Near West Watershed Study Report

City of Madison, Dane County, WI

June 3, 2025

MSA Professional Services
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Project 00373095

Acknowledgments

The Near West watershed study is only possible with the contributions from the City of Madison Engineering Division, USGS staff, and members of the public who participated in public information meetings and focus groups. Specifically, the following individuals are acknowledged for their efforts on this project.

City of Madison

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1 Executive Summary

Background

Recognizing the changing rain patterns, and likelihood of more frequent future large rain events, the City of Madison (City) is conducting a multi-faceted approach to address stormwater flooding. As one component of that approach, the City is developing comprehensive stormwater management studies for each watershed within the City. The studies are conducted in two phases. Throughout both phases, the City incorporates multiple opportunities for public involvement and interaction.

Phase 1, Existing Conditions: Development of a hydrologic/hydraulic stormwater runoff model representing the physical and drainage properties of the watershed under existing conditions. The model is then calibrated to measured runoff events and used to identify the areas of the watershed most likely to flood under various rain conditions.

Phase 2, Recommended Solutions: Using the model, evaluate alternative methods and/or infrastructure improvements to eliminate, or reduce flooding impacts from large rain events.

It should be noted that the improvements documented in this report are not meant to be full design-level efforts; they are conceptual solutions that help the City's Engineering Division understand the magnitude of solution needed in a given area to meet the targets. As projects are looked at further, and if they move to the point they are contemplated for programming, then projects will then go into a more detailed design phase. This project phase collects detailed data needed for design and looks at refined design, permitting, and environmental issues associated with the particular project.

This document reports the methods, procedures, and results of the Near West Watershed Project. The project area covers approximately 1,271 acres (2.0 square miles) on the west side of the isthmus in Madison. **Figure ES-1** shows the extent of the project area.

City's Flood Mitigation Targets

The City developed a set of flood mitigation targets that exceed their current minimum design standards, to better understand where targets are being met and where the flooding conditions could be improved. The City's flood mitigation targets for the Near West Watershed Study are as follows, grounded by Annual Exceedance Probability (AEP) design storm events. Note that these targets may change in the future.

10% AEP design storm event:

a) No surcharging onto the street for up to the 10-year design storm; water shall be contained within the pipes and structures.
b) For locations limited by known inlet capacity, allow no more than 0.5 feet of water above storm sewer inlet rim. *Note that this target was not included in the scope for the Near West Watershed Study.*

4% AEP design storm event:

a) Centerline of street to remain passable during 25-year design storm with no more than 0.5 feet of water at the centerline.

1% AEP design storm event:

a) No home or business will be flooded during the 100-year design storm. *This is defined as no more than 0.5 feet of water at the 5-foot buffer around a structure.*
b) Enclosed depressions to be served to the 100-year design storm (which can include safe overland flow within street, easements, greenways, or other public lands). *For purposes of this watershed study, enclosed depressions are defined as depressions in public right-of-way where stormwater needs to reach private property to overflow from the depression.*
c) Greenway crossings at streets to be served to the 100-year design storm.

0.2% AEP design storm event:

a) Safely convey stormwater, i.e. limited impact on private property. *For purposes of this watershed study, limited impact is defined as no more than 0.5 feet of water at the 5-foot buffer around a structure.*

Existing and Recommended Solution Conditions Results

The existing conditions analysis found numerous locations where the system does not meet the identified flood mitigation targets, as outlined in **Table ES-1.** Following the existing conditions analysis, an extensive process was conducted to brainstorm, evaluate and select a series of solutions that would reduce flooding across the watershed. The all the recommended solutions were integrated into the model and compared against the flood mitigation targets, to assess the anticipated flood reduction. **Table ES-1** shows how the recommended solutions reduce flooding relative to the City's targets, and **Figure ES-2** shows the location of the recommended solutions.

There are still some locations within the watershed where the flood mitigation targets are not yet met, even with the recommended solutions. This is due to a variety of reasons and the Near West Watershed has more constraints than some other areas of the City:

- The watershed is fully developed and highly impervious with no available space for regional detention.
- The are many enclosed depressions (low-lying areas without a natural outlet for surface runoff).
- There are extensive utility conflicts due to the high population density, which limits the size of piped stormwater improvements.
- Finally, all improvements are limited by the lake levels. All the stormwater pipes drain to either Lake Mendota or Monona, and many outfalls are underwater creating a tailwater condition that reduces the effectiveness of larger piped improvements.

However, the recommended solutions do provide some notable improvements. **Table ES-1** lists the collective improvements, but the select list below can provide some geographic context for some of the largest improvements.

- Regent St contains a large, enclosed depression and the piped infrastructure currently has a ~5 yr level of service. With the recommended solutions, it would have a ~10-yr level of service.
- Orchard St has a similar improvement transitioning from a ~5-yr level of service to a ~10-yr level of service.
- There are significant reductions to flooding on S Park St near both St Mary's and Meriter Hospital. S Park St between Milton St and Olin St (the edge of the Near West watershed) will serve the 100-yr event, providing access to both hospitals as a critical emergency route.

Table ES.1: Existing Conditions and Recommended Solutions Results based on the City's Flood Mitigation Targets for the Near West Watershed

Design Storm Event	ID	Target	Watershed-wide metric	Existing Condition	Recommended Solutions Condition
10% AEP	1a	No surcharging onto the street	465 modeled public structures	268 modeled public structures within 10-ft of inundation (57.6%)	223 modeled public structures within 10-ft of inundation (48.0%)
	1b	No more than 0.5' of water at locations limited by inlet capacity	*Inlet capacity restrictions not included as part of this watershed study*		
4% AEP	2a	Centerline of street remain passable	49.9 miles of road centerlines	4.2 miles of roads with more than 0.5-ft of water (8.4%)	2.9 miles of roads with more than 0.5-ft of water (5.8%)
1% AEP	3a	No homes or businesses will be flooded*	4,678 buildings/structures	319 buildings/structures impacted (6.8%)	235 buildings/structures impacted (5.0%)
	3b	Enclosed depressions served	58 enclosed depressions	9 enclosed depressions impact private property when overflowing (15.5%)	7 enclosed depressions impact private property when overflowing (12.1%)
	3c	Greenway crossings at streets served	*No greenway crossings present in this watershed*		
0.2% AEP	4a	Safely convey stormwater; i.e. limited impact on private property*	4,678 buildings/structures	542 buildings/structures impacted (11.6%)	485 buildings/structures impacted (10.4%)

**This metric includes structures that are not occupied, such as garages and sheds.*

Recommended Solutions Cost

Improvements were recommended across the watershed by upsizing existing piped infrastructure. New regional ponds were not feasible for the Near West Watershed since the watershed is effectively entirely developed. **Table A.2** lists the final recommended solutions, along with an estimated design and construction cost for each. Figures of the recommended solutions are included later within this report.

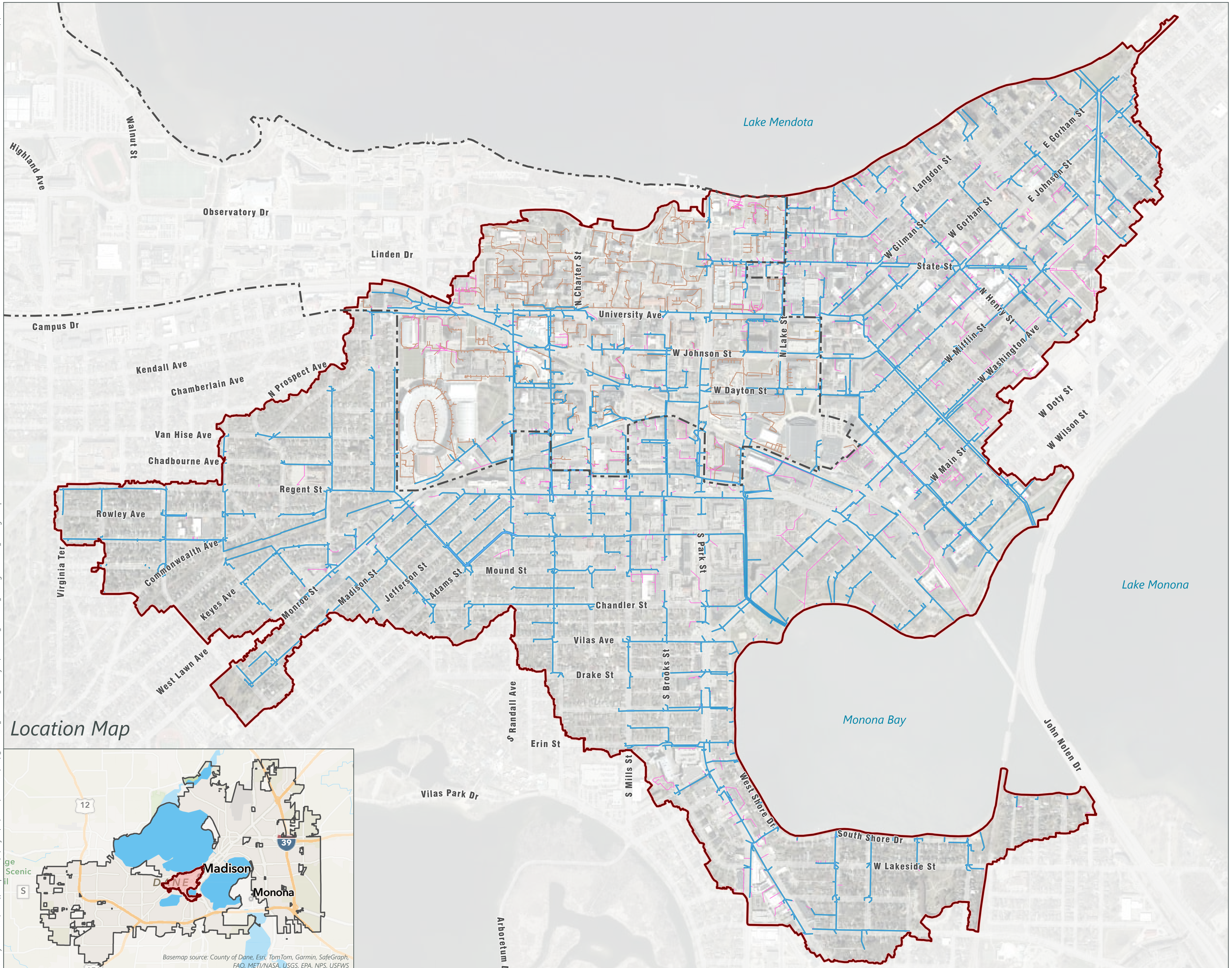
Table ES.2: Recommended Solutions Project Cost Estimates for the Near West Watershed

Project	Estimated Cost
N Hancock St to Outfall Storm System Improvements	$1.43M
E Johnson St/N Pickney St/N Hamilton St/Gorham St Storm System Improvements	$0.74M
University Ave/Lake St Storm System Improvements	$1.56M
Regent St Storm System Improvements	$6.04M
S Mills St Bypass and Vilas Ave/ S Park St Storm System Improvements	$32.27M
Vilas Ave/S Park Storm System Improvements Alternative*	$0.72M
Emeral St/S Park St Storm System Improvements	$0.35M
Erin St/Delaplaine Ct Storm System Improvements	$6.52M
Parr St Storm System Improvements	$0.17M
Oakland Ave/Adams St Storm System Improvements	$2.92M

Study Area

FIGURE ES-1
Near West Watershed
Study Report

City of Madison
Dane County, WI



- Watershed Study Area
- UW Madison Campus
- Public Storm System
- Private Storm System
- UW Storm System

Data Sources:
Aerial: City of Madison (2022)
Watershed Boundaries: MSA
Stormwater System: City of Madison and UW Madison

MSA

0 0.1 0.2 Miles

N

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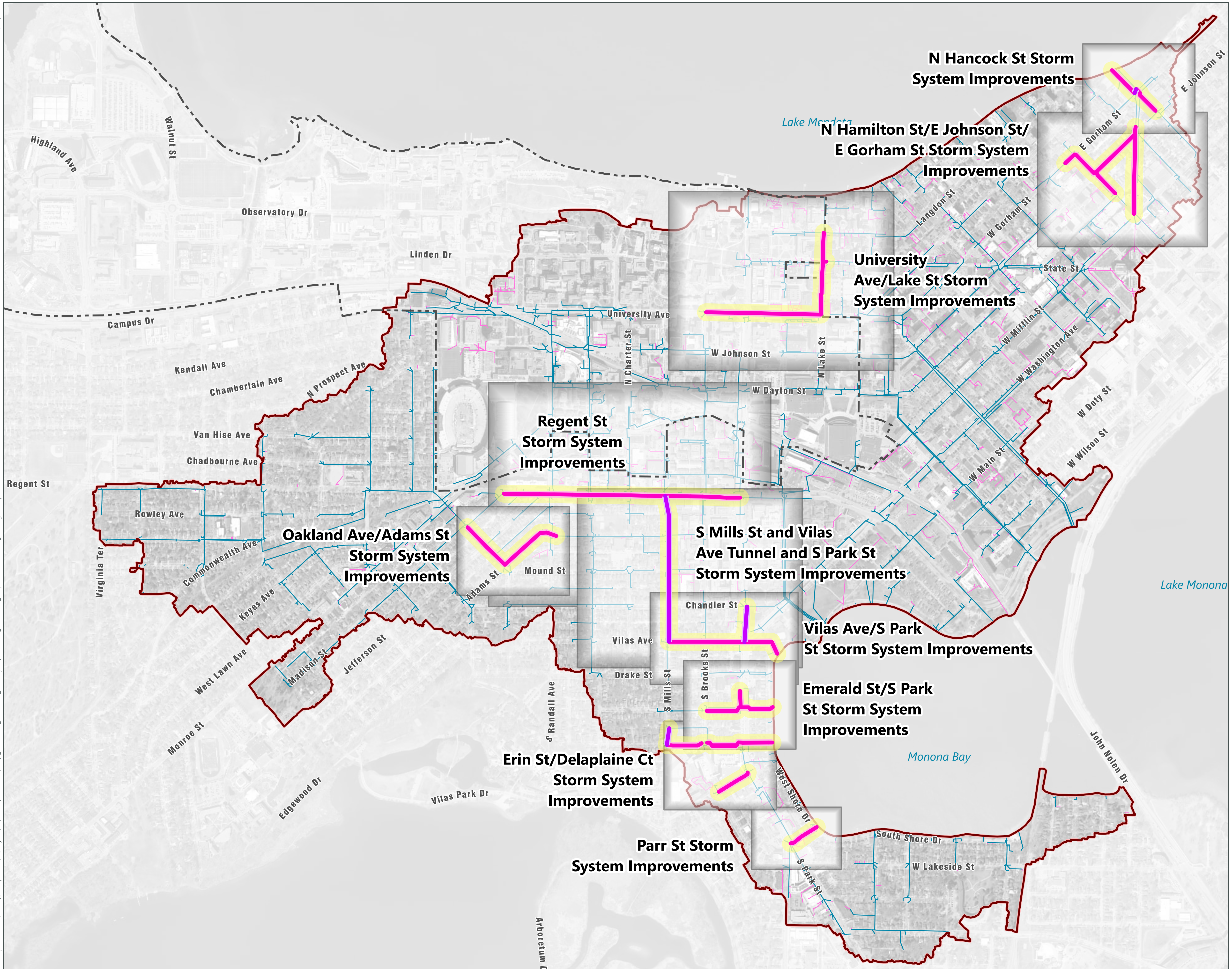


Recommended Solutions Map

FIGURE ES-2
Near West Watershed
Study Report

City of Madison
Dane County, WI

Watershed Study Area
Map Extents (Figures 27A - J)
UW Madison Campus
Public Storm System
Private Storm System
UW Storm System
Improvement Area of Interest

Proposed Storm Improvement

New Pipe
Upsize Pipe

Data Sources:
Aerial: City of Madison (2022)
Watershed Boundaries: MSA
Land Use: Dane County, revised by MSA

MSA

0 0.1 0.2 Miles

2 Introduction

2.1 Project Background and Purpose

The City of Madison has experienced increased frequency and intensity of rainfall events over the past ten to fifteen years. In August 2018, an unprecedented rainfall event occurred on the City of Madison's west side. A nearby United States Geological Survey (USGS) rain gauge in Middleton's Pheasant Branch Conservancy (site # 05427948) recorded 10.5 inches of rain over a 12-hour period. For reference, NOAA Atlas 14 statistics show the 12-hour 0.1-percent chance recurrence interval storm at 8.92 inches for the Madison area. This event caused flash flooding, most significantly across the western half of Madison, and prompted the City of Madison (City) to begin a comprehensive watershed planning process.

In response to the 2018 summer floods, the City of Madison initiated a city-wide focus on identifying and addressing issues within the urban drainage system. This includes creating comprehensive watershed plans for watersheds throughout the City, including the Near West watershed (the watershed).

Figure 1 provides a detailed view of the watershed, with an inset map to show its location within the City.

2.2 Scope of Study

The scope of work includes:

- Development of an existing conditions XP-SWMM computer model of the 1,271 acre watershed. An additional 732 acres were modeled to include the entire University of Wisconsin (UW) Madison campus.
- Calibration of the model against rainfall and flow/depth data collected at selected locations within the watershed during the summer of 2022.
- Evaluation of calibrated model output for purposes of identifying locations within the Near West watershed where the existing stormwater management system does not meet City of Madison flood mitigation targets.
- Evaluation of flood mitigation alternatives.

During this project, significant resources were allocated to public involvement including multiple public information meetings, focus group meetings, and online data reporting efforts. Information collected during the public information meetings was used in the model development and the problem identification efforts of this project.

The first half of this report documents the development and calibration of the existing conditions Near West watershed model. Flood mitigation alternatives are documented in the second half of the report.

2.3 Historic Flooding in the Watershed

Within the Near West watershed, there are several areas that have experienced flooding in the past. **Figure 2** depicts known flooding reports provided by the City in the Near West watershed. The known flooding locations include flood reports from a variety of data sources, including resident reports, emergency services reports, operations staff reports, and inlets with repetitive clogging history. These flood reports are limited to areas within the City of Madison.

Known flooding locations were discussed with City staff throughout the project. A summary of the major flooding locations is described below and displayed in **Figure 2**.

Regent Street Box Culvert:
Regent Street (from Monroe Street to Park Avenue) has a 4' x 9 ½' box culvert that is in poor condition. The City recently televised the pipe, and portions of the top of the box culvert were removed, and replaced with elliptical pipes. The rationale for this repair is unknown. However, the City anticipates needing to replace the pipe in the near future as part of a larger street reconstruction effort. Previous modeling by the City indicated that there was roughly a 5-yr capacity within the box culvert.

Enclosed Depression near Camp Randall & Bike Path:
There is a natural enclosed depression southeast of Camp Randall on the University of Wisconsin (UW) campus, inclusive of part of Monroe Street (in front of the Police Station) and portions of the bike path. The area flooded in 2006 and cause extensive damage to the building and underground parking. The City restructured the stormwater system along Randall Avenue to discharge to both Regent Street and the College Court relief sewer. When modeling was completed at that time, it was assumed that the Randall Street system had ~2-yr capacity and that the Regent Street system had ~10-yr capacity. The newly added connection would equalize the flood risk between the systems, intended to bring them both to 5-yr capacity.

The James building (apartments and mixed use):
A newer development, The James, was built too low, and the sidewalk and curb work associated with the redevelopment to be ADA compliant made the building additionally prone to flooding. The flood risk was reduced with the Bassett Street project (#11430), but the area is still an enclosed depression. Runoff currently overtops the north sidewalk and enters the James building, approximately during the 5-yr storm event. Additional inlets have been added, but the site is still prone to flooding.

West Washington Street and Bassett Street
The intersection of West Washington Street and Bassett Street is an enclosed depression. The City recently reconstructed the street (project #13173) but found that they could not serve this to the 100-year. There is potential to add a box on the eastern side of South Bassett Street to drain the depression, but the size of the new storm sewer that would serve this area to meet the 100-yr capacity is unknown.

Spring Street and N Park Street
The northwest corner of Spring Street and North Park Street (just south of the bike path bridge) used to flood frequently. The City installed a pump with 10-yr capacity, and the amount of regular flooding has been reduced.

Pipes discharging to Monona Bay
All of the pipes that outlet to Monona Bay are regularly under water. Since these outlets drain a large portion of the watershed area, the pipes will exhibit a tailwater condition, as water cannot freely flow out of the outlet. Alternatively, the pipes that outlet to Lake Mendota are less likely to be underwater and therefore less likely to have backwater present.

2.4 Flood Mitigation Targets

The following flood mitigation targets have been established by the City of Madison, grouped by Annual Exceedance Probability (AEP) design storm event, with a final target focused on ensuring the solutions do not have negative impacts elsewhere within the watershed:

10% AEP design storm event:

a) No surcharging onto the street for up to the 10-year design storm; water shall be contained within the pipes and structures.
There are locations within the City where low points exist that pond water; these low points are excluded from this target and will be addressed as streets are redesigned.

b) For locations limited by known inlet capacity, allow no more than 0.5 feet of water above storm sewer inlet rim.
Note that this target was not included in the scope for the Near West Watershed Study.

4% AEP design storm event:

a) Centerline of street to remain passable during 25-year design storm with no more than 0.5 feet of water at the centerline.
Note that the Watershed Study modeling approach will not explicitly account for cross flow conditions where more gutter flow on one side of the street can overtop the crown.

1% AEP design storm event:

a) No home or business will be flooded. *This is defined as no more than 0.5 feet of water at the 5-foot buffer around a structure.*

b) Enclosed depressions to be served (which can include safe overland flow within street, easements, greenways or other public lands). *For purposes of this watershed study, enclosed depressions are defined as depressions in public right-of-way where stormwater needs to reach private property to overflow from the depression*.

c) Greenway crossings at streets to be served.

0.2% AEP design storm event:

a) Safely convey stormwater; i.e. limited impact on private property. For purposes of this watershed study, limited impact is defined as no more than 0.5 feet of water at the 5-foot buffer around a structure.

Provide flooding solutions that do not negatively impact downstream properties.

The City also stated that ‘due to the inherent variability and complexity of stormwater conveyance systems, it may not be practical to meet the above level of service targets in all areas of the City.’

The focus of the Watershed Study is on the capacity/deficiencies within City-owned infrastructure and the right-of-way and that the Watershed Study should be considered a “planning-level” analysis. Therefore, there are several limitations to the study that are documented further in Section 7.3.

2.5 Summary of Past Studies

There are not many drainage studies within the Near West watershed, and no published reports/memos were available at the time of writing this report.

City staff completed a study in 2006 to support a specific reconstruction project, near Regent Street and Monroe Street after flooding in 2006. The was not a formal technical memo outlining the findings of that study, but the raw modeling outputs were documented, and results/findings were verbally described by City staff. The study resulted in a re-design of the system, so that the enclosed depression adjacent to Monroe Street and the bike path (which previously drained only to the College Court storm system) had a second connection to the Regent Street box culvert. The goal was to bring both systems to ~5-yr design capacity.

3 Water Resources Inventory

3.1 Study Setting

The Near West watershed is located on the west side of the isthmus in the City of Madison, as shown in **Figure 1**. Generally, the watershed is bound to the north by Lake Mendota and includes portions of the UW Madison campus. It extends SW towards Forest Hill Cemetery and is inclusive of portions of the Vilas Park neighborhood. The watershed includes all the land areas draining to Monona Bay.

The majority of the watershed is fully developed, where 22% of the land area is single family homes/duplexes, 17% is multifamily residential, 32% is transportation & utilities (inclusive of roads and recreational trails), 4% is institutional (including schools, government offices, hospitals, and religious facilities), 8% is commercial, 4% is recreational (including city parks), 3% is sporting arenas/stadiums (inclusive of the Kohl's Center and Camp Randall), and 10% is the UW Madison Campus.

Prominent features within the watershed include:

- Western half of the Wisconsin State Capitol
- Eastern portions of the UW Madison Campus
- Camp Randall
- The Kohl's Center
- State Street
- UnityPoint Health Meriter Hospital
- Portions of SSM Health Street Mary's Hospital
- The Overture Center for the Arts
- Madison Children's Museum
- Wisconsin Veterans Museum
- Brittingham Park
- Portions of James Madison Park

3.2 Watershed

The Near West watershed is bound by the major watersheds listed below (**Figure 3**). Of these, Willow Creek and East Isthmus and Yahara watershed studies are complete. Wingra Proper and John Nolen Drive have ongoing Watershed Studies. The UW Campus opted to join with the City's modeling efforts, and the UW Campus watershed was modeled in conjunction with the Near West Watershed study.

- Willow Creek
- Wingra Proper
- John Nolen Drive
- East Isthmus and Yahara
- Isthmus Central
- UW-Madison Campus

The Near West watershed (as defined by this study) is approximately 1,271 acres (2.0 square miles). An additional 732 acres (1.1 square miles) were modeled to include the entire University of Wisconsin (UW) Madison campus.

However, under runoff conditions above a certain threshold, some of the stormwater runoff during small rain events would flow to the southwest to the Wingra Proper watershed, will instead flow to the northeast into Near West. Storm sewer on Vista Road/Rugby Row will surcharge runoff into Near West during a 3.45 in rainfall event (20% AEP) and above. Storm sewer on Monroe Street will discharge runoff into Near West during a 6.66 in rainfall event (1% AEP) and above. **Figure 3** shows the connection between these two watersheds.

3.3 Topography

The following data sources were used for topography within the watershed. Topographic data was needed for delineating the model study area and defining overland flow paths/channels.

- 2022 Aerial Photography obtained from the City of Madison
- 2022 LiDAR DEM obtained from the City of Madison County, and 1-foot contours generated from that DEM
- GIS data describing storm drainage infrastructure provided by the City of Madison
- Site observations by MSA and City staff

3.4 Drainage System

The Near West watershed has full urban drainage, with most streets/neighborhoods being served by stormwater infrastructure. The major drainage system is comprised of large storm sewer pipes; there are not any regional public stormwater ponds or greenways. The major system is supplemented by the minor drainage system, which consists of street storm sewer, street surface flow, and private stormwater infrastructure.

The overall drainage system is shown schematically in **Figure 1**.

3.5 Runoff Conditions

Runoff conditions within the watershed are dictated primarily by three components: land use, impervious area, and underlying soils.

3.5.1 Land Use

Land use within the watershed is shown in **Figure 4**. As previously mentioned, the majority of the watershed is fully developed, with ~40% of the watershed consisting of single family, duplexes, and multi-family residential properties. The remaining land is associated with the road network, commercial properties, institutional properties, recreational parks, sporting arenas/stadiums, and the eastern portion of the UW Madison campus. In recent years, there has been redevelopment in the watershed, but land use types have generally remained the same (i.e. a commercial property is redeveloped into a different commercial property). There have been many recent redevelopments, including the following. Note this list was updated as of January 2023.

- Madison Children's Museum Expansion (complete)
- Sellery Hall Addition and Renovation (UW-Madison, complete)
- Chemistry Building Project (UW-Madison, complete)

- 1313 Regent Development (apartments, complete)
- Oliv Madison (10-story mixed use structure, under construction)
- Verve (12-story multi-family residential structure, under construction)
- School of Computer, Data & Information Sciences Building (UW-Madison, under construction)
- Kohler Center Addition and Renovation (UW-Madison, under construction)
- State Street Campus Garage Mixed Use Project (under construction)
- Madison Senior Center Courtyard Renovation (under construction)
- 800 Regent Street (mixed use, under construction)
- Atmosphere Madison (apartments, under construction)
- Monona Bay Triangle Project (community housing, under construction)
- 519-547 West Washington Avenue (apartments, under construction)
- 402 West Wilson Street (apartments, under construction)
- The Luminous (live/work building, under construction)

The northwest portion of the watershed encompasses a portion of the University of Wisconsin (UW) Madison campus. This region was included within the modeling to ensure any stormwater runoff from the campus was incorporated into the existing conditions results. However, the UW-Campus was not included within the targets analysis.

3.5.2 Impervious Area

The total impervious area for the watershed is displayed in **Figure 5**. Impervious area for this study was obtained from several sources:

- City of Madison's impervious area layer (based on 2020 imagery)
- Digitized impervious area by MSA using the most recent high-resolution aerial imagery available at the time (2022) to supplement with new development.

The Near West watershed is approximately 1,271 acres (2.0 square miles) and is occupied by 853 acres of impervious, making it on average roughly 67% impervious.

3.5.3 Soils

The Hydrologic Soil Group (HSG) classifications within the watershed are shown in **Figure 6**. The HSG is a parameter that quantifies a soil's ability to infiltrate stormwater runoff. Well-drained soils with high infiltration rates are classified as 'HSG A', while poorly drained soils with correspondingly low infiltration rates are classified as 'HSG D'. Soils with classifications as 'HSG B' or 'HSG C' fall between these two values. Soils that have dual classifications such as B/D, indicate the respective HSG for drained and undrained conditions. Dual classed soils were treated as though they were in the drained condition; the City of Madison modeling guidance recommended treating dual classed soils as though they were in the undrained condition, but this was modified during the Near West model calibration process.

The soils in this study are classified as HSG B or HSG C. Swathes of dual classification HSG 'B/D' and 'C/D" were treated in the drained HSG 'B' or 'C' condition, respectively.

4 Guidance and Data Sources

4.1 Model Guidance Documentation

The most current version of the Modeling Guidance Document that was available during model development was applied to the existing conditions calibrated model (**Appendix A**). Differences between the existing conditions modeling approach and the Modeling Guidance are noted in this report.

All elevations listed in this report are relative to the National Adjusted Vertical Datum of 1988 (NAVD88) unless otherwise noted.

4.2 Data Sources

The following is a list of data used in this analysis:

- City of Madison 2022 LiDAR DEM
- Dane County 2022 Aerial Imagery
- NRCS Soils Data for Web Soil Survey (downloaded 04/25/2023)
- Observed impervious surfaces as digitized by MSA using recent aerial photographs
- Existing storm sewer, inlet and structure data from the City's GIS database
- Various construction drawings provided by the City
- Limited survey data provided by the Burse Surveying and Engineering, Inc.
- Site observations performed by MSA staff
- Input obtained through Public Information Meetings (PIMs)
- Rainfall and pipe flow monitoring data collected by the City and the USGS

5 Model Development

5.1 Modeling Software

The version of XP-SWMM that was used for this study was XPSWMM 2020.1.

5.1.1 Modeling Approach

Three elements of XP-SWMM were used for this model, the hydrologic model, the 1D-hydraulic model, and the 2D-hydraulic model. The hydrologic model was used to simulate the runoff resulting from various rainfall events. The 1D/2D hydraulic models were used to simulate the accumulation and flow of runoff through the watershed.

The one-dimensional (1D) portion of the model only includes subsurface drainage systems (storm sewer and culverts) and their connection to the surface drainage system. The surface drainage was modeled almost entirely in two dimensions (2D). Additional detail on the 2D portion of the hydraulic model development is included in Section 5.6.

5.2 Rainfall Files

Two different rainfall data sources were needed for this study:

- Design rainfall distributions, and
- Measured rainfall data (gauged data) used for the model calibration.

5.2.1 Design Rainfall Events

The MSE 24-hour rainfall intensity distribution with NOAA Atlas 14 rainfall depths were used for event-based modeling. The rainfall distribution uses a time step of 6 minutes**. Table 5.1** lists the design depths used in the analysis.

Table 5.1: NOAA Atlas 14 Design Storm Rainfall Depths

Rainfall Duration	100% AEP (inches)	50% AEP (inches)	20% AEP (inches)	10% AEP (inches)	4% AEP (inches)	2% AEP (inches)	1% AEP (inches)	0.5% AEP (inches)	0.2% AEP (inches)
24-hours	2.49	2.84	3.45	4.09	5.02	5.74	6.66	7.53	8.94

5.2.2 Measured Rainfall Events

Rainfall data was collected in a series of incrementally-recording tipping-bucket style rain gauges operated by the USGS and the City in regions near the watershed in the spring and summer of 2022.

The City of Madison engineering staff developed a Thiessen polygon for each rain gauge indicating the area of influence that each gauge was to be assigned for purposes of calibrating the various watershed models. The Near West watershed was divided into two regions corresponding to three separate rain gauges (**Table 5.2**, **Figure 7**).

Table 5.2: Rain Gage Locations for the Near West Watershed

Gauge Location	Operated by
Fire Station	City
SW Commuter	USGS

Rain events to be used in the model calibration process were selected in coordination with the City of Madison engineering staff. The event selection criteria focused on the largest events recorded, with the most complete rainfall station records during the monitoring period. The total duration, total depth, and 5-day antecedent rainfall for the five selected calibration events used in the study are summarized in **Table 5.3**.

Table 5.3: Calibration Events Rainfall Summary

Name	Start	Stop	Duration	Total Rainfall Depth		5-Day Antecedent Rainfall		Atlas 14 AEP Rainfall Event
				Fire Station	SW Commuter	Fire Station	SW Commuter	
15 -Jun	6/15/2022 18:55	6/15/2022 21:25	2.5 hours	0.95”	0.95”	1.18”	0.19	Less than 1-yr event for 3-hr storm (>100% AEP)
05 -Jul	7/5/2022 19:35	7/6/2022 1:00	5.42 hours	1.46”	1.14”	0.29”	0.47”	Less than 1-yr event for 6-hr storm (>100% AEP)
23 - Jul	7/23/2023 18:45	7/23/2023 19:10	0.42	0.93”	0.49”	0”	0”	Less than 1-yr event for 1-hr storm (>100% AEP)
07 - Aug	08/07/2023 23:45	08/08/2023 3:25	3.67	1.82”	0.53”	0.44”	1.98”	~2-yr event for 3-hr storm (~50% AEP)
25 – Aug	08/25/2023 0:05	08/25/2023 4:40	4.58	2.17”	1.30”	0.18”	0.20”	~2-yr event for 6-hr storm (~50% AEP)

In addition to the five calibration events, the August 2018 flood event was evaluated based on rainfall hyetographs passed on to MSA by the City. Specific rainfall was applied to all watersheds located within each Thiessen polygon to produce this simulation. At the Public Information Meeting #2 (PIM 2), residents were asked to provide feedback on the modeled inundation extents for the 20% AEP, 10% AEP and the 1% AEP design storm events. This portion of Madison in recent years has received less rainfall than the more western areas of the City, and the meeting attendees did not have feedback on the mapped inundation extents. Therefore, no additional changes were made to the model to account residential feedback.

5.3 Hydrologic Model Development

5.3.1 Methodology

Subcatchment runoff was computed using the XP-SWMM runoff (SWMM Runoff) routing methodology with Horton infiltration parameters. This approach was directed by the City.

The SWMM runoff method requires primary input values including subwatershed area, the percentage of directly connected impervious area, the subcatchment width, and the average subcatchment slope. Additionally, each subwatershed is assigned unique parameters describing the infiltration capacity of the soils within the subwatershed.

5.3.2 Subwatershed Input Data

5.3.2.1 Level of Detail

Subwatersheds (or subcatchments) were delineated to a level of detail such that subwatersheds:

- Contributed to each group of inlets along a street or at an intersection;
- Corresponded to level of detail for the modeled storm sewer system (discussed later in **Section 5.3**);
- Contributed to points along long stretches of streets with no existing storm sewer such that the model could demonstrate whether new storm sewer would need to be extended further up the street.

This approach is consistent with the Modeling Guidance referenced in **Section 4.1**.

5.3.2.2 Input Data

Appendix B contains input data for each subwatershed. The list below provides a summary overview of the input parameters and how they were calculated for use in the “pre-calibrated” model recognizing that parameters would potentially need to be adjusted as part of the calibration process.

- Subwatershed Area – calculated using GIS. A total of 249 subwatersheds were delineated within the Near West watershed with areas ranging from 0.5 to 21.9 acres with a median size of 4.9 acres. Two additional watersheds were delineated that drain directly to Lake Mendota and Lake Monona. Since these areas do not drain through City infrastructure, they were not included within the inundation mapping. An additional 83 subwatersheds were added to cover the entirety of the UW campus.

- Impervious / Pervious Area

- Total Impervious Area – The impervious area within the watershed was provided by the City based on 2020 imagery, and manually updated by MSA using 2022 aerial imagery into the following five categories:
    - Street
    - Roof
    - Driveway
    - Parking
    - Sidewalk

- Directly-connected impervious area. Impervious area within the watershed was assigned a level of 'direct connectivity' according to ratios published in the WinSLAMM computer model standard land use data tables.

- Indirectly-connected impervious area. Impervious area not classified as directly connected were classified as indirectly connected per Modeling Guidance. Runoff from indirectly connected impervious areas were directed via model routing, to flow over pervious areas within the hydrologic model before being transferred to the hydraulic model.

- Pervious area, corresponding to lawns, terraces, parks, and greenways.

Internal subwatershed routing was used as follows:

- Directly-connected impervious area assigned as subcatchment 1 and routed to subwatershed outlet.

- Indirectly-connected impervious area assigned as subcatchment 2 and routed to pervious area.

- Pervious area assigned as Subcatchment 3 and runoff (including run-on from Subcatchment 2) routed to subwatershed outlet.

The sum of the area of directly connected impervious, indirectly connected impervious, and pervious areas equaled the total area of the subwatershed.

- Subwatershed width was calculated by manually delineating (in GIS) the principal flow path of each subwatershed from its outlet to its physically most distant upstream watershed boundary. The subcatchment area was then divided by the length of this flow path to calculate the subwatershed width.

  Width = Area / Hydraulic Length

  The same width value was assigned to each of the three subcatchments described above (directly connected impervious area, indirectly connected impervious area, and pervious area).

- Slope for the subwatershed was computed using the LiDAR DEM and computed as the average percent slope along the hydraulic length of each subwatershed. The same slope was assigned to all three subcatchments. Subwatershed slopes range from 0.7% to 19.6% with a median of 3.9% (this is inclusive of both the Near West subwatersheds and the UW Madison Campus subwatersheds).

- Infiltration parameters were assigned as an area-weighted average of the different hydrologic soil groups (HSGs) within a subwatershed. Horton infiltration parameters for each soil HSG were initially taken from the Modeling Guidance Document referenced previously; however, infiltration parameters were ultimately modified during the calibration task.

- Antecedent runoff conditions were assumed to be standard for all statistical events simulated, with identical initial infiltration rates assigned for each event.

- Depression storages for impervious and pervious areas were set consistent with the Modeling Guidance referenced previously and applied to all events simulated.

- Runoff routing destination / receiving node – All subwatersheds were routed to either 1D or 2D surface nodes to begin inundation on the surface. Receiving nodes fall into two categories:

    - “Orphan” nodes are nodes where no storm sewer currently exists, but runoff to the 2D surface is needed to accurately reflect the potential inundation / flooding risk. Flows from these nodes may flow over the 2D surface and contribute to the 1D system. Similarly, excess runoff from nearby 1D system elements may flow overland to collect at the location of an orphan node.

    - A surface node that is the upstream end of a culvert or storm sewer system. These nodes are also connected to both the 1D and 2D model systems.

5.4 1D Hydraulic Model Development

5.4.1 Level of Detail

City of Madison Modeling Guidance requires, with flexibility, the following level of detail for the 1D hydraulic model:

- **Public System**
    - Standard: 18” pipes (or equivalent) and larger
    - Process exemptions: Provided justification for reason that the pipe does not need to be modeled in order to evaluate the system relative to the City’s Flood Mitigation Targets that are outlined in the Modeling Guidance.
    - Process for requiring inclusion of smaller pipes: Necessary when they are only pipes draining a part of the public system
- **Private System**
    - UW Campus Stormwater System Standard: 18” pipes (or equivalent) or larger.
    - Process for requiring inclusion of UW pipes: Additional pipes were added so that subwatershed areas were approximately the same size.
    - Non-UW Private System Standard: Not included
    - Process for requiring inclusion of private pipes: Necessary for modeling stormwater detention facilities or when they are a major part of the system

Figure 8 illustrated the 1D storm sewer system that is included in the model.

5.4.2 Hydraulic Conveyance Systems Analysis

All storm sewer and culverts were modeled with inputs consistent with the Modeling Guidance referenced previously. Inverts, pipe sizes, pipe types, and pipe shape were input from a variety of sources as outlined in **Section 4.2**. Where conflicts in data sources existing, the most reliable data source was used.

5.4.3 Inlet Capacity Analysis

Per the scope of work for this specific study, inlet capacity analysis was not included in this watershed study. It was assumed that sufficient inlets were present to accommodate stormwater flows.

5.5 Detention Pond Analysis

There are no public stormwater detention ponds within the Near West watershed. Underground storage was included beneath UW Madison Parking Lot 45 on North Mills Street as well as the storm sewer pump station at the railway underpass on N Park St. The UW Madison campus has several stormwater detention ponds (15, inclusive of the 1918 Marsh) that were reviewed as part of this study and eight were modeled. Hydraulic structures controlling discharges from the ponds were entered into the 1D model system according to the information provided by construction plans, GIS databases, topographic survey and visual inspections. The stormwater detention ponds included within the XPSWMM model are:

- 1918 Marsh/Nielsen Tennis
- Eagle Heights 1
- Eagle Heights 2
- Lot 60 Storm Basin
- Near West Playfield CoGen (3)
- Nielsen Pond

5.5.1 Connections to the Wingra Proper Watershed

The Near West watershed (as defined by this study) is approximately 1,271 acres.

However, under runoff conditions above a certain threshold, some of the stormwater runoff that during small rain events would flow to the southwest to the Wingra Proper watershed, will instead flow to the northeast into Near West. Storm sewer on Vista Road/Rugby Row will surcharge runoff into Near West during a 3.45 in rainfall event (20% AEP) and above. Storm sewer on Monroe Street will discharge runoff into Near West during a 6.66 in rainfall event (1% AEP) and above. **Figure 3** shows the connection between these two watersheds. This additional area equates to approximately seven (7) acres.

5.6 2D Hydraulic Model Development

5.6.1 2D Modeling Area

With the exception of the University Bay Drive greenway channels (8) and the various UW detention ponds (8), the entire surface drainage system was modeled in the 2D model layer.

5.6.2 2D Terrain Data

The 2022 LiDAR DEM was used for the 2D terrain. The DEM was modified according to the available construction plans to reflect an approximately finished grading condition. This was needed in certain areas where the 2022 LiDAR DEM contained construction projects where the ground surface was temporarily lowered and ultimately filled in.

It should be noted that the LiDAR DEM for wet detention ponds (such as the 1918 Marsh in the UW Campus) reflect the pond water level and not the true ground surface. However, since the permanent pool of these ponds is not typically available for flood storage, the LiDAR DEM did not need to be edited to accurately model these systems.

5.6.3 2D Grid

For the Near West watershed, a 10-foot grid cell was assigned. A grid orientation default of 0 degrees was used as this visually appeared to match the orientation of most public streets within the watershed.

5.6.4 2D Land Use and Roughness Values

Figure 9 shows the Manning's n roughness value that was assigned to the 2D terrain. All values assigned were in accordance with City Modeling Guidance.

Figure 10 shows the Land Use designations which were assigned throughout the watershed. As described in **Section 5.3.2.2**, the land use was used in conjunction with the digitized impervious data to determine DCIA and UCIA within each subwatershed.

5.6.5 Inactive Areas

Per the Modeling Guidance, all buildings were modeled as inactive areas within the 2D surface. It is important to note that this approach requires engineering judgment when evaluating model output to determine whether a building is at risk for flooding, since it is unknown whether a building has low openings above or below modeled flood elevations. Additionally, this approach ignores any minor storage that flooded buildings provide.

All open channels (8) and detention ponds (8) which were modeled using the 1D hydraulic model layer, were indicated as inactive in the 2D model layer to not 'double count' the hydraulic conveyance capacity and flood storage volume of the channel.

5.6.6 1D-2D Interface Lines

1D-2D interface lines were drawn completely around all channels and detention ponds, thereby allowing flow to pass between the 1D and 2D layers as hydraulic conditions between the two model layers dictated.

5.6.7 2D Boundary Conditions

There are several locations where surface flow was predicted to leave the study area under the scenarios evaluated in this study. In these locations, a 2D boundary line was added to the model with an elevation set below the road ground elevation as defined by the 2D surface to allow surface flow to leave the model. These locations include:

- Lake Mendota (set lake level elevation to 850.9’)
- Monona Bay (set lake level elevation to 846’)
- University Houses parking lot (into Willow Creek Study Area)
- North Allen Street (into Willow Creek Study Area)
- Commonwealth Avenue (into Wingra Proper Study Area)
- Madison Street (into Wingra Proper Study Area)
- South Randall Avenue (into Wingra Proper Study Area)
- East Johnson Street (into East Isthmus and Yahara Study Area)

6 Model Calibration

6.1 Recorded Rainfall and Flow Data

Refer to **Figure 7** for locations of the three storm sewer Level Loggers, the one Flow Meter, and three Rain Gages which recorded data from Spring to Summer of 2022.

6.2 Baseflow Conditions

Level logger data obtained during the metering process was very steady in periods without rainfall. Baseflow conditions within the metersheds were considered to be negligible. The one exception to this was the presence of high-water levels appearing occasionally at the Regent Street meter after large rainfall events. However, this effect had dissipated before each of our calibration events.

6.3 Selected Runoff Events

As described previously in **Section 5.2.2**, five (5) rainfall events were used to calibrate the model using rainfall, water level and flow monitoring data collected by the USGS under a separate contract with the City.

The 5 events for use in the calibration were selected in collaboration with City staff. Events were selected with the following considerations (generally in order of importance):

- Total rainfall/recurrence interval estimate
- Functioning monitoring equipment
- Differences between events (i.e. attempting to avoid similar events)

Based on these factors, the events summarized in **Section 5.2.2** were selected for use in the calibration.

6.3.1 Metering Gauge Issues

Data collected at the Bassett Street flow meter appeared to be inconsistent and the readings did not match the rainfall responses anticipated within the piped system. Results from this meter were subsequently not used when analyzing model accuracy. Issues with flow meters were recorded in other watershed studies; therefore it was assumed to be an equipment error. Refer to the Calibration Memo (**Appendix C)** for further detail.

The Regent Street Flow meter also reported unexpected readings within the large dual box culvert. City staff knew the box could be in poor condition and entered the box culvert to take size measurements and make note of the system's condition. It was discovered that portions of the dual box culvert had been replaced with two elliptical pipes, with less capacity than the upstream and downstream boxes. The flow meter was located downstream of this restriction. Therefore the meter readings were likely impacted by turbulence, as the flow is constricted within the elliptical pipes and then transition back to the larger boxes. Based on this, the Regent Street flow meter readings were given less weight when completing the calibration.

6.4 Calibration Performance

The criteria for calibration are as follows:

- Overall average model bias for water surface elevations (or flow) is within +/- 5% with reasonable effort made to minimize the largest absolute error while at the same time balancing that effort with the relative importance of the model results at each monitoring site location.
- The largest absolute error at each monitored location is defined as +/- 25 percent.
- These calibration criteria are set recognizing that there may be some circumstances where calibration at a specific location cannot be accomplished. For example, to calibrate a larger portion of the model and/or produce results that are more accurate for the larger events, a particular gage may have an error that exceeds the 25% threshold.

6.4.1 Calibration Results

Tables 6.1, 6.2 and **6.3** summarize the model bias for each event at each level logger. Graphs comparing model results against metered data are shown in the Calibration Memo, seen in **Appendix C**. The metric of Stage x Time was used to estimate overall simulation bias.

Table 6.1: North Brooks Street Level Logger Bias Summary

Event	Metered Data		Modeled Data			
	Maximum Stage (ft)	Stage x Time (ft-s)	Maximum Stage (ft)	*% Difference*	Stage x Time (ft-s)	*% Difference*
Jun 15	2.53	141.2	2.12	-20%	79.7	-77%
Jul 05	1.77	119.1	2.03	13%	150.1	21%
Jul 23	2.63	114.9	4.80	45%	156.3	26%
Aug 07	3.32	132.2	3.84	14%	179.8	26%
Aug 25	1.95	153.0	1.81	-8%	175.0	13%
Combined		**660.4**			**740.8**	**12%**

Table 6.2: Regent Street Level Logger Bias Summary

Event	Metered Data		Modeled Data			
	Maximum Stage (ft)	Stage x Time (ft-s)	Maximum Stage (ft)	*% Difference*	Stage x Time (ft-s)	*% Difference*
Jun 15	1.38	68.2	1.42	3%	49.9	-37%
Jul 05	1.36	113.1	1.48	9%	73.8	-53%
Jul 23	1.59	110.4	1.64	3%	74.3	-49%
Aug 07	1.90	130.6	1.66	-15%	104.9	-25%
Aug 25	1.30	152.8	1.44	10%	129.9	-18%
Combined		**575.1**			**432.8**	**-25%**

Table 6.3: Camp Randall Level Logger Bias Summary

Event	Metered Data		Modeled Data			
	Maximum Stage (ft)	Stage x Time (ft-s)	Maximum Stage (ft)	*% Difference*	Stage x Time (ft-s)	*% Difference*
Jun 15	2.81	102.4	2.39	-17%	76.1	-35%
Jul 05	2.16	160.1	2.07	-4%	129.9	-23%
Jul 23	2.88	171.0	3.36	14%	131.6	-30%
Aug 07	2.66	172.3	2.55	-4%	148.1	-16%
Aug 25	2.19	218.2	1.84	-19%	174.9	-25%
Combined		**824.0**			**660.6**	**-20%**

7 Results Evaluation

As noted in the Executive Summary, **Figures 11-19** illustrate the calibrated model results for the design storm events. Inundation figures were prepared for the 50% AEP, 20% AEP, 10% AEP, 4% AEP, 2% AEP, 1% AEP, 1% AEP as a long duration storm, 0.5% AEP, and 0.2% AEP.

7.1 Model Results Compared to City Observations

Existing conditions model results can be compared against the City Staff observations outlined in **Section 2.3**.

Flooding from the August 2018 event was less intense in the Near West Watersheds compared to areas further west. Therefore, residents in this watershed did not report highwater marks or provided anecdotal evidence to the City staff about flooding during this event. This event was not mapped as the inundations results were insignificant compared with even the smallest of the Design Rainfall Events.

To better understand and quantify the modeling results, a set of 25 locations were identified, and maximum flooding depth and duration of flooding was tabulated for a range of design storm events to use as quick reference for City staff. A map of the identified locations and associated tables are included in **Appendix D**.

7.2 Model Results Compared to Flood Mitigation Targets

The City identified five (5) major Flood Mitigation Targets. **Figures 20 - 25** show that there are numerous locations where the system does not meet the identified flood mitigation targets. Note that for each target, only regions within the City limits were included within the analysis. MSA prepared a series of GIS python scripts to determine problem locations based on the inundation maps produced by the Near West model and other GIS datasets; these scripts will be provided to the City at the end of the project for future use.

Note that some of the Target criteria refer to “street centerlines”. Centerlines are defined as the centerline of the road; for most roads, there is a single centerline but there are two centerlines for boulevards where there is a median between each side of traffic.

Target 1: 10% AEP design storm event:

a) **No surcharging onto the street for up to the 10-year design storm; water shall be contained within the pipes and structures*.**

   **There are locations within the City where low points exist that pond water; these low points are excluded from this target and will be addressed as streets are redesigned.*

   This criterion was evaluated by buffering all of the modeled publicly owned access structures and inlets by 15-feet. Any buffered structure that intersected the 10% AEP inundation raster was classified as a ‘potential problem location’.

   Of the 465 modeled publicly owned access structures and inlets, 268 of them were classified as a potential problem location (**Figure 20**). Note that the model did not include all of the publicly owned structures.

b) **For locations limited by known inlet capacity, allow no more than 0.5 feet of water above storm sewer inlet rim.**

Evaluating inlet capacity restrictions was beyond the scope of this watershed study. See **Section 5.4.3**.

Target 2: 4% AEP design storm event:

a) **Centerline of street to remain passable during 25-year design storm with no more than 0.5 feet of water at the centerline**.**

***Note that the watershed study modeling approach will not explicitly account for cross flow conditions where more gutter flow on one side of the street can overtop the crown.*

This criterion was evaluated by using a road centerline dataset, split at 100-ft intervals and intersected with the 4% AEP inundation raster. Any segments with an average of 0.5-feet or more of water depth were classified as a ‘potential problem location’.

There are 4.2 miles of road centerlines (8.4% of all centerlines) with more than 0.5 feet of water at the centerline during the 4% AEP design storm (**Figure 21**).

Target 3: 1% AEP design storm event:

a) **No home or business will be flooded during the 100-year design storm.**

This criterion was evaluated by buffering all buildings by 5-ft, and intersecting them with the 1% AEP inundation raster. Any buffered building with an inundation depth of 0.5-feet or greater was classified as a ‘potential problem location’. Note that this analysis does not account for modifications residents take to mitigate flooding on their own properties. This metric does include structures that are not occupied, such as garages, sheds, and parking facilities.

There are 319 structures (6.8% of all structures) that could be impacted by the 1% AEP design storm (**Figure 22).**

b) **Enclosed depressions to be served to the 100-year design storm (which can include safe overland flow within street, easements, greenways or other public lands).**

This criterion was evaluated by identifying all of the enclosed depressions at least 0.25 acres in size, based on the 2017 LiDAR DEM. This was completed using the LiDAR processing GIS tool created by Dr. Qiusheng Wu (https://github.com/giswqs/lidar). All depressions were intersected with the 1% AEP inundation raster. Any depression that had a maximum depth of 1-foot or more and touched public land (e.g. street ROW, greenway or SWU lands, etc) was flagged for review. The public lands and private ponds were removed from this subset of enclosed depressions, to determine if the depression also encompassed a portion of privately owned land.

Any enclosed depression that touched public land, included at least 0.25 acres of private land, and had more than 1-foot of inundation depth during the 1% AEP event was classified as a potential problem area.

There are nine (9) depressions within the watershed at that are not adequately draining during the 1% AEP design storm (**Figure 23**).

c) **Greenway crossings at streets to be served to the 100-year design storm.**

The Near West watershed does not have any greenway crossings; therefore this target was not applicable to the Near West Watershed. See **Figure 24**.

Target 4: 0.2% AEP design storm event:

a) **Safely convey stormwater; i.e. limited impact on private property**

This criteria was evaluated by buffering all buildings by 5-ft, and intersecting them with the 0.2% AEP inundation raster. Any buffered building with an inundation depth of 0.5-feet or greater was classified as a 'potential problem location'. Note that this analysis does not account for modifications residents take to mitigate flooding on their own properties. This metric does includes structures that are not occupied, such as garages, sheds, and parking facilities.

There are 542 structures (11.6 % of all structures) that could be impacted by the 0.2% AEP design storm (**Figure 25**).

Target 5: Provide flooding solutions that do not negatively impact downstream properties

This was incorporated into the recommended improved designs (See **Section 9**)

7.3 Limitations of Study

The Near West Watershed Study is a planning-level study, and as such, it has several limitations for using the model and results beyond the scope of this study. While not an exhaustive list, the following limitations should be considered when reviewing results of using the study for future work:

- Flooding on private property due to localized drainage issues (such as backyards that do not drain well) are outside the scope of this study. Inaccuracies in the LiDAR DEM due to the coarseness of the 10 ft grid cell could introduce some errors where a finer detail would not. An example of this would be a narrow landscaped swale from a back of lot to the street. Such grading may not be reflected in the modeled surface.
- Because this study covers two (2) square miles, it is not possible to review and confirm flood inundation (or lack thereof) at every location throughout the watershed. Further model calibration has its limitations as well, as described in **Section 6**.
- Inlets were modeled as simplified combined inlets into the system. Inlet capacity was not evaluated, and additional analysis may be required. Further, storm sewer laterals were in general not included in the analysis. Therefore, additional site-specific evaluations that more accurately looks at each individual inlet may be needed.
- Because every inlet was not modeled, there may be locations where there is bypass flow or flooding depth on one side of the road than the other than what is shown in the model results.
- As noted in the calibration (see **Appendix C**), the model may be biased to estimate marginally less runoff volume than actual rainfall would produce. Peak runoff rates appear to closely match that of actual rainfall.
- This study is not intended to be used for FEMA floodplain mapping purposes.

8 Public Engagement

As part of the Near West Watershed Study, the City carried out an extensive public information effort. In addition, various social media and web-based communication methods and public meetings were held. Key elements in the public information program are summarized below; with additional information available via the City's project website:

https://www.cityofmadison.com/engineering/projects/near-west-watershed-study

Since the Covid-19 global pandemic in 2020, in-person meetings were canceled and replaced with online meetings conducted over Zoom. On-site focus group meetings (where residents walked through their neighborhood to report historical observations) were not completed for watershed studies since that date. Instead, focus groups were conducted as online break-out sessions, where residents viewed maps of the calibrated inundation depth rasters from different storm events. While not ideal, residents were still able to communicate their thoughts on the current model calibration, provide feedback on their observations across the entire watershed and ask questions of City and MSA staff.

8.1 Public Informational Meeting

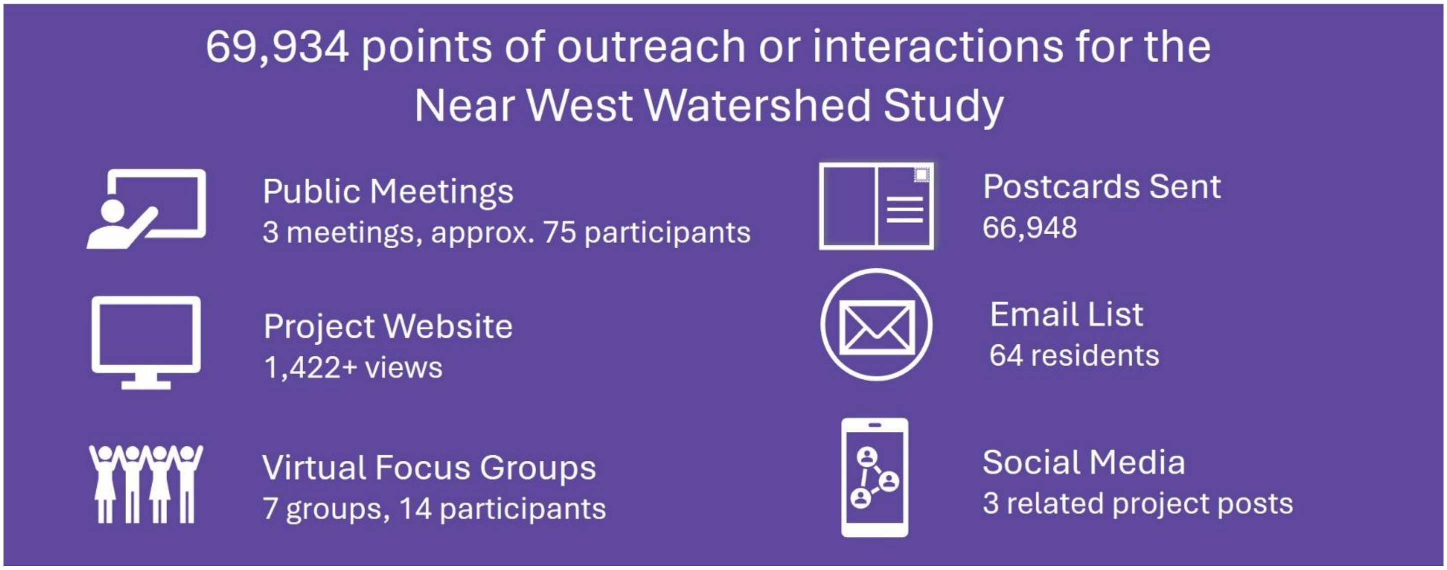
An initial public information meeting (PIM #1) was held on October 24, 2022 over Zoom. The purpose of the meeting was to inform the public that the study was ongoing, provide an overview of what will be accomplished by the study, and collected feedback from residents on experienced flooding.

A second public information meeting (PIM #2) was held on October 25th, 2023, also over Zoom. Attendance was estimated to be around 20 individuals, and 'break out sessions' were held to allow residents to provide comments based on Focus Group areas. The discussion focused on the existing conditions modeling results, asking residents if the maximum inundation depth maps aligned with their local understanding of flooding within their neighborhoods.

The final public information meeting (PIM #3) was held on March 18th, 2025 over Zoom. It was a combined meeting presenting the results of both the Near West And John Nolen watersheds. This presentation restated the targets of the watershed studies and presented the recommended solutions within the Near West Watershed. Attendees were encouraged to ask questions about the project and recommended solutions within the meeting, either by writing in comments into the "chat" feature or asking questions aloud.

8.2 Focus Groups

City Staff made efforts to identify residents interested in focus groups but due to very low interest among residents standalone focus groups were not scheduled for this watershed study. However, approximately 10 individuals participated in break-out sessions conducted immediately after PIM #2. This meeting was intended to allow residents to ask questions and provide historical observations on local flooding. Since the online platform allowed residents outside of the designated Focus Group areas to attend, residents provided feedback on known flooding concerns across the watershed. Similar breakout sessions were included in PIM #3. Questions and comments from the public information meetings are summarized in **Appendix E**.


69,934 points of outreach or interactions for the Near West Watershed Study
Public Meetings
3 meetings, approx. 75 participants
Postcards Sent
66,948
Project Website
1,422+ views
Email List
64 residents
Virtual Focus Groups
7 groups, 14 participants
Social Media
3 related project posts

9 Recommended Solutions Development

Upon completion of the Existing Conditions analysis (outlined in Sections 1-7 of this report), a draft Existing Conditions report was approved by the City, and the project team moved into the second phase of the study, evaluating different flood mitigation alternatives. The recommended solutions development process focused on Peak Flow Control (PFC) solutions. PFC solutions are defined by the City as any stormwater control measure that can store or convey water, but not infiltrate water.

9.1 Overall Process and Methodology

This chapter outlines the methodology or process used to identify the recommended solutions and elicit feedback from different agencies within the City. A list of all the solutions considered, including those that were not ultimately recommended, is included with brief descriptions of each potential solution. **Chapter 10** provides specific details on each of the recommended alternatives.

9.1.1 Data Review

The existing conditions modeling was reviewed to identify locations within the watershed where City targets were not met for one or more targets. These locations were identified by reviewing the existing flood conditions and identifying a qualitative cause(s) at each location. Possible causes of flooding included: storm system is undersized, inadequate inlet capacity or poorly placed inlets, enclosed depressions with undersized outlets, and often tailwater conditions limiting discharge from the stormwater system.

9.1.2 Solution Brainstorming

After the initial data review, MSA met with the City Engineering staff on February 1st, 2024, and again on March 7th, 2024 to discuss the existing condition model results, outline conceptual scenarios and identify potential opportunities for flood mitigation measures. Note that although the Near West watershed has many outfalls, many are restricted by the existing lake levels. Increasing the pipe capacity only has a limited effect when the outlet is underwater, creating a tailwater effect. The City noted that many of the outfalls to Lake Monona are regularly underwater.

Improvements were grouped by areas/neighborhoods, and some involve a combination of improvements. Most involve upsizing piped infrastructure or changing routing to reduce strain on intersections prone to flooding. Solutions were targeted within street-right-of-way areas and lands already owned by the City for stormwater use. Regional storage solutions, such as detention basins, were not viable in this watershed simply because there is not much, if any, available public open space within the study area for regional storage.

9.1.3 Evaluation of Potential Solutions

Following the brainstorming sessions, MSA developed preliminary solutions to address the flood mitigation targets for each of the identified problem areas. The calibrated existing conditions XPSWMM model was used to evaluate most of the flood control solutions (see **Section 9.2** for a brief description of all the solutions considered through this phase of the study). In one area, a HydroCAD were used to determine inlet capacity requirements; in another, a spreadsheet tool estimated the capacity of the street for overland flow. In both situation, the XPSWMM model was too coarse to easily support solution development.

