System-Wide Evaluation of Flood-Risk Mitigation Options

Resiliency Study for Battle Creek and Fish Creek Tributary Areas

Prepared for
Ramsey-Washington Metro Watershed District

June 2024

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System-Wide Evaluation of Flood-Risk Mitigation Options

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Certifications

I hereby certify that this report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the State of Minnesota.

Brandon Barnes
PE #: 49540

June 28, 2024
Date

Abbreviations

LiDAR	light detection and ranging
MDNR	Minnesota Department of Natural Resources
MnDOT	Minnesota Department of Transportation
NOAA	National Oceanic and Atmospheric Administration
RCP	reinforced concrete pipe
RWMWD	Ramsey-Washington Metro Watershed District
TP40	Technical Paper 40

1 Introduction

The Ramsey-Washington Metro Watershed District (RWMWD or District) has a long history of planning and managing water resources to mitigate flood risk. The District was formed in 1975 in response to concerns about severe erosion and flooding on Battle Creek. Since then, the District has continued to work closely with the 12 cities and two counties in the watershed to identify and mitigate flood risk throughout the watershed.

In 2019, the District completed an evaluation to identify potentially flood-prone structures based on updated rainfall depths published in Atlas 14 (Reference [1]). As a result, numerous structures were identified in flood-prone areas. In 2020, the District completed the Beltline Resiliency Study (Reference [2]), which evaluates potential system modifications that could be implemented in the Beltline watershed to reduce flood risk to habitable structures. This current study follows a similar methodology as the Beltline Resiliency Study to complete a planning-level evaluation of system modifications that could be implemented to reduce flood risk for habitable structures. While not the primary focus, a cursory benefit would also be protecting some non-habitable structures and low-lying lands. Much of this study is centered on evaluating ways to optimize the use of the outlet control structures on Tanners Lake, Battle Creek Lake, and Carver Lake to lower flood levels upstream. Similar to the Beltline Resiliency Study, for this evaluation, we assumed 1) the size and/or the peak capacity of the Battle Creek tunnel would not be increased and 2) flood-prone homes would not be purchased and removed from the floodplain.

1.1 Identification of Potentially Flood-Prone Structures

In 2013, the National Oceanic and Atmospheric Administration (NOAA) released updated precipitation frequency estimates for the Midwestern states (NOAA Atlas 14, Volume 8) (Reference [1]). These estimates, which serve as an update to the U.S. Weather Bureau's Technical Paper 40 (TP 40) (Reference [3]), published in 1961, reflect the results of statistical analyses performed for a much longer period of recorded precipitation data. The results show significant increases in rainfall amounts in the Twin Cities area; for example, the 100-year, 4-day rainfall depth increased by approximately 23% when compared to TP 40. Following the release of Atlas 14, the District updated the hydrologic and hydraulic model of the stormwater system to incorporate the updated precipitation estimates to calculate the 100-year floodplain.

Floodplain extents were intersected with available building structure outlines to identify habitable structures. RWMWD defines the term "habitable" as *Any enclosed space usable for living or business purposes, which includes but is not limited to: working, sleeping, eating, cooking, recreation, office, office storage, or any combination thereof. An area used only for storage incidental to a residential use is not included in the definition of Habitable* (reference [4]).

Auxiliary structures, such as detached garages, sheds, park pavilions, etc., are not considered habitable, and potential system modifications to mitigate flood risk for auxiliary structures were not evaluated. There

were 777 structures identified as potentially flood-prone throughout the District; these are shown in Figure 1-1.

1.2 Area Background

This portion of the watershed includes the Tanners Lake, Battle Creek Lake, Battle Creek, Carver Lake, Fish Creek, and Snake Creek subwatersheds. The evaluation will identify modifications to the drainage system to reduce flood risk to habitable structures within the 100-year floodplain of District-managed water bodies. It will also assess the active management of outlet control structures on Tanners Lake, Battle Creek Lake, and Carver Lake. This evaluation will allow RWMWD to identify potential system-wide strategies for mitigating flood risk in the portion of the District that is tributary to the Beltline (Reference [2]).

Subwatershed	Impacted Structures
Battle Creek	38
Battle Creek Lake	30
Beaver Lake	24
Blufflands	Not Modeled
Carver Lake	33
Fish Creek	2
Gervais Creek	113
Gervais Lake	6
Grass Lake	60
Keller Lake	32
Kohlman Creek	49
Kohlman Lake	10
Lake Owasso	99
Lake Phalen	48
Lake Wabasso	3
Snail Lake	34
Snake Creek	1
St. Paul Beltline	75
Tanners Lake	68
Twin Lake	0
Willow Creek	47
Vadnais Lake	5

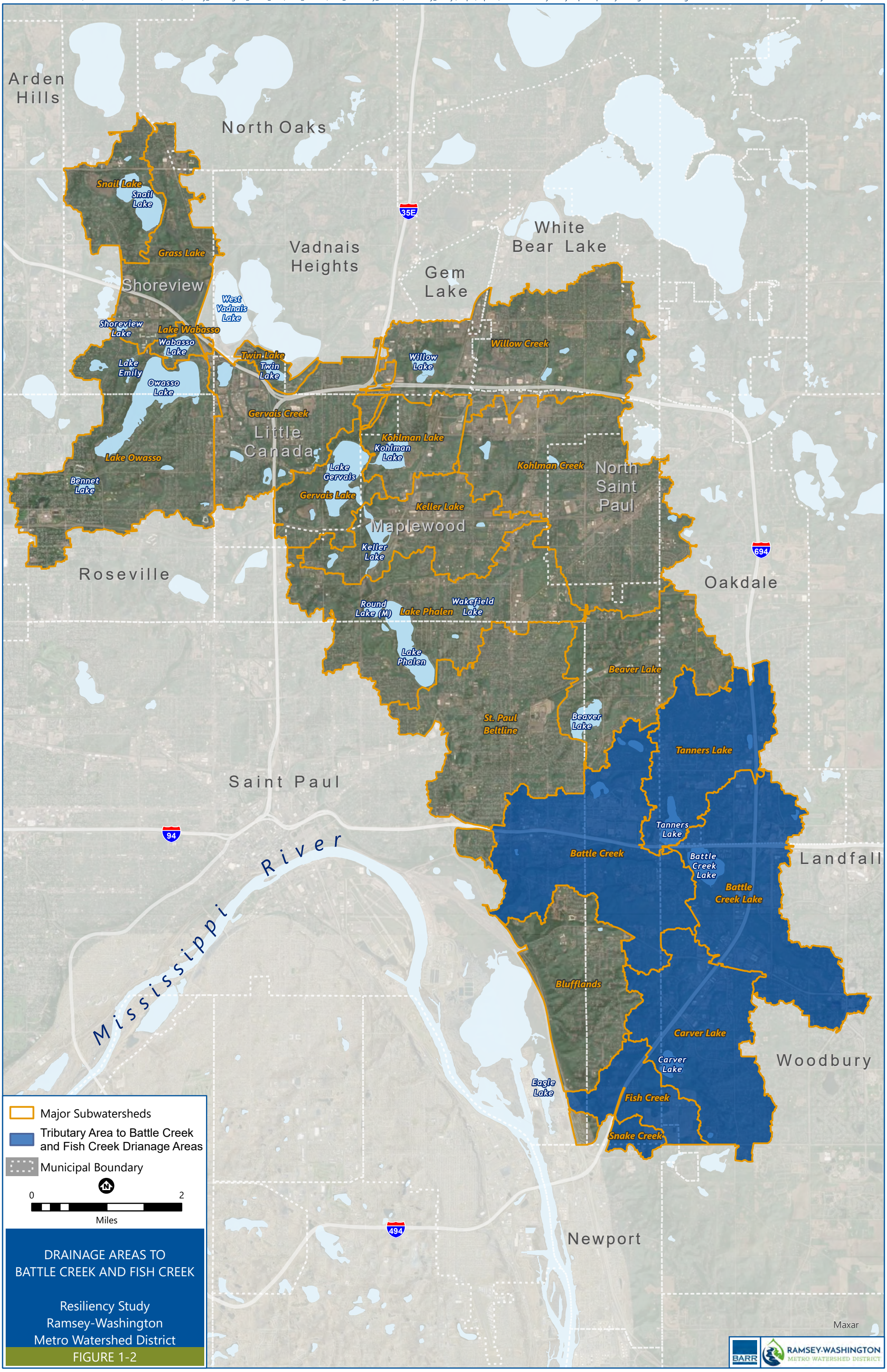
Potentially Impacted Structures
Major Subwatersheds
Municipal Boundary

0 2
Miles

POTENTIALLY FLOOD-PRONE STRUCTURES IN RWMWD

Resiliency Study
Ramsey-Washington
Metro Watershed District

FIGURE 1-1


Arden Hills
North Oaks
Vadnais Heights
White Bear Lake
Gem Lake
Shoreview
Little Canada
Maplewood
North Saint Paul
Roseville
Oakdale
Saint Paul
Landfall
Woodbury
Newport
Mississippi River
35E
694
94
494
Snail Lake
Snail Lake
Grass Lake
West Vadnais Lake
Shoreview Lake
Lake Wabasso
Wabasso Lake
Lake Emily
Owasso Lake
Twin Lake
Twin Lake
Willow Creek
Willow Lake
Gervais Creek
Kohlman Lake
Kohlman Lake
Kohlman Creek
Lake Owasso
Bennet Lake
Lake Gervais
Gervais Lake
Keller Lake
Keller Lake
Round Lake (M)
Lake Phalen
Wakefield Lake
Lake Phalen
Beaver Lake
St. Paul Beltline
Beaver Lake
Tanners Lake
Tanners Lake
Battle Creek
Battle Creek Lake
Battle Creek Lake
Blufflands
Carver Lake
Carver Lake
Eagle Lake
Fish Creek
Snake Creek
Major Subwatersheds
Tributary Area to Battle Creek and Fish Creek Drianage Areas
Municipal Boundary
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2
Miles
DRAINAGE AREAS TO BATTLE CREEK AND FISH CREEK
Resiliency Study
Ramsey-Washington Metro Watershed District
FIGURE 1-2
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BARR
RAMSEY-WASHINGTON METRO WATERSHED DISTRICT

2 Methodology

The purpose of this project is to evaluate system-scale modifications to reduce flood risk in the Battle Creek, Fish Creek, and Snake Creek tributary areas. This portion of the District includes the Tanners Lake, Battle Creek Lake, Battle Creek, Carver Lake, Fish Creek, and Snake Creek subwatersheds. The evaluation will identify modifications to the drainage system to reduce flood risk to habitable structures within the 100-year floodplain of District-managed water bodies, including actively managing outlet control structures on Tanners Lake, Battle Creek Lake, and Carver Lake. This evaluation will allow RWMWD to identify potential system-wide strategies for mitigating flood risk consistent with the rest of the watershed.

Phase 1 includes the following:

- Evaluating the potential for increasing floodplain storage north of 15th Street North in Oakdale
- Modifying the Tanners Lake and Battle Creek Lake outlet control structures
- Increasing the conveyance capacity between Tanners Lake and Battle Creek Lake
- Increasing the conveyance capacity between Battle Creek Lake and Battle Creek
- Identifying opportunities for floodplain storage within the Battle Creek tributary area

Phase 2 includes the following:

- Identifying opportunities for floodplain storage upstream of Carver Lake
- Modifying operation of existing pumped outlets
- Actively managing the Carver Lake outlet control structure
- Improving conveyance capacity near I-494

The following sections describe the methodology for identifying potentially flood-prone structures and evaluating system modifications. The limitations of the evaluation are also described.

Barr Footer: ArcGISPro 3.1, 2024-05-07 15:32 File: I:\Client\Ramsey_Washington_Metro_WD\Work_Orders\2023_Feasibility_Studies\Resiliency_Study\Maps\Report\South Resiliency Study Report.aprx Layout: Figure 2.1 Battle Creek and Fish Lake Resiliency Study Phases User: jrv

Arden Hills
North Oaks
Vadnais Heights
White Bear Lake
Gem Lake
Shoreview
Little Canada
Roseville
Maplewood
North Saint Paul
Oakdale
Saint Paul
Landfall
Woodbury
Newport
Mississippi River
35E
694
94
494

Snail Lake
Snail Lake
Grass Lake
West Vadnais Lake
Shoreview Lake
Lake Wabasso
Wabasso Lake
Lake Emily
Owasso Lake
Lake Owasso
Bennet Lake
Twin Lake
Twin Lake
Willow Lake
Willow Creek
Gervais Creek
Kohlman Lake
Kohlman Lake
Lake Gervais
Gervais Lake
Kohlman Creek
Keller Lake
Keller Lake
Round Lake (M)
Lake Phalen
Wakefield Lake
Lake Phalen
Beaver Lake
St. Paul Beltline
Beaver Lake
Tanners Lake
Tanners Lake
Battle Creek
Battle Creek Lake
Battle Creek Lake
Blufflands
Carver Lake
Carver Lake
Eagle Lake
Fish Creek
Snake Creek

Major Subwatersheds
Municipal Boundary
Phase 1: Battle Creek
Phase 2: Fish Creek

0 2
Miles

BATTLE CREEK AND FISH CREEK RESILIENCY STUDY PHASES

Resiliency Study
Ramsey-Washington
Metro Watershed District

FIGURE 2-1

BARR
RAMSEY-WASHINGTON METRO WATERSHED DISTRICT

2.1 Identification of Potentially Flood-Prone Structures

In 2017, RWMWD collected stage data at 11 ponds, wetlands, and lakes and flow-rate data at five streams. The monitoring data was used to validate the results of the District stormwater models (Reference [5]). After validating the models to the measured stage data, the 100-year, 4-day Atlas 14 rainfall event (8.3 inches) was simulated, and floodplain elevations were calculated.

