Non-Point Source Runoff Storage Capacity Opportunities for Sediment & Nutrient Reduction in the Lower Fox River Basin

Project Summary

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Project Summary

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Executive Summary

The Lower Fox River Basin is a 638 square mile basin located in Northeast Wisconsin. It encompasses Brown, Calumet, Outagamie and Winnebago Counties. The Lower Fox River empties the Wolf River and Upper Fox River basins which drain approximately 6,349 square miles.

The Lower Green Bay & Fox River were designated as a Great Lakes Area of Concern (AOC) in 1987. The Lower Green Bay-Fox River AOC was identified as facing the Eutrophication or Undesirable Algae beneficial use impairment (BUI) due to land use changes in the Fox-Wolf Basin that have resulted, in part, in a significant nutrient and sediment loading to the AOC. In addition to the land use change from woodlands and oak savannah to agriculture and urbanization, several of the watersheds in the region have experienced substantial conversion of wetlands and as such, these watersheds have lost the associated water storage capacity services these wetlands historically provided, leading to an increase in sediment and nutrient runoff, the flashiness of streams, and streambank erosion.

The water storage capacity analysis quantifies the amount of water storage capacity needed to return to pre-settlement land use runoff conditions. This analysis data will guide the implementation of conservation practices that will permanently restore water storage capacity while trapping sediment and phosphorus. Additionally, the data will help site other conservation practices on the landscape to where they will have the best benefit.

The main takeaways of the analysis are described below:

- The Stage II Remedial Action Plan identified 11 confirmed and 2 suspected BUIs out of the list of 14. Nutrient and sediment pollution stemming from point and nonpoint sources and transported to the AOC contributed to the listing of 8 of the 13 BUIs
    - Eutrophication or Undesirable Algae
    - Beach Closings
    - Degradation of Aesthetics
    - Restrictions on Drinking Water Consumption, or Taste and Odor Issues
    - Degradation of Phytoplankton and Zooplankton Populations
    - Degradation of Benthos
    - Degradation of Fish and Wildlife Populations
    - Loss of Fish and Wildlife Habitat
- Given the magnitude of impact water quality plays on the ability to make progress and eventually delist the Area of Concern, WDNR has spent several years working with AOC stakeholders to identify how to make a meaningful contribution to ameliorate the eutrophication issues in the basin consistent with the scope of the program.
- Preliminary results from the Plum Creek Sediment Fingerprinting study have shown that streambank erosion is a significant source of total phosphorous and total suspended solids in Plum Creek (Fitzpatrick et al. 2019), indicating that a combination of practices that increase water holding capacity and streambank stabilization are necessary in the Lower Fox River Basin to realize meaningful improvements in water quality.

- In 2016, WDNR and USEPA determined that a set of 5 structural best management practices (BMPs) had characteristics consistent with other AOC management actions. The 5 BMPs include: Agricultural Runoff Treatment Systems (ARTS), Wetland Creation/Enhancement/Restoration, Streambank Protection/Stabilization, Two-Stage Ditches, and Saturated Buffers.
    - ARTS provide the most opportunity to store water and reduce downstream flow rates, thereby also reducing streambank erosion and the need for streambank stabilization practices. An Agricultural Runoff Treatment system is similar to a storm water pond in that it will be designed to retain water and settle out sediment. ARTS are designed with wetland cells that mimic wetland functions.
- From 2017-2018, WDNR and technical experts estimated the total amount of opportunity in the basin to implement the 5 AOC-like practices and found that implementation could result in significant reductions in sediment and nutrient runoff.
- In 2019, WDNR partnered with Outagamie County to better refine where the structural practices were most needed by analyzing the water storage capacity needs for 17 of 20 subwatersheds in the basin.
- This analysis identified that 2/3 of historically present wetlands in the basin have been converted to urban or agricultural land uses. An estimated 1.6 billion gallons of water storage capacity based on the MSE4 2-year rainfall event has been lost in the analyzed areas due to land use changes and loss of wetlands.
- If Agricultural Runoff Treatment Systems were implemented in each subwatershed analyzed to create water storage to mitigate the impacts of land use change and lost wetlands for the 2-year rainfall event, it would contribute to a 29% reduction in total phosphorus and 47% reduction in sediment in the Lower Fox Basin for a total estimated cost of $184,968,637.
- An acreage efficiency factor for ARTS was developed based on the estimated costs, phosphorus reduction, and ARTS area needed. This efficiency factor can be used to rank priority catchments within a HUC12 watershed to implement the ARTS practice.
- Going forward, additional methods of prioritization will be considered and conversations with WDNR, USEPA, and AOC stakeholders will occur to determine the order of magnitude of AOC-sponsored implementation of structural practices as part of a broader watershed implementation and funding strategy plan.

1.0 Introduction

The Lower Green Bay-Fox River Area of Concern (AOC) was identified as facing the Eutrophication or Undesirable Algae beneficial use impairment (BUI) due to land use changes in the Fox-Wolf Basin that have resulted, in part, in a significant nutrient and sediment loading to the AOC. In addition to the land use change from woodlands and oak savannah to agriculture and urbanization, several of the watersheds in the region have experienced substantial conversion of wetlands and as such, these watersheds have lost the associated water storage capacity services these wetlands historically provided, leading to an increase in sediment and nutrient runoff, the flashiness of streams, and streambank erosion. This transport of sediment and nutrients through the tributaries located in the Lower Fox River Basin (LFRB) to the Lower Fox River has also caused significant and persistent algal blooms that pose an aesthetic and human health risk in the AOC, resulting in large part to the listing of the Degradation of Aesthetics and Beach Closings BUIs in the Stage II Remedial Action Plan along with impacting 8 of the 11 confirmed and 2 suspected BUIs in Green Bay.

While a variety of best management practices are being implemented throughout several of the HUC12 watersheds in the LFRB, a need exists to implement BMPs that will permanently restore water storage capacity to 1) capture and store water during storm events, slowly releasing water to the streams, thus reducing flood events and flashiness of streams leading to reduced downstream streambank erosion and 2) capture sediment and phosphorus from upstream fields.

Preliminary results from the Plum Creek Sediment Fingerprinting study have shown that streambank erosion is a significant source of total phosphorous and total suspended solids in Plum Creek (Fitzpatrick et al. 2019), indicating that a combination of practices that increase water holding capacity and streambank stabilization are necessary in the LFRB to realize meaningful improvements in water quality. This is important because the aforementioned nutrient and sediment loads that were determined to be emanating from “Natural Areas” were attributed to the “agriculture” reduction in the LFRB Total Maximum Daily Load (TMDL). This combination of sources hides the fact that the water conveyance system in the LFRB is just as important to stabilize as the agriculture land. Therefore, the theme of this report is, if we can store and slowly release water from strategic subwatersheds of the LFRB, we have an opportunity to both capture and treat nutrient and sediment from non-point sources as well as reduce the erosive force of runoff on downstream receiving streams. What remains unclear is how much storage capacity each HUC12 watershed needs and where the greatest reduction in downgradient streambank erosion is needed in each watershed to have the biggest impact on water quality, as each watershed is unique and needs to be analyzed according to its particular attributes. This study attempts to clarify the subwatersheds that would see the most beneficial response to restoring pre-settlement hydrology.

In 2016, WDNR and USEPA explored how AOC Great Lakes Restoration Initiative (GLRI) funding might be applied toward nutrient management practice implementation, with consideration for the project attributes that previous AOC GLRI-funded projects have shared and arrived at a set of five “AOC-like” practices for nutrient management that could be installed on the landscape including:

- Agricultural runoff treatment systems (constructed/treatment wetlands)
- Wetland creation/enhancement/restoration
- Streambank protection/stabilization
- Two-stage ditches
- Saturated buffers

Agricultural runoff treatment systems (ARTS) provide the most opportunity to store water and reduce downstream flow rates. Wetland restoration and creation on the landscape also provides water storage but will have a larger footprint than ARTS for same storage capacity and are not meant for treatment of runoff or to regulate flows artificially. This analysis will provide insight on how much storage is needed and where ARTS and wetland restoration/creation practices will be most beneficial in nutrient and sediment reduction. In 2017 and 2018, WDNR convened technical experts to estimate the total opportunity on the landscape to implement these practices, and how much phosphorus and sediment reduction would potentially be realized. The group found that these practices have the potential to contribute significantly to nutrient and sediment reductions in the Lower Fox Basin if implemented.

2.0 Watershed Characteristics

The Lower Fox River Basin is a 638 square mile basin located in Northeast Wisconsin. It encompasses Brown, Calumet, Outagamie and Winnebago Counties. The Lower Fox River empties the Wolf River and Upper Fox River basins which drain approximately 6,349 square miles. The Lower Fox River flows northeast from the outlet of Lake Winnebago to the bay of Green Bay.

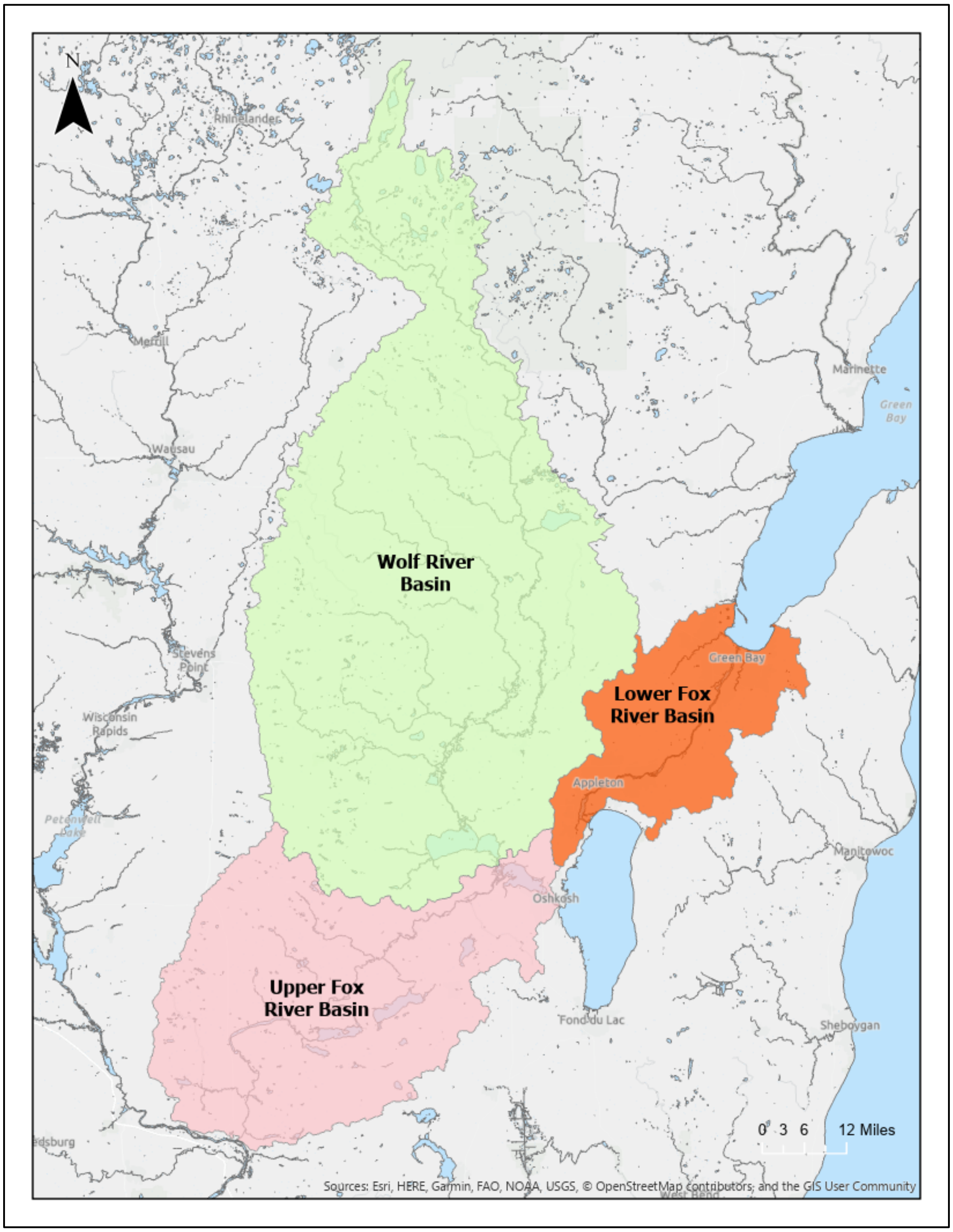

Figure 1. Map of Lower Fox River Basin drainage.

Historic Land Use

In 1990, the Wisconsin Department of Natural Resources digitized original vegetation cover data from a 1976 map that was created from land survey notes written in the mid-1800's when Wisconsin was first surveyed. The original pre-settlement land cover in the Lower Fox Basin was mostly hardwood forest consisting of Beech, Sugar Maple, Basswood, Red Oak, White Oak, and Black Oak. There were also large areas of Swamp conifers (white cedar, black spruce, tamarack, hemlock) present. Other vegetation communities found in the basin are shown in Table 1 & Figure 2.

Table 1. Pre-settlement vegetation summary by area in Lower Fox River Basin.

Vegetation Type	Area (Acres)
Beech, sugar maple, basswood, red oak, white oak, black oak	137,061
Sugar maple, basswood, red oak, white oak, black oak	125,704
Swamp conifers - white cedar, black spruce, tamarack, hemlock	35,583
Oak - white oak, black oak, bur oak	32,802
Oak openings - bur oak, white oak, black oak	22,193
Hemlock, sugar maple, yellow birch, white pine, red pine	9,667
Beech, hemlock, sugar maple, yellow birch, white pine, red pine	8,548
Lowland hardwoods - willow, soft maple, box elder, ash, elm, cottonwood, river birch	8,049
Marsh and sedge meadow, wet prairie, lowland shrubs	7,012
Water	5,700
Area with vegetation cover type not interpreted on the source map	5,234
White pine, red pine	4,696
Jack pine, scrub (hill's), oak forest and barrens	4,445
Brush	4,245
Prairie	2,595
Aspen, white birch, pine	378

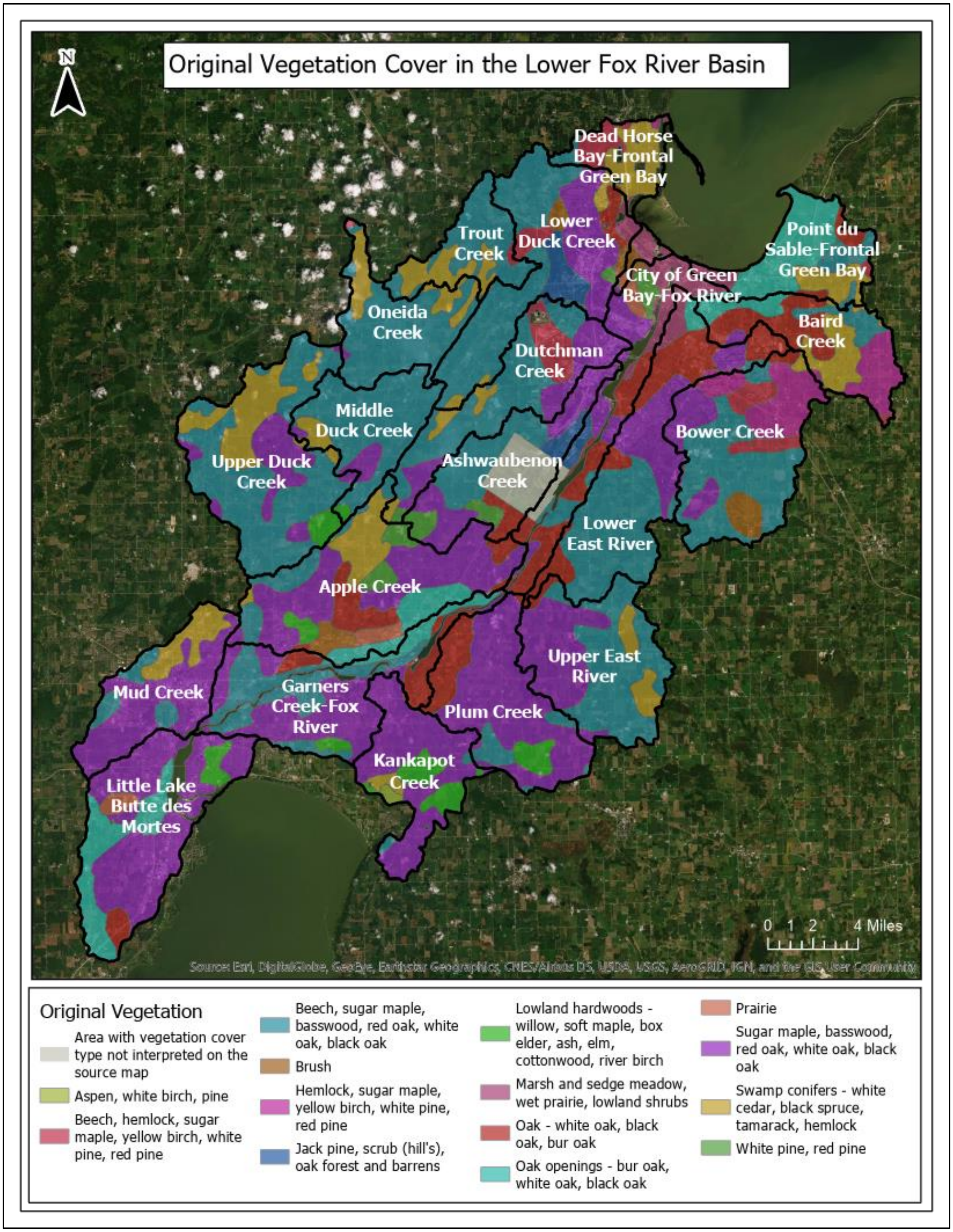

Figure 2. Map of pre-settlement vegetation cover in Lower Fox River Basin.

Wetlands

The amount of existing wetlands and potentially restorable wetlands was determined using WDNR GIS data. There are approximately 32,078 acres of existing wetlands in the Lower Fox Basin and an estimated 62,688 acres of potentially restorable wetlands (historic/lost wetlands) in the basin (Figure 3). A summary of existing wetland and potentially restorable wetland acreage is shown in Table 2. The majority of the historic wetlands in the basin have been filled for urban development, are currently farmed through, or have been artificially drained for farming. The loss of wetlands in the basin has likely contributed to significant changes in hydrology since pre-settlement times.

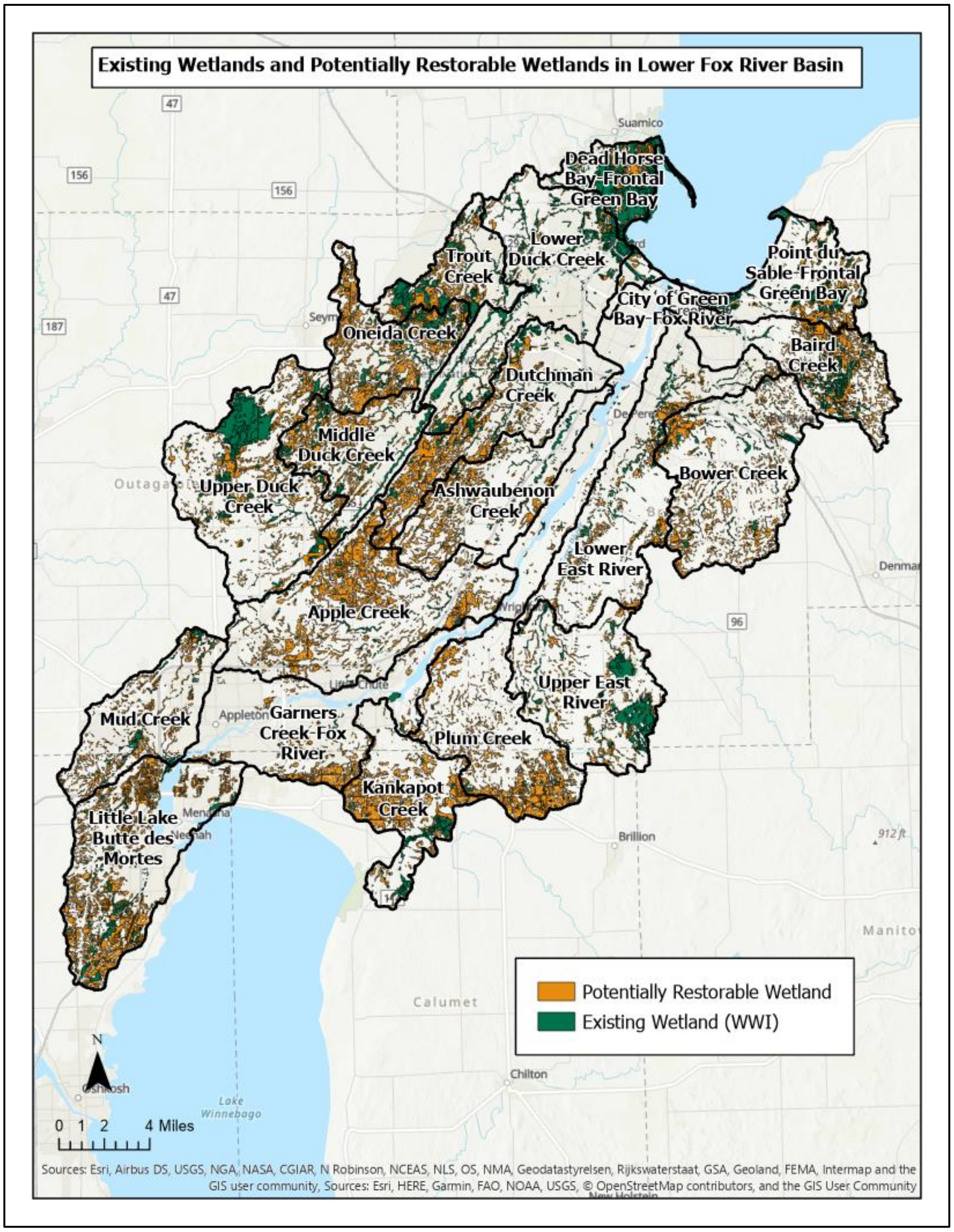

Figure 3. Existing and potentially restorable (lost) wetlands in the Lower Fox River Basin.