9.1.4 Discussions of Potential Solutions with City Engineering Staff

Throughout the solutions modeling, MSA met with the City to review the intermediate modeling results and discuss the benefits and drawbacks of each. These discussions ultimately led to some new solutions being added to the list, while others were removed from further consideration. Some solutions were modeled individually at first, and then subsequently modeled in tandem with other improvements to determine their relative contribution to flood reductions.

9.1.5 Convergence on Solutions

As the evaluation progressed, a set of solutions (described in **Section 9.2.2**) were determined to provide the most viable path towards meeting the flood control targets for the project. This convergence was based on the performance of the solutions, technical feasibility and import from the City Engineering staff. All the recommended solutions were subsequently mapped using the City's preferred template (to ensure that recommended solutions from the various watershed studies appeared in a similar format) and provided to the City of internal review.

9.1.6 City Agency Meetings

Once there was a convergence on solutions, the City Engineering Staff met with different City of Madison agencies to discuss the potential solutions and the challenges/obstacles to implementation. Engineering staff presented the set of solutions at a regularly scheduled Public Works Infrastructure (PWI) meeting. This standing meeting includes representatives from the Mayor's Office, Water Utility, Parks Division, Fire Department, Metro Transit, Planning Division, Community Development Division, Economic Development Division, Streets Division, Forestry, Transportation Engineering, Streets Design Section, and Engineering Operations Section.

At the meeting agencies were given an opportunity to ask questions, provide comments, or request additional agency specific meetings or coordination. Do to the fact that the solutions in the Near West Watershed are all storm sewer improvement projects, there were no additional agency meetings or coordination requested at PWI. Engineering staff only met directly with the Parks Department to discuss potential park impacts within the watershed from the recommended solutions.

Appendix F provides a summary of the information shared in the City's internal meetings about the Near West watershed recommended solutions.

9.1.7 Finalization of Solutions

The City agency meetings indicated that the improvement at the James Madison Park should incorporate "… plans for green infrastructure and amenities in the area of the proposed upsized outfall". The James Madison Park Master Plan, approved in 2019 shows a proposed emergent wetland/living shoreline and boardwalk, with the intention to provide both some stormwater treatment and education. The City Engineering Staff should coordinate closely with Parks Department to ensure that any stormwater improvements match the planned uses as indicated in the Park Master Plan. A link to the master plan is included below for reference.

https://www.cityofmadison.com/parks/projects/james-madison-park-master-plan

9.1.8 Drafts sent to all City Agencies for Comment

A copy of the recommended solution designs and cost estimates were provided to the City Agencies for additional comment. There were no changes or comments on the recommended solutions. It was noted that any stormwater improvements within James Madison Park should have good coordination with the Parks department and comply with the master plan.

9.2 Description of All Solutions Considered

9.2.1 Solutions Not Recommended

The following flood mitigation methods were considered within the evaluation process; however, they were not ultimately recommended. Alternative solutions described below were evaluated only so far as was necessary to find them infeasible or to be less feasible than other solutions addressing the same flooding concern. If, in the future, recommended alternatives are abandoned in favor of any of the solutions described herein, additional detailed investigations into the feasibility of each alternative will be required.

9.2.1.1 N Hamilton St (from E Gorham St to E Johnson St)

- **Conceptual Project Description**: Some of the recommended improvements focused on the outfall in James Madison Park, immediately downstream of N Hamilton St. This concept including upsizing pipes along Hamilton St from E Gorham St to E Johnson, so there was increased capacity for the entire length of the improvement.

- **Reason for Exclusion**: The City indicated that this portion of N Hamilton St had been recently reconstructed, and there was no room in the ROW for enlarged pipes. Therefore, MSA was asked to exclude upsizing pipes along N Hamilton St. The final recommended improvements therefore do not include any improvements along N Hamilton St.

9.2.1.2 Outfall at James Madison Park

- **Conceptual Project Description**: There are two piped outfalls at James Madison Park, downstream of N Hamilton St. One is a 5'x4' box culvert and the other is a 38"x60" elliptical pipe. Originally, the City indicated that the two pipes could be consolidated into one, but the existing pipes are underwater and have limited cover. Increasing the vertical dimension of the pipes would not likely be feasible. The City then directed MSA to increase the capacity of the elliptical pipe in the recommended solution, resulting in a 54" equivalent pie size. However, it was then realized that the box culvert was significantly older (installed in 1928) and therefore requested the box be upsized, to match the vertical dimension. Ultimately, upsizing either outfall will provide benefit to this system, and the final design can decide which to upsize based on site-specific factors.

- **Reason for Exclusion**: When discussing the recommended improvement with the Parks department, it was noted that the box culvert was quite old, and likely would need repair before the elliptical pipe. Therefore, the recommended solution was shifted to increase the capacity of the box culvert and leave the elliptical pipe as-is. If this project moves into design, both options would be viable, and should be considered by the design staff.

9.2.1.3 Outfall at N Lake St (from Langdon St to Lake Mendota)

- **Conceptual Project Description**: One of the recommended solutions increases the pipes capacity along N Lake Street (from University Avenue to Langdon Street). The City anticipated that N Lake St would be reconstructed in the near future, and noted there would not be any improvements made to State St as part of that project. The City requested that MSA model the improvements up to Langdon St, keeping the existing 4'x8' box size to the outfall at Lake Mendota (the outfall was not upsized). MSA also ran a scenario where the outfall size was increased to 4'x10'.
- **Reason for Exclusion**: The City indicated they would only like the recommended improvement to reach Langdon St and keep the existing outfall (4'x8' box). The City indicated that Lake St had scheduled construction and the stormwater system was not upsized as part of that project due to competing factors.

9.2.1.4 N Bassett St, W Johnson St, and W Mifflin St Improvements

- **Conceptual Project Description**: There is limited capacity in the existing N Bassett St trunkline discharging to Lake Monona. There are currently two parallel pipes (6.5' circular and a 3'x6' box) with ~600cfs for the Q100 running from W Johnson St to the outfall. An alternative was modeled increasing the capacity by replacing these with two parallel box culverts (two 6'x10' boxes) with ~900 cfs for the Q100. The scenario provided flood reduction benefits, but the City indicated that these improvements would likely not occur for several decades. Additional improvements were also incorporated including:
  - Increasing the pipe capacity along W Mifflin St (increased pipe sizes ranged from 30"- 48")
  - Increasing the pipe capacity along W Johnson St (increased pipe sizes ranging from a 36"-60")
  - Increasing the pipe capacity along N Bassett from University Ave to W Johnson, immediately upstream of the proposed parallel 6'x10' boxes (increased to 72")

- **Reason for Exclusion:** Although the scenarios did show flood reduction, an upgrade to the entire N Bassett St system was determined by staff to be very unlikely. The City originally considered upsizing the pipes at the very downstream end of Basset St (under North Shore Dr) potentially as part of an upcoming reconstruction of John Nolen Dr. However, upon further consideration, improvements at the outfall to increase capacity would likely be sunk costs, with little future benefit, as it would be unlikely for the rest of the required improvements along N Bassett St to be constructed. Therefore, the City's opinion was cost-benefit ranked low, relative to other projects proposed within the City. Once the trunkline improvement along N Bassett St was removed from consideration, the other improvements in upstream areas, along W Johnson St, and W Mifflin St, were also removed from consideration.

9.2.1.5 North Prospect Ave Storm Sewer Reroute

- **Conceptual Project Description**: Existing conditions modeling had flooding on Regent St between S Allen St and S Prospect Ave; water from the region contributes to inundation on Commonwealth Ave before eventually looping back to main trunkline along Regent St. A scenario was run to cut through the hill on Regent St, to take water from N Prospect directly to the box culvert at Regent and Spooner (bypassing the connection to Monroe St). The new pipe would be deep, but still constructable. It was hoped that the direct routing of this system would change the event timing, and water from this area would reach the Regent St box before the peak in a large storm event.

- **Reason for Exclusion:** The model was run with a 36” pipe from N Prospect St to Spooner, with the main box culvert along Regent St also upsized to a 4’x14’ box. While this did reduce flooding in the upper portions of the watershed, for larger storm events (roughly those bigger than a 5-year event) there was increasing in flood depths in downstream areas of the watersheds. It was generally found that improvements upstream of the main trunkline along Regent St would shift the flooding impacts, and therefore was not selected to be a recommended improvement.

9.2.1.6 Rowley Ave/Commonwealth Relief Sewer

- **Conceptual Project Description**: This scenario was also an attempt to address inundation along Commonwealth Ave. Starting at roughly the Blessed Sacrament Church, a pipe could be run east along Rowley Ave, connecting at Regent St and Spooner.

- **Reason for Exclusion:** This scenario was not optimized in XPSWMM after reviewing the North Prospect Ave scenario (see **Section 9.2.1.5**). It would likely provide a small benefit to the low points along Commonwealth Ave but would put more pressure on the Regent St box, shifting problems downstream. This improvement was not recommended, as it shifted flooding to downstream areas within the watershed.

9.2.1.7 Madison St and Lincoln St Storm Sewer Reroute

- **Conceptual Project Description**: There is an enclosed depression on Madison St at Lincoln St and the flood inundation maps indicate that most of the water stays within the right-of-way but could impact several properties for the 1% AEP event. City staff have not heard reports of flooding from residents in this area, so it is possible the model is over-predicting inundation depths in this area. A scenario was run to create a bypass storm system that would run northeastern along Madison St, and then turn southwest on Van Buren St to connect to he Wingra Proper Watershed (leaving the Near West Watershed). Other parallel streets (other than Van Buren) could be considered, but this was the shortest possible run for the new storm sewer.

- **Reason for Exclusion:** MSA modeled a new 24” pipe along Van Buren, leaving the Near West watershed. The solution did reduce flooding along Madison St, but the scenario did not integrate the modeling of additional pipes from the Wingra Proper Watershed (modeling completed by Brown and Caldwell). Therefore, it was not possible to determine if the additional water entering the Wingra Proper watershed would increase flooding downstream. Staff noted that the Wingra Proper watershed had noted there were already issues at the bottom on Van Buren with overflower/erosion, and an improvement to this system might be included within their list of recommended improvements. However, those improvements had not yet been finalized at the time of writing this report.

  Since the Wingra Proper watershed had noted some erosion/overflow concerns near the outfall on Van Buren St, this scenario was not included in the recommended solutions. However, if the Van Buren system is upsized, as part of the Wingra Proper watershed study, this alternative could be revisited.

9.2.1.8 Upsizing Pipes along Milton St, Under Meriter Hospital

- **Conceptual Project Description**: The Milton St stormwater system parallel's the Regent St storm system and could provide supplementary capacity to help drain this area.

- **Reason for Exclusion:** The City indicated that the pipes that leave Milton St are underneath the Meriter Hospital and are unlikely to be upsized anytime in the future. Access to these pipes is a concern under existing conditions, and creating a larger outlet through this corridor was not desirable for long-term maintenance. MSA did not model any scenarios for this portion of the system.

9.2.1.9 Upsizing Pipes along Park St, from Regent St to the outfall

- **Conceptual Project Description**: The piped conveyance along Regent St combined with another piped system at Regent and E Campus Mall and turns south. A third trunkline joins at Braxton Place, eventually passing underneath W Washington Ave and discharging into Lake Monona. Increasing the capacity of some/all of these trunklines could improve conveyance and reduce inundation upstream.

- **Reason for Exclusion:** The City indicated that the storm sewer draining to the outfall was already as large as will fit into the existing ROW. Therefore, MSA was told not to model any improvements to this trunkline system.

9.2.1.10 State Street Campus Garage Stormwater System Improvements

- **Conceptual Project Description**: The State Street Campus Garage, at N Lake St and University Ave, was set to be demolished and reconstructed while the Existing Conditions Watershed model was being developed. The City indicated that Hawthorne Court (a small alley immediately behind the existing garage) had experienced flooding in the past. MSA completed a site visit and visual inspect suggested the existing drainage system with the garage was undersized. The existing conditions model was revised to account for the unmapped drainage system in the garage and discussed modeling outputs with City staff.

- **Reason for Exclusion:** The City determined that the garage construction project would not incorporate modifications to the piped system within the ROW. Therefore, the new garage would need to connect to an existing drainage system. It was recommended that the new garage be designed to direct flow away from the Hawthorne Ct, and flow entirely west toward the storm system along N Lake St. While this is technically a "recommendation", it did not result in any recommended changes to the piped system within the ROW.

9.2.2 Solutions Recommended

The following flood mitigation methods were recommended for implementation within the Near West watershed. The locations of the solutions are all displayed in **Figure 26** (an index map) and individual maps **Figure 27-A** through **27-J**. Further details about each design is provided in **Chapter 10**. The solutions are all piped improvements as the watershed did not have available space for new detention basins and there are no existing regional detention basins to retrofit.

9.2.2.1 N Hancock St to Outfall System Improvements

- **Conceptual Project Description**: The existing conditions modeling showed inundation at E Johnson St and N Hamilton St, even during smaller events. This region drains northwest towards James Madison Park, with two existing outlets. This project involved upsizing the piped capacity along N Hancock St and increasing the capacity at the outfall. Note that the City requested the existing box culvert to be upsized, as it was the older of the two systems (see **Section 9.2.1.2**).
- **Iterations Considered**: Various pipe sizes were considered, accounting for existing elevations and utility conflicts. The box culvert was sized to be a 5'x7' to serve the 1% AEP event.

9.2.2.2 E Johnson St/N Pickney St/N Hamilton St/Gorham St Storm System Improvements

- **Conceptual Project Description**: The existing conditions modeling showed inundation at E Johnson St from N Hamilton St to N Pickney St, even during smaller events. This region drains northwest towards James Madison Park. This project involved upsizing the piped capacity along several connecting road segments, ending at N Hamilton and E Johnson St. Note that one portion of N Hamilton St was not upsized based on feedback from the City (see **Section 9.2.1.1**).
- **Iterations Considered**: Various pipe sizes were considered, accounting for existing elevations and utility conflicts. The original solution included the segment of N Hamilton St from E Johnson St to E Gorham St. Pipes were sized to serve the 1% AEP event.

9.2.2.3 University Ave/Lake St Storm System Improvements

- **Conceptual Project Description**: Portions of University Ave and N Lake St have inundation during large rain events.

- **Iterations Considered**: Various pipe sizes were considered, accounting for existing elevations. The original concept including upsizing the outlet (from Langdon St to Lake Mendota) but the City indicated the project would unlikely extend to the outfall (see **Section 9.2.1.3**). Pipe sizes range from 24" up to a 4'x8' box and were sized to serve the 2% AEP event.

9.2.2.4 Regent St Storm System Improvements

- **Conceptual Project Description**: The Regent St storm system is a major trunkline in the Near West watershed, and the existing conditions model displayed flooding in small storm events. The Regent St box has been repaired and patched over the years. The original design was likely a single box, but a 'cinder block wall' was built down the center to effectively create two boxes with a unique shape. Two segments were removed entirely and replaced with HERCP elliptical pipes, creating a flow restriction. **Appendix G** contains a diagram provided by the City describing the findings from a field visit. The City indicated that the HERPC elliptical pipes would have to be replaced, and that all future improvements should be compared against this new, updated baseline condition (a box for the entire length of Regent St). The City also indicated that Regent St will be reconstructed soon, and the maximum space within the ROW, accounting for the other utilities, was a 4'x14' box culvert.

- **Iterations Considered**: The existing conditions model was adjusted to account for the HERCP elliptical pipes. The first proposed scenario was replacing the elliptical pipes with dual boxes, mimicking the adjacent box segment dimensions; this was considered the new baseline for comparing all proposed conditions modeling. The final concept including replacing the Regent St box culvert with a 4'x14' box from Madison St to N Park St, serving the 4% AEP event. Downstream improvements were not considered feasible at the time of the study but could possibly be considered in the future if conditions change.

9.2.2.5 S Mills St Bypass and Vilas Ave/ S Park St Storm System Improvements

- **Conceptual Project Description**: The Regent St area has inundation event during small rainfall events. Increasing the capacity along Regent St provides some benefits, but targets are still not being met. MSA therefore considered adding in a secondary bypass, connecting to the outfall from Vilas St. The bypass system would connect to the Regent St box and head south on S Mills St. Topography in this area would require micro tunneling (the storm system is going through a hill) and therefore only circular pipes were considered. A 9'-diameter pipe was modeling up to Vilas Ave, where the improvement was changed to a box culvert, assuming this would be less expensive to construct. A secondary connection from a low point in S Park St would also be tied into the system.

  Note the 9' bypass pipe would also connect to the pipes flowing east on Milton St, directing some of the flow south rather than east under the Meriter Hospital. Not all the Milton St flows would be captured by the tunnel bypass system.

- **Iterations Considered**: The main bypass system was constrained to a circular shape along S Mills St, and capped at 9' considering to would be more challenging to fit a larger equivalent box along Vilas Ave to the outfall. The City expressed interest in understanding how much larger the bypass could be, still fitting with the ROW and capturing a larger volume of flow from Milton St, to reduce the flows passing under Meriter Hospital. Therefore, additional modeling was completed for the tunnel alternative, increasing the tunnel sizing, ranging from 5-ft to 13-ft. Increasing past 13-ft did not provide more flood reduction.

9.2.2.6 Vilas Ave/S Park Storm System Improvements Alternative

- **Conceptual Project Description**: This improvement should only be considered it the S Mill St Bypass is not constructed. Vilas Ave and S Park Street have inundation during small events. This improvement would increase the pipe capacity on Vilas Ave from S Mills St to the outfall to Monona Bay, and redirect flows from the sag on S Park St and Chandler St to the south (it currently drains east).

- **Iterations Considered**: Various pipe sizes were considered, accounting for existing elevations. Pipe sizes range from 30" up to a 5'x7' box and were sized to serve the 4-10% AEP event.

9.2.2.7 Emerald St/S Park St Storm System Improvements

- **Conceptual Project Description**: Emerald St shows inundation during small storm events. This improvement increases the capacity of the pipes along Emerald St from S Brooks St to the outfall.

- **Iterations Considered**: Various pipe sizes were considered, accounting for existing elevations. Pipe sizes range from 30" up to a 36" and were sized to serve the 4% AEP event.

9.2.2.8 Erin St/Delaplaine Ct Storm System Improvements

- **Conceptual Project Description**: Emerald St and Delaplaine Ct (from S Brooks St to S Park St) both show inundation during small storm events. This improvement increases the capacity of the pipes along Erin St (from S Mills to the outfall) and along Delaplaine Ct (from S Brooks to S Park St) . SSM Health St. Mary's Hospital is located between these improvements.

- **Iterations Considered**: Various pipe sizes were considered, accounting for existing elevations. Pipe sizes range from 18" up to a 48" and were sized to serve the 1% AEP event.

9.2.2.9 Parr St Storm System Improvements

- **Conceptual Project Description**: Parr St (from Park St to the outfall) both had inundation during the 25% AEP storm event. This improved would increase the pipe capacity for this road segment.

- **Iterations Considered**: Various pipe sizes were considered, accounting for existing elevations. The pipe is upsized to 48" and was sized to serve the 4% AEP event.

9.2.2.10 Oakland Ave/Adams St/Milton St Storm

- **Conceptual Project Description**: Oakland Ave serves as a bypass system for a portion of the upstream watershed to Regent St. The system currently has two parallel elliptical pipes from Madison St to Jefferson St, and three parallel pipes for the remainder of Oakland Ave and Adams St ultimately connecting to a 10'x4' box on Milton Ave. This improvement would replace the ageing parallel elliptical pies and replace them with equivalent size boxes (Dual 38"x60" → 3'x8' box, Triple 38"x60" → 3'x11' box). This improvement was recommended because the City recognized the age of the pipes would require replacement. Increasing the size of these pipes would require increased downstream capacity, and it was unlikely for this to occur, prior to replacing the elliptical pipes.

- **Iterations Considered**: The baseline scenario was simply replacing the existing capacity of the elliptical pipes with an equivalent box culvert. Iterations of larger box culverts, in tandem with larger S Mills St tunnel diameters were considered. The maximum box size was determined by the available space in the right-of-way (Dual 38"x60" → 3'x10' box, Triple 38"x60" → 3'x15' box).

9.2.2.11 Engineering Drive

- **Conceptual Project Description**: The University of Wisconsin Madison (UW-Madison) was in the process of redeveloping Engineering Hall during this study. Engineering Drive has flooded in the past, but improvements were not recommended in this location since there is limited downstream capacity on Regent St. In May of 2025, the UW reached out to City staff during construction, noting that some of the existing storm sewer does not match the City's mapped GIS records. The UW's engineering team had proposed a solution to improve drainage, and City staff referenced the existing conditions modeling to access this change.

- **Iterations Considered**: Conversations with the UW about Engineering Dr in May 2025 occurred after the Existing and Proposed conditions modeling was completed for the Near West Watershed, and the project had transitioned to drafting the final report. Therefore, was not modeled by the City's consulting engineer. However, the model was provided back to the City to review the area and to support construction design choices during the project. *Note that this improvement is not listed in Chapter 10, since it was recommended after the proposed solutions modeling was completed. This brief documentation in the Near West report is intended to help future City staff have a better picture of recommended improvements within the watershed.*

10 Recommended Solutions

The recommended solutions were introduced in **Section 9.2.2** and **Figure 26** is an index map, displaying all the recommended solutions within the Near West watershed. Within this chapter, the solutions are described in more detail, with specific reference to the flood reduction benefits, the land ownership for the project, known utility conflicts, other known concerns (e.g. wetlands, archeological, etc.), any anticipated permit requirements, and potential water quality benefits. A detailed figure is provided along with each recommended solution using the City's preferred template, to allow for easy comparison with recommended improvements from other watershed studies. **Figures 27 A-J** display each of the recommended improvements at a zoomed in scale, with all the City's mapped utility information. **Figures 28-36** display predicted maximum inundation depths with all the solutions implemented. *Note that **Figure 28-36** show the outputs with the S Mills St Bypass included, not the smaller Vilas Ave/Park St improvements.*

It should be noted that while there are improvements to the stormwater system functionality, even with all of the solutions implemented, there are some locations where targets were not met. These are described in further detail in **Chapter 10.9**.

It should also be noted that the improvements documented in this report are not meant to be full design-level efforts; they are conceptual solutions that help the City's Engineering Division understand the magnitude of solutions needed in a given area to meet the targets. As projects are looked at further, and if they move to the point they are contemplated for programming, then projects will then go into a more detailed design phase. This project phase collects detailed data needed for design and looks at refined design, permitting, and environmental issues associated with the project.

10.1 N Hancock St to Outfall System Improvements

Detailed Project Description

James Madison Park serves as the outfall for 61.6 acres in the northwest portion of the Near West watershed. There are two outfalls to Lake Mendota, run in parallel; one is a 5'x4' box (installed in 1928) and the other is a 38x60" HERCP (installed in 1987). The upstream watershed area is fully developed with a mix of apartment buildings, commercial properties, institutional facilities and a quarter of the Wisconsin State Capitol. Water flows north from the Capitol towards James Madison Park, and outfalls into Lake Mendota after passing through a seawall.

The existing conditions model indicated that the combined capacity of the two outfalls is not adequate to serve even the 50% AEP design storm with inundation on the street. City staff have noted that E Gorham St and E Johnson St become impassable during large storm events, but there are no reports of flooding buildings in this region. This improvement would increase the capacity of one of the outfalls. The City requested the box culvert to be replaced, as it was older and likely to require maintenance/repair sooner than the elliptical pipe. However, if this project is selected for construction, the pipes could be consolidated into a single pipe if that is preferred, or the elliptical pipe could be replaced instead. Note that the existing pipes are nearly underwater and have very minimal cover.

This improvement also extends up N Hancock St, replacing the existing 14" x 23" elliptical pipe with a 36" circular pipe to better convey water from E Johnson St to the outfall. Improvements were not extended up N Hamilton St, as the City indicated that segment was recently reconstructed, and there was not available space for upsizing storm pipes (see **Section 9.2.1.1**). Pipes were sized to serve the 1% AEP design event.

The City agency meetings indicated that the improvement at the James Madison Park should incorporate "… plans for green infrastructure and amenities in the area of the proposed upsized outfall". The James Madison Park Master Plan, approved in 2019, shows a proposed emergent wetland/living shoreline and boardwalk, with the intention to provide both some stormwater treatment and education. The City Engineering Staff should coordinate closely with Parks Department to ensure that any stormwater improvements match the planned uses as indicated in the Park Master Plan. A link to the master plan is included below for reference.

https://www.cityofmadison.com/parks/projects/james-madison-park-master-plan

A map of the recommended storm sewer improvements for the N Hancock St to Lake Mendota outfall are shown on **Figure 27-A**.

Associated Flood Reduction Benefits

As a result of the local storm sewer improvements, the City's flood control targets will be met as follows:

- **Target 1a**: The proposed solution reduces the flooding but does not eliminate all flooding within the street. This individual solution does not prevent any stormwater structures from flooding in the 10% AEP design storm.
- **Target 2a**: Inundation along the street centerline decreases with this recommended improvement, with 90 -ft of additional centerline along East Johnson St no longer having 0.5-ft of water during the 4% AEP design storm event.
- **Target 3a**: One (1) building at E Johnson St and N Hancock St is no longer impacted by the 1% AEP design storm.
- **Target 3b**: There are not any enclosed depression in this area.
- **Target 3c**: There are not any greenways within this watershed.
- **Target 4a**: This individual solution does not prevent any additional buildings from being impacted by the 0.2% AEP design storm.

Project Constraints/Considerations

This recommended solution is piped infrastructure and will be contained with the City right-of-way and within James Madison Park. Engineering staff should coordinate closely with Parks Department to ensure that stormwater improvements match the planned uses as indicated in the Park Master Plan. The upsized outfall will also pass through the existing seawall to Lake Mendota. It is anticipated the project will require close communication and coordinate with the WDNR to modify the shoreline in this area.

Anticipated permits

Based on the planning level design, the following environmental permits would be needed:

- City of Madison Erosion Control
- WDNR Stormwater NOI (>1 acre disturbance)
- WDNR Water Quality Certification (if wetlands are present)
- Intake or Outfall Structure General Permit. *Note there are exceptions to this permit, but it depends on the final design.*

Water Quality Benefits

Local storm sewer improvements will not provide water quality benefits.

Additional Notes/Information

Note that **Figures 28-36** show the inundation after all the improvements have been built. Flood reductions in the area are based on a combination of improvements, including recommended solutions upstream in this subwatershed (see **Section 10.2**)

10.2 E Johnson St/N Pickney St/N Hamilton St/Gorham St Storm System Improvements

Detailed Project Description

E Johnson St and Hamilton St conveys water for 43.8 acres, in the northeast portion of the near west watershed. The upstream watershed area is fully developed with a mix of apartment buildings, commercial properties, institutional facilities and a quarter of the Wisconsin State Capitol. Water flows north from the Capitol towards James Madison Park, and outfalls into Lake Mendota after passing through a seawall. This project contains piped improvements *upstream* of those recommended for the James Madison Park outfall and should be constructed after the outfall is upsized (see **Section 10.1**).

The existing conditions model indicated that the streets near E Johnson and Hamilton St have inundation in the streets using the 50% AEP event, could leave the ROW potentially impacting buildings for the 1% AEP event. This improvement would increased the piped capacity along south and west of the N Butler/N Hamilton/E Johnson St intersection. Pipe sizing ranges from 24" to 54"in the improvement area. Note that the City requested the improvements not continue down N Hamilton St, as there is no available space for additional storm sewer (see **Section 9.2.1.1**). Pipes were sized to serve the 1%AEP design event.

A map of the recommended storm sewer improvements for E Johnson St/N Pickney St/N Hamilton St/Gorham St are shown on **Figure 27-B**.

Associated Flood Reduction Benefits

This project would be completed in after of the N Hancock St to outfall improvement. As a result of the local storm sewer improvements, the City's flood control targets will be met as follows:

- **Target 1a**: The proposed solution reduces the flooding but does not eliminate all flooding within the street. The solution prevents six (6) stormwater structures from flooding in the 10% AEP design storm.
- **Target 2a**: Inundation along the street centerline decreases with this recommended improvement, but no additional street segments are now achieving this target. Note there are improvements further downstream associated with the N Hancock to Outfall System improvement.
- **Target 3a**: Five (5) additional buildings are no longer impacted by the 1% AEP design storm.
- **Target 3b**: There are not any enclosed depression in this area.
- **Target 3c**: There are not any greenways within this watershed.
- **Target 4a**: This individual solution does not prevent any additional buildings from being impacted by the 0.2% AEP design storm.

Project Constraints/Considerations

This recommended solution is piped infrastructure and will be contained with the City right-of-way.

Anticipated permits

Based on the planning level design, the following environmental permits would be needed:

- City of Madison Erosion Control
- WDNR Stormwater NOI (>1 acre disturbance)

Water Quality Benefits

Local storm sewer improvements will not provide water quality benefits.

Additional Notes/Information

Note that **Figures 28-36** show the inundation after all the improvements have been built. Flood reductions in the area are based on a combination of improvements, including recommended solutions downstream in this subwatershed (see **Section 10.1**).

10.3 University Ave/Lake St Storm System Improvements

Detailed Project Description

The N Lake St system conveys flows from a 60.6 acre watershed, discharging into Lake Mendota, immediately east of the Wisconsin Alumni Association building. The upstream watershed is fully developed with multi-family residential/study housing, commercial properties, and portions of the UW Madison campus. There have been some historic and operational flooding reported in this area (see **Figure 2**). The existing conditions modeling only showed minor inundation during the smaller storm events, and more inundation in the streets for larger events. The City plans to reconstruct N Lake St in 2026 and would like to use the opportunity to improve stormwater conveyance. The State Street Campus garage is also currently under construction, and stormwater from the new building plan to be directly connected to the N Lake St System (see Section **9.2.1.10**).

This improvement extends south and west to University Ave, to capture some of the street inundation on this major transportation corridor. Pipe sizing ranges from a 24” pipe at the upstream end to a 4’x8’ box at Langdon St and N Lake St. The City requested the improvement end of Langdon St, and the final pipe segments to the outfall were not upsized (see **Section 9.2.1.3**). Note that there is an enclosed depression that is mainly contained within the street right-of-way on Langdon St immediately west of the intersection of N Lake St. Modeling showed that inundation depths would increase in this depression, likely because the proposed improvement does not extend further to the outfall at the lake and the modeling did not increase the inlet capacity in the depression. If this project moves forward with formal design, this enclosed depression should be reviewed to ensure that inundation does not impact private property.

A map of the recommended storm sewer improvements along University Ave and N Lake St are shown on **Figure 27-C**.

Associated Flood Reduction Benefits

As a result of the local storm sewer improvements, the City’s flood control targets will be met as follows:

- **Target 1a**: The proposed solution reduces the flooding but does not eliminate all flooding within the street. The solution prevents eight (8) stormwater structures from flooding in the 10% AEP design storm.
- **Target 2a**: Inundation along the street centerline decreases with this recommended improvement, but no additional street segment are now achieving this target.
- **Target 3a**: Two (2) additional buildings are no longer impacted by the 1% AEP design storm.
- **Target 3b**: One (1) enclosed depression on University Ave in front of the Chazen Art Museum will now meet this target under recommended conditions. Note that there is a second enclosed depression on Langdon St at the intersection of N Lake St that will need to be accounted for if this project transitions to formal design.

- **Target 3c**: There are not any greenways within this area.
- **Target 4a**: Five (5) buildings are no longer impacted by the 0.2% AEP design storm.

Project Constraints/Considerations
This recommended solution is piped infrastructure and will be contained with the City right-of-way.

Anticipated permits
Based on the planning level design, the following environmental permits would be needed:

- City of Madison Erosion Control
- WDNR Stormwater NOI (>1 acre disturbance)

Water Quality Benefits
Local storm sewer improvements will not provide water quality benefits.

Additional Notes/Information
Note that **Figures 28-36** show the inundation after all the improvements have been built. There are no other recommended improvements upstream within this subwatershed; so any improvements in this area can be attributed to this proposed project.

10.4 Regent St Storm System Improvements

Detailed Project Description
Regent St is a trunkline system, connecting much of the western reaches (~390 acres) of the Near West watershed to the outfall into Monona Bay. The drainage area is fully developed, including the primarily residential Vilas neighborhood, mixed commercial/residential Monroe St neighborhood, and large portions of the UW Madison campus (including Camp Randall, Engineering Hall, the Discovery Building, Union South, and others). The Regent St area is an enclosed depression (see **Figure 23**) and the existing conditions modeling indicated that there is flooding in this location during the 50% AEP design event. The City has noted that there is little elevation difference between the lake level and the stormwater system, and the whole piped system can experience tailwater conditions from the downstream lake levels.

Some of the upstream watershed drains to Madison St and Oakland Ave, where there a diversion and flow splits. Some water flows northeast along Madison St toward the Regent Street box culvert, while the rest continues southeast along Oakland Ave to Milton St, and ultimately connect to the large trunkline system along and E Campus Mall. City staff completed a site visit of this diversion structure, and notes from that field visit are included in **Appendix G**. Details from the site visit were incorporated into the existing conditions model, to estimate flows in each system.

The City did not know the condition of the Regent St box culvert and therefore completed televising in 2022. Televising found the existing structure has a ‘retaining wall’ built down the middle, likely constructed to provide support, effectively making two parallel boxes with a unique shape. The wall was not continuous, allowing water to pass between one cell to the other. City staff completed a site visit of the Regent St box, walking/crawling through a portion of the existing structure to get more measurements and better understand its condition. Each box segment ranges from 55” W x 46”H to 62” W x 46” H. Portions of the wall were being undermined and portions of the roof were collapsing. Two portions of the box must have collapsed historically and were replaced with HERCP elliptical pipes (38” x 63” in one segment and

38” x 60” in the other) creating a restriction to flow. The system converts back to a single cell box (without the retaining wall buttress) starting at Park St. **Appendix G** contains photos and a diagram provided by the City describing the findings of their site visit.

The City indicated that the HERPC elliptical pipes would have to be replaced, and that all future improvements should be compared against this new, updated baseline condition (a box for the entire length of Regent St).

The City also indicated that Regent St will be reconstructed soon, and the maximum space within the ROW, accounting for the other utilities was a 4’x14’ box culvert. The Regent St improvement starts from Madison St and extends to Park St.

A map of the recommended storm sewer improvements for the Regent St box culvert are shown on **Figure 27-D**.

Associated Flood Reduction Benefits

This improvement is physically close to two other Recommended Solutions: **S Mills St Bypass** and **Oakland Ave/Adam St St/Milton St Storm System Improvements**. Since the proposed conditions modeling was completed showing all these improvements collectively, it is not possible to attribute specific targets to one mitigation action. Therefore, the list of the City’s flood control targets listed below are as a result of all three of these improvements completed together:

- **Target 1a**: The proposed solution reduces the flooding but does not eliminate all flooding within the street. The solution prevents twenty (20) stormwater structures from flooding in the 10% AEP design storm.
- **Target 2a**: Inundation along the street centerline decreases with this recommended improvement, with 1.26 miles of additional centerline no longer having 0.5-ft of water during the 4% AEP design storm event.
- **Target 3a**: 74 additional buildings/structures are no longer impacted by the 1% AEP design storm.
- **Target 3b**: One (1) enclosed depression at the intersection of S Park St and Chandler St will now meet this target under recommended conditions.
- **Target 3c**: There are not any greenways within this watershed.
- **Target 4a**: 43 additional buildings/structures are no longer impacted by the 0.2% AEP design storm.

Project Constraints/Considerations

This recommended solution is piped infrastructure and will be contained with the City right-of-way. There are existing utilities that will need to be relocated as part of the project, to accommodate a large box culvert.

Anticipated permits

Based on the planning level design, the following environmental permits would be needed:

- City of Madison Erosion Control
- WDNR Stormwater NOI (>1 acre disturbance)

Water Quality Benefits

Local storm sewer improvements will not provide water quality benefits.

Additional Notes/Information

Note that **Figures 28-36** show the inundation after all the improvements have been built. The complete set of improvements assumes the S Mills St Bypass would also be constructed, which removes some water from the Regent St system.

10.5 S Mills St Bypass and Vilas Ave/ S Park St Storm System Improvements

Detailed Project Description

The Regent St area experiences flooding even during small events, and the Regent St stormwater system is often overwhelmed by the large upstream watershed and the shallow pipe slopes dictated by the topography of the region. Regent St is in an enclosed depression (see **Figure 23**) and the large stormwater infrastructure along Regent St does not have capacity to meet the City's flood mitigation targets. Upsizing the outfall for the Regent St area was not feasible (see **Section 9.2.1.9).** However, it might be feasible to add a secondary bypass to remove some water from the Regent St box culvert and convey it through a secondary outfall, along Vilas St to the south. The main outfall from Regent St is usually underwater (due to the elevations of the lake) and therefore is inaccessible; its condition is unknown. An additional bypass tunnel would provide a second outfall for contingency if the primary outfall needs repair or replacement.

This improvement would create a secondary outlet from the Regent St box culvert along S Mills St, heading south and then east along Vilas Ave to the outfall in Monona Bay at Brittingham Park. As the Regent St area is an enclosed depression, this recommendation would require working against the topography of the area, cutting through a large hill on S Mills St. Since this would be unlikely to be constructed using open cut techniques and would instead require a trenchless construction technique (tunneling). Once the bypass reaches Vilas Ave, however, the storm system would transition to a box culvert to fit under the existing road profile to the outfall. After reviewing the existing utilities in this area, the City indicated that the maximum dimension for a box culvert along Vilas Ave would be 5' in the vertical dimension.

The tunnel could also provide some relief to the Milton St stormwater system, that parallels Regent St and passes underneath the Meriter Hospital. There is also an enclosed depression on S Park St (see **Figure 23**). This improvement also adds a connection to this depression, to direct flows south to the updated Vilas Ave system and disconnects existing piped system that flows east.

After modeling a series of tunnel size alternatives, the recommended alternative has a 9-ft tunnel along S Mills St transitioning to a 5' x 15' box culvert on Vilas Ave to the outfall. In addition, there is a 48" circular pipe connecting the enclose depression along Park St to the new box along Vilas Ave.

A map of the recommended storm sewer improvements for the S Mills St Bypass and Vilas Ave/S Park St improvements are shown on **Figure 27-E**.

Alternatives Analysis for Sizing the Bypass Tunnel

To support decision making, a series of tunnel sizes were considered ranging from 5-ft to 17.5-ft. **Table 10-1** shows intermediate model results generated to help facilitate tunnel size selection. *Note these values should not be taken for design use; instead they are included to help understand the modeling iteration process.* The table shows the approximate pipe capacity for each sized alternative and the equivalent size box with a 5' vertical dimension (to fit underneath Vilas Ave). Then select locations were identified where water would spill to the surface. There is a notable reduction between the 5-ft to the 9-ft box, but modest improvements at increasing sizes.

The City reviewed these outputs, along with inundation maps and "subtraction maps" to show the relative amount of flood reduction modeled with increasing pipe sizes. Ultimately, the City selected the 9-ft diameter tunnel, since increasing the pipe sizes past this point only resulted in 0.1-0.2' of flood reduction improvements.

Table 10-1: Model Iterations for S Mills St Bypass Tunnel Sizing

			Overflows- surface elevations (100-yr event)					
Diameter of Tunnel (ft) - all circular	Capacity (cfs)	Equivalent Box	Regent / Mills	Regent / Charter	Regent / Orchard	Regent / Randall	Bowen / Orchard	Mills / Bowen
5	77	3.5x6	853'	853.2'	854.1'	854.7'	854.2'	853.1'
9	369	5x14.5	851.5'	852.7'	853.6'	854.5'	853.7'	851.7'
10	488	5x18.5	n/a	n/a	853.4'	854.5'	853.6'	n/a
11	629	5x23	n/a	n/a	853.3'	854.4'	853.6'	n/a
12	794	5x28	n/a	n/a	853.3'	854.4'	853.6'	n/a
13	983	5x35	n/a	n/a	853.2'	854.4'	853.5'	n/a
17.5	1435	5x49	n/a	n/a	853.2	854.4	853.5	n/a

There are also increasing costs associated with tunneling new storm sewer, rather than traditional open cut sewer. As part of this design effort, MSA corresponded with CDM Smith, an engineering consulting firm with expertise in large tunneling projects. It was asked if there was a "tipping point" where costs increase dramatically after reaching a specific pipe size. It was said that the biggest cost difference is encountered with pipes are constructed in segments versus being pre-cast.

Pre-cast pipes are manufactured off site and then carried in by truck to the project. Pre-cast pipes are generally less expensive (~$4K-$5K per linear foot) but there are logistical issues when the pipes are very large: they become oversized loads and are difficult to transport along roads and stored onsite before they are installed.

Therefore, pipes that have 10' inner diameters (12' outer diameter) are commonly constructed in segments, and the smaller pieces are assembled onsite. Segmented pipes are more expensive (~$5K-$6K per linear foot), but easier to transport particularly for large pipes. *Note that the costs provided as part of this conversation were intended to provide an order of magnitude scale for comparing costs and are not specific to this proposed solution.*

Associated Flood Reduction Benefits

This improvement is physically close to two other Recommended Solutions: **Regent St** and **Oakland Ave/Adam St St/Milton St Storm System Improvements**. Since the proposed conditions modeling was completed showing all these improvements collectively, it is not possible to attribute specific targets to one mitigation action. Therefore, the list of the City's flood control targets listed below are as a result of all three of these improvements completed together:

- **Target 1a**: The proposed solution reduces the flooding but does not eliminate all flooding within the street. The solution prevents twenty (20) stormwater structures from flooding in the 10% AEP design storm.
- **Target 2a***: Inundation along the street centerline decreases with this recommended improvement, with 1.26 miles of additional centerline no longer having 0.5-ft of water during the 4% AEP design storm event.
- **Target 3a**: 74 additional buildings/structures are no longer impacted by the 1% AEP design storm.
- **Target 3b**: One (1) enclosed depression at the intersection of S Park St and Chandler St will now meet this target under recommended conditions.
- **Target 3c**: There are not any greenways within this watershed.
- **Target 4a**: 43 additional buildings/structures are no longer impacted by the 0.2% AEP design storm.

*Areas of shallow flooding on S Park St may not exceed the City's standard targets; however, it is a critical emergency route for Meriter and St Mary's Hospitals.

Project Constraints/Considerations
This recommended solution is piped infrastructure and will be contained with the City right-of-way. Engineering staff should coordinate closely with Parks Department to ensure that stormwater improvements match the planned uses for Brittingham Park.

This project will require extensive coordination with Madison Metropolitan Sewerage District (MMSD) since there are both existing and abandoned sewer interceptors along the edge of Monona Bay. The box culvert sizing was selected to reduce conflict with the mains, based on a preliminary review of the sizing and inverts. However, if the project moves forward, additional consideration will be required to account for offsets from the sanitary utilities.

There are also many existing utilities along the Vilas Ave corridor and along S Park St. Both sanitary and water mains will likely need to be adjusted and/or moved to allow for the large box culvert and outfall improvements.

Anticipated permits
Based on the planning level design, the following environmental permits would be needed:

- City of Madison Erosion Control
- WDNR Stormwater NOI (>1 acre disturbance)
- Intake or Outfall Structure General Permit. *Note there are exceptions to this permit, but it depends on the final design.*

Water Quality Benefits
Local storm sewer improvements will not provide water quality benefits.

Additional Notes/Information
Note that **Figures 28-36** show the inundation after all the improvements have been built. Any improvements will likely also be impacted by the recommended improvements along Regent St.

10.6 Vilas Ave/S Park Storm System Improvements Alternative

Detailed Project Description

If the S Mill St Bypass tunnel is not constructed, this improvement is recommended to address specific flooding concerns along Vilas Ave.

The upstream watershed to the existing Vilas Ave outfall is 20.6 acres and it is fully developed. Land use is primarily residential with some commercial properties along Park St. The existing conditions modeling for this area shows inundation in the street during the 50% AEP storm event, as does the enclosed depression along S Park St.

This improvement recommends increasing the piped capacity along Vilas Ave from S Mills St to the outfall. It also recommends providing a new piped connection the enclosed depression on S Park St and removing the existing piped outflow from the depression; the existing alignment connects to the already overtaxed outfall further to the east, also discharging into Monona Bay through Brittingham Park. Changing the piped outlet connection for the enclosed depression on S Park St reduced flooding on this major throughfare.

A map of the recommended storm sewer improvements for the Vilas Ave/S Park Storm System are shown on **Figure 27-F**.

Associated Flood Reduction Benefits

This improvement was not included in the final modeled set of recommendations, as the larger improvement (S Mills St Bypass) was included instead. Therefore, outputs could not be assessed to determine which targets could be achieved and attributed to this recommended solution. However, the primary design for this improvement was to drain the enclosed depression at the intersection of S Park St and Chandler St.

Project Constraints/Considerations

This recommended solution is piped infrastructure and will be contained with the City right-of-way. Engineering staff should coordinate closely with Parks Department to ensure that stormwater improvements match the planned uses for Brittingham Park. Note this improvement should only be considered if the S Mills St Bypass is not constructed.

This project will require extensive coordination with Madison Metropolitan Sewerage District (MMSD) since there are both existing and abandoned sewer interceptors along the edge of Monona Bay. Although this improvement is smaller in scale than the S Mills St Bypass (see **Section 9.2.2.5**), it will still require an outfall improvement to Monona Bay and will cross the MMSD interceptors. If the project moves forward, additional consideration will be required to account for offsets from the sanitary utilities.

There are also many existing utilities along the Vilas Ave corridor and along S Park St. Some sanitary and water mains will likely need to be adjusted and/or moved since there is limited space within the right-of-way.

Anticipated permits

Based on the planning level design, the following environmental permits would be needed:

- City of Madison Erosion Control
- WDNR Stormwater NOI (>1 acre disturbance)
- Intake or Outfall Structure General Permit. *Note there are exceptions to this permit, but it depends on the final design.*

Water Quality Benefits

Local storm sewer improvements will not provide water quality benefits.

Additional Notes/Information

Note that **Figures 28-36** show the inundation after all the improvements have been built – and it includes the S Mills St Bypass alternative, which is a larger improvement and therefore has larger impacts to inundation depths. The flood reduction from this alternative are therefore not displayed in these figures.

10.7 Emerald St/S Park St Storm System Improvements

Detailed Project Description

There are several smaller outfalls draining the southern portion of the Near West watershed directly to Monona Bay. The watershed draining Emerald Ct is 13.2 acres, and is primarily residential with commercial along S Park St. Existing conditions modeling shows some minor inundation along the streets during smaller storms, but there's a potential for the inundation to leave the ROW during the 1% AEP design storm and impact some private properties. These improvements are comparatively modest compared to the major trunkline improvements but could be integrated into a street reconstruction project when completed.

The Emerald Ct improvements extend from S Brooks St to the outlet in Monona Bay. Pipe sizes range from 30" to 36" at the outfall and are sized to serve the 4% AEP event.

A map of the recommended storm sewer improvements for the Emerald St/S Park St are shown on **Figure 27-G**.

Associated Flood Reduction Benefits

As a result of the local storm sewer improvements, the City's flood control targets will be met as follows:

- **Target 1a**: The proposed solution reduces the flooding but does not eliminate all flooding within the street. The solution prevents three (3) stormwater structures from flooding in the 10% AEP design storm.
- **Target 2a***: Inundation along the street centerline decreases with this recommended improvement, but no additional street segments are now achieving this target.
- **Target 3a**: One (1) additional building is no longer impacted by the 1% AEP design storm.
- **Target 3b**: There are not any enclosed depressions in this area.
- **Target 3c**: There are not any greenways within this watershed.
- **Target 4a**: One (1) additional building is no longer impacted by the 0.2% AEP design storm.

*Areas of shallow flooding on S Park St may not exceed the City's standard targets; however, it is a critical emergency route for Meriter and St Mary's Hospitals.

Project Constraints/Considerations

This recommended solution is piped infrastructure and will be contained with the City right-of-way. Both the Emerald St and Erin St improvements include modifications to the outfall into Monona Bay, which is included within the Madison Parks. Engineering staff should coordinate closely with Parks Department to ensure that stormwater improvements match the intended uses for the shoreline of Monona Bay.

Anticipated permits

Based on the planning level design, the following environmental permits would be needed:

- City of Madison Erosion Control
- WDNR Stormwater NOI (>1 acre disturbance)
- Intake or Outfall Structure General Permit. *Note there are exceptions to this permit, but it depends on the final design*

Water Quality Benefits

Local storm sewer improvements will not provide water quality benefits.

Additional Notes/Information

Note that **Figures 28-36** show the inundation after all the improvements have been built. As there are no recommended solutions upstream of this area, all the improvements seen in this region can likely be attributed to the Emerald St and Erin St improvements.

10.8 Erin St/Delaplaine Ct Storm System Improvements

Detailed Project Description

There are several smaller outfalls draining the southern portion of the Near West watershed directly to Monona Bay. The watershed draining Delaplaine Ct is 7.6 acres and is primarily residential and a fraction of the SSM Health St. Mary's Hospital. The watershed draining the improvement along Erin St is 16.7 acres, with residential areas, commercial properties along S Park St and a fraction of the SSM Health St. Mary's Hospital. Existing conditions modeling shows some minor inundation along the streets during smaller storms, but there's a potential for the inundation to leave the ROW during the 1% AEP design storm and impact some private properties. These improvements are comparatively modest compared to the major trunkline improvements but could be integrated into a street reconstruction project when completed.

The Erin St improvements include an extension up S Mills St to connect a low point to the upsized infrastructure, with a18" pipe. This moves the stormwater system into the street ROW (it currently drains east through a back alley). Improvements continue down Erin St as an 18", increasing to a 48" pipe at the outfall into Monona Bay. All the pipes are sized to serve the 1% AEP event.

The Delaplaine Ct improvement is just one block of 30" pipe, from S Brooks St to Park St. It does not extend to the outfall at Monona Bay.

A map of the recommended storm sewer improvements for the Erin St and Delaplaine Ct are shown on **Figure 27-H**.

Associated Flood Reduction Benefits

As a result of the local storm sewer improvements, the City's flood control targets will be met as follows:

- **Target 1a**: The proposed solution reduces the flooding but does not eliminate all flooding within the street. The solution prevents eight (8) stormwater structures from flooding in the 10% AEP design storm.
- **Target 2a***: Inundation along the street centerline decreases with this recommended improvement, with 200-ft of additional centerline no longer having 0.5-ft of water during the 4% AEP design storm event.
- **Target 3a**: One (1) additional building is no longer impacted by the 1% AEP design storm.
- **Target 3b**: There are not any enclosed depressions in this area.
- **Target 3c**: There are not any greenways within this watershed.

- **Target 4a**: Five (5) additional buildings are no longer impacted by the 0.2% AEP design storm.

*Areas of shallow flooding on S Park St may not exceed the City's standard targets; however, it is a critical emergency route for Meriter and St Mary's Hospitals.

Project Constraints/Considerations

This recommended solution is piped infrastructure and will be contained with the City right-of-way.

Anticipated permits

Based on the planning level design, the following environmental permits would be needed:

- City of Madison Erosion Control
- WDNR Stormwater NOI (>1 acre disturbance)

Water Quality Benefits

Local storm sewer improvements will not provide water quality benefits.

Additional Notes/Information

Note that **Figures 28-36** show the inundation after all the improvements have been built. As there are no recommended solutions upstream of this area, all the improvements seen in this region can likely be attributed to the Delaplaine Ct and Parr St improvements.

10.9 Parr St Storm System Improvements

Detailed Project Description

There are several smaller outfalls draining the southern portion of the Near West watershed directly to Monona Bay. The watershed draining the improvement along Parr St is 20.9 acres, with primarily residential areas and some commercial properties along S Park St. This area also includes the S Park/Fish Hatchery intersection.

Existing conditions modeling shows does not show any street inundation until the 4% AEP design event. Water stays primarily within the street ROW during the larger events; however, the S Park St/Fish Hatchery intersection is inundation and is a major throughfare for the area. These improvements are comparatively modest compared to the major trunkline improvements but could be integrated into a street reconstruction project when completed.

The Parr St improvements is a 48” pipe from the S Park St/Fish Hatchery interaction to the outfall at Monona Bay.

A map of the recommended storm sewer improvements for Parr St are shown on **Figure 27-I**.

Associated Flood Reduction Benefits

As a result of the local storm sewer improvements, the City’s flood control targets will be met as follows:

- **Target 1a**: The proposed solution reduces the flooding but does not eliminate all flooding within the street. This individual solution does not prevent any stormwater structures from flooding in the 10% AEP design storm.
- **Target 2a***: Inundation along the street centerline decreases with this recommended improvement, but no additional street segments are now achieving this target.

- **Target 3a**: One (1) additional building is no longer impacted by the 1% AEP design storm.
- **Target 3b**: There are not any enclosed depressions in this area.
- **Target 3c**: There are not any greenways within this watershed.
- **Target 4a**: Three (3) additional building is no longer impacted by the 0.2% AEP design storm.

*Areas of shallow flooding on S Park St may not exceed the City's standard targets; however, it is a critical emergency route for Meriter and St Mary's Hospitals.

Project Constraints/Considerations

This recommended solution is piped infrastructure and will be contained with the City right-of-way. The Parr St improvements include modifications to the outfall into Monona Bay, which is included within the Madison Parks. Engineering staff should coordinate closely with Parks Department to ensure that stormwater improvements match the intended uses for the shoreline of Monona Bay.

Anticipated permits

Based on the planning level design, the following environmental permits would be needed:

- City of Madison Erosion Control
- WDNR Stormwater NOI (>1 acre disturbance)
- Intake or Outfall Structure General Permit. *Note there are exceptions to this permit, but it depends on the final design*

Water Quality Benefits

Local storm sewer improvements will not provide water quality benefits.

Additional Notes/Information

Note that **Figures 28-36** show the inundation after all the improvements have been built. As there are no recommended solutions upstream of this area, all the improvements seen in this region can likely be attributed to the Delaplaine Ct and Parr St improvements.

10.10 Oakland Ave/Adams St/Milton St Storm System Improvements

Detailed Project Description

Oakland Ave and Adams St serve as a bypass system to Regent St, conveying water along Milton St, under the Meriter Hospital along Braxton Place, before turning south to discharge into Monona Bay. The upper system starts at Monroe St as a 2’x6’ box culvert and transition to 2 parallel elliptical pipes (38”x57”) for one block from Madison St to Jefferson St. A third parallel pipe is added at Jefferson St, and the system turns to the northeast along Adams St to connect to Milton St at S Randall Ave. At this point, the system converts back to a box (4’x10’) increasing capacity incrementally to the outfall into Monona Bay (4’x12’).

The City once completed a site inspection of the parallel pipes along Oakland Ave and Adams St and thought them to be in considerably good condition considering their age (estimated install date of 1966). Originally, the City indicated they should not be included in the recommended improvements, because they appeared to be in fine condition. However, upon further consideration, it was decided the pipes should at least be sized to be convert to a box culvert and reduce entrance and exit losses within the system.

There was also the potential to increase the capacity of the Oakland/Adams/Milton St system if the S Mills St tunnel is constructed. The City indicated that improvements could not be made to the pipes that pass underneath Meriter Hospital, and therefore any upstream improvements would need to have adequate capacity to convey water through another outlet, so as not to transfer flooding concerns downstream in the watershed.

After reviewing several design alternatives (in tandem with the S Mills St Tunnel), the City selected replacing the ellipticals with the equivalent size box culverts. This would not provide increased capacity but would assist future designers when it is time to replace the street and infrastructure. The equivalent box sizes are as follows:

- 3' x 8' from Madison St to Jefferson St on Oakland Ave
- 3' x 11' from Jefferson St on Oakland Ave and Adams St

A map of the recommended storm sewer improvements for the Oakland Ave/Adams St/Milton St improvements are shown on **Figure 27-J**.

Associated Flood Reduction Benefits

This improvement is physically close to two other Recommended Solutions: **Regent St** and **S Mills St Bypass System Improvements**. Since the proposed conditions modeling was completed showing all these improvements collectively, it is not possible to attribute specific targets to one mitigation action. Therefore, the list of the City's flood control targets listed below are as a result of all three of these improvements completed together:

- **Target 1a**: The proposed solution reduces the flooding but does not eliminate all flooding within the street. The solution prevents twenty (20) stormwater structures from flooding in the 10% AEP design storm.
- **Target 2a**: Inundation along the street centerline decreases with this recommended improvement, with 1.26 miles of additional centerline no longer having 0.5-ft of water during the 4% AEP design storm event.
- **Target 3a**: 74 additional buildings/structures are no longer impacted by the 1% AEP design storm.
- **Target 3b**: One (1) enclosed depression at the intersection of S Park St and Chandler St will now meet this target under recommended conditions.
- **Target 3c**: There are not any greenways within this watershed.
- **Target 4a**: 43 additional buildings/structures are no longer impacted by the 0.2% AEP design storm.

Project Constraints/Considerations

This recommended solution is piped infrastructure and will be contained with the City right-of-way.

Anticipated permits

Based on the planning level design, the following environmental permits would be needed:

- City of Madison Erosion Control
- WDNR Stormwater NOI (>1 acre disturbance)

Water Quality Benefits

Local storm sewer improvements will not provide water quality benefits.

Additional Notes/Information

Note that **Figures 28-36** show the inundation after all the improvements have been built. The complete set of improvements assumes that the Regent St box is upsized and S Mills St Bypass would also be constructed. Improvements in this area are the result of these three projects combined.

11 Areas where Flood Control Targets are Not Met

The downtown portion of the City of Madison is fully developed, which limits the potential flood mitigation solutions that are viable in the Near West Watershed. There is not any available real estate to create storage in the upper reaches of the watershed. Another compounding factor is the limited topography. The outlets discharging to Lake Monona and Monona Bay are effectively underwater; increasing the piped capacity upstream has a limited effect on reducing inundation on the ground surface. The largest outfalls (those draining Regent St and passing through Brittingham Park) are also not viable for upsizing due to limited space. Finally, all the recommended improvements within the watershed needed to ensure that flooding issues were not simply transferred from one location to another.

With all these limitations, the recommended improvements will reduce flooding in some areas of the watershed, but they will not remove the flooding entirely.

This section is included to see how much the recommended improvements reduced flooding with respect to each target, with the understanding that flooding will still occur within the watershed.

11.1 Target 1a: Flooding Storm Sewer (10% AEP)

No surcharging onto the street for up to the 10% AEP design storm; all water shall be contained within the pipes and structures.

This criterion was evaluated by buffering all of the modeled publicly owned access structures and inlets by 15-feet. Any buffered structure that intersected the 10% AEP inundation raster was classified as a 'potential problem location'. Of the 465 modeled publicly owned access structures and inlets, 269 of them were classified as potential problem location (58%). Under the recommended conditions, 223 were still classified a potential problem locations (48.0%).

11.2 Target 2a: Street Centerlines (4% AEP)

Centerline of street to remain passable during 4% AEP design storm with no more than 0.5 feet of water at the centerline.

This criterion was evaluated by using a road centerline dataset, split at 100-ft intervals and intersected with the 4% AEP inundation raster. Any segments with an average of 0.5-feet or more of water depth were classified as a 'potential problem location'. This watershed has 49.9 miles of roads. Under existing conditions, 5.0 miles were classified as problem locations (10.0%). Under the recommended conditions, 2.9 miles were classified as problem locations (5.8%).

11.3 Target 3a: Homes and Businesses (1% AEP)

No homes or businesses will be flooded during the 1% Annual Exceedance Probability (AEP) design storm.

This criteria was evaluated by buffering all buildings by 5-ft, and intersecting them with the 1% AEP inundation raster. Any buffered building with an inundation depth of 0.5-feet or greater was classified as a 'potential problem location'. Note that this analysis does not account for modifications residents take to mitigate flooding on their own properties. There are 4,678 buildings/structures within the watershed in the City of Madison. Under the recommended conditions, 235 structures would still be impacted by flooding during the1% AEP design storm (5.0%).

11.4 Target 3b: Enclosed Depressions (1% AEP)

Enclosed depressions to be served to the 1% AEP design storm (which can include safe overland flow within street, easements, greenways or other public lands).

This criteria was evaluated by identifying all of the enclosed depressions at least 0.25 acres in size, based on the 2017 LiDAR DEM. This was completed using the LiDAR processing GIS tool created by Dr. Qiusheng Wu (https://github.com/giswqs/lidar). All depressions were intersected with the 1% AEP inundation raster. Any depression that had a maximum depth of 1-foot or more and touched public land (e.g. street ROW, greenway or SWU lands, etc) was flagged for review. The public lands and private ponds were removed from this subset of enclosed depressions, to determine if the depression also encompassed a portion of privately owned land.

Any enclosed depression that touched public land, included at least 0.25 acres of private land, and had more than 1-foot of inundation depth during the 1% AEP event was classified as a potential problem area. There are fifty-eight (58) enclosed depressions within the watershed. Under the existing conditions, modeling predicts that the 1% AEP service levels are not achieved in nine (9) enclosed depressions classified as a potential problem location. Under the recommended conditions, seven (7) enclosed depressions are still classified as potential problem locations.

11.5 Target 3c: Greenways (1% AEP)

Greenway crossings at streets to be served to the 1% AEP design storm.

The Near West watershed does not have any greenway crossings; therefore this target was not applicable to this watershed.

11.6 Target 4a: Safely Convey Stormwater (0.2% AEP)

No homes or businesses will be flooded during the 1% Annual Exceedance Probability (AEP) design storm.

This criteria was evaluated by buffering all buildings by 5-ft, and intersecting them with the 0.2% AEP inundation raster. Any buffered building with an inundation depth of 0.5-feet or greater was classified as a ‘potential problem location’. Note that this analysis does not account for modifications residents take to mitigate flooding on their own properties. There are 4,678 buildings/structures within the watershed in the City of Madison. Under the recommended conditions, 485 structures would still be impacted by flooding during the 0.2% AEP design storm (10.4%).

12 Climate Resilience Analysis

12.1 0.2% Chance Analysis

The following section describes anticipated changes in 0.2% AEP (500-yr) flooding between existing and recommended conditions. As described in previous sections of the report, storm sewer capacity improvements are recommended for those areas impacted by flooding during large events, and where there was available space to complete improvements. Improvements can be grouped into four regions:

Regent Street Neighborhood

- Upsizing the Regent St box culvert
- Upgrading the pipe system along Oakland Ave and Adams St
- Adding in a new tunnel bypass system along S Mills St and Vilas Ave.

James Madison Park Outfall

- Increased outfall capacity
- Improvements to the upstream storm system

N Lake St System

- Improvements to the upstream storm system

Monona Bay Outfall Improvements

- Increased upstream capacity and the outfall draining Emerald St
- Increased upstream capacity and the outfall draining Erin St
- Increased upstream capacity draining Delaplaine Ct
- Increased upstream capacity and the outfall draining Parr St

These improvements often were modest, due to the lack of available space for upstream detention, and the outfalls to Lake Monona, Monona Bay, and sometimes Lake Mendota being underwater. Even though topography and limited available space in public ROW reduce the scale of the recommended improvements, modeling still predicts moderate improvements in flooding in each of these regions:

- Along Regent St from Madison St to Park St, 0.2% AEP flood depths are expected to be reduced by 0.2'-0.7'. Improvements near the Regent/Madison intersection are around 0.2' and increase to 0.7' at the S Park/Regent St intersection. At the sag at S Park St and Chandler St (just west of UnityPoint Health-Meriter Hospital) 0.2% AEP flood depths are expected to be reduced by approximately 1.5' feet.
- At the intersection of E Gorham St and Hancock St (adjacent to James Madison Park) 0.2% AEP flood depths are expected to be reduced by approximately 0.1' feet.
- Along N Lake St from University Ave to Langdon St, 0.2% AEP flood depths are expected to be reduced by approximately 0.2' feet.
- For S Park St intersections with Emerald St, Erin St, Delaplaine Ct and Parr St, 0.2% AEP flood depths are expected to be reduced by 0.2'-ft, 0.2'-ft, 0.7'-ft and 0.5-ft respectively

Across the watershed, regarding buildings at risk of 0.2% AEP event flooding, there is a substantial improvement under recommended conditions. Under existing conditions, 542 buildings are anticipated to be affected by 0.2% AEP event flood conditions. Under full-watershed improved conditions, this number is anticipated to be reduced to 485. This is a net reduction of 57 buildings.