For this study, the 100-year floodplain elevation represents the elevation that each water body has a 1-percent chance of exceeding due to a storm that has a 1-percent chance of occurring in any given year. This elevation is called the annual exceedance elevation. In this case, it is assumed that the water body is at the control elevation when this storm occurs (the invert of an outlet or the crest of an overflow weir, for example). In other words, prior to these large storm events, the water body had adequate time to drain down to its control elevation. Outlet control structures for water bodies are also assumed to be free of debris and sediment and functioning as designed.

Historically, several water bodies in RWMWD have experienced high elevations due to several consecutive years of very wet weather. Certain RWMWD water bodies have stayed high because they are landlocked or have very restricted outlets that have not drawn down to their outlet elevations for several years. High elevations in these areas were not used as the starting elevations for the purposes of calculating the annual exceedance elevation to identify flood-prone structures. The reason is the way practitioners typically look at hydrologic probability. Combining the already unlikely (though existing) recent high-water levels with a coincident (and rare) storm event that has a 1 percent chance of happening in any given year compounds risk in a way that is typically not evaluated. This type of evaluation uses what is called "conditional probability."

While this study does not examine the conditional probability of certain flood levels in the landlocked or highly restricted portions of RWMWD, RWMWD has acknowledged the vulnerability of these areas and prioritized efforts to minimize flood risks to habitable structures. RWMWD regularly uses the stormwater model to estimate resulting water levels, assuming a 100-year rainfall event occurs when starting water levels are high, to help plan flood response strategies undertaken by both the District and its member cities.

Floodplain extents were intersected with building structure outlines in Ramsey and Washington Counties. The building outlines in Ramsey County are based on the footprint derived from the Minnesota Department of Natural Resources' (MDNR) light detection and ranging (LiDAR) data (Reference [6]), corrected by Ramsey County in 2015 (Reference [7]). Building outlines in Washington County were based on the nationwide Microsoft Building Footprints dataset (Reference [8]). Habitable structures (e.g., residences, office and commercial buildings, apartments, etc.) that intersected the floodplain were identified as potentially flood-prone. Within the Ramsey County dataset, structures identified as "residential," "non-residential," and "mobile home" were considered habitable structures. Because similar data categories do not exist in the Washington County dataset, aerial imagery and Google Street View were used to estimate what structures were habitable in Washington County. Auxiliary structures, such as detached garages, sheds, park pavilions, etc., were not considered habitable.

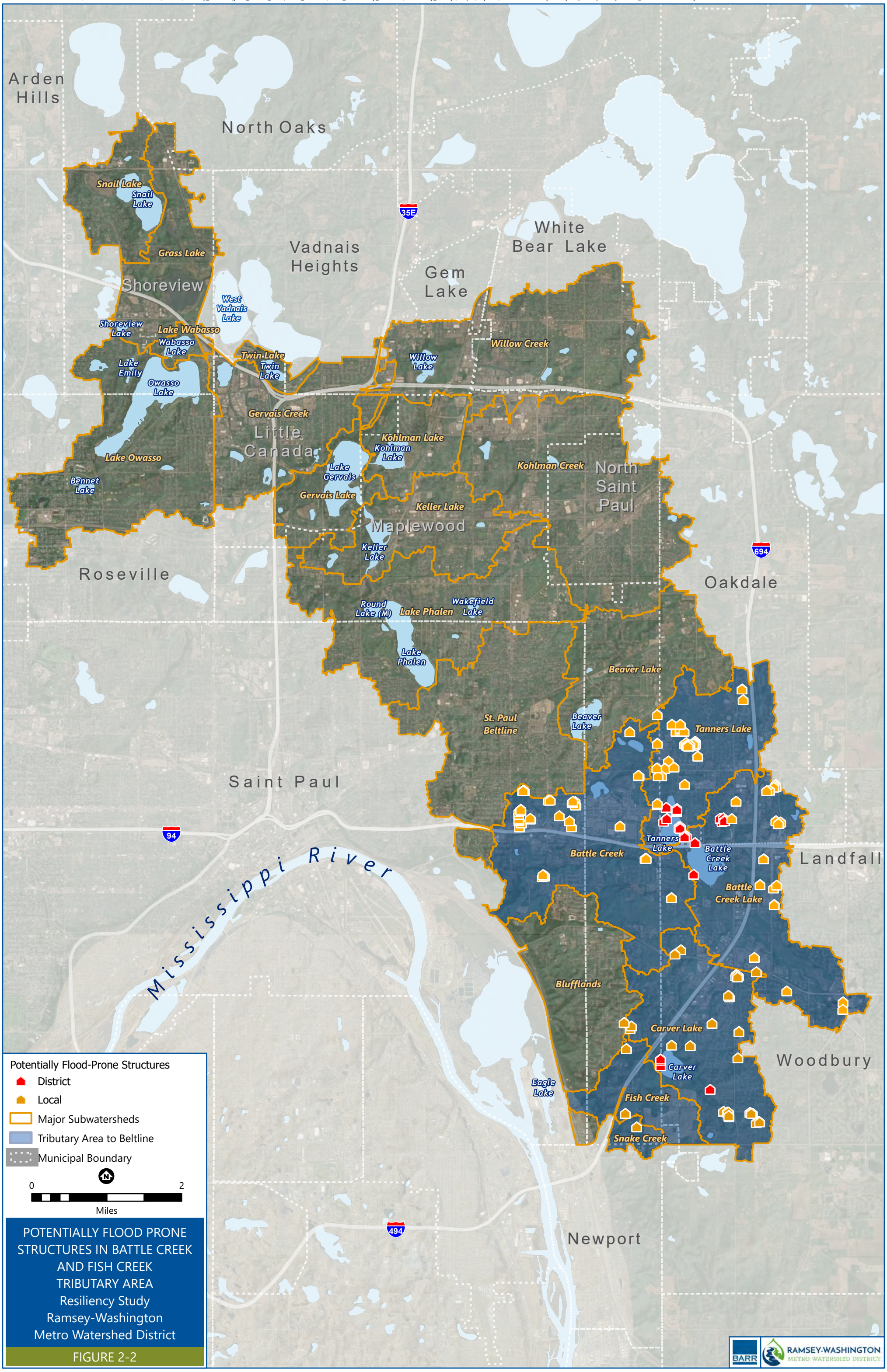
Using the best available information, a desktop planning-level identification of potentially flood-prone structures was completed. However, a field survey of the low adjacent grade or low-entry elevation was not completed as part of the analysis. A field survey, as part of future feasibility studies, may change the number of structures identified within the floodplain or the elevations of structures identified.

A high-level evaluation of each potentially flood-prone structure, shown in Figure 1-1, upstream of Battle Creek or Fish Creek, was completed to estimate if flooding was caused by:

- Proximity to District-managed water bodies or facilities (e.g., the high-water level of a District-managed water body, capacity through a District-managed culvert, etc.). These structures were classified as "District."
- Local flooding potentially not related to District-managed water bodies or facilities (e.g., the high-water levels of municipal ponds, capacity through municipal storm sewer infrastructure, etc.). These structures were classified as "Local."

There were 136 structures identified as potentially flood-prone. Of the 136 structures upstream of Battle Creek, 29 were classified as "District" and 107 were classified as "Local." There were 36 structures upstream of Fish Creek; four structures were classified as "District" and 32 were classified as "Local." These two types of flood-risk areas are shown in Figure 2-2.

Although potentially flood-prone structures classified as "Local" or "District" are shown in Figure 2-2, only system modifications to reduce flood levels adjacent to structures classified as "District" were considered for this evaluation. These areas typically require system modifications that affect peak discharge rates or water levels across municipal boundaries. However, the District intends to continue to work cooperatively with the cities to address localized flooding concerns and manage inflows to District water bodies.


Arden Hills
North Oaks
Snail Lake
Snail Lake
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Shoreview
Vadnais Heights
West Vadnais Lake
Shoreview Lake
Lake Wabasso
Wabasso Lake
Lake Emily
Owasso Lake
Twin Lake
Twin Lake
Gem Lake
White Bear Lake
Willow Lake
Willow Creek
Gervais Creek
Little Canada
Kohlman Lake
Kohlman Lake
Kohlman Creek
North Saint Paul
Lake Owasso
Bennet Lake
Lake Gervais
Gervais Lake
Keller Lake
Maplewood
Keller Lake
Roseville
Oakdale
Round Lake (M)
Lake Phalen
Wakefield Lake
Lake Phalen
Beaver Lake
St. Paul Beltline
Beaver Lake
Tanners Lake
Saint Paul
Tanners Lake
Battle Creek
Battle Creek Lake
Landfall
Mississippi River
Battle Creek Lake
Blufflands
Carver Lake
Carver Lake
Woodbury
Eagle Lake
Fish Creek
Snake Creek
Newport
35E
694
94
494
Potentially Flood-Prone Structures
District
Local
Major Subwatersheds
Tributary Area to Beltline
Municipal Boundary
0
2
Miles
POTENTIALLY FLOOD PRONE STRUCTURES IN BATTLE CREEK AND FISH CREEK TRIBUTARY AREA
Resiliency Study
Ramsey-Washington Metro Watershed District
FIGURE 2-2
BARR
RAMSEY-WASHINGTON METRO WATERSHED DISTRICT

2.2 System Modifications Considered

The District stormwater model was used to evaluate possible modifications to the stormwater system within the watershed. Several types of modifications were evaluated as part of this analysis to determine which, if any, implementation recommendations could be made for future feasibility studies. In general, potential system modifications can be classified in the following categories:

- **Decrease conveyance capacity—**Barr Engineering Co. (Barr) evaluated reducing the conveyance capacity through culverts and lake outlet structures. This was done for locations upstream of potentially flood-prone structures where the 100-year water level was more than 2 feet lower than the low adjacent grade of existing structures in the upstream location.

- **Flood storage volume—**Barr evaluated the feasibility of providing additional flood storage volume either aboveground (e.g., excavating stormwater ponds to increase surface area or to create new stormwater ponds) or underground (e.g., storage chambers).

- **Modification of overflow—**Barr evaluated modifications to existing overflows to either redirect runoff or provide additional upstream storage volume. Overflow modifications assessed included raising roads and/or trails.

- **Modification to the storm sewer system—**We evaluated storm sewer modifications that redirected drainage from flood-prone areas to downstream locations with available storage volume.

- **Mechanical operation of outlet structures—**We evaluated the operation of the Tanners Lake, Battle Creek Lake, and Carver Lake outlet structures to optimize floodplain storage and control discharge into Battle Creek and Fish Creek. Mechanical operation was not considered for outlet structures from smaller stormwater ponds and wetlands.

- **Increase conveyance capacity—**Increasing the conveyance capacity of culverts, storm sewers, or lake outlets was considered. In general, increasing conveyance capacity was evaluated in locations where options for providing additional floodplain storage volume were limited. In locations where conveyance capacity was increased as a part of the evaluations, downstream system modifications also needed to be considered and evaluated to mitigate increases in 100-year water elevations. For the purposes of reducing flood risk, it was assumed that increasing conveyance capacity, which may increase discharge rates, would be acceptable, provided that 1) there are no adverse impacts to the downstream system and 2) freeboard requirements for habitable structures are maintained.

- **Site-specific floodproofing—**Barr evaluated site-specific floodproofing (i.e., localized grading or structural modifications) in a few locations. Typically, these modifications were considered for locations where the 100-year water level was within the accuracy of the LiDAR data, and further system modifications did not appear feasible.

The goal of each system modification evaluated was to lower the 100-year floodplain elevation below the low adjacent grade of the lowest habitable structure. System modifications were not assessed to provide freeboard above the flood elevation generated by the 100-year event. Potential future increases to the 100-year floodplain due to climate change were not considered in the planning-level evaluation of system modifications.

