Appendix D LLBDM AOI Justification Tech Memo

Technical Memorandum

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To: Michael Kading, City of Neenah
CC: Little Lake Butte des Morts Leadership Team
From: Korin Doering, Project Manager
Date: September 9, 2024
Re: Little Lake Butte des Morts Area of Interest (AOI) Selection and Justification
Little Lake Butte des Morts Phase 1
City of Neenah, Wisconsin
Project No.: 2403578

1. Background

Clearly defining the geographic scope is an important step for developing a plan that is relevant, focused, and effective in achieving its objectives. For lake management planning, a clearly defined geographic scope helps to support several aspects of the planning process, including:

1. **Resource allocation**: Determining where resources (financial, personnel, and material) should be prioritized and allocated for efficient and effective use within a defined area.
2. **Stakeholder identification**: Identifying relevant stakeholders. This might include local governments, businesses, community groups, and residents who are directly affected by or have an interest in the planning process or implementation.
3. **Data Collection and Analysis**: Collecting and analyzing data specific to the area and essential for making informed decisions as well as more easily being able to filter out irrelevant information.
4. **Identification of Challenges and Solutions**: Identifying problems and opportunities that are specific to the defined project area which allows for more targeted and effective solutions that address local needs and conditions.
5. **Coordination and Integration**: Facilitating coordination with other planning efforts and initiatives that may be happening in adjacent or overlapping areas.
6. **Communication and Engagement:** Tailoring communication and engagement strategies to the specific needs and interests of the people and organizations within the project area.

When evaluating and recommending management actions for a lake, it is important to consider the issues within the lake as well as the surrounding watersheds and broader areas that affect a lake's condition. As such, the geographic scope for the Little Lake Butte des Morts (LLBDM) planning effort has been divided into three nested areas of interest (AOI):

1. LLBDM – Lake AOI
2. LLBDM – Watershed AOI
3. LLBDM – Drainage Basin AOI

The Lake AOI is geographically nested within the Watershed AOI which are both nested within the Drainage Basin AOI, as shown in Figure 1. The development of each AOI, including considerations and justifications, are described in the sections below.

2. LLBDM Lake AOI

LLBDM is an approximately 1,234-acre lake bordered by the Village of Fox Crossing, City of Neenah, and City of Menasha, located in Winnebago County, Wisconsin (Figure 2). The lake is riverine in nature with connectivity to the lower portion of the Fox River (referred to as Lower Fox River or LFR). LLBDM begins at the outfall of Lake Winnebago at the Neenah and Menasha dams and ends downstream at the north end of Stroebe Island where the lake conjoins with the Lower Fox River [1]. The southern boundary of LLBDM starts at Fox River mile 40.09 and ends approximately at Fox River mile 35.81 [2].

Section 2.1 provides a background on waterbody identification codes and lists examples of waterbody databases used to obtain information. Section 2.2 describes the Lake AOI selection process with justification.

2.1. Waterbody Identification

The WDNR identifies lakes in the state's Register of Waterbodies (ROW) using unique Waterbody Identification Codes (WBIC). Each WBIC is associated with a GIS-based polygon that defines physical features of a waterbody, such as the shape and shoreline of a lake. This geospatial information is part of the WDNR's 24k Hydrography geodatabase[1].

The ROW is the official WDNR surface water inventory database that is accessible internally by WDNR staff. It contains waterbody name, WBIC and various physical characteristic data such as size, depth, sediment composition and shoreline length. The ROW is maintained by the Water Division of WDNR [3]. Much of the information is made available to the public through the WDNR website, the Surface Water Data Viewer (SWDV), and the Water Explorer web-based tool.

In addition to a WBIC[2], surface waters in Wisconsin are also assigned an Assessment Unit Identification Code for the Water Assessment Tracking and Electronic Reporting System (WATERS) database. This unique code is typically referred to as the WATERS ID. The database holds Clean Water Act (CWA) Section 305(b) and 303(d) data, designated uses, codified uses, and other data describing the quality of Wisconsin's rivers, lakes, and Great Lakes shoreline. WDNR sends data from this system to the U.S. Environmental Protection Agency (EPA) in fulfillment of CWA requirements [4].

Because LLBDM overlaps geographically with a portion of the Lower Fox River, the same stretch of water is identified and documented under two different waterbody names and sets of identification codes within WDNR databases. This is important to note for documenting and communicating impairments, monitoring data, and prescribing management actions. The Lower Fox River is a segment of the large Fox River. The Lower Fox River and Fox River share the same WBIC ID but have different WATERS IDs.

[1] A geodatabase is a type of digital container for spatial data and related attributes.
[2] WBICs are sometimes referred to as the ROW ID.

The identification codes for LLBDM and the portion of the Lower Fox River that overlaps with LLBDM are listed in Table 1. These IDs allow users to search online data infrastructure for information on a specific waterbody, such as the various databases listed in Table 2.

Table 1. LLBDM Lake AOI – WBIC and WATERS ID

Waterbody Name	Water Type	WBIC ID	WATERS ID	River Miles
Fox River *(headwaters in Columbia County to the mouth of the river in Green Bay)*	River	117900	5535277 6778560	Start: 199.45 End: 0
Lower Fox River *(Lake Winnebago Outlet to the mouth of the river in Green Bay)*	River	117900	357364	Start: 40.09 End: 0
Little Lake Butte des Morts	Lake	129800	1525284	Start: 40.09 End: 35.81

Table 2. Examples of Available Online Data Infrastructure

Resource Title	Acronym	Agency	Description	Access
Surface Water Integrated Monitoring System	SWIMS	WDNR	A database that holds comprehensive sets of data for each waterbody that integrates with the SWDV to enable viewing of monitoring results geographically using Web mapping applications. http://dnr.wi.gov/topic/surfacewater/swims/	Public access
Surface Water Data Viewer	SWDV	WDNR	An interactive web map application that has multiple themes that support a broad range of programs including datasets of dam safety, floodplain management, fish consumption advice, construction permits, designated waters review, and wetland and wetland indicators. http://dnrmaps.wi.gov/sl/?Viewer=swdv	Public access
Statewide Fisheries Management Database	FMDB	WDNR	A centralized database for all statewide fish surveys, wadeable stream habitat surveys, fish propagation information, fishing tournament permits, and fish kill investigations. https://dnr.wisconsin.gov/topic/Fishing/data/infosystem.html	WDNR Staff *(subset available to the public)*
Drinking Water System	DWS	WDNR	A data system created and maintained by the WDNR's Bureau of Drinking Water and Groundwater. It contains monitoring / reporting requirements for each public water system and their drinking water sampling results. This system is used to report public water supply data to EPA as required by the Safe Drinking Water Act. The DWS also contains information on public and private well construction and high-capacity well approvals. http://dnr.wi.gov/topic/drinkingwater/	WDNR Staff *(subset available to the public*
Water Condition Viewer	WCV	WDNR	A supplement for the SWDV that provides summary assessment data and various Water Quality Program-specific work functions including Clean Water Assessments, Watershed and Quality Planning, Targeted Watershed Assessments, Monitoring Studies and Results, and Fisheries and Habitat. http://dnrmaps.wi.gov/sl/?Viewer=WaterConditionViewer	Public access
Explore Wisconsin's Water		WDNR	An online web search platform: https://apps.dnr.wi.gov/water/default.aspx	Public access
Wisconsin Water Explorer	WEx	WDNR	This tool allows users to explore characteristics of Wisconsin's water resources and was designed as a companion tool to the Surface Water Data Viewer (SWDV) https://dnr.wisconsin.gov/topic/SurfaceWater/WEx.html	Public access
Water Assessment Tracking and Electronic Reporting System	WATERS	WDNR	An intranet-based tabular and spatial database supports water quality standards and assessment, goals reporting, and watershed planning. WATERS contains records of decisions and information about the status of rivers, streams, and lakes, including a variety of use designation, assessment, management uses, and links to documents or reports that support decisions for a waterbody.	WDNR Staff *(internal only)*
24K Hydrography Geodatabase	24K Hydro	WDNR	This geodatabase includes information about surface water features represented on the USGS 1:24,000-scale topographic map series such as perennial and intermittent streams, lakes, etc. https://data-wi-dnr.opendata.arcgis.com/datasets/wi-dnr::24k-hydro-full-file-geodatabase/about	Public access

Resource Title	Acronym	Agency	Description	Access
STOrage and RETrieval repository	STORET	EPA	A repository for water quality, biological, and physical data. STORET consists of two data management systems: the STORET Legacy Data Center (LDC), and Modernized STORET. The LDC is a static, archived database and Modernized STORET is an operational system actively being populated with water quality data.	Public access
National Water Information System	NWIS	USGS	Water data collected through USGS activities at approximately 1.5 million sites around the country. Many types of data are stored in this NWIS network, including site information, time-series (flow, stage, precipitation, chemical), peak flow, ground water, and water quality. http://www.epa.gov/storet	Public access
Great Lakes Beach Health database		USGS	Stores data on water quality samples from Great Lakes swimming beaches and other related information from WDNR, various local cooperators throughout the state, and the public. http://www.epa.gov/beaches http://greatlakesbeaches.usgs.gov/data.html	Public access

USGS = United States Geological Survey; Source: [4]

2.2. Lake AOI Selection and Justification

To define the Lake AOI for this project, GEI Staff began by exploring the WDNR Surface Water Data Viewer (SWDV) to assess various features such as the shoreline, tributaries, development, overlap between waterbodies, and more. The SWDV was also used to obtain the ID codes for LLBDM and the Lower Fox River.

GEI Staff compared the LLBDM polygon from the WDNR 24k Hydrography geodatabase (24K Hydro) to recent aerial and satellite imagery (Figure 3). The WDNR polygon for LLBDM represents the approximate spatial extent of the lake. However, the WDNR's 24K Hydro dataset was developed using several different data sources that span multiple years. As a result, physical observations of water features can vary from the 24k Hydro dataset polygon [5].

During the comparison, GEI Staff noted that the WDNR polygon does not fully encompass the shoreline or the backwater area behind Stroebe Island. These features had previously been identified by the LLBDM Leadership Team as being of interest to stakeholders. With these considerations in mind, GEI staff created the LLBDM Lake AOI specifically for the lake planning project by slightly adjusting the WDNR 24k polygon for LLBDM to include the in-lake, river, and shoreline features of interest for this project.

