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BARR

Memorandum

DRAFT

To: Randy Anhorn, Nine Mile Creek Watershed District
From: Janna Kieffer
Subject: 2020 screening-level flood vulnerability analysis for land-locked lakes— Spring 2020 snowmelt analysis results
Date: March 16, 2020

2019 was the wettest year on record in the Twin Cities metro area, with 44.17 inches of precipitation recorded at the Minneapolis International Airport gaging station. This broke the record previously set in 2016 of 40.32 inches. Not only was 2019 a wet year, but the Twin Cities metro area has been in a wet cycle over the past decade. The last six years (2014-2019) have been the wettest six years on record in the area. This wet period has resulted in high water levels for many land-locked lakes (lakes that do not have low level outlets), with historic high water levels reached in 2019 in several lakes within the Nine Mile Creek watershed. Recorded groundwater levels are also higher than average throughout the watershed.

With higher-than-normal lake levels and groundwater levels, an increased risk of flooding affecting land-locked lakes from spring snowmelt/runoff and rainfall exists throughout 2020. At the February 19, 2020 Nine Mile Creek Watershed District (NMCWD) regular board meeting, the board authorized Barr to conduct a screening-level analysis to better understand the potential for flooding of structures and/or infrastructure adjacent to land-locked lakes as a result of existing and potential high water conditions. Because time is of the essence with regard to potential impacts of spring snowmelt and rainfall runoff, completion and summary of the analysis will be split into two parts, with the results of the flood risk analysis from spring snowmelt and/or rainfall on frozen ground (Tasks 1-3 of the February 12, 2020 scope of work) being summarized in this memo. Results of the analysis pertaining to flood risk throughout the remainder of 2020 (Task 4 of the February 21, 2020 scope of work) will be summarized prior to the NMCWD's April 15, 2020 regular board meeting.

Spring 2020 Snowmelt Analysis

The objective of the spring 2020 snowmelt analysis was to understand the potential for flood impacts on land-locked lakes resulting from snowmelt and/or rainfall runoff. The land-locked lakes evaluated as part of this analysis include:

- Shady Oak Lake (Minnetonka)
- Lone Lake (Minnetonka)
- Birch Island Lake (Eden Prairie)
- Bush Lake (Bloomington)
- Arrowhead Lake (Edina)
- Indianhead Lake (Edina)

The lakes included in this analysis represent the land-locked lakes within the Nine Mile Creek watershed that do not have a permanent pumped outlet, with exception of Bush Lake. While Bush Lake does have a pumped outlet, pumping has been halted, at times, due to already high water levels in the downstream Anderson Lakes.

Methodology

Late-February lake level measurements, collected by NMCWD as part of the monthly lake level program initiated in 1963, were used to identify and map current inundation areas for each of the land-locked lakes. Figures 1 through 6 show the extent of inundation for each of lake based on February 28, 2020 water surface elevation measurements using DNR LiDAR elevation data (2011). Approximate elevations of structures (primarily single family homes) adjacent to each lake were identified by intersecting building footprints with the DNR LiDAR elevation data in GIS. Figures 1 through 6 show the building footprints adjacent to the lakes and identify the lowest structures (i.e. the structure(s) at greatest risk of impacts from potential rise of water levels). Note that the elevation of the structures are based on the lowest point of intersection with the DNR's LiDAR elevation data grid and should be considered approximate. The approximate elevations do not represent the elevation at which surface water can enter a structure (the low entry elevation), which may be higher. Elevations of low structures should be field verified for increase accuracy.

When evaluating flood potential for snowmelt scenarios, it is typically assumed that snowmelt will occur prior to ground thaw. Under this assumption, frozen ground conditions prevent infiltration and all of the snowmelt and/or rainfall runoff reaches the downstream lake. To evaluate flood potential for the selected land-locked lakes, watershed areas for each lake were calculated and a spreadsheet model was developed using stage/storage information to approximate how much runoff from snowmelt or rainfall on frozen ground it would take for lake levels to reach the lowest structure. It is important to note that the simplified approach used to estimate potential runoff to the land-locked lakes for this screening-level analysis that assumed runoff from the entire tributary land area would reach the downstream land-locked lake. The analysis did not consider depression storage in the upstream watershed. Therefore, the results should be considered to be conservative.