Finally, the evaluation did not consider any system modifications that conveyed water to adjacent watershed districts, increased the capacity of the Battle Creek Tunnel (i.e., replacing the existing pipe with a larger pipe or conveyance system), or purchased flood-prone structures. If the evaluated alternatives are ultimately ineffective or not feasible, these options may need to be considered as part of future feasibility studies.

2.3 Study Limitations

The system modifications being evaluated represent an approach for possible mitigation of flood risk for habitable structures within the District. However, as with any study and model of natural systems, there are limitations. There are practical limits to the level of detail used to achieve the study objectives. Although data sets for model inputs are frequently updated, they are not always complete or error-free. Nonetheless, the data is useful and appropriate for this study. Acknowledging study limitations is important so that the findings and recommendations can be used with professional judgment to develop recommendations that are consistent with the intent of the study. Understanding the limitations also makes it easier for future evaluations to build on the results of this study.

Major assumptions for this study are listed below:

- System modifications presented are intended to demonstrate one possible option for mitigating flood risk. There may be other options found to be preferable (i.e., less impactful, more cost-effective, etc.) during future feasibility studies.
- Possible system modifications may require permits and approvals from cities or agencies. During the evaluation, potential system modifications were not discussed with other local permitting jurisdictions to determine permit requirements, which may change the configuration or function of system modifications.
- Potentially flood-prone structures were identified based on topographic information and aerial photographs available at the time of the evaluation. Only limited survey information was available in many parts of RWMWD. Additional field survey work may change the number and location of potentially flood-prone structures.
- The District stormwater model was developed and calibrated to District-managed lakes, creeks, and facilities. It is important to note that the models developed do not simulate all local storm sewer systems within the watershed. As a result, each city may identify separate, localized flooding areas that are not discussed in this report. The District intends to continue to work

cooperatively with the cities to address localized flooding concerns and manage inflows to District water bodies.

- Data sets used for model development are not always complete or error-free. In general, the RWMWD stormwater model was developed using a combination of survey information, as-built plans, LiDAR, and GIS information that is publicly accessible and/or provided by municipalities and other public agencies within the District. As additional information is collected or provided by the municipalities and public agencies, the number of potential flood-prone structures may change, and the potential system modifications necessary to mitigate flood risk may change accordingly.

3 Resiliency Study Phases

The resiliency study represents a nontraditional approach to optimizing a regional urban stormwater system. In general, the study was phased so that flood-prone areas in the upstream portion of the watershed were addressed first, working downstream. This approach was followed to ensure that we were reasonably confident there were no adverse impacts downstream (e.g., increased flood levels) due to upstream system modifications and/or operations. The following sections describe the current flooding concerns, system modifications, and post-modification flood concerns for each of the two phases (Phase 1: Battle Creek and Phase 2: Fish Creek).

3.1 Phase 1—Battle Creek Tributary Area

The Battle Creek tributary area is divided into three main subwatersheds: Battle Creek, Battle Creek Lake, and Tanners Lake. The Battle Creek subwatershed is mostly within Ramsey County, while the Battle Creek Lake and Tanners Lake subwatersheds are mostly within Washington County. The three subwatersheds cover approximately 7,314 acres and include portions of the municipalities of St. Paul, Maplewood, Woodbury, Landfall, and Oakdale. There are many flood-prone areas within these subwatersheds where habitable structures are located within the 100-year floodplain.

3.1.1 Current Condition Flooding Concerns

There are 136 potentially flood-prone habitable structures within the Battle Creek, Battle Creek Lake, and Tanners Lake subwatersheds. The 29 structures classified as "District" are near District-managed facilities, lakes or creeks, or are in locations where addressing flooding may change downstream peak flow rates and water levels in multiple municipalities. An additional 107 structures are classified as "Local," which indicates that the structure is likely not adjacent to District-managed facilities, lakes, or creeks and that flooding may be a result of the local storm drainage system. Potentially flood-prone structures within these three subwatersheds are shown in Figure 3-1.

Most of the 38 potentially flood-prone structures in the Battle Creek subwatershed are located around depressions north and northeast of Suburban pond, with the remainder scattered throughout the subwatershed. None of the structures in the Battle Creek subwatershed are classified as "District."

Eight of the 30 potentially flood-prone structures in the Battle Creek Lake subwatershed are near 4th Street Place North, and the rest are scattered around ponds and wetlands throughout the subwatershed. The eight structures near 4th Street Place North—as well as one residence on the west side of Battle Creek Lake and one business north of Hudson Road—are classified as "District."

Nineteen of the 68 potentially flood-prone structures in the Tanners Lake subwatershed are located near Tanners Lake, with 22 more near Granada Avenue North in Oakdale and another 13 around the large wetland complex north of 15th Street North. Like the other two subwatersheds, the rest of the potentially impacted structures are scattered around depressions. The 19 structures near Tanners Lake are the only ones classified as "District" in this subwatershed.

Many of the potentially impacted structures and homes within the subwatersheds likely have basements. For these structures, the elevation of the low adjacent grade was used to evaluate system modifications to mitigate flood risk. In other words, system modifications were evaluated to remove the ground adjacent to the structure from the floodplain; system modifications to lower the floodplain below a basement elevation or provide freeboard between the 100-year floodplain and the estimated low ground elevation were not considered.

The District has a long history of implementing flood-risk reduction projects within these subwatersheds. Some previous District projects include the construction of the Battle Creek tunnel, control structures, and the McKnight basins in 1981; the Tanners Lake Water Quality Improvement Projects in the late 1990s; and the installation of two 60-inch-equivalent RCP arch pipes under I-94 north of Battle Creek Lake in 2023. In the early 2000's RWMWD developed Emergency Response Plans for flood-prone structures on Tanners Lake and Weir Drive east of Battle Creek Lake, which is inundated during flood events and cuts off access to structures northeast of Battle Creek Lake. Recently RWMWD has installed instrumentation to record continuous lake level and rainfall measurements throughout the subwatersheds.

Table 3-1 lists the potentially flood-prone structures in the Battle Creek Lake and Tanners Lake subwatersheds classified as "District." (None of the flood-prone structures in the Battle Creek subwatershed were classified as "District.") The system modifications discussed in Section 3.1.2 were evaluated to remove the structures listed in Table 3-1 from the floodplain.

Table 3-1 Potentially Flood-Prone Structures in the Battle Creek Lake and Tanners Lake Subwatersheds

Parcel ID	Address	Lowest Adjacent Grade[2]	Source for Lowest Adjacent Grade	Existing 100-Year Water Surface Elevation
Tanners Lake				
3102921230064	509 Gentry Avenue North 55128	966.3	LiDAR[3]	967.5
3102921320002	460 Glenbrook Avenue North 55128	966.9	LiDAR[3]	967.5
3102921320003	488 Glenbrook Avenue North 55128	966.3	LiDAR[3]	967.5
3102921320005	474 Glenbrook Avenue North 55128	966.9	LiDAR[3]	967.5
3102921320006	448 Glenbrook Avenue North 55128	966.9	LiDAR[3]	967.5
3102921320008	436 Glenbrook Avenue North 55128	967.0	LiDAR[3]	967.5
3102921320052	407 Gentry Avenue North 55128	965.3	LiDAR[3]	967.5
3102921320064	329 Geneva Avenue North 55128	966.7	LiDAR[3]	967.5
3102921340010[1]	50 Aspen Way 55128	966.0	LiDAR[3]	967.5
Battle Creek Lake				
3102921410059	6826 4th Street North 55128	1014.6	LiDAR[3]	1015.0

Parcel ID	Address	Lowest Adjacent Grade[2]	Source for Lowest Adjacent Grade	Existing 100-Year Water Surface Elevation
3102921410076	6836 4th Street North 55128	1013.8	LiDAR[3]	1015.0
3102921410077	6864 4th Street North 55128	1014.8	LiDAR[3]	1015.0
3102921410078	6890 4th Street North 55128	1014.4	LiDAR[3]	1015.0
3102921410097	6889 4th Street Place North 55128	1014.0	LiDAR[3]	1015.0
3102921410098	6883 4th Street Place North 55128	1015.0	LiDAR[3]	1015.0
3102921410105	6841 4th Street Place North 55128	1014.1	LiDAR[3]	1015.0
3102921410106	6835 4th Street Place North 55128	1013.9	LiDAR[3]	1015.0
3102921340003	2967 Hudson Boulevard North 55128	963.1	LiDAR[3]	964.9
0602821240028	381 Meadow Lane 55125	960.1	LiDAR[3]	961.5

(1) 50 Aspen Way 55128 is owned by WCCDA Family Housing LLC in Landfall Village and includes approximately 300 manufactured homes; the lowest adjacent grade listed is the lowest among the 11 potentially impacted structures on this parcel. It is assumed that all utilities below the low floor of manufactured homes located within the 100-year floodplain are flood-proofed.

(2) A limited survey was conducted in this area; therefore, LiDAR is the primary source for the lowest adjacent grade analysis. The manufactured homes' building outline could change over time; the estimated elevations listed are based on the 2019 high-resolution aerial image provided by Near Map.

(3) Reference [6]

Lake Phalen
Beaver Lake
694
94
Tanners Lake Tributary Area
Tanners Lake
Battle Creek
Battle Creek Tributary Area
Battle Creek Lake
Battle Creek Lake Tributary Area
494
Mississippi River
Eagle Lake
Carver Lake

Study Area
Ramsey County
Mississippi River
Washington County

Potentially Flood-Prone Structures
- District
- Local

District Facilities
- Outfall
- Stormwater Structure
- Storm Sewer / Culvert
- Existing Conditions 100-Year Floodplain
- Major Subwatersheds
- Subwatersheds
- Municipal Boundary

0 3,000
Feet

CURRENT CONDITIONS - POTENTIALLY FLOOD-PRONE STRUCTURES IN THE BATTLE CREEK TRIBUTARY AREA

Resiliency Study
Ramsey-Washington
Metro Watershed District

FIGURE 3-1

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RAMSEY-WASHINGTON METRO WATERSHED DISTRICT

3.1.2 Evaluation of Potential System Modifications

The District stormwater model was used to evaluate potential system modifications within the Battle Creek tributary area. The stormwater model was modified to evaluate the impact that potential system modifications would have on the 100-year floodplain. The goal for each system modification was to prevent the 100-year flood level from inundating habitable structures.

Evaluation of potential system modifications did not include discussions with property owners, permitting agencies, or other stakeholders. Additional evaluation for system modifications, including detailed feasibility studies that further evaluate economic and social considerations, is necessary prior to modifying the drainage system.

Based on available topographic information (reference [6]), the lowest adjacent grade to the lowest structure around Tanners Lake was estimated to be 965.3 feet at 407 Gentry Avenue North, and the lowest adjacent grade within the Village of Landfall was estimated to be 966.0 feet. The lowest opening of the home at 407 Gentry Avenue North was surveyed in 1999 at 966.18.

There are eight single-family residential buildings potentially impacted by the 100-year flood level in the 4th Street Place North area in the Battle Creek Lake subwatershed. The lowest adjacent grade of these eight homes is 1013.8 feet, estimated from available topographic information (reference [6]).

There are two structures potentially impacted by the 100-year flood levels near Battle Creek Lake. The business at 2967 Hudson Boulevard North 55128, north of I-94, has a low adjacent grade elevation of 963.1, estimated from available topographic information (reference [6]). The other potentially impacted structure is a single-family home on the west side of Battle Creek Lake near the public boat launch. The lowest adjacent grade of this home is 960.1 feet, estimated from available topographic information (reference [6]).

The potential system modifications in the Battle Creek tributary area include increased conveyance out of Tanners Lake, Battle Creek Lake, and 4th Street Place North, as well as adding storage at McKnight Basin. The potential system modifications were divided into four project areas (areas 1A through 1D) and are described in the following sections.

1A McKnight Basin

Potential system modifications near McKnight Basin are shown in Figure 3-2. These possible system modifications are intended to increase the storage volume at McKnight Basin so the 100-year flood level will not increase due to increased outflows from Battle Creek Lake. System modifications shown in Figure 3-2 include:

- Excavating in the open area on the north side of McKnight Basin to add storage between elevations 894 and 909. An estimated 10 ac-ft of storage volume will be needed, but this volume may change as the upstream designs are refined.

1B Battle Creek Lake

Potential system modifications at Battle Creek Lake are shown in Figure 3-3. Possible modifications include installing a new outlet structure and pipe from the lake and raising a trail to protect the potentially impacted home. Modifications shown in Figure 3-3 include:

- Installing a new outlet structure near the public boat launch on the west side of the lake. The outlet structure will include a 15-foot-long adjustable weir that can be raised or lowered to control the timing of outflow from the lake. This detailed operation plan will depend on the event size and actual water level ahead of the storm.
- Modify the outlet from Battle Creek Lake by installing a 4-foot-high by 10-foot-wide box culvert (or equivalent) approximately 575 feet long between the new outlet structure and Battle Creek downstream of Edgewood Drive.
- Modifications near 381 Meadow Lane:
    - Raising the park path between the home and Battle Creek Lake by approximately 0.5 feet to prevent overtopping during the 100-year event.
    - Installing a 12-inch-diameter pipe with backflow prevention under the path to maintain drainage to Battle Creek Lake.

