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technical memorandum

To: RWMWD Board of Managers
From: Lulu Fang, Evan Christianson, Erin Anderson Wenz, and Brad Lindaman
Subject: Grass Lake/Snail Lake optimization study
Date: December 15, 2017
Project: 23/62-1200.00 008 002

1.0 Introduction

This memorandum summarizes recommendations for changes to the Snail Lake/Grass Lake systems that will assist in reducing flood risk in the Snail Lake and Grass Lake areas. In this study, we evaluated options to optimize the Snail Lake/Grass Lake system (from Snail Lake to Grass Lake to Highway 694), with the goal of lowering flood levels in the area's water bodies to reduce the risk of flooding to habitable structures and to lessen the impacts to surrounding properties. Specifically, we studied possible changes to overflow and outlet elevations of water bodies in the system, pipe changes to modify discharge rates and volumes, and the possibility of lowering the existing 15-inch reinforced concrete pipe under Highway 694. No alternations of control points downstream of Highway 694 were evaluated as a part of this study. This work utilizes and builds on the pumping and associated monitoring efforts pursued in the Grass Lake area in 2017.

An important part of this project was evaluating the risk (actual and perceived) involved in undertaking recommended actions. Particular attention was paid to the following structures and roadways: Interstate Highway 694, Crestview Addition homes, Snail Lake homes, Gramsie Road (new profile), Rice Street, Vadnais Boulevard, and the St. Paul Regional Water Treatment Facility. This evaluation included the surveying of low points of concern not covered by recent previous surveys. Barr used monitoring data that was collected for the area by the Ramsey-Washington Metro Watershed District (RWMWD), and built on an existing XP-SWMM model for these tasks. In addition, the existing regional Twin Cities Metropolitan Area Groundwater Flow Model Version 3.0 (Metro Model 3; Metropolitan Council, 2014) was used to create a more localized, detailed version for use in evaluating options.

An outcome of this study is updated flood levels of Snail, Grass and West Vadnais lakes for potential management and regulatory use by the RWMWD. The RWMWD is currently in discussion with the Minnesota Department of Natural Resources (MnDNR) to determine whether the new normal water levels proposed for Snail, Grass, and West Vadnais lakes will be permitted via the placement of new outlet structures.

2.0 Background information

The Snail Lake and Grass Lake Subwatersheds are a part of the former Grass Lake Watershed Management Organization (GLWMO). In 2013, the GLWMO was dissolved and its watershed was added to the

RWMWD. One of the primary goals of the RWMWD is to: *Reduce the public's risk to life and property from flooding through programs and projects that protect public safety and well-being* (Barr, RWMWD Strategic Overview of the Watershed Management Plan, 2017). As such, in 2016, the RWMWD began to evaluate high water conditions in the area, at the request of area residents and in response to flooding on Gramsie Road in late summer 2016.

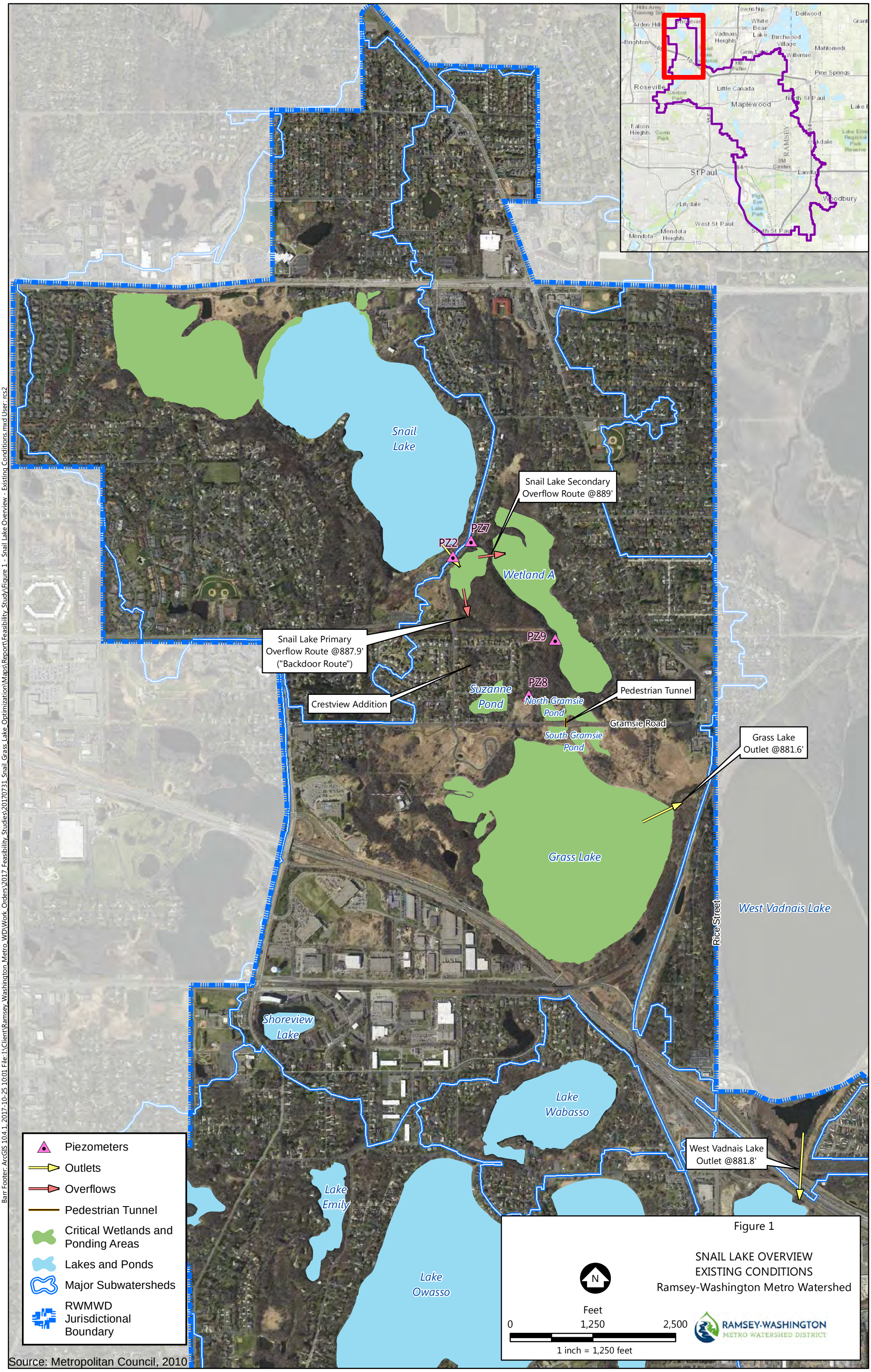
The Snail Lake and Grass Lake subwatersheds are located in the northwestern corner of the RWMWD (Figure 1). West Vadnais Lake and its subwatershed are not a part of the RWMWD, although West Vadnais Lake receives water from the Grass Lake area, and ultimately drains to the Phalen Chain of Lakes through a 15-inch reinforced concrete pipe under Hwy 694.