Table 2. Existing and potentially restorable (lost) wetlands in Lower Fox River Basin subwatersheds.

Watershed (HUC 12)	Watershed Area	Existing Wetlands (WWI)		Potentially Restorable (lost) Wetlands (PRW)	
	acres	acres	percent	acres	percent
Apple Creek	33,190	608	1.8%	7,090	21.4%
Upper Duck Creek	30,851	3,857	12.5%	4,298	13.9%
Plum Creek	22,322	250	1.1%	4,621	20.7%
Oneida Creek	14,939	1,542	10.3%	4,609	30.9%
Bower Creek	26,991	1,126	4.2%	3,750	13.9%
Little Lake Butte des Mortes	27,918	1,427	5.1%	6,505	23.3%
Kankapot Creek	16,386	957	5.8%	4,023	24.6%
Ashwaubenon Creek	18,984	797	4.2%	2,680	14.1%
Dutchman Creek	19,741	1,287	6.5%	4,366	22.1%
Upper East River	22,997	2,670	11.6%	1,969	8.6%
Lower East River	28,696	1,155	4.0%	2,429	8.5%
Middle Duck Creek	14,780	1,231	8.3%	3,165	21.4%
Baird Creek	15,695	1,623	10.3%	2,959	18.9%
Point du Sable-Frontal Green Bay	13,686	2,319	16.9%	1,889	13.8%
Trout Creek	10,182	1,954	19.2%	1,863	18.3%
Lower Duck Creek	27,623	3,601	13.0%	1,217	4.4%
Mud Creek	16,359	702	4.3%	2,047	12.5%

Current Land Use

Existing land use and cover was determined for the watersheds using the United States Department of Agriculture (USDA) 2018 Cropland Data Layer. Table 3 summarizes land use data for the subwatersheds analyzed in the Lower Fox River Basin. A map of current land use/cover is shown in Figure 4. Approximately 50% of the basin is agricultural land, 30% is urban/developed and 15% is natural area (forest and wetlands). Most of the urban areas are concentrated near the main stem of the Lower Fox River near Lake Winnebago and Bay of Green Bay.

Table 3. Current land use summary of analyzed subwatersheds.

Watershed (HUC 12)	Watershed Area	Land Use							
		Agriculture		Urban/Developed		Natural Background		Water	
	acres	acres	percent	acres	percent	acres	percent	acres	percent
Apple Creek	33,190	20,715	62.4%	9,761	29.4%	2,551	7.7%	112	0.3%
Upper Duck Creek	30,851	13,464	43.6%	10,396	33.7%	4,674	15.2%	113	0.4%
Plum Creek	22,322	17,592	78.8%	2,064	9.2%	2,642	11.8%	18	0.1%
Oneida Creek	14,939	10,216	68.4%	1,129	7.6%	3,557	23.8%	20	0.1%
Bower Creek	26,991	18,314	67.9%	5,210	19.3%	3,417	12.7%	157	0.6%
Little Lake Butte des Mortes	27,918	6,446	23.1%	15,908	57.0%	2,731	9.8%	1,534	5.5%
Kankapot Creek	16,386	11,730	71.6%	3,745	22.9%	2,327	14.2%	24	0.1%
Ashwaubenon Creek	18,984	12,685	66.8%	4,687	24.7%	1,571	8.3%	36	0.2%
Dutchman Creek	19,741	10,641	53.9%	6,861	34.8%	2,218	11.2%	17	0.1%
Upper East River	22,997	16,761	72.9%	1,459	6.3%	4,756	20.7%	16	0.1%
Lower East River	28,696	13,464	46.9%	10,396	36.2%	4,674	16.3%	16	0.1%
Middle Duck Creek	14,780	10,081	68.2%	1,049	7.1%	3,542	24.0%	18	0.1%
Baird Creek	15,695	10,347	65.9%	3,969	25.3%	3,417	21.8%	157	1.0%
Point du Sable-Frontal Green Bay	13,686	7,702	56.3%	4,819	35.2%	2,663	19.5%	94	0.7%
Trout Creek	10,182	5,270	51.8%	1,163	11.4%	3,722	36.6%	22	0.2%
Lower Duck Creek	27,623	6,903	25.0%	12,413	44.9%	7,958	28.8%	157	0.6%
Mud Creek	16,359	4,034	24.7%	11,029	67.4%	1,335	8.2%	66	0.4%

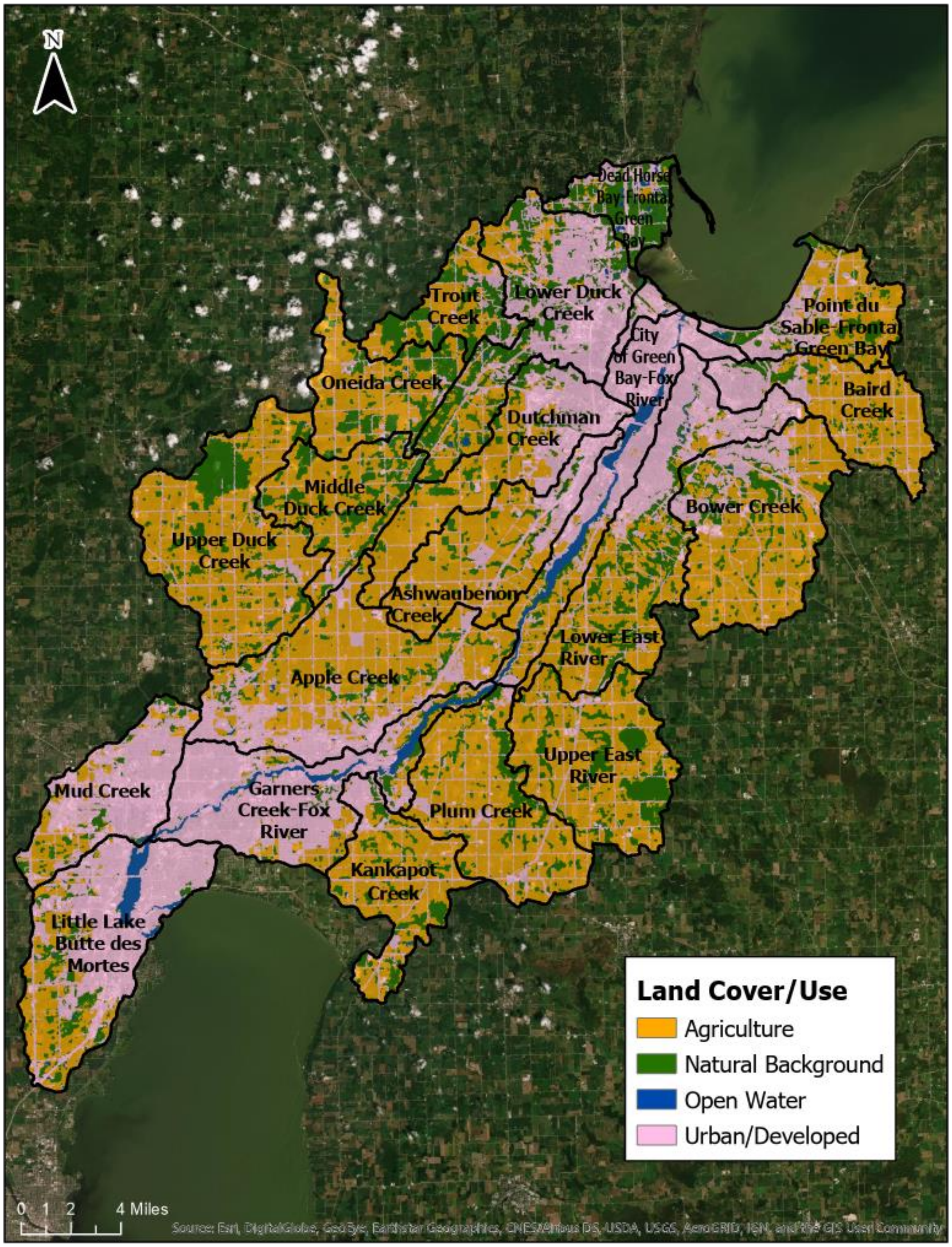

Figure 4. Map of land use/cover in Lower Fox River Basin.

3.0 Methods

The purpose of this analysis was to estimate current flow rates and pre-settlement flow rates for catchments of subwatersheds (HUC12) in the Lower Fox River Basin. The amount of storage needed can be calculated based on the difference between the flow rates. The analysis was completed using ESRI 10.7 ArcGIS tools/models and the NRCS EFH2 Spreadsheet. Outagamie County Land Conservation consulted with Robert D. Givens, P.E., P.H., C.F.M from OMNNI Associates on methods used to conduct the analysis described in this section.

ESRI Arc Hydro[1] is a water resource data model that contains a set of tools to support water resources analyses. Arc Hydro was used to condition the digital elevation model (DEM), generate flow lines, delineate catchments of each subwatershed (HUC12), and to characterize slope and watershed length. A DEM and a Culvert Polyline layer are needed to run Arc Hydro. The majority of the HUC 12 watersheds in the Lower Fox Basin already had a 3-meter resolution DEM created and a culvert polyline layer created for prior GIS analysis that had been done for 9 Key Element Plan creation. DEM and culvert polyline files for those watersheds that had not already been done were provided by Tom Simmons of the Wisconsin Department of Natural Resources.

The focus of this analysis was on agricultural dominant headwater drainages. Outlets for catchment delineation were selected if the majority land use was agricultural land and that the topography of the catchment was suitable for agricultural runoff treatment system.

Once the hydrologic parameters of each subwatershed were determined, the EFH2 runoff method was used to estimate runoff volume and peak discharge for each catchment. It is a single event rainfall-runoff model for small watersheds (<2,000 acres) where urban land use is less than 10%. Inputs into the EFH2 model include drainage area, runoff curve number, watershed length, and watershed slope. The EFH2 spreadsheet model uses NRCS storm distributions MSE3 and MSE4 from NOAA Atlas 14, Volume 8. The Lower Fox River Basin is in the MSE4 rainfall region.

Runoff curve number is a parameter used in hydrology for predicting runoff or infiltration from rainfall. Runoff curve number is calculated based on hydrologic soil group, land use, treatment, and hydrologic condition. Runoff curve number for current conditions was calculated using gSSURGO soils data and cropland data layers from 2014-2018 in the EVAAL Create Curve Number Raster tool. To calculate a curve number for pre-settlement conditions the land cover was assumed to be woods in good condition based on Wisconsin Land Survey data from the mid-1800s.

EFH2 runoff and peak discharge (flow rate) data was then used to calculate storage volumes needed and area required to return to pre-settlement conditions. Current and historic flow rates from the EFH2 were adjusted based on the amount of wetlands in a catchment. The adjustment factor for pond and swamp areas from Technical Release 55-Urban Hydrology for Small Watersheds was used to adjust the flow rates. The maximum adjustment factor is 0.72 for 5% pond and swamp areas in a catchment. The WDNR GIS Potentially Restorable Wetlands

[1] For additional information on Arc Hydro: https://www.esri.com/library/fliers/pdfs/archydro.pdf

(Historic) and Wisconsin Wetland Inventory (WWI) data sets were clipped by catchment boundaries in GIS to determine acres in each catchment.

Baseline phosphorus and sediment loads from the Lower Fox River TMDL were used to estimate reductions. An area weighted average lbs/ac baseline load was calculated for nonpoint sources (urban non-regulated, agriculture and natural background) for each TMDL subwatershed (Appendix A). The load for each catchment was then calculated using the area weighted average times the catchment acres. The reduction efficiency used for Agriculture Runoff Treatment Systems was 60% for TP and 80% for TSS. This efficiency was chosen by the AOC technical advisory team based on the fact that the open water components of the ARTS systems would be designed to the WI DNR Technical Standard 1001 Wet Detention Pond. Therefore, they would be able to achieve similar reduction efficiencies as a wet detention basin does.

4.0 Analysis Results Summary

The hydrologic analysis was completed for 17 out of 20 subwatersheds (HUC12) in the Lower Fox River Basin (Figure 5). Subwatersheds that were mostly urban were not analyzed (Garners Creek-Fox River, City of Green Bay- Fox River, Dead Horse Bay-Frontal Green Bay). A partial analyses was completed for the agricultural portion of the Mud Creek and Little Lake Butte des Mortes subwatersheds.

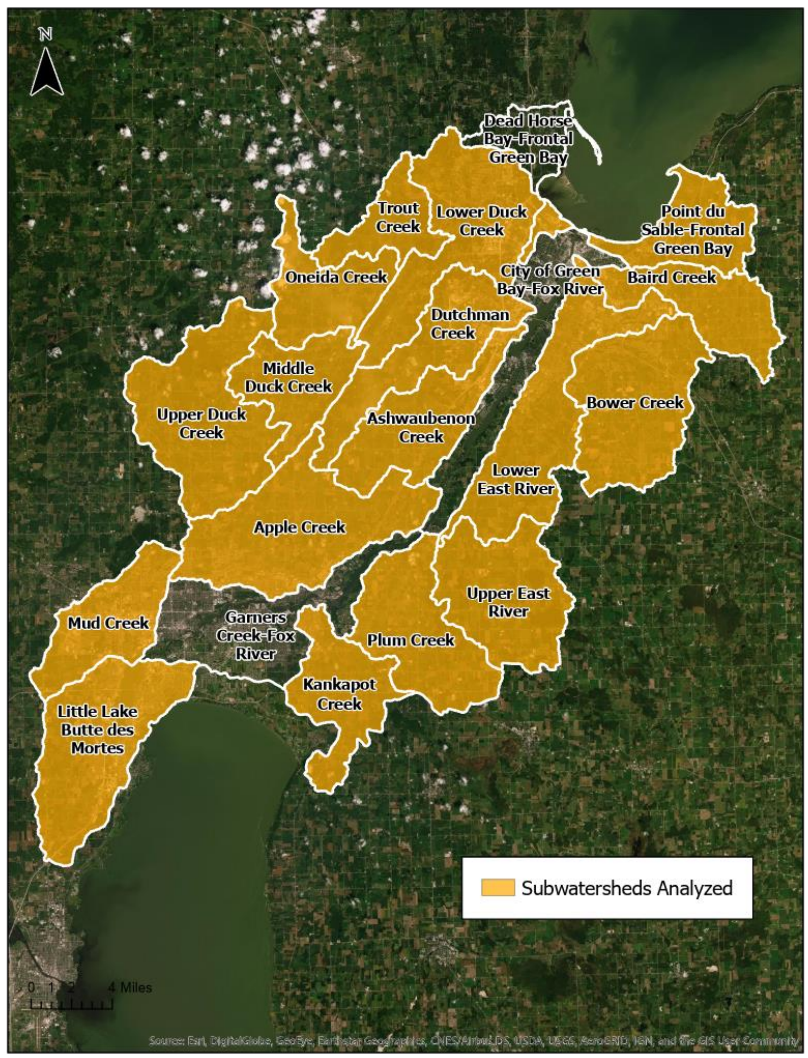

Figure 5. Subwatersheds analyzed.

Curve numbers are used to characterize runoff properties for a particular soil type and ground cover. Figure 6 shows the mean estimated curve number for pre-settlement land use conditions and for current land use conditions for the catchments analyzed in each subwatershed. The mean curve number for current conditions for all catchments was 83 while the mean curve number for pre-settlement conditions for all catchments was 73.

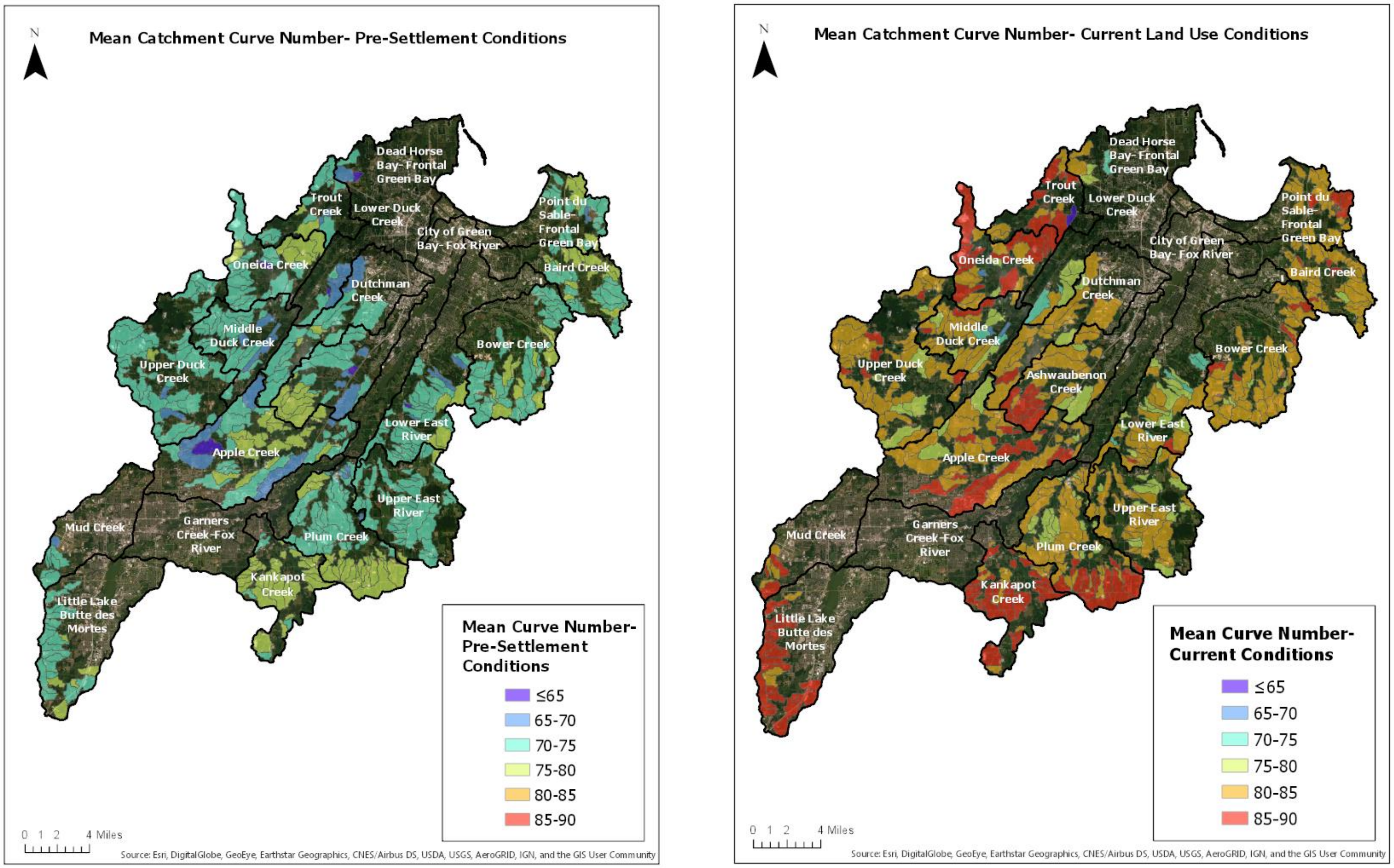

Figure 6. Pre-settlement mean curve number by catchment (left) and current mean curve number by catchment (right).

Water Storage Needed

The hydrologic analysis modeled runoff and storage needs for the 1-yr, 2-yr, 5-yr, 10-yr, 25-yr, 50-yr, and 100-yr MSE-4 rainfall events. Current and historic flow rates for the analyzed area of each watershed using EFH2 are shown in Table 4. Table 5 shows the storage volume in millions of gallons needed to restore hydrology to pre-settlement conditions for analyzed areas for all storm events. It is commonly accepted that peak discharge control on the 2-yr design storm will help control stream bank erosion (Donovan et al. 2000). Because streambank erosion is also a significant source of nutrients and sediment, controlling the rate of erosion is important. Therefore, the 2-yr rainfall event was chosen as the basis for the volume needed to be retained in the subwatersheds to restore hydrology. Figure 7 shows the acres needed, assuming a 2 ft storage depth, to meet required volume retention and Figure 8 shows what percent of each catchment is required. Detailed maps of results for each subwatershed are shown in Appendix B.

Table 4. Current and historic flow rates for analyzed area of each watershed.