1C Tanners Lake

Potential system modifications along the Tanners Lake outlet are shown in Figure 3-4. Possible modifications include installing a new outlet structure and increasing the pipe capacity between the new outlet and Battle Creek Lake to decrease the Tanners Lake 100-year flood levels and better protect the potentially impacted structures around the lake. The modifications will also lower flood levels on the north side of I-94 and help protect the potentially impacted business at 2967 Hudson Boulevard North. Modifications shown in Figure 3-4 include:

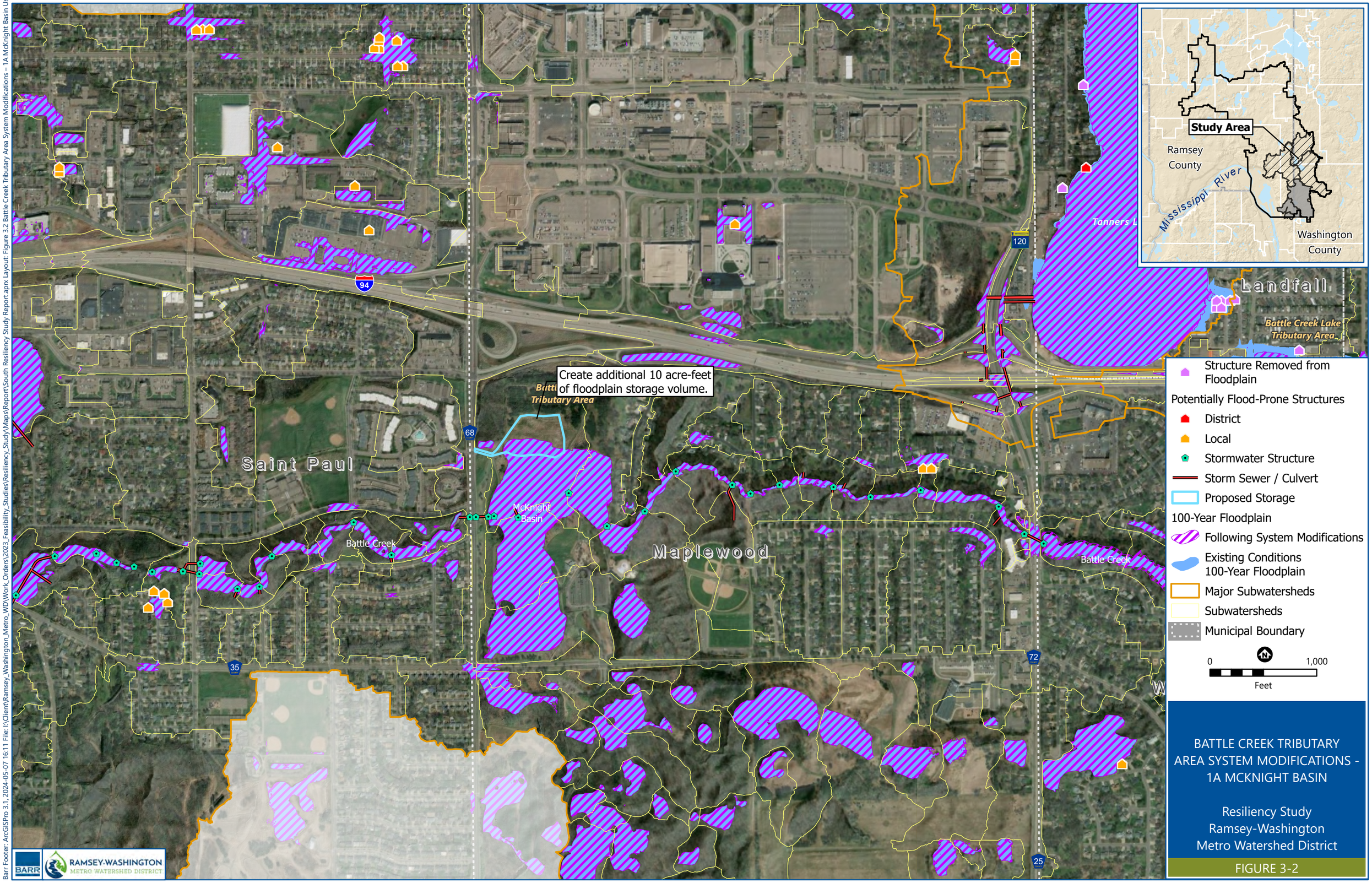
- Installing a new rectangular outlet structure on the east side of the lake. The outlet structure will include a 20-foot-long adjustable weir that can be raised or lowered to control outflows from the lake. Operation of the outlet will depend on the event size and actual water level ahead of the storm.
- Installing a 48-inch-diameter outlet structure with a short 24-inch-diameter pipe connecting to the new outlet structure. This smaller outlet will allow the lake to match existing outflows when the larger capacity structure is not needed.
- Increasing the outflow capacity from Tanners Lake by installing approximately 1,025 feet of 60-inch-diameter (or equivalent) pipe from the new outlet structure to the existing two 60-inch-equivalent arch RCPs (reinforced concrete pipes) under I-94.

- Removing the plug and flow-reducing orifice from the two 60-inch-equivalent arch RCPs under I-94 to accommodate outflow from Tanners Lake.

1D 4TH STREET PLACE NORTH

Potential system modifications near 4th Street Place North are shown in Figure 3-5. Possible modifications include adding conveyance capacity to drain the 4th Street North/4th Street Place North intersection more quickly and adding live storage to prevent increases in 100-year flood levels downstream. Modifications shown in Figure 3-5 include:

- Increasing storm sewer capacity by adding approximately 550 feet of 48-inch-diameter pipe from the 4th Street North/4th Street Place North intersection to the area just south of the 4th Street Place North cul-de-sac. Also, increasing catch basin capacity in the intersection will drain the surface flooding more efficiently.
- Constructing a berm across the narrow point in the channel south of the new pipe outlet with parallel 100-foot-long, 54-inch-diameter culverts under the berm. The berm is approximately 100 feet long and approximately 7.5 feet high at its highest point. The berm and culverts will temporarily pool water north of the berm and prevent downstream impacts.
- Reinforcing the open channels downstream of the new outlet as needed to prevent erosion and scour.



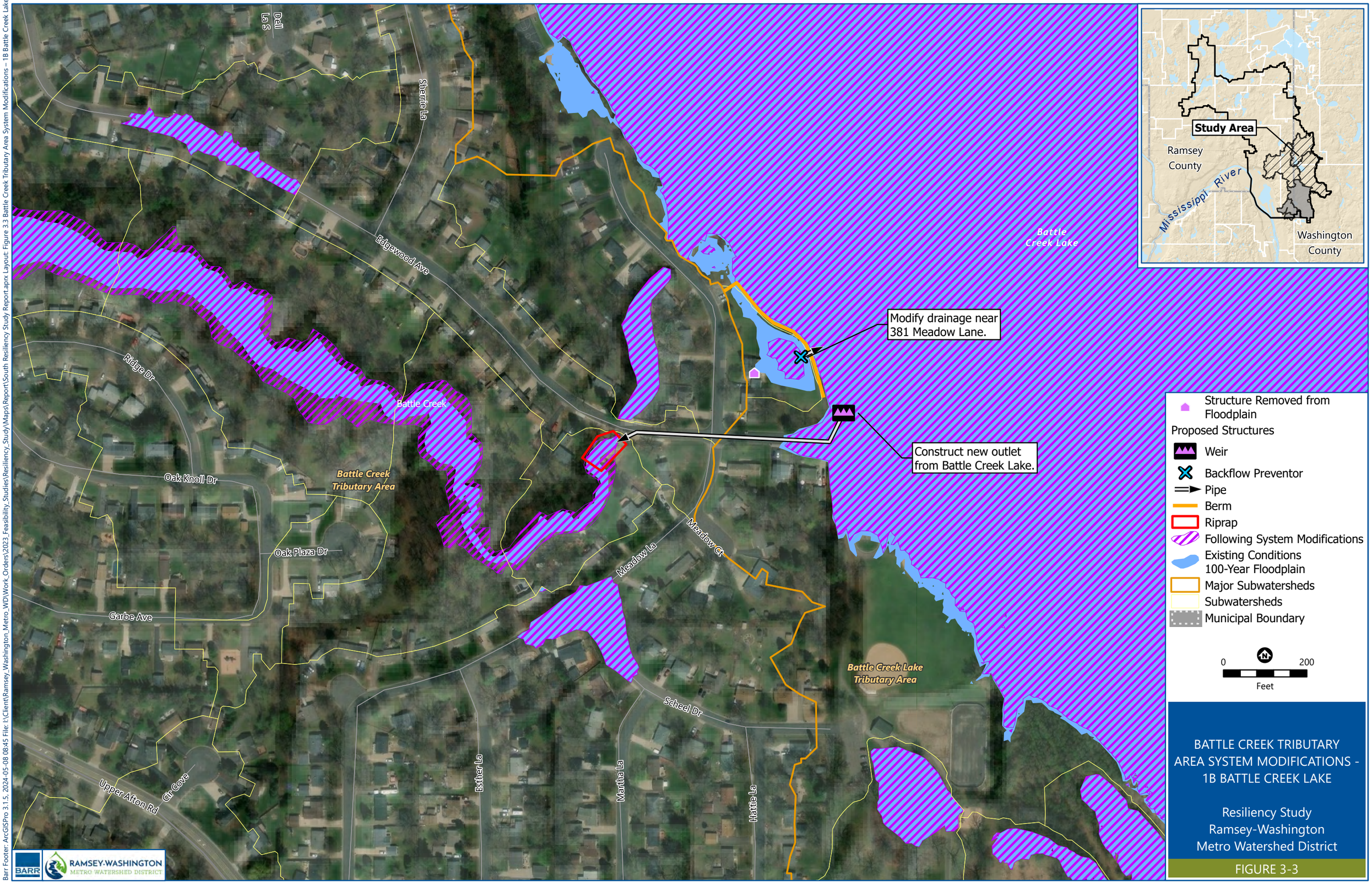
BATTLE CREEK TRIBUTARY AREA SYSTEM MODIFICATIONS - 1A MCKNIGHT BASIN

Resiliency Study
Ramsey-Washington Metro Watershed District

FIGURE 3-2

BARR | RAMSEY-WASHINGTON METRO WATERSHED DISTRICT

Barr Footer: ArcGISPro 3.1.5, 2024-05-08 08:45 File: I:\Client\Ramsey_Washington_Metro_WD\Work_Orders\2023_Feasibility_Studies\Resiliency_Study\Maps\Report\South Resiliency Study Report.aprx Layout: Figure 3.3 Battle Creek Tributary Area System Modifications – 1B Battle Creek Lake User

