September 2025

John Nolen Watershed Study Report

DRAFT

City of Madison, Dane County, WI

MSA Professional Services
1702 Pankratz St
Madison, WI 53704
(608) 242-7779
Project #00373127

Acknowledgments

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City of Madison

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- Makenzie Gingras, Water Resources Engineer
- Sarah Morrison, GIS Analyst
- Alistair Hancox, Water Resources Engineer
- Eric Thompson, Water Resources Team Leader
- Amber Converse, Project Manager, Senior GIS Analyst

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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, 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 John Nolen Watershed Project. The project area covers approximately 1,316 acres (2.1 square miles) on the south side of 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 John Nolen Watershed Study are as follows, grounded by Annual Exceedance Probability (AEP) design storm event. 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. When using rain-on-grid hydrology, the target is met if there is less than 0.25 feet of curb depth.
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 John Nolen 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 1-1**. 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. All the recommended solutions were integrated into the model and compared against the flood mitigation targets, to assess the anticipated flood reduction. **Table 1-1** 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, including the lack of physical space for improvements, lack of topographical relief to adequately drain regions, and localized flooding on private property that cannot be remedied with public improvements.

Table 1-1. Existing Conditions and Recommended Solutions Results

Based on the City's Flood Mitigation Targets for the John Nolen Watershed

Design Storm Event	ID	Target	Watershed-wide metric	Existing Condition	Recommended Solutions Condition
10% AEP	1a	No surcharging onto the street	354 modeled public structures	176 modeled public structures within 10-ft of inundation (49.7%)	135 modeled public structures within 10-ft of inundation (38.1%)
	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	32.7 miles of road centerlines	0.7 miles of roads with more than 0.5-ft of water (2.0%)	0.4 miles of roads with more than 0.5-ft of water (1.2%)
1% AEP	3a	No homes or businesses will be flooded*	2,107 buildings/structures	43 buildings/structures impacted (2.1%)	16 buildings/structures impacted (0.8%)
	3b	Enclosed depressions served	66 enclosed depressions	13 enclosed depressions impact private property when overflowing (19.7%)	9 enclosed depressions impact private property when overflowing (13.6%)
	3c	Greenway crossings at streets served	2 crossings @ Burdette Ct & Rimrock Road	1.9' inundation depth on road @ Burdette Ct Rimrock Road does not overtop crossing	Burdette Ct does not overtop crossing Rimrock Road does not overtop crossing
0.2% AEP	4a	Safely convey stormwater; i.e. limited impact on private property	2,107 buildings/structures	75 buildings/structures impacted (3.6%)	32 buildings/structures impacted (1.5%)

**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 John Nolen watershed since the watershed is effectively entirely developed. **Table 1-2** 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 1-2. Recommended Solutions Project Cost Estimates

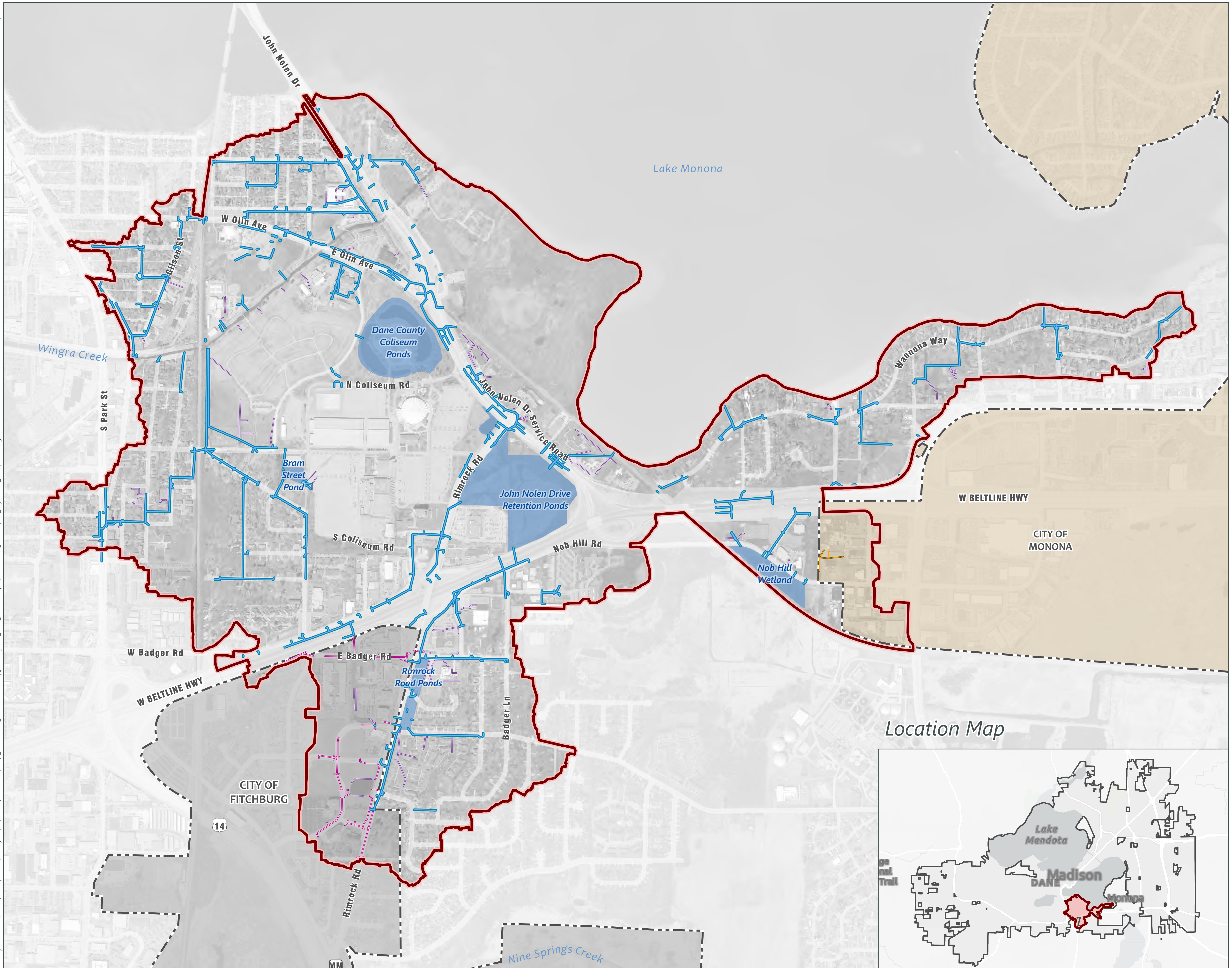
Project	Estimated Cost
W Lakeside and Sayle St Storm System Improvements	$3.14M
Gilson St Storm System Improvements	$0.89M
Bram to Wingra and Alliant Energy Outlet Improvements	$8.63M
Brams Addition Storm System Improvement	$1.41M
Nygard and Sunstrom Street Improvements*	$0.18M
Rimrock Pond Outlet Improvement	$7.57M
Badger Lane Storm System Improvements	$1.20M
Holtzman Rd and Coyier Ln Storm System Improvements	$0.52M

**Costs only accounted for inlets requirements for the 10% AEP design event, not complete reconstruction.*

Study Area

FIGURE ES-1
John Nolen Watershed
Study Report

City of Madison
Dane County, WI



- Watershed Study Area
- City of Fitchburg
- City of Monona
- Public Storm System
- Private Storm System
- Monona Storm System
- Fitchburg Storm System
- Stormwater Management Pond

Data Sources:
Aerial: City of Madison (2022)
Watershed Boundaries: MSA
Stormwater System: City of Madison
County of Dane, Esri, TomTom, Garmin, SafeGraph, FAO, METI/ NASA, USGS, EPA, NPS, USFWS

MSA

0 0.13 0.25 Miles

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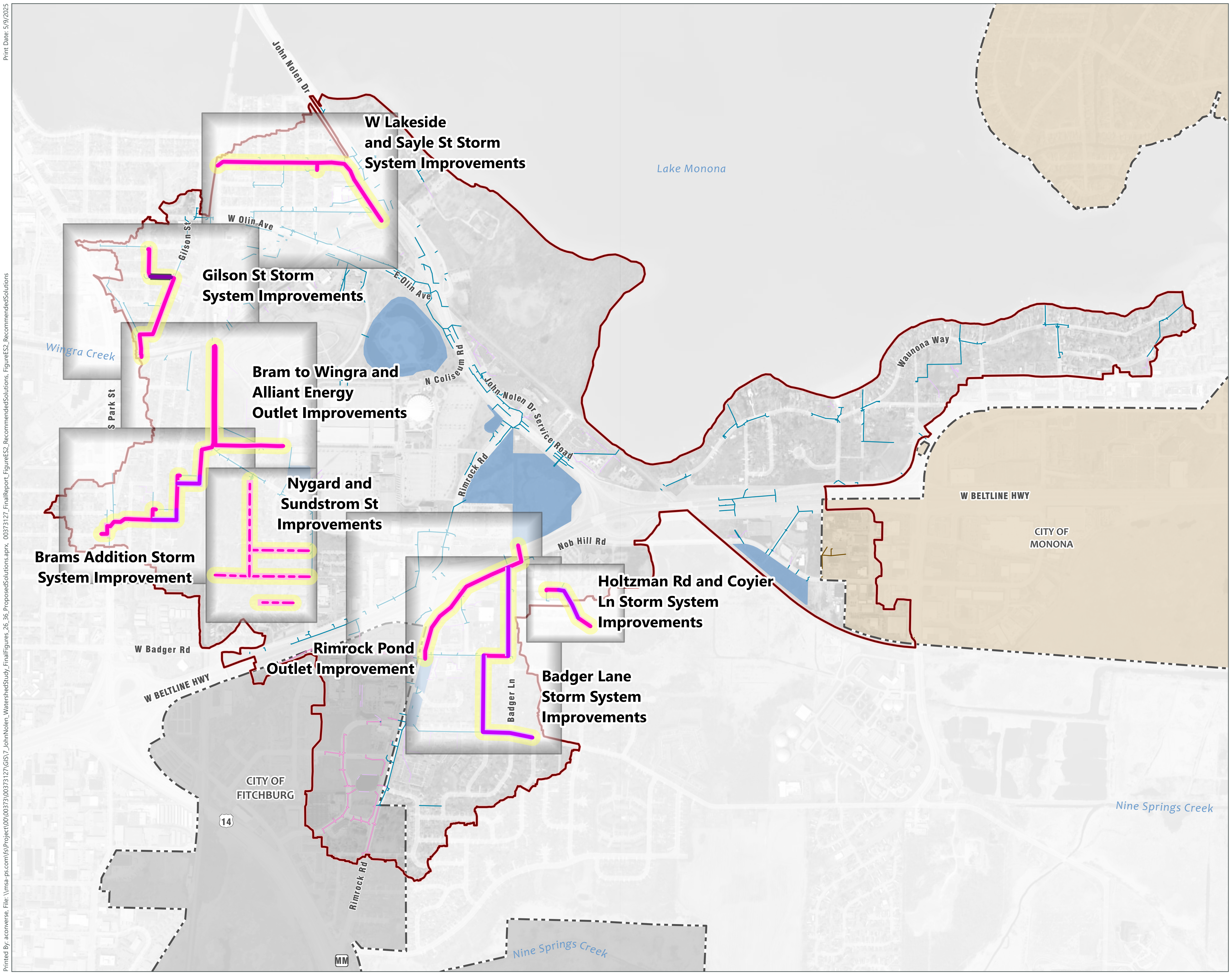
Recommended Solutions Map

FIGURE ES-2
John Nolen Watershed
Study Report

City of Madison
Dane County, WI



Watershed Study Area
City of Fitchburg
City of Monona
Public Storm System
Private Storm System
Monona Storm System
Fitchburg Storm System
Stormwater Management Pond
Map Extents (Figures 27 A - H)

Proposed Storm Improvement

New
Parallel
Removal
Special
Upsize
Proposed Street Improvement

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

MSA

0 0.13 0.25 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 John Nolen 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 1,316 acre watershed.
- Calibration of the model against rainfall and flow/depth data collected at selected locations within the watershed during the spring to fall of 2023.
- Evaluation of calibrated model output for purposes of identifying locations within the John Nolen 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 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 John Nolen watershed model. Flood mitigation alternatives are documented in the second half of the report.

2.3 Historic Flooding in the Watershed

Within the John Nolen watershed, there are several areas that have experienced flooding in the past. **Figure 2** depicts known flooding reports provided by the City in the John Nolen 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.

Dual pipes under John Nolen Drive
There are two 24”x38” HERCP pipes passing underneath John Nolen Drive that are in poor condition and will likely be replaced. The marsh area upstream of the pipes needed to be included in modeling to account for its storage capacity.

The Alliant Energy Center
The Alliant Energy Center is owned by Dane County and was previously located within the Town of Madison prior to the City’s annexation of the land in 2022. The area has a large amount of impervious pavement and was previously subject to different stormwater regulations (as it was outside of the City limits when constructed). Drainage from the Alliant Energy Center area has contributed to some of the flooding issues along Bram Street. The City is in discussions with the County about redevelopment plans, which likely will require improvements to the stormwater infrastructure. At the time of this report writing, the final redevelopment plans were not yet available; therefore, both the existing and proposed conditions modeling for this study assumed no change to the development conditions for this area.

Discharge to Wingra Creek
Two pipes drain north from Bram Street to Wingra Creek and are capacity limited (54” RCP and a 48”x76” HERCP). This is partially due to the pipe outfall being submerged in Wingra Creek and high-water levels in the creek. The City noted that there were cover issues when the pipes were installed, and proposed improvements in this area would likely need to account for the existing topography.

Bram Street and Koster Street
The land between Bram and Koster Streets is low lying, and there have been reports of flooding from this neighborhood. Flooding reports in 2018 were noticeably pronounced. This area was previously within the Town of Madison and annexed into the City. Koster Street was reconstructed in 2019 from an unimproved section with roadside ditches to new asphalt

pavement with concrete curb and gutter and sidewalk on one side of the street. One property on Bram Street was acquired by the city and removed due to repeated flooding.

Bram Street and the Railroad Bridge

The City has received a few flooding reports at the Bram Street and Third Avenue intersection, as well as flooding under the railroad bridge above Bram Street. The City suspects the existing 30” pipe serving this relatively large drainage area is undersized, and that flooding is underreported.

Sundstrom Street

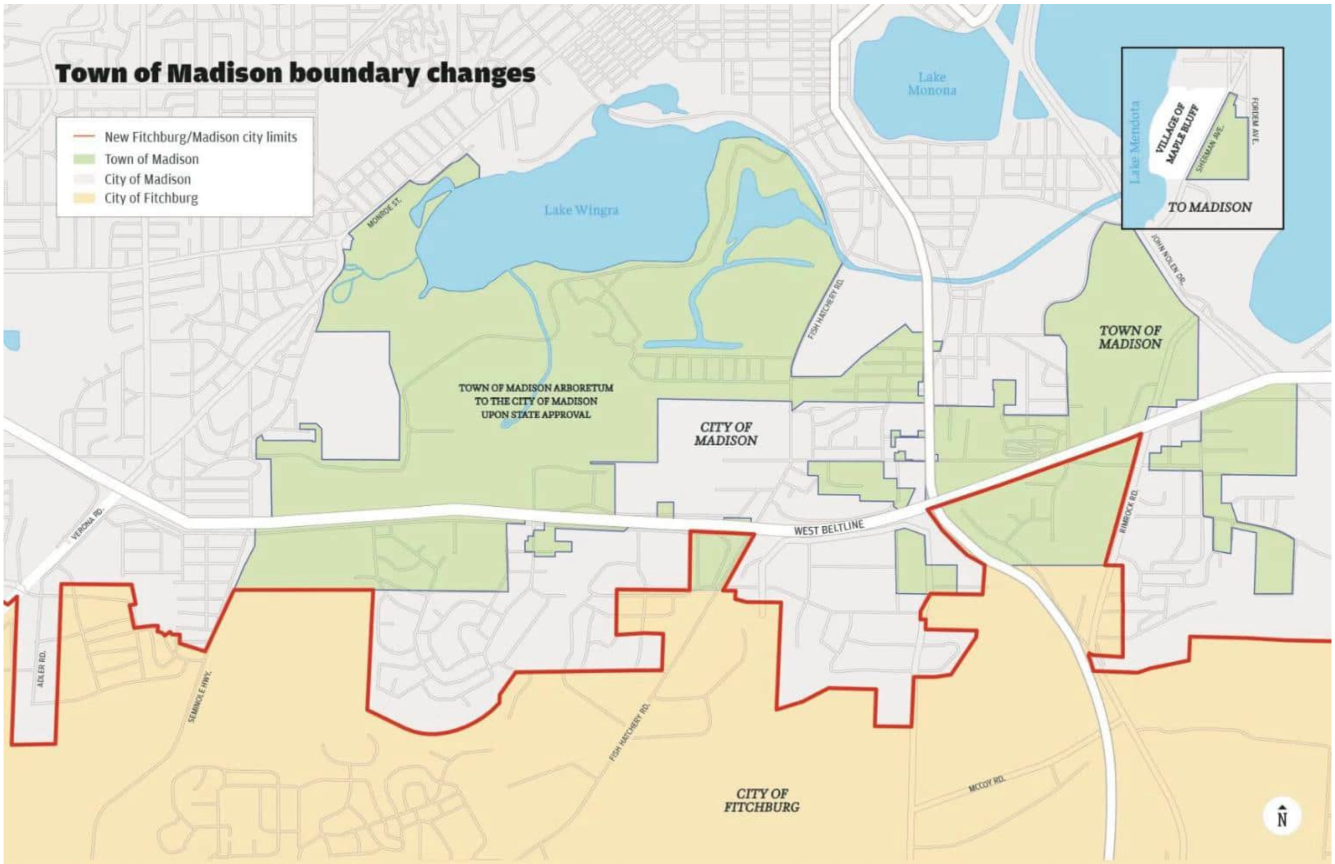
Sundstrom Street is served by a 24” storm pipe but the inlet placement is not optimal. The City indicated that any recommended improvements could include adding and/or relocating inlets along with pipe improvements.

Future Residential Development

The parcels west of Sundstrom Street and north of the railroad tracks may be developed in the future with low density residential. The City indicated that recommendations for this area might include recommendations for future development in this area. The timing and nature of any future development was not known at the time of writing this report.

Former Town of Madison

Some of the flooding locations are within the former Town of Madison. In 2022, the remaining portions of the town were annexed to Madison and Fitchburg. These areas were developed with different stormwater design standards from the City of Madison, and therefore the existing stormwater system in these areas often has less conveyance capacity. A graphic from The Capital Times is included to understand the changing City limits in recent years.



Graphic Source: The Captial Times, "A 'Midwest goodbye': The town of Madison merges with Madison and Fitchburg", October 19, 2022. Graphic credit to Brandon Raygo.

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. When using rain-on-grid hydrology, the target is met if there is less than 0.25 feet of curb depth.

   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 John Nolen 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 John Nolen watershed, and no published reports/memos were available at the time of writing this report.

3 Water Resources Inventory

3.1 Study Setting

The John Nolen watershed is located on the southwest side of the isthmus in the City of Madison, including portions of the City of Fitchburg and the City of Monona, as shown in **Figure 1**. Generally, the watershed is bound to the north by Lake Monona. It extends west to include portions of the Bay Creek and Burr Oaks neighborhoods roughly to Park Street and is inclusive of most of the Bram's Addition and Capitol View neighborhoods. It extends to the east along Lake Monona to include the Waunona Way neighborhood. US Highway 12 (the Beltline) cuts through the middle of the watershed and it is bounded to the south by a ridgeline in the Indian Springs neighborhood.

92% of the watershed area is within the City of Madison, 6% is within the City of Fitchburg, and 2% is within the City of Monona. The watershed boundary just parallels the boundary with the Town of Blooming Grove to the east. In 2022, the Town of Madison was annexed into Fitchburg and Madison. Portions of the watershed areas include land that was formerly within the Town of Madison, and there is less known about the storm sewer within these regions.

Much of the watershed is fully developed; where 27% of the land is single family homes/duplexes, 6% is multifamily residential and mobile homes, 10% is the Alliant Energy Center*, 3% is institutional (including schools, government offices, hospitals, and religious facilities), 15% is commercial, 6% is light industrial and 24% is park and open space, 8% is wooded, and 1% is water.

Note that the Alliant Energy Center is owned by Dane County and therefore a publicly owned institution. However, portions of the Alliant Energy Center were modeled as commercial (specifically as a shopping center) because of the impervious area on the site and high level of connectivity. Please refer to **Section 5.1.1 for more details on model development and connectivity within the model.*

Prominent features within the watershed include:

- The Alliant Energy Center
- Olin Park
- Quann Park
- Goodman Pool
- Penn Park
- Portions of US Highway 12, known locally as "The Beltline"

3.2 Watershed

The John Nolen watershed is bound by the Near West, Wingra, and Nine Springs watersheds (**Figure 3**). All three of these watershed studies are still underway at the time of writing this report. The John Nolen watershed (as defined by this study) is approximately 1,316 acres (2.1 square miles).

There is one location at South Park Street. where, under high runoff conditions, some stormwater runoff will flow into the John Nolen watershed from the Wingra watershed. In this location, piped flow will empty outside of the modeled area into the Wingra watershed, while any surcharged flow and excess surface runoff was incorporated into the John Nolen watershed study area.

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, 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 John Nolen watershed has primarily urban drainage, with many streets/neighborhoods served by stormwater infrastructure. The major drainage system is comprised of large storm sewer pipes and regional public stormwater ponds. The list below identifies the ponds within the study area. The major system is supplemented by the minor drainage system, which consists of street storm sewer, street surface flow, and private stormwater infrastructure.

- Bram Street Pond
- Alliant Energy Center Ponds
- John Nolen Drive Retention Ponds
- Rimrock Road Ponds
- Nob Hill Wetland

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, much of the watershed is fully developed with ~33% 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, and the Alliant Energy Center. There has not been extensive development in this area in recent years; however, some redevelopment is planned to occur, including the following. Note this list was updated as of October 2024.

- Woodland Montessori School Renovation and Addition (proposed)
- Olin Avenue Mixed-Use Development (proposed mixed-use with 200 residential units)
- Several residential property additions/accessory dwelling units (as listed on the City of Madison DPCED Planning website)

Alliant Energy Center falls within the watershed and is potentially planned for redevelopment. However, at the time of writing this report, redevelopment plans were not yet finalized.

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 John Nolen watershed is approximately 1,316 acres (2.1 square miles) and is occupied by 543 acres of impervious, making it ~41% 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 John Nolen model calibration process.

The soils in this study are primarily HSG B or HSG C. Small patches are classified as HSG A and HSG D. Swathes of dual classification HSG ‘A/D’, ‘B/D’ and ‘C/D” were treated in the drained HSG ‘A’, ‘B’, or ‘C’ condition, respectively.

4 Guidance and Data Sources

4.1 Modeling 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 9/26/2023)
- Observed impervious surfaces as digitized by MSA using recent aerial photographs
- Existing storm sewer, inlet, and structure data from the City's GIS database and the City of Fitchburg
- Various construction drawings provided by the City
- Limited survey data provided by MSA staff
- 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 XP-SWMM 2024.1.

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 through fall of 2023.

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 John Nolen watershed was divided into three regions corresponding to three separate rain gauges (Baxter Park, Fire Station 1, and Paunack Park). The majority of the John Nolen watershed was within the Thiessen polygon for Baxter Park (**Figure 7, Table 5-2**).

For calibration, only the Baxter Park and Fire Station 1 rain gages were referenced. The Paunack Park rain gage only covered the far eastern part of the watershed study area and had similar rainfall patterns to the Baxter gage during the selected calibration events.

Table 5-2. Rain Gage Locations for the John Nolen Watershed

Gauge Location	Operated by
Fire Station 1	City
Baxter Park	USGS
Paunack Park	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 3 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	Baxter Park	Fire Station	Baxter Park	
12 - Jul	7/12/23 11:15	7/12/23 16:50	5.5 hours	1.41”	1.6”	0.1”	0.1”	Less than 1-yr event for 6-hr storm (>100% AEP)
28 - Jul	7/28/23 21:50	7/28/23 22:30	0.67 hours	1.71”	2.4”	0.2”	0.2”	~25-yr event for a 1-hr storm (~4% AEP)
14 - Aug	8/14/23 6:20	8/14/23 11:20	5.0 hours	1.57”	1.5”	0.4”	1.0”	Less than 1-yr event for a 3-hr storm (>100% AEP)

Other City of Madison watershed studies also evaluated the August 2018 flood event using rainfall hyetographs. However, this event was relatively small for the John Nolen watershed, and therefore the City did not request this event to be included within the modeling or calibration. The estimated rainfall in the watershed for this event was generally 3" or less in 12 hours. This roughly equates to a 5-year recurrence interval, estimated using NOAA Atlas 14.

5.3 Hydrologic Model Development

5.3.1 Methodology

Subcatchment runoff was computed using the XP-SWMM runoff (SWMM Runoff) routing method 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 5.4.1**)
- 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 the 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 180 subwatersheds were delineated with areas ranging from 0.14 to 50.5 acres with a median size of 4.5 acres. Ten additional watersheds were delineated that drain directly to Wingra Creek and Lake Monona. Since these areas do not drain through City infrastructure, they were not included within the inundation mapping.

- **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 5 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 areas 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.

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

- **Subwatershed width** - 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** - computed using the LiDAR DEM 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 1.7% to 15.3% with a median of 3.4%.

- **Infiltration parameters** - 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** - 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** - 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, or another loading point within a 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 the only pipes draining a part of the public system

Private System

- 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 illustrates 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 exist, 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 eleven (11) ponds and two wetlands within the John Nolen watershed. Storage was inferred from LiDAR contours, as construction plans were either unavailable or did not contain the necessary information to infer the storage volume. Hydraulic structures controlling discharges from the ponds were entered into the 1D model system according to the information provided by GIS databases, topographic survey and visual inspections. The stormwater detention features included within the XPSWMM model are:

- Bram Street Pond
- Van Deusen Street/Colby Street Fish Pond
- Alliant Energy Center Ponds (4)
- Rimrock Road Ponds (2)
- Novation Pkwy Ponds (2)
- Holiday Inn Express Pond, near John Nolen Drive
- John Nolen Drive Retention Ponds (wetland area)
- Nob Hill Wetland (wetland area)

5.6 2D Hydraulic Model Development

5.6.1 2D Modeling Area

With the exceptions of the eleven ponds previously listed, and one new development at the corner of Sayle Street and East Lakeside Street, 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 approximate finished grading condition for a construction project at Sayle Street and East Lakeside Street. Small DEM modifications were made for ditches and minor ridgelines, to ensure correct flow direction.

It should be noted that the LiDAR DEM for wet detention ponds 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

A 10-foot grid cell was assigned in the model. A grid orientation default of 0 degrees was used as this visually appeared to match the orientation of many public streets within the watershed.

5.6.4 Roughness Values and 2D Land Use

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 through 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 and detention ponds that were modeled using the 1D hydraulic model layer, were indicated as inactive in the 2D model layer so as to not 'double count' the hydraulic conveyance capacity and flood storage volume of the channel. Wetland areas were not modeled as ponds.

- Bram Street Pond (1)
- Van Deusen Street/Colby Street Pond (fish pond) (1)
- Alliant Energy Center Ponds (4 total ponds. Three connected to each other, one separate.)

- Rimrock Road Ponds (2)
- Novation Parkway Ponds (2)
- Holiday Inn Express Pond, near John Nolen Drive

5.6.6 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 ground elevation as defined by the 2D surface to allow surface flow to leave the model. These locations include:

- Lake Monona (set lake level elevation to 846')
- Wingra Creek (set creek level as variable, starting at 847' to 846')
- West Lakeside Street at Rowell Street (into Near West Study Area)
- South Park Street at Cedar Street (into Wingra Proper Study Area)
- Rimrock Road at Mahoney Drive (into Nine Springs Study Area)
- Badger Lane near Holtzman Road (into Nine Springs Study Area)

6 Model Calibration

6.1 Recorded Rainfall and Flow Data

Refer to **Figure 7** for locations of the two storm sewer Level Loggers, the one greenway channel Level Logger, the one Flow Meter, and three Rain Gages which recorded data from Spring to Fall of 2023.

6.2 Baseflow Conditions

Level logger data obtained during the metering process was steady in periods without rainfall, and baseflow conditions within the metersheds were considered to be negligible. The one exception to this was the presence of high-water levels appearing at the East Olin flow meter after large rainfall events. The level issues did not resolve after cleaning of the pipe outfall after this meter. Due to the unreliability of the East Olin meter, its data was not utilized during the calibration process.

6.3 Selected Runoff Events

As described previously in **Section 5.2.2**, three (3) rainfall events were used to calibrate the model using rainfall, water level and flow monitoring data collect by the USGS under a separate contract with the City.

The 3 events used 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 Gage Issues

The East Olin flow meter appeared to malfunction during the monitoring period and therefore was not used in the calibration process. Velocity measurements would jump to a high value and remain high immediately following a rainfall event. Refer to the Calibration Memo (**Appendix C**) for more details.

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 gauge may have an error that exceeds the 25% threshold.

6.4.1 Calibration Results

Table 6-1, **Table 6-2,** and **Table 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 Calibration Memo contains detailed discussion regarding the overall model calibration process.

Table 6-1. Rimrock Road Level Logger Bias Summary

Event Date (2023)	Maximum Stage – Metered Data (ft)	Maximum Stage – Modeled Data (ft)	*% Difference*
July 12th	3.17	3.21	*+1%*
July 28th	5.46	6.16	*+11%*
August 14th	3.90	3.62	*-8%*

Table 6-2. Sayle Street Level Logger Bias Summary

Event Date (2023)	Maximum Stage – Metered Data (ft)	Maximum Stage – Modeled Data (ft)	*% Difference*
July 12th	0.86	0.98	*+12%*
July 28th	2.93	2.34	*-25%*
August 14th	1.41	1.67	*+16%*

Table 6-3. Bram Street Level Logger Bias Summary

Event Date (2023)	Maximum Stage – Metered Data (ft)	Maximum Stage – Modeled Data (ft)	*% Difference*
July 12th	1.46	0.82	*-78%*
July 28th	4.50	4.88	*+8%*
August 14th	2.81	1.69	*-66%*

7 Results Evaluation

As noted in the Executive Summary**, Figure 11-Figure 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 John Nolen Watershed compared to areas further west.

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. **Figure 20** through **Figure 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 John Nolen 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 criteria was evaluated by buffering all of the modeled publicly owned access structures and inlets by 10-feet. Any buffered structure that intersected the 10% AEP inundation raster was classified as a ‘potential problem location’.

Of the 354 modeled publicly owned access structures and inlets, 175 of them were classified as a potential problem location (**Figure 20**). Note that the model did not include all 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**.

<u>Target 2: 4% AEP design storm event:</u>

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 0.7 miles of road centerlines (2.0% of all centerlines) with more than 0.5 feet of water at the centerline during the 4% AEP design storm (**Figure 21**).

Note there are two areas where roads cross over Wingra Creek (John Nolen Dr and E Olin Ave) where the DEM (Digital Elevation Model) reflects the stream elevation; the bridges have been removed. The street centerlines at these two bridge crossings are therefore incorrectly appearing as problem locations: the inundation depth in the model reflects the water in the Creek, not the water on the road surface. These short road segments were reviewed by MSA and the City and deemed to be a modeling artifact, not a real problem. Proposed solutions were not required at these locations.

<u>Target 3: 1% AEP design storm event:</u>

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 41 structures (1.9% 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 13 depressions within the watershed 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.**

This criterion was evaluated by identifying all the locations where channelized overland flow enters the piped stormwater system at roadway. Each location was intersected with the 1% AEP inundation raster, to determine the maximum water depth at the road centerline. See **Figure 24**.

John Nolen has two greenway crossings: one at Burdette Ct between the two Rimrock Road Greenway ponds, and one at Rimrock Road near the John Nolen Drive intersection. The Rimrock Road crossing does not overtop the road. The Burdette Ct greenway crossing overtops as water flows from south to north. Maximum water depth on the road: 1.9'.

<u>**Target 4: 0.2% AEP design storm event**</u>:

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

This criterion 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 include structures that are not occupied, such as garages, sheds, and parking facilities.

There are 75 structures (3.6% 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 target was taken into account with the recommended solutions designs (See **Chapter 10**).

7.3 Limitations of the Study

The John Nolen 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 2.1 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 review each inlet may be needed.
- Because every inlet was not modeled, there may be locations where there is more or less 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 discussion (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 with rates of actual rainfall.
- This study is not intended to be used for FEMA floodplain mapping purposes.

8 Public Engagement

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

https://www.cityofmadison.com/engineering/projects/john-nolen-drive-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 Meetings

An initial public information meeting (PIM #1) was held on May 23rd, 2023, 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 collect feedback from residents on experienced flooding.

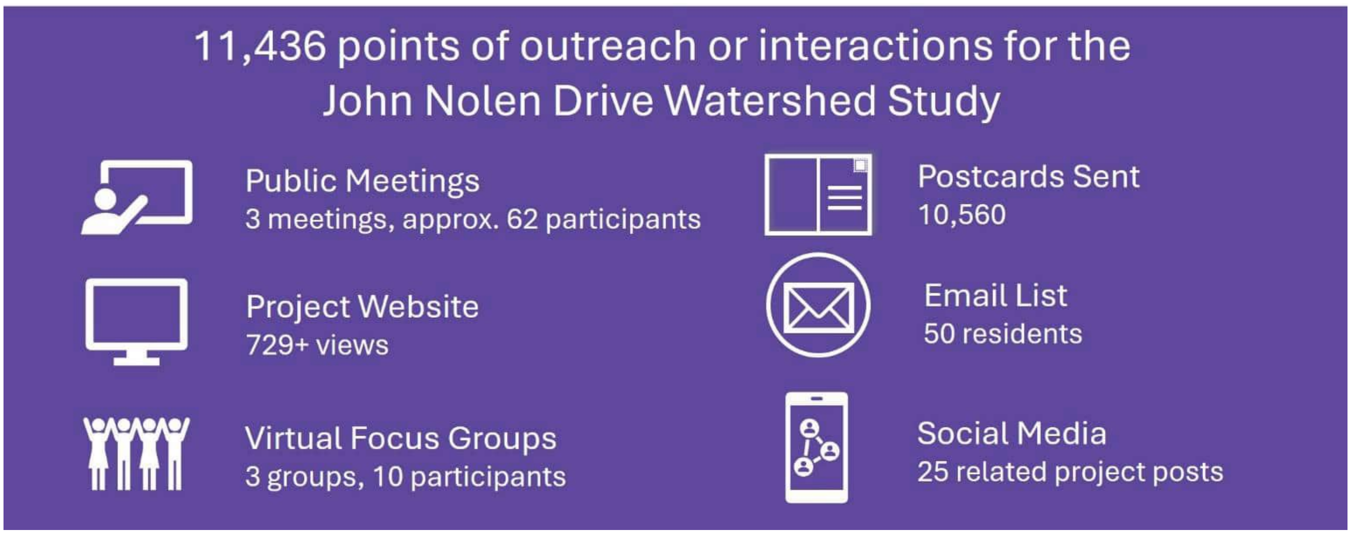
A second public information meeting (PIM #2) was held on April 24th, 2024, also over Zoom. Attendance was estimated to be around 12 individuals, and 'break out sessions' were intended to be held to allow residents to provide comments based on Focus Group areas. However, due to the small size of the group, City staff elected to keep everyone in the same Zoom room.

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 John Nolen and Near West watersheds. This presentation restated the targets of the watershed studies and presented the recommended solutions within the John Nolen 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 the low interest among residents standalone focus groups were not scheduled for this watershed study. However, participants in the PIMs were asked to participate in break-out sessions conducted after PIM #2 and #3. These meetings were 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 watersheds. Questions and comments from the public information meetings are summarized in **Appendix E**.



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** will provide more specifics 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, streets without existing storm sewer, and inadequate overland flow channels. Several areas within the City were annexed from the Town of Madison in 2022; these areas were developed with different stormwater design standards from the City, and therefore the existing stormwater system in these areas often has less conveyance capacity.

9.1.2 Solution Brainstorming

After the initial data review, MSA met with the City Engineering staff on February 27th, 2024 to discuss the existing condition model results, outline conceptual scenarios and identify potential opportunities for flood mitigation measures. Note that although the John Nolen watershed has many outfalls, many are restricted by the existing lake levels (which control water levels in Wingra Creek). Increasing the pipe capacity only has a limited effect when the outlet is underwater, creating a tailwater effect.

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).

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 **Chapter 10**) 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 importance 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 for 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. Since the solutions in the John Nolen 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 John Nolen watershed recommended solutions.

9.1.7 Finalization of Solutions

The City agency meetings did not result in any revisions to the solutions developed for the John Nolen watershed. Following this, the solutions were finalized.

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 Quann Park will require good coordination with the Parks department if/when designed and constructed.

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 it 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 Rimrock Pond retrofitted as a water quality improvements

- **Conceptual Project Description**: The City expressed interest in seeing if the existing Rimrock Pond could be retrofitted to provide water quality benefits, in addition to flood storage. The existing pond has a paved cunette in the main flow path, which limits infiltration during small storm events.

- **Reason for Exclusion**: The City indicated that staff were reviewing the site internally for water quality benefits, and it was outside of the scope of this study to review. However, MSA completed a high-level analysis using "rules of thumb". The upstream contributing area is ~177 acres; the current footprint of both portions of the ponds (north and south of Burdette Ct) is 3 acres. If the Rimrock Road pond was converted to a wet pond with a surface area of 3 acres (approximately that of the existing dry pond floor) the ratio of pond-area-to-watershed-area would be approximately 1.7%. WDNR Conservation Practice Standard 1001 Wet Detention Pond indicated that at this ratio, a pond serving a mix of commercial and residential lands could potentially achieve an 80% TSS reduction. This would likely require modification to the pond's current outlet to better control low flows. This could have negative implications for management of large flow events. Additional evaluation (beyond the scope of this project) would be required before a recommendation could be made regarding this modification.

9.2.1.2 Increased flood storage at the Alliant Energy Center

- **Conceptual Project Description**: The Alliant Energy Center is a large site in the center of the watershed, with substantial amounts of impervious area. This part of the City used to be part of the Town of Madison before it was annexed into the City in 2022. There are some stormwater facilities on site that could be expanded to provide additional flood control.

- **Reason for Exclusion**: The Alliant Energy Center is owned by Dane County, and the City has been in discussions about future redevelopment of the site. At this time, there are no finalized plans for the site and future redevelopment will require additional stormwater controls to meet the City of Madison's stormwater requirements. Therefore, the City indicated that recommended solutions should be focused on City owned land or right-of-way. For this area, this entails augmenting piped infrastructure downstream of the Alliant Energy Center along Bram St.

9.2.1.3 Planning for new development south of Bram St

- **Conceptual Project Description**: The City has historically been approached by potential developers about land west of Sunstrom St, south of Bram St and north of Nygard St. Stormwater from this area follows the natural topography, heading north and contributes to known flooding concerns along Bram St and Koster St. The City indicated they would like to model this area for future development, to guide City staff on how best to handle future development and not increase flooding downstream.

- **Reason for Exclusion**: This region was modeled, adjusting the land use classification and estimating potential increased impervious area. Items considered included modeling a direct outlet to Bram St, so that stormwater would not reach Koster St (via Sundstrom St). Flood reduction with this alternative was negligible. The City also has stormwater requirements in place so that developers do not increase flows from their site and negative impact downstream properties. Therefore, this solution was not modeled further.

9.2.1.4 Waunona Way outfall improvements

- **Conceptual Project Description**: Three properties along Waunona Way and Woodley Lane were identified by modeling as potential problem locations. The City has no records of flood problems in this area and so it is speculated that problems may be artifacts of model construction (2D grid cell size is too coarse to appropriately capture stormwater within the street allowing overflows out of the right-of-way). Regardless, drainage condition could be improved by increasing inlet capacity and pipe capacity.
- **Reason for Exclusion**: Model inlet capacity and pipe capacity were increased in this area, and there were negligible improvements. The City indicated that a berm was constructed within/near Thut Park to divert drainage away from private properties. The berm is small and was not originally reflected in the 2D model surface. In a subsequent model revision, MSA revised the surface in this area to include the berm, and flooding was reduced downstream. However, two properties were still identified as not meeting City flood reduction goals. Two alternative model simulations were conducted where existing storm sewer and inlet capacity along Waunona Way were increased along the current alignment, and where storm sewer pipes were realigned to discharge to Lake Monona through nearby Ester Beach (a park and recreation area). However, there were cover issues, and the pipe could not remain underground in this modeling scenario; the City also indicated that it was unlikely that park land in this area could be used for stormwater infrastructure.

  To further explore drainage conditions in this location, a manual calculation of the hydraulic capacity of the existing street cross-section was completed. This calculation determined the street can convey approximately 46 cfs at curb-full depth. Modeling had shown the storm sewer pipe capacity to be approximately 23 cfs. Modeling indicated that 100-yr peak flows in the street are only 58 cfs total, which is less than the sum of available street and pipe capacity. It was therefore concluded that the model resolution in this area was likely the cause of these two properties being flagged and an improvement was not recommended for this area.

  Finally, residents who live in this area attended Public Information Meeting #3 reviewed the modeled inundation in this area and indicated that they had not seen water flowing/accumulating in this manner. See **Appendix E** for more details on public comments.

9.2.1.5 Localized improvements on private properties

- **Conceptual Project Description**: There are several buildings that were identified to be impacted by the 100-yr storm, but most were adjacent to Wingra Creek, existing open drainage channels and/or private storm sewer systems. Improvements would be local (not regional) in nature, requiring work on private properties.

- **Reason for Exclusion**: The City could not provide solutions for these areas within City owned land, right-of-way or easements. Residents would have to implement localized solutions, if desired, to mitigate flooding risk.

9.2.2 Solutions Recommended

The following flood mitigation methods were recommended for implementation within the John Nolen watershed. The locations of the solutions are all displayed in **Figure 26** (an index map) and individual maps **Figure 27-A** through **27-H**. Further details about each design are provided in **Chapter 10**. The solutions are all piped improvements as the watershed did not have available space for new detention basins.

9.2.2.1 W Lakeside and Sayle St Storm System Improvements

- **Conceptual Project Description**: The model predicted flooding along Lakeside St, with shallow depths at the intersection of Whittier and Lakeside St extending east to Sayle St. Inundation is present in the right-of-way during the 50% AEP design storm. Pipes were undersized and portions of the street were not meeting Target 2a (streets to remain passable during the 4% AEP design storm). The City indicated that the pipes along Sayle St were aging and likely in need of repair/replacement.
- **Iterations Considered**: Pipes were upsized ultimately to serve the 1% AEP (100-yr) design storm, following the current storm system alignment. Alternatives considered included increasing the ditch capacity along the railroad adjacent to Sayle Street; the City indicated the railroad would be unlikely to support this design. Another alternative was shifting the improvements to reach Wingra Creek via Colby Ct; the flood reduction was effectively the same as the recommended solution (along the existing alignment) because Sayle St would have fewer utility conflicts.

9.2.2.2 Gilson St Storm System Improvements

- **Conceptual Project Description**: Modeling predicted flooding along Gilson St in the 20% AEP design event, with inundation primarily staying within the right-of-way until larger events (2% AEP). There is some flooding in backyard/parking/storage areas on private properties, but the City preferred improvements to be on City-owned/maintained lands. If the land is redeveloped, lower areas like these could be addressed. The improvement would be upsizing the existing stormwater pipes to serve the 10% AEP design event.
- **Iterations Considered**: Larger pipe sizing were considered to serve bigger design storm events; however, the City staff indicated there were few reports of flooding in this area and larger improvements might not be warranted.

9.2.2.3 Bram to Wingra and Alliant Energy Outlet Improvements

- **Conceptual Project Description**: The outlet to Wingra Creek, from Bram's St, would need to be upsized if improvements were to be considered upstream. The outlet from Alliant Energy Center was also upsized, as improvements onsite could not be considered at this time (see **Section 9.2.1.2**). There are known cover issues for this outfall, and it would require work in Quann Park, a retired landfill site.
- **Iterations Considered**: Converting the outfall to an open channel was considered, as there are known cover issues in this area and increasing the pipe capacity would be challenging. It could be a single open concrete-lined channel instead of double adjacent parallel pipes. However, the water levels in the creek would limit the functionality of an open channel system and this option was not pursued further. The current alignment for the pipe draining the Alliant Energy Center passes underneath some tennis courts and the Quann community garden. The alignment was shifted south, to fall within the Bram Street right-of-way.

9.2.2.4 Brams Addition Storm System Improvements

- **Conceptual Project Description**: There are known flooding reports from the Bram's Addition Neighborhood, and some of the existing storm sewer system passes between homes on private property. There are no available locations for upstream detention as the neighborhood is fully built out. This improvement would require first upsizing the outfall to Wingra Creek, so as not to negatively impact properties further downstream. Pipes were sized to accommodate the 1% AEP design event.
- **Iterations Considered**: This area is a known concern for City staff; therefore, smaller improvements were not modeled. The original improvements stayed east of Park St. However, there is a sag west of Park St at the intersection with Ridgewood Way and the City requested that the improvements extend to serve this depression. The outlet pipe to Wingra Creek will also require sizing to serve the 1% AEP design event. It was noted that the large box culvert will be underwater when levels of Wingra Creek are high and there is minimal cover. The City will use the recommended improvements as a guide. If the outfall to Wingra Creek cannot be sized to serve the 1% AEP design event, then pipes in the Bram's Addition neighborhood will be reduced to match the outfall design.

9.2.2.5 Nygard and Sunstrom St Improvements

- **Conceptual Project Description**: This area was formerly in the Town of Madison and annexed into the City in 2022. The existing street does not have a traditional system of curb and gutter and there is limited storm sewer serving the area. Stormwater runoff is not effectively captured by the existing drainage system and overland flooding is predicted by the model. The City indicated that the streets in this neighborhood will be

reconstructed in the future following standard curb-and-gutter designs which are anticipated to correct model reported issues.
- **Iterations Considered:** The City originally requested that modeling be completed to determine necessary system improvements; however, it was then discussed that redevelopment is feasible in this area, and providing specific pipe sizes and inlet placement might not be useful for future designers. The City instead requested that model design-event peak flows for the 10% and 1% AEP design storms be tabulated for use in design of new drainage systems at the time redevelopment is planned.

