From Retention to Redemption

Team 8
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Engr339/340 Senior Design Project
Calvin College
14 Dec 2012
Executive Summary

The team consists of four senior civil engineers; Brian Benson, Tyler DeNoooyer, Tyler Hanna, and Brad Quist. All four members are interested in water resources as well as environmental quality and it was their goal to incorporate both of these interests into the project. The project involves the evaluation of the feasibility of redesigning three detention basins along the Silver Creek Drain. Silver Creek Drain is an underground stormwater runoff conduit that flows through Grand Rapids and eventually into Plaster Creek, and ultimately the Grand River. Silver Creek has four in-line detention basins that can be seen below in Figure 1.

The Kent County Drain Commission has requested that the Calvin Senior Design team assess the feasibility of the redesign of the three basins along the Silver Creek Drain. Currently, all three basins have little to no water flow through them during small rain events. The goal of the team will be to redesign each basin in order to utilize each one to its full potential. The team will specifically be looking at increasing retention time and water quality.

When the project began, the initial approach was to invest the majority of the time and effort into research and data collection. The team researched other similar projects, the options available, and the pros and cons of each option. It was also necessary to gather a base knowledge of detention basins in general, and the work that would go into evaluating them. Once this base knowledge was gathered and was better understood, the team invested their time into learning as much as they could about the specific basins. Through several meetings with their mentor, Brad Boomstra, an employee of the Kent County Drain Commission (KCDC), and gathering as much information available through KCDC, the team began to understand the problems they would be facing with each basin. Early in this process, the team divided into two groups, where one would be focused on research and alternatives and the other would be focused on modeling. Once enough information was gathered the modeling group began the lengthy process of delineating the watershed and setting up a program to do the modeling.
Some of the alternatives and options considered for redesign are: creating an infiltration basin, a wet pond, a dry pond, an infiltration trench, constructed wetland, and various other common practices. The team made decisions based on all of the feasible alternatives for each individual basin. The main focus for the design of each basin is to improve water quality by treating smaller rain events, and increase detention time.

At this point in the project, the team has narrowed their future designs down to a few options. The most feasible design the team recommends for the Calvin Basin involves installing a filtering media in place of the existing soil. Utilizing current underdrains, in addition to redesigning the outlet structure to regulate low flows, would increase the pollutant removal of the basin. This option is the most feasible, and will provide the largest impact on water quality. However, it will not improve the storage capacity.

For the Southfield Basin, the team proposes a design which involves demolishing the current 6” underdrain located on the south side of the basin (Figure 2). During the construction of this underdrain, the clay liner was modified to be deeper in this location to allow room for the drain. The proposed design would utilize the extra foot of space to install an earthen channel. This earthen channel will stretch from the basin inlet to the basin outlet. In addition to this channel, a diversion structure would be installed at the inlet. This structure would be a weir diverting water into the basin inlet. The water would then flow through the channel to the outlet. The process of exposing the stormwater to the outside air is called daylighting. This process helps to reduce pollution in the stormwater runoff. The earthen channel would also be vegetated, allowing for more pollutant removal.

Figure 2: Underdrain

In addition to this channel, a new inlet would be constructed at the eastern most end of the basin. This decision has been made because the Silver Creek Drain is higher in elevation at the upstream end of the pond. Excavating the bed of the Southfield Basin three to four feet on the East half will allow water to flow directly into the basin. In addition to the construction of a new inlet, a diversion structure would be installed at the inlet. This structure would be a weir that would force water into the basin inlet directing water through the channel. A final weir height will be determined next semester based on modeling results. This depends on the magnitude of storm event the team would attempt to divert into the Southfield Basin. Based on the size of the chosen storm event, a flow depth in the drain could be
determined. From which, a weir tall enough to divert flow into the Southfield Basin could be designed. This option would preserve the integrity of the Silver Creek Drain by not altering the upstream conditions, and it would lower the peak flow rates for lower storm events by providing greater storage capacity. Error! Reference source not found. shows a rough model of the proposed design. The red hatch shows the area that will be excavated to the elevation of the Silver Creek Drain. The black “Y” represents the location of the new inlet, and the blue line displays the proposed creek meander.

Figure 3: Proposed Revisions for the Southfield Basin

Currently the Otsego Basin utilizes a two-way pipe which acts as both the inlet and outlet. The group is assessing the feasibility of installing an earthen weir on the pond side of the inlet/outlet structure. The basin would then be able to detain a certain volume of water during rain events that cause surcharging higher than the elevation of the weir. The group is considering installing an infiltration basin along with an underdrain that will distribute the less polluted water back into the Silver Creek Drain. Leaving the basin “as is” is also being considered by the group. The group will have to determine how much the water quality can be improved provided water will flow the Southfield Basin and have already been treated prior to entering the Otsego Basin and how much water will be added from the watershed between the Southfield and Otsego basins.

At this point in the design, the team has estimated a projected total cost ranging between $266,000 and $385,000. This estimate is based primarily off previous similar projects, and is the total projected cost of redesigning the Southfield and Otsego Basins. It accounts for labor time involved in engineering, drafting, surveying, office coordination, and modification of the detention basin bottoms for the Otsego and Southfield Basins. The team has also estimated the cost for demolition of the current inlet to the Southfield and Otsego basins, and the cost for constructing new inlets.

The next step in the Otsego Basin design is to research how close the water table elevation is to the ground surface elevation. Provided there is enough vertical separation between the water table and the ground surface, an appropriate filtering media would be utilized.