Watershed (HUC 12)	Watershed Area (acres)	Total Area Analyzed (Acres)	Percent of Watershed Analyzed	Current Flow Rate (cfs)							Historic Flow Rate (cfs)							Percent Change in Flow Rate						
				1 yr	2 yr	5 yr	10 yr	25 yr	50 yr	100 yr	1 yr	2 yr	5 yr	10 yr	25 yr	50 yr	100 yr	1 yr	2 yr	5 yr	10 yr	25 yr	50 yr	100 yr
Apple Creek	33,190	20,379	61.4%	4,545	5,916	8,583	11,114	14,940	18,198	21,728	1,135	1,677	2,821	3,983	5,867	7,575	9,499	75%	72%	67%	64%	61%	58%	56%
Upper Duck Creek	30,851	16,417	53.2%	3,812	4,997	7,323	9,546	12,935	15,832	18,964	906	1,393	2,466	3,561	5,321	6,931	8,756	76%	72%	66%	63%	59%	56%	54%
Plum Creek	22,322	16,756	75.1%	4,018	5,323	7,860	10,306	14,187	17,545	21,227	1,258	1,870	3,143	4,436	6,596	8,566	10,806	69%	65%	60%	57%	54%	51%	49%
Oneida Creek	14,939	10,839	72.6%	2,333	2,998	4,279	5,482	7,272	8,799	10,454	627	920	1,536	2,152	3,146	4,045	5,055	73%	69%	64%	61%	57%	54%	52%
Bower Creek	26,991	13,590	50.4%	3,161	4,239	6,337	8,355	11,551	14,292	17,245	949	1,454	2,505	3,552	5,308	6,916	8,718	70%	66%	60%	57%	54%	52%	49%
Little Lake Butte des Mortes	27,918	7,554	27.1%	2,387	3,033	4,263	5,419	7,193	8,731	10,407	605	883	1,458	2,040	3,012	3,903	4,911	75%	71%	66%	62%	58%	55%	53%
Kankapot Creek	16,386	8,655	52.8%	2,869	3,712	5,315	6,832	9,259	11,358	13,697	852	1,235	1,997	2,775	4,110	5,321	6,712	70%	67%	62%	59%	56%	53%	51%
Ashwaubenon Creek	18,984	10,319	54.4%	1,775	2,347	3,460	4,528	6,175	7,598	9,137	467	701	1,202	1,716	2,569	3,349	4,229	74%	70%	65%	62%	58%	56%	54%
Dutchman Creek	19,741	9,255	46.9%	1,422	1,879	2,769	3,622	4,940	6,067	7,284	424	644	1,119	1,602	2,401	3,132	3,957	70%	66%	60%	56%	51%	48%	46%
Upper East River	22,997	11,327	49.3%	2,282	3,121	4,773	6,386	8,990	11,276	13,734	690	1,095	1,980	2,884	4,401	5,806	7,396	70%	65%	59%	55%	51%	49%	46%
Lower East River	28,696	10,829	37.7%	2,117	2,918	4,495	6,033	8,513	10,688	13,046	699	1,103	1,973	2,860	4,347	5,720	7,267	67%	62%	56%	53%	49%	46%	44%
Middle Duck	14,780	8,742	59.1%	1,569	2,095	3,131	4,123	5,653	6,974	8,411	453	698	1,242	1,819	2,763	3,636	4,627	71%	67%	60%	56%	51%	48%	45%
Baird Creek	15,695	7,308	46.6%	1,588	2,130	3,188	4,207	5,822	7,210	8,701	591	897	1,526	2,151	3,198	4,154	5,222	63%	58%	52%	49%	45%	42%	40%
Point du Sable-Frontal Green Bay	13,686	5,581	40.8%	1,224	1,633	2,426	3,187	4,379	5,406	6,510	371	575	1,005	1,438	2,163	2,830	3,579	70%	65%	59%	55%	51%	48%	45%
Trout Creek	10,182	4,551	44.7%	990	1,287	1,863	2,404	3,237	3,951	4,724	242	367	634	904	1,351	1,762	2,226	76%	72%	66%	62%	58%	55%	53%
Lower Duck	27,623	5,135	18.6%	578	804	1,256	1,698	2,412	3,043	3,735	118	197	387	601	976	1,333	1,744	80%	75%	69%	65%	60%	56%	53%
Mud Creek	16,359	1,828	11.2%	659	844	1,202	1,540	2,060	2,511	3,004	119	182	320	463	701	923	1,176	82%	78%	73%	70%	66%	63%	61%

Table 5. Water storage needed to return flow rates back to pre-settlement conditions.

HUC 12 NAME	HUC 12 Area (Acres)	Million Gallons of Storage Needed (1 yr)	Million Gallons of Storage Needed (2 yr)	Million Gallons of Storage Needed (5 yr)	Million Gallons of Storage Needed (10 yr)	Million Gallons of Storage Needed (25 yr)	Million Gallons of Storage Needed (50 yr)	Million Gallons of Storage Needed (100 yr)	Total Area Analyzed (Acres)	Percent of Watershed Analyzed
Apple Creek	33,190	146.0	175.9	230.5	279.7	351.5	410.9	473.8	20,379	61.4%
Upper Duck Creek	30,851	144.2	172.8	224.8	272.8	344.3	403.4	465.8	16,417	53.2%
Plum Creek	22,322	133.4	162.4	216.0	267.0	344.6	409.7	479.7	16,756	75.1%
Oneida Creek	14,939	103.5	122.7	158.0	190.1	236.1	274.1	314.2	10,839	72.6%
Bower Creek	26,991	101.3	123.9	166.1	206.0	266.8	317.4	370.7	13,590	50.4%
Little Lake Butte des Mortes	27,918	85.0	99.7	126.6	151.3	187.7	218.3	250.7	7,554	27.1%
Kankapot Creek	16,386	84.1	100.9	132.3	161.0	205.5	243.0	283.9	8,655	52.8%
Ashwaubenon Creek	18,984	83.6	102.2	136.0	166.9	213.2	251.9	292.9	10,319	54.4%
Dutchman Creek	19,741	75.4	91.3	120.0	146.5	186.1	218.9	253.3	9,255	46.9%
Upper East River	22,997	74.9	92.2	123.9	154.0	201.4	241.5	283.5	11,327	49.3%
Lower East River	28,696	66.6	82.7	112.4	140.5	184.5	221.7	260.9	10,829	37.7%
Middle Duck Creek	14,780	64.7	77.7	101.3	122.9	154.9	181.5	209.5	8,742	59.1%
Baird Creek	15,695	47.6	58.1	78.0	96.8	125.4	149.1	173.8	7,308	46.6%
Point du Sable-Frontal Green Bay	13,686	42.5	51.4	67.6	82.8	105.8	124.8	144.6	5,581	40.8%
Trout Creek	10,182	41.8	49.9	64.6	78.0	97.8	114.2	131.4	4,551	44.7%
Lower Duck Creek	27,623	35.9	44.9	60.5	74.4	95.3	112.9	131.6	5,135	18.6%
Mud Creek	16,359	22.1	26.2	33.4	40.0	49.9	58.2	66.9	1,828	11.2%
Total	361,340	1,352.4	1,634.8	2,152.2	2,630.8	3,350.8	3,951.3	4,587.3	169,065	46.8%

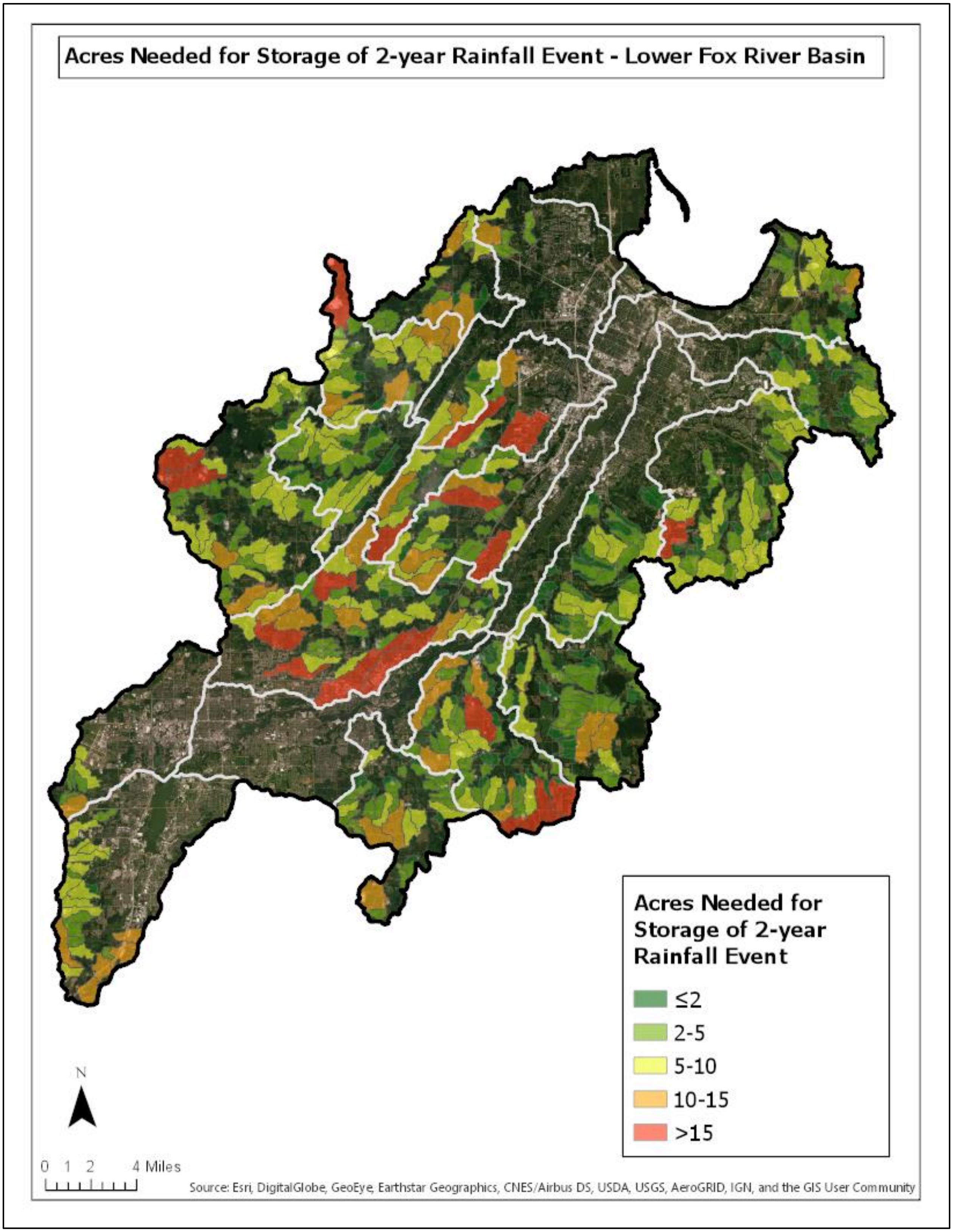

Figure 7. Map of acres needed for storage of 2- year rainfall event for catchments analyzed.

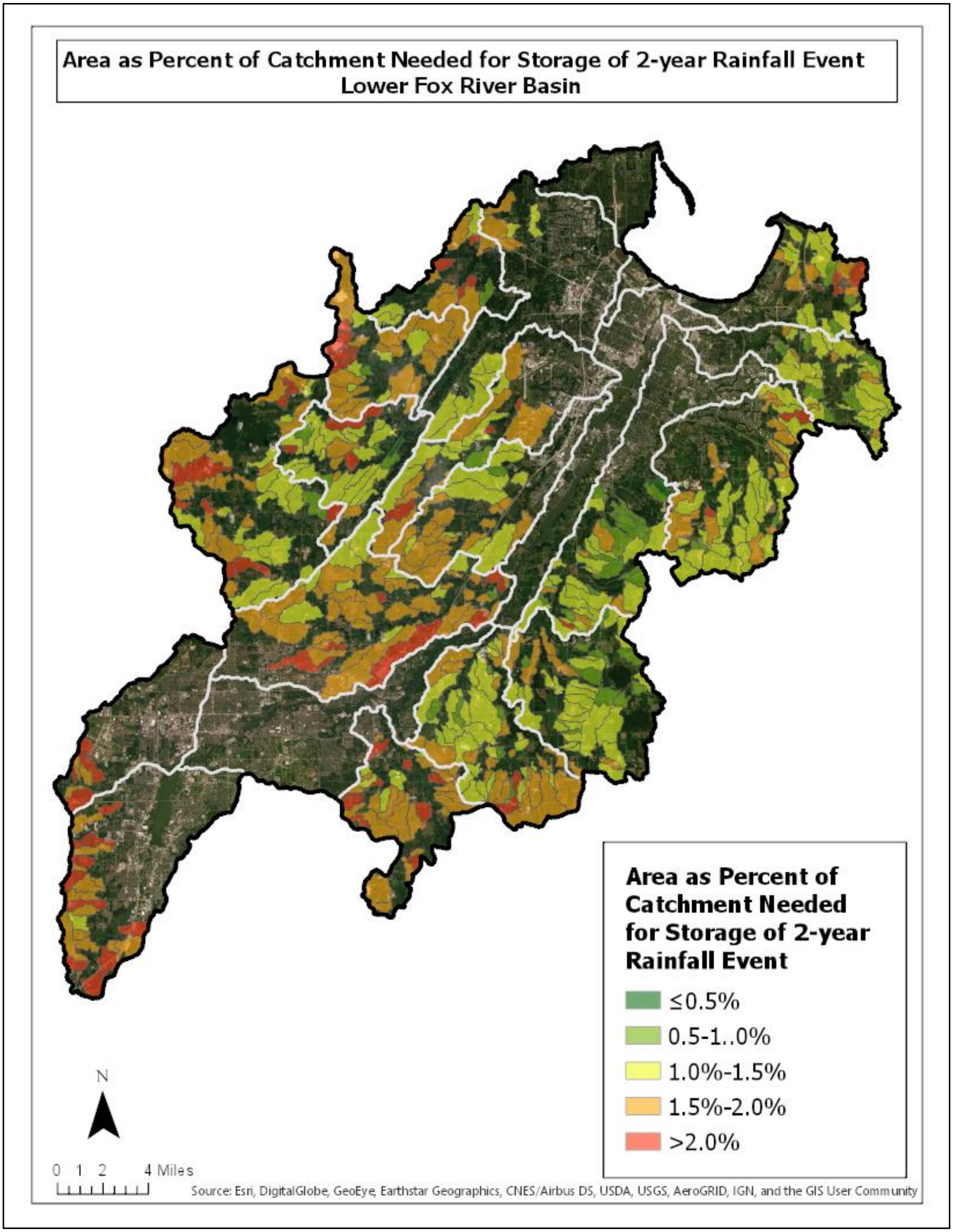

Figure 8. Map of area as a percent of catchment needed for storage of 2-year rainfall event.

Flood Control

This study focuses on the 1 and 2-yr MSE-4 24-hour rainfall event for the purpose of identifying and determining the need for increasing water storage capacity to improve water quality by reducing nutrient and sediment load reductions for the BUIs. This study includes numbers for larger storm events as well with the potential to help mitigate regional flooding issues. The analysis data from the other rainfall events such as the 25-yr, 50-yr and 100-yr can also be used by local communities and other local entities looking for ways to reduce the impact of flooding. Local communities can use this data to identify priority watersheds for potential downstream storm water practices (detention basins) and to identify opportunities to work with upstream communities or agriculture producers to reduce runoff rates from headwaters of priority watersheds. Communities may also want to partner with local land conservation departments to provide additional funding to increase the storage capacity of a potential ARTS system from a 2-yr rainfall to a 10-yr or 25-yr rainfall capacity if it benefits them downstream. The data can also be used to better plan urban development as communities in the Lower Fox Basin continue to expand by designing regional treatment that provides for both future development and create storage needed for this analysis.

Nutrient and Sediment Load Reductions

Best management practices (BMPs) with the greatest potential to store significant volumes of water for agriculture land use include agricultural runoff treatment systems (ARTS) and wetland restoration/creation. An Agricultural Runoff Treatments system is similar to a storm water pond in that it will be designed to retain water and settle out sediment. ARTs are designed with wetland cells that mimic wetland functions. Phosphorus and sediment reductions were estimated based on the installation of ARTS to store water volumes at the 2-year rainfall event level. For the purposes of this study a 60% TP and 80% TSS reduction efficiency was used for ARTS. Table 6 shows the reductions that could be achieved if all the volume of the 2-yr rainfall event were to be stored for all catchments analyzed using the ARTS practice. Wetland restoration and creation in the watershed will also help to achieve water storage goals and thus reduce downstream flow rates and erosion impacts. Due to the variety in wetland types it is difficult to estimate phosphorus and sediment reductions from wetland restoration/creation from currently available data. Restored wetlands and created wetlands don't allow for regular maintenance or regulation of flow which also affects the phosphorus and sediment retention ability. However, ARTS will offer new opportunities to restore adjacent wetlands and provide them with a cleaner source of water.

Table 6. Estimated total phosphorus and total suspended sediment reductions if all storage required was implemented using ARTS.

Watershed (HUC12)	TP Reduction (lbs)	TSS Reduction (tons)
Apple Creek	13,083	2,993
Upper Duck Creek	7,092	1,886
Plum Creek	12,969	3,477
Oneida Creek	4,682	1,245

Watershed (HUC12)	TP Reduction (lbs)	TSS Reduction (tons)
Bower Creek	8,562	2,072
Little Lake Butte des Mortes	4,261	965
Kankapot Creek	6,335	1,511
Ashwaubenon Creek	5,758	1,115
Dutchman Creek	4,276	795
Upper East River	7,068	1,860
Lower East River	6,757	1,779
Middle Duck Creek	3,776	1,004
Baird Creek	3,288	507
Point du Sable-Frontal Green Bay	2,177	438
Trout Creek	1,338	305
Lower Duck Creek	2,218	590
Mud Creek	1,020	226
Total	94,662	22,770

Discussion

Assuming all the storage needed for the 2-year rainfall event was implemented using ARTS in the analyzed subwatersheds significant phosphorus and sediment reductions would be achieved. The total area needed for storage practices (ARTS or Wetland Restoration/Creation with an assumed storage depth of 2 ft) is less than 1% of the total watershed area in most watersheds (Table 7). The estimated cost to install all ARTS needed to restore the 2-yr hydrology is $184,968,637 (Table 8). This cost takes into account the following costs: land acquisition, outreach, administration, design, survey, construction/construction oversight and operation and maintenance. The average upfront cost to reduce a pound of phosphorus is $2,195 and $9,684 to reduce a ton of sediment. It should be noted that these practices will be designed to achieve annual reductions for 10-20 years before needing maintenance to remove accumulated sediment.

In comparison, it is estimated that the upfront cost to reduce a pound of phosphorus is $1,960 for implementing conservation cover on a farm field, this includes using no-till, cover crops, and low disturbance manure injection. This cost assumes 7 years of cost sharing at $280/acre is needed for a farmer to adopt these practices for the long term. Current proposals include farmers agreeing to use the practices for another 14 years in order to receive the 7 years of funding.

When comparing the ARTS upfront cost to the upfront cost of conservation cover they are very similar; however, the cost of ARTS does not include the cost benefit of reduced downstream flooding and streambank erosion. Additionally, ARTS once constructed are a permanent structure, while full adoption of conservation cover would be an entirely new way of farming and may not be fully resilient to change in climate. However, encouraging adoption of conservation cover is still an important strategy in meeting reduction goals in the basin.

Table 7. Summary of acres of storage needed for 2-year rainfall event.

HUC 12 NAME	HUC 12 Area (Acres)	Acres of storage needed for 2-year rainfall event. (2 yr)	Total Area Analyzed (Acres)	Percent of Watershed Analyzed	Percent of Watershed Needed for Storage (2 yr)
Apple Creek	33,190	355.2	20,379	61.4%	1.1%
Upper Duck Creek	30,851	265.2	16,417	53.2%	0.9%
Plum Creek	22,322	249.2	16,756	75.1%	1.1%
Oneida Creek	14,939	188.3	10,839	72.6%	1.3%
Bower Creek	26,991	190.1	13,590	50.4%	0.7%
Little Lake Butte des Mortes	27,918	152.9	7,554	27.1%	0.5%
Kankapot Creek	16,386	154.8	8,655	52.8%	0.9%
Ashwaubenon Creek	18,984	156.8	10,319	54.4%	0.8%
Dutchman Creek	19,741	140.0	9,255	46.9%	0.7%
Upper East River	22,997	141.5	11,327	49.3%	0.6%
Lower East River	28,696	126.9	10,829	37.7%	0.4%
Middle Duck Creek	14,780	119.2	8,742	59.1%	0.8%
Baird Creek	15,695	89.2	7,308	46.6%	0.6%
Point du Sable-Frontal Green Bay	13,686	78.8	5,581	40.8%	0.6%
Trout Creek	10,182	76.6	4,551	44.7%	0.8%
Lower Duck Creek	27,623	68.9	5,135	18.6%	0.2%
Mud Creek	16,359	40.1	1,828	11.2%	0.2%

Table 8. Estimated costs for full implementation of ARTS practice for 2-year rainfall event storage needs.

Watershed (HUC12)	Cost	Cost/Pound of Phosphorus	Cost/ Ton of Sediment
Apple Creek	$22,295,474.23	$1,704.15	$7,448.69
Upper Duck Creek	$18,606,803.49	$2,623.55	$9,865.72
Plum Creek	$18,137,341.51	$1,398.52	$5,216.16
Oneida Creek	$11,738,490.03	$2,507.01	$9,427.49
Bower Creek	$15,458,663.09	$1,805.53	$7,459.89
Little Lake Butte des Mortes	$9,720,592.67	$2,281.48	$10,077.98
Kankapot Creek	$11,953,905.64	$1,886.87	$7,908.78
Ashwaubenon Creek	$11,625,209.21	$2,018.95	$10,423.52
Dutchman Creek	$8,683,831.46	$2,030.83	$10,919.99
Upper East River	$11,234,795.29	$1,589.54	$6,039.18
Lower East River	$11,155,962.27	$1,650.92	$6,272.36
Middle Duck Creek	$8,342,442.99	$2,209.12	$8,307.27
Baird Creek	$7,986,083.25	$2,428.50	$15,737.66
Point du Sable-Frontal Green Bay	$5,482,676.68	$2,518.94	$12,517.68
Trout Creek	$5,116,331.67	$3,823.73	$16,748.77
Lower Duck Creek	$4,631,217.22	$2,087.71	$7,850.73
Mud Creek	$2,798,816.63	$2,743.72	$12,410.81
Total	$184,968,637.32		

An acreage efficiency factor for ARTS was developed based on the estimated costs, phosphorus reduction, and ARTS area needed. This efficiency factor can be used to rank priority catchments within a HUC12 watershed to implement the ARTS practice. Implementation of ARTS will reduce the need for other practices such as streambank stabilization/restoration downstream of ARTS projects or conservation cropping practices in the contributing area to ARTS to achieve reduction and eutrophication BUI goals. In catchments where ARTS can't be implemented to the extent needed or at all, there still exists opportunity to install the other AOC like practices (streambank restoration, two-stage ditches, wetland restoration, and saturated buffers). Estimated reductions and cost estimates for the area of opportunity determined by AOC technical group for the other AOC like practices are shown in Table 9. Additionally, implementing conservation practices such as cover crops, reduced tillage, and buffers in drainage area to an ARTS should extend the amount of time needed before sediment is needed to be cleaned out.