9.2.2.6 Rimrock Pond Outlet Improvement

- **Conceptual Project Description**: Modeling predicted flooding adjacent to the Rimrock Pond, and water overtopping Burdette Ct (which crosses between the two greenway basins). Increasing the outlet capacity of this area would reduce the flooding surrounding the ponds and reduce flooding on the adjacent roads that lead to the pond.
- **Iterations Considered**: The recommended solution kept the same alignment but increased the piped capacity to serve the 1% AEP design event. This alternative was considered after the high-level analysis of using the pond for water quality benefits (see **Section 9.2.1.1**). The original improvement had a box culvert underneath the HWY 12 Beltline; however, City staff indicated it was more likely to be bored/micro-tunneled to minimized traffic impacts. The improvement was adjusted to be an equivalent-sized circular pipe under the Beltline.

9.2.2.7 Badger Lane Storm System Improvements

- **Conceptual Project Description**: There is not any existing storm sewer along Badger Lane, save for at two intersections. This improvement would add new storm sewer to direct some of the flows away from the Rimrock Rd Pond, and provide some relief to that area.
- **Iterations Considered**: Typically, proposed solutions in the watershed study are all modeled together (all improvements in place). However, the City requested that the Badger Lane improvements be modeled separately from the Rimrock Pond Outlet improvements (see **Section 9.2.2.6**) because they share an outfall underneath the beltline. This was done to determine if the improvement of the Rimrock Pond outlet, specifically upsizing the culvert under the beltline, would need to be completed *before* the Badger Lane improvements. The City did not want to recommend a solution that would negatively impact downstream properties; modeling both scenarios would help determine the needed implementation order.

  The City reviewed the inundation maps for the 1% AEP design storm for both alternatives: (A) Badger Lane improvements alone without upsizing the pipe under the beltline and (B) Badger Lane in conjunction with the Rimrock Pond Outlet improvements which upsized the pipe under the beltline. There were no negative impacts to downstream properties when the Badger Lane improvements were modeled without upsizing the pipe under the beltline. Therefore, the Badger Ln improvements could happen *before* the Rimrock Pond outlet (including the pipe under the beltline) was upsized. The Badger Ln improvements were sized for the 1% AEP design event.

9.2.2.8 Holtzman Rd and Coyier Ln Storm System Improvements

- **Conceptual Project Description**: Holtzman Rd is another location that was formerly within the Town of Madison and was annexed into the City in 2022. Modeling predicted that one existing building could be impacted by flooding during the 1% AEP design event. The City indicated that this area might be redeveloped in the future, and the outlet for this system passing *underneath* a building to the south. The City requested that a piped improvement be recommended for this area, keeping the infrastructure within the right-of-way and/or open spaces where it can be accessed and maintained. There have not been reports of flooding in this area, but this could be because the area was only recently added to the City.
- **Iterations Considered**: The alignment was adjusted to head east in along Coyier Ln right-of-way and then southeast into the existing open space. It would likely require an easement to work within green space, as it is not currently owned by the City. Keeping the same alignment (underneath the building) was not considered as a model alternative but it could be considered if the site is redeveloped and the building is moved. Pipes were sized for the 10% AEP design event.

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 John Nolen 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. landfills, wetlands, 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-H** 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.

It should be noted that while there are improvements to the stormwater system functionality, even with all the solutions implemented, there are some locations where targets were not met. These are described in further detail in **Chapter 11.**

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 each 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 W Lakeside and Sayle St Storm System Improvements

Detailed Project Description

The existing W Lakeside and Sayle St storm system serves most of the Bay Creek neighborhood. Water flows from west to east and discharges to Wingra Creek at Sayle St. Modeling predicted inundation within the Lakeside St right-of-way during small events (50% AEP) and portions of the street are not meeting the Target 2a, as the road centerline has more than 0.5' of water during the 4% AEP design storm. Existing pipe sizes along the trunkline start at 12" at the upstream end and the discharge to Wingra Creek is a 38"x57" elliptical pipe.

This alternative increases the piped capacity along the main trunkline along W Lakeside St to Sayle St. The improvement increases the pipe sizing at W Lakeside St and Rowell St to 30" and pipe sizing increases moving east along W Lakeside St. The improvement becomes a box culvert at W Lakeside and Lawernce St (4'x6') and ultimately becomes a 4'x8' box at the intersection of W Lakeside and Sayle St. This large improvement was intended to serve the sag in the right-of way at this interception and protect adjacent private property during the 1% AEP design storm.

One of the modeling iterations considered adding a secondary trunkline along Colby St. The results were very similar for this alternative; however, the City indicated there were fewer utility conflicts along Sayle St, and therefore the Colby alternative was not included in the set of recommended solutions. However, if the project proceeds to design phase, shifting the improvements to this would be a viable alternative. A map of the Colby St alternative was not included in the report (so as not to cause confusion), but a summary of the alternative is listed below in case the City would like to reference it during the design phase:

Colby St Alternative Solution

- A new 43x68 elliptical pipe was added connecting to the W Lakeside St pipe at Colby St, heading south.
- This pipe passed underneath the existing Van Deusen St stormwater pipes (they were kept separate).
- The improvement would turn east at W Olin Ave, creating a new outfall at Wingra Creek.
- The existing Lakeside/Sayle St system was left in place (not upsized), to provide additional capacity.

A map of the recommended storm sewer improvements for the W Lakeside and Sayle St Storm System Improvements 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. The solution prevents 10 stormwater structures from flooding in the 10% AEP design storm.
- **Target 2a**: Inundation along the street centerline decreases with this recommended improvement, with 422-ft of additional centerline along W Lakeside St and Colby St no longer having 0.5-ft of water during the 4% AEP design storm event.
- **Target 3a**: Three (3) additional buildings are no longer impacted by the 1% AEP design storm.
- **Target 3b**: Three (3) enclosed depressions will now meet this target under recommended conditions. One is at the W Lakeside St/Sayle St intersection, one is north of Van Deusen St, and one is on Bresland Ct.
- **Target 3c**: There are not any greenways within this area.
- **Target 4a**: Five (5) additional 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.

This project will require extensive coordination with Madison Metropolitan Sewerage District (MMSD) since there are existing sewer interceptors along the edge of Wingra Creek at the outfall of this improvement. If the project moves forward, additional consideration will be required to account for offsets from the sanitary utilities.

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) *Note there are not mapped wetlands at the outfall, but a wetland survey would likely be required*.
- 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.

10.2 Gilson St Storm System Improvements

Detailed Project Description

The Gilson St area is a ~40 acre watershed that encompasses part of the Bay Creek neighborhood. The upstream watershed includes part of W Olin Ave, with the primary trunk sewer heading southwest along Gilson St, ultimately discharging into Wingra Creek. The drainage area is mixed residential and commercial, including some residential neighborhoods with alleys.

Inundation along Gilson St appears in the modeling in the 20% AEP design storm event, and Cedar St also shows shallow inundation depths. Some private backyard areas also exhibit flooding, outside of the street-right-of-way; in the smaller events, this flooding is local (not originating in the street) and therefore any flood mitigation efforts would need to be undertaken by the property owner.

The City staff indicated that residents had not complained about flooding, possibly because the mapped flooding occurs in the commercial areas of the watershed. The City also noted that the existing storm sewer system is likely undersized, and improvements should be proposed to serve the 10% AEP design storm event. This improvement follows the existing storm sewer alignment, upsizing the pipes starting at the intersection of Spruce St and Hickory St to the outfall at Wingra Creek.

The existing pipe sizing starts at 15" and transitions to a 42" at the outfall. This recommended solution would increase the pipe size to 18" at the upstream end and increase to a 54" at the outfall. Note that the proposed solution includes keeping one pipe segment that is appropriately sized (24"x38" elliptical along Cedar St). If this pipe is found to be in disrepair during construction, it can also be replaced. Note that this improvement is relatively more modest than others recommended within the watershed, as it was sized for the 10% AEP design event.

A map of the recommended storm sewer improvements for the Gilson St Storm System Improvements are shown on **Figure 27-B**.

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 nine (9) stormwater structures from flooding in the 10% AEP design storm.
- **Target 2a**: Inundation along the street centerline decreases with this recommended improvement, with 300-ft of additional centerline along Gilson St no longer having 0.5-ft of water during the 4% AEP design storm event.
- **Target 3a**: Five (5) buildings at Gilson St and Beld St are no longer impacted by the 1% AEP design storm.
- **Target 3b**: Gilson St is an enclosed depression; however, it is not served for the 1% AEP design storm.
- **Target 3c**: There are not any greenways within this area.
- **Target 4a**: Four (4) 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.

This project will require extensive coordination with Madison Metropolitan Sewerage District (MMSD) since there are existing sewer interceptors along the edge of Wingra Creek at the outfall of this improvement. If the project moves forward, additional consideration will be required to account for offsets from the sanitary utilities.

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) *Note there are not mapped wetlands at the outfall, but a wetland survey would likely be required.*
- 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.

10.3 Bram to Wingra and Alliant Energy Outlet Improvements

Detailed Project Description

The City is aware of known flooding concerns in the areas adjacent to Brams St. There is relatively steep topography to the south, carrying water north to Wingra Creek. The piped system passes through Quann Park, with two separate outfalls: one from the residential neighborhoods Brams Addition and Capitol View and a second from the Alliant Energy Center along Brams St.

This neighborhood used to be part of the Town of Madison, and the stormwater infrastructure is comparatively undersized relative to other areas in the City. Shallow inundation within the street was visible for small storm events (50% and 20% AEP design storms) and spills from the right-of-way in the 4% AEP design storm. Properties along Bram St and Koster St are notably impacted; and the City has purchased properties that were impacted by repeated flooding events. **Figure 2** shows the reported historical flooding in this area, with flooding often reported by Bram St and Koster St, and in the upstream watersheds (Brams Addition neighborhood).

This improvement is intended to increase the outlet capacity for both outfalls, providing more capacity for piped improvements in the upstream areas. There is limited vertical space for large pipes, construction will be limited by a MMSD sanitary main crossing, and there is a historical landfill in Quann Park. However, if improvements are to be made upstream to reduce flooding in residential neighborhoods, the outlets need to be upsides to provide more capacity and not shift flooding within the watershed.

It was considered to make this an open channel section, to reduce installation costs. However, the existing enclosed pipes currently act as underground storage, and an open channel system would spill over to the adjacent areas and increase surface flooding. The topography was restrictive, and therefore an enclosed system was recommended for the improvement. The

Alliant Energy outfall was shifted from its current alignment (passing underneath community gardens and tennis courts) to fall within the street right-of-way.

The existing outlet pipes are a 54” RCP (from the residential neighborhoods, ~110 acres) and a 48”x76” box (from Alliant, ~70 acres). The recommended solution increases both outlets to be 48”x96” boxes, intended to serve the 1% AEP design storm.

More comprehensive improvements to the Alliant Energy Center were not considered as part of this project; a plan is underway to redevelop this large site, but it was not completed during the time of this modeling. Therefore, the proposed improvements were limited to the right-of-way, with the understanding that the Alliant Energy Center is expected to add stormwater controls to meet the City standards if/when redevelopment occurs. The City has reviewed the existing stormwater pond onsite (south of Bram St adjacent to a horse arena) and is aware that it is not in an ideal location (on a hillside rather than a low point). Runoff from the Alliant parking lots to the east are known contributors to the flooding concerns along Bram St and should be accounted for in redevelopment planning.

The City and County have begun conversations around the potential redevelopment of the site, including potential coordination and timing of implementations of the recommendations adjacent to the AEC identified in this study. At the time of this report the County is still early in the preliminary design process and intends to utilize the John Nolen Watershed Study XP-SWMM model as part of their site development evaluation.

A map of the recommended storm sewer improvements for the Bram to Wingra and Alliant Energy Outlet Improvements are shown on **Figure 27-C**.

Associated Flood Reduction Benefits

This improvement is physically close to another Recommended Solution: Brams Addition Storm System Improvements. Since the proposed conditions modeling was completed showing all the 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 is due to both two improvements:

- **Target 1a**: This set of solutions prevents twelve (12) stormwater structures from flooding in the 10% AEP design storm.
- **Target 2a**: Inundation along the street centerline decreases with this set of recommended improvements, with 555-ft of additional centerline no longer having 0.5-ft of water during the 4% AEP design storm event. Improvements are on Koster St, Baird St, Center St, Fisher St, and Ridgewood Way.
- **Target 3a**: Fifteen (15) buildings at are no longer impacted by the 1% AEP design storm. These buildings are on Bram St, Koster St, Baird St, Center St, Dane St, and Ridgewood Way.

- **Target 3b**: One (1) enclosed depression (at S Park St and Ridgewood Way) will now meet this target under recommended conditions.
- **Target 3c**: There are not any greenways within this area.
- **Target 4a**: 26 buildings are no longer impacted by the 0.2% AEP design storm. These buildings are on Koster St, Baird St, Center St, Dane St, Ridgewood Way, and one of the Alliant Energy Center buildings.

Project Constraints/Considerations

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

This project will require extensive coordination with Madison Metropolitan Sewerage District (MMSD) since there is existing sewer in Quann Park, crossing the proposed outfalls to Wingra Creek. If the project moves forward, additional consideration will be required to account for offsets from the sanitary utilities.

The project also falls within the historic landfill in Quann Park. The cost estimate was adjusted to include a line item for removal and hauling of this waste offsite. However, the cost will vary significantly based on what is found onsite, and therefore should be revised carefully early in the design process.

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) *Note there are not mapped wetlands at the outfall, but there are wetland indicators. A wetland survey would likely be required.*
- 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. Reduced inundation in this area are also a result of recommended solutions in the Brams Addition neighborhood.

10.4 Brams Addition Storm System Improvements

Detailed Project Description

The Brams Addition neighborhood falls between the railroad tracks on the east, S Park St on the west, Wingra Creek to the north, and the beltline to the south. The watershed draining is area encompasses ~60 acres, all of which drains to the railroad bridge over Bram St. The existing storm sewer is undersized, and in several locations leaves the right-of-way, instead passing between homes. Residents in this neighborhood have reported flooding, specifically at the railroad bridge over Bram St, and at locations at Fischer St, Dane St, Taft St and S Park St. **Figure 2** shows the reported historical flooding in this area.

This improvement increases the piped capacity from the connection to the outfall at Bram St upstream to S Park St. The City explicitly request the improvement be expanded to serve an enclosed depression at S Park St and Ridgewood Way. The trunkline is also shifted to fall within the right-of-way along Dane St and Center St, disconnecting the trunkline pipe located on private properties at these two locations.

The existing pipes vary from 12” at Ridgewood Way to 30” at the railroad bridge over Bram St. The recommended solution upsizes the pipes to serve the 1% AEP design event, significantly reducing flooding for this neighborhood. The proposed pipes would range from 30” at the upstream end to 60” at the downstream connection on Bram St.

A map of the recommended storm sewer improvements for the Bram Addition Storm System Improvements are shown on **Figure 27-D**.

Associated Flood Reduction Benefits

This improvement is physically close to another Recommended Solution: Bram to Wingra and Alliant Energy Outlet Improvements. Since the proposed conditions modeling was completed showing all the 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 is due to both two improvements:

- **Target 1a**: This set of solutions prevents twelve (12) stormwater structures from flooding in the 10% AEP design storm.
- **Target 2a**: Inundation along the street centerline decreases with this set of recommended improvements, with 555-ft of additional centerline no longer having 0.5-ft of water during the 4% AEP design storm event. Improvements are on Koster St, Baird St, Center St, Fisher St, and Ridgewood Way.
- **Target 3a**: Fifteen (15) buildings at are no longer impacted by the 1% AEP design storm. These buildings are on Bram St, Koster St, Baird St, Center St, Dane St, and Ridgewood Way.

- **Target 3b**: One (1) enclosed depression (at S Park St and Ridgewood Way) will now meet this target under recommended conditions.
- **Target 3c**: There are not any greenways within this area.
- **Target 4a**: 26 buildings are no longer impacted by the 0.2% AEP design storm. These buildings are on Koster St, Baird St, Center St, Dane St, Ridgewood Way, and one of the Alliant Energy Center buildings.

Project Constraints/Considerations

This recommended solution is piped infrastructure and will be contained with the City right-of-way. Work will likely occur on private property, to disconnect existing stormwater pipes between homes.

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. Reduced inundation in this area is also a result of recommended solutions in the Bram to Wingra and Alliant Energy Outlet Improvements.

10.5 Nygard and Sunstrom St Improvements

Detailed Project Description

This improvement focused on a portion of the Capitol View neighborhood, upstream of Bram St. Most of this area used to be within the Town of Madison and was recently annexed into the City of Madison in 2022. The City is aware of issues with the storm sewer design for this area, with inlet placement not capturing some of the overland flow, reducing the functionality of the storm sewer. The existing conditions model was developed assuming all inlets were functioning as designed and therefore is likely underpredicting the overland flows from these areas.

As part of this project, various design alternatives were considered. This included modeling potential new development in the land west of Sunstrom St. One idea was to redirect the flows directly to the outfall (at Brams St) rather than connected to the piped system along Sunstrom St. However, modeling results for these alternatives were not very different. It was ultimately decided that future development will have stormwater controls in place that limit runoff, meaning flows should not increase even with new development.

Another idea was to place and size inlets along Sunstrom St, Sunnymeade Ln, and Nygard St. However, the City anticipated that this area might have a large redesign, beyond the realm of stormwater, and providing that level of detail in the recommended solutions might not be helpful for future designers.

Therefore, this area was not modeled in XPSWMM. Instead, the proposed improvement lists the flows for the 10% and 1% AEP design storms, to help with future planning efforts. If a street is reconstructed, or realigned, the modeled flows can be used to size piped infrastructure and quantify the number and size of inlets required. This recommended improvement is notably different from the others and complete cost estimates could not be developed without knowing the future design layout; therefore, the estimate is generalized based on the approximate number of inlets required to capture the flows for the 10% SEP design event (assuming 1.5 cfs per inlet).

A map of the recommended storm sewer improvements for the Nygard and Sunstrom St Improvements are shown on **Figure 27-E**.

Associated Flood Reduction Benefits

This improvement was conceptual in nature, and purposefully not modeled in XPSWMM to allow for flexibility in any future designs for this area. Therefore, the proposed conditions modeling results for this area are the same as under existing conditions. Tracking improvements towards individual targets is therefore not possible.

- **Target 1a**: Improvement not modeled in XPSWMM.
- **Target 2a**: Improvement not modeled in XPSWMM.
- **Target 3a**: Improvement not modeled in XPSWMM.
- **Target 3b**: Improvement not modeled in XPSWMM.
- **Target 3c**: Improvement not modeled in XPSWMM.
- **Target 4a**: Improvement not modeled in XPSWMM.

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.

This improvement was conceptual in nature, and purposefully not modeled in XPSWMM to allow for flexibility in any future designs for this area. Therefore, the proposed conditions modeling results for this area are the same as under existing conditions.

10.6 Rimrock Pond Outlet Improvement

Detailed Project Description

The Rimrock Pond consists of two pond areas in series, connected by a cross culvert passing underneath Burdette Ct. The main flow path through the pond follows a paved cunette, which concentrates the flow during smaller storms. In larger events, the water spills into the wide shallow basin, discharging to a 60" circular pipe that heads northeast, ultimately passing underneath the USH 12/Beltline. The outlet structure includes a rectangular orifice with a riser to allow for additional flow capacity during large events and a trash rack. The ponds serve a ~175 acre watershed, with a mixture of residential and commercial lands. Portions of the upstream watershed include the City of Fitchburg.

The City has considered converting the pond to a water quality treatment basin, but there is limited space for this improvement and the modifications were not supported by local residents. Further modeling water quality improvements was beyond the scope of this study. Therefore, improvements were limited to flood mitigation efforts only.

Modeling suggests there is substantial inundation on Rimrock Rd, with flows coming from both the west (commercial areas within Fitchburg) and the south (mainly residential lands in Madison). The City has not had many reports of flooding in this area, but this area has historically not experienced the intense storms compared to other portions of the City. City staff reached out to Fitchburg to inquire if any residents within that community have complained about flooding, but there are minimal reports there as well. The public information meetings did not have significant turnout for this area; therefore, it is unknown if modeling is over predicting flooding, if large events simply have not occurred in this area recently, or if residents are not vocal about concerns with City officials. However, model calibration using the gage located in the Rimrock Pond had a good fit for all three metered storm events (see **Appendix C**); therefore, improvements were recommended based on the modeling outputs for large events.

There is shallow flooding on streets adjacent to the Rimrock Pond (Moorland Rd, Dunwoody Dr and Badger Ln) event during the smaller storm events (50% and 20% AEP). Spillover from the pond appears in larger events (2% AEP) encroaching on private property. Flooding could impact nearby buildings in the 0.2% AEP design storm. Water also overtops Burndette Ct, the road connecting the two pond areas in the 1% AEP event (Target 3c).

This recommended improvement would increase the outlet capacity of the pond to a 5’x10’ box culvert to serve the 1% AEP design event, following the same alignment paralleling Rimrock Rd and under Nob Hill Rd. The pipe would then transition to a circular 8.5’ pipe to pass underneath Beltline. The City indicated that installing a box culvert under the Beltline would likely be infeasible; therefore, a circular pipe was recommended to allow for boring or microtunneling. The outfall is into East Friede Pond (one of the John Nolen Dr Retention basins). There are mapped wetlands at the outfall that will require additional permitting.

This improvement was proposed in tandem with the improvements to Badger Lane, which would redirect some of the stormwater away from the Rimrock Pond and connect to the existing system outlet to the East Friede Pond. The Badger Ln improvement was modeled separately from the Rimrock Pond Outlet improvement to help understand the order of operations for the improvement. Either improvement can be completed first; the Badger Ln improvement did not necessitate the Rimrock Pond Outlet being upsized first.

A map of the recommended storm sewer improvements for the Rimrock Pond Outlet Improvement is shown on **Figure 27-F.**

Associated Flood Reduction Benefits

This improvement is physically close to another Recommended Solution: Badger Lane Storm System Improvements. Since the proposed conditions modeling was completed showing all the 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 is due to both two improvements:

- **Target 1a**: The proposed solution reduces the flooding but does not eliminate all flooding within the street. This set of solutions prevents ten (10) stormwater structures from flooding in the 10% AEP design storm.
- **Target 2a**: Inundation along the street centerline decreases with this recommended improvement, with 311-ft of additional centerline along Rimrock Rd no longer having 0.5-ft of water during the 4% AEP design storm event.
- **Target 3a**: Three (3) buildings at Nob Hill Rd and E Badger Rd are no longer impacted by the 1% AEP design storm.
- **Target 3b**: The Rimrock Pond is within an enclosed depression; however, it is still not served for the 1% AEP design storm.
- **Target 3c**: The Burdette Ct crossing is no longer overtopped. However, there is still inundation on the street, but this is primarily from overrun from Rimrock Rd.
- **Target 4a**: Seven (7) 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. This improvement would pass underneath the US HWY 12/Beltline and therefore will require extensive coordination with the DOT. It will also require boring or microtunneling under the beltline, increasing costs and complexity. The project also works adjacent to the Rimrock/Beltline onramp which will require additional DOT coordination. *Note the improvement follows the existing alignment adjacent to the onramp, not underneath it.*

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) *Note there are mapped wetlands at the outfall. A wetland survey will be required.*
- 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. If the Rimrock Pond is revised it could provide water quality treatment (see **Section 9.2.1.1**)

Additional Notes/Information

Note that **Figures 28-36** show the inundation after all the improvements have been built. Note that the Badger Ln Storm System Improvements are adjacent to this project and the inundation mapping in this part of the watershed will reflect both of these improvements.

10.7 Badger Lane Storm System Improvements

Detailed Project Description

Portions of the John Nolen watershed do not have storm sewer within the street right-of-way. Instead, the drainage relies on surface flow, most often in the streets. Bager Lane currently does not have stormwater pipes from the intersection with E Badger Rd to Coyier Lane. Badger Ln area was on the historical boundary between the City of Madison and the Town of Madison.

Modeling predicts surface flooding of Badger Ln in small events (50% and 20% AEP), which was anticipated since there is not existing storm sewer within this area. Water flows overland eventually to the Rimrock Pond, with the primary flow path in the street. Inundation depths remain relatively shallow (1-6”) in the streets but these flows contribute to some of the flooding concerns at the pond.

This improvement would add storm sewer to Badger Ln to serve the 1% AEP event and provide some relief to the Rimrock Pond system. The new pipes would connect at Nob Hill Rd and eventually continue to the East Friede Pond (one of the John Nolen Dr Retention basins). This improvement was modeled separately from the Rimrock Pond Outfall improvements, and it was shown to function *without* the outlet improvement in place and flood risks are not shifted within the watershed.

A map of the recommended storm sewer improvements for the Badger Ln Storm System Improvements are shown on **Figure 27-G.**

Associated Flood Reduction Benefits

This improvement is physically close to another Recommended Solution: Rimrock Pond Outlet Improvement. Since the proposed conditions modeling was completed showing all the 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 is due to both improvements:

- **Target 1a**: The proposed solution reduces the flooding but does not eliminate all flooding within the street. This set of solutions prevents ten (10) stormwater structures from flooding in the 10% AEP design storm.
- **Target 2a**: Inundation along the street centerline decreases with this recommended improvement, with 311-ft of additional centerline along Rimrock Rd no longer having 0.5-ft of water during the 4% AEP design storm event.
- **Target 3a**: Three (3) buildings at Nob Hill Rd and E Badger Rd are no longer impacted by the 1% AEP design storm.
- **Target 3b**: The Rimrock Pond is within an enclosed depression; however, it is still not served for the 1% AEP design storm.
- **Target 3c**: The Burdette Ct crossing is no longer overtopped. However, there is still inundation on the street, but this is primarily from overrun from Rimrock Rd.
- **Target 4a**: Seven (7) 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. Note that the Rimrock Pond Outlet Improvements are adjacent to this project and the inundation mapping in this part of the watershed will reflect both improvements.

10.8 Holtzman Rd and Coyier Ln Storm System Improvements

Detailed Project Description

Holtzman Rd and Coyier Ln are east of Rimrock Rd, and were formerly within the Town of Madison, annexed into the City in 2022. The area is primarily commercial/industrial, and the existing storm sewer system collects water from Coyier Ln, passing underneath an existing building in a 24” pipe and discharges to the surface east of Holtzman Rd. Modeling predicted there would be some overland flow adjacent to one of the existing buildings during the 1% AEP design event. The upstream watershed is ~23 acres, with 12” pipes at the upstream end, increasing in size downstream up to a 27” pipe and ultimately a 24”x38” box.

The City prefers to have stormwater infrastructure in either public owned land or in easements with maintenance corridors. Therefore, this improvement would relocate the existing stormwater out from underneath the private building and redirect flows within the right-of-way. City staff indicated the improvement is likely to happen when the area is re-developed. The recommended solution would make use of the same outfall into the open space south of Holtzman Rd, but it is not owned by the City of Madison. It will require coordination with the landowner and potential easements.

The solution was sized for the 10% AEP design storm, replacing the existing system with 36” pipe that connects to the existing 24”x38” box at the outfall.

A map of the recommended storm sewer improvements for the Holtzman Rd and Coyier Ln Storm System Improvements 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**: 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 segment are now achieving this target.
- **Target 3a**: One (1) building north of Coyier Lane 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 area.
- **Target 4a**: One (1) building is no longer impacted by the 0.2% AEP design storm.

Project Constraints/Considerations

This recommended solution is piped infrastructure, most of which will be contained within the City right-of-way. However, the piped outfall appears to be on private property (perhaps within a utility easement). If this project moves forward, the design team will need to understand the easement status and width, to ensure there is adequate space for the improvement. Note there are mapped wetlands near the discharge point, although this project might not impact them directly.

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) *Note there are mapped wetlands near the project to the southeast. A wetland survey would likely be required.*

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.

11 Areas where Flood Control Targets are Not Met

This portion of the City of Madison is fully developed, existing park land, or mapped wetlands which limits the potential flood mitigation solutions that are viable in the John Nolen Watershed. There is not much available real estate to create storage in the upper reaches of the watershed; portions of the upper watershed area are also within the City of Fitchburg and outside of the purview for improvements by Madison. Another compounding factor is the limited topography. The outlets discharging to Wingra Creek (which drain to Lake Monona) are sometimes underwater; increasing the piped capacity upstream will have a limited effect on reducing inundation on the ground surface. 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 the modeled publicly owned access structures and inlets by 10-feet. Any buffered structure that intersected the 10% AEP inundation raster was classified as a 'potential problem location'. Of the 354 modeled publicly owned access structures and inlets, 176 of them were classified as potential problem location (50%). Under the recommended conditions, 135 were still classified a potential problem locations (38%).

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 32.7 miles of roads. Under existing conditions, 0.7 miles were classified as problem locations (2%). Under the recommended conditions, 0.4 miles were classified as problem locations (1%).

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 2,107 buildings/structures within the watershed in the City of Madison in this watershed. Under existing conditions, 43 buildings were classified as potentially impacted (2%). Under the recommended conditions, 16 structures would still be impacted by flooding during the1% AEP design storm (1%).

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 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 sixty-six (66) enclosed depressions within the watershed. Under the existing conditions, modeling predicts that the 1% AEP service levels are not achieved in thirteen (13) enclosed depressions classified as a potential problem location. Under the recommended conditions, nine (9) 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.

This criterion was evaluated by identifying all the locations where channelized overland flow enters the piped stormwater system at roadway. Each location was intersected with the 1% AEP inundation raster, to determine the maximum water depth at the road centerline. John Nolen has two greenway crossings: one at Burdette Court between the two Rimrock Road Greenway ponds, and one at Rimrock Road near the John Nolen Drive intersection. The Rimrock Road crossing does not overtop the road under existing conditions, but the Burdette Court greenway crossing does overtop. Under proposed conditions, Burdette Court is no longer overtopping from the greenway. Note there is still inundation on the road, but this is runoff from the adjacent road areas, not from the greenway. Note that the culvert connecting the two greenways is out of capacity during this large event.

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 2,107 buildings/structures within the watershed in the City of Madison in this watershed. Under existing conditions, 75 buildings were classified as potentially impacted (3%). Under the recommended conditions, 32 structures would still be impacted by flooding during the 0.2% AEP design storm (0.2%).

12 Climate Resilience Analysis

12.1 0.2% Chance Analysis

The following section describes anticipated changes in 0.2% AEP 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. All the recommended improvements were sized for either the 10% AEP or 1% AEP design storm. Improvements can be grouped into three regions, based on discharge location:

Outfall to Wingra Creek

- W Lakeside and Sayle St improvements (serves 1% AEP)
- Gilson St improvements (serves 10% AEP)
- Bram St and Alliant Energy outfall improvements (serves 1% AEP)
- Brams Addition neighborhood improvements (serves 1% AEP)
- Nygard and Sunstrom St improvements (serves 10% or 1% AEP)

Increasing the improvements to Wingra Creek are limited by the creek water levels (which are tied to the water levels on Lake Monona). The lake levels are set by the County, as they open and close dams to release and maintain water levels throughout the chain of lakes in the Madison area. The modeling completed for this work was assuming high water levels, to emulate the “worst case scenario” of a large storm event coinciding with high lake levels. Those recommended solutions that discharge to Wingra Creek are limited by the tailwater condition at the outfall and potentially cover issues (limited by topography). Increasing the pipe capacity beyond those values recommended in this report might provide marginally more underground storage but would not significantly increase conveyance. The exception is for the Gilson St improvements, which were only sized for the 10% AEP event. This improvement could be increased to serve a larger event, but it would likely run into utility conflicts with MMSD at the outfall.

Although the piped improvements to Wingra Creek are not sized to serve the 0.2% AEP design event, there are notable improvements for this large storm event.

- The ponding at the sag point at W Lakeside St and Sayle St falls by ~1.7-ft.
- Along Gilson St, the peak water levels in the enclosed depression fall by ~0.8-ft.
- Predicted flooding for the enclosed depression along Bram St drops by 1.8-ft and 5 buildings in this area are no longer impacted by flooding (Target 4a).

- Flooding in the Bram's Addition neighborhood is greatly reduced, with 20 buildings in this area no longer impacted by flood depths (Target 4a), and street flooding is reduced significantly (dropping by 0.5- to 1-ft).

Outfall to East Friede Pond (John Nolen Dr Retention Ponds)

- Rimrock Pond outlet improvement (serves 1% AEP)
- Badger Ln improvements (serves 1% AEP)

There are notable reductions to the inundation depths for the 0.2% AEP storm with the improvements near the Rimrock Pond and Badger Ln. Water depths at the intersection of Rimrock Rd and Moorland Rd (upstream of the Rimrock Pond) are reduced by ~1.8-ft and four (4) nearby buildings are no longer at risk of flooding. The shallow flooding along Badger Ln is negligible under the proposed conditions, reducing the strain on the Rimrock Pond.

Outfall to Greenspace (ultimately Nine Springs Creek)

- Holtzman Rd improvements (serves 10% AEP)

The improvements along Coyier Ln and Holtzman Rd are modest in nature, relative to some of the other recommended solutions. The City anticipates that the future development of this region will allow this solution to be implemented. When development occurs, the piped capacity could be increased to serve a larger event if desired.

However, improving the piped capacity to just the 10% AEP event does remove overland flooding concerns. In existing conditions, there is 6" of flooding during the modeled 0.2% AEP event on Coyier Ln. This is reduced to negligible amounts under proposed conditions and one building is no longer at risk of flooding (Target 4a).

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

12.2 Infrastructure modifications

The John Nolen 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) 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 John Nolen were within the street right-of-way, except for the Holtzman Rd & Coyier Ln improvement, where the end of the project would likely fall into an easement on private land. 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 three (3) projects listed below would be ‘main drivers’; therefore, they have the street reconstruction costs incorporated into the estimate.

- Bram to Wingra and Alliant Energy Outlet Improvements
- Rimrock Pond Outlet Improvement
- Holtzman Rd and Coyier Ln Storm System Improvements

The City provided 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 was 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.

The total cost estimate for each of the stand-alone projects are provided in **Table 13-1.** A detailed breakdown for each cost estimate, with quantities, average unit costs, and adjustments is provided in **Appendix G.**

Table 13-1: Stand-Alone Project Cost Estimates for John Nolen Watershed

Project	Estimated Cost
W Lakeside and Sayle St Storm System Improvements	$3.14M
Gilson St Storm System Improvements	$0.89M
Bram to Wingra and Alliant Energy Outlet Improvements	$8.63M
Brams Addition Storm System Improvement	$1.41M
Nygard and Sunstrom Street Improvements*	$0.18M
Rimrock Pond Outlet Improvement	$7.57M
Badger Lane Storm System Improvements	$1.20M
Holtzman Rd and Coyier Ln Storm System Improvements	$0.52M

**Costs only accounted for inlets requirements for the 10% AEP design event, not complete reconstruction.*

14 Recommended Implementation Order

14.1 Technical Implementation Needs

Implementing an 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 John Nolen Watershed, there is one 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 Bram to Wingra and Alliant Energy Outlet improvement should be completed before any improvements in the upstream watershed in the Bram's Addition Neighborhood.

2. The Rimrock Pond Outlet Improvement can be completed before or after the Badger Lane improvements. Modeling the Badger Ln improvements without upsizing the Rimrock Pond outlet did not show shifting inundation within the watershed.

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/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 Boards, committees, commissions, City Council and other applicable City Agencies. Results can also be presented to stakeholders, including local Friends Groups, Neighborhood Organizations, interested Developers and neighborhood residents.

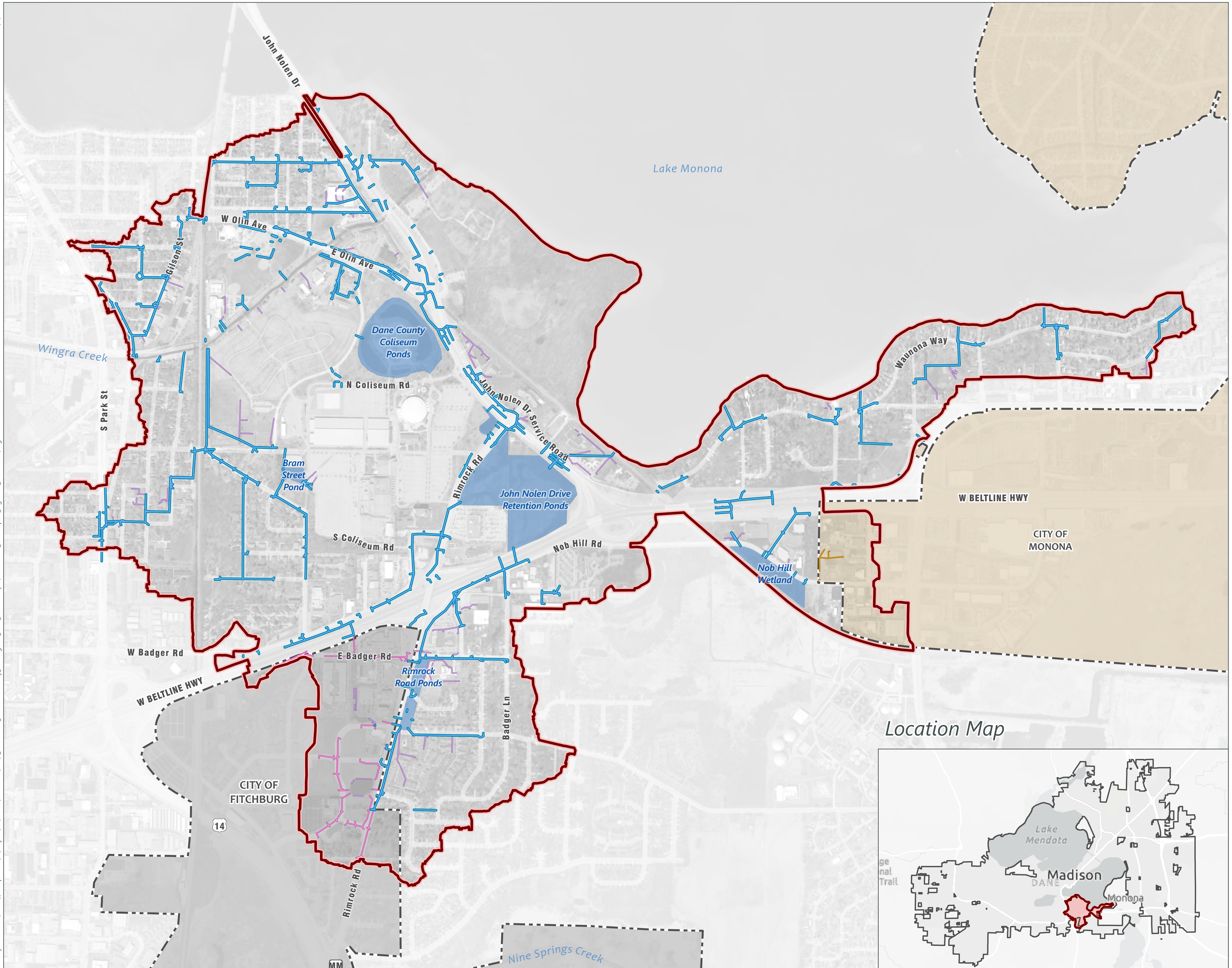
Each individual recommended potential project identified in this study will go through full design and public information process prior to construction; including resident and stakeholder engagement.

Figures

Watershed Area

FIGURE 1
John Nolen Watershed
Study Report

City of Madison
Dane County, WI



- Watershed Study Area
- City of Fitchburg
- City of Monona
- Public Storm System
- Private Storm System
- Monona Storm System
- Fitchburg Storm System
- Stormwater Management Pond

Data Sources:
Aerial: City of Madison (2022)
Watershed Boundaries: MSA
Stormwater System: City of Madison
Sources: Esri, TomTom, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community

MSA

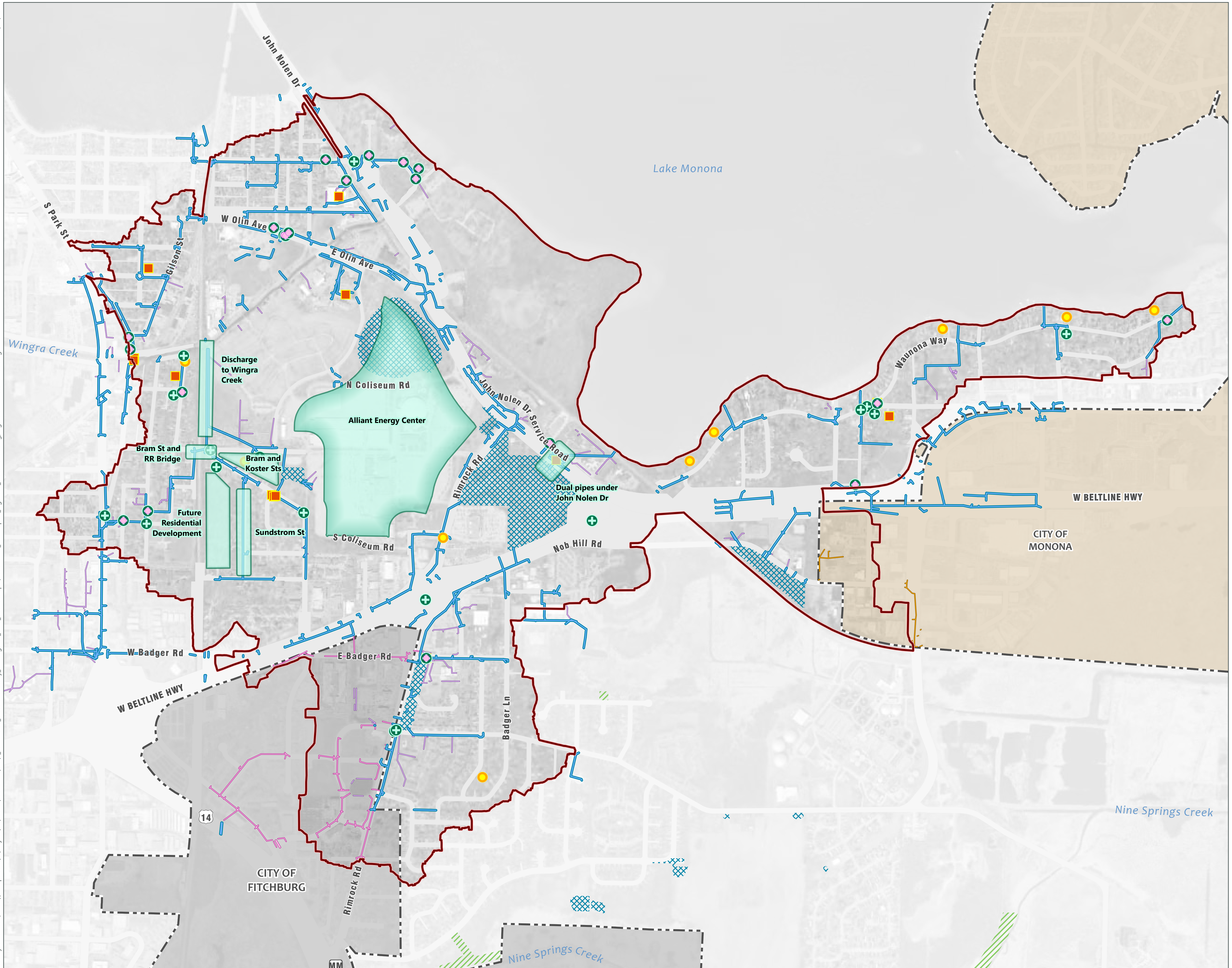
0 0.13 0.25 Miles

Print Date: 5/9/2025

Historic Flooding

FIGURE 2
John Nolen Watershed
Study Report

City of Madison
Dane County, WI



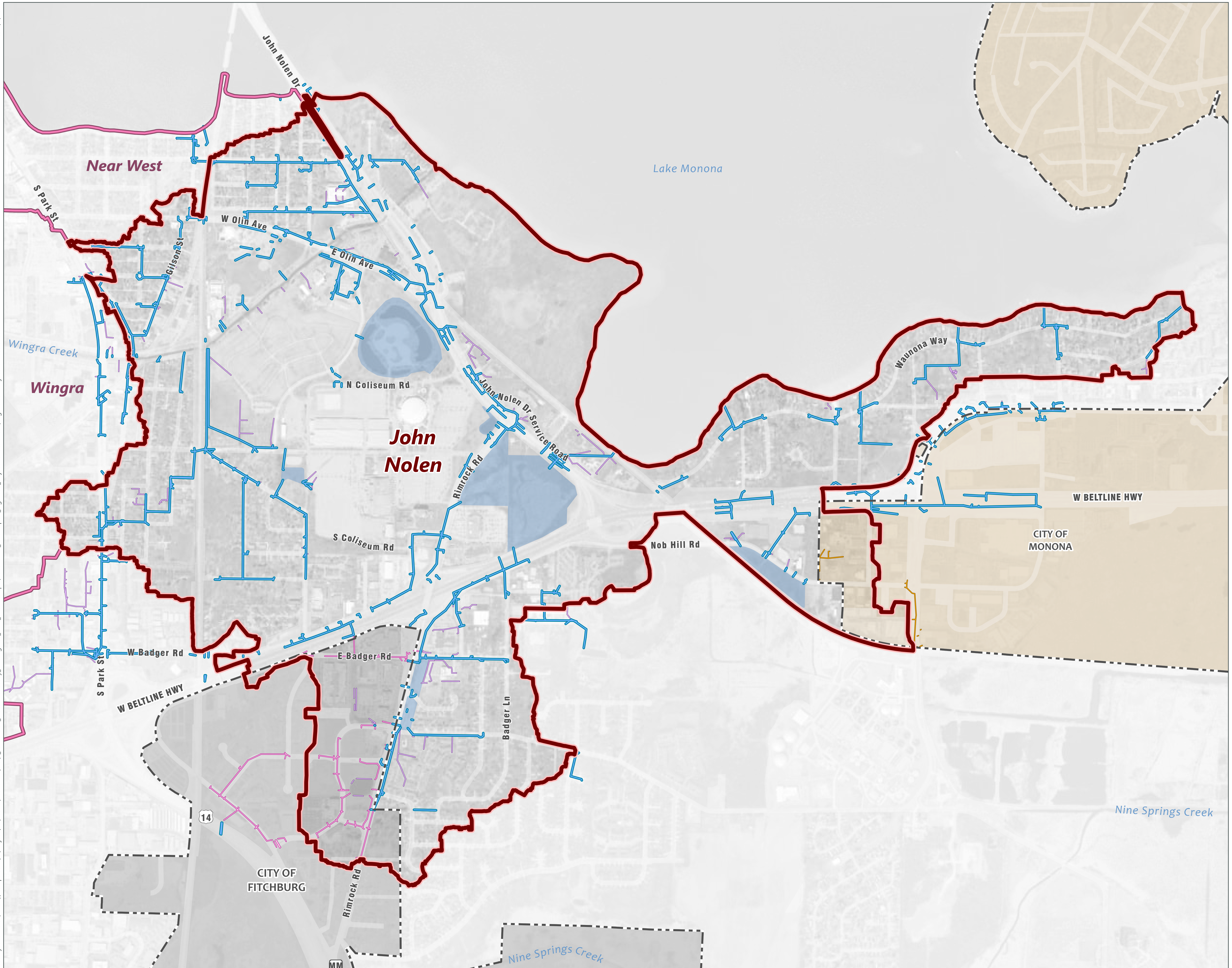
- Watershed Study Area
- Greenway
- Pond
- Observations by City Engineering Staff
- Reported Flooding
- Priority Inlets
- Operations Flooding Points
- Historic/Observed Flood Points