Figure 3 provides a visual comparison of the LLBDM Lake AOI selected for this project and the WDNR's LLBDM polygon from their 24K Hydro dataset. Table 3 shows the differences in the surface area, polygon permitter and shoreline miles between the two. The LLBDM Lake AOI is slightly larger in surface area and includes more shoreline than the WDNR 24k polygon.

Table 3. WDNR 24k polygon for LLBDM compared to the LLBDM Lake AOI

	Polygon Source	Surface Area (Acres)	Perimeter[1] (Miles)	Shoreline (Miles)
A	WDNR 24k Hydrography geodatabase	1,204	12.46	12.16
B	LLBDM Lake AOI	1,234	13.13	12.83
C	Difference *(C = B - A)*	30	0.67	0.67

Table Notes:
1. The perimeter is the total length of the outline of the entire polygon boundary. The shoreline total does not include the portion of the polygon that crosses over water.

3. LLBDM Watershed and Drainage Area AOIs

Building from the LLBDM Lake AOI, GEI Staff developed two additional AOIs that capture the watersheds relevant to LLBDM management:

1. LLBDM – Watershed AOI
2. LLBDM – Drainage Basin AOI

Section 3.1 describes the framework used to define the watershed boundaries and hierarchical structure for the Little Lake Butte des Morts Phase 1 planning project. Section 3.2 lists the watersheds identified as being relevant to this project and Sections 3.3 and 3.4 provide justification for the development of the LLBDM Watershed and Drainage Basin AOIs.

According to the USGS, "Hydrology is the science that encompasses the occurrence, distribution, movement and properties of the waters of the earth and their relationship with the environment within each phase of the hydrologic cycle".

The hydrologic cycle is a continuous process of evaporation, precipitation, streamflow, overland flow, infiltration, and groundwater flow.

Source:https://www.usgs.gov/special-topics/water-science-school/science/what-hydrology

3.1. Watershed Framework

The term "watershed" can be used generally to describe an area of land that channels surface water runoff (such as rainfall and snowmelt) to creeks, streams, and rivers, eventually reaching outflow points such as lakes. The size of a watershed can vary depending on the area of land that is of interest. The term can also be used in a more specific way to identify a hydrologic unit within a standardized system.

The United States Geologic Service (USGS) Watershed Boundary Dataset (WBD) is a standardized, nationwide system used to delineate drainage areas on the landscape based on surface hydrologic features [6]. This system allows for consistency in organizing, collecting, managing, communicating, and reporting hydrologic information in the U.S across agencies and organizations.

The WBD is based on a nested, hierarchical structure that divides the country into hydrologic units (HU). Each unit is assigned a unique hydrologic unit code (HUC) using a progressive two-digit system where two digits are added to each successively smaller unit within a nested set of units. The WBD contains eight levels of progressive HUs identified by unique 2- to 16-digit codes. Currently, the dataset is complete for the United States to the 12-digit HU *(14- and 16-digit HUs are optional and only available in some areas of the U.S.)* [7].

An example of how the HUs are nested is shown in Illustration 1 and the WBD hydrologic unit hierarchy levels are listed in Table 4[3]. This USGS Watershed Boundary Dataset framework was used to define the watershed and basin AOIs for this project.

[3] *A complete list of HUCs for the U.S., including descriptions, names, and drainage areas, can be found in the USGS Water-Supply Paper 2294, entitled "Hydrologic Unit Maps".*

Table 4. HUC Hierarchy Levels and Digits in the U.S.

Hierarchy Level	Digits	Average Area *(square miles)*	Quantity in U.S.
Region	2	177,560	22
Subregion	4	16,800	245
Basin	6	10,596	405
Subbasin	8	700	~2,400
Watershed	10	227	~19,000
Subwatershed	12	40	~105,000

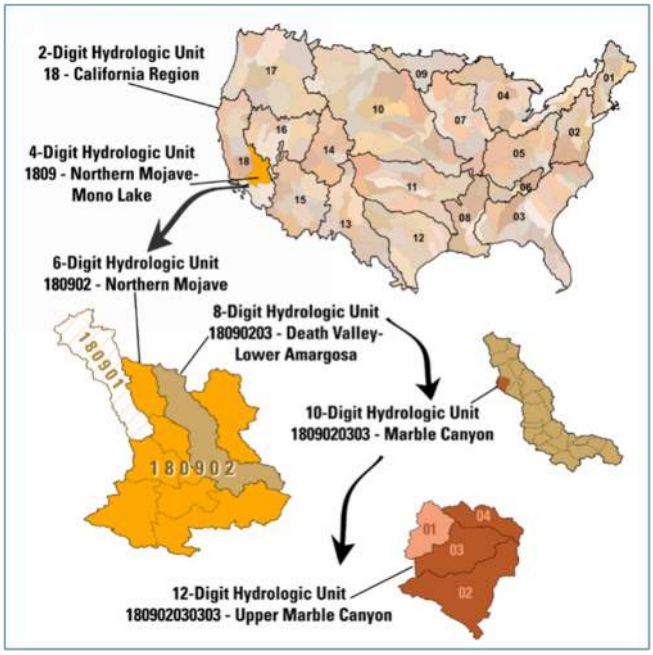

Illustration 1. Watershed Boundary Dataset structure.

3.2. Watershed Identification

As shown in Figure 4, the lake is located within the LLBDM HUC 12 Subwatershed where Lake Winnebago discharges into the Lower Fox River (LFR) as part of the Fox Basin (HUC 6). The Fox Basin is nested within the Northwestern Lake Michigan Subregion (HUC 4) which is part of the larger Great Lakes Region (HUC 2). The HUCs associated with LLBDM are listed in Table 5 below.

Table 5. Hydrologic Units Associated with Little Lake Butte des Morts

Hydrologic Unit Name	Alternative Name	HUC Level	HUC ID	Area *(square miles)*
Great Lakes Region	Great Lakes Basin	2	04	~327,693
Northwestern Lake Michigan Subregion	Lake Michigan Basin	4	0403	~20,722
Fox Basin	Fox Wolf Basin	6	040302	~6,567
Wolf Subbasin	Wolf River Subbasin	8	04030202	~3,726
Upper Fox Subbasin	Upper Fox River Subbasin	8	04030201	~ 1,620
Lake Winnebago Subbasin		8	04030203	~ 572
Lower Fox Subbasin	Lower Fox River Subbasin	8	04030204	~648
Plum Creek – Fox River Watershed	Plum Creek Watershed	10	0403020402	~170
Little Lake Butte des Morts Subwatershed	LLBDM HUC 12	12	040302040201	~44
Mud Creek Subwatershed	Mud Creek HUC 12	12	040302040202	~26
Garners Creek – Fox River Subwatershed	Garners Creek HUC 12	12	040302040205	~29

Table Notes:

2. The Lower Fox Subbasin is part of the WDNR Lower Fox Water Management Unit [1].
3. Little Lake Butte des Morts is located within the Little Lake Butte des Morts HUC 12 Subwatershed.
4. Garners Creek – Fox River Subwatershed was ultimately not selected to be part of the LLBDM – Watershed AOI.
5. The WDNR uses the USGS HUC system in some cases and in others they use their own delineated watershed boundaries. LLBDM is located within a small local watershed defined by the WDNR with the HYRDO ID 600054495.

The Fox Basin (HUC 6) is divided into four HUC 8 subbasins: Wolf, Upper Fox, Lake Winnebago, and Lower Fox Subbasins. Water from the Wolf drains south into the Upper Fox Subbasin. The Upper Fox drains northeast into the Lake Winnebago HUC 8 Subbasin. The Lake Winnebago Subbasin drains into the LLBDM HUC 12 Subwatershed[4] which is part of the Plum Creek – Fox River HUC 10 Watershed nested within the Lower Fox HUC 8 Subbasin. Water then flows through the lake, eventually emptying into the LFR where the LLBDM and Mud Creek HUC 12 Subwatersheds end and the Garners Creek HUC 12 Subwatershed begins. The LFR flows north, eventually draining into Green Bay in Lake Michigan.

The LLBDM HUC 12 Subwatershed covers approximately 44 square miles [1,8] and contains approximately 100 waterway features [1]. Eight main tributaries drain directly into LLBDM, as shown on Figure 5 and listed in Table 6 [1].

The northern extent of LLBDM is directly adjacent to the Mud Creek HUC 12 Subwatershed [1]. Although the Mud Creek HUC 12 does not drain to LLBDM, the geographic proximity and habitat connectivity makes Mud Creek an important consideration for protecting and restoring the lake.

Table 6. Tributaries in the LLBDM HUC 12 Subwatershed that drain to the lake

Map No.	Waterbody Name	WBIC	Length (miles)	Condition
1	Neenah Slough	130800	4.5	Poor / impaired
2	Little Lake Butte des Morts Tributary	130500	3.75	Suspected Poor
3	Unnamed	130200	Unknown	Unknown
4	Unnamed	129900	Unknown	Unknown
5	Unnamed	130000	Unknown	Unknown
7	Unnamed	5022094	Unknown	Unknown
8	Fox River	117900	199.45	Poor / impaired

3.3. LLBDM Watershed AOI Selection and Justification

Due to the large, wide-spread area that the basin, watersheds, and subwatersheds surrounding and contributing to LLBDM cover, the watershed focus of the LLBDM Phase 1 Action Plan needed to be narrowed down into a more manageable AOI. The development of the LLBDM Watershed AOI took into consideration land cover, hydrologic connections, habitat connectivity, locations of ongoing management activities, funding availability, and anticipated municipality readiness and willingness to coordinate.

The GEI Project Manager and Project Management Assistant met with senior environmental scientist, Jon Gumtow, who is a riparian landowner on LLBDM and has decades of experience conducting restoration initiatives and working with the landowners adjacent to and within the LLBDM watersheds. Mr. Gumtow currently works for Merjent and has knowledge of local municipality management efforts, landowner perceptions, and the LLBDM Project Area. He was able to supplement GEI staff's experience working in the region with additional insight into existing conditions, past restoration initiatives, and important landscape scale connections to consider when developing the LLBDM Watershed AOI.

[4] The Little Lake Butte des Morts Subwatershed is part of the Plum Creek Watershed located within the Lower Fox Subbasin.