2.1 2016-2017 flooding in the Snail Lake/Grass Lake subwatersheds

In late summer 2016, record high levels of precipitation, combined with high regional groundwater levels, began to create a number of flooding problems that had never before been experienced. By mid-August, Gramsie Road was flooded and water in Grass Lake was backflowing through a culvert under the trail on the northeast side of the lake, pooling in a shallow depression in the park and then rising to flow into Wetland A, a typically landlocked wetland located in the Snail Lake Regional County Park. As a result, Wetland A bounced nearly 10 feet higher than what is considered its typical elevation, in part from its own watershed drainage, and in part from flows coming from Grass Lake.

At the same time, groundwater flooding began to affect the lowest home in the Crestview Addition, and the RWMWD was compelled to study whether management of the high surface water levels in the area could lessen the flood risk to this and other Crestview Addition homes. Pumping of Wetland A and the ponds around Gramsie Road commenced in late spring 2017 but had to stop soon after due to storms that again raised water levels in the area and reduced the available storage in Grass Lake that could accept pumped waters. Nevertheless, the effort helped the RWMWD to conclude that the most effective way to manage groundwater flooding and protect the Crestview Addition homes was to keep the flooding in the area of the pedestrian tunnel under Gramsie Road (and ponds in its direct vicinity, namely "North Gramsie Pond" and "South Gramsie Pond", shown in Figure 1) as dry as possible, and to maintain the pumping capacity of Suzanne Pond.

Although they have receded somewhat since fall 2016, the high water levels in the area have largely persisted through 2017 due to diminished seepage rates to groundwater (because of currently high groundwater levels) and the restricted nature of the Grass Lake outlet system that drains the entire area. The system's ultimate outlet is located south of West Vadnais Lake; it is a 15-inch reinforced concrete pipe under Highway 694. Its small size was deliberately chosen decades ago to restrict flows from the Grass Lake area into the downstream Phalen Chain of Lakes, which has its own flooding problems, specifically around Owasso Basin (immediately downstream) and around Gervais Lake. Conveyance between Grass Lake's own outlet and the 15-inch reinforced concrete pipe is also restricted under existing conditions; it is a flat system with several pinch points (including a 12" pipe under West Vadnais Blvd) that can be made worse, at times, by vegetal clogging of pipes. Recent dredging has improved this situation but nonetheless, the RWMWD has been looking into other improvements that could help maintain outflows as high as possible without significantly increasing flows to the Phalen Chain of Lakes.



2.2 Groundwater modeling

A local-scale groundwater model was developed to establish the maximum stage elevations for Wetland A and water bodies along Gramsie Road that will be protective of structures and the potential impacts resulting from high groundwater levels. During winter and early spring 2017, the home located at 4000 Crestview Lane experienced high groundwater levels and required pumping from a sump system in excess of 10,000 gallons per day. This home has the lowest known basement elevation in the area with a basement threshold elevation of 877.74 feet (NAVD88). During this period, water bodies including Grass Lake, Wetland A, the ponds on the north and south side of Gramsie Road, and Suzanne Pond were all near record levels. The prolonged period of the surface water bodies being at high levels influenced groundwater levels in the area. While above-normal precipitation has resulted in higher-than-normal groundwater levels across the region for the last several years, the effect of these surface waters being at near record levels exasperated the high groundwater conditions in the area. While it is not in the RWMWD's power to manage the levels of *regional* groundwater systems, in this instance, the RWMWD may be able to manage surface water features to affect *localized* flooding due to groundwater seepage. Therefore, the localized groundwater model was designed to determine which surface water bodies have the most impact on groundwater levels and to establish maximum stages for these water bodies to mitigate potential impacts to structures from high groundwater.

In spring 2017, two piezometers were installed in the area between Crestview Lane and Wetland A (Figure 1). These new piezometers, in addition to two older piezometers near Snail Lake, and the stage of surface water bodies in the area, were monitored throughout spring and summer 2017. During this time, pumping was conducted in Wetland A and nearby ponds to monitor the response of groundwater and surface water levels in the area. Additionally, the homeowner at 4000 Crestview Lane installed an automated monitoring system on the home's sump system and shared the data for analysis.

Review of the monitoring data from spring and summer 2017 indicates that the groundwater levels around the home located at 4000 Crestview Lane are highly influenced by water levels in the pond on the northwest side of Gramsie Road (shown as "North Gramsie Pond" in Figure 1) and Suzanne Pond. Significant reductions in groundwater levels observed at Piezometer PZ8 occurred when Suzanne Pond was lowered after blockages were removed from the pumping system, and when the pond on the northwest side of Gramsie Road was lowered as a result of pumping operations. These changes also correspond with significant reductions in pumping from the sumps at 4000 Crestview Lane and, starting in mid-April 2017, pumping was only intermittently needed from the sumps. Changes in the stage of Wetland A and Grass Lake had some influence on groundwater levels but were not as significant as the pond on the northwest side of Gramsie Road and Suzanne Pond ("North Gramsie Pond" in Figure 1).