Figure 19 and **Figure 36** present a comparison of flooding conditions under 0.2% AEP (500-yr) conditions.

12.2 Infrastructure modifications

The Near West watershed is capacity limited for many of the outfalls. To meet the stormwater needs for the 0.2% AEP design storm, alternative solutions that were not recommended due to other concerns (e.g. cost, public feedback, etc) would need to be reconsidered. For example, placing large regional stormwater detention basins via property acquisition; this would require removing any development on the property and replacing it with a detention facility. This could retain water during large events and effectively delay the water from entering the piped system to reduce peak flows. Expanding the diameter of existing outlets could also be considered, but it would also require property acquisition and removal of existing development. Note that this might only have marginal flood reduction benefits in those areas were the outfall is submerged, as the upsized pipe would still be submerged. Both options could be reevaluated in the future, if the City’s design targets change.

13 Cost Estimates

To help the City plan for future implementation, planning level cost estimates were developed for each of the stand-alone solutions outlined in **Chapter 10.** For each solution, cost estimates were prepared by creating a tabulated list of estimated quantities. All the recommended improvements in Near West were within the street right-of-way, and it was assumed that the pipe replacements would require the entire street to be reconstructed (rather than simply replacing/repairing pavement areas impacted by selectively modifying just the stormwater system).

The 'main driver' for a project might be the stormwater project, but in many cases, the project would be completed when the roadway is already planned for reconstruction. The City requested that the costs associated with the street reconstruction **only** be incorporated into those recommended solutions where the stormwater improvements would be the 'main driver' in the project. The City reviewed the list of recommendations, and the two (2) projects listed below would be 'main drivers'; therefore have the street reconstruction costs incorporated into the estimate.

- N Hancock St Storm System Improvements
- S Mills St and Vilas Ave Tunnel and S Park St Storm System Improvements

The City provide approximate costs for street replacements on a per linear foot basis for Local, Collector and Principal Arterial Streets. The City also provided average unit costs for typical stormwater bid items, specifically for pipe materials. The cost of the piped improvements were added to the street-replacement costs, to calculate an estimated cost for each of the recommended projects.

Standard unit costs were adjusted by MSA based on specific project conditions that may result in higher or lower than average unit costs. In these cases, a note was added to justify the rationale for the cost revision. Initial cost estimates were provided to the City for review prior to finalizing them in the report.

Note that the S Mills St and Vilas Ave Tunnel improvement is atypical, as the City does not often encounter projects that require microtunneling. These cost estimates were developed based on a high level cost estimate prepared for another community in southern Wisconsin. MSA coordinated with the City staff to discuss the nuances for this less common construction method and also provided a more detailed excel file with the calculations used to derive the estimates.

The total cost estimates for each of the stand-alone projects is provided in **Table 13.1.** A detailed breakdown for each cost estimate, with quantities, average unit costs, and adjustments is provided in **Appendix H.**

Table 13.1: Stand-Alone Project Cost Estimates for Near West Watershed

Project	Estimated Cost
N Hancock St to Outfall Storm System Improvements	$1.43M
E Johnson St/N Pickney St/N Hamilton St/Gorham St Storm System Improvements	$0.74M
University Ave/Lake St Storm System Improvements	$1.56M
Regent St Storm System Improvements	$6.04M
S Mills St Bypass and Vilas Ave/ S Park St Storm System Improvements	$32.27M
Vilas Ave/S Park Storm System Improvements Alternative*	$0.72M
Emeral St/S Park St Storm System Improvements	$0.35M
Erin St/Delaplaine Ct Storm System Improvements	$6.52M
Parr St Storm System Improvements	$0.17M
Oakland Ave/Adams St Storm System Improvements	$2.92M

**only to be constructed if the S Mills St Bypass is not constructed.*

14 Recommended Implementation Order

14.1 Technical Implementation Needs

Implementing one improvement in one area of the watershed can impact other parts of the watershed. For example, increasing the pipe capacity upstream can negatively impact downstream areas without adequate capacity to handle the increase in peak flows. Within the Near West Watershed, there are some known limitations for implementation order that should be considered prior to advancing any of the recommended solutions. The following guidelines are recommended for implementation.

1. In general, improvements should be implemented from downstream end, progressing towards the upstream projects. In this vein, the N Hancock St to Outfall improvement should be completed before any improvements in the upstream watershed.

2. The City indicated that N Lake St is scheduled for reconstruction in 2026. It is recommended that the State Street Campus garage (currently under construction) be connected to the upsized stormwater system on N Lake St.

3. Regent St is likely to be reconstructed soon. The City should consider if the S Mills Bypass Tunnel will be completed in the future and adjust the Regent St design to accommodate the future bypass infrastructure if feasible.

4. If the S Mills Bypass tunnel is not completed, the City should consider the smaller alternative (upsizing pipes along Vilas Ave and Park St).

5. The smaller projects draining to Monona Bay (Emerald St, Erin St, Delaplaine Ct and Parr St) are not connected to any of the other improvements and can likely be prioritized based on the street reconstruction schedule.

14.2 Citywide Implementation Prioritization

The City is conducting similar studies for all the watersheds in the City, all of which will have numerous recommendations. The City has developed a process to rank and prioritize the order in which the solutions might be implemented if and when funding and public support are obtained. The process includes an extensive process to score projects based on feasibility, constructability, cost, projected benefits, and racial equity and social justice parameters. This working database of projects is updated as each study is completed and reevaluated at least annually as part of the Storm Water Utility budgeting process.

15 Next Steps

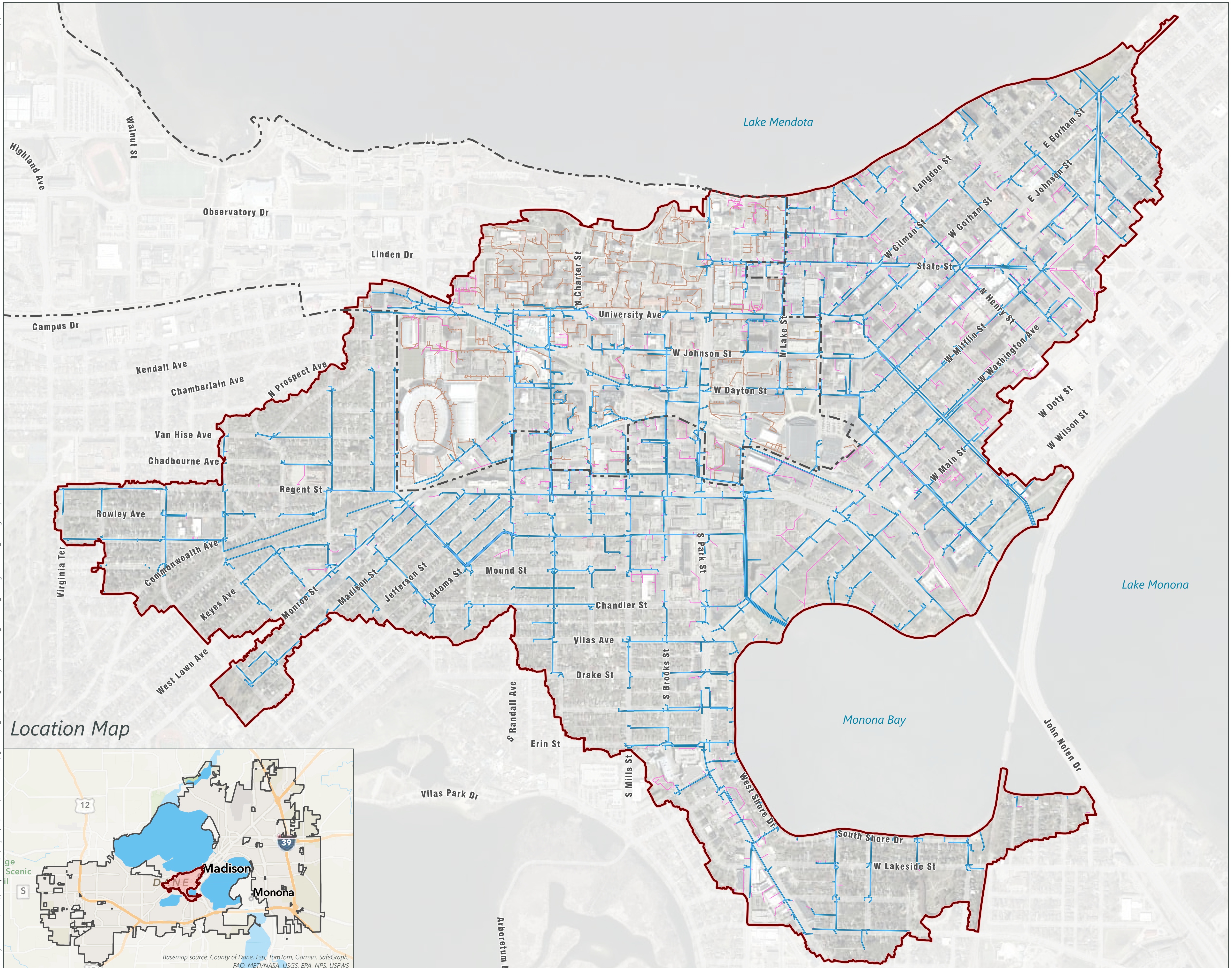
At this point, the next steps in the watershed study are to disseminate the findings, for both the existing conditions modeling and the recommended solutions with interested parties. This includes coordinating with City design staff, presenting the information to City Council and other applicate Cities Agencies. Results can also be presented to stakeholders, including local Friends Groups, Neighborhood Organizations, interested Developers and neighborhood residents.

Figures

Study Area

FIGURE 1
Near West Watershed
Study Report

City of Madison
Dane County, WI



Watershed Study Area
UW Madison Campus
Public Storm System
Private Storm System
UW Storm System

Data Sources:
Aerial: City of Madison (2022)
Watershed Boundaries: MSA
Stormwater System: City of Madison and UW Madison

MSA

0 0.1 0.2 Miles

N

Print Date: 3/7/2024
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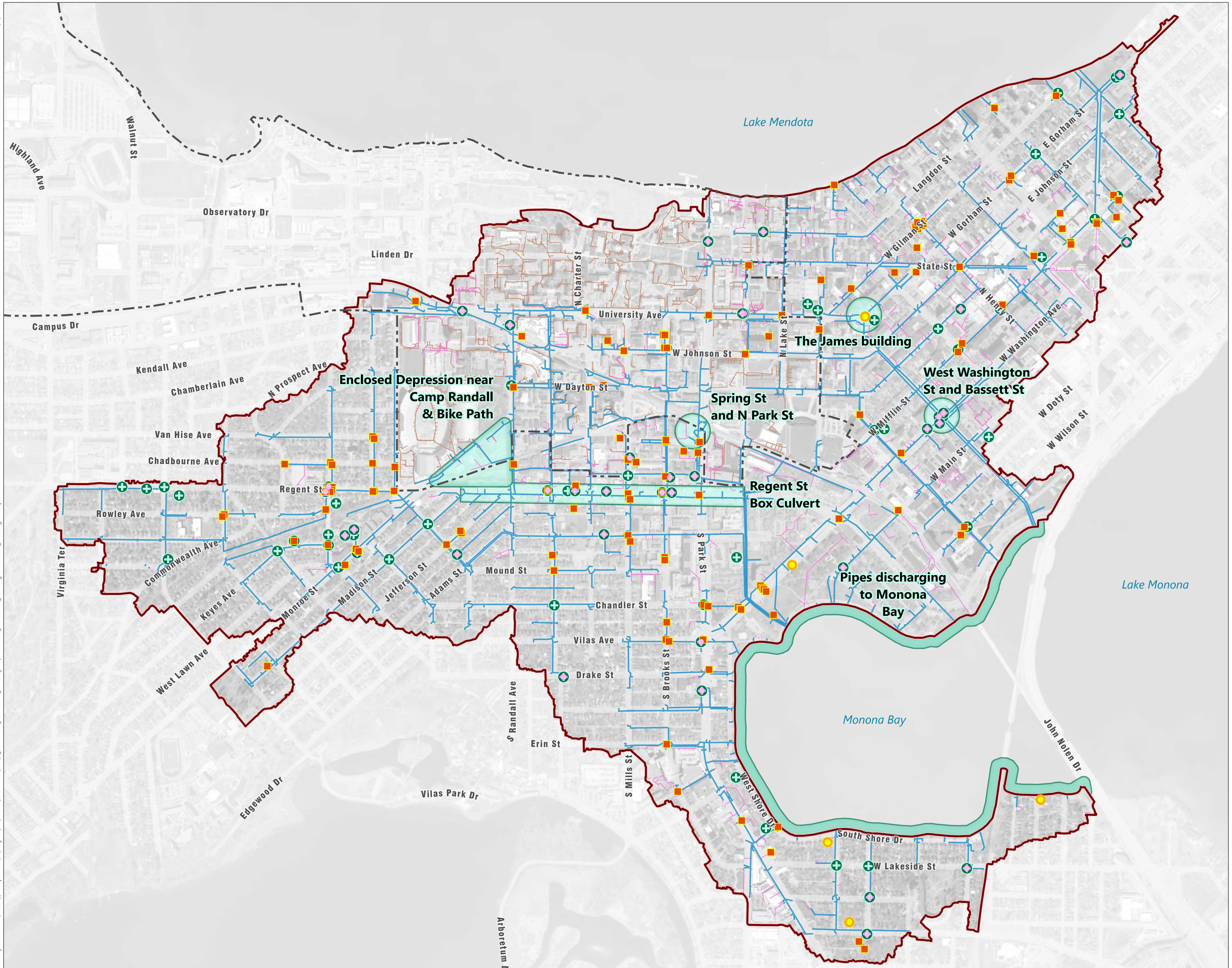
Historical Flooding

FIGURE 2
Near West Watershed
Study Report

City of Madison
Dane County, WI

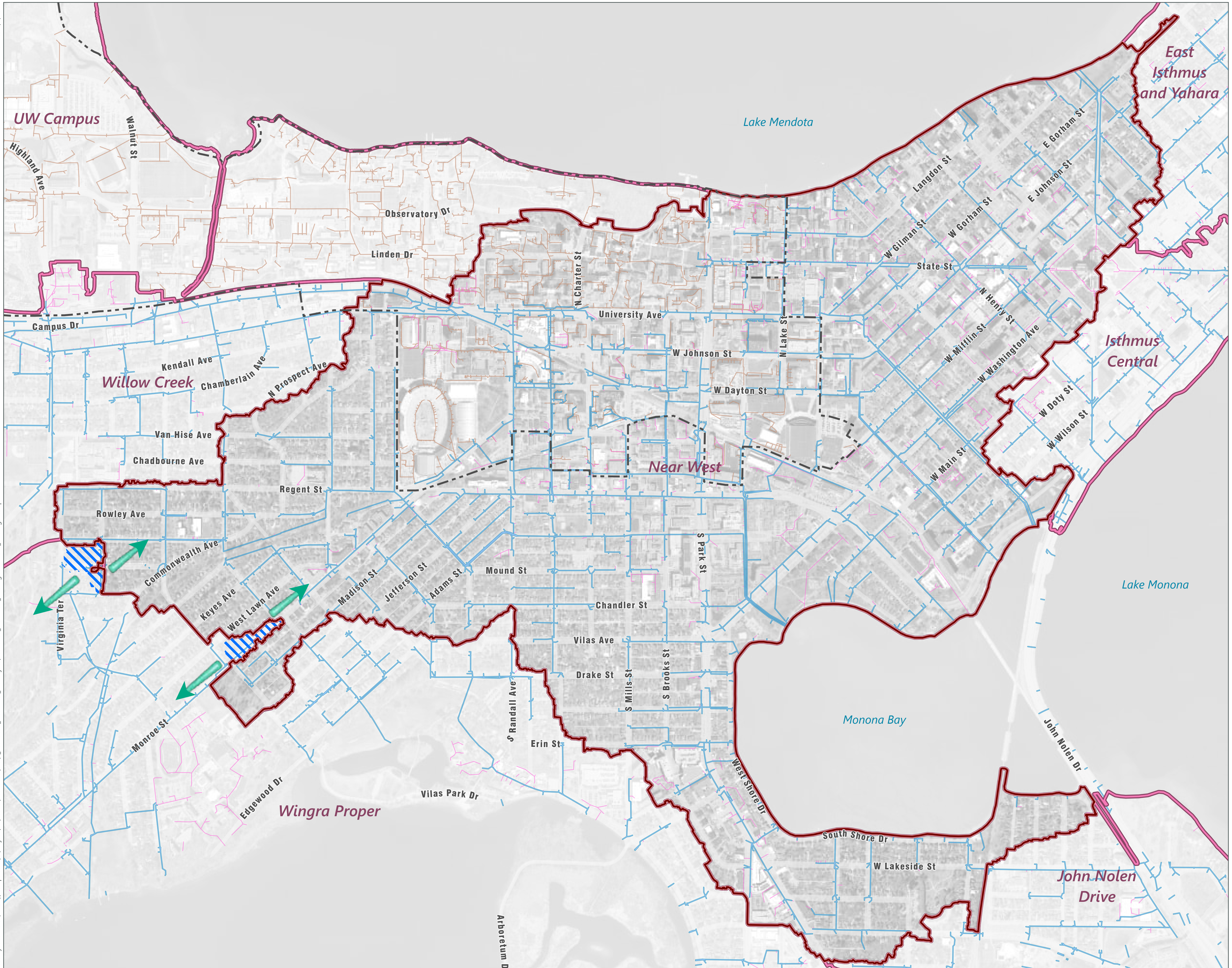


- Watershed Study Area
- UW Madison Campus
- Public Storm System
- Private Storm System
- UW Storm System
- Observations by City Engineering Staff
- Priority Inlets
- Reported Flooding
- Operations Flooding Points
- Historic/Observed Flood Points

Data Sources:
Aerial: City of Madison (2022)
Watershed Boundaries: MSA
Stormwater System: City of Madison and UW Madison

MSA

0 0.1 0.2 Miles



Adjacent Watersheds

FIGURE 3
Near West Watershed
Study Report

City of Madison
Dane County, WI

- Watershed Study Area
- Other Watershed Study Areas
- Overflow with Wingra Proper Watershed
- UW Madison Campus
- Public Storm System
- Private Storm System
- UW Storm System

Data Sources:
Aerial: City of Madison (2022)
Watershed Boundaries: MSA
Stormwater System: City of Madison and UW Madison

MSA

0 0.1 0.2 Miles

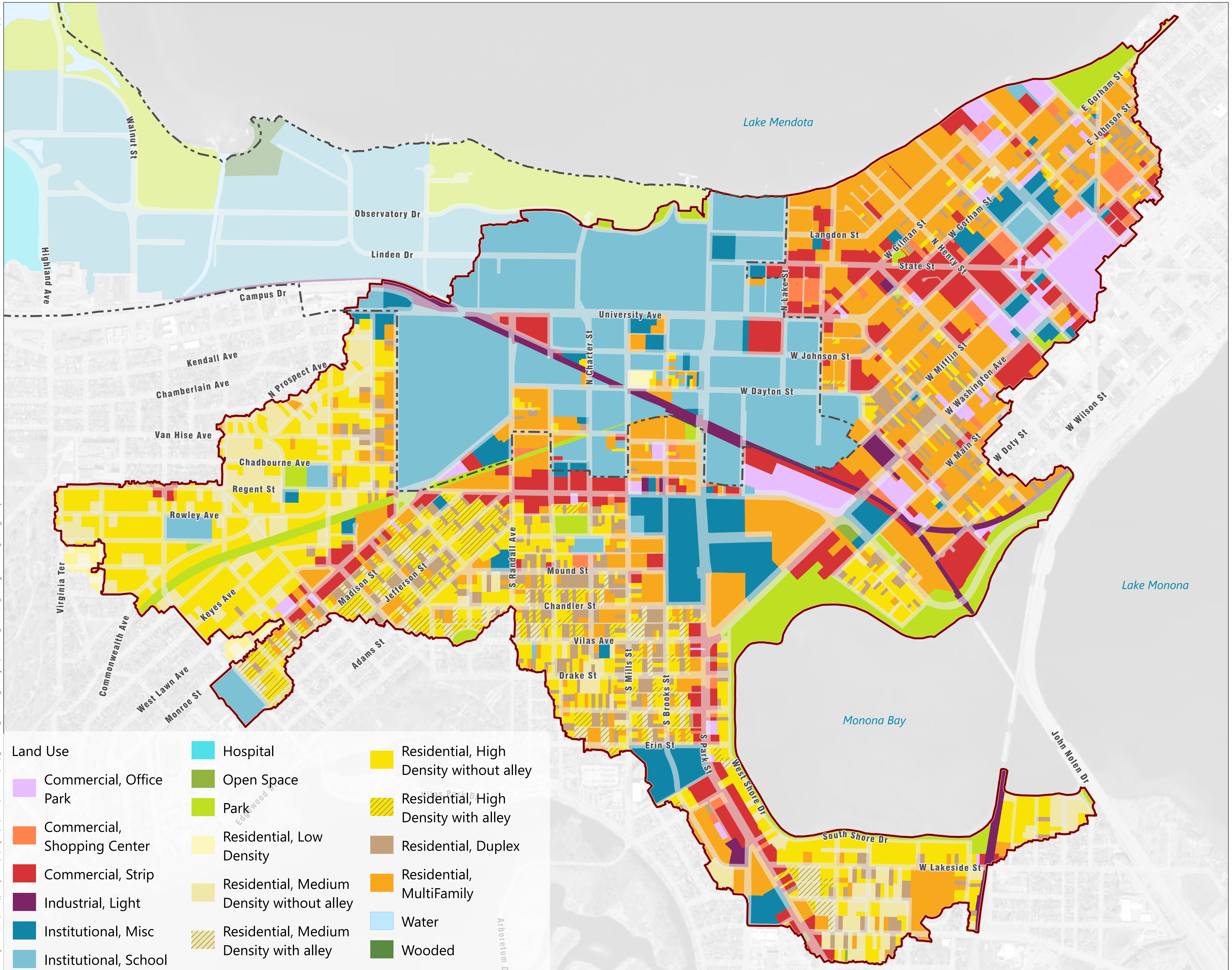
Print Date: 3/7/2024

Land Use

FIGURE 4
Near West Watershed
Study Report

City of Madison
Dane County, WI

Watershed Study Area
UW Madison Campus

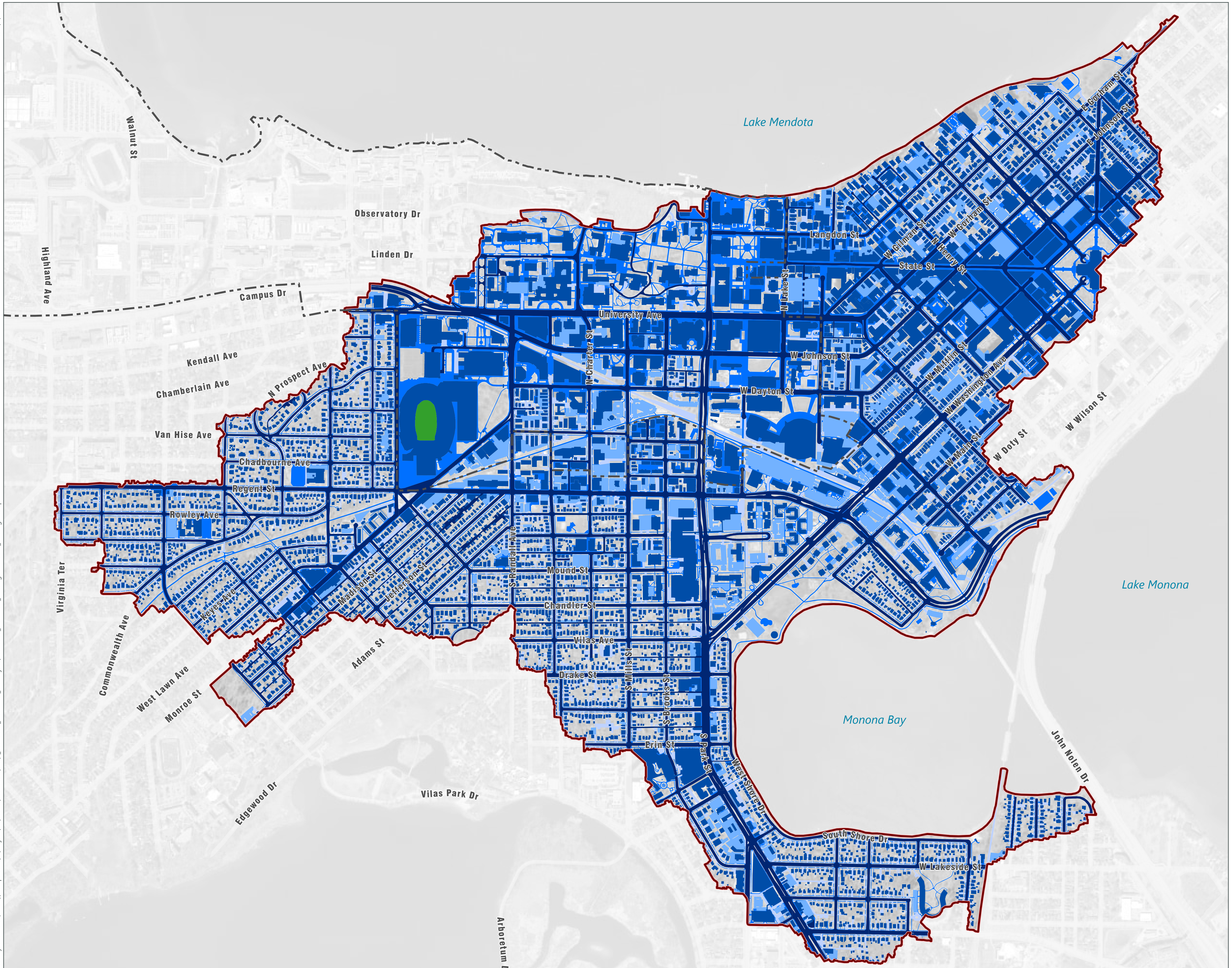


Data Sources:
Aerial: City of Madison (2022)
Watershed Boundaries: MSA
Land Use: Dane County, revised by MSA

MSA

0 0.1 0.2 Miles

Print Date: 3/7/2024



Impervious Area

FIGURE 5
Near West Watershed
Study Report

City of Madison
Dane County, WI

Watershed Study Area
UW Madison Campus

Impervious Area

- Driveway
- Parking
- Sidewalk
- Roof
- Street
- Artificial Turf

Data Sources:
Aerial: City of Madison (2022)
Watershed Boundaries: MSA
Land Use: City of Madison, supplemented by MSA

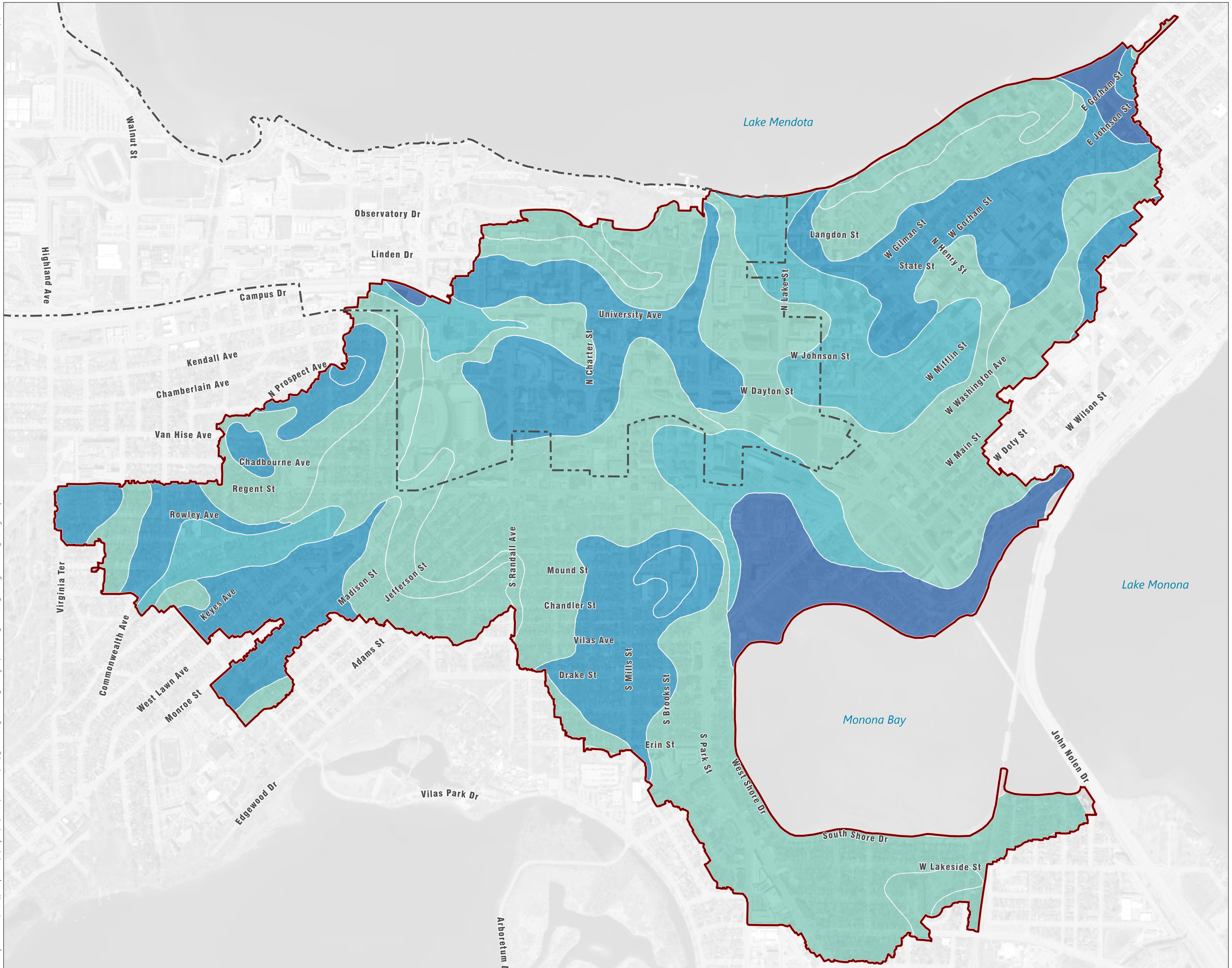
MSA

0 0.1 0.2 Miles

Soils

FIGURE 6
Near West Watershed
Study Report

City of Madison
Dane County, WI



Watershed Study Area
UW Madison Campus

Hydrologic Soil Group

- B
- B/D
- C
- C/D

Data Sources:
Aerial: City of Madison (2022)
Watershed Boundaries: MSA
Soils: USDA NRCS (SSURGO)

MSA

0 0.1 0.2 Miles

N

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Gage Locations

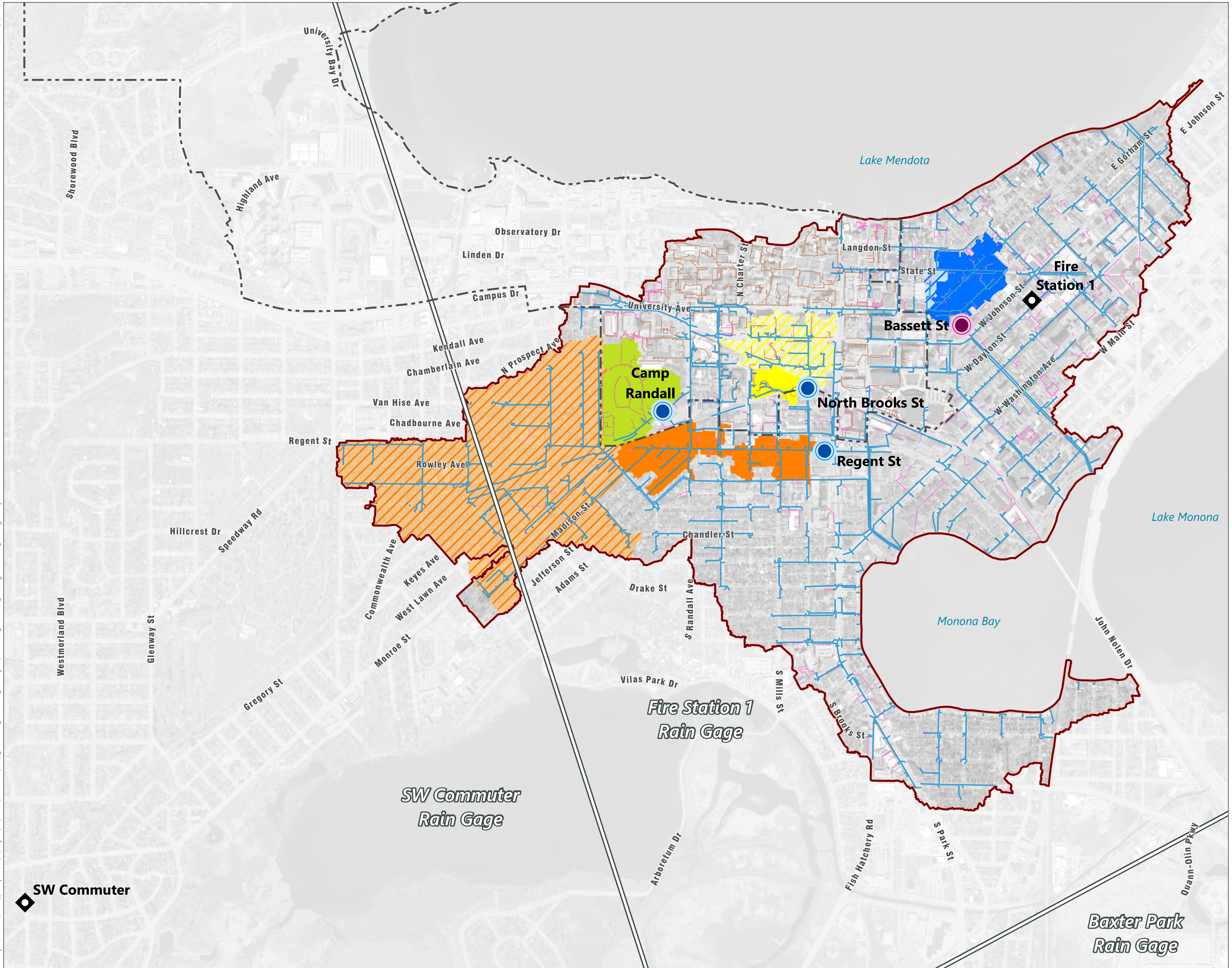

FIGURE 7
Near West Watershed
Study Report

City of Madison
Dane County, WI

- Watershed Study Area
- UW Madison Campus
- Thiessen Polygons for Rain Gages

Remote Monitoring

- Rain Gage
- Water Level
- Flow Meter

Metershed

- Bassett St FM
- Bassett St FM (Partial)
- Camp Randall LL
- North Brooks LL
- North Brooks LL (Partial)
- Regent St LL
- Regent St LL (Partial)

Data Sources:
Aerial: City of Madison (2022)
Watershed Boundaries: MSA
Soils: USDA NRCS (SSURGO)

MSA

0 0.13 0.26 Miles

N

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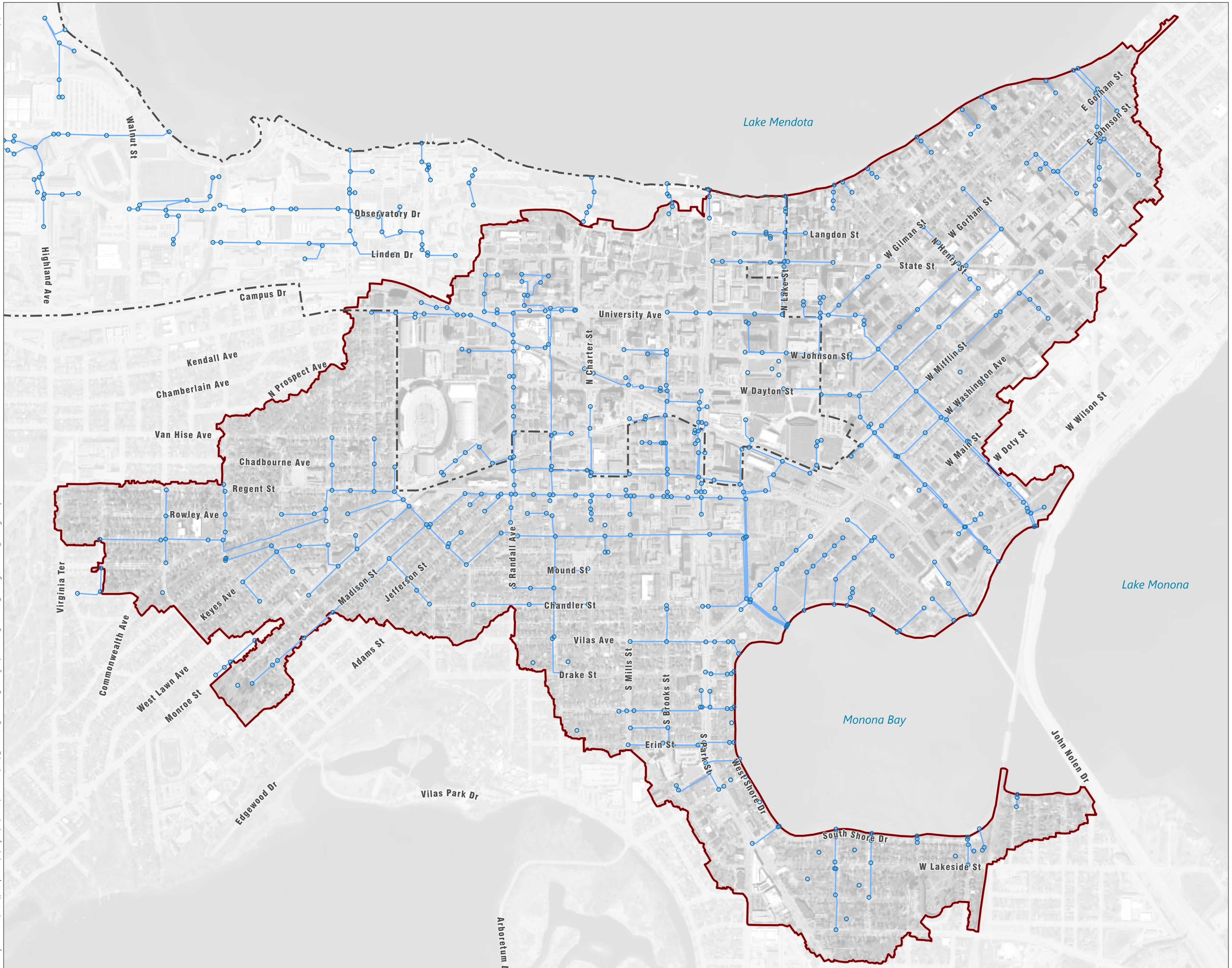

Model Network

FIGURE 8
Near West Watershed
Study Report

City of Madison
Dane County, WI

- Watershed Study Area
- UW Madison Campus
- Modeled Link (610)
- Modeled Node (653)

Data Sources:
Aerial: City of Madison (2022)
Watershed Boundaries: MSA
Modeled Links and Nodes: MSA

MSA

0 0.1 0.2 Miles

N

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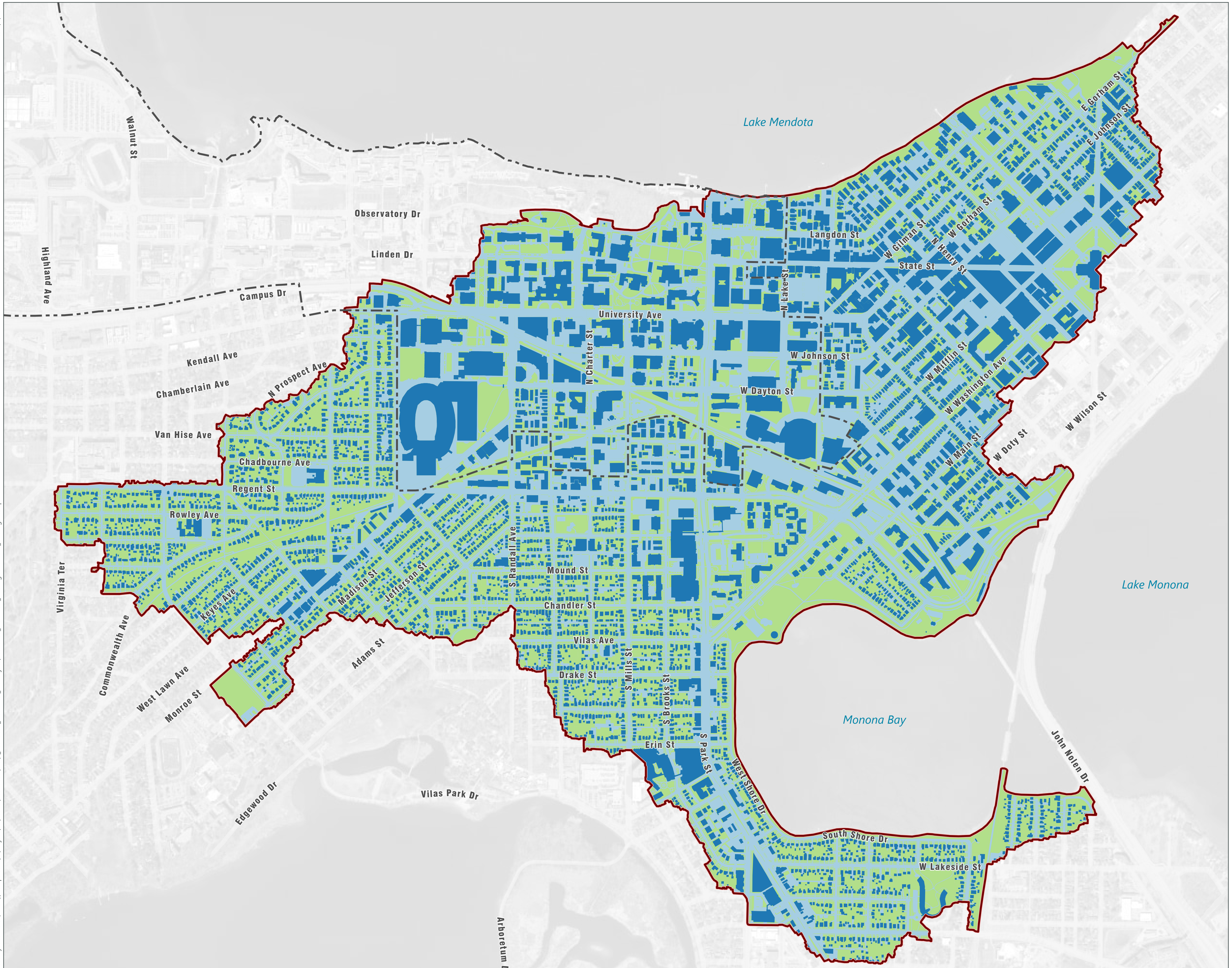
Surface Roughness

FIGURE 9
Near West Watershed
Study Report

City of Madison
Dane County, WI



Watershed Study Area

UW Madison Campus

Surface Roughness (Manning's n)

Buildings, Inactive

Streets, Sidewalk, Driveway, Parking = 0.016

Turf Grass, Variable*

***Variable Manning's Roughness (n) based on water depth**

	Depth (ft)	Roughness
Turf Grass	0 - 1	0.24 - 0.03
	1+	0.03

Data Sources:
Aerial: City of Madison (2022)
Watershed Boundaries: MSA
Modeled Links and Nodes: MSA
Impervious Areas: City of Madison, supplemented by MSA
Wooded & Turf Areas: MSA

MSA

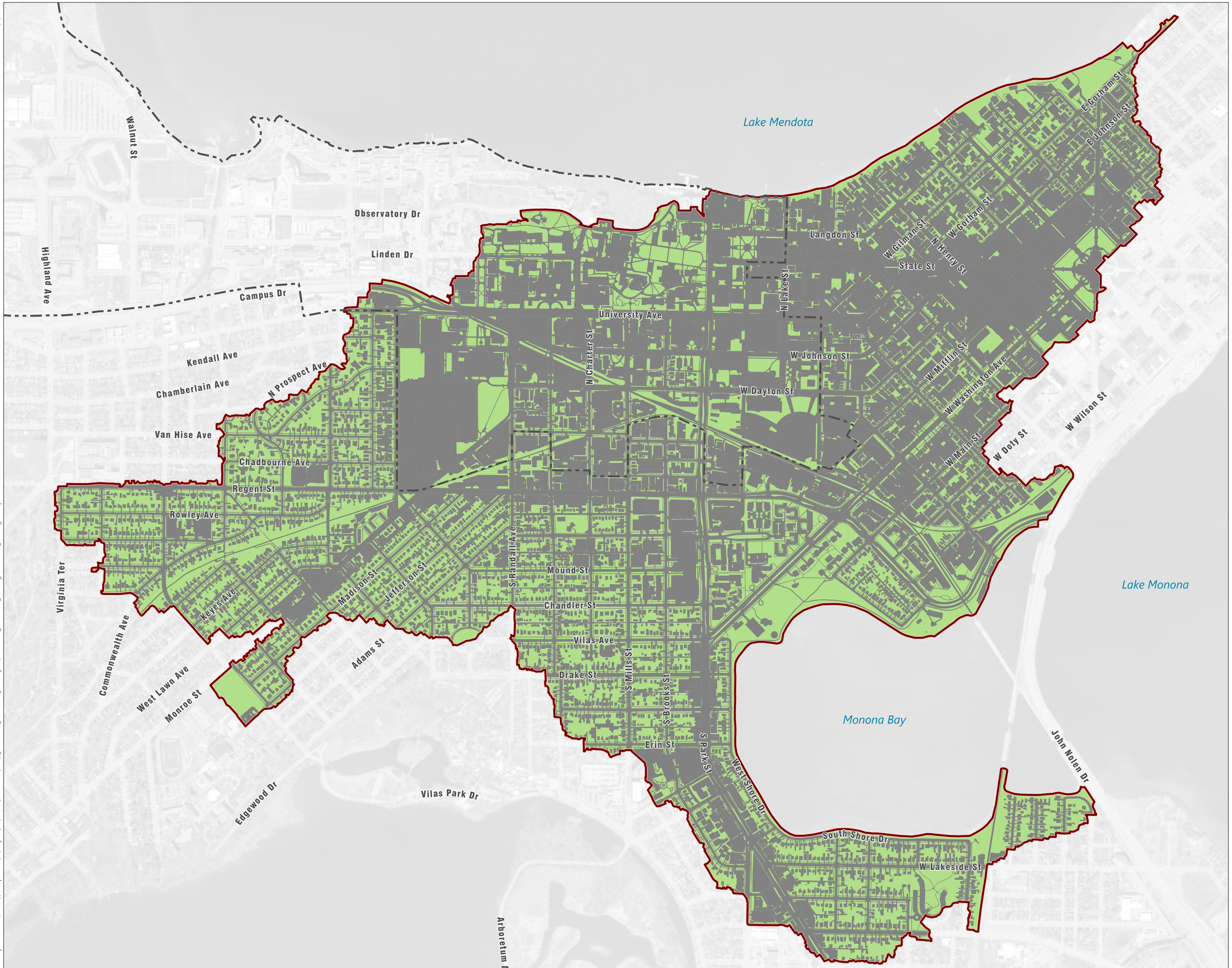
0 0.1 0.2 Miles

N

2D Land Use

FIGURE 10
Near West Watershed
Study Report

City of Madison
Dane County, WI



Watershed Study Area
UW Madison Campus
Impervious
Turf Grass

Data Sources:
Aerial: City of Madison (2022)
Watershed Boundaries: MSA
Modeled Links and Nodes: MSA
Impervious Areas: City of Madison, supplemented by MSA
Wooded & Turf Areas: MSA

MSA

0 0.1 0.2 Miles

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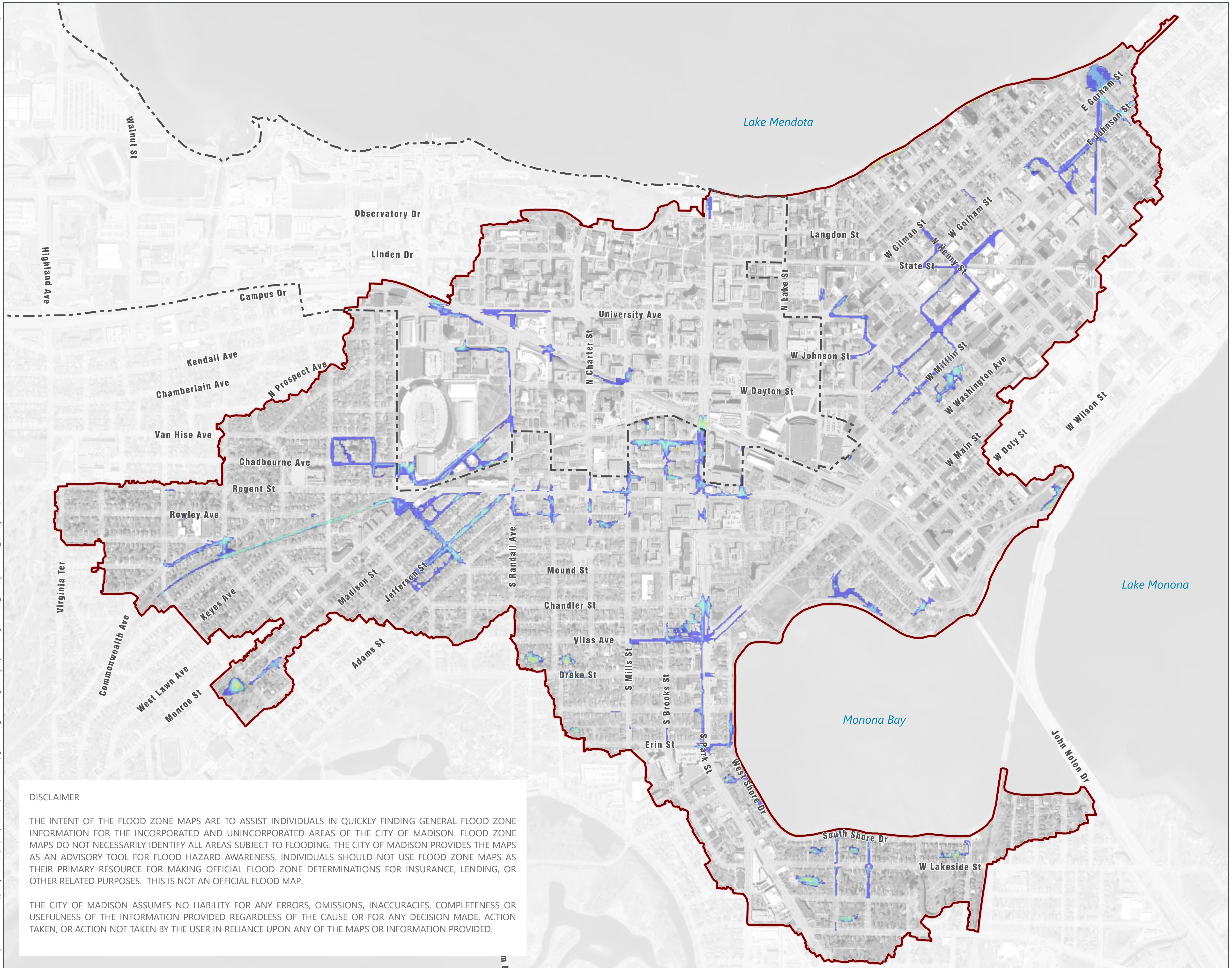
50% AEP Inundation

FIGURE 11
Near West Watershed
Study Report

City of Madison
Dane County, WI



Watershed Study Area

UW Madison Campus

50% Annual Exceedance Probability Storm

Maximum Water Depth (ft)

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1 - 3
- 3 - 6
- \> 6

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Data Sources:
Aerial: City of Madison (2022)
Watershed Boundaries: MSA
Stormwater System: City of Madison and UW Madison

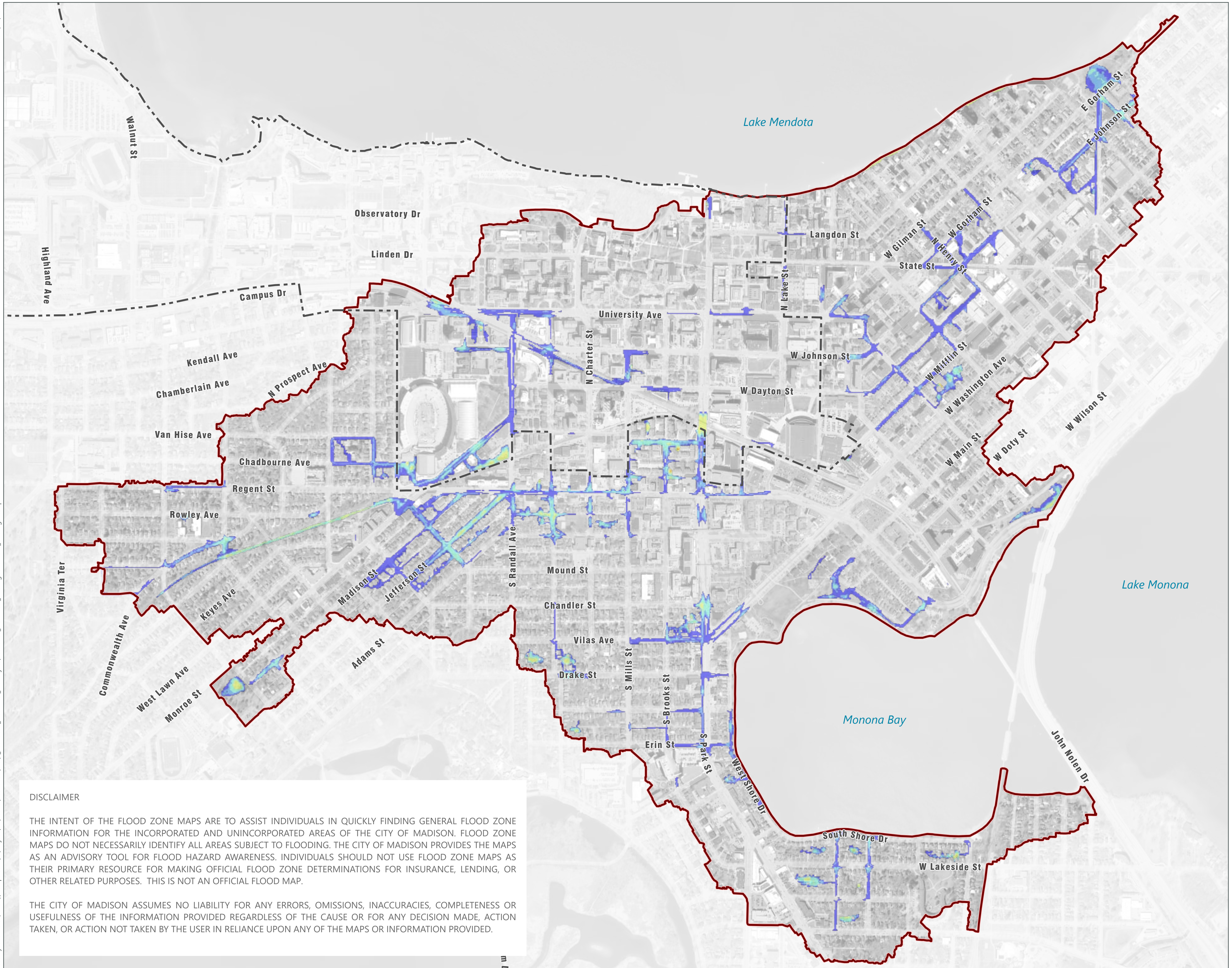
MSA

0 0.1 0.2 Miles

20% AEP Inundation

FIGURE 12
Near West Watershed
Study Report

City of Madison
Dane County, WI



Watershed Study Area

UW Madison Campus

20% Annual Exceedance Probability Storm

Maximum Water Depth (ft)

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1 - 3
- 3 - 6
- > 6

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Data Sources:
Aerial: City of Madison (2022)
Watershed Boundaries: MSA
Stormwater System: City of Madison and UW Madison

MSA

0 0.1 0.2 Miles

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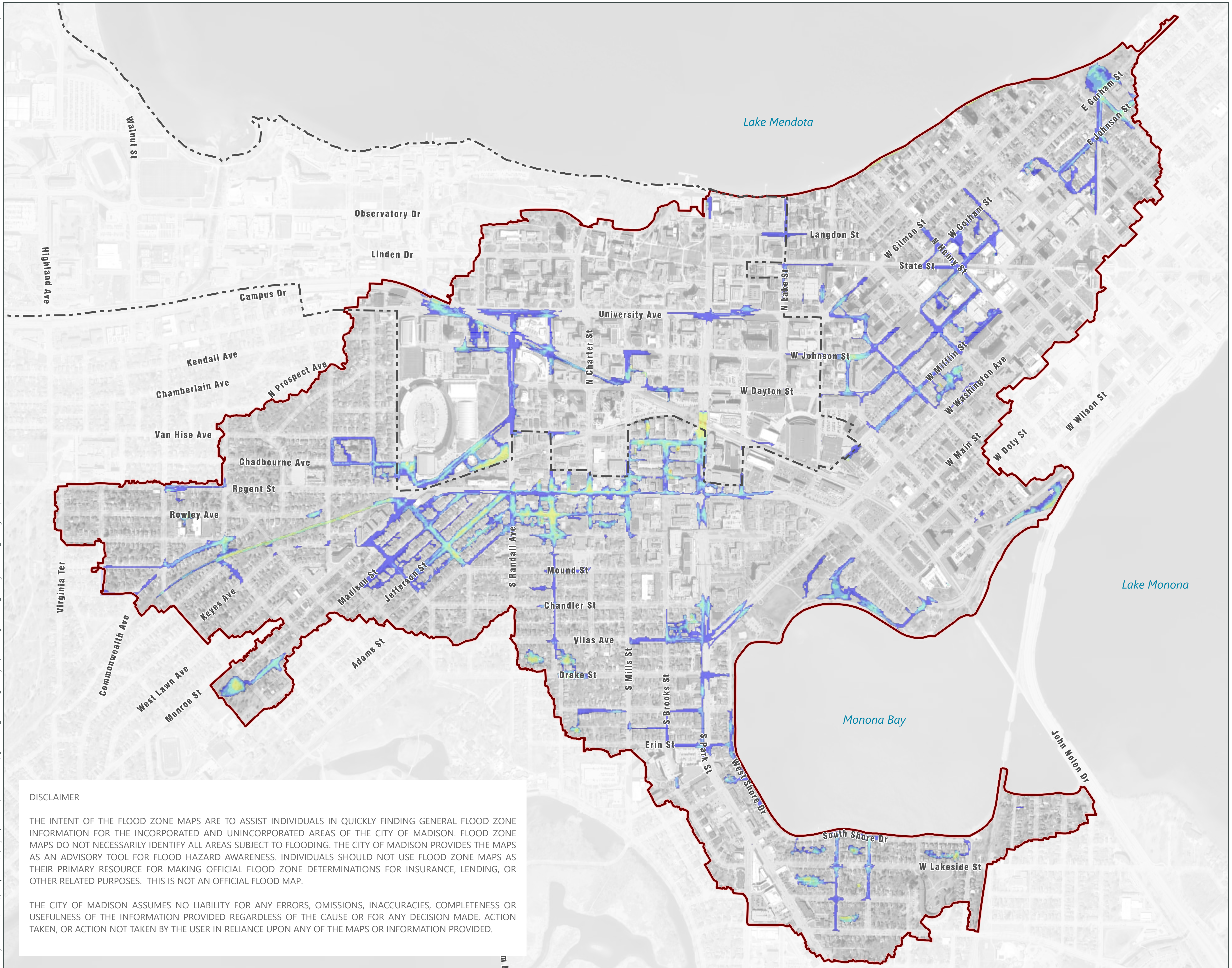

10% AEP Inundation

FIGURE 13
Near West Watershed
Study Report

City of Madison
Dane County, WI

Watershed Study Area

UW Madison Campus

10% Annual Exceedance Probability Storm

Maximum Water Depth (ft)

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1 - 3
- 3 - 6
- > 6

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Data Sources:
Aerial: City of Madison (2022)
Watershed Boundaries: MSA
Stormwater System: City of Madison and UW Madison

MSA

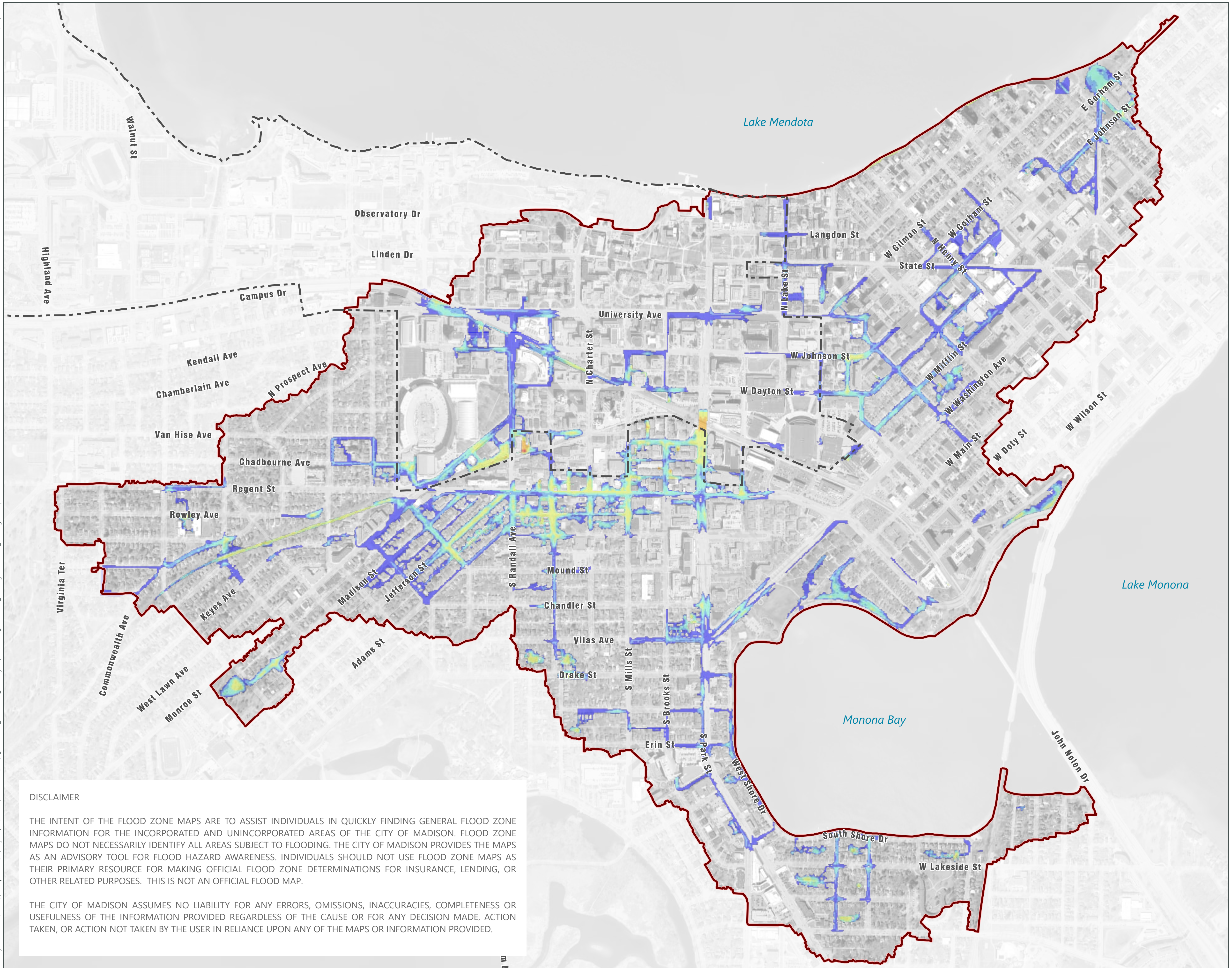
0 0.1 0.2 Miles

Print Date: 4/14/2025

4% AEP Inundation

FIGURE 14
Near West Watershed
Study Report

City of Madison
Dane County, WI



Watershed Study Area

UW Madison Campus

4% Annual Exceedance Probability Storm

Maximum Water Depth (ft)