Table 9. Estimate reductions and costs for other AOC like practices.

Practice	Estimated Opportunity Area	Units	Estimated TP Reduction (lbs)	Estimated TSS Reduction (tons)	Estimate Cost ($)
Wetland restoration/creation	5,745	ac	TBD*	TBD*	$6,894,000
Two-stage ditch	592,975	linear ft	3,730	1,248	$6,522,725
Streambank stabilization	284,189	linear ft	5,866	5,866	$17,051,340
Saturated buffer	151,745	linear ft	273	55	$1,062,215

*Due to the variation in natural wetlands (topography, vegetation, location) it is difficult to provide estimated phosphorus and sediment reductions. Overall wetlands would still provide the important service of water storage.

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Fitzpatrick, F.A., Blount, J.D., Kammel, L.E., Francart, S.A., Gellis, A.C. and Eickenberry, B.C. 2019. Stream Corridor Sources of Suspended Sediment and Phosphorus from an Agricultural Tributary to the Great Lakes. Proceedings of the Joint 11th Federal Interagency Sedimentation Conference and 6th Federal Interagency Hydrologic Modeling (SEDHYD) Conference.

United States Department of Agriculture Soil Conservation Service (USDA SCS). 1986. Urban Hydrology for Small Watersheds. Technical Release No. 55 (TR-55). USDA SCS, Washington, DC.

Appendices

Appendix A. Lower Fox River TMDL baseline total phosphorus and sediment loads.

Lower Fox TMDL Subbasin	**Area**					**Total Phophorus**						**Total Suspended Sediment**					
	Total (acres)	Agriculture (acres)	Urban (non-regulated) (acres)	Natural Background (acres)	Total (Agriculture + Urban (non-regulated) + Natural Background) (acres)	Total baseline (lbs/yr)	Agriculture Baseline (lbs/yr)	Urban (non-regulated) Baseline (lbs/yr)	Natural Background (lbs/yr)	Total (Agriculture + Urban (non-regulated) + Natural Background) (lbs/yr)	Total (Agriculture + Urban (non-regulated) + Natural Background) (lbs/ac/yr)	Total Baseline (tons/yr)	Agricultu re Baseline (tons/yr)	Urban (non-regulated) Baseline (tons/yr)	Natural Backgrou nd (tons/yr)	Total (Agriculture + Urban (non-regulated) + Natural Background) (tons/yr)	Total (Agriculture + Urban (non-regulated) + Natural Background) (tons/ac/yr)
East River	48,861	26,520	4,423	8,571	39,514	48,748	38,020	2,195	853	41,068	1.04	9,898	7,682	291	140	8,113	0.205
Baird Creek	16,372	8,633	1,437	3,149	13,219	12,748	9,018	588	263	9,869	0.75	1,896	1,073	54	20	1,148	0.087
Bower Cree	26,938	17,142	2,983	3,468	23,593	27,777	22,946	1,435	283	24,664	1.05	5,159	4,245	194	59	4,498	0.191
Apple Creek	34,232	20,613	5,378	2,343	28,334	35,088	27,297	2,837	255	30,389	1.07	6,368	4,725	443	34	5,203	0.184
Ashwaubenon Creek- State	14,408	8,220	454	1,276	9,950	11,887	8,797	154	113	9,064	0.91	1,871	1,278	28	12	1,318	0.132
Ashwaubenon Creek - Oneida	4,120	3,244	112	379	3,735	3,794	3,472	38	34	3,544	0.95	565	504	7	4	515	0.138
Dutchman Creek - State	7,454	1,809	398	1,459	3,666	4,791	1,890	156	122	2,168	0.59	913	268	17	10	294	0.080
Dutchman Creek - Oneida	11,732	7,888	634	379	8,901	10,489	8,240	248	32	8,520	0.96	1,604	1,167	27	3	1,197	0.134
Plum Creek	22,804	17,382	2,465	2,833	22,680	31,569	27,660	1,316	359	29,335	1.29	6,019	5,586	224	74	5,884	0.259
Kankapot Creek	16,401	11,367	1,120	2,172	14,659	20,050	17,195	493	269	17,957	1.22	3,627	3,072	96	31	3,200	0.218
Garners Creek	7,037	2,256	201	558	3,015	6,575	2,908	46	67	3,021	1.00	1,432	495	13	9	517	0.172
Mud Creek	9,585	1,474	335	532	2,341	6,594	1,884	245	49	2,178	0.93	1,462	340	18	4	361	0.154
Duck Creek - State	52,203	30,098	5,407	8,972	44,477	38,690	30,382	2,070	790	33,242	0.75	7,873	6,362	239	57	6,659	0.150
Duck Creek - Oneida	35,066	18,760	3,585	8,020	30,365	24,482	18,937	1,372	707	21,016	0.69	4,824	3,966	159	51	4,175	0.138
Trout Creek-Oneida	9,630	4,580	584	2,517	7,681	4,518	3,272	253	211	3,736	0.49	726	611	20	14	645	0.084
Neenah Slough	14,461	6,302	1,447	1,616	9,365	11,912	8,015	572	173	8,760	0.94	2,423	1,360	124	12	1,495	0.160
Lower Fox Mainstem	53,744	9,157	3,183	4,328	16,668	237,339	12,779	1,618	454	14,851	0.89	11,990	2,471	238	64	2,774	0.166
Lower Green Bay	18,609	7,135	809	6,677	14,621	12,652	8,670	324	575	9,569	0.65	2,151	1,345	54	34	1,434	0.098
Totals	**######**	**202,580**	**34,955**	**59,249**	**296,784**	**#####**	**251,382**	**15,960**	**5,609**	**272,951**		**70,801**	**46,551**	**2,246**	**632**	**49,429**	

Appendix B. Subwatershed analysis maps for 2-year rainfall event.

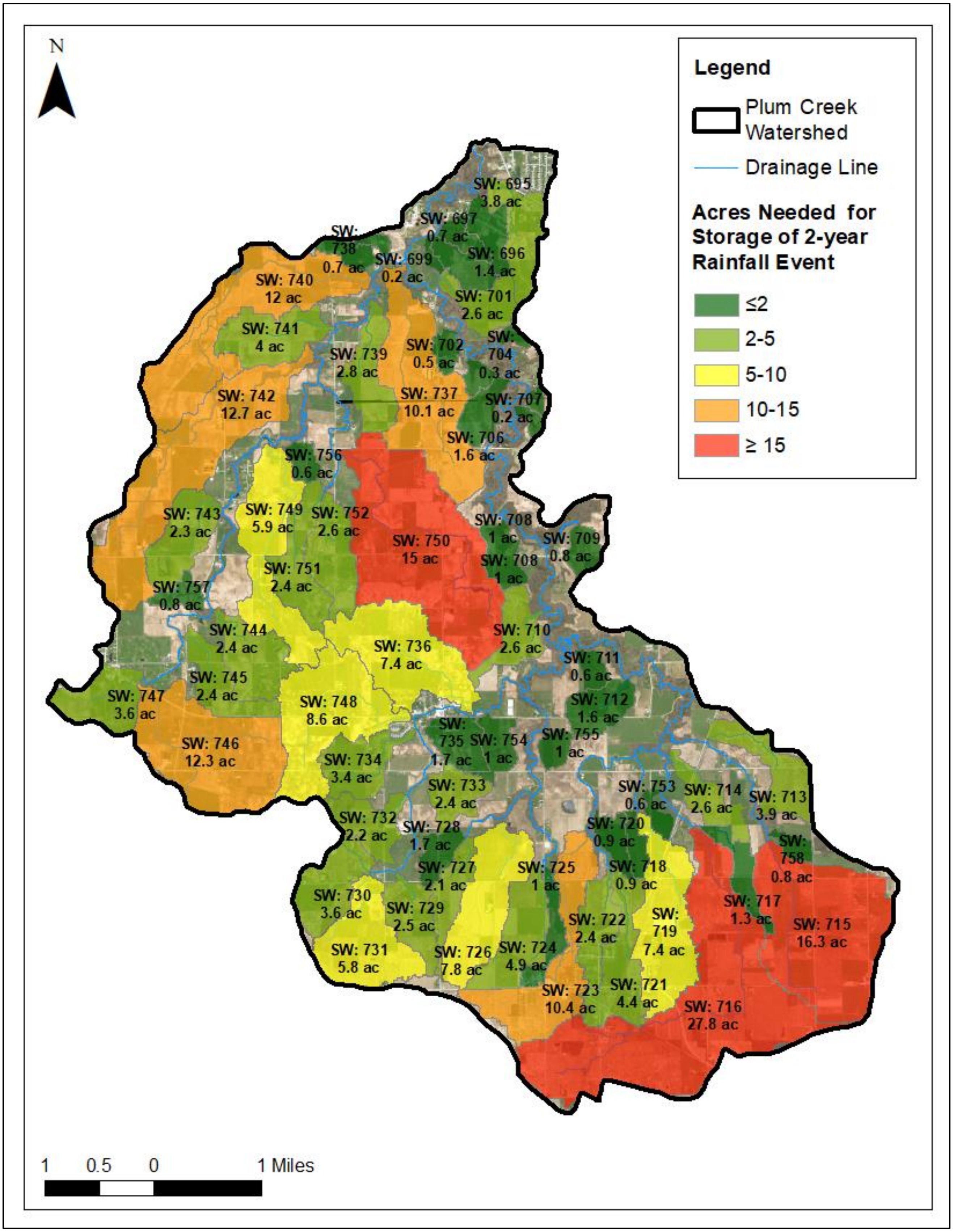

Figure B-1. Plum Creek acres of storage needed for 2-year rainfall event.

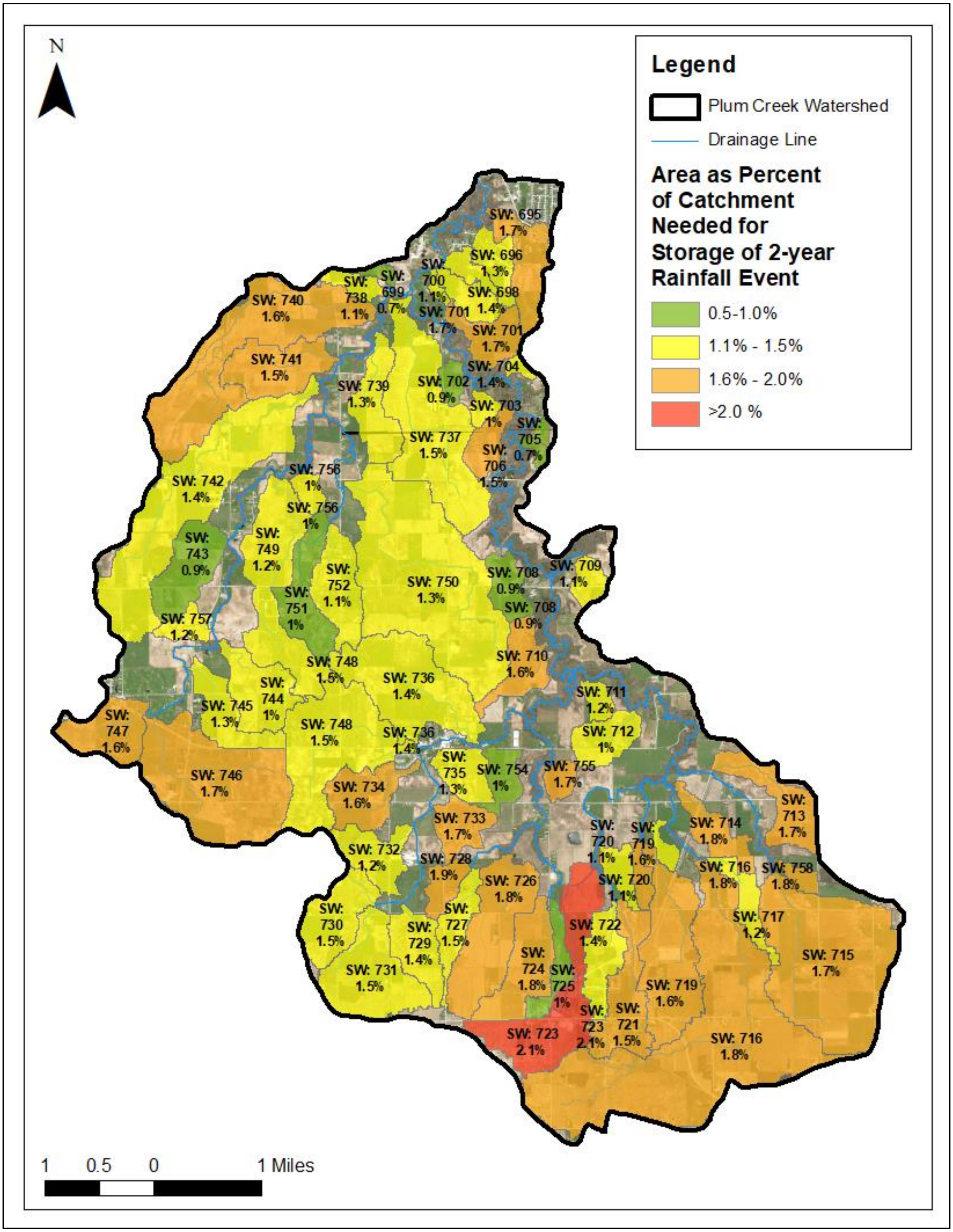

Figure B-2. Plum Creek percent of catchment needed for 2-year rainfall event.

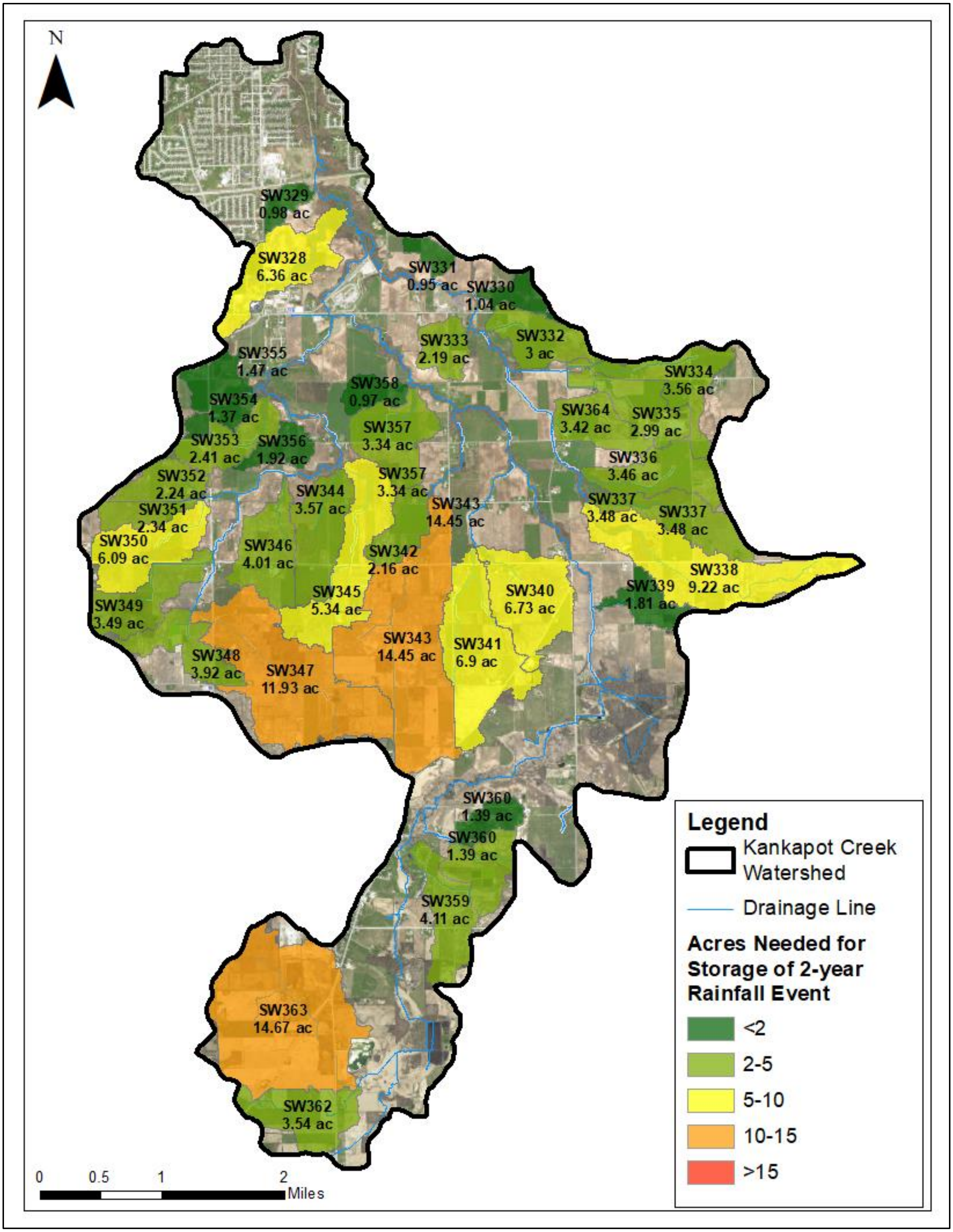

Figure B-3. Kankapot Creek acres of storage needed for 2-year rainfall event.

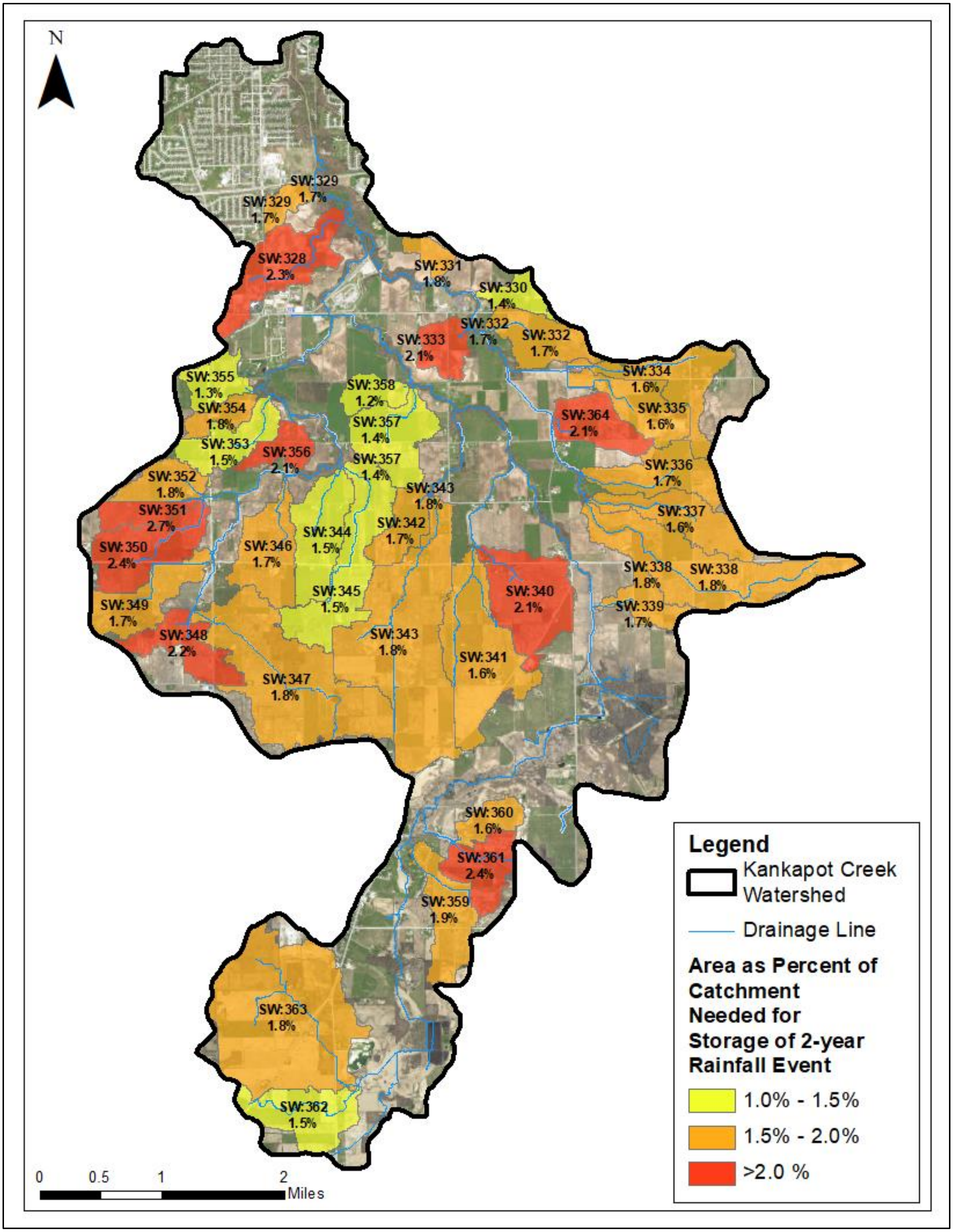

Figure B-4. Kankapot Creek percent of catchment needed for 2-year rainfall event.

