The following report is a student effort to evaluate flood risk mitigation in the Morningside neighborhood. Development of a more formal Flood Risk Reduction Strategy to be led by the City is planned for 2019.

Each semester, the University of Minnesota - College of Science and Engineering requests proposals for senior student capstone project ideas from local professionals who act as project mentors.

Read the November 2018 Edition: Edina story, "U of M Partners with Edina on Capstone Projects."

Attachments:

- Capstone description of commitments and benefits to mentors
- Project description
- Student final report

ENGINEERING DEPARTMENT

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CEGE Senior Capstone Design
Mentor Commitments and Potential Benefits

Mentors provide a real world engineering project (current or past). Based on indicated areas of emphasis and preferences, students are assigned to the projects in teams of 3-5. Ideal projects have a preliminary phase (analyzing alternatives with a minor cost/benefit component) and some form of design phase. Past projects have included projects in all areas of civil, environmental, and geo- engineering:

- environmental: water treatment, wastewater treatment, site remediation
- general civil engineering/municipal engineering: site plans (grading, utility, and hydrologic components)
- geo-engineering: landslide stabilization, foundation analyses
- structural: building design (overall structural analysis and detailed design of representative portion of structure), bridge design including structural drawings
- transportation: Intersection Control Evaluation (ICE), traffic impact studies, signal optimization, corridor design
- water resources/hydrology: retention ponds, sewer capacity studies, stream restoration, sediment control

Mentors provide a written description of their project, which consists of a one to two paragraph project description and list of expected tasks. Students review those descriptions to indicate their project preferences. The instructors assign the projects to the student teams during the first week of class, and the students immediately contact their mentors to set up an initial meeting to complete a project development work plan. The work plan further fleshes out the project tasks and expected timeline/deliverables. In addition, the mentors/teams identify where and when meetings will take place and preferred methods of communication between mentor/team meetings. Some mentors ask students to prepare detailed agenda and meeting minutes.

Mentors should expect to spend on average about one to two hours per week meeting with the students with additional email or phone contact over a 13 week period. The students are expected to accommodate your schedule and your preferred meeting location. Most often students meet their mentors at the mentors' offices (it is helpful for students to see and work in a professional office). Each student on the team is expected to work an average of eight (8) hours per week on their selected project in addition to the time they spend in class each week. The design project culminates in a final oral presentation and project report. The reports are 15 pages plus appendices, which can be quite extensive (e.g., contain structural drawings and sample calculations). Students submit three drafts of the reports (1st draft, midterm, and final) during the semester.

Commitments:

- Mentors provide project description including list of tasks.
- Mentors provide background information and technical assistance on the project for the students.
- Mentors provide guidance to the students, but let the team make important decisions.
- Mentors are encouraged to provide feedback on second (near final) draft of written reports.
- Mentors are encouraged to attend final oral presentations in the Civil Engineering Building

Potential Benefits to Mentors:

- Mentors receive continuing education credit towards their required PDHs.
- Mentors help strengthen our profession by providing a vital education component.
- Mentors work with students that your firm may want to hire in the future.
- Mentors receive reimbursement for parking expenses when on campus.
- Mentors are invited to attend a reception and receive a plaque or small gift honoring their service.
- Mentors may obtain real help on a current project from the students in exploring various design options for which the mentors themselves may not be able to dedicate sufficient time or budget to accomplish.

Project Description
CEGE 4102W/4103W/4104W, S17

Project Title: Evaluating Flood Mitigation Improvements Adjacent to Weber Pond

Mentor(s):

Ross Bintner, PE
City of Edina
7450 Metro Boulevard
Edina, MN 55439
952.903.5713
rbintner@EdinaMN.gov

Jessica Wilson, CFM
City of Edina
7450 Metro Boulevard
Edina, MN 55439
952.826.0445
jwilson@EdinaMN.gov

Project Description:
Weber Pond is a stormwater pond that serves about 228 acres of residential area. During the modeled 1% annual chance (100-year) flood event, several residential structures are at risk and incremental improvements to mitigate flood risk are necessary.

A major residential street reconstruction project in the watershed is anticipated in 2020, presenting an opportunity for green infrastructure practices to reduce stormwater drainage to Weber Pond. Additionally, the City recently purchased a 9.77 acre park on the northern edge of Weber Pond that could accommodate further flood mitigation improvements. The Capstone team would prepare feasibility studies for a variety of options with the goal of reducing flood impacts to private property.

Project tasks include;

- Feasibility study for various flood mitigation projects including 1) green infrastructure options during the upcoming street reconstruction, 2) potential improvements in the new adjacent park, and 3) regular pond maintenance.
- Estimates of reductions in the modeled 1% annual chance (100-year) flood elevation for various improvements.
- Estimates of costs associated with various improvements.

Required Software: None
Provided/Available through Mentor? Y/N

Group 8 Engineering Company
University of Minnesota
Department of Civil, Environmental, and Geo- Engineering
500 Pillsbury Drive SE
Minneapolis, MN 55455

May 4, 2017

Jessica Wilson, CFM
Ross Bintner, PE
City of Edina
7450 Metro Boulevard
Edina, MN 55439

RE: Weber Park Pond Flood Mitigation Feasibility Study, 08S_W_Edina

Dear Ms. Wilson and Mr. Bintner:

This letter is in response to your request for a feasibility study of flood mitigation strategies to reduce the flood impacts of a 1% annual chance (100-year) storm event to private, residential properties near Weber Pond in the Morningside watershed. The completed report is attached.

Multiple flood mitigation strategies were evaluated using a decision matrix that considered risk mitigation, water quality improvement, social benefits, and overall cost. The flood mitigation strategies that were quantitatively considered include the following: excavation of additional pond volume, underground storage tanks, permeable pavement, predictive monitoring system, and property acquisition.

After completing our analysis, it is recommended that the City of Edina install and operate a predictive monitoring system in Weber Pond and excavate the recently acquired wooded area that lies north of Weber Pond. It is also recommended that the City of Edina further evaluate the potential benefits of installing permeable pavers in the road reconstruction area that is planned for 2020 or 2021 in the Morningside neighborhood, which could contribute additional water quality improvements in and downstream of Weber Pond.

It was a pleasure to work with you and your staff on this matter and please do not hesitate to contact us if you require further analysis.

Sincerely,

Emily Caouette, Jack Cottle, Acadia Stephan, and Rena Weis

Feasibility Study for Stormwater Flood Mitigation Within Weber Pond

Prepared for the City of Edina, Minnesota
Prepared by Emily Caouette, Jack Cottle, Acadia Stephan, and Rena Weis

Submitted May 4, 2017

Certification Page

By signing below, the team members submit that this report was prepared by them and is their original work to the best of their abilities.

Rena Weis, *Project Manager*

Emily Caouette, *Team Member*

Jack Cottle, *Team Member*

Acadia Stephan, *Team Member*

Executive Summary

The City of Edina has requested a feasibility study to evaluate various stormwater mitigation methods designed to reduce the elevation of Weber Pond during a 1% annual chance (100-year) storm event, which has the potential to flood and cause structural damage to six residential properties. The Morningside neighborhood, which contains most of Weber Pond's drainage area, is scheduled for a road reconstruction project in 2020 or 2021. During this timeframe, the City of Edina plans to make improvements that will reduce the flood risk posed by Weber Pond's high floodplain.

The objective of this study was to evaluate best management practices for implementation in the Morningside neighborhood that either reduce the total amount of water entering Weber Pond or increase the total storage capacity of Weber Pond itself. Three options were quantitatively evaluated. Modeling was performed using HEC-HMS to quantify their effects on the peak flood elevation of Weber Pond. These options are:

1. Excavate additional storage in low lying areas and install predictive monitoring system.
2. Install underground storage tanks connected to the upstream storm sewer.
3. Install PaveDrain permeable pavement for the 2020 or 2021 road reconstruction.

In the course of modeling and analysis, Options 2 and 3 were found to create an insufficient amount of additional storage or reduction of discharge to Weber Pond. The amount of required flood reduction necessitated a large amount of additional storage, which could only be achieved through Option 1.

The final recommendation is to increase the area and volume of Weber pond through excavation and install a predictive monitoring system to create additional storage in anticipation of a storm event. Additionally, the feasibility and effectiveness of permeable pavement in the 2020 or 2021 road reconstruction area should be evaluated. In whole, this recommendation creates 63.5 acre-feet of additional storage volume and lowers the peak flood elevation by 1.9 ft. The estimated cost of this recommendation is $1,541,000 for excavation and development, $70,000 for the predictive monitoring system, and $3,250,000 for PaveDrain installation.

Implementation of this recommendation will reduce the risk of flooding to six residential properties, open up the possibility of park development north of Weber Pond, and potentially improve runoff quality if the PaveDrain is installed. It is recommended that the City of Edina explore these options further, using a more sophisticated hydrological model of the Morningside watershed, to confirm the results of this study and quantify any water quality improvements.

Table of Contents

List of Tables

List of Figures

1.0 Introduction

The City of Edina provides municipal services for its residents including stormwater and drainage system management (City of Edina and Barr Engineering Company). The City has requested a feasibility study for flood mitigation strategies to reduce the 1% annual chance (100-year) storm event flood elevation of Weber Pond from 869.0-ft (Barr Engineering Company). This elevation is above the low entry elevation of six residential properties, which puts the homes at risk of flooding and, in turn, structural damage.

The owners of these properties have requested that actions be taken to reduce the risk of flood damage. To protect these properties, the 1% annual chance flood elevation of Weber Pond must be reduced by 1.9-ft.

When selecting feasible design options, consideration was given to the needs and values of the community. Additionally, upcoming projects in the City of Edina were considered because they may include project components that could reduce flood risk. These areas include a road reconstruction area and a newly acquired wooded area that lies north of Weber Pond. A successful flood mitigation design will reduce the flood elevation at Weber Pond and will be beneficial to the City of Edina and its residents by considering the following criteria:

- Protecting and improving water quality
- Developing land with the City's values in mind
- Meeting city budgetary need

The City of Edina has outlined their commitment to stormwater management, flood control, and water quality in their Comprehensive Water Resource Management Plan (City of Edina and Barr Engineering Company), which was updated in 2011.

Four final feasible design options were selected, and assessed using the criteria above. Section 4.0 introduces the feasible design options analyzed in this report. HEC-HMS modeling was performed to determine the total volume reduction for each option. In addition to evaluating each option individually, the final options were also analyzed in conjunction with each other.

This document outlines options to mitigate flood risk by reducing the high-water level near Weber Park in a 1% annual chance storm event and the methodology used in the selection of these options. In addition, a final recommendation is made for the City of Edina in Section 6.0.

2.0 Background and Site Information

Weber Pond is a stormwater detention pond that lies directly east of Weber Park between West 41st Street and West 42nd Street in Edina, Minnesota. The pond collects runoff from a 452-acre drainage area (Barr Engineering Company). This drainage area is primarily composed of the Morningside neighborhood – a residential area located in the northeast corner of Edina – and small portions of St. Louis Park. The storm sewer system through the Morningside neighborhood either drains into Weber Pond or into a temporary inundation area (TIA) that lies west of Weber Pond. See Appendix A for a complete description of the TIA, including photos. Figure 3 shows the complete layout of the stormwater system within the Morningside drainage area. The outlet of Weber Pond runs north into St. Louis Park where it eventually connects with the Minneapolis storm sewer system and discharges into Lake Calhoun.

The City of Edina designed its stormwater management systems to protect against 1% annual chance (100-year) flood elevations (City of Edina and Barr Engineering Company). However, Weber Pond was designed for a 2% annual chance (50-year) storm event because of site and downstream capacity constraints. As described by a report completed by Barr Engineering Company in 2006, the discharge capacity of Weber Pond is dictated by the capacity of the downstream Minneapolis sewer system. The available capacity in the Minneapolis sewer system from Weber Pond is 25 cfs (Barr Engineering Company). However, the downstream capacity required to decrease the 1% annual chance flood elevation of Weber Pond to a substantial level is 105-cfs (Barr Engineering Company).

These restrictions in downstream capacity have implications for the City of Edina. Modeling of existing conditions completed by Barr calculated the 1% annual chance flood level of Weber Pond to be 869.0-feet, which was above the lowest entry elevation of four residential properties (Barr Engineering Company). Thus, the storm event could result in structural damage to the properties on these lots. Figure 1 illustrates the Federal Emergency Management Agency (FEMA) 1% annual chance storm floodplain and the location of the six threatened properties. In their report, Barr investigated options for flood mitigation, but no action has been taken by the City of Edina to implementing those options.

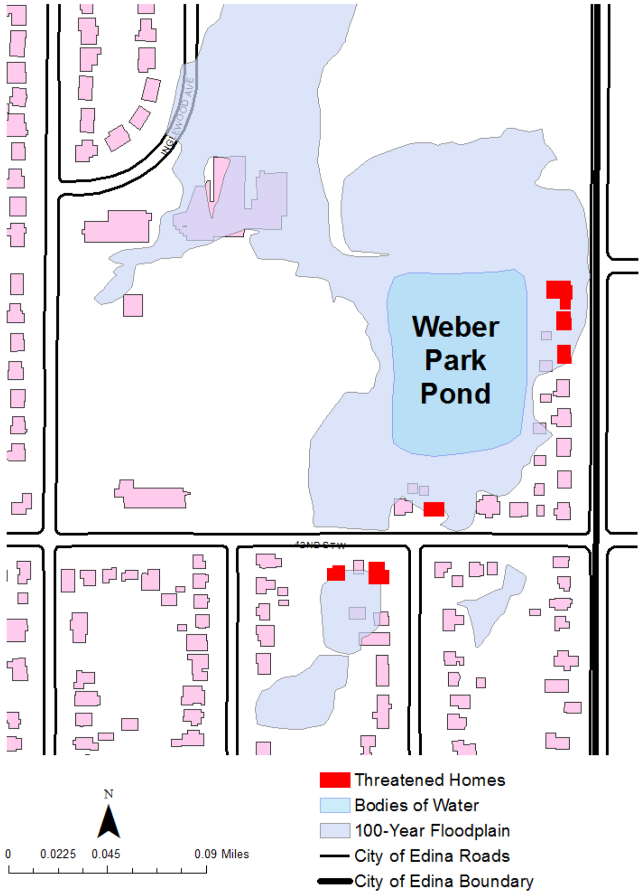

Figure 1. 1% annual chance (100-year) storm FEMA floodplain of Weber Pond with threatened properties depicted in red.

The report completed by Barr in 2006 describes four threatened properties, and the City of Edina has recently surveyed the low-entry elevations of two additional properties located in the floodplain. The threatened properties include three residences on France Avenue and three residences on 42nd Street. The following table provides the lowest point of entry for each of the six threatened properties and the needed 1% annual chance elevation change to remove each of the properties from the 1% annual chance storm floodplain. Figure 2 depicts the water elevation of the 1% annual chance flood event over time. The red line indicates where the flood elevation is equal to the lowest point of entry of the six threatened properties. The low entry elevations of each threatened property are plotted on the figure for reference.

Table 1. Surveyed low-entry elevations of the six residential properties affected by the 1% annual chance (100-year) flood.

Address		Lowest Point of Entry (MSL) (ft)	Needed 1% annual chance Elevation Change[1]
a.	4000 42nd St W	869.00	> 0.0
b.	4003 42nd St W	868.58	> 0.0
c.	4108 France Avenue	868.50	-0.10
d.	4104 France Avenue	867.50	-1.10
e.	4100 France Avenue	866.80	-1.80
f.	4005 42nd St W	866.74	-1.86

1. Modeled peak water surface elevation is 868.6 ft under existing conditions

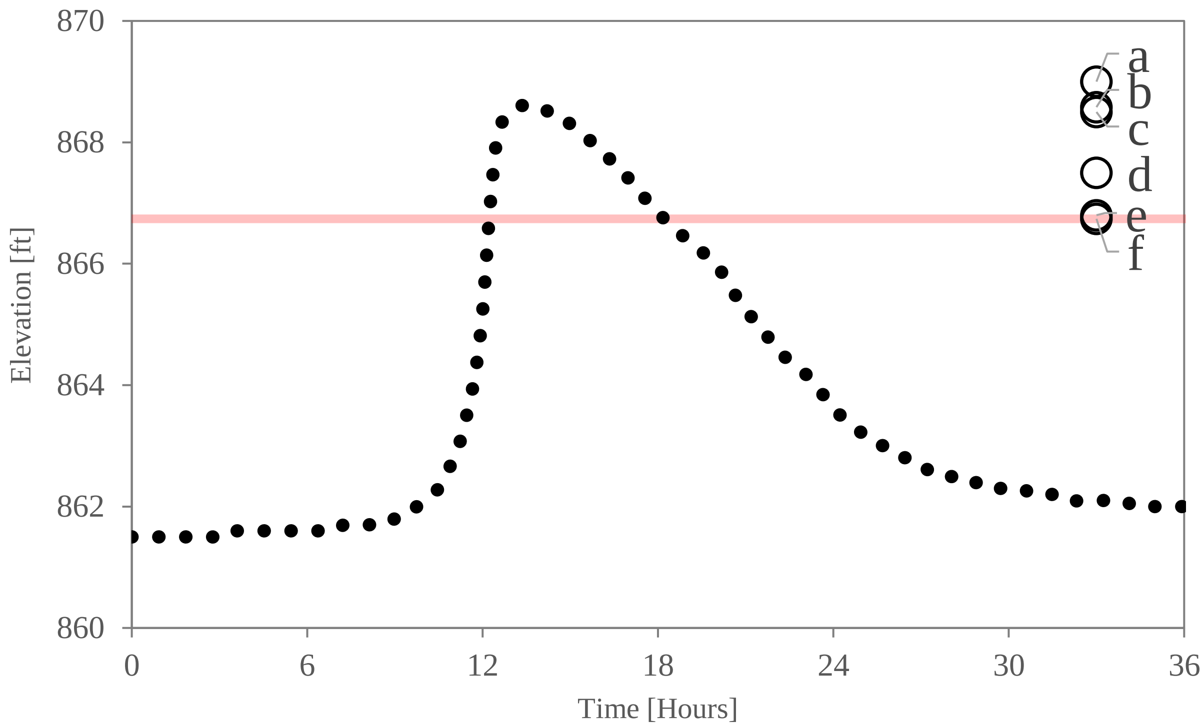

Figure 2. Water elevation over time in Weber Pond, with six threatened residential properties indicated.