To implement the proposed modifications to the Southfield Basin, the team will survey on site to obtain specific elevations including inlet/outlet inverts and basin elevations. This data will be used to determine how much of the basin bed would need to be excavated in order to match the invert of Silver Creek at the proposed inlet location. The team will determine the new inlet and diversion structure based on a desired storm event to divert into Southfield and be treated.
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Abbreviations

BOD – 5 Day Biochemical Oxygen Demand
COD – Chemical Oxygen Demand
BMP – Best Management Practice
EMC – Event Means Time
EPA – Environmental Protection Agency
GIS – Geographic Information Systems
HEC-HMS – Hydrologic Engineering Center Hydrologic Modeling System
HEC-RAS – Hydrologic Engineering Center River Analysis System
HVAC – Heating Ventilation and Air Conditioning
ISIR – Initial Sample Inspection Reports
KCDC – Kent County Drain Commission
MDEQ – Michigan Department of Environmental Quality
NURP – Nationwide Urban Runoff Program
RMA – Return Material Authorizations
TSS – Total Suspended Solids
1 Introduction

Integrated into the Calvin College Engineering Department curriculum is a senior design project. Team 8, From Retention to Redemption, is comprised of four senior engineering students: Tyler Hanna, Brad Quist, Tyler DeNooyer and Brian Benson. All four members of the team will be graduating in May 2013 with a Bachelor’s of Science in Engineering with a civil & environmental concentration. The following report is a project proposal and feasibility study on a redesign of three detention ponds along the Silver Creek Drain.

1.1 Team 8

The team currently is enjoying working closely with the Kent County Drain Commission (KCDC). KCDC has been an excellent client for the team, providing data, figures, models and feedback. Additionally, Dr. David Wunder has been an invaluable resource, acting as the team’s advisor. The team is pictured below in Figure 4.

Figure 4: Team 8 from left to right: Tyler Hanna, Brad Quist, Tyler DeNooyer and Brian Benson

Tyler Hanna grew up in Traverse City, Michigan. Tyler had an engineering internship with KCDC last summer. He enjoys various outdoor activities and sports, including fishing and camping, and is currently captaining the Calvin College Ultimate Frisbee Team. Tyler is still unsure what he wants to do after
graduating. He is interested in pursuing water resource or environmental engineering as a career upon graduation, and possibly pursuing a master’s degree in one of these areas.

Brad was born and raised in Grand Rapids, Michigan. He enjoys various outdoor activities including fishing, hunting, and camping. Brad is interested in pursuing a career in water resources or environmental engineering after graduation.

Tyler has lived his whole life in Grand Rapids, Michigan, excluding one amazing semester in Amsterdam, Netherlands. In Amsterdam, Tyler was able to study the Dutch environmental history and sustainable water management. Tyler has had a traffic engineering internship with the City of Grand Rapids Traffic Safety Department last summer. He enjoys various outdoor activities and sports, including playing soccer at Calvin College, and currently captaining the Calvin College Ultimate Frisbee Team. Tyler is still unsure what he wants to do after graduating. He is interested in pursuing water resource or environmental engineering as a career upon graduation, or possibly pursuing a master’s degree in one of these areas.

Brian was born and raised in Traverse City, MI. He enjoys playing frisbee and spending time with his daughter, Zoey. Brian has been working as a design and quality technician at Aurora North America, a heating, ventilation and air conditioning (HVAC) company located in Caledonia, MI. Brian has been doing a significant amount of 3D modeling, as well as handling much of the internal quality issues including issuing return material authorizations and initial sample inspection reports. He is also currently working on a design for a climate chamber to be used for vehicle HVAC testing. Brian is unsure what he wants to do after graduating. He is interested in water resources and structures, but is also interested in the mechanical side of engineering especially in manufacturing. Brian enjoys working with his hands and being outdoors and is looking forward to a career that will utilize both of these.

1.2 Silver Creek
Silver Creek is an underground drain, and a tributary of Plaster Creek. Silver Creek is located in the Plaster Creek Watershed which encompasses approximately 58 square miles of land. Historically, Plaster Creek has been a heavily polluted stream which flows through parts of Grand Rapids and Kentwood before discharging into the Grand River.

The Silver Creek watershed drains an area of approximately 3,160 acres (5 square miles) in a predominantly urbanized residential/industrial area. The creek is roughly bounded by Franklin Street to the north, Burton Street to the south, Breton Avenue to the east, and discharges to Plaster Creek near Clyde Park Avenue (see Figure 5 for full map). The primary conduit for the Silver Creek watershed is a concrete, cast in place arch sewer constructed in 1926. The creek’s furthest upstream detention basin is the Kreiser detention basin (SE of Plymouth Avenue and Hall Street near Kreiser Street) before passing by the Calvin detention basin (NW corner of Calvin Avenue and Ramona Street), the Southfield detention basin (north of Cottage Grove Street between Madison and Jefferson Avenues) and finally the Otsego detention basin (NE corner of Cottage Grove Street and Division Avenue).
The series of four basins were constructed in 1993 over the alternative of providing parallel relief sewers because the drain was “hydraulically overloaded during periods of intense rainfall causing the drain to discharge to low lying areas and ponding in streets adjacent to catch basins.” The Silver Creek drain is a chapter 20 drain, meaning that the drain is an intracounty drain. Thus, all associated costs are assessed and paid for by the municipalities. This is in contrast to a chapter 4 drain in which the costs are assessed to the residents within the drainage district.