Data Sources:
Aerial: City of Madison (2022)
Watershed Boundaries: MSA
Stormwater System: City of Madison
Reported Flooding: City's Online Public Reporting (through July YEAR TO UPDATE)
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 0.13 0.25 Miles

Print Date: 11/21/2024
Printed By: smorrison, File: \\msa-ps.com\fs\Project\00\00373\00373127\GIS\7_JohnNolen_WatershedStudy_FinalFigures_1-10_SiteData.aprx, 00373127_FinalReport_Figure02_HistoricFlooding, Figure 02 - Historic Flooding



Adjacent Watersheds

FIGURE 3
John Nolen Watershed
Study Report

City of Madison
Dane County, WI

- Watershed Study Area
- Other Watershed Study Areas
- Stormwater Management Pond
- City of Fitchburg
- City of Monona
- Public Storm System
- Private Storm System
- Monona Storm System
- Fitchburg Storm System

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

MSA

0 0.13 0.25 Miles

N

Print Date: 8/7/2024

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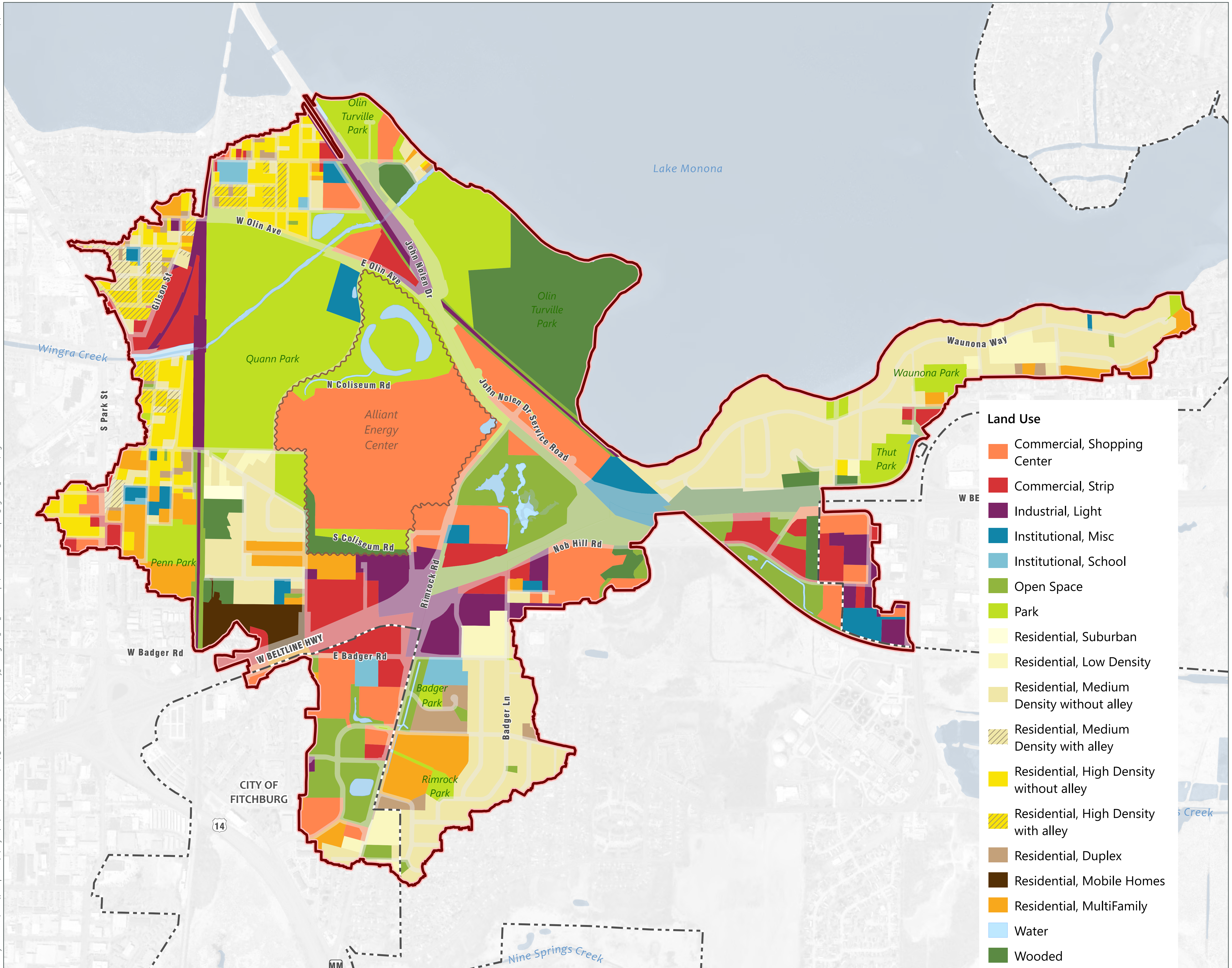
Land Use

FIGURE 4
John Nolen Watershed
Study Report

City of Madison
Dane County, WI

Watershed Study Area
Surrounding Municipalities
Alliant Energy Center



Data Sources:
Aerial: City of Madison (2022)
Watershed Boundaries: MSA
Stormwater System: City of Madison
Land Use: Dane County (2020)

MSA

0 0.13 0.25 Miles

Print Date: 8/9/2024

Impervious Areas

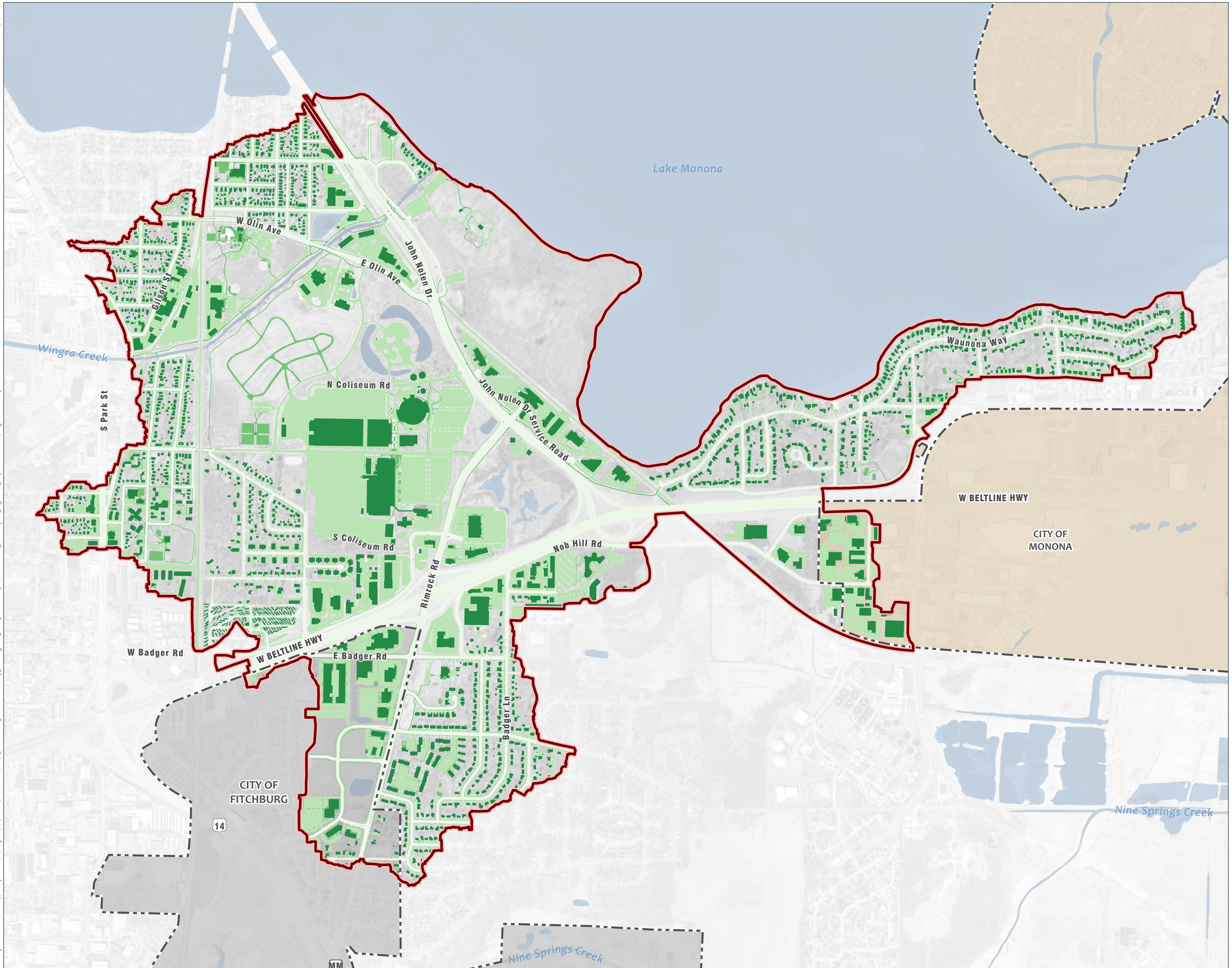


FIGURE 5
John Nolen Watershed
Study Report

City of Madison
Dane County, WI

Watershed Study Area
City of Fitchburg
City of Monona

Impervious Area

Roof
Sidewalk/Other
Driveway/Parking
Street

Data Sources:
Aerial: City of Madison (2022)
LiDAR/Hillshade (2022)
Watershed Boundaries: MSA
Stormwater System: City of Madison
Impervious Areas: MSA

MSA

0 0.13 0.25 Miles

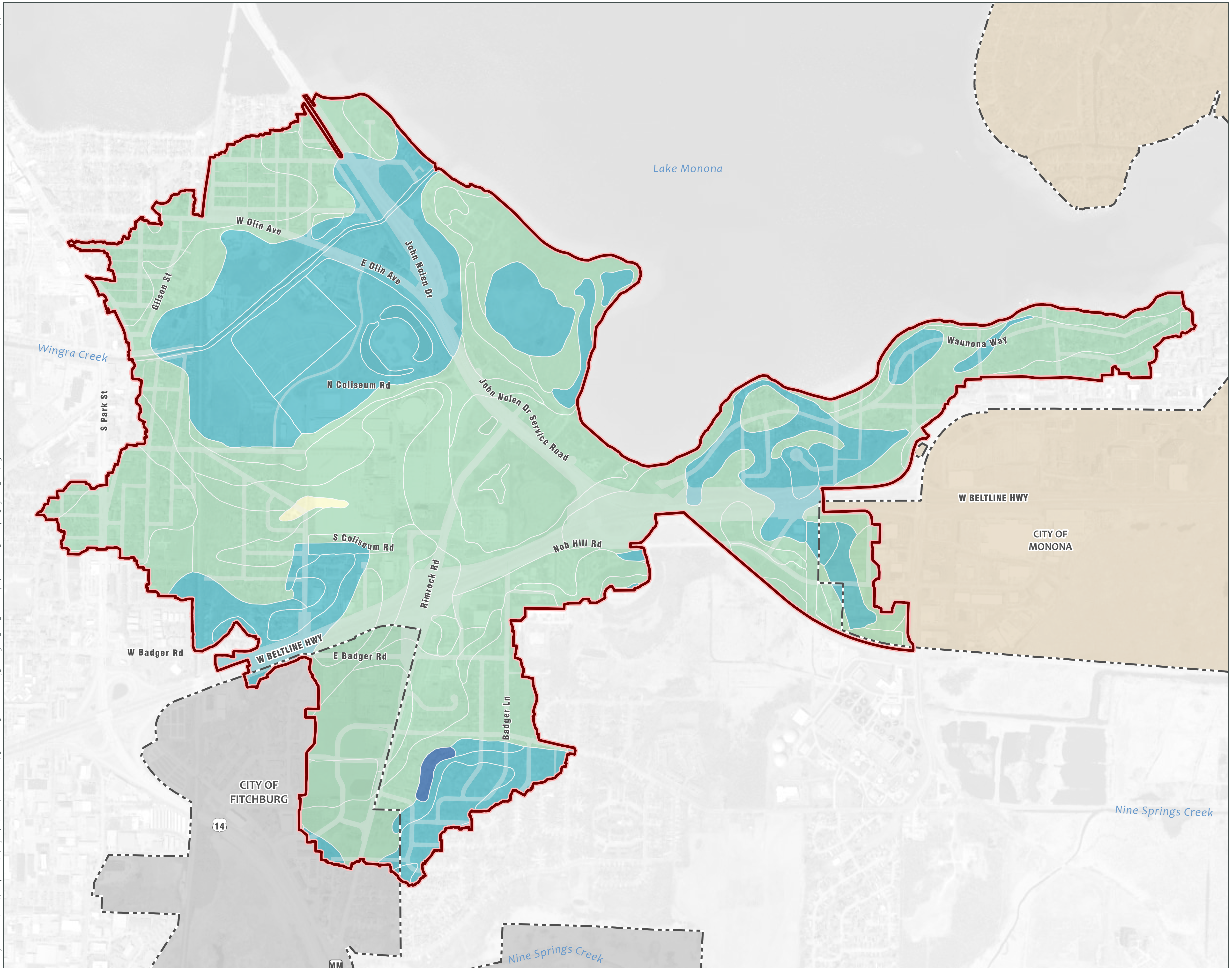
N

Print Date: 8/7/2024

Soils

FIGURE 6
John Nolen Watershed
Study Report

City of Madison
Dane County, WI



Watershed Study Area
City of Fitchburg
City of Monona

Modeled Hydrologic Soil Group

A
B
C
D

Data Sources:
Aerial: City of Madison (2018)
Watershed Boundaries: MSA
Stormwater System: City of Madison
Soils: USDA NRCS (SSURGO, Oct 2020)

MSA

0 0.13 0.25 Miles

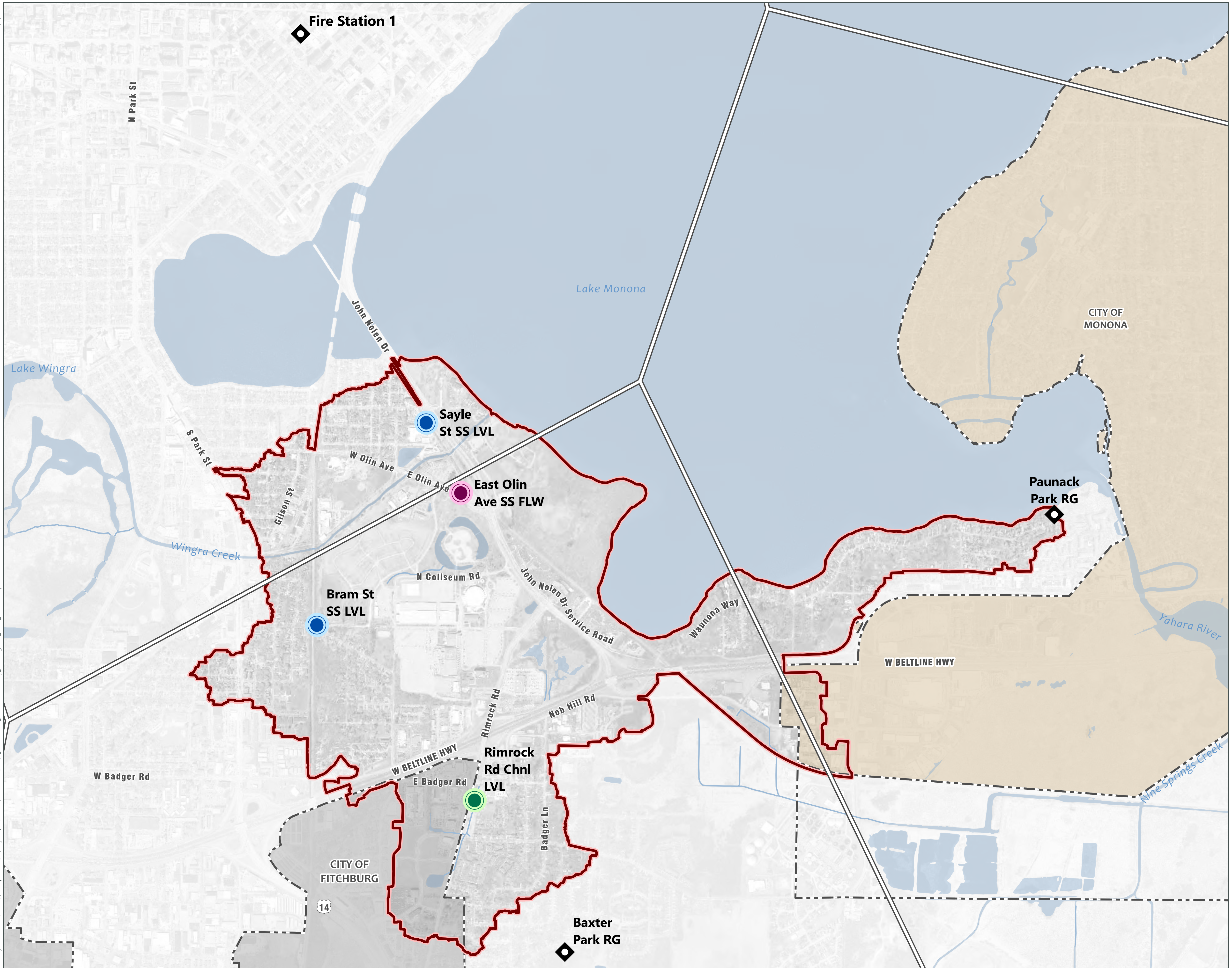
N

Print Date: 8/7/2024

Gage Locations

FIGURE 7
John Nolen Watershed
Study Report

City of Madison
Dane County, WI



Watershed Study Area
City of Fitchburg
City of Monona
Thiessen Polygons for Rain Gages

Remote Monitoring

Rain Gage
Level Logger (Greenway)
Flow Meter (in pipe)
Level Logger (in pipe)

Data Sources:
Aerial: City of Madison (2022)
Watershed Boundaries: MSA
Gage Locations: City of Madison and USGS

MSA

0 0.15 0.3 Miles

N

Model Network

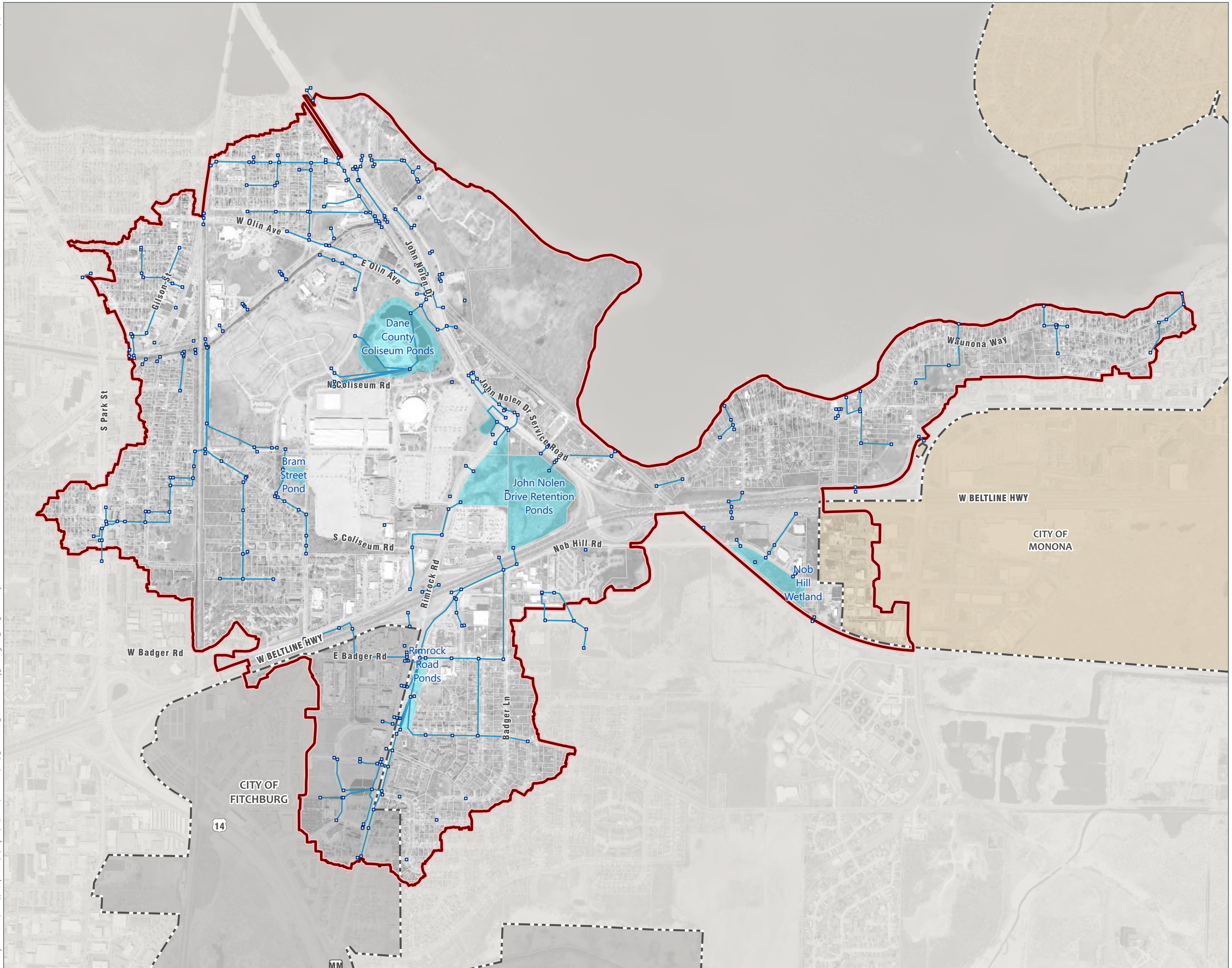


FIGURE 8
John Nolen Watershed
Study Report

City of Madison
Dane County, WI

- Watershed Study Area
- City of Fitchburg
- City of Monona
- Modeled Stormwater Detention
- Modeled Links
- Modeled Nodes

Data Sources:
Aerial: City of Madison (2022)
Watershed Boundaries: MSA
Model Network: MSA

MSA

0 0.13 0.25 Miles

N

Print Date: 10/1/2024

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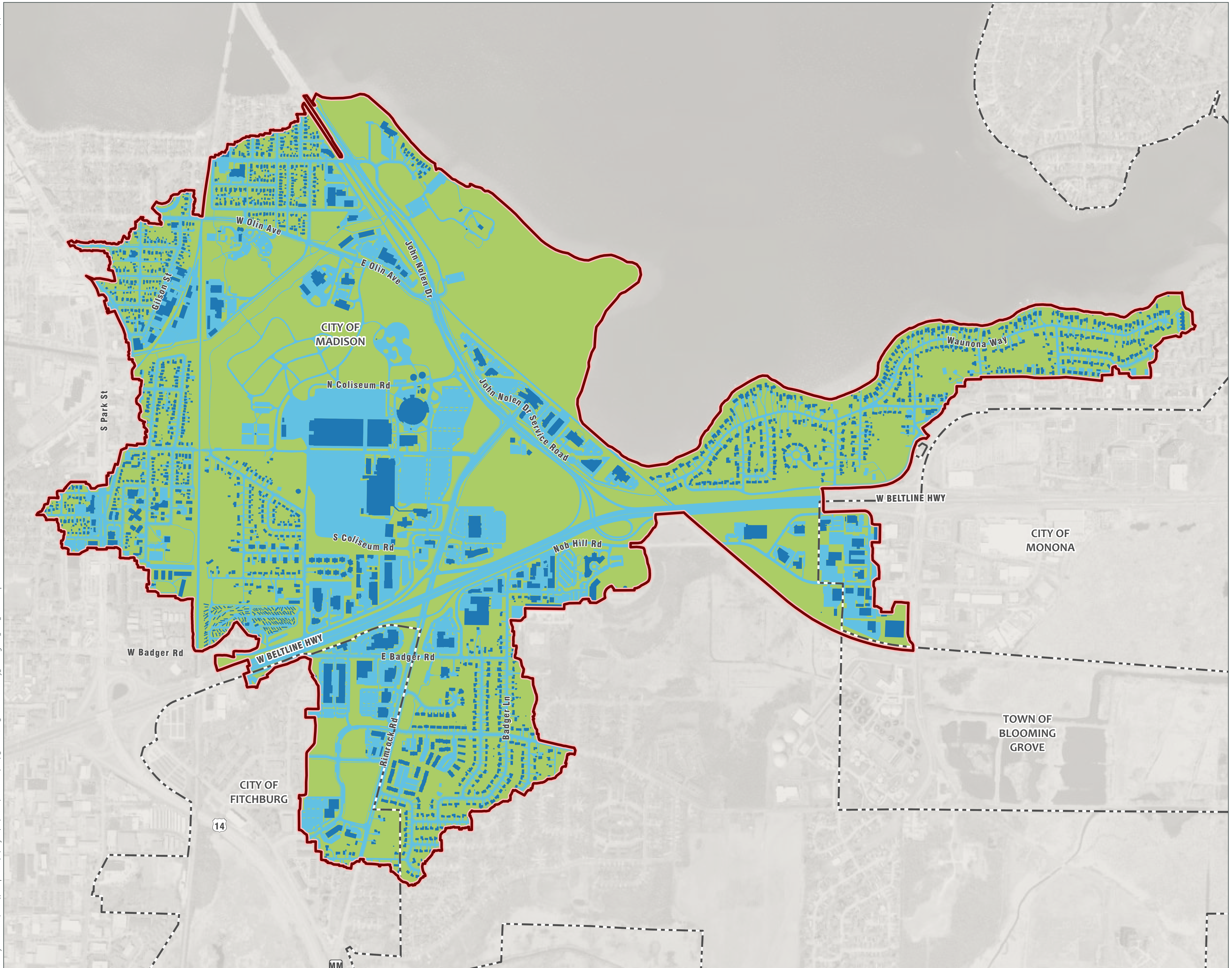


Surface Roughness

FIGURE 9
John Nolen Watershed
Study Report

City of Madison
Dane County, WI

Watershed Study Area

Municipalities

Surface Roughness (Manning's n)

Buildings, Inactive

Streets, Sidewalk, Driveway, Parking = 0.016

Turf Grass = 0.03

Data Sources:
Aerial: City of Madison (2022)
Watershed Boundaries: MSA
Impervious Areas: City of Madison supplemented by MSA

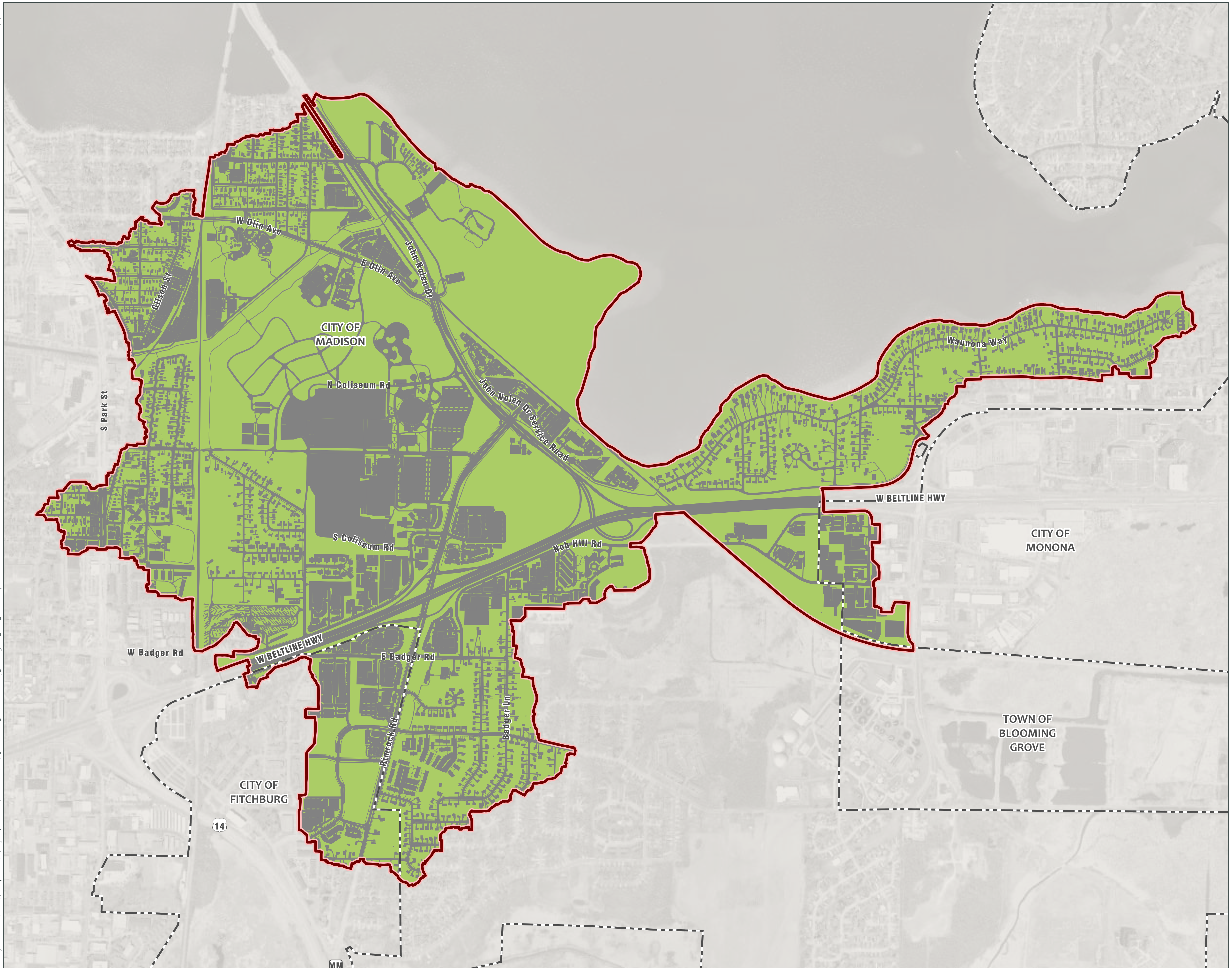
0 0.13 0.25 Miles

Print Date: 8/7/2024
Printed By: aconverse, File: \\msa-ps.com\fs\Project\00\00373\00373127\GIS\7_JohnNolen_WatershedStudy_FinalFigures_1-10_SiteData.aprx

2D Land Use

FIGURE 10
John Nolen Watershed
Study Report

City of Madison
Dane County, WI



Watershed Study Area
Municipalities
Impervious
Turf Grass

Data Sources:
Aerial: City of Madison (2022)
Watershed Boundaries: MSA
Impervious Areas: City of Madison supplemented by MSA

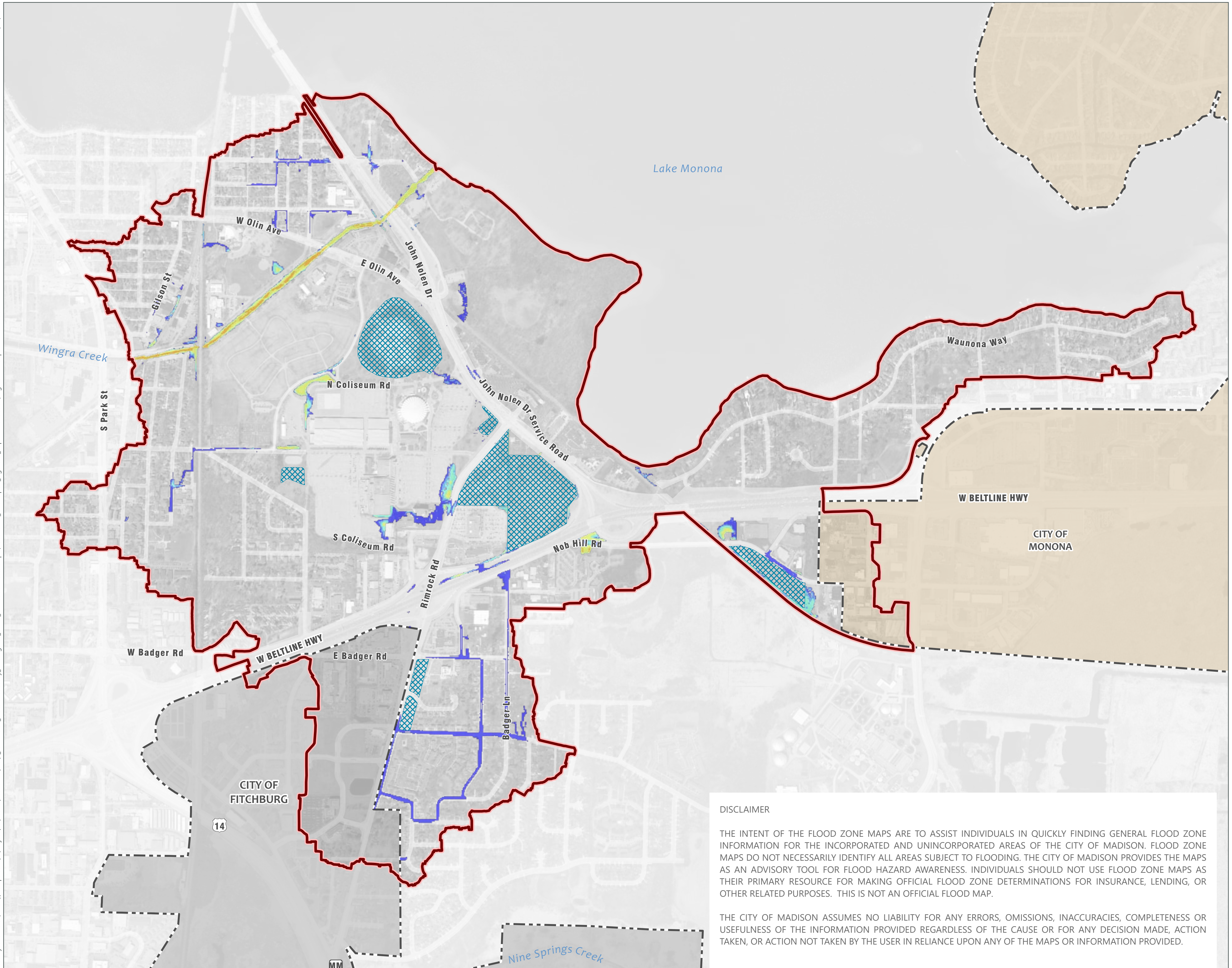
MSA

0 0.13 0.25 Miles

50% AEP Inundation

FIGURE 11
John Nolen Watershed
Study Report

City of Madison
Dane County, WI



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Watershed Study Area
City of Fitchburg
City of Monona
Greenway/Pond

Maximum Water Depth (ft)

0.1 - 0.3
0.3 - 0.5
0.6 - 1
1.1 - 3
3.1 - 6
6.1+

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

MSA

0 0.1 0.2 Miles

N

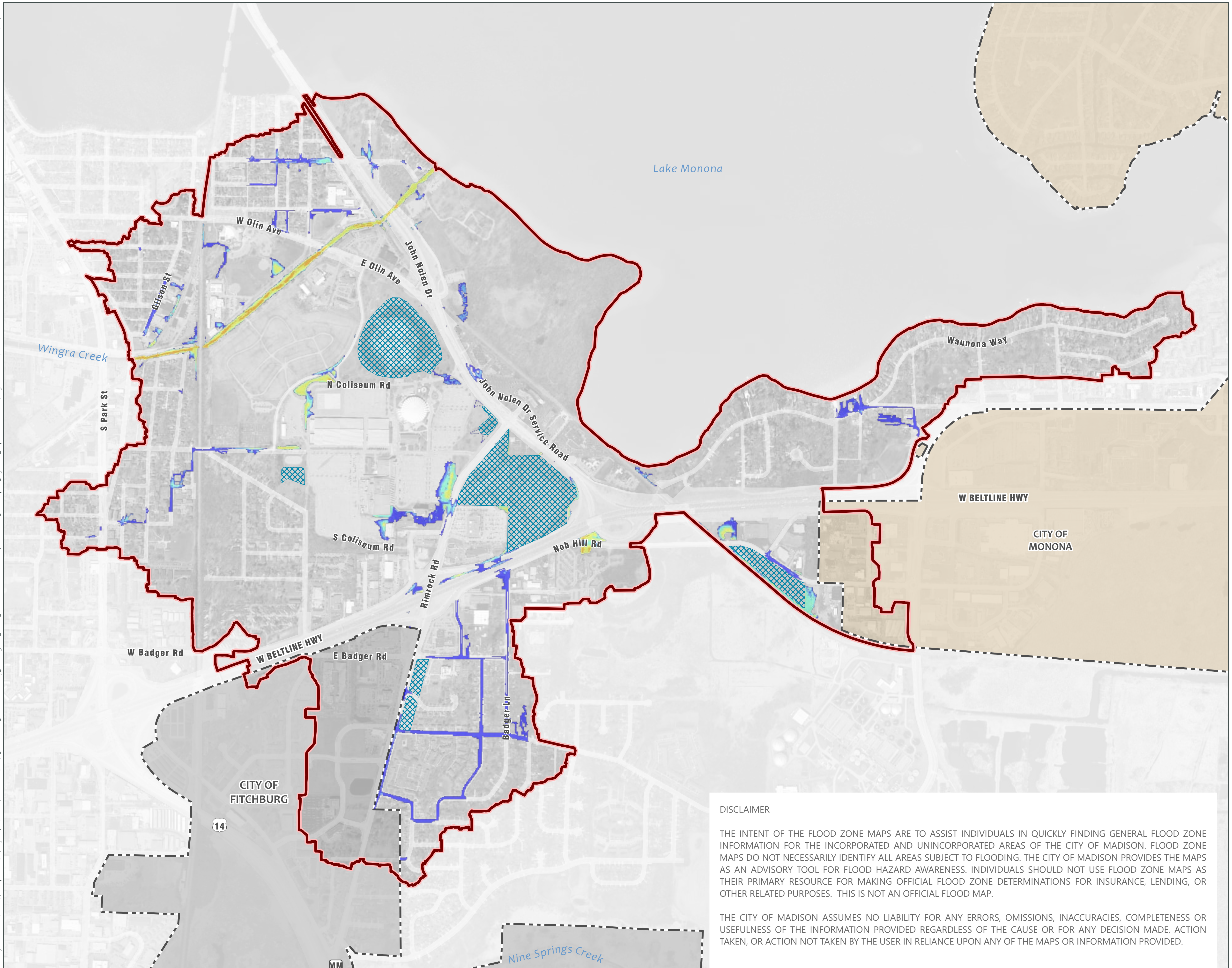
Print Date: 4/24/2025

Printed By: aconverse, File: \\msa-ps.com\fs\Project\00\00373\00373127\GIS\7_JohnNolen_WatershedStudy_FinalFigures_11-19_InundationRasters.aprx, 00373127_FinalReport_Figure11_50pAEPInundation, Figure 11 - 50p AEP Inundation

20% AEP Inundation

FIGURE 12
John Nolen Watershed
Study Report

City of Madison
Dane County, WI



- Watershed Study Area
- City of Fitchburg
- City of Monona
- Greenway/Pond

Maximum Water Depth (ft)

- 0.1 - 0.3
- 0.3 - 0.5
- 0.6 - 1
- 1.1 - 3
- 3.1 - 6
- 6.1+

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

MSA

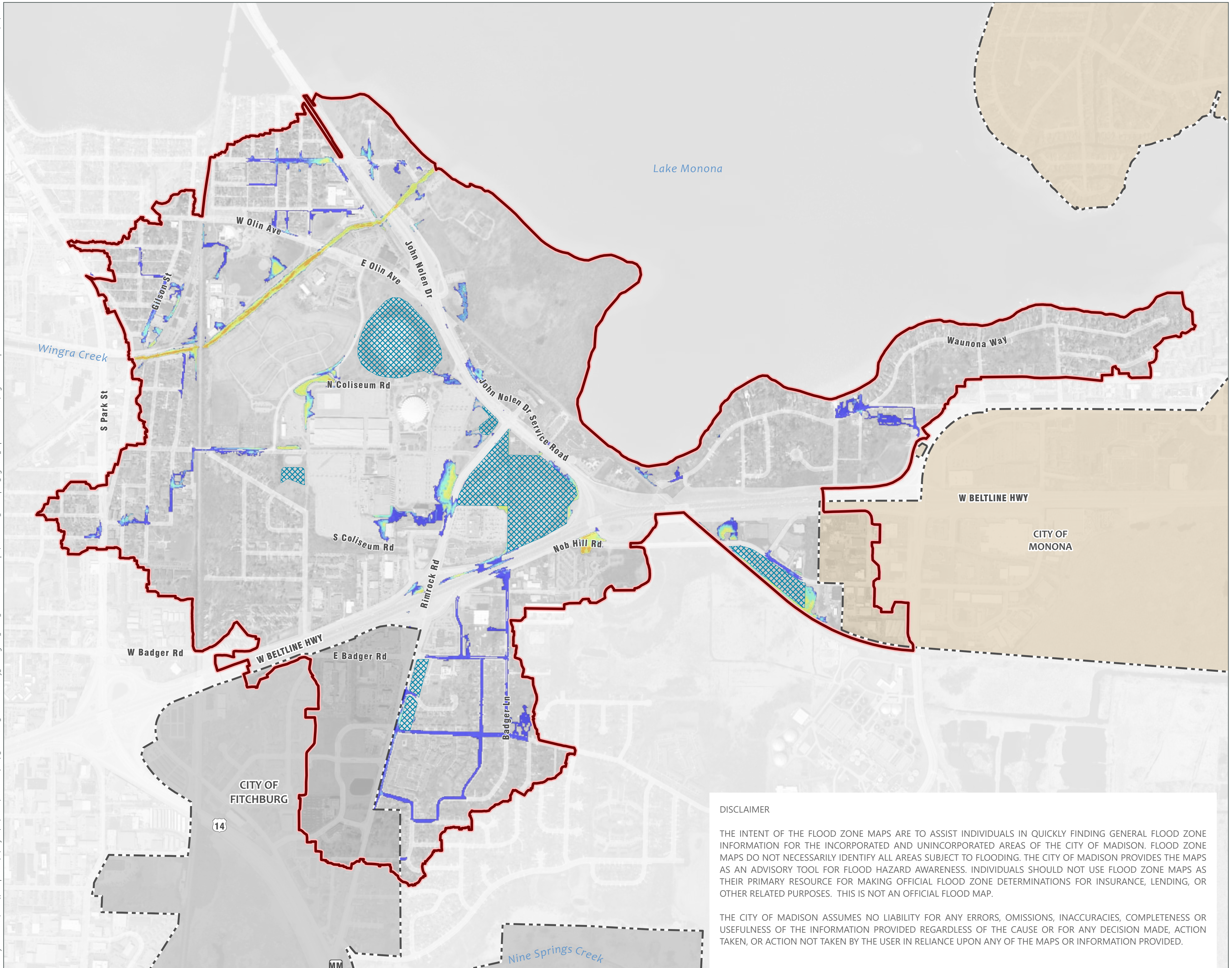
0 0.1 0.2 Miles

N

10% AEP Inundation

FIGURE 13
John Nolen Watershed
Study Report

City of Madison
Dane County, WI



Watershed Study Area
City of Fitchburg
City of Monona
Greenway/Pond

Maximum Water Depth (ft)

- 0.1 - 0.3
- 0.3 - 0.5
- 0.6 - 1
- 1.1 - 3
- 3.1 - 6
- 6.1+

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

MSA

0 0.1 0.2 Miles

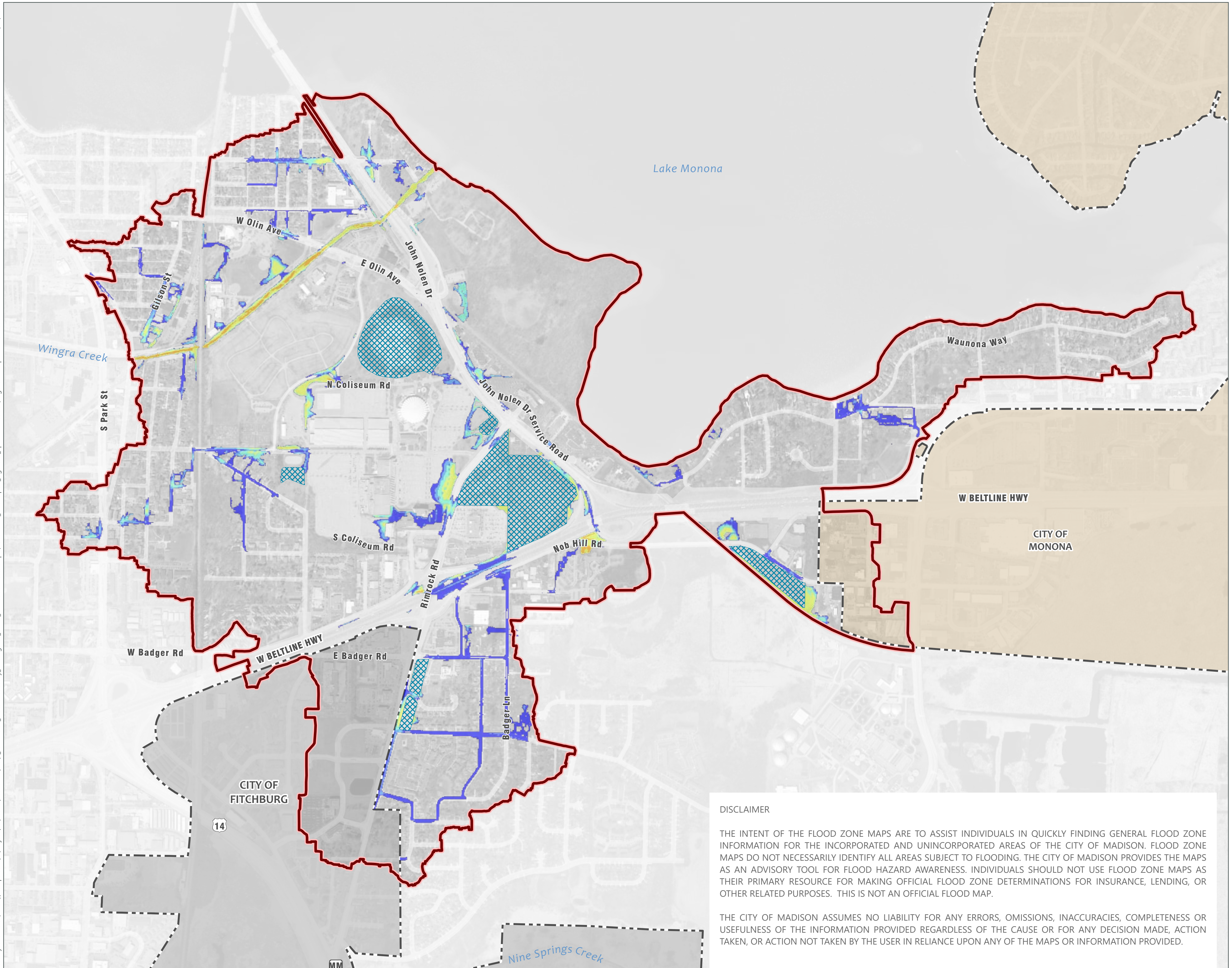
N

Print Date: 4/24/2025

4% AEP Inundation

FIGURE 14
John Nolen Watershed
Study Report

City of Madison
Dane County, WI



Watershed Study Area
City of Fitchburg
City of Monona
Greenway/Pond

Maximum Water Depth (ft)