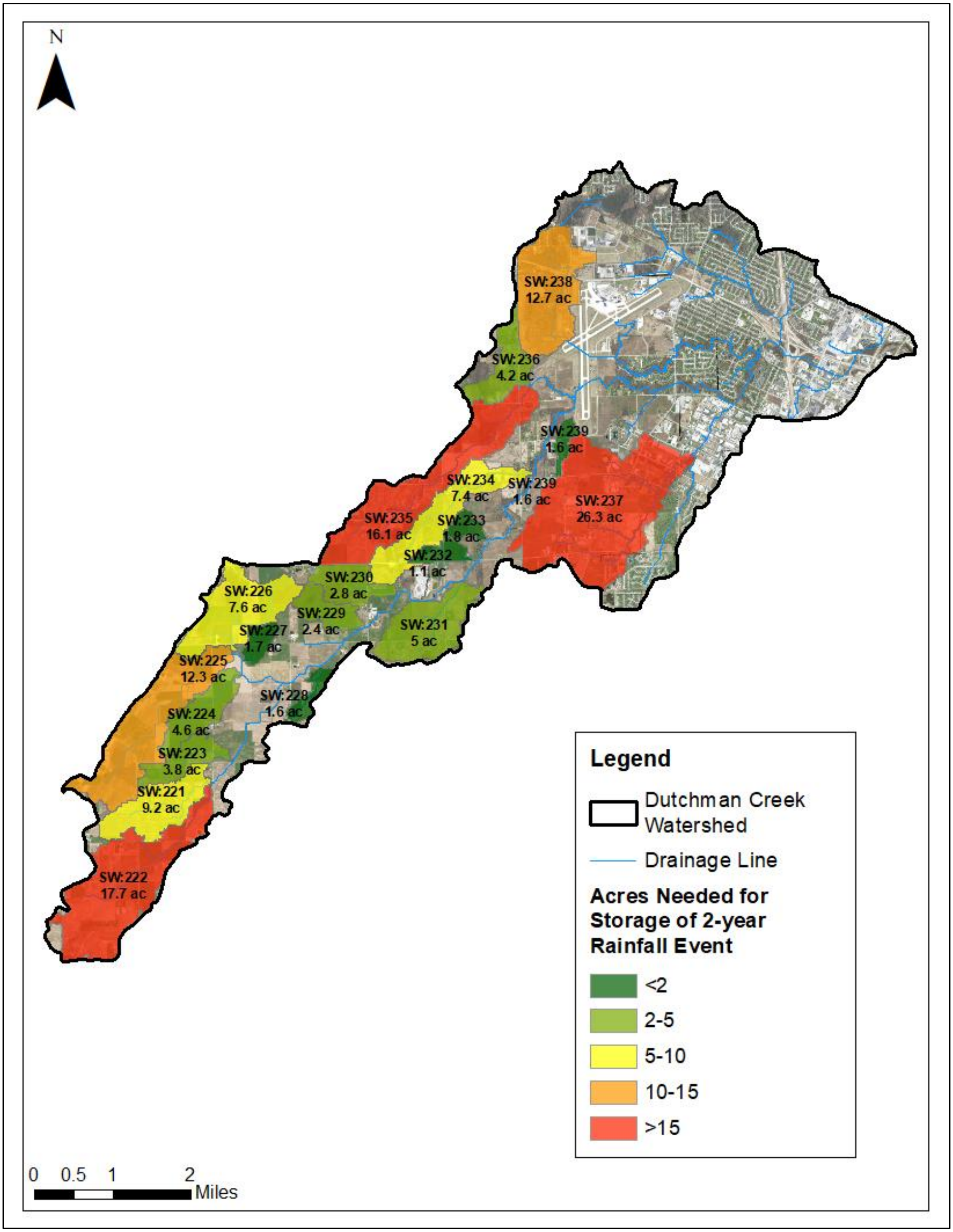

Figure B-5. Dutchman acres of storage needed for 2-year rainfall event.

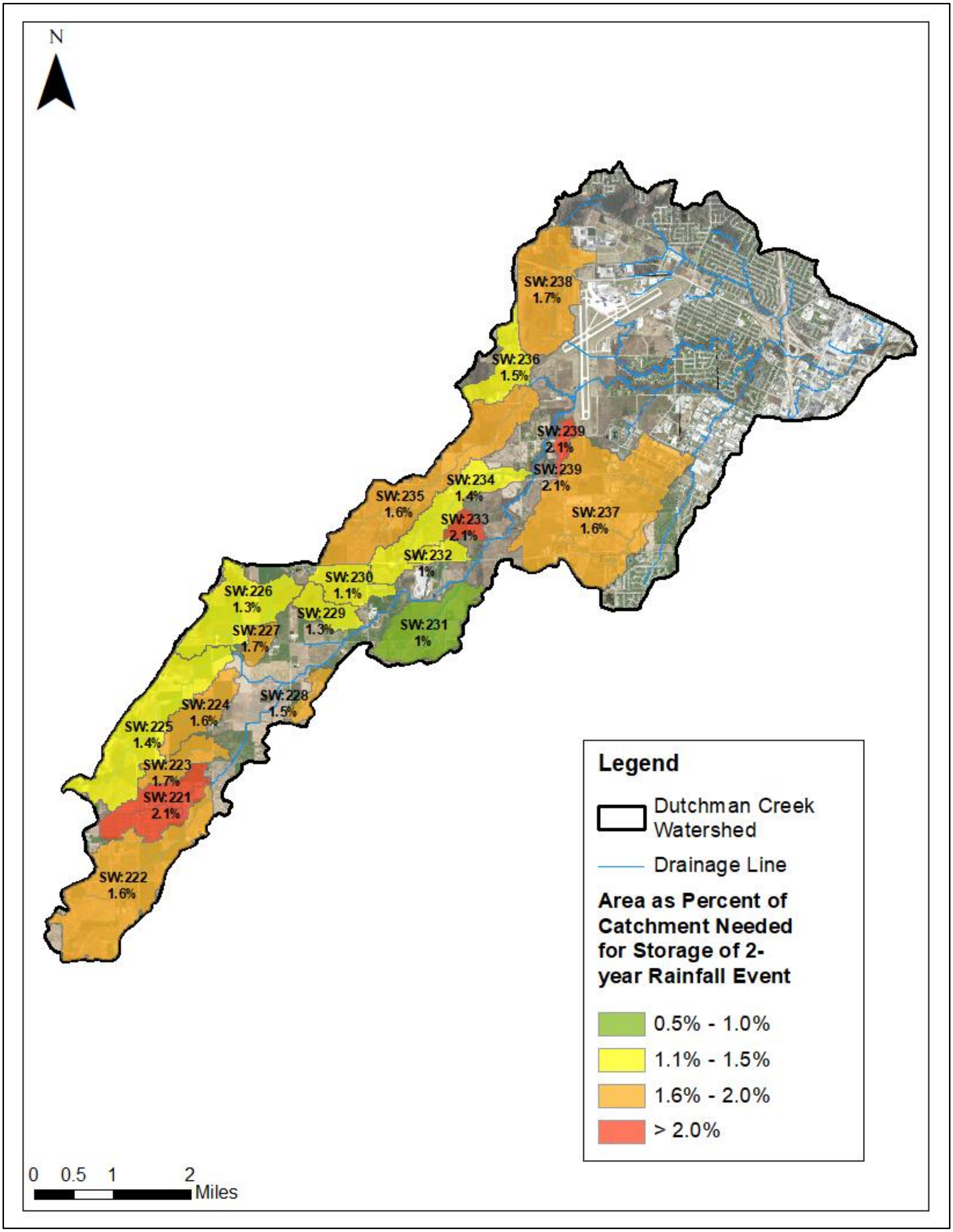

Figure B-6. Dutchman Creek percent of catchment needed for 2-year rainfall event.

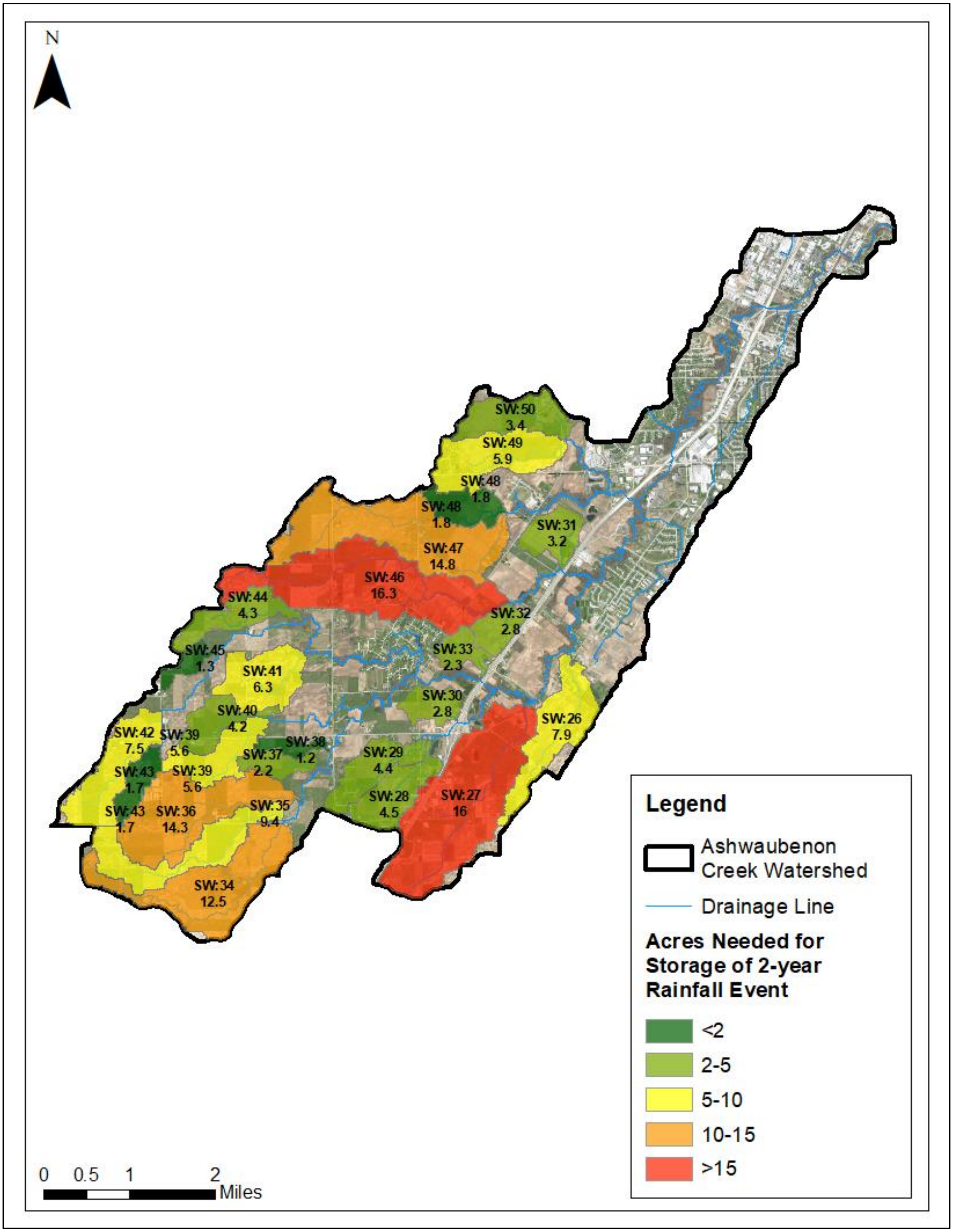

Figure B-7. Ashwaubenon Creek acres of storage needed for 2-year rainfall event.

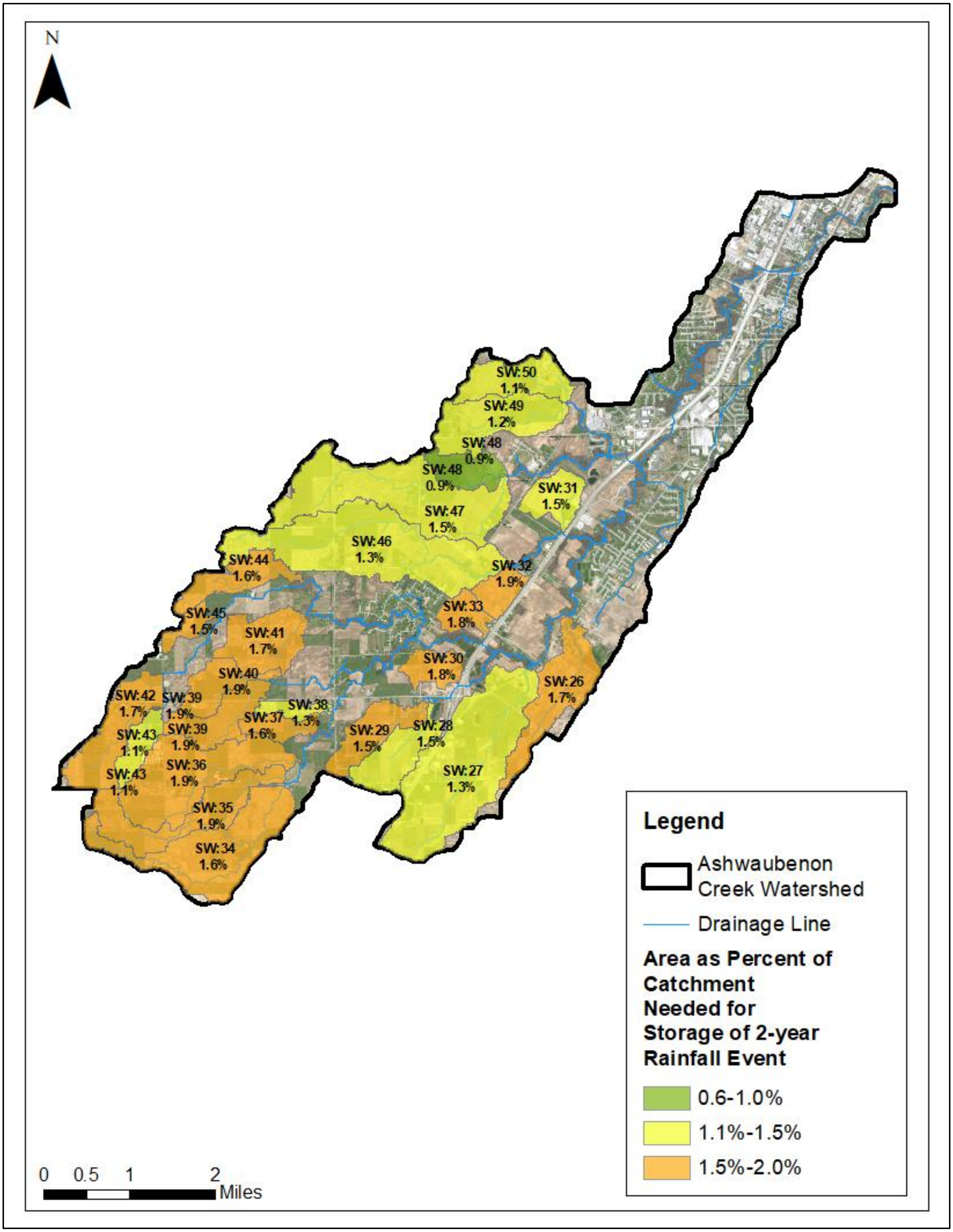

Figure B-8. Ashwaubenon Creek percent of catchment needed for 2-year rainfall event.

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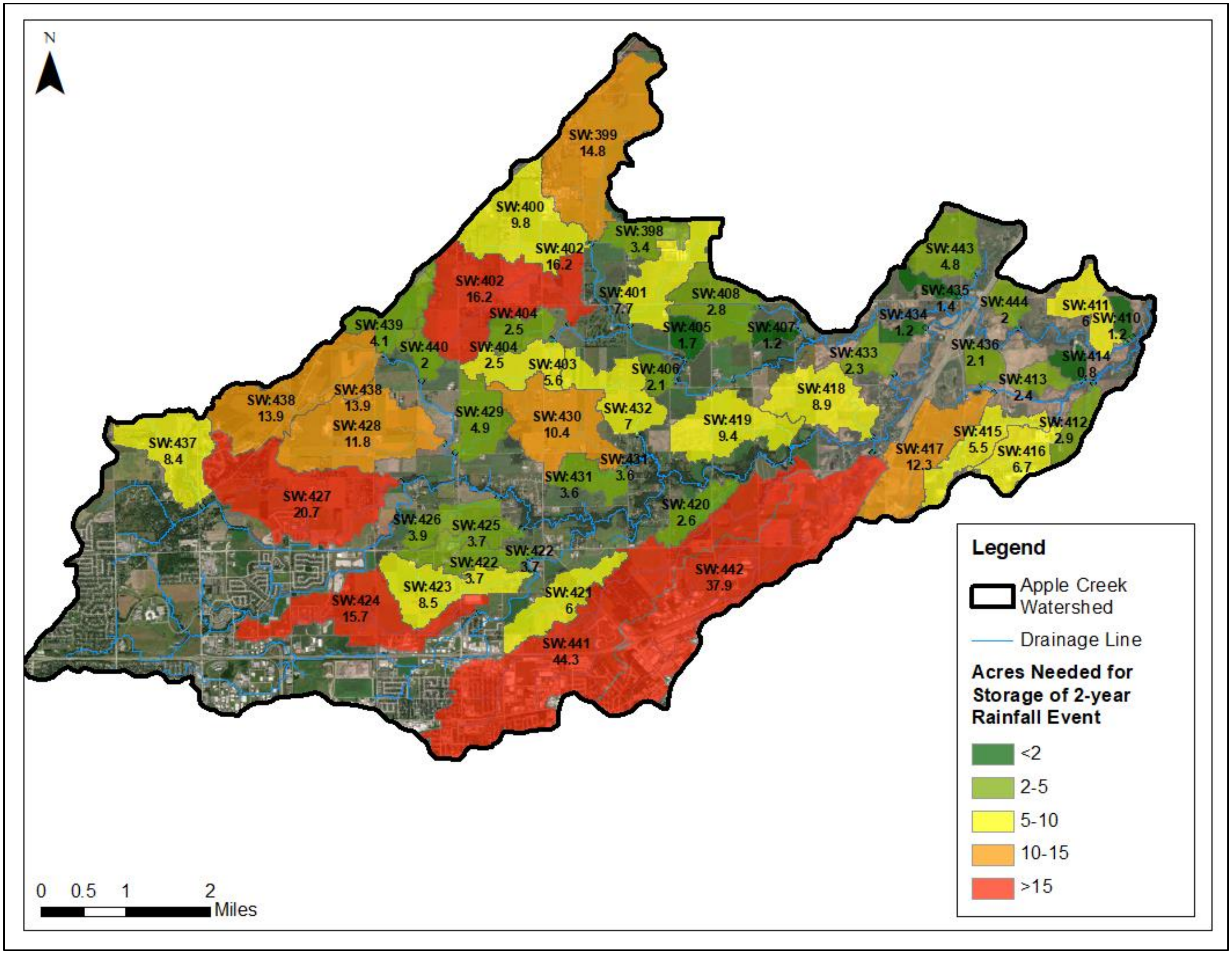

Figure B-9. Apple Creek acres of storage needed for 2-year rainfall event.

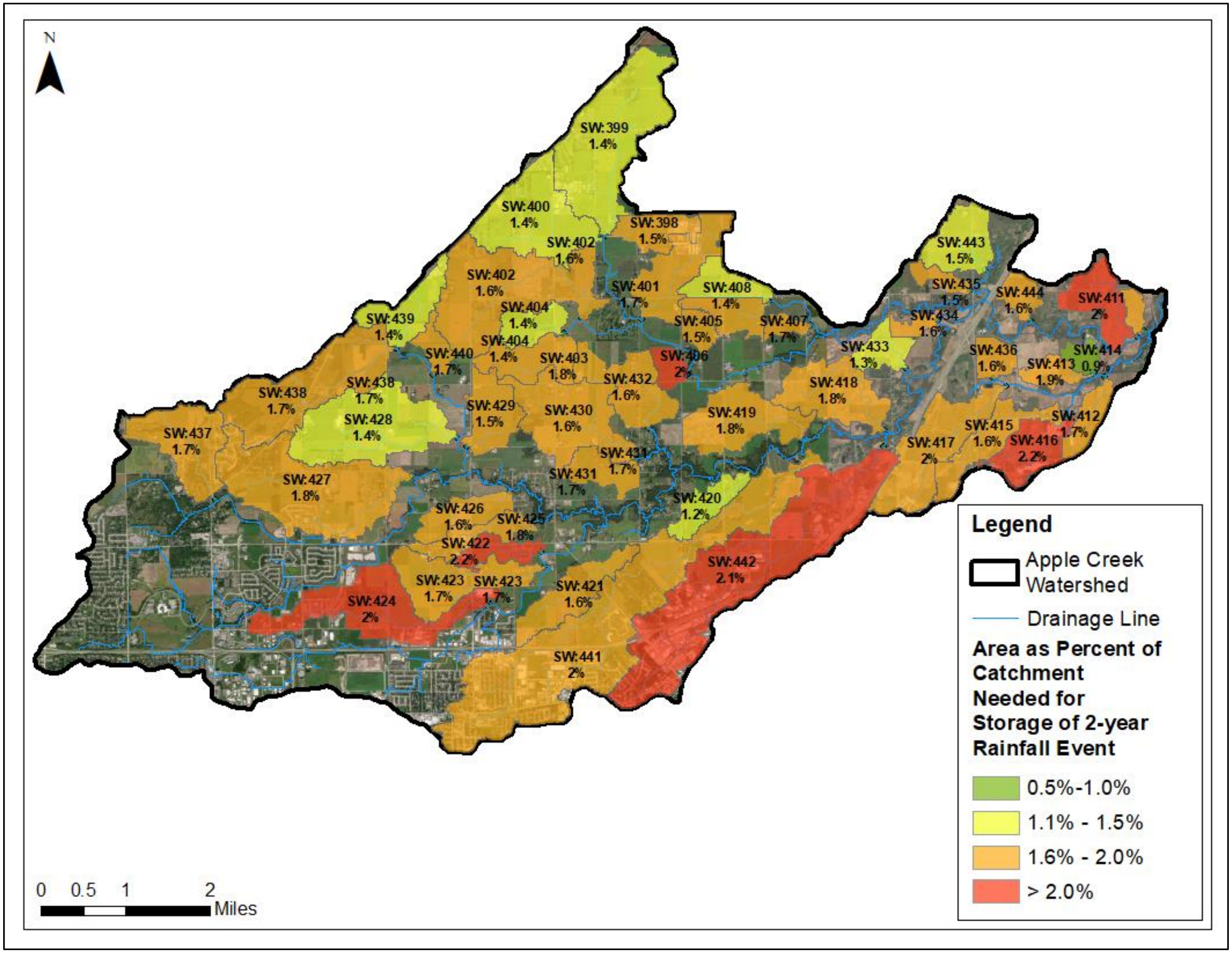

Figure B-10. Apple Creek percent of catchment needed for 2-year rainfall event.