Using the rate of inflow and outflow from Weber Pond, the theoretical required storage for stormwater peak attenuation is 55.8 ac-ft. See Appendix D for the inflow and outflow hydrograph for Weber Pond used in this calculation.

2.1 Opportunities for Flood Improvements

The City of Edina is currently planning for the development/redevelopment of two areas within the Morningside drainage area. These areas were considered when selecting flood mitigation strategies so that the implementation of the mitigation strategies could be coupled with the ongoing projects in the City of Edina, which would save time and resources. The development/redevelopment of these areas provides opportunities for the implementation of various flood mitigation strategies. The city recently purchased the 9.77-acre wooded area located north of Weber Park (Braun Intertec Corporation). This space is unoccupied and the city is receptive to proposals for development of this land which would reduce flood levels within Weber Pond (Braun Intertec Corporation). Additionally, a large road reconstruction project is being planned for 2020 or 2021, which presents a unique opportunity to utilize green infrastructure for further flood level reduction. Figure 3 shows the newly purchased parcel and the anticipated road reconstruction areas relative to Weber Pond.

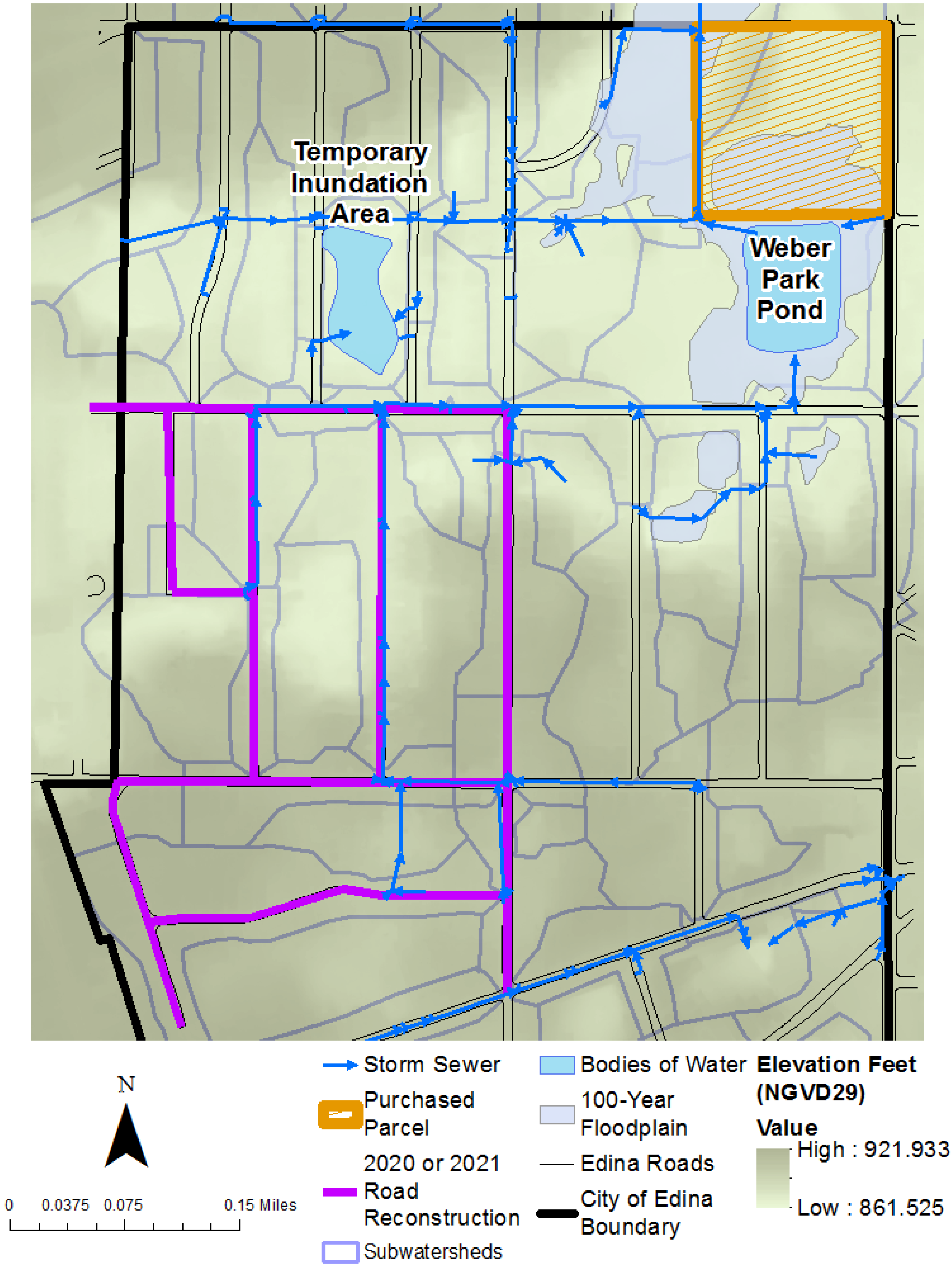

Figure 3: Figure of Edina' stormwater infrastructure, subwatersheds, and redevelopment projects in the Morningside Neighborhood

3.0 Methodology

The flood mitigation strategies presented in this document were initially selected based on high-level considerations of the site's background information. The background information considered includes:

1. The most accurate 1% annual chance (100-year) flood information available, from NOAA Atlas 14. See Appendix G for this information.
2. Projected plans for an anticipated road reconstruction area in 2020 or 2021.
3. Recently purchased park land north of Weber Park pond.
4. Existing storm sewer infrastructure including gravity mains and catch basin placement.
5. Topography of the Morningside drainage area, including Weber Park.
6. General political feasibility.

The initial options were classified into broad categories based on ongoing projects within the City of Edina. A detailed description of the options that were not selected for further evaluation can be found in the Appendix F. These initial flood mitigation strategies were then consolidated based on background information and on the desires of the City of Edina. The feasible design options that were selected are presented in Section 3.1.

These options were evaluated in-depth using the HEC-HMS modeling software, a cost analysis, and a final decision matrix evaluating additional criteria. The results from the post-development models can be found in the Model Results sections for each feasible design option. See Section 4.5 for total cost, and cost per storage. See Section 6 .0 for evaluation of options and a decision matrix.

To quantify the change in flood elevation achieved by modeling the feasible design options, a pre-development model was compared to post-development models. A pre-development model of the Morningside drainage area was created in HEC-HMS and is intended to match as closely as possible the current conditions in the watershed. A detailed description of the methods used to construct this model is presented in Section 3.2. The post-development models incorporate the final flood mitigation strategies outlined Section 3.1.

3.1 Introduction to Feasible Design Options

The following four feasible design options were quantitatively considered individually and in various combinations with each other.

A. A predictive monitoring system used in combination with additional temporary and/or permanent storage volume created through the excavation of low-lying areas located within the floodplain.
B. Subsurface storage/release system installed within Morningside drainage basin.
C. Permeable pavement installed in the anticipated road reconstruction area.
D. Evaluation of options listed above in combination with the option(s) of doing nothing and/or acquiring the at-risk properties

3.2 Model Development

The Edina Comprehensive Water Resource Management Plan (CWRMP) contained most of the source data for the pre-development model, including sub-basin properties, storm sewer dimensions, and storm sewer layout (City of Edina and Barr Engineering Company). The remaining source data, including stage-area curves and infiltration parameters, were collected in correspondence with Barr Engineering and the City of Edina. See Appendix G for a detailed figure and the complete data input into the modeling software including flow routing parameters, sub basin properties, and elevation-area relationships and outlet pipe dimensions for reservoirs.

Infiltration parameters were given in Horton, which HEC-HMS does not accept as an input (Stratton). To model the flow lost to infiltration accurately, the rate of infiltration versus time was plotted using the given Horton's parameters, and the total infiltrated depth was determined by integrating the curve. A similar plot was created using the Green-Ampt equation, with parameters chosen to yield an equal total infiltration depth. The Green-Ampt parameters were used as inputs for the HEC-HMS model. See Figure 21, Appendix G for this figure.

There are four sub-basins in the Morningside neighborhood that do not have any connection downstream. It has been determined that these areas do not overflow during the 1% annual chance storm event, so they are not included in the flow to Weber Pond.

The 1% annual chance storm FEMA floodplain spans multiple sub-basins, which are not included in the stage-storage curve for Weber Pond. To solve this, the stage-storage curve was created directly from the 2-ft contour file to exactly match the dimensions of the 1% annual chance floodplain area. See Appendix G for the final elevation-area relationships used.

The inlet to Weber Pond from the west bypasses the pond in low-flow conditions. To model this, an inflow-diversion function was developed to divert the flow at this inlet. See Appendix G for a figure and flow quantities.

4.0 Feasible Design Options Analysis

Descriptions of the four feasible design options are provided along with a quantification of the potential for each option to reduce the 1% annual chance flood elevation.

4.1 Predictive Monitoring and Excavation

Weber Pond is currently designed to hold a set amount of stormwater runoff volume. The concept of this option is to create effective storage within Weber Pond and the floodplain by using predictive monitoring and excavation.

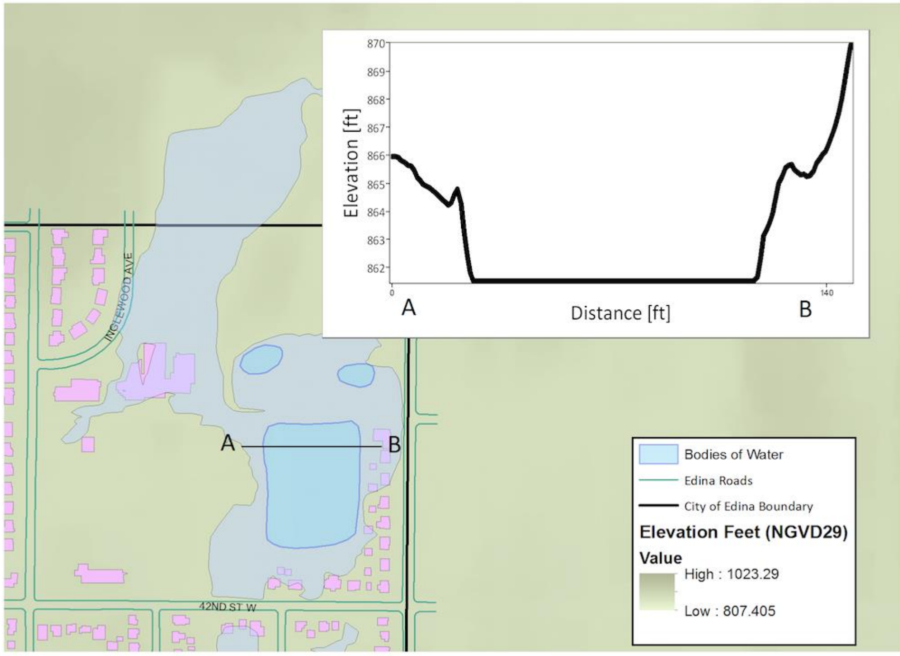

Figure 4. Elevation profile of a cross section within Weber Pond.

Predictive monitoring systems are a form of active stormwater management that can automatically pump water based on forecasted weather data (OptiRTC). A predictive monitoring system installed at Weber Pond would have the potential to predict the size of an approaching storm events and pump down the water elevation of Weber Pond to create additional storage in the pond in anticipation of the rainfall event (OptiRTC).

This system could completely empty Weber Pond, making room for additional stormwater runoff generated by the 1% annual chance storm event. The water pumped from Weber Pond would be routed directly downstream to the City of Minneapolis' storm sewer system before it is fully utilized for storm runoff. The results of a predictive monitoring system installed on the existing Weber Pond were quantified in Table 2. The predictive monitoring system also has the potential to improve the water quality downstream of Weber Pond (Capitol Region Watershed District). The water that would be pumped out prior to a storm would be relatively clear compared to flood water because it would have had time to sit, allowing for sediments to settle out (Capitol Region Watershed District).

To maximize the potential of the predictive monitoring system, the concept of predictive monitoring was paired with excavation. Increasing the surface area of Weber pond allowed for more water to be pumped out in anticipation of a storm event. The newly purchased, approximately 10-acre parcel north of Weber Pond and the TIA were the two proposed pond expansion areas: See Appendix B for the final design of the excavated areas. The results of a predictive monitoring system installed at Weber Pond in conjunction with creation of additional pond volume were quantified in Table 2. The results achieved through the use of predictive monitoring may depend on the maximum discharge to the pond and the total upland contributing area (Eshenaur).

The TIA excavation option requires a re-routing of the upstream storm sewer to reduce the total amount of water flowing into Weber Pond. In its current state, the TIA receives runoff only from small, neighboring watersheds. In the post-development model, 10% of the upstream flow is diverted from the storm sewers into the TIA. This diverted amount is approximately the maximum volume that the TIA can handle without overflowing.

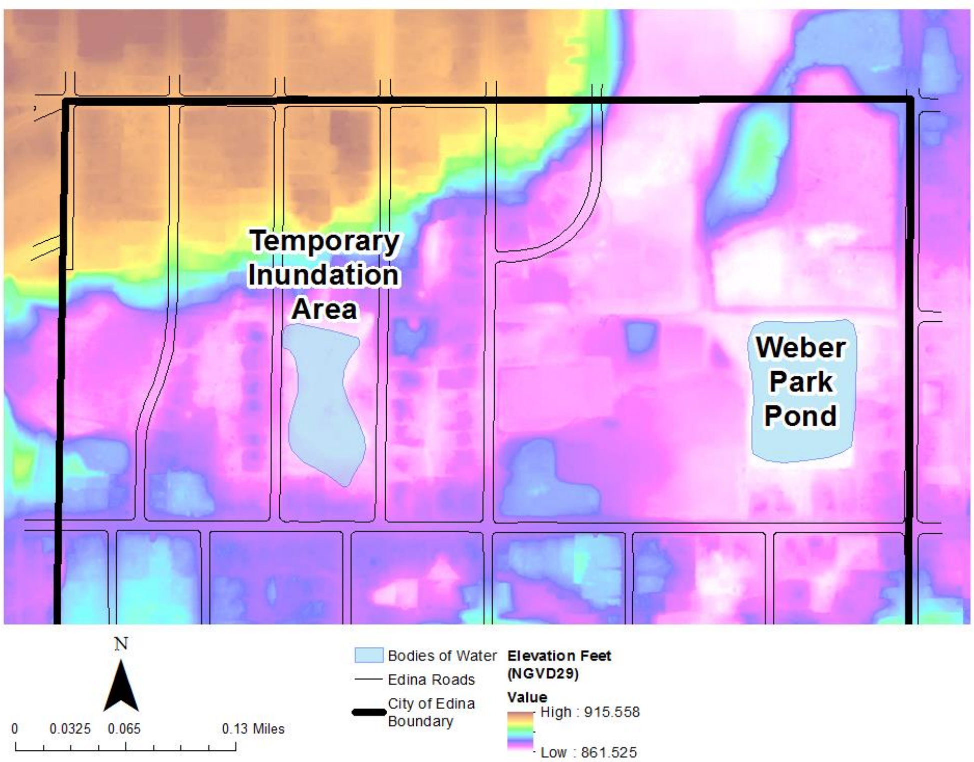

Figure 5. The TIA and area located north of Weber Pond identified as low-lying, publicly owned areas that could be excavated

4.1.1 Model Results for Predictive Monitoring and Excavation

Table 2. 1% annual chance flood mitigation achieved through predictive monitoring and excavation

Predictive Monitoring and Excavation	
Excavation Area	**1% Annual Chance (100-year) Flood Elevation Change (ft)**
None	-0.2
North of Weber Pond	-1.9
North of Weber Pond & TIA	-2.3

4.2 Underground Storage Units

Underground storage tanks have the ability to detain water while keeping the land surface available for use. Alterations would be made to the City's existing Edina stormwater system to redirect flows to a subsurface storage tank. The discharge from a tank would be controlled to allow for extended storage and the slow, measured release of the detained water to the City's storm sewer system resulting in a reduction of the peak of Weber Pond's hydrograph (Lake Superios Streams Duluth). See Figure 20 in Appendix E for a diagram illustrating the concept of slow release.