- 0.1 - 0.3
- 0.3 - 0.5
- 0.6 - 1
- 1.1 - 3
- 3.1 - 6
- 6.1+

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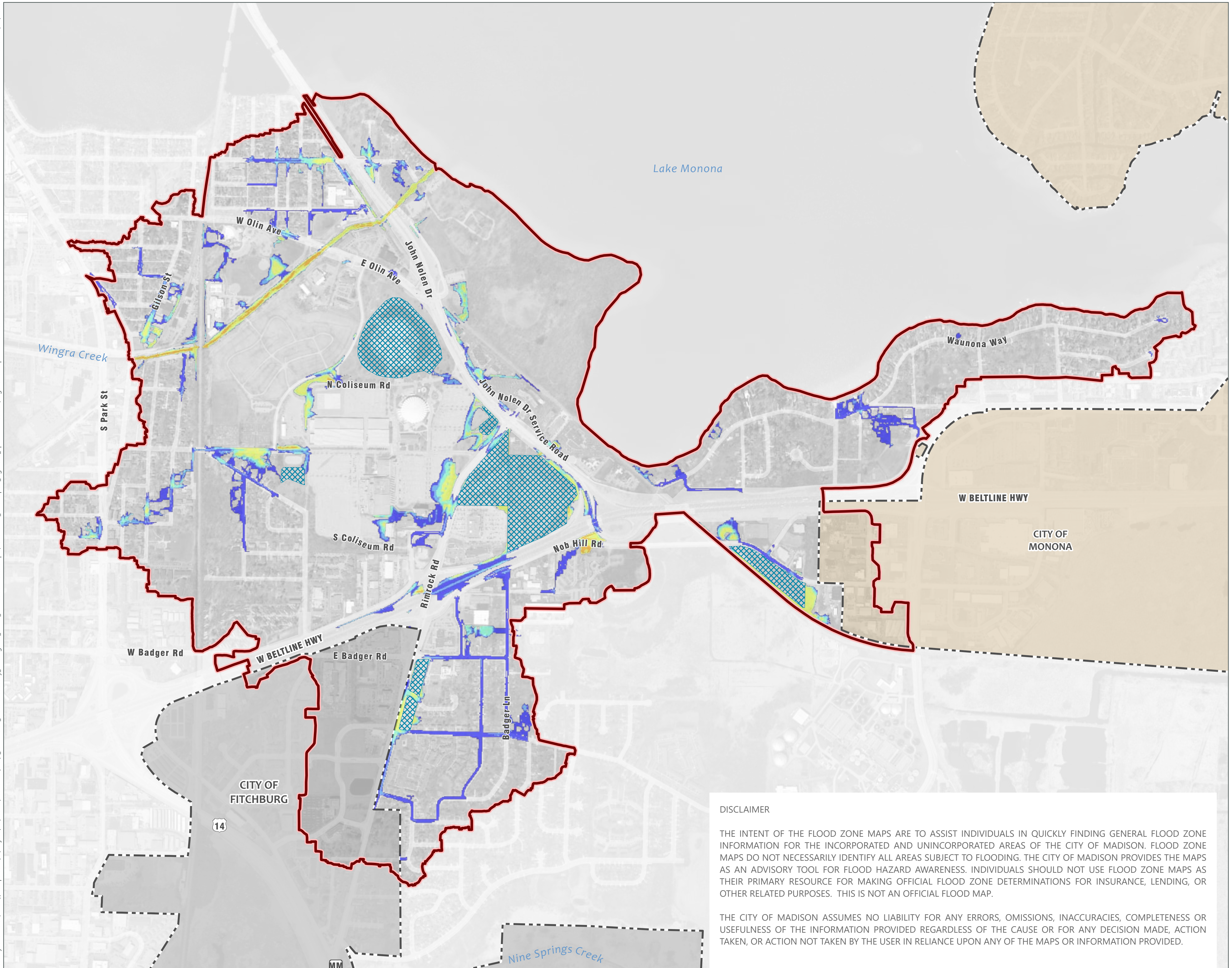
Data Sources:
Aerial: City of Madison (2022)
Watershed Boundaries: MSA
Stormwater System: City of Madison

MSA

0 0.1 0.2 Miles

N

Print Date: 4/24/2025



2% AEP Inundation

FIGURE 15
John Nolen Watershed
Study Report

City of Madison
Dane County, WI

- Watershed Study Area
- City of Fitchburg
- City of Monona
- Greenway/Pond

Maximum Water Depth (ft)

- 0.1 - 0.3
- 0.3 - 0.5
- 0.6 - 1
- 1.1 - 3
- 3.1 - 6
- 6.1+

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

MSA

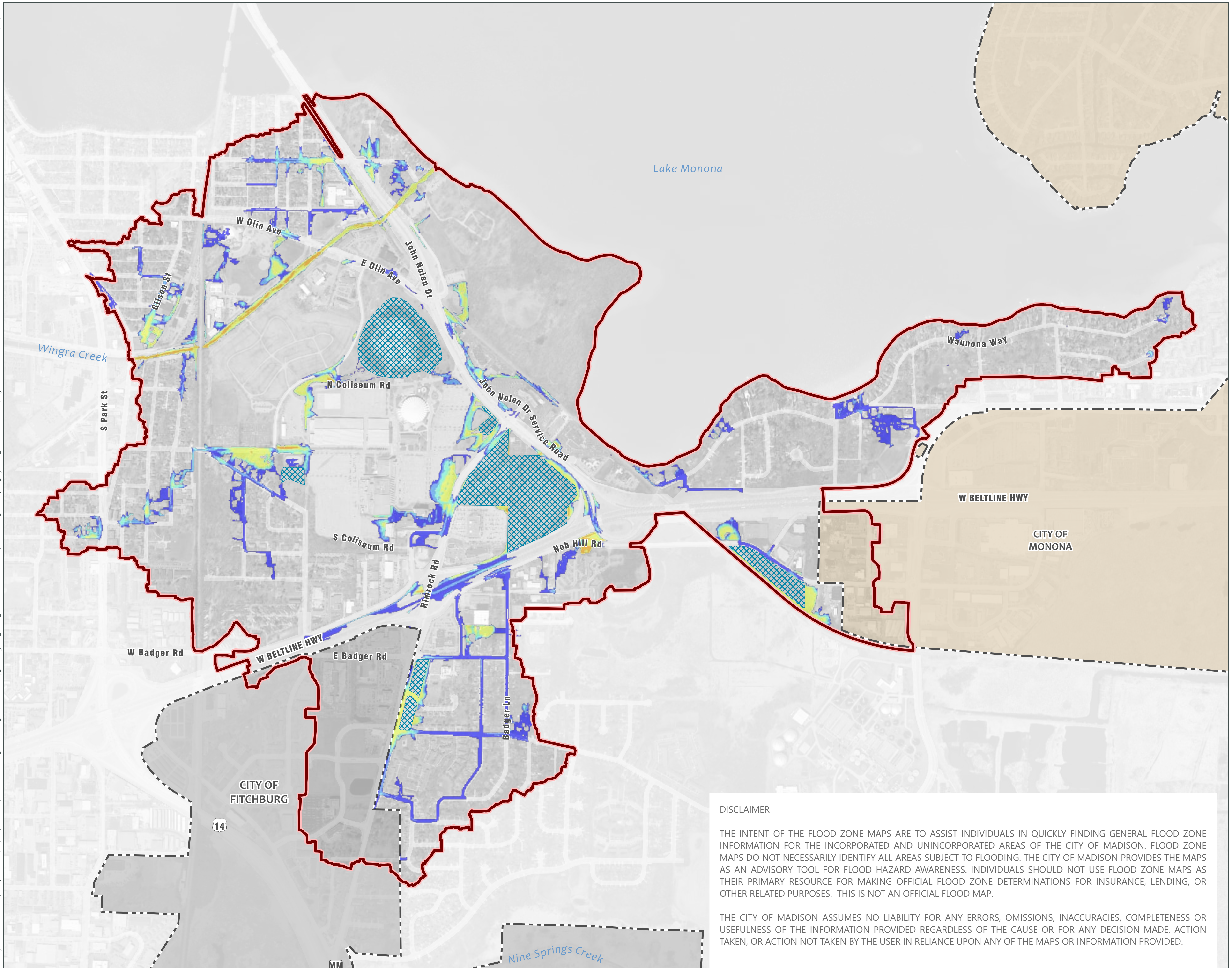
0 0.1 0.2 Miles

N

1% AEP Inundation

FIGURE 16
John Nolen Watershed
Study Report

City of Madison
Dane County, WI



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Watershed Study Area
City of Fitchburg
City of Monona
Greenway/Pond

Maximum Water Depth (ft)

0.1 - 0.3
0.3 - 0.5
0.6 - 1
1.1 - 3
3.1 - 6
6.1+

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

MSA

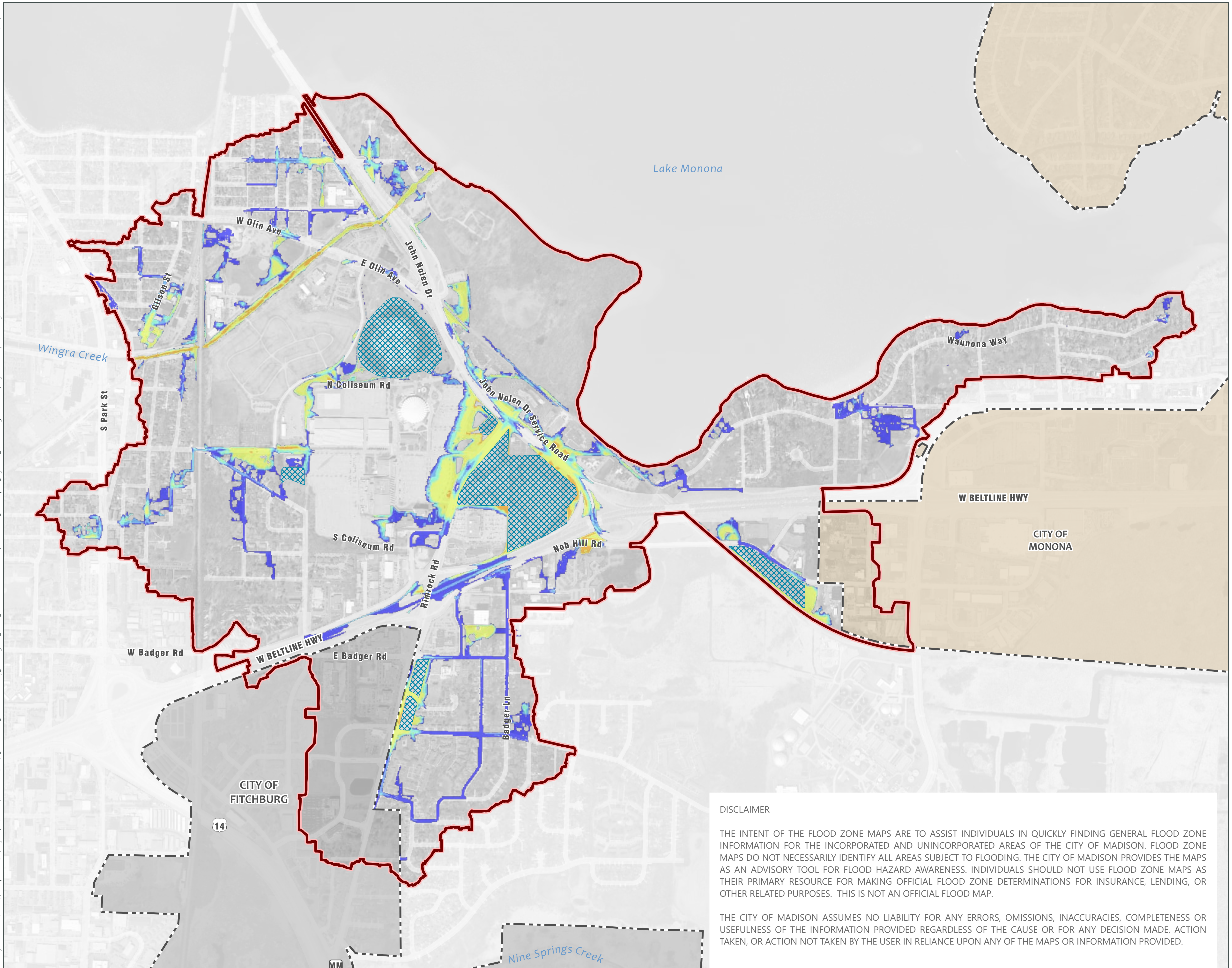
0 0.1 0.2 Miles

N

Long 1% AEP Inundation

FIGURE 17
John Nolen Watershed
Study Report

City of Madison
Dane County, WI



Watershed Study Area
City of Fitchburg
City of Monona
Greenway/Pond

Maximum Water Depth (ft)

- 0.1 - 0.3
- 0.3 - 0.5
- 0.6 - 1
- 1.1 - 3
- 3.1 - 6
- 6.1+

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

MSA

0 0.1 0.2 Miles

N

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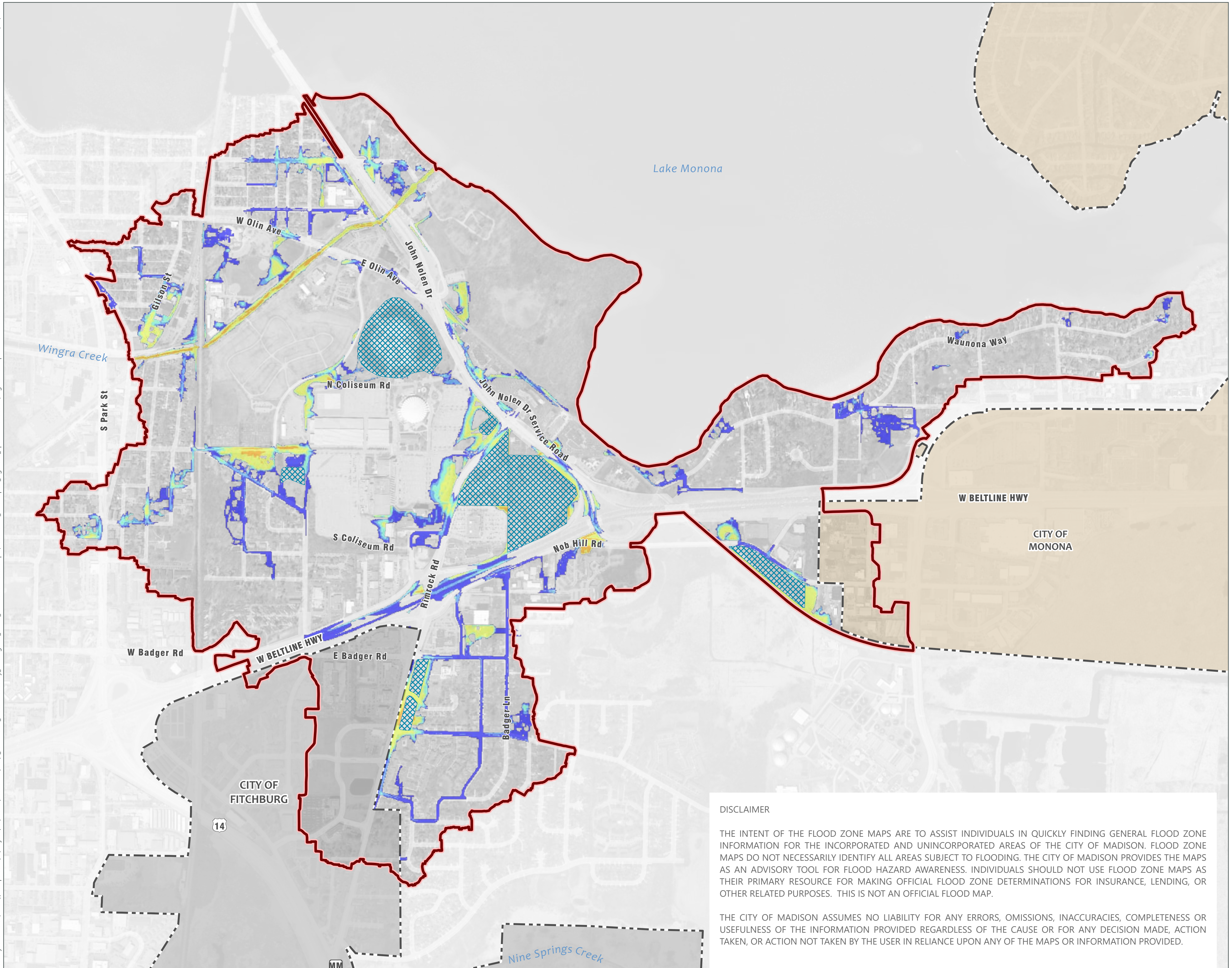
0.5% AEP Inundation

FIGURE 18
John Nolen Watershed
Study Report

City of Madison
Dane County, WI



Watershed Study Area
City of Fitchburg
City of Monona
Greenway/Pond

Maximum Water Depth (ft)

0.1 - 0.3
0.3 - 0.5
0.6 - 1
1.1 - 3
3.1 - 6
6.1+

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

MSA

0 0.1 0.2 Miles

N

Print Date: 4/24/2025

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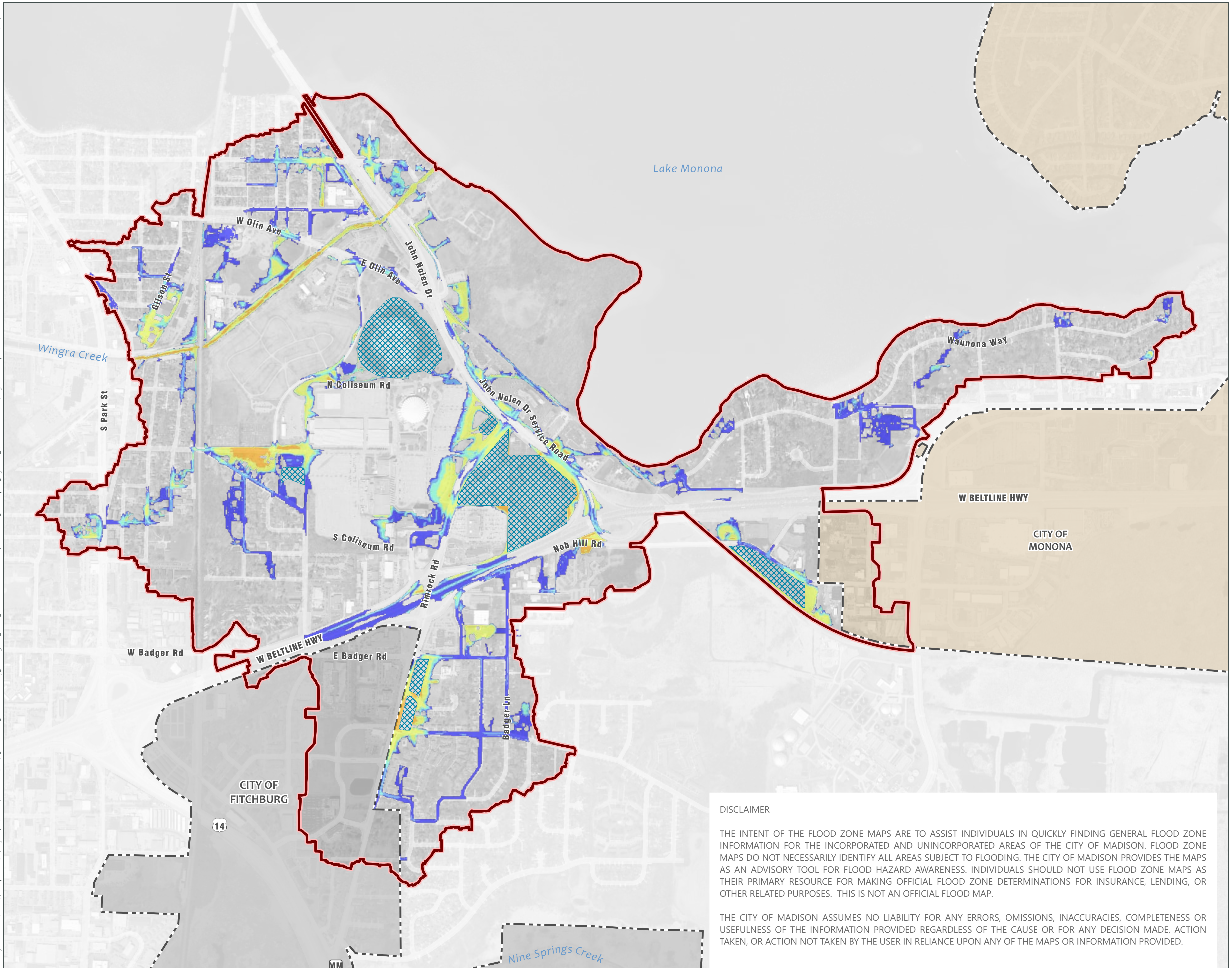

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0.2% AEP Inundation

FIGURE 19
John Nolen Watershed
Study Report

City of Madison
Dane County, WI

- Watershed Study Area
- City of Fitchburg
- City of Monona
- Greenway/Pond

Maximum Water Depth (ft)

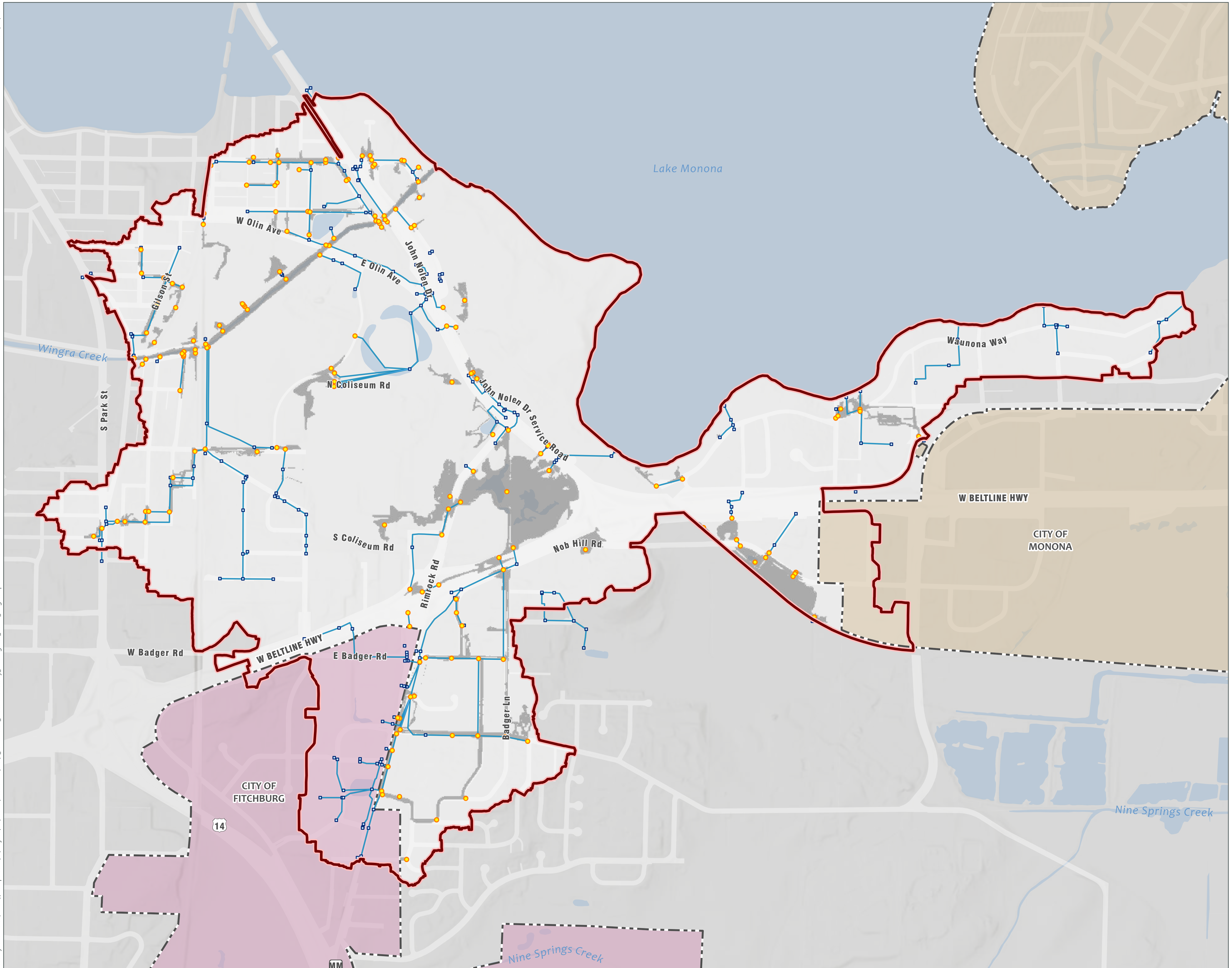
- 0.1 - 0.3
- 0.3 - 0.5
- 0.6 - 1
- 1.1 - 3
- 3.1 - 6
- 6.1+

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

MSA

0 0.1 0.2 Miles

N



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
John Nolen Watershed
Study Report

City of Madison
Dane County, WI

Watershed Study Area
City of Monona
City of Monona
Modeled Nodes
Street Surcharging at Modeled Node
Modeled Links
Inundation Extent, 10% AEP Event

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

MSA

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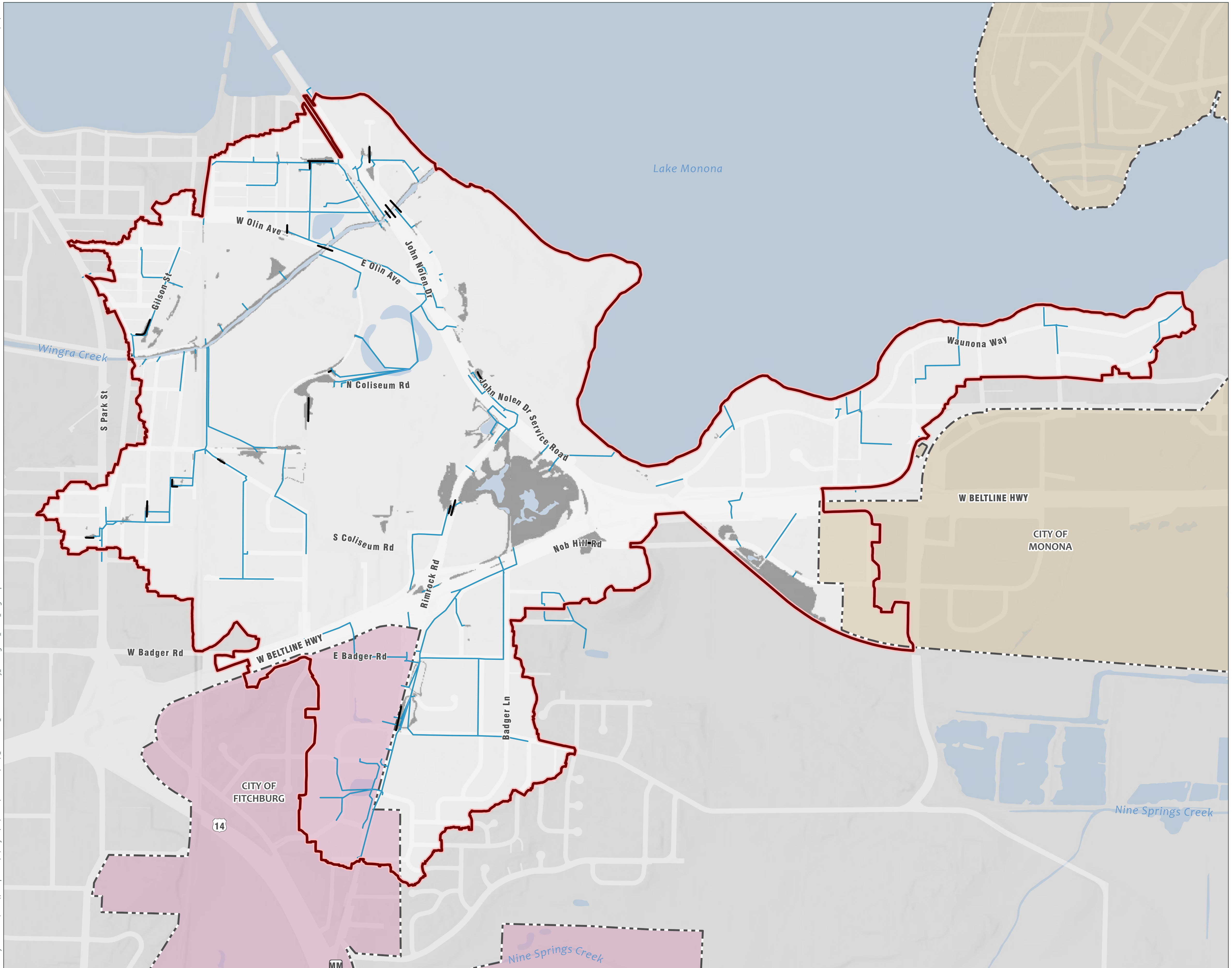


Target 2a

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

FIGURE 21
John Nolen Watershed
Study Report

City of Madison
Dane County, WI

- Watershed Study Area
- City of Monona
- City of Monona
- Modeled Links
- 0.5' or Greater Inundation at Centerline

4% AEP Storm

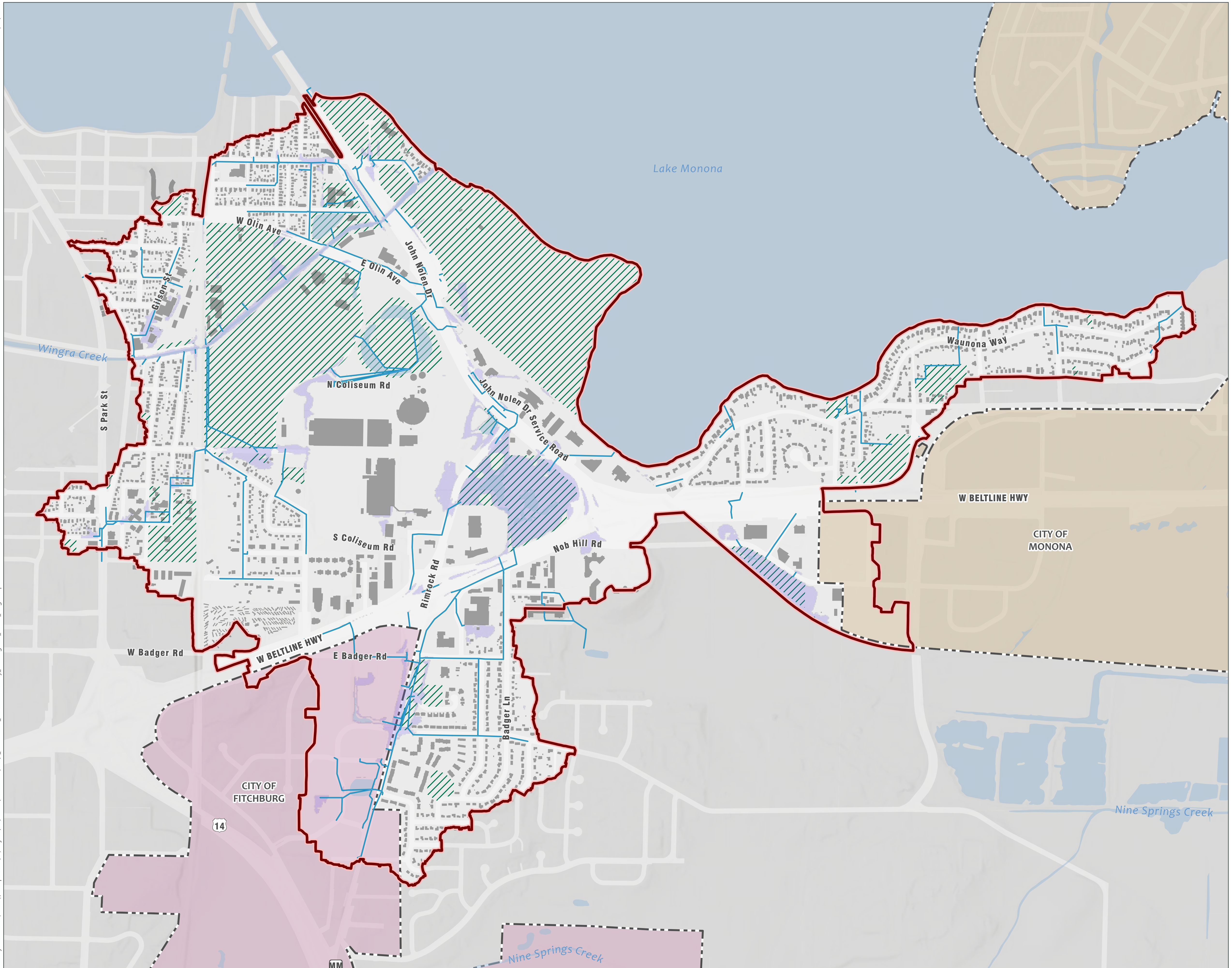
- Inundation > 0.5 ft

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

MSA

0 0.1 0.2 Miles

Print Date: 4/24/2025



Target 3a

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

FIGURE 22
John Nolen Watershed
Study Report

City of Madison
Dane County, WI

- Watershed Study Area
- City of Monona
- City of Monona
- SWU Lands & Parks
- Building Footprint
- Modeled Links

1% AEP Storm

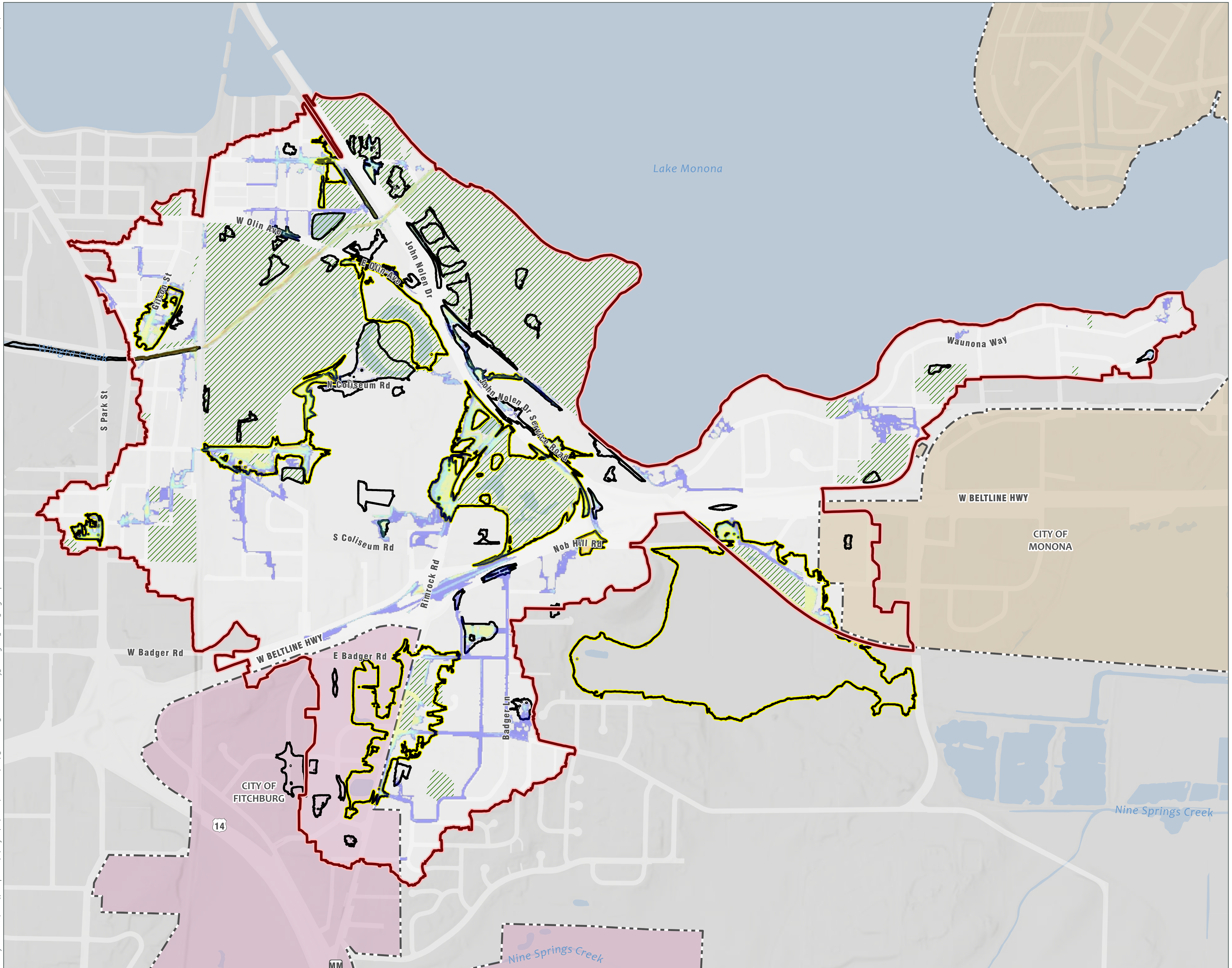
- Inundation >0.5 ft

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

MSA

0 0.1 0.2 Miles

Print Date: 4/24/2025
Printed By: aconverse, File: \\msa-ps.com\fs\Project\00\00373\00373127\GIS\7_JohnNolen_WatershedStudy_FinalFigures_20-25_Targets.aprx



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
John Nolen Watershed
Study Report

City of Madison
Dane County, WI

Watershed Study Area
City of Monona
City of Monona
SWU Lands & Parks
Modeled Links
Enclosed Depression
Enclosed Depression Not Meeting Criteria*

Flood Event Inundation Depth

0.1 - 0.3
0.3 - 0.5
0.6 - 1
1.1 - 3
3.1 - 6
6.1+

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

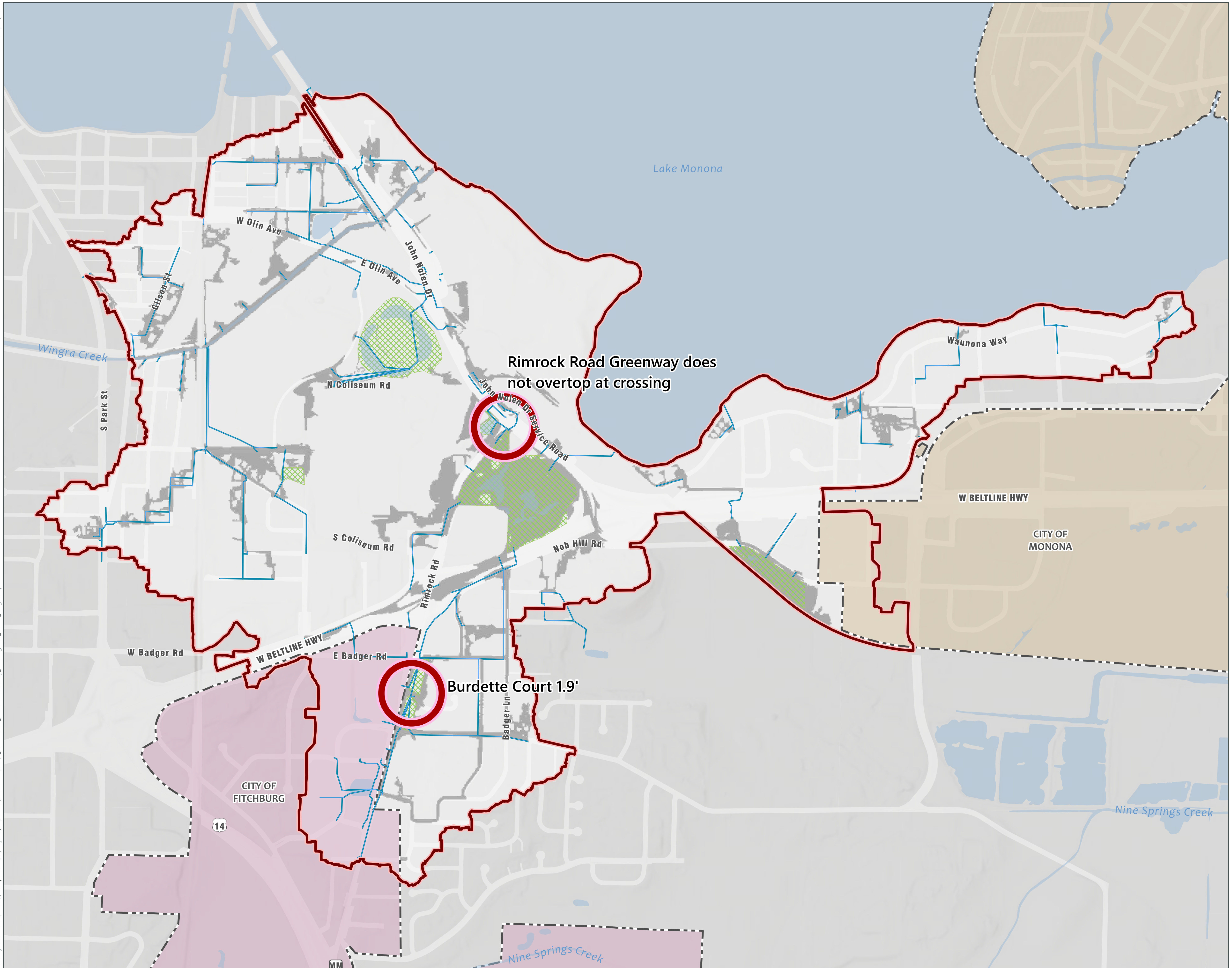
Print Date: 4/24/2025

Target 3c

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

FIGURE 24
John Nolen Watershed
Study Report

City of Madison
Dane County, WI



- Watershed Study Area
- City of Monona
- City of Monona
- Modeled Links
- Greenway Crossing
- City Greenway/Pond
- Lake/Pond

Flood Event Inundation Depth

- Inundation Extent, 1% AEP Event

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

MSA

0 0.1 0.2 Miles

Print Date: 4/24/2025

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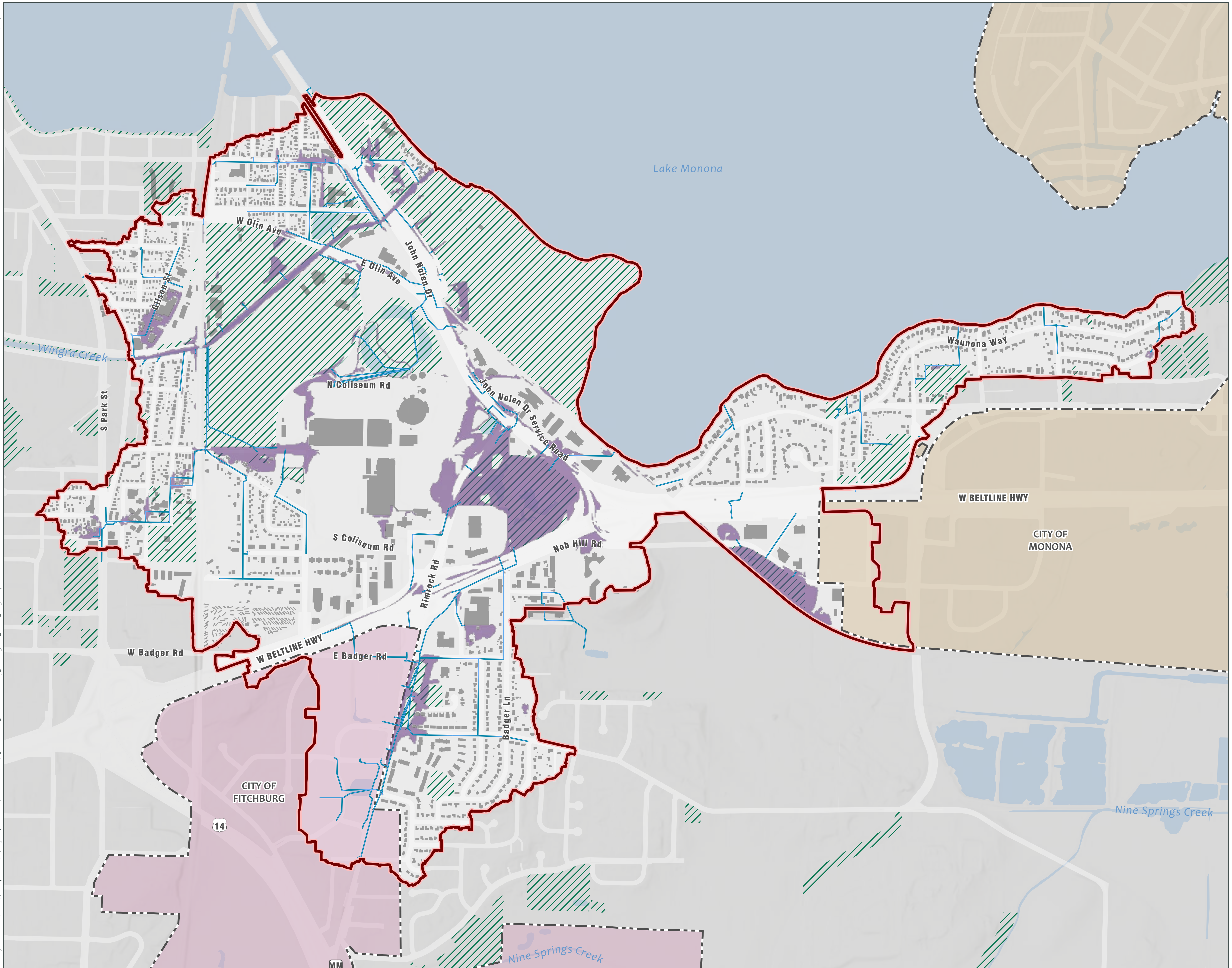