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1 - 3
- 3 - 6
- > 6

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Data Sources:
Aerial: City of Madison (2022)
Watershed Boundaries: MSA
Stormwater System: City of Madison and UW Madison

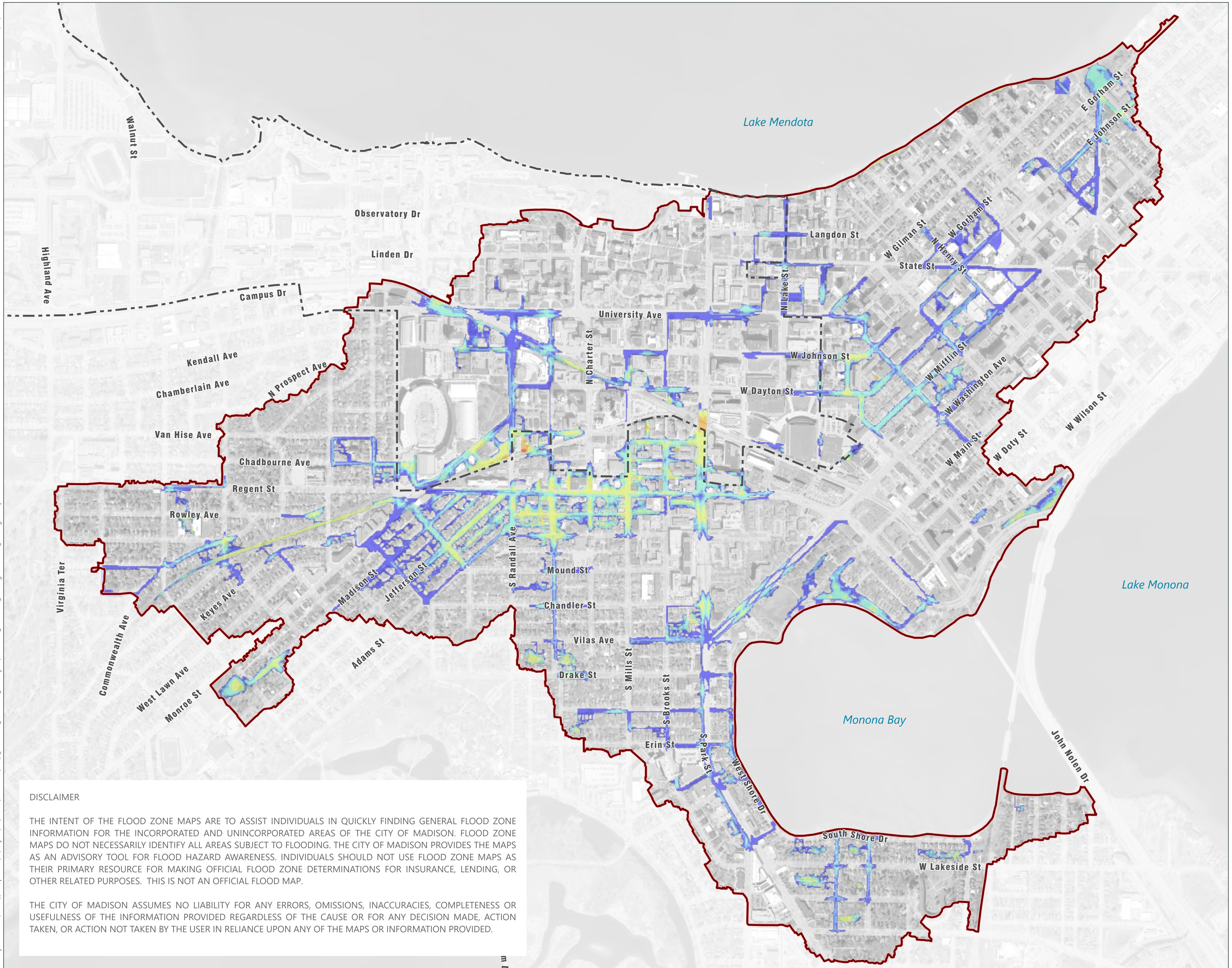
MSA

0 0.1 0.2 Miles

2% AEP Inundation

FIGURE 15
Near West Watershed
Study Report

City of Madison
Dane County, WI



Watershed Study Area

UW Madison Campus

2% Annual Exceedance Probability Storm

Maximum Water Depth (ft)

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1 - 3
- 3 - 6
- > 6

Data Sources:
Aerial: City of Madison (2022)
Watershed Boundaries: MSA
Stormwater System: City of Madison and UW Madison

MSA

0 0.1 0.2 Miles

N

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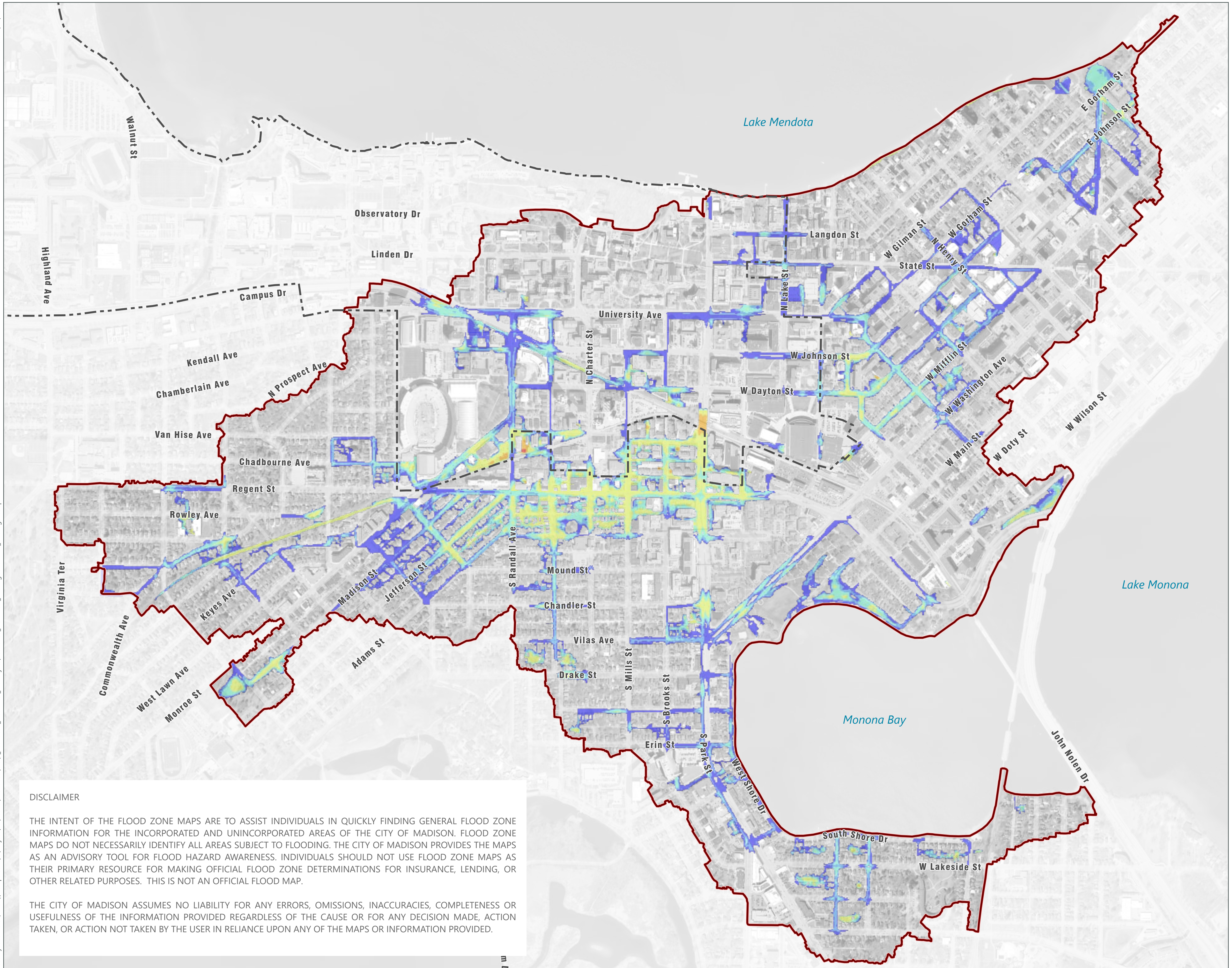
1% AEP Inundation

FIGURE 16
Near West Watershed
Study Report

City of Madison
Dane County, WI



Watershed Study Area

UW Madison Campus

1% Annual Exceedance Probability Storm

Maximum Water Depth (ft)

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1 - 3
- 3 - 6
- > 6

DISCLAIMER

THE INTENT OF THE FLOOD ZONE MAPS ARE TO ASSIST INDIVIDUALS IN QUICKLY FINDING GENERAL FLOOD ZONE INFORMATION FOR THE INCORPORATED AND UNINCORPORATED AREAS OF THE CITY OF MADISON. FLOOD ZONE MAPS DO NOT NECESSARILY IDENTIFY ALL AREAS SUBJECT TO FLOODING. THE CITY OF MADISON PROVIDES THE MAPS AS AN ADVISORY TOOL FOR FLOOD HAZARD AWARENESS. INDIVIDUALS SHOULD NOT USE FLOOD ZONE MAPS AS THEIR PRIMARY RESOURCE FOR MAKING OFFICIAL FLOOD ZONE DETERMINATIONS FOR INSURANCE, LENDING, OR OTHER RELATED PURPOSES. THIS IS NOT AN OFFICIAL FLOOD MAP.

THE CITY OF MADISON ASSUMES NO LIABILITY FOR ANY ERRORS, OMISSIONS, INACCURACIES, COMPLETENESS OR USEFULNESS OF THE INFORMATION PROVIDED REGARDLESS OF THE CAUSE OR FOR ANY DECISION MADE, ACTION TAKEN, OR ACTION NOT TAKEN BY THE USER IN RELIANCE UPON ANY OF THE MAPS OR INFORMATION PROVIDED.

Data Sources:
Aerial: City of Madison (2022)
Watershed Boundaries: MSA
Stormwater System: City of Madison and UW Madison

MSA

0 0.1 0.2 Miles

N

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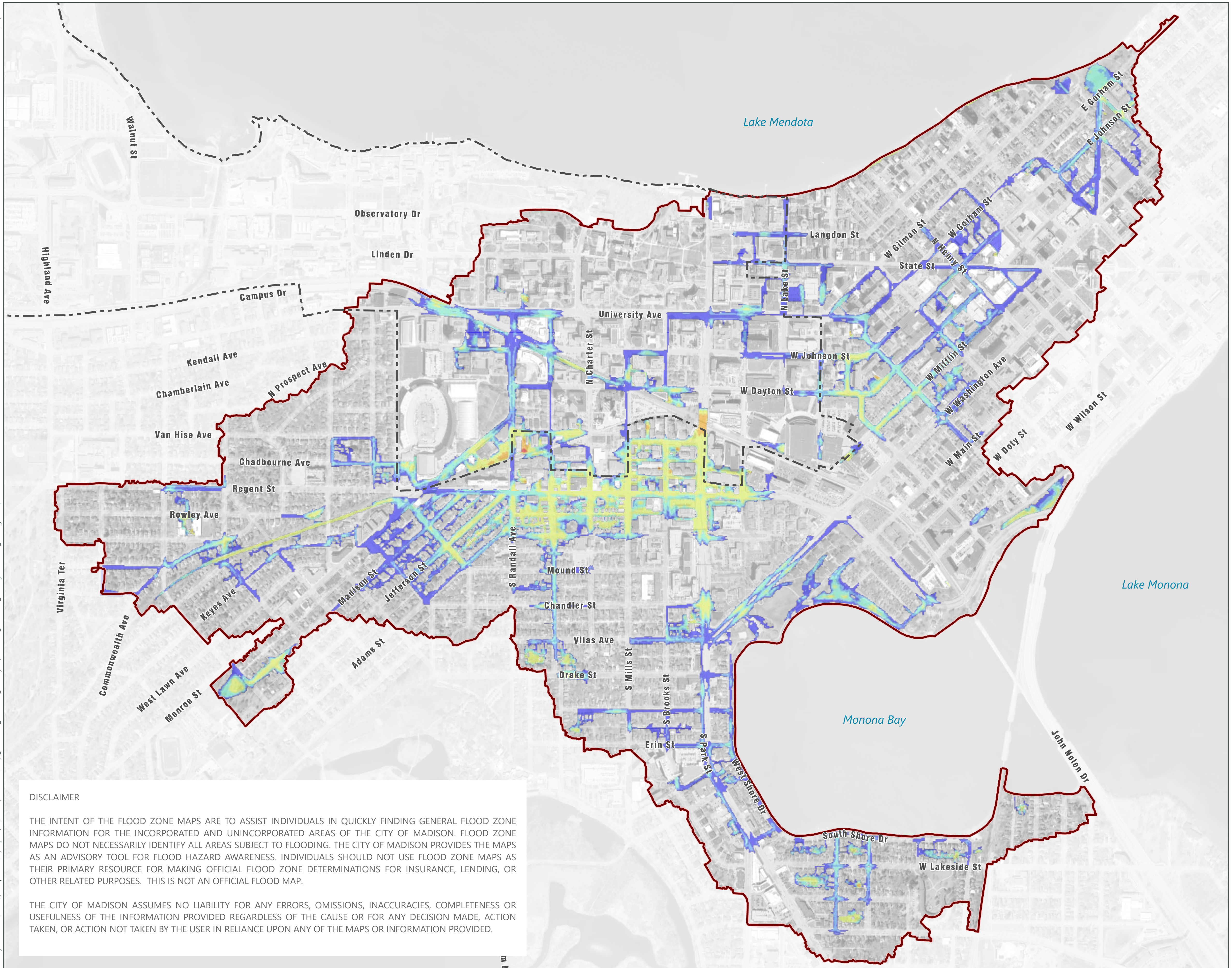

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Long 1% AEP Inundation

FIGURE 17
Near West Watershed
Study Report

City of Madison
Dane County, WI

Watershed Study Area

UW Madison Campus

Long 1% Annual Exceedance Prob. Storm

Maximum Water Depth (ft)

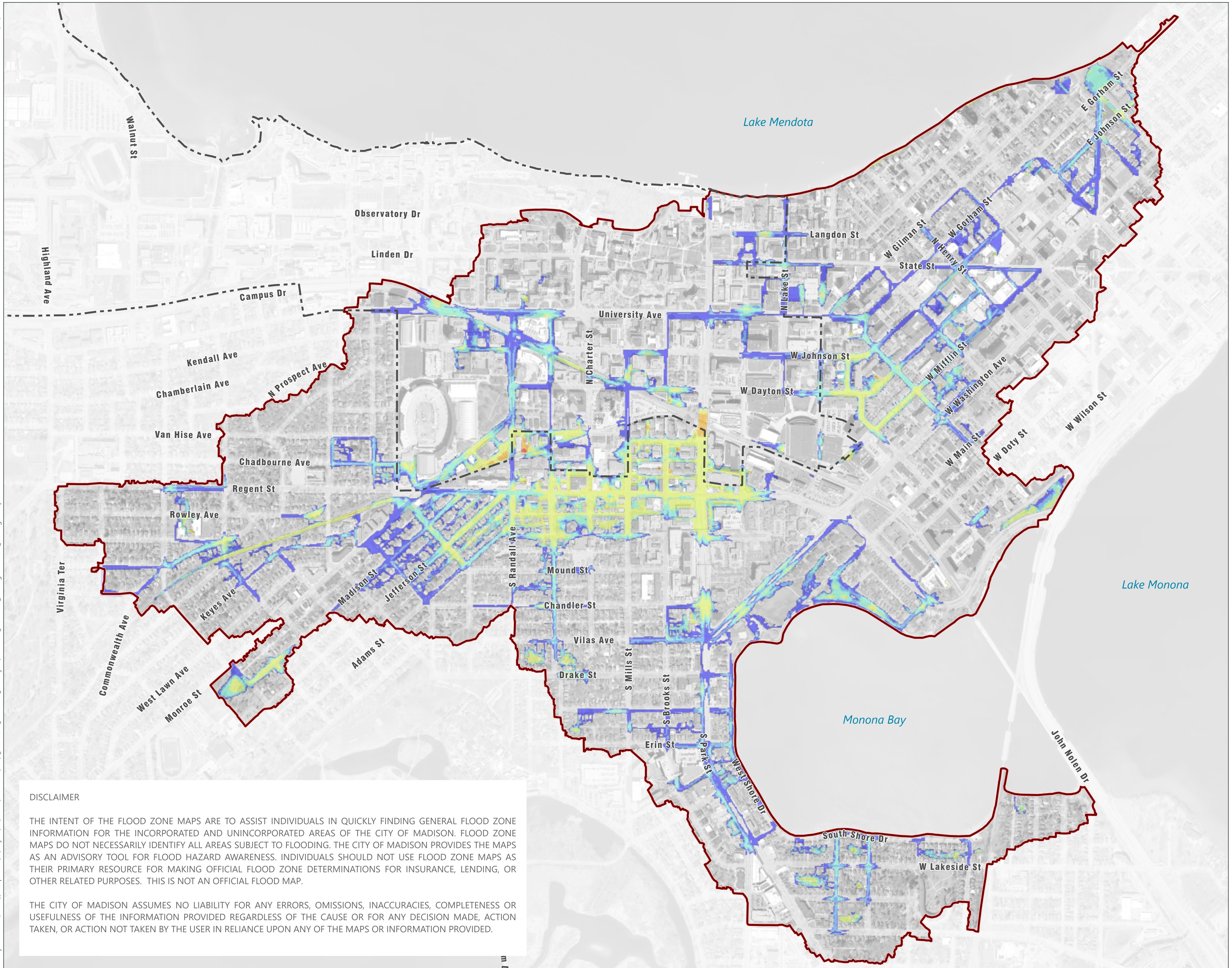
- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1 - 3
- 3 - 6
- > 6

Data Sources:
Aerial: City of Madison (2022)
Watershed Boundaries: MSA
Stormwater System: City of Madison and UW Madison

MSA

0 0.1 0.2 Miles

N



0.5% AEP Inundation

FIGURE 18
Near West Watershed
Study Report

City of Madison
Dane County, WI

Watershed Study Area

UW Madison Campus

0.5% Annual Exceedance Probability Storm

Maximum Water Depth (ft)

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1 - 3
- 3 - 6
- > 6

Data Sources:
Aerial: City of Madison (2022)
Watershed Boundaries: MSA
Stormwater System: City of Madison and UW Madison

MSA

0 0.1 0.2 Miles

N

DISCLAIMER

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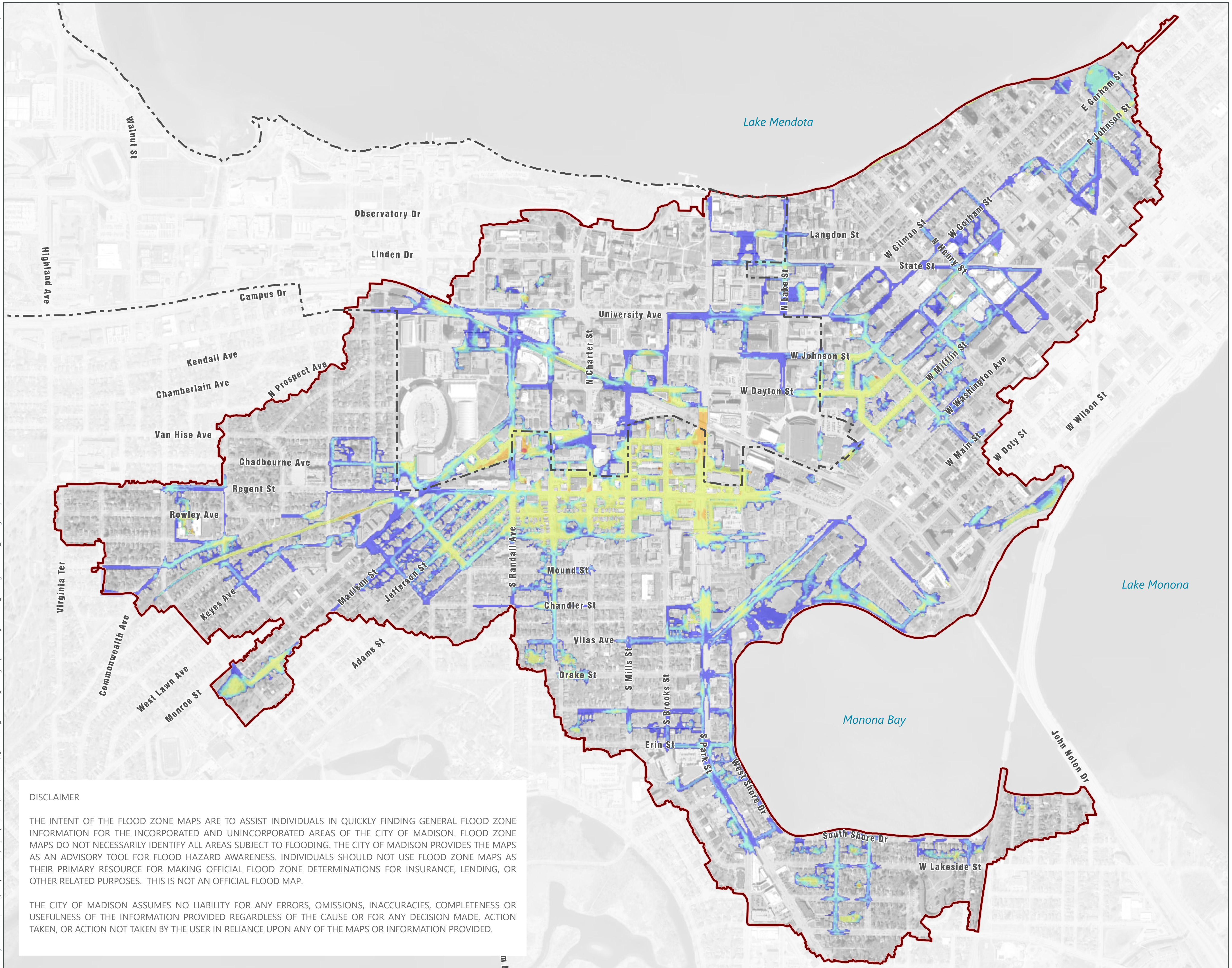
0.2% AEP Inundation

FIGURE 19
Near West Watershed
Study Report

City of Madison
Dane County, WI



Watershed Study Area

UW Madison Campus

0.2% Annual Exceedance Probability Storm

Maximum Water Depth (ft)

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1 - 3
- 3 - 6
- > 6

DISCLAIMER

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Data Sources:
Aerial: City of Madison (2022)
Watershed Boundaries: MSA
Stormwater System: City of Madison and UW Madison

0 0.1 0.2 Miles

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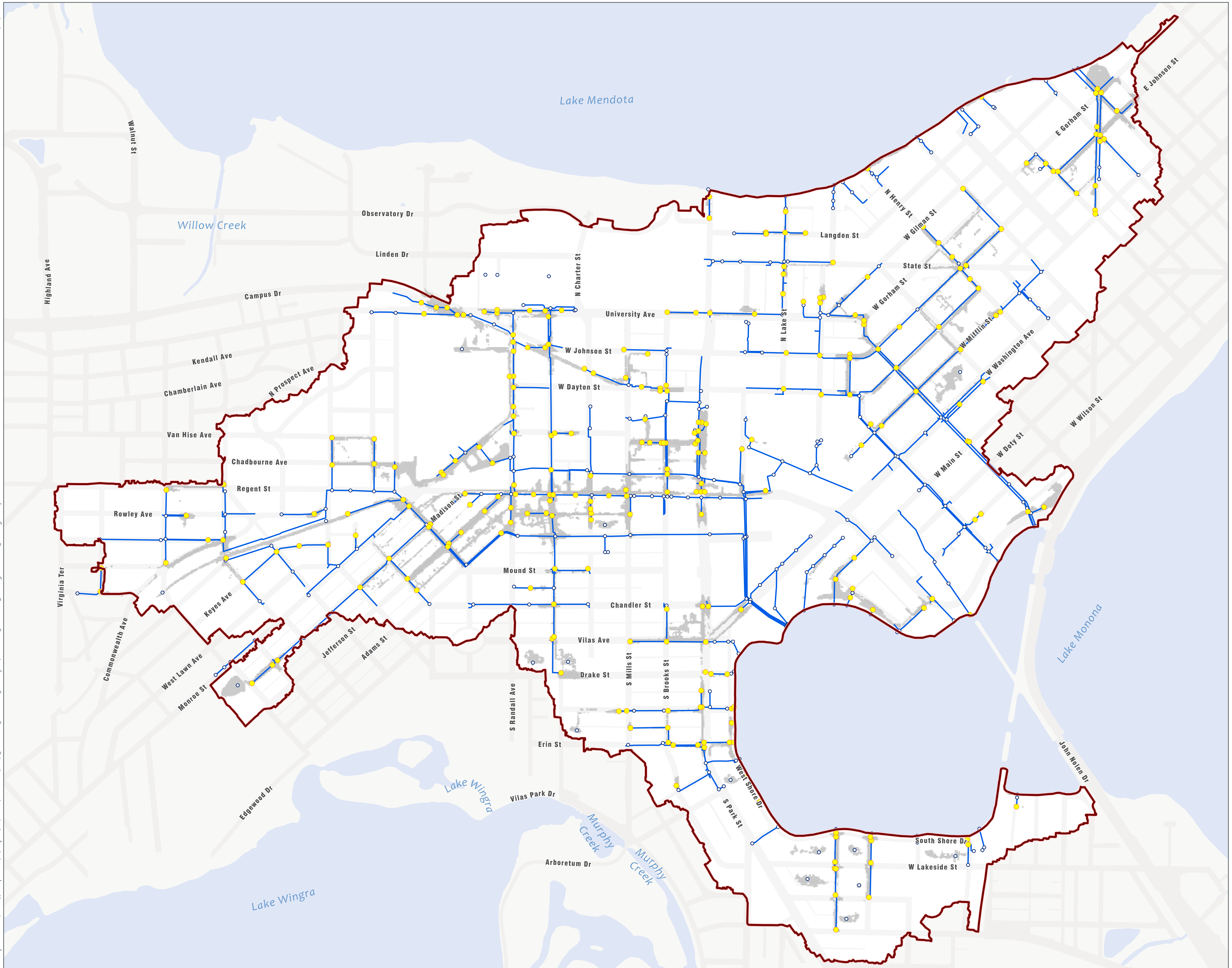


Target 1a

Eliminate flooding from the storm sewer system for the 10% AEP design storm; all water shall be contained within the system, except at low points.

FIGURE 20
Near West Watershed
Study Report

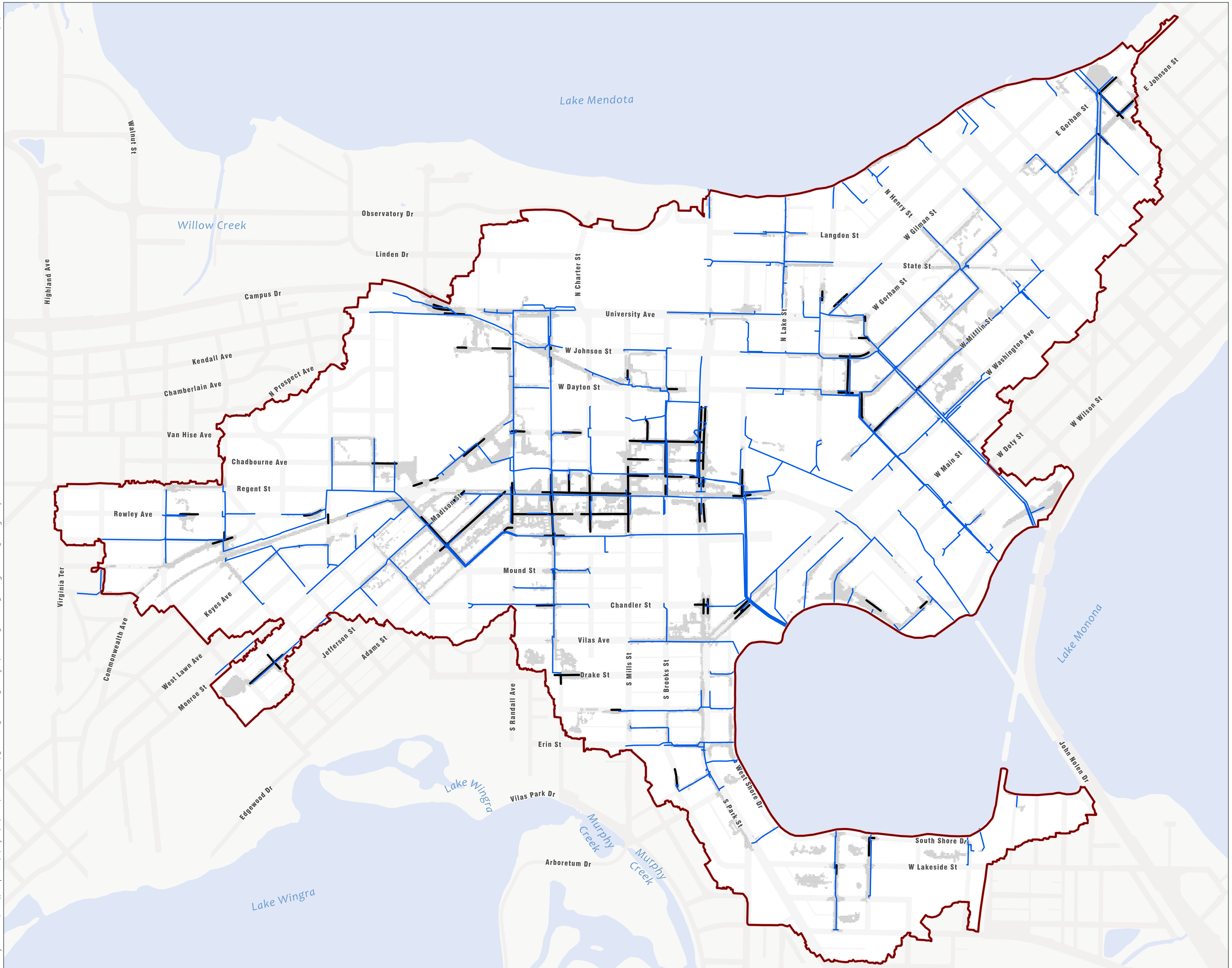
City of Madison
Dane County, WI

Watershed Study Area
Modeled Link
Modeled Nodes
Inundation on modeled public structure
Inundation Extent, 10% AEP Event

Data Sources:
Watershed Boundaries: MSA
Stormwater System: City of Madison

0 0.1 0.2 Miles

Print Date: 4/14/2025



Target 2a

Streets to remain passable during 4% AEP design storm with no more than 0.5-ft of water at the centerline.

FIGURE 21
Near West Watershed
Study Report

City of Madison
Dane County, WI

Watershed Study Area
Modeled Link
0.5" or Greater Inundation at Centerline
Inundation Extent, 4% AEP Event

Data Sources:
Watershed Boundaries: MSA
Stormwater System: City of Madison

MSA

0 0.1 0.2 Miles

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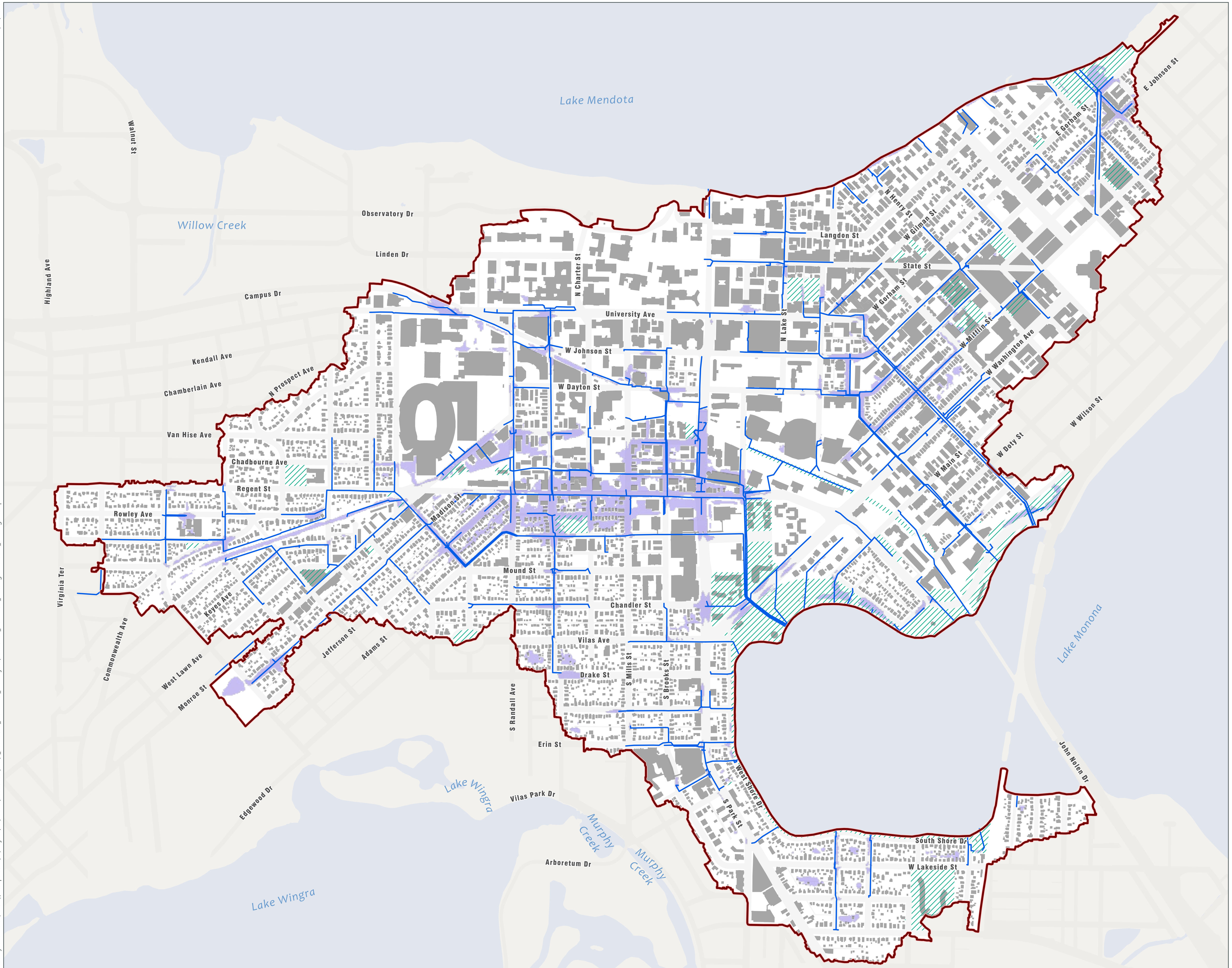


Target 3a

No home or business will be flooded during the 1% AEP design storm.

FIGURE 22
Near West Watershed
Study Report

City of Madison
Dane County, WI

Watershed Study Area

SWU Land/Parks

Building Footprint

1% AEP Storm

Inundation >0.5 ft

Data Sources:
Watershed Boundaries: MSA
Stormwater System: City of Madison

MSA

0 0.1 0.2 Miles

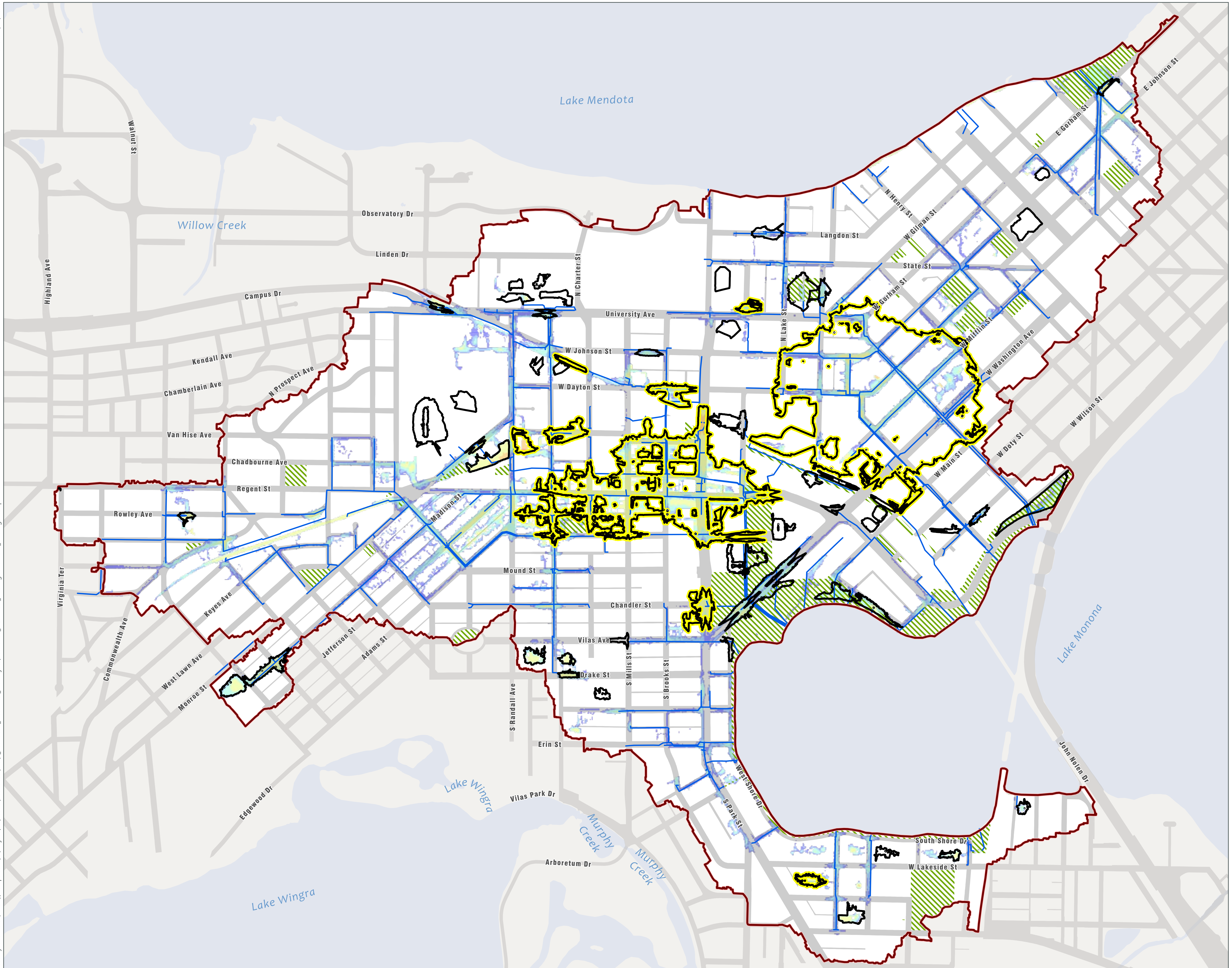
N

Target 3b

Enclosed depressions to be served to the 100-year design storm
(which can include safe overland flow within street, easements, greenways or other public lands).

FIGURE 23
Near West Watershed
Study Report

City of Madison
Dane County, WI



Watershed Study Area
SWU Lands and Parks
Modeled Link

1% Annual Exceedance Probability Storm

Maximum Water Depth (ft)

- 0.1 - 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1 - 3
- 3 - 6
- >6

Enclosed Depression
Enclosed Despression Not Meeting Criteria*

Data Sources:
Watershed Boundaries: MSA
Stormwater System: City of Madison
Enclosed Depressions: Derived from 2022 LiDAR DEM, with a minimum size of 0.25 acres. Note that some identified depressions are due to the age of the DEM and recent construction projects.

**Enclosed depressions do not meet the goal criteria if all three of the following are true:*
1) The depression touches the public ROW or public lands
2) The residual depression area outside of public lands and street ROW was greater than 0.25 acres
3) The maximum inundation depth is 1' or greater during the the100-year design storm event

MSA

0 0.1 0.2 Miles

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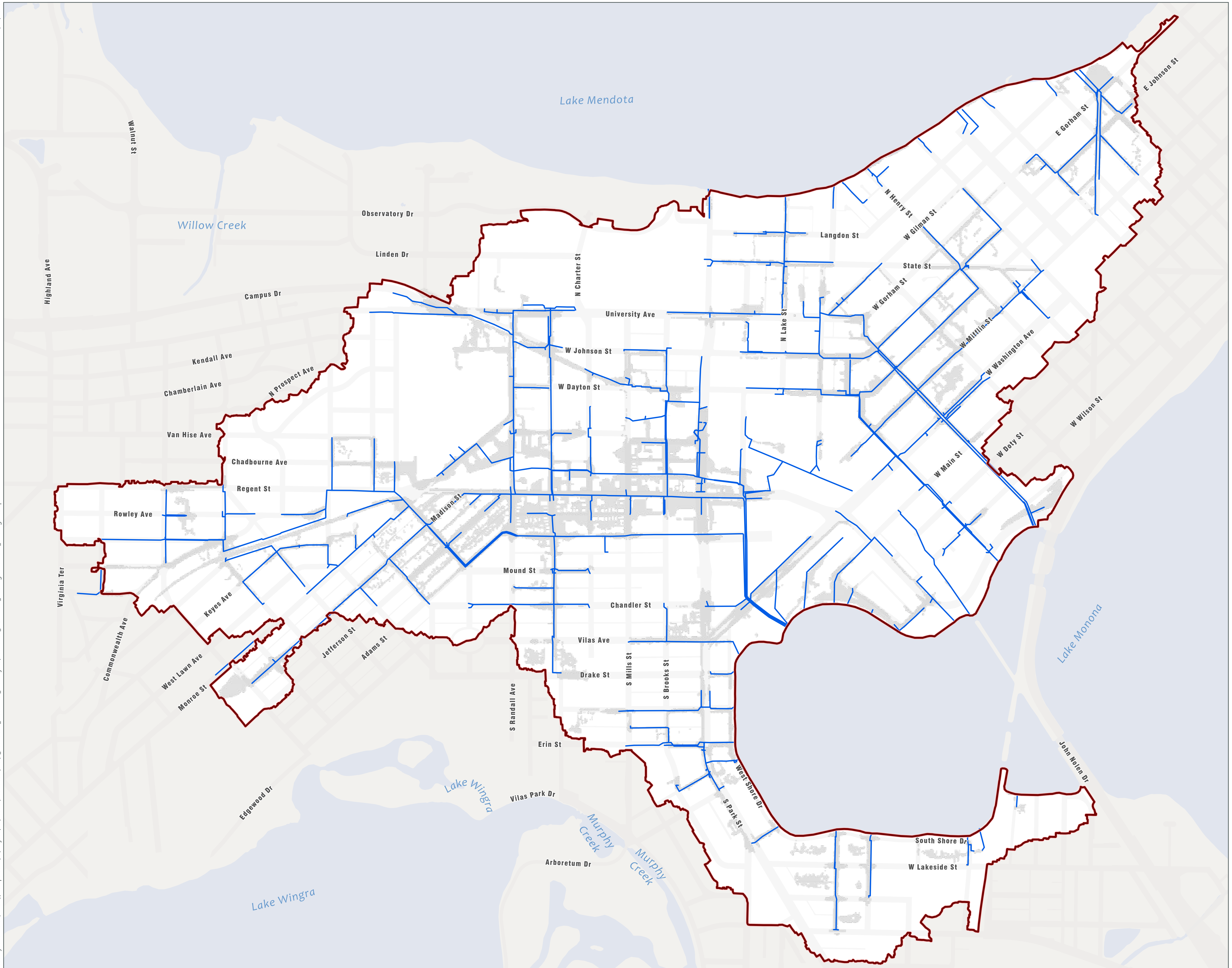
Target 3c

Greenway crossings at streets to be served to the 1% AEP design storm.

FIGURE 24
Near West Watershed
Study Report

City of Madison
Dane County, WI



The Near West Watershed does not have any greenway crossings.

Data Sources:
Watershed Boundaries: MSA
Stormwater System: City of Madison

MSA

Print Date: 4/14/2025

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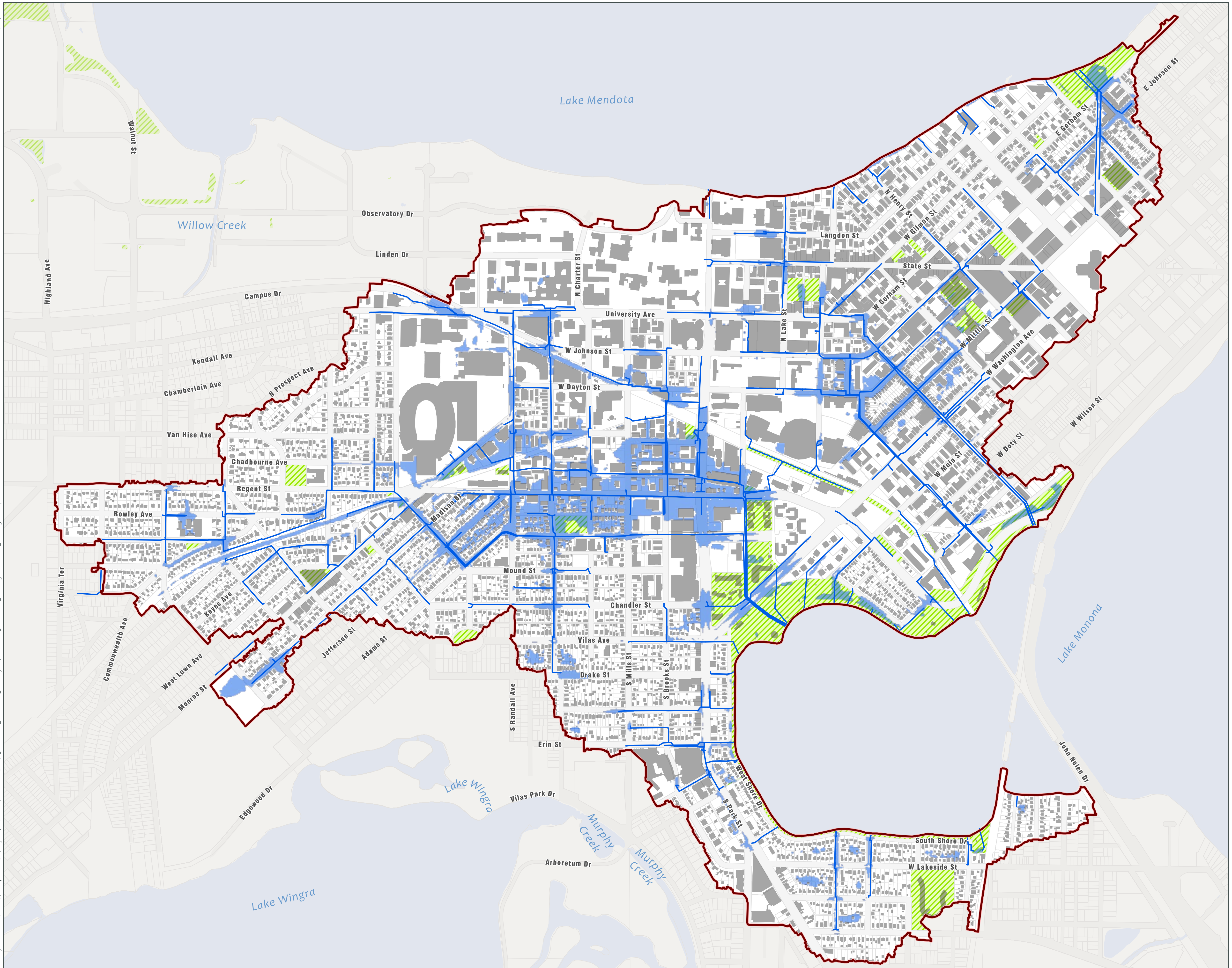


Target 4a

Safely convey stormwater with limited impact on private property during the 0.2% AEP design storm.

FIGURE 25
Near West Watershed
Study Report

City of Madison
Dane County, WI

Watershed Study Area

SWU Land/Parks/Private Pond

Building Footprint

0.2% Annual Exceedance Probability Storm

Inundation >0.5 ft

Modeled Link

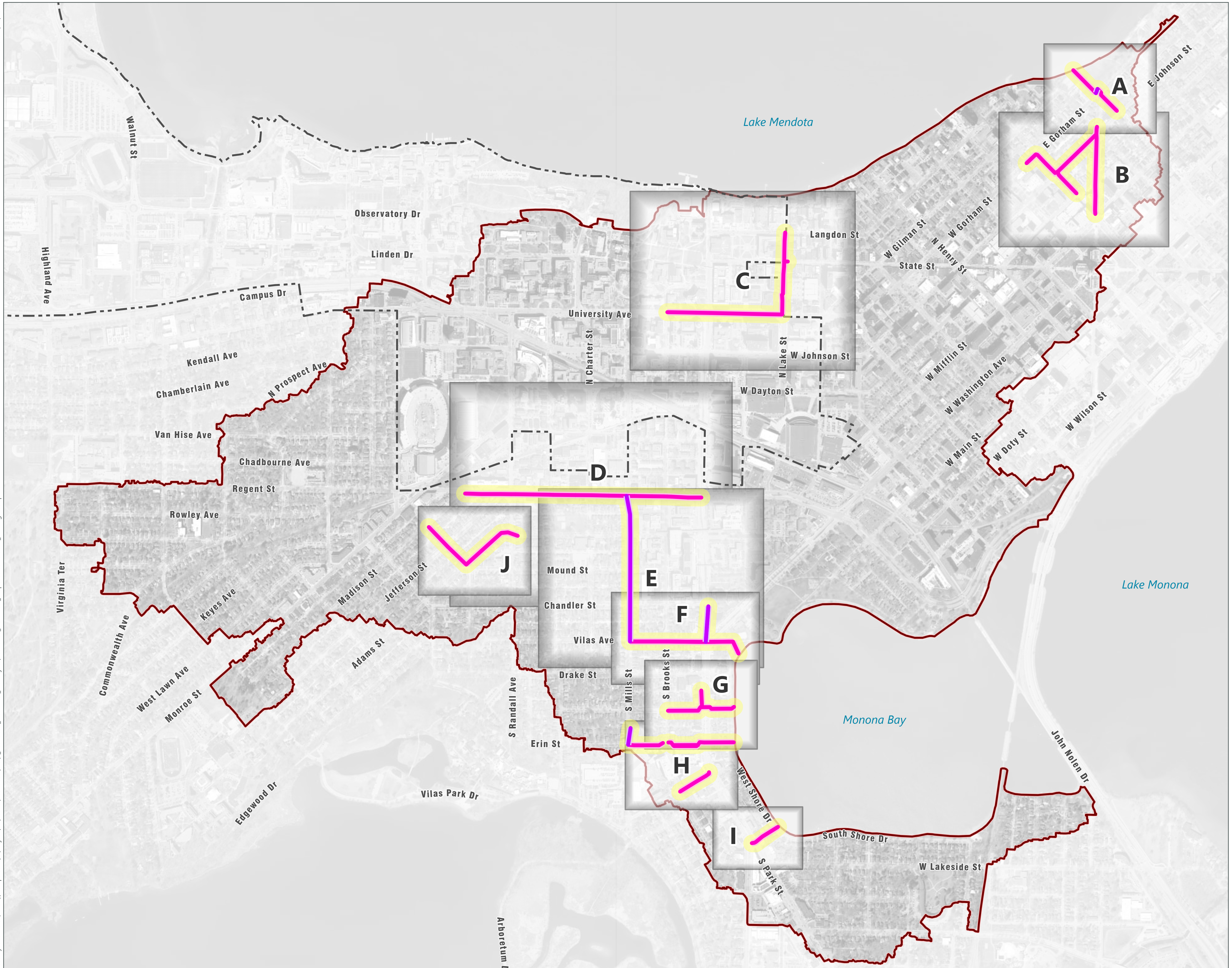
Data Sources:
Watershed Boundaries: MSA
Stormwater System: City of Madison

MSA

0 0.1 0.2 Miles

N

Print Date: 4/14/2025



Recommended Solutions Index

FIGURE 26
Near West Watershed
Study Report

City of Madison
Dane County, WI

Watershed Study Area
Map Extents (Figures 27A - J)
UW Madison Campus
Improvement Area of Interest

Proposed Storm Improvement

New
Upsize

Data Sources:
Aerial: City of Madison (2022)
Watershed Boundaries: MSA
Land Use: Dane County, revised by MSA

MSA

0 0.1 0.2 Miles

N

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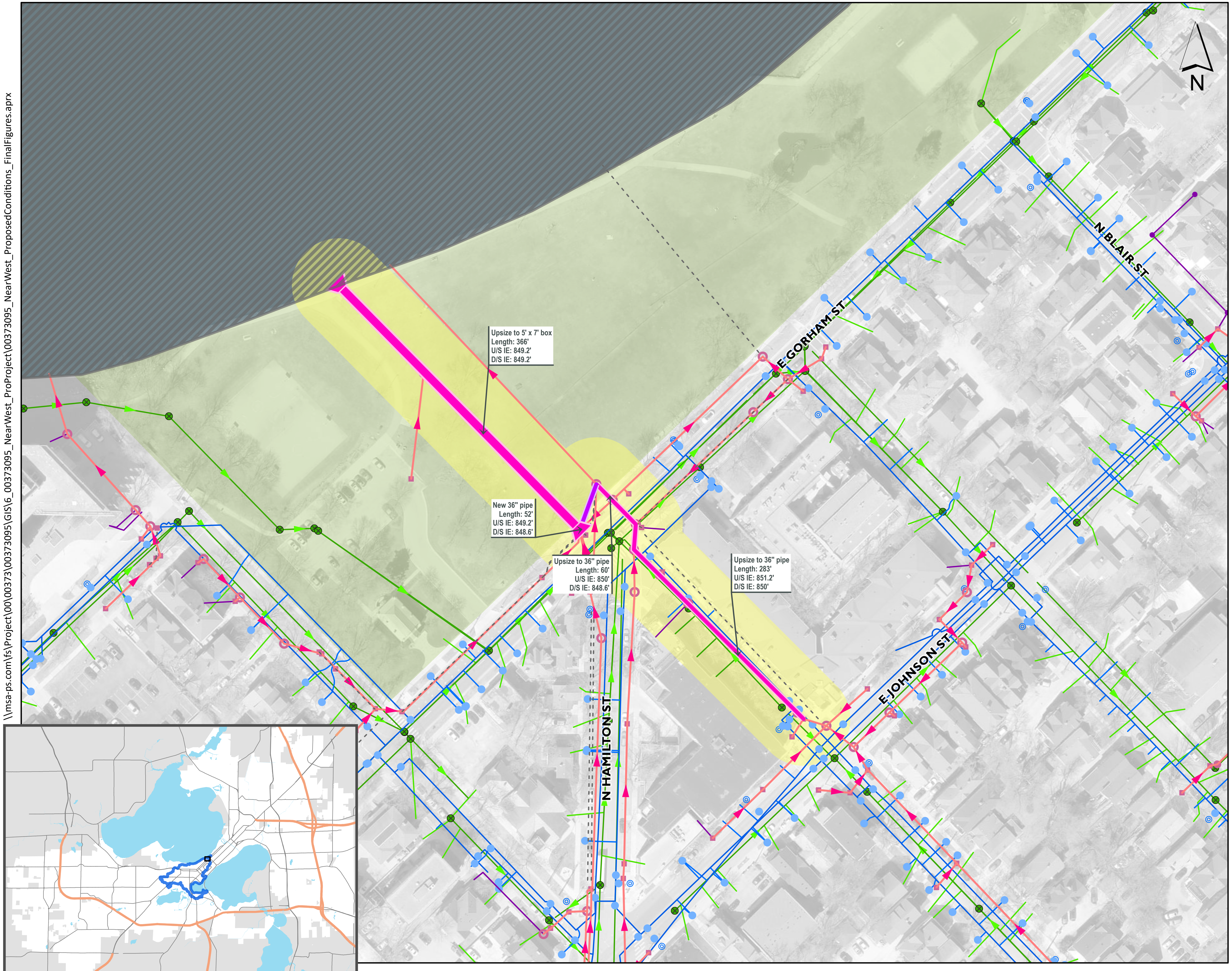
N Hancock St to Outfall Storm System Improvements

Figure 27 -A

Location
City of Madison



Stormwater System
- Storm Pipe
- Abandoned Storm Pipe
- Inlet
- Bend
- Access

Water System
- Water Main/Service
- Valve
- Hydrant

Sanitary System
- Sanitary Main
- Lateral
- Access

- Outside of City of Madison
- Park
- Waterbody
- Railroad
- **Improvement Area of Interest**

Proposed Storm Box
- Upsize

Proposed Storm Pipes
- New
- Upsize

0 25 50 100 Feet

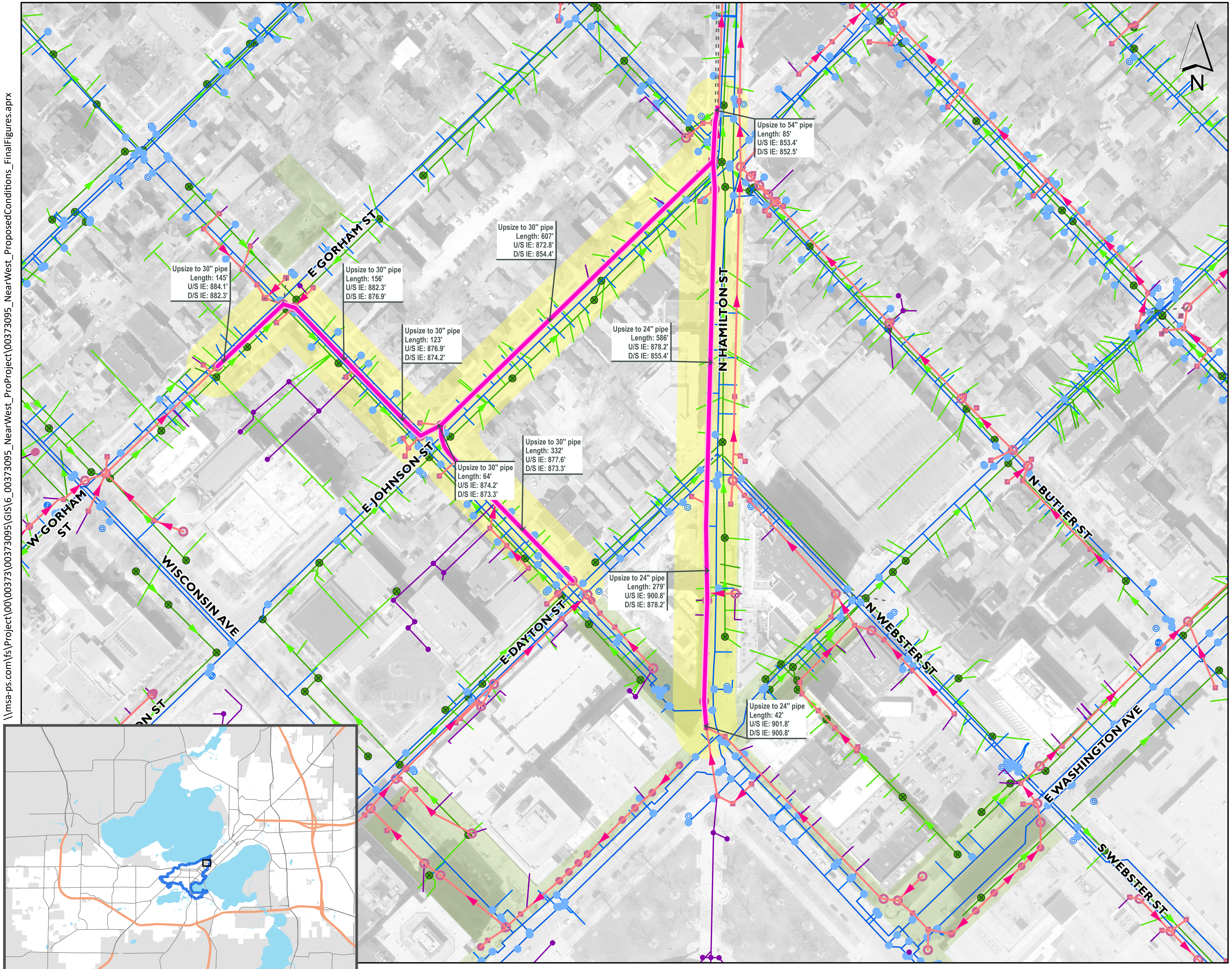
Date: 4/18/2025; User Name: aconverse

\\msa-ps.com\fs\Project\00\00373\00373095\GIS\6_00373095_NearWest_ProProject\00373095_NearWest_ProposedConditions_FinalFigures.aprx