Three flat, low-lying areas were identified where underground storage tanks could potentially be installed. These include on the Susan Lindgren School property, at the Weber Park ball fields, and at the anticipated road reconstruction area, as shown in Figure 6.

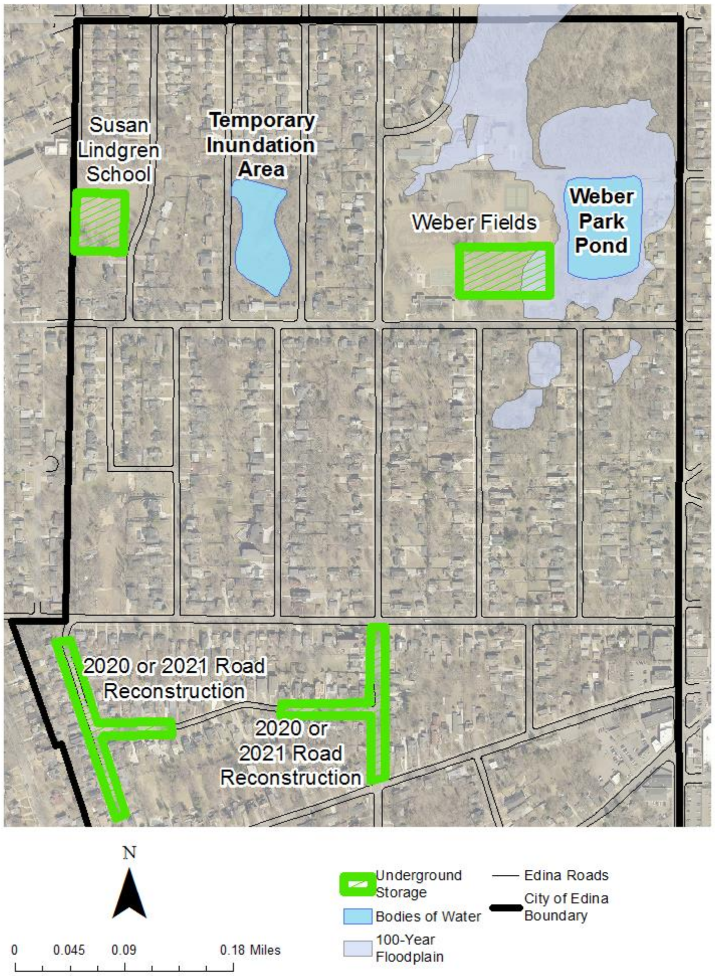

Figure 6. Location of proposed placement of underground storage within the Morningside neighborhood

The maximum underground storage volume was calculated for each of the sites, as shown in Table 3. It was assumed that the top of the underground storage system was 18" below the ground surface (Contech Engineered Solutions). To avoid the water table, it was assumed that the invert of the underground storage system was at the invert elevation of the existing storm sewer system, which is above the water table. Additionally, this allows the stormwater sewer and underground storage system to be operated as a gravity fed system. See Table 16 in Appendix E for the values of invert depth used in this calculation.

Proposed storage systems under the Susan Lindgren School and Weber Park Fields were assumed to be networks of parallel solid corrugated metal pipe (CMP) (Contech Engineered Solution). The proposed storage system beneath the anticipated road reconstruction area was assumed to be a single manifold solid CMP. All proposed locations for underground storage will require maintenance of the pretreatment chamber in order to prevent accumulation of sediments within the underground system (New York City Department of Environmental Protection). See Appendix B for the final designs of the underground storage systems.

Table 3: Additional storage volume created through underground systems.

Location	Underground Storage Volume (ac-ft)
Susan Lindgren School	5.2
Weber Park Fields	12.0
2020 or 2021 Road Reconstruction Area	1.7

Additionally, the system below the anticipated road reconstruction area could be installed as perforated metal pipe or other infiltration system, such as ChamberMaxx technology (Contech Engineered Solutions). The use of infiltration below the permeable pavement will create a dynamic system that will increase the effective storage created.

4.2.1 Model Results for Underground Storage Units

Table 4: 1% Annual Chance (100-year) flood mitigation achieved through underground storage system.

Underground Storage	
Location	**1% Annual Chance (100 year) Flood Elevation Change (ft)**
Susan Lindgren School	-0.1
Weber Park Fields	-0.3
2020 or 2021 Road Reconstruction Area	-0.1

4.3 Permeable Pavement

Permeable pavement captures stormwater by filtering it through surface voids that lead to an underlying reservoir for temporary storage and/or infiltration (Minnesota Pollution Control Agency). The 2015 Edina Living Streets Plan discusses the need for streets to be constructed and maintained to meet future health, economic and environmental challenges. Among these, the City strives to promote water quality improvements (City of Edina). To accomplish this goal, the City has already installed pervious pavement in some areas (City of Edina). Installation of pervious pavement, rather than bituminous asphalt, was considered for use in the anticipated 2020 or 2021 road reconstruction site, and the effects on Weber Pond's 1% annual chance flood elevation were quantified. To do so, the surface area of the road over the entire road reconstruction area was calculated, and the percent change in impervious area was computed, as shown in Table 18 in Appendix E.

In addition to permeable pavement's potential to manage water quantity, permeable pavement's filtration properties can improve water runoff quality by reducing amounts of total suspended solids (TSS) and total phosphorus (TP) loads into receiving waters (Minnesota Pollution Control Agency). Pretreatment of water may be required in order to prevent significant clogging of the pavement, and pervious pavement requires regular vacuuming maintenance (Minnesota Pollution Control Agency). Site specific water quality improvements were not quantified in this study.

4.3.1 Model Results for Permeable Pavement

Table 5. 1% annual chance flood mitigation achieved through permeable pavement, and permeable pavement with additional infiltration of underground storage

Permeable Pavement	
Description	**1% Annual Chance (100 year) Flood Elevation Change (ft)**
2020 or 2021 Road Reconstruction Area	0.0
2020 or 2021 Road Reconstruction Area With Underground Storage	-0.1

4.4 Alternative Options

The above strategies may be evaluated in combination with the options of the City of Edina acquiring the at-risk properties or taking no action. See Table 14 in Appendix C for the cost of property acquisition for each of the threatened six properties and the effects of taking no action.

Despite the relatively low cost of acquiring all six properties, acquisitions are not common place in Edina and thus this option is likely not feasible overall due to other political factors. The solution presented within this report is able to reduce the flood elevation within Weber Pond by the required 1.9-ft and thus, succeeds in removing all six threatened properties from the 1% annual chance floodplain. However, if an alternate solution was selected by the city, the potential overall annual cost of damages for residents due to flooding in residential properties could be computed using the probability of a storm event, and the elevation and duration of flooding.

4.5 Cost Analysis

The cost of each feasible design option discussed in this report is summarized in Table 6. See Appendix C for calculations and source information used in completing the cost analysis.

Table 6. Summary cost analysis for feasible design options

		Total Cost	Additional Storage (Acre-ft)	Cost/Storage ($/Acre-ft)
Predictive Monitoring				
Excavation Area	None	$70,000	6.64	$10,542
	Weber Pond	$1,610,605	63.5	$25,364[3]
	Weber Pond & TIA	$2,204,396	75.8	$29,101[3]
Underground Storage				
	Susan Lindgren School	$1,485,000	12.0	$124,208
	Weber Park Fields	$679,800	5.2	$130,965
	2020 Reconstruction	$264,000	1.7	$151,453
Permeable Pavement	2020 or 2021 Road Reconstruction Area	See below [1]	0.0	N/A[2]
Acquire Properties		$ 2,431,000	0.0	N/A

1. The cost of the permeable pavement was computed as a marginal cost analysis between permeable pavement and bituminous materials. The marginal cost was calculated to be **$ 2,780,000.**
2. The storage volume (ac-ft) created by permeable pavement is insignificant and thus, Cost/Storage is not computed for this option.
3. Cost calculated additional excavation to ensure an acceptable standing water level in Weber Pond

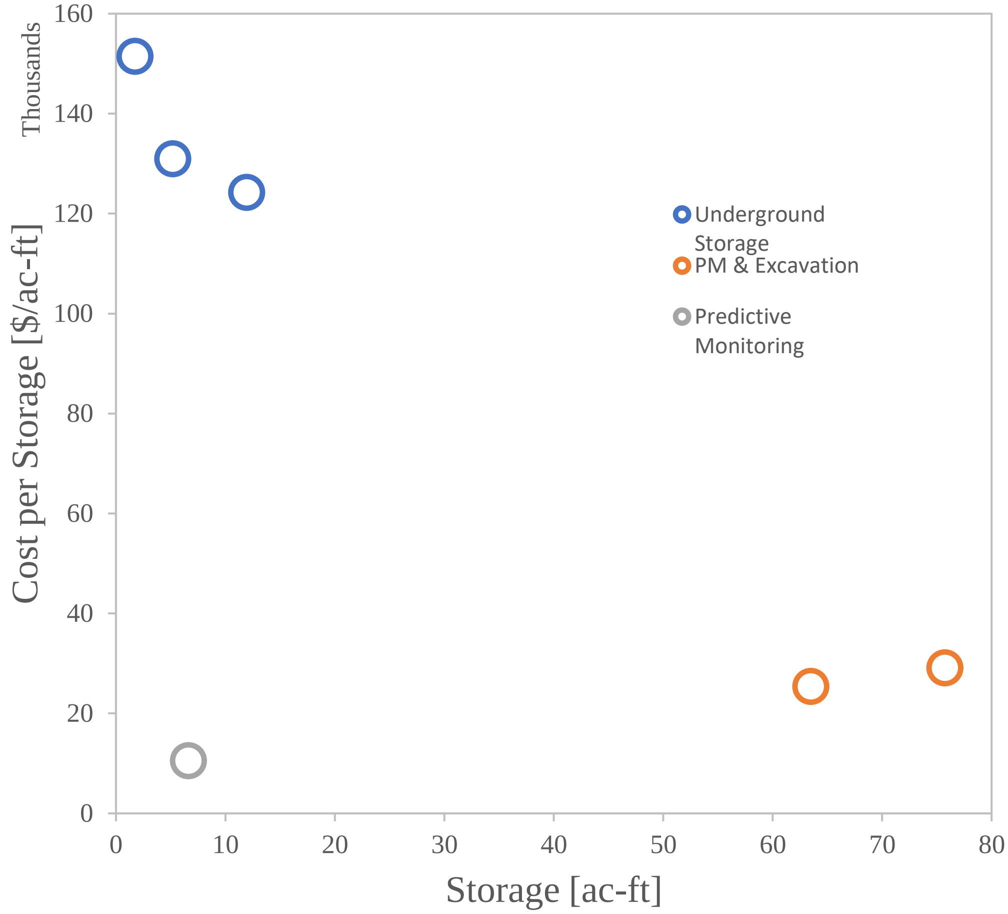

Figure 7. Cost per acre-ft of added storage plotted for each feasible design option

The cost was estimated assuming that the bottom elevation was excavated to an elevation of 858-ft. This elevation allows for 3.5-ft of standing water at Weber Pond. Although excavating the bottom elevation to 860 ft would be cheaper and successfully mitigate flood risk, a more shallow pond would foster a marshy environment which could lead to potential public health concerns.

The City could consider grant and cost-share opportunities for water quality and flood mitigation projects from local partners including the Minnehaha Creek Watershed District (MCWD). In addition, MCWD suggests that municipalities seeking funding reach out to Hennepin County for natural resources grants (Minnehaha Creek Watershed District). Similar projects have been funded by the Minnesota Board of Water and Soil Resources Clean Water Fund (Capitol Region Watershed District).

5.0 Sustainability

As the climate continues to warm, rain events will likely become more intense and more prevalent, meaning the risk and severity of floods is also likely to increase. To accommodate the changing climate, the proposed mitigation systems were designed with a focus on resilience. This forethought will increase the lifespan of the flood mitigation systems, which will reduce the cost and energy associated with repairing or replacing damaged infrastructure.

Sustainability was also given weight in the decision matrix and in the final recommendation. The decision matrix was used to help select a flood mitigation strategy that solves not only the Weber Pond flooding problem but also optimizes social, environmental, and economic benefits. Social issues that are addressed by the recommended flood mitigation options include park development and relief of economic burdens to the affected homeowners by preventing flood damage that is either insured at a high cost and/or causes a disruption in the homeowners' lives. Environmentally, options that improve the water quality of Weber Pond such as predictive monitoring systems and permeable pavers were preferential to options that provided similar magnitudes of flood mitigation but lacked water quality improvements. Additionally, decreasing the amount of storm water runoff will reduce pond contamination from sediments, pollutants, and nutrients. Finally, a cost analysis was conducted to estimate the cost associated with each improvement option. Grants and cost-share programs through other government agencies were also considered. For further detail on the cost analysis, see Section 4.5.

6.0 Final Recommendation and Summary

The goal of this feasibility study, completed for the City of Edina, was to identify and recommend a stormwater management design which would reduce the 1% annual chance flood elevation within Weber Pond by 1.9 ft. This design was completed with consideration given to upcoming and ongoing projects within the City of Edina including a newly purchased parcel of park land north of Weber Pond and upcoming road reconstruction project.

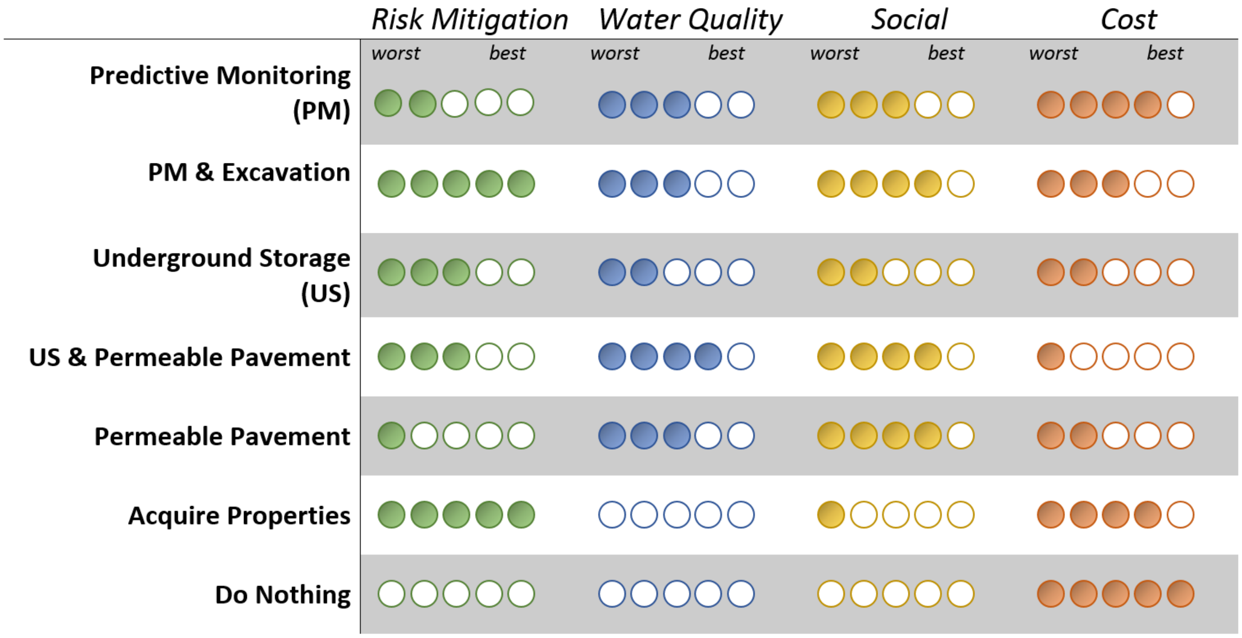

Figure 8. The feasible design options presented in Section 4.0 evaluated using the criteria outlined in the Introduction (Section 1.0) of the report.

To reduce the 1% annual chance flood elevation of Weber Pond, the total effective storage can be increased in the floodplain, peak flows traveling to the pond captured and released more slowly, or the total volume of stormwater runoff reaching the pond must be reduced After an evaluation of the benefits and drawbacks of each option contained in this report, our team recommends that the City of Edina:

- Create 25-ac-ft of additional flood storage within Weber Pond through excavation of the wooded area north of Weber Pond.
- Install and manage a predictive monitoring system to lower the water elevation within Weber Pond and excavated area north of Weber Pond in anticipation of a storm event.
- Utilize permeable pavement within the anticipated road reconstruction area in accordance with the vision of the city's 2015 Living Streets Plan.