A local-scale groundwater flow model was developed using Metro Model 3 as a starting point to define initial boundary conditions, aquifer geometry, recharge, and high capacity pumping. Metro Model 3 was developed by Barr Engineering Co. for the Metropolitan Council for water-supply planning purposes. The model simulates all major aquifers and surface waters in the 11-county metropolitan area and is the standard model used for most local model evaluations across the Twin Cities.

Changes made to the local model, for the purpose of this analysis, include:

- *Model grid refinement*. The telescopic mesh refinement (TMR) approach was used to refine the model grid, allowing for much more detailed inclusion of surface water bodies, and for more accurate calculation of groundwater levels across the model domain. The model cell size was refined from 500 meters by 500 meters used in Metro Model 3 down to 15.6 meters by 15.6 meters used for the local-scale model.
- *Additional layers added*. Additional model layers were added near the groundwater surface to better capture shallow groundwater flow.
- *Surface waters simulated with Reservoir Package*. In Metro Model 3, all surface water is simulated with the River Package of MODFLOW. For this analysis, Snail Lake, Grass Lake, West Vadnais Lake, Wetland A, Suzanne Pond, and the ponds near Gramsie Road were all simulated with the Reservoir Package. This change was made to allow for the surface area of these water bodies to change based on different stages—not something the River Package accounts for.
- *Model recalibration*. The local-scale groundwater model was calibrated using data collected during spring and summer 2017, in addition to the calibration dataset used in development of Metro Model 3.

2.3 XP-SWMM (surface water) modeling

The RWMWD has an XP-SWMM hydrologic/hydraulic model that covers the entire Grass Lake area as well as the Phalen Chain of Lakes downstream. Data from 2017 was used to update the model, to ensure that it could simulate the high water levels in 2017, and therefore be used to evaluate future changes to the area under similar conditions (sustained heavy precipitation and high groundwater levels).

The XP-SWMM model for the Grass Lake area was calibrated to the daily monitoring data from early May to late July 2017. Monitoring data indicated that during this time period, infiltration to groundwater was not as significant as it usually is in the area, due to high groundwater levels. Evaporation plays a significant role, however, and was simulated in the model using data sourced from the University of Minnesota. The simulated water surface elevation hydrograph before and after model validation is plotted against monitoring data, as shown in Figures 2 and 3, below. These charts generally show good agreement with the monitoring data, particularly between May and early July, and gave us confidence that the XPSWMM model could be used to test the effects of potential changes to the system.

Figure 2: Snail Lake water surface elevation hydrograph, modeled vs. monitored

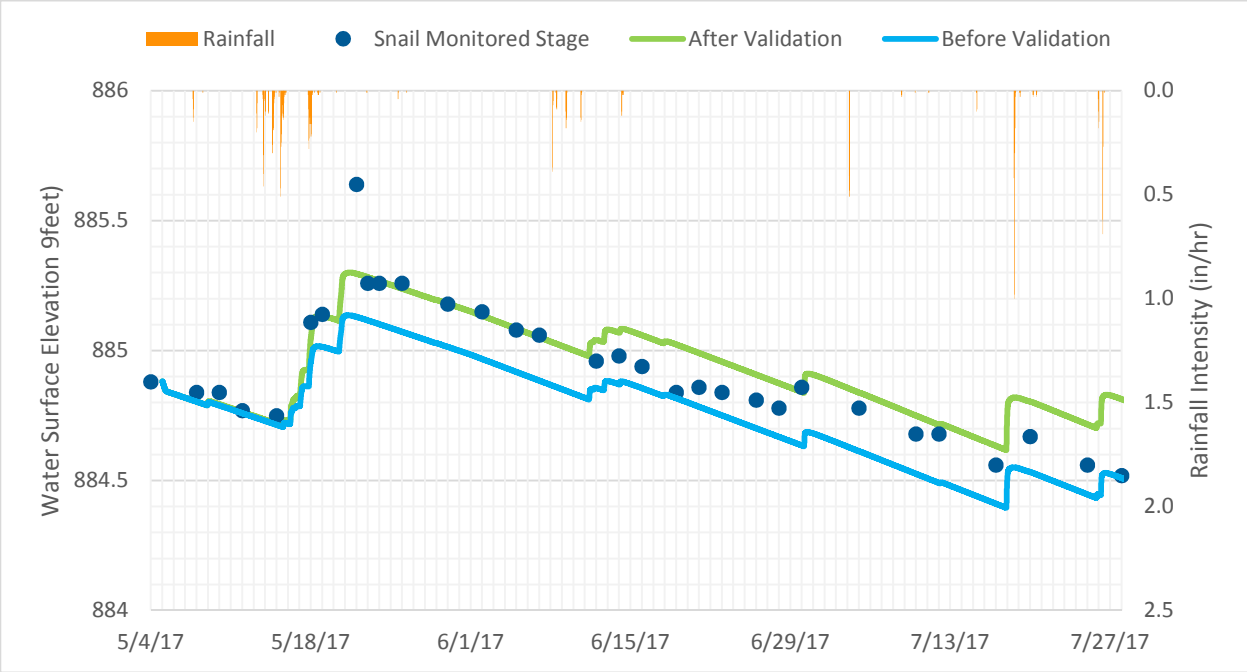
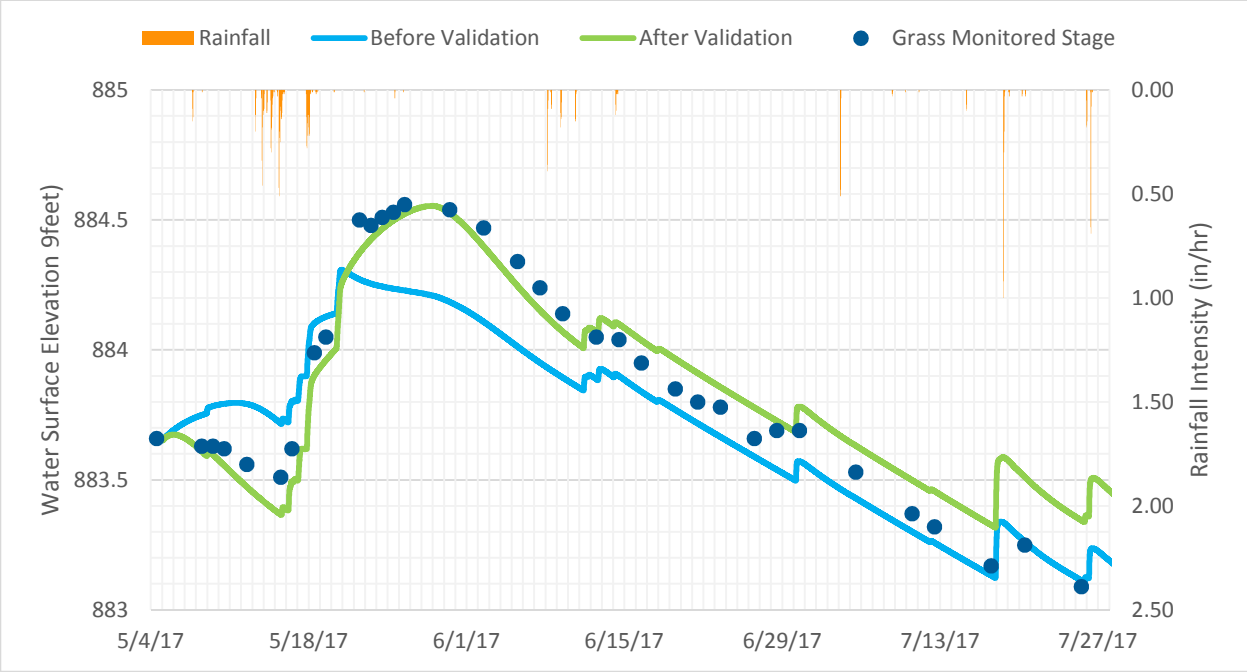