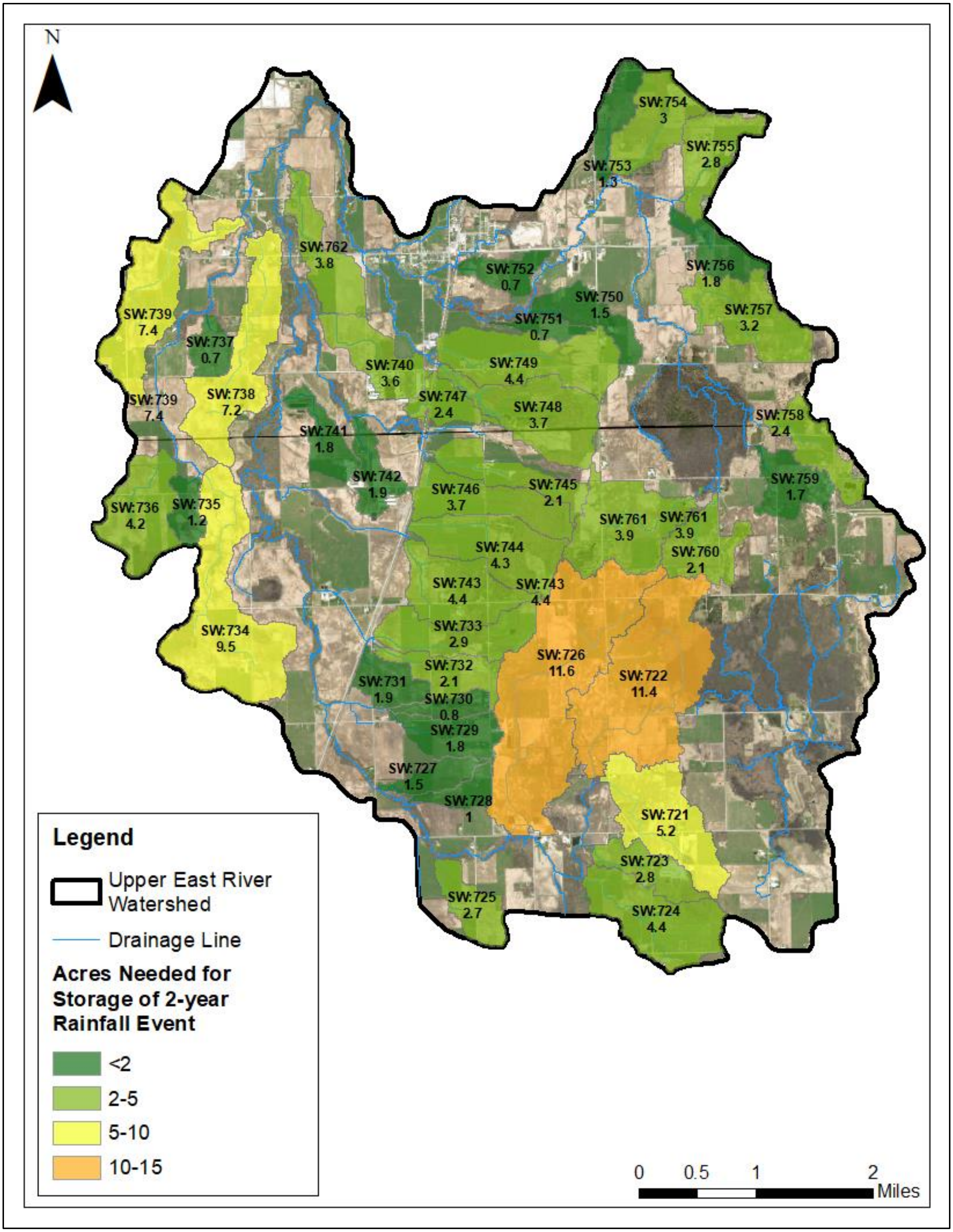

Figure B-11. Upper East River acres of storage needed for 2-year rainfall event.

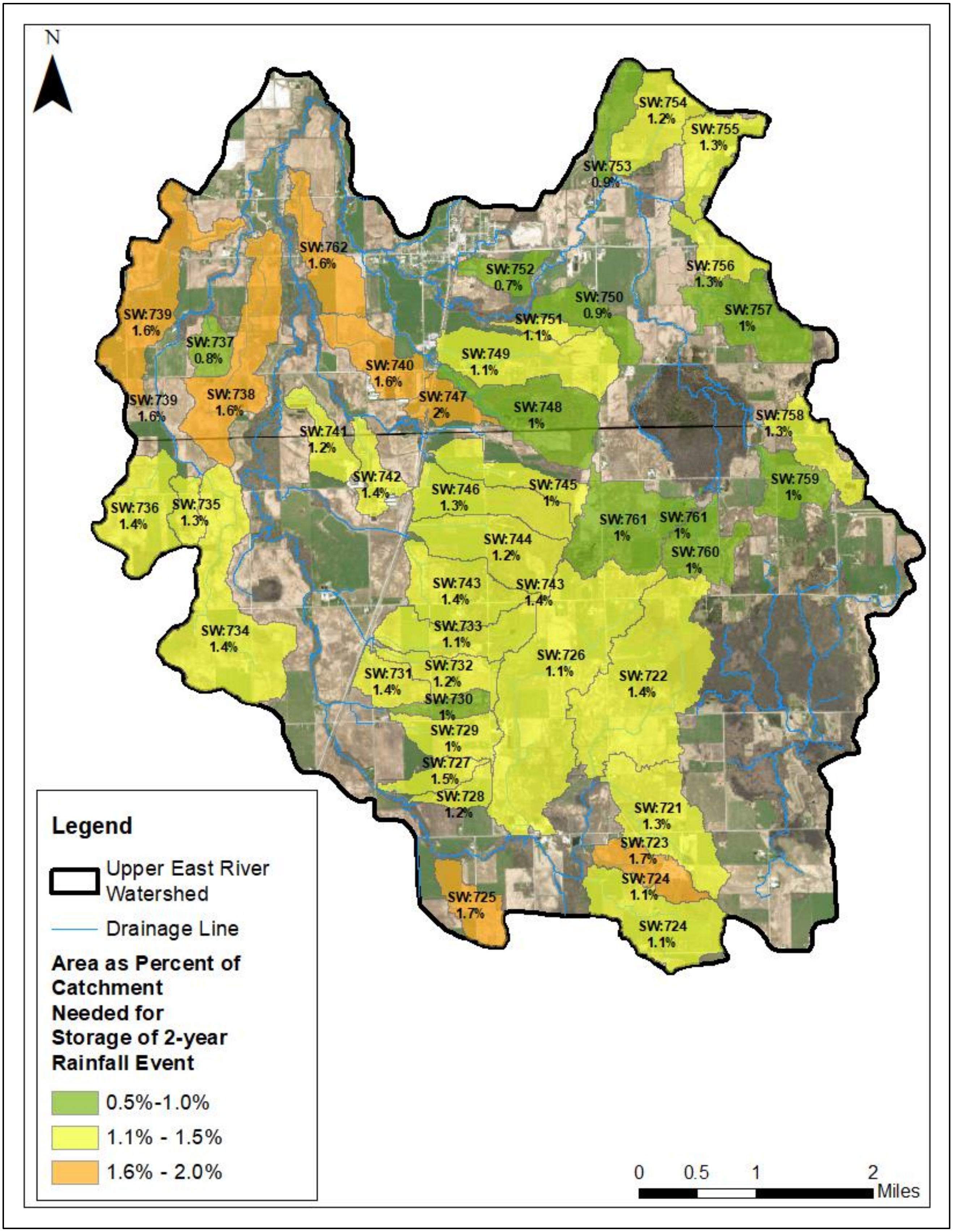

Figure B-12. Upper East River percent of catchment needed for 2-year rainfall event.

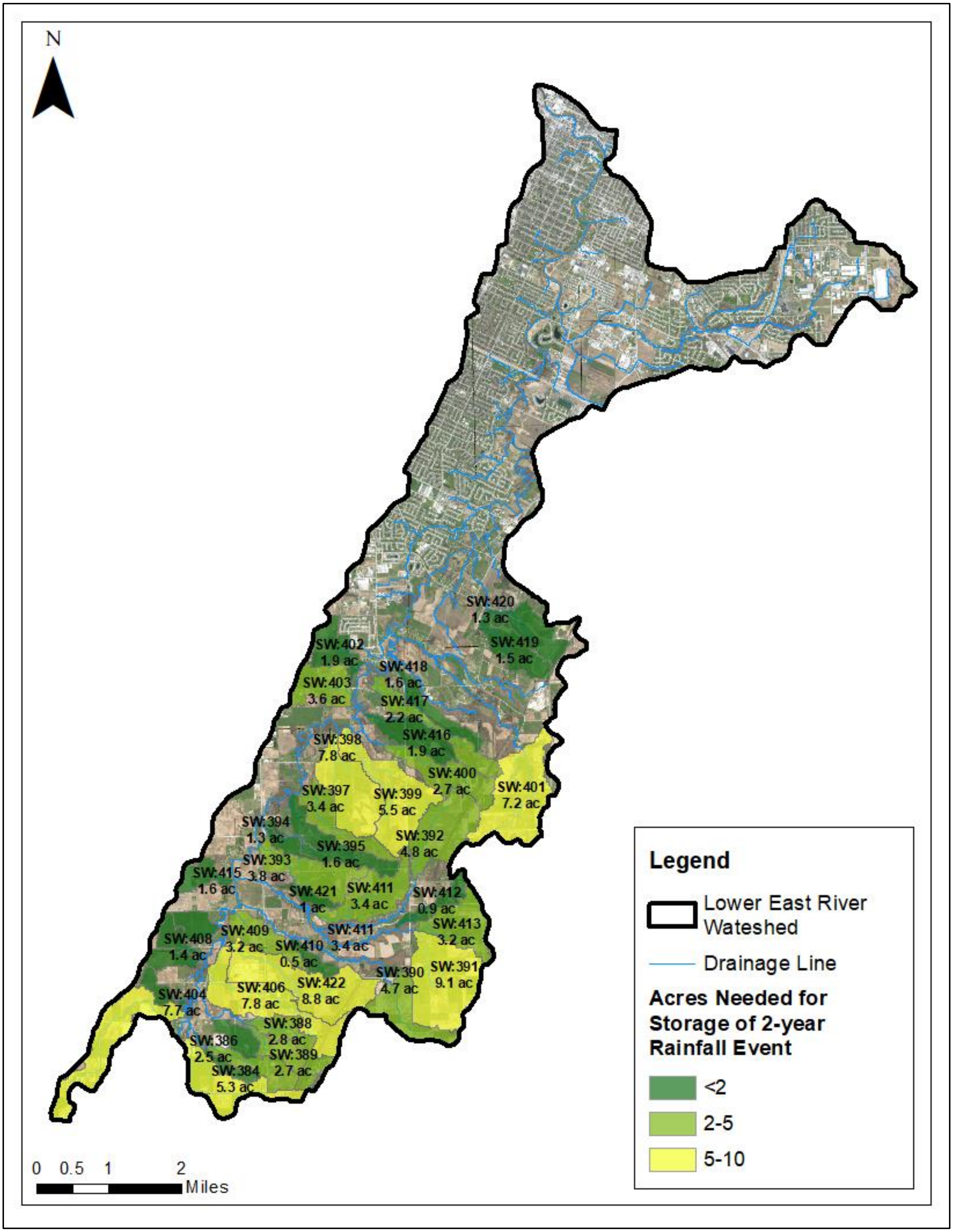

Figure B-13. Lower East River acres of storage needed for 2-year rainfall event.

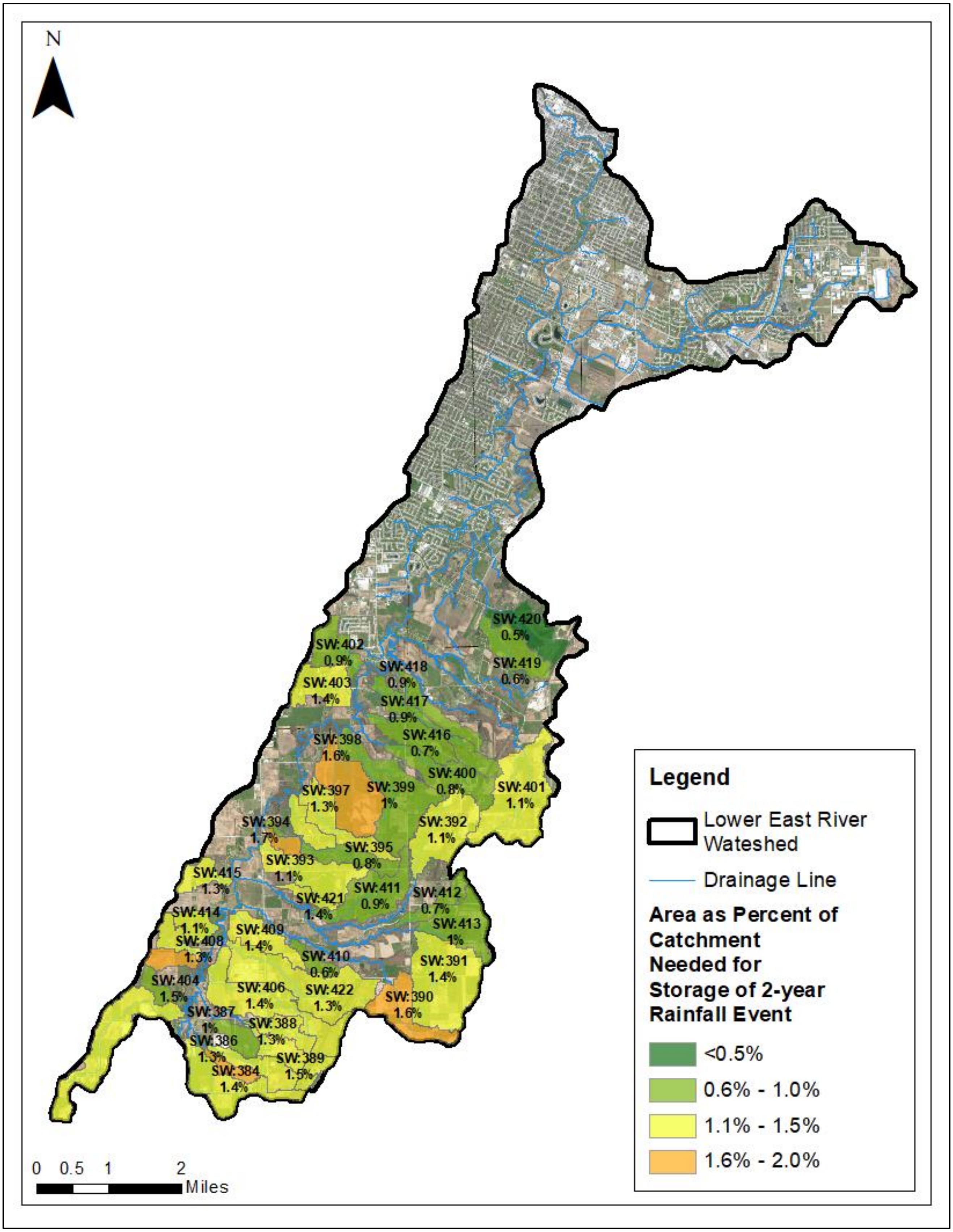

Figure B-14. Lower East River percent of catchment needed for 2-year rainfall event.

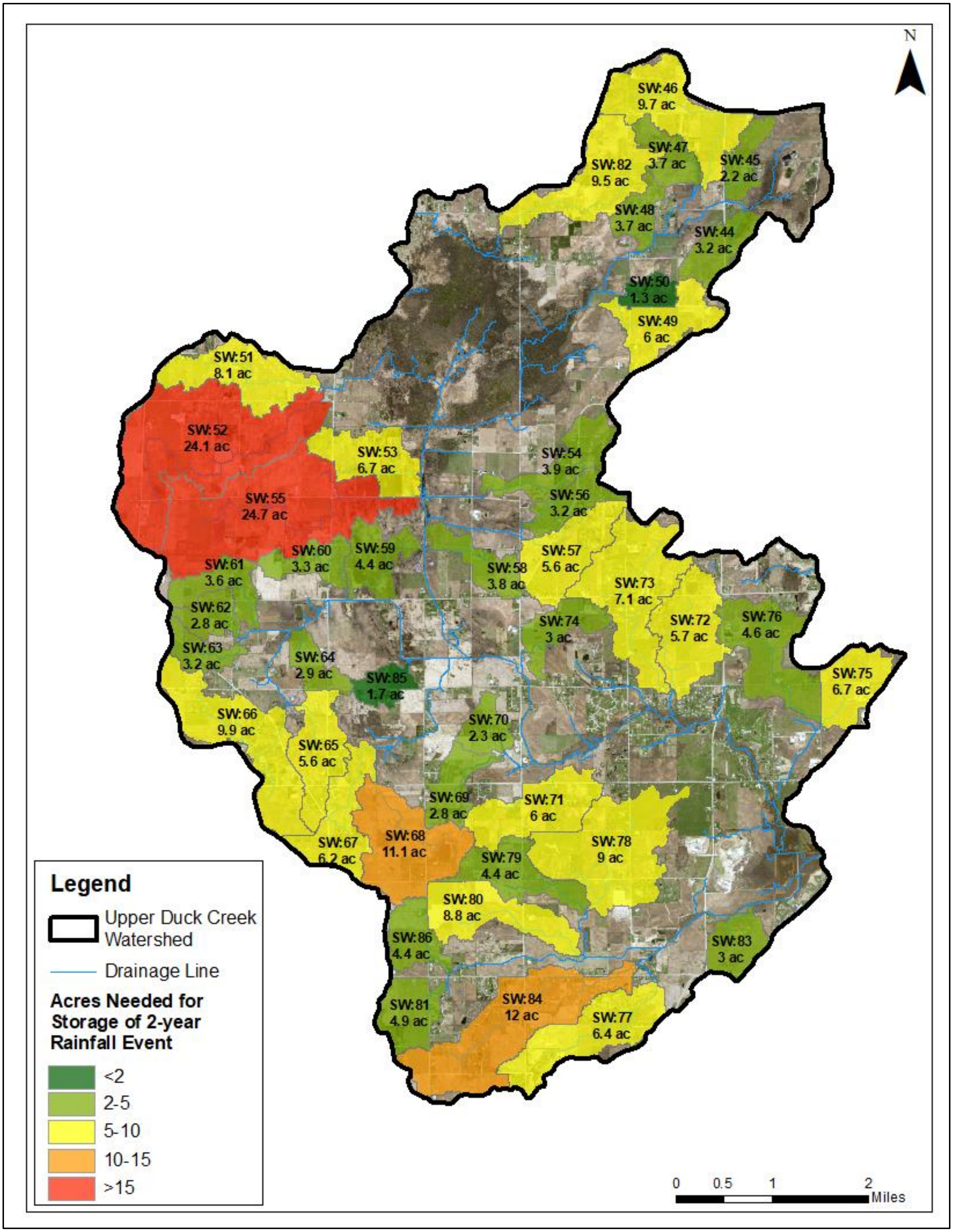

Figure B-15. Upper Duck Creek acres of storage needed for 2-year rainfall event.

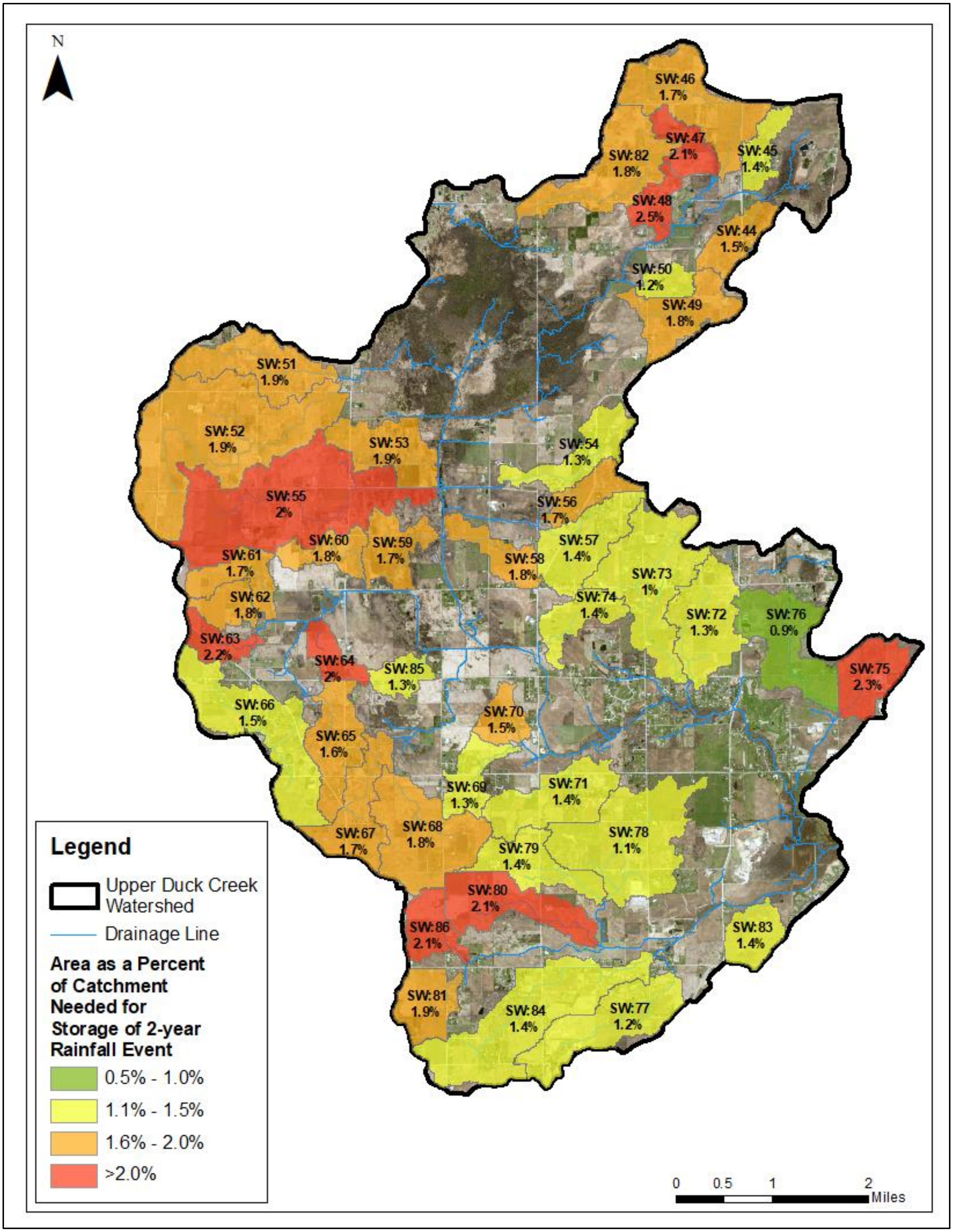

Figure B-16. Upper Duck Creek percent of catchment needed for 2-year rainfall event.

