Memorandum

To: Mr. Kevin Springob, City of Plymouth
From: Rita Weaver, Barr Engineering Company
Subject: Turtle Lake Feasibility Study
Date: November 10, 2011
Project: 23/27-1198

We appreciated the opportunity to complete the Turtle Lake Feasibility Study. We understand several of the residents around the main open water basin are concerned the lake level is decreasing, while residents around the northeast wetland are concerned with flooding issues. The following questions were addressed as part of this study:

1. Are the main basin and the northeast wetland hydraulically connected?
2. What impacts will altering the existing lake outlet structure have on the lake level?
3. What improvements could alleviate flooding in the northeast wetland?
4. What permits would be required for work in the lake and/or wetland?
5. What are the opinion of costs for proposed options?

This memorandum summarizes the modeling methodology, results, and our opinion of costs.

Project Background

Turtle Lake is located northeast of Viking Lane and Old Rockford Road and the lake and its watershed are entirely within the city limits. Turtle Lake consists of the main open water basin and the "large" northeast wetland (See Figure 1). The total area of the lake (main basin and northeast wetland) is approximately 28 acres and the lake's drainage area is approximately 416 acres. The Turtle Lake watershed is almost entirely developed and consists primarily of single family residential homes.

The existing outlet is a 14x24-inch reinforced concrete arch pipe under Old Rockford Road. The outlet pipe discharges into a downstream pond and then to Plymouth Creek. Normal water levels are not controlled by the outlet however, as the lake flows through an existing channel between the main basin and the outlet structure. Although the outlet at Old Rockford Road is at elevation 959.5, topographic data indicates the normal water level for the Turtle Lake main basin, based on the overflow at the upstream end of the channel between old Rockford Road and Turtle Lake is approximately 962.9 feet. The main basin is very shallow, with a maximum depth of 1.5 feet.

Residents surrounding the main basin are concerned that the open water area has decreased over the past several years. However residents along the south edge of the "small" northeast wetland (See Figure 1) have concerns with high water levels.

Existing Information and Site Survey

Data from several sources was reviewed and evaluated for this study. The following is a list of resources and how the information was applied for this analysis:

- The *Turtle Lake Watershed Lake and Management Plan* prepared by Barr Engineering Company for the Bassett Creek Watershed Management Commission (BCWMC) in April 1995 was reviewed. This plan was completed to help the city and the BCWMC establish priorities and provide guidelines to help meet the lake's water quality goals. Water quality modeling was completed as part of the study, and some of the modeling inputs and assumptions were also used for the current analysis. The Modeling Methodology section describes in more detail how these inputs were used.
- Historical air photos of Turtle Lake were reviewed to identify if there have been significant changes in the open water area over time. Air photos from 1937, 1947, 1972, and 1979 were provided by the City, and air photos from 1997, 2000, 2006, 2008 and 2009 were also available and reviewed. The photos generally indicated fluctuation in open water area, however there did not appear to be a significant overall change in the open water area. Further evaluation of the photos would need to be completed by comparing of the time of the year the photo was taken and the yearly precipitation records in order to determine specific trends in open water area.
- The MnDNR reviewed and established the Ordinary High Water Level (OHW) of Turtle Lake in 1991 due to a request by the city. The OHW was determined to be 963.2 feet for the main basin and 963.8 feet for the "large" northeast wetland.

- LiDAR topography collected in 2008 by the US Army Corps of Engineers (USACE) was reviewed. This 1-meter resolution topographic data was used to update the subwatershed divides and recalculate the lake, wetland, and watershed pond storage areas for the model. It was also used to help define overflow locations and elevations between watersheds.
- Survey data, including low floor elevations for homes surrounding the lake, was collected by the City was reviewed.