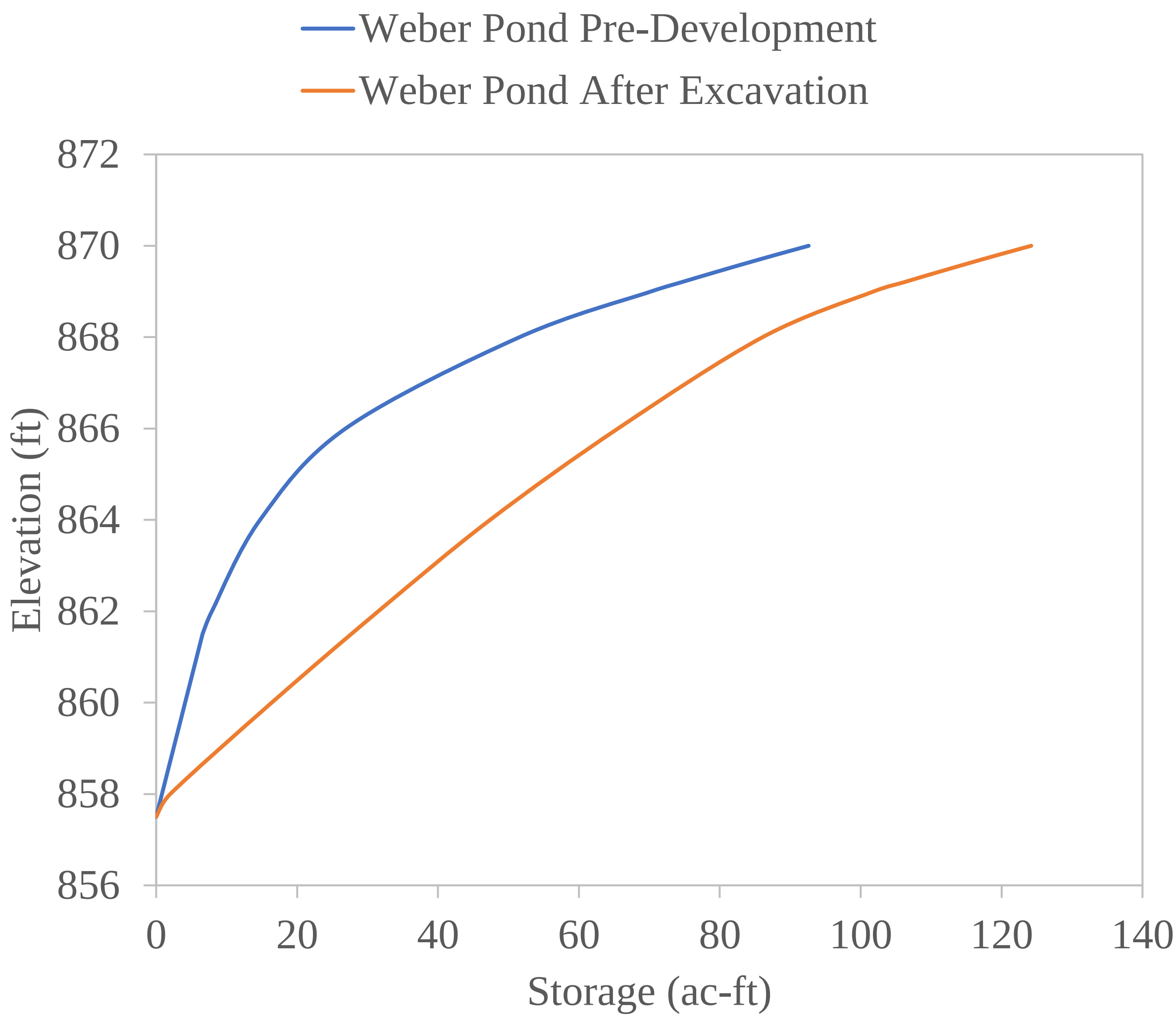

Figure 9. Pre-development and post-development stage-storage curves for 1% annual chance floodplain, where excavation of area north of Weber Pond adds an additional 25 [ac-ft] of storage.

The City of Edina, through the first and second goal of their Comprehensive Water Resource Management Plan (CWRMP), conveys their commitment to balancing stormwater management and flood control with protecting water quality (City of Edina and Barr Engineering Company). The combination of these options is recommended with the city's commitment to comprehensive water resource management in mind. The recommended combination of options will provide the city with the most cost effective flood mitigation solution for its residents while ensuring the city is able to fulfill their commitment to water quality by using permeable pavement. Since site specific water quality benefits were not quantified for this report, it is recommended that the City of Edina further evaluate the potential benefits of permeable pavement. Figure 10 provides the resulting water elevation over time in Weber Pond for the recommended solution.

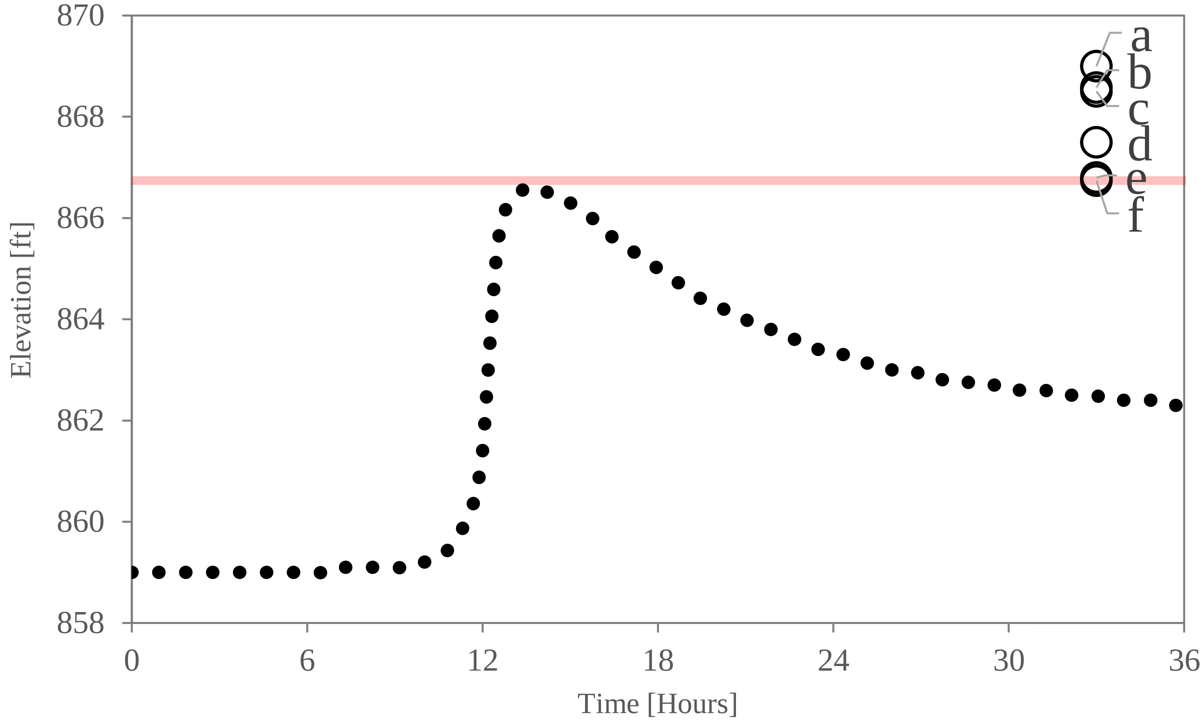

Figure 10. Final recommendation water elevation over time in Weber Pond, with six threatened residential properties indicated.

In summary, by implementing the recommended solution, the City of Edina will be able to accomplish their intended goal of ensuring flood protection to their residents while demonstrating their commitment to additional values such as water quality management, and sustainable land use development.

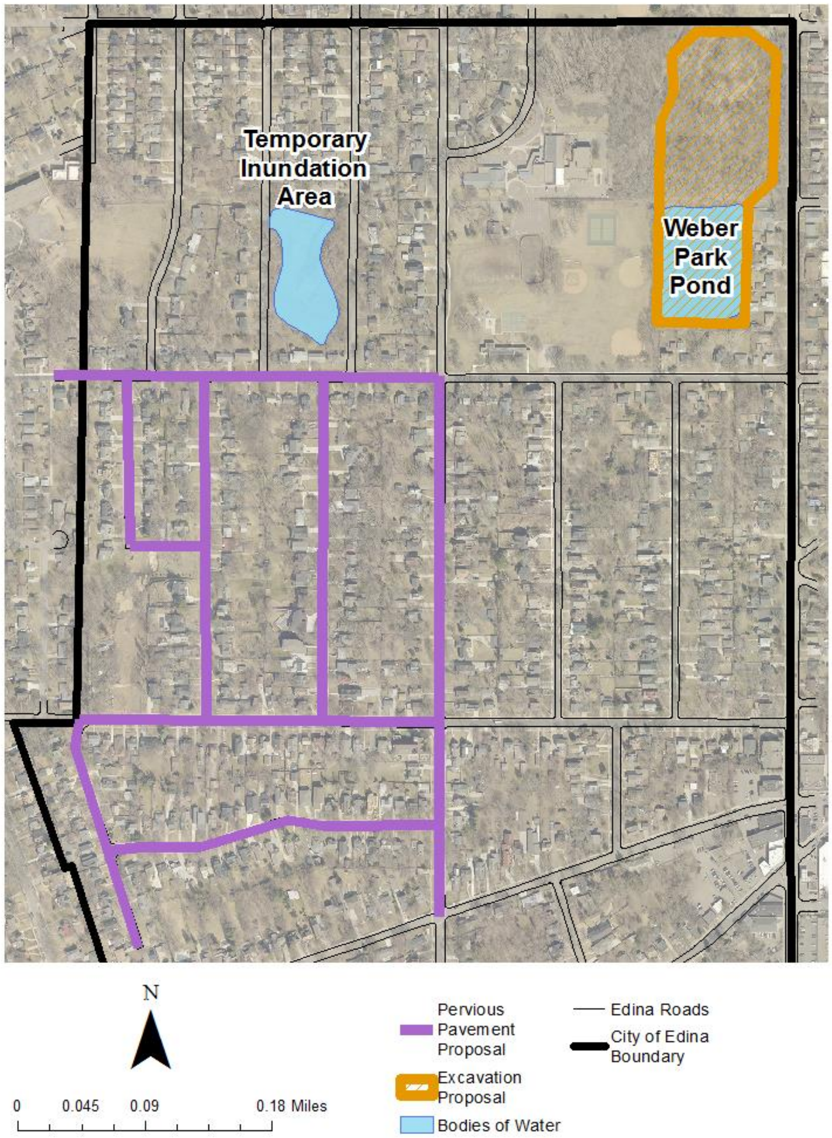

Figure 11. Final recommendation design schematic, showing the proposed combination of options

7.0 References

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Appendix A: *Description and Photos of Temporary Inundation Area (TIA)*

As the name suggests, stormwater runoff is stored within the design capacity of the temporary inundation area before it is piped directly to Weber Pond via the City of Edina's stormwater system. The TIA is a low-lying, marshy area which could be further excavated to increase its capacity, thus reducing the amount of water discharged to Weber Pond from this area.

Figure 12. The outlet structure that transports water from the TIA to Weber Pond via the stormsewer system

Figure 13. The TIA exhibiting its current capacity to hold stormwater that will later be transported to Weber Pond

Figure 14. Example of an area within the TIA that could be excavated to increase capacity

Appendix B: Final Designs

Final Design for Section 4.1 - Excavation of Weber Pond and Temporary Inundation Area (TIA)

The final design of Weber Pond is to be excavated to 858-ft, with a side slope of 3:1 H:V, as requested by City of Edina. The final design was completed, and its dimensions measured using AutoCAD. Figure 15 shows the final proposed excavation plans for Weber Pond and the TIA.

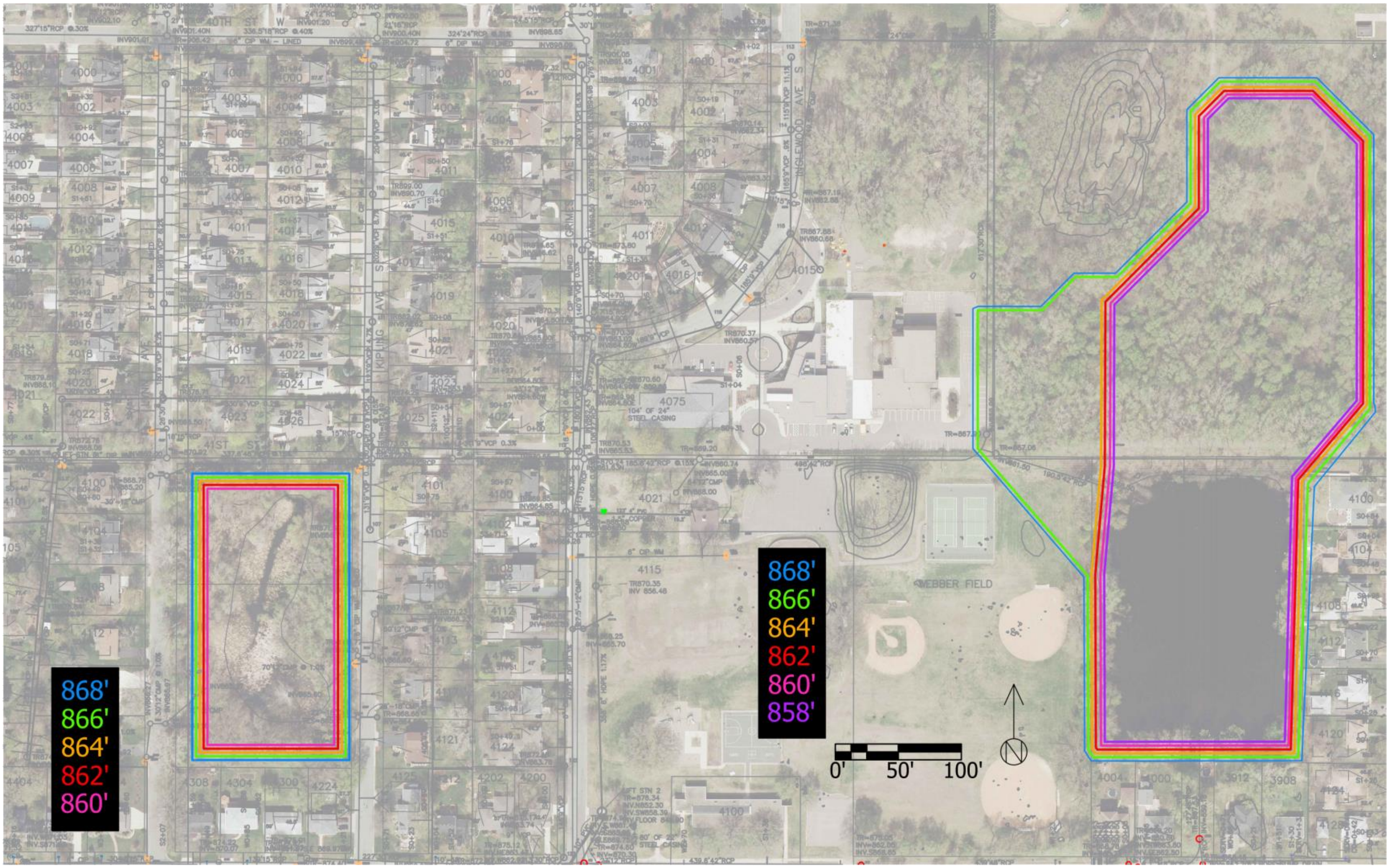

Figure 15. CAD Excavation Proposal of Weber Pond and TIA

Figure 16 provides a web-based dashboard of the OptiRTC interface. The program provides a graph of Pond Level over time and a precipitation forecast (Microsoft New England).

Figure 16. Example of OptiRTC web-based dashboard

Final Design for Section 4.2 - Underground Storage

These designs were completed using the online "Design Your Own Detention or Infiltration System (DYODS)" provided by Contech Engineered Solutions (Contech Engineered Solutions). Using GIS, the values for invert depth and limiting length and width were recorded in Table 16.