1.3 Problem Overview
Currently, the Calvin, Southfield, and Otsego basins are underutilized. The three basins were originally constructed to handle the 25-50 year storm. The intended designs of these basins are adequate to prevent local flooding during large storm surges. However, some aspects of the original designs, including the 25-50 year design storm requirements, are not operating according to their original intents due to changes in hydrology in the watershed. The Calvin Basin is an in-line detention basin where the creek is daylighted for a brief period, and the Southfield and Otsego basins are off-line basins which currently detain water only during a minimum of a 25-50 year design storm. Overall, the 3 basins have little to no effect on the water quality flowing through the drain, underutilizing the available space. The ensuing problem investigated in this report is two-fold. The basins are not designed according to their original 25-50 year capabilities. In addition, the pollution goes largely untreated and flows directly into the already heavily polluted Plaster Creek.

1.4 Project History
In the late 1990’s, East Grand Rapids completed a stormwater project to alleviate flooding in the Wilshire/Boston/Richards neighborhoods. This project resulted in redirecting stormwater from the area to Kreiser. However, a major rain event a few years ago resulted in the Kreiser Basin backing up and...
flooding properties to the east. In 2011, the cities of Grand Rapids, East Grand Rapids, along with KCDC redesigned and reconstructed the basin back to the original goal of handling a 25-50 year storm (approximately 5.5 inches of rain over a 24 hour period). Prior to construction, Kreiser was an in-line basin; however Silver Creek had carved a short, straight path through the basin from the inlet to the outlet. The conditions failed to fully utilize the space available, or improve the water quality of the creek. KCDC took the opportunity to increase retention time in the basin, and improve the removal of pollutants during smaller storm events. The redesign increased the capacity of the basin and achieving these goals by modifying the outlet structure, removing about 7,000 cubic yards of soil, creating steepest recommended side slopes of 1:4 that still allow for mowing and safety, and constructing a longer channel around the whole basin. An island in the middle of the basin forces the water to travel around the outside of the basin in order to outlet, making the most of the ample space in the basin. Furthermore, KCDC is planning to plant vegetation in the channel in order to further filter out pollutants in the future.

It is a future goal for the KCDC to make similar improvements to the three succeeding basins along the Silver Creek Drain. Brad Boomstra from KCDC approached the team with the idea for the senior design project.

1.5 Project Objectives

It is the team’s goal to evaluate and redesign the three downstream detention basins along Silver Creek. The main goal is to increase the frequency that storm runoff reaches the basins, thereby increasing retention time and improving water quality. A secondary goal will be to return the designs back to their original capabilities to handle the 25-50 year storm. A best design will be chosen for each basin to achieve these goals based on factors such as feasibility, cost, environmental impact, aesthetics and ease of maintenance and modification.

1.6 Project Management

Project management is essential for a year-long project such as this senior design project. The team used Microsoft Project 2010, individual notebooks, and Google Drive to keep track of proposed deadlines, log hours worked, mark completed tasks, and record meeting minutes. All important resources given to the team from consulting professors and professionals, such as Geographic Information System (GIS) files, maps of the Silver Creek Watershed, and construction plans for the current detention basins were stored at Calvin College for future reference. Additionally, the team used Calvin’s NetStorage server and Google Docs to save documents, plan files, pictures, calculations, and anything used by team members due to the ease of access and up to date status of materials. Due to the large nature of a senior design project, the team met every Monday, Wednesday, and Friday between 9:00 and 10:30 A.M in order to stay organized, evaluate project status, and work on the project as a group. Decisions were made only by unanimous vote. Tyler Hanna and Tyler DeNooyer performed the majority of the watershed delineation and were in charge of modeling on the Environmental Protection Agency’s Stormwater Management Model (EPA SWMM). Brian Benson and Brad Quist handled the majority of the research, cost analysis, and finances. The team worked together on designing the new detention ponds. In the fall semester of 2012, the team created a hydrologic model and selected best redesign for the basins. The main deliverable was this project proposal and feasibility study. In the spring semester of 2013, the team will improve the hydrologic model based on the decisions made in the fall semester and draw plans for the changes to be made. A detailed design report is the deliverable for the spring.
2 Hydrologic Model
To best understand and evaluate the existing basins and possible design improvements, a hydrologic model was created for the Silver Creek watershed. To account for a realistic range of rainfall the system was modeled using 1, 2, 5, 10, 25, 50, and 100 year design storms.

2.1 Software
In order to evaluate approximately 2500 acres of the watershed, software was chosen which would best model the runoff which is primarily conveyed through storm sewers and passes through several detention basins. EPA SWMM, Hydrologic Engineering Center Hydrologic Modeling System (HEC-HMS), and Hydrologic Engineering Center River Analysis System (HEC-RAS) were identified as the most relevant programs. However, EPA SWMM was chosen as the modeling software based on the limitations of HEC-HMS in modeling closed conduit flow. HEC-RAS is still being considered for water surface profiling in the future.

2.2 Delineation
The delineation for the Silver Creek watershed was a challenge due to the large total area and storm sewer conveyance of runoff. Using GIS data, including contours and storm utilities, the total contributing area of the Silver Creek watershed was determined. The watershed was then divided into four subbasins using the inlet to each of the four detention basins as the design points: Kreiser subarea, Calvin subarea, Southfield subarea, and Otsego subarea (Figure 6). The Kreiser and Calvin basins are both in-line with the Silver Creek Drain, thus both the Calvin and Kreiser subareas runoff will all contribute to the flow. Each subbasin will be further divided next semester to increase the accuracy of our model.

Figure 6: Preliminary watershed sub areas
2.3 Curve Number Calculations

After the subareas were established, GIS soil type and land use layers were to determine a curve number, which represents the amount of runoff for each subarea (Figure 7). The present land use in the watershed is encompassed by, ranging from the most impervious area to the least: commercial, industrial, residential, and open areas.