Results

Table 1 summarizes the results of this analysis, including the tributary watershed area, observed water surface elevation, apparent low structure elevation, available storage volume, and the amount of runoff from snowmelt or rainfall on frozen ground necessary to impact the apparent low structure. This information is also summarized in Figures 1 through 6. As shown in Table 1, the runoff amount required to impact the lowest structures varies for each lake, ranging from 4 inches (Shady Oak Lake) to over 28 inches (Lone Lake). For comparison purposes, a "100-year" or 1% chance snowmelt event is 7.2 inches for the District area.

How much runoff do we expect from 2020 spring snowmelt and/or rainfall? The amount of runoff will depend on numerous factors, including the amount of snow and associated water content, the timing of ground thaw, and whether we receive rainfall with frozen ground conditions. As of February 28, 2020

(coinciding with the most recent lake level measurements), snow depth observations across the Nine Mile Creek watershed ranged from 4 to 7 inches. Based on snow depth and snow water equivalent (i.e., the amount of water in the snow) observations throughout the Twin Cities Metro Area on February 28, 2020, the snow water density was approximately 30%. Given this, the estimated water equivalency in the snowpack throughout the Nine Mile Creek watershed at the end of February ranged from approximately 1.2 to 2.1 inches. The average March precipitation is 1.6 inches, with a 90th percentile range of 0.4 to 3.2 inches, based on precipitation records from the Minneapolis-St. Paul International Airport gaging station (1871-2019). Under frozen ground conditions, there is potential for much of the precipitation (either from rainfall or snowmelt) to reach the downstream waterbody in the form of snowmelt or rainfall runoff. The timing of ground thaw can vary widely depending on several factors, including temperatures, snow cover, soil moisture upon initial freeze, and vegetation. Data obtained through the Hennepin County West Mesonet indicate frost depths currently range from 10 to 20 inches across the Nine Mile Creek watershed (see figure below).

Results of the analysis indicate that the runoff amount required to impact the lowest structures varies for each lake, with Shady Oak Lake having the greatest risk of flood impacts from spring snowmelt and/or rainfall on frozen ground with an available volume of 147 acre-feet as of February 28, 2020, equivalent to 4 inches of runoff across the entire watershed. Note that this analysis assumes that no infiltration will occur across the watershed and all runoff from the tributary watershed will reach the downstream land-locked lake. Therefore, the results should be considered to be conservative.

Next steps

As mentioned previously, this memo summarizes results regarding flood risk analysis from spring snowmelt and/or rainfall on frozen ground (Tasks 1-3 of the February 12, 2020 scope of work). The analysis pertaining to flood risk throughout the remainder of 2020 (Task 4 of the February 21, 2020 scope of work) will be completed in the upcoming weeks and summarized in a subsequent memo prior to the NMCWD's April 15, 2020 regular board meeting. The screening-level analysis included as Task 4 will help assess the potential for water levels to reach elevations that could impact structures or other infrastructure throughout the remainder of 2020.