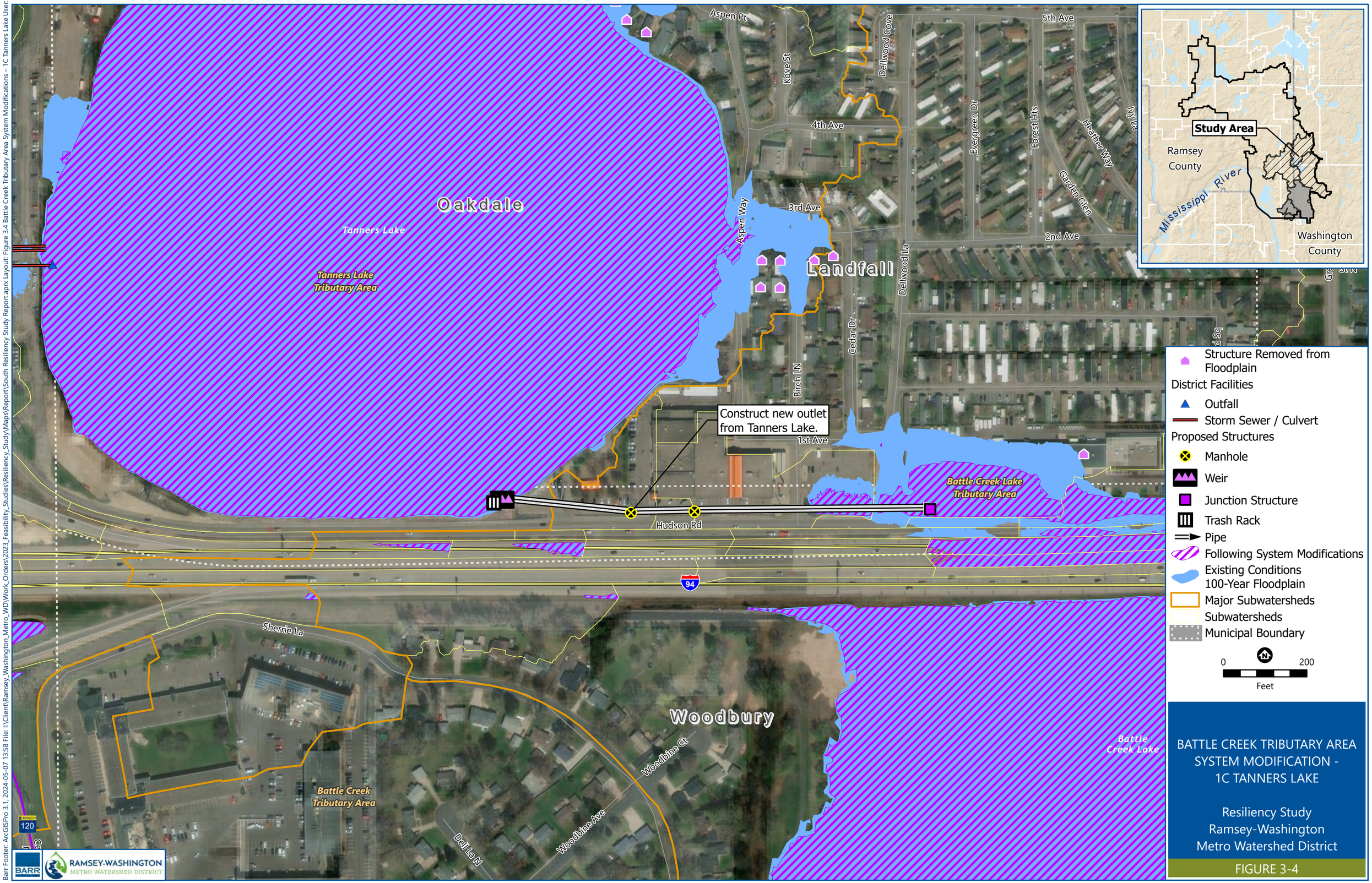


BARR | RAMSEY-WASHINGTON METRO WATERSHED DISTRICT

BATTLE CREEK TRIBUTARY AREA SYSTEM MODIFICATIONS - 1B BATTLE CREEK LAKE

Resiliency Study
Ramsey-Washington Metro Watershed District

FIGURE 3-3



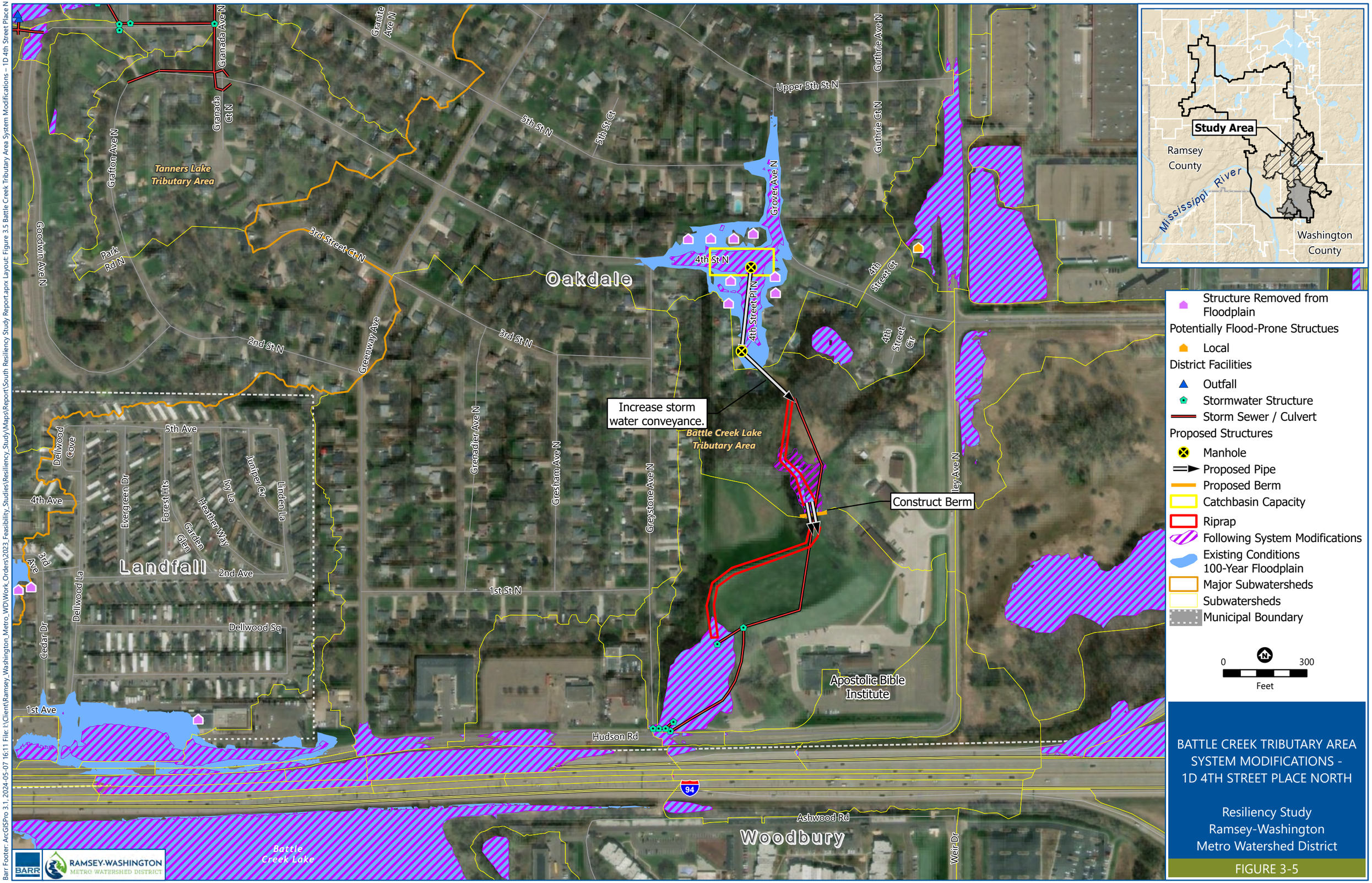
BATTLE CREEK TRIBUTARY AREA SYSTEM MODIFICATION - 1C TANNERS LAKE

Resiliency Study
Ramsey-Washington Metro Watershed District

FIGURE 3-4

BARR | RAMSEY-WASHINGTON METRO WATERSHED DISTRICT

Barr Footer: ArcGISPro 3.1, 2024-05-07 13:58 File: I:\Client\Ramsey_Washington_Metro_WD\Work_Orders\2023_Feasibility_Studies\Resiliency_Study\Maps\Report\South Resiliency Study Report.aprx Layout: Figure 3.4 Battle Creek Tributary Area System Modifications – 1C Tanners Lake User: jrv



BATTLE CREEK TRIBUTARY AREA SYSTEM MODIFICATIONS - 1D 4TH STREET PLACE NORTH

Resiliency Study
Ramsey-Washington Metro Watershed District

FIGURE 3-5

BARR | RAMSEY-WASHINGTON METRO WATERSHED DISTRICT

Barr Footer: ArcGISPro 3.1, 2024-05-07 16:11 File: I:\Client\Ramsey_Washington_Metro_WD\Work_Orders\2023_Feasibility_Studies\Resiliency_Study\Maps\Report\South Resiliency Study Report.aprx Layout: Figure 3.5 Battle Creek Tributary Area System Modifications – 1D 4th Street Place N User:

3.1.3 Flooding Concerns Following System Modifications

The potential system modifications result in lowering the 100-year floodplain below the low adjacent grade of most of the "District" habitable structures within the Battle Creek Lake and Tanners Lake subwatersheds. The 100-year floodplain following system modifications is shown in Figure 3-6.

With these modifications, the 100-year flood level in McKnight Basin and Battle Creek Lake should at least match existing conditions, and there is the potential to decrease the flood level in Battle Creek Lake as the outlet operation plan is refined. The 100-year flood level at 381 Meadow Lane 55125 could be reduced up to 2.5 feet from 961.5 to 959.0 and would be approximately 1.1 feet below the lowest adjacent grade (960.1).

The 100-year flood level at 4th Street Place North could be reduced by up to 1.4 feet, from 1015.0 to 1013.6, and would be approximately 0.2 feet below the lowest adjacent grade at 6836 4th Street North 55128. The proposed berm and culverts downstream would need to be constructed on private property owned by the Apostolic Bible Institute. The 100-year flood levels upstream of the proposed berm would increase relative to existing conditions, but no structures would be threatened, and the increase would only last a few hours during the peak of the storm.

These modifications could also reduce the 100-year flood level in Tanners Lake up to 1.6 feet from 967.5 to 965.9. The resulting floodplain would still extend into the Village of Landfall but would not reach existing habitable structures in that area. The lowest habitable structure at 407 Gentry Avenue North 55128 could still have water next to the exterior basement wall, but the 100-year water surface elevation is now below its lowest low opening (966.18). The 100-year flood levels on the north side of I-94 could also be reduced by up to 1.7 feet, from 964.9 to 963.2. Flood waters may still reach the foundation of the business at 2967 Hudson Boulevard North, but it appears that all the openings to the business are at least a couple of feet above the parking lot in this low area and well above the estimated 100-year flood level.

During the next phase of evaluation, additional information, including collection of survey information, would be required. Additional modeling will also be needed to refine the operational plans for the proposed lake outlet structures and weirs and to minimize downstream impacts. Model simulations indicate that the 100-year water levels and flow rates could increase in Battle Creek between Battle Creek Lake and McKnight Basin, due to the system modifications discussed in Section 3.1.2. However, the increased 100-year flood levels in this section of the creek do not threaten any existing structures, and higher water levels last for less than a day during the peak of the 100-year storm. These impacts may be reduced as operation of the lake outlets are refined.

Table 3-2 lists the existing 100-year water surface elevation and the elevation following modifications to the drainage system.

Table 3-2 also includes planning-level considerations related to project sequencing to avoid increases in downstream water levels. Project sequencing refers to the order in which system modifications should be constructed to prevent adverse downstream impacts. For this evaluation, sequencing does not refer to prioritization, which refers to which area should be addressed first. For example, improvements to the

downstream portion of the system should be constructed prior to increasing the discharge conveyed from upstream areas. Prerequisite system modifications listed in the last column of Table 3-2 refer to modifications that should be constructed prior to the system modification to mitigate flood risk for each parcel. For example, the sizing of system modifications presented in step 1C (Figure 3-4Figure 3-5), modifying the Tanners Lake outlet, assumes that system modifications presented in steps 1A (Figure 3-2), adding storage to McKnight Basin, and 1B (Figure 3-3), modifying the Battle Creek Lake outlet, have already been constructed. If these system modifications are not in place, then the sizing, function, or configuration of system modifications included in step 1C may change or impact downstream water levels.