During the meeting, future landowner collaboration opportunities southwest of LLBDM along the Neenah Slough were discussed. These were locations of landowners that either expressed previous interest in collaborating on a watershed/ waterway project or would be good starting points for connecting landowners in that area and initiating collaborative management efforts. Land use in this region consists mainly of agricultural, residential, and industrial development, as shown in Figure 6. Due to the hydrologic connection of the Neenah Slough, high number of landowner collaboration opportunities, and previous connections/ experience to build from, the entire LLBDM HUC 12 Subwatershed was included in the LLBDM Watershed AOI. There are also opportunities to collaborate with the City of Neenah, Winnebago County, and private landowners.

Opportunities for municipality and landowner coordination to the northwest of LLBDM along Mud Creek were also discussed. These were locations of landowners and municipalities that have been involved in waterway and watershed restoration work previously, as well as those that could offer additional opportunities to expand landowner collaboration. Land use in this region is a mix of agricultural, industrial, and commercial development, as well as a golf course and college campus. Specifically, Outagamie County and Fox Valley Tech College, were identified as entities to collaborate with moving forward. Due to the habitat connectivity of Mud Creek with LLBDM, the high number of landowner collaboration opportunities in the watershed, and previous restoration initiatives, the entire Mud Creek HUC 12 subwatershed was included in the LLBDM Watershed AOI.

Lastly, the consideration of extending the northeastern portion of the LLBDM Watershed AOI to further encapsulate the Fox River within the Garners Creek – Fox River HUC 12 Subwatershed was discussed. Although the hydrologic connection is important to the broader ecosystem, the management of the Lower Fox River beyond the LLBDM Lake AOI was determined to be outside of the scope of this project. For this reason, the Garners Creek – Fox River HUC 12 Subwatershed was not included in the LLBDM Watershed AOI.

The LLBDM Watershed AOI is shown in Figure 7, which includes the LLBDM HUC 12 Subwatershed and Mud Creek HUC 12 subwatershed as listed in Table 7. Both HUC 12 Subwatersheds are part of the Lower Fox River HUC 8.

Table 7. LLBDM Watershed AOI HUC 12s

Hydrologic Unit Name	Alternative Name	HUC Level	HUC ID	Area *(square miles)*
Little Lake Butte des Morts Subwatershed	LLBDM HUC 12	12	040302040201	~44
Mud Creek Subwatershed	Mud Creek HUC 12	12	040302040202	~26

3.4. LLBDM Drainage Basin AOI Selection and Justification

While the LLBDM Watershed AOI will help to narrow the focus and make the development and implementation of the LLBDM Aquatic Plant Management Plan and Phase 1 Action Plan more manageable, the impairments of the lake are predominately driven by upstream issues such as nutrient and sediment pollution.

There are significant efforts being made both upstream and downstream of LLBDM to address nutrient and sediment pollution. Communication and collaboration across regional efforts could be of great benefit to LLBDM restoration. To incorporate this broader context in planning and restoration efforts, the LLBDM Drainage Basin AOI is the Fox Basin HUC 6 which includes the Upper Fox, Wolf, Lake Winnebago, and Lower Fox HUC 8 Subbasins, as shown in Figure 8 and listed in Table 8.

Table 8. LLBDM – Drainage Basin AOI

Hydrologic Unit Name	Alternative Name	HUC Level	HUC ID	Area *(square miles)*
Fox Basin	Fox Wolf Basin	6	040302	~6,567
Wolf Subbasin	Wolf River Subbasin	8	04030202	~3,726
Upper Fox Subbasin	Upper Fox River Subbasin	8	04030201	~ 1,620
Lake Winnebago Subbasin		8	04030203	~ 572
Lower Fox Subbasin	Lower Fox River Subbasin	8	04030204	~648

4. Conclusion

The three LLBDM AOIs (lake, watershed, and drainage basin), which are geographically nested, will be used to develop an aquatic plant management plan and set the stage for working toward a comprehensive lake management plan for LLBDM. The LLBDM Lake AOI will be used to identify in-lake and shoreline challenges and implement solutions. The LLBDM Watershed AOI offers a wide range of collaborative restoration and protection opportunities with landowners, local municipalities, agencies, colleges, and non-profit organizations from the lake into two HUC 12 watersheds. The LLBDM Drainage Basin AOI will be used to assess opportunities for collaboration on a broader, landscape scale.

This nested approach provides the flexibility needed to find cost effective ways to restore LLBDM, collaborate with stakeholders, prescribe impactful and focused management actions, and optimize potential funding opportunities to maximize long-term resiliency of LLBDM while minimizing overlap and preventing duplication of efforts.

5. References

1. Wisconsin Department of Natural Resources. WDNR Surface Water Data Viewer [Internet]. [cited 2024 Jun 5]. Available from: https://dnrmaps.wi.gov/H5/?Viewer=SWDV

2. WDNR. Lower Fox River (Appleton Dam To L. Winnebago Outlet), Fox River - Appleton,Plum and Kankapot Creeks,Little Lake Butte des Morts,Lake Winnebago Watershed (LF03) (117900) [Internet]. Water Detail. [cited 2024 Jul 1]. Available from: https://apps.dnr.wi.gov/water/waterDetail.aspx?key=357364

3. WDNR. Databases and Tools - Water Resources [Internet]. Wisconsin Department of Natural Resources; [cited 2024 Jun 29]. Available from: https://apps.dnr.wi.gov/swims/Documents/DownloadDocument?id=89074113

4. WDNR. Wisconsin's Water Monitoring Strategy 2015 to 2020 [Internet]. Wisconsin Department of Natural Resources; 2015. Report No.: EGAD #3200-2016-01. Available from: https://dnr.wisconsin.gov/sites/default/files/topic/SurfaceWater/Strategy_2015_2020.pdf

5. WDNR. 24k Hydro Full File Geodatabase [Internet]. Wisconsin Department of Natural Resources Data Curator; 2022. Available from: https://data-wi-dnr.opendata.arcgis.com/datasets/cb1c7f75d14f42ee819a46894fd2e771/about

6. USGS. Watershed Boundary Dataset | U.S. Geological Survey [Internet]. United States Geologic Service. [cited 2024 Jun 29]. Available from: https://www.usgs.gov/national-hydrography/watershed-boundary-dataset

7. ESRI. Watershed Boundary Dataset HUC 2s [Internet]. 2023. Available from: https://services.arcgis.com/P3ePLMYs2RVChkJx/arcgis/rest/services/Watershed_Boundary_Dataset_HUC_2s/FeatureServer

8. Wisconsin Department of Natural Resources. WDNR Watershed Detail - Little Lake Butte des Morts [Internet]. [cited 2024 May 10]. Available from: https://apps.dnr.wi.gov/water/watershedDetail.aspx?code=LF06&Name=Little%20Lake%20Butte%20des%20Morts

Appendix A Figures

A.1. Figure 1 – Nested Areas of Interest Map

A.2. Figure 2 - LLBDM - Lake AOI Map

A.3. Figure 3 - LLBDM - Lake AOI compared to the WDNR 24K Polygon

A.4. Figure 4 - Hydrologic Units Associated with Little Lake Butte des Morts

A.5. Figure 5 - Main tributaries of LLBDM

A.6. Figure 6 – Land Cover Map

A.7. Figure 7 – LLBDM – Watershed AOI Map

A.8. Figure 8 – LLBDM – Drainage Basin AOI Map

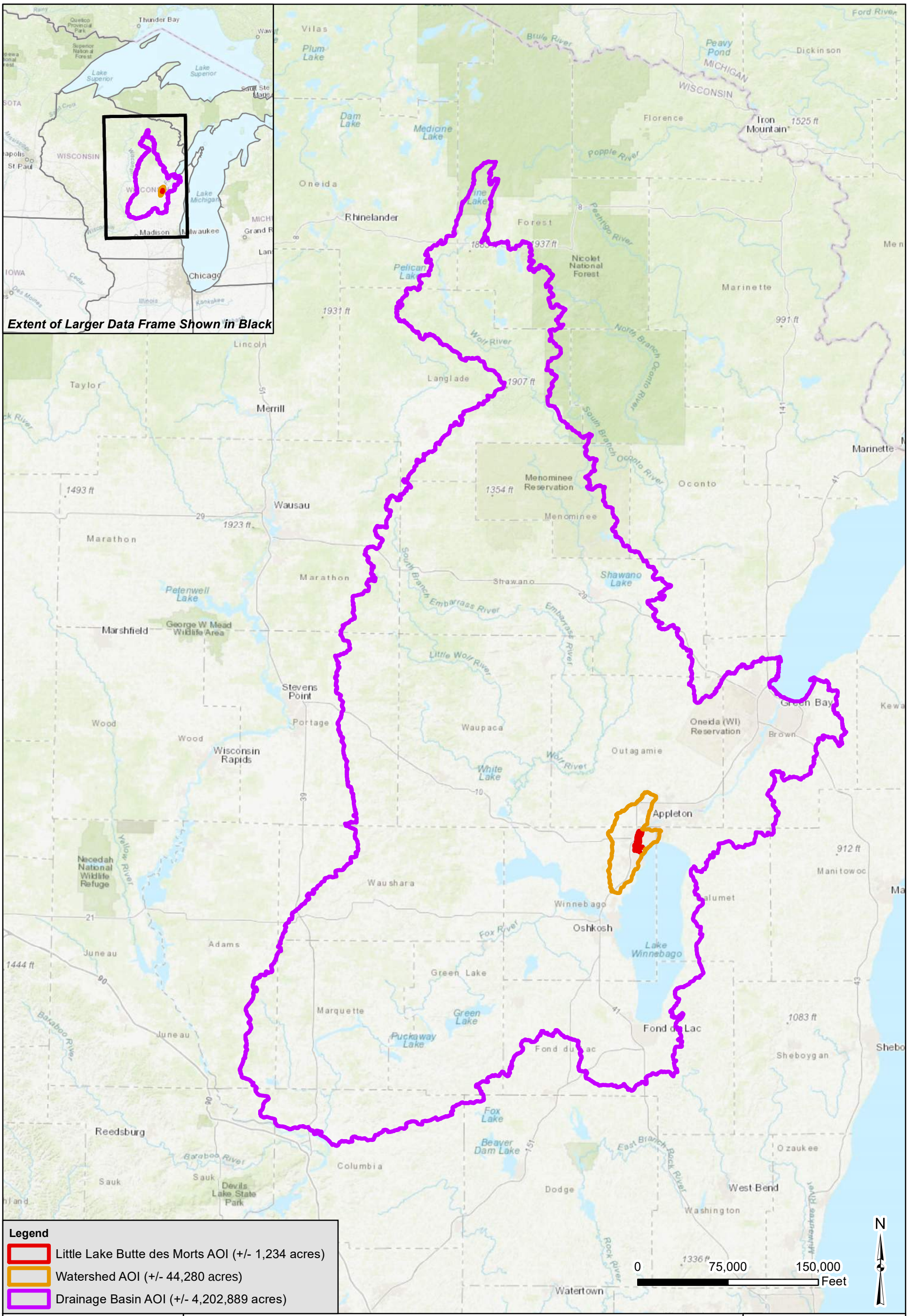

FIGURE 1
AREAS OF INTEREST (AOI) USGS TOPOGRAPHIC MAP

CITY OF NEENAH
LITTLE LAKE BUTTE DES MORTS MANAGEMENT PROJECT
WINNEBAGO COUNTY, WISCONSIN

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3159 Voyager Drive
Green Bay, WI 54311
www.geiconsultants.com