The soil types, which range from A to D, represent the ability of the soil to absorb water. A is a sandy soil that absorbs the most amount of water and D is commonly a clayey soil that absorbs the least amount of water. The predominant land uses for our drainage area are residential and industrial and the soil types are A and C. There were a few cases in the watershed where the soil type is unknown, due to the lack of GIS data. The largest portion of unknown soil types is located in the heavily industrialized area near the downstream end of the watershed. This area was modeled as soil type A, which is most representative of what it is surrounded by. The other three areas were modeled as soil type B for the same rationale. These are all used in a Michigan Department and Environmental Quality (MDEQ) spreadsheet (Figure 8) that calculates a curve number for each basin.

Figure 7: GIS land use and soil type areas used for curve number calculations
Using the curve number method on SWMM, a preliminary model was created to incorporate the hydrology and the hydraulics of the watershed. Storage volumes for the design storms were used as guidelines for the storage capacity of the basins. In existing conditions and smaller storms, the hydraulics of Silver Creek is not even affected by the Southfield or Otsego Basins. Silver Creek and surrounding subbasin parameters were modeled based on GIS data and a 1992 SWMM model built when the basins were constructed.

2.5 Challenges

The first challenge is modeling the four detention basins. It is difficult for the team to model the flow through the two in-line basins because SWMM does not model open channel flow very accurately. It is also difficult to model the off-line basins due to the complex nature of the inlet and outlet structures. Furthermore, the team does not have accurate information regarding baseflow through the system during dry conditions. This information will be determined in January when the basins are surveyed.

Another challenge the team faces is that the hydrologic results gathered thus far based on the curve number calculations yield time of concentrations that are too long, and the peak discharges are too low. This is believed to be the case because the present model does not properly take into consideration the

Figure 8: MDEQ SCS Spreadsheet of Calvin Basin Data

2.4 Construction

Using the curve number method on SWMM, a preliminary model was created to incorporate the hydrology and the hydraulics of the watershed. Storage volumes for the design storms were used as guidelines for the storage capacity of the basins. In existing conditions and smaller storms, the hydraulics of Silver Creek is not even affected by the Southfield or Otsego Basins. Silver Creek and surrounding subbasin parameters were modeled based on GIS data and a 1992 SWMM model built when the basins were constructed.
faster storm sewer conveyance in the system. Currently, the runoff is modeled as sheet flow. The team is considering new methods to more accurately model the runoff in the urban environment.

The lack of creditable information and data for the watershed is another challenge the team is facing. Because Silver Creek was converted to an underground drain 86 years ago, quality records of the design and implementation are scarce. These challenges have made it difficult to accurately model the rainfall response in the system. The model is not yet to a high enough standard to feel comfortable basing any design decisions upon. Once the detention ponds are surveyed, the modeling method is improved and more data is gathered on the system, the team will feel more comfortable drawing conclusions from, and basing designs on the model.
3  Pollutants

As previously mentioned, Plaster Creek is a highly polluted creek, and with Silver Creek being a tributary of Plaster Creek, addressing water quality concerns associated with urban runoff is a focus for this project. If the water quality of Silver Creek is improved, so too will Plaster Creek. Stormwater pollution standards are often measured during the “first flush”. The MDEQ refers to “first flush” as the “large percentage of storm pollutant loading that is produced by a relatively small percentage of the runoff volume during the initial stages of the runoff.”

Dodson has outlined the idea of stormwater pollution benchmarks. These benchmarks are the concentrations at which a stormwater discharge could potentially endanger human life through means of ingesting water or fish. These benchmarks can be seen in the following sections and are good indicators of the level of pollution present in water.

Stormwater gathers water over a large area, can travel long distances, and will be in contact with many different forms of pollution. The Silver Creek watershed is an urbanized and industrialized watershed and much of the urbanized land is concrete and thus, impervious. Due to this, any pollutants in the watershed that gather on the concrete will be washed away with the storm water and collected in Silver Creek. There are several auto-shops, gas stations, and manufacturing companies located within the Silver Creek watershed which will contribute pollutants such as oil, gasoline, trash, heavy metals, and many other similar compounds. Ideally the water will be tested for pollutants and the amounts of each pollutant to better understand what can be done to minimize this.

3.1  Oil and Grease

Oil and Grease are major factors in this project because nearly the entire watershed is on impervious surfaces like parking lots. The oil and grease that collects on these surfaces will be flushed into Silver Creek during a storm event. Oil and grease can disrupt aquatic life and could possibly endanger human life due to consumption of water or fish. The maximum concentration for oil and grease in stormwater is 15 mg/L.

3.2  Heavy Metals

A heavy metal is any metal with a relatively high density that is toxic at low concentrations. They can be a major problem for stormwater because of bioaccumulation; which is the tendency for chemicals to be retained in the fatty tissue of animals. Copper, lead, and zinc are the most common stormwater heavy metals, and the Nationwide Urban Runoff Program (NURP) gives the median event-mean concentration (EMC) to be 34 µg/L, 144 µg/L, and 160 µg/L respectively.

3.3  Nitrates and Phosphates

Nitrates and Phosphates are essential to life, but they can also be quite harmful and dangerous when found in excess. An excess of these nutrients can lead to a large growth of algae. This process is called eutrophication and can reduce the amount of sunlight that reaches the plants growing at lower depths. This can completely change the ecosystem in that area and result in animal death, a decline in property value due to a decline in aesthetic appeal, and issues with taste and odor. The maximum concentration for Nitrates and Phosphates in stormwater is 0.68 mg/L and 2.0 mg/L respectively.

3.4  Total Suspended Solids

Suspended particles in water can be quantified by their total dry weight, or Total Suspended Solids (TSS). TSS can be detrimental to the health of humans and the ecosystem because, where high concentrations are present; there are typically higher concentrations of viruses and bacteria that can cause health problems.
for humans. High TSS concentrations can also impede photosynthesis and cause solids to be stuck in the gills of fish. The benchmark value for TSS is 100 mg/L.