A site visit was completed in order to better understand the flooding concerns in the "small" northeast wetland area and to observe the lake outlet and the overflow between the northeast wetland and main basin areas. Limited topographical survey was completed to supplement the survey data collected by the city. The topographical survey was performed to define the overflow channel between the lake and the "large" northeast wetland, and between the "large" northeast wetland and the "small" northeast wetland. Topographical survey data was also collected at the existing outlet structure and at the upstream trail crossing east of the "small" northeast wetland.

Modeling Methodology

The water quality evaluation completed in 1996 for the BCWMC used the P8 Urban Catchment Model (P8) modeling software for its analysis. Several of the model inputs were used for the creation of the hydrologic and hydraulic model for this study. The United States Environmental Protection Agency's Storm Water Management Model, with a computerized graphical interface provided by XP Software (XP-SWMM), was chosen as the surface water computer modeling package for this study.

For the analysis we used the SCS hydrology method to calculate stormwater runoff. This method requires the calculation of a curve number, watershed area, the percentage of watershed area covered with impervious surfaces (percent impervious), and the watershed time of concentration. The required hydraulic parameters to route runoff hydrographs include pond stage-storage curves and pipe or channel information connecting the watersheds. The following are a description of the input parameters and how they were calculated:

- **Watershed Delineation:** The watershed boundaries from the original P8 model were adjusted using 2008 LiDAR data and storm sewer alignments obtained from the city. The northeast wetland area watershed was split into two subwatersheds to separate the "large" northeast wetland and the "small" northeast wetland to calculate individual maximum water surface elevations and individually evaluate their potential for flooding. Watershed areas were calculated using the new boundaries.

- **Curve Number:** The SCS method in XP-SWMM requires a pervious area curve number for each watershed. This pervious area curve number is calculated using the hydrologic soil group (HSG) and pervious land use type for each watershed. This method was also used in the 1996 analysis, however the curve numbers were updated based on new land use information.

  Soil types were defined by the National Resources Conservation Service's (NRCS) Soil Survey Geographic (SSURGO) database. The majority of the Turtle Lake watershed is type B soils, except for in the lake and wetland areas. Land use data was obtained from the 2006 National Land Cover Database (NLCD2006) created by the U.S. Geological Survey. NLCD2006 uses a 16 land cover classification scheme based on 2006 satellite data. Eight land use types were present in the Turtle Lake watershed, and a pervious area curve number was applied to each of the land use types, assuming hydrologic soil group type B soils. All open water and wetland areas were classified with a curve number of 98 to simulate impervious area. The following table summarizes the curve number assigned to each land use type.

Table 1 - Pervious area curve numbers applied to NLCD land use data

Land Use from the 2006 NLCD	Curve Number
Deciduous Forest	60
Evergreen Forest	60
Developed Open Space	61
Developed Low Intensity	61
Developed Medium Intensity	69
Developed High Intensity	79
Emergent Herbaceous Wetlands	98
Open Water	98

- **Percent Impervious:** The NLCD2006 Percent Developed Imperviousness dataset was used to calculate the percent impervious area in each of the watersheds. The NLCD Percent Developed Impervious dataset contains percent impervious values for every cell in a 30 meter grid of the conterminous United States. This grid was used to determine the percent impervious value for each watershed. Percent impervious values range from 8-percent to 42-percent for the subwatersheds.

- **Time of Concentration:** The time of concentration was calculated using the SCS method, which uses the pervious curve number and the length and slope of the longest flow path in the watershed. In watersheds where the longest flow path included storm sewer, time of concentration was calculated separately for the pervious area and the storm sewer. A curve number of 98 was assumed to calculate the time of concentration for the storm sewer sections. The total time of concentration was then the time of concentration for the pervious areas plus the time of concentration for the storm sewer section. Time of concentration for the subwatersheds range from 8-minutes to 49 minutes.

- **Pond Volume:** Pond stage-storage curves were calculated using the 2008 LiDAR data in ArcGIS.