N Hamilton St/E Johnson St/E Gorham St Storm System Improvements

Figure 27 -B

Location
City of Madison



Stormwater System
- Storm Pipe
- Abandoned Storm Pipe
- Inlet
- Bend
- Access

Water System
- Water Main/Service
- Valve
- Hydrant

Sanitary System
- Sanitary Main
- Lateral
- Access

- Park
- Waterbody
- Railroad
- **Improvement Area of Interest**

Proposed Storm Pipes
- Upsize

0 40 80 160 Feet

CITY OF MADISON ENGINEERING

Date: 4/18/2025; User Name: aconverse

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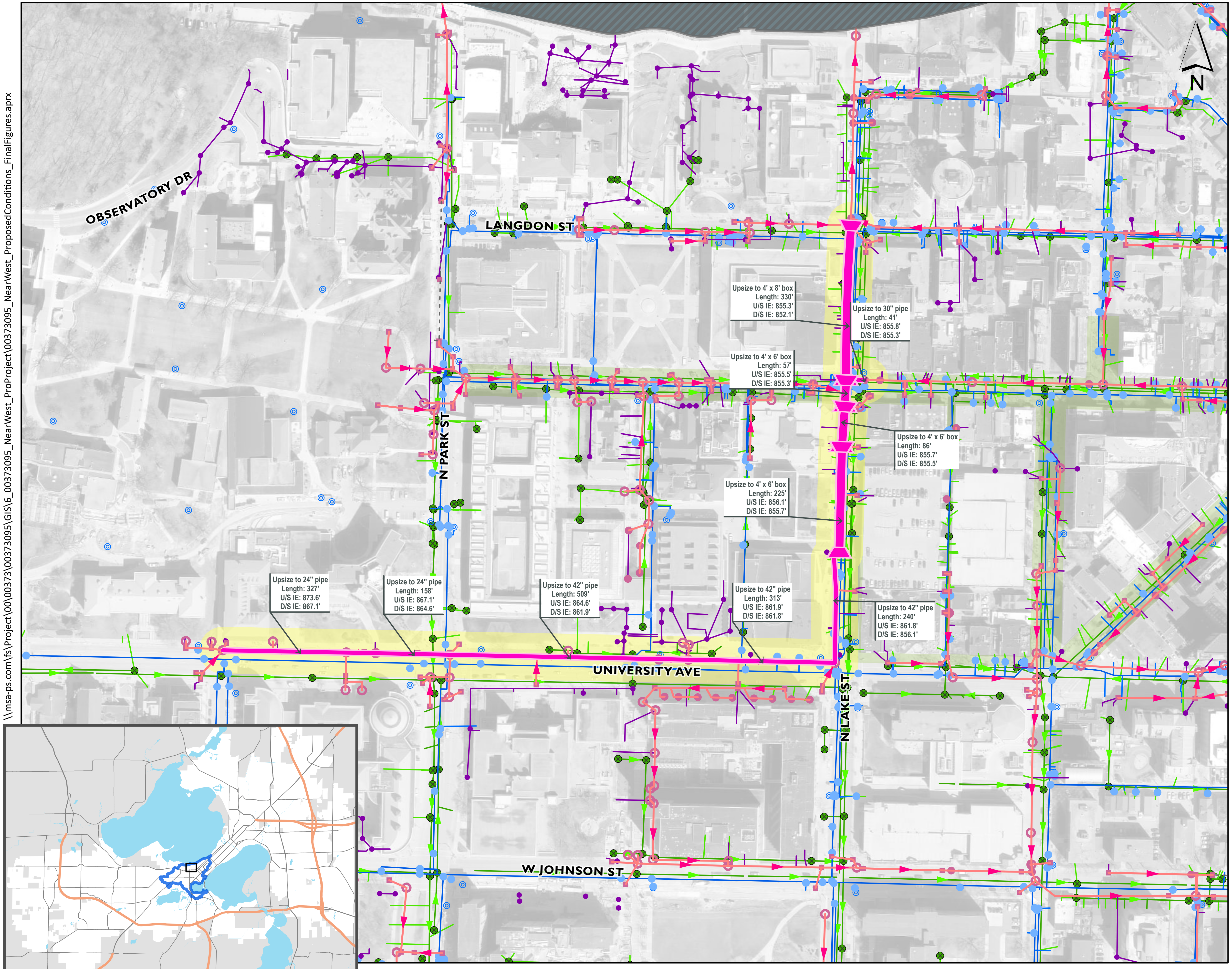
University Ave/Lake St Storm System Improvements

Figure 27 -C

Location
City of Madison



Stormwater System
- Storm Pipe
- Abandoned Storm Pipe
- Inlet
- Bend
- Access

Water System
- Water Main/Service
- Valve
- Hydrant

Sanitary System
- Sanitary Main
- Lateral
- Access

- Outside of City of Madison
- Park
- Waterbody
- Railroad
- Improvement Area of Interest

Proposed Storm Box
- Upsize

Proposed Storm Pipes
- Upsize

0 50 100 200 Feet

CITY OF MADISON ENGINEERING

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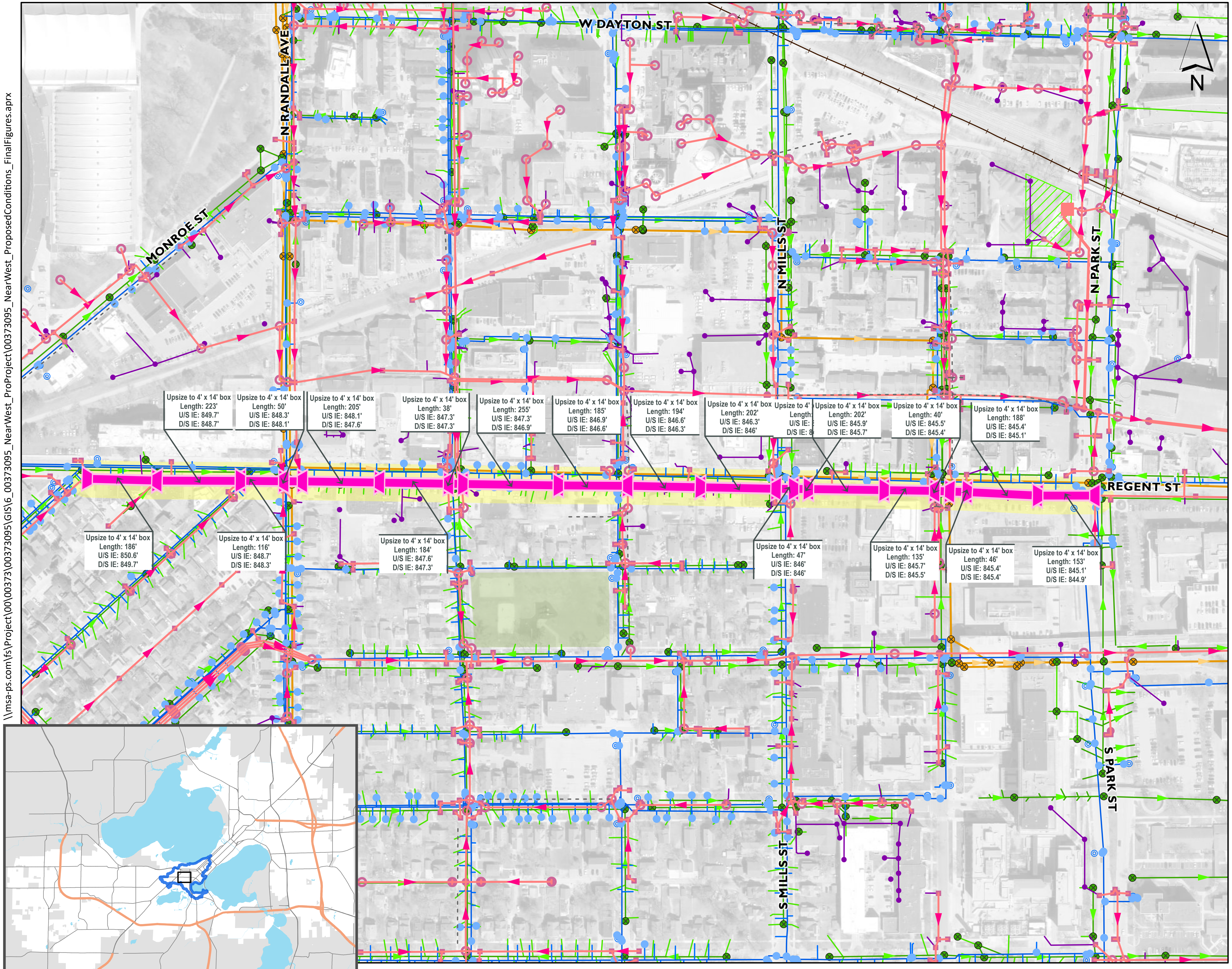
Regent St Storm System Improvements

Figure 27 -D

Location
City of Madison



Stormwater System
- Storm Pipe
- Abandoned Storm Pipe
- Inlet
- Bend
- Access
- Storm_Lift_Stations

Water System
- Water Main/Service
- Valve
- Hydrant

Sanitary System
- Sanitary Main
- Lateral
- Access
- MMSD Main
- MMSD Access

- Park
- City of Madison Ponds/Greenways
- Waterbody
- Railroad
- **Improvement Area of Interest**

Proposed Storm Box
- Upsize

0 65 130 260 Feet

CITY OF MADISON ENGINEERING

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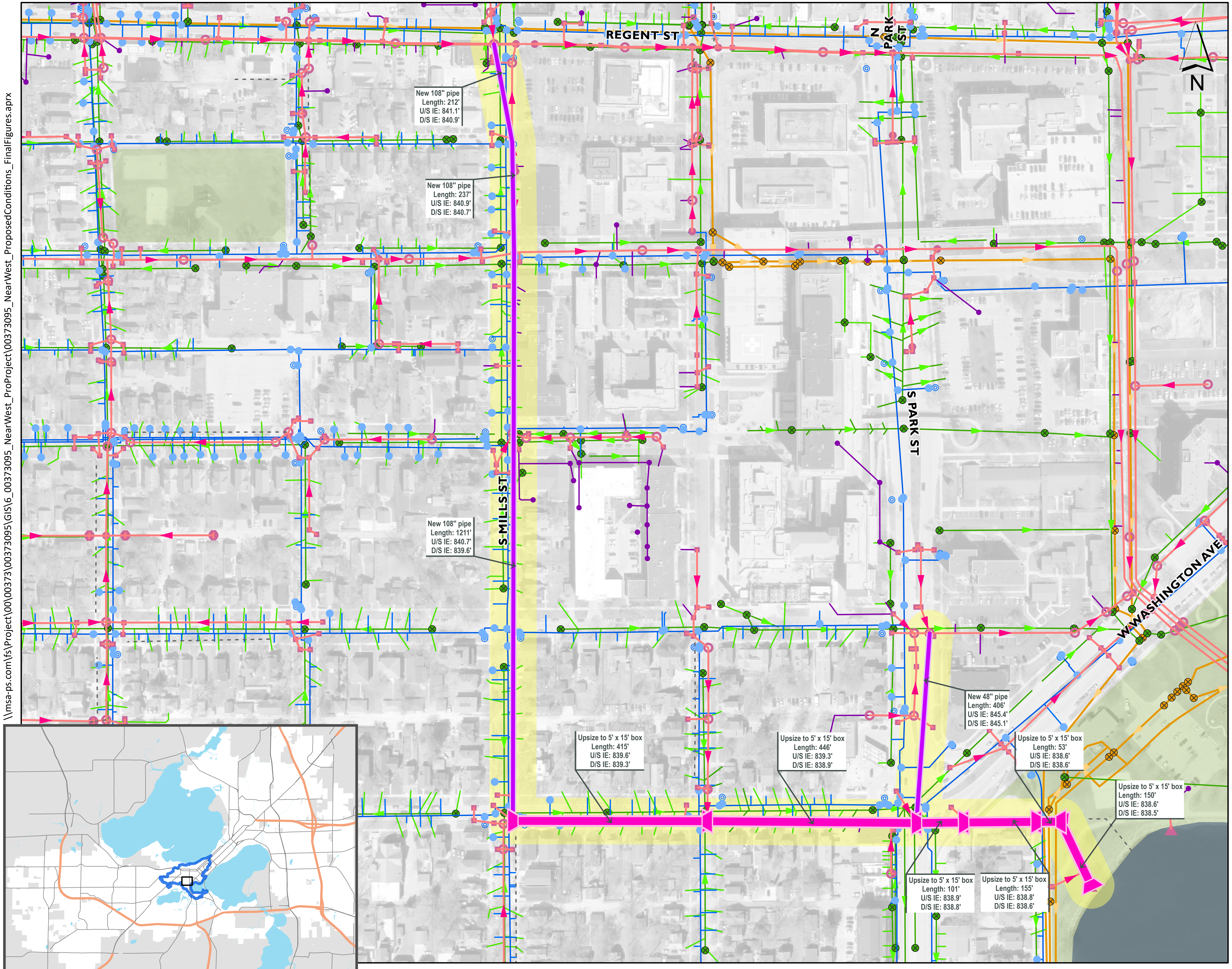
S Mills St Bypass and Vilas Ave/ S Park St Storm System Improvements

Figure 27 -E

Location
City of Madison



Stormwater System
- Storm Pipe
- Abandoned Storm Pipe
- Inlet
- Bend
- Apron End
- Access

Water System
- Water Main/Service
- Valve
- Hydrant

Sanitary System
- Sanitary Main
- Lateral
- Access
- MMSD Main
- MMSD Access

- Park
- Waterbody
- Railroad
- **Improvement Area of Interest**

Proposed Storm Box
- Upsize

Proposed Storm Pipes
- New

If tunnel along S Mills St and Vilas Ave is not constructed, please reference the smaller recommended improvements along Vilas Ave and S Park St (Figure 27-F).

0 50 100 200 Feet

CITY OF MADISON ENGINEERING

Date: 4/18/2025; User Name: aconverse

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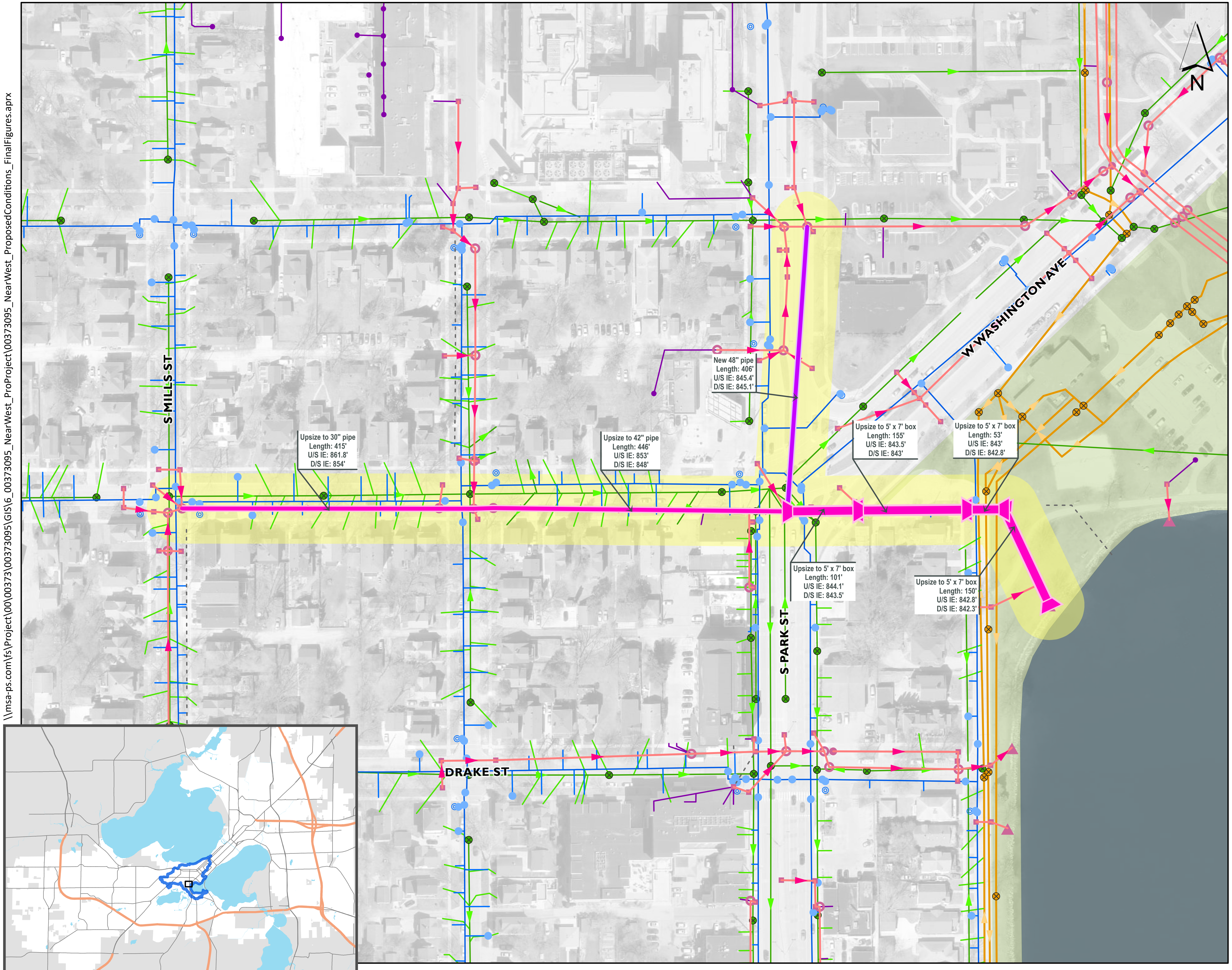

Vilas Ave/S Park St Storm System Improvements

Figure 27 -F

Location
City of Madison

Stormwater System
- Storm Pipe
- Abandoned Storm Pipe
- Inlet
- Bend
- Apron End
- Access

Water System
- Water Main/Service
- Valve
- Hydrant

Sanitary System
- Sanitary Main
- Lateral
- Access
- MMSD Main
- MMSD Access

- Park
- Waterbody
- Railroad
- **Improvement Area of Interest**

Proposed Storm Box
- Upsize

Proposed Storm Pipes
- New
- Upsize

This is a recommended improvement only if the tunnel along S Mills St and Vilas Ave is not constructed (see Figure 27-E).

0 35 70 140 Feet

CITY OF MADISON ENGINEERING

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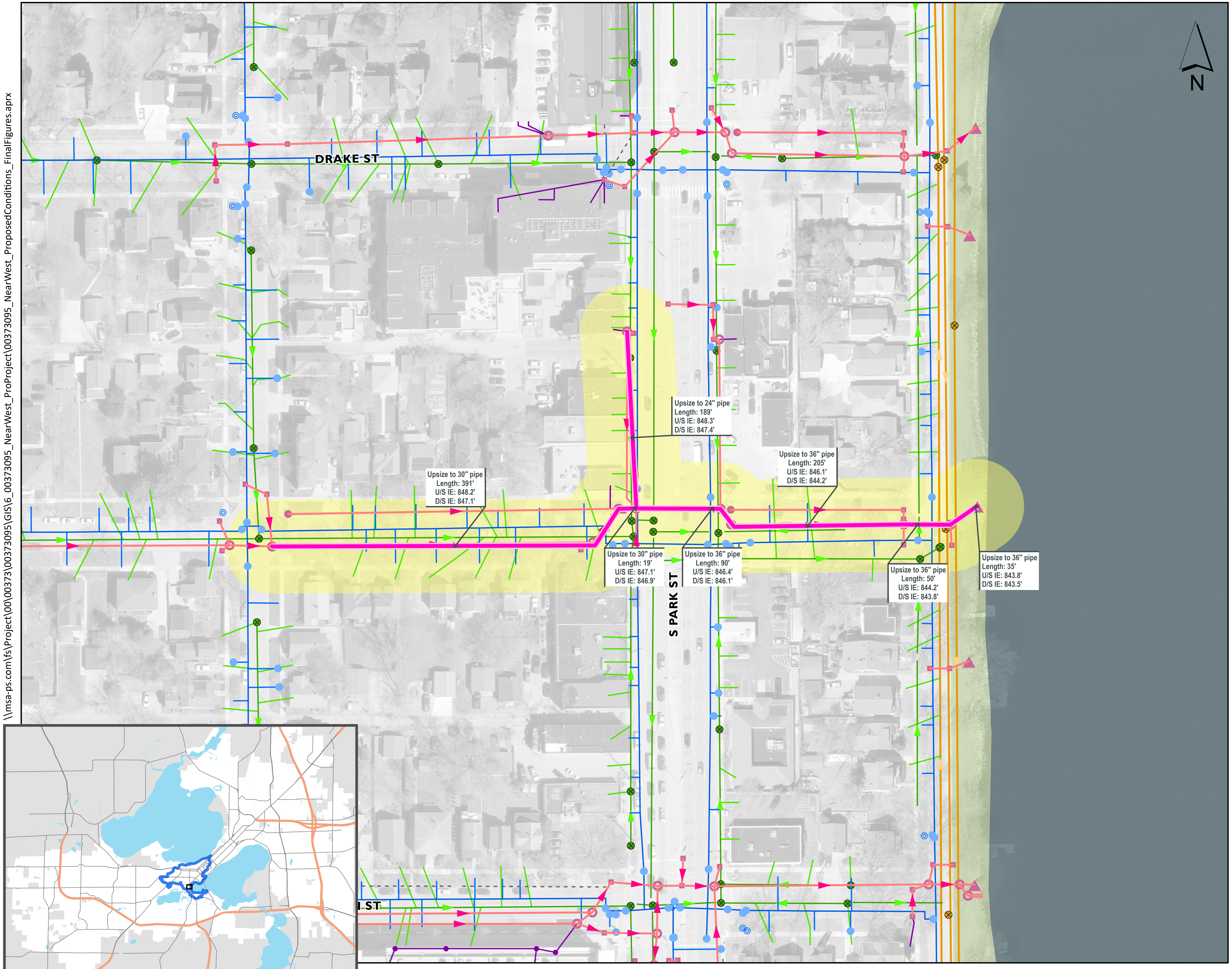
Emerald St/S Park St Storm System Improvements

Figure 27 -G

Location
City of Madison



Stormwater System
- Storm Pipe
- Abandoned Storm Pipe
- Inlet
- Bend
- Apron End
- Access

Water System
- Water Main/Service
- Valve
- Hydrant

Sanitary System
- Sanitary Main
- Lateral
- Access
- MMSD Main
- MMSD Access

- Park
- Waterbody
- Railroad
- **Improvement Area of Interest**

Proposed Storm Pipes
- Upsize

0 25 50 100 Feet

Date: 4/18/2025; User Name: aconverse

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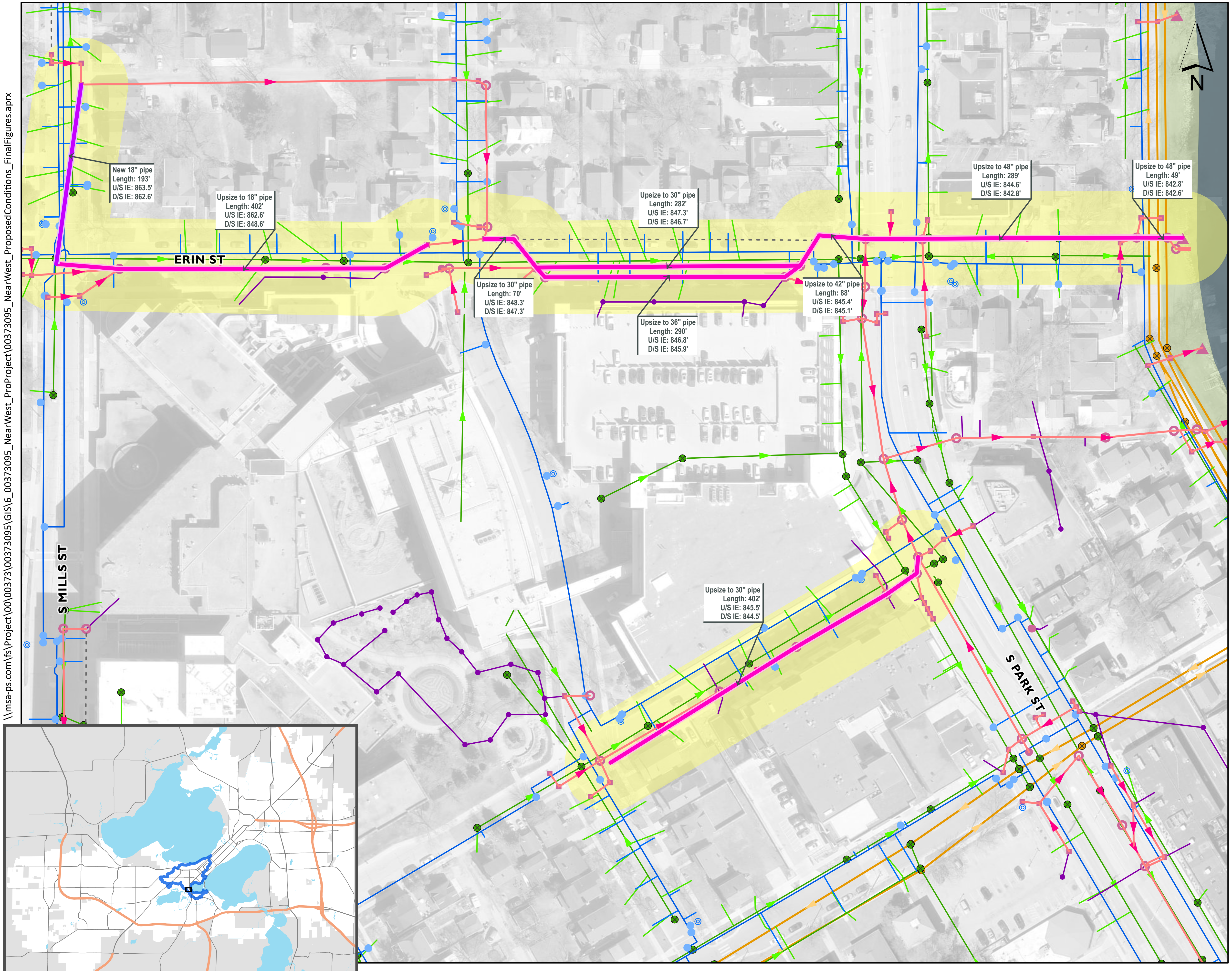


Erin St/Delaplaine Ct Storm System Improvements

Figure 27 -H

Location
City of Madison

Stormwater System
- Storm Pipe
- Abandoned Storm Pipe
- Inlet
- Bend
- Apron End
- Access

Water System
- Water Main/Service
- Valve
- Hydrant

Sanitary System
- Sanitary Main
- Lateral
- Access
- MMSD Main
- MMSD Access

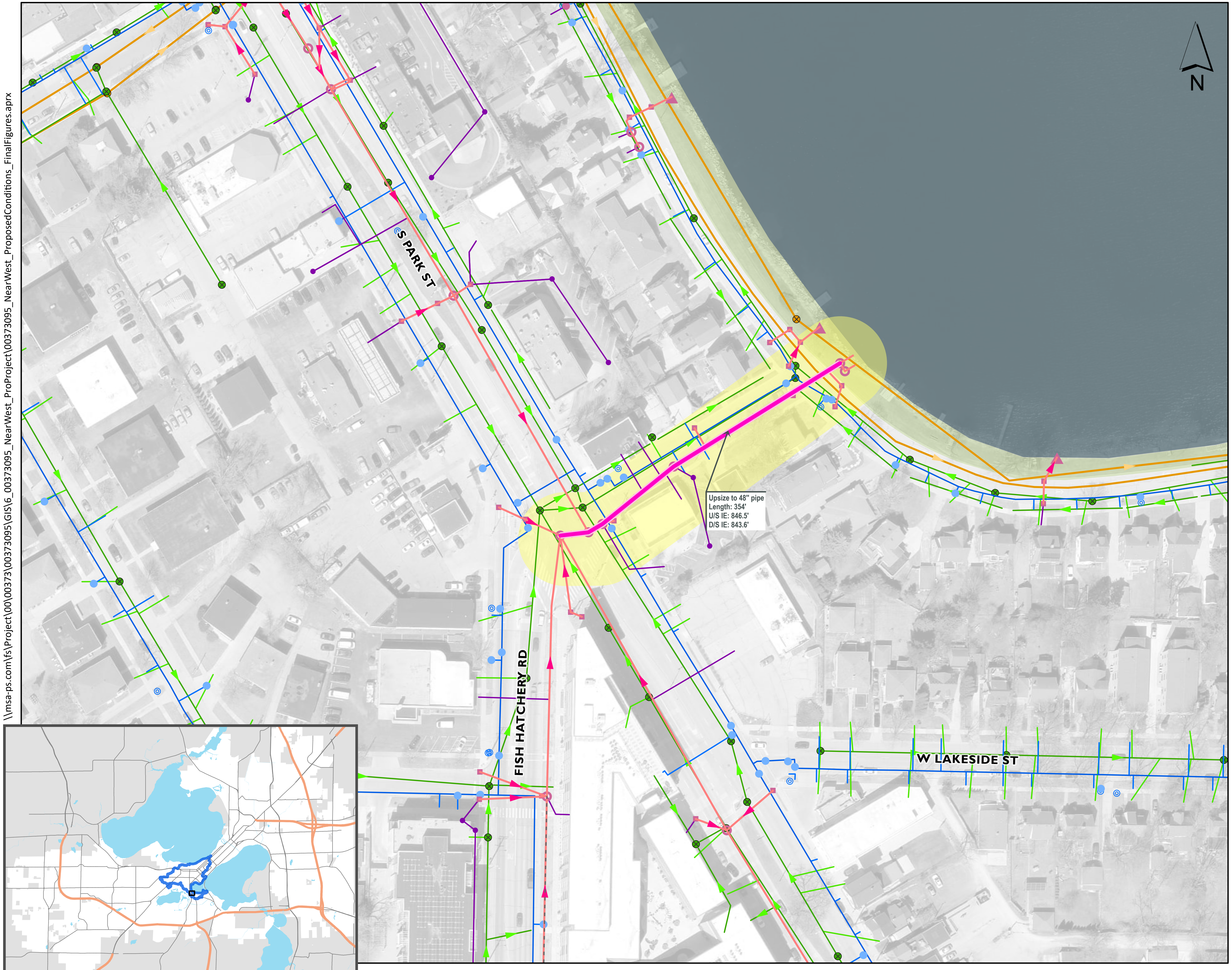
- Park
- Waterbody
- Railroad
- **Improvement Area of Interest**

Proposed Storm Pipes
- New
- Upsize

0 25 50 100 Feet

Date: 4/18/2025; User Name: aconverse

\\msa-ps.com\fs\Project\00\00373\00373095\GIS\6_00373095_NearWest_ProProject\00373095_NearWest_ProposedConditions_FinalFigures.aprx



Parr St Storm System Improvements

Figure 27 -I

Location
City of Madison

Stormwater System
- Storm Pipe
- Abandoned Storm Pipe
- Inlet
- Bend
- Apron End
- Access

Water System
- Water Main/Service
- Valve
- Hydrant

Sanitary System
- Sanitary Main
- Lateral
- Access
- MMSD Main
- MMSD Access

- Park
- Waterbody
- Railroad
- **Improvement Area of Interest**

Proposed Storm Pipes
- Upsize

0 25 50 100 Feet

CITY OF MADISON ENGINEERING

Date: 4/18/2025; User Name: aconverse

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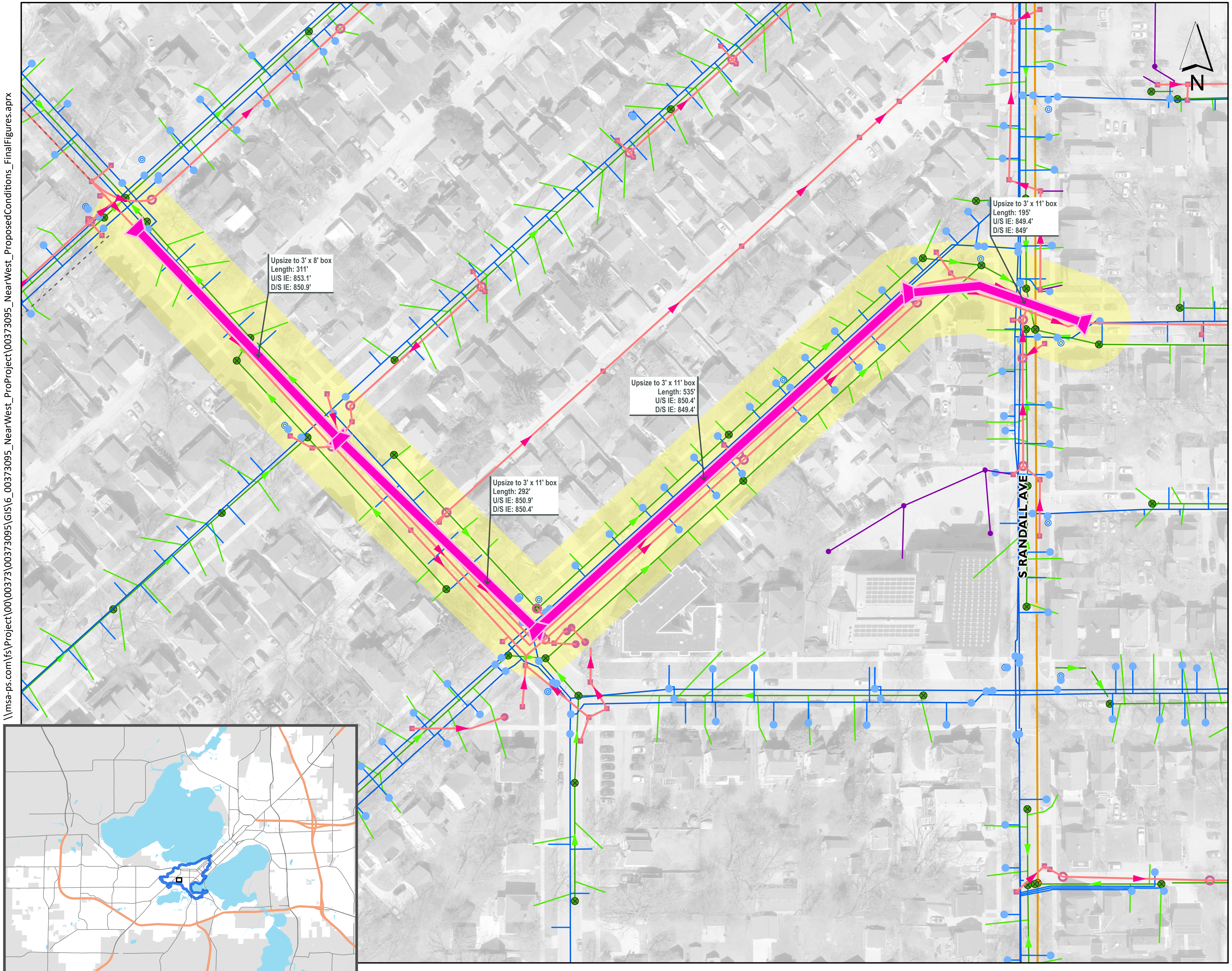


Oakland Ave/Adams St Storm System Improvements

Figure 27 -J

Location
City of Madison

Stormwater System
- Storm Pipe
- Abandoned Storm Pipe
- Inlet
- Bend
- Access

Water System
- Water Main/Service
- Valve
- Hydrant

Sanitary System
- Sanitary Main
- Lateral
- Access
- MMSD Main
- MMSD Access

- Waterbody
- Railroad
- **Improvement Area of Interest**

Proposed Storm Box
- Upsize

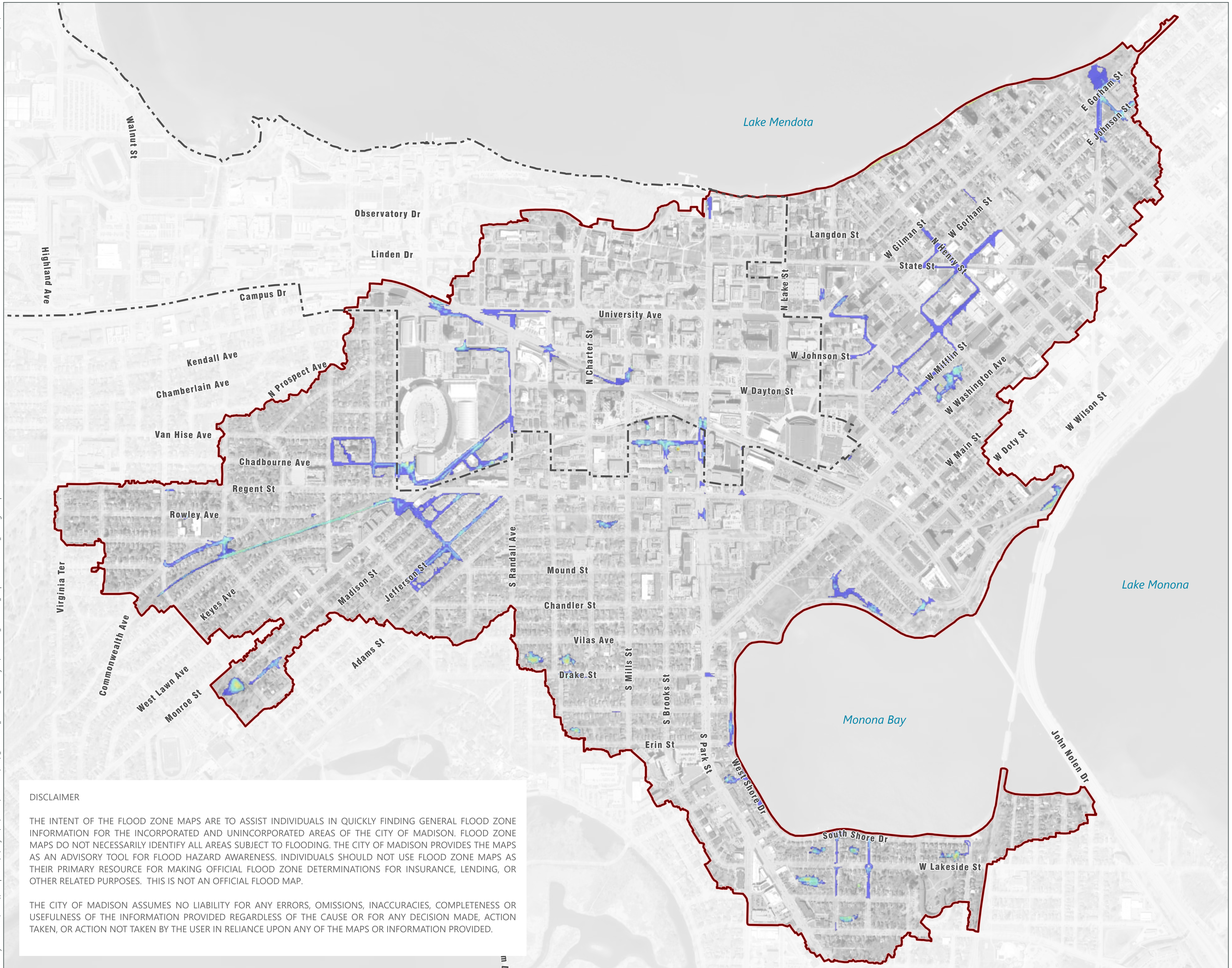
0 25 50 100 Feet

CITY OF MADISON ENGINEERING

50% AEP Inundation Recommended Conditions

FIGURE 28
Near West Watershed
Study Report

City of Madison
Dane County, WI



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Watershed Study Area
UW Madison Campus

50% Annual Exceedance Probability Storm

Maximum Water Depth (ft)

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1 - 3
- 3 - 6
- > 6

Data Sources:
Aerial: City of Madison (2022)
Watershed Boundaries: MSA
Stormwater System: City of Madison and UW Madison

MSA

0 0.1 0.2 Miles

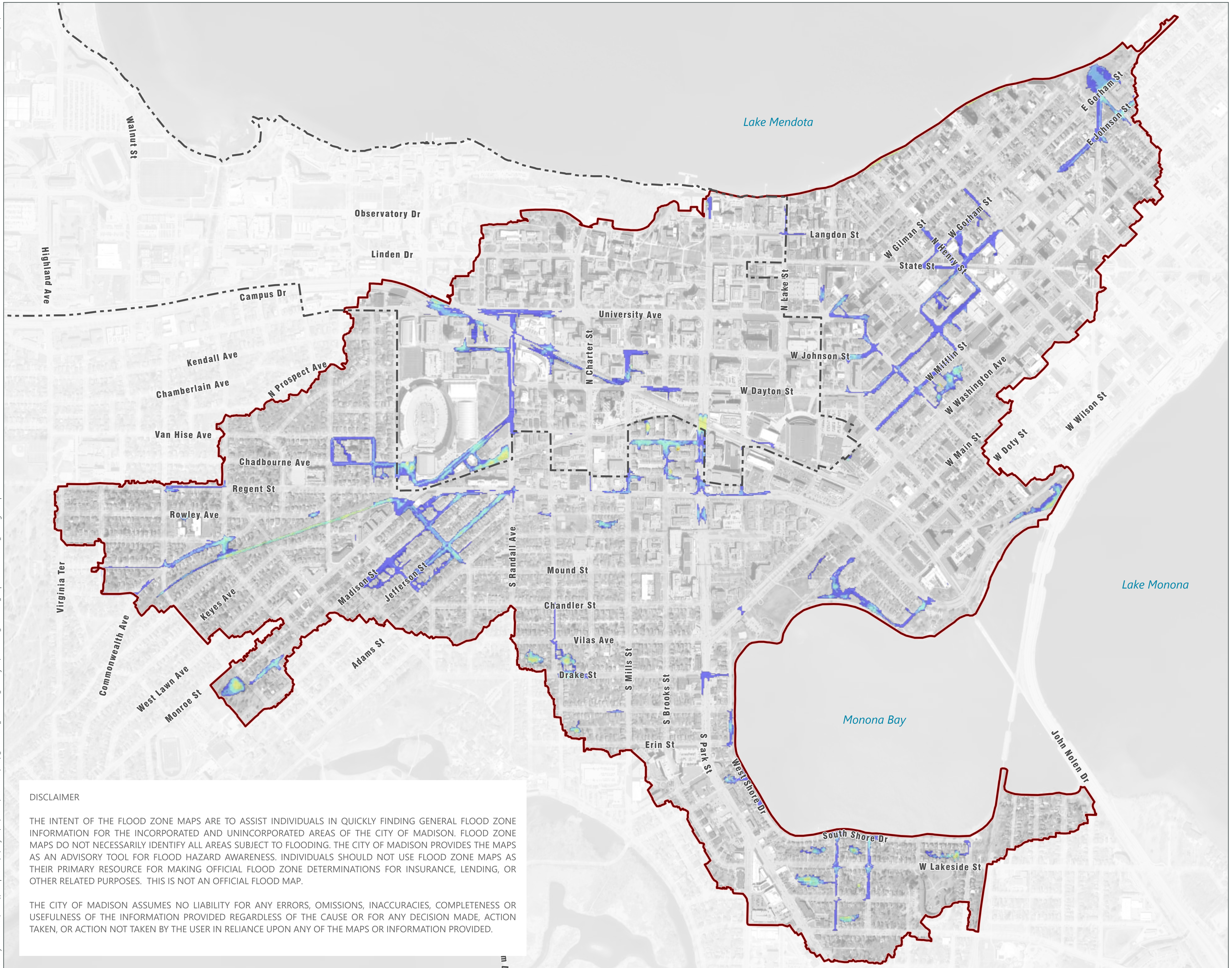
N

Print Date: 4/15/2025

20% AEP Inundation Recommended Conditions

FIGURE 29
Near West Watershed
Study Report

City of Madison
Dane County, WI



Watershed Study Area
UW Madison Campus

20% Annual Exceedance Probability Storm

Maximum Water Depth (ft)

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1 - 3
- 3 - 6
- > 6

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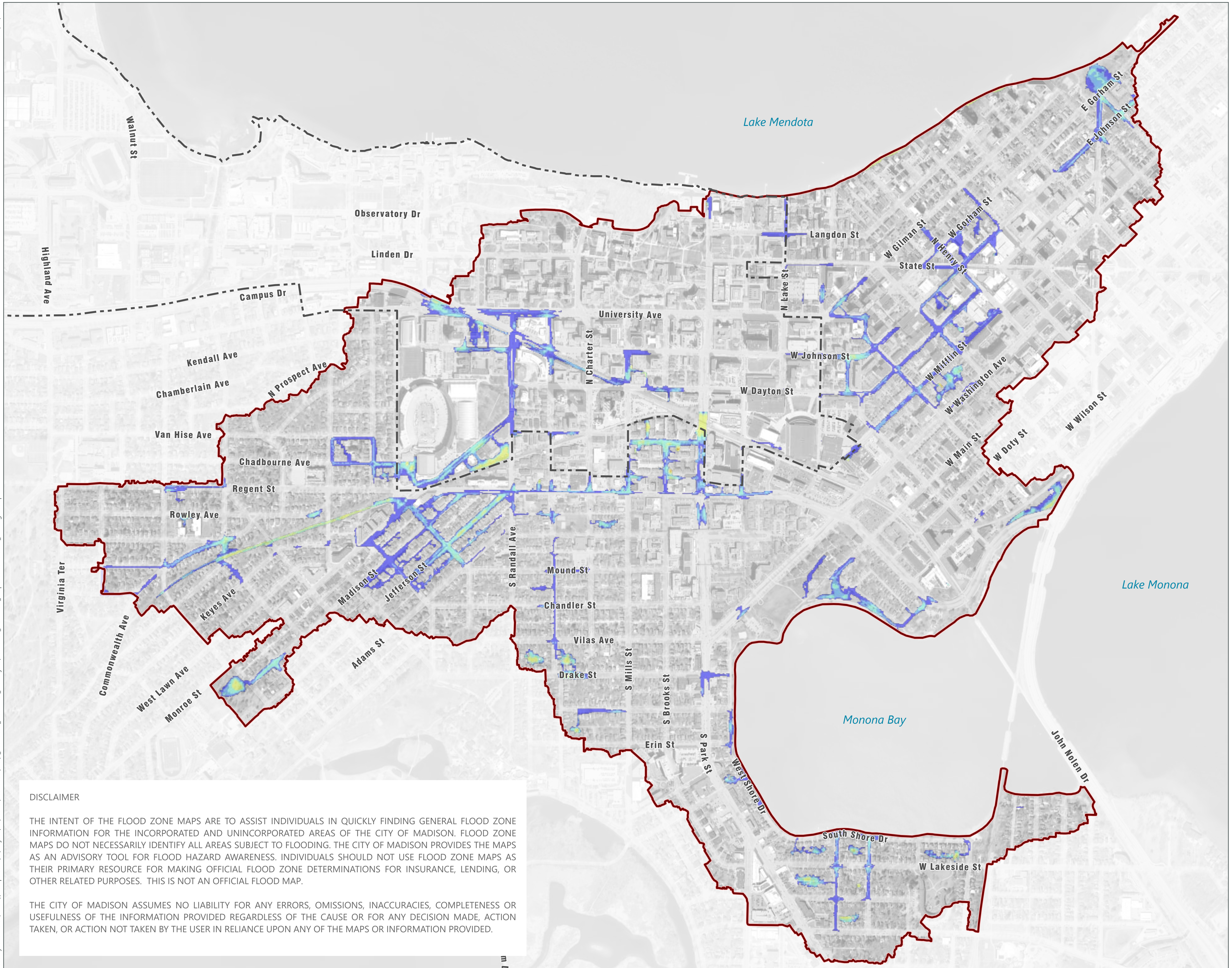
Data Sources:
Aerial: City of Madison (2022)
Watershed Boundaries: MSA
Stormwater System: City of Madison and UW Madison

MSA

0 0.1 0.2 Miles

Print Date: 4/15/2025



10% AEP Inundation Recommended Conditions

FIGURE 30
Near West Watershed
Study Report

City of Madison
Dane County, WI

Watershed Study Area

UW Madison Campus

10% Annual Exceedance Probability Storm

Maximum Water Depth (ft)

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1 - 3
- 3 - 6
- > 6

Data Sources:
Aerial: City of Madison (2022)
Watershed Boundaries: MSA
Stormwater System: City of Madison and UW Madison

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MSA

0 0.1 0.2 Miles

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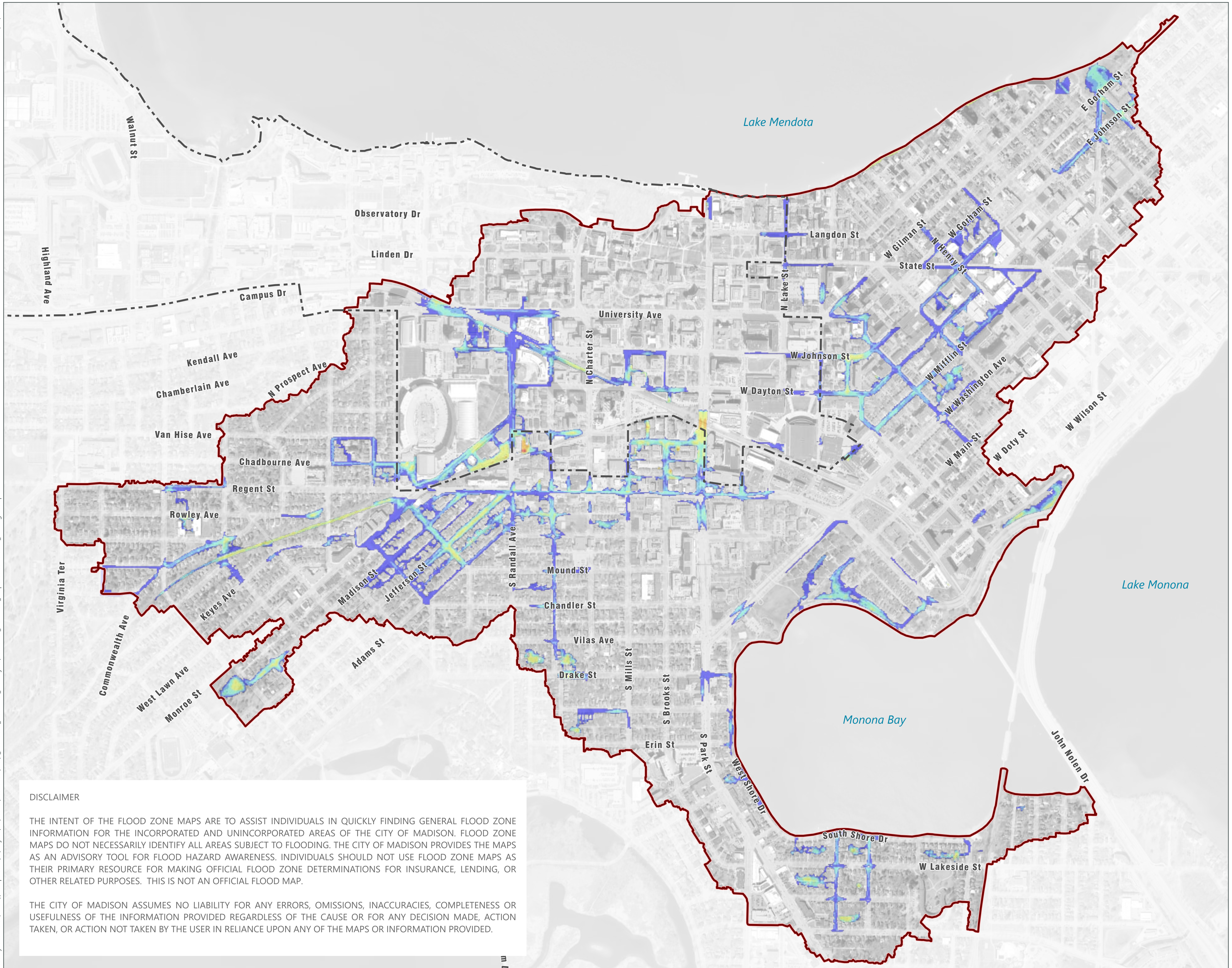
4% AEP Inundation Recommended Conditions

FIGURE 31
Near West Watershed
Study Report

City of Madison
Dane County, WI



Watershed Study Area

UW Madison Campus

4% Annual Exceedance Probability Storm

Maximum Water Depth (ft)

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1 - 3
- 3 - 6
- > 6

Data Sources:
Aerial: City of Madison (2022)
Watershed Boundaries: MSA
Stormwater System: City of Madison and UW Madison

MSA

0 0.1 0.2 Miles

N

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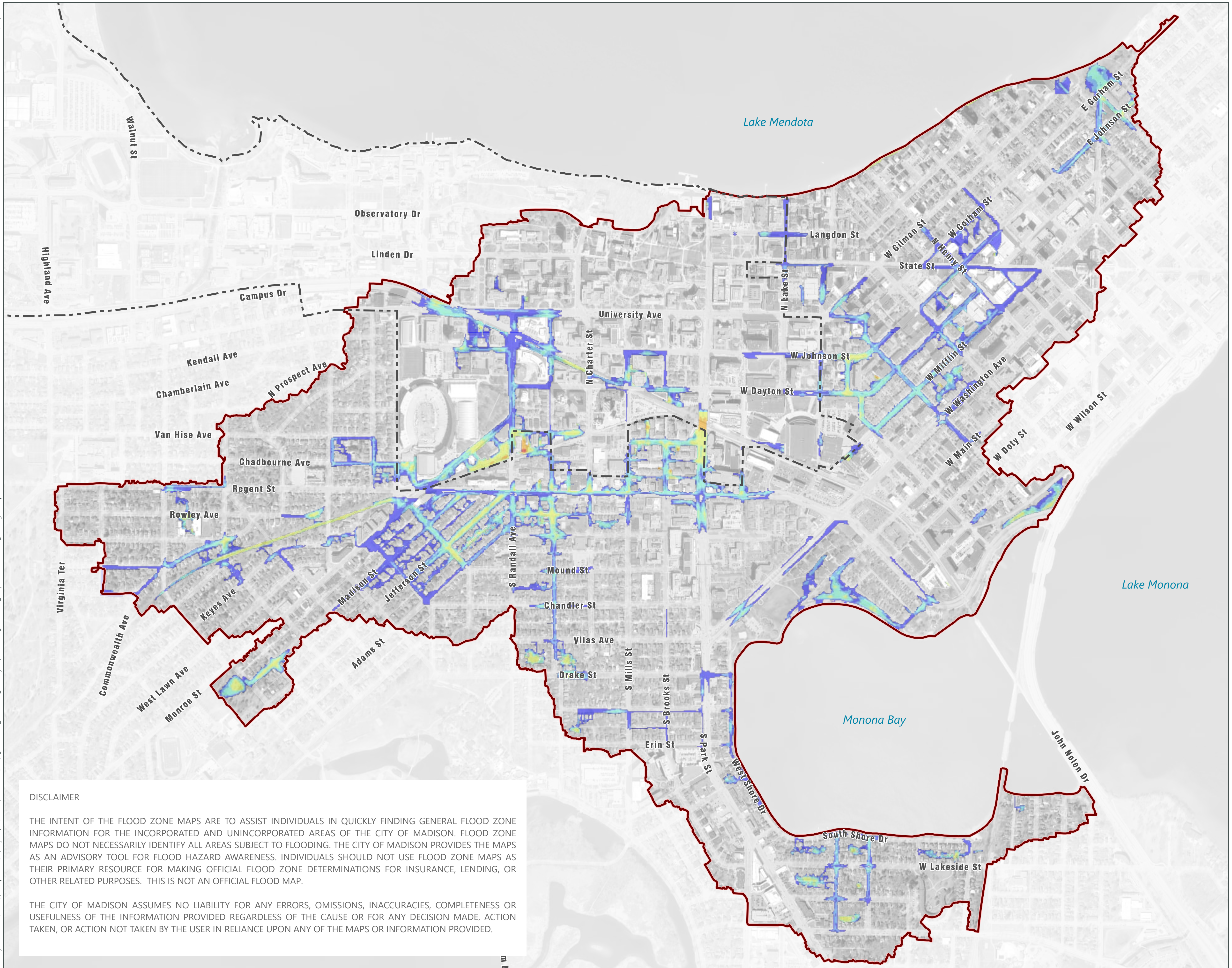
Print Date: 4/15/2025

2% AEP Inundation Recommended Conditions

FIGURE 32
Near West Watershed
Study Report

City of Madison
Dane County, WI



Watershed Study Area

UW Madison Campus

2% Annual Exceedance Probability Storm

Maximum Water Depth (ft)

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1 - 3
- 3 - 6
- > 6

Data Sources:
Aerial: City of Madison (2022)
Watershed Boundaries: MSA
Stormwater System: City of Madison and UW Madison

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MSA

0 0.1 0.2 Miles

Print Date: 4/15/2025

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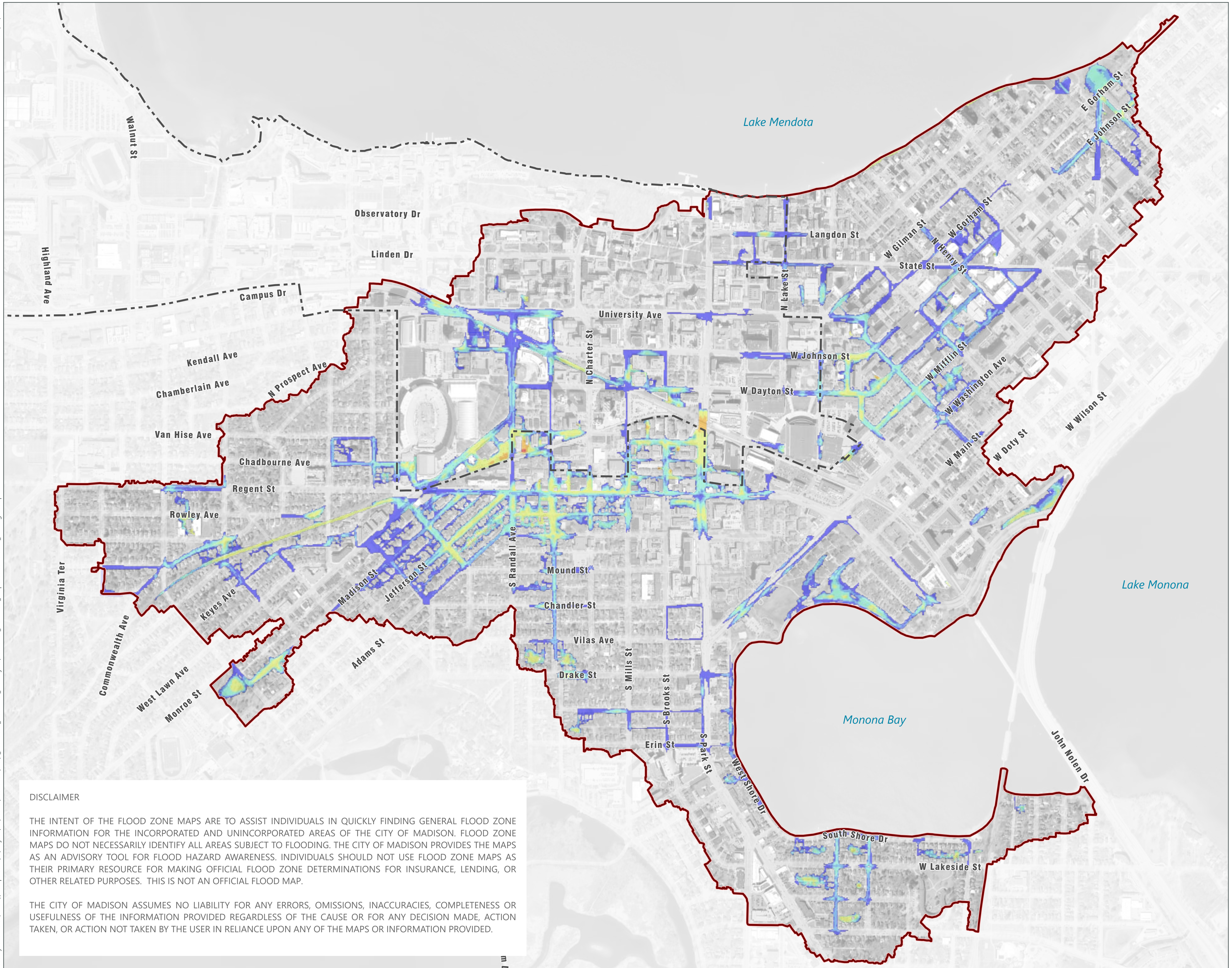

1% AEP Inundation Recommended Conditions

FIGURE 33
Near West Watershed
Study Report

City of Madison
Dane County, WI

Watershed Study Area

UW Madison Campus

1% Annual Exceedance Probability Storm

Maximum Water Depth (ft)

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1 - 3
- 3 - 6
- > 6

Data Sources:
Aerial: City of Madison (2022)
Watershed Boundaries: MSA
Stormwater System: City of Madison and UW Madison

0 0.1 0.2 Miles

MSA

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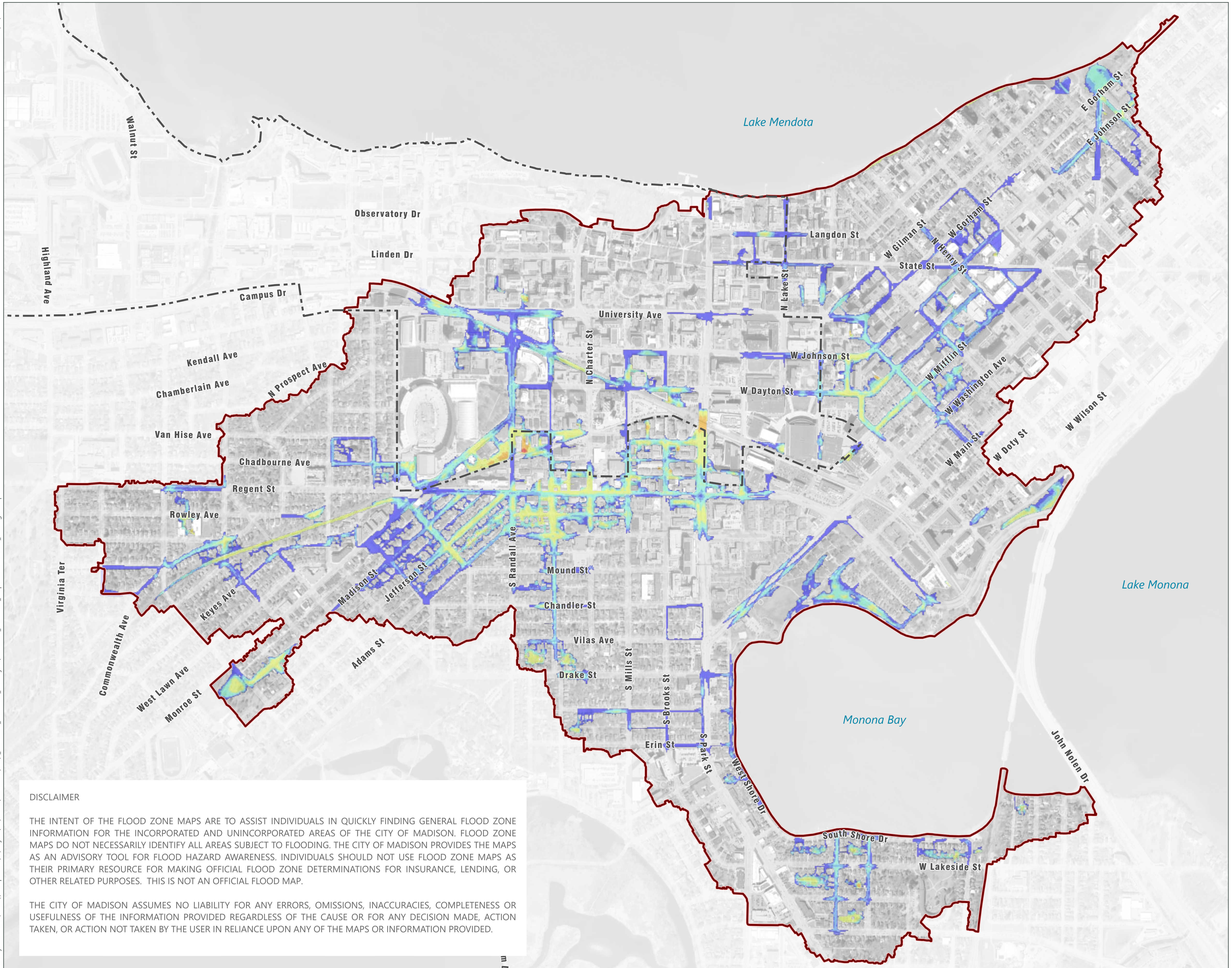
Print Date: 4/15/2025

Print Date: 4/16/2025



Long 1 % AEP Inundation Recommended Conditions

FIGURE 34
Near West Watershed
Study Report

City of Madison
Dane County, WI

Watershed Study Area
UW Madison Campus

Long 1% Annual Exceedance Probability Storm

Maximum Water Depth (ft)

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1 - 3
- 3 - 6
- > 6

Data Sources:
Aerial: City of Madison (2022)
Watershed Boundaries: MSA
Stormwater System: City of Madison and UW Madison

MSA

0 0.1 0.2 Miles

N

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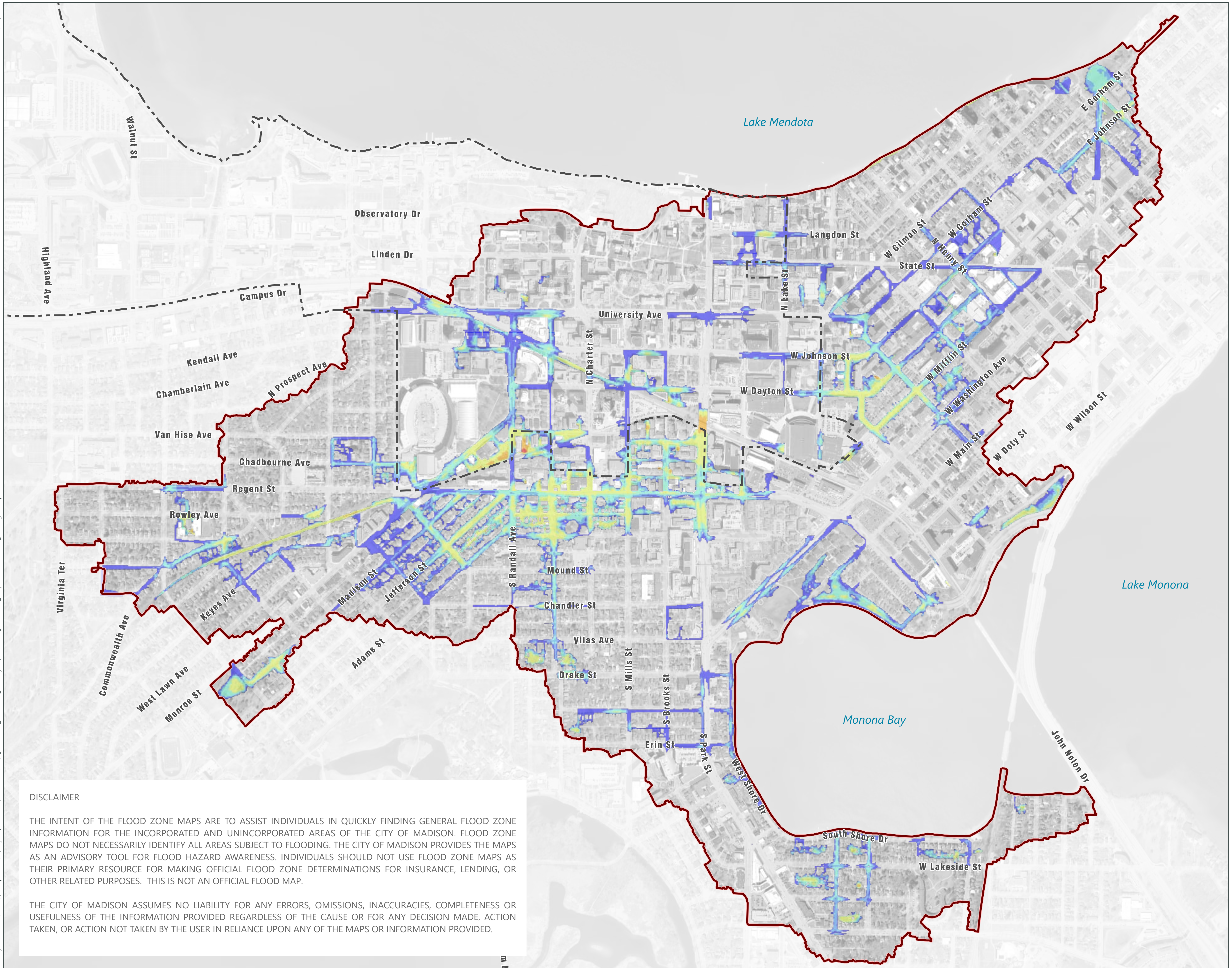
0.5% AEP Inundation Recommended Conditions

FIGURE 35

Near West Watershed

City of Madison
Dane County, WI



Watershed Study Area

UW Madison Campus

0.5% Annual Exceedance Probability Storm

Maximum Water Depth (ft)

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1 - 3
- 3 - 6
- > 6

Data Sources:
Aerial: City of Madison (2022)
Watershed Boundaries: MSA
Stormwater System: City of Madison and UW Madison

MSA

0 0.1 0.2 Miles

N

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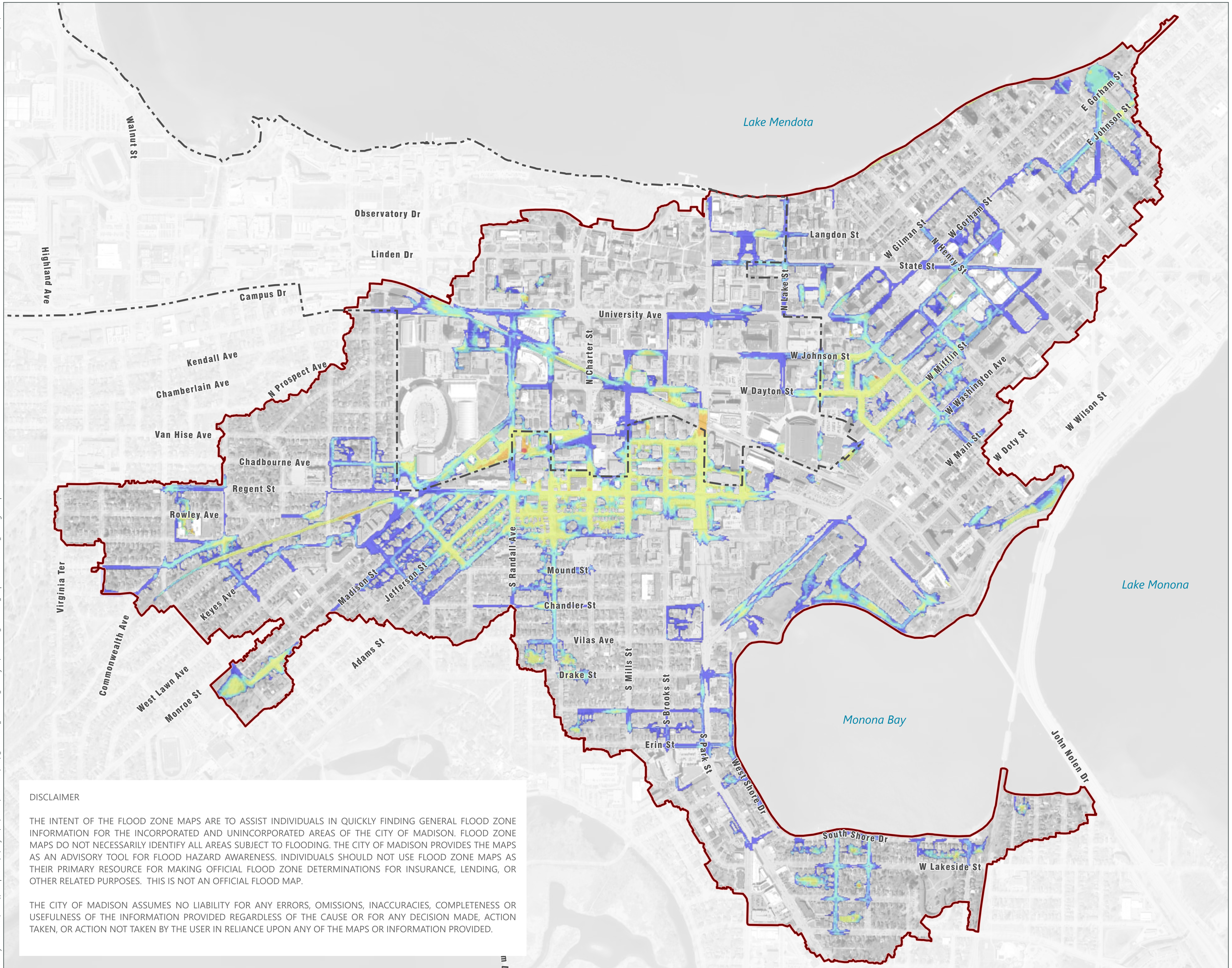
0.2% AEP Inundation Recommended Conditions

FIGURE 36
Near West Watershed
Study Report

City of Madison
Dane County, WI



Watershed Study Area
UW Madison Campus

0.2% Annual Exceedance Probability Storm

Maximum Water Depth (ft)

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1 - 3
- 3 - 6
- > 6

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Data Sources:
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Watershed Boundaries: MSA
Stormwater System: City of Madison and UW Madison

MSA

0 0.1 0.2 Miles

Print Date: 4/16/2025
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Appendix A: Modeling Guidance

EXHIBIT 5 - MODELING GUIDANCE

Version 2021_12_03 (DRAFT)

The City recognizes that an important aspect of modeling is professional judgement; and it will be up to the Consultant to appropriately define parameters, variables, and methodology. However, it is in the City's best interest to have relative uniformity amongst City models. This guidance document was developed to provide uniformity. Where inputs and assumptions differ from those outlined in this document, the Consultant will be expected to justify and document the differences and reasons for the differences.