Table 3-2 Potentially Flood-Prone Structures in the Battle Creek Tributary Area

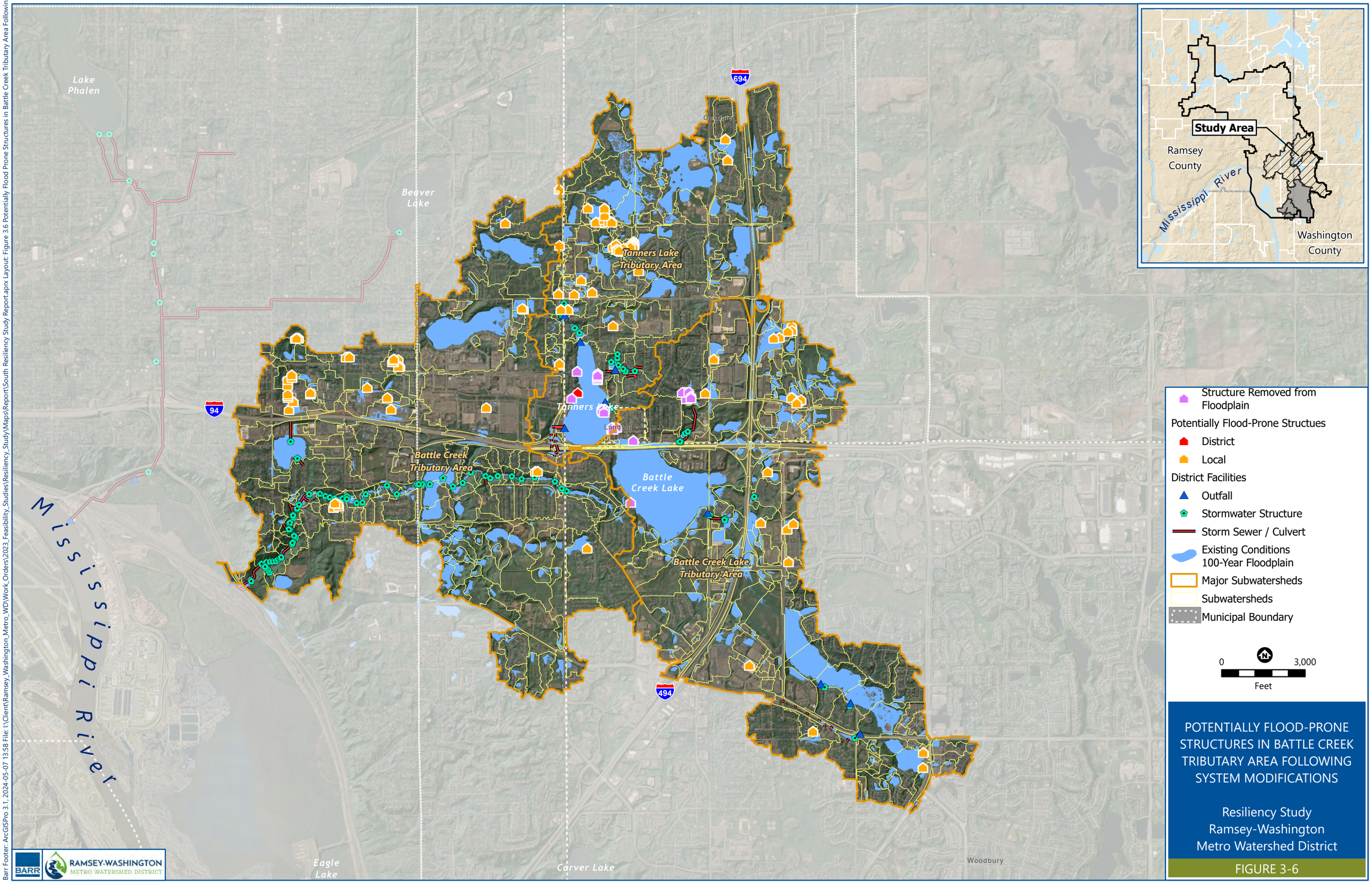
Parcel ID	Address	Lowest Adjacent Grade[2]	Existing 100-Year Water Surface Elevation	100-Year Water Surface Elevation Following System Modifications	System Modification to Reduce Flood Risk	Prerequisite System Modifications
Tanners Lake Subwatershed						
3102921230064	509 Gentry Avenue North 55128	966.3	967.5	965.9[3]	1C	1A, 1B
3102921320002	460 Glenbrook Avenue North 55128	966.9	967.5	965.9[3]	1C	1A, 1B
3102921320003	488 Glenbrook Avenue North 55128	966.3	967.5	965.9[3]	1C	1A, 1B
3102921320005	474 Glenbrook Avenue North 55128	966.9	967.5	965.9[3]	1C	1A, 1B
3102921320006	448 Glenbrook Avenue North 55128	966.9	967.5	965.9[3]	1C	1A, 1B
3102921320008	436 Glenbrook Avenue North 55128	967.0	967.5	965.9[3]	1C	1A, 1B
3102921320052	407 Gentry Avenue North 55128	965.3	967.5	965.9[3]	1C	1A, 1B
3102921320064	329 Geneva Avenue North 55128	966.7	967.5	965.9[3]	1C	1A, 1B
3102921340010[1]	50 Aspen Way 55128	966.0	967.5	965.9[3]	1C	1A, 1B
Battle Creek Lake Subwatershed						
3102921410059	6826 4th Street North 55128	1014.6	1015.0	1013.6	1D	None
3102921410076	6836 4th Street North 55128	1013.8	1015.0	1013.6	1D	None
3102921410077	6864 4th Street North 55128	1014.8	1015.0	1013.6	1D	None
3102921410078	6890 4th Street North 55128	1014.4	1015.0	1013.6	1D	None
3102921410097	6889 4th Street Place North 55128	1014.0	1015.0	1013.6	1D	None
3102921410098	6883 4th Street Place North 55128	1015.0	1015.0	1013.6	1D	None
3102921410105	6841 4th Street Place North 55128	1014.1	1015.0	1013.6	1D	None
3102921410106	6835 4th Street Place North 55128	1013.9	1015.0	1013.6	1D	None

Parcel ID	Address	Lowest Adjacent Grade[2]	Existing 100-Year Water Surface Elevation	100-Year Water Surface Elevation Following System Modifications	System Modification to Reduce Flood Risk	Prerequisite System Modifications
3102921340003	2967 Hudson Boulevard North 55128	963.1	964.9	963.2	1C	1A, 1B
0602821240028	381 Meadow Lane 55125	960.1	961.5	959.0	1B	1A

(1) 50 Aspen Way 55128 is owned by WCCDA Family Housing LLC in Landfall Village and includes approximately 300 manufactured homes; the lowest adjacent grade listed is the lowest among the 11 potentially impacted structures on this parcel.

(2) A limited survey was conducted in this area; therefore, LiDAR is the primary source for the lowest adjacent grade analysis. The manufactured homes' building outline could change over time; the estimated elevations listed are based on 2019's high-resolution aerial image provided by Near Map.

(3) The 100-year flood level following system modifications will likely vary in Tanners Lake, depending on the operation plan of the controllable outlet. The drawdown depth could vary from 0.5 feet to 1 foot depending on the actual event size and the real-time water level.



Barr Footer: ArcGISPro 3.1, 2024-05-07 13:58 File: I:\Client\Ramsey_Washington_Metro_WD\Work_Orders\2023_Feasibility_Studies\Resiliency_Study\Maps\Report\South Resiliency Study Report.aprx Layout: Figure 3.6 Potentially Flood Prone Structures in Battle Creek Tributary Area Following System

3.2 Phase 2—Fish Creek Tributary Area

The Carver Lake and Fish Creek subwatersheds are approximately 3,228 acres and includes portions of Woodbury and Maplewood. There are three structures on Carver Lake and one structure upstream of the lake within the 100-year floodplain. The Carver Lake subwatershed consists of primarily residential land use and there are limited parcels for storing stormwater runoff during a flood event. Potential watershed system modifications consider on adding storage in the few open parcels and evaluating potential changes to the outlet control structures. There are no

3.2.1 Current Condition Flooding Concerns

Four potentially flood-prone habitable structures are within the drainage area tributary to Carver Lake, as shown in Figure 3-7. One structure upstream of Carver Lake is classified as "District," which indicates that it is near District-managed facilities, lakes, or creeks or located where system modifications may change downstream peak flow rates and water levels in multiple municipalities. The remaining structures within the subwatershed are classified as "Local."

There are three potentially flood-prone, habitable structures classified as "District" on the west side of Carver Lake. The lowest home in this watershed, 1130 Century Ave South, is on Carver Lake and has a low adjacent grade elevation of 910.6 feet. The current 100-year water level on Carver Lake is 914.1; the lowest home is approximately 3.8 feet below the floodplain. The second lowest home is 1138 Century Ave South.

The other low home (3272 York Alcove) is on the pond upstream of the Stratford Road pond, and it has a low adjacent grade elevation of 955.9 feet. The current 100-year water level on the Stratford Road pond pond is 957.5, meaning the lowest home upstream is approximately 1.6 ft below the floodplain.

Many of the potentially impacted structures and homes within the subwatersheds likely have basements. For these structures, the elevation of the low adjacent grade was used to evaluate system modifications to mitigate flood risk. In other words, system modifications were evaluated to remove the ground adjacent to the structure from the floodplain; system modifications to lower the floodplain below a basement elevation or provide freeboard between the 100-year floodplain and the estimated low ground elevation were not considered.

Several auxiliary structures, such as sheds and garages are also below the 100-year floodplain. As discussed in Section 2.1, potential system modifications to remove these structures from the floodplain were not considered as part of the evaluation.

The District has a long history of implementing flood-risk reduction projects within the Carver Lake and Fish Creek subwatersheds. Some previous District projects include the Fish Creek stabilization and flood control project completed in 1988 to prevent bank erosion caused by an increase in stormwater runoff. The Fish Creek project included construction of an underground pipe for flood flows in an approximately half mile of the creek, and construction of upstream control structures. In 2007 RWMWD completed

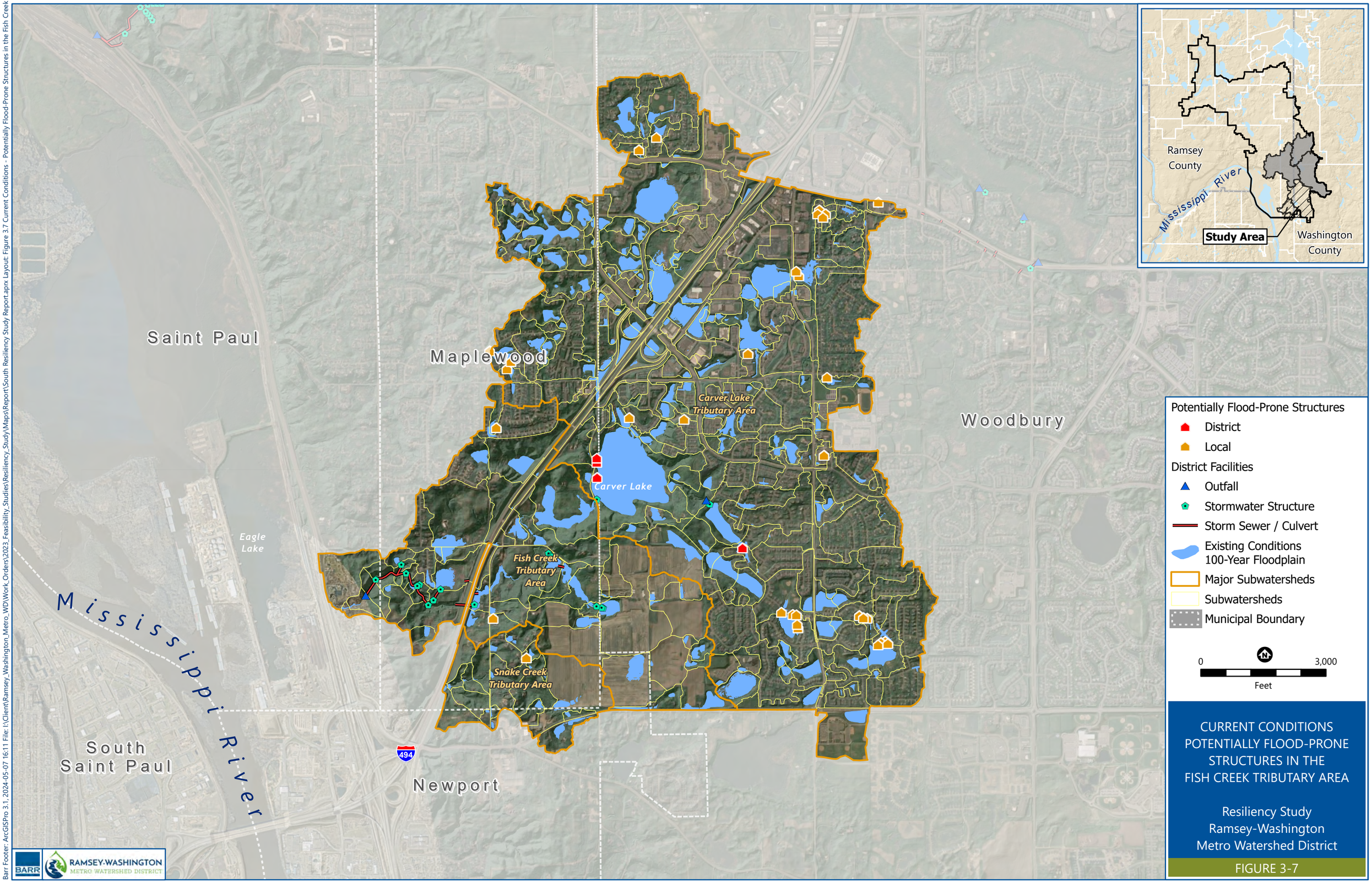
another stabilization project on Fish Creek to repair erosion and scour that resulted from a large flood event in 2005.

Table 3-1 lists the potentially flood-prone structures in the Carver Lake subwatershed classified as "District." (None of the flood-prone structures in the Fish Creek subwatershed were classified as "District.") The system modifications discussed in Section 3.2.2 were evaluated to remove the structures listed in Table 3-3 from the floodplain.

