat
- 3 Phase Voltage Monitor
- UL/CUL 508A
- KWIKSWITCH 4-Port KIT, 100FT Manifold cable
(4) 25FT Float N.O., SS Mt Bracket & 6-Pos hook Bracket

Net Price: $ 6,508.00
(Price valid for 30 days, US Dollars)
Job/Configuration Name: UC Storm Water Well 2 Control Panel
Model Number below based on your selections in configurator:

ACC-D-463-ST-ID-N27-FDN-2A-00-5AH-6C-6K-6N-00-10G-10K-26E-508-PX

- Duplex Pump Control Panel
- 3 Phase Power @ 460 VAC. Panel Includes Control Transformer with Primary Fuses and Control/Alarm Circuit Breaker
- NEMA 4X 304 Stainless Steel Enclosure, Pad-Lockable
- 22mm Lights and Switches Mounted on Aluminum Inner Door
- NEMA Rated Starting Device(s)
- 9 – 27 FLA NEMA Starter Size 1
- Float Control, Using DPC-4F (simplex or duplex) or TPC-4F (triplex). Floats not included, must be ordered separately.
- Pump Down (Emptying) Application
- Full Alarm Package on a Separate Incoming Power Feed, Including Amber Flashing Beacon, Audible Alarm, and Test/Silence Switches, Auxiliary Contact
- Seal Failure/Thermal Cutout Module for CLS or FLS Leakage Sensors, Auto/Manual Thermal Cutout Switch
- Pump Run Auxiliary Contact(s)
- Pump Fail Auxiliary Contact(s)
- Power Fail Auxiliary Contact(s)
- Elapsed Time Meter(s)
- 3 Phase Lightning Arrester
- Anti-Condensation Heater w/Adjustable Thermostat
- 3 Phase Voltage Monitor
- UL/CUL 508A
- KWIKSWITCH 4-Port KIT, 100FT Manifold cable
(4) 25FT Float N.O., SS Mt Bracket & 6-Pos hook Bracket

Net Price: $ 6,508.00
(Price valid for 30 days, US Dollars)
HI TAYLOR,

SEE BELOW, HOPE THIS WILL HELP YOU WITH YOUR BUDGET PLANNING. LET ME KNOW ANY QUESTIONS OR ANYTHING ELSE I CAN HELP WITH.

THANKS!
MICHELLE
636-812-9009
MMEYERS@FEDSTEEL.COM

<table>
<thead>
<tr>
<th>Description &amp; Piece Length</th>
<th>Qty</th>
<th>Price</th>
<th>UM</th>
<th>Pounds</th>
<th>Item Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.525&quot; X .280 A53-B ERW</td>
<td>4,224</td>
<td>12.0000</td>
<td>FT</td>
<td>80129</td>
<td>50,688.00</td>
</tr>
<tr>
<td>6&quot; STD WELDED PIPE. IMPORT MATERIAL STOCK, SUBJECT TO SALE.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>EA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FREIGHT DELIVERY ESTIMATE</td>
<td>2</td>
<td>2,000.0000</td>
<td>EA</td>
<td></td>
<td>5,600.00</td>
</tr>
<tr>
<td>2 FULL TRUCKLOADS OF MATERIAL. PRICING IS SUBJECT TO RATE AND AVAILABILITY AT TIME OF BOOKING.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

This quotation and sales resulting from it, are made subject to FSSLLC Standard Terms and Conditions of Sale. Acceptance of our offer of goods, constitutes express acceptance of the associated terms & conditions. Prices in U.S. $. Terms: Net 30 days, subject to final approval. All items are offered subject to prior sale. All prices subject to final confirmation.

<table>
<thead>
<tr>
<th>Weight Total</th>
<th>Taxable Total</th>
<th>Total Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>80,129</td>
<td></td>
<td>56,288.00</td>
</tr>
</tbody>
</table>

**Figure D7: Pipe Quote**
Introduction

Founded in 1819, the University of Cincinnati is a public research university that serves a diverse community of 46,388 students across 14 colleges – the highest enrollment in our history thanks to nearly a decade of steadily rising enrollment and unrivaled momentum, and has been named "Among the top tier of the Best National Universities," according to U.S. News & World Report.

The university has nearly 200 years of history as a research pioneer, with a culture strongly emphasizing collaboration in order to achieve innovative results that can be applied to solving complex problems and furthering scientific advancement.

The UC campus setting continues to garner worldwide acclaim, with The New York Times highlighting UC’s dramatic campus renovation of the past quarter century “the most ambitious campus design program in the country.” In addition, Forbes, Delta Sky and Travel + Leisure magazines have all highlighted UC as one of the world’s most beautiful campuses. It’s also a sustainable one where all new construction and major renovations are completed to LEED Silver standards or higher whenever possible.