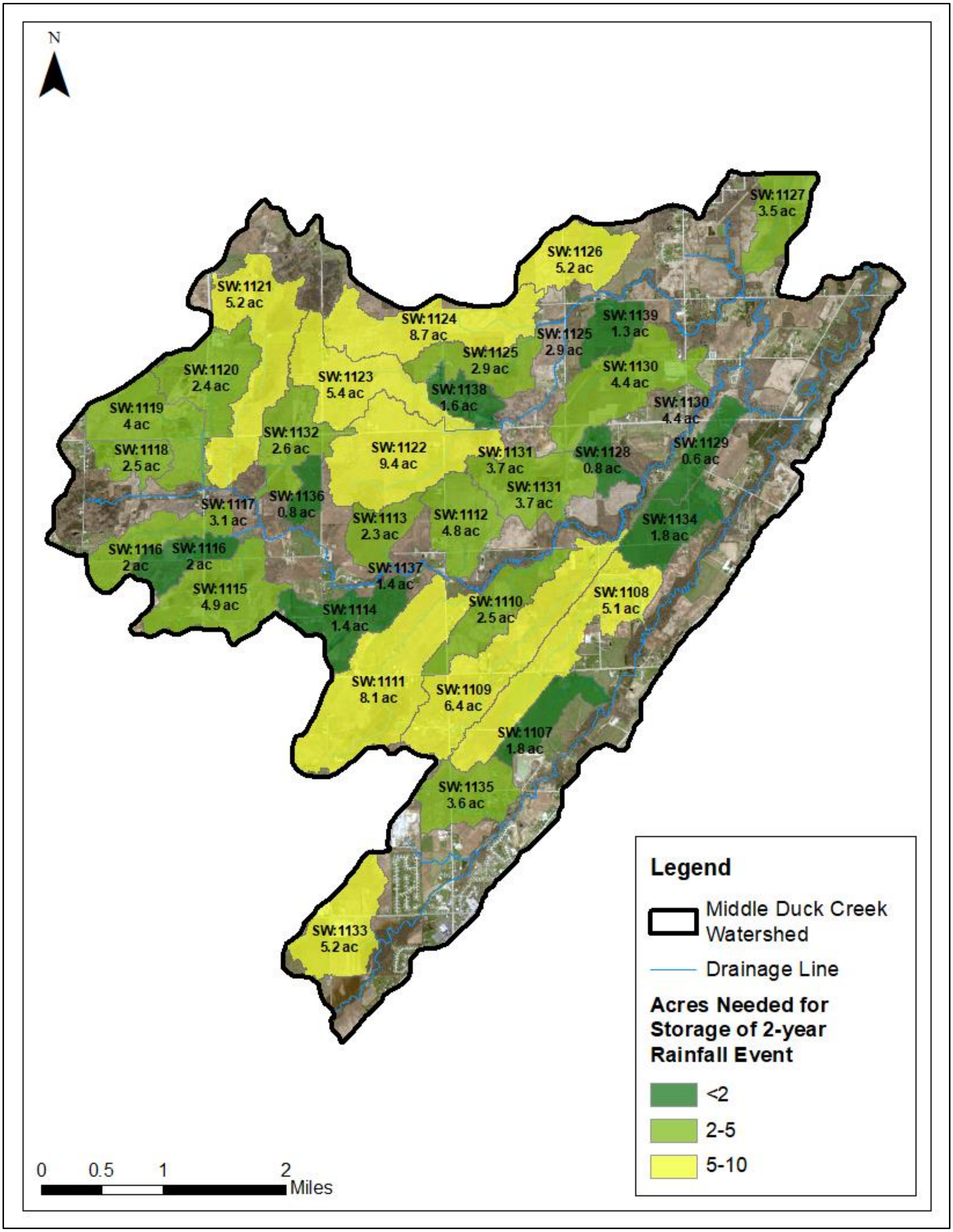

Figure B-17. Middle Duck Creek acres of storage needed for 2-year rainfall event.

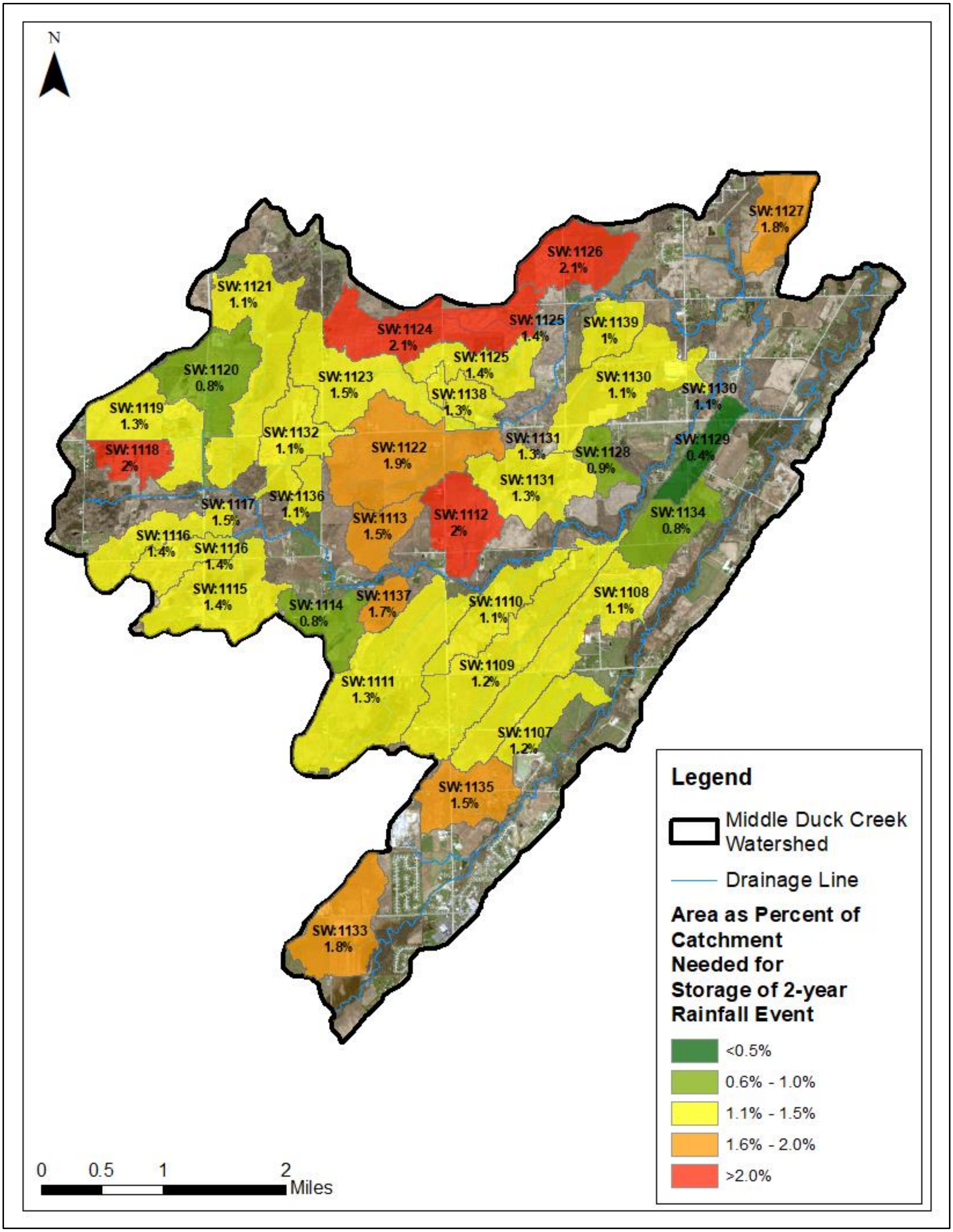

Figure B-18. Middle Duck Creek percent of catchment needed for 2-year rainfall event.

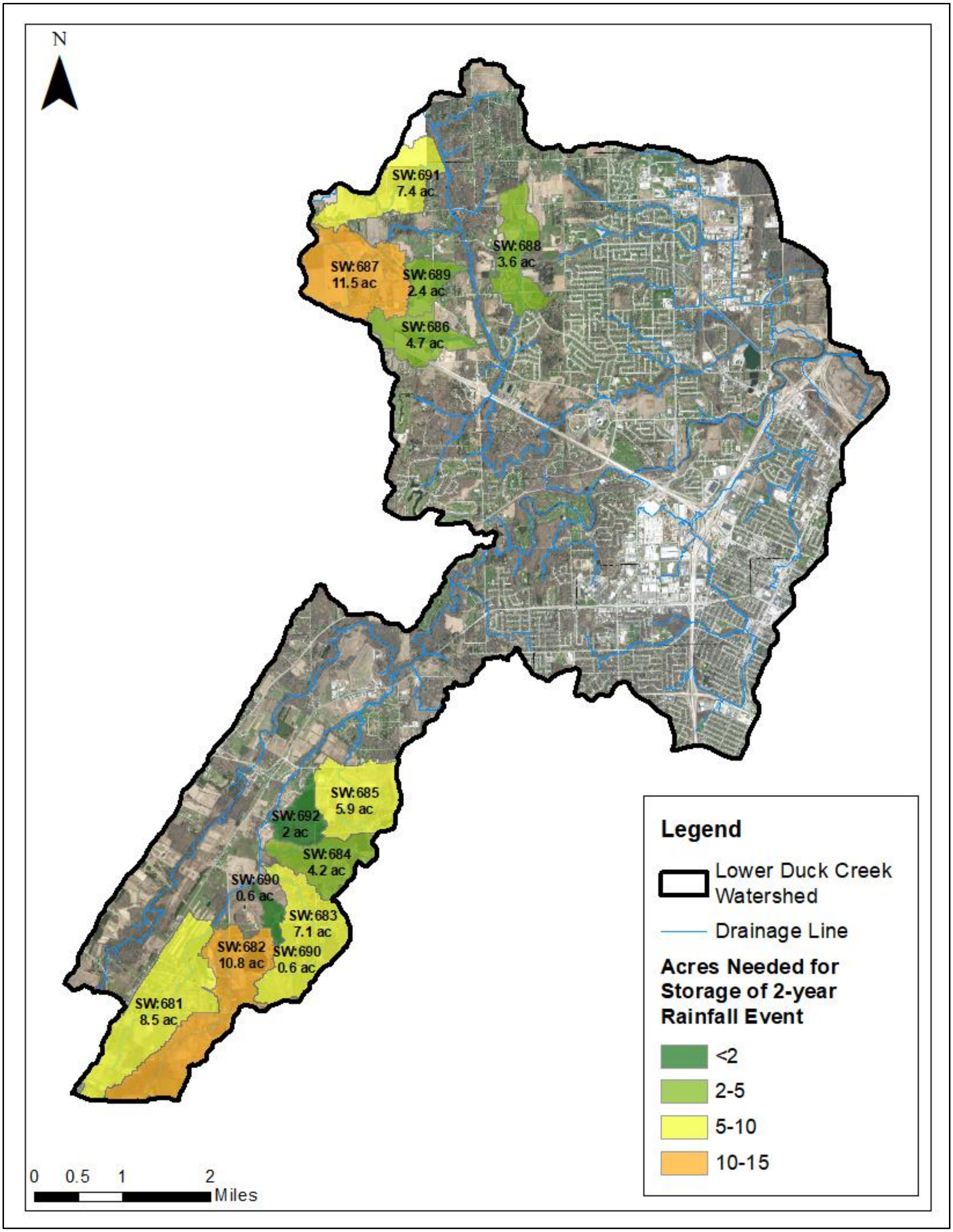

Figure B-19. Lower Duck Creek acres of storage needed for 2-year rainfall event.

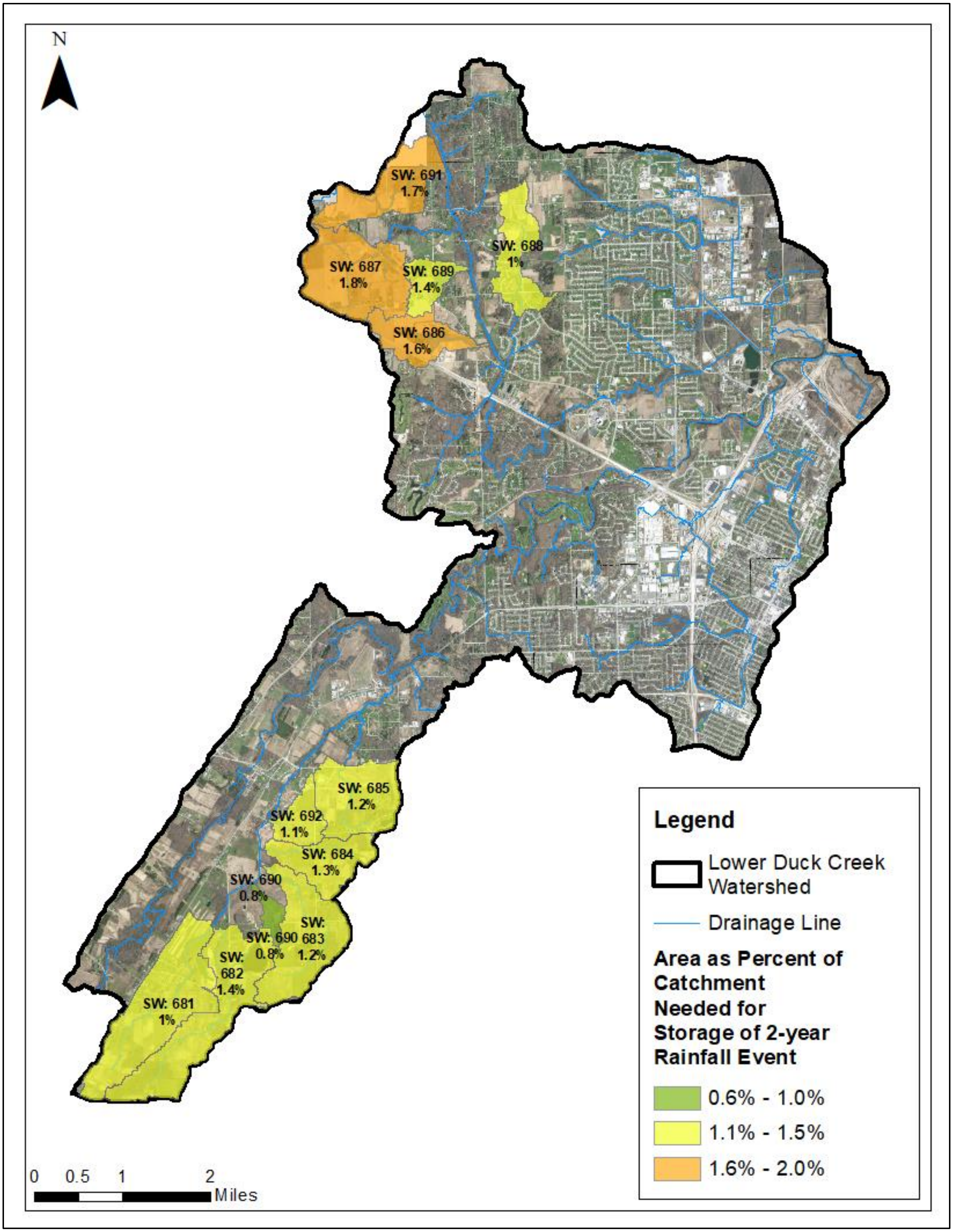

Figure B-20. Lower Duck Creek percent of catchment needed for 2-year rainfall event.

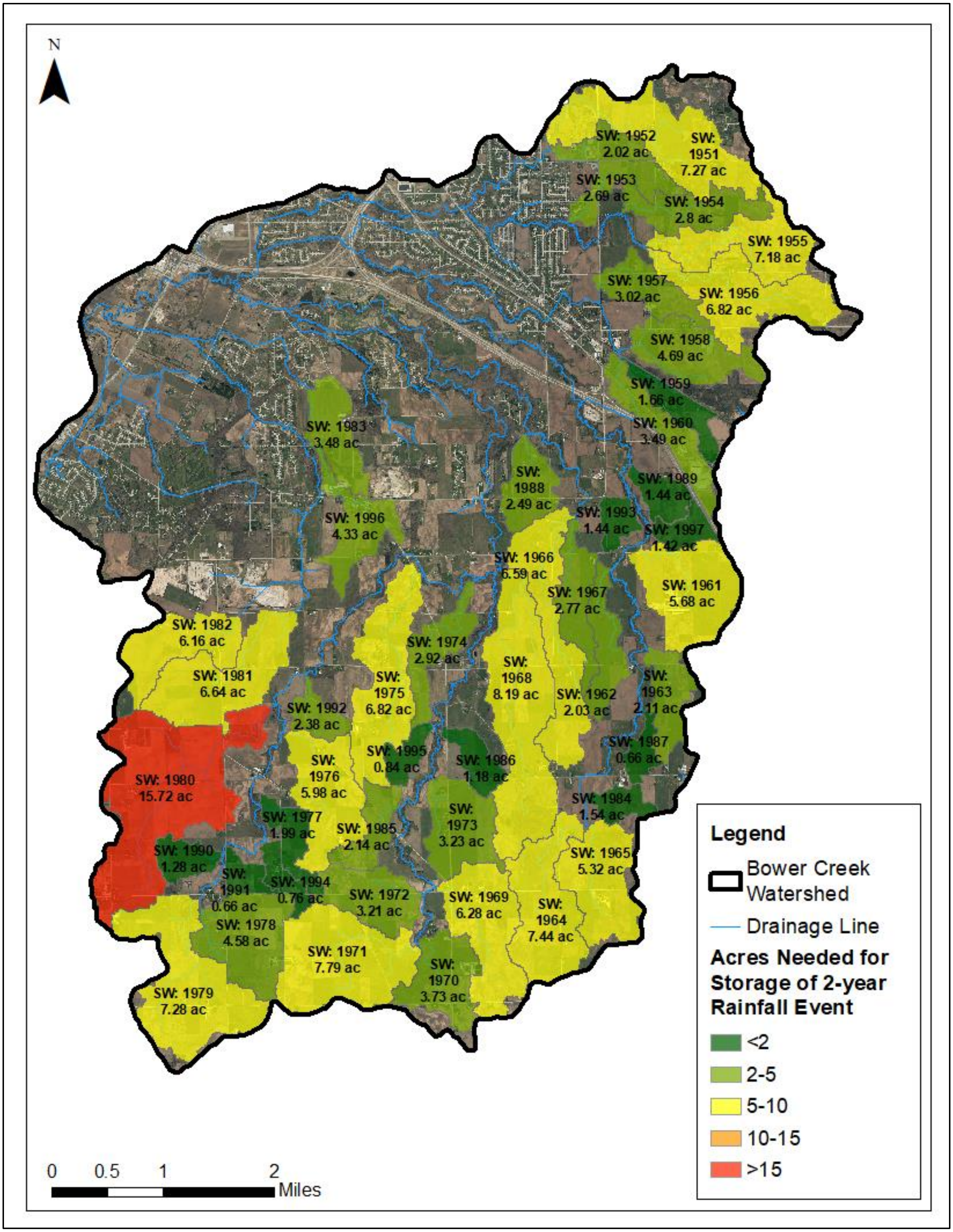

Figure B-21. Upper East River acres of storage needed for 2-year rainfall event.