Figure 3: Grass Lake water surface elevation hydrograph, modeled vs. monitored



3.0 Optimization study tasks and related recommendations

The following sections discuss each of the recommended changes to the system's conveyance. Figure 4 shows the locations of the proposed changes to the Snail Lake/Grass Lake subwatersheds.

3.1 Snail Lake's overflow path and outlet elevation

Task 1: Evaluate Snail Lake's overflow path and elevation and establish a feasible 100-year flood level for Snail Lake.

Recommendation: Install a flat 15" rcp outlet pipe from Snail Lake to Grass Lake at elevation 882' (NAVD88 datum) with backflow protection via a manual gate at the inlet to the pipe that can be opened or closed depending on downstream conditions.

Reasoning behind recommendation:

Snail Lake is currently landlocked; it has no piped outlet. In the past, lake level changes in Snail Lake have been attributable to runoff from the lake's tributary watershed, seepage to groundwater, evaporation, and at times, augmentation water pumped from Sucker Lake. Above an elevation of approximately 883, Snail Lake equilibrates with the wetland area that is immediately west of the north end of the lake (shown in green in Figure 1). The lake's existing overflow elevation (887.9) via its primary overflow path (via the "back-door" route, Figure 1) has been identified in recent surveys. Barr evaluated other options that would potentially change this overflow elevation and path to reduce flood risk to Crestview Addition homes and Gramsie Road. In addition, we evaluated options for the outlet elevation that may reduce flood risk to low-lying homes on Snail Lake.

The City of Shoreview has identified homes around Snail Lake that are potentially vulnerable to rising floodwaters under existing conditions. As a part of this task, low entry elevations of these homes were surveyed to help guide the design of a potential outlet for Snail Lake and to determine how much freeboard protection these homes would have during the 100-year, 96-hour storm event at different Snail Lake outlet elevations.

In order to control Snail Lake's outflow rate and minimize its impacts to Grass Lake, a 15-inch pipe was used as the proposed outlet from Snail Lake into Grass Lake. Also, a backflow preventer was assumed for the 15-inch outlet pipe from Snail Lake to Grass Lake, allowing only flow from Snail Lake to Grass Lake (and blocking flow in the reverse direction). This backflow prevention would only send water to Grass Lake when Snail Lake's elevation is higher than Grass Lake's. We also assumed that Grass Lake and West Vadnais Lake would be able to accommodate more flood storage by lowering their outlets as described in Section 3.4, below.

Using the validated XP-SWMM model, various outlet elevations for Snail Lake were evaluated for their effect on Grass Lake's peak water surface elevation. Results are shown in Table 1. For Snail Lake itself, in order to provide 2 feet of freeboard to the lowest home, which has a low entry of 886.0 feet, the outlet elevation would have to be set at 881.5 feet. All other tested elevations could provide more than 3 feet of freeboard to the rest of the lowest homes. The lowest home would still be above the flood elevation, but would have less than 2 feet of freeboard.

Water surface elevations for Grass Lake and Snail Lake, as well as a flow hydrograph for each potential Snail Lake outlet elevation, are shown in Figure 5. The figure shows that that the 882-foot outlet elevation would regulate the volume from Snail Lake entering into Grass Lake during Grass Lake's off-peak period, without taking the capacity of Grass Lake ahead of its own peak. In this scenario, Grass Lake's peak stays just below its proposed overflow elevation of 884 feet. Higher proposed Snail Lake outlet elevations, if not throttled back from flowing into Grass Lake during its own peak through the use of a gate or other control structure, would cause Grass Lake to overflow northward during the 100-year, 96-hour storm.

There are several things to consider when choosing the elevation of a Snail Lake outlet. Outflow from the lake cannot be sent downstream without causing Grass Lake to overflow during the 100-day, 96-hour storm if Snail Lake outflows are not controlled by Grass Lake tailwater, or throttled back with a gate or other control structure. We recommend that whatever elevation is chosen, a manual gate be placed to hold outflows back from Snail Lake until they can be accepted downstream.

Another consideration for the City of Shoreview is what Snail Lake's "normal" elevation should be. For example, at Snail Lake elevation 883, the county beach is exposed. Placing an outlet higher than this means that there would be no mechanism other than seepage to groundwater to draw the lake back and expose the beach after high water levels. The MnDNR will likely have other parameters that will need to be taken into consideration. Regardless, our main conclusion is that there is a range of outlet elevations that could work for Snail Lake, but only if:

- Backflow from Grass Lake is prevented.
- There is a way to stop flows from Snail Lake into Grass Lake when Grass Lake levels are high.
- Additional storage can be created in Grass Lake and West Vadnais Lake by lowering their outlets as described in Section 3.4 of this memorandum.