Table 3-3 Potentially Flood-Prone Structures in the Fish Creek Tributary Area

Parcel ID	Address	Lowest Adjacent Grade	Source for Lowest Adjacent Grade	Existing 100-Year Water Surface Elevation
132822440003	1130 Century Ave S, Maplewood 55119	909.9[1]	LiDAR[2]	914.1
132822440020	1138 Century Ave S, Maplewood 55119	911.9[1]	LiDAR[2]	914.1
132822440007	1168 Century Ave S, Maplewood 55119	913.4[1]	LiDAR[2]	914.1
1902821130001	3272 York Alcove, Woodbury 55125	955.9[1]	LiDAR[2]	957.5

(1) A limited survey was conducted in this area; therefore, LiDAR is the primary source for the lowest adjacent grade analysis.
(2) Reference [6]



3.2.2 Evaluation of Potential System Modifications

As described in Section 3.1.2, the District stormwater model was used to evaluate potential system modifications within the Carver Lake and Fish Creek subwatershed. The stormwater model was modified to evaluate the impact that potential system modifications would have on the 100-year floodplain. The goal for each system modification was to lower the 100-year flood level below the lowest ground elevation adjacent to habitable structures.

Evaluation of potential system modifications did not include discussions with property owners, permitting agencies, or other stakeholders. Additional evaluation for system modifications, including detailed feasibility studies that further evaluate economic and social considerations, is necessary prior to modifying the drainage system.

Based on available topographic information (Reference [6]), the lowest adjacent grade to the low home on Carver Lake is 910.3 feet; the low structure upstream of Carver Lake is 955.9 feet. Flooding within these areas is primarily a result of runoff volume. In other words, flooding typically occurs following long-duration rainfall events with high rainfall depths and not short, intense rainfall events. Since the Carver Lake subwatershed is substantially developed, there are few locations where additional stormwater storage volume could be feasible, system modifications considered were adding storage upstream of Carver Lake and changes to outlet control structures and conveyance systems.

Two Potential system modifications to mitigate flood risk in the Carver Lake subwatershed were evaluated (2A and 2B) and are described in the following sections.

2A Storage

Potential system modifications upstream of Carver Lake are shown in Figure 3-8. One possible system modification includes a new retention pond and rerouting the outlet from Stratford Road pond to the new pond. Potential system modifications include:

- A new pond upstream of York Alcove pond with approximately 42 ac-ft of live storage.
- Additional 60-inch-equivalent arch pipe or culvert with equivalent capacity at the invert of 946.57 feet to route water nfrom the Stratford Road pond into the new pond.
- Additional 12-inch-equivalent pipe or culvert with equivalent capacity at the invert of 938 feet to route water from the new pond into Carver Lake.
- Grading at 1168 Century Ave South, Maplewood 55119.

Table 3-4 lists the existing 100-year water surface elevation and the elevation following modifications to the drainage system.

Table 3-4 Potentially Flood-Prone Structures in the Fish Creek Tributary Area (Option 2A)

Parcel ID	Address	Lowest Adjacent Grade	Existing 100-Year Water Surface Elevation	100-Year Water Surface Elevation Following System Modifications
132822440003	1130 Century Ave S, Maplewood 55119	909.9[1]	914.1[2]	914.0
132822440020	1138 Century Ave S, Maplewood 55119	911.9[1]	914.1[2]	914.0
132822440007	1168 Century Ave S, Maplewood 55119	913.4[1]	914.1[2]	914.0
1902821130001	3272 York Alcove, Woodbury 55125	955.9[1]	957.5[2]	955.5

(1) A limited survey was conducted in this area; therefore, LiDAR is the primary source for the lowest adjacent grade analysis.
(2) Reference [6].

2B Outlet Modification and Conveyance

Another potential system includes modifications to the upstream pond, the Carver Lake outlet, and Fish Creek conveyance are shown in Figure 3-9. System modifications include operation of the outlet control structures for the Stratford Road pond and Carver Lake to provide live storage volume prior to the peak of the flood event.

System modifications shown in Figure 3-9, are listed below:

- Replacing existing pipe with a 48-inch-equivalent arch pipe or culvert with equivalent capacity at the invert 901.9 to route water at the driveway crossing in the park upstream of Carver Avenue.
- Restoring Fish Creek's hydraulic capacity between the Carver Lake outlet and Carver Avenue through selective excavation of sediment deposits.
- Replacing existing pipe with a 60-inch-equivalent arch pipe or culvert with equivalent capacity at the invert of 905.9 to route water at the driveway crossing in the park downstream of Carver Lake.
- Adding a new adjustable outlet opening of 72-inch-equivalent pipe at 904 feet for Carver Lake. The operation of the outlet will depend on the forecasted rainfall depth and water level in Carver Lake prior to the rainfall event. n
- Modifying the outlet from Stratford Road pond to allow for adjusting the outlet elevation The operation of the outlet will depend on the forecasted rainfall depth and water level in Carver Lake prior to the rainfall event.
- Modify the operation of the stormwater lift station for the York Alcove pond.
- Grading at 1130 and 1138 Century Ave South, Maplewood 55119.
- Grading at 3272 York Alcove, Woodbury 55125.

Table 3-5 Potentially Flood-Prone Structures in the Fish Creek Tributary Area (Option 2B)

Parcel ID	Address	Lowest Adjacent Grade	Existing 100-Year Water Surface Elevation	100-Year Water Surface Elevation Following System Modifications
132822440003	1130 Century Ave S, Maplewood 55119	909.9[1]	914.1[3]	912.8[2]
132822440020	1138 Century Ave S, Maplewood 55119	911.9[1]	914.1[3]	912.8[2]
132822440007	1168 Century Ave S, Maplewood 55119	913.4[1]	914.1[3]	912.8[2]
1902821130001	3272 York Alcove, Woodbury 55125	955.9[1]	957.5[3]	956.1[2]

(1) A limited survey was conducted in this area; therefore, LiDAR is the primary source for the lowest adjacent grade analysis.
(2) The 100-year water surface elevation following system modifications may be optimized during development of an operation plan for adjustable outlet control structures.
(3) Reference [6].

Grading at 1168 Century Ave South

Construct new outlet to Carver Lake.

Create additional 42 acre-feet of floodplain storage volume.

Carver Lake

Carver Lake Tributary Area

Fish Creek Tributary Area

Snake Creek Tributary Area

Fish Creek

Snake Creek

Saint Paul

Maplewood

Woodbury

Newport

Ramsey County

Washington County

Mississippi River

Study Area

Structure Removed from Floodplain

Potentially Flood-Prone Structures

- District
- Local

District Facilities

- Outfall
- Stormwater Structure
- Storm Sewer / Culvert
- Proposed Pipe
- Grading
- Proposed Storage

100-Year Floodplain

- Following System Modifications
- Existing Conditions 100-Year Floodplain

- Major Subwatersheds
- Subwatersheds
- Municipal Boundary

0 800

Feet

FISH CREEK TRIBUTARY AREA SYSTEM MODIFICATIONS - 2A

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Ramsey-Washington Metro Watershed District

FIGURE 3-8

BARR

RAMSEY-WASHINGTON METRO WATERSHED DISTRICT

Grading at 1130 and 1138 Century Ave South

Modify Carver Lake Outlet

Fish Creek Conveyance Improvements

Grading at 3272 York Alcove

Carver Lake

Carver Lake Tributary Area

Fish Creek Tributary Area

Maplewood

Woodbury

Ramsey County

Washington County

Mississippi River

Study Area

Marnie St S
O Day St S
Mcdeland St S
Fernidale St S
Dennis St
Farrel St S
Courtly Rd
Courtly Alcove
Tahoe CT
Alpine DR
Tahoe Pl
Tahoe Rd
Cobble Hill Dr
Cornelia Tr
S Crest Ave
Nemitz Ave
Mallard DR
Carver Park Dr
Carver Park Cir
Lake RD
Jordan Dr
Jordan Ct
Century Ave S
Marnie Ct
Schadt Dr
Mary Pl
Sterling St S
Fish Creek
Carver Ave
Henry La
M-982
Stratford Road Pond
Stratford Alc
Buckingham Alc
York Alc
York Alcove Pond
York Bay
Chamberlain Ctr
Chamberlain Dr
Falstaff Ter
Falstaff Dr
Chamberlain Draw
Avon Dr

Structure Removed from Floodplain

Potentially Flood-Prone Structures
- District
- Local

District Facilities
- Outfall
- Stormwater Structure
- Storm Sewer / Culvert
- Add Capacity; Outlet Modification
- Fish Creek Improvements
- Grading

100-Year Floodplain
- Following System Modifications
- Existing Conditions 100-Year Floodplain

- Major Subwatersheds
- Subwatersheds
- Municipal Boundary

0 500
Feet

FISH CREEK TRIBUTARY AREA SYSTEM MODIFICATIONS - 2B

Resiliency Study
Ramsey-Washington Metro Watershed District

FIGURE 3-9

BARR
RAMSEY-WASHINGTON METRO WATERSHED DISTRICT

Barr Footer: ArcGISPro 3.1, 2024-05-07 16:11 File: I:\Client\Ramsey_Washington_Metro_WD\Work_Orders\2023_Feasibility_Studies\Resiliency_Study\Maps\Report\South Resiliency Study Report.aprx Layout: Figure 3.9 Fish Creek Tributary Area System Modifications---2B User: jrv

4 Concept Planning-Level Opinion of Probable Construction Cost

There are several factors that affect the cost of implementing a flood-risk-reduction project:

- The volume of stormwater that must be stored within the watershed or conveyed downstream
- The potential to reduce flood risk by retrofitting existing stormwater infrastructure
- The potential to reduce flood risk by constructing new flood-detention facilities
- The potential need to acquire property when other flood-reduction alternatives are not feasible

Evaluating the most cost-efficient flood-reduction project for a given flood-risk area requires (1) review of the source(s) and cause(s) of flooding (requiring detailed hydrologic and hydraulic review), (2) high-level review of available options to mitigate flooding (e.g., Is there sufficient available space for a flood detention project? Is there enough grade to excavate and tie-in to existing storm sewer utilities?, etc.), and (3) preliminary design and cost-comparison analysis of feasible flood-mitigation alternatives. Due to the large number of flood-risk areas identified, it was not practical to perform a detailed analysis of multiple flood-mitigation alternatives and develop associated cost estimates for each within the scope of this project.

A planning-level opinion of cost was developed for each system modification. However, more cost-effective modifications may be identified during a detailed feasibility study.

The opinions of cost, project reserves, contingency, documentation, and discussion are intended to provide background information for planning-level alternatives assessment, analysis purposes, and budget consideration by RWMWD. The cost of time escalation is not included in the opinions of probable cost. All costs are presented in 2024 US dollars.

Opinions of cost are primarily based on stochastic estimating methods using recent bid prices for similar projects within RWMWD and the Twin Cities metropolitan area, published construction cost index resources, and similar stormwater projects. Quantities were estimated using calculations based on available information. Dimensions, areas, and volumes for construction were estimated using Excel, GIS, and available information on the drainage system.

Costs associated with base planning engineering and design (PED) and construction management (CM) are based on percentages of estimated construction costs. Costs associated with construction management are based on Barr's experience with similar projects but may change depending on the type of system modification ultimately selected for a given location.

Due to the limited project definition available at this time, costs associated with mobilization (10%); planning, engineering, and design (10%); construction management (7%); and erosion control (3%) were

estimated as a percentage of the construction cost for each modification. The percentages are based on projects of similar scale to the potential system modification.

The estimates do not include costs associated with permitting and regulatory approvals, easement or land acquisition, wetland mitigation, utility relocation, or regional restoration for disturbed areas outside of the construction extents.

The opinions of cost include tasks and items related to engineering and design and construction of each system modification. The opinions of cost do not include other tasks following the construction of each modification presented, such as operations and maintenance or monitoring.

The contingency used in these opinions of probable cost is intended to help identify an estimated construction cost for minor items in the project scope that have not yet been quantified or estimated. Those cost estimates will be refined during site-specific feasibility evaluations. Stated another way, contingency is the result of the pluses and minuses that cannot be estimated at the level of project definition that exists. The contingency includes the cost of ancillary items not currently itemized in the quantity summaries but commonly identified in more detailed design and required for completeness of the work. A 50% contingency is applied to the estimated construction cost to account for the costs of these items.

Industry resources for cost estimating (Reference [9], [10]) provide guidance on cost uncertainty, depending on the level of project design developed. The opinion of probable cost for the alternatives evaluated generally corresponds to a Class 5 estimate, characterized by the completion of limited engineering and the use of stochastic estimating methods. As the level of design detail increases, the level of uncertainty is reduced. Figure 4-1 provides a graphic representation of how uncertainty (or accuracy) of cost estimates can be expected to improve as a more detailed design is developed.