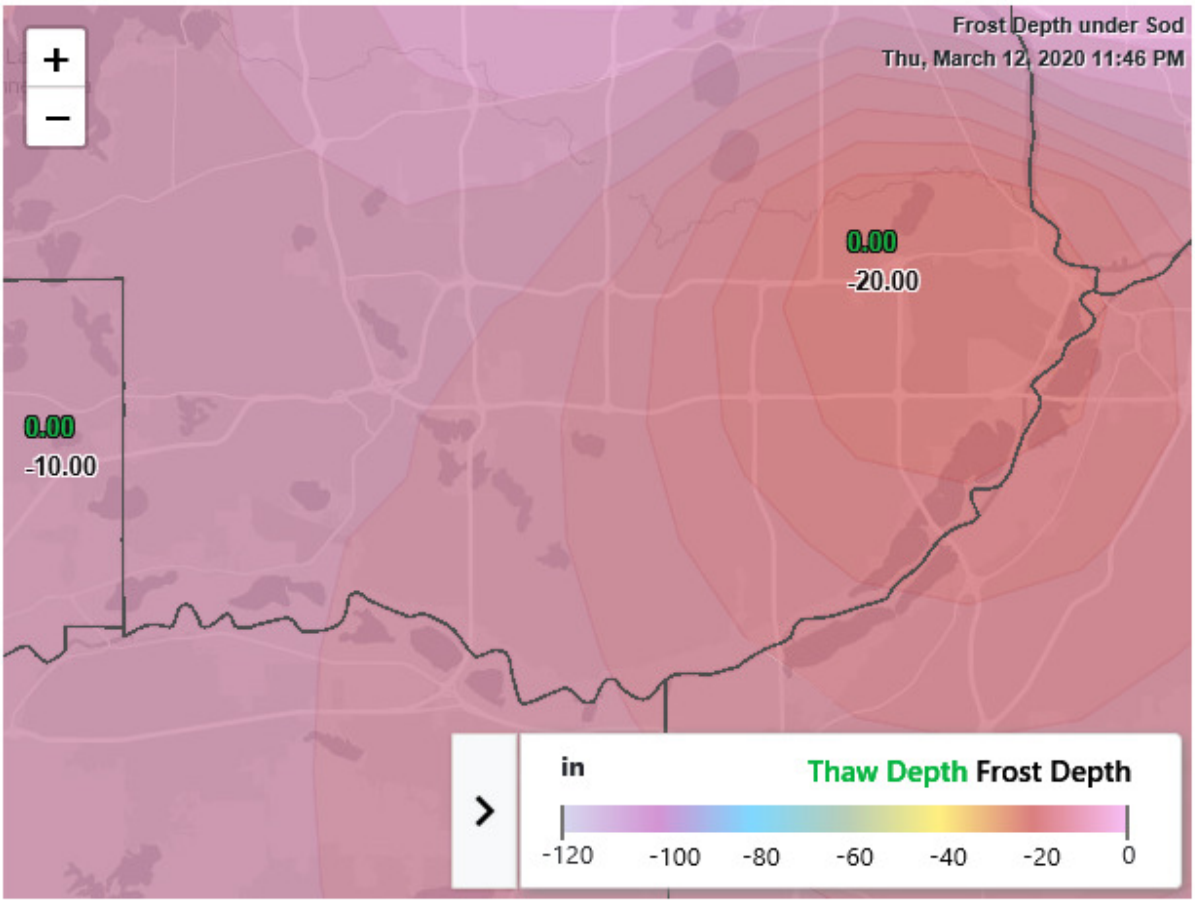

Figure 7. Observed frost depths across southern portion of Hennepin County (source: Hennepin West Mesonet, March 12, 2020)

Table 1. Estimated amount of runoff required for lake level to reach apparent low structure

Lake	Watershed Area (acres)	Water Surface Elevation[1] (feet MSL)	Apparent Low Structure (feet MSL)	Available Storage Volume[2] (acre-feet)	Amount of Runoff for Lake Level to Reach Apparent Low Structure[3] (inches)
Arrowhead	178	875.3	879.3	97	6.5
Birch Island Lake	1208	886.6	896.3	797	7.9
Bush Lake	1,219	833.8	837.3	685	6.8
Indianhead	108	863.6	869.0	91	10.2
Lone Lake	101	901.3	910.4	238	28.3
Shady Oak Lake	445	903.6	905.1	147	4.0

[1] Based on surveyed elevation from 2/28/2020
[2] Available storage volume refers to the storage volume between the observed surface water elevation on 2/28/20 and the apparent low structure adjacent to the lake.
[3] Runoff can include snowmelt runoff or runoff from rainfall on frozen ground.