- **Watershed Routing and Pipe Information:** Pipe information (pipe sizes and inverts) between watersheds was obtained from the 1996 P8 model. This information was checked using the storm sewer network dataset provided by the city of Plymouth. Channels and/or overflow points between Turtle Lake and the “large” northeast wetland, between the “large” northeast wetland and the “small” northeast wetland, and between the “small” northeast wetland and the upstream drainage area were surveyed. This information was entered into the model as trapezoidal channels for routing between watersheds.

Study Results

The data review and modeling results showed that although the normal water elevations may vary, the main basin and the “large” northeast wetland are hydraulically connected, so the storage areas will often equalize during storm events. However the “small” northeast wetland tended to be at a higher elevation than the main basin and “large” northeast wetland (1.5-feet to 1.8-feet). Table 2 summarizes the elevations of the main basin, the “large” northeast wetland and the “small” northeast wetland during the 100-, 10- and 2-year, 24-hour storm events. Also included is the normal water level of each water body and the elevation of the lowest home elevation that is along each water body, as surveyed by the city.

Table 2 – Summary of Maximum Water Surface Elevations, Existing Conditions

Water Body	Maximum Water Surface Elevation			Ordinary High Water Level	Normal Water Level	Lowest Home Elevation
	100-year, 24-hour Storm Event	10-year, 24-hour Storm Event	2-year, 24-hour Storm Event			
Turtle Lake Main Basin	965.2	964.0	963.6	963.2	962.9	966.1
“Large” Northeast Wetland	965.2	964.3	964.0	963.8	963.4	968.4
“Small” Northeast Wetland	966.7	966.0	965.8	--	964.9	968.2

Note: The existing outlet elevation at Old Rockford Road is 959.5 feet.

The existing outlet pipe at Old Rockford Road is approximately 3.4 feet lower than the normal water level in the main basin because of a channel between the downstream edge of the lake and the lake outlet. The channel extends approximately 300’ feet between the lake and the existing outlet. Increasing the lake elevation would require significant changes to the outlet under Old Rockford Road or construction of a berm at the downstream edge of the lake (at the upstream end of the channel). However, as shown in Table 2, since the change in elevation between the “large” and “small” northeast wetlands is less than two feet, it would be difficult to raise the lake elevation without adversely affecting the low homes and property owners around the “small” northeast wetland and “large” northeast wetland who are concerned about flooding. In addition, the City of Plymouth and the BCWMC currently requires the lowest floor of a permanent structure to be at least two (2) feet above the established 100-year floodplain elevation. Therefore, due to resulting flood elevations, altering the lake outlet to increase its normal water elevation would not be consistent with current floodplain management policies and was not evaluated further.

Since the "small" northeast wetland is at a higher elevation than Turtle Lake, improvements could be implemented to reduce flood elevations in the "small" northeast wetland. The estimated overflow elevation of the "small" northeast wetland is approximately 964.9, based on the LiDAR data and survey data. This elevation is higher than the "large" northeast wetland, so channel drainage, maintenance and/or excavating could be performed to improve flow. These channel improvement alternatives were modeled as part of this study. The alternatives included excavating a 5 foot, 8 foot, and 12 foot channel from the "small" northeast wetland to the "large" northeast wetland. Each alternative assumed the overflow would be decreased from 964.9 to 964.2, or approximately the lowest point surveyed in the "small" northeast wetland. Table 3 summarizes the peak water surface elevation in the "small" northeast wetland during the 100-year, 10-year and 2-year storm events for each alternative.

Table 3 – Maximum Water Surface Elevations in Small Northeast Wetland, Proposed Conditions

Scenarios Modeled	100-year, 24-hour Storm Event		10-year, 24-hour Storm Event		2-year, 24-hour Storm Event		NWL
	Maximum Water Surface Elevation	Change in Elevation	Maximum Water Surface Elevation	Change in Elevation	Maximum Water Surface Elevation	Change in Elevation	
Existing Conditions	966.7	NA	966.0	NA	965.8	NA	964.9
Proposed Channel *(5-foot bottom width, 3:1 side slopes)*	966.5	-0.2	965.7	-0.3	965.4	-0.4	964.2
Proposed Channel *(8-foot bottom width, 3:1 side slopes)*	966.3	-0.4	965.5	-0.5	965.2	-0.6	964.2
Proposed Channel *(12-foot bottom width, 3:1 side slopes)*	966.0	-0.7	965.3	-0.7	965.0	-0.8	964.2