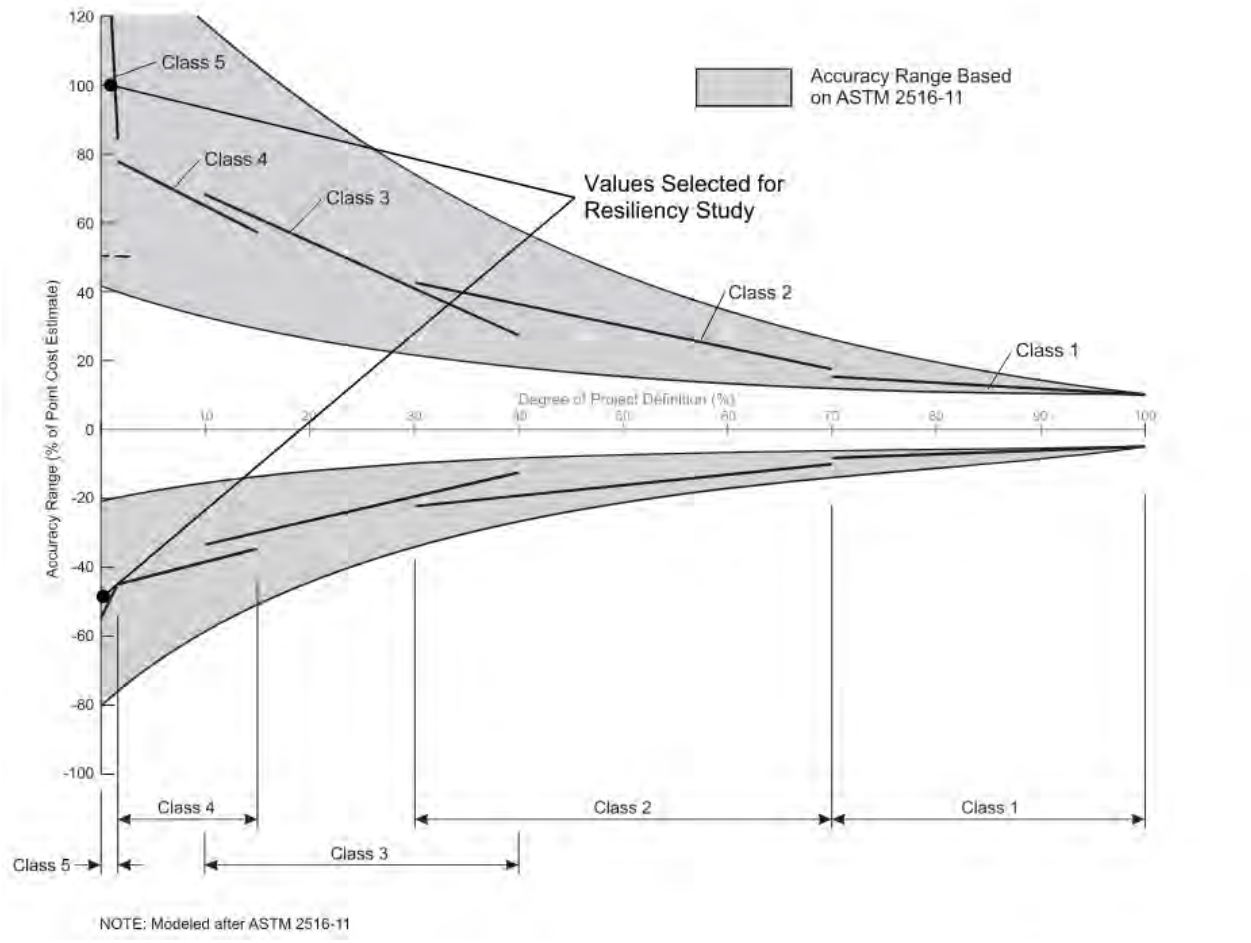

Figure 4-1 Relationship between Cost Accuracy and Degree of Project Definition

At this early stage of project definition, the range of uncertainty of total project cost is high. Due to the early stage of project definition, it is standard practice to place a broad accuracy range around the point cost estimate.

The accuracy range is based on professional judgment considering the level of design completed, the complexity of the project, and the uncertainties in the project scope; the accuracy range does not include costs for future scope changes that are not part of the project as currently defined or risk contingency. The estimated accuracy range for this point estimate is -50% to +100%.

The opinion of probable cost provided is made based on Barr's experience and qualifications and represents our best judgment as experienced and qualified professionals familiar with the project. It is acknowledged that additional investigations and site-specific information that becomes available in the next stage of evaluation may change the proposed configuration, cost, and functioning of project features. These opinions are based on project-related information available to Barr at this time and include a planning-level feasibility design of the project. The opinions of cost may change as more information becomes available and further evaluation is completed. In addition, because we have no

control over the eventual cost of labor, materials, equipment, or services furnished by others; over the contractor's methods of determining prices and/or for constructing system modifications; or over competitive bidding or market conditions, Barr cannot and does not guarantee that proposals, bids, or actual costs will not vary from the opinions of cost presented.

To reduce the uncertainty associated with the opinions of cost, additional evaluation is needed to define system modifications better. In many locations, this may include the completion of feasibility studies to identify the optimal type of system modification for the specific location.

Table 4-1 and Table 4-2 include opinions of cost for system modifications for each phase. Modifications 1A, 1B, and 1C will need to be constructed together, so a combined cost is included as well as the individual costs. Modification 1D is a stand-alone project and does not depend on any of the other projects. Modifications 2A and 2B are two options for addressing flooding around Carver Lake; if one is constructed, the other will not be needed. As additional evaluation is completed and site-specific information is available, the final cost of flood mitigation may be significantly lower or higher than the planning-level opinions of cost included in these tables.

Table 4-1 Opinions of Probable Cost for the Battle Creek Tributary Area Modifications

System Modification	Description	Low Cost (-50%) ($)	High Cost (+100%) ($)	Figure
Phase 1	**Battle Creek Tributary Area**	**$5,342,000**	**$21,378,000**	
1A	*McKnight Basin*	$1,007,000	$4,028,000	Figure 3-2
1B	*Battle Creek Lake*	$1,790,000	$7,160,000	Figure 3-3
1C	*Tanners Lake*	$1,676,000	$6,702,000	Figure 3-4
1A, 1B and 1C Total:		$4,473,000	$17,890,000	
1D	*4th Street Place N*	$872,000	$3,488,000	Figure 3-5

Table 4-2 Opinions of Probable Cost for the Fish Creek Tributary Area Modifications

System Modification	Description	Low Cost (-50%) ($)	High Cost (+100%) ($)	Figure
Phase 2	**Fish Creek Tributary Area**			
2A	*Carver Lake Storage*	$6,879,000	$27,514,000	Figure 3-8
2B	*Carver Lake Outlet*	$815,000	$3,260,000	Figure 3-9

5 Conclusions and Recommended Next Steps

The study includes several potential system-level flood damage reduction options, including real-time operation of Tanners Lake, Battle Creek Lake, and Carver Lake outlet structures to actively manage stormwater runoff. System modifications presented are intended to demonstrate options for mitigating flood risk that do not include purchasing flood-prone properties.

The study was phased such that, in general, upstream system modifications were evaluated prior to downstream modifications. System modifications that result in increased outlet capacity should be sequenced such that downstream modifications are constructed first to avoid increases to the 100-year water level in those areas. Beyond that general recommendation, this study does not include further priority recommendations. The study phases were selected to efficiently complete the stormwater modeling required to evaluate system modifications and are not intended to imply prioritization. The general sequencing discussion is intended to illustrate considerations to avoid downstream impacts on the floodplain and not provide a recommendation regarding which flood-risk areas should be prioritized or addressed first.

The following items are recommended as next steps by the District for further evaluation as they are the backbone of the added resiliency:

1. **Active management of the Tanners Lake and the Battle Creek Lake control structures.** Active management of the control structures on Tanners Lake and Battle Creek Lake could optimize the use of live storage volume while minimizing the impact on downstream water levels along Battle Creek. Without optimizing the live storage, additional floodplain storage volume would be needed to mitigate flood risk for structures and infrastructure around Battle Creek Lake. Preliminary design and permitting discussions with the MDNR could begin regarding potential modifications. Implementation of the control modification must be coupled with operating plans for each structure. These plans should be developed in concert with structure modifications.

   Active management of the outlet control structures could also impact the water quality of Battle Creek, which is impaired for several pollutants, including chloride, nutrients, sediment, and E. coli. The District will conduct detailed water quality monitoring of Battle Creek during the 2024 monitoring season to better understand the sources of these pollutants. Based on the results of the monitoring data, actively managing the Battle Creek Lake outlet to manipulate the duration and magnitude of flows could help address some of Battle Creek's impairments. The 2024 monitoring data and a detailed study will be needed to quantify the potential impacts of actively managing the Battle Creek Lake outflows.

2. **Refining the Tanners Lake and Battle Creek Lake outlet modifications and McKnight Basin floodplain storage.** Additional conveyance capacity will also be needed to mitigate flood risk for structures around Tanners Lake and Battle Creek Lake. Floodplain storage will need to be added around McKnight Basin to maintain the existing 100-year flood levels at

this high-hazard dam. Feasibility studies for these locations are needed to define permit requirements and utility conflicts and optimize the location, storm sewer size, and storage volumes needed. The feasibility studies should include the active management of the Tanners Lake and Battle Creek Lake control structures.

3. **Refining the 4th Street Place North modifications.** Additional conveyance capacity and floodplain retention will be needed to mitigate flood risk for structures near 4th Street Place North and prevent increasing downstream water levels. Since a portion of the project will need to be constructed on private property owned by the Apostolic Bible Institute, early engagement with this property owner is essential to determine if the project can proceed. If the Apostolic Bible Institute agrees to the project, feasibility studies for this location are needed to define permit requirements and utility conflicts and optimize the location, storm sewer size, and storage volumes needed.

4. **Active management of the Carver Lake control structures.** Active management of the control structures on Carver Lake could optimize the use of live storage volume while minimizing the impact on downstream water levels along Fish Creek. Without optimizing the live storage, additional floodplain storage volume would be needed to mitigate flood risk for structures and infrastructure around Carver Lake. Preliminary design and permitting discussions with the MDNR could begin regarding potential modifications. Implementation of the control modification must be coupled with operating plans for each structure. These plans should be developed in concert with structure modifications.

   Similar to Battle Creek, active management of the Carver Lake outlet control structure could also impact the water quality of Fish Creek, which is impaired for sediment and E. coli. The District will be conducting detailed water quality monitoring of Fish Creek during the 2024 monitoring season to better understand the sources of these pollutants. Based on the results of the monitoring data, actively managing the Carver Lake outlet to manipulate the duration and magnitude of flows could help address some of Fish Creek's impairments. The 2024 monitoring data and a detailed study will be needed to quantify the potential impacts of actively managing the Carver Lake outflows.

5. **Stakeholder review (all phases).** Potential system modifications presented should be reviewed with municipalities, counties, and MnDOT. Many system modifications presented may impact municipal, county, or state drainage systems. Coordination with stakeholders may identify opportunities for partnerships related to funding or optimization of system modifications.

The Battle Creek and Fish Creek tributary area resiliency study combines traditional and nontraditional approaches to modifying a regional urban stormwater system to add resiliency and optimize the system's performance under flood conditions. The modifications evaluated and presented represent options for mitigating flood risk to habitable structures without purchasing flood-prone structures. As detailed feasibility studies are completed for individual system modifications or continued coordination with stakeholders, the project definition, cost, and function of system modifications will be updated.

6 References

[1] NOAA, "Precipitation-Frequency Atlas of the United States, Volume 8 Version 2.0," 2013.

[2] Barr Engineering Co., "System-Wide Evaluation of Flood-Risk Mitigation Options Beltline Resiliency Study," November 2020.

[3] U. D. o. Commerce, "Technical Paper No. 40, Rainfall Frequency Atlas of the United States for Durations from 30 Minutes to 24 Hours and Return Periods from 1 to 100 Years," 1961.

[4] Ramsey-Washington Metro Watershed District, "Ramsey-Washington Metro Watershed District Rules. Revised 6/5/2019," 2019.

[5] Barr Engineering Co., "RWMWD 2018 Model Update and Validation," Minneapolis, February 2019.

[6] Minnesota Department of Natural Resources, *LiDAR Elevation, Twin Cities Metro Region, Minnesota,* 2011.

[7] Ramsey County, "Building Dataset," 2015. [Online]. Available: http://openramsey-ramseygis.opendata.arcgis.com.

[8] Microsoft, *Microsoft Building Footprints,* 2019.

[9] American Society for Testing and Materials, ASTM E2516-06 Standard Classification for Cost Estimate Classification System, West Conshohocken, PA: DOI: 10.1520/E2516-06, 2006.

[10] Association for the Advancement of Cost Estimating, AACE International Recommended Practice NO. 18R-97, February 2, 2005.

[11] Barr Engineering Co., *Gervais Lake Emergency Response Plan,* Little Canada, 2014.

[12] Barr Engineering Co., *Low Home Survey in Lake Owasso,* Roseville, 2017.

[13] Barr Engineering Co., *Beltline Resiliency Study Phase 1 – Owasso Basin Technical Memorandum,* Little Canada, 2018.