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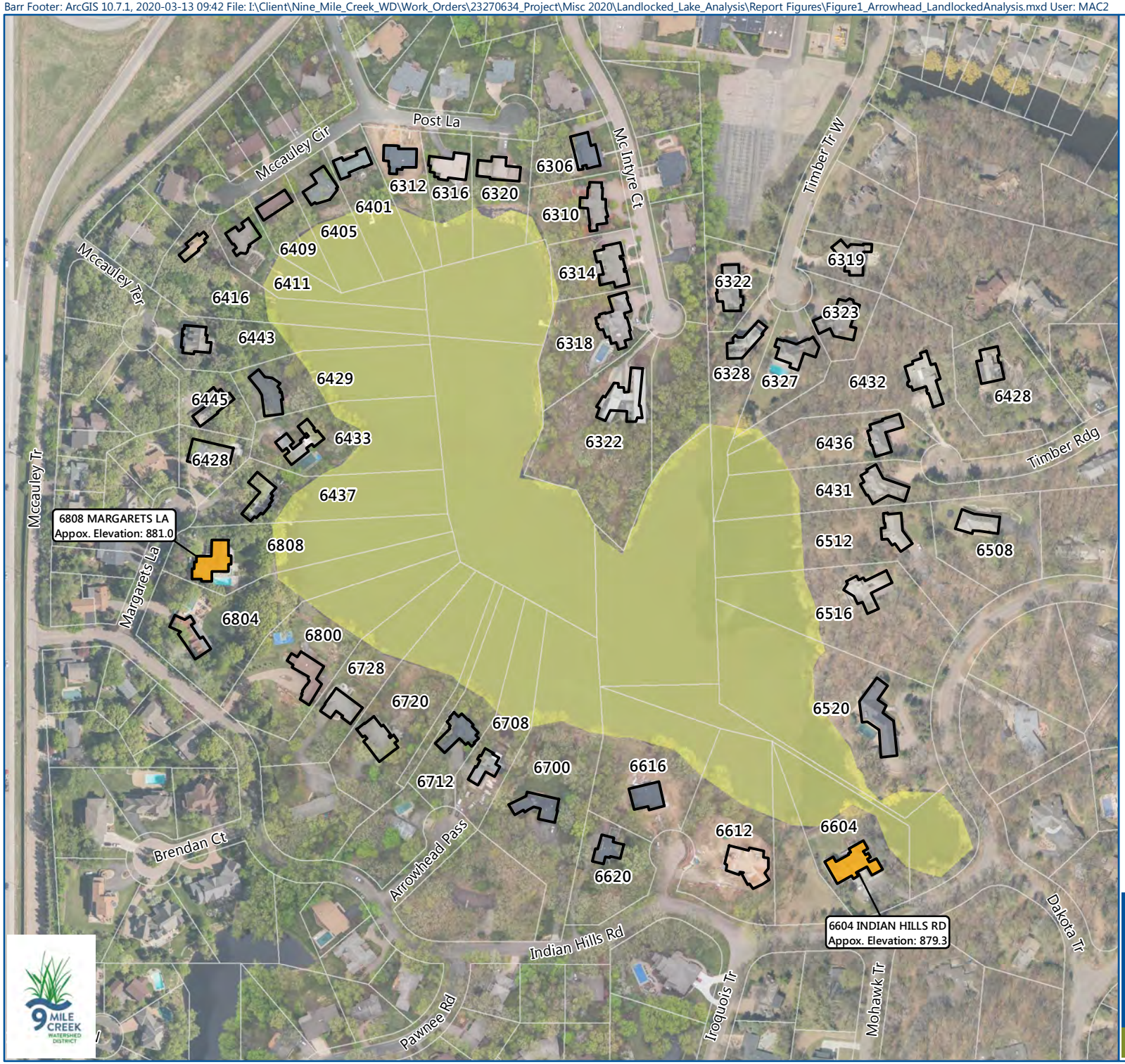

Inundation Area as of 2/28/20

Structure

Lowest Apparent Structures*

Parcel Boundary

Parcels with structures adjacent to the lake or potentially impacted by the lake levels are labeled with the house number.

Potential tributary area to Arrowhead Lake = 178 acres

Surface water elevation as of 2/28/20 = 875.3

Lowest Apparent Structure* = 6604 Indian Hills Road (879.3)

Amount of snowmelt or runoff from rainfall on frozen ground to impact apparent low structure = 6.5 inches

**Elevation of apparent low structure based on MDNR LiDAR elevation data (2011). Elevations have not been field verified.*

N

0 300 600

Feet

1 inch = 300 feet

Aerial Image: Hennepin County Imagery Circa 2018

ARROWHEAD LAKE
SPRING 2020
LANDLOCKED LAKE ANALYSIS
Nine Mile Creek
Watershed District

FIGURE 1

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Inundation Area as of 2/28/20

Structure

Lowest Apparent Structures*

Parcel Boundary

Parcels with structures adjacent to the lake or potentially impacted by the lake levels are labeled with the house number.