Target 4a

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

FIGURE 25
John Nolen Watershed
Study Report

City of Madison
Dane County, WI

- Watershed Study Area
- City of Monona
- City of Monona
- SWU Lands & Parks
- Building Footprint
- Modeled Links

0.2% AEP Storm

- Inundation > 0.5 ft

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

MSA

0 0.1 0.2 Miles

N

Print Date: 4/24/2025

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Date: 3/14/2025; Document Path: ; User Name: aconverse

Recommended Solutions Index

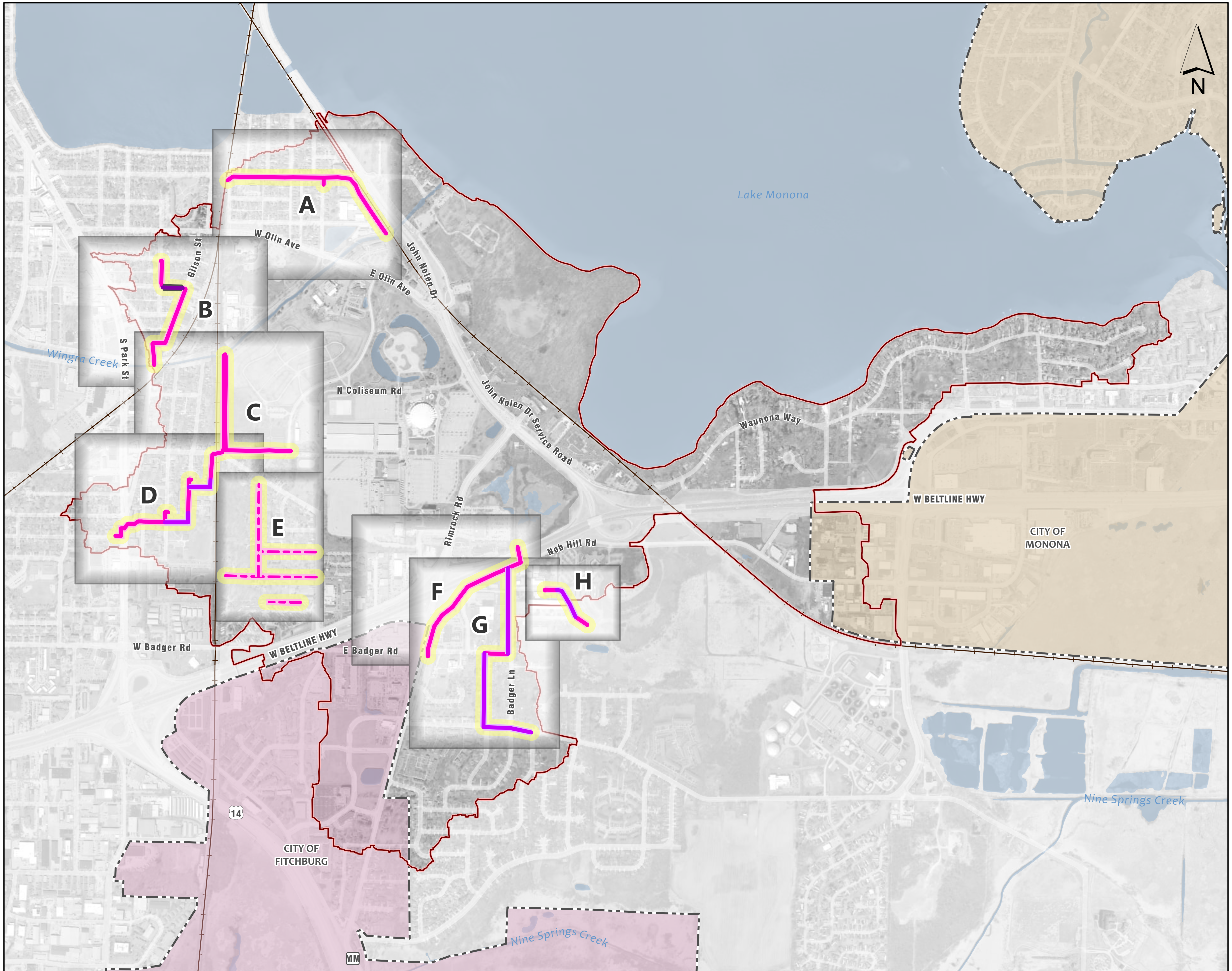

Figure 26

John Nolen Watershed Study
City of Madison

- Map Extents (Figures 27A - H)
- Watershed Study Area
- City of Monona
- City of Monona
- Lake/Pond
- Railroad
- Improvement Area of Interest

Proposed Storm Improvement

- New
- Special
- Upsize
- Proposed Street Improvement

0 435 870 1,740 Feet

CITY OF MADISON ENGINEERING

\\msa-ps.com\fs\Project\00\00373\00373127\GIS\7_JohnNolen_WatershedStudy_FinalFigures_ProposedSolutions.aprx

Date: 5/9/2025; User Name: aconverse

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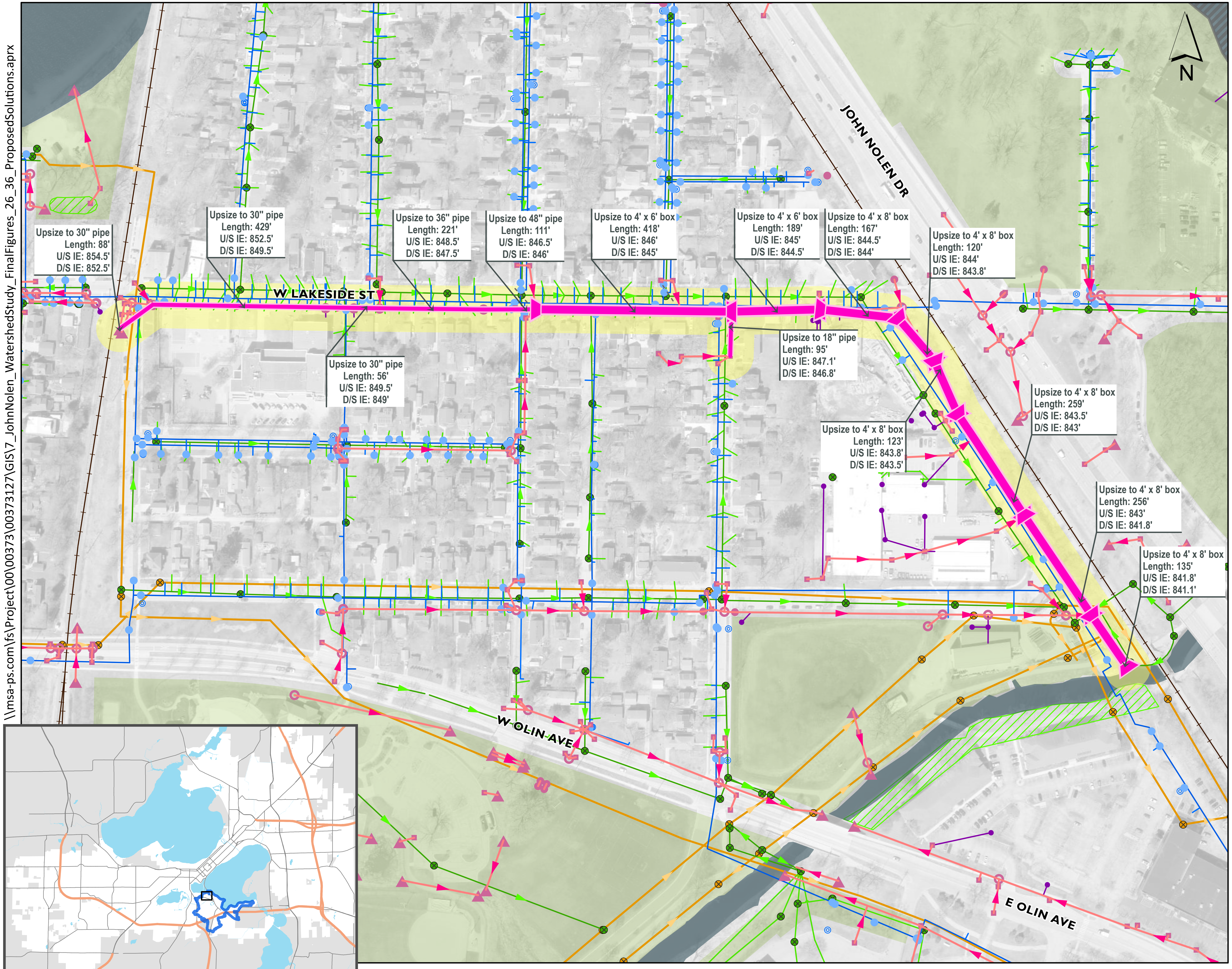

W Lakeside and Sayle St Storm System Improvements

Figure 27 - A

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

- Outside of City of Madison
- Park
- City of Madison Ponds/Greenways
- Waterbody
- Railroad
- **Improvement Area of Interest**
- Increased Inlet Capacity

Proposed Storm Box
- Upsize

Proposed Storm Pipes
- Upsize

0 50 100 200 Feet

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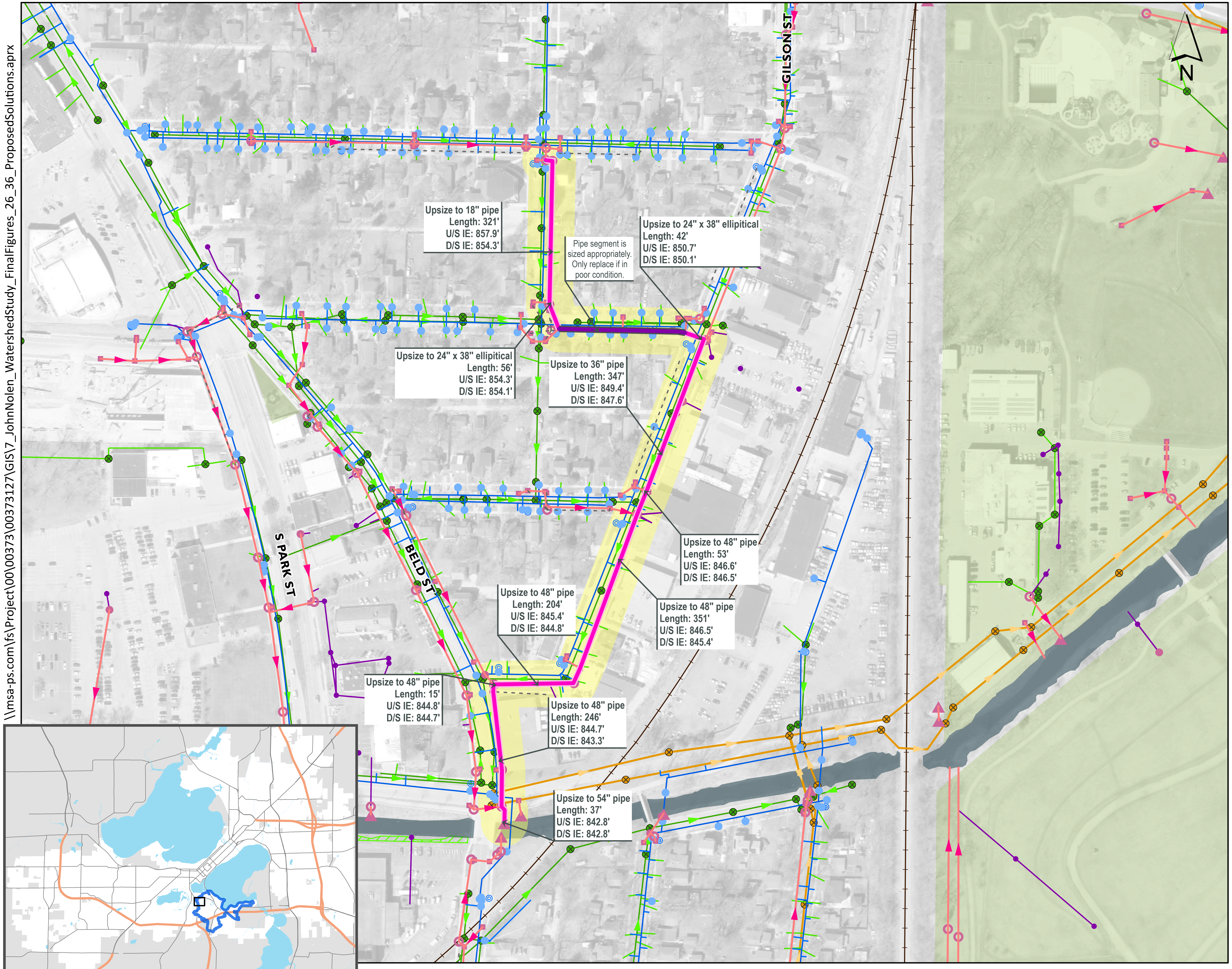
Gilson St Storm System Improvements

Figure 27 - B

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
- City of Madison Ponds/Greenways
- Waterbody
- Railroad
- **Improvement Area of Interest**
- Increased Inlet Capacity

Proposed Storm Pipes
- Special
- Upsize

0 50 100 200 Feet

CITY OF MADISON ENGINEERING

Date: 5/9/2025; User Name: aconverse

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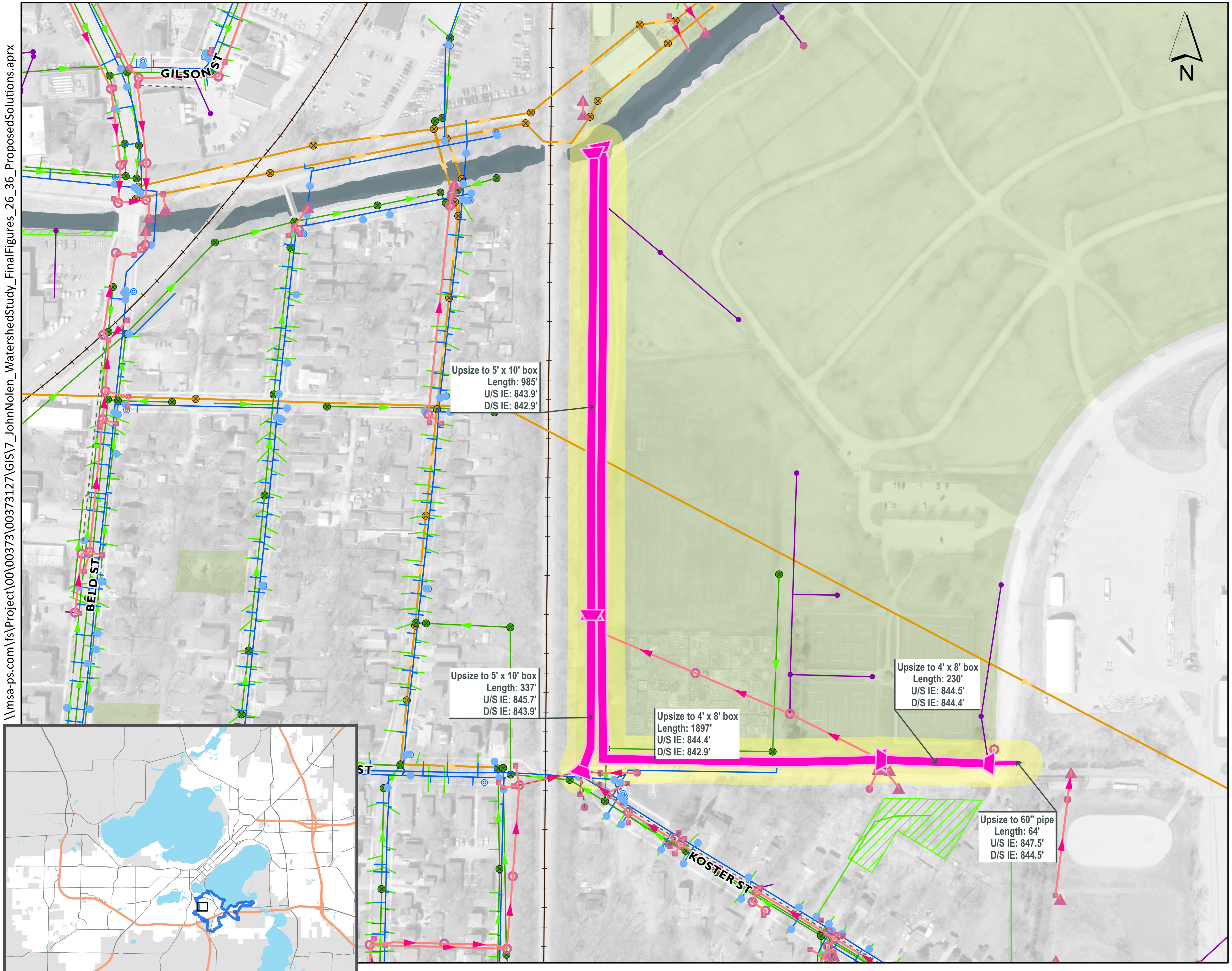

Bram to Wingra and Alliant Energy Outlet Improvements

Figure 27 - C

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
- City of Madison Ponds/Greenways
- Waterbody
- Railroad
- **Improvement Area of Interest**
- Increased Inlet Capacity

Proposed Storm Box
- Upsize

Proposed Storm Pipes
- Upsize

0 50 100 200 Feet

CITY OF MADISON ENGINEERING

Date: 5/9/2025; User Name: aconverse

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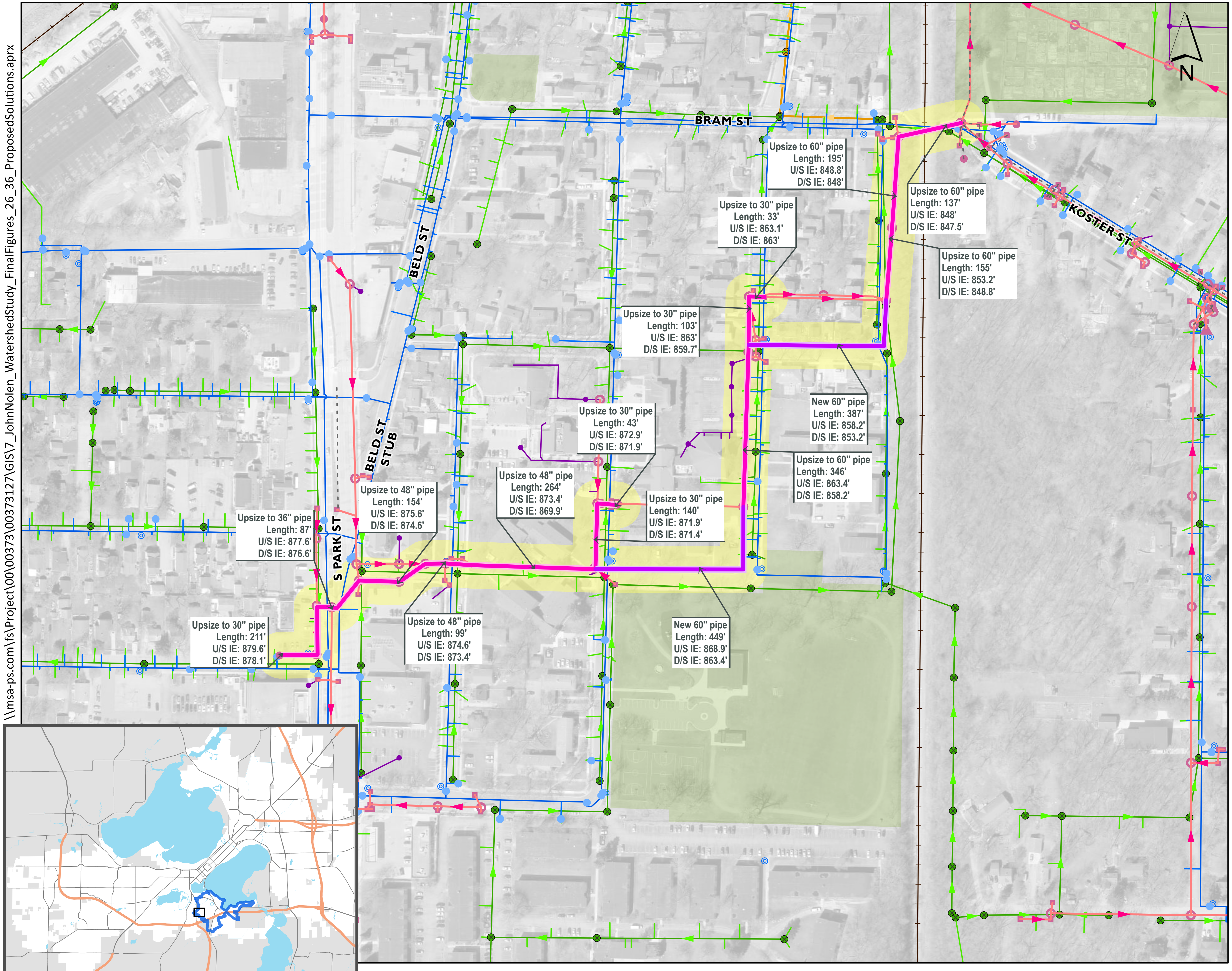

Brams Addition Storm System Improvement

Figure 27 - D

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
- City of Madison Ponds/Greenways
- Waterbody
- Railroad
- **Improvement Area of Interest**
- Increased Inlet Capacity

Proposed Storm Pipes
- New
- Upsize

0 50 100 200 Feet

CITY OF MADISON ENGINEERING

Date: 5/9/2025; User Name: aconverse

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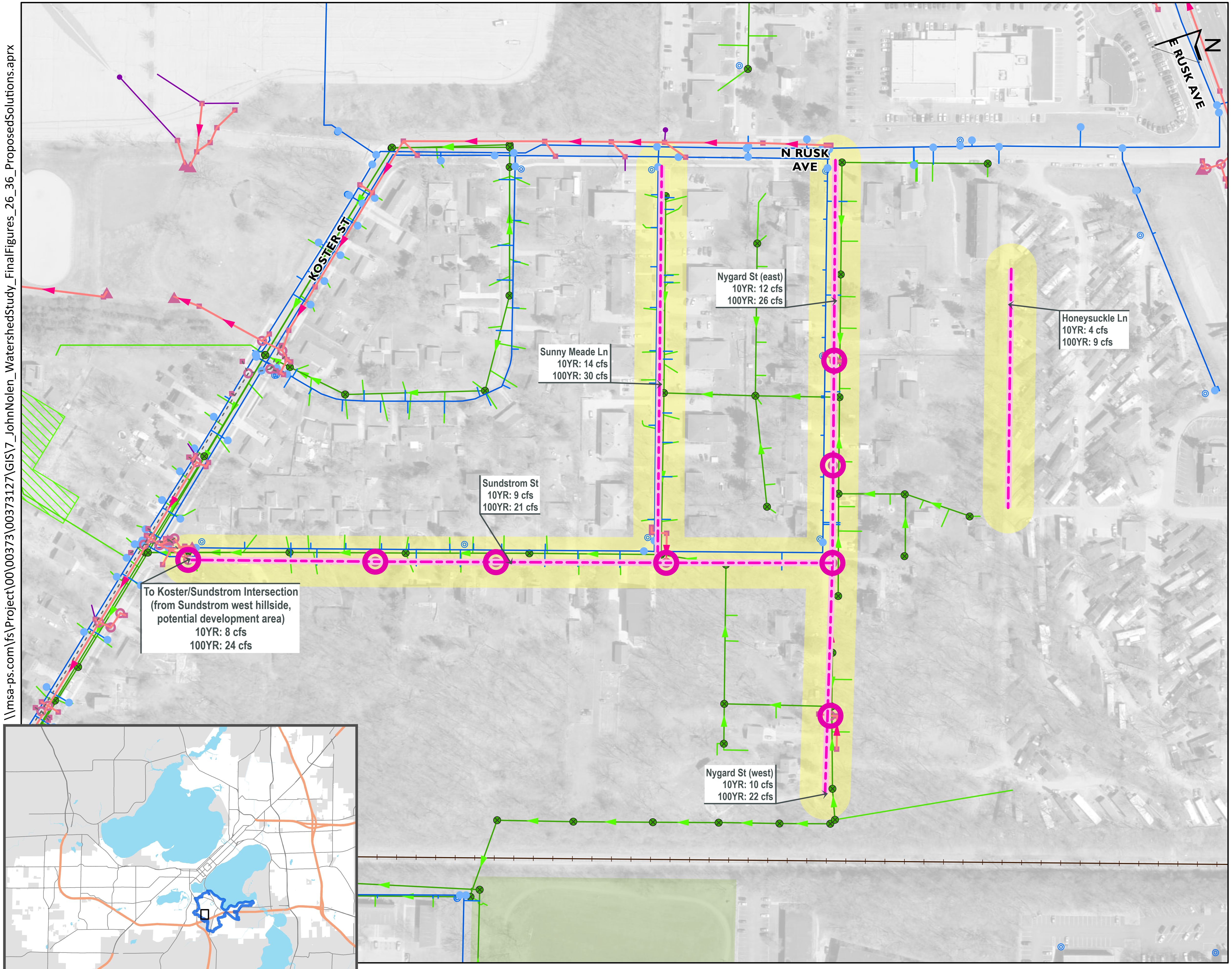
Nygard and Sundstrom St Improvements

Figure 27 - E

Location
City of Madison



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

Water System
- Water Main/Service
- Valve
- Hydrant

Sanitary System
- Sanitary Main
- Lateral
- Access

- Park
- City of Madison Ponds/Greenways
- Waterbody
- Railroad
- **Improvement Area of Interest**
- Increased Inlet Capacity
- Proposed Street Improvement

0 45 90 180 Feet

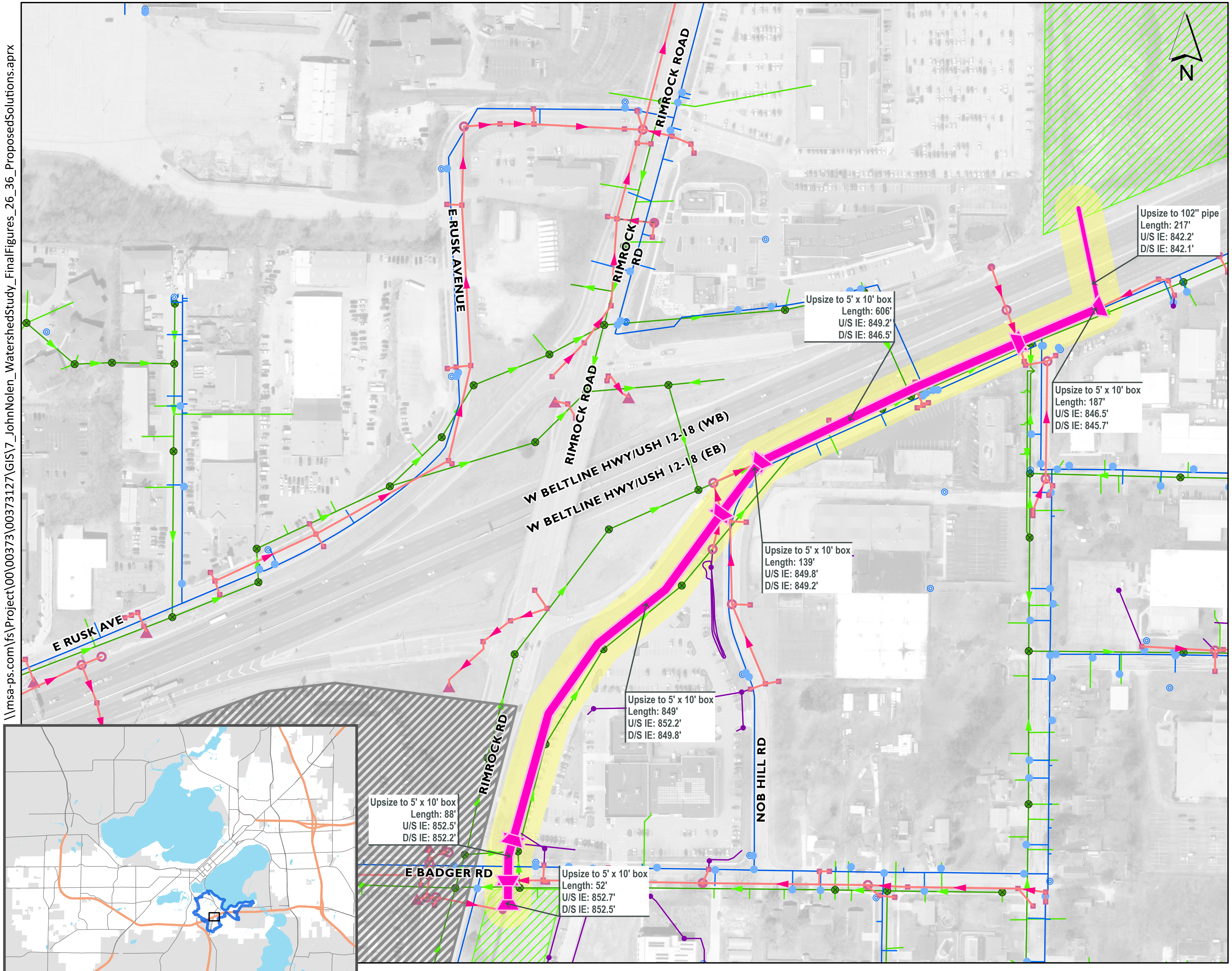
Date: 5/9/2025; User Name: aconverse

\\msa-ps.com\fs\Project\00\00373\00373127\GIS\7_JohnNolen_WatershedStudy_FinalFigures_26_36_ProposedSolutions.aprx

Rimrock Pond Outlet Improvement

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

- Outside of City of Madison
- City of Madison Ponds/Greenways
- Waterbody
- Railroad
- **Improvement Area of Interest**
- Increased Inlet Capacity

Proposed Storm Box
- Upsize

Proposed Storm Pipes
- Upsize

0 50 100 200 Feet

CITY OF MADISON ENGINEERING

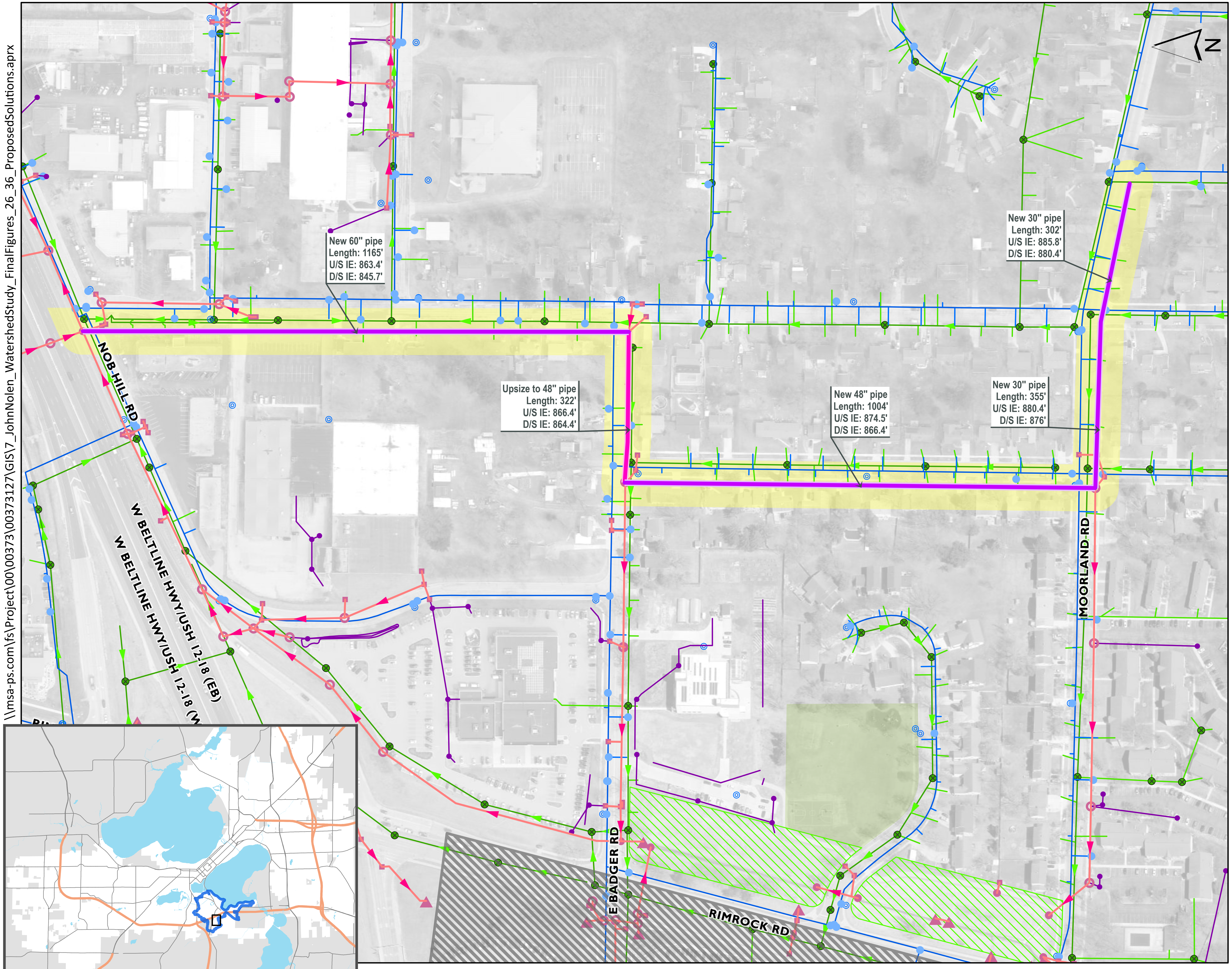
Date: 5/9/2025; User Name: aconverse

\\msa-ps.com\fs\Project\00\00373\00373127\GIS\7_JohnNolen_WatershedStudy_FinalFigures_26_36_ProposedSolutions.aprx

Badger Lane Storm System Improvements

Figure 27 - G

Location
City of Madison



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

Water System
- Water Main/Service
- Valve
- Hydrant

Sanitary System
- Sanitary Main
- Lateral
- Access

- Outside of City of Madison
- Park
- City of Madison Ponds/Greenways
- Waterbody
- Railroad
- **Improvement Area of Interest**
- Increased Inlet Capacity

Proposed Storm Pipes
- New
- Upsize

0 50 100 200 Feet

Date: 5/9/2025; User Name: aconverse

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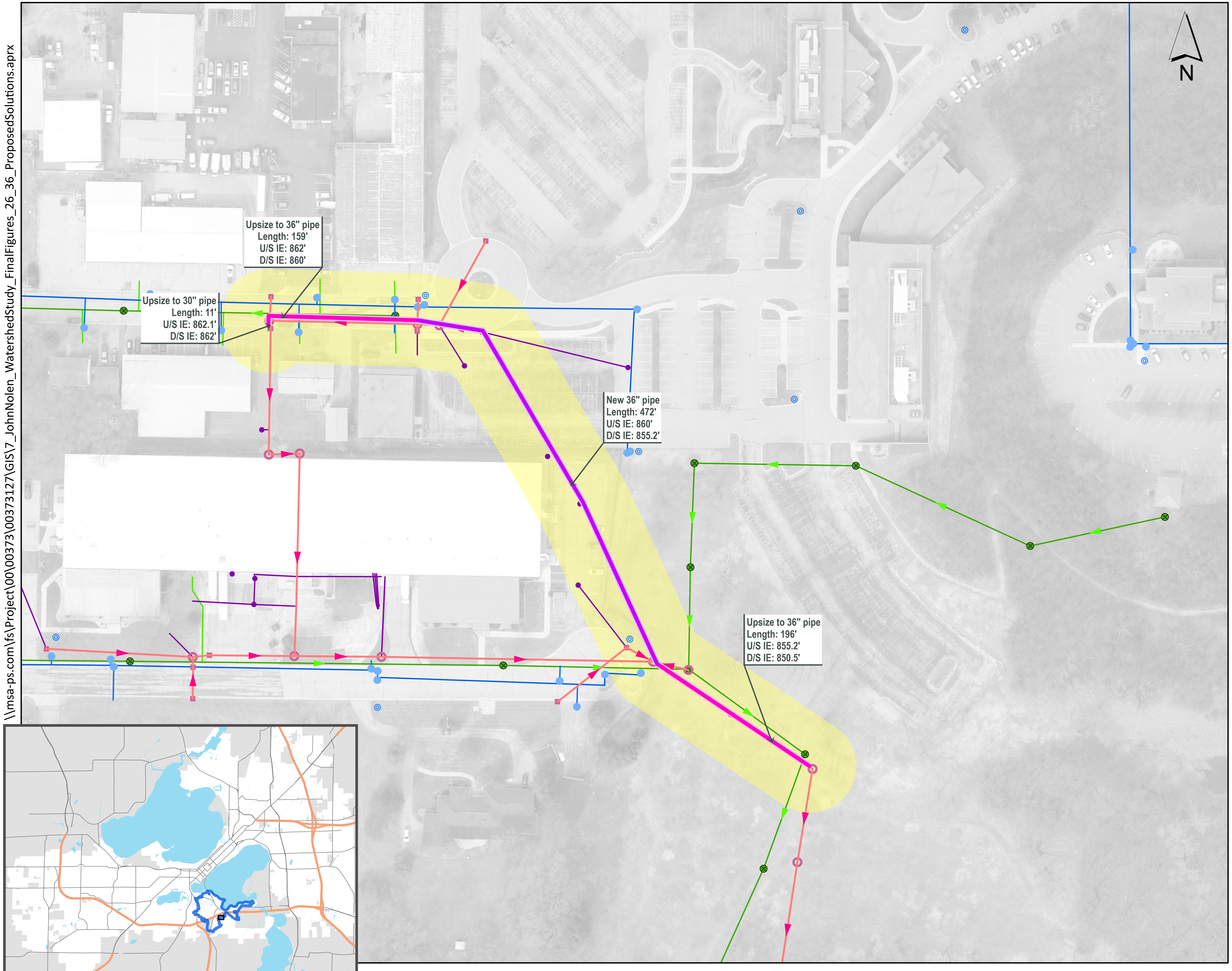


Holtzman Rd and Coyier Ln Storm System Improvements

Figure 27 - H

Location
City of Madison

Stormwater System
- Storm Pipe
- Inlet
- Access

Water System
- Water Main/Service
- Valve
- Hydrant

Sanitary System
- Sanitary Main
- Lateral
- Access

- Waterbody
- Railroad
- **Improvement Area of Interest**
- Increased Inlet Capacity

Proposed Storm Pipes
- New
- Upsize

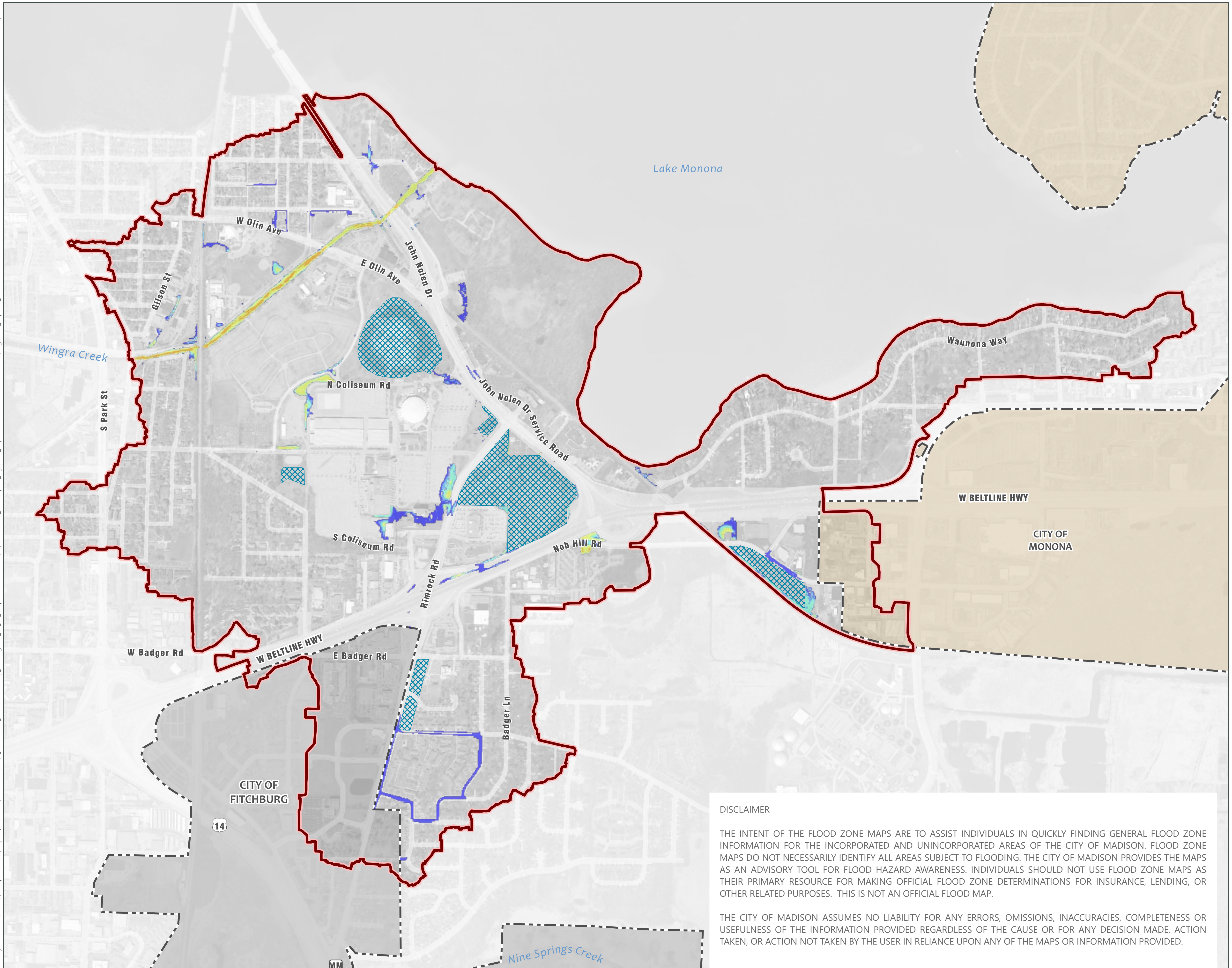
0 25 50 100 Feet

CITY OF MADISON ENGINEERING

50% AEP Inundation Recommended Conditions

FIGURE 28
John Nolen Watershed
Study Report

City of Madison
Dane County, WI



Watershed Study Area
City of Fitchburg
City of Monona
Greenway/Pond

Maximum Water Depth (ft)

- 0.1 - 0.3
- 0.3 - 0.5
- 0.6 - 1
- 1.1 - 3
- 3.1 - 6
- 6.1+

DISCLAIMER

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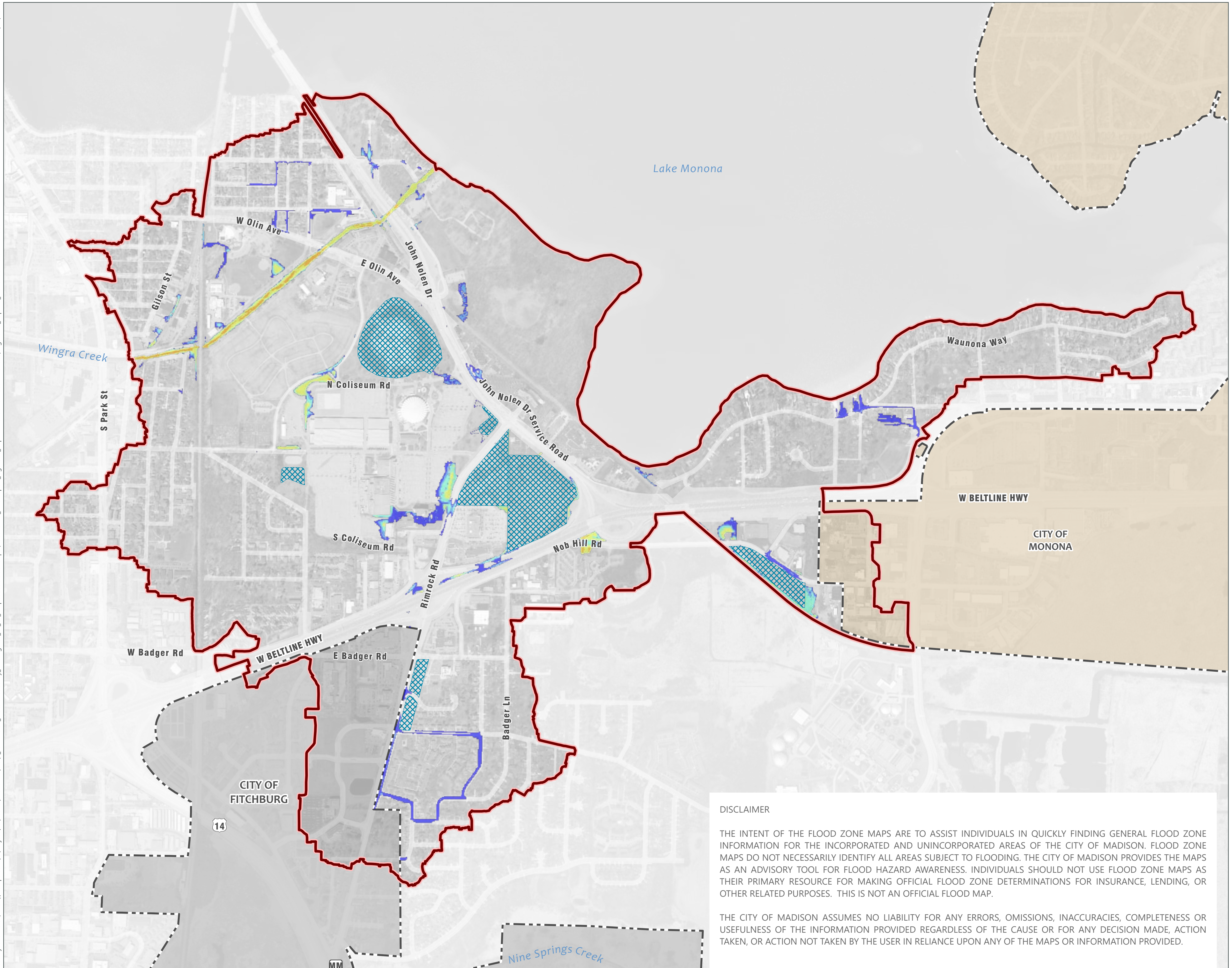
Data Sources:
Aerial: City of Madison (2022)
Watershed Boundaries: MSA
Stormwater System: City of Madison