The focus of this RFP is on water usage and, in particular, supporting the goal of reducing water usage, as well as reducing combined sewer overflows (CSOs) to the Mill Creek. In particular, the UC Utilities has embarked on a program to reduce its water/sewage usage volume by 20% annually. First year reductions reached over one million gallons of decreased consumption through the collection and reclamation of plant process water streams. Currently UC’s west campus water usage is in excess of 33 million gallons annually at a cost of $460,000 per year. In addition, another 54 million gallons of water drains from the 137 acre main campus geographic area via combined sewers on an annual basis.

Utilities personnel have had several discussions with Cincinnati Metropolitan Sewer District (MSD) over the last twelve months regarding the need to construct additional large sized drains not only to remove stormwater from the UC campus, but as well from the broader UC community area to insure the stormwater, at significant cost and energy consumption. MSD’s goal is to reduce CSO discharges into the Mill Creek, and to reduce sewer backups of private properties.

Site Description

UC’s main campus is located in a combined sewer overflow (CSO) drainage shed. When major storm events occur, campus sewers back up, drains are overwhelmed, and ultimately water gets to places that have far too often resulted in significant damage to University buildings, classrooms, and living areas. This has resulted in significant cost to the University.
Stormwater currently leaves the west campus at multiple locations. The attached drawing details the complex stormwater drainage system on main campus. The UC west campus has the ability to collect a significant amount of stormwater through “detention” tanks that are strategically located under buildings throughout the vast network of buildings on campus. Please see the attached spreadsheet. These storage tanks could then be utilizes for storage and reuse of stormwater on campus.

**Project Goal**

The goal of this project is to get as much stormwater from the 137 acre campus out of the greater Cincinnati area’s sewage collection and treatment systems. The overall intent is to reuse the reclaimed stormwater in a multitude of different beneficial use purposes, including irrigation for the broad “green” campus area, toilet flushing, and potentially utility process makeup. We do not intend to reuse the reclaimed stormwater for sinks, drinking water, or related activities. Collecting and reusing campus stormwater will not only reduce costs for the university, but also reduce CSOs into the Mill Creek.

**Description of Services Required**

The student team will conduct a thorough review of the existing campus stormwater re-use systems, review options for separating the existing storm and sanitary sewer collection systems, review options for stormwater pre-treatment, review options for storm water storage, review options for stormwater treatment, and review potential regulatory hurdles for re-using stormwater in Cincinnati. Upon completion of the initial report and approval after the Fall Semester, the student team will develop conceptual drawings and perform an economic analysis of their recommended system.

CEAS and University staff will coordinate closely with the student team throughout this project and they will provide access to resources necessary to ensure project success.

**Deliverables**

During the Fall Semester, the student team should complete the following tasks:

- Conduct a campus site visit to understand the collection area and network of stormwater removal;
- Conduct a technological review of existing data;
- Conduct literature searches and review for similar projects;
- Conduct literature searches for grey and green infrastructure solutions;
- Conduct a review of the existing stormwater collection system;
- Develop a sanitary and stormwater separation approach for existing buildings;
- Review options for treatment and storage;
- Review options for pre-treatment;
- Review potential regulatory hurdles for re-using stormwater in Cincinnati;
- Meet with CEAS and University staff as needed;
- Prepare a project proposal report on key findings and recommended options; and
- Provide a presentation on the proposed options to CEAS and University staff.
During the Spring Semester, the consultant team should complete the following tasks:

- Develop conceptual design drawings of the recommended reuse options;
- Conduct a thorough economic analysis of the recommended reuse options, including energy costs and savings derived from reduced Cincinnati Water Works and MSD charges;
- Identify the infrastructure changes required to support deployment of the reuse options;
- Prepare a final report that includes all tasks from the Fall Semester and Spring Semester; and
- Provide an oral presentation of key findings at the end of the semester.
### West Campus Storm Water Detention Tank Inventory