Potential tributary area to
Birch Island Lake = 1,208 acres

Surface water elevation as of 2/28/20 = 886.6

Lowest Apparent Structure* =
6350 Indian Chief Rd (896.3)

Amount of snowmelt or runoff from rainfall on frozen ground to impact apparent low structure = 7.9 inches

**Elevation of apparent low structure based on MDNR LiDAR elevation data (2011). Elevations have not been field verified.*

N

0 500 1,000

Feet

1 inch = 500 feet

Aerial Image: Hennepin County Imagery Circa 2018

BIRCH ISLAND LAKE
SPRING 2020
LANDLOCKED LAKE ANALYSIS
Nine Mile Creek
Watershed District

FIGURE 2

Inundation Area as of 2/28/20

Structure

Lowest Apparent Structures*

Parcel Boundary

Potential tributary area to Bush Lake = 1,219 acres

Surface water elevation as of 2/28/20 = 833.8

Lowest Apparent Structure* = 8757 W Bush Lake Rd (837.3)

Amount of snowmelt or runoff from rainfall on frozen ground to impact apparent low structure = 6.8 inches

**Elevation of apparent low structure based on MDNR LiDAR elevation data (2011). Elevations have not been field verified.*

***Inundation area for waterbodies east of East Bush Lake Road from survey conducted on 2/7/20.*

N

0 1,250 2,500

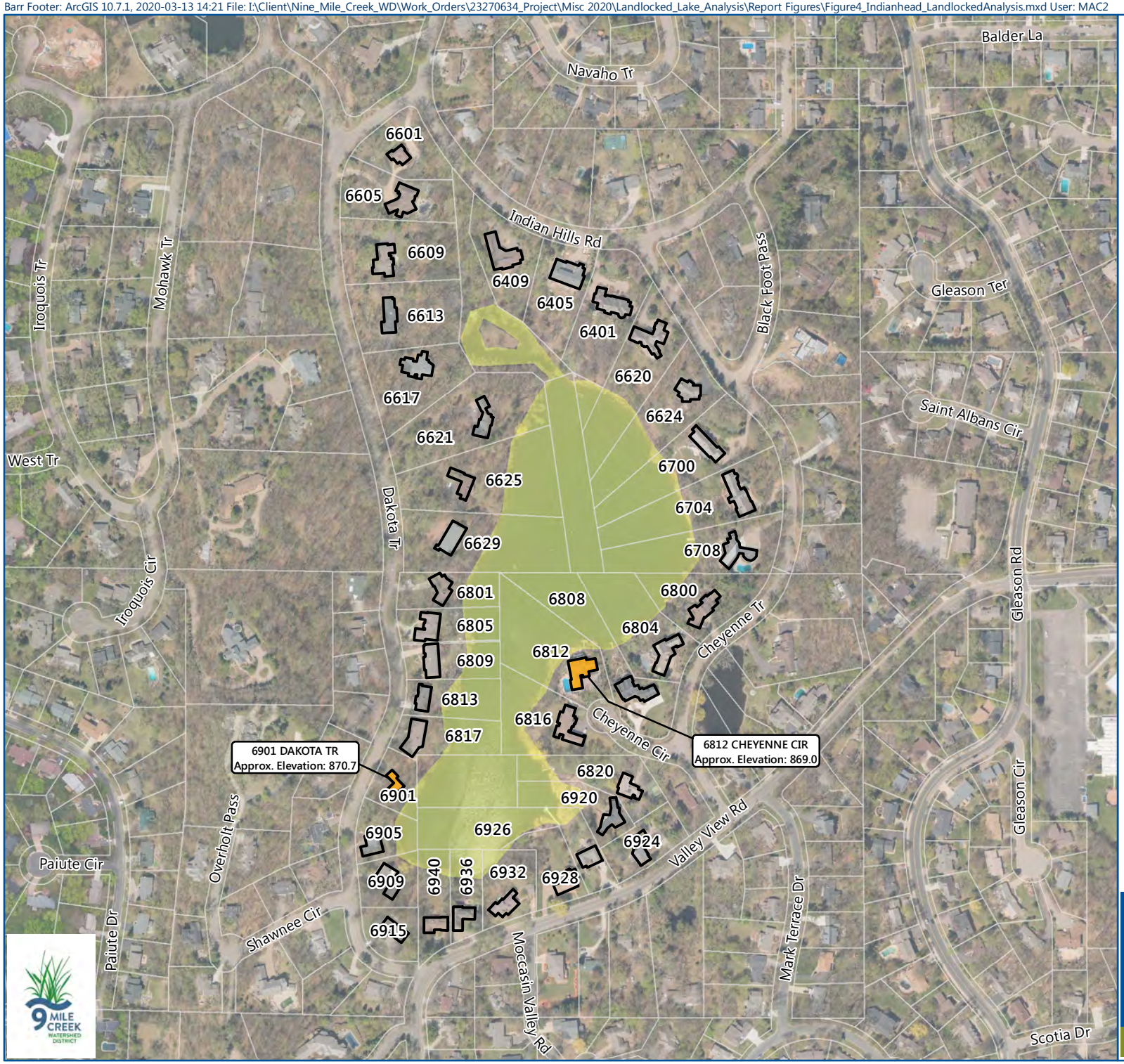
Feet

1 inch = 1,250 feet

Aerial Image: Hennepin County Imagery Circa 2018

BUSH LAKE
SPRING 2020
LANDLOCKED LAKE ANALYSIS
Nine Mile Creek
Watershed District

FIGURE 3