Final Design for Section 4.3 - Permeable Pavement

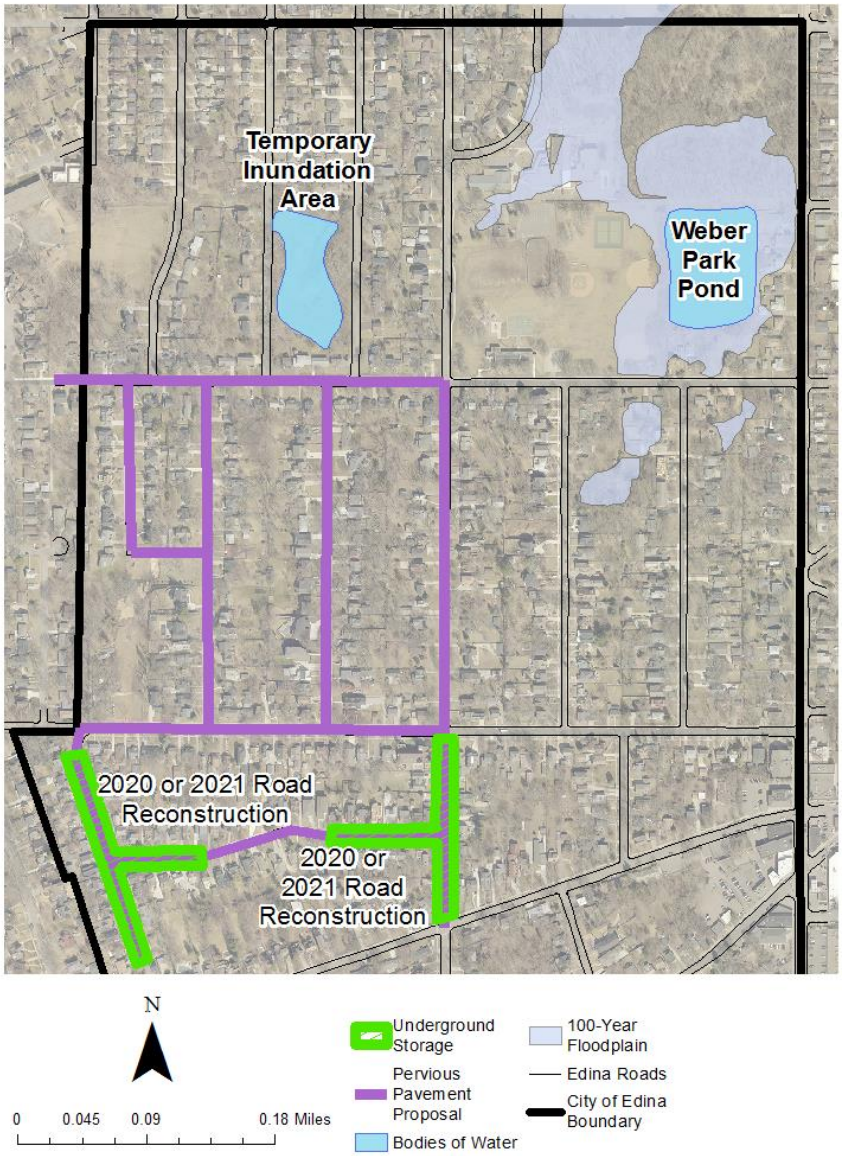

Figure 17: Proposed location of permeable pavement and underground storage in 2020 or 2021 road reconstruction area

Appendix C: *Cost Analysis Calculations*

Cost Analysis for Section 4.1: Predictive Monitoring and Excavation

Bob Fossum (Fossum) and Forrest Kelley (Kelley) from the Capitol Region Watershed District provided a general cost estimate for a predictive monitoring system. This estimate was based on the cost of previous projects in the area that utilized predictive monitoring systems including the Curtiss Field and the Upper Villa stormwater projects. Viktor Hlas at OptiRTC was contacted to confirm this estimate; he can be contacted in the future for further information (Hlas).

Table 7. Cost Estimate for Weber Pond expansion through excavation

Item Description	Unit	Estimated Quantity	Unit Price ($) [1]	Extension ($)
Project Mobilization/Demobilization (10%)	L.S.	1	10% of Total	140,055
Site Work, Excavation, and Restoration				
Erosion Control- Silt Fence	L.F.	3100	3.5	10,850
Tree and Grub Removal	L.S.	6.5	10,000	65,000
Remove and Replace Existing Fence	L.S	1	1,500	1,500
Pond Excavation & Material Disposal	C.Y.	87,547	15	1,313,200
Seeding- turf grass	AC.	5	2,000	10,000
			SUBTOTAL	1,400,550
			TOTAL	**1,540,605**

1. Unit price provided by the City of Edina (Gerk)

Table 8. Cost estimate for excavation of TIA

Item Description	Unit	Estimated Quantity	Unit Price ($) [1]	Extension ($)
Project Mobilization/Demobilization (10%)	L.S.	1	10% of Total	53,981
Site Work, Excavation, and Restoration				
Erosion Control- Silt Fence	L.F.	1500	3.5	5,250
Tree and Grub Removal	L.S.	2.6	10,000	26,000
Pond Excavation & Material Disposal	C.Y.	33,557	15	503,360
Seeding- turf grass	AC.	2.6	2,000	5,200
			SUBTOTAL	539,810
			TOTAL	**593,791**

1. Unit price provided by the City of Edina (Gerk)

Cost Analysis for Section 4.2: Underground Storage Units

Table 9. Budgetary cost estimate for underground storage located at Susan Lindgren Elementary

Item Description	Unit	Estimated Quantity	Unit Price ($) [1]	Extension ($)
Project Mobilization/Demobilization (10%)	L.S.	1	10% of Total	61,800
Underground Pipe System	L.S.	1	618,000	618,000
			SUBTOTAL	618,000
			TOTAL	**679,800**

1. Unit price provided by Contech Engineered Solutions (Byers and Holmquist)

Table 10. Budgetary cost estimate for underground storage located at Weber Park Fields

Item Description	Unit	Estimated Quantity	Unit Price ($) [1]	Extension ($)
Project Mobilization/Demobilization (10%)	L.S.	1	10% of Total	135,000
Underground Pipe System	L.S.	1	1,350,000	1,350,000
			SUBTOTAL	1,350,000
			TOTAL	**1,485,000**

1. Unit price provided by Contech Engineered Solutions (Byers and Holmquist)

Table 11. Budgetary cost estimate for underground storage located in the 2020 or 2021 road reconstruction area

Item Description	Unit	Estimated Quantity	Unit Price ($) [1]	Extension ($)
Project Mobilization/Demobilization (10%)	L.S.	1	10% of Total	24,000
Underground Pipe System	L.S.	1	240,000	240,000
			SUBTOTAL	240,000
			TOTAL	**264,000**

1. Unit price provided by Contech Engineered Solutions (Byers and Holmquist)

Cost Analysis for Section 4.3: Permeable Pavement

Table 12: Budgetary cost estimate for permeable pavement [1]

Item Description	Unit	Estimated Quantity	Unit Price ($) [1]	Extension ($)
6" of AASHTO #57 stone	S.F.	270950	0.50	140,000
Installation[1]	S.F.	270950	2.00	540,000
PaveDrain Material	S.F.	270950	8.50	2,300,000
Delivery	S.F.	270950	1.00	270,000
			TOTAL	3,250,000

1. Unit price from PaveDrain (PaveDrain)

Table 13: Budgetary cost estimate for bituminous pavement

Item Description [1]	**Unit**	**Estimated Quantity**	**Unit Price ($)** [2]	**Extension ($)**
Class V Rock	Ton	9483	14.00	130,000
TYPE SP 9.5 Wearing Course Mixture (SPWEA340B)	Ton	2455	53.00	130,000
TYPE SP 12.5 Non Wearing Course Mixture (SPNWB330B)	Ton	4092	41.00	170,000
Project Mobilization/Demobilization (10%)	L.S.	1	10% of Total	43,000
			SUBTOTAL	430,000
			TOTAL	473,000

1. Olinger road used as provided by the City of Edina (Gerk)
2. Unit Price as provided in bid tabs by the City of Edina (Gerk)

Unit price from PaveDrain

Table 13, the total budgetary cost of permeable pavement and bituminous pavement in the 2020 or 2021 road reconstruction area are $3,250,000 and $470,000, respectively. Both estimates consider the cost of rock, installation, surface material, and mobilization. While other items will contribute to the overall cost of this installation, it was assumed that these costs would be the same, regardless of the type of pavement used. For example, the cost of installing new curb and gutter will be the same, regardless of whether permeable pavement or bituminous asphalt is installed. With this information, a marginal cost estimate was performed, which shows that the additional cost of paving the 2020 or 2021 road reconstruction area with PaveDrain, rather than bituminous pavement, is approximately $2,780,000.

Cost Analysis for Section 4.4: Alternative Options

Table 14. Budgetary cost estimate for property acquisitions

Street Address	**Type**	**Value ($)[1]**
4000 42ND ST W	Residential	399,100
4100 FRANCE AVE S	Residential	426,000
4104 FRANCE AVE S	Residential	269,500
4108 FRANCE AVE S	Residential	331,600
4005 42ND ST W	Residential	365,100
4003 42ND ST W	Residential	451,800
	TOTAL	2,243,100

1. Values ($) from Hennepin County (Hennepin County)

Hennepin County property information database was used to determine the market price of these houses, which totaled $2,243,100. Six additional properties lie within the 1% annual chance flood map of Weber Pond. However, they were not considered for property acquisition because they have a Letter of Map Amendment (LOMA). A LOMA was issued for these six properties because, although they are mapped within a floodplain, the properties all sit on naturally high ground that is above the base flood elevation.

Appendix D: Modeled Inflow and Outflow Hydrographs for Weber Pond

It should be noted that the inflow and outflow values in our model are much greater than realistically expected, and ~5 times greater than previously modeled (Barr Engineering Company; City of Edina and Barr Engineering Company). The modeling program used, HEC-HMS, has limited capabilities and could not account for the backup of water from the downstream storm sewer or storage within the storm sewer system. Consequently, we chose to keep the outlet to Minneapolis unrestricted for our model.

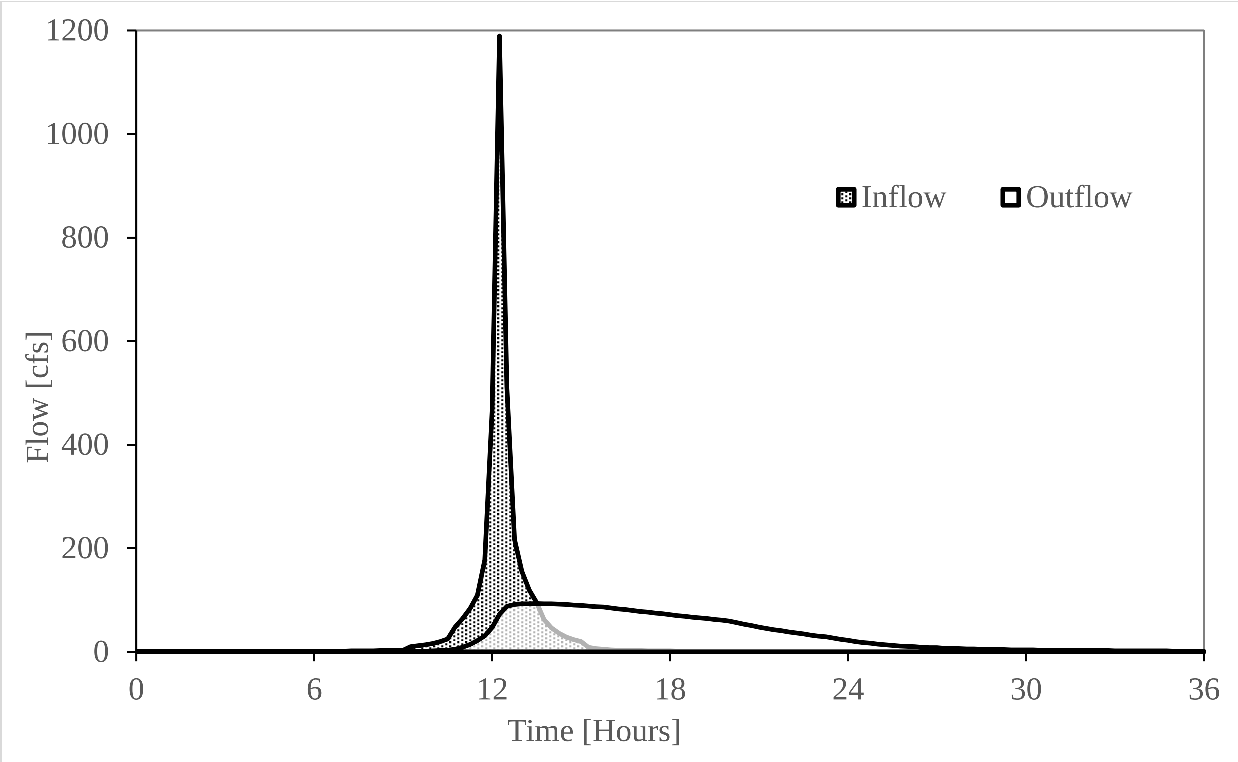

Figure 18. Pre-development inflow and outflow hydrograph for Weber Pond

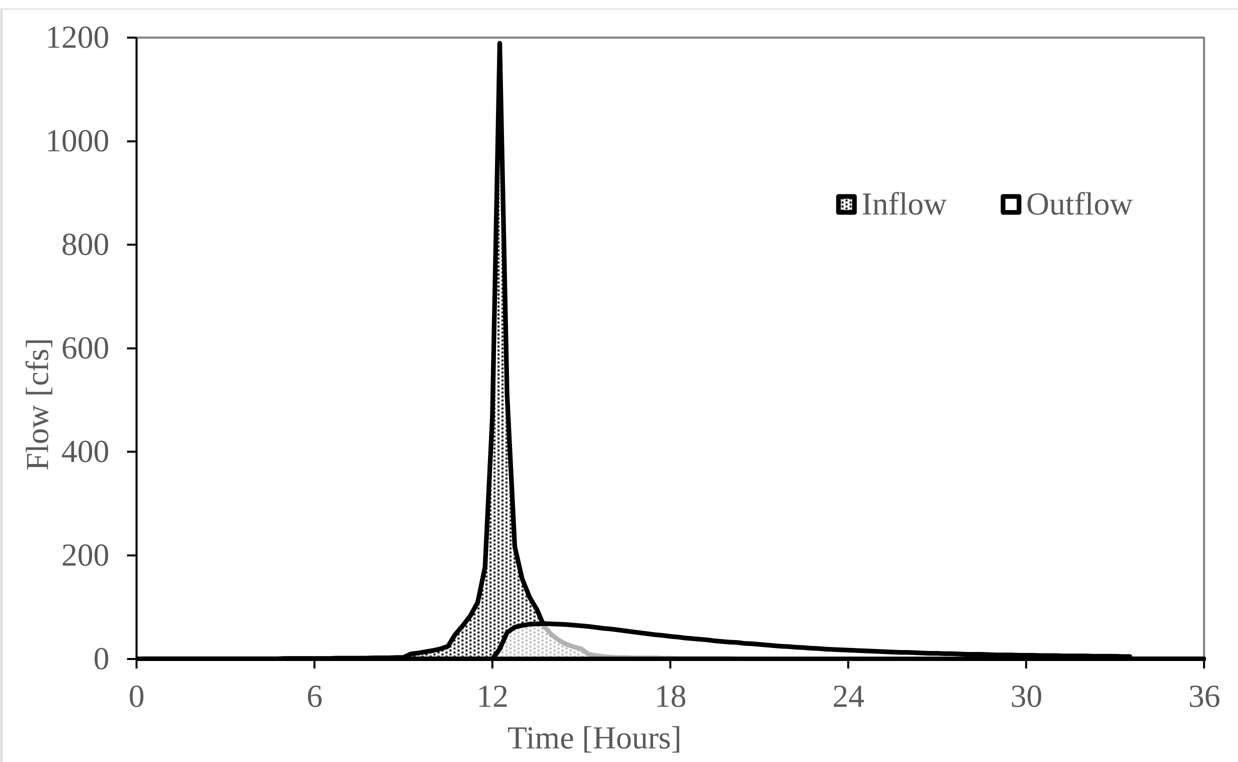

Figure 19. Post-development inflow and outflow hydrograph of Weber Pond

Appendix E: *HEC-HMS Model Inputs for Feasible Design Options*

Model Inputs for Section 4.1: Predictive Monitoring and Excavation

Table 15. Changes in initial pond elevation for predictive monitoring model

Model Run	Initial Pond Elevation [ft]
Pre-Development	861.5
PM Only	858
PM & Excavation	859

The model simulated predictive monitoring by changing the initial water surface elevation in Weber Park Pond. This is the result of predictively discharging water in the time period leading up to a storm event.

Underground storage tanks were modeled as one-acre rectangular reservoirs with vertical sides. The capacities of the tanks were specified by varying the main outlet elevations. The storage in acre-ft is equal to the height of the outlet in feet above the bottom of the tank. The main outlet is a long weir which immediately discharges all water above the specified elevation. The secondary outlet is a 1-ft diameter outlet pipe at the bottom of the tank. This outlet discharges the full tank slowly once the peak inflow period is over. Figure 20 illustrates a typical storage-time relationship for an underground storage tank.

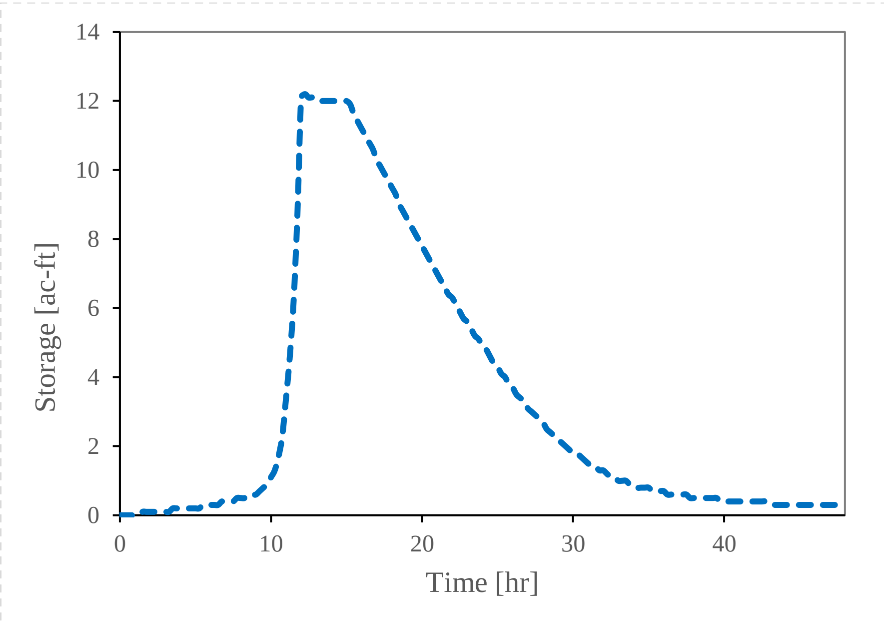

Figure 20. Discharge over time for a 12 acre-ft Underground Storage Tank

Model Inputs for Section 4.2: Underground Storage

Table 16. Values for invert depth of stormwater mains assessed for locations of underground storage to find feasible design volume.