Snail Lake

Snail Lake **Primary** Overflow Route @**887.9**

Backflow Prevention

Wetland A

Proposed 15" pipe @ 882'

Snail Lake **Secondary** Overflow Route @**889** ("Backdoor Route")

Proposed Outlet for >100-year Event Overflow

Crestview Addition

Suzanne Pond

North Gramsie Pond

Pedestrian Tunnel

Proposed Emergency Outflow @ 884.0'

Gramsie Road

South Gramsie Pond

Grass Lake Outlet @**881.2** **With Increased Capacity**

Proposed Outlet

Proposed Berm and Trail Raise to 885'

Grass Lake

West Vadnais Lake

Rice Street

Shoreview Lake

Increased Capacity Under West Vadnais Blvd

Lake Wabasso

West Vadnais Lake Outlet @**881.0**

Lake Emily

Lake Owasso

- Backflow Prevention
- Proposed Berm
- Outlets
- Overflows
- Pedestrian Tunnel
- Critical Wetlands and Ponding Areas
- Lakes and Ponds
- Major Subwatersheds
- RWMWD Jurisdictional Boundary

Source: Metropolitan Council, 2010

Figure 4

SNAIL LAKE OVERVIEW
PROPOSED CONDITIONS
Ramsey-Washington Metro Watershed

N

Feet
0 1,250 2,500

1 inch = 1,250 feet

RAMSEY-WASHINGTON METRO WATERSHED DISTRICT

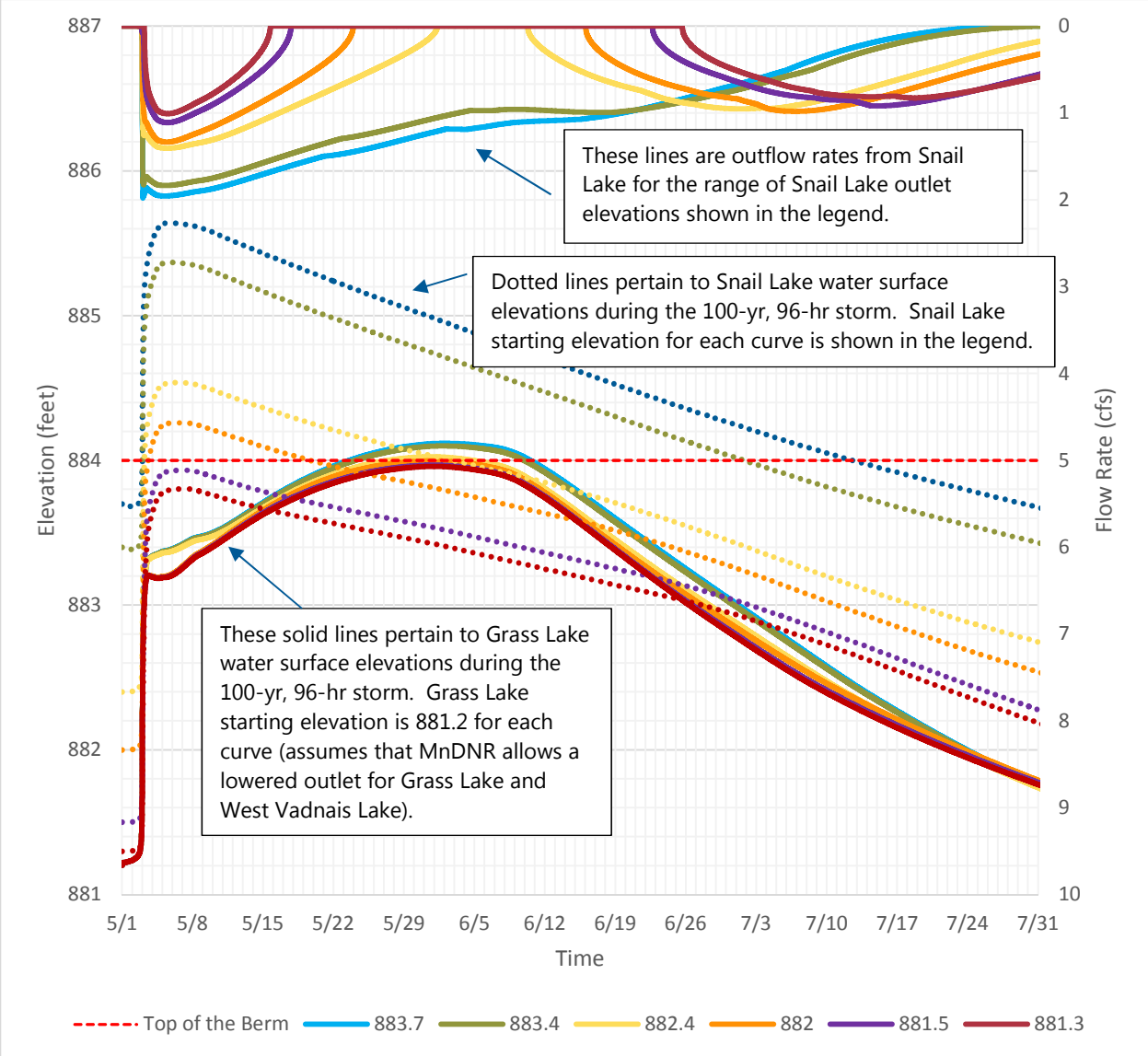
Barr Footer: ArcGIS 10.4.1, 2017-10-25 07:44 File: I:\Client\Ramsey_Washington_Metro_WD\Work_Orders\2017_Feasibility_Studies\20170731_Snail_Grass_Lake_Optimization\Maps\Report\Feasibility_Study\Figure 4 - Snail Lake Overview - Proposed Conditions.mxd User: rcs2

Table 1: Snail Lake and Grass Lake peak elevation in 100-year, 96-hour design event