Drawn: SLC 8/20/2024
Approved: KD 8/20/2024
Scale: AS SHOWN
Project Number: 2403578

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Service Layer Credits: 2013 National Geographic Society, Esri

Extent of Larger Data Frame Shown in Black

Legend

- Little Lake Butte des Morts AOI (+/- 1,234 acres)
- Watershed AOI (+/- 44,280 acres)

0 7,500 15,000 Feet

N

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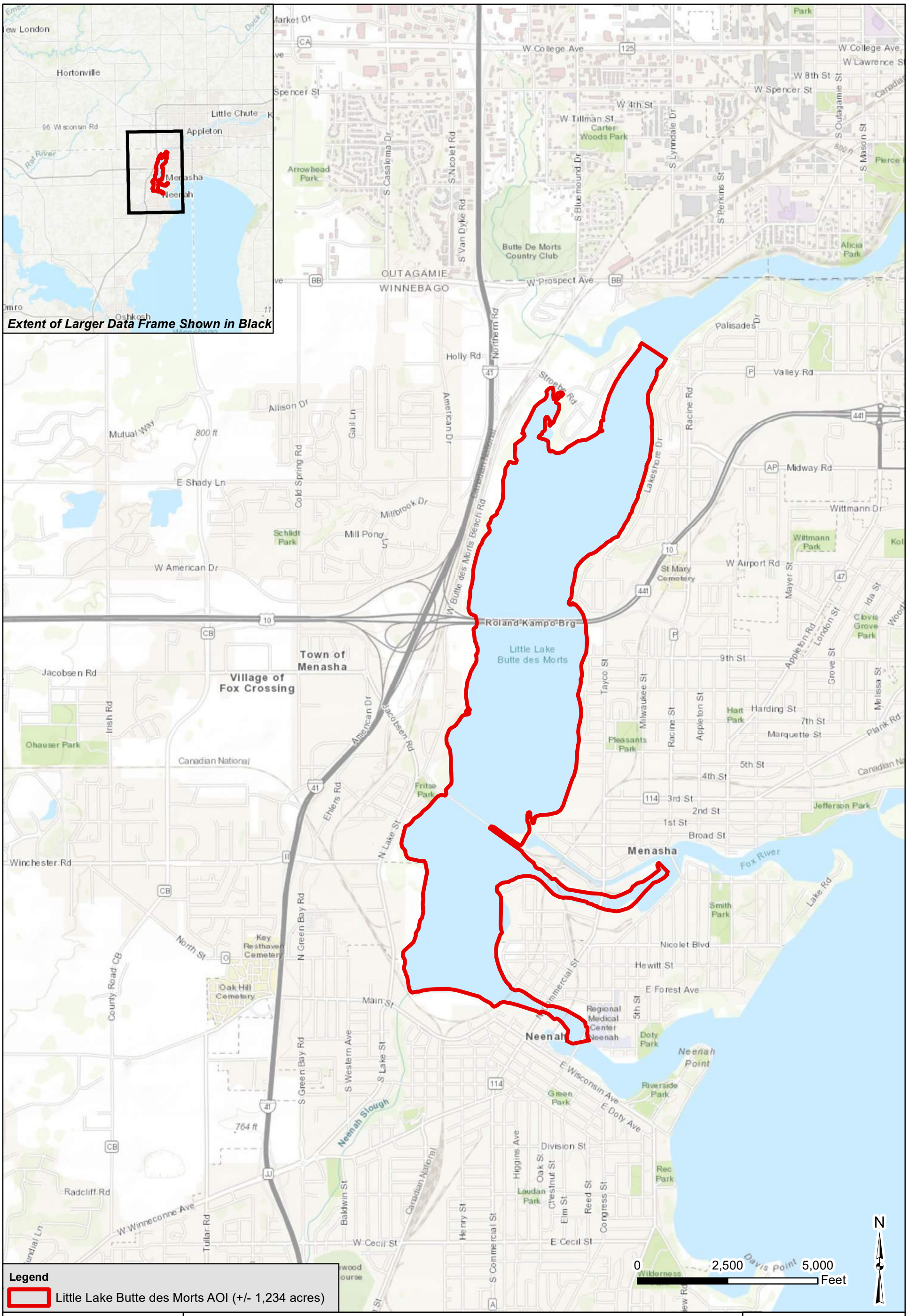

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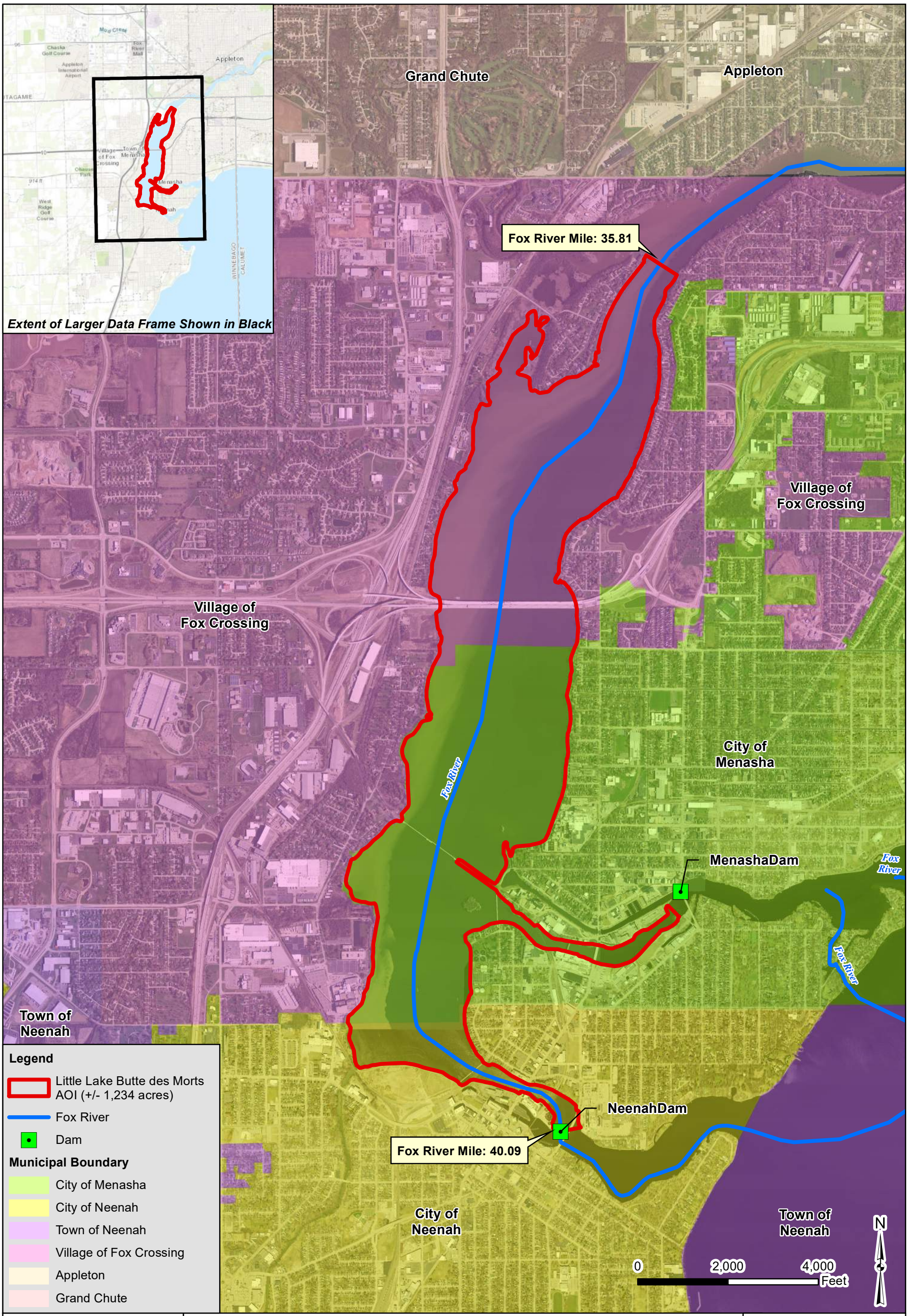

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FIGURE 2
MUNICIPAL BOUNDARIES AND DAM LOCATION MAP

CITY OF NEENAH
LITTLE LAKE BUTTE DES MORTS MANAGEMENT PROJECT
WINNEBAGO COUNTY, WISCONSIN

Drawn: SLC 8/20/2024
Approved: KD 8/20/2024
Scale: AS SHOWN
Project Number: 2403578
Page 1 of 1

Document Path: B:\Working\NEENAH, CITY OF\2403578 LLBDM Management\05_GIS\AOI Maps\UPDATED-VERTICAL\Figure 2 - Municipal Boundaries and Dam Location Map.mxd

Service Layer Credits: WDNR Orthophoto (2023), WDNR 24K Hydrography dataset, Wisconsin Repository of Dams data

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FIGURE 3
LLBDM WDNR BOUNDARY AND AREA OF INTEREST (AOI) MAP

CITY OF NEENAH
LITTLE LAKE BUTTE DES MORTS MANAGEMENT PROJECT
WINNEBAGO COUNTY, WISCONSIN

Drawn: SLC 8/20/2024
Approved: KD 8/20/2024
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Page 1 of 1