Detailed survey may need to be completed to confirm the total volume that would need to be maintained and/or excavated, but based on the LiDAR and available survey data, estimated total excavation volume for each of the scenarios is follows: 310 cubic yards for the 5 foot bottom width channel, 410 cubic yards for the 8 foot bottom width channel, and 560 cubic yards for the 12 foot bottom width channel. Figure 2 shows the approximate limits of excavation for the 5 foot and 12 foot channels.

At this time we have only considered lowering the channel to its existing low point elevations as surveyed. An additional alternative the city may want to investigate is lowering the channel bottom elevation further to the OHW level of the "large" northeast weltand. This will further reduce flood elevations in the "small" northeast wetland, however it may change the permitting requirements of the project as discussed in the next section.

Permitting

Work in any wetland or water area usually requires a permit from the United States Army Corps of Engineers, however the MnDNR generally has jurisdiction for work below the OHW and work would require a MnDNR permit to work in public waters. Previous discussions with the MnDNR have indicated that significant excavation in the main basin and northeast wetland would be discouraged. Conditions for permit approval for work in the main basin would most likely include demonstrating a significant water quality improvement for the lake or wetland and limiting the excavation to a maximum depth of six feet.

Recent discussions with the MnDNR regarding the "small" northeast wetland indicated that any work in wetlands is discouraged and permit approval would require documentation of structural flooding. Permit applications that show backyard flooding where structures are not affected are less likely to get approved. Another condition for approval is the quality of the plant community in the wetland where work will take place. If permitting for this work is pursued, the MnDNR would likely require detailed evaluation of the plant quality in the wetland.

Although, the proposed work in the "small" northeast wetland may not extend below the OHW of the "large" northeast wetland, it is not known if the MnDNR would establish an OWH or defer to the Local Governmental Unit (LGU) for review. The Minnesota Wetland Conservation Act (WCA) regulates wetlands above the OHW not covered by the MnDNR. The City of Plymouth is the LGU responsible for review of work in wetlands for conformance to the WCA.

Opinion of Cost

Since the option of maintaining and/or excavation the channel between the "large" northeast wetland and the "small" northeast wetland will achieve the city's goal of reducing flood elevations in the smaller northeast wetland, "Budgeting Level" opinion of construction costs for the three alternatives are summarized below. The total cost includes $10,000 for plan preparation (1 sheet with notes), permitting, and contingency.

Table 4 – Opinion Level Costs for Proposed Channel Excavation

Proposed Options	**Opinion Level Construction Costs**	**Opinion Level Total Costs**
Excavated Channel *(5-feet bottom width, 3:1 side slopes)*	$21,000	$40,000
Excavated Channel *(8-feet bottom width, 3:1 side slopes)*	$23,000	$45,000
Excavated Channel *(12-feet bottom width, 3:1 side slopes)*	$26,000	$50,000