The purpose of the watershed modeling is to construct planning-level models of the watershed to identify locations with significant conveyance system deficiencies. The identified solutions will be conceptual solutions, not design-level solutions.

City of Madison Flooding Level of Service Goals

1. 10-year design storm event:
    a. No surcharging onto the street for up to the 10-year design storm; water shall be contained within the pipes and structures.
        i. When using rain-on-grid hydrology, the goal is met if there is less than 0.25' of curb depth using the FHA method.
    b. There are locations within the City where low points exist that pond water; these low points are excluded from this goal and will be addressed as streets are redesigned.
    c. For locations limited by known inlet capacity, allow no more than 0.5 feet of water above storm sewer inlet rim.
2. 25-year design storm event:
    a. Street to remain passable for emergency vehicles during 25-year design storm.
        i. This is defined as no more than 0.5 feet of water on the centerline of the street for a length of 100-feet using the depth raster.
        ii. To define the centerline of street, the County's centerline data (Dane County SDE – GISdw.DCL.RoadCenterline) should be used.
    b. Note that the Watershed Study modeling approach will not explicitly account for cross flow conditions where more gutter flow on one side of the street can overtop the crown.
3. 100-year design storm event:
    a. No home or business will be flooded during the 100-year design storm.
        i. This is defined as no more than 0.5 feet of water at the 5-foot buffer around a structure.
    b. Enclosed depressions to be served to the 100-year design storm (which can include safe overland flow within street, easements, greenways or other public lands).
        i. For purposes of the watershed studies, enclosed depressions are defined as depressions in public right-of-way where stormwater needs to reach private property to overflow from the depression.
        ii. Solutions will also be developed for enclosed depressions where the stormwater collected is solely from private property. In these cases, the solutions may be implemented thru public-private cooperation or solely by the private property owners.
    c. Greenway crossings at streets to be served to the 100-year design storm.
4. 500-year design storm event:
    a. Safely convey stormwater; i.e. limited impact on private property.
    b. Limited impact is defined as no more than 0.5 feet of water at the 5-foot buffer around a structure.
5. Provide flooding solutions that do not negatively impact downstream properties.

Due to the inherent variability and complexity of stormwater conveyance systems, it is understand it may not be practical to meet the above level of service goals in all areas of the City.

Guidance for Solutions

1. For the purpose of the watershed studies “deficiencies” in the system shall be defined as existing infrastructure, drainage capacity, or system limitations that fail to meet the goals stated in 1-5 above.
2. Watershed deficiencies will be reviewed, and solutions will be provided up to, the 100-yr design storm.
3. In areas where flooding occurs in events exceeding the 100-year storm, those areas will not be prioritized for engineering solutions, but will be identified in existing conditions model for 500-year event storms.
4. Proposed solutions will be identified for only the publicly owned drainage system.
5. Drainage issues that are private (water from the public infrastructure such as streets, greenways, ponds and/or easements is not the cause of the drainage issue) will not require modeling solutions but should be noted, where possible, in the existing conditions analysis so staff may work with property owners if necessary. (See Also Hydraulics section of Modeling Guidance for discussion on private system existing conditions modeling.)

Emergency Vehicle Allowable Flood Depths (email from Fleet on 5/12/2020)

1. SUVs – up to 6-inches
2. Large Trucks – up to 3-feet
3. Ambulances, vans, and pick-up trucks – between 6-inches and 3-feet

MODELING PARAMETERS:

Initial model parameters are the following items:

1. Include storm sewers and culvert segments for the trunk line drainage system and major conveyance to that system. Additional conveyance components may be included if felt necessary by the modeler to understand the conveyance system drainage.
2. Inlet capacity will not be included in the model. It is assumed that sufficient inlets are present accommodate stormwater. In areas where there is known chronic flooding that has been reported to Engineering, additional detail may be requested.
3. Incorporate significant existing storm water management facilities (public and private) into the model.
4. Subdivide provided outfall basins into smaller watersheds as needed in order to properly execute the model.
5. Coordinate System and Vertical Datum
    a. Horizontal Coordinate System: NAD 1983 HARN WISCRS Dane County Feet (WKID 103412).
    b. Vertical Datum: NAVD88 (pre 2007 adjustment) ft (City of Madison Datum + 845.6)
    c. Various data sources have different horizontal and vertical datums, check datum for each data source prior to use.
    d. When setting up PC-SWMM Models, the default coordinate system that looks like it matches the City’s preferred coordinate system is not the same. PC-SWMM’s default coordinate system is State Plane and the exact coordinate system the City uses is not in PC-SWMM’s database. To create a PC-SWMM model with the same coordinate system:
        i. Open up a new, blank model.
        ii. Add one of the City’s shapefiles with the preferred coordinate system.
        iii. Then, in PC-SWMM, select that coordinate system as the default.
6. Monitoring Data Time Zone: Different sources of monitoring data use different time zones. Also, some adjust for daylight savings time whereas others do not. When using the monitoring data, check both the time zone and if the data is adjusted for daylight savings time.
7. Monitoring Data Review: Familiarize yourself with the location of the monitoring gage at each site. Also, visit the monitoring site following a rain event to review the site conditions for things that would impact the measurements. For example, is there debris clogging anything?
8. Naming convention

a. Names are limited to 20 characters where possible. Both PC-SWMM and XP-SWMM can take lengthy names but both indicate shorter is better for avoiding truncating names.
b. Subcatchments:
   i. Begin with Subcatchments naming convention provided by the City in the Outfall Basin feature class.
      1. Add a three-digit designator to the end of the name, beginning with 000
      2. As subcatchments are subdivided, increase the added designator by 1.
      3. Example: ME04-A-0014-H *(Provided by City)* → ME04-A-0014-H-MAD-C-000 *(For the original basin)* → ME04-A-0014-H-001 *(For first subdivision)*
   ii. Final outfall basin feature class file, including supporting files used to compute runoff timing and volume parameters shall be part of the deliverables provided to the City of Madison.
   iii. Note first downstream stormwater control practice as attribute in subcatchment feature class.
c. Structures and Junctions:
   i. Node (Junction/Storage/Outfall) names for existing structures shall retain the asset identification provided by the City.
   ii. Proposed Structure names are to be determined by the Consultant but shall be given a "logical" name that reflects general location, function, or other.
   iii. For junctions that need to be added that are storm sewer tees as constructed, use the downstream manhole / structure with "_01" added in increasing order moving from downstream to upstream. For example, the first junction added for a tee upstream of MI3350-001 would be MI3350-001_01
d. Pipes:
   i. Conduit names for existing pipes shall retain the asset identification provided by the City, except that:
      1. The first two letters (i.e AE, IN, etc) can be removed
      2. Leads with an asset ID that takes up all 20 characters can be shortened to the corresponding assigned ID. For example, IN3350-032_AS3350-007_3350-001 can be changed to 3350-032_3350-001_001
   ii. Proposed Pipe names are to be determined by the Consultant but shall be named in a manner similar to the City pipe naming convention, which includes the upstream and downstream structure names.
e. Channel/Street Flow Segments:
   i. Conduit names for drainage-ways shall be named in a manner that identifies the greenway segment it represents by Greenway Node Number and the distance from the upstream end. Example: GR7541-062_125 would represent a channel segment that begins 125 feet into the North Door Creek Greenway – Sprecher Road Section.
   ii. Conduit names for streets shall be named with "Rd_"[US_Node_Name]_[DS_Node_Name] and remove the first two letters in the node name similar to how pipes are named.
f. Natural Channels:
   i. Natural channel transects shall be named with the same ID as the conduit name.
   ii. Street models as natural channels shall be named in a manner that is easily identifiable for the street or street type it represents.
   iii. A shapefile shall be created documenting where natural channel transects are cut.
g. Other SWMM Features (Weirs, orifices, etc)
   i. Other SWMM features shall have readily identifiable names corresponding to the type of feature they are trying to model. For example, an orifice for a detention pond should have an ID that is "<Detention Pond ID>_ORIF_01", keeping within a 20 character limit.
h. Ponds
   i. Use the pond name identifier from GT-Viewer combined with a common name. For example, the ponds at Odana Hills Golf Course would be "PD3461-001_OdanaHills"

ii. Use abbreviation of name if unofficial full name creates a model name longer than 20 characters.

i. Non-City owned infrastructure

   i. Consultant may choose name if consistent naming convention is not created by entity that owns infrastructure

   ii. If Consultant chooses name, all infrastructure owned by another entity shall start with the same few characters. For example, DOT infrastructure could all start with "DOT-" or Fitchburg owned infrastructure could start with "Fit-"

9. Data Notation

   The GIS data describing the conveyance system is not complete. In some instances the modeler will be able to make assumptions based on available data. In other locations, the data will require survey. The City is tracking the accuracy of the data with the ultimate goal of having a complete record.

   When the modeling is creating the GIS data describing the structures and pipes, they shall create a new attribute in their GIS data and categorize the data as the following:

   a. Structures:
      - Source_IE
      - Source_Rim
   b. Pipes:
      - Source_ToIE
      - Source_FromIE
   c. Private:
      - Notes
   d. Source –enter Number and text in bold in attribute

      0. **Converted:** legacy EI's taken from the structure, all EI's received the structures outgoing EI by default when converted in 2020. *This does not mean this data is ****better***** than the survey data, if it looks suspect, you should investigate and try to clarify the source (especially for pre-2005 data, or structures/pipes within ponds/gwys)*
      1. **Survey:** Survey data (current)
      2. **AsBuilt >2004:** As-Builts (2005-present) since City used GPS-Survey Grade to set control improving consistency citywide
      3. **AsBuilt pre-2005:** As-Builts (pre-2005)
      4. **ConstPlan**: Construction plans
      5. **GTV**: GTV in-line text, no plans to support
      6. **Interpolate:** interpolated (saddled structure had inverts on either side and interpolated—should eventually be surveyed)
      7. **Inferred:** best guess, (can't get survey now or is pulled from LiDAR, but should eventually be surveyed)
      8. **No data:** Needs survey (searched and unable to find—should eventually be surveyed, but a higher priority)

   e. When creating a model, Engineers will verify/update:

      i. Structures:
         - Source_IE
         - Source_Rim
         - Project_No

      ii. Pipes:
         - Source_ToIE
         - Source_FromIE
         - Project_No

      iii. Private:
         - Notes
            - PLP_address
            - GTV
            - Survey (survey will need to confirm all fields)

10. Rainfall
    a. MSE4 24-hour Distribution and NOAA Atlas 14 Depths

Recurrence Interval (years)	Rainfall Depth (inches)
1	2.49
2	2.84
5	3.45
10	4.09
25	5.02
50	5.74
100	6.66
200	7.53
500	8.94

    b. Long-Duration Storm – Two 24-hour, 100-year MSE4 storm events with the time between peak rainfalls shorted from 24 hours to 12 hours.

11. Hydrology (SWMM Method with Horton Infiltration) (References: A, B, C, J, L)
    - Parameters listed are default parameters and may need to be adjusted based on calibration data.
    a. Subcatchment Detail for Street Drainage
        i. Contributing area to the existing storm sewer system that is to be modeled (Determined on a watershed by watershed basis)
    b. SWMM Routing Parameters (if calibration is not available to adjust parameters)
        i. Percent Impervious:
            1. In areas where impervious areas are delineated:
                a. Use impervious/Pervious areas from City provided feature class.
            2. In areas where Impervious areas are not delineated:
                a. Use City provided WinSLAMM land use file and the "HowTo_CalculateCN" Document.
                b. Areas not delineated in City Provided WinSLAMM land use file shall defer to Dane County Land Use Map.
                c. Match WinSLAMM land uses with Dane County Land Use.
            3. Note: The City had a set of surface cover data built off the 2018 ortho image. The deliverables from Task 4 are the easiest to utilize in models. The impervious type is defined in a domain and to use it you may need to "Export a table to include domain descriptions and coded values"
        ii. DCIA
            1. In areas where impervious areas are delineated:
                a. Use impervious/Pervious areas from City provided feature class.
            2. In areas where Impervious areas are not delineated:
                a. Reference WinSLAMM Standard Land Use DCIA Spreadsheet
        iii. Width – Estimated based on subcatchment shape. Estimation methodology shall be documented.
            A single width shall be calculated for the entire subcatchment and used for all three sub-areas.
            It is expected Width is one of the first calibration parameters for peak flow.
        iv. Slope – Computed manually or estimated based on LiDAR. Computation or estimation methodology shall be documented.
        v. In XP-SWMM, each subcatchment is to be split into area of (1) DCIA, (2) non-DCIA, and (3) pervious area. Within the model, the non-DCIA shall be routed to the pervious area.
        vi. In PC-SWMM, indicate the percent being routed to pervious in the subcatchment attribute.

c. Horton Infiltration
   i. For typical urban pervious area (Based on range of values for different soil types, moisture conditions, and vegetation conditions found in Reference A):

HSG Group[a]	Max Infil. Rate (in/hr)	Min Infil. Rate (in/hr)	Decay Rate (1/hr)	Dry Days[b]	Maximum Infiltration Volume (in)
A	4.0	1.0	4.0	3.1	
B	2.0	0.5	4.0	4.4	
C	1.0	0.2	4.0	7.0	
D	0.5	0.1	4.0	9.9	
Water	0	0	0	0	

[a]For HSG listed as A/D, B/D, C/D, the default approach will be to assume the HSG associated with the lower infiltration rate (HSG D).

[b]Use equation 4-12, pg 99, SWMM Reference Manual Volume 1 – Hydrology (Revised), January 2016

   ii. Impervious Manning's n – 0.016
   iii. Pervious Manning's n – 0.20
   iv. Depression Storage for Impervious – 0.05 inches
   v. Depression Storage for Pervious – 0.15 inches
   vi. Zero Depression Storage – 25 percent
   vii. Factors for adjusting (L)
      1. Forest – Multiply max and min infiltration rates by 2.
      2. Farmland (row crops) – Multiply max and min infiltration rates by 1.2.
      3. Farmland (close crops) - Multiply max and min infiltration rates by 1.8.
      4. Other land uses – discuss with City staff
   viii. Area-weight the Horton Infiltration parameters for each subcatchment based on the area of each soil type within a subcatchment. Remove impervious area from area-weighting.
   ix. It is understood the NRCS/SCS updates the soil mapping at various times. The project teams will identify a date the soils data will be downloaded and that will be the data used for the duration of the project.

d. Evaporation: Turn off evaporation from calibration and design storm event runs.

12. Hydrology (SCS CN Hydrology – ONLY USE WHERE DESIGNATED BY CITY) (References B, K)
   a. Runoff Curve number, Percent Impervious, Directly Connected impervious Area
      i. In areas where impervious areas are delineated:
         1. Use impervious/Pervious areas from City provided shapefile.
         2. Impervious areas shall use a runoff curve number of 98.
         3. Urban pervious areas that are mowed and maintained can assume the area is Open Space in good condition listed in Table 4-9 of Reference B.
         4. All other pervious land uses shall match descriptions listed in Table 4-9 of Reference B.
         5. Create a composite subbasin runoff curve number that incorporates both impervious and pervious areas.
      ii. In areas where Impervious areas are not delineated:
         1. Use City provided WinSLAMM land use file and the "HowTo_CalculateCN" Document.
         2. Areas not delineated in City Provided WinSLAMM land use file shall defer to Dane County Land Use Map.
         3. Match WinSLAMM land uses with Dane County Land Use and repeat item "i." of this section.
         4. Impervious areas shall use a runoff curve number of 98.
         5. Urban pervious areas that are mowed and maintained can assume Open Space in good condition listed in Table 4-9 of Reference B.
         6. All other pervious land uses shall match descriptions listed in Table 4-9 of Reference B.

7. Create a composite subbasin runoff curve number that incorporates both impervious and pervious areas.

b. Routing Parameters
   i. Width - In PC-SWMM only, Estimated based on subbasin shape. Estimation methodology shall be documented. It is expected that width is one of the first calibration parameters to be adjust for peak flow.
   ii. Slope - In PC-SWMM only, computed manually or estimated based on LiDAR. Computation or estimation methodology shall be documented.
   iii. Time of Concentration - In XP-SWMM only, calculate each watershed time of concentration based on equations listed in SCS Urban Hydrology for Small Watershed, 2nd Ed., (TR-55), June 1986 (Reference K). The max flow length for sheet flow is 75 feet in urban areas and 150 feet in agricultural/natural areas.
   iv. In XP-SWMM and PC-SWMM, the percent impervious shall be zero and the composite runoff curve number shall incorporate impervious and pervious areas.

13. 1D Hydraulics (References: A, B, D, E, F, G)
- Dynamic mode with constant / variable timestep sufficient to model system accurately.
- Conduit lengthening shall not be used unless prior approval from City on reason.
- Parameters are default parameters and may need to be adjusted based on calibration data.
- This list is not intended to be exhaustive.

a. System to be Modeled
   i. Public
      1. Standard: Trunk line and major conveyance components to trunk line.
      2. Process for Exceptions: Provide justification for conveyance components not included.
      3. Use engineering judgement for inclusion of additional detail beyond this standard.
   ii. Private
      1. Standard: Not included
      2. Process for requiring inclusion of private pipes:
         a. Stormwater management detention facilities providing significant detention
         b. When necessary to understand the functioning of the public system. For example, the West Towne Mall parking lot drainage system.
   iii. Greenways and major surface drainages
   iv. Significant stormwater detention facilities (public and private).
      1. Private systems may be simplified if serving a single site.
      2. Provide justification for detention facilities not included.

b. Loss Coefficients (see drawing at end of document)
   i. Entry
      1. Culverts – Select Inlet Type based on the Help File or HEC-RAS Hydraulic Reference Manual
      2. Storm Sewer (internal at MHs) = 0.05
      3. Storm Drainage Structures (MH) at 45 degree bend = 0.25
      4. Storm Drainage Structures (MH) at 90 degree bend = 0.5
      5. For culverts and entrances to storm sewer from an open channel or pond, both the energy loss coefficient and the inlet control (culvert code) shall be used.
   ii. Exit
      1. Culverts –
         a. Exit closed conduit to open channel = 0.5
         b. Exit closed conduit to lake or pond = 1.0
      2. Storm Sewer (internal at MHs) = 0.05
      3. Storm Drainage Structures (MH) at 45 degree bend = 0.25
      4. Storm Drainage Structures (MH) at 90 degree bend = 0.5

c. Coefficient of Discharge
   i. Weirs
      1. Sharp Crested – 3.0
      2. Roadway embankment – 2.6
      3. Flatter overflow – Use engineering judgment
   ii. Orifices
      1. 0.6
d. Manning's n
   i. Pipes
      1. Concrete Pipe: 0.013
      2. Other n values shall be chosen within generally acceptable ranges.
   ii. Channels
      1. Use Chow's Open Channel Hydraulics, Reference E
   iii. Bank Flow, including developed urban areas
      1. Use Chow's Open Channel Hydraulics, Reference E
e. Transect Placement and Modifiers
   i. Splitting long open channels
      1. Changes in cross section
      2. Significant changes in slope and roughness
      3. Overflow points
   ii. Segment Lengths
   iii. Channel Geometry
   iv. Provide shapefile where natural channel transects are selected along with XS Identifier
f. Tailwater Conditions:
   i. Lake Mendota: one foot over Summer Maximum – 851.10
   ii. Lake Monona: TBD
   iii. Lake Wingra (100-year WSE): 848.0
   iv. Yahara River between Lakes Mendota and Monona: TBD
g. Inlet Clogging Factors
   i. Continuous Slopes
      1. Street slope < 1% - 25% Clogging
      2. Street slope >= 1% - No Clogging
   ii. Sags – 50% Clogging

14. 2D Data (References: A, G, H, I)
   a. Surface Roughness – The average Manning's n may vary by land cover / land use. Referencing TR-55, the following roughness can be used for sheet flow conditions. Choose based on professional judgement and document in the report.
      i. Impervious areas - 0.1
      ii. Turf grass areas - 0.24
      iii. Wooded – 0.4
      iv. Prairie – 0.15
      v. Other – reference TR-55
   b. Channel Roughness - Where the 2D surface experiences channel flow, rather than sheet flow, utilize the Manning's n values for open channels
   c. Impervious Area/Inactive Areas - The City had a set of surface cover data built off the 2018 ortho image. The deliverables from Task 4 are the easiest to utilize in models. The impervious type is defined in a domain and to use it you may need to "Export a table to include domain descriptions and coded values"
      i. Average the roughness within the ROW based impervious and pervious area.
   ~~c.~~d. Blocked Obstructions – enter roofs as Inactive Areas in XP-SWMM and Obstructions in PC-SWMM
      i. Non-residential – use City impervious area data for roofs
      ii. Residential – use Dane County roof layer
   ~~d.~~e. Grid cell/mesh size: Use size that balances model run time and sufficient 2D overland flow

detail.

~~e.~~f. Grid/mesh orientation: Where possible, align grid/mesh with major channel flow direction. If not practical, then use orientation that minimizes run time.

15. Rain-on-Grid Analysis (Do not use without discussion with City)
    a. Hydrology
       For a full study area Rain-on-Grid model, no nodes or pipes should be active within the Runoff Mode.
       i. Rainfall - All runoff is generated using Rainfall / Flow Area layers. Individual layers shall be created for each rainfall event, with only the applicable one active during each scenario. Rainfall distributions stated above in Section 9 shall be used.
       ii. Landuse – Layers for the following land uses must be created: Buildings, Impervious, Turf Grass, Wooded, Prairie, Water and any other applicable layers. Land use layers for Turf Grass, Wooded, Prairie, and any other pervious land coverage, shall be additionally divided up into Hydrologic Soil Groups A, B, C, and D. These layers should cover the entire study area. Under the Land use data tab, inputs for Manning's Roughness, Rainfall Abstraction, and Infiltration must be completed.
          1. Manning's Roughness:
             a. Buildings – Variable roughness must be used. A Depth-Roughness relationship as follows is appropriate:

Depth (ft)	Roughness
0.00	0.01
0.30	0.01
0.31	0.1
10.0	0.3

             b. Impervious – A constant roughness of 0.016
             c. Turf Grass, Prairie, Wooded, and other Pervious – Variable roughness must be used to account for sheet flow at low flow depths. The consultant shall use roughness coefficients stated above in Sections 10.c and 12.a to develop these roughness curves.
             d. Water – A constant roughness of 0.01.
          2. Rainfall Abstraction:
             a. Buildings and Impervious – Initial Abstraction of 0.04 inches (XP-SWMM Default). Continuing loss should remain 0.0.
             b. Pervious - This shall remain unchecked, as Initial and Continuing losses will be accounted for via the Horton Infiltration parameters.
          3. Infiltration:
             a. Buildings and Impervious – This shall remain unchecked
             b. Pervious – Horton Infiltration as described above in Section 10.c shall be created for each pervious land use layer.
    b. 2D Model Settings
       i. Grid extent shall cover the entire study area.
       ii. Default area type shall be set to Active Area. There should not be any inactive areas within the model.
       iii. Default land use should be set to one of the pervious layers (suggested to use layer with largest total area). However, this should not have any impact on the modeling if there is full coverage of land use layers.
       iv. Head boundaries shall be set anywhere where surface flow is able to leave the study area.

    c. 1D Model Network
       i. The 1D storm sewer network shall be extensive enough to include enough inlets throughout the watershed so that surface water can adequately pass from the 2D

surface into the 1D model. Multiple inlets at the same location may be combined to a single node. Inlets either side of the street shall remain separate nodes.

ii. Each inlet node must have Link Spill Crest to 2D checked. Each culvert inlet/outlet must have Link Invert to 2D checked. If calibration shows not enough flow is entering each inlet node, Spill Crest elevations may be lowered below the 2D cell elevation (0.5 ft is an acceptable initial lowering value)

d. 1D/2D Interface Lines at Intersections
    i. In steeper watersheds, the water on the grid may not enter the pipe due to the limitations of the xp2d grid module. Pipes should be reviewed after a simulation for this occurrence. Where this occurs, add 1D/2D interface lines to connect the flow at appropriate intersections to the 1D node.

16. Suggested Proposed Solutions Organization
    a. The Proposed Solutions simulations should be set up in the following way (unless discussed with City staff first). The purpose is to have a model with just the proposed storm sewer improvements, just the regional improvements, and then both.
        i. Add the proposed storm sewer to the Existing Conditions Model as a Scenario.
        ii. Once complete, save the model file with a new name. Add the regional solutions in the Base Scenario, keeping the proposed storm sewer as a scenario.

17. Non-Modeling Data
    a. When utilizing XP-SWMM, provide attributed describing the source of data in the representative GIS feature classes
    b. When utilizing PC-SWMM, also add attributes to the entities describing their data sources.

18. Solutions
    a. Analysis – what are the underlying causes of flooding in:
        i. Areas reported in the “Flood Download” from City staff
        ii. Other flooded areas in the modeling not identified in the “Flood Download”
            1. If more than 10 total areas, work with City staff to prioritize locations to evaluate
        iii. City to identify suggested solutions and provide to Consultant for consideration
        iv. Consultant to identify solutions independently and take lead on overall solutions for watershed
    b. Prioritize Solutions
        i. Property Damage
        ii. Major arterials where emergency vehicles cannot get through
        iii. More criteria - TBD
    c. Displaying solutions/Order of solutions
        i. Show each solution independently and then combined
        ii. Order
            1. Property/pipe owned by Stormwater Utility
            2. Pipe size needed to solve remainder of issues
            3. Other public properties
                a. Janet will provide areas where there are non-starters in Parks
            4. Private properties
        iii. Show structures removed from the 100-yr event
            1. Intersect the flood raster with the building outlines
            2. Buffer buildings by 5-feet to account for in accuracies of building footprint layer
            3. Any building outline that intersects the buildings is considered “flooded” if depth of intersection is 6 inches or greater.
    d. In SWU-owned land all proposed grading must have the following conditions for maintenance access:
        i. be offset from the property line on 1 side by 15 feet (parallel to channel flow, from Pond access to pond outlet)

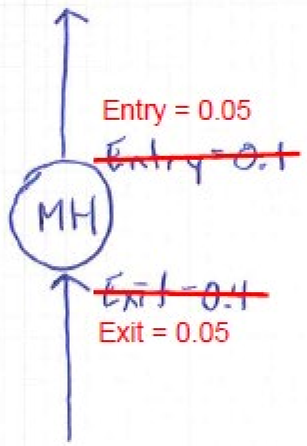
            1. Shall be extended to reach all priority inlets or sanitary access structures within greenway
        ii. All proposed berms must be 10 feet wide @ top of berm
        iii. Slopes no steeper than 4:1
    e. Overlay TIP map with inundation mapping to understand where immediate future project opportunities are
    f. Freeboard – City does not have a minimum freeboard requirement
    g. Properties adjacent to greenway and new greenway crossings – Current ordinance states property low building opening must be 4' above invert of downstream greenway street structure crossing. Therefore, may need to make structures wider, instead of deeper, to not flood upstream properties

REFERENCES

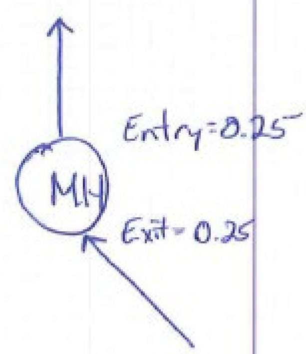
A. Model Help Files and User Forums
B. Storm Water Management Model version 5.1 User's Manual. (Available at: https://www.epa.gov/water-research/storm-water-management-model-swmm-version-51-users-manual)
C. SWMM reference manual volume I – hydrology (Available at: https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100NYRA.txt)
D. SWMM reference manual volume volume II – hydraulics (Available at: https://nepis.epa.gov/Exe/ZyPDF.cgi/P100S9AS.PDF?Dockey=P100S9AS.PDF)
E. Chow, Open Channel Hydraulics, 1959
F. HEC-RAS Hydraulic Reference Manual. (Available at: https://www.hec.usace.army.mil/software/hec-ras/documentation/HEC-RAS%205.0%20Reference%20Manual.pdf)
G. ASCE Two-Dimensional Modeling Using HEC-RAS, Lecture 8 – Troubleshooting and Reviewing, Page 31; 2017.
H. Australian Rainfall & Runoff Revision Projects, Project 15: Two Dimensional Modeling in Urban and Rural Floodplains, November 2012.
I. FLO-2D Reference Manual, FLO-2D Software, 2012.
J. ASCE Manual of Engineering Practice No 28.
K. SCS Urban Hydrology for Small Watershed, 2nd Ed., (TR-55), June 1986
L. Found during calibration in the Pheasant Branch Watershed. Area underlain with Prairie du Chein geology. Areas with other geology will need to select appropriate multipliers.

References/Notes

Straight-Through Manhole

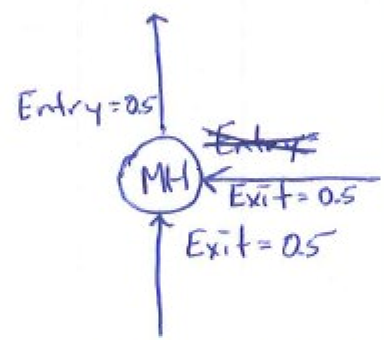


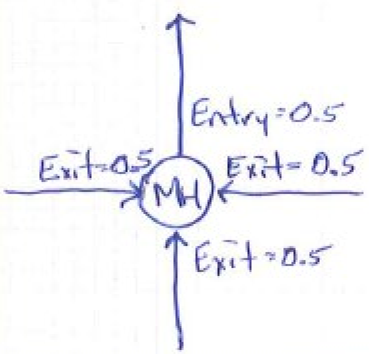
45° Bend Manhole



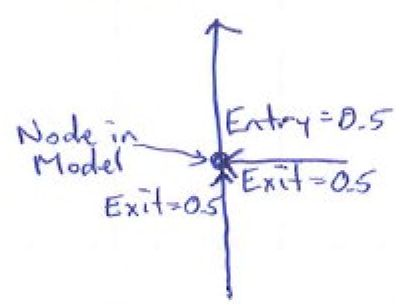
90° Bend Manhole

TEE Manhole





TEE (No Manhole)



Appendix B: Hydrology Input Parameters per Subbasin

Subcatchment	**DCIA**	**UCIA**	**Pervious**	**Max Infil. Rate (in/hr)**	**Min Infil. Rate (in/hr)**	**Decay Rate (1/s)**
14MH062	5.931	0.013	3.636	1.93	0.48	0.001
14MH126	1.401	0	0.744	1.39	0.32	0.001
7MH070	5.193	0.002	1.455	2.00	0.50	0.001
AE4353-052	0.916	0.506	3.215	1.94	0.48	0.001
AE4353-052A	0.406	0.224	1.425	1.94	0.48	0.001
AS4253-067	0.899	0.403	1.596	1.16	0.25	0.001
AS4254-057	1.034	0.423	1.498	1.75	0.42	0.001
AS4353-040	4.886	1.066	4.643	1.24	0.27	0.001
AS4353-045	1.023	0.306	1.606	1.49	0.35	0.001
AS4353-049	1.966	0.674	2.642	1.44	0.33	0.001
AS4353-058	0.958	0.303	1.205	2.00	0.50	0.001
AS4353-061	4.709	0.663	2.836	1.68	0.40	0.001
AS4353-074	1.043	0.355	1.424	1.99	0.50	0.001
AS4353-078	2.307	1.199	3.894	1.54	0.36	0.001
AS4353-101	1.409	0.541	1.506	1.17	0.25	0.001
AS4353-107	3.502	1.321	4.382	1.48	0.34	0.001
AS4353-110	1.849	0.695	2.629	1.58	0.37	0.001
AS4354-018	1.981	0.803	2.725	1.01	0.20	0.001
AS4354-024	1.671	0.468	1.662	1.00	0.20	0.001
AS4355-023	0.653	0.059	0.439	1.37	0.31	0.001
AS4355-031	2.921	1.053	3.932	1.22	0.27	0.001
AS4450-059	1.895	0.488	1.996	1.31	0.29	0.001
AS4452-007	2.239	0.865	2.678	2.00	0.50	0.001
AS4452-012	2.997	1.242	4.255	1.54	0.36	0.001
AS4452-015	3.813	1.538	6.643	1.31	0.29	0.001
AS4452-020	3.399	0.973	3.909	1.75	0.42	0.001
AS4453-009	2.777	0.288	1.448	1.90	0.47	0.001
AS4453-023	0.856	0.17	0.525	1.22	0.27	0.001
AS4453-058	1.378	0.429	1.428	2.00	0.50	0.001
AS4453-070	0.458	0.253	1.606	1.94	0.48	0.001
AS4453-070A	1.669	0.922	5.86	1.94	0.48	0.001
AS4453-088	1.695	0.27	1.25	1.97	0.49	0.001
AS4453-112	0.483	0	0.083	1.00	0.20	0.001
AS4453-116	2.504	0.261	0.284	1.00	0.20	0.001
AS4454-009	2.42	0.57	2.334	1.59	0.38	0.001
AS4454-014	1.98	0.324	1.264	1.00	0.20	0.001
AS4454-047	1.083	0.259	1.137	1.00	0.20	0.001
AS4550-089	2.714	0.002	1.216	1.16	0.25	0.001
AS4550-113	2.807	0.026	0.961	1.60	0.38	0.001
AS4550-132	7.086	0.171	2.03	1.67	0.40	0.001
AS4552-039	1.735	0.123	0.734	2.00	0.50	0.001
AS4552-058	17.491	0.013	4.443	1.77	0.43	0.001
AS4553-009	2.559	0.297	1.088	2.00	0.50	0.001
AS4553-070	3.365	0.64	1.74	2.00	0.50	0.001

Subcatchment	DCIA	UCIA	Pervious	Max Infil. Rate (in/hr)	Min Infil. Rate (in/hr)	Decay Rate (1/s)
AS4553-080	2.949	1.043	4.398	2.00	0.50	0.001
AS4553-087	2.195	0.789	3.087	2.00	0.50	0.001
AS4553-138	5.369	0.719	3.314	1.81	0.44	0.001
AS4650-004	4.662	0	0.612	1.69	0.41	0.001
AS4650-072	3.132	0.008	0.911	1.43	0.33	0.001
AS4650-089	1.033	0	0.039	2.00	0.50	0.001
AS4651-034	13.136	0.149	2.359	1.44	0.33	0.001
AS4652-029	1.751	0.177	1.208	1.99	0.50	0.001
AS4652-085	3.744	0.541	2.501	1.03	0.21	0.001
AS4652-130	5.624	0.091	0.62	2.00	0.50	0.001
AS4653-003	5.098	0.255	0.996	1.97	0.49	0.001
AS4653-003a	5.098	0.255	0.996	1.97	0.49	0.001
AS4653-029	2.484	0.409	1.504	2.00	0.50	0.001
AS4653-089	3.107	0.949	3.646	1.96	0.49	0.001
AS4653-114	2.13	0.408	1.696	2.00	0.50	0.001
AS4653-138	1.757	0.207	1.462	2.00	0.50	0.001
AS4653-153	0.504	0.103	0.218	1.00	0.20	0.001
AS4653-158	5.487	0.184	1.394	2.00	0.50	0.001
AS4654-019	1.636	0.493	1.528	1.81	0.44	0.001
AS4654-042	2.796	1.154	3.9	1.82	0.45	0.001
AS4654-053	1.56	0.579	2.411	2.00	0.50	0.001
AS4655-020	3.138	1.267	4.492	1.13	0.24	0.001
AS4749-010	2.237	0.115	0.709	1.99	0.50	0.001
AS4749-024	5.688	0.007	5.813	1.84	0.45	0.001
AS4749-034	1.393	0.025	0.123	1.68	0.40	0.001
AS4750-057	2.44	0.103	1.397	1.87	0.46	0.001
AS4750-065	4.066	0.001	1.012	1.33	0.30	0.001
AS4751-003	2.424	0.073	1.122	1.17	0.25	0.001
AS4751-018	4.756	0.776	2.394	1.57	0.37	0.001
AS4751-048	2.392	0.008	0.841	1.00	0.20	0.001
AS4751-061	1.098	0.044	0.414	2.00	0.50	0.001
AS4751-065	5.215	0.169	0.563	1.27	0.28	0.001
AS4752-014	3.665	0.142	2.419	1.77	0.43	0.001
AS4752-074	2.792	0.509	1.194	2.00	0.50	0.001
AS4752-108	3.357	0.058	0.373	1.81	0.44	0.001
AS4752-138	1.96	0.385	0.495	2.00	0.50	0.001
AS4754-059	0.816	0.195	1.182	1.61	0.38	0.001
AS4754-062	2.086	0.877	3.32	1.09	0.23	0.001
AS4754-086	1.384	0.13	0.696	2.00	0.50	0.001
AS4754-104	5.818	0.465	2.533	1.44	0.33	0.001
AS4755-011	2.719	0.398	1.177	1.62	0.39	0.001
AS4755-025	2.794	0.263	0.921	1.91	0.47	0.001
AS4755-074	1.214	0.189	0.794	2.00	0.50	0.001
AS4756-078	0.78	0.227	0.745	1.99	0.50	0.001

Subcatchment	DCIA	UCIA	Pervious	Max Infil. Rate (in/hr)	Min Infil. Rate (in/hr)	Decay Rate (1/s)
AS4756-081	1.539	0.123	0.506	2.00	0.50	0.001
AS4756-112	3.024	0.426	2.028	1.55	0.37	0.001
AS4756-134	2.788	0.098	0.479	2.00	0.50	0.001
AS4756-143	6.565	0.305	1.646	2.00	0.50	0.001
AS4756-151	3.432	0.28	1.321	2.00	0.50	0.001
AS4849-017	2.914	0.001	1.362	2.00	0.50	0.001
AS4849-031	11.025	0.294	1.139	2.00	0.50	0.001
AS4849-062	5.167	0.554	0.522	1.45	0.33	0.001
AS4849-093	1.988	0.358	0.299	2.00	0.50	0.001
AS4850-007	2.249	0.407	0.164	1.91	0.47	0.001
AS4850-127	4.349	0.008	0.759	2.00	0.50	0.001
AS4851-021	4.938	0.071	2.419	2.00	0.50	0.001
AS4851-076	6.232	0.763	1.152	2.00	0.50	0.001
AS4851-081	4.4	0.001	0.484	1.99	0.50	0.001
AS4851-083	5.251	0.001	1.09	1.84	0.45	0.001
AS4851-090	5.058	0.055	0.649	2.00	0.50	0.001
AS4851-100	2.245	0.265	0.434	1.99	0.50	0.001
AS4851-113	4.965	0	1.563	1.99	0.50	0.001
AS4852-007	1.055	0.007	1.285	1.75	0.42	0.001
AS4852-011	8.509	0.049	0.753	2.00	0.50	0.001
AS4852-013	3.269	0.046	0.755	2.00	0.50	0.001
AS4853-025	5.335	0.528	2.804	1.19	0.26	0.001
AS4853-048	2.585	0.019	0.622	2.00	0.50	0.001
AS4853-063	3.269	0.507	2.82	1.09	0.23	0.001
AS4853-072	1.751	0.155	1.227	1.89	0.47	0.001
AS4854-001	1.625	0.023	1.802	1.00	0.20	0.001
AS4854-032	1.089	0.408	1.949	1.40	0.32	0.001
AS4857-002	11.44	1.207	3.649	2.00	0.50	0.001
AS4857-025	2.404	0.596	1.838	2.00	0.50	0.001
AS4857-054	2.054	0.562	2.003	2.00	0.50	0.001
AS4858-038	4.534	1.226	4.921	2.00	0.50	0.001
AS4858-048	2.265	0.516	1.787	2.00	0.50	0.001
AS4949-042	6.901	0.788	1.805	1.02	0.20	0.001
AS4950-001	3.485	0.262	0.438	1.61	0.38	0.001
AS4950-068	2.833	0	0.005	2.00	0.50	0.001
AS4950-085	5.634	0.461	0.272	1.37	0.31	0.001
AS4950-118	1.976	0.144	0.48	1.00	0.20	0.001
AS4951-017	4.303	0.801	1.076	1.74	0.42	0.001
AS4951-064	6.237	1.173	2.305	2.00	0.50	0.001
AS4951-091	4.929	0.754	0.768	1.28	0.28	0.001
AS4951-116	2.528	0.49	1.08	2.00	0.50	0.001
AS4952-001	3.503	0.39	0.677	2.00	0.50	0.001
AS4952-068	4.111	0.63	1.066	2.00	0.50	0.001
AS4952-084	5.459	1.002	1.283	2.00	0.50	0.001

Subcatchment	DCIA	UCIA	Pervious	Max Infil. Rate (in/hr)	Min Infil. Rate (in/hr)	Decay Rate (1/s)
AS4952-102	4.079	0.423	0.847	2.00	0.50	0.001
AS4953-052	2.224	0.503	1.164	2.00	0.50	0.001
AS4953-078	2.896	0.532	1.305	2.00	0.50	0.001
AS4954-038	2.245	0.56	1.915	1.11	0.23	0.001
AS4957-019	1.358	0.553	1.796	2.00	0.50	0.001
AS4957-060	0.526	0.1	0.34	2.00	0.50	0.001
AS4957-062	2.133	0.697	4.117	2.00	0.50	0.001
AS4958-051	1.667	0.738	2.488	2.00	0.50	0.001
AS5047-002	3.306	0.502	1.888	1.78	0.43	0.001
AS5048-018	4.137	0.509	2.265	1.51	0.35	0.001
AS5048-037	5.329	0.791	1.614	1.38	0.31	0.001
AS5048-063	5.932	0.646	1.915	1.45	0.34	0.001
AS5049-071	6.107	0.237	1.226	1.00	0.20	0.001
AS5050-005	6.191	0.06	2.827	1.65	0.39	0.001
AS5050-017	5.051	0.036	0.894	2.00	0.50	0.001
AS5050-128	3.522	0.168	0.815	2.00	0.50	0.001
AS5052-034	0.702	0.147	0.231	2.00	0.50	0.001
AS5056-004	0.649	0.311	1.313	2.00	0.50	0.001
AS5147-045	2.111	0.296	1.258	1.25	0.28	0.001
AS5148-053	2.742	0.162	0.329	1.72	0.41	0.001
AS5148-061	1.965	0.21	0.72	1.97	0.49	0.001
CB4254-055	0.27	0.104	0.486	2.00	0.50	0.001
CB4453-076	1.61	0.497	1.564	1.21	0.26	0.001
CB4652-110	5.811	0.68	2.064	1.24	0.27	0.001
CB4751-033	0.957	0.044	0.627	2.00	0.50	0.001
CB4752-127	0.694	0.127	0.296	2.00	0.50	0.001
CB4754-121	3.669	0.909	3.23	1.00	0.20	0.001
CB4755-090	1.283	0.374	1.546	1.04	0.21	0.001
CB4756-103	2.692	0.17	1.415	2.00	0.50	0.001
CB4854-050	4.765	0.347	2.295	1.86	0.46	0.001
CB4948-042	1.575	0.31	0.437	2.00	0.50	0.001
CB4948-051	1.343	0.11	0.766	2.00	0.50	0.001
CB4951-138	6.209	0.632	0.941	2.00	0.50	0.001
CB5047-022	1.679	0.096	0.719	2.00	0.50	0.001
CB5049-123	5.356	0.128	0.888	1.63	0.39	0.001
CB5148-101	3.004	0.228	0.699	1.09	0.23	0.001
D001	0.117	0.138	0.703	2.00	0.50	0.001
D002	0.544	0.02	3.892	1.25	0.27	0.001
D003	0.5	0.276	0.929	2.00	0.50	0.001
D004	0.242	0.252	1.085	2.00	0.50	0.001
D005	0.076	0.084	0.362	2.00	0.50	0.001
D006	0.825	0.419	1.429	2.00	0.50	0.001
D007	0.163	0.129	0.527	2.00	0.50	0.001
D008	0.414	0.097	0.261	2.00	0.50	0.001

Subcatchment	DCIA	UCIA	Pervious	Max Infil. Rate (in/hr)	Min Infil. Rate (in/hr)	Decay Rate (1/s)
D009	0.168	0.185	0.601	2.00	0.50	0.001
D010	0.128	0.098	0.487	2.00	0.50	0.001
D011	0.632	0.297	1.163	1.90	0.47	0.001
D012	0.324	0.187	1.008	1.23	0.27	0.001
D013	1.333	0.228	0.494	2.00	0.50	0.001
IN4353-109	1.582	0.448	1.907	1.10	0.23	0.001
IN4355-061	1.242	0.434	1.248	1.00	0.20	0.001
IN4452-004	6.088	1.289	2.919	1.80	0.44	0.001
IN4454-091	1.175	0.112	0.126	1.00	0.20	0.001
IN4552-013	6.079	0.002	0.333	2.00	0.50	0.001
IN4553-099	1.811	0.543	1.716	2.00	0.50	0.001
IN4554-018	2.13	0.757	3.151	2.00	0.50	0.001
IN4554-039	1.188	0.411	2.27	2.00	0.50	0.001
IN4554-047	1.643	0.439	1.784	2.00	0.50	0.001
IN4651-009	2.061	0.13	0.696	1.17	0.25	0.001
IN4651-055	4.579	0.166	0.489	1.00	0.20	0.001
IN4651-125	4.62	0.041	0.252	1.91	0.47	0.001
IN4651-159	0.942	0.006	0.286	1.00	0.20	0.001
IN4653-161	1.841	0.53	1.952	1.00	0.20	0.001
IN4654-072	1.186	0.258	1.472	1.00	0.20	0.001
IN4655-027	1.695	0.46	1.665	1.43	0.33	0.001
IN4753-068	4.992	0.231	0.966	1.98	0.49	0.001
IN4754-073	1.257	0.147	0.712	1.00	0.20	0.001
IN4754-097	5.618	0.623	4.214	1.34	0.30	0.001
IN4755-067	0.614	0.066	0.268	2.00	0.50	0.001
IN4755-081	0.466	0.128	0.397	2.00	0.50	0.001
IN4756-080	0.933	0.259	1.061	1.33	0.30	0.001
IN4756-122	0.571	0.152	0.357	2.00	0.50	0.001
IN4849-027	3.635	0.766	0.723	1.94	0.48	0.001
IN4849-083	1.001	0.1	0.148	2.00	0.50	0.001
IN4849-087	0.565	0.087	0.24	2.00	0.50	0.001
IN4850-053	2.037	0.012	0.15	2.00	0.50	0.001
IN4851-031	2.542	0.172	0.525	2.00	0.50	0.001
IN4856-005	0.468	0.131	0.453	2.00	0.50	0.001
IN4856-008	0.362	0.129	0.343	2.00	0.50	0.001
IN4857-060	0.922	0.225	0.83	2.00	0.50	0.001
IN4948-037	0.556	0.09	0.223	2.00	0.50	0.001
IN4949-041	5.686	0	0.094	1.00	0.20	0.001
IN4949-091	1.787	0.332	1.318	1.95	0.49	0.001
IN4949-116	4.563	0.771	1.912	1.60	0.38	0.001
IN4950-147	6.31	0.638	0.417	1.39	0.32	0.001
IN4953-057	0.578	0.05	0.639	2.00	0.50	0.001
IN4953-097	1.796	0.136	0.576	2.00	0.50	0.001
IN4954-017	3.726	0.479	3.372	1.54	0.36	0.001

Subcatchment	DCIA	UCIA	Pervious	Max Infil. Rate (in/hr)	Min Infil. Rate (in/hr)	Decay Rate (1/s)
IN4954-019	1.421	0.494	2.308	1.00	0.20	0.001
IN4957-038	1.271	0.431	1.252	2.00	0.50	0.001
IN4957-046	2.447	0.625	3.78	2.00	0.50	0.001
IN5048-056	0.51	0.117	0.349	2.00	0.50	0.001
IN5049-146	3.119	0.004	1.104	1.03	0.21	0.001
IN5050-085	3.934	0.017	0.006	2.00	0.50	0.001
IN5051-059	5.108	0.275	2.096	2.00	0.50	0.001
IN5053-061	3.087	0.285	4.607	1.16	0.25	0.001
IN5057-041	0.301	0.029	0.955	2.00	0.50	0.001
IN5148-111	5.288	1.221	1.892	1.16	0.25	0.001
MI4652-001	4.837	0.323	1.125	2.00	0.50	0.001
Private-4460	1.298	0.414	0.465	2.00	0.50	0.001
Private-48967	0.39	0.012	0.593	2.00	0.50	0.001
Private-48972	0.62	0.005	0.343	1.87	0.46	0.001
Private-48974	0.519	0	0.257	1.00	0.20	0.001
Tap1	2.257	0.512	1.703	2.00	0.50	0.001
Tap5	5.389	0.258	2.744	1.64	0.39	0.001
TP4653-108	3.22	0.826	2.5	2.00	0.50	0.001
TP4752-016	2.773	0.309	0.761	2.00	0.50	0.001
TP4752-044	10.724	0.084	2.381	1.99	0.50	0.001
TP4753-011	5.768	0.294	1.507	1.29	0.29	0.001
TP4753-013	5.64	0.743	2.714	1.24	0.27	0.001
TP4753-027	4.077	0.177	0.981	1.97	0.49	0.001
TP4849-074	4.343	0.435	0.545	1.41	0.32	0.001
TP4850-088	3.536	0.287	0.709	1.62	0.39	0.001
TP4952-155	8.106	0.773	1.443	2.00	0.50	0.001
UW4650-018	14.17	0.062	5.355	1.64	0.39	0.001

Appendix C: Calibration Memo

Memo

To:	Ryan Stenjem, P.E. – City of Madison
From:	Alistair Hancox, P.E.
Subject:	Near West Watershed Study – Existing Conditions Model Calibration
Date:	March 6, 2024

INTRODUCTION

The memorandum presents the results of MSA's efforts to calibrate the 1D/2D XP-SWMM model for the Near West watershed. Monitoring equipment consisting of two rain gauges, three level loggers, and one flow meter installed within storm sewer structures and operational from Spring until Fall 2022. The location of these can be seen in the attached map.

CALIBRATION RAINFALL EVENTS

Five rainfall events were chosen, each with varying duration and intensity. Of the two rain gauges only Fire Station 1 was within the study area. The SW Commuter rain gauge, of which the Thiessen polygon only covered a small portion of the Regent St LL metershed, was the other.

Table 1 – Calibration Storms

Event Date	7-Day Antecedent Rainfall (in)	Start Time	Stop Time	Duration (hr)	Total Depth (in)	Peak Intensity (in/hr)
June 15th	1.18	18:55	21:25	2.5	0.95	3.72
July 5th	0.29	19:35	1:00	5.42	1.46	2.76
July 23rd	0.00	18:45	19:10	0.42	0.93	4.32
August 7th	0.44	23:45	3:25	3.67	1.82	3.36
August 25th	0.18	0:05	4:40	4.58	2.17	2.04

As shown in the table above, rainfall captured from the Fire Station 1 gauge only.

UNCALIBRATED MODEL

The Near West Existing Conditions model was built following the City of Madison Modeling Guidance documentation.

See attached comparative charts for Modeling Calibration Results. The results of the initial comparison of the Uncalibrated Model to the Metered data can be summarized by three main findings:

1. Flows at the Regent St LL were being overpredicted
2. Flows at the Camp Randall LL were being underpredicted.
3. Flows at the N Brooks St LL were being modeled accurately.

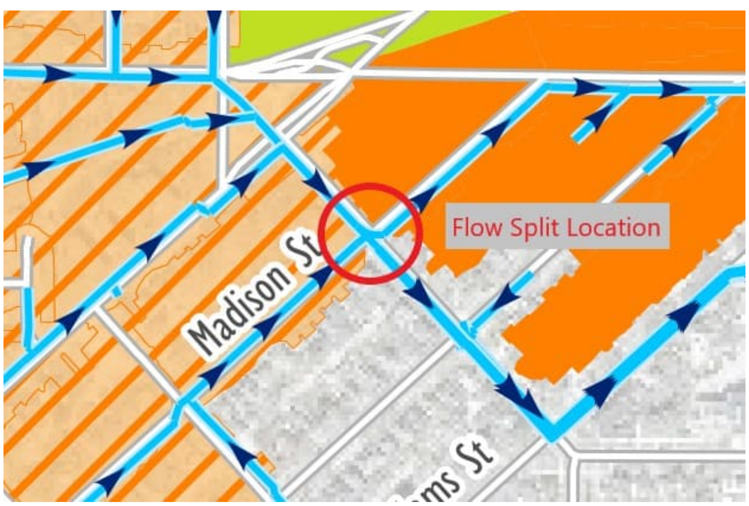
Because the results in the North Brooks metershed were so well matched, differences in the characteristics of all three metersheds were looked at to determine the cause. We found that the Regent St metershed had unique hydraulic characteristics which were affecting flow response results more than anticipated. Key locations within the storm sewer system needed to be analyzed in more detail, and sensitivity checks conducted, to determine accurate estimates for flow splits and hydraulic losses.

CALIBRATED MODEL

Regent St Level Logger

The metershed draining to this location is relatively large. Approximately 36 acres drained directly to this meter location, with another 204 acres of "partial" metershed contributing to this flow route and adjacent flow routes. The complexity of the upstream storm sewer meant that flow-split locations were critical to accurate response estimates.

The storm sewer junction at the intersection of Madison St and Oakland Ave was identified as a location which needed careful review. Additional inspections were conducted to confirm accurate pipe geometry was being modeled.



The main storm sewer trunk along Regent Street is predominantly a 4' x 11' box. However, at two locations directly upstream of the level logger, the storm sewer transitions to a much smaller capacity horizontal elliptical for short sections. These appear to have been put in place as sewer repairs, though are clearly acting as "bottlenecks" to the system.

To match the response recorded for our 5 rainfall events best, we set our entry loss coefficients into these two HE pipe sections up to 4.0 and our exit loss coefficients to 1.0.

Camp Randall Level Logger

The metershed to the Camp Randall Level Logger contains Camp Randall Stadium and some of the surrounding infrastructure. Storm sewer draining this area is largely private pipes and therefore little was known about these when building the model. That meant that only two large watersheds (IN4552-013 and AS4552-058) were delineated which drain to this meter and standard assumptions for flow length and slope were applied.

Upon reviewing the uncalibrated results, it was clear that the model response at this location needed to be "sped up". Runoff was reaching the meter faster than the model was predicting. Given that the stadium infrastructure is likely relatively efficient at collecting and conveying runoff, it was decided that Impervious flow lengths would be reduced to 1/3 of the previously assumed length. Subsequently, Widths for these subcatchments were tripled.

It was not deemed appropriate to roll this change out to the rest of the model.

North Brooks Level Logger

Results at the North Brooks Level Logger were well matched to that of the uncalibrated model. It was deemed suitable to leave all parameters effecting this meter and the contributing land uses unchanged.