Document Path: B:\Working\NEENAH, CITY OF\2403578 LLBDM Management\05_GIS\AOI Maps\UPDATED-VERTICAL\Figure 3 - LLBDM WDNR Boundary and AOI Map.mxd

Service Layer Credits: WDNR Orthophoto (2023), WDNR 24K Hydrography dataset

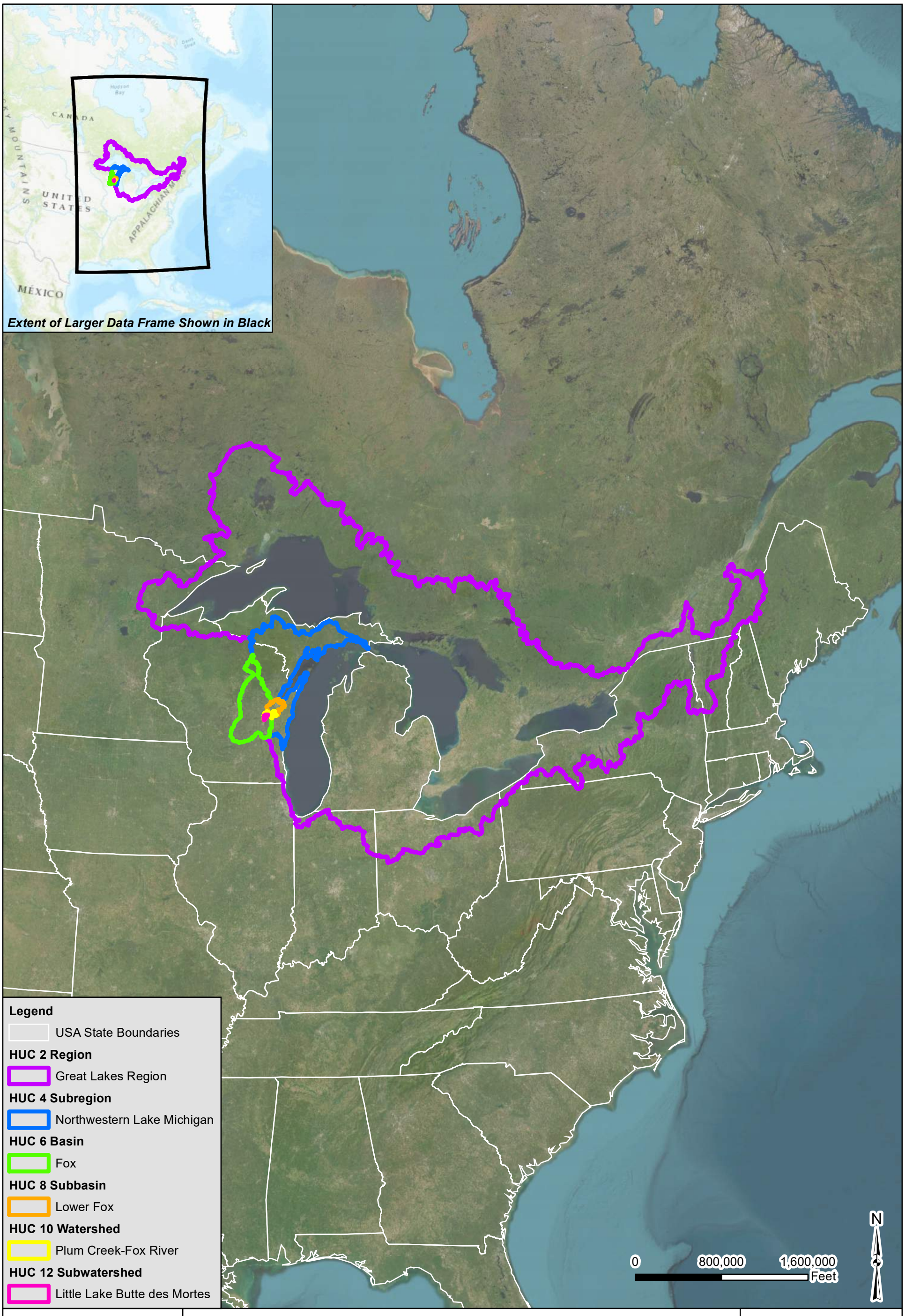

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FIGURE 4
HYDROLOGIC UNITS ASSOCIATED WITH LLBDM

CITY OF NEENAH
LITTLE LAKE BUTTE DES MORTS MANAGEMENT PROJECT
WINNEBAGO COUNTY, WISCONSIN

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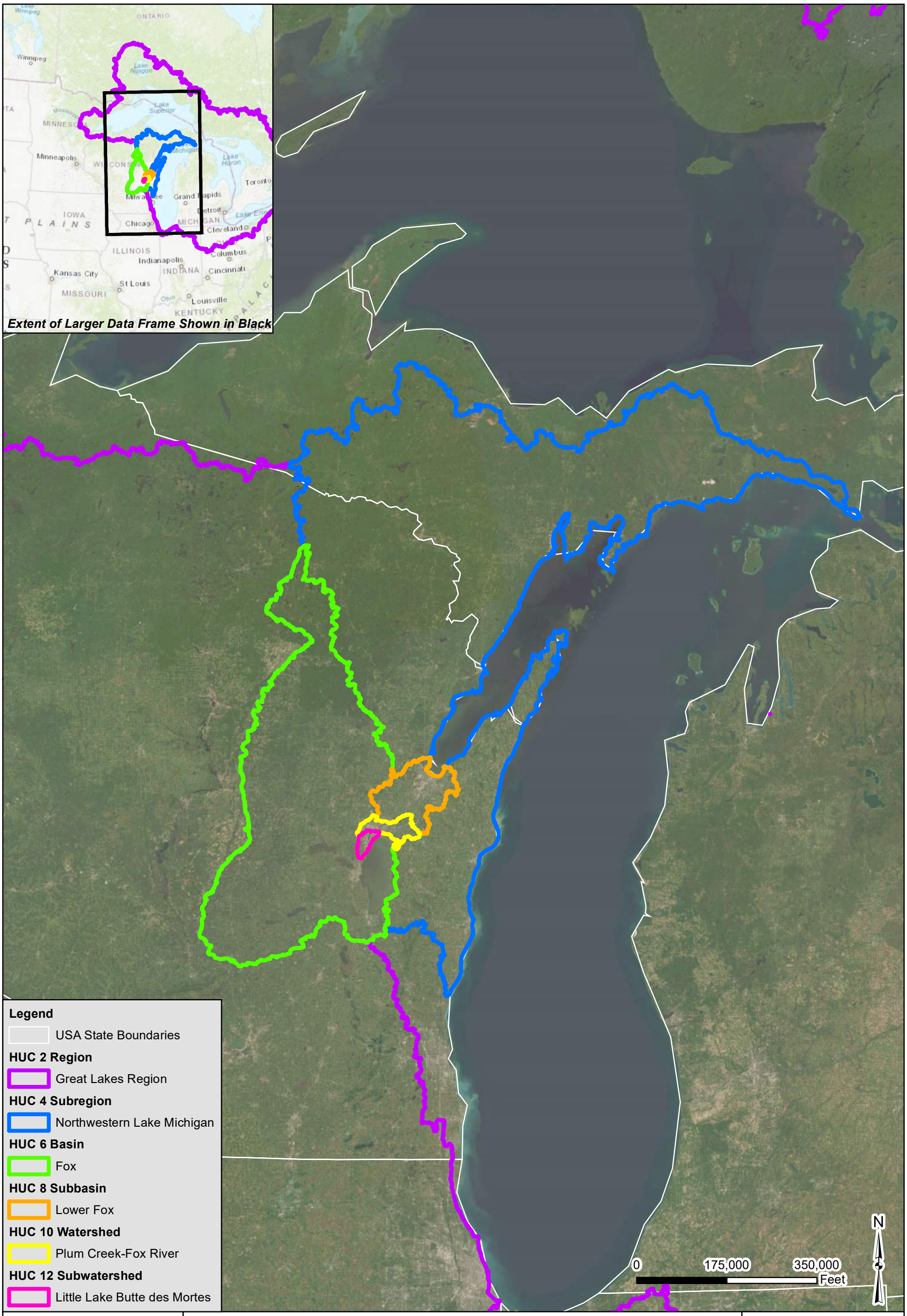
Document Path: B:\Working\NEENAH, CITY OF\2403578 LLBDM Management\05_GIS\AOI Maps\UPDATED-VERTICAL\Figure 4 - Hydrologic Units Associated With LLBDM.mxd

Service Layer Credits: World Imagery, Esri, WDNR 24K Hydrography dataset, Wisconsin Counties (2009), USGS National Hydrography Dataset