Snail Lake outlet elevation	883.7[1]	883.4[2]	882.4[3]	882	881.5	881.3
Snail Lake peak elevation(feet)	885.6	885.4	884.5	884.3	883.9	883.8
Grass Lake peak elevation (feet)[4]	884.1	884.1	884.0 (brimming)	884.0 (just under top of berm)	884.0 (just under top of berm)	884.0 (just under top of berm)
Snail Lake high water level[5] duration (day)	normal water level above current OHW	normal Water level above current OHW	60	52	37	30
Freeboard to the lowest home at Snail Lake's peak elevation (feet)[6]	0.4	0.6	1.5	1.7	2.1	2.2
Freeboard to the second lowest home at Snail Lake's peak elevation (feet)[7]	3.2	3.4	4.3	4.5	4.9	5.0

1: proposed upper limit for augmentation
2: current OHW for the lake defining the property line
3: current upper limit for augmentation
4: Grass Lake starts at 881.2, West Vadnais Lake at 881, with the expansion of outlets shown in Section 3.4
5: high water level is using the current OHW (883.4)
6: the lowest home has a low entry elevation at 886.01
7: the second lowest home has low entry elevation at 888.8

Figure 5: Water surface elevation and flow hydrographs for various proposed Snail Lake outlet elevations



As shown in Figure 5, only outlet elevations at 882 feet or lower would keep the peak of Grass Lake below its proposed overflow elevation of 884 feet during the 100-year, 96-hour storm. At higher Snail Lake proposed outlet elevations, water from Snail Lake can still flow to Grass Lake when Grass Lake's water levels are high as well (note the blue and green flow lines compared to the others that show flow is stopped due to tailwater from Grass Lake).

In summary, 882 feet (or lower) is not the only elevation that the Snail Lake outlet could be set to in order to regulate its outflow to Grass Lake. However, the hydrograph comparisons in Figure 5 do suggest that when Grass Lake is above 882 feet, no additional volume should be sent downstream until Grass Lake's own peak passes. In practice, a continuous water-surface monitoring device or a manual gate to stop Snail Lake outflows would be recommended at higher Snail Lake outlet elevations.

Regardless of the ultimate elevation of the potential Snail Lake outlet, the planning level opinion of cost for the 15" diameter, 3,700 foot long high density polyethylene pipe is $580,000 (including 40% contingency and 35% engineering).

In terms of the overflow route from Snail Lake, we would recommend that if an outlet pipe is permitted by the MnDNR to carry flows from Snail Lake to Grass Lake, the primary overflow route from Snail Lake be changed to Wetland A, as opposed to the "back door route". This would be accomplished by building up the low point in the ditch along the "back door route" to an elevation of ~889, while bringing down the overflow into Wetland A to elevation 887.9, preserving the elevation of lake's current primary overflow path (Figure 4).

The RWMWD is currently exploring another potential option for reducing the volume in Snail Lake during high water periods- pumping Snail Lake water to Sucker Lake. Even if Sucker Lake has the capacity to take on more water, there may be some special considerations in transferring water between Snail and Sucker Lake, as Sucker Lake is part of the chain of waterbodies that delivers water to East Vadnais Lake (and into the St. Paul water supply). The RWMWD met the Vadnais Lake Area Watershed Management Organization and the St. Paul Regional Water Service to discuss the potential for this option on Wednesday, November 1. Going forward, the feasibility of this option will be weighed against the above recommendation and a planning level opinion of cost will also be determined.

3.2 Maximum water elevation for Wetland A and other water bodies along Gramsie Road, southeast of the Crestview Addition

Task 2: Establish a maximum water elevation for wetland A and other isolated water bodies along Gramsie Road, southeast of Crestview Addition.

Recommendation: Maintain a maximum stage of 880.0 for Wetland A and the northeast pond along Gramsie Road if the following management options are unsuccessful in keeping groundwater level in the Crestview Addition below low floor elevations. Maintain a maximum stage of 877.0 for the northwest pond along Gramsie Road (shown as "North Gramsie Pond" in Figure 4). Construct a 12" outlet pipe for North Gramsie Pond at 877' that can carry water from North Gramsie Pond to Suzanne Pond, where it can be pumped to Grass Lake. In this scenario, a manual gate valve in the pipe is recommended to separate North Gramsie Pond flows from Suzanne Pond in the event of a pump failure in Suzanne Pond. An operating plan for this gate valve should be prepared and an MOU developed with the City of Shoreview regarding when it should be closed and which party will be responsible for closing/opening it.

Reasoning behind recommendation:

The local-scale groundwater model was used to define maximum stage elevations for water bodies in the area that do not cause impacts to homes and structures, with specific focus on homes in the Crestview Addition area, as these homes have some of the lowest known basement elevations and have historically been impacted by high groundwater levels.

Based on initial model simulations, the stage of Snail Lake and Grass Lake did not have much impact on groundwater near homes in the Crestview Addition area. Additionally, allowing the two ponds on the south side of Gramsie Road to bounce with the stage of Grass Lake did not significantly influence groundwater in the Crestview Addition area. Various stage combinations of Wetland A, along the northwest ("North Gramsie Pond") and northeast ponds near Gramsie Road, were evaluated. For all simulations, it was assumed that Suzanne Pond is able to operate similarly to its operation in summer 2017 and that the stage was fixed at 873 feet. The stage for Snail Lake was fixed at an artificially high level of 886 feet, and Grass Lake and the ponds on the south side of Gramsie Road were fixed at 884 feet.

Two hundred and fifty model simulations were conducted with different combinations of stage for Wetland A and the northeast and northwest pond near Gramsie Road. Based on the results of these simulations, it was determined that a stage of 880.0 feet for Wetland A and the northeast pond and a stage of 877.0 feet for the northwest pond are the maximum stage that still protect homes from a groundwater perspective. These stage elevations allow for groundwater at the 4000 Crestview Lane to be less than a target goal of 876.74 feet, which is 1 foot below the basement threshold.