Inundation Area as of 2/28/20

Structure

Lowest Apparent Structures*

Parcel Boundary

Parcels with structures adjacent to the lake or potentially impacted by the lake levels are labeled with the house number.

Potential tributary area to Indianhead Lake = 108 acres

Surface water elevation as of 2/28/20 = 863.6

Lowest Apparent Structure* = 6812 Cheyenne Circle (869.0)

Amount of snowmelt or runoff from rainfall on frozen ground to impact apparent low structure = 10.2 inches

**Elevation of apparent low structure based on MDNR LiDAR elevation data (2011). Elevations have not been field verified.*

N

0 400 800

Feet

1 inch = 400 feet

Aerial Image: Hennepin County Imagery Circa 2018

INDIANHEAD LAKE
SPRING 2020
LANDLOCKED LAKE ANALYSIS
Nine Mile Creek
Watershed District

FIGURE 4

Inundation Area as of 2/28/20

Structure

Lowest Apparent Structures*

Parcel Boundary

Parcels with structures adjacent to the lake or potentially impacted by the lake levels are labeled with the house number.

Potential tributary area to Lone Lake = 101 acres

Surface water elevation as of 2/28/20 = 901.3

Lowest Apparent Structure* = 11895 Douglynn Drive (910.4)

Amount of snowmelt or runoff from rainfall on frozen ground to impact apparent low structure = 28.3 inches

**Elevation of apparent low structure based on MDNR LiDAR elevation data (2011). Elevations have not been field verified.*