<table>
<thead>
<tr>
<th>Building</th>
<th>Campus Location</th>
<th>Roof SF</th>
<th>Retained sqft</th>
<th>Storm Retention</th>
<th>Tank Material</th>
<th>Tank Dimensions</th>
<th>Tank Size CF</th>
<th>Ratio of SF/CF</th>
<th>Tank Size (Gallons)</th>
<th>Tank Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Joseph Shapiro Student Life Center</td>
<td>W</td>
<td>21,601</td>
<td>21,601</td>
<td>Yes</td>
<td>concrete</td>
<td>10' x 10' x 11'</td>
<td>110,000</td>
<td>2</td>
<td>622,800</td>
<td>Man Street tank north of CRC</td>
</tr>
<tr>
<td>Lindner Athletic Center</td>
<td>W</td>
<td>36,100</td>
<td>36,100</td>
<td>Yes</td>
<td>steel</td>
<td></td>
<td>90,000</td>
<td>2</td>
<td>441,220</td>
<td>under Shafer lawn</td>
</tr>
<tr>
<td>Shoemaker CTR</td>
<td>W</td>
<td>90,370</td>
<td>90,370</td>
<td>Yes</td>
<td>concrete</td>
<td>44' x 64' x 9'</td>
<td>32,824</td>
<td>3</td>
<td>246,015</td>
<td>north west corner of plaza</td>
</tr>
<tr>
<td>Calhoun Street Garage</td>
<td>W</td>
<td>127,700</td>
<td>127,700</td>
<td>Yes</td>
<td>concrete</td>
<td></td>
<td>22,400</td>
<td>6</td>
<td>168,150</td>
<td>under garage ramp</td>
</tr>
<tr>
<td>ESOM Emery and PCC</td>
<td>W</td>
<td>151,556</td>
<td>151,556</td>
<td>Yes</td>
<td>concrete</td>
<td>(2) - 7' x 12' dia</td>
<td>17,151</td>
<td>9</td>
<td>126,507</td>
<td>north of the building under the road</td>
</tr>
<tr>
<td>Carl H. Lindner Hall (New CCB)</td>
<td>W</td>
<td>57,210</td>
<td>57,210</td>
<td>Yes</td>
<td>metal</td>
<td>188' x 9'</td>
<td>14,705</td>
<td>4</td>
<td>110,450</td>
<td>under roadway north of building</td>
</tr>
<tr>
<td>ShAP Anzoff Center</td>
<td>W</td>
<td>49,670</td>
<td>49,670</td>
<td>Yes</td>
<td>concrete</td>
<td>240' x 8'</td>
<td>12,064</td>
<td>4</td>
<td>90,237</td>
<td>north of Closkey</td>
</tr>
<tr>
<td>Shailey Athletics Center and Bubble</td>
<td>W</td>
<td>62,430</td>
<td>62,430</td>
<td>Yes</td>
<td>plastic</td>
<td>600' of 36&quot; and 60' of 48&quot; piping</td>
<td>10,000</td>
<td>8</td>
<td>74,800</td>
<td>S, E, Northbound full field and E side of half field</td>
</tr>
<tr>
<td>Engineering Research Center</td>
<td>W</td>
<td>25,786</td>
<td>25,786</td>
<td>Yes</td>
<td>concrete</td>
<td></td>
<td>6,815</td>
<td>3</td>
<td>66,933</td>
<td>under entry</td>
</tr>
<tr>
<td>Central Power Plant</td>
<td>W</td>
<td>42,827</td>
<td>42,827</td>
<td>Yes</td>
<td>concrete</td>
<td>135 x 6' dia + 6700</td>
<td>8,577</td>
<td>5</td>
<td>64,156</td>
<td>two tanks (1) - west under parking + (1) - north of the building</td>
</tr>
<tr>
<td>Edwards CTR</td>
<td>W</td>
<td>49,650</td>
<td>49,650</td>
<td>Yes</td>
<td>steel</td>
<td>(2) - 80' x 7-5' dia</td>
<td>5,509</td>
<td>9</td>
<td>36,713</td>
<td>north side in the garage</td>
</tr>
<tr>
<td>Marian Spencer Hall</td>
<td>W</td>
<td>16,745</td>
<td>16,745</td>
<td>Yes</td>
<td>Plastic</td>
<td>30' x 18' x 6' Modules</td>
<td>3,963</td>
<td>5</td>
<td>26,576</td>
<td>between Scollo and Spencer Hall</td>
</tr>
<tr>
<td>University Pavilion</td>
<td>W</td>
<td>17,196</td>
<td>17,196</td>
<td>Yes</td>
<td>concrete</td>
<td>45' x 8' dia</td>
<td>2,262</td>
<td>8</td>
<td>16,919</td>
<td>south of the building in the lawn</td>
</tr>
<tr>
<td>French Hall-West</td>
<td>W</td>
<td>34,086</td>
<td>34,086</td>
<td>Yes</td>
<td>steel</td>
<td>56' x 7' dia</td>
<td>2,195</td>
<td>16</td>
<td>16,120</td>
<td>west side under walk</td>
</tr>
<tr>
<td>Balden Hall</td>
<td>W</td>
<td>27,256</td>
<td>27,256</td>
<td>Yes</td>
<td>concrete</td>
<td>70' x 6' dia</td>
<td>1,979</td>
<td>14</td>
<td>14,804</td>
<td>Southeast corner under walk</td>
</tr>
<tr>
<td>Campus Green Garage</td>
<td>W</td>
<td>70,576</td>
<td>70,576</td>
<td>Yes</td>
<td>brick</td>
<td>170' x 3' 6&quot; dia</td>
<td>1,636</td>
<td>40</td>
<td>12,234</td>
<td>under garage center north - used for sewer</td>
</tr>
</tbody>
</table>

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**Legend:****
- **W**: West Campus
- **CF**: Cubic Feet
- **Gallons**: Estimated volume in gallons