Location	**Description of Location**	**Invert Depth Upstream** [ft]	**Invert Depth Upstream** [ft]	**Maximum Diameter** [ft][1]	**Limiting Length** [ft]	**Limiting Width** [ft]	**Maximum Volume** [ft^3]
Susan Lindgren Elementary	Deeded private property, directly on edge of Edina municipal boundary. Low elevation of ~871 ft.	863.17 MSL	863.17 MSL	8.83	288	198	226,106
Weber Park Fields	Deeded City property. Low Elevation of ~870.	862.05 MSL	860.8 MSL	7.95	452	344	520,791
2020/2021 Road Reconstruction Area	Deeds/easements necessary for right of way. Collects small area including MS_3/MS_7.	(Composite of two locations noted below. See below for values)					
	1. Grimes Avenue south of Morningside Rd	8.5	3.8	7	See total installed length below.	Width limited by the right of way.	
	2. Morningside Rd near Crocker Avenue	10	8.7	7	Total 1,973	Width limited by the right of way.	Total 75,9230

1. Selected using the invert depth and assumption of required 18 inches of cover material as per Contech (Contech Engineered Solutions)
2. Limiting width will be determined by the deeds/easements which allow for installation of underground systems in right of way. Limiting width assumed to be large enough to allow for 7-ft pipe installed.
3. Length established using a visual assessment of topographic map, selecting areas for which the grade was not too steep for the installation of underground storage

Model Inputs for Section 4.3: Permeable Pavement

The length of streets within the 2020 or 2012 Road Reconstruction area were measured using GIS. The paved width of each street was determined using the City of Edina's Living Streets Report based on the type of street (City of Edina) and aerial imagery in Google Maps. The dimensions are shown in Table 17, which shows that the entire paved surface area of the 2020 or 2021 Road Reconstruction area is approximately 270,936-sqft.

Table 17: Dimensions of streets within 2020 or 2021 Road Reconstruction area

Street Name (within 2020 or 2021 Road Reconstruction Area)	Type of Street	Length of Street [ft]	Details	Paved Width [ft]	Surface Area [sqft]
Grimes Ave	Local Street Connector	2027.8	2 sidewalk, 2 parking	30	60,834
Crocker Ave	Local Street	1286.7	1 sidewalk, 1 parking	24	30,880.8
Lynn Ave	Local Street	1286.7	2 sidewalk, 1 parking	24	30,880.8
Littel St	Local Street Connector	274.3	2 sidewalk, 1 parking	24	6,583.2
Oakdale Ave S	Local Street	1,526.5	2 sidewalk, 1 parking	24	36,636.0
West 42 St	Local Street Connector	1,444.5	0 sidewalk, 2 parking	24	34,668.0
Morningside Rd	Local Street Connector	1,343.8	2 sidewalk, 2 parking	30	40,314.0
Branson St	Local Street	1,255.8	2 sidewalk, 1 parking	24	30,139.0
TOTAL	**-**	**10,446.1**		**-**	**270,936.0**

Using the street dimensions presented in Table 17, the proposed percentage of impervious land surface was computed for each subwatershed. It was assumed that PaveDrain is 100% permeable. The proposed percent of impervious surface area for each subwatershed is shown in Table 18, and these values were used in the HEC-HMS model.

Table 18: Change in percent impervious from existing conditions to proposed permeable pavement at 2020 or 2021 Road Reconstruction area

Subwatershed ID	% Impervious Decrease [1]	Existing % Impervious [2]	Proposed % Impervious [3]
MS_2	6.64	20	13.4
MS_5	10.73	20	9.3
MS_8	12.97	20	7.0
MS_18	4.08	17	12.9
MS_19	20.05	20	0.0
MS_21	9.49	20	10.5
MS_45	22.6	20	0.0
MS_47	15.68	20	4.3
MS_48	10.78	20	9.2

1. Percent impervious was calculated assuming PaveDrain product is 100% permeable.
2. Existing percent impervious was obtained from Barr's previously developed model (Barr Engineering Company).
3. In some cases, the % impervious decrease is less than the existing % impervious. This is due to minor errors when measuring streets in GIS, and the errors are negligible.

Appendix F: Analysis of Initial Options

In addition to the feasible design options outlined in Section 4.0 of this report, a number of additional options were initially considered before it was determined that (based on the background information outlined in Section 4.0 Methodology) these options either failed to significantly lower the 1% annual chance flood elevation or were currently not feasible for the City of Edina to implement. The options are classified into broad categories based on ongoing projects within the City of Edina. Each option is given a general description, including reasoning for rejecting each option at this time.

Park Development – Public

Direct Flow to Park Swale

In this option, the curb is altered to have gaps that redirect stormwater flow away from stormwater catch basins and into above ground Best Management Practices (BMPs) located on parkland (Columbia). Thus, the curb gaps are placed where stormwater runoff would typically enter stormwater catch basins (Columbia). It is proposed that gaps be placed on the south side of Weber Park where the flow would then enter the Park and be stored or infiltrated by a bioretention pond or similar system. Although this option could possibly be implemented to slow the volume of water reaching Weber Pond through stormwater pipes, the majority of available land for the use of BMPs is currently located primarily within the 1% annual chance floodplain and, therefore, do not allow for infiltration in the 1% annual chance event. Thus, this option was rejected.

Underground Storage

(This option was selected for the feasibility study. See Section 4.3 for description and results)

Stormwater Reuse

A stormwater collection and reuse system could be implemented near Weber Pond and the stored water could be used to irrigate the neighboring ball fields. This option would capture some of the volume of stormwater before it reaches Weber Pond, reducing the peak flood elevation and the peak discharge of the stormwater into the pond. The reuse systems could also reduce stress on existing water and stormwater infrastructure, which, when implemented in a park area, could be used as an education feature to inform the public about stormwater management. Public perception is often an issue when implementing water reuse systems, so public education is important (Minnesota Pollution Control Agency). However, as the ball fields are located mainly within the 1% annual chance floodplain and do not require irrigation following a storm event, this option was rejected.

Excavation

(This option was selected for the feasibility study. See Section 4.1 for description and results)

Road Reconstruction – Public

Pervious Pavement

(This option was selected for the feasibility study. See Section 4.4 for description and results)

Underground Storage

(This option was selected for the feasibility study. See Section 4.3 for description and results)

Road Reconstruction – Private

Residential Rain Gardens

Installation of rain gardens in the yards of residential properties along the street reconstruction area has the potential to reduce stormwater runoff to Weber Pond from the south and to improve water quality. A cost share program could be used to incentivize eligible residents to install rain gardens in their front yards (City of Bloomington). However, there are many potential issues that could arise from installing these projects on private land including changes in property ownership, which places the rain gardens at risk of being under-maintained or removed. In addition, this option is not likely to produce the amount of volume reduction desired for decreasing flood levels in Weber Park Pond during peak rain events. For these reasons, this option was rejected.

Pond Maintenance

Dredge Pond

Sediment buildup from runoff has the potential to reduce the total volume of the pond, reducing the effective storage volume of the pond during the 1% annual chance storm event. Dredging would remove the accumulated sediment from the bottom of the pond. Given the relatively large amount of additional stormwater detention volume that would be needed to reduce the risk of flooding, though, it is reasonable to assume that dredging Weber Pond will not significantly reduce the risk of flooding. Dredging could, however, improve the water quality of the pond.

Forecast Based Control System

(This option was selected for the feasibility study. See Section 4.1 for description and results)

Increasing Outlet Pipe Size

The current downstream capacity of the Minneapolis sewer system from the Morningside neighborhood is approximately 25-cfs (Barr Engineering Company). To decrease the flooding in Weber Pond to an acceptable level, the downstream capacity would need to be increased to 105-cfs (Barr Engineering Company). This would require structural renovations to the stormwater infrastructure operated by the City of Minneapolis or the installation of a 48-in outlet pipe directly to Lake Calhoun, parallel to existing outlets (Barr Engineering Company). These improvements are not feasible at this time and, thus, this option was rejected.

Alter Outlet Structure

The current outlet structure of Weber Pond is a 42-in reinforced concrete pipe (RCP) and has an invert elevation of 861.5-ft. These values were found using the City of Edina's CAD data. The Manning's roughness of the pipe is 0.013 (City of Edina and Barr Engineering Company). Choosing a smoother pipe might increase discharge capacity, but these improvements would be marginal and likely limited by the downstream sewer capacity. Increased flow rates would be proportional to any decrease in the roughness parameter of the outlet, up to the limit of the downstream capacity.

The outlet invert elevation could be lowered, resulting in a lower normal water elevation in Weber Pond. This would likely increase flow rates through the downstream storm sewer during storm events, which would be unacceptable. Thus, this option was rejected.

Projects That Require Other Partners

Increase Infiltration for Surface Flow

Increasing infiltration within the section of land west of Weber Park Pond and the newly acquired land north of Weber Park could ensure that sheet flow of rainfall runoff will be infiltrated at the maximum rate. This would involve considering replacement of turf grass areas with a land cover that allows for a higher infiltration rate. This option is not likely to produce the amount of volume reduction desired for decreasing levels in Weber Park Pond. Thus, this option was rejected.

Other Options

Acquire the At-Risk Properties

(This option was selected for the feasibility study. See Section 4.4 for description and results)

No Action by the City of Edina

Based on feasibility of other options, the City of Edina could decide to do nothing. Damage to the residential properties is a likely result of this option. The total damage at each residential property will depend on frequency, depth, and duration of flooding. Threatened properties flood during a 1% annual chance (100-year) storm and may also be affected by other storm events. The total depth and duration of flooding experienced by each home could be found using the elevation over time graph of Weber Pond.

This option could be chosen if it is determined that the risk and potential loss of property from flooding is determined to be less than the cost to implement any other option. However, although the City of Edina has yet to implement flood mitigation options, the City has communicated their interest in taking action through their request to complete a feasibility study for stormwater flood mitigation within Weber Pond.

Appendix G: *HEC-HMS Model Input Data for Pre-development Model*

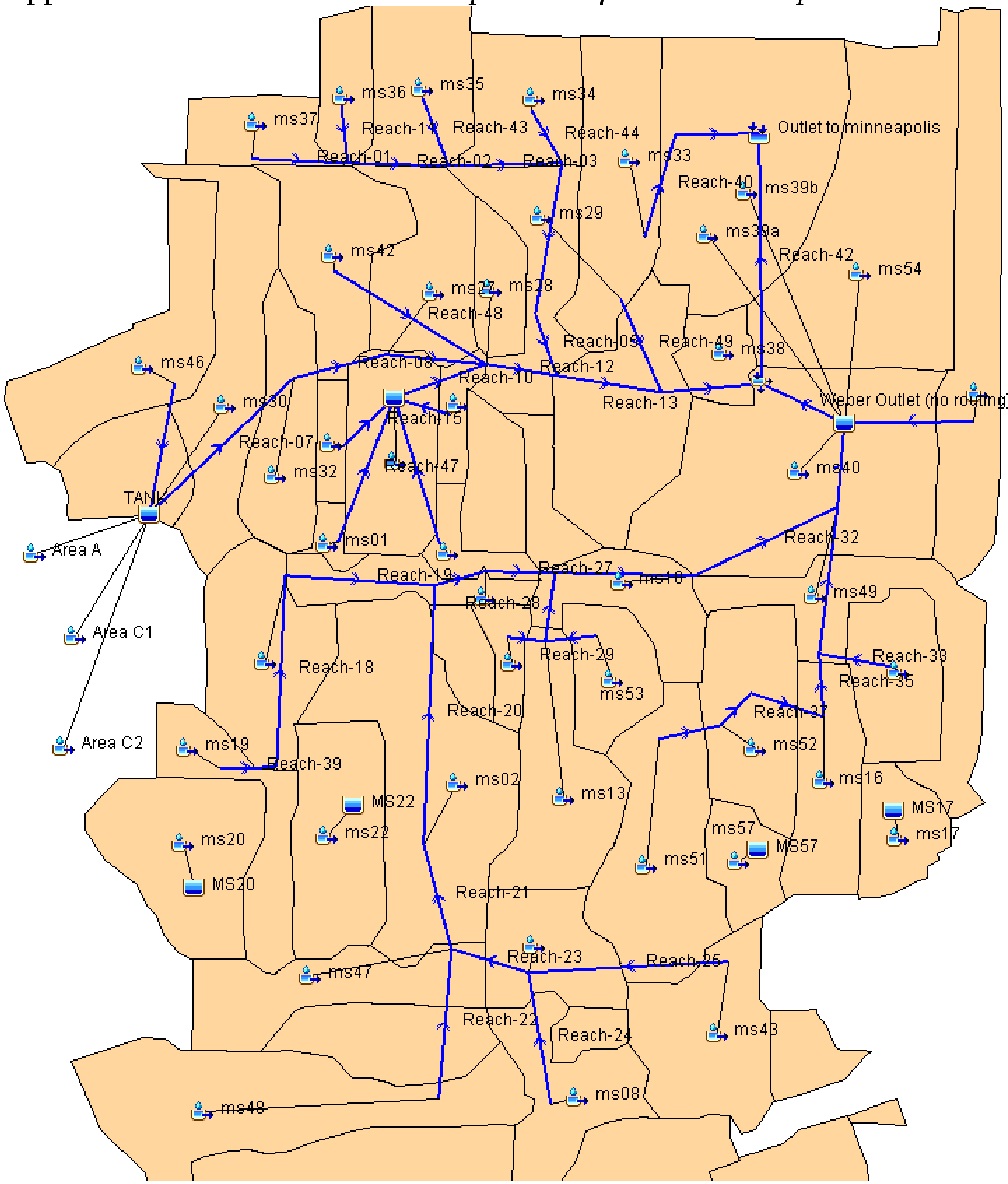

Figure 21. Labeled Overview of Pre-Development Model

Table 19. Flow Routing Parameters where shape is modeled as a circle for all reaches (City of Edina and Barr Engineering Company)

Label	Length (ft)	Slope (ft/ft)	Manning's *n*	Diameter (ft)
Reach-01	901.01	0.003	0.013	1.25
Reach-02	899.48	0.0039	0.013	1.5
Reach-03	898.09	0.0032	0.013	2
Reach-04	1764.48	0.0665	0.013	1.75
Reach-05	3450.12	0.0061	0.013	2.25
Reach-06	863	0.0015	0.013	4.5
Reach-07	862.42	0.003	0.013	4.5
Reach-08	862	0.0031	0.013	4.5
Reach-09	861.5	0.0016	0.013	3.5
Reach-10	861.31	0.0015	0.013	3.5
Reach-11	901.4	0.0048	0.013	1.25
Reach-12	861	0.0016	0.013	3.5
Reach-13	860	0.0016	0.013	3.5
Reach-14	861.5	0.0001	0.014	3.5
Reach-15	864.5	0.0133	0.024	1
Reach-16	858	0.0025	0.013	2
Reach-18	2617.66	0.0065667	0.013	1
Reach-19	860	0.006567	0.013	1
Reach-20	3471.04	0.05515	0.013	2.3125
Reach-21	1776.59	0.041	0.013	2.25
Reach-22	892.66	0.0056	0.015	1.25
Reach-23	1789.77	0.0005	0.013	2.25
Reach-24	898.09	0.0001	0.013	2.25
Reach-25	2658.24	0.0123667	0.013	1.8333
Reach-26	861.02	0.0011	0.013	2.5
Reach-27	860.78	0.0011	0.013	2.5
Reach-28	866	0.0045	0.013	1.25
Reach-29	1733.38	0.013	0.013	1.25
Reach-30	864.3	0.0102	0.013	2.5
Reach-31	860.6	0.0004	0.013	3.5
Reach-32	860.28	0.0007	0.013	3.5
Reach-33	860.43	0.0028	0.013	1.25
Reach-34	1719.94	0.0029	0.013	3
Reach-35	862.62	0.001	0.013	1.75
Reach-36	1725.48	0.0007	0.013	1.75
Reach-37	1725.87	0.0056	0.013	1.5
Reach-38	1717.13	0.01195	0.013	3.75

Reach-39	876.1	0.0233	0.013	1
Reach-40	861.48	0.0056	0.024	2.08
Reach-41	860	0.0041	0.024	2
Reach-42	859.67	0.0005	0.013	2.5
Reach-43	900.4	0.0033	0.013	1.25
Reach-44	898.29	0.0001	0.013	1.25
Reach-45	865.6	0.01	0.024	1
Reach-46	865.5	0.0041	0.024	1.5
Reach-47	865.27	0.01	0.024	1
Reach-48	2585.02	0.0015	0.013	4
Reach-49	1720.77	0.00145	0.013	3.5
Reach-50	869.5	0.0375	0.013	1.25

Table 20. Subbasin Properties (Horton Method) (Stratton)