Several potential options will maintain the stage of the northwest pond near Gramsie Road at 877.0 feet. Pumping could be periodically conducted, similar to what was done during summer 2017. However, this pumping would need to be done frequently during periods of high groundwater, as after the pond is pumped down, it will fill back up with groundwater. Also, if the high groundwater persists into winter pumping and piping, potential icing in this area would be a challenge. An alternative option is to connect the northwest pond near Gramsie Road to Suzanne Pond via a 12" pipe (gravity flow). Suzanne Pond is designed to be maintained at a lower stage and already has a lift station for pumping water to Grass Lake. An additional evaluation would be necessary to verify that the Suzanne Pond pumps are properly sized. However, connecting the northwest pond near Gramsie Road to Suzanne Pond would eliminate the need to actively manage the stage of an additional water body. In this scenario, a manual gate value would be recommended in the pipe to separate North Gramsie Pond flows from Suzanne Pond in the event of a pump failure in Suzanne Pond.

Although there is little justification for the RWMWD to pump Wetland A to below elevation 880 feet, the County may choose to do so in the future to expose the walking paths in the area, if they are not reconstructed as floating paths, or are not moved to different locations. The lowest elevation in the walking path surrounding Wetland A is at approximately 873 feet. If a manhole was placed along the pipe proposed to connect Snail Lake and Grass Lake, it could serve as a discharge point for pumped waters from Wetland A in the future. It should be noted that the RWMWD would not automatically need to pump Wetland A down to 880 feet if it were to rise above that level again. They should only consider this option if the other management options recommended in this memorandum are unsuccessful in keeping groundwater level in the Crestview Addition below low floor elevations.

3.3 Permanent overflow elevation for Grass Lake

Task 3: Establish a permanent overflow elevation for Grass Lake.

Recommendation: Raise the temporary berm along the north side of Grass Lake to an elevation of 885' and place the trail on top of it, creating a permanent barrier. Create a new emergency overflow on the northeast side of the lake at elevation 884' that directs flows from flood events above the 100-year, 96-hour storm to Wetland A through a new culvert under the road, bypassing the pedestrian tunnel and nearby ponding areas on either side of Gramsie Road.

Reasoning behind recommendation:

There are many reasons for putting the overflow elevation for Grass Lake at 884 feet. Rice Street's low point is 884.1 feet. Placing the berm any higher on Grass Lake puts the street at greater risk of flooding. During 2017, the temporary berm placed on the north side of Grass Lake caused Grass Lake to bounce to 884.5 feet, which created some localized flooding problems upstream on Gramsie Road, as the outflow from adjacent ponds was impeded.

The 884' overflow target elevation for Grass Lake was determined early in this study. Plans are already underway to create the permanent berm and the emergency overflow in winter, 2017.

3.4 Regional storage options in the Lake Owasso, Lake Wabasso, Snail Lake, Wetland A, and Grass Lake tributary area

Task 4: Evaluate regional storage options in the Lake Owasso, Lake Wabasso, Snail Lake, Wetland A, and Grass Lake tributary areas.

Recommendation: Increase the outflow capacity from Grass Lake to West Vadnais Lake, and under West Vadnais Blvd. Lower the outlet elevation of Grass Lake to 881.2 feet and lower the outlet elevation of West Vadnais Lake to 881 feet to increase storage in the two lakes.

Reasoning behind recommendation:

The validated XPSWMM model was used to test the feasibility of providing additional regional storage to help the system contain a 100-year, 96-hour design event within the Grass Lake and West Vadnais Lakes without damage to structures or overflowing the proposed 884-foot overflow elevation in Grass Lake.

A first step in this evaluation was to upsize the current Grass Lake outlet and the 12-inch pipe under West Vadnais Lake Boulevard to remove flow restrictions between the two water bodies.

Assuming two 26-inch by 44-inch arch pipes to provide the similar capacity as the current 48-inch culvert under the railroad, and two 26-inch by 44-inch arch pipes under West Vadnais Lake Boulevard, the system could allow Grass Lake to equalize with West Vadnais Lake and provide the least restriction of outflow up to the 15-inch pipe under Highway 694.

The results suggest that lowering the current Grass Lake and West Vadnais Lake normal water levels would still be needed to contain the 100-year, 96-hour storm event under the proposed Grass Lake overflow elevation of 884 feet. The model indicates that the Grass Lake normal water level would need to be lowered to 881.2 feet, while the West Vadnais Lake normal water level would need to be lowered to

881 feet to pass the peak of Grass Lake below the berm during the 100-year, 96 hour event. The peak elevation of both lakes in this scenario would be 883.9 feet.

By lowering Grass Lake from 881.9 feet to 881.2 feet, approximately 96 acre-feet of storage would be provided. Lowering West Vadnais Lake from 881.8 feet to 881 feet would result in approximately 152 additional acre-feet. A total of approximately **248 acre-feet** would be provided by pursuing this option, which is roughly the volume of water contained in 122 Olympic-sized swimming pools.

If this magnitude of storage were to be sought out in the areas tributary to the lakes instead, consider that a typical rain garden has an average depth of about one foot. In order to retrofit this amount of storage in the areas tributary to Grass Lake, ~248 acres would have to be converted to rain gardens from other kinds of landuse. To put this into perspective, the current acreage of green space (parks and other natural areas) in the entire Grass Lake tributary area (including Lake Owasso, Lake Wabasso and all other tributary areas) is approximately 530 acres.

Another option for increasing the available storage in West Vadnais Lake would be to connect West Vadnais Lake to East Vadnais Lake, making the water in West Vadnais Lake available to the St. Paul Regional Water Service. The RWMWD met with the Vadnais Lake Area Watershed Management Organization and the St. Paul Regional Water Service to discuss the potential for this option on Wednesday, November 1, 2017.

3.5 Options for optimizing outflow through the 15-inch outlet to allow flows during off-peak periods downstream

Task 5: Evaluate options for optimizing the outflow through the 15-inch outlet to allow flows during off-peak periods downstream.

Recommendation: Only pursue this option if the recommendations described above are not permitted, and even then, only if coincident flows can be released downstream at the same time (to be studied in 2018 under a separate scope).