N

0 400 800

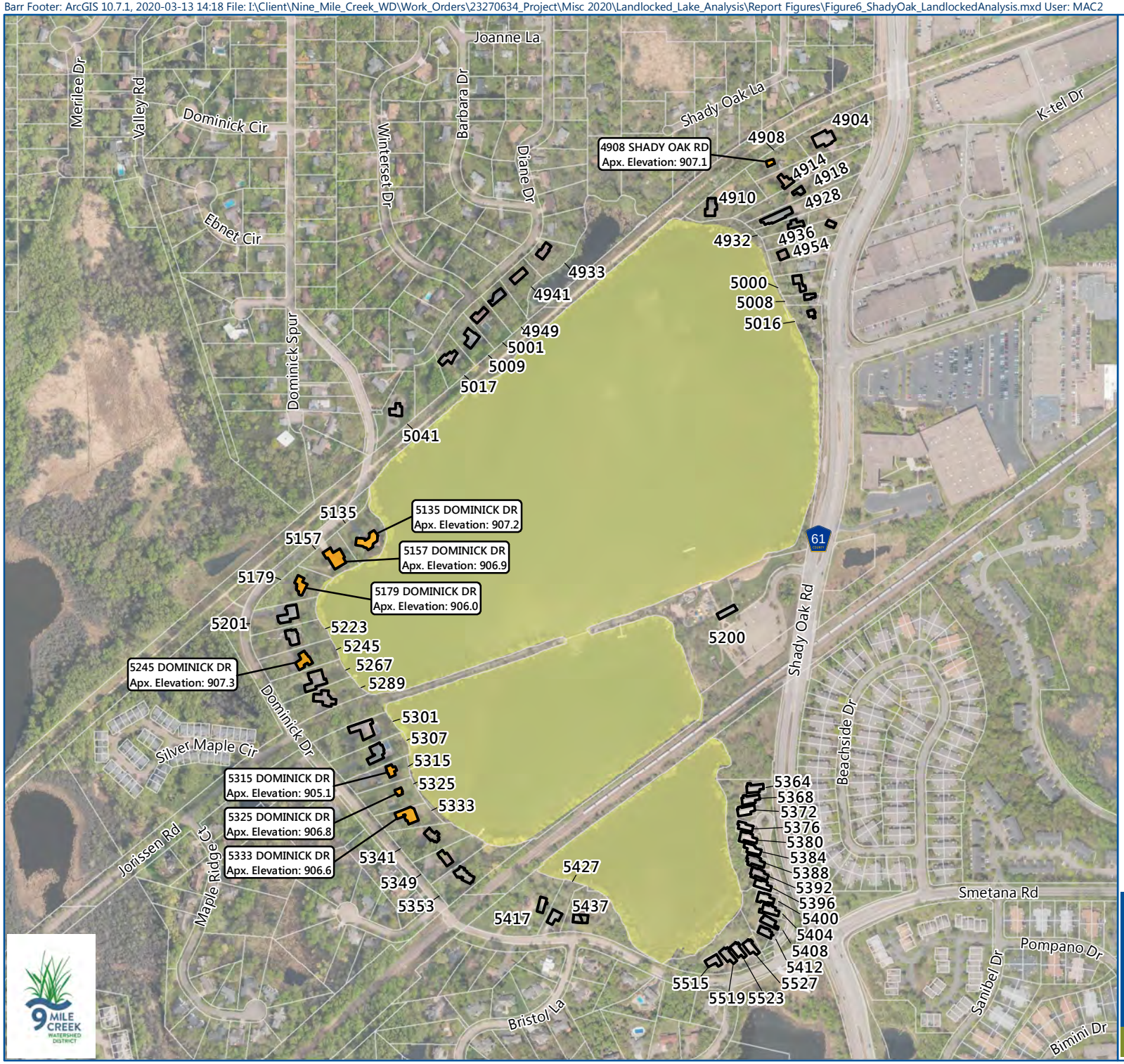
Feet

1 inch = 400 feet

Aerial Image: Hennepin County Imagery Circa 2018

LONE LAKE
SPRING 2020
LANDLOCKED LAKE ANALYSIS
Nine Mile Creek
Watershed District

FIGURE 5



Inundation Area as of 2/28/20

Structure

Lowest Apparent Structures*

Parcel Boundary

Parcels with structures adjacent to the lake or potentially impacted by the lake levels are labeled with the house number.

Potential tributary area to Shady Oak Lake = 445 acres

Surface water elevation as of 2/28/20 = 903.6

Lowest Apparent Structure* = 5315 Dominick Drive (905.1)

Amount of snowmelt or runoff from rainfall on frozen ground to impact apparent low structure = 4.0 inches

**Elevation of apparent low structure based on MDNR LiDAR elevation data (2011). Elevations have not been field verified.*

N

0 600 1,200

Feet

1 inch = 600 feet

Aerial Image: Hennepin County Imagery Circa 2018

SHADY OAK LAKE
SPRING 2020
LANDLOCKED LAKE ANALYSIS
Nine Mile Creek
Watershed District

FIGURE 6