Subwatershed	**Area (ac)**	**Horton f_o values**	**Horton f_c values**	**Horton α values**
MS_01	0.52	1	0.03	0.00115
MS_10	3.25	2.909	0.221	0.00115
MS_11	1.48	1.425	0.072	0.00115
MS_13	4.83	3	0.23	0.00115
MS_14	1.35	3	0.23	0.00115
MS_15	1.21	3	0.23	0.00115
MS_16	3.99	3	0.23	0.00115
MS_17	2.19	3	0.23	0.00115
MS_18	2.31	2.851	0.215	0.00115
MS_19	3.2	3	0.23	0.00115
MS_02	9.98	3	0.23	0.00115
MS_20	5.44	2.82	0.212	0.00115
MS_21	5.03	2.87	0.217	0.00115
MS_22	4.81	3	0.23	0.00115
MS_23	1.39	1.028	0.033	0.00115
MS_24	2	1	0.03	0.00115
MS_25	0.96	1	0.03	0.00115
MS_26	4.28	1.002	0.03	0.00115
MS_27	3.96	2.83	0.213	0.00115
MS_28	1.65	2.184	0.148	0.00115
MS_29	3.97	2.107	0.141	0.00115
MS_03	3.27	3	0.23	0.00115
MS_30	5.86	2.086	0.139	0.00115

MS_31	6	1.119	0.042	0.00115
MS_32	3.62	1.526	0.083	0.00115
MS_33	5.42	2.516	0.182	0.00115
MS_34	3.42	3	0.23	0.00115
MS_35	3.83	3	0.23	0.00115
MS_36	1.82	3	0.23	0.00115
MS_37	2.15	3	0.23	0.00115
MS_38	1.45	1.764	0.106	0.00115
MS_39a	5.47	1.097	0.04	0.00115
MS_39b	8.7	1.809	0.111	0.00115
MS_04	3.69	3	0.23	0.00115
MS_40	11.98	1.672	0.097	0.00115
MS_41	0.86	1	0.03	0.00115
MS_42	4.39	2.935	0.224	0.00115
MS_43	5.2	3	0.23	0.00115
MS_44	1.11	1.095	0.04	0.00115
MS_45	2.07	2.407	0.171	0.00115
MS_46	5.52	2.486	0.179	0.00115
MS_47	4.32	3	0.23	0.00115
MS_48	10.24	3	0.23	0.00115
MS_49	5.25	2.781	0.208	0.00115
MS_05	3.26	3	0.23	0.00115
MS_50	3.34	3	0.23	0.00115
MS_51	6.9	3	0.23	0.00115
MS_52	4.5	3	0.23	0.00115
MS_53	1.04	3	0.23	0.00115
MS_54	10.13	2.869	0.209	0.00115
MS_55	6.72	1.792	0.109	0.00115
MS_56	0.77	3	0.23	0.00115
MS_57	1.77	3	0.23	0.00115
MS_58	2.83	1.344	0.064	0.00115
AREA_A	96.2	2.6	0.19	0.00115
AREA_C-1	2.1	3	0.23	0.00115
Area_C-2	7.2	2.4	0.17	0.00115

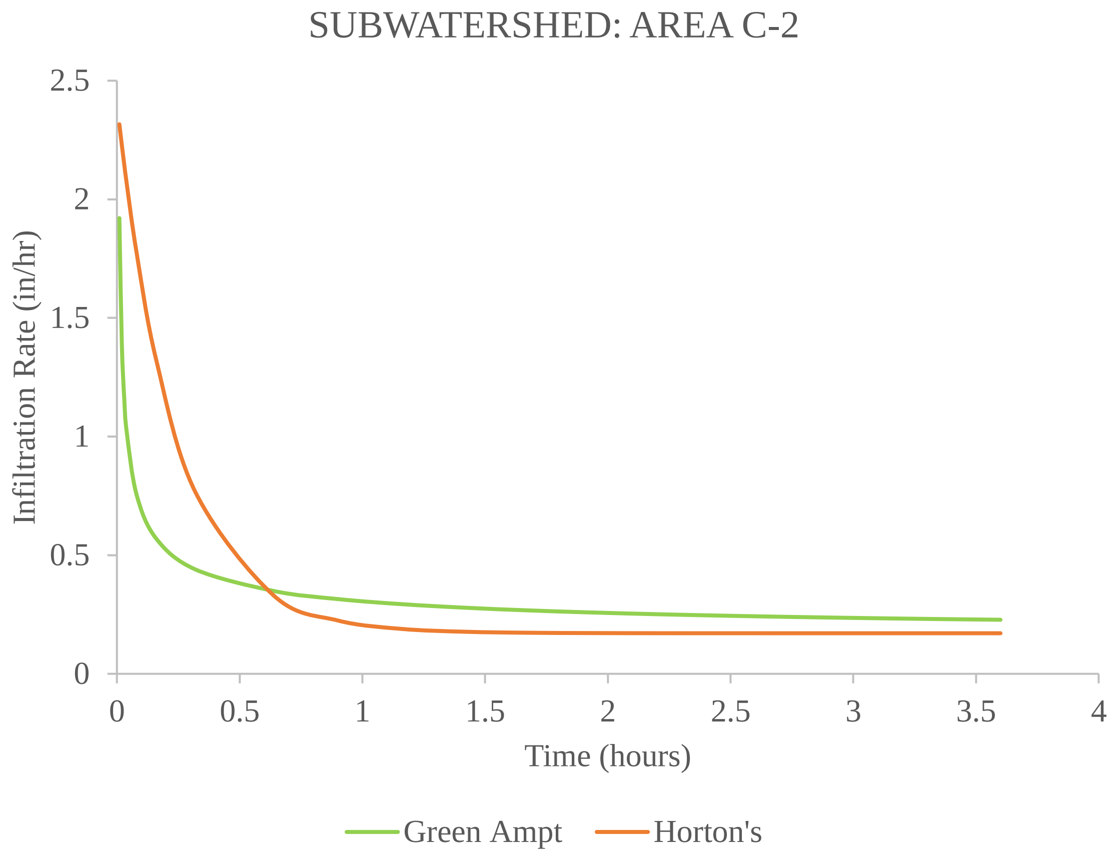

Figure 22. Sample of Infiltration curve comparison between Horton and Green-Ampt methods

Table 21. Subbasin Properties (Green-Ampt Method)

Label	Area (ac)	Initial	Saturated	Suction (in)	Conductivity (in/hr)	% Impervious
Area A	96.2	0.2	0.4	2	0.19	20
Area C1	2.1	0.2	0.4	2.25	0.23	20
Area C2	7.2	0.2	0.4	1.9	0.17	20
MS_01	0.5	0.1	0.3	1.6	0.03	17
MS_02	10.0	0.1	0.3	2.275	0.23	20
MS_05	3.3	0.1	0.3	2.275	0.23	20
MS_08	3.8	0.1	0.3	2.275	0.23	20
MS_09	2.5	0.1	0.3	2.275	0.23	20
MS_13	4.2	0.1	0.3	2.275	0.23	20
MS_16	3.6	0.1	0.3	2.275	0.23	20
MS_17	2.2	0.1	0.3	2.275	0.23	20
MS_18	3.0	0.1	0.3	2.15	0.215	17

MS_19	3.2	0.1	0.3	2.275	0.23	20
MS_20	5.4	0.1	0.3	2.15	0.212	17
MS_21	5.0	0.1	0.3	2.2	0.217	20
MS_22	4.8	0.1	0.3	2.275	0.23	20
MS_25	1.0	0.1	0.3	1.6	0.03	17
MS_26	4.3	0.1	0.3	1.6	0.03	24
MS_27	4.0	0.1	0.3	2.15	0.213	20
MS_28	1.7	0.1	0.3	1.8	0.148	20
MS_29	4.0	0.1	0.3	1.75	0.141	20
MS_30	5.9	0.1	0.3	1.75	0.139	17
MS_32	3.6	0.1	0.3	1.5	0.083	20
MS_33	5.4	0.1	0.3	1.975	0.182	20
MS_34	3.4	0.1	0.3	2.275	0.23	20
MS_35	3.8	0.1	0.3	2.275	0.23	20
MS_36	1.8	0.1	0.3	2.275	0.23	20
MS_37	2.2	0.1	0.3	2.275	0.23	20
MS_38	1.5	0.1	0.3	1.6	0.106	14
MS_39a	14.2	0.1	0.3	1.45	0.04	0
MS_39b	14.2	0.1	0.3	1.6	0.111	0
MS_40	12.0	0.1	0.3	1.55	0.097	32
MS_41	0.9	0.1	0.3	1.6	0.03	16
MS_42	4.4	0.1	0.3	2.2	0.224	20
MS_43	5.2	0.1	0.3	2.275	0.23	20
MS_44	1.1	0.1	0.3	1.45	0.04	18
MS_45	2.1	0.1	0.3	1.925	0.171	20
MS_46	35.7	0.1	0.3	1.95	0.179	23
MS_47	4.3	0.1	0.3	2.275	0.23	20
MS_48	10.2	0.1	0.3	2.275	0.23	20
MS_49	5.2	0.1	0.3	2.15	0.208	17
MS_50	3.3	0.1	0.3	2.275	0.23	20
MS_51	7.6	0.1	0.3	2.275	0.23	20
MS_52	4.5	0.1	0.3	2.275	0.23	20
MS_53	1.0	0.1	0.3	2.275	0.23	20
MS_54	10.1	0.1	0.3	2.25	0.209	0

Table 22. Inflow-Diversion Function

Inflow (cfs)	Diversion (cfs) (To Weber Pond)
0	0
1.4605	0
6.4405	0
15.223	0
27.865	0
44.332	0
64.535	0
88.342	0
115.6	0
146.11	0
179.69	0
216.1	0
255.12	0
296.49	0
339.96	0
385.23	0
432.02	20.747
480.04	68.761
528.95	117.68
578.45	167.17
628.17	216.89
677.76	266.48
726.84	315.56
775	363.73
821.84	410.56
866.88	455.6
909.64	498.36
949.57	538.3
986.07	574.8
1018.4	607.17
1045.8	634.57
1067.2	655.93
1081	669.77
1085	673.72

Figure 23. Plan View of Diversion Location

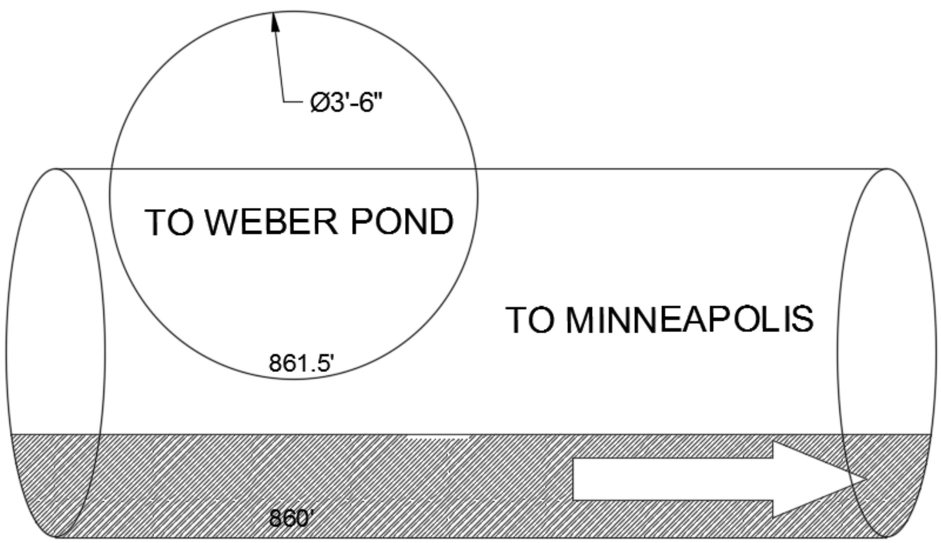

Figure 24. Profile View of Diversion

Table 23. Modeled Reservoirs

Weber Elevation-Area			TIA Elevation-Area		
	Pre-Dev	Excavated		Pre-Dev	Excavated
Stage	(ac)	(ac)	Stage	(ac)	(ac)
857.5	1.00	1.00	860	0.00	1.88
858	2.29	7.02	862	0.00	2.05
860	2.29	7.38	864	0.00	2.22
862	3.06	7.75	866	1.53	2.41
864	3.78	8.12	868	2.53	2.60
866	8.36	10.03			
868	16.33	10.50			
869	21.00	21.00			
869.2	21.60	21.60			
869.4	22.09	22.09			
869.6	22.58	22.58			
869.8	23.15	23.15			
870	23.91	23.91			

Table 24. Reservoir Outlets

Parameter	Weber Pond Outlet	TIA Outlet
Length (ft)	190	100
Diameter (ft)	3.5	2.5
Inlet Elevation (ft)	858.5	866.7
Entrance Coefficient	0.5	0.5
Outlet Elevation (ft)	861.5	866
Exit Coefficient	0.5	0.5
Manning's *n*	0.013	0.013

Table 25. Precipitation data from NOAA Atlas 14, MSP Station (National Oceanic and Atmospheric Administration)

Duration	Partial-Duration Depth (in)
5 Minutes	1.01
15 Minutes	1.81
1 Hour	3.68
2 Hours	4.75
3 Hours	5.51
6 Hours	6.58
12 Hours	7.12
24 Hours	7.50

Appendix H: HEC-HMS Model Output Data for Feasible Design Options (Post-Development Model)

Table 26. Water Elevation over time data for pre-development and each post development option

	Pre-develop. model	US Susan Lindgren School	US Weber Park Fields	US 2020 or 2021 Road Re-construction	Pave Drain	Weber Pond Exc.	PM	PM + Weber Pond Exc.	PM + Weber Pond Exc. + TIA Exc.
Time (hr)	Elevation (ft)								
0	861.5	861.5	861.5	861.5	861.5	861.5	858	859	859
0.25	861.5	861.5	861.5	861.5	861.5	861.5	858	859	859
0.5	861.5	861.5	861.5	861.5	861.5	861.5	858	859	859
0.75	861.5	861.5	861.5	861.5	861.5	861.5	858	859	859
1	861.5	861.5	861.5	861.5	861.5	861.5	858	859	859
1.25	861.5	861.5	861.5	861.5	861.5	861.5	858	859	859
1.5	861.5	861.5	861.5	861.5	861.5	861.5	858	859	859
1.75	861.5	861.5	861.5	861.5	861.5	861.5	858	859	859
2	861.5	861.5	861.5	861.5	861.5	861.5	858	859	859
2.25	861.5	861.5	861.5	861.5	861.5	861.5	858.1	859	859
2.5	861.5	861.5	861.5	861.5	861.5	861.5	858.1	859	859
2.75	861.5	861.5	861.5	861.5	861.5	861.5	858.1	859	859
3	861.5	861.6	861.5	861.5	861.5	861.5	858.1	859	859
3.25	861.6	861.6	861.5	861.5	861.5	861.5	858.1	859	859
3.5	861.6	861.6	861.5	861.5	861.5	861.5	858.1	859	859
3.75	861.6	861.6	861.5	861.6	861.5	861.5	858.1	859	859
4	861.6	861.6	861.5	861.6	861.5	861.5	858.1	859	859
4.25	861.6	861.6	861.5	861.6	861.6	861.5	858.1	859	859
4.5	861.6	861.6	861.5	861.6	861.6	861.5	858.1	859	859