MSA

0 0.1 0.2 Miles

N



20% AEP Inundation Recommended Conditions

FIGURE 29
John Nolen Watershed
Study Report

City of Madison
Dane County, WI

Watershed Study Area
City of Fitchburg
City of Monona
Greenway/Pond

Maximum Water Depth (ft)

0.1 - 0.3
0.3 - 0.5
0.6 - 1
1.1 - 3
3.1 - 6
6.1+

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

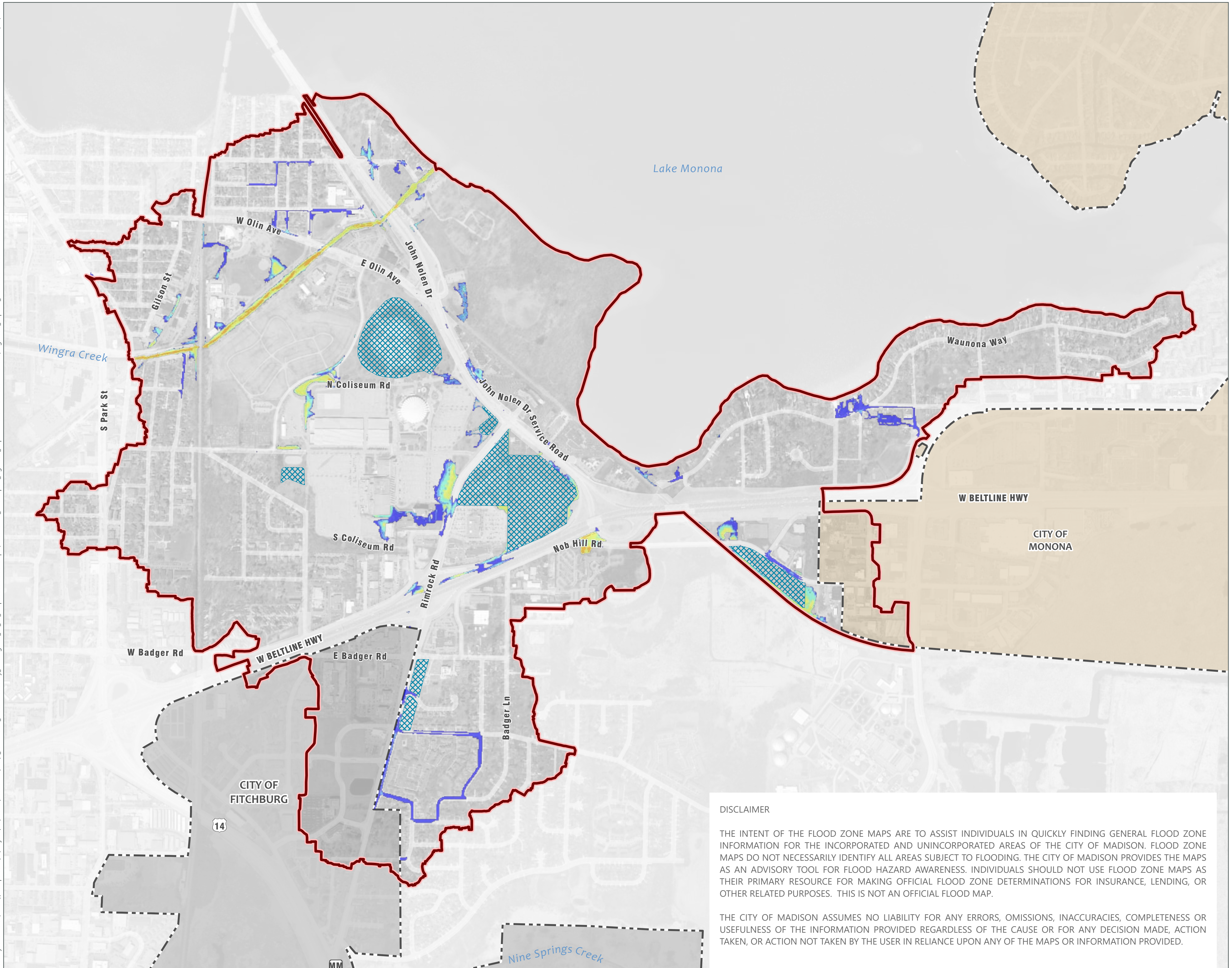
MSA

0 0.1 0.2 Miles

10% AEP Inundation Recommended Conditions

FIGURE 30
John Nolen Watershed
Study Report

City of Madison
Dane County, WI



Watershed Study Area
City of Fitchburg
City of Monona
Greenway/Pond

Maximum Water Depth (ft)

- 0.1 - 0.3
- 0.3 - 0.5
- 0.6 - 1
- 1.1 - 3
- 3.1 - 6
- 6.1+

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

MSA

0 0.1 0.2 Miles

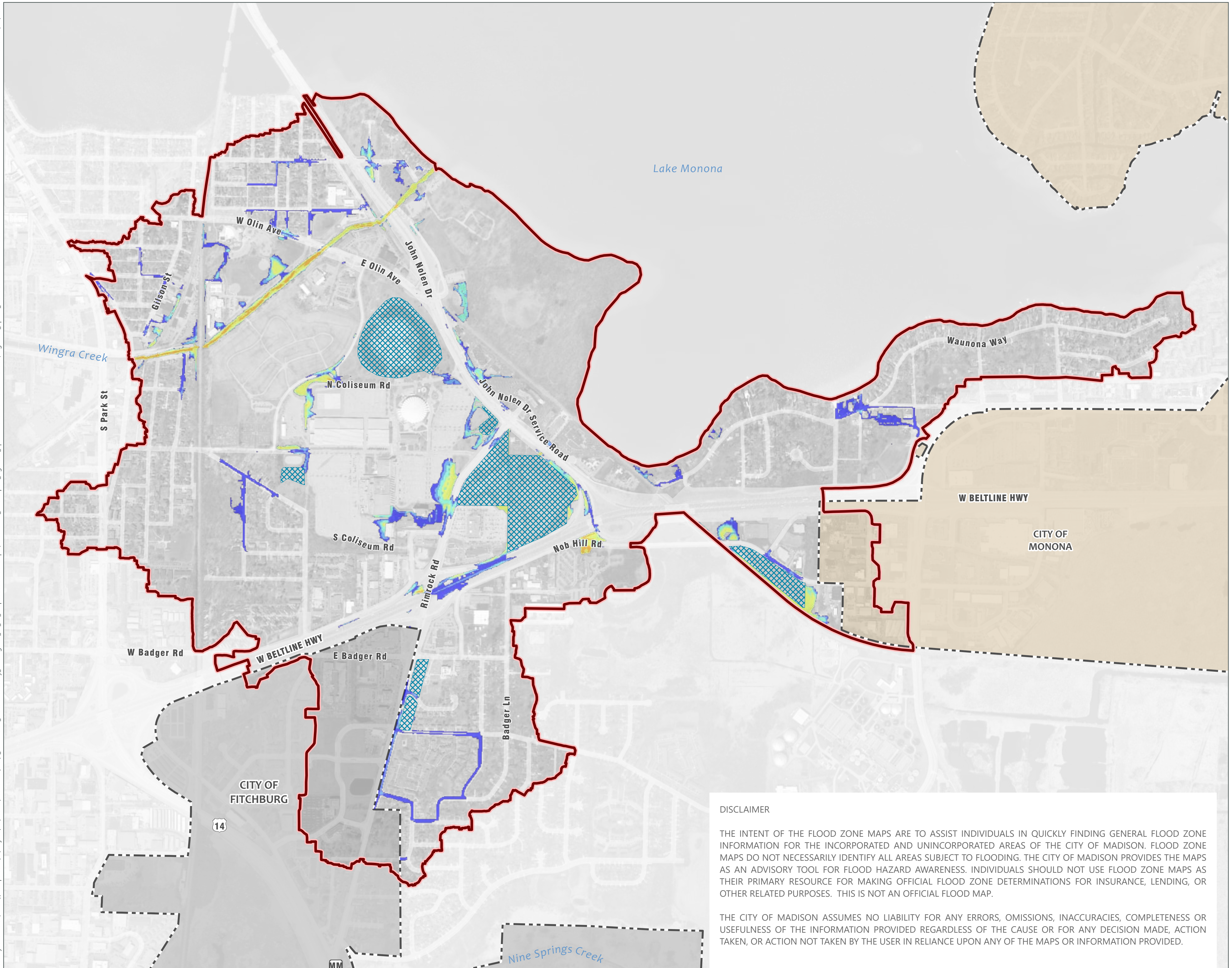
N

Print Date: 4/24/2025

4% AEP Inundation Recommended Conditions

FIGURE 31
John Nolen Watershed
Study Report

City of Madison
Dane County, WI



Watershed Study Area
City of Fitchburg
City of Monona
Greenway/Pond

Maximum Water Depth (ft)

- 0.1 - 0.3
- 0.3 - 0.5
- 0.6 - 1
- 1.1 - 3
- 3.1 - 6
- 6.1+

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

MSA

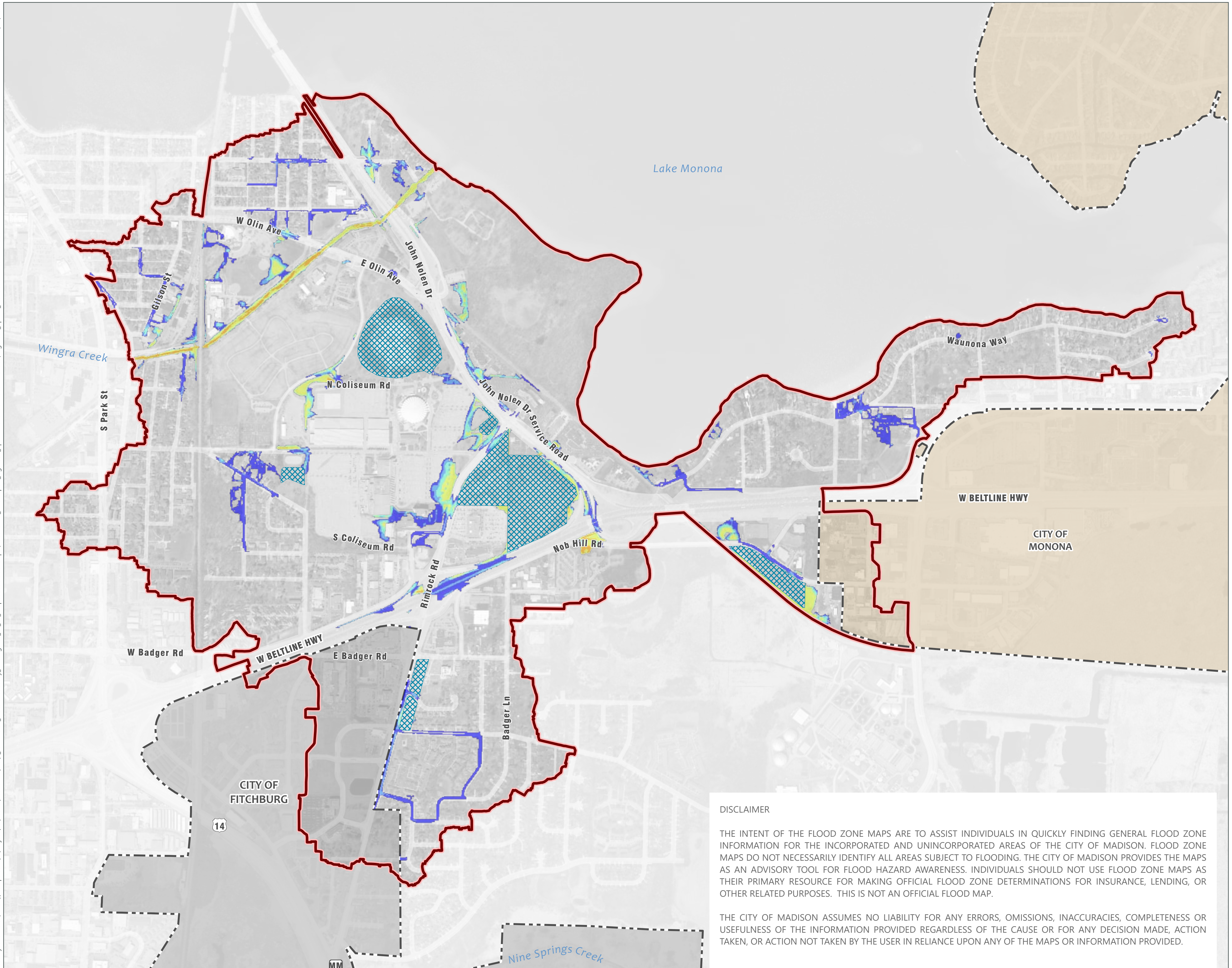
0 0.1 0.2 Miles

N

2% AEP Inundation Recommended Conditions

FIGURE 32
John Nolen Watershed
Study Report

City of Madison
Dane County, WI



Watershed Study Area
City of Fitchburg
City of Monona
Greenway/Pond

Maximum Water Depth (ft)

- 0.1 - 0.3
- 0.3 - 0.5
- 0.6 - 1
- 1.1 - 3
- 3.1 - 6
- 6.1+

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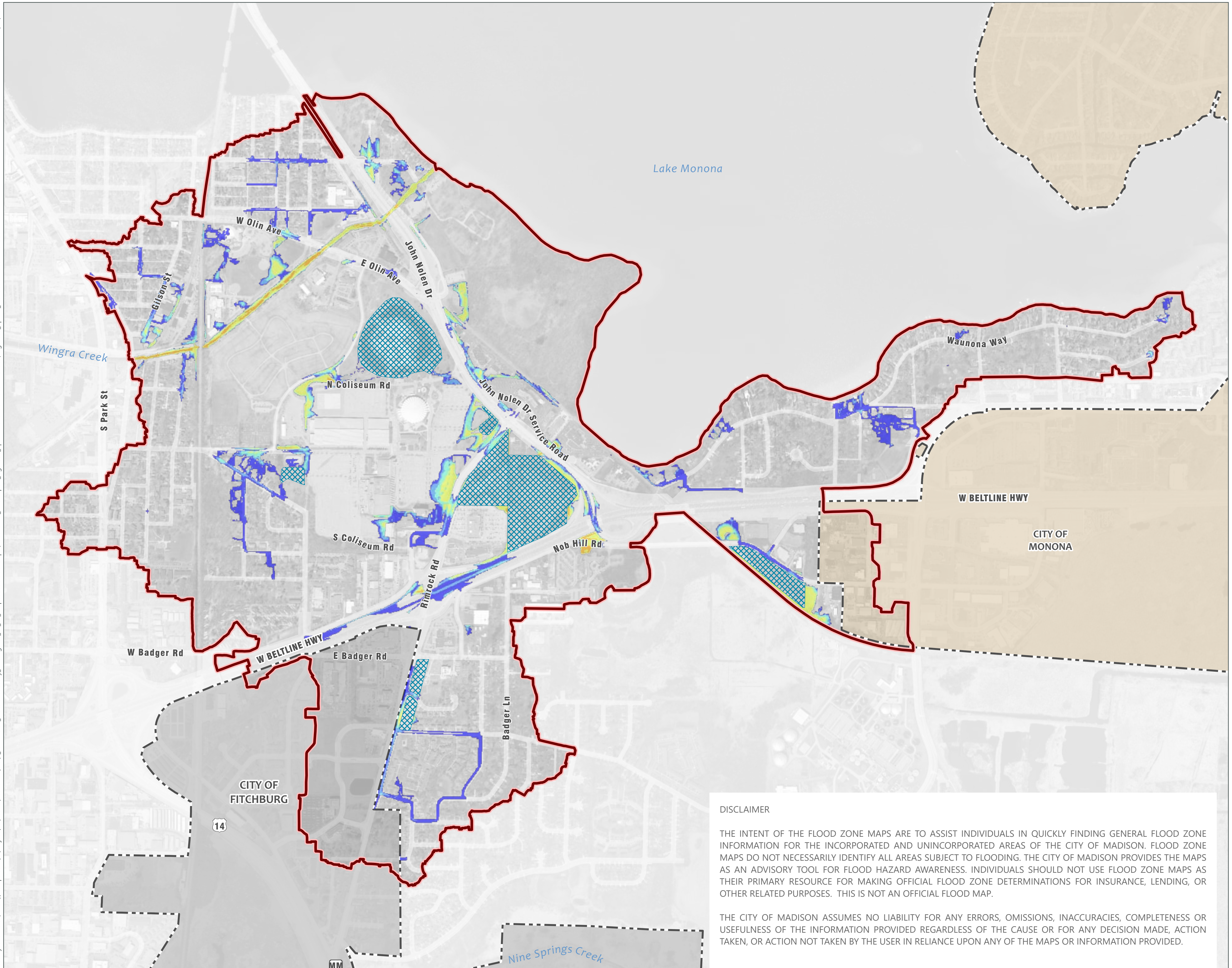
Data Sources:
Aerial: City of Madison (2022)
Watershed Boundaries: MSA
Stormwater System: City of Madison

MSA

0 0.1 0.2 Miles

N

Print Date: 4/24/2025



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1% AEP Inundation Recommended Conditions

FIGURE 33
John Nolen Watershed
Study Report

City of Madison
Dane County, WI

Watershed Study Area
City of Fitchburg
City of Monona
Greenway/Pond

Maximum Water Depth (ft)

0.1 - 0.3
0.3 - 0.5
0.6 - 1
1.1 - 3
3.1 - 6
6.1+

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

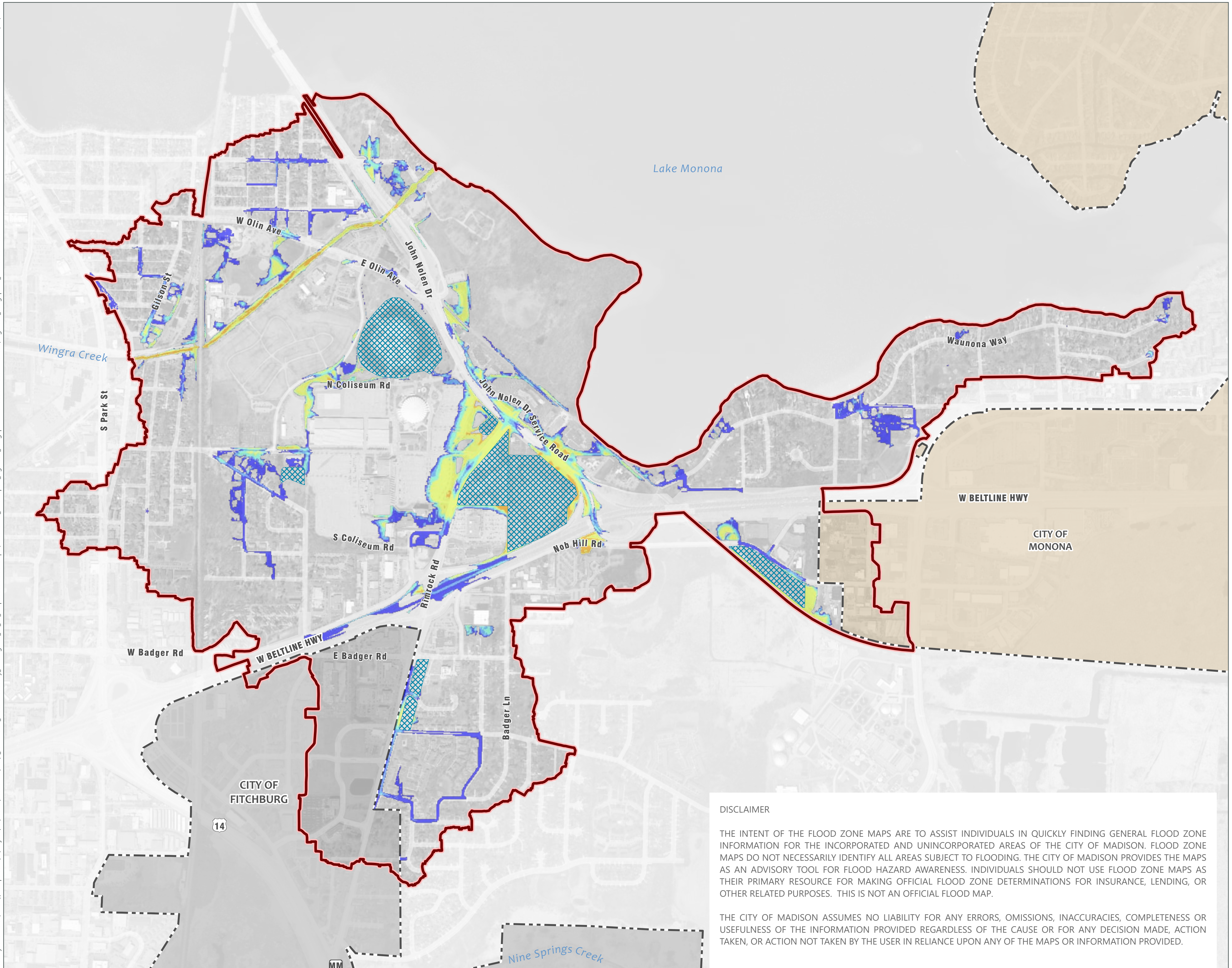
MSA

0 0.1 0.2 Miles

Long 1% AEP Inundation Recommended Conditions

FIGURE 34
John Nolen Watershed
Study Report

City of Madison
Dane County, WI



- Watershed Study Area
- City of Fitchburg
- City of Monona
- Greenway/Pond

Maximum Water Depth (ft)

- 0.1 - 0.3
- 0.3 - 0.5
- 0.6 - 1
- 1.1 - 3
- 3.1 - 6
- 6.1+

DISCLAIMER

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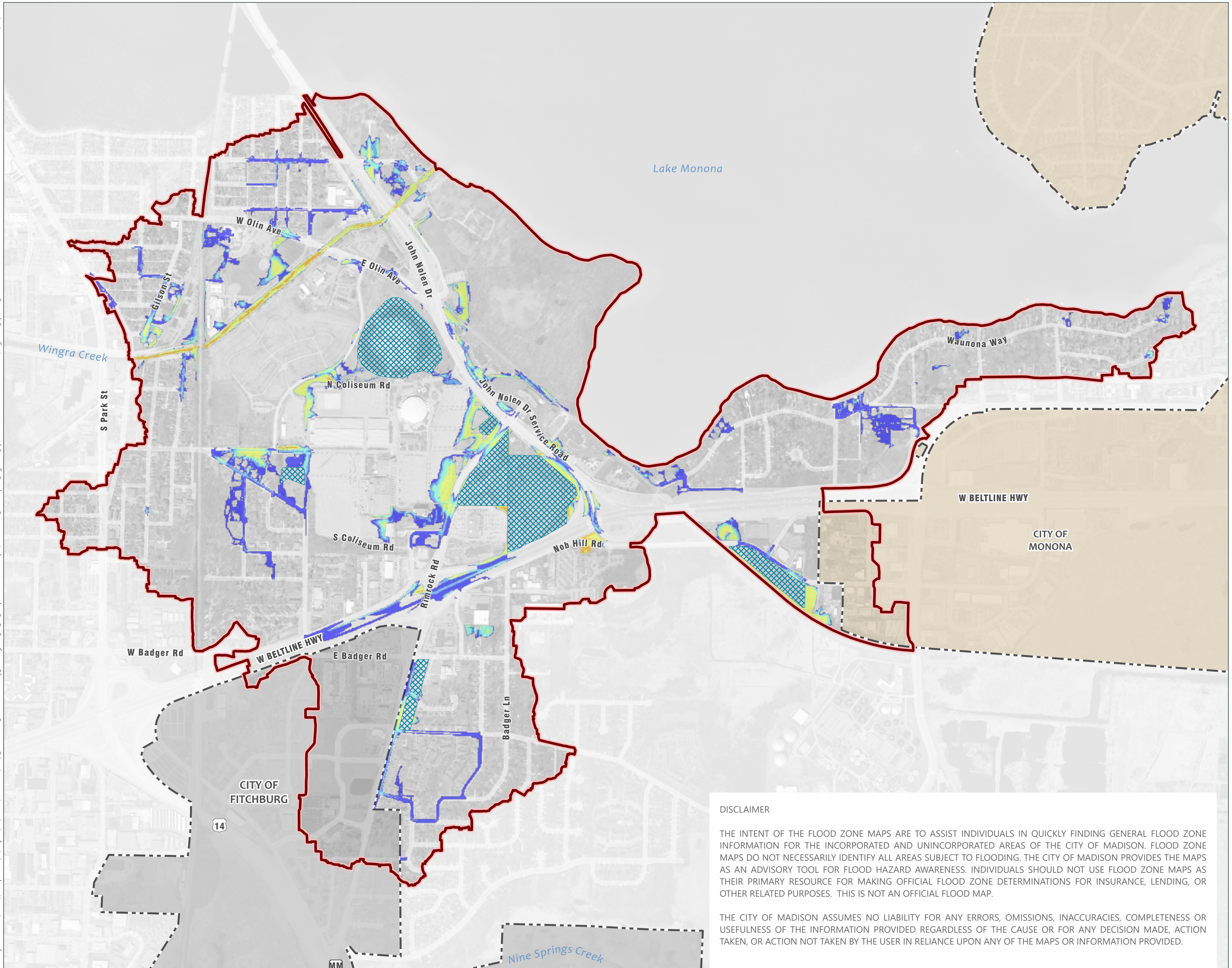
Data Sources:
Aerial: City of Madison (2022)
Watershed Boundaries: MSA
Stormwater System: City of Madison

MSA

0 0.1 0.2 Miles

N

Print Date: 4/24/2025



DISCLAIMER

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0.5% AEP Inundation Recommended Conditions

FIGURE 35
John Nolen Watershed Study Report

City of Madison
Dane County, WI

Watershed Study Area
City of Fitchburg
City of Monona
Greenway/Pond

Maximum Water Depth (ft)

0.1 - 0.3
0.3 - 0.5
0.6 - 1
1.1 - 3
3.1 - 6
6.1+

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

MSA

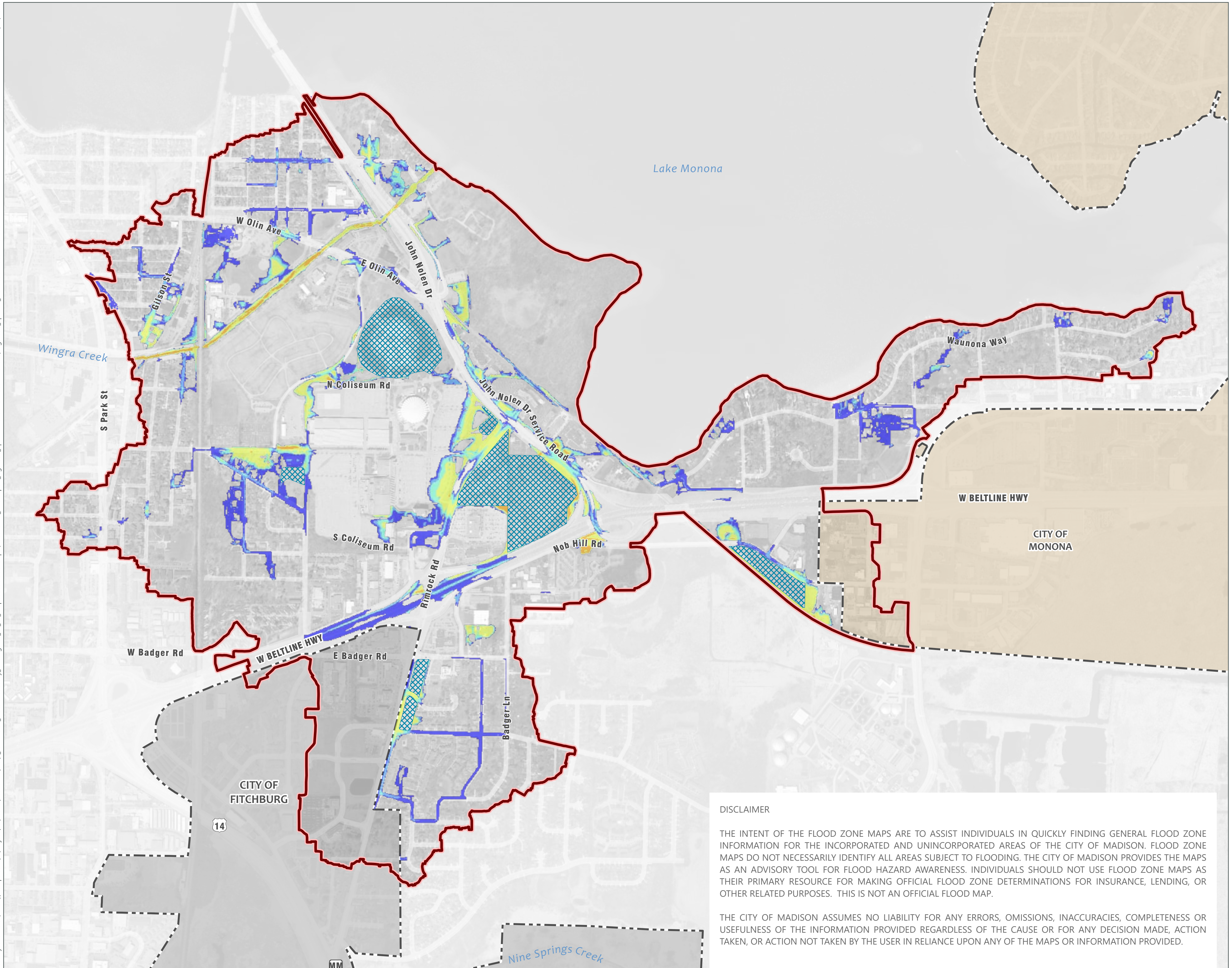
0 0.1 0.2 Miles

Print Date: 4/24/2025

0.2% AEP Inundation Recommended Conditions

FIGURE 36
John Nolen Watershed
Study Report

City of Madison
Dane County, WI



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Watershed Study Area
City of Fitchburg
City of Monona
Greenway/Pond

Maximum Water Depth (ft)

- 0.1 - 0.3
- 0.3 - 0.5
- 0.6 - 1
- 1.1 - 3
- 3.1 - 6
- 6.1+

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

MSA

0 0.1 0.2 Miles

N

Print Date: 4/24/2025

Printed By: aconverse, File: \\msa-ps.com\fs\Project\00\00373\00373127\GIS\7_JohnNolen_WatershedStudy_FinalFigures_26_36_ProposedSolutions.aprx, 00373127_FinalReport_Figure36_0p2AEPInundationRecommended, Figure36_0p2AEP_InundationRecommended

Appendix A. Modeling Guidance

MODELING GUIDANCE

Version 2022_05_17 (DRAFT)

Round 4, 5, and 6 Watershed Studies

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.
    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

e. Grid cell/mesh size: Use size that balances model run time and sufficient 2D overland flow detail.

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:

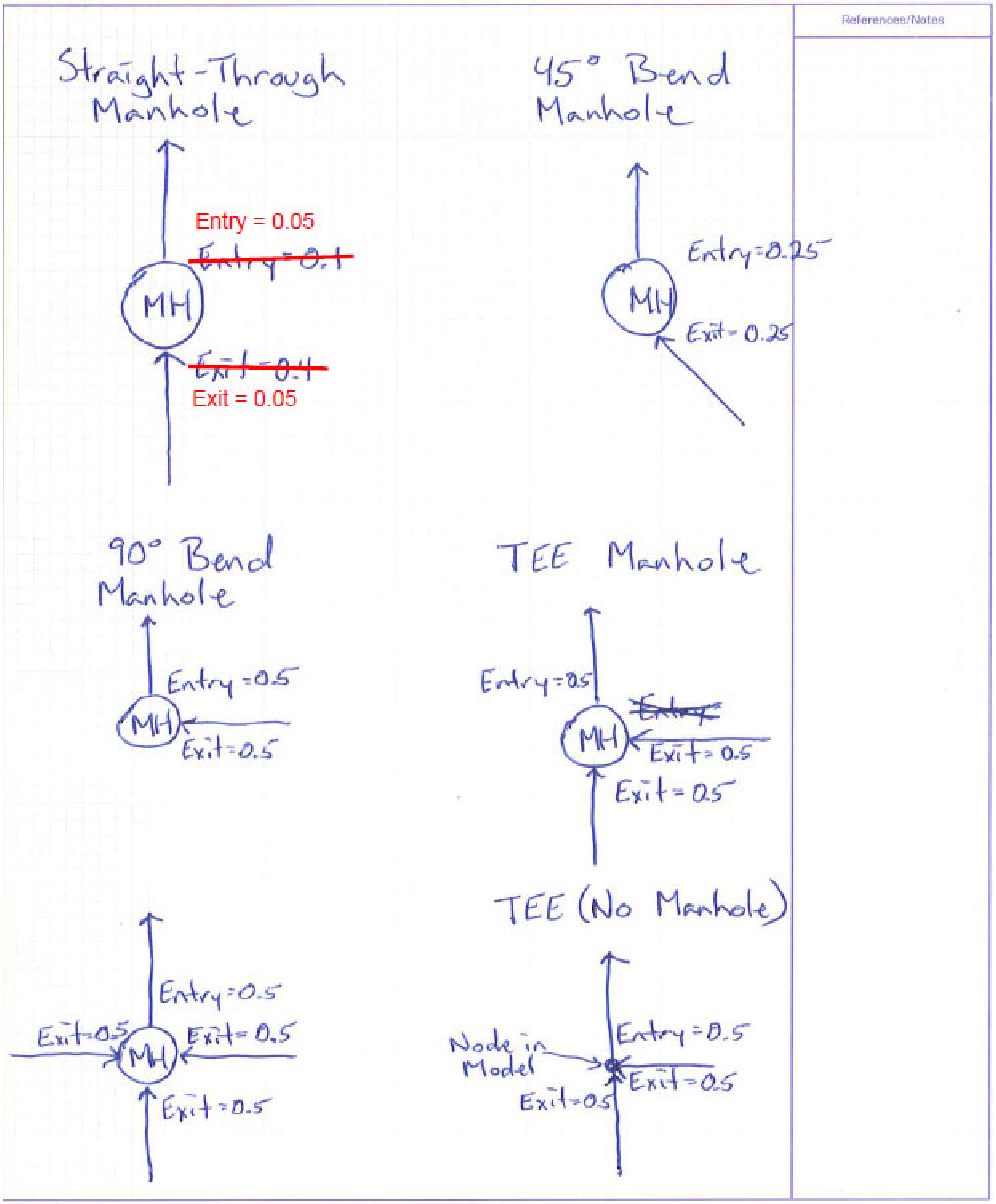
  i. be offset from the property line on 1 side by 15 feet (parallel to channel flow, from Pond access to pond outlet)
     1. Shall be extended to reach all priority inlets or sanitary access structures within greenway
  ii. All proposed berms must be 10 feet wide @ top of berm
  iii. Slopes no steeper 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

19. Water that overflows Watershed Study Boundaries
    a. There may be locations along a watershed study boundary where water overflows that boundary and enters an adjacent watershed. When this occurs
       i. 2D outflow boundaries should be drawn in the locations to allow the water to leave the model as it would normally.
       ii. A 2D flow recording line should be added in this location, just upstream of the 2D outflow boundary.
       iii. The model should be run for all design storm events.
          1. If flow is found to be significant, hydrographs should be exported from the model and provided to the City Project Manager so they can be inserted into the adjacent watershed study model.
          2. If flow is not found to be significant, the flow can be ignored.
       iv. The watershed should report should include a section showing the locations of the overflow. Text and tables in the report should briefly describe the magnitude of the overflow and the duration.

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
Entry = 0.05
~~Entry = 0.1~~
MH
~~Exit = 0.1~~
Exit = 0.05
45° Bend Manhole
Entry = 0.25
MH
Exit = 0.25
90° Bend Manhole
Entry = 0.5
MH
Exit = 0.5
TEE Manhole
Entry = 0.5
~~Entry~~
MH
Exit = 0.5
Exit = 0.5
TEE (No Manhole)
Entry = 0.5
Exit = 0.5
Exit = 0.5
MH
Exit = 0.5
Entry = 0.5
Node in Model
Exit = 0.5
Exit = 0.5

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)
AE5058-042	0.121	0.013	0.222	4.00	1.00	0.001
AE5060-007	1.929	0.404	4.154	3.28	0.82	0.001
AE5158-001	2.136	0.005	0.821	0.87	0.22	0.001
AE5159-013-A	0.875	0.15	0.885	2.00	0.50	0.001
AE5258-001	2.216	0.038	16.172	3.12	0.78	0.001
AE5259-034	0.517	0	1.983	2.80	0.70	0.001
AE5261-022	13.019	0	7.064	3.67	0.92	0.001
AE5265-032X	1.457	0.033	0.368	4.00	1.00	0.001
AE5362-018	19.821	0.071	30.632	3.72	0.93	0.001
AS4959-035	2.185	1.013	1.912	4.00	1.00	0.001
AS4959-043	2.313	1.672	3.855	4.00	1.00	0.001
AS4959-055	0.854	1.4	1.553	4.00	1.00	0.001
AS4960-025	0.388	0.951	1.627	3.61	0.90	0.001
AS4960-050	1.598	0.024	0.334	3.91	0.98	0.001
AS4961-015	1.085	2.599	4.765	4.00	1.00	0.001
AS4962-008	2.224	3.405	5.356	4.00	1.00	0.001
AS4962-010	0.803	0.152	0.559	4.00	1.00	0.001
AS4962-030	1.876	2.805	6.678	3.35	0.84	0.001
AS4963-008	1.287	1.058	2.37	4.00	1.00	0.001
AS4963-018	0.505	0	0.092	4.00	1.00	0.001
AS4963-022	4.971	2.621	4.258	4.00	1.00	0.001
AS5057-005	2.198	2.074	3.918	4.00	1.00	0.001
AS5057-020	0.395	0.026	0.146	4.00	1.00	0.001
AS5058-003	0.417	0.021	0.676	4.00	1.00	0.001
AS5058-004	0.662	1.174	1.539	4.00	1.00	0.001
AS5058-033	1.592	0.867	2.595	3.90	0.98	0.001
AS5058-041	1.018	0.594	1.571	4.00	1.00	0.001
AS5058-065	0.208	0.682	1.145	4.00	1.00	0.001
AS5058-066	0.922	0.449	0.823	4.00	1.00	0.001
AS5061-006	4.067	0.86	15.503	2.74	0.69	0.001
AS5062-052	1.464	2.525	9.516	3.33	0.83	0.001
AS5062-058	0.833	2.61	15.32	5.15	1.29	0.001
AS5062-075	0.919	1.413	3.377	4.03	1.01	0.001
AS5063-002	0.227	0.084	0.357	4.00	1.00	0.001
AS5063-010	0.821	1.645	5.208	3.41	0.85	0.001
AS5063-011	0.176	1.158	3.94	3.98	1.00	0.001
AS5157-003	0.833	0.197	0.404	3.99	1.00	0.001
AS5157-009	1.323	0.066	0.582	2.64	0.66	0.001
AS5157-040	1.791	0	3.57	3.26	0.81	0.001
AS5157-057	0.971	2.093	3.114	4.00	1.00	0.001
AS5157-065	2.032	0	0.887	2.16	0.54	0.001
AS5158-008	2.38	0	0.137	3.11	0.78	0.001
AS5158-013	0.714	0.019	0.419	3.55	0.89	0.001
AS5158-018	0.776	0.515	0.941	4.00	1.00	0.001

Subcatchment	DCIA	UCIA	Pervious	Max Infil. Rate (in/hr)	Min Infil. Rate (in/hr)	Decay Rate (1/s)
AS5158-022	0.289	0.161	0.219	3.77	0.94	0.001
AS5159-001	3.927	0.032	0.805	2.00	0.50	0.001
AS5159-008	2.174	0.055	1.203	2.00	0.50	0.001
AS5164-033	3.202	0.078	1.561	2.83	0.71	0.001
AS5166-012	1.119	3.257	5.866	2.89	0.69	0.001
AS5166-029	0.842	0.813	5.475	3.50	0.88	0.001
AS5167-015	0.574	0.54	3.555	3.24	0.81	0.001
AS5167-031	0.424	0.58	0.385	2.90	0.72	0.001
AS5257-004	0.128	0.337	0.287	2.00	0.50	0.001
AS5259-029	6.039	0.125	14.327	1.71	0.43	0.001
AS5260-005	7.839	0.017	3.162	4.00	1.00	0.001
AS5260-018	1.718	0	0.397	2.17	0.54	0.001
AS5261-015	2.649	0	1.225	4.00	1.00	0.001
AS5262-005	1.112	0	0.702	4.00	1.00	0.001
AS5263-027	5.831	0.386	3.417	4.50	1.13	0.001
AS5265-008	0.869	1.494	3.956	4.00	1.00	0.001
AS5266-006	0.95	1.395	4.278	2.17	0.54	0.001
AS5461-001	7.565	0.468	6.52	4.01	1.00	0.001
AS5462-002	1.117	1.4	5.019	3.84	0.96	0.001
AS5561-015	1.005	1.601	4.163	2.84	0.71	0.001
AS5561-016	0.405	0.599	1.707	2.16	0.54	0.001
AS5562-002	0.876	0	0.703	3.95	0.99	0.001
AS5562-032	3.241	0.027	5.141	4.13	1.03	0.001
AS5563-005	1.629	0.017	2.664	3.03	0.76	0.001
AS5661-001	3.319	2.884	12.968	3.19	0.80	0.001
AS5661-004	1.515	2.059	8.542	2.68	0.67	0.001
AS5760-017	0.525	0.448	0.998	3.31	0.83	0.001
AS5859-018	1.075	1.618	5.695	4.00	1.00	0.001
AS5860-008	1.202	2.439	3.64	4.00	1.00	0.001
AS5959-002	0.401	0.607	1.408	4.00	1.00	0.001
CB4959-063	1.283	1.857	2.942	4.00	1.00	0.001
CB5859-033	0.395	1.795	7.652	3.99	1.00	0.001
D_1	7.016	0.074	10.442	4.74	1.18	0.001
D_113	0.511	0.006	1.105	2.00	0.50	0.001
D_126	1.902	0.077	2.431	3.95	0.99	0.001
D_129	2.254	0	2.348	2.00	0.50	0.001
D_130	1.818	0.031	0.817	2.00	0.50	0.001
D_139	1.673	0	0.487	3.23	0.81	0.001
D_144	1.051	0	1.025	4.00	1.00	0.001
D_147	20.12	0.082	4.71	4.00	1.00	0.001
D_149	4.462	1.001	2.234	4.06	1.02	0.001
D_160	0.714	0	2.666	3.50	0.87	0.001
D_162	10.365	0.568	14.768	3.76	0.94	0.001
D_180	0.132	0.053	0.76	4.33	1.08	0.001

Subcatchment	DCIA	UCIA	Pervious	Max Infil. Rate (in/hr)	Min Infil. Rate (in/hr)	Decay Rate (1/s)
D_181	0.474	0.017	12.664	4.95	1.24	0.001
D_20	3.889	0.156	0.802	3.89	0.97	0.001
D_30	4.131	0.069	1.601	4.00	1.00	0.001
D_34	0.409	0	1.124	4.00	1.00	0.001
D_34A	0.269	0	0.922	4.00	1.00	0.001
D_35	1.872	0	0.924	4.00	1.00	0.001
D_69	0.291	0.92	4.356	2.74	0.68	0.001
D_70	0.351	0.208	0.228	2.78	0.70	0.001
D_73	0	0.182	0.454	4.00	1.00	0.001
D_75	5.749	0.316	1.749	2.68	0.67	0.001
D_76	0.613	0.023	0.4	2.83	0.71	0.001
D_8	0.505	0.786	1.966	2.00	0.50	0.001
D_81	0.57	0.031	0.437	2.54	0.63	0.001
DT5157-007	0.683	0.602	1.716	3.99	1.00	0.001
DT5157-087	0.174	0	5.656	3.94	0.98	0.001
Fitchburg-5	12.666	0.114	4.802	3.70	0.93	0.001
HD5959-005	0.017	0.923	2.413	4.00	1.00	0.001
IN4859-012	0.829	0.437	1.21	4.00	1.00	0.001
IN4959-087	0.953	1.326	2.464	4.00	1.00	0.001
IN4960-027	0.337	0.485	0.9	4.00	1.00	0.001
IN4960-059	2.062	0.419	1.065	4.00	1.00	0.001
IN4962-021	2.244	3.128	9.322	3.95	0.99	0.001
IN4963-009	2.328	1.057	1.475	4.00	1.00	0.001
IN5057-003	0.819	0.628	1.105	4.00	1.00	0.001
IN5059-016	4.101	0.205	11.934	2.43	0.61	0.001
IN5059-019	1.089	0.03	0.89	2.00	0.50	0.001
IN5060-006	1.696	0.514	0.853	2.00	0.50	0.001
IN5062-043	14.727	0.606	7.722	5.09	1.27	0.001
IN5063-006	0.53	2.167	3.659	3.61	0.90	0.001
IN5156-005	1.135	0	0.389	2.81	0.70	0.001
IN5157-044	1.435	0.363	0.803	2.56	0.64	0.001
IN5157-060	0.16	0.631	1.216	4.00	1.00	0.001
IN5158-042	0.05	0.257	1.421	4.00	1.00	0.001
IN5159-014	5.173	0.549	8.55	1.96	0.49	0.001
IN5162-006	0.531	0.973	1.648	4.14	1.03	0.001
IN5163-004	0.682	0.491	1.246	2.00	0.50	0.001
IN5165-010	4.76	0.02	1.403	3.99	1.00	0.001
IN5166-005	0.946	5.138	6.19	2.64	0.64	0.001
IN5166-035	2.275	0.047	8.694	3.46	0.87	0.001
IN5166-046	1.011	0	4.209	4.00	1.00	0.001
IN5166-050	1.321	0.007	1.816	4.00	1.00	0.001
IN5166-057	0.297	0	1.026	4.00	1.00	0.001
IN5167-022	0.225	0.214	0.405	3.05	0.76	0.001
IN5167-038	0.37	0	0.256	4.00	1.00	0.001

Subcatchment	DCIA	UCIA	Pervious	Max Infil. Rate (in/hr)	Min Infil. Rate (in/hr)	Decay Rate (1/s)
IN5167-042	1.496	1.264	2.88	3.50	0.88	0.001
IN5257-007	0.083	0.013	0.208	3.63	0.91	0.001
IN5263-020	2.939	0.391	0.696	4.25	1.06	0.001
IN5264-021	13.028	1.195	4.81	2.85	0.71	0.001
IN5264-029	2.916	0.019	1.515	4.00	1.00	0.001
IN5265-003	2.26	0.398	1.685	4.00	1.00	0.001
IN5265-013	1.197	2.085	6.74	4.00	1.00	0.001
IN5265-015	0.97	1.256	3.046	3.99	1.00	0.001
IN5265-024	0.759	0	0.138	4.00	1.00	0.001
IN5361-007	2.576	0.001	0.712	4.00	1.00	0.001
IN5362-003	2.647	0.001	3.157	4.00	1.00	0.001
IN5562-014	0.793	1.1	5.662	2.81	0.70	0.001
IN5563-018	12.006	0.551	8.545	4.07	1.02	0.001
IN5661-026	0.334	0.739	2.901	2.99	0.75	0.001
IN5662-007	0.615	0.126	1.595	3.63	0.91	0.001
IN5760-012	1.154	1.54	6.348	3.04	0.76	0.001
IN5760-014	0.432	0.746	5.616	3.78	0.94	0.001
IN5960-007	0.417	1.067	1.588	4.00	1.00	0.001
L_16	0.204	0	0.712	4.00	1.00	0.001
L_2	0.231	0	3.098	2.00	0.50	0.001
L_20	0.241	0	0.065	4.00	1.00	0.001
L_21	0.256	0	0.121	2.00	0.50	0.001
L_3	1.954	0	10.068	2.00	0.50	0.001
L_4	8.417	0	1.869	1.79	0.45	0.001
L_5	8.334	0.073	9.484	3.41	0.85	0.001
L_6	0.371	0	0.111	4.00	1.00	0.001
L_7	1.249	0.003	1.585	4.02	1.01	0.001
L_8	0.042	0	2.466	3.91	0.98	0.001
L_9	0.109	0.004	0.027	4.00	1.00	0.001
MI4960-053	0.787	0.958	1.584	4.00	1.00	0.001
N00001	10.091	0	4.357	3.45	0.86	0.001
N00011	3.959	0.489	1.425	4.00	1.00	0.001
Node845	19.075	0.216	9.96	1.92	0.48	0.001
PD5265-017	0.417	0.603	3.623	3.74	0.93	0.001
PD5265-018	1.363	0.374	7.199	3.90	0.98	0.001
S116a	0.715	1.428	3.705	2.13	0.53	0.001
S116b	0.914	1.46	4.286	2.18	0.54	0.001
S41a	0.894	1.614	3.335	2.07	0.51	0.001
S41b	0.822	1.081	2.753	2.00	0.50	0.001
S41c	0.303	0.469	0.788	2.00	0.50	0.001
TO5064-005	1.363	3.522	5.203	2.00	0.50	0.001
TO5164-009	1.585	0.002	0.108	2.53	0.63	0.001
TO5164-016	0.939	0.366	0.099	2.40	0.60	0.001
TO5264-013	6.84	0.763	1.94	4.00	1.00	0.001

Subcatchment	DCIA	UCIA	Pervious	Max Infil. Rate (in/hr)	Min Infil. Rate (in/hr)	Decay Rate (1/s)
TO5264-020	0.651	0.827	4.791	4.00	1.00	0.001
TO5363-001	7.507	1.187	2.685	4.00	1.00	0.001
TO5562-016	2.856	0	3.044	5.80	1.45	0.001
TO5562-023	2.032	0	0	8.00	2.00	0.001

Appendix C. Calibration Memo

Memo

To: Ryan Stenjem, P.E. – City of Madison

From: Makenzie Gingras, P.E.