3.5 5 Day Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD)
5 Day Biochemical Oxygen Demand (BOD) is a measurement of the amount of dissolved oxygen needed for aerobic biological species to break down organic compounds in water. If the concentration of dissolved oxygen in water is too low, it can result in a difficult environment for aquatic life to survive. Chemical Oxygen Demand (COD) is very similar, but it represents the amount of oxygen needed to break down all the organic compounds found in a given water sample. Instead of it accounting only for biological processes that break down organic compounds, COD takes account for all the processes that break down organic compounds. The benchmark concentrations for BOD and COD are 30 mg/L and 120 mg/L respectively.

3.6 pH
pH is measured on a scale from 1 to 14 and is a measurement of the concentration of hydrogen ions found in water. Anything below 7 is considered acidic and anything above 7 is considered basic with 7 being neutral. While fish can survive in a relatively large range of pH levels, their eggs cannot so the benchmark level is from 6 to 9.
4  Design Alternatives

There are several different design alternatives when it comes to stormwater management. Recently when designing structures that manage stormwater, it has become common to apply Best Management Practices (BMPs). The goal of the BMP’s, that were considered, is to reduce or eliminate pollutants collected by stormwater before they run into a natural waterway. Currently the Calvin Basin consistently has flow because it is an inline pond. The Southfield and Otsego basins are offline ponds, and only see water during large rain events. For this project the team has identified the following BMP’s for consideration at our project sites.

4.1 Infiltration Trench

Infiltration trenches are designed to capture runoff and let it percolate into the soil of the catch basin. These trenches are usually lined with a filter fabric that is held down by gravel.

![Figure 9: A Typical Infiltration Trench (Runoff Quantity Reduction and Quality Improvement)](image)

Some advantages of infiltration trenches are that they reduce the volume of runoff downstream. Infiltration trenches can be very effective for removing fine sediment, heavy metals, nutrients, bacteria, and organics. Some limiting factors of an infiltration trench are that they require frequent inspection and maintenance. Infiltration trenches are also limited to soils that are sufficiently permeable and provided there is adequate vertical distance to the groundwater table.

4.2 Vegetated Swale

A vegetated swale is an earthen stormwater channel designed to infiltrate and filter stormwater. Vegetated swales have a large amount of plants to slow stormwater and create a riprap effect allowing for the stormwater to react with the oxygen in the air and pollutants to remove. Vegetated swales are a stand-alone stormwater Best Management Practice (BMP). Some advantages of vegetated swales are that they can effectively remove pollutants from the storm water. Different plants will remove different pollutants; therefore vegetated swales may look very different from each other. A disadvantage of vegetated swales is that they are vulnerable to large storms because the high flow rates can wash away the vegetated cover.
4.3 Dry Pond

Dry ponds are also known as detention ponds. They are earthen structures that provide temporary storage of runoff, and release the stored water to help reduce flooding. Most dry ponds are designed to empty within 24 hours of the end of the storm. They are constructed either by utilizing a natural depression in the ground or by excavating the existing ground. Dry ponds are also intended to enhance the settling process to maximize water quality benefits and achieve a reduced runoff volume with the goal of reducing flooding downstream. Some advantages of dry ponds are that they can perform well in cold weather and they can also serve as recreational areas if designed properly. Some limiting factors of dry ponds is that they provide marginal removal of storm water pollutants, the outlet could potentially get clogged, and that the settled sediments need to be removed.

4.4 Wet Pond

Wet ponds, also known as wet retention ponds, are the most commonly used stormwater BMP’s. They are designed to permanently hold a designated amount of water with storage room for excess runoff during rain events and reduce peak flow. Wet ponds treat the incoming storm water by allowing the suspended...
solids to settle and algae to take up the nutrients. To maintain a permanent pond a large drainage area is required. Some limiting factors for wet ponds are they can encourage mosquito breeding, and if a wet pond is going to accept highly contaminated storm water there needs to be significant separation from the ground water.

Figure 12: Cross-Section of a Typical Wet Pond (Environmental Protection Agency (EPA) - Stormwater Menu of BMP’s)

4.5 Infiltration Basin

Infiltration Basins are designed to capture stormwater runoff in order to prevent flooding downstream. Infiltration basins are generally shallow ponds with the goal of allowing the surcharge stormwater to infiltrate through permeable soils into the ground. Although infiltration basins are designed to not discharge back into the source, they are usually designed with overflow structures such as pipes or weirs to prevent flooding of the basin into the surroundings. Some advantages of infiltration basins is that they are believed to high contaminant removal efficiency and can improve the groundwater quality. One of the limiting factors for infiltration basins are that the basin can become saturated and no longer effectively removes the contaminants.
Figure 13: A Typical Infiltration Basin (Stormwater Best Management Practices in an Ultra-Urban Setting: Selection and Monitoring)
5 Calvin Basin Design Alternatives
The Calvin Basin is located downstream of Kreiser. It is an in-line basin that uses a 3 foot deep open channel to convey water through the basin before any storage capacity is used. The basin also has a storm sewer inlet from both the north end, and the southeast end which merge with Silver Creek before exiting the basin (see Figure 14 below).

![Figure 14: Plan view of the Calvin Basin](image)

5.1 Challenges
The biggest challenge with the Calvin Basin is that there is minimal room for expansion. The lack of expansion ability is a result of two factors. The first factor is the water table is approximately 2 feet below the bottom of the basin, thus leaving no room for downward expansion. The second reason is because there is minimal room for the basin boundaries to be expanded outward, mainly due to the presence of roads to the south and east, and the Adams Park Apartments to the west. Additionally, the side slopes of the basin are already at maximum.