Legend

Watershed Divides

Study Areas

Turtle Lake - Main Basin

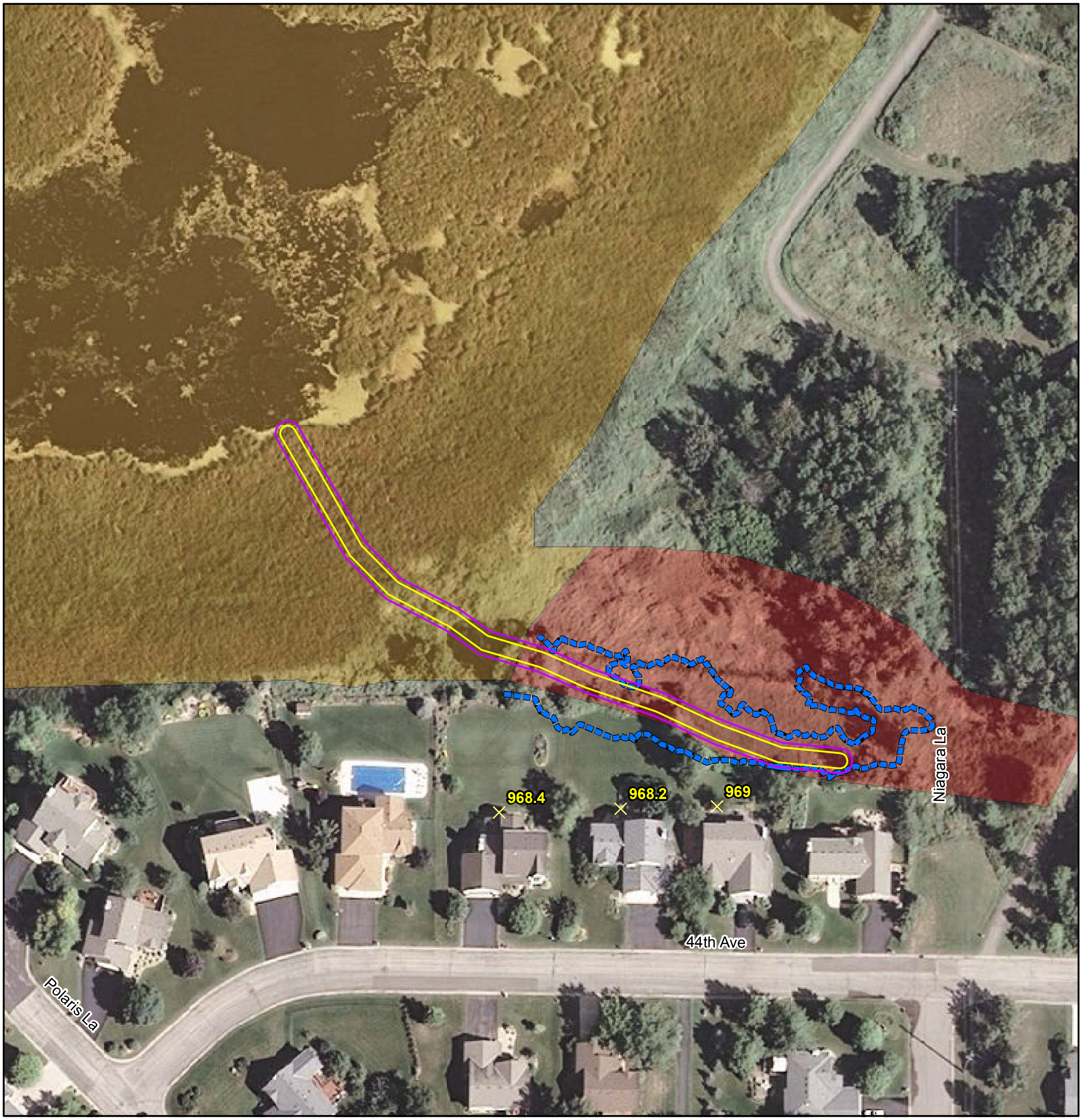
Large Northeast Wetland

Small Northeast Wetland

0 250 500 1,000 Feet

Figure 1

STUDY AREAS
Turtle Lake Feasibility Study
City of Plymouth



Legend

Approximate 100-year Elevation*

Low Home Elevations

Approximate Channel Limits

5 foot bottom width

12 foot bottom width

Study Areas

Turtle Lake - Main Basin

Large Northeast Wetland

Small Northeast Wetland

*Existing Conditons, based on LiDAR data

0 50 100 200 Feet

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Figure 2

APPROXIMATE EXTENT OF CHANNEL EXCAVATION
Turtle Lake Feasibility Study
City of Plymouth