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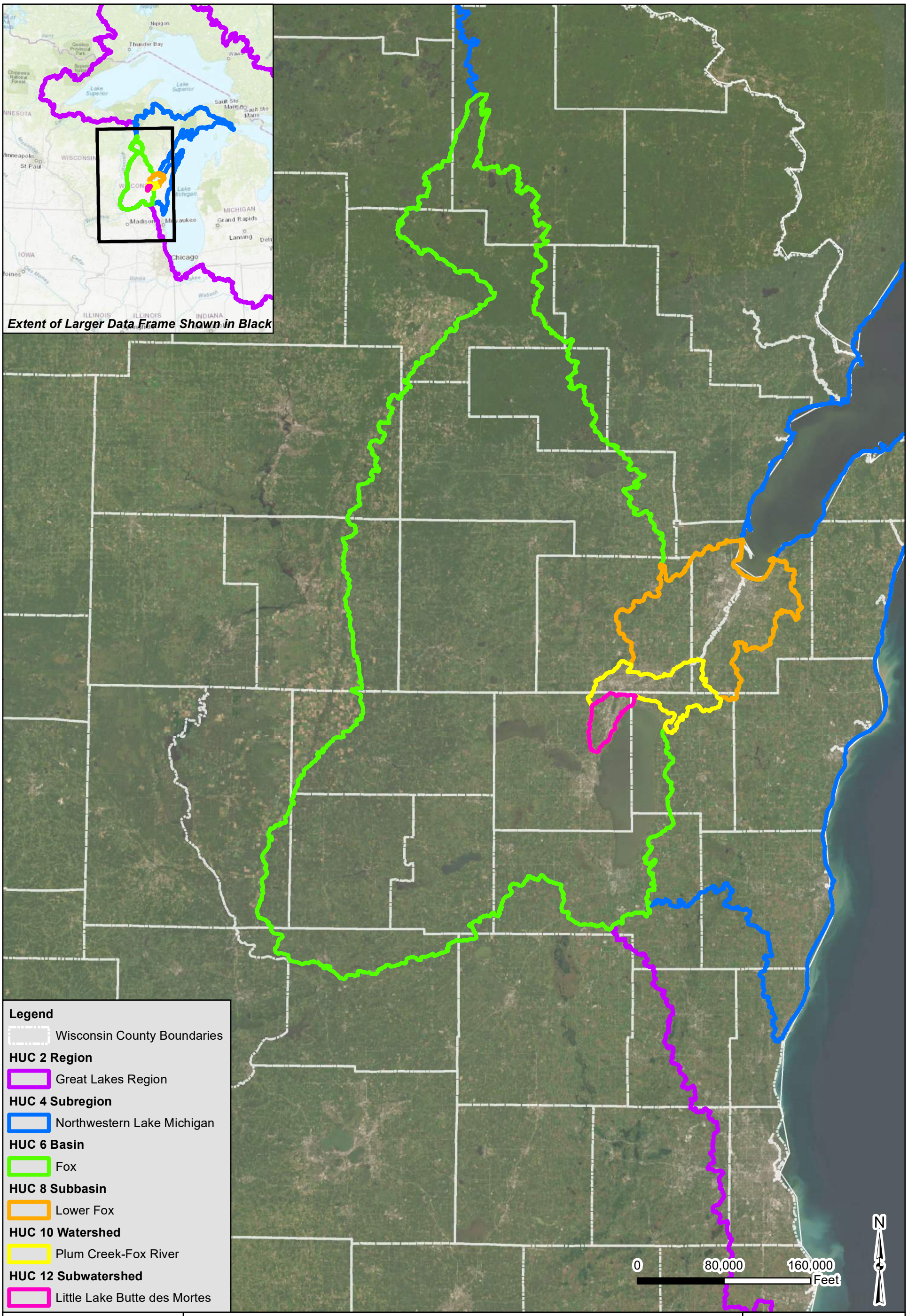

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FIGURE 4
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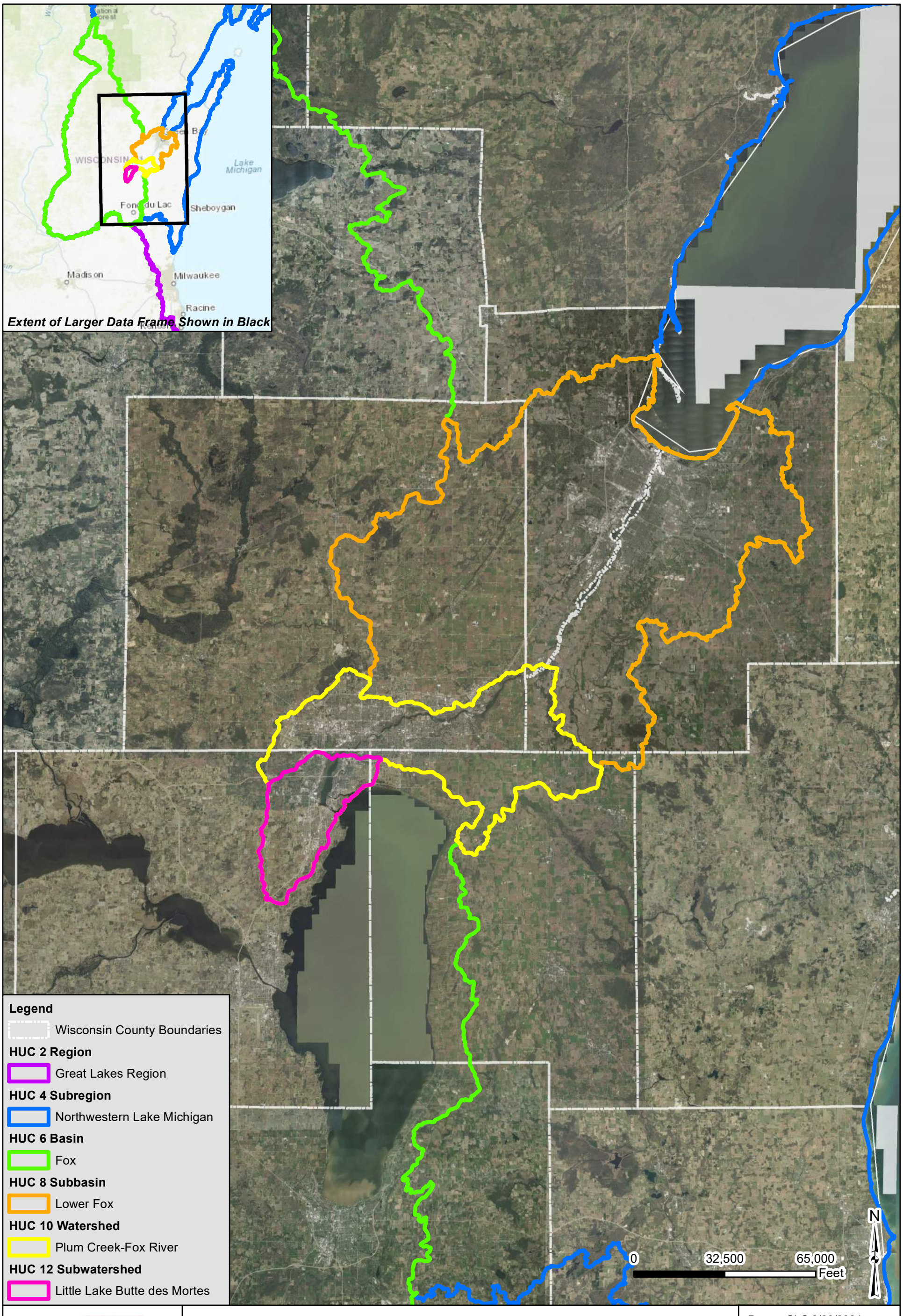

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FIGURE 4
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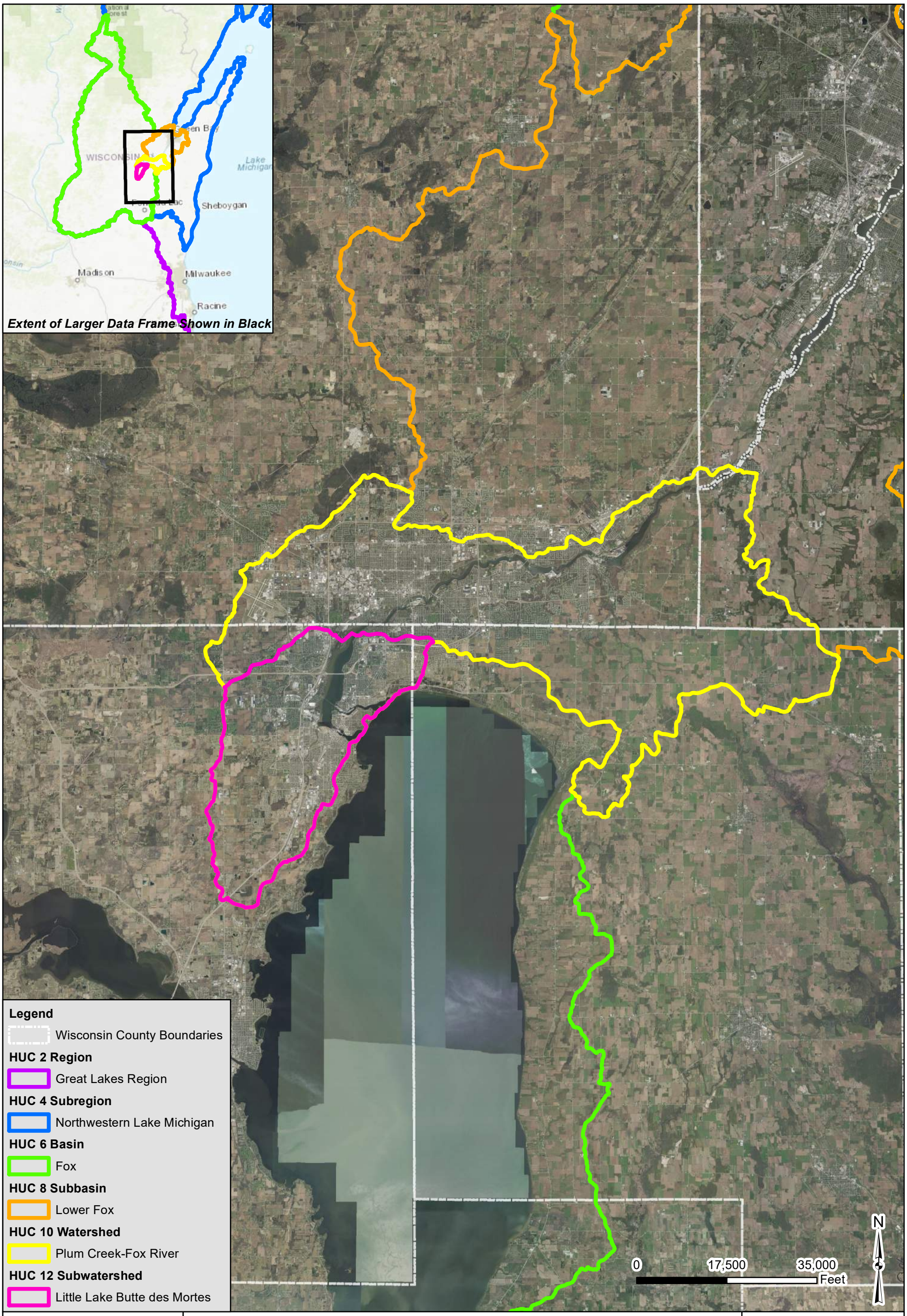

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FIGURE 4
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Service Layer Credits: World Imagery, Esri, WDNR 24K Hydrography dataset, Wisconsin Counties (2009), USGS National Hydrography Dataset, WDNR Orthophoto (2023)