Subject: John Nolen Drive Watershed Study – Existing Conditions Model Calibration

Date: July 29, 2024

INTRODUCTION

The memorandum presents the results of MSA's efforts to calibrate the 1D/2D XP-SWMM model for the John Nolen Drive watershed. Monitoring equipment consisting of two rain gauges, three level loggers, and one flow meter operational from Spring until Fall 2023. The location of these can be seen in the attached map.

CALIBRATION RAINFALL EVENTS

Three rainfall events were chosen, each with varying duration and intensity. Only two rain gauges were used for calibration purposes; Baxter Park and Fire Station 1. Both of these rain gauges are outside the John Nolen Drive watershed study area, however the majority of the study area is located within the Thiessen polygon for Baxter Park. The northernmost section of the study area, which contains the Sayle St. LL metershed, is located within the Thiessen polygon for Fire Station 1. The Paunack Park rain gauge is located at the far east edge of the watershed study area, however, the decision was made to apply the Baxter rainfall data to the Paunack Thiessen polygon section. This is due to similar rainfall patterns during each chosen calibration event, as well as to simplify model building.

Table 1 – Calibration Storms

Event Date (2023)	5-Day Antecedent Rainfall (in)	Start Time	Stop Time	Duration (hr)	Total Depth (in)	Peak Intensity (in/hr)
July 12th	0.1	11:15	16:50	5.50	1.6	0.72
July 28th	0.2	21:50	22:30	0.67	2.4	6.84
August 14th	1.0	6:20	11:20	5.00	1.5	2.88

Table 1 above only includes the rainfall data from the Baxter Park rain gauge.

MODEL PARAMETERS

The John Nolen Existing Conditions model was built following the City of Madison Modeling Guidance documentation, version 2022_05_17.

UNCALIBRATED MODEL

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 Rimrock Rd LL were being overpredicted during each calibration event.
2. Flows at the Sayle St LL were being overpredicted during each calibration event.
3. Flows at the Bram St LL were being overpredicted during the larger July 28th event. The modeled flows in the smaller two events had a relatively close fit, however the elevation peaks occur slightly early.

The most weight was placed on the Rimrock Rd LL during the calibration process. It is the closest monitoring location to the Baxter Rd rain gauge and should have observed rainfall that most closely reflects the gauge data. The location of the Rimrock Rd LL is within the channel, however the area behaves as a pond during high flow events, which makes this meter volume driven. The July 28th event was also given more weight than the other two calibration events due to its larger intensity and the model overpredicting at each Level Logger for this event.

The East Olin flow meter appeared to be malfunctioning during the calibration process. The velocity measurement within the flow meter appeared to jump up and remain at a maximum value immediately following a rain event. The data is sporadic and unreliable. Also, the tailwater condition was expected to match similarly to the Sayle Street Level Logger due to both having piped outlets near each other on Wingra Creek. The tailwater condition does not seem to return to “pre-rain event” conditions as quickly as the other meter, which suggests the outlet pipe may have been clogged, or there is residual flow coming from somewhere upstream. The issues did not seem to resolve after cleaning of the pipe outfall. Elevation data from this meter was recorded and is displayed below. However, due to the above-mentioned reliability issues, this data was not used when deciding calibration parameters.

CALIBRATED MODEL

The following model input variables were adjusted to achieve a better fit of the modeled data. These adjustments were applied globally to the entire study area.

- Directly connected impervious area (DCIA) for residential land uses
    - Only streets will be fully connected, other impervious areas will be disconnected. Making this change will slow down and reduce the initial peak flow at each meter location.
- DCIA for mobile homes
    - The streets have been changed to disconnected, there will be no connected impervious for this land use. This change will reduce the peak flow that arrives at the Bram St LL, by removing all of the faster connected impervious runoff from this land use.

- Infiltration Rates
    - Increased both maximum and minimum infiltration rates for each HSG "up" a group (C to B parameters, etc.). See Table 2 below for the infiltration rate adjustment at each HSG. Making this change will lower the peak flows, particularly the initial peak flows, at each meter location. This change had the biggest effect on the July 28th shorter duration event. The rain fell in a very short period at a high intensity during this event, so the initial infiltration rate is a big contributing factor to reducing the initial peak flows.

Table 2 – Infiltration Rate Adjustments

HSG	Infiltration Rate (in/hr)			
	Maximum (from Modeling Guidance)	**Minimum (from Modeling Guidance)**	**Maximum (for Calibration)**	**Minimum (for Calibration)**
A	4	1	4	1
B	2	0.5	4	1
C	1	0.2	2	0.5
D	0.5	0.1	1	0.2

- Watershed slope
    - The slope for the disconnected impervious area (UCIA) and pervious components was divided by 3, DCIA component slope remains the same. This change will slow down the UCIA and pervious components of the runoff, which will reduce peak flows throughout each calibration event.
- Wingra Creek tailwater
    - The calibrated condition was given a variable tailwater to emulate the storm sewer backing up during the event. This change will make the model better match what is happening in the actual storm sewer system.
        - The calibrated existing conditions model will have backwater reaching up to 846' within the pipe sections draining to Wingra Creek. This same condition will be utilized in the future Proposed Conditions Model iterations.

Rimrock Road Level Logger

With the calibrated model adjustments, the flows at the Rimrock Rd LL have a much better fit to the metered data for all three events. The model adjustment that had the biggest effect on this location was the DCIA adjustment. The increased infiltration rates also have an effect in the undeveloped parts of this metershed. The Rimrock Rd LL has the largest metershed of the three level loggers used in the calibration process.

Sayle Street Level Logger

With the calibrated model adjustments, the flows at the Sayle St LL have reduced peaks for all three events. A slight overprediction still remains in the smaller events, however the elevation match following each storm event has a much better fit for all three events. The Wingra Creek tailwater condition, as well as the adjustments to DCIA for residential land uses had the largest effect on this metershed location.

Bram Street Level Logger

With the calibrated model adjustments, the flows at the Bram St LL have been reduced for all three events. The peak has also been slightly shifted in the calibrated model to better match the metered data pattern. The model adjustments that had the biggest effect on this metershed location were the adjustments to DCIA for residential land uses, including mobile homes. This meter is also affected by the Wingra Creek tailwater condition.

The Bram St LL metershed area includes a storm sewer run that comes from Park St. to the Bram St. connection through Bram's Addition. The GIS storm sewer system data has a split flow condition in the pipe along Park St. It appears that some of the flow wants to head east through Bram's Addition towards the Bram meter, and some wants to head south down Park St. MSA reviewed this split flow condition and decided to turn off the pipe that heads south, therefore sending all the runoff in the model toward the Bram St. meter. This change produced a better fit to the metered data and is how the model will proceed throughout the project.

Calibration Performance- Bias Summary

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, in order to calibrate a larger portion of the model and/or produce results that are more accurate for the larger events, a particular meter may have an error that exceeds the 25 percent threshold.

Tables 3.1, 3.2, and 3.3, summarize the model bias at each Level Logger for each calibration event.

Table 3.1 – Rimrock Road Level Logger Bias Summary

Event Date (2023)	Maximum Stage – Metered Data (ft)	Maximum Stage – Modeled Data (ft)	% Difference
July 12th	3.17	3.21	+1%
July 28th	5.46	6.16	+11%
August 14th	3.90	3.62	-8%

Table 3.2 – Sayle Street Level Logger Bias Summary

Event Date (2023)	Maximum Stage – Metered Data (ft)	Maximum Stage – Modeled Data (ft)	% Difference
July 12th	0.86	0.98	+12%
July 28th	2.93	2.34	-25%
August 14th	1.41	1.67	+16%

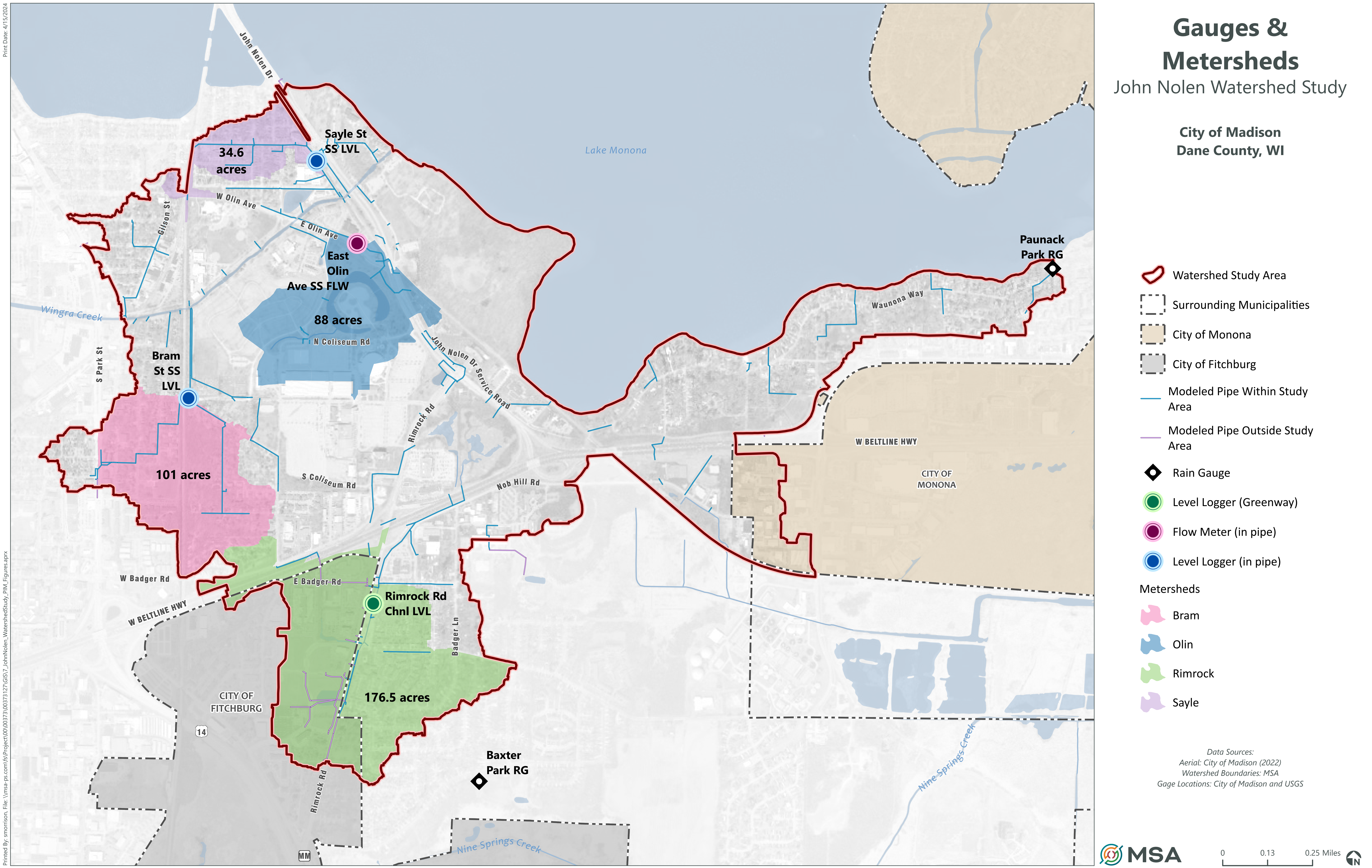
Table 3.3 – Bram Street Level Logger Bias Summary

Event Date (2023)	Maximum Stage – Metered Data (ft)	Maximum Stage – Modeled Data (ft)	% Difference
July 12th	1.46	0.82	-78%
July 28th	4.50	4.88	+8%
August 14th	2.81	1.69	-66%

The Rimrock Road and Sayle Street meter locations fit within the absolute error criteria of +/- 25 percent. The large July 28th event, which was given more weight in the calibration process, will also fit the criteria at each meter location.

CONCLUSION

The model modifications listed and explained in this memo will give an overall good match to the metered data observed throughout the watershed. The metersheds used for the calibration process are representative of the rest of the John Nolen Drive watershed study area. The model modifications will be reflected in the final version of the XP-SWMM Existing Conditions Model, as well as the future Proposed Conditions Model iterations.

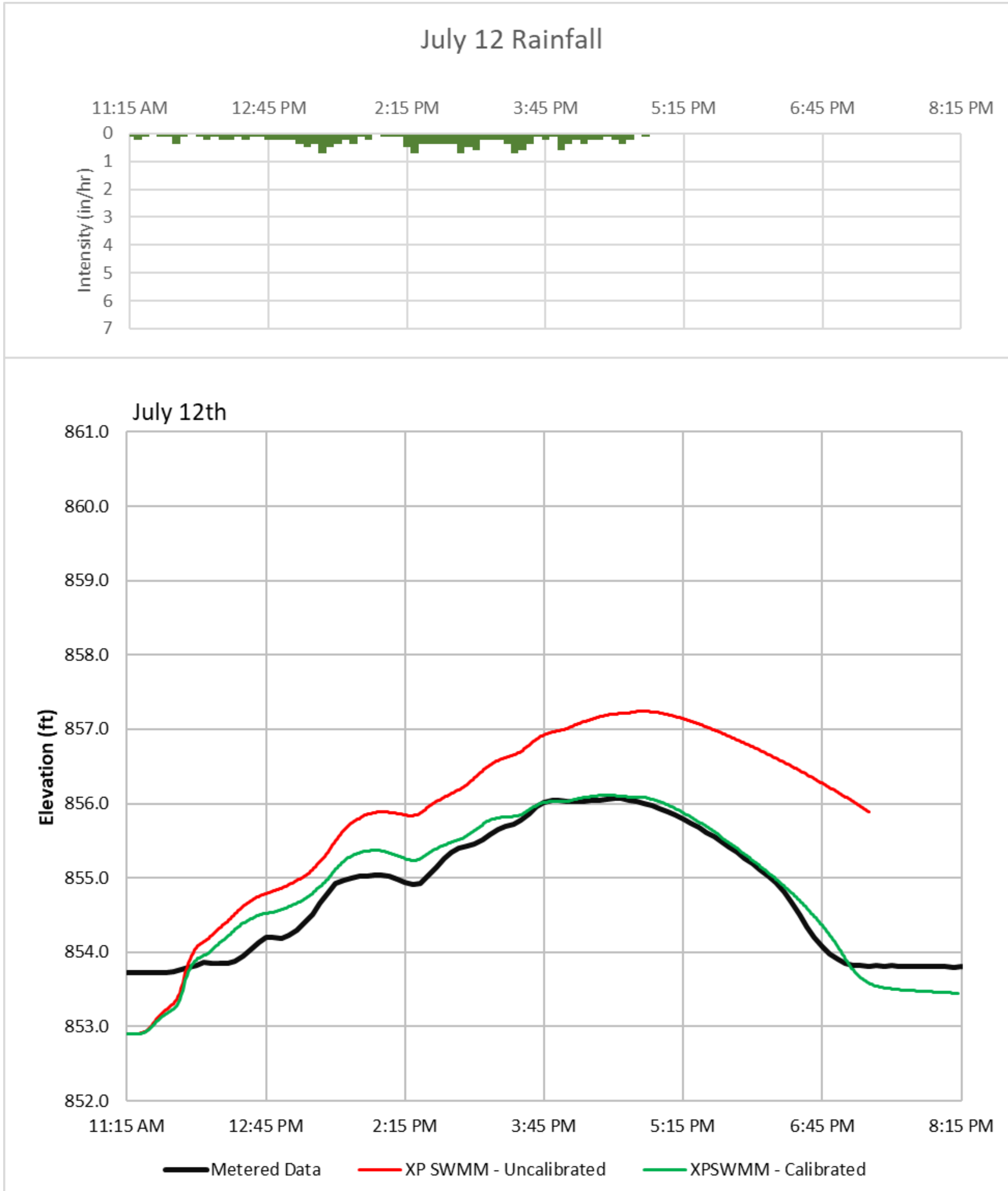

Gauges & Metersheds
John Nolen Watershed Study
City of Madison
Dane County, WI
Watershed Study Area
Surrounding Municipalities
City of Monona
City of Fitchburg
Modeled Pipe Within Study Area
Modeled Pipe Outside Study Area
Rain Gauge
Level Logger (Greenway)
Flow Meter (in pipe)
Level Logger (in pipe)
Metersheds
Bram
Olin
Rimrock
Sayle
Data Sources:
Aerial: City of Madison (2022)
Watershed Boundaries: MSA
Gage Locations: City of Madison and USGS
0
0.13
0.25 Miles
MSA
Lake Monona
John Nolen Dr
Sayle St SS LVL
34.6 acres
W Olin Ave
E Olin Ave
Gilson St
East Olin Ave SS FLW
88 acres
N Coliseum Rd
Wingra Creek
S Park St
Bram St SS LVL
101 acres
John Nolen Dr Service Road
Rimrock Rd
S Coliseum Rd
Nob Hill Rd
W Badger Rd
E Badger Rd
W BELTLINE HWY
Rimrock Rd Chnl LVL
Badger Ln
176.5 acres
CITY OF FITCHBURG
14
Baxter Park RG
Nine Springs Creek
Paunack Park RG
Waunona Way
W BELTLINE HWY
CITY OF MONONA
MM