5.2 Goals
The goal for this basin is to improve water quality and increase storage capacity.

5.3 Options
To increase storage capacity of this basin, an option is to excavate the rest of the basin and put in walls around the length of the basin. This option will only improve storage volume a small amount and have minimal effects on water quality improvement. Given that this pond has not flooded in the past and that this option will only minimally increase storage capacity this option is not very appealing.
Another option would be to purchase some of the surrounding property and excavate that to create a large storage basin in terms of acres. This route will provide the biggest opportunity to install BMP’s that will maximize water quality improvement; however this route is the most expensive and not very feasible.

The third and most promising option would be to install a filtering media in place of the existing soil and utilize underdrains as well a redesigned outlet structure to regulate low flows. This is the most feasible option, and would provide the most water quality improvement, but would not improve storage capacity.
6 Southfield Basin Design Alternatives

Figure 15: Plan View of the Southfield Basin

6.1 Challenges
The pond is only utilized as surcharge storage for Silver Creek, because the Silver Creek Drain invert is lower than the elevation of Southfield. In addition, a clay liner is also located below the pond surface in order to prevent infiltration to and pollution of the water table. The clay liner is located approximately two feet below the soil surface, which increases the difficulty of excavating the surface of the basin elevation to lower than the drain invert.

6.2 Goals
The goal for Southfield Basin is to have it be utilized during smaller rain events. To utilize the pond effectively, the basin should have water flow through during more common rain events allowing for suspended solids to settle, thus improving water quality. It is a goal to move the existing inlet structure, located in the “middle” of the basin, to the eastern most end.

6.3 Options
One option is to implement a two stage detention basin. A two stage detention basin will hold water to a predetermined elevation, and then water will overflow into the second stage of the basin. This option is not very feasible for this project because a two stage detention basin will minimally improve water quality.

Another option is to develop a structure to place in the Silver Creek Drain that would divert a larger portion of the flow into the Southfield Basin utilizing the existing inlet structure. Implementing this would likely cause flooding upstream as the diversion structure will restrict flows through the Silver Creek Drain.

Finally, an option to better utilize the Southfield Basin would be to move the inlet to the beginning of the basin and design a trench structure from one end of the basin to the other. This appears to be the most feasible design as the Silver Creek Drain is higher in elevation at the eastern most end of the basin and with downward excavation of the eastern end of the basin it is anticipated that water will flow through the basin without compromising the integrity of Silver Creek.
7 Otsego Basin Design Alternatives

7.1 Challenges
There is a two-way pipe that acts as the inlet and outlet. This will increase the difficulty of detaining the water and due to the layout of Silver Creek “daylighting” will not be feasible without constructing a new inlet. The pond is currently only used as a surcharge storage location for Silver Creek. Finally, due to local pollutant levels, a clay liner is located under the soil surface to separate the stormwater from the groundwater, increasing the difficulty of excavation.

7.2 Goals
The design goals for the Otsego Basin would be to utilize it during smaller rain events. To accomplish this, the pond would receive water during these events, allowing for suspended solids to settle.

7.3 Options
In order to meet the goals, the team is assessing several options. These include installing a weir, earthen or otherwise, in the pond to retain a desired volume of water. The size of rainfall event that reaches the basin must also be optimized by adjusting the inlet/outlet grade or installing a diversion structure within the Silver Creek Drain. A filtering media would replace the soil, and underdrains would outlet the water.

A second option is to run a pipe from the western end of the Southfield Basin to the eastern end of the Otsego Basin. This option would allow for the same amount of water that is in the Southfield Basin to flow into the Otsego Basin. This option is appealing because it would provide water quality improvement in both basins. However, there are sanitary and clean water pipes crossing between the Southfield and Otsego Basins making it very difficult to install. The difficulty of installation and the high cost of installing a new pipe both limit the feasibility of this option.

A third option for this pond is to leave it as is. The team has to determine how much stormwater runoff is added to the Silver Creek Drain between the Southfield and Otsego Basins. If a negligible amount of stormwater runoff is added between the two basins the cost benefit of diverting water into the Otsego Basin will not be worth it, considering a majority of the stormwater will have already been treated after flowing through the Southfield Basin. If there is a significant amount of stormwater runoff added to the
system between the two basins, a way will have to be determined to divert water into the Otsego Basin and a way to detain it.
8 Final Design Decisions

Below, Table 1 is a Pass/Fail Test for each of the BMP’s for each basin being considered. The criteria for the Pass/Fail Test was largely based on how well each BMP could remove pollutants as well as how much storage capacity the BMP could add to each basin. The “-” in the Dry Pond section for the Southfield and Otsego Basins are there because those basins currently are dry ponds.

<table>
<thead>
<tr>
<th>Pass/Fail Test for Calvin, Southfield, and Otsego Basins</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infiltration Trench</td>
</tr>
<tr>
<td>---------------------</td>
</tr>
<tr>
<td>Pass</td>
</tr>
<tr>
<td>Calvin Basin</td>
</tr>
<tr>
<td>Southfield Basin</td>
</tr>
<tr>
<td>Otsego Basin</td>
</tr>
</tbody>
</table>

8.1 Calvin Basin

The infiltration trench and infiltration basin passed the test for the Calvin Basin. The team has decided to install an infiltration trench because the cost benefit was much better than that of an infiltration basin. Below, Table 2 is a decision matrix displaying how the final decision was made. It is recommended that an infiltration trench be installed. Also, it is proposed to replace the existing soil with a filtering media, and utilize underdrains and a redesigned outlet structure to regulate low flows.