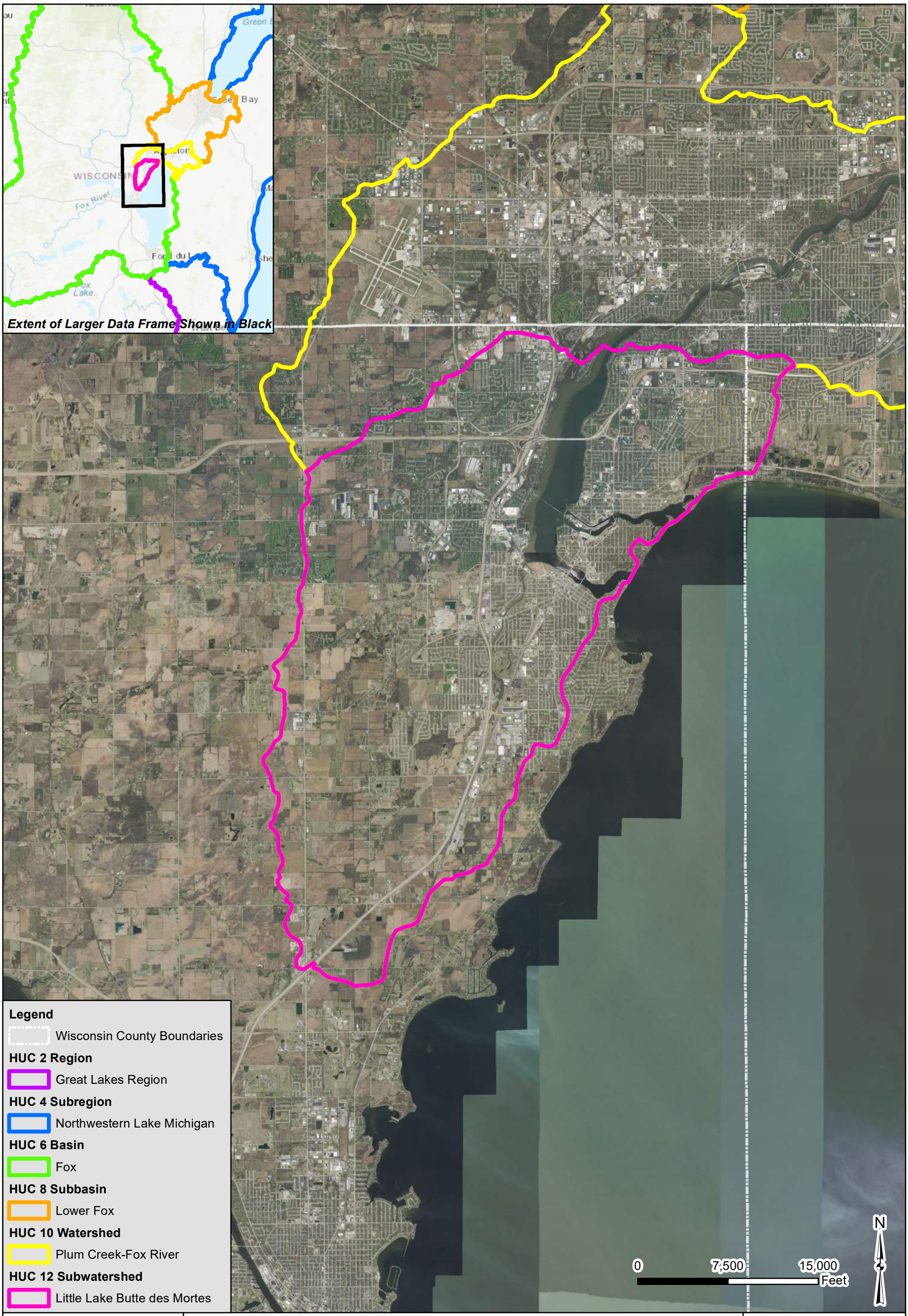

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FIGURE 4
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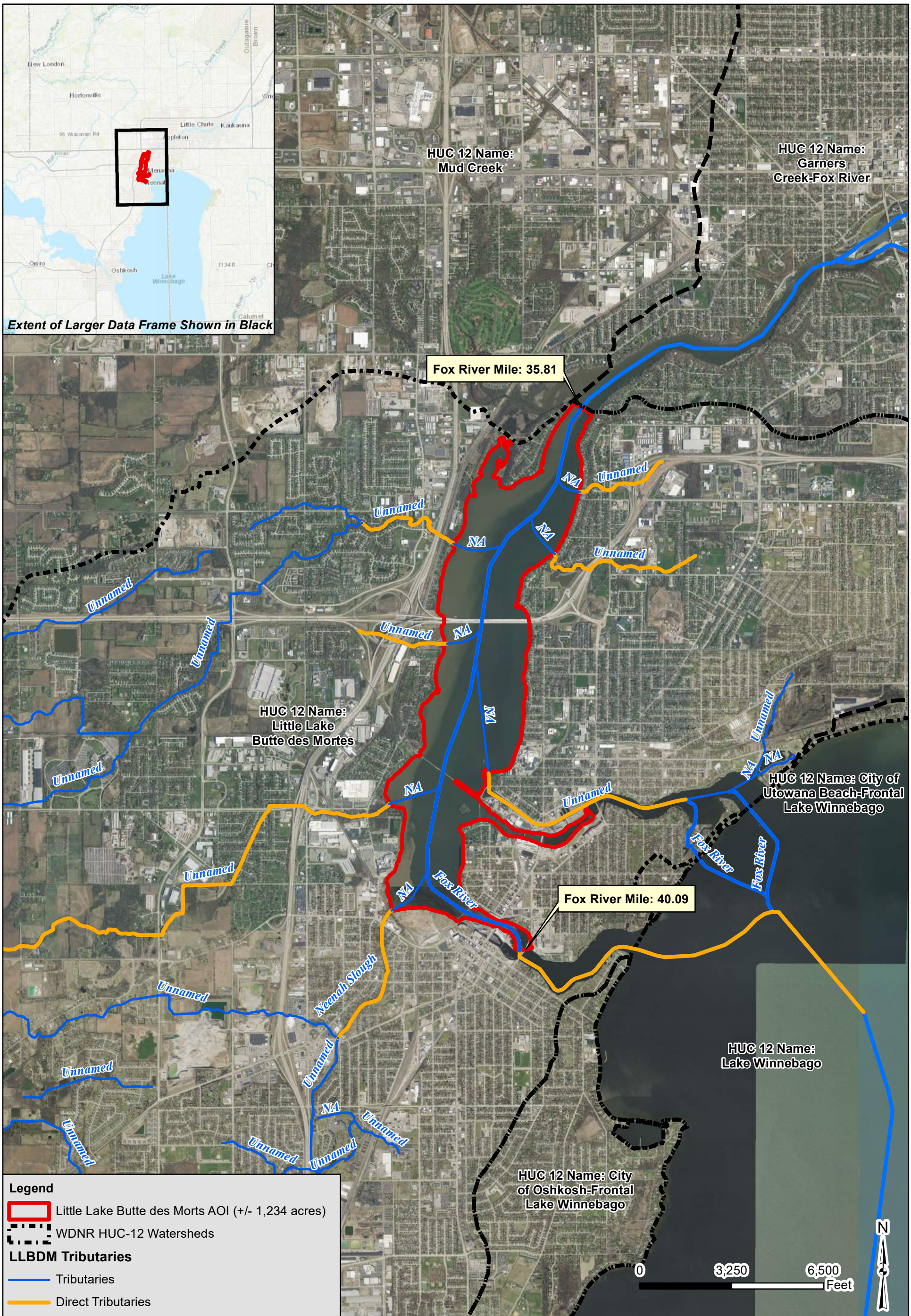

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FIGURE 5
MAIN TRIBUTARIES OF LLBDM

CITY OF NEENAH
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WINNEBAGO COUNTY, WISCONSIN

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Document Path: B:\Working\NEENAH, CITY OF\2403578 LLBDM Management\05_GIS\AOI Maps\UPDATED-VERTICAL\Figure 5 - Main Tributaries of LLBDM.mxd

Service Layer Credits: WDNR Orthophoto (2023), WDNR 24K Hydrography dataset, World Imagery, Esri