Bassett Street Flow Meter

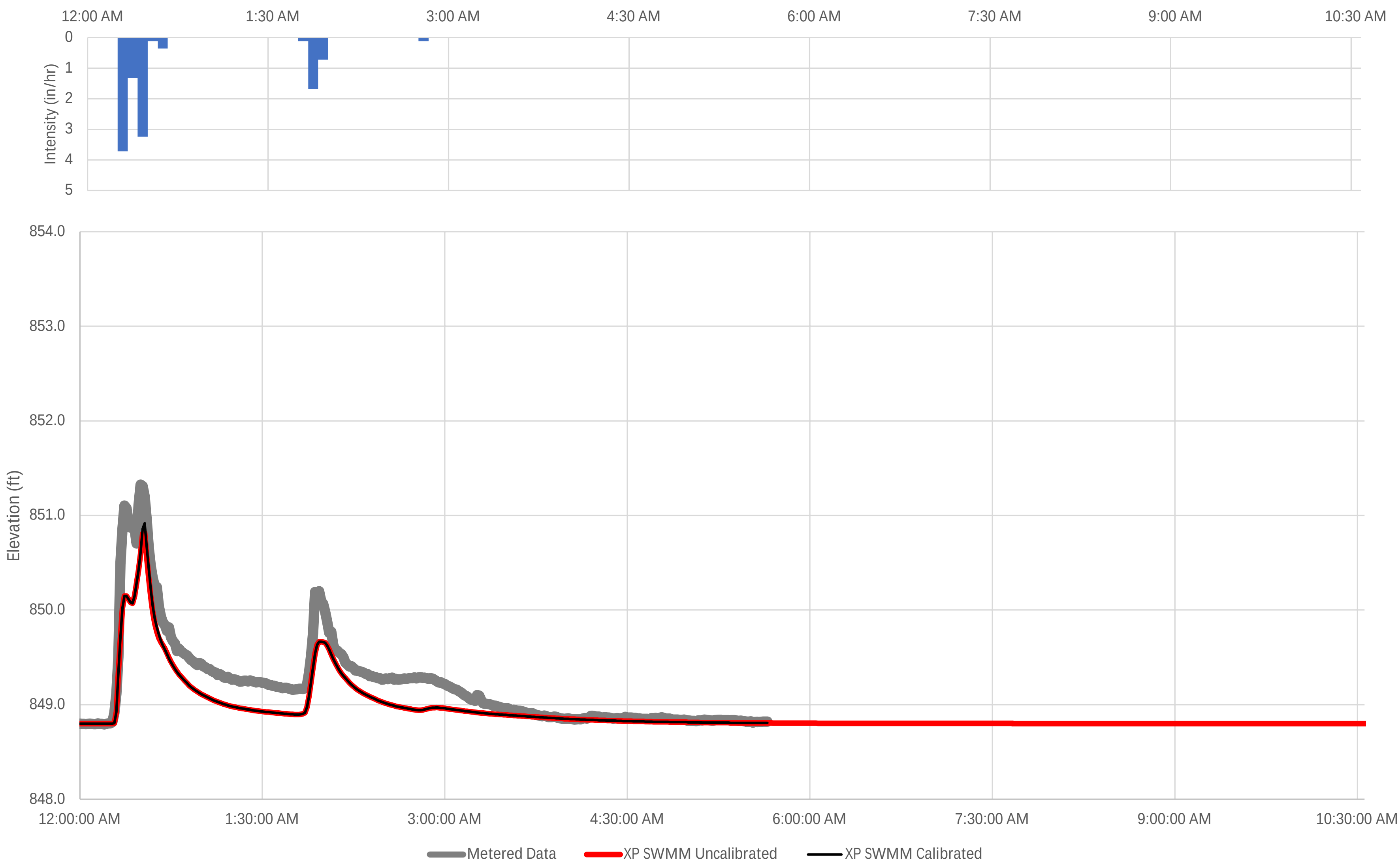
Results at the Bassett Street Flow meter were very inconsistent. Velocity recorded would bounce from 0.000 ft/s to 8.594 ft/s each time there was a rainfall event. It is believed that this meter was faulty, therefore data collected at this location was ignored.

CONCLUSION

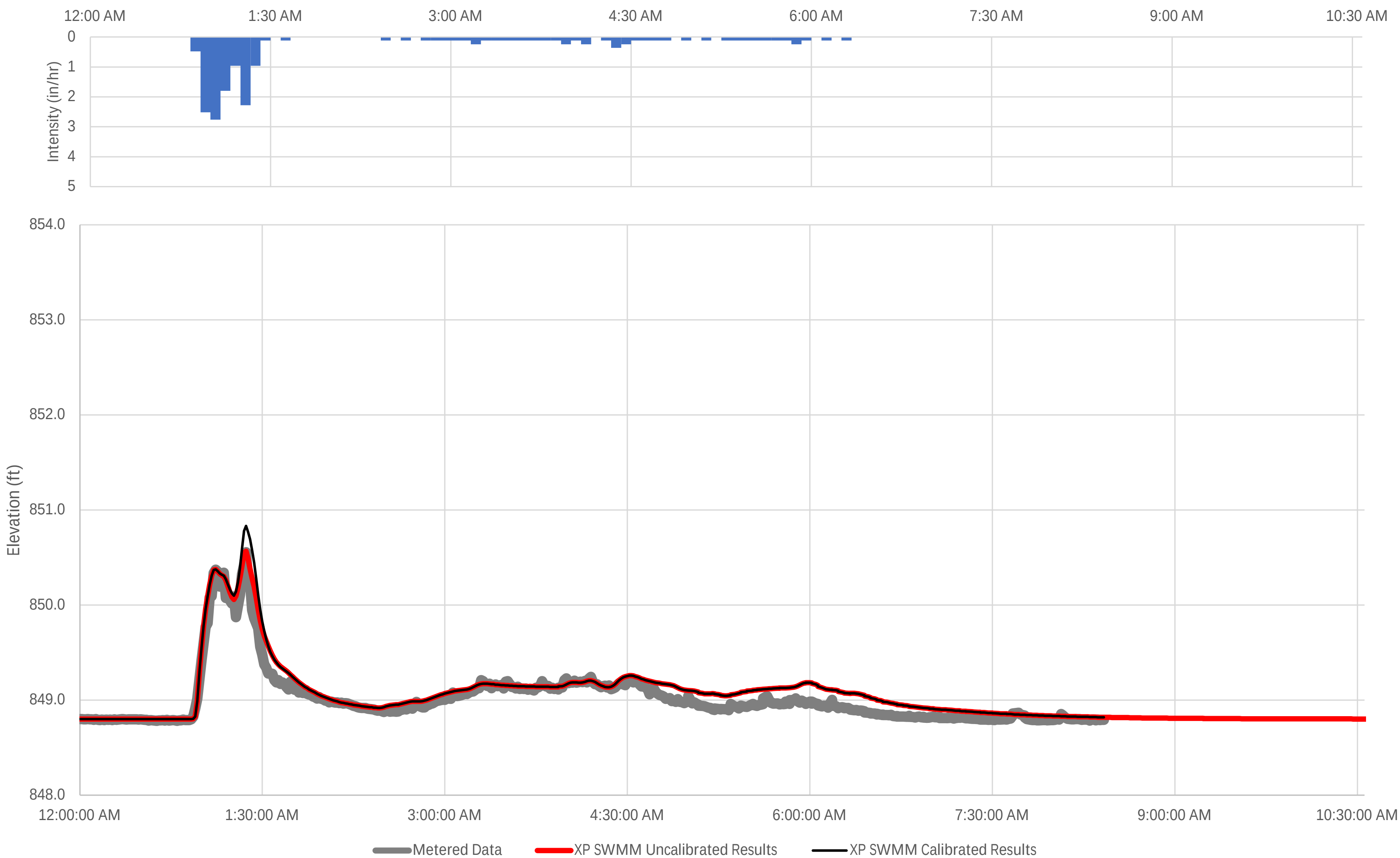
Model calibration was confined to only hydraulic modeling changes, with the one exception of the Camp Randall impervious watersheds being “widened”. Other factors affecting runoff generation were left unchanged.

Given that the calibration changes to the model were largely based around the hydraulics of the storm sewer and not the hydrologic parameters affecting infiltration, some degree of caution should be taken when analyzing model results. With so many cross connections and complexity to the storm sewer network, numerous flow restriction combinations could have resulted in similar calibrated results at the Regent St Level Logger. However, this becomes less relevant during events larger than the calibration storms which produce more widespread inundation and significant overland flow.

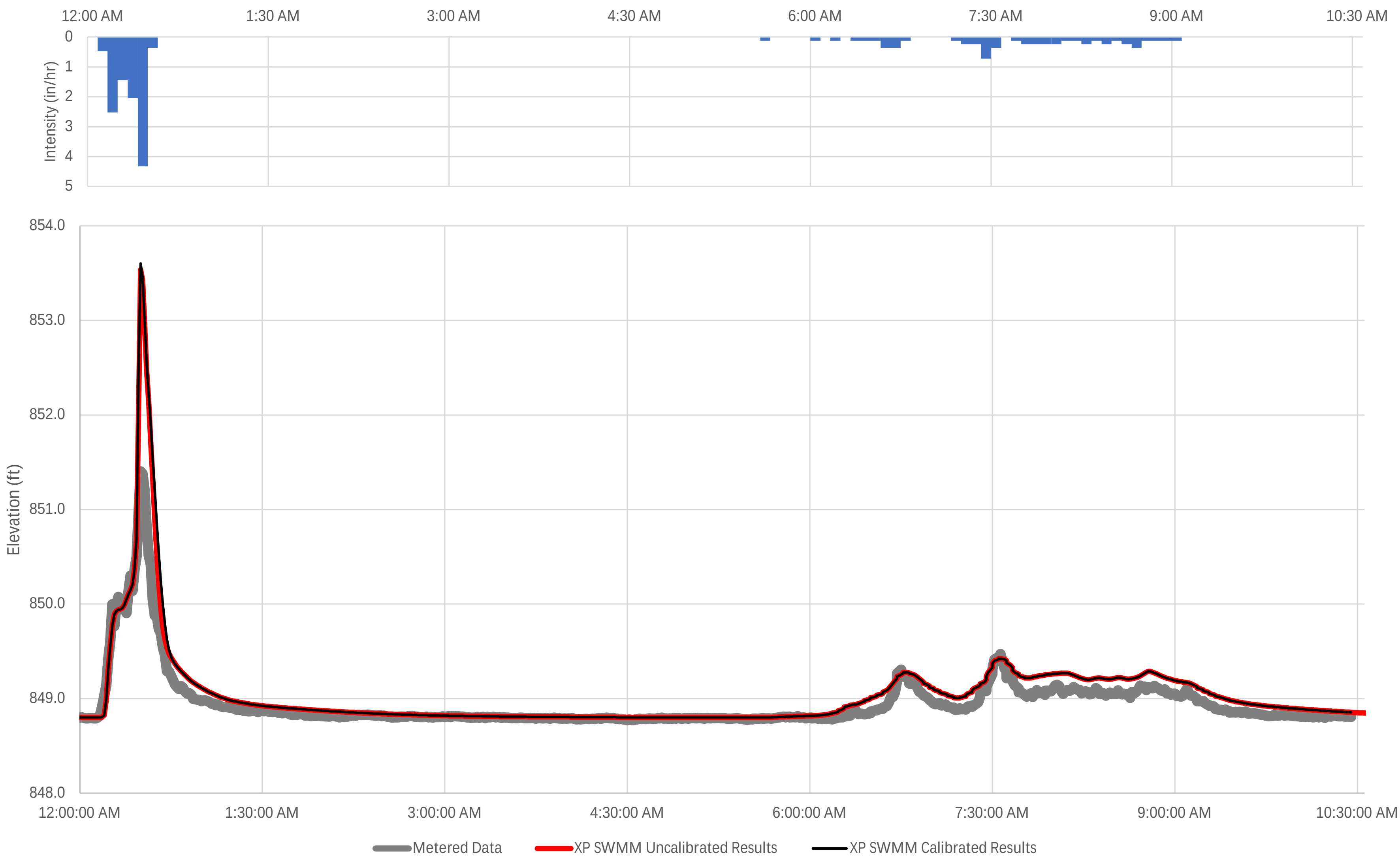
North Brooks Level Logger - June 15 Rainfall Event



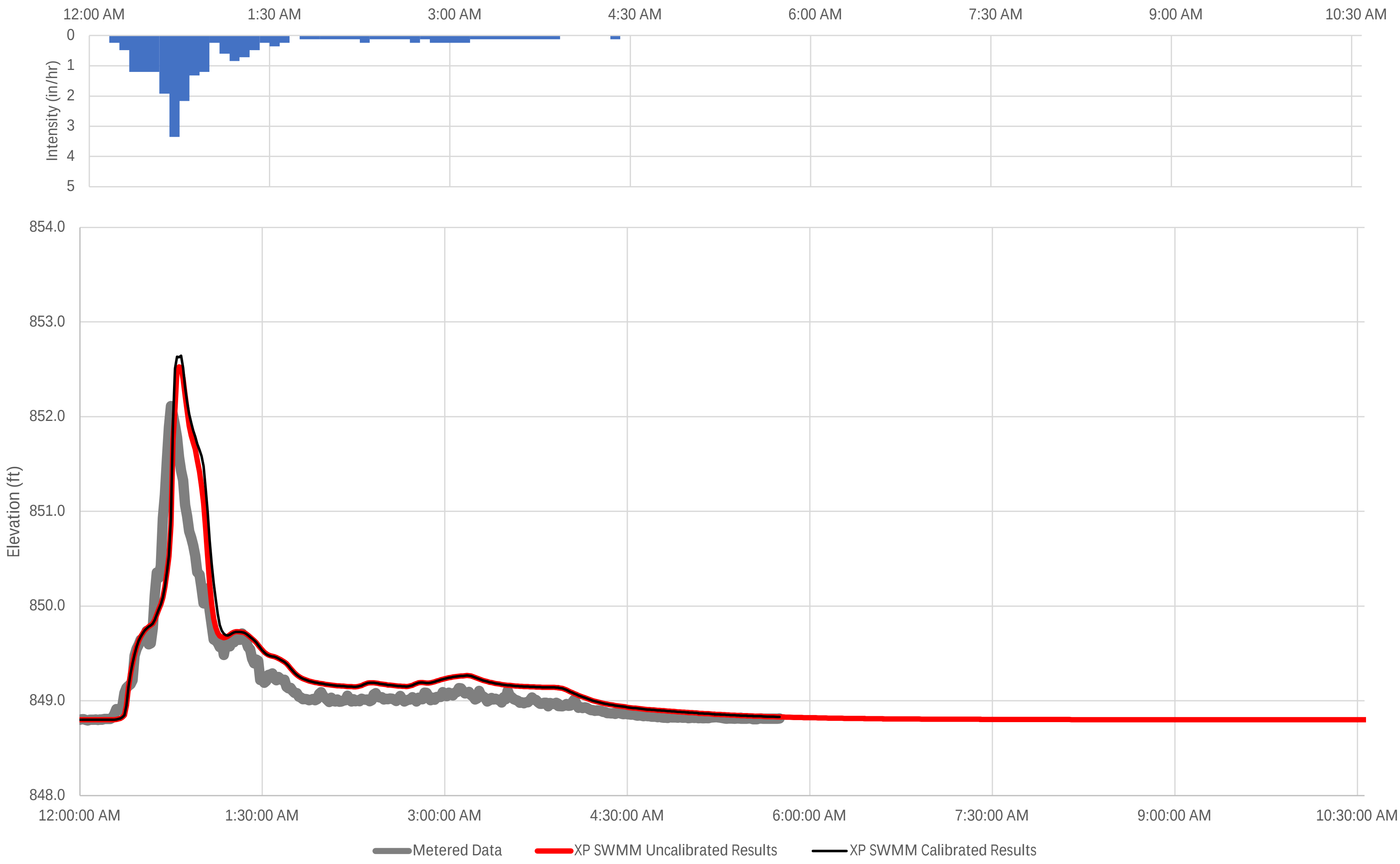
North Brooks Level Logger - July 5 Rainfall Event



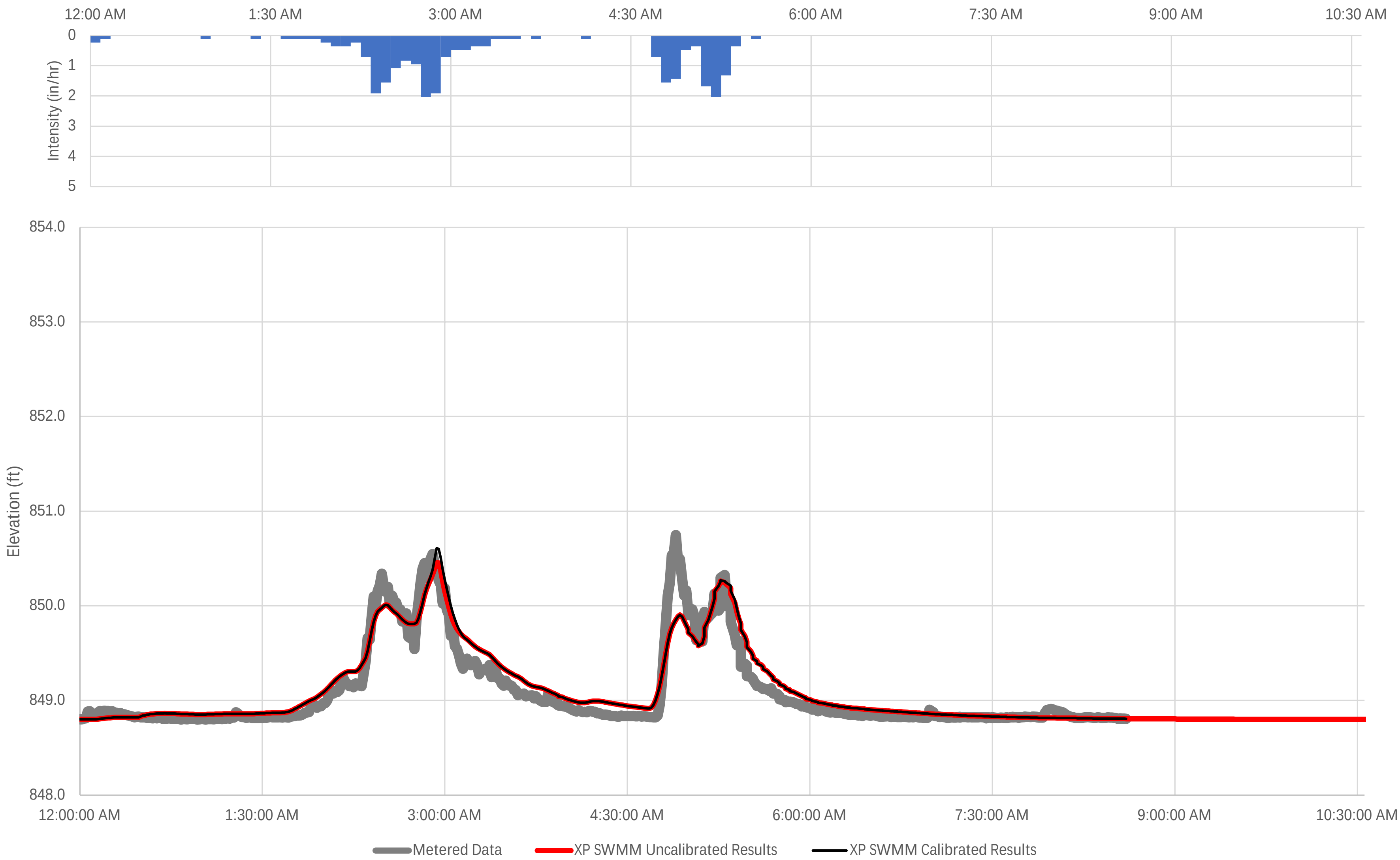
North Brooks Level Logger - July 23 Rainfall Event



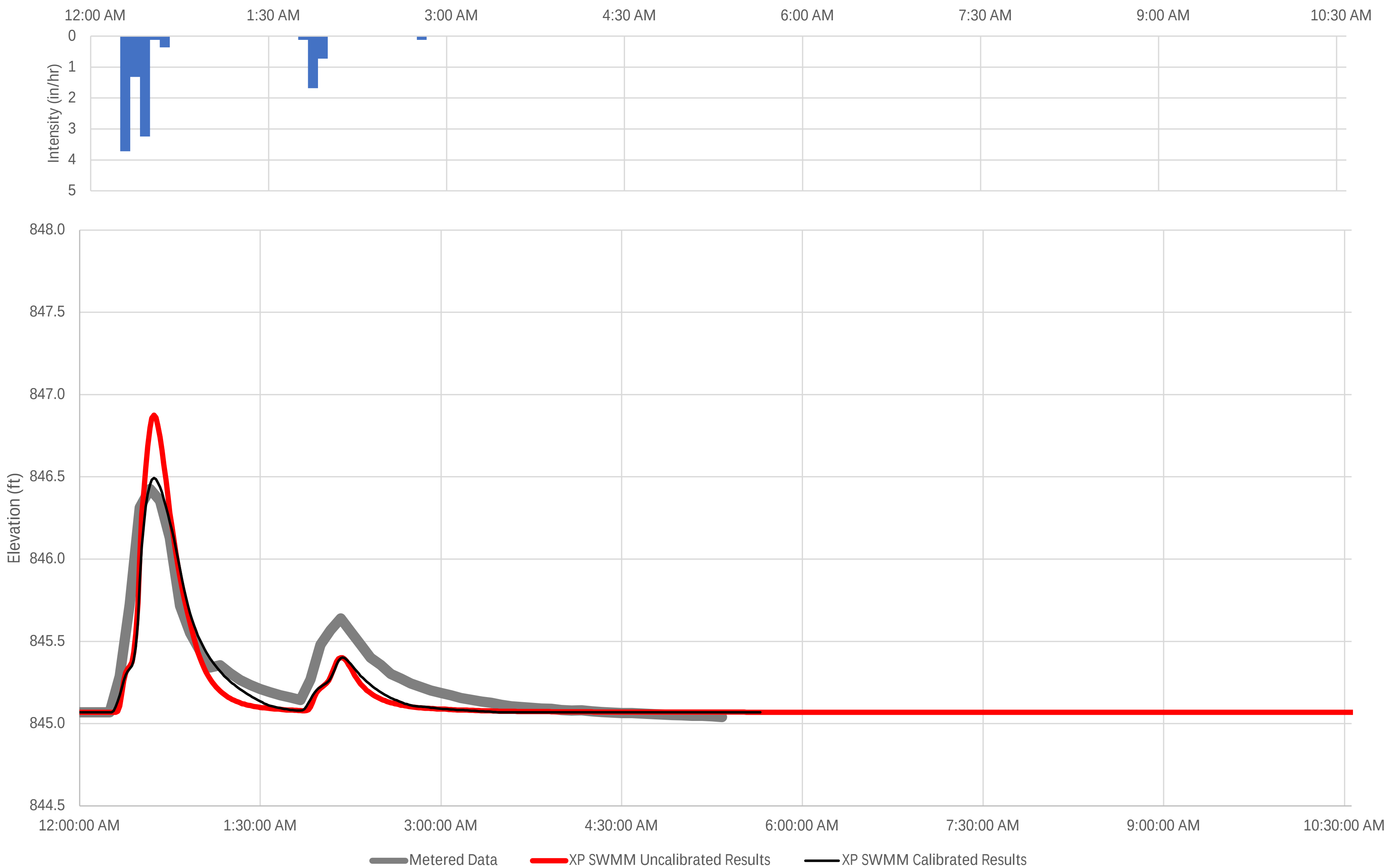
North Brooks Level Logger - August 7 Rainfall Event



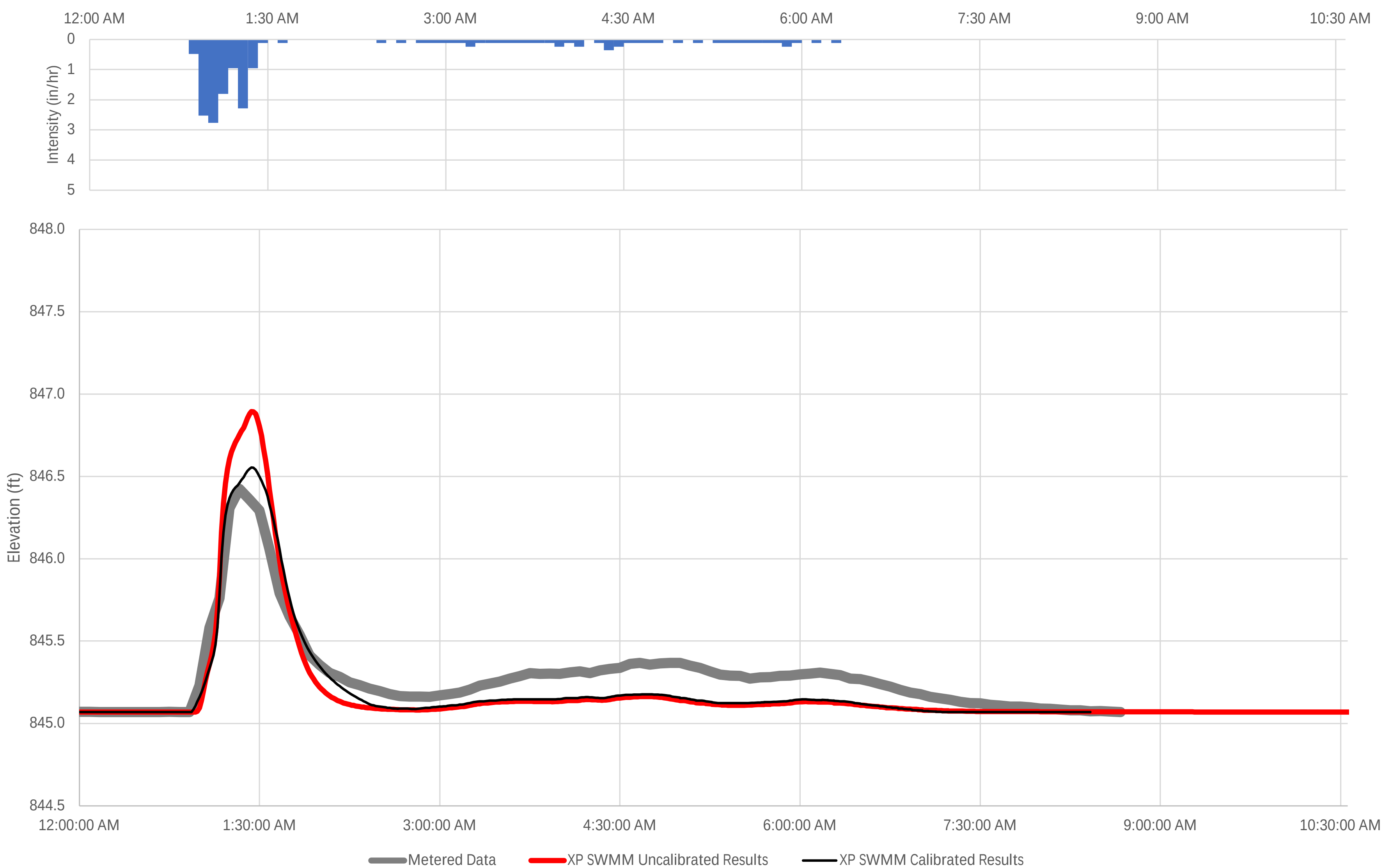
North Brooks Level Logger - August 25 Rainfall Event



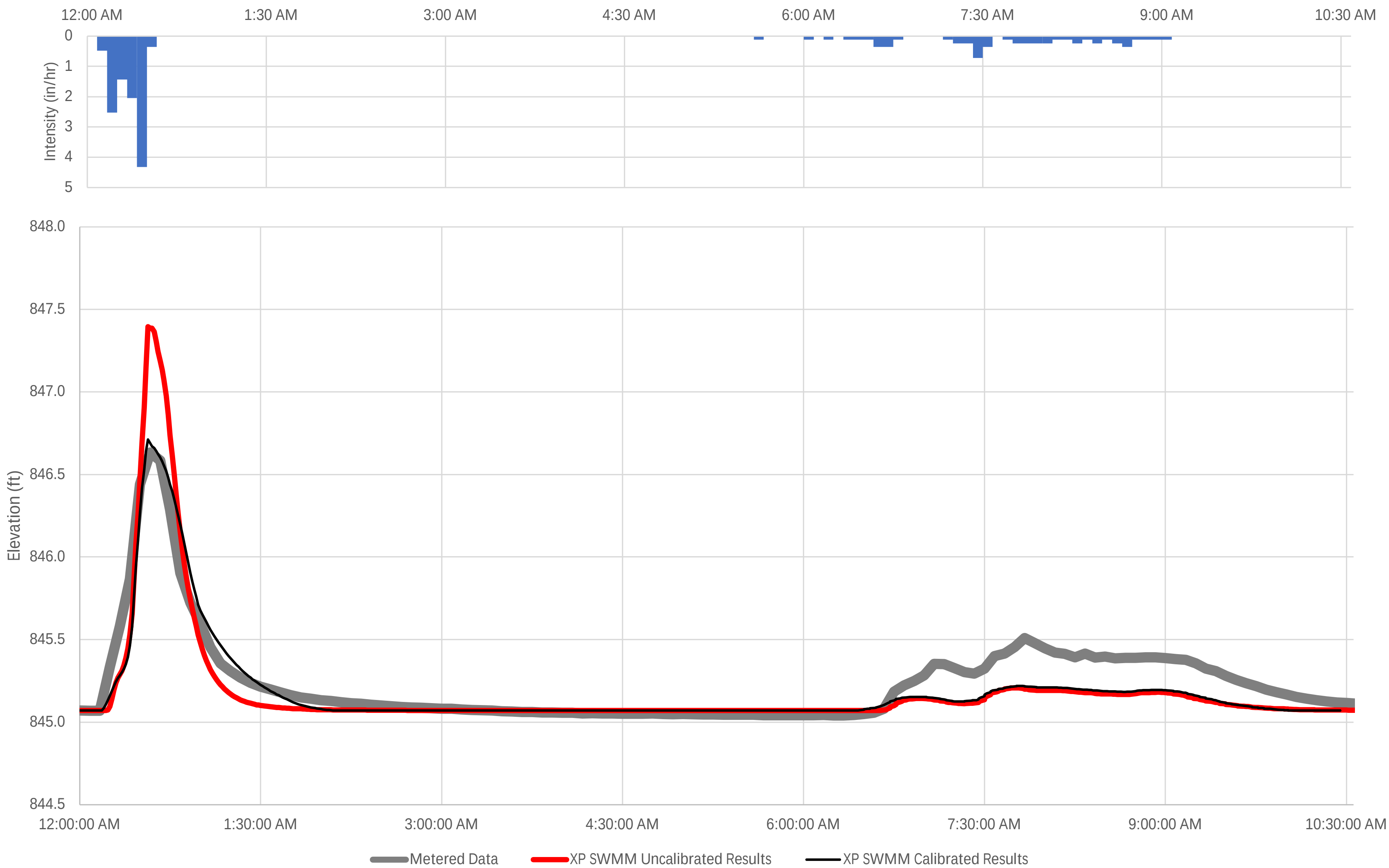
Regent Street Level Logger - June 15 Rainfall Event



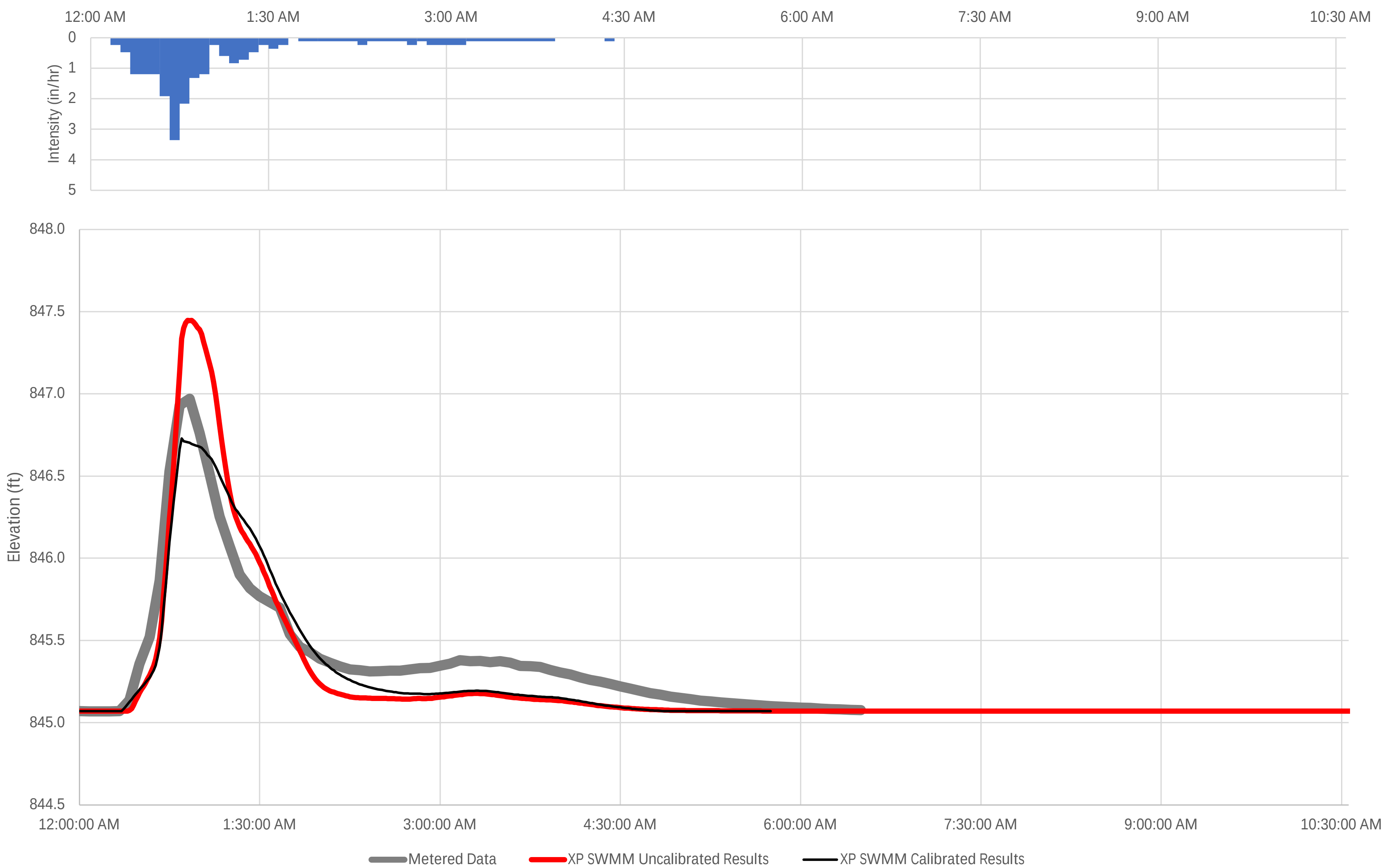
Regent Street Level Logger - July 5 Rainfall Event



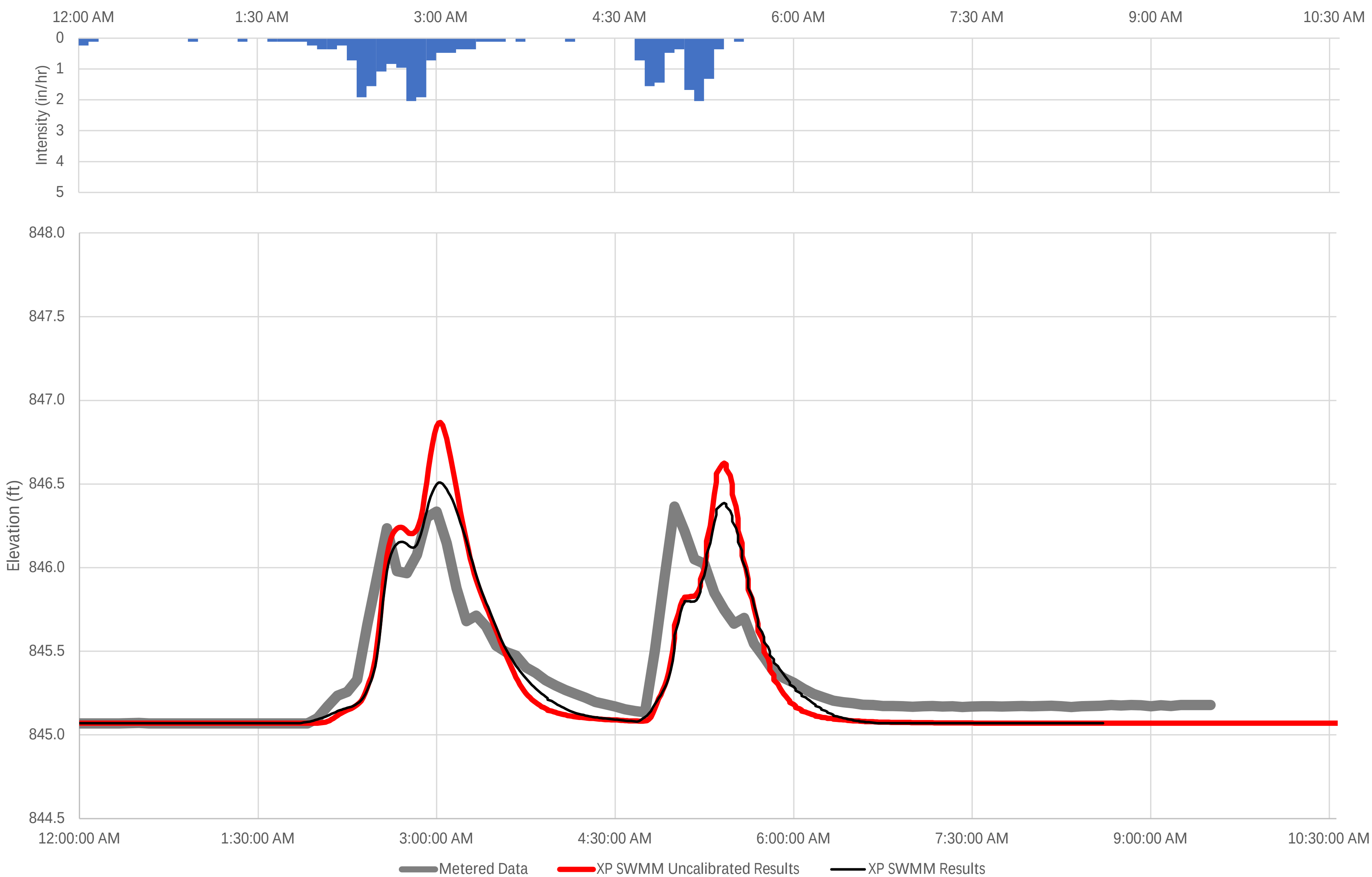
Regent Street Level Logger - July 23 Rainfall Event



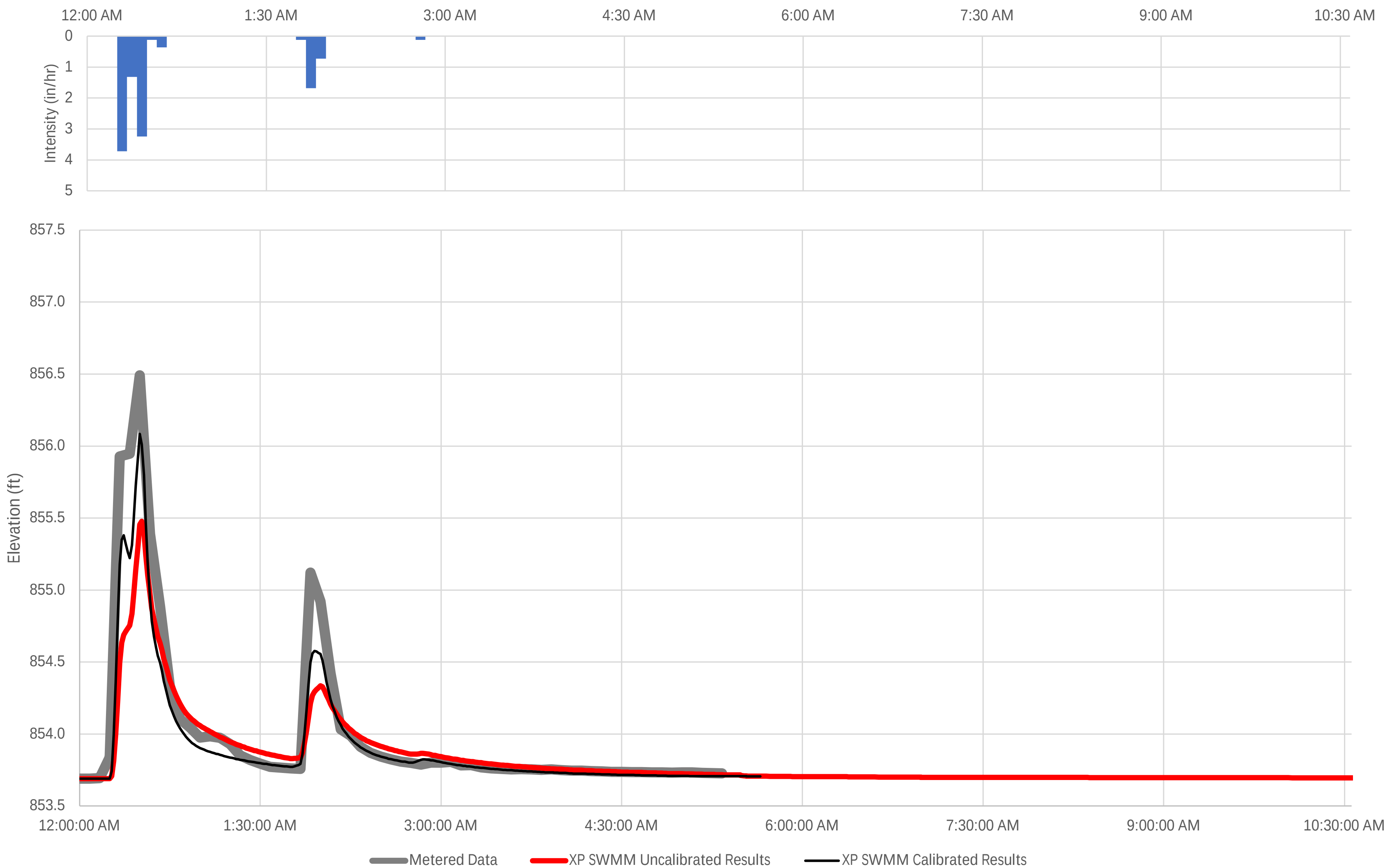
Regent Street Level Logger - August 7 Rainfall Event

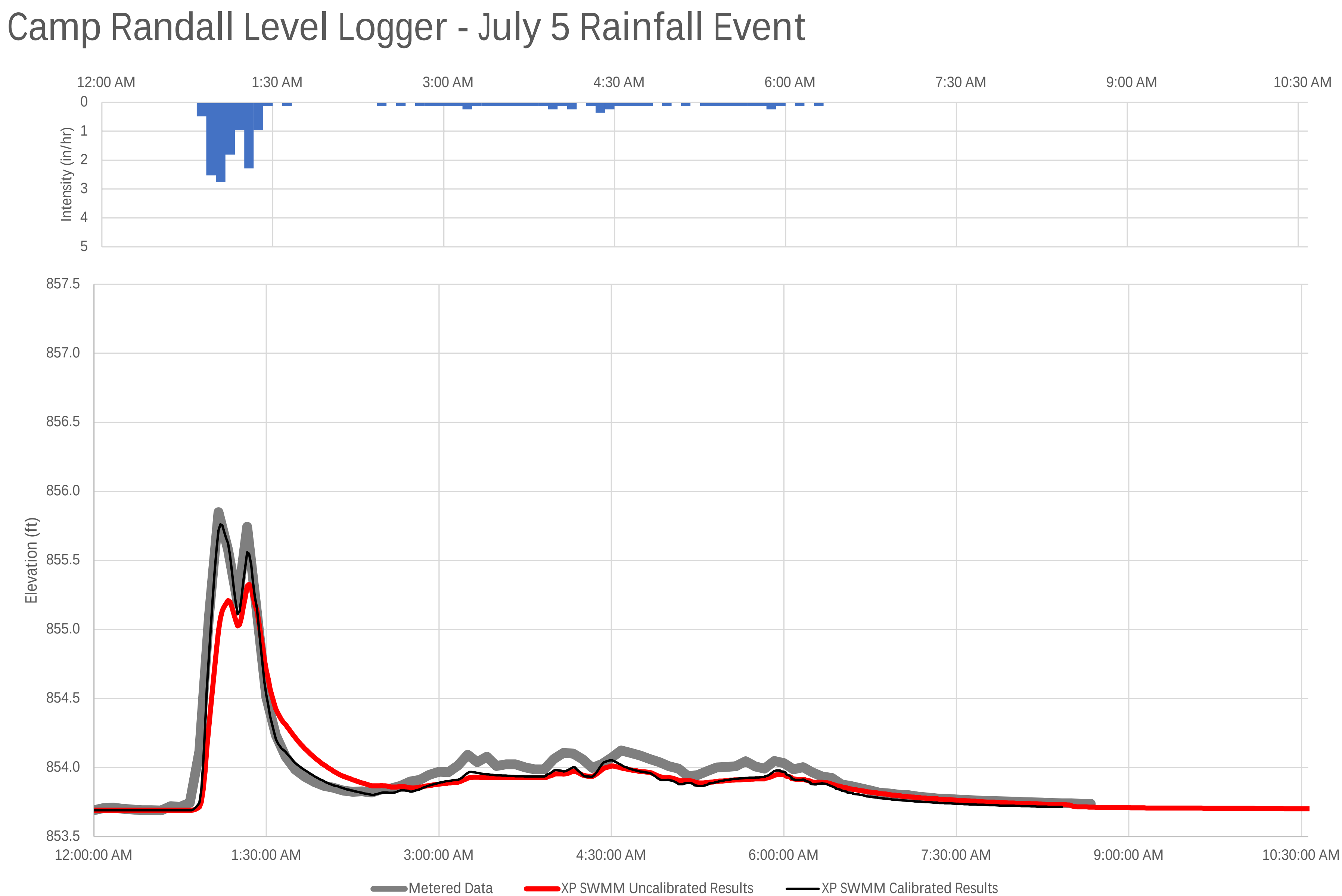


Regent St Level Logger - August 25 Rainfall Event



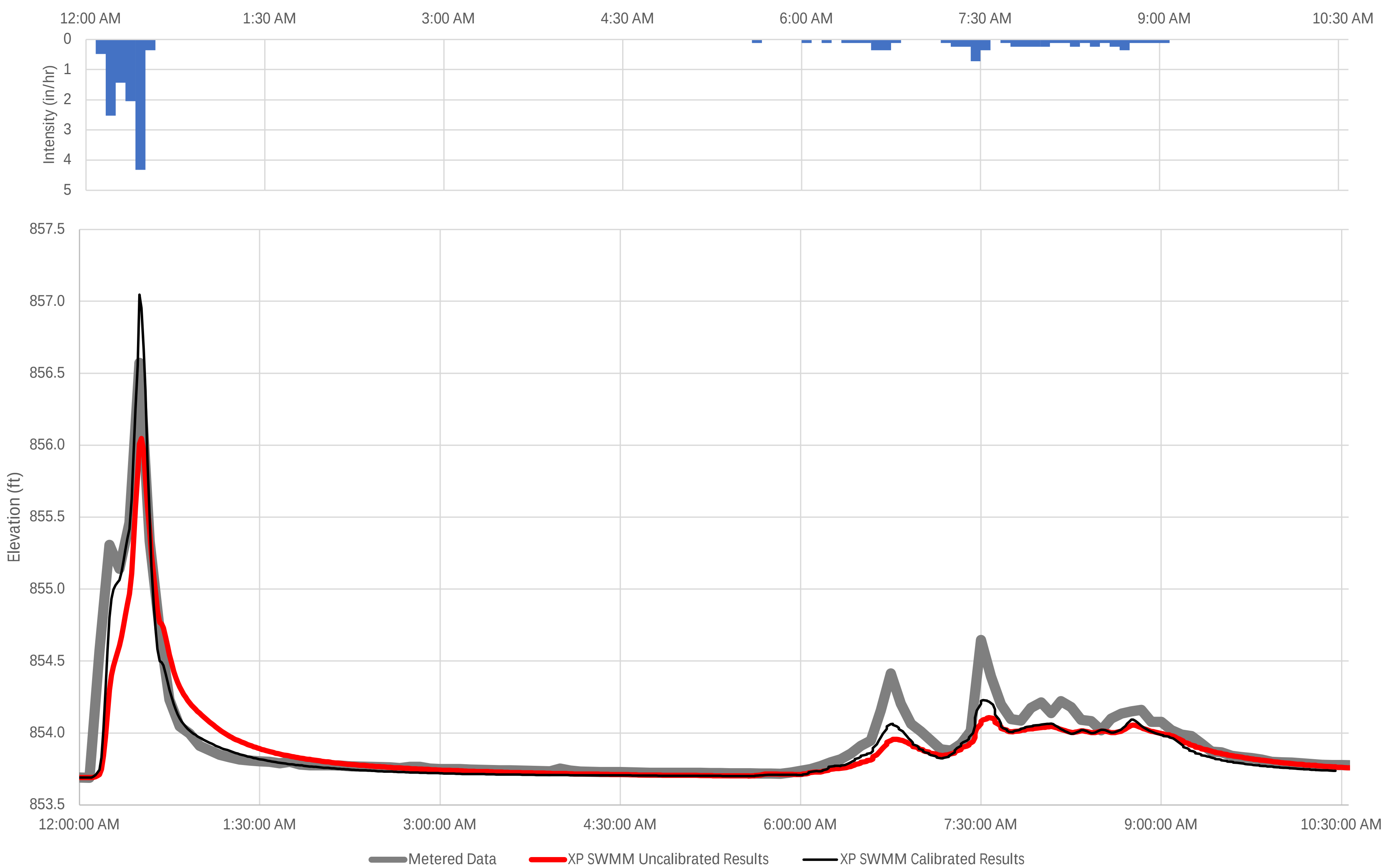
Camp Randall Level Logger - June 15 Rainfall Event



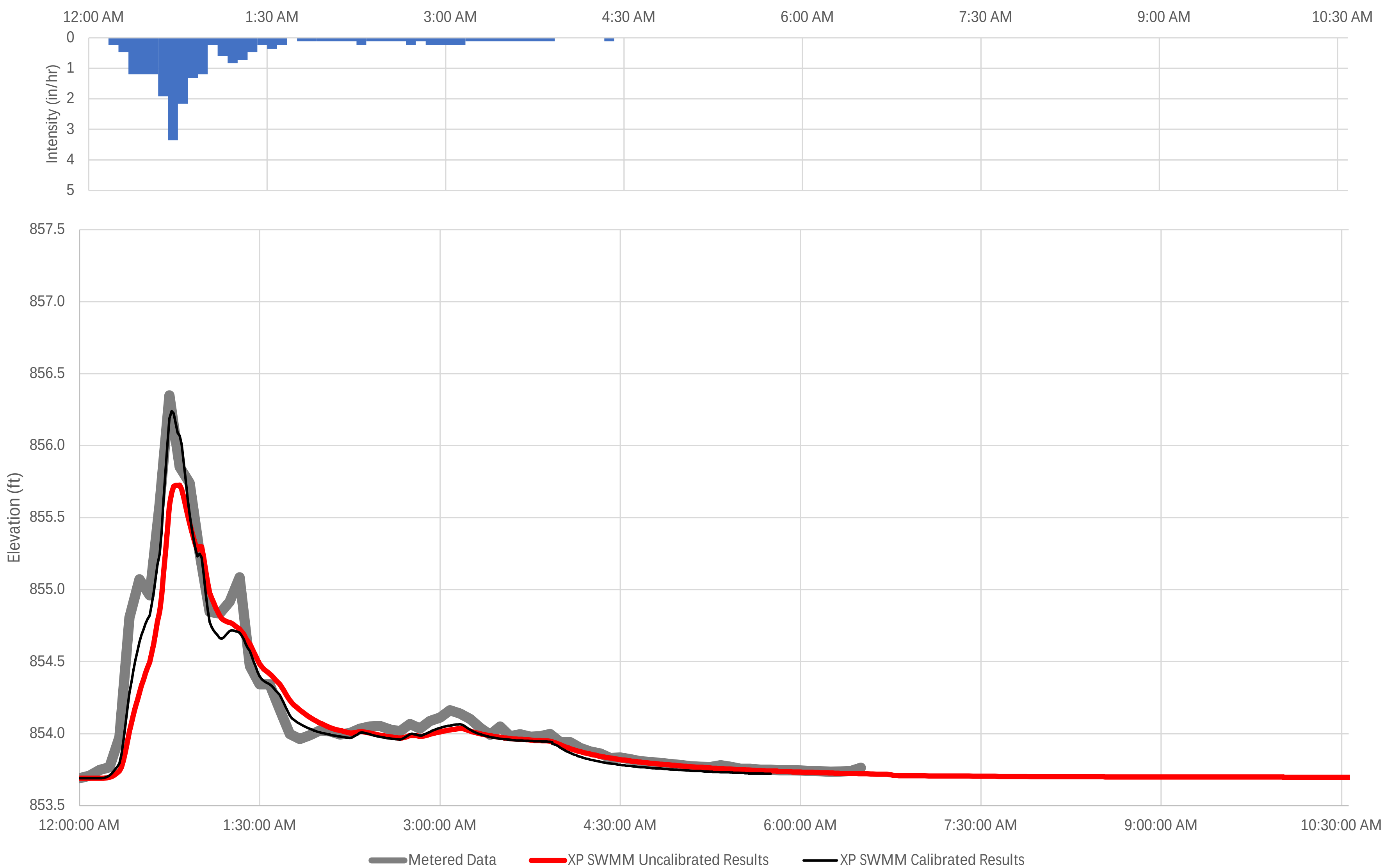


Camp Randall Level Logger - July 5 Rainfall Event
12:00 AM
1:30 AM
3:00 AM
4:30 AM
6:00 AM
7:30 AM
9:00 AM
10:30 AM
Intensity (in/hr)
0
1
2
3
4
5
Elevation (ft)
857.5
857.0
856.5
856.0
855.5
855.0
854.5
854.0
853.5
12:00:00 AM
1:30:00 AM
3:00:00 AM
4:30:00 AM
6:00:00 AM
7:30:00 AM
9:00:00 AM
10:30:00 AM
Metered Data
XP SWMM Uncalibrated Results
XP SWMM Calibrated Results

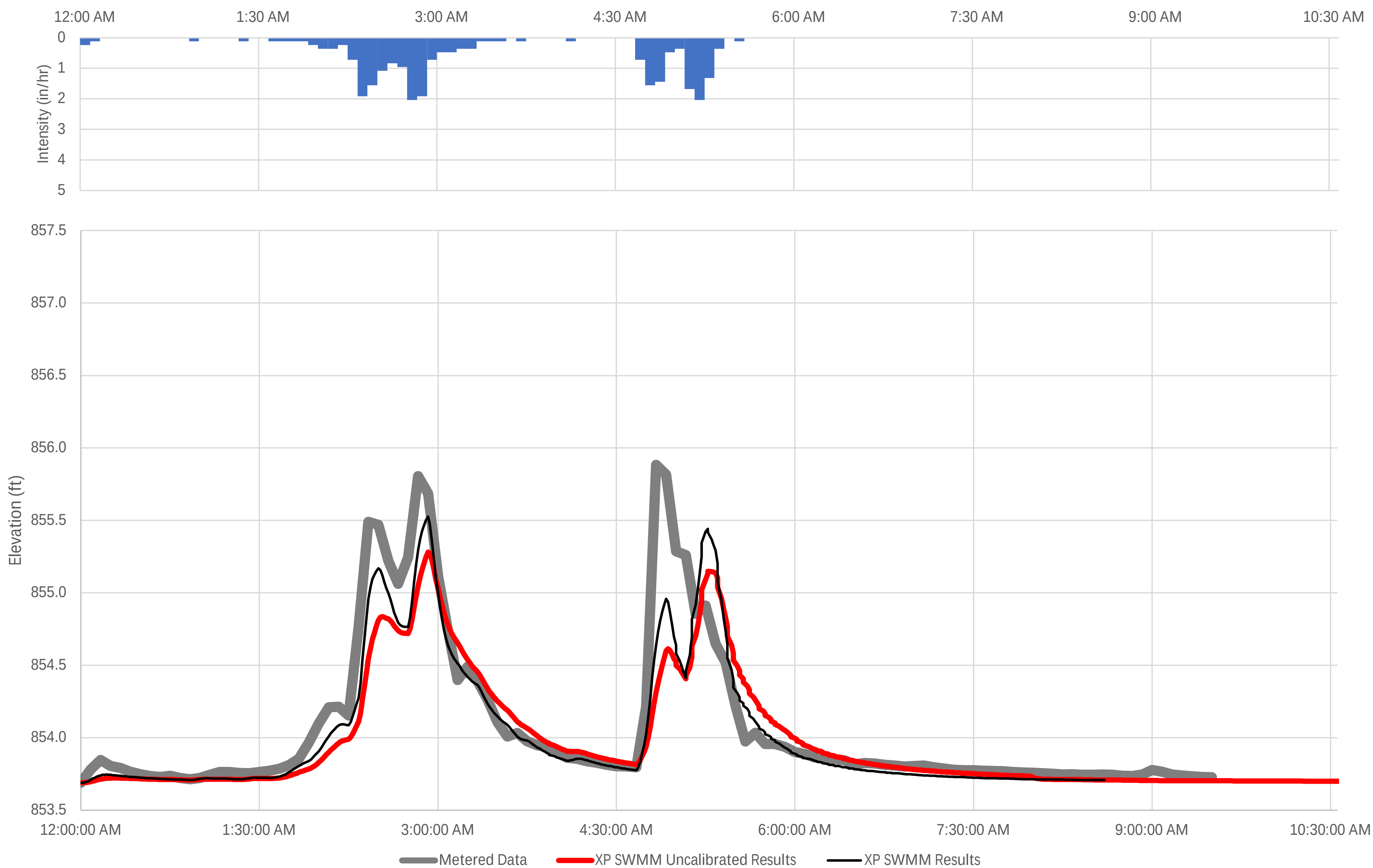
Camp Randall Level Logger - July 23 Rainfall Event



Camp Randall Level Logger - August 7 Rainfall Event



Camp Randall Level Logger - August 25 Rainfall Event

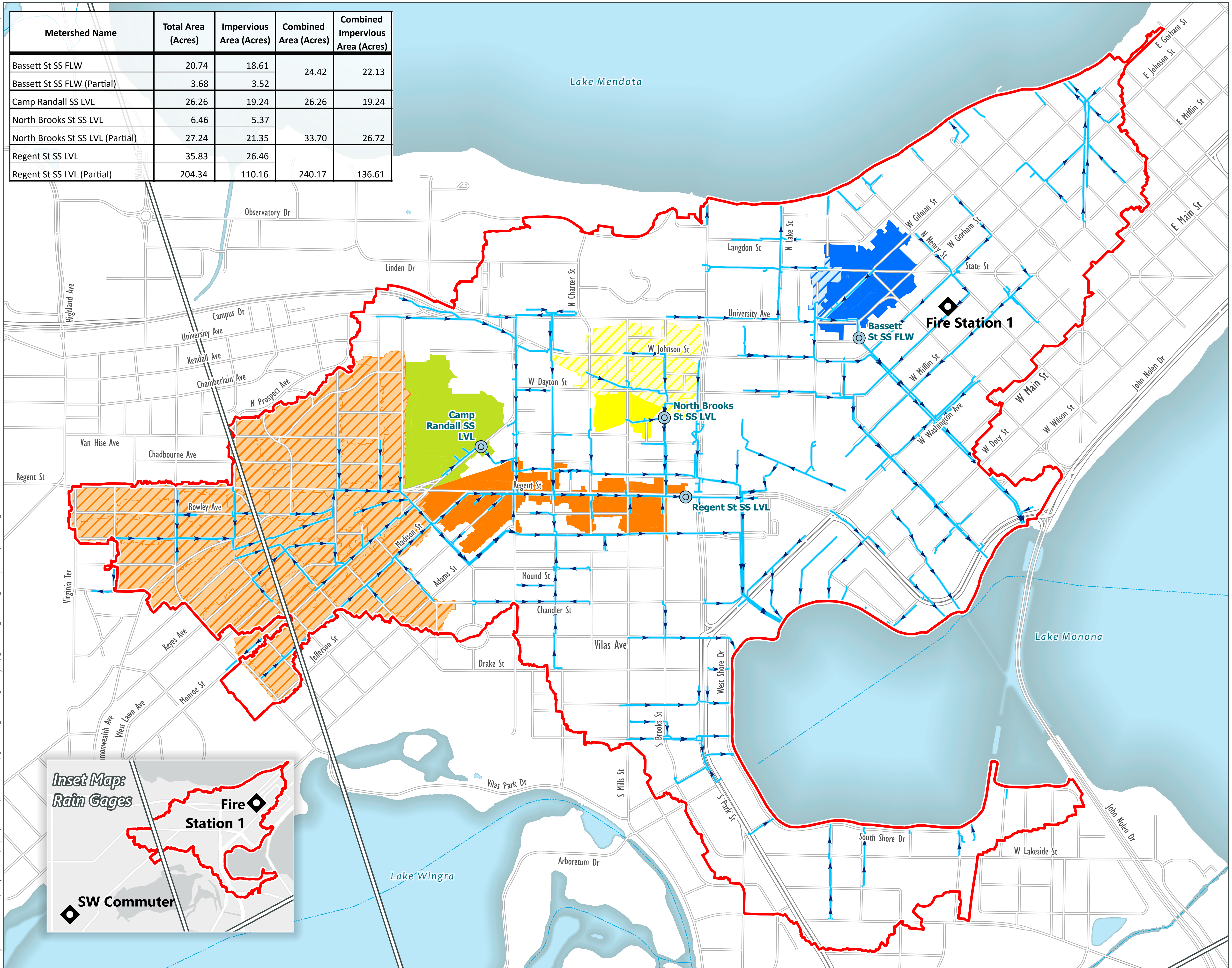


Study Area Metersheds

Near West Watershed

City of Madison
Dane County, WI

Metershed Name	Total Area (Acres)	Impervious Area (Acres)	Combined Area (Acres)	Combined Impervious Area (Acres)
Bassett St SS FLW	20.74	18.61	24.42	22.13
Bassett St SS FLW (Partial)	3.68	3.52		
Camp Randall SS LVL	26.26	19.24	26.26	19.24
North Brooks St SS LVL	6.46	5.37	33.70	26.72
North Brooks St SS LVL (Partial)	27.24	21.35		
Regent St SS LVL	35.83	26.46	240.17	136.61
Regent St SS LVL (Partial)	204.34	110.16		



Water Level Meter
Rain Gage
Modeled Storm System
Near West Study Boundary
Thiessen Polygons for Rain Gages

Metershed
- Bassett St FM
- Bassett St FM (Partial)
- Camp Randall LL
- North Brooks LL
- North Brooks LL (Partial)
- Regent St LL
- Regent St LL (Partial)

Data Sources:
Data Sources:
Aerial: Dane County (2022)
Watershed Boundaries: City of Madison
Stormwater System: City of Madison
Reported Flooding: City's Online Public Reporting (through July 2020)
Historic Flooding ,Observations and Priority Inlets: City of Madison
Observations by City Staff: Based on discussions of known flooding concerns with City Engineering Staff and prior Watershed Studies

MSA

0 520 1,040 Feet

Print Date: 6/10/2024

Appendix D: Select Locations: Flooding Depth & Duration

Flood report locations were selected by MSA at keep locations where preliminary modeling showed structure damage or street flooding. Twenty-five (25) locations were identified, and flooding depths and durations were summarized for the 2-, 5-, 10 -, 25-, 100-, 200-, and 500-yr events.