<table>
<thead>
<tr>
<th>Decision Matrix for Design Alternatives for the Calvin Basin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Storage Volume Impact</td>
</tr>
<tr>
<td>------------------------</td>
</tr>
<tr>
<td>Weight</td>
</tr>
<tr>
<td>Infiltration Trench</td>
</tr>
<tr>
<td>Infiltration Basin</td>
</tr>
</tbody>
</table>
8.2 Southfield Basin

The infiltration trench was the only option that passed the test for the Southfield Basin. Also, for the Southfield Basin, we propose replacing the current 6” underdrain located on the south side of the basin. During the construction of this underdrain the clay liner was modified to be deeper in this location to allow room for the drain. This can be seen in Figure 17. It is also proposed to utilize this extra foot of space to install an earthen channel. This earthen channel will stretch from the basin inlet to the basin outlet. Another option is to not utilize the depression in the clay liner and instead create a meandering channel through the basin, thus maximizing detention time and improving water quality. It is necessary to determine the increase in pollution removal using this method. In addition to this channel a new inlet will be constructed at the eastern most end of the basin. The decision has been made based on the fact that the Silver Creek Drain is higher in elevation at this end of the basin. Coupling this with excavating the bed of the Southfield Basin three to four feet will allow water to flow directly into the basin. In addition to the construction of a new inlet a diversion structure would be installed at the inlet. This structure would be a weir that would force water into the basin inlet, to then flow through the channel. This process of exposing the stormwater to the outside air is called daylighting. This process would help reduce the pollution in the stormwater. The earthen channel would also be vegetated allowing for more pollutant removal. The final weir height has yet to be decided. This depends on what design storm is chosen to divert into the Southfield Basin. Based on the size of the chosen storm event, the team will be able to determine how deep the water is flowing in the Silver Creek Drain, and design a weir tall enough to divert it into the Southfield Basin. This option is also appealing because the approach described above will not have an impact on the upstream conditions and provide storage for more frequent rain events, thus improving the integrity of the Silver Creek Drain.

Figure 17: Existing Underdrain
8.3 Otsego Basin

The infiltration trench and the infiltration basin passed the test for the Otsego Basin. Due to the basin having a single inlet that also serves as the outlet, makes it difficult to have this basin retain any volume of water for an extended period of time. It is recommended that an infiltration basin be implemented should the redesign for the Otsego Basin be pursued. Table 3 is a decision matrix displaying how the final decision was made. It should be noted that the team is also considering leaving the pond “as is” due to the low amount of stormwater runoff entering Silver Creek Drain between the Southfield and Otsego basins. Since there would be a relatively low amount of untreated runoff entering Silver Creek Drain, the team will be determining how much the quality can be improved after a majority of it has been treated after flowing through the Southfield Basin.

Table 3: Decision Matrix (Otsego)

<table>
<thead>
<tr>
<th></th>
<th>Decision Matrix for Design Alternatives for the Otsego Basin</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Storage Volume Impact</td>
</tr>
<tr>
<td>Weight</td>
<td>0.2</td>
</tr>
<tr>
<td>Infiltration Trench</td>
<td>1</td>
</tr>
<tr>
<td>Infiltration Basin</td>
<td>5</td>
</tr>
</tbody>
</table>
9 Cost Considerations

9.1 Team Budget
The team will require a budget of less than the $500 average. So far the team has not spent any money on the project. In the future the team will possibly have to purchase different low cost items that we do not foresee right now. The team will request $200 for transportation to and from the basins, for surveying and data collection as well as miscellaneous purchases. We would also like to use some of these funds in the construction of a scale model for the final presentation.

9.2 Design Cost Estimates
At this point in the design the team has estimated a projected total cost ranging between $266,000 and $385,000. This estimate is based primarily off previous similar projects and is the total for work on the Southfield Basin and the Otsego Basin. It accounts for labor time involved in engineering, drafting, surveying, and office coordination. It also accounts for modification of the detention basin bottoms for the Otsego Basin and the Southfield Basin. This modification will involve the construction of a berm or weir in the Otsego Basin, and the construction of a channel in the Southfield Basin. The team has also looked in the cost for demolition of the current inlet to the Southfield and Otsego basins and the cost for constructing new inlets. The breakdown of the cost estimates can be seen in Table 4.

Table 4: Breakdown of Cost Estimate for Otsego Basin and Southfield Basin

<table>
<thead>
<tr>
<th>Labor</th>
<th>Cost Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Field Inspection</td>
<td>$4,400</td>
</tr>
<tr>
<td>a. Field Survey, 40 hrs @ $110/hr.</td>
<td></td>
</tr>
<tr>
<td>b. Office Coordination, 2 hrs @ $70/hr.</td>
<td>$140</td>
</tr>
<tr>
<td>Sub-Total</td>
<td>$6,800</td>
</tr>
<tr>
<td>Engineering</td>
<td></td>
</tr>
<tr>
<td>a. Engineer, 180 hrs @ $70/hr.</td>
<td>$11,200</td>
</tr>
<tr>
<td>b. Drafting, 80 hrs @ $50/hr.</td>
<td>$4,000</td>
</tr>
<tr>
<td>Sub-Total</td>
<td>$15,200</td>
</tr>
<tr>
<td>Modify Detention Basin Bottom:</td>
<td></td>
</tr>
<tr>
<td>Construction of Otsego berm</td>
<td>$10,000-$25,000</td>
</tr>
<tr>
<td>Construction of Southfield channel</td>
<td>$25,000-$35,000</td>
</tr>
<tr>
<td>Site Clearing</td>
<td>$4,000-$8,000</td>
</tr>
<tr>
<td>Southfield Excavation (~1000 cu. yds)</td>
<td>$100,000-$125,000</td>
</tr>
<tr>
<td>Sub-Total</td>
<td>$139,000-$193,000</td>
</tr>
<tr>
<td>Structures:</td>
<td></td>
</tr>
<tr>
<td>New Inlet Construction (Southfield)</td>
<td>$50,000-$80,000</td>
</tr>
<tr>
<td>New Inlet Construction (Otsego)</td>
<td>$50,000-$80,000</td>
</tr>
<tr>
<td>Sub-Total</td>
<td>$100,000-$160,000</td>
</tr>
<tr>
<td>Miscellaneous:</td>
<td></td>
</tr>
<tr>
<td>Soil Erosion and Sedimentation Control</td>
<td>$2,000-$5,000</td>
</tr>
<tr>
<td>Plain Rip rap 100 Sq. Yd.</td>
<td>$4,000-$6,000</td>
</tr>
<tr>
<td>Sub-Total</td>
<td>$6,000-$11,000</td>
</tr>
<tr>
<td>Project Total</td>
<td>$285,000-$385,000</td>
</tr>
</tbody>
</table>
10 Implementation Factors