4.75	861.6	861.6	861.5	861.6	861.6	861.5	858.1	859	859
5	861.6	861.6	861.5	861.6	861.6	861.5	858.1	859	859
5.25	861.6	861.6	861.5	861.6	861.6	861.5	858.2	859	859
5.5	861.6	861.6	861.5	861.6	861.6	861.5	858.2	859	859
5.75	861.6	861.6	861.5	861.6	861.6	861.5	858.2	859	859
6	861.6	861.6	861.5	861.6	861.6	861.5	858.2	859	859
6.25	861.6	861.6	861.5	861.6	861.6	861.5	858.2	859	859
6.5	861.6	861.6	861.5	861.6	861.6	861.5	858.2	859	859
6.75	861.6	861.6	861.5	861.6	861.6	861.5	858.2	859.1	859.1
7	861.6	861.7	861.5	861.6	861.6	861.6	858.2	859.1	859.1
7.25	861.7	861.7	861.6	861.6	861.6	861.6	858.3	859.1	859.1
7.5	861.7	861.7	861.6	861.6	861.6	861.6	858.3	859.1	859.1
7.75	861.7	861.7	861.6	861.6	861.6	861.6	858.3	859.1	859.1
8	861.7	861.7	861.6	861.7	861.6	861.6	858.3	859.1	859.1
8.25	861.7	861.7	861.6	861.7	861.7	861.6	858.4	859.1	859.1
8.5	861.7	861.7	861.6	861.7	861.7	861.6	858.4	859.1	859.1
8.75	861.7	861.8	861.6	861.7	861.7	861.6	858.4	859.1	859.1
9	861.8	861.8	861.6	861.7	861.7	861.6	858.5	859.1	859.1
9.25	861.8	861.9	861.6	861.8	861.7	861.6	858.5	859.1	859.1
9.5	861.9	862	861.7	861.8	861.8	861.6	858.7	859.2	859.2
9.75	862	862.1	861.8	861.9	861.9	861.7	858.8	859.2	859.2
10	862.1	862.2	861.9	862	862	861.7	859	859.2	859.2
10.25	862.2	862.3	862	862.1	862.1	861.8	859.3	859.3	859.3
10.5	862.3	862.5	862.1	862.2	862.2	861.8	859.6	859.3	859.3
10.75	862.5	862.8	862.2	862.4	862.4	861.9	860	859.4	859.4
11	862.8	863.1	862.4	862.7	862.7	862.1	860.7	859.6	859.6
11.25	863.1	863.6	862.6	863	863	862.3	861.6	859.8	859.8
11.5	863.6	864.2	862.9	863.5	863.5	862.5	862.3	860.1	860.1
11.75	864.2	865.1	863.3	864.1	864.1	862.8	863.1	860.5	860.5
12	865.2	866.7	864.2	865	865.1	863.6	864.5	861.4	861.3
12.25	866.9	867.9	866.2	866.8	866.8	865.5	866.6	863.5	863.3
12.5	868.1	868.3	867.5	868	868.1	867.1	867.9	865.4	865.1
12.75	868.4	868.4	868	868.3	868.4	867.7	868.2	866.1	865.8
13	868.5	868.5	868.2	868.4	868.5	867.9	868.4	866.4	866.1
13.25	868.6	868.5	868.3	868.5	868.5	868	868.4	866.5	866.2
13.5	868.6	868.5	868.3	868.5	868.6	868	868.4	866.6	866.3
13.75	868.6	868.4	868.3	868.5	868.5	868	868.4	866.6	866.3
14	868.6	868.4	868.3	868.5	868.5	868	868.4	866.6	866.3
14.25	868.5	868.3	868.2	868.4	868.4	867.9	868.3	866.5	866.3
14.5	868.4	868.2	868.2	868.4	868.4	867.8	868.3	866.5	866.2
14.75	868.4	868.2	868.1	868.3	868.3	867.7	868.2	866.4	866.1
15	868.3	868.1	868	868.2	868.2	867.5	868.1	866.3	866.1
15.25	868.2	868	867.9	868.1	868.1	867.4	868	866.2	866
15.5	868.1	867.9	867.8	868	868.1	867.3	867.9	866.1	865.8
15.75	868	867.7	867.7	867.9	867.9	867.1	867.8	866	865.7
16	867.9	867.6	867.6	867.8	867.8	867	867.6	865.8	865.6
16.25	867.8	867.5	867.5	867.7	867.7	866.9	867.5	865.7	865.5
16.5	867.6	867.3	867.3	867.5	867.5	866.7	867.4	865.6	865.4
16.75	867.5	867.2	867.2	867.4	867.4	866.6	867.3	865.5	865.3

17	867.4	867.1	867.1	867.3	867.3	866.5	867.1	865.4	865.2
17.25	867.2	867	867	867.2	867.1	866.3	867	865.3	865.1
17.5	867.1	866.8	866.9	867	867	866.2	866.9	865.2	865
17.75	867	866.7	866.8	866.9	866.9	866.1	866.8	865.1	864.9
18	866.9	866.6	866.7	866.8	866.8	866	866.6	865	864.8
18.25	866.7	866.5	866.6	866.7	866.7	865.8	866.5	864.9	864.7
18.5	866.6	866.4	866.5	866.6	866.5	865.7	866.4	864.8	864.6
18.75	866.5	866.3	866.4	866.5	866.4	865.6	866.3	864.7	864.5
19	866.4	866.2	866.3	866.4	866.3	865.5	866.2	864.6	864.5
19.25	866.3	866.1	866.2	866.3	866.2	865.3	866.1	864.5	864.4
19.5	866.2	865.9	866.2	866.2	866.1	865.2	866	864.4	864.3
19.75	866.1	865.7	866.1	866.1	866	865.1	865.8	864.4	864.2
20	866	865.5	866	865.9	865.8	865	865.6	864.3	864.2
20.25	865.8	865.4	865.8	865.7	865.6	864.9	865.4	864.2	864.1
20.5	865.6	865.2	865.7	865.5	865.4	864.8	865.3	864.1	864
20.75	865.4	865	865.5	865.4	865.3	864.7	865.1	864.1	864
21	865.2	864.9	865.4	865.2	865.1	864.7	864.9	864	863.9
21.25	865.1	864.7	865.2	865	864.9	864.6	864.8	863.9	863.8
21.5	864.9	864.6	865.1	864.9	864.8	864.5	864.7	863.9	863.8
21.75	864.8	864.5	865	864.8	864.7	864.4	864.5	863.8	863.7
22	864.6	864.4	864.9	864.6	864.5	864.3	864.4	863.8	863.6
22.25	864.5	864.2	864.7	864.5	864.4	864.3	864.3	863.7	863.6
22.5	864.4	864.1	864.6	864.4	864.3	864.2	864.2	863.6	863.5
22.75	864.3	864	864.5	864.3	864.2	864.1	864.1	863.6	863.5
23	864.2	863.9	864.4	864.2	864.1	864.1	864	863.5	863.4
23.25	864.1	863.8	864.4	864.1	864	864	863.8	863.5	863.4
23.5	863.9	863.6	864.3	864	863.8	863.9	863.7	863.4	863.4
23.75	863.8	863.5	864.2	863.8	863.7	863.9	863.5	863.4	863.3
24	863.6	863.4	864.1	863.7	863.5	863.8	863.4	863.3	863.3
24.25	863.5	863.3	864	863.5	863.4	863.7	863.3	863.3	863.2
24.5	863.4	863.2	863.9	863.4	863.3	863.7	863.2	863.3	863.2
24.75	863.3	863.1	863.8	863.3	863.2	863.6	863.1	863.2	863.2
25	863.2	863	863.7	863.2	863.1	863.6	863.1	863.2	863.1
25.25	863.1	863	863.6	863.2	863.1	863.5	863	863.1	863.1
25.5	863	862.9	863.6	863.1	863	863.5	862.9	863.1	863.1
25.75	863	862.8	863.5	863	862.9	863.4	862.9	863.1	863
26	862.9	862.8	863.4	862.9	862.9	863.4	862.8	863	863
26.25	862.8	862.7	863.3	862.9	862.8	863.3	862.7	863	863
26.5	862.8	862.7	863.3	862.8	862.7	863.3	862.7	863	862.9
26.75	862.7	862.6	863.2	862.8	862.7	863.2	862.7	863	862.9
27	862.7	862.6	863.2	862.7	862.7	863.2	862.6	862.9	862.9
27.25	862.6	862.6	863.1	862.7	862.6	863.2	862.6	862.9	862.8
27.5	862.6	862.5	863.1	862.6	862.6	863.1	862.5	862.9	862.8
27.75	862.6	862.5	863	862.6	862.5	863.1	862.5	862.8	862.8
28	862.5	862.5	863	862.6	862.5	863.1	862.5	862.8	862.8
28.25	862.5	862.4	863	862.5	862.5	863	862.4	862.8	862.8
28.5	862.5	862.4	862.9	862.5	862.4	863	862.4	862.8	862.7
28.75	862.4	862.4	862.9	862.5	862.4	863	862.4	862.7	862.7
29	862.4	862.3	862.9	862.4	862.4	862.9	862.4	862.7	862.7

29.25	862.4	862.3	862.8	862.4	862.4	862.9	862.3	862.7	862.7
29.5	862.3	862.3	862.8	862.4	862.3	862.9	862.3	862.7	862.7
29.75	862.3	862.3	862.8	862.4	862.3	862.9	862.3	862.7	862.6
30	862.3	862.3	862.8	862.3	862.3	862.8	862.3	862.6	862.6
30.25	862.3	862.2	862.7	862.3	862.3	862.8	862.2	862.6	862.6
30.5	862.3	862.2	862.7	862.3	862.2	862.8	862.2	862.6	862.6
30.75	862.2	862.2	862.7	862.3	862.2	862.8	862.2	862.6	862.6
31	862.2	862.2	862.7	862.3	862.2	862.7	862.2	862.6	862.5
31.25	862.2	862.2	862.6	862.2	862.2	862.7	862.2	862.6	862.5
31.5	862.2	862.2	862.6	862.2	862.2	862.7	862.2	862.5	862.5
31.75	862.2	862.1	862.6	862.2	862.2	862.7	862.1	862.5	862.5
32	862.2	862.1	862.6	862.2	862.1	862.7	862.1	862.5	862.5
32.25	862.1	862.1	862.6	862.2	862.1	862.6	862.1	862.5	862.5
32.5	862.1	862.1	862.5	862.2	862.1	862.6	862.1	862.5	862.5
32.75	862.1	862.1	862.5	862.1	862.1	862.6	862.1	862.5	862.4
33	862.1	862.1	862.5	862.1	862.1	862.6	862.1	862.5	862.4
33.25	862.1	862.1	862.5	862.1	862.1	862.6	862.1	862.4	862.4
33.5	862.1	862.1	862.5	862.1	862.1	862.5	862.1	862.4	862.4
33.75	862.1	862	862.4	862.1	862.1	862.5	862.1	862.4	862.4
34	862.1	862	862.4	862.1	862.1	862.5	862	862.4	862.4
34.25	862	862	862.4	862.1	862	862.5	862	862.4	862.4
34.5	862	862	862.4	862.1	862	862.5	862	862.4	862.4
34.75	862	862	862.4	862.1	862	862.5	862	862.4	862.4
35	862	862	862.3	862	862	862.5	862	862.4	862.3
35.25	862	862	862.3	862	862	862.4	862	862.4	862.3
35.5	862	862	862.3	862	862	862.4	862	862.3	862.3
35.75	862	862	862.3	862	862	862.4	862	862.3	862.3
36	862	862	862.3	862	862	862.4	862	862.3	862.3

Table 27. Inflow and outflow hydrograph for pre-development and final recommendation

	Pre-development		**Final Recommendation**	
Time (hr)	**Inflow (cfs)**	**Outflow (cfs)**	**Inflow (cfs)**	**Outflow (cfs)**
0	0	0	0	0
0.25	0.2	0	0.2	0
0.5	0.3	0	0.3	0
0.75	0.4	0	0.4	0
1	0.5	0	0.5	0

1.25	0.5	0	0.5	0
1.5	0.5	0	0.5	0
1.75	0.5	0	0.5	0
2	0.6	0	0.6	0
2.25	0.6	0	0.6	0
2.5	0.6	0	0.6	0
2.75	0.6	0	0.6	0
3	0.6	0	0.6	0
3.25	0.6	0	0.6	0
3.5	0.6	0	0.6	0
3.75	0.7	0	0.7	0
4	0.7	0	0.7	0
4.25	0.7	0	0.7	0
4.5	0.7	0	0.7	0
4.75	0.7	0	0.7	0
5	0.8	0	0.8	0
5.25	0.8	0	0.8	0
5.5	0.8	0.1	0.8	0
5.75	0.8	0.1	0.8	0
6	0.9	0.1	0.9	0
6.25	1.1	0.1	1.1	0
6.5	1.2	0.1	1.2	0
6.75	1.4	0.1	1.4	0
7	1.5	0.1	1.5	0
7.25	1.6	0.1	1.6	0
7.5	1.7	0.2	1.7	0
7.75	1.9	0.2	1.9	0
8	2.1	0.2	2.1	0
8.25	2.3	0.3	2.3	0
8.5	2.5	0.3	2.5	0
8.75	2.7	0.3	2.7	0
9	3	0.4	3	0
9.25	9.7	0.6	9.7	0
9.5	11.8	0.9	11.8	0
9.75	13.9	1.3	13.9	0
10	16.4	1.8	16.4	0
10.25	19.8	2.4	19.8	0
10.5	24.7	3.4	24.7	0
10.75	47.5	5.1	47.5	0
11	63.8	8.6	63.8	0
11.25	83.4	14	83.4	0
11.5	109.5	21.5	109.5	0
11.75	177.4	31	177.4	0
12	466.9	47.2	466.9	0
12.25	1189.4	72.3	1189.2	19.7
12.5	511.7	87.8	510.1	51.3
12.75	216.8	91.2	216.8	61.6
13	155.1	92.6	155.1	64.9
13.25	119.5	93	119.5	66.9

13.5	95.4	93.2	95.4	68
13.75	62.6	93	62.6	68.4
14	46.6	92.7	46.6	67.9
14.25	35.7	91.9	35.7	67.3
14.5	28.4	91.2	28.4	66.3
14.75	23.3	90.3	23.3	65.2
15	19.6	89.5	19.6	63.9
15.25	8.9	88.4	8.9	62.6
15.5	6.4	87.4	6.4	60.9
15.75	4.7	86.4	4.7	59.4
16	3.6	84.9	3.6	57.6
16.25	3	83.1	3	55.8
16.5	2.7	81.6	2.7	54
16.75	2.4	79.9	2.4	52.2
17	2.3	78.2	2.3	50.5
17.25	2.1	76.7	2.1	48.7
17.5	2	75	2	47
17.75	1.9	73.3	1.9	45.4
18	1.8	71.9	1.8	43.8
18.25	1.3	70.1	1.3	42.3
18.5	1.1	68.8	1.1	40.9
18.75	1	67	1	39.5
19	0.9	65.7	0.9	38.1
19.25	0.9	64	0.9	36.7
19.5	0.8	62.6	0.8	35.2
19.75	0.8	61	0.8	33.8
20	0.8	59.3	0.8	32.7
20.25	0.7	56.3	0.7	31.7
20.5	0.7	53.4	0.7	30.3
20.75	0.7	50.6	0.7	29.2
21	0.7	47.9	0.7	28.3
21.25	0.7	45.4	0.7	27
21.5	0.6	42.9	0.6	25.7
21.75	0.6	40.6	0.6	24.8
22	0.6	38.4	0.6	23.8
22.25	0.6	36.3	0.6	22.6
22.5	0.6	34.4	0.6	22
22.75	0.6	32.4	0.6	20.9
23	0.6	30.5	0.6	20.2
23.25	0.5	28.9	0.5	19.2
23.5	0.5	26.8	0.5	18.6
23.75	0.5	24.2	0.5	17.7
24	0.5	22	0.5	17
24.25	0.3	19.7	0.3	16.5
24.5	0.2	18.1	0.2	15.7
24.75	0.1	16.5	0.1	15
25	0	15	0	14.5
25.25	0	13.6	0	14
25.5	0	12.4	0	13.6

25.75	0	11.3	0	13
26	0	10.5	0	12.5
26.25	0	9.7	0	12
26.5	0	8.9	0	11.6
26.75	0	8.2	0	11.2
27	0	7.8	0	10.8
27.25	0	7.1	0	10.5
27.5	0	6.7	0	10.1
27.75	0	6.2	0	9.7
28	0	5.7	0	9.3
28.25	0	5.4	0	8.9
28.5	0	5.1	0	8.8
28.75	0	4.8	0	8.5
29	0	4.6	0	8.1
29.25	0	4.3	0	7.9
29.5	0	4	0	7.8
29.75	0	3.8	0	7.4
30	0	3.6	0	7.1
30.25	0	3.5	0	7.1
30.5	0	3.3	0	6.7
30.75	0	3	0	6.6
31	0	3	0	6.4
31.25	0	2.8	0	6.1
31.5	0	2.6	0	6.1
31.75	0	2.6	0	5.7
32	0	2.4	0	5.7
32.25	0	2.4	0	5.4
32.5	0	2.2	0	5.4
32.75	0	2.2	0	5.2
33	0	2	0	5.1
33.25	0	2	0	4.9
33.5	0	1.9	0	4.8
33.75	0	1.8	0	4.7
34	0	1.8	0	4.6
34.25	0	1.6	0	4.6
34.5	0	1.6	0	4.3
34.75	0	1.6	0	4.3
35	0	1.5	0	4.2
35.25	0	1.5	0	4
35.5	0	1.5	0	4
35.75	0	1.4	0	3.8
36	0	1.4	0	3.8

Appendix I: Budget for Completion of Feasibility Study

Table 28. Budget for completion of feasibility study for flood mitigation options within Weber Pond

Project Task	**Projected Time expenditure**	**Projected cost[1]**	**Responsible Team Member**	**Actual time Expenditure**	**Actual Cost**
Project Development Work Plan	8	800	Acadia	10.5	1,050
Meet with City of Edina	30	3,000	All	77.5	7,750
Biweekly Project Reports	32	3,200	All	27.5	2,750
Group Meetings	32	3,200	All	92.75	9,275
Report Writing (Draft & Final)	132	13,200	Acadia	112.75	11,275
Presentation (Midterm & Final)	100	10,000	Rena	73.5	7,350
Task #1: Gain familiarity with the project background	52	5,200	Acadia	17.5	1,750
Task #2: Conduct research and select preliminary options	50	5,000	Jack	37.0	3,700
Task #3: Consider advantages and disadvantages of each option/ narrow choices down. (multiple times)	36	3,600	Emily	10.25	1,025
Task #4: Perform hydrologic and cost estimate calculations for approximately six options	68	6,800	Rena	41.5	4,150
Task #5: Learn modeling software	66	6,600	Jack	35.25	3,525
TOTALS:	**606**	**60,600**		**536.0**	**53,600**

1. Cost has been estimated using an hourly billing rate of $100 for each team member.