Model Calibration Results

Rimrock Rd Level Logger

Metershed Area = 176.5 acres

Downstream Pipe = 60" Circular

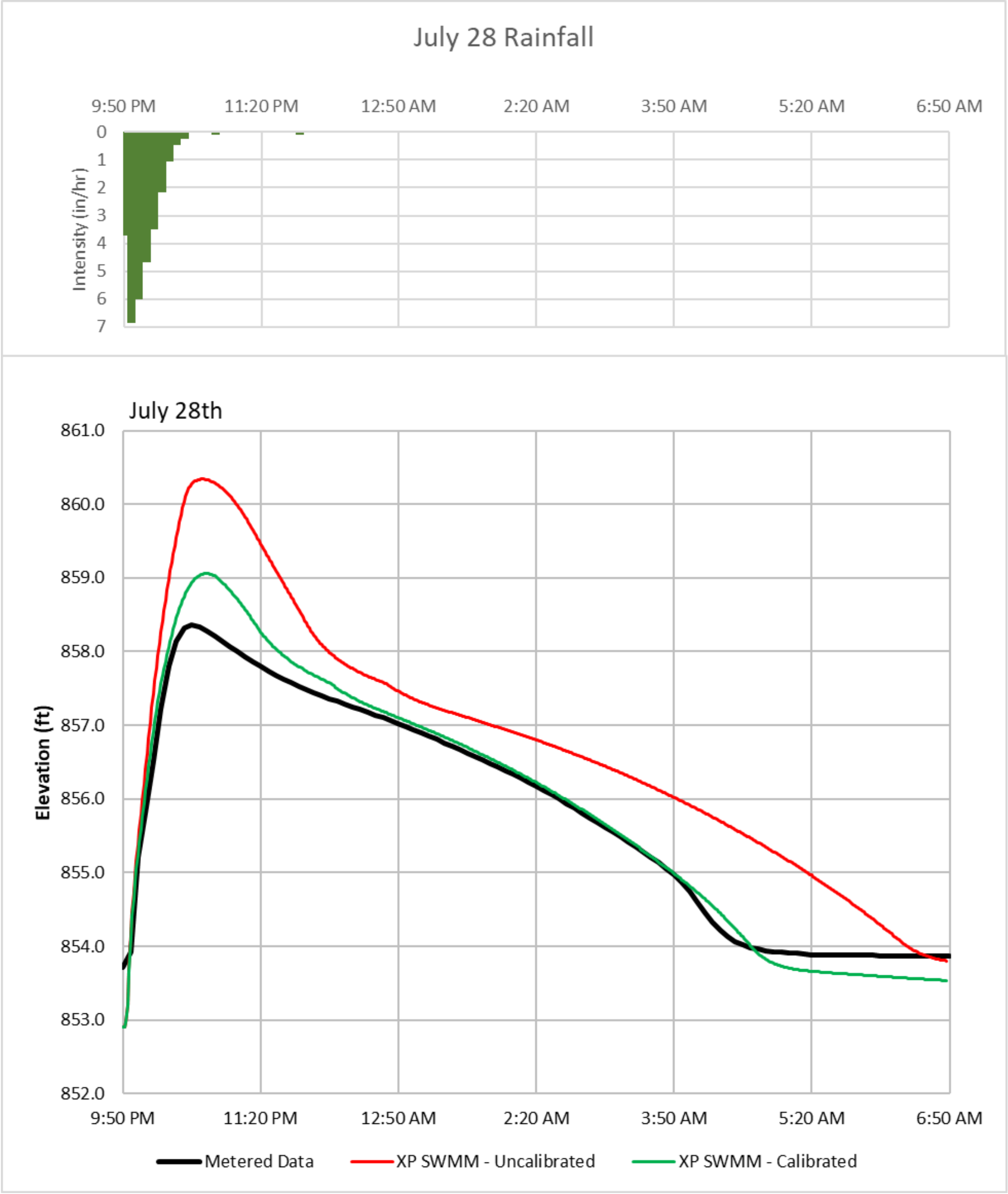


Model Calibration Results

Rimrock Rd Level Logger

Metershed Area = 176.5 acres

Downstream Pipe = 60" Circular

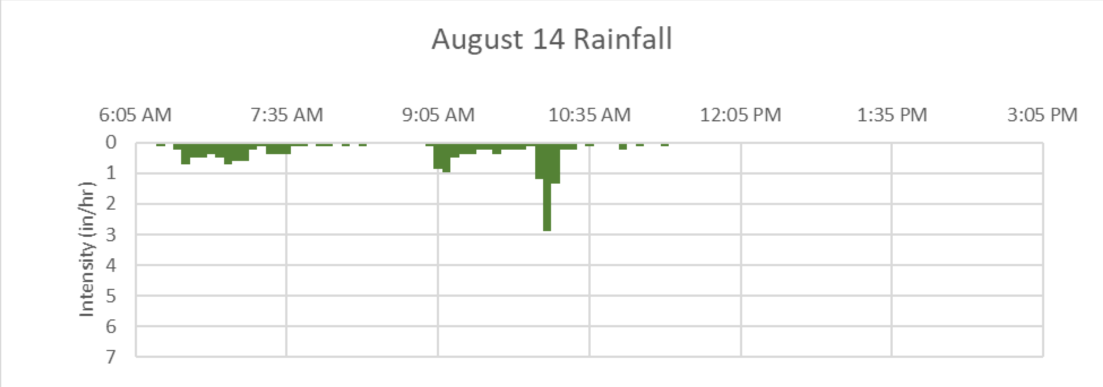


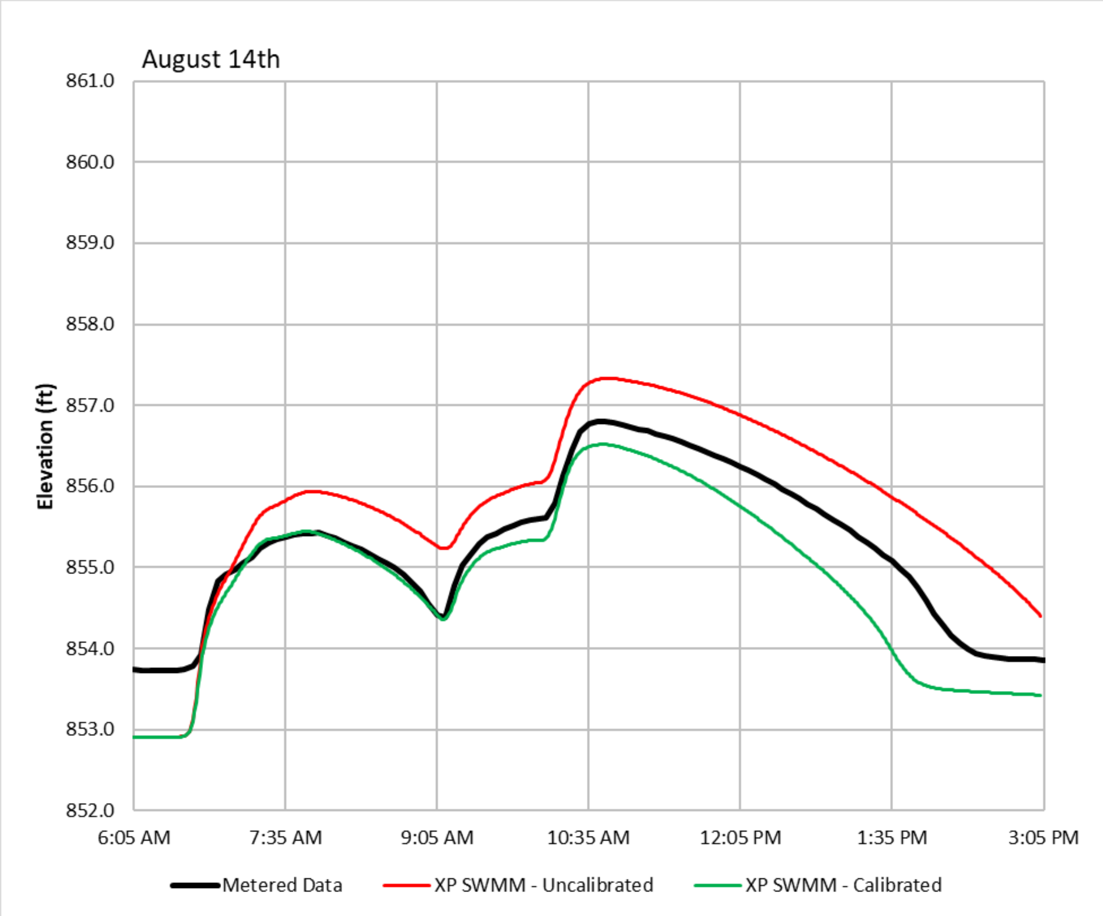
Model Calibration Results

Rimrock Rd Level Logger

Metershed Area = 176.5 acres

Downstream Pipe = 60" Circular



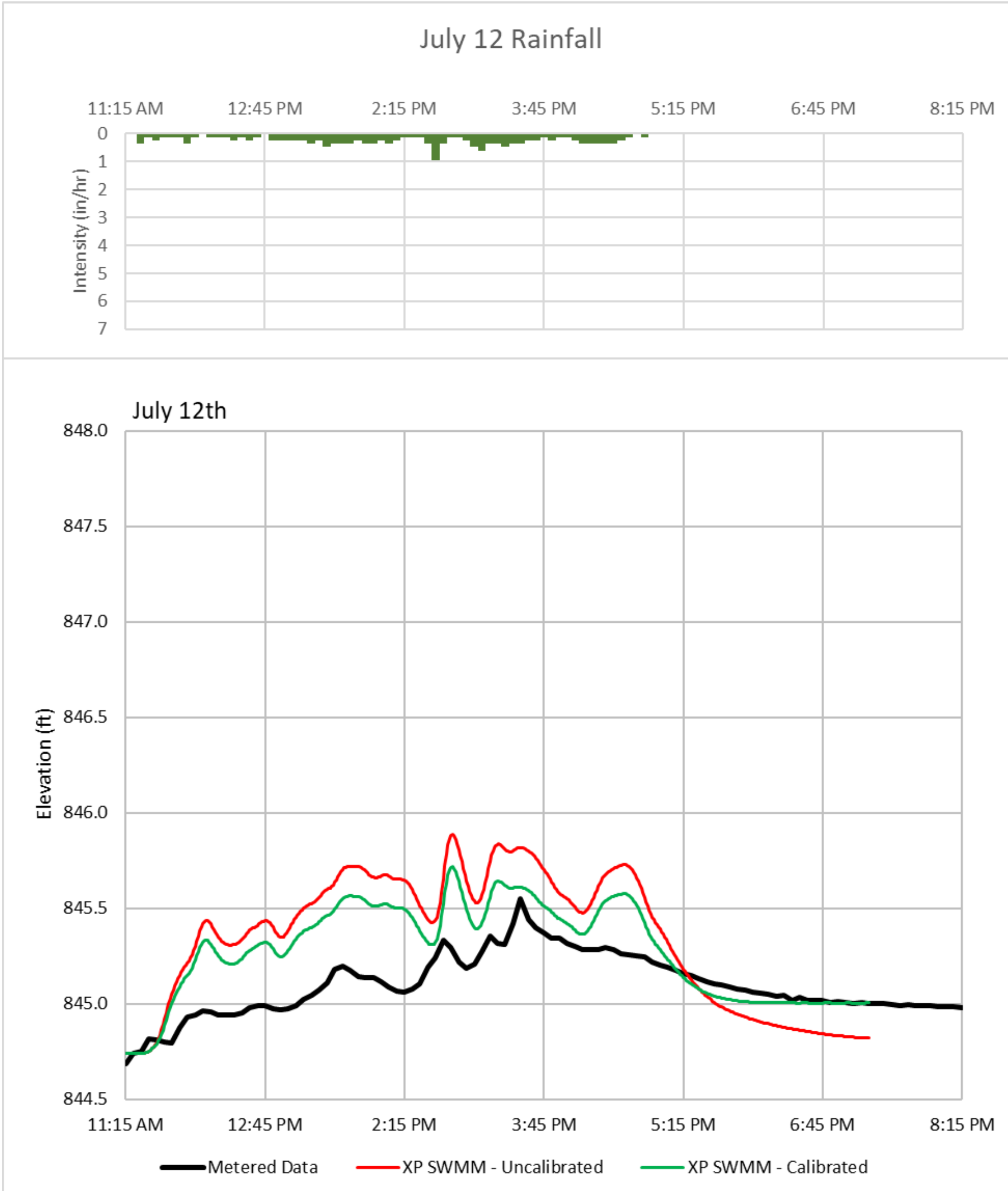


Model Calibration Results

Sayle St Level Logger

Metershed Area = 34.6 acres

Downstream Pipe = 38”x57” Elliptical

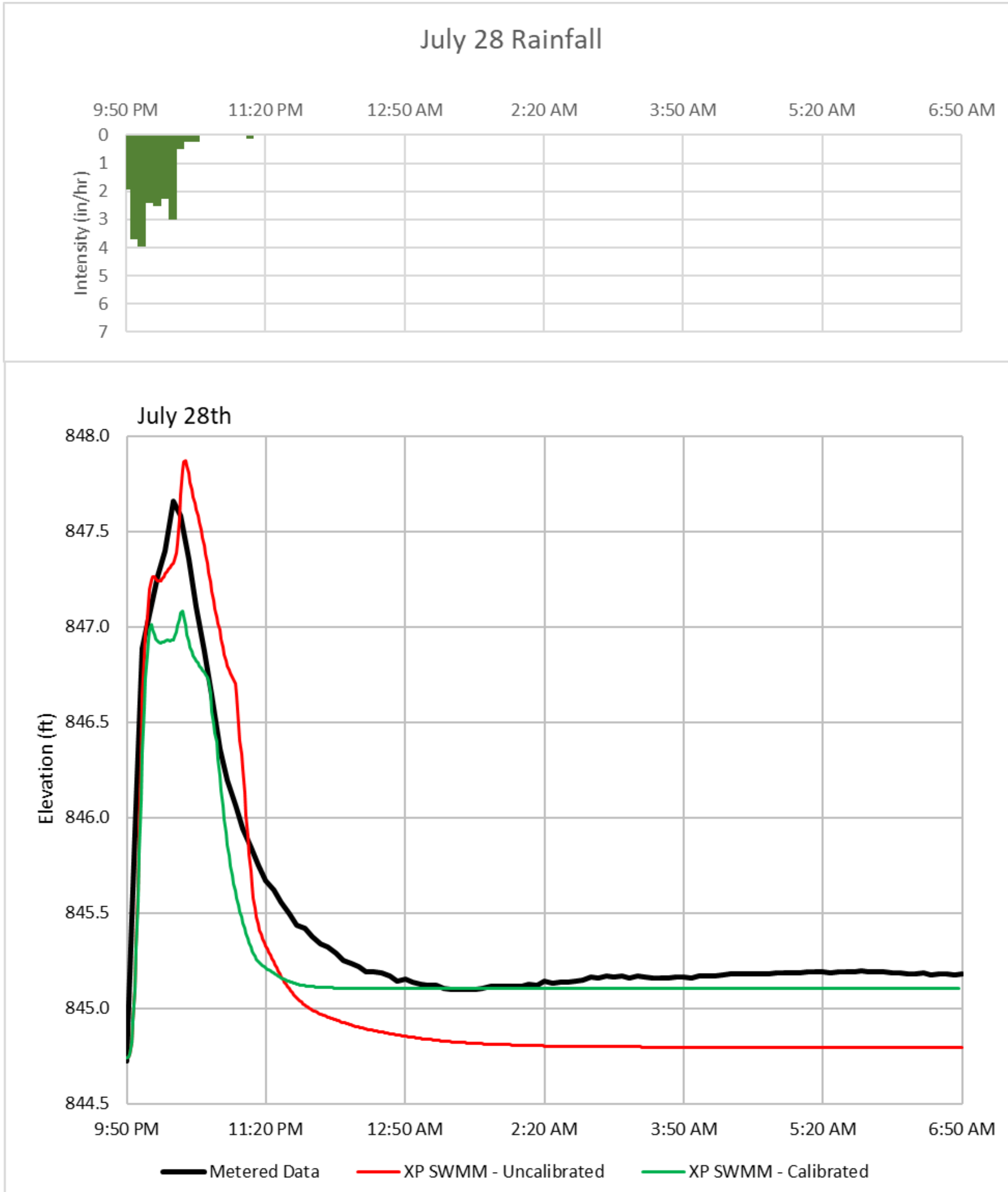


Model Calibration Results

Sayle St Level Logger

Metershed Area = 34.6 acres

Downstream Pipe = 38”x57” Elliptical

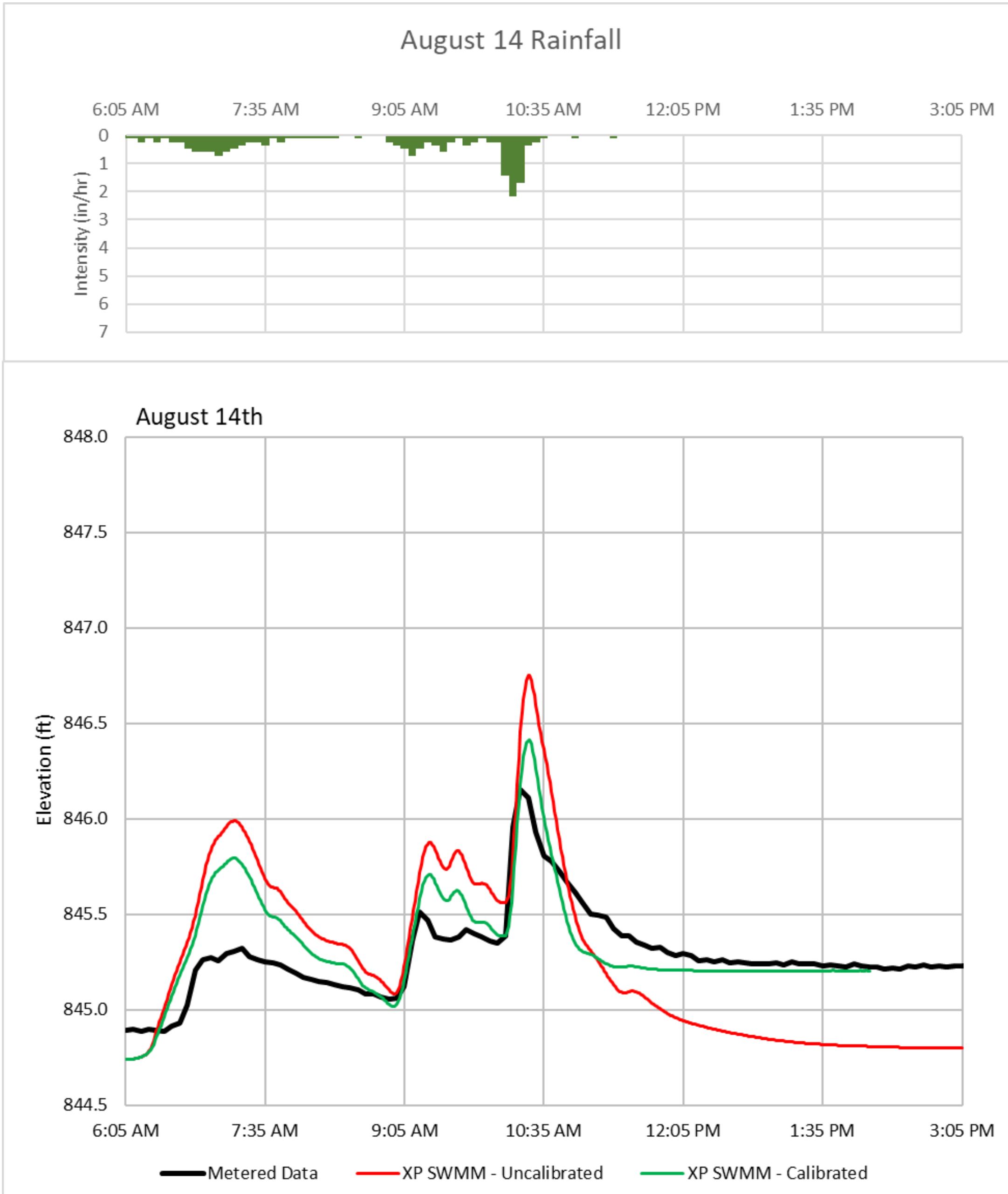


Model Calibration Results

Sayle St Level Logger

Metershed Area = 34.6 acres

Downstream Pipe = 38”x57” Elliptical

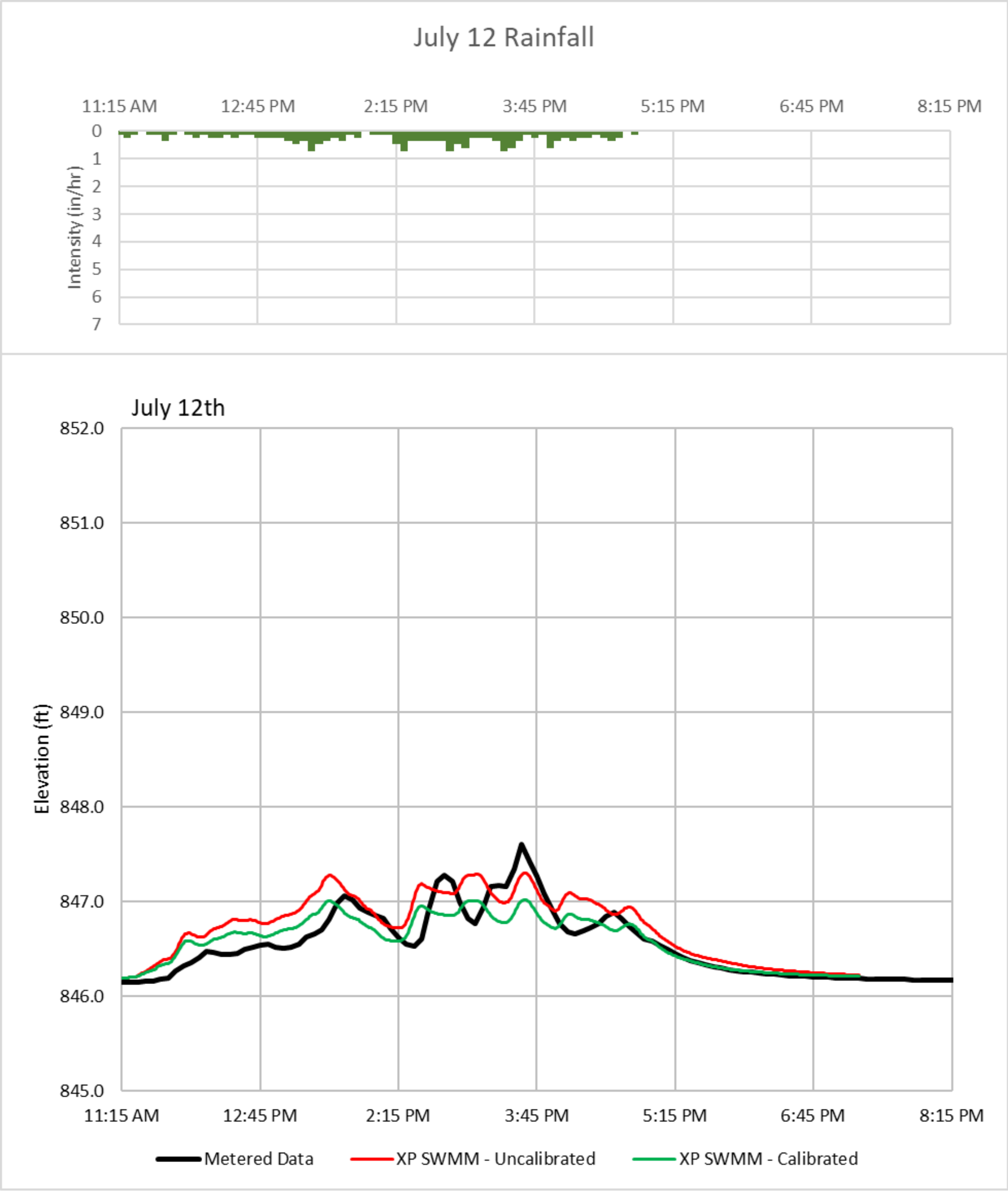


Model Calibration Results

Bram St Level Logger

Metershed Area = 100.96 acres

Downstream Pipe = 54" Circular

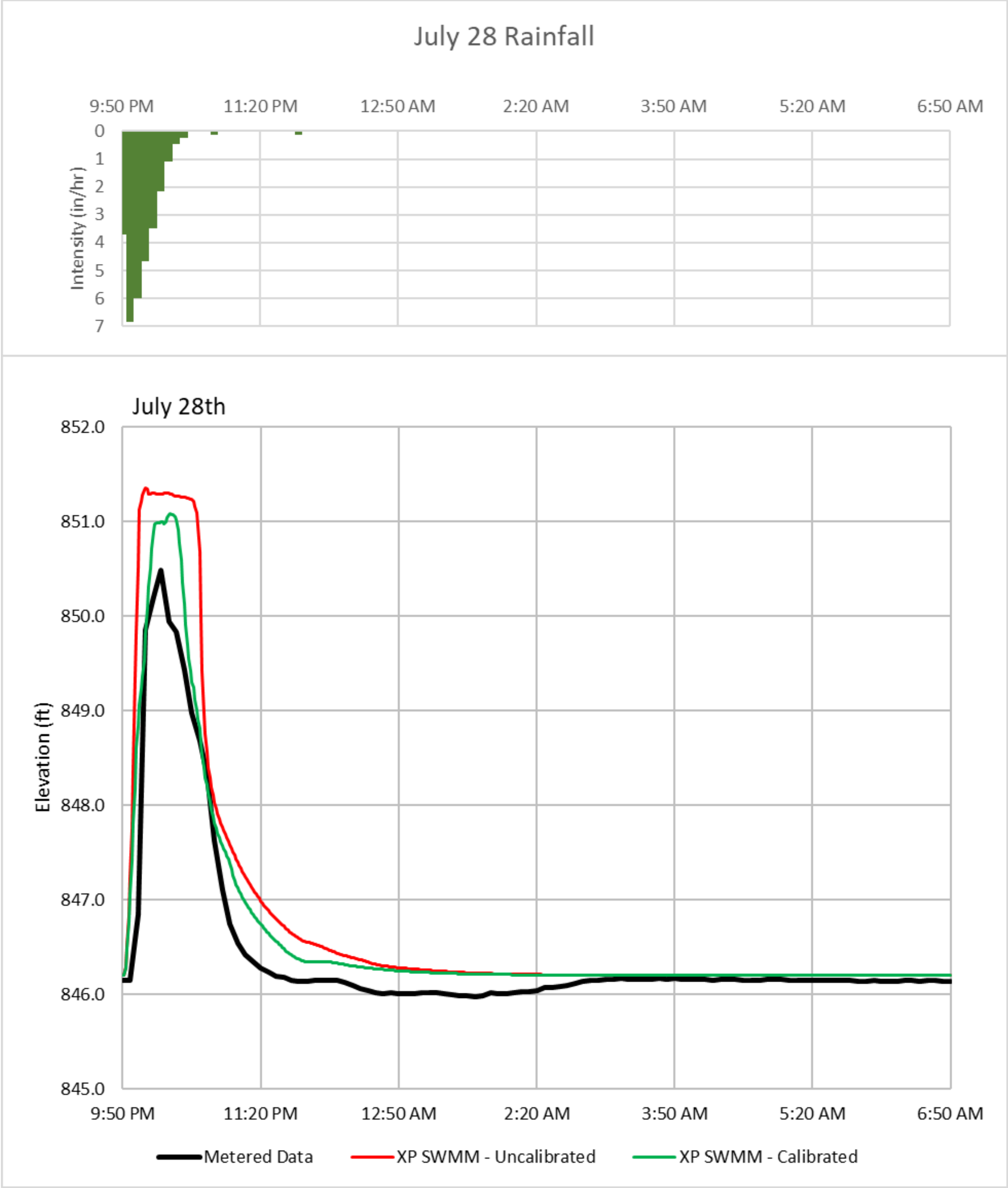


Model Calibration Results

Bram St Level Logger

Metershed Area = 100.96 acres

Downstream Pipe = 54" Circular

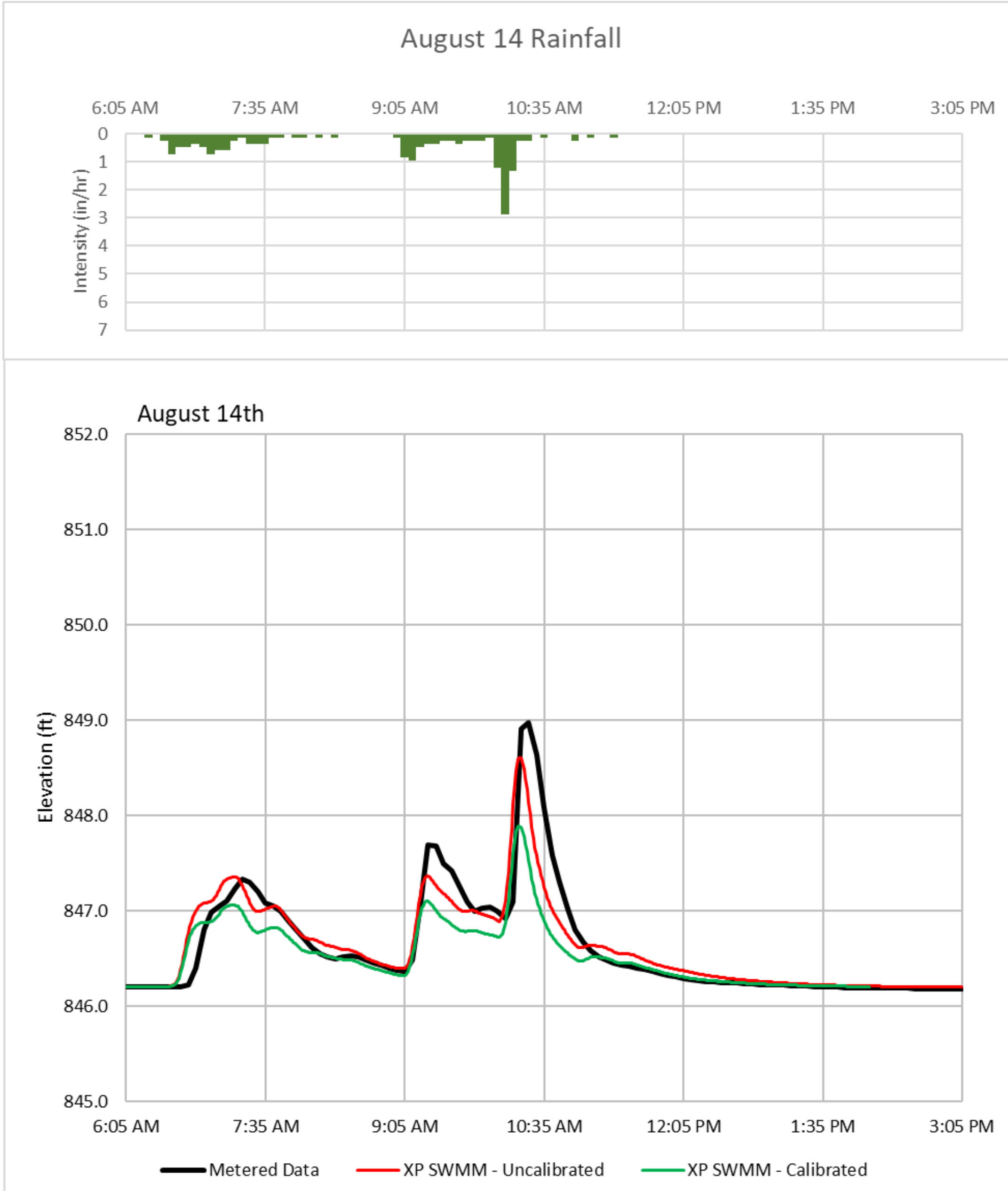


Model Calibration Results

Bram St Level Logger

Metershed Area = 100.96 acres

Downstream Pipe = 54" Circular

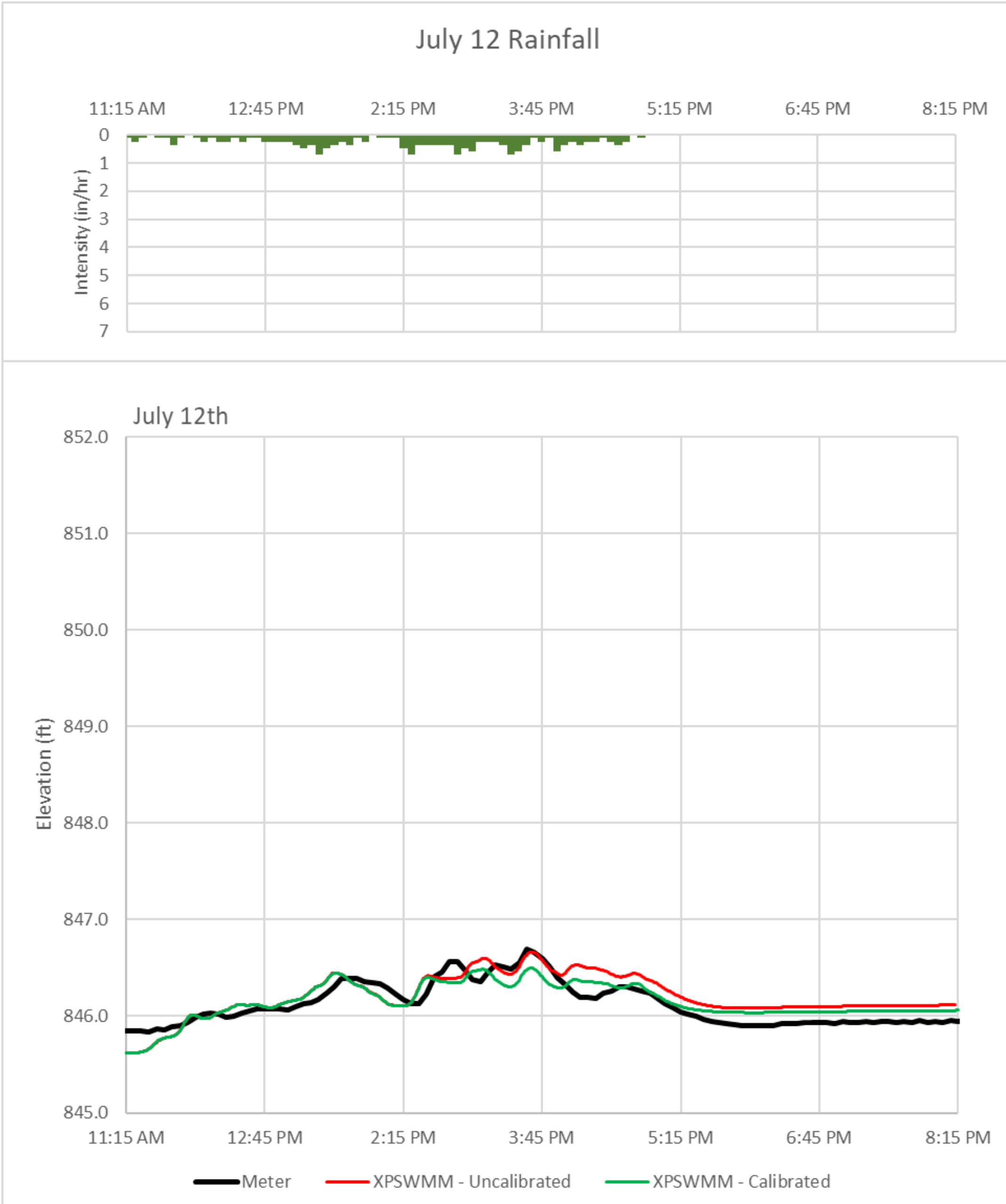


Model Calibration Results

East Olin Ave Flow Meter

Metershed Area = 88 acres

Downstream Pipe = 36" Circular

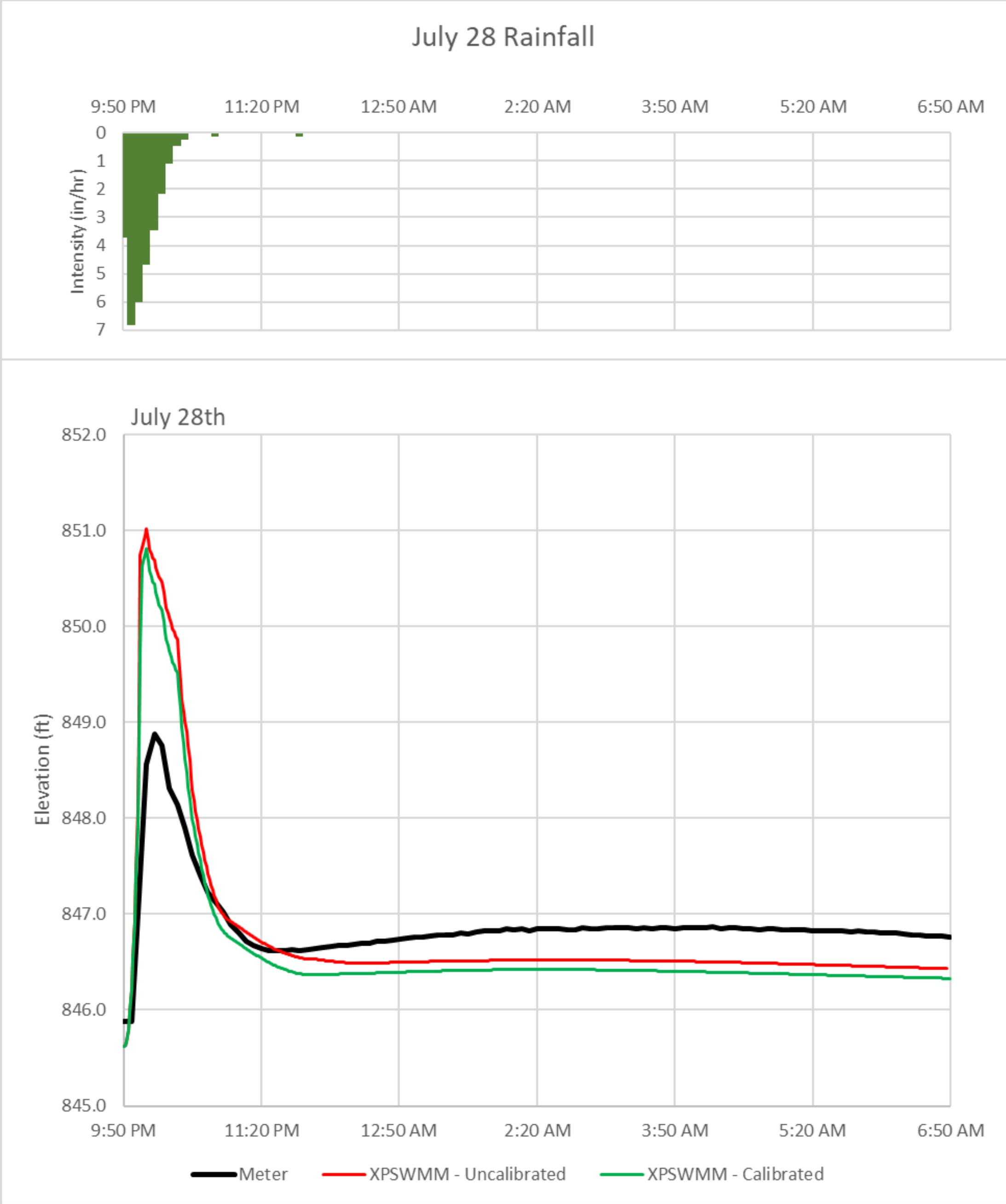


Model Calibration Results

East Olin Ave Flow Meter

Metershed Area = 88 acres

Downstream Pipe = 36" Circular



Model Calibration Results

East Olin Ave Flow Meter

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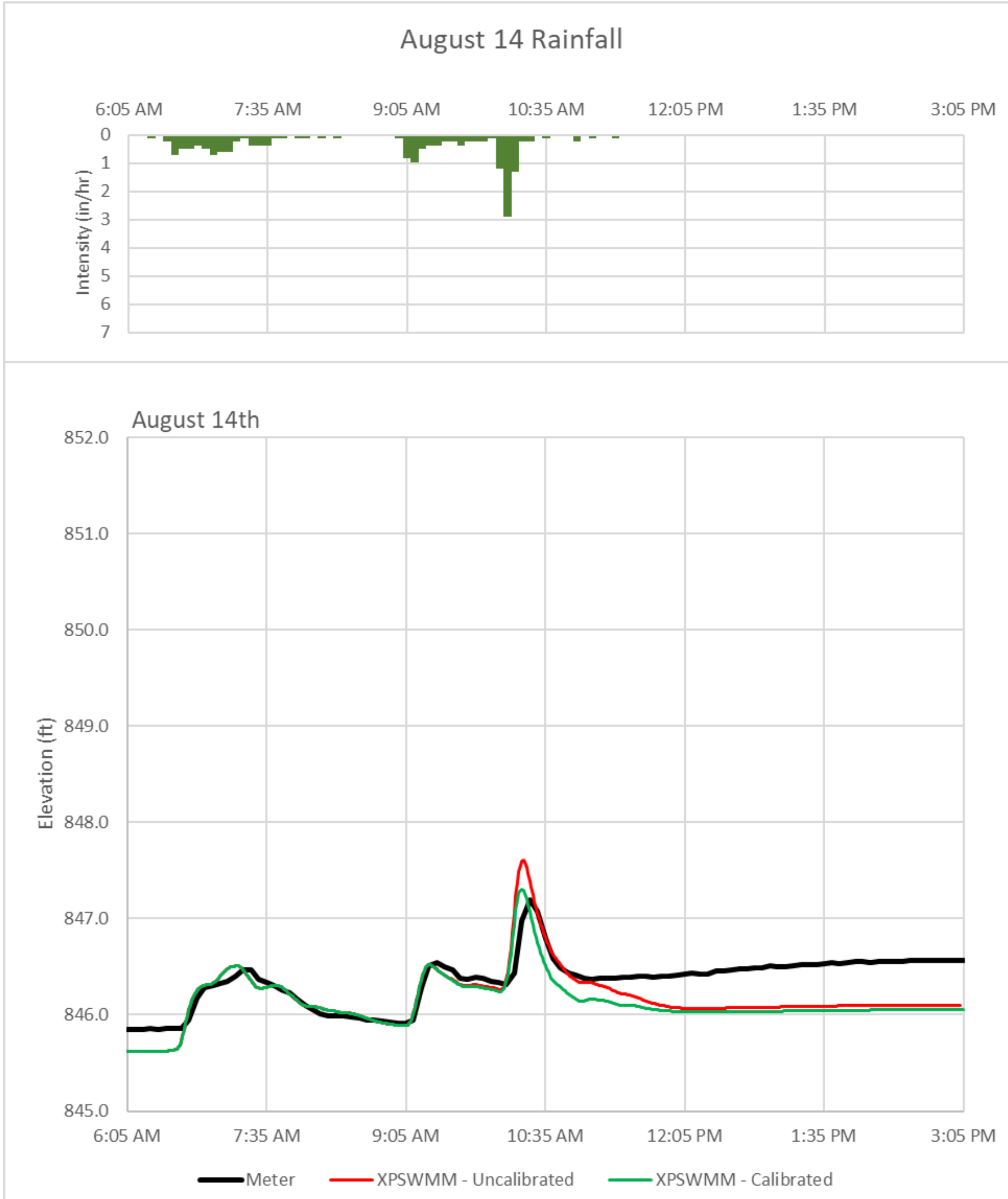
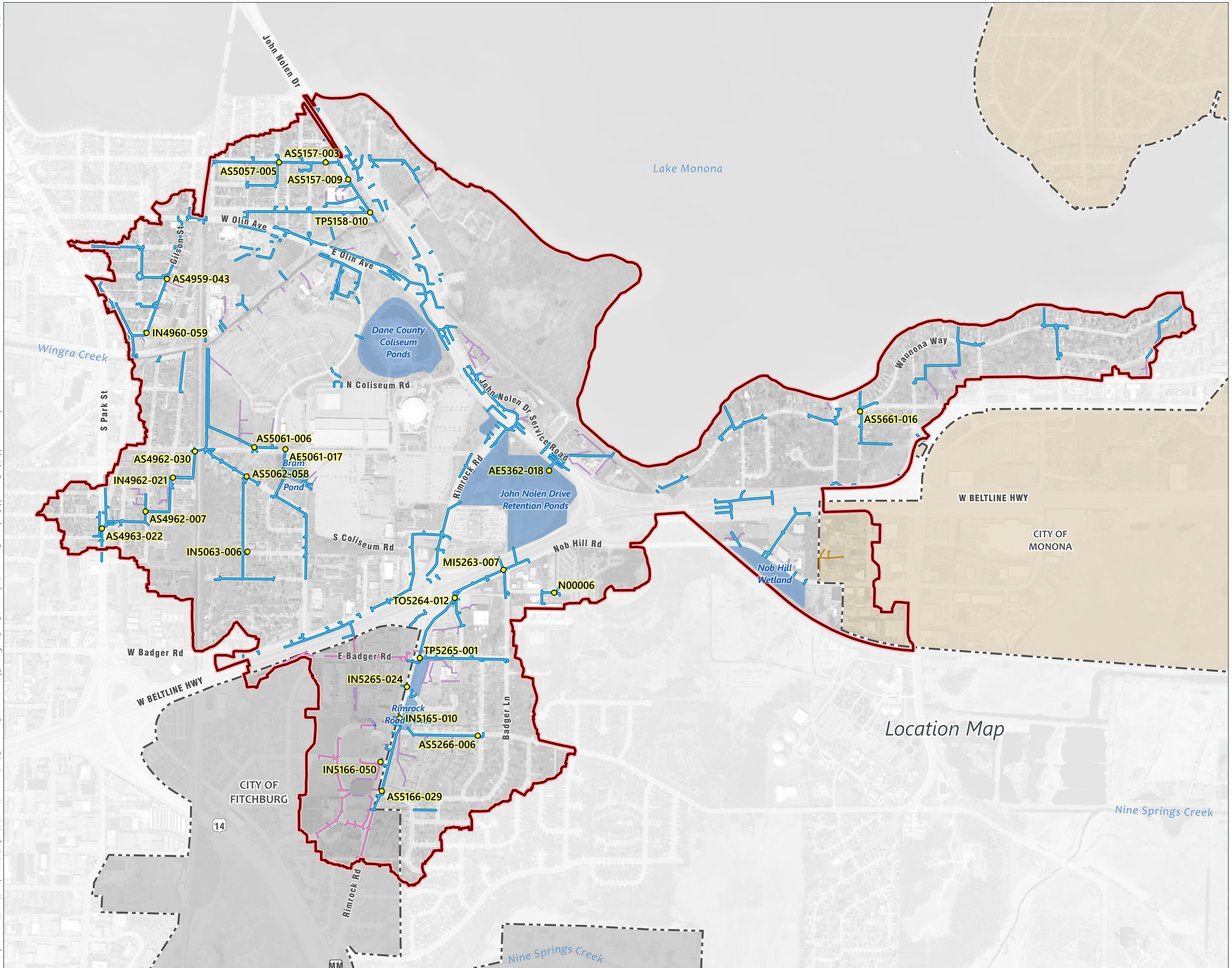
Downstream Pipe = 36" Circular



Appendix D. Select Locations Flooding Depth & Duration

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)
AE5061-017	Bram St (near Alliant west side entrance)	850.00	0.89	0.97	1.03	1.29	2.43	2.74	3.54
AE5362-018	WisDOT water quality pond outlet at John Nolen Drive	850.75	0.00	0.00	0.00	0.00	0.00	1.27	1.93
AS4959-043	Gilson St and Cedar St	855.39	-0.13	0.22	0.27	0.34	0.56	0.66	0.81
AS4962-007	Fisher St (east of housing complex)	876.53	-0.53	-0.15	0.26	0.90	1.31	1.40	1.52
AS4962-030	Bram St and Third Ave (west of railroad bridge)	856.54	-3.37	-3.01	-1.07	0.00	0.04	0.11	0.20
AS4963-022	S Park St (between Dane St and Ridgewood Way)	885.42	-1.77	0.03	0.12	0.22	0.33	0.36	0.52
AS5057-005	W Lakeside St and Lawrence St	852.77	0.12	0.24	0.33	0.41	0.53	0.60	0.70
AS5061-006	Bram St (near Quann Park tennis courts)	850.78	-3.68	-3.35	-3.07	-2.63	-0.31	1.52	2.67
AS5062-058	Koster St and Sundstrom St	855.20	-5.83	-4.22	-2.13	-0.17	0.31	0.39	0.49
AS5157-003	E Lakeside St (between Colby St and Sayle St)	850.26	-0.32	0.60	0.98	1.34	1.66	1.81	1.95
AS5157-009	Sayle St	849.70	-2.19	-1.75	-1.07	-0.31	0.17	0.25	0.41
AS5166-029	Rimrock Rd and Kent Ln	864.23	-6.15	-5.74	-5.08	-4.03	-2.81	-2.28	-1.54
AS5266-006	Moorland Rd and Dunwoody Dr	881.17	-2.46	-2.31	-2.15	-1.87	0.21	0.31	0.48
AS5661-016	Waunona Way and Woodley Ln	854.07	-1.16	0.09	0.32	0.46	0.44	0.36	0.38
IN4960-059	Gilson St (south end near Beld St)	850.60	0.05	0.42	1.19	1.69	2.42	2.69	3.15
IN4962-021	Baird St (near Center St)	867.83	-0.81	-0.26	0.43	0.80	1.09	1.21	1.39
IN5063-006	Sunny Meade Ln and Sundstrom St	889.85	-2.69	-2.34	-0.90	0.00	0.00	0.13	0.35
IN5165-010	Rimrock Rd (north of Moorland Rd)	858.03	0.46	0.53	1.00	2.01	3.29	3.84	4.57
IN5166-050	Rimrock Rd and Latitude 43 St	861.24	-0.90	0.00	0.00	0.00	0.31	0.63	1.37
IN5265-024	Rimrock Rd and Burdette Ct	860.38	-2.61	-2.30	-1.72	-0.43	0.94	1.49	2.23
MI5263-007	Nob Hill Rd and Badger Ln (near Beltline Hwy)	856.68	-3.86	-3.20	-2.69	-2.01	-1.36	-0.94	-0.24
N00006	Coyier Ln	867.47	-6.58	-2.81	-1.09	0.16	0.36	0.44	0.52
TO5264-012	Nob Hill Rd (north of car dealership, west of Rubin's Furniture)	856.29	-2.75	-1.10	-0.07	0.78	1.46	2.10	2.79
TP5158-010	South of Sayle St and Van Deusen St, north of Wingra Creek	850.92	-4.31	-4.14	-3.90	-3.59	-3.35	-3.29	-3.19
TP5265-001	E Badger Rd and Rimrock Rd	862.06	-6.63	-5.08	-3.77	-2.61	-1.20	-0.69	0.80



Select Locations for Flooding Depth and Duration

Appendix D
John Nolen Watershed
Study Report

City of Madison
Dane County, WI

- Watershed Study Area
- City of Fitchburg
- City of Monona
- Public Storm System
- Private Storm System
- Monona Storm System
- Fitchburg Storm System
- Stormwater Management Pond
- Select Locations for Flooding Depth and Duration

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

MSA

0 0.13 0.25 Miles

N

Print Date: 9/2/2025

Appendix E. Summary of Public Comments

PIM	Date	Postcards Sent	Registered	Attendees
1	5/30/2023	3,826	19	?
2	4/24/2024	3,366	20	12
3	3/18/2025	3,368	96	38

PIM 1

The John Nolen Watershed study held the first Public Information Meeting (PIM) on 5/30/2023 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.

Question #1: How are you planning for climate change? More storms, with faster rates of rainfall are going to be happening more often. The 1 Percent storm of today is not going to be a 1 percent storm in 20 years or 40 years.

Response: The city understands larger storms will be occurring. We are considering this by looking at events larger than the 1% storm, including the 0.5% and 0.2% chance storms. We set goals for the 500-yr storm. There's real challenges and limitations in what we can do, but we are thinking about this and preparing for it where we can with these models. Unfortunately, paying for improvements will be a real challenge. Recent updates to the stormwater ordinance and increasing requirements on new developments and detention up to the 200-yr storm. There are also increased standards on redevelopment.

Question #2: Please speak to the city's support for raingardens in the terrace sections of private and public property, and the value of these rain gardens for reducing flooding.

Response: Early on in street projects, we encourage residents to choose to have a rain garden installed. Improves water quality and reduces flows in smaller events. The stormwater utility (SWU) does offer stormwater utility bill credits and adjustments to reduce runoff as well. Raingardens certainly do help, but unfortunately they don't make any significant impact during the very large events.

Question #3: Will the watershed study also address water quality in Lake Monona?

Response: This watershed study and all other watershed studies like it are looking specifically at flooding and not water quality. It's different types of modeling that we cannot be integrated into water quality modeling. However, efforts are given to improving water quality and the city has requirements to meet permit requirements.

PIM 2

The John Nolen study held the second PIM on 4/24/2024 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.

Question #1: Regarding stormwater inlets, how do you take into consideration inlets on private property or parking lots?

Response: We mostly do not model private storm sewers, but we do try to look for areas where we do have private pipes or inlets. We do try and determine if private drainage is significant or not.

Question #2: This question is about Quan Park and Alliant Energy. How do we bring into the model that we have large public ownership in the middle of the study area? How was Alliant Energy Center involved in the study? With lots of water coming out of public property, how was this all brought into the study?

Response: We have some stormwater management plans/drainage patterns for the Alliant Energy Center. The city is mostly concerned about flooding on city land or public lands since those are the only areas we can control, but we do have the land cover from the Alliant Energy Center and drainage patterns included. *Note that the Alliant Energy Center is owned by Dane County, not the City.*

Question #3: Is the Alliant Energy Center concerned about flooding that results from runoff from their property and where can they reduce flooding? (This followed by a discussion around the pond at the end of Bram St)

Response: City has ordinances to regulate stormwater runoff with new development and redevelopment. City only has a certain amount of jurisdiction. The Alliant Energy Center was previously located in the Town of Madison and not within the City's jurisdiction. The city will work as closely with Alliant to try to control/migrate stormwater runoff to the extent possible. However, they will only be required to meet the standards of the redevelopment ordinance.

Question #4: The was a technical question about the flow meter, wondering what caused issues with the monitoring.

Response: The flow meter routinely clogged with debris, there was very long tails on the data.

Question #5: There was a model calibration related question. What parameter(s) were found to be most useful to adjust?

Response: Generally, it is the percent or proportion of connected vs disconnected impervious areas.

Question #6: What is the cause of flooding around the Ester Beach Area? There is flooding shown but haven't been observed previously. A resident near the Woodley Lane/Waunona Way intersection indicated that they haven't seen extensive flooding at that intersection, as shown on the inundation maps. However, they have a neighbor who has seen flooding through their yard more similar to the inundation mapping.

Response: It's likely an issue with the resolution of the 2D grid. The model grid cells likely don't capture the curb and so there are likely a few areas that water is flowing out of the street in the model but might not actually be doing so.

Question #7: There were general questions and discussions around the drainage of unimproved streets in the Capital Hill neighborhood. The inlets and pipes do not convey much water. A resident who lives near the Sundstrom Street/Sunney Meade Lane intersection indicated that they have not seen the flooding as shown on the inundation maps but indicated that the storm drains on Nygard Street are covered in weeds/debris, particularly on the south side.

Response: In general, the existing storm sewer system is not capturing much stormwater from that area. Capturing the flow in curb and gutter and directing to inlets could happen with street reconstruction, but there is not time frame set yet for this street to be reconstructed. The model might be underestimating flooding in this area, due to the poor performance of ditches and drains.

Question #8: A resident in a condo near Paunack Park expressed that the entire park was underwater during the August 2018 large rainfall event.

Response: The group reviewed the 10% and 1% inundation maps for this area; the flooding appears to only be extensive during the larger rain event.

PIM 3

The John Nolen 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?

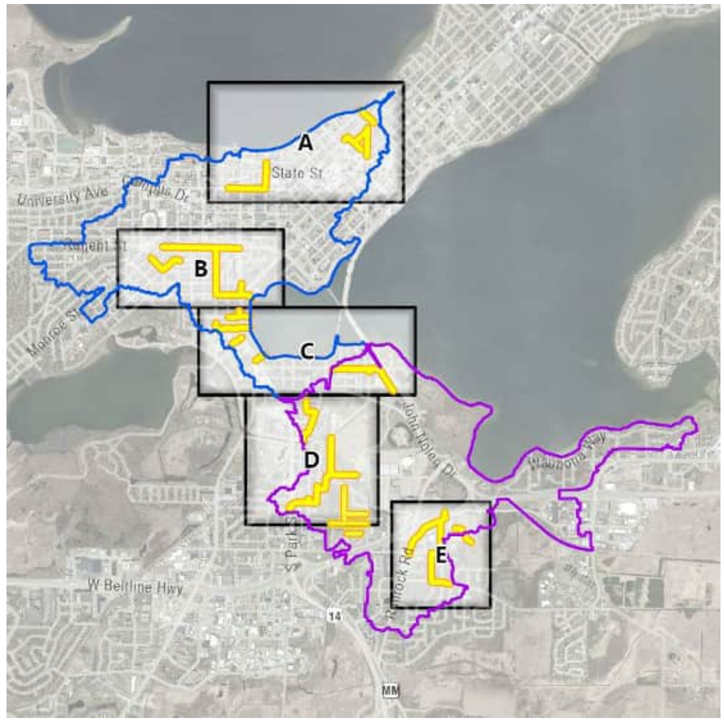
Response: Land cover is included in the models including the ability of pervious areas to absorb rainfall/runoff. Trees are not explicitly modeled, but the models are calibrated with monitoring data to try and establish baseline conditions. Lots of research is coming out on the effectiveness of trees 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 C through E covered the John Nolen Study Area. Only those comments from pertinent to John Nolen are included here.

<u>**Area C** (including S Park St and W Lakeside St)</u>



Question #3: 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 #4: 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 #5: 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.

<u>**Area D** (including Bram St and Wingra Creek)</u>

Question #6: Will the Bram to Wingra and Alliant Energy outlet improvements to the drainage pipes cause greater flooding in Wingra Creek? The residents live along Wingra Creek at the train bridge, and experience frequent flooding from the creek. There is a lot of erosion right by the train bridge, and the water comes right up to their house. The frequent flooding here is a big concern for the safety of our home, and we're hoping something can be done to help reduce the flooding here.

Response: Impacts to the creek levels would be studied if the project is implemented. Wingra Creek levels are most tied to the lake level elevations, which is outside the scope of this study.

There was a general discussion high-level discussion about the study and potential projects.

Area E (including Rimrock Pond and Badger Ln)

Question #7: How does Madison cooperate with adjacent communities when watershed boundaries cross City-boundaries?

Response: City staff members invited other municipalities to participate in this study, expanding the scope of work to include more detail in areas outside of Madison. If there is a project identified outside of Madison, that would provide mutual benefit, City staff have open discussions with the adjacent community staff. There is generally a cost-share component to this, but it is decided upon by leaders of the impacted communities.

Appendix F. Internal City Meetings and Discussions

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.

Bimonthly Coordination Meeting with Parks Department (3/19/25)

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 John Nolen Drive 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. Only the Bram St outfall and Bram's addition improvements were presented. The proposed project(s) would include the installation of two large box culverts through Quann Park.

There were no major questions or concerns from Parks staff in regards to the information presented. Engineering will work closely with Parks if/when any project are adjacent or within to park land.

Appendix G. Cost Estimates

John Nolen Solution A

Lakeside and Sayle St Storm System Improvements

Conceptual Cost Estimate

1/29/2025

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	1,060	L.F.	$ 1,200.00	N/A	$ 1,272,000
Special	WW16	4'X8' BOX CULVERT WING WALLS	1	EACH	$ 35,000.00	N/A	$ 35,000
Special	WW7	4'x6' BOX CULVERT	607	L.F.	$ 800.00	N/A	$ 485,600
Standard	50411	48 INCH TYPE I RCP STORM SEWER PIPE	111	L.F.	$ 250.00	N/A	$ 27,750
Standard	50409	36 INCH TYPE I RCP STORM SEWER PIPE	221	L.F.	$ 200.00	N/A	$ 44,200
Standard	50407	30 INCH TYPE I RCP STORM SEWER PIPE	573	L.F.	$ 150.00	N/A	$ 85,950
Standard	50403	18 INCH TYPE I RCP STORM SEWER PIPE	95	L.F.	$ 115.00	N/A	$ 10,925
Special	NW11	MMSD COORDINATION: DEWATERING AND SHORING	1	EACH	$ 150,000.00	N/A	$ 150,000
Standard	20501	ADJUST SEWER ACCESS STRUCTURE	14	EACH	$ 750.00	N/A	$ 10,500
Standard	50741	TYPE "H" INLET	28	EACH	$ 3,600.00	N/A	$ 100,800
Standard	20314	REMOVE PIPE	2,667	L.F.	$ 38.00	N/A	$ 101,346
Standard	30301	5 INCH CONCRETE SIDEWALK	260	S.F.	$ 8.00	N/A	$ 2,080
Standard	20323	REMOVE CONCRETE SIDEWALK & DRIVE	260	S.F.	$ 4.00	N/A	$ 1,040
					Subtotal		**$ 2,327,191**
					Contingency	**25%**	**$ 581,798**
					Design	**10%**	**$ 232,719**
					Total		**$ 3,141,708**
					Land Acquisition	**0**	**$ -**
					Wetland Mitigation	**0.000**	**$ -**
					Total Total		**$ 3,141,708**

John Nolen Solution B

Gilson St Storm System Improvements

Conceptual Cost Estimate

1/29/2025

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	37	L.F.	$ 280.00	N/A	$ 10,360
Standard	50471	54 INCH RCP AE	1	EACH	$ 3,350.00	N/A	$ 3,350
Standard	50411	48 INCH TYPE I RCP STORM SEWER PIPE	869	L.F.	$ 250.00	N/A	$ 217,250
Standard	50409	36 INCH TYPE I RCP STORM SEWER PIPE	347	L.F.	$ 200.00	N/A	$ 69,400
Standard	50420	24 INCH X 38 INCH TYPE I HERCP STORM SEWER PIPE	98	L.F.	$ 160.00	N/A	$ 15,680
Standard	50403	18 INCH TYPE I RCP STORM SEWER PIPE	321	L.F.	$ 115.00	N/A	$ 36,915
Special	NW11	MMSD COORDINATION: DEWATERING AND SHORING	1	EACH	$ 150,000.00	N/A	$ 150,000
Standard	20501	ADJUST SEWER ACCESS STRUCTURE	11	EACH	$ 750.00	N/A	$ 8,250
Standard	50741	TYPE "H" INLET	24	EACH	$ 3,600.00	N/A	$ 86,400
Standard	20314	REMOVE PIPE	1,672	L.F.	$ 38.00	N/A	$ 63,536
					Subtotal		**$ 661,141**
					Contingency	**25%**	**$ 165,285**
					Design	**10%**	**$ 66,114**
					Total		**$ 892,540**
					Land Acquisition	**0**	**$ -**
					Wetland Mitigation	**0.000**	**$ -**
					Total Total		**$ 892,540**

John Nolen Solution C

Bram to Wingra and Alliant Energy Outlet Improvements

Conceptual Cost Estimate

5/8/2025

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	2,127	L.F.	$ 1,200.00	N/A	$ 2,552,400
Special	WW16	4'X8' BOX CULVERT WING WALLS	1	EACH	$ 35,000.00	N/A	$ 35,000
Special	WW11	5'x10' BOX CULVERT	1,322	L.F.	$ 1,700.00	N/A	$ 2,247,400
Special	JN1	5'x10' RCB CULVERT WINGWALL & RAILING	1	EACH	$ 40,000.00	N/A	$ 40,000
Special	NW11	MMSD COORDINATION: DEWATERING AND SHORING	1	EACH	$ 150,000.00	N/A	$ 150,000
Standard	20501	ADJUST SEWER ACCESS STRUCTURE	9	EACH	$ 750.00	N/A	$ 6,750
Standard	50741	TYPE "H" INLET	6	EACH	$ 3,600.00	N/A	$ 21,600
Standard	20314	REMOVE PIPE	3,536	L.F.	$ 38.00	N/A	$ 134,368
Standard	20701	TERRACE SEEDING	137,550	S.Y.	$ 3.00	N/A	$ 412,650
Standard	20336	PIPE PLUG	1	EACH	$ 540.00	N/A	$ 540
Special	JN4	LANDFILL -- COSTS ASSOCIATED WITH HAULING AND DISPOSAL	3,449	YARDAGE	$ 75.00	N/A	$ 258,675
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	890	L.F.	$ 500.00	N/A	$ 445,000
					Subtotal		**$ 6,391,383**
					Contingency	**25%**	**$ 1,597,846**
					Design	**10%**	**$ 639,138**
					Total		**$ 8,628,367**
					Land Acquisition	**0**	**$ -**
					Wetland Mitigation	**0.000**	**$ -**
					Total Total		**$ 8,628,367**

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

John Nolen Solution D

Brams Addition Storm System Improvement

Conceptual Cost Estimate

1/29/2025

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	1,669	L.F.	$ 310.00	N/A	$ 517,390
Standard	50411	48 INCH TYPE I RCP STORM SEWER PIPE	517	L.F.	$ 250.00	N/A	$ 129,250
Standard	50409	36 INCH TYPE I RCP STORM SEWER PIPE	87	L.F.	$ 200.00	N/A	$ 17,400
Standard	50407	30 INCH TYPE I RCP STORM SEWER PIPE	530	L.F.	$ 150.00	N/A	$ 79,500
Standard	20501	ADJUST SEWER ACCESS STRUCTURE	18	EACH	$ 750.00	N/A	$ 13,500
Standard	50741	TYPE "H" INLET	36	EACH	$ 3,600.00	N/A	$ 129,600
Standard	20314	REMOVE PIPE	1,967	L.F.	$ 38.00	N/A	$ 74,746
Standard	20335	ABANDON SEWER PIPE WITH SLURRY	133	C.Y.	$ 600.00	N/A	$ 79,674
					Subtotal		**$ 1,041,060**
					Contingency	**25%**	**$ 260,265**
					Design	**10%**	**$ 104,106**
					Total		**$ 1,405,431**
					Land Acquisition	**0**	**$ -**
					Wetland Mitigation	**0.000**	**$ -**
					Total Total		**$ 1,405,431**

John Nolen Solution E

Nygard and Sunstrom Street Improvements

Conceptual Cost Estimate

1/29/2025

Standard/ Special	Item #	Item	Quantity	Unit	"Average" Unit Cost provided by City	Adjusted Unit Cost (if used)	Total Item Cost
Standard	50741	TYPE "H" INLET	38	EACH	$ 3,600.00	N/A	$ 136,800
					Subtotal		**$ 136,800**
					Contingency	**25%**	**$ 34,200**
					Design	**10%**	**$ 13,680**
					Total		**$ 184,680**
					Land Acquisition	**0**	**$ -**
					Wetland Mitigation	**0.000**	**$ -**
					Total Total		**$ 184,680**

John Nolen Solution F

Rimrock Pond Outlet Improvement

Conceptual Cost Estimate

5/8/2025

Standard/ Special	Item #	Item	Quantity	Unit	"Average" Unit Cost provided by City	Adjusted Unit Cost (if used)	Total Item Cost
Special	WW11	5'x10' BOX CULVERT	1,921	L.F.	$ 1,700.00	N/A	$ 3,265,700
Special	JN1	5'x10' RCB CULVERT WINGWALL & RAILING	1	EACH	$ 40,000.00	N/A	$ 40,000
Special	JN2	108" STORM SEWER - TRENCHLESS INSTALLATION	217	L.F.	$ 3,200.00	N/A	$ 694,400
Special	JN3	108" TRENCHLESS INSTALLATION - BORE PIT	2	EACH	$ 90,000.00	N/A	$ 180,000
Standard	20501	ADJUST SEWER ACCESS STRUCTURE	6	EACH	$ 750.00	N/A	$ 4,500
Standard	50741	TYPE "H" INLET	4	EACH	$ 3,600.00	N/A	$ 14,400
Standard	20314	REMOVE PIPE	2,138	L.F.	$ 38.00	N/A	$ 81,244
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	COLLECTOR	COLLECTOR STREET	795	L.F.	$ 1,500.00	N/A	$ 1,192,500
Standard	20701	TERRACE SEEDING	16,125	S.Y.	$ 3.00	N/A	$ 48,375
					Subtotal		**$ 5,608,119**
					Contingency	25%	**$ 1,402,030**
					Design	10%	**$ 560,812**
					Total		**$ 7,570,961**
					Land Acquisition	0	**$ -**
					Wetland Mitigation	0.000	**$ -**
					Total Total		**$ 7,570,961**

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

John Nolen Solution G

Badger Lane Storm System Improvements

Conceptual Cost Estimate

1/29/2025

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	1,165	L.F.	$ 310.00	N/A	$ 361,150
Standard	50411	48 INCH TYPE I RCP STORM SEWER PIPE	1,326	L.F.	$ 250.00	N/A	$ 331,500
Standard	50407	30 INCH TYPE I RCP STORM SEWER PIPE	657	L.F.	$ 150.00	N/A	$ 98,550
Standard	20501	ADJUST SEWER ACCESS STRUCTURE	2	EACH	$ 750.00	N/A	$ 1,500
Standard	50741	TYPE "H" INLET	24	EACH	$ 3,600.00	N/A	$ 86,400
Standard	20314	REMOVE PIPE	322	L.F.	$ 38.00	N/A	$ 12,236
					Subtotal		**$ 891,336**
					Contingency	**25%**	**$ 222,834**
					Design	**10%**	**$ 89,134**
					Total		**$ 1,203,304**
					Land Acquisition	**0**	**$ -**
					Wetland Mitigation	**0.000**	**$ -**
					Total Total		**$ 1,203,304**

John Nolen Solution H

Holtzman Rd Storm System Improvements

Conceptual Cost Estimate*

1/29/2025

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	827	L.F.	$ 200.00	N/A	$ 165,400
Standard	50407	30 INCH TYPE I RCP STORM SEWER PIPE	11	L.F.	$ 150.00	N/A	$ 1,650
Standard	20501	ADJUST SEWER ACCESS STRUCTURE	6	EACH	$ 750.00	N/A	$ 4,500
Standard	50741	TYPE "H" INLET	10	EACH	$ 3,600.00	N/A	$ 36,000
Standard	20314	REMOVE PIPE	243	L.F.	$ 38.00	N/A	$ 9,234
Standard	20335	ABANDON SEWER PIPE WITH SLURRY	45	C.Y.	$ 600.00	N/A	$ 26,808
Standard	20701	TERRACE SEEDING	9,225	S.Y.	$ 3.00	N/A	$ 27,675
Special	LOCAL	LOCAL STREET	230	L.F.	$ 500.00	N/A	$ 115,000
			.				
					Subtotal		**$ 386,267**
					Contingency	**25%**	**$ 96,567**
					Design	**10%**	**$ 38,627**
					Total		**$ 521,461**
					Land Acquisition	**0**	**$ -**
					Wetland Mitigation	**0.000**	**$ -**
					Total Total		**$ 521,461**

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