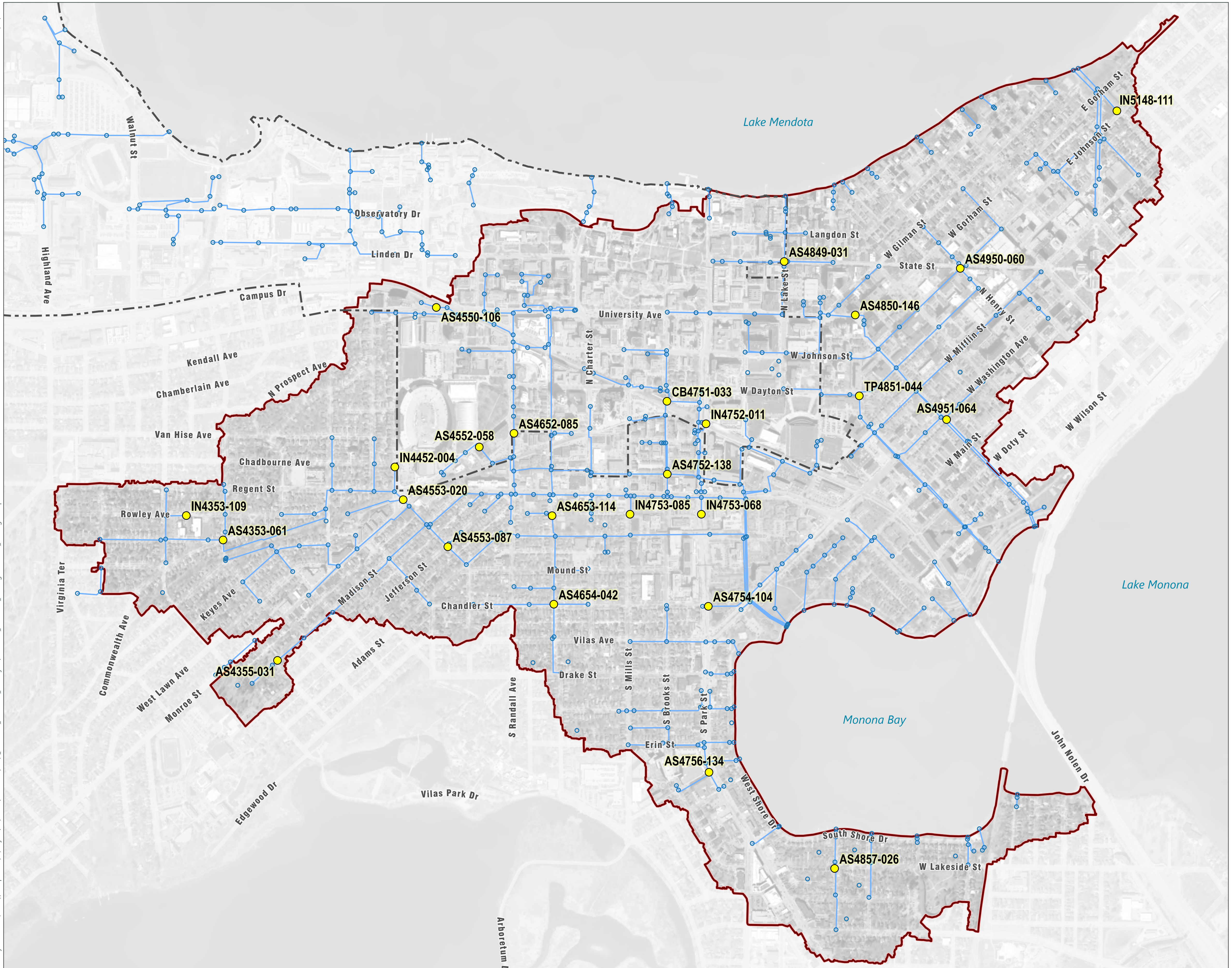
The 1D results at the summarized locations for are based on the Max Water Level and the ground surface elevation.

Node	Location Description	Ground Elevation	50% AEP (2-yr) Depth (ft)	20% AEP (5-yr) Depth (ft)	10% AEP (10-yr) Depth (ft)	4% AEP (25-yr) Depth (ft)	1% AEP (100-yr) Depth (ft)	0.5% AEP (200-yr) Depth (ft)	0.2% AEP (500-yr) Depth (ft)
AS4353-061	Commonweath Ave and Hollister Ave	898.54	0.47	0.68	0.80	0.92	1.11	1.19	1.32
AS4355-031	Madison St and Lincoln St	908.79	0.42	0.62	0.83	1.09	1.52	1.69	1.88
AS4550-106	University Ave and Campus Dr	876.28	0.14	0.31	0.45	0.58	0.76	0.83	0.91
AS4552-058	Monroe St (near ROTC building)	861.35	-2.61	0.57	0.93	1.29	1.62	1.76	1.92
AS4553-020	Monroe St and S Breese Ter	871.55	0.62	0.68	0.76	0.59	0.93	0.88	0.97
AS4553-087	Oakland Ave and Jefferson St	855.65	0.28	0.61	0.80	1.05	1.32	1.44	1.66
AS4652-085	N Randall Ave and Spring St	859.88	-2.78	-1.77	-1.31	-0.63	1.72	2.03	2.37
AS4653-114	S Orchard St and Bowen Ct	852.07	0.25	0.93	1.25	1.53	2.03	2.26	2.53
AS4654-042	S Orchard St and Chandler St	856.34	-1.93	0.20	0.30	0.50	0.84	1.00	1.22
AS4752-138	N Brooks St and College Ct	851.31	0.05	0.61	0.55	0.92	1.69	2.05	2.61
AS4754-104	S Park St and Chandler St	850.85	-2.59	-1.08	0.56	0.91	1.51	1.71	1.94
AS4756-134	S Park St and Delaplaine Ct	850.39	-4.17	-4.00	-3.77	-3.39	-2.62	-2.02	-1.15
AS4849-031	State St and N Lake St	860.74	-3.67	-3.28	-2.97	-2.32	0.39	0.77	0.85
AS4850-146	University Ave (near the James building)	856.57	-0.67	-0.04	0.00	0.00	0.13	0.21	0.31
AS4857-026	Lowell St and W Lakeside St	851.30	0.32	0.37	0.39	0.43	0.57	0.64	0.75
AS4950-060	W Johnson St and N Henry St	872.05	-6.59	-6.48	-6.37	-6.21	-5.80	-4.61	-3.37
AS4951-064	S Bassett St and W Washington Ave	854.48	-2.75	-1.53	-0.89	-0.17	0.52	0.74	0.92
CB4751-033	Near W Dayton St, north of Railroad (behind Dayton House)	856.66	-1.54	-0.85	-0.50	-0.18	1.20	2.19	3.02
IN4353-109	Rowley Ave, east of S Allen St	904.38	1.05	1.41	1.70	2.04	2.41	2.56	2.85
IN4452-004	N Breese Ter and Chadbourne Ave	876.48	0.88	0.96	1.01	1.10	1.24	1.31	1.40
IN4752-011	N Park Street, near Railroad underpass	847.68	1.55	2.98	4.01	4.39	5.32	5.68	6.25
IN4753-068	N Park St, south of Regent St	850.20	0.42	0.49	0.55	1.81	2.79	3.16	3.71
IN4753-085	S Mills St and Bowen Ct	850.63	1.40	1.57	1.77	2.05	2.51	2.77	3.31
IN5148-111	N Hancock St and E Johnson St	855.52	0.73	0.84	0.95	1.07	1.25	1.32	1.45
TP4851-044	N Bedford St and W Dayton St	852.97	-2.64	-2.17	-1.69	0.35	1.26	1.83	2.35

Select Locations Flooding Depth

Appendix D
Near West Watershed
Study Report

City of Madison
Dane County, WI



Watershed Study Area
UW Madison Campus
Select Model Node Location (25)
Modeled Link
Modeled Node

Data Sources:
Aerial: City of Madison (2022)
Watershed Boundaries: MSA
Modeled Links and Nodes: MSA

MSA

0 0.1 0.2 Miles

Print Date: 8/26/2024

Appendix E: Summary of Public Comments

PIM	Date	Postcards Sent	Registered	Attendees
1	10/24/2022	20,467	?	~20
2	10/25/2023	21,758	42	~15
3	3/18/2025	24,723	96	38

PIM 1

The Near West Watershed study held the first Public Information Meeting (PIM) on 10/24/2022 online over Zoom to review the existing conditions model and gather feedback from residents.

Immediately after the presentation, attendees could ask questions; a summary of this discussion with residents is recorded below.

Question #1: Do you have to complete the watershed study for the full city before developing solutions?

> **Response:** No- each watershed study area has its own schedule and progression. We will come back in several months and present existing conditions flooding maps... then after that meeting will start to develop solutions for this watershed.

Question #2: How will the lakes levels be handled in the models since they are the receiving waters?

> **Response:** Lakes levels are boundary conditions in the models. Lake levels generally 1' above the summer max. they want some resistance in the system but not too unrealistic.

Question #3: How are the results/data from the Westmorland Green Infrastructure (GI) study incorporated int o this model?

> **Response:** Did a separate GI analysis to determine what levels are needed to meet targets. Will take results from pilot study to hopefully validate modeling.

Question #4: In the section about least likely event, it seems that streets will be flooded with no way to get through. Is that correct?

> **Response:** We must set some sort of target to aim for since we have limitations in pipe sizing and alignments. Determined that 6" of water in centerline of road is the clearance needed for the lowest clearance emergency vehicles.

Question #5: Could a Suck the Muck project be done on Monona Bay, would it help?

Response: Targeted on water quality and P with Dane County to remove historical sediment. There aren't current plans and it's unlikely that it would provide any help.

Question #6: Explain how study boundaries were determined and how they differ between Central Isthmus Study.

Response: All boundaries are largely based on topography. Some smaller areas were added to adjacent study boundaries.

PIM 2

The Near West Watershed study held the second PIM on 10/25/2023 online over Zoom to review the existing conditions model and gather feedback from residents.

Immediately after the presentation, attendees could ask questions; a summary of this discussion with residents is recorded below. Generally, there was concurrence on areas that flooded, and there was relatively little feedback from residents. Breakout rooms were very sparsely attended with 1-3 people per room.

Question #1: They lived on Monona Bay and monitor the USGS Lake Level Data. Over the last several years, they noticed that the maximum annual lake levels have been going down. Is this because of the Yahara River dredging?

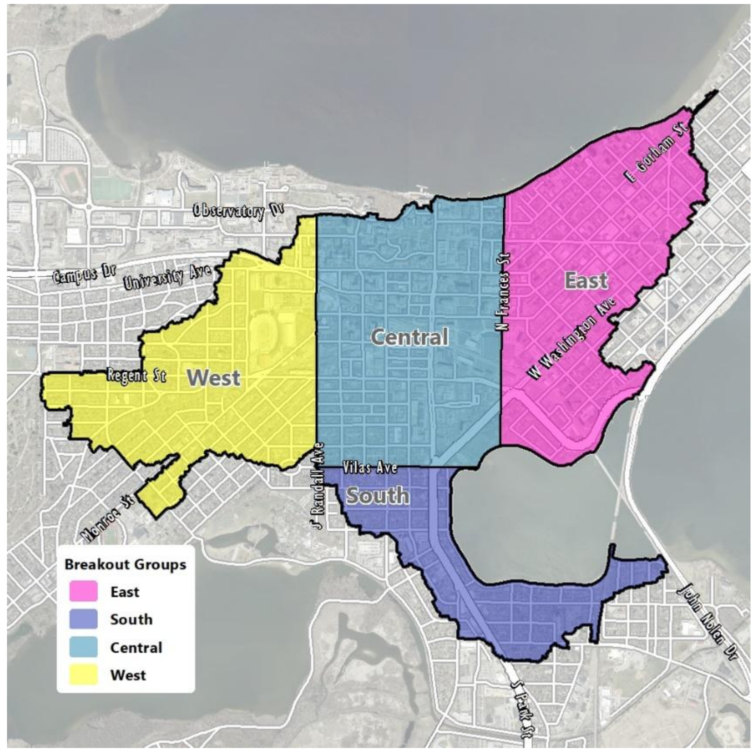
> **Response**: Dams control the water levels in Lake Mendota and Lake Kegonsa. Monona and Waubesa are online with the river, so the dredging of the Yahara does affect their ability to pass water, with the limitations put into place by the dams located on either side of the lakes. He also commented that the weather has been more drought-like conditions, and this will also impact lake levels.

Question #2, Alder Vidaver: The Alder was surprised by the level of impervious area density within the watershed.

> **Response**: He stated that the area is a ‘heavily urbanized downtown area’ that is approximately twice the density of the average residential neighborhood. Greg Fries, from the City of Madison, concurred with that general statement. He also provided some more geographic landmarks for where this level of impervious density is common.

Question #3: They wanted to know if there were efforts underway to create more green infrastructure. Are there any efforts regarding the creation of more pervious surface infrastructure, permeable pavement, rain gardens, rooftop gardens etc.Is there consideration to the runoff that might impact the lakes, tire wear, turbidity, etc.?

> **Response**: The City has several programs on-going that address green infrastructure. The evaluation of green infrastructure was not part of the Near West Watershed Study. However, it was evaluated as part of other/prior studies. There is a peer-reviewed white paper documenting the findings of these efforts. In short, the studies show there is very little benefit to flood reduction. This is simply because the traditional green infrastructure is addressing small storms, and its capacity is too small to make a difference in flood control. There are benefits to water quality – but that is not the focus of this study.
>
> Many cities are pursuing GI because they have combined sewers and so they need to reduce combined sewer overflows. The City does a lot of modeling of water quality with the Rock River TMDL and MS4 compliance.



Participants were asked to join smaller “breakout rooms” to review the inundation maps more carefully and to allow for additional questions in a smaller setting. The breakout groups were organized by region of the study area: West, Central, East and South.

In the breakout rooms, some participants voiced their desire for more Green Infrastructure. MSA staff reiterated the City’s response, that green infrastructure has benefits for water quality, but the capacity was too small to assist with flood control.

Alder Vidaver asked about infrastructure planning, and MSA staff discussed how many infrastructure projects are influenced by non-stormwater issues. This both presents opportunities as well as challenges. One example given was the box culvert under Regent Street. The box culvert is potentially poor structural condition currently, and the new rapid bus transit project will result heavier vehicles will be traveling on the road, over the weakened culvert. Therefore, the culvert may need to be replaced regardless of capacity issues. MSA also noted that there are capacity issues along Regent Street, but those issues are also controlled by pipes further downstream.

Some residents were surprised by the amount of inundation along Regent Street but said they have not been present on the street during a large storm event.

Residents asked to zoom into the inundation maps, but no additional feedback was provided.

PIM 3

The Near West Watershed study held the third PIM on 03/18/2025 online over Zoom to review the recommended solutions and gather feedback from residents. It was a joint meeting, discussing recommended solutions for the Near West and John Nolen watersheds (which are adjacent to one another).

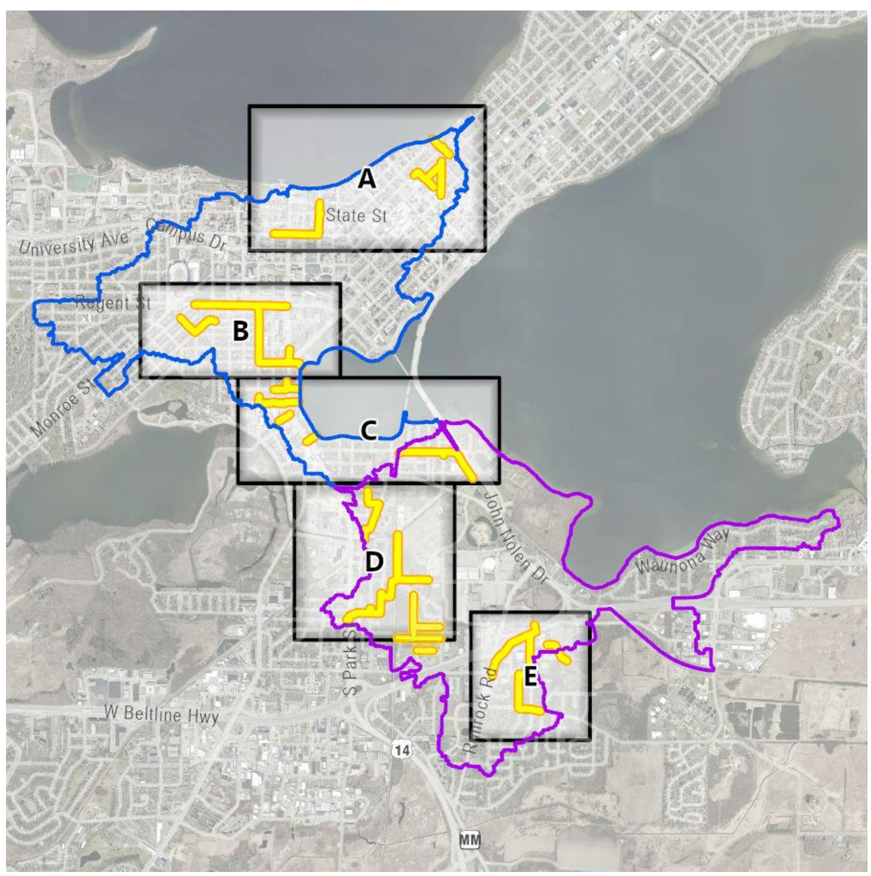
During the presentation, attendees could type questions into the comment section; a summary of this question from residents is recorded below.

Question #1: It seems that trees and impermeable surfaces are missing from opportunities to absorb rain events?

> **Response**: Land cover is included in the models including the ability of pervious areas to absorb rainfall/runoff. Trees are not explicitly modeled, but the models are calibrated with monitoring data to try and establish baseline conditions. Lots of research is coming out on the effectiveness of trees at intercepting rainfall and reducing runoff. However, for very large storm events (like the 1% storm) we would not expect as much impact from tree interception, and we are generally trying to be quite conservative in sizing our infrastructure.

Question #2: It seems like several dozen properties in each watershed will still be at risk after these projects are complete - are there any plans to prioritize other mitigation measures like green infrastructure for those areas?

> **Response**: The City's goal is to meet all the targets but it cannot be achieved everywhere due to topography, extraordinary costs, or maybe some other limitations. Described that our desktop analysis is conservative and that the conclusions of the study won't be the end of the opportunities to relieve and address flooding.



Participants were asked to join smaller "breakout rooms" to review the inundation maps more carefully and to allow for additional questions in a smaller setting. The breakout groups were organized by region of the study area, and areas A through C covered the Near West Study Area. Only those comments from pertinent to Near West are included here.

<u>**Area A** (including James Madison Park)</u>

Question #3: Is the City considering distributed green infrastructure and increased tree canopy?

> **Response**: Land cover is included in the models including the ability of pervious areas to absorb rainfall/runoff. Trees are not explicitly modeled, but the models are calibrated with monitoring data to try and establish baseline conditions. Lots

of research is coming out on the effectiveness of trees at intercepting rainfall and reducing runoff. However, for very large storm events (like the 1% storm) we would not expect as much impact from tree interception, and we are generally trying to be quite conservative in sizing our infrastructure.

Area B (including Regent St and S Mills St)

Question #4: What happens if, while Regent St is reconstructed, there is a big rainfall event. Is Regent St overwhelmed and out of luck?

Response: The Regent St project has limited space -- so the new box culvert will be in the same space as the old box culvert. During construction, they would remove 50-100' of the old box culvert and then install the new culvert in its place. This means during a rain event, only a portion of the culvert would not be in place, but the reset of the stormwater system would be functioning as it currently is.

There were other questions about the Regent St construction project, mainly pertaining to timing and construction workflows but not specific to the recommended stormwater improvement.

Area C (including S Park St and Lakeside St)

Question #5: Some properties and streets are still not meeting their targets.

Response: The City's goal is to meet all the targets but it cannot be achieved everywhere due to topography, extraordinary costs, or maybe some other limitations. Described that our desktop analysis is conservative and that the conclusions of the study won't be the end of the opportunities to relieve and address flooding.

Question #6: What is the City doing with Green Infrastructure?

Response: The City does complete Green Infrastructure (GI) projects, but not with this study. The City has also reviewed whether green infrastructure can solve our flooding problems; there was a lot of analysis completed in earlier watershed studies and found that it doesn't solve all the issues on its own. GI typically just absorbs early runoff and is then full when the peak of the storm occurs. Many cities are pursuing GI because they have combined sewers and so they need to reduce combined sewer overflows. The City does a lot of modeling of water quality with the Rock River TMDL and MS4 compliance

Question #7: What are the potential impacts to commutes and business with all these construction projects?

Response: Not all the projects will take place at the same time. Major street reconstruction (Regent St or Park St) would be very disruptive but would not occur at the same time. Also, only Regent St is programmed now, and it could be many years before any of the other projects are implemented or streets are reconstructed.

There was a general discussion about the watershed study program and the August 2018 flood event.

Other Resident Contacts Outside PIM On Project

City staff made field visits to properties and businesses on Regent Street to confirm that flooding aligns with predictions of the existing conditions model. One business owner at the corner of Mills and Regent Street pointed out the approximate high-water level of a storm in late July 2023. The predicted flood inundation did match well to the calibrated model results for that storm event.

Appendix F: Internal City Meetings and Discussions Regarding Solutions in the Near West Watershed Recommendations

Bimonthly Coordination Meeting with Parks Department – 1/8/25

Attendees
Lisa Laschinger, Parks
Greg Fries, Engineering
Jojo O'Brien, Engineering
Corey Steljes, Parks
Phil Gabler, Parks
Adam Kaniewski, Parks
Hannah Penn, Parks
Ryan Stenjem, Engineering
Janet Schmit, Engineering
Sarah Lerner, Engineering
Michael Sturm, Parks

Engineering gave a presentation on the findings of the Near West Watershed Study and the recommended projects that could impacts parks. The presentation included an overview of the watershed study, areas of flooding concerns, and a description of the major project elements that could impact Park lands in the future. The projects described included the Hamilton St outfall that goes through James Madison Park, the Mills St relief sewer and Vilas Ave outfall that would touch Brittingham Park, as well as the smaller outfalls that cross Park St and outlet to Monona Bay since the shoreline of Monona Bay is maintained by Parks.

A brief summary of the discussion is provided below:

> There were no major concerns regarding the projects since all recommended projects align with existing storm sewer pipes. The only request was to coordinate closely with Parks if/when any projects were to be constructed in James Madison Park. There is a recent master plan update for the park that included stormwater features, shoreline improvements, and a boardwalk in the area of the proposed pipe improvements. Any projects initiated by engineering would need to conform to the master plan.

Public Works Improvements Meeting – 2/6/25

Partial list of attendees
Mayor Satya Rhodes Conway
Chistine Baumel, Mayor's Office
Ian Brown, Streets (Forestry)
Jim Wolfe, Engineering
Ryan Stenjem, Engineering
Janet Schmidt, Engineering
Fadi El Musa Gonzalez, Engineering
Tom Lynch, Transportation
Matt Mikolajewski, Economic Development
Megan Blake-Horst, Economic Development
Doran Viste, City Attorneys' Office
Rebecca Cnare, Planning

Engineering presented the findings of, and project recommendations from the Near West and John Nolen Drive Watershed Studies to the Public Works Improvement team. A monthly meeting to discuss major ongoing and upcoming public works projects within the City. Several representatives from most of the public works agencies were present at the meeting including the Mayor's office. A brief overview of the watershed study program, flood mitigation target, and each watershed study project was given. The flood inundation maps were presented and the major stand-alone projects from each watershed were described and cost estimates were provided.

A summary of the discussion is provided below:

- Transportation asked if it was possible to do a risk analysis with the data developed from the study. I.e. likelihood of damages and estimated dollars of damage done. It was described that we likely had the data necessary to complete the risk analysis for existing and proposed conditions, but that it was outside of the current scope of the study.
- Streets/Forestry asked about if the studies took into account modeling of GI and for example modeling of tree well or tree pits. The difficulties is modeling small scale GI in the watershed studies was described and the findings of previous modeling of widescale, intensive green infrastructure studies completed within engineering. In general, GI does not show much impact at levels we'd likely be able to implement.
- There was a general sentiment that engineering should continue to push for and evaluate GI's ability to control flooding.
- There were no substantial comments on the recommended projects in terms of scope, or other considerations.

Board of Parks Commissioners – 3/12/25

An informational presentation on the Near West and John Nolen Drive Watershed recommended projects was given to the board of Parks Commissioners at the regularly scheduled meeting. All projects that touched any park area were described and relative benefits in terms of reduced flooding to the project service areas presented. The Near West projects included were the Hamilton St Outfall through James Madison Park, the Mills Relief Sewer Outfall through Brittingham Park, and several small sewer upgrades crossing Park St that outlet to Monona Bay. In the John Nolen Drive Watershed the Bram St and Bram's Addition outfalls were presented, which cross Quann Park. There were no comments or questions from the commissioners or staff present.

Appendix G: Site Visits by City Staff

Site Visits by City Staff

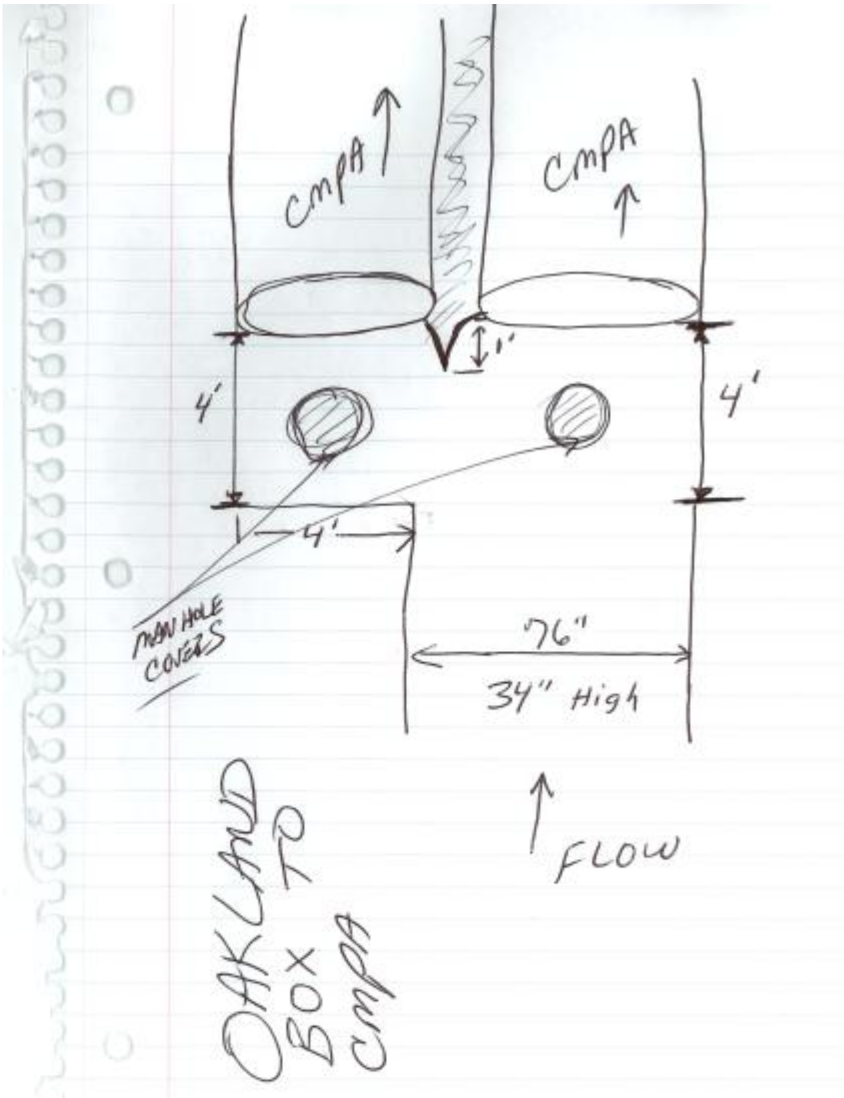
Oakland Ave and Madison St Diversion

Greg Fries (City of Madison) completed a field visit in July of 2023 to understand the stormwater flow diversion structure at Oakland Ave and Madison St as part of the Near West Watershed Study. The text below is based on email communication on 7/12/23.

Greg was able to enter structure AS4553-031 and took the following photos and sketched the shape of the transition from a box to twin CMPAs. This is the yellow circle to the SW in the map below.

He attempted to access structureAS4553-029 to confirm the size of the diversion pipe heading along Madison St, but there is only a 18” diameter access under the manhole cover, and therefore he was not able to inspect the size or condition of the connecting pipes. This is the yellow circle to the NE in the map below.

Photos of the transition from the box structure to twin CMPAs in structure AS4553-031.



Sketch of the transition from the box culvert to the twin CMPAs.

Regent St Box Culvert

The City wanted to understand the condition of the box culvert under Regent St and completed televising in late 2022. The City received the televising footage in late December and noted that the records on file did not match the televising record.

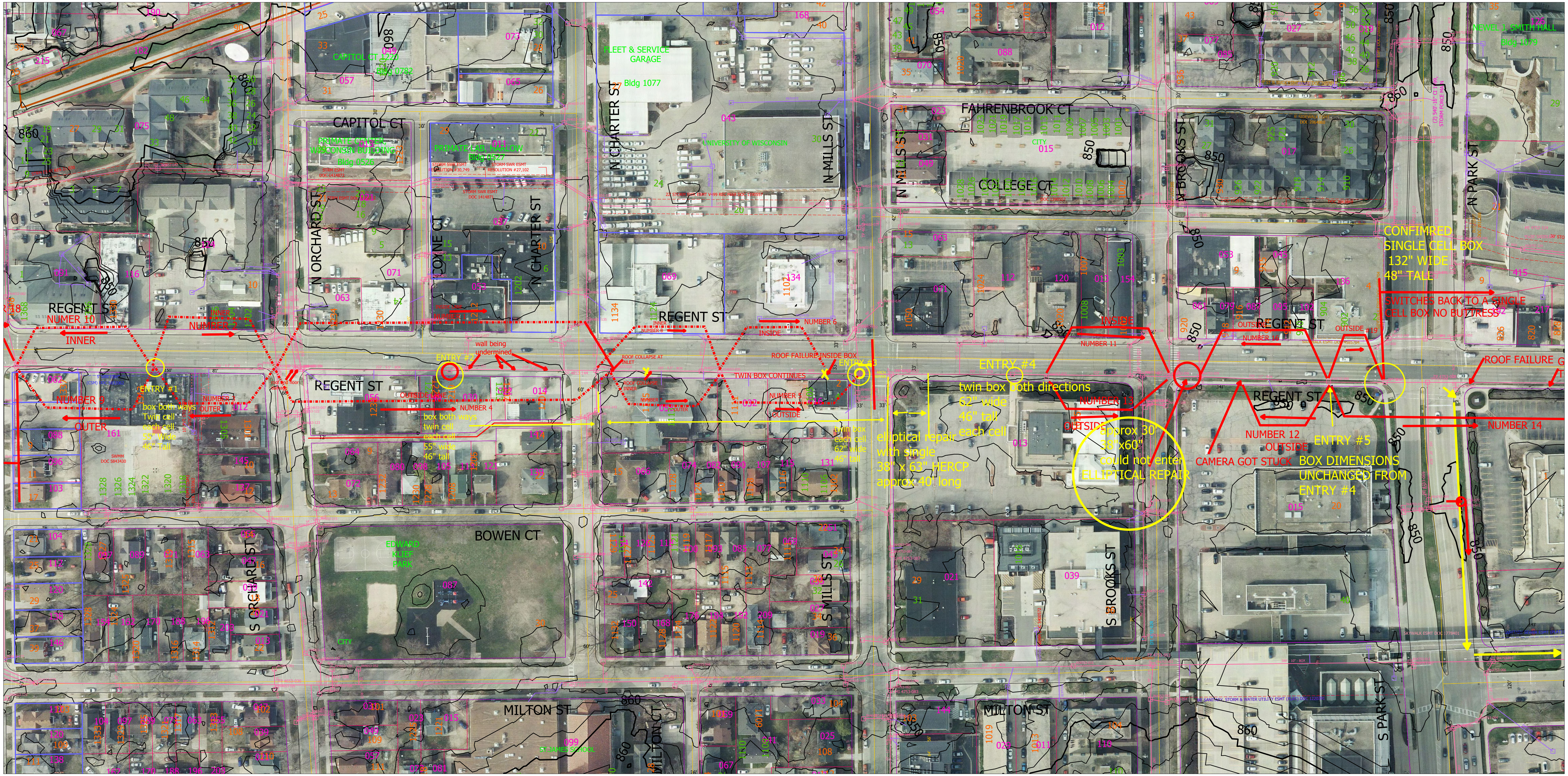
The televising crew took preliminary measurements, and noted there was two cells (rather than the assumed one), and there was lots of debris on the floor. The City guesses that perhaps in the 1970s, staff built a column out of cinderblock to split the span of the box. The wall was not continuous, with regular breaks to allow water to pass from one cell to the other. The wall has an upsize down T-support that is ~3' wide at the bottom to support the ~1' thick wall. The base of the T is ~1' tall.

The televising also revealed that portions of the box culvert were replaced entirely with elliptical pipes. The televising video was not comprehensive, and City staff completed a site visit to take more detailed measurements on 1/27/24. The photo below is of the exiting box, and the cinderblock wall creating two cells taken during the site visit, the second is a screen capture of the televising footage showing one the elliptical pipes, and the third is also from the televising footage showing the gaps in the cinderblock wall.

City staff also made a map showing the best estimate of pipe sizing and arrangement. This graphic was used by MSA to update the existing conditions model to more appropriately capture the storm sewer network along Regent St.


Distance:207.4 ft.
MGO - General Observation
Clock from:
Clock to:
Rating:
Dimension 1:
Dimension 2:
%:
AS 4653-11
A


Upstream MH No: ACB AS4753-040
A
Downstream MH No: ACB AS4753-037 110.9



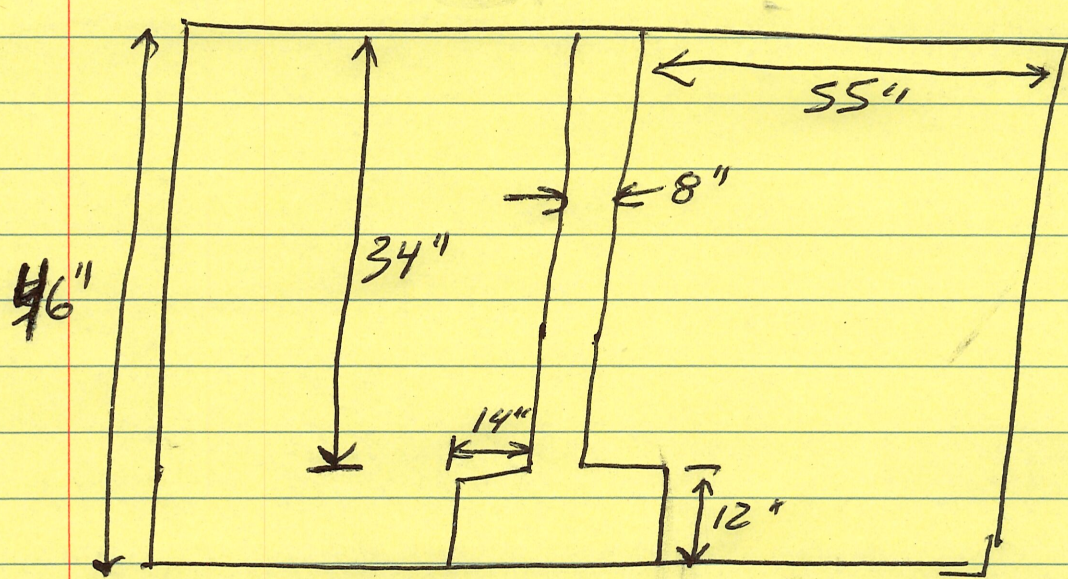
Time: 1/27/2023 12:36:14 PM
Session: C:\GTViewer_Sessions\GTViewer.gts

City of Madison, WI - GIS/Mapping data

Printed By: engtf
Disclaimer: The City makes no representation about the accuracy of these records and shall not be liable for any damages

BOX DOWN MIDDLE CONFIRMED

#1

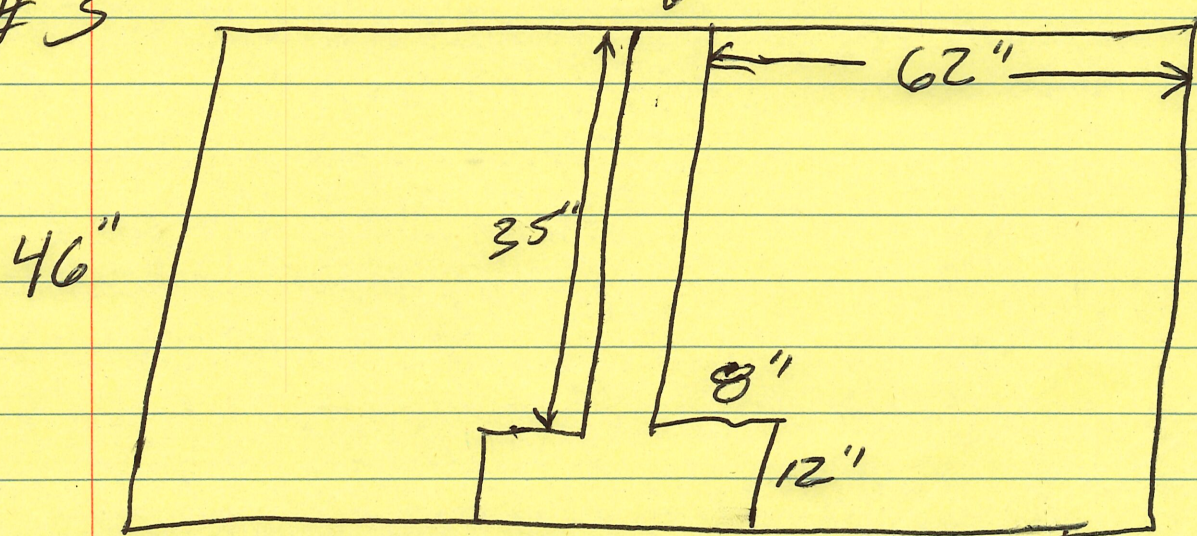


#2

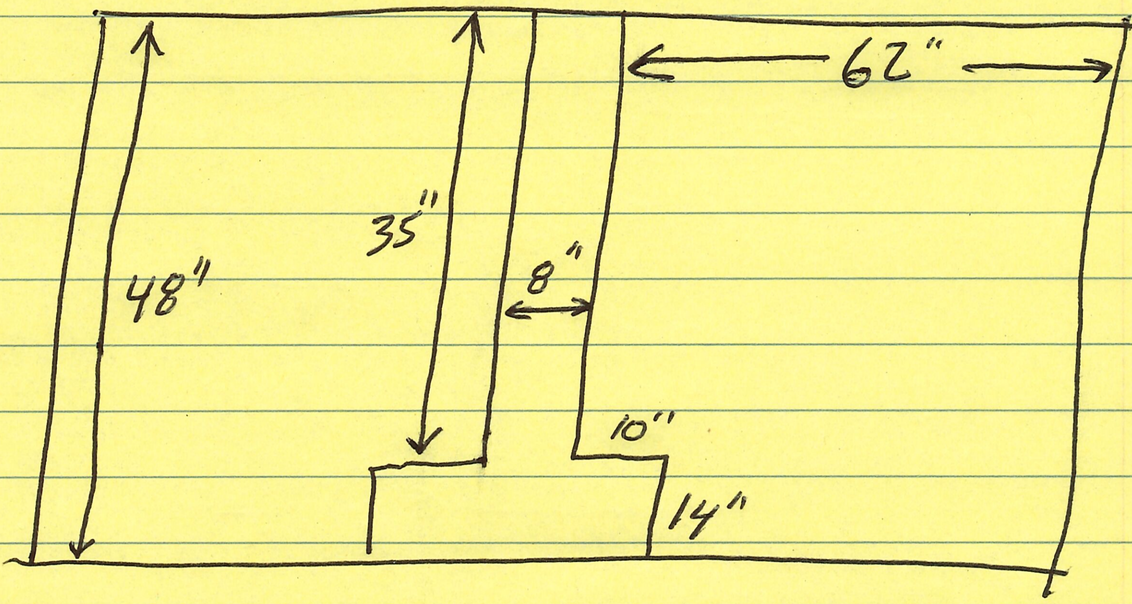
SAME AS #1

BOX SPLIT IN MIDDLE

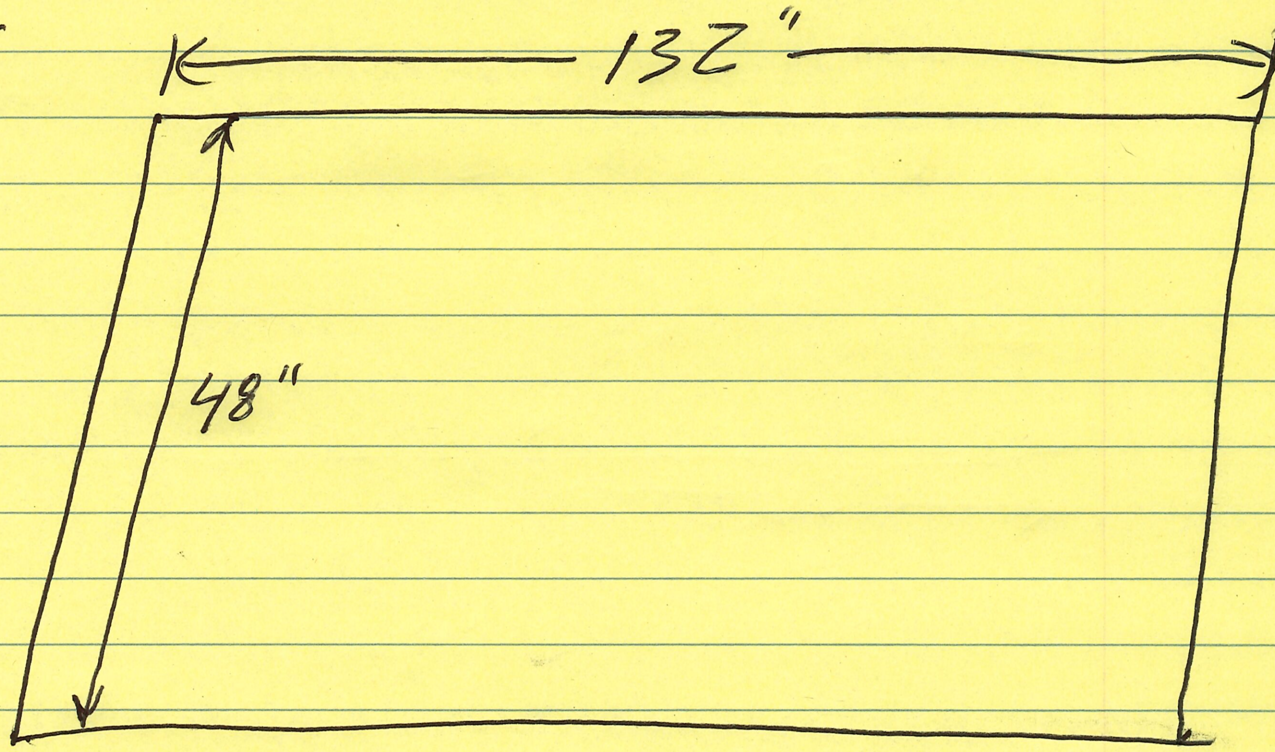
#3



4



5



Appendix H: Cost Estimates

Near West Solution A

N Hancock St to Outfall Storm System Improvements

Conceptual Cost Estimate*

1/23/2025

Standard/ Special	Item #	Item	Quantity	Unit	"Average" Unit Cost provided by City	Adjusted Unit Cost (if used)	Total Item Cost
Special	NW5	5'x7' BOX CULVERT	366	L.F.	$ 1,500.00	N/A	$ 549,000
Special	NW6	5'x7' RCB CULVERT WINGWALL & RAILING	1	EACH	$ 35,000.00	N/A	$ 35,000
Standard	50409	36 INCH TYPE I RCP STORM SEWER PIPE	52	L.F.	$ 200.00	N/A	$ 10,400
Standard	50411	48 INCH TYPE I RCP STORM SEWER PIPE	60	L.F.	$ 250.00	N/A	$ 15,000
Standard	50409	36 INCH TYPE I RCP STORM SEWER PIPE	283	L.F.	$ 200.00	N/A	$ 56,600
Standard	20501	ADJUST SEWER ACCESS STRUCTURE	7	EACH	$ 750.00	N/A	$ 5,250
Standard	50741	TYPE "H" INLET	4	EACH	$ 3,600.00	N/A	$ 14,400
Standard	20314	REMOVE PIPE	762	L.F.	$ 38.00	N/A	$ 28,956
Standard	20701	TERRACE SEEDING	5,490	S.Y.	$ 3.00	N/A	$ 16,470
Standard	10701	TRAFFIC CONTROL	1	LUMP SUM	$ 7,000.00	N/A	$ 7,000
Standard	10911	MOBILIZATION	1	LUMP SUM	$ 80,000.00	N/A	$ 80,000
Special	LOCAL	LOCAL STREET	300	L.F.	$ 500.00	N/A	$ 150,000
Special	ARTERIAL	PRINCIPAL ARTERIAL STREET	30	L.F.	$ 3,000.00	N/A	$ 90,000
					Subtotal		**$ 1,058,076**
					Contingency	**25%**	**$ 264,519**
					Design	**10%**	**$ 105,808**
					Total		**$ 1,428,403**
					Land Acquisition	**0**	**$ -**
					Wetland Mitigation	**0.000**	**$ -**
					Total Total		**$ 1,428,403**

**Costs include street reconstruction as well as storm system improvements.*

Near West Solution B

N Hamilton St/E Johnson St/E Gorham St Storm System Improvements

Conceptual Cost Estimate

1/23/2025

Standard/ Special	Item #	Item	Quantity	Unit	"Average" Unit Cost provided by City	Adjusted Unit Cost (if used)	Total Item Cost
Standard	50412	54 INCH TYPE I RCP STORM SEWER PIPE	85	L.F.	$ 280.00	N/A	$ 23,800
Standard	50407	30 INCH TYPE I RCP STORM SEWER PIPE	1,427	L.F.	$ 150.00	N/A	$ 214,050
Standard	50405	24 INCH TYPE I RCP STORM SEWER PIPE	907	L.F.	$ 130.00	N/A	$ 117,910
Standard	20501	ADJUST SEWER ACCESS STRUCTURE	11	EACH	$ 750.00	N/A	$ 8,250
Standard	50741	TYPE "H" INLET	26	EACH	$ 3,600.00	N/A	$ 93,600
Standard	20314	REMOVE PIPE	2,419	L.F.	$ 38.00	N/A	$ 91,922
					Subtotal		**$ 549,532**
					Contingency	**25%**	**$ 137,383**
					Design	**10%**	**$ 54,953**
					Total		**$ 741,868**
					Land Acquisition	**0**	**$ -**
					Wetland Mitigation	**0.000**	**$ -**
					Total Total		**$ 741,868**

Near West Solution C

University Ave/Lake St Storm System Improvements

Conceptual Cost Estimate

1/23/2025

Standard/ Special	Item #	Item	Quantity	Unit	"Average" Unit Cost provided by City	Adjusted Unit Cost (if used)	Total Item Cost
Special	SM3/WW8	4'x8' BOX CULVERT	330	L.F.	$ 1,200.00	N/A	$ 396,000
Standard	50407	30 INCH TYPE I RCP STORM SEWER PIPE	41	L.F.	$ 150.00	N/A	$ 6,150
Special	WW7	4'x6' BOX CULVERT	368	L.F.	$ 800.00	N/A	$ 294,400
Standard	50410	42 INCH TYPE I RCP STORM SEWER PIPE	1,062	L.F.	$ 235.00	N/A	$ 249,570
Standard	50405	24 INCH TYPE I RCP STORM SEWER PIPE	485	L.F.	$ 130.00	N/A	$ 63,050
Standard	20501	ADJUST SEWER ACCESS STRUCTURE	9	EACH	$ 750.00	N/A	$ 6,750
Standard	50741	TYPE "H" INLET	15	EACH	$ 3,600.00	N/A	$ 54,000
Standard	20314	REMOVE PIPE	2,286	L.F.	$ 38.00	N/A	$ 86,868
					Subtotal		**$ 1,156,788**
					Contingency	**25%**	**$ 289,197**
					Design	**10%**	**$ 115,679**
					Total		**$ 1,561,664**
					Land Acquisition	**0**	**$ -**
					Wetland Mitigation	**0.000**	**$ -**
					Total Total		**$ 1,561,664**

Near West Solution D

Regent St Storm System Improvements

Conceptual Cost Estimate

1/23/2025

Standard/ Special	Item #	Item	Quantity	Unit	"Average" Unit Cost provided by City	Adjusted Unit Cost (if used)	Total Item Cost
Special	SH13	10' x 4' RCB CULVERT, EXCAVATION, BACKFILL & JOINT SEALING	2,688	LF	$ 1,600.00	N/A	$ 4,300,800
Standard	20501	ADJUST SEWER ACCESS STRUCTURE	12	EACH	$ 750.00	N/A	$ 9,000
Standard	50741	TYPE "H" INLET	18	EACH	$ 3,600.00	N/A	$ 64,800
Standard	20314	REMOVE PIPE	2,688	L.F.	$ 38.00	N/A	$ 102,144
					Subtotal		**$ 4,476,744**
					Contingency	**25%**	**$ 1,119,186**
					Design	**10%**	**$ 447,674**
					Total		**$ 6,043,604**
					Land Acquisition	**0**	**$ -**
					Wetland Mitigation	**0.000**	**$ -**
					Total Total		**$ 6,043,604**

Near West Solution E

S Mills St Bypass and Vilas Ave/ S Park St Storm System Improvements

Conceptual Cost Estimate

1/23/2025

Standard/ Special	Item #	Item	Quantity	Unit	"Average" Unit Cost provided by City	Adjusted Unit Cost (if used)	Total Item Cost
Special	TUNNEL1	TUNNEL MOBILIZATION	1	LUMP SUM	$ 410,000.00	N/A	$ 410,000
Special	TUNNEL2	RECEIVING SHAFT: TEMPORARY FENCE	1	UNIT	$ 38,000.00	N/A	$ 38,000
Special	TUNNEL3	RECEIVING SHAFT: CHAIN LINK VEHICULAR GATE	1	UNIT	$ 16,000.00	N/A	$ 16,000
Special	TUNNEL4	RECEIVING SHAFT: GRAVEL SITE WORK AREA	1	UNIT	$ 142,000.00	N/A	$ 142,000
Special	TUNNEL5	RECEIVING SHAFT: SHORING (assume 30-ft dia 10-ft deep)	10	LF (DEPTH)	$ 18,000.00	N/A	$ 180,000
Special	TUNNEL6	RECEIVING SHAFT: EXCAVATE SHAFT- Soil 30-ft dia 10-ft deep	10	LF (DEPTH)	$ 2,000.00	N/A	$ 20,000
Special	TUNNEL7	RECEIVING SHAFT: POUR MUDSLAB (assume 3 foot thick)	1	UNIT	$ 34,000.00	N/A	$ 34,000
Special	TUNNEL8	RECEIVING SHAFT: HAUL SPOILS (Shaft)	7,068	CF	$ 3.00	N/A	$ 21,204
Special	TUNNEL9	RECEIVING SHAFT: SHAFT STRUCTURE	10	LF (DEPTH)	$ 30,000.00	N/A	$ 300,000
Special	TUNNEL10	RECEIVING SHAFT: SHAFT EXCAVATION	1	UNIT	$ 672,000.00	N/A	$ 672,000
Special	TUNNEL11	LAUNCHING SHAFT: SHORING (assume 35-ft dia 10-ft deep)	10	LF (DEPTH)	$ 20,000.00	N/A	$ 200,000
Special	TUNNEL12	LAUNCHING SHAFT: EXCAVATE SHAFT- Soil 10 vf	10	LF (DEPTH)	$ 4,000.00	N/A	$ 40,000
Special	TUNNEL13	LAUNCHING SHAFT: POUR MUDSLAB (assume 3 foot thick)	1	UNIT	$ 38,000.00	N/A	$ 38,000
Special	TUNNEL14	LAUNCHING SHAFT: HAUL SPOILS (Shaft)	9,621	CF	$ 3.00	N/A	$ 28,863
Special	TUNNEL15	LAUNCHING SHAFT: MONITOR SETTLEMENT ARRAY	1	UNIT	$ 106,000.00	N/A	$ 106,000
Special	TUNNEL16	TUNNEL: TBM ASSEMBLY/LAUNCH	1	UNIT	$ 3,140,000.00	N/A	$ 3,140,000
Special	TUNNEL17	TUNNEL: TUNNEL 108 INCH	1,660	LF (LENGTH)	$ 4,000.00	N/A	$ 6,640,000
Special	TUNNEL18	TUNNEL: HAUL SPOILS	1,660	LF (LENGTH)	$ 1,000.00	N/A	$ 1,660,000
Special	TUNNEL19	TUNNEL: DISASSEMBLY/REMOVAL	1	UNIT	$ 1,450,000.00	N/A	$ 1,450,000
Special	NW3	5'x15' BOX CULVERT	1,320	L.F.	$ 2,300.00	N/A	$ 3,036,000
Special	NW4	5'x15' BOX CULVERT WING WALLS	1	EACH	$ 50,000.00	N/A	$ 50,000
Standard	50411	48 INCH TYPE I RCP STORM SEWER PIPE	406	L.F.	$ 250.00	N/A	$ 101,500
Standard	50741	TYPE "H" INLET	10	EACH	$ 3,600.00	N/A	$ 36,000
Standard	20314	REMOVE PIPE	1,726	L.F.	$ 38.00	N/A	$ 65,588

Near West Solution E

S Mills St Bypass and Vilas Ave/ S Park St Storm System Improvements

Conceptual Cost Estimate

1/23/2025

Standard/ Special	Item #	Item	Quantity	Unit	"Average" Unit Cost provided by City	Adjusted Unit Cost (if used)	Total Item Cost
Special	NW7	12" WATER MAIN	468	L.F.	$ 300.00	N/A	$ 140,520
Special	NW8	8" WATER MAIN	115	L.F.	$ 215.00	N/A	$ 24,704
Special	NW9	6" WATER MAIN	46	L.F.	$ 210.00	N/A	$ 9,723
Special	NW10	4" WATER MAIN	263	L.F.	$ 205.00	N/A	$ 53,997
Special	NW11	MMSD COORDINATION: DEWATERING AND SHORING	1	EACH	$ 150,000.00	N/A	$ 150,000
Special	COLLECTOR	COLLECTOR STREET	2,535	L.F.	$ 1,500.00	N/A	$ 3,802,500
Special	ARTERIAL	PRINCIPAL ARTERIAL STREET	400	L.F.	$ 3,000.00	N/A	$ 1,200,000
Standard	50301	8 INCH PVC SANITARY SEWER PIPE	514	L.F.	$ 170.00	N/A	$ 87,380
Standard	20311	REMOVE SEWER ACCESS STRUCTURE	4	EACH	$ 805.00	N/A	$ 3,220
Standard	20701	TERRACE SEEDING	3,300	S.Y.	$ 3.00	N/A	$ 9,900
					Subtotal		**$ 23,907,099**
					Contingency	**25%**	**$ 5,976,775**
					Design	**10%**	**$ 2,390,710**
					Total		**$ 32,274,584**
					Land Acquisition	**0**	**$ -**
					Wetland Mitigation	**0.000**	**$ -**
					Total Total		**$ 32,274,584**

**Costs include street reconstruction as well as storm system improvements.*
Does not include relocation of water conflicts or MMSD sanitary conflicts
Does not include new sanitary sewer access structures.

Near West Solution F

Vilas Ave/S Park St Storm System Improvements

Conceptual Cost Estimate

1/23/2025

Standard/ Special	Item #	Item	Quantity	Unit	"Average" Unit Cost provided by City	Adjusted Unit Cost (if used)	Total Item Cost
Standard	50413	60 INCH TYPE I RCP STORM SEWER PIPE	459	L.F.	$ 310.00	N/A	$ 142,290
Standard	50472	60 INCH RCP AE	1	EACH	$ 3,800.00	N/A	$ 3,800
Standard	50411	48 INCH TYPE I RCP STORM SEWER PIPE	406	L.F.	$ 250.00	N/A	$ 101,500
Standard	50410	42 INCH TYPE I RCP STORM SEWER PIPE	446	L.F.	$ 235.00	N/A	$ 104,810
Standard	50407	30 INCH TYPE I RCP STORM SEWER PIPE	415	L.F.	$ 150.00	N/A	$ 62,250
Standard	20501	ADJUST SEWER ACCESS STRUCTURE	7	EACH	$ 750.00	N/A	$ 5,250
Standard	50741	TYPE "H" INLET	10	EACH	$ 3,600.00	N/A	$ 36,000
Standard	20314	REMOVE PIPE	1,726	L.F.	$ 38.00	N/A	$ 65,588
Standard	20701	TERRACE SEEDING	3,300	S.Y.	$ 3.00	N/A	$ 9,900
					Subtotal		**$ 531,388**
					Contingency	**25%**	**$ 132,847**
					Design	**10%**	**$ 53,139**
					Total		**$ 717,374**
					Land Acquisition	**0**	**$ -**
					Wetland Mitigation	**0.000**	**$ -**
					Total Total		**$ 717,374**

Near West Solution G

Emeral St/S Park St Storm System Improvements

Conceptual Cost Estimate

1/23/2025

Standard/ Special	Item #	Item	Quantity	Unit	"Average" Unit Cost provided by City	Adjusted Unit Cost (if used)	Total Item Cost
Standard	50409	36 INCH TYPE I RCP STORM SEWER PIPE	380	L.F.	$ 200.00	N/A	$ 76,000
Standard	50468	36 INCH RCP AE	1	EACH	$ 2,100.00	N/A	$ 2,100
Standard	50407	30 INCH TYPE I RCP STORM SEWER PIPE	410	L.F.	$ 150.00	N/A	$ 61,500
Standard	50405	24 INCH TYPE I RCP STORM SEWER PIPE	189	L.F.	$ 130.00	N/A	$ 24,570
Standard	20501	ADJUST SEWER ACCESS STRUCTURE	14	EACH	$ 750.00	N/A	$ 10,500
Standard	50741	TYPE "H" INLET	10	EACH	$ 3,600.00	N/A	$ 36,000
Standard	20314	REMOVE PIPE	979	L.F.	$ 38.00	N/A	$ 37,202
Standard	20701	TERRACE SEEDING	3,300	S.Y.	$ 3.00	N/A	$ 9,900
					Subtotal		**$ 257,772**
					Contingency	**25%**	**$ 64,443**
					Design	**10%**	**$ 25,777**
					Total		**$ 347,992**
					Land Acquisition	**0**	**$ -**
					Wetland Mitigation	**0.000**	**$ -**
					Total Total		**$ 347,992**

Near West Solution H

Erin St/Delaplaine Ct Storm System Improvements

Conceptual Cost Estimate

1/23/2025

Standard/ Special	Item #	Item	Quantity	Unit	"Average" Unit Cost provided by City	Adjusted Unit Cost (if used)	Total Item Cost
Standard	50411	48 INCH TYPE I RCP STORM SEWER PIPE	338	L.F.	$ 250.00	N/A	$ 84,500
Standard	50470	48 INCH RCP AE	1	EACH	$ 3,000.00	N/A	$ 3,000
Standard	50410	42 INCH TYPE I RCP STORM SEWER PIPE	88	L.F.	$ 235.00	N/A	$ 20,680
Standard	50409	36 INCH TYPE I RCP STORM SEWER PIPE	290	L.F.	$ 200.00	N/A	$ 58,000
Standard	50407	30 INCH TYPE I RCP STORM SEWER PIPE	352	L.F.	$ 150.00	N/A	$ 52,800
Standard	50403	18 INCH TYPE I RCP STORM SEWER PIPE	595	L.F.	$ 115.00	N/A	$ 68,425
Standard	50407	30 INCH TYPE I RCP STORM SEWER PIPE	402	L.F.	$ 150.00	N/A	$ 60,300
Standard	20501	ADJUST SEWER ACCESS STRUCTURE	15	EACH	$ 750.00	N/A	$ 11,250
Standard	50741	TYPE "H" INLET	12	EACH	$ 3,600.00	N/A	$ 43,200
Standard	20314	REMOVE PIPE	1,872	L.F.	$ 38.00	N/A	$ 71,136
Standard	20701	TERRACE SEEDING	3,300	S.Y.	$ 3.00	N/A	$ 9,900
					Subtotal		**$ 483,191**
					Contingency	**25%**	**$ 120,798**
					Design	**10%**	**$ 48,319**
					Total		**$ 652,308**
					Land Acquisition	**0**	**$ -**
					Wetland Mitigation	**0.000**	**$ -**
					Total Total		**$ 652,308**

Near West Solution I

Parr St Storm System Improvements

Conceptual Cost Estimate

1/23/2025

Standard/ Special	Item #	Item	Quantity	Unit	"Average" Unit Cost provided by City	Adjusted Unit Cost (if used)	Total Item Cost
Standard	50411	48 INCH TYPE I RCP STORM SEWER PIPE	354	L.F.	$ 250.00	N/A	$ 88,500
Standard	50470	48 INCH RCP AE	1	EACH	$ 3,000.00	N/A	$ 3,000
Standard	20501	ADJUST SEWER ACCESS STRUCTURE	5	EACH	$ 750.00	N/A	$ 3,750
Standard	50741	TYPE "H" INLET	2	EACH	$ 3,600.00	N/A	$ 7,200
Standard	20314	REMOVE PIPE	354	L.F.	$ 38.00	N/A	$ 13,452
Standard	20701	TERRACE SEEDING	3,300	S.Y.	$ 3.00	N/A	$ 9,900
					Subtotal		**$ 125,802**
					Contingency	**25%**	**$ 31,451**
					Design	**10%**	**$ 12,580**
					Total		**$ 169,833**
					Land Acquisition	**0**	**$ -**
					Wetland Mitigation	**0.000**	**$ -**
					Total Total		**$ 169,833**

Near West Solution J

Oakland Ave/Adams St Storm System Improvements

Conceptual Cost Estimate

1/23/2025

Standard/ Special	Item #	Item	Quantity	Unit	"Average" Unit Cost provided by City	Adjusted Unit Cost (if used)	Total Item Cost
Special	NW1	3'x8' BOX CULVERT	311	L.F.	$ 1,200.00	N/A	$ 373,200
Special	NW2	3'x11' BOX CULVERT	1,022	L.F.	$ 1,600.00	N/A	$ 1,635,200
Standard	20501	ADJUST SEWER ACCESS STRUCTURE	6	EACH	$ 750.00	N/A	$ 4,500
Standard	20311	REMOVE SEWER ACCESS STRUCTURE	9	EACH	$ 805.00	N/A	$ 7,245
Standard	20314	REMOVE PIPE	3,688	L.F.	$ 38.00	N/A	$ 140,144
					Subtotal		**$ 2,160,289**
					Contingency	**25%**	**$ 540,072**
					Design	**10%**	**$ 216,029**
					Total		**$ 2,916,390**
					Land Acquisition	**0**	**$ -**
					Wetland Mitigation	**0.000**	**$ -**
					Total Total		**$ 2,916,390**