During the second semester, the team will be focusing its efforts on researching and choosing an appropriate filtering media to install at the Calvin, Southfield, and possibly Otsego Basins. The team will also be creating detailed plans for the proposed improvements. Table 5 shows a timetable of projects to be completed for the Spring Semester of 2013.

Table 5: Spring 2013 Projects

<table>
<thead>
<tr>
<th>Date</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/11/2013</td>
<td>Determine elevations needed for redesign of Southfield and schedule time to survey with Brad Boomstra</td>
</tr>
<tr>
<td>1/14-18/2013</td>
<td>Survey with Brad Boomstra</td>
</tr>
<tr>
<td>1/28/2013</td>
<td>Complete SWMM model for existing conditions</td>
</tr>
<tr>
<td>2/15/2013</td>
<td>Determine what size storm for Southfield to Treat</td>
</tr>
<tr>
<td>3/1/2013</td>
<td>Determine filtering media for infiltration trenches</td>
</tr>
<tr>
<td>3/29/2013</td>
<td>Completed As-built for inlet/diversion structure for Southfield</td>
</tr>
<tr>
<td>4/12/2013</td>
<td>Final Design Proposals for each basin</td>
</tr>
<tr>
<td></td>
<td>Note: 3 weeks extra to deal with unforeseen problems/ create model</td>
</tr>
</tbody>
</table>

10.1 Calvin Basin

Prior to redesigning the Calvin Basin, the team will research how close the water table elevation is to the ground surface elevation. Provided there is enough vertical separation between the water table and the ground surface, the team will research various filtering medium that will best remove the common pollutants in the stormwater runoff. After a filtering media is selected, the team will utilize AutoCAD to design an outlet structure that will regulate low flows through the Calvin Basin. The main objective of this outlet structure will be to increase detention time. This will allow for maximum treatment by preventing stagnation.

10.2 Southfield Basin

To implement the proposed modifications to the Southfield Basin, surveying will be conducted at the site to obtain various invert and basin elevations. These elevations will be used to determine how much of the basin bed will need to be excavated in order to match the invert of Silver Creek at the proposed inlet location. The team will also be designing a new inlet and diversion structure to be placed near the eastern end of the basin. The team will determine the desired design storm event to divert into the Southfield Basin to be treated. The team will be able to calculate what depth the Silver Creek Drain will be flowing at, and will design a diversion structure to place in the drain that will divert a chosen percentage of the flows into the Southfield Basin.
10.3 Otsego Basin

Before any changes are to be suggested for the Otsego Basin, two circumstances will be evaluated. First, the team will have to determine how much stormwater runoff is added to the system between the Southfield and Otsego basins. If a considerable amount of stormwater is added, the team will have to spend time designing an inlet/outlet structure that will allow for the stormwater to be detained and treated in the Otsego Basin before it re-enters the Silver Creek Drain. If a minimal amount of stormwater is added, the team will have to determine how much the water quality can be improved from utilizing the Otsego Basin, considering a majority of the stormwater has already been treated by the Southfield Basin. If the Otsego Basin only minimally increases the water quality, the cost benefit of modifying the basin will be too high and will likely result in determining the Otsego Basin as unfeasible to re-design. The determination of whether the amount of stormwater added is considerable or minimal will also be a decision that the team will have to make.
11 Conclusion

In conclusion, the team has vastly expanded their knowledge of intricacies of stormwater engineering. The experiences the team has had throughout the first 4 months of the project have been invaluable and rewarding. Looking forward to another semester where the team can incorporate their school-based knowledge into real-world experience brings excitement. The team hopes to finish their senior years in engineering with a quality senior design project in May that represents the hard work and Christian ethics they have developed during their Calvin careers.
12 Acknowledgements

We would like to thank everyone who has assisted us with our project. When we first took on the challenge, we did not have the knowledge, tools or understanding in order to achieve our project proposal and feasibility study. Through the teaching, experience, and feedback of many faculty, staff, and local engineers, we were able to finish our initial report. A special thanks to:

Brad Boomstra, Civil Engineer, Kent County Drain Commission
Bill Byl, Drain Commissioner, Kent County Drain Commission
Prof. David Wunder, Engineering, Calvin College
Prof. Robert Hoeksema, Engineering, Calvin College
Glenn Remelts, Library, Calvin College
Gail Heffner, Director of Community Engagement, Calvin College
Nathan Haan, Biology, Calvin College
Carrie Rivette, Stormwater Engineer, City of Grand Rapids
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