Reasoning behind recommendation:

Since January, 2011 the RWMWD has monitored the hourly water elevations of the Phalen Chain of Lakes from its monitoring station at the Spoon Lake weir between Keller Lake and Lake Phalen. The level measured by this gauge can be considered the level of Kohlman, Gervais and Keller Lakes (the three lakes equilibrate above the elevation of the Spoon Lake weir, whose elevation is 858 MSL, NAVD88 datum). Over the past 5 years, the level at the Spoon Lake weir has dipped below this level for only three measurements, and even then, only at a discrete, one hour interval.

XP-SWMM modeling showed that significantly increasing flows from the Grass Lake area to downstream areas would increase the flood level in downstream waterbodies, such as Gervais Lake, taking up freeboard that the lake needs for its own bounce during the 100-year, 96 hour storm. Given that there are already structures at risk around Gervais Lake and other areas (Owasso Basin, for example), it was

determined that trying to time the release of increased flows from the Grass Lake area downstream was impractical.

However, if the recommendations described in Sections 3.1 through 3.4 of this memorandum are not ultimately pursued, this option could be considered if increased flows from the Grass Lake area were accompanied by coincident flows out of the downstream lakes, all the way to the Beltline storm sewer. This way, there would be no additional downstream bounce from increased upstream flows. This effort would require a larger system-wide study, which is currently planned for 2018 and is outside of the scope of this Grass Lake/Snail Lake Optimization Study.

3.6 Permits

The following permits will likely be required for the recommended improvements:

- **Rule D Flood Control (RWMWD):** This permit is required because some work may cause alterations of land below the 100-year flood elevation. The following are required for flood control management:
    - No placement of fill within the 100-year floodplain without compensatory storage.
    - Emergency overflow swales or areas must be constructed to convey the peak 100-year discharge.
- **Excavating and Grading Permit (City of Shoreview):** An excavating and grading permit application, along with an erosion control plan, must be submitted with the final grading plans to the City of Shoreview.
- **Public Waters Work Permit (DNR):** This permit is required if any work would be below the ordinary high water level (OHW) elevation.
- **Section 404 Clean Water Act Permit (USACE):** The U.S. Army Corp of Engineers may have jurisdiction over these waterbodies, and a Section 404 permit may be required for work below the OHW.

4.0 Next steps

The next steps for this study include the following:

- Meeting with the MnDNR to discuss lowering the normal water levels of Snail Lake, Grass Lake and West Vadnais Lake: **October 25, 2017**. The discussions at this meeting indicated that lowering the lake outlets is a possibility, pending further discussion of impacts to shorelines and vegetation in the three lakes, as well as to demonstrate that there would not be any appreciable downstream impacts.

  If, ultimately, the MnDNR cannot permit lowering the normal water levels of Grass Lake and West Vadnais Lake, no outlet will be constructed from Snail Lake, overflow elevations and locations will be evaluated and an emergency Response Plan (ERP) for the area will be created to help guide the City in the event of an overflow from Snail Lake.

- Meeting with Vadnais Lakes Area Watershed Management Organization (VLAWMO) and the St. Paul Regional Water Service (SPRWS) to discuss the possibility of pumping water from Snail Lake to Sucker Lake, or from West Vadnais Lake to East Vadnais Lake: **November 1, 2017.**
- Presentation of the study and its conclusions to the RWMWD Board of Managers on **November 1, 2017** to gage interest in moving forward with the recommendations presented in this memorandum. Next steps would include continuing discussions with VLAWMO and the SPRWS if pumping Snail Lake water to Sucker Lake or pumping West Vadnais Lake to East Vadnais Lake are possibilities, and continuing discussions with the MnDNR about lowering lake outlet levels. RWMWD staff followed up with the Board at the December 6th meeting for more discussion on these options, and were directed to continue pursuing these possibilities.
- Continued discussions with the County about the connection between Snail Lake and the Snail Lake marsh on the northwest side of the lake to better understand the elevation at which the two waterbodies equilibrate (in case there is a way to optimize the connection to the benefit of flood storage). A survey of this area is recommended to define the connection elevation between these two waterbodies more precisely, and to help guide future decisions about whether excavation in this area is warranted to better allow equilibration between Snail Lake and the wetland.
- Continued discussions with the City about the potential for linking North Gramsie Pond and Suzanne Pond via a pipe with a manual gate valve. The RWMWD can provide design guidance and help the City determine whether new pumps in Suzanne Pond are warranted for this scenario. An operating plan and memorandum of understanding (MOU) would be needed to define roles for pump operation and maintenance, and use of the manual gate valve.
- Some of the recommendations shown in Figure 4 and described above are already being planned for **this winter as part of the RWMWD's CIP 2018 Maintenance Project or under separate contract**:
    - Place a permanent berm and trail section to elevation 885 along the north end of Grass Lake.
    - Construct a Grass Lake emergency overflow at elevation 884, sending overflowing water north to Wetland A (bypassing he pedestrian tunnel and North Gramsie Pond)
    - Increase capacity of Grass Lake outlet
    - Increase capacity of culvert under West Vadnais Blvd.
- The next phase of this study (already underway) includes:
    - Working with the MnDNR and other regulators regarding the potential for lowering the Grass Lake outlet by 0.7 feet and the West Vadnais Lake outlet by 0.8 feet. This work involves sharing XP-SWMM model results showing the differences in Grass Lake and West Vadnais Lake peak elevations and inundation time with and without the proposed change in outlet

elevation for each waterbody. Discussions with the MnDNR will also involve any potential impacts to shoreline vegetation as a result of the change.

- Working with the St. Paul Regional Water Service and the Vadnais Lake Watershed District to further explore the possibility of reversing pump flow from Snail Lake to Sucker Lake (via the augmentation system pipes) to manage water levels in Snail Lake. This work includes a feasibility study that evaluates the planning level cost of this option.
- Working with the St. Paul Regional Water Service and the Vadnais Lake Watershed District to further explore the possibility of operating East Vadnais Lake levels to be able to accept treated West Vadnais Lake flows for introduction into the St. Paul Regional Water Service drinking water supply system. This work includes a feasibility study that evaluates the planning level cost for this option.