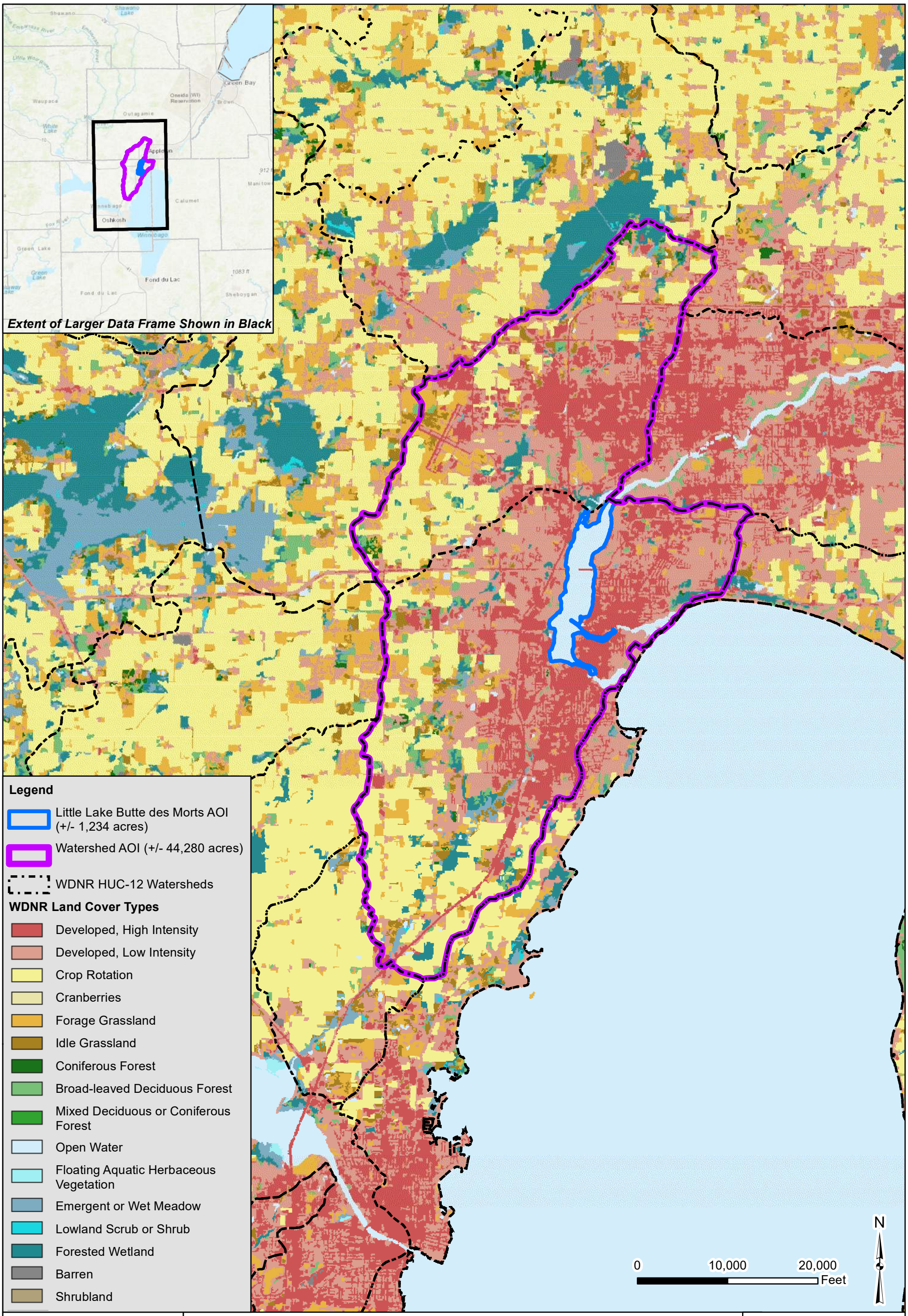

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FIGURE 6
LAND COVER MAP

CITY OF NEENAH
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WINNEBAGO COUNTY, WISCONSIN

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Service Layer Credits: WDNR Wiscland Level2 (2019)

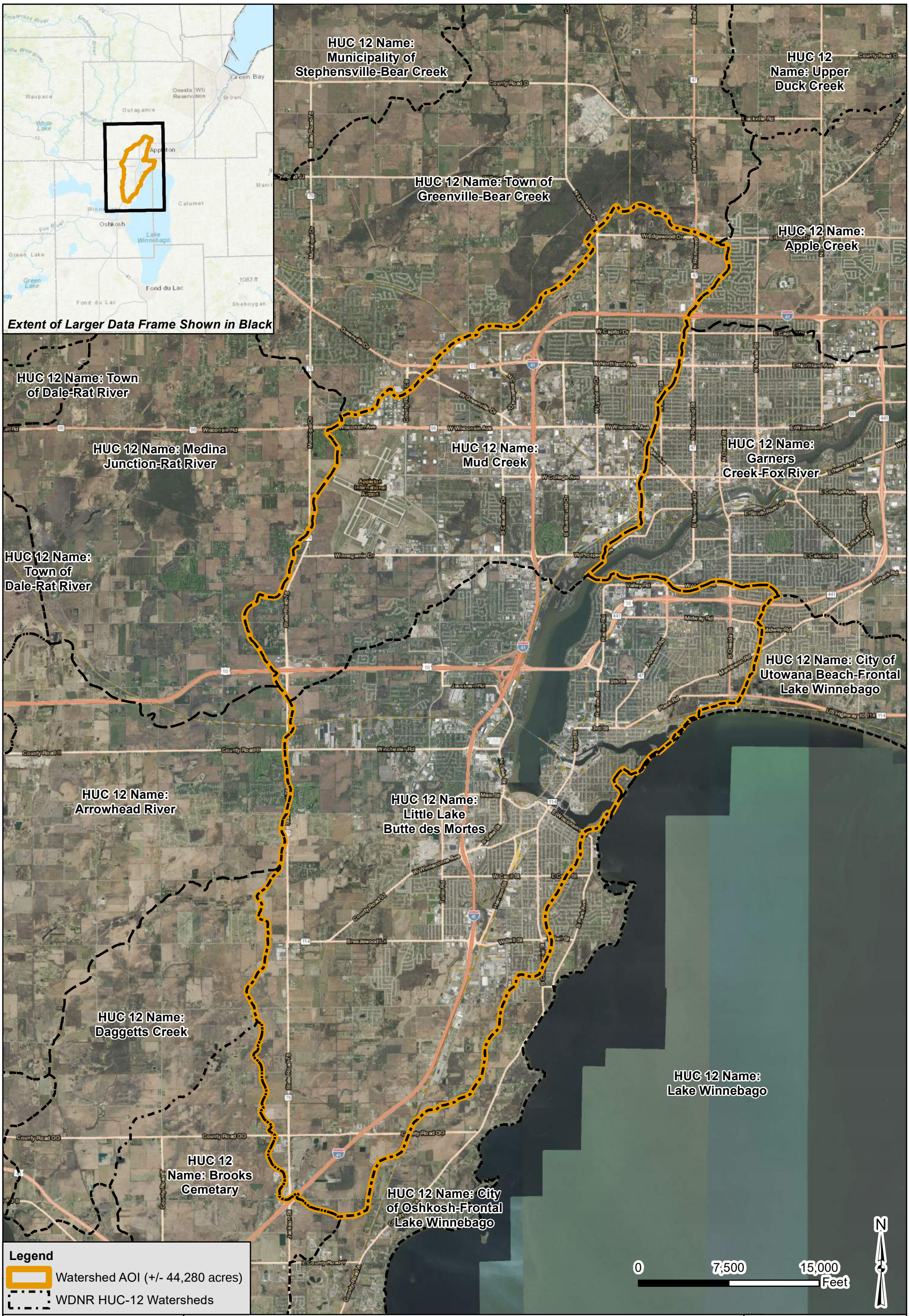

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FIGURE 7
WATERSHED AREA OF INTEREST (AOI) MAP

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Document Path: B:\Working\NEENAH, CITY OF\2403578 LLBDM Management\05_GIS\AOI Maps\UPDATED-VERTICAL\Figure 7 - Watershed AOI Map.mxd

Service Layer Credits: WDNR Orthophoto (2023), WDNR 24K Hydrography dataset

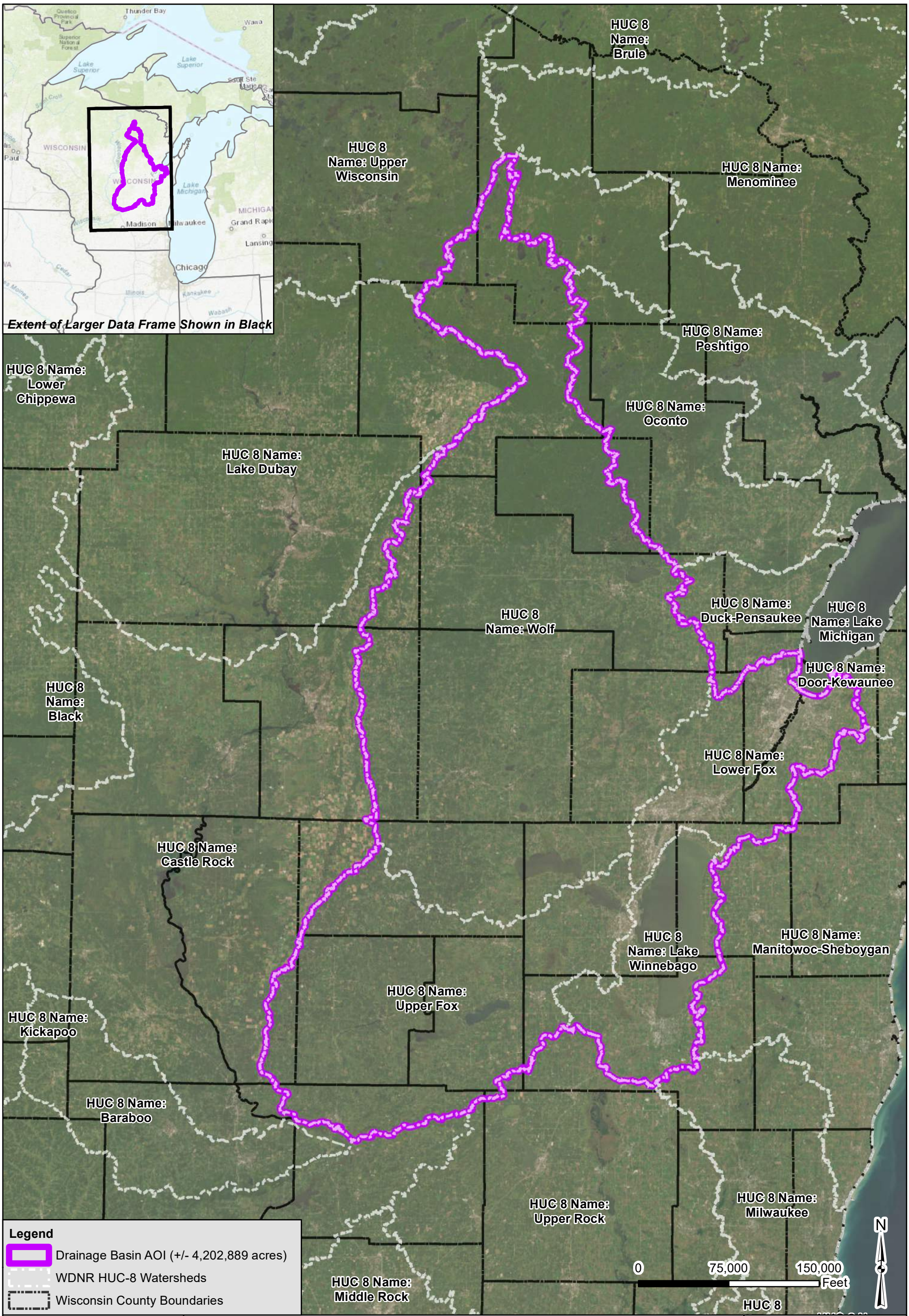

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FIGURE 8
DRAINAGE BASIN AREA OF INTEREST (AOI) MAP

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WINNEBAGO COUNTY, WISCONSIN

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Service Layer Credits: WDNR Orthophoto (2023), WDNR 24K Hydrography dataset, Wisconsin Counties (2009)