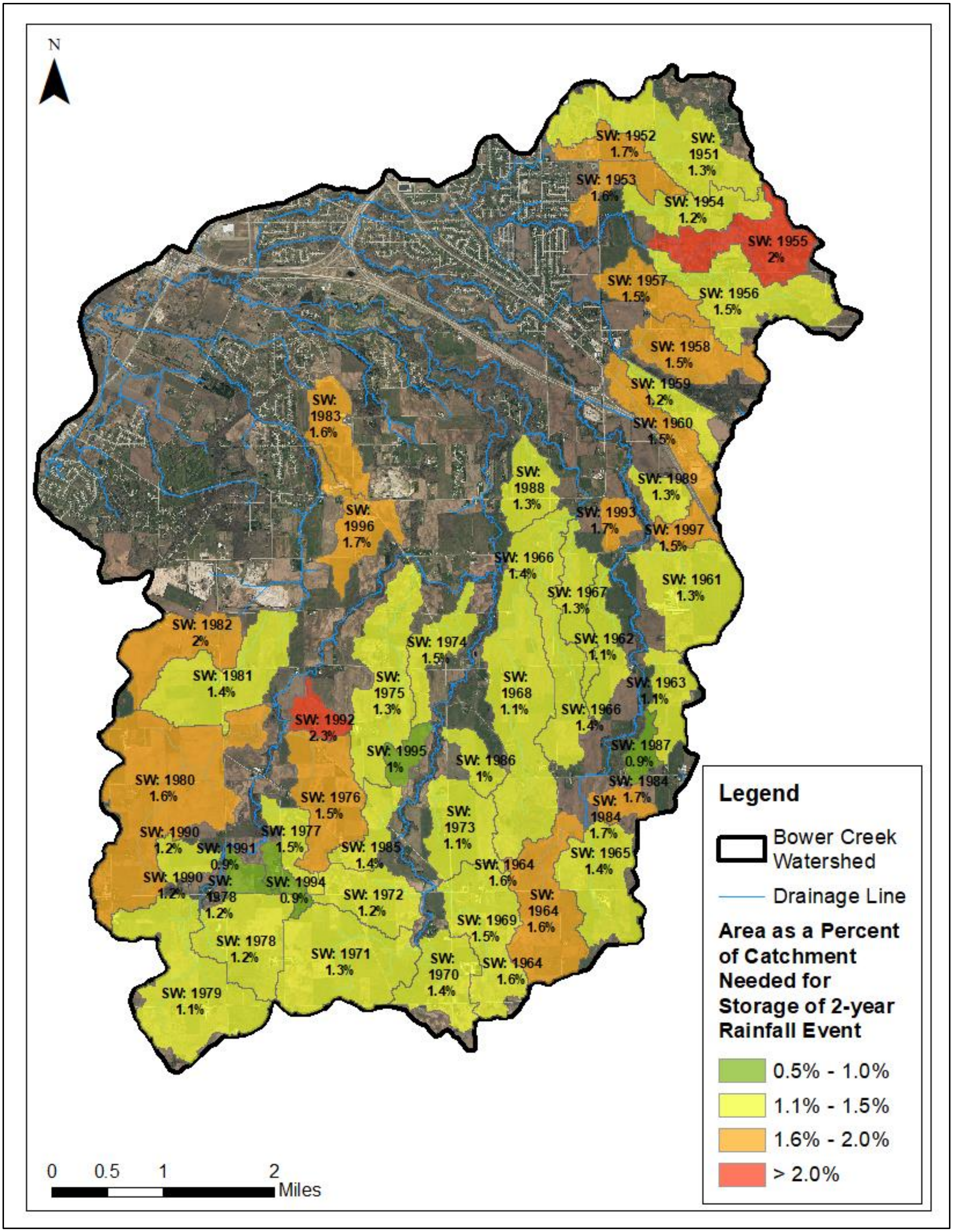

Figure B-22. Upper East River percent of catchment needed for 2-year rainfall event.

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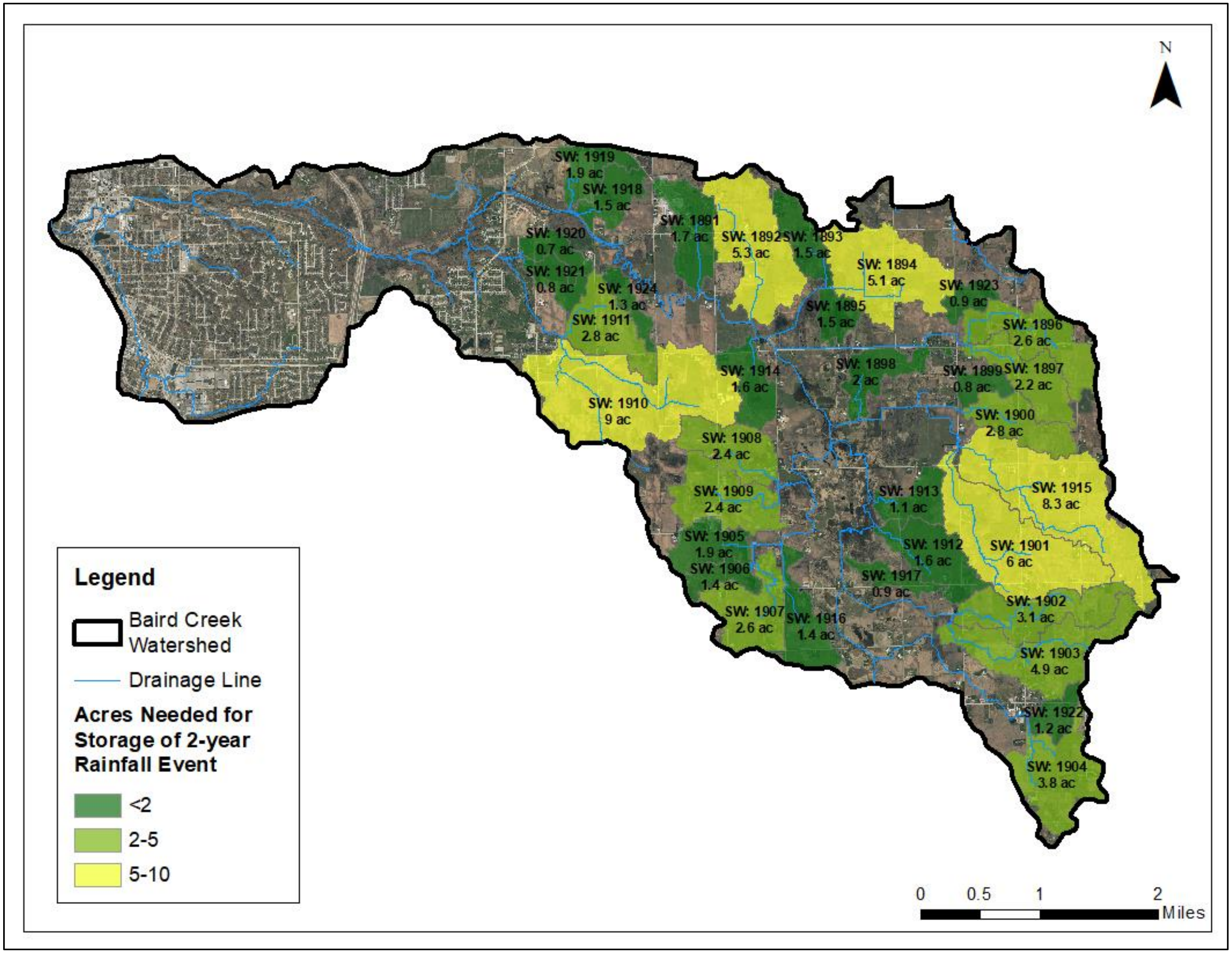

Figure B-23. Baird Creek acres of storage needed for 2-year rainfall event.

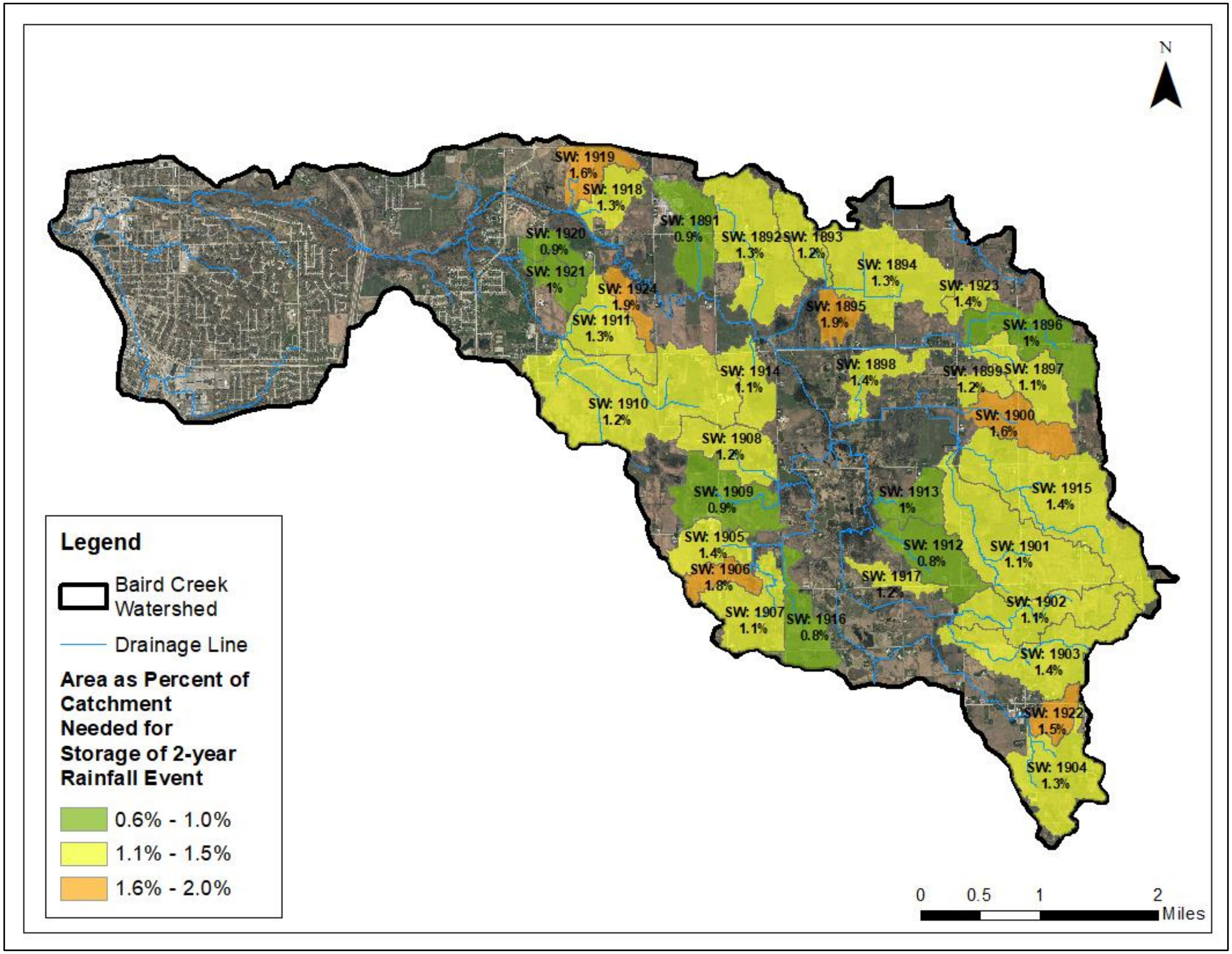

Figure B-24. Baird Creek percent of catchment needed for 2-year rainfall event.

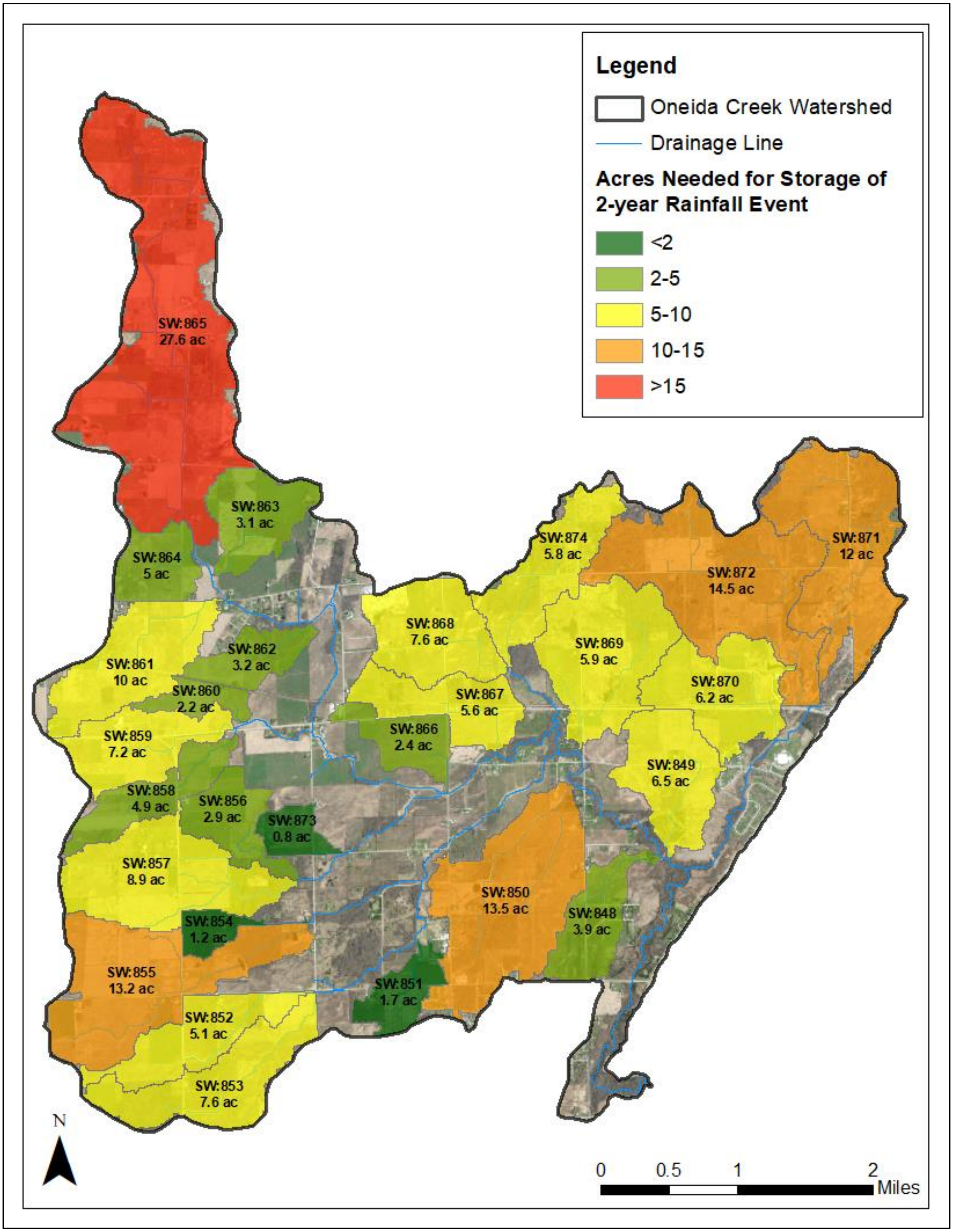

Figure B-25. Oneida Creek acres of storage needed for 2-year rainfall event.

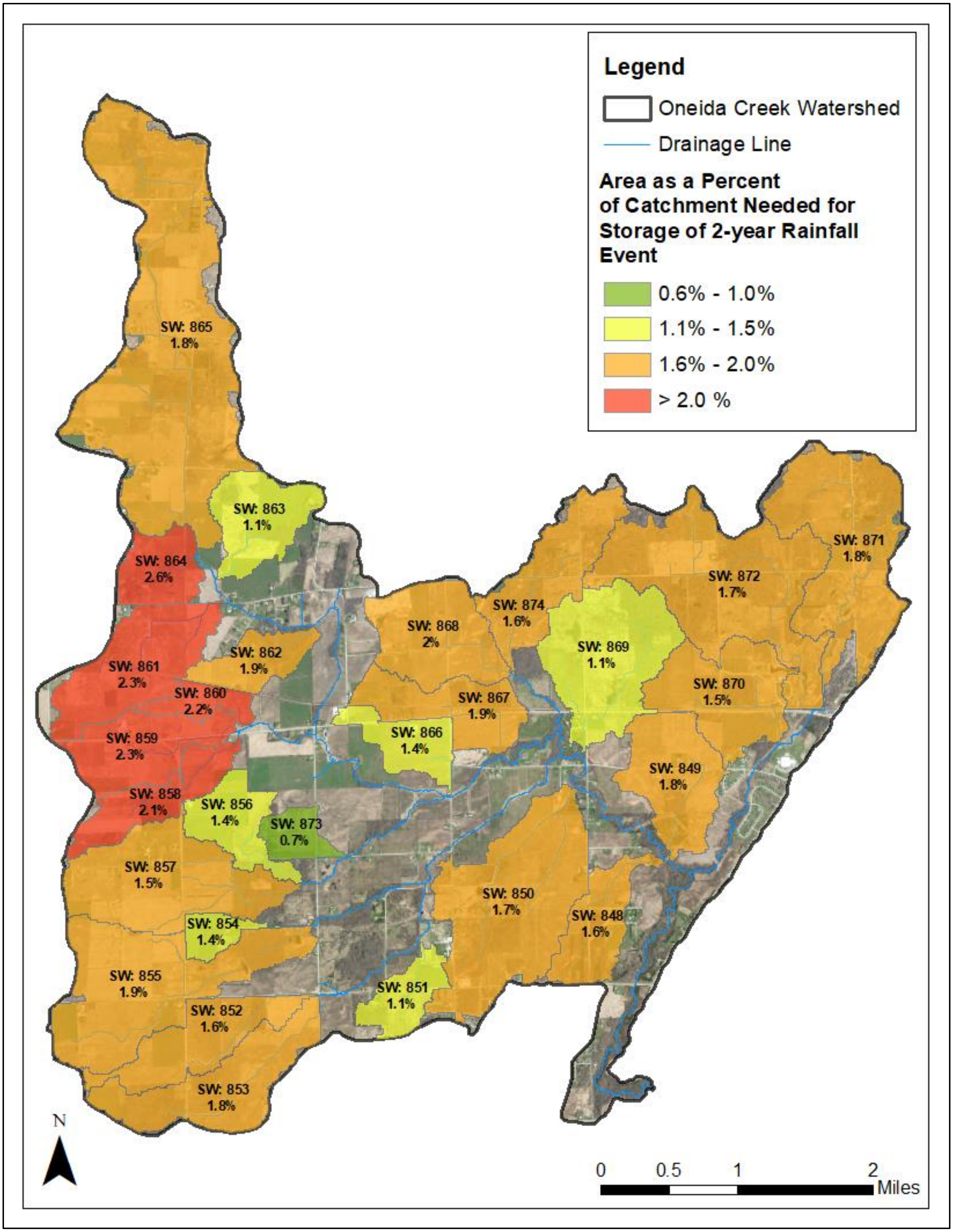

Figure B-26. Oneida Creek percent of catchment needed for 2-year rainfall event.

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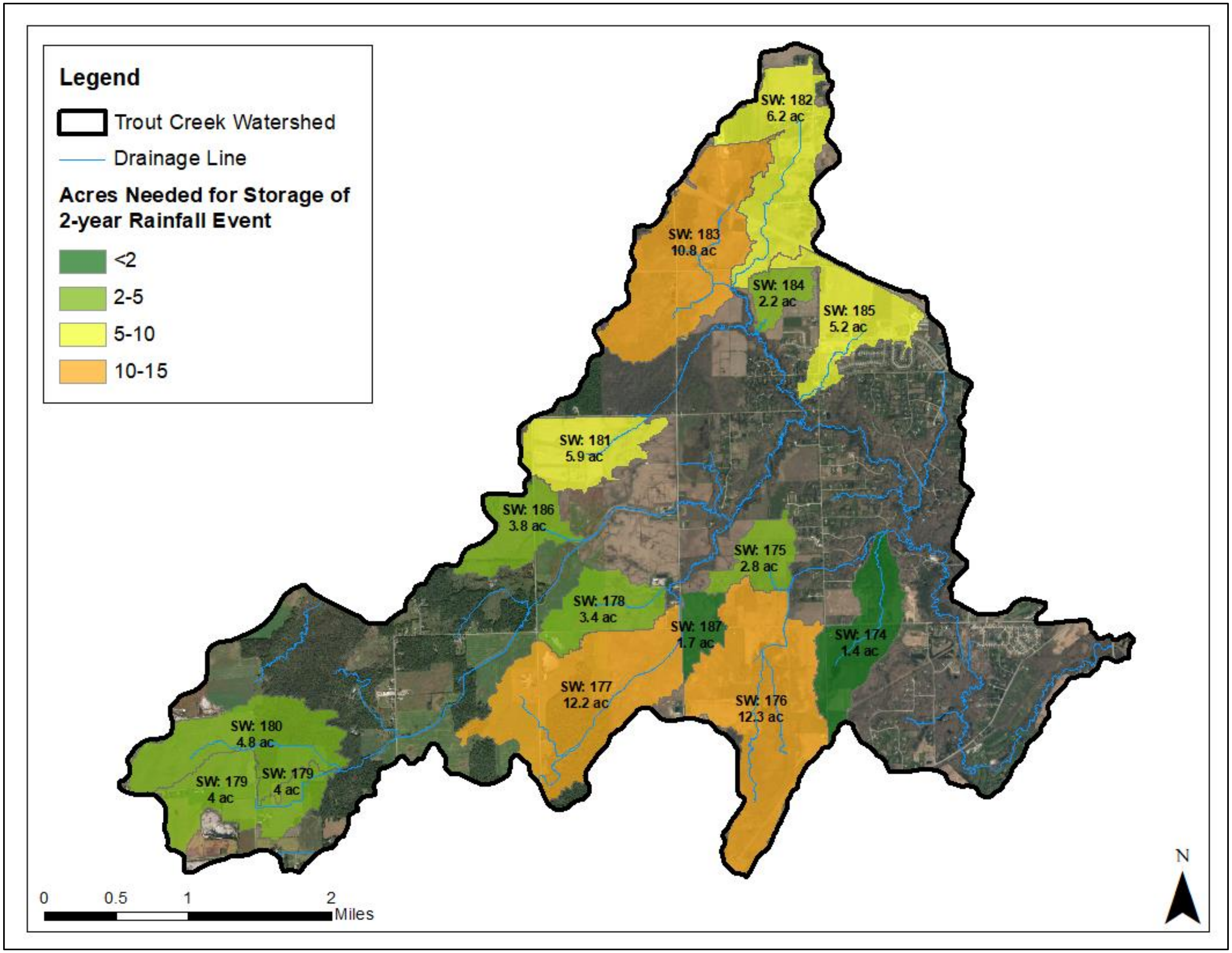

Figure B-27. Trout Creek acres of storage needed for 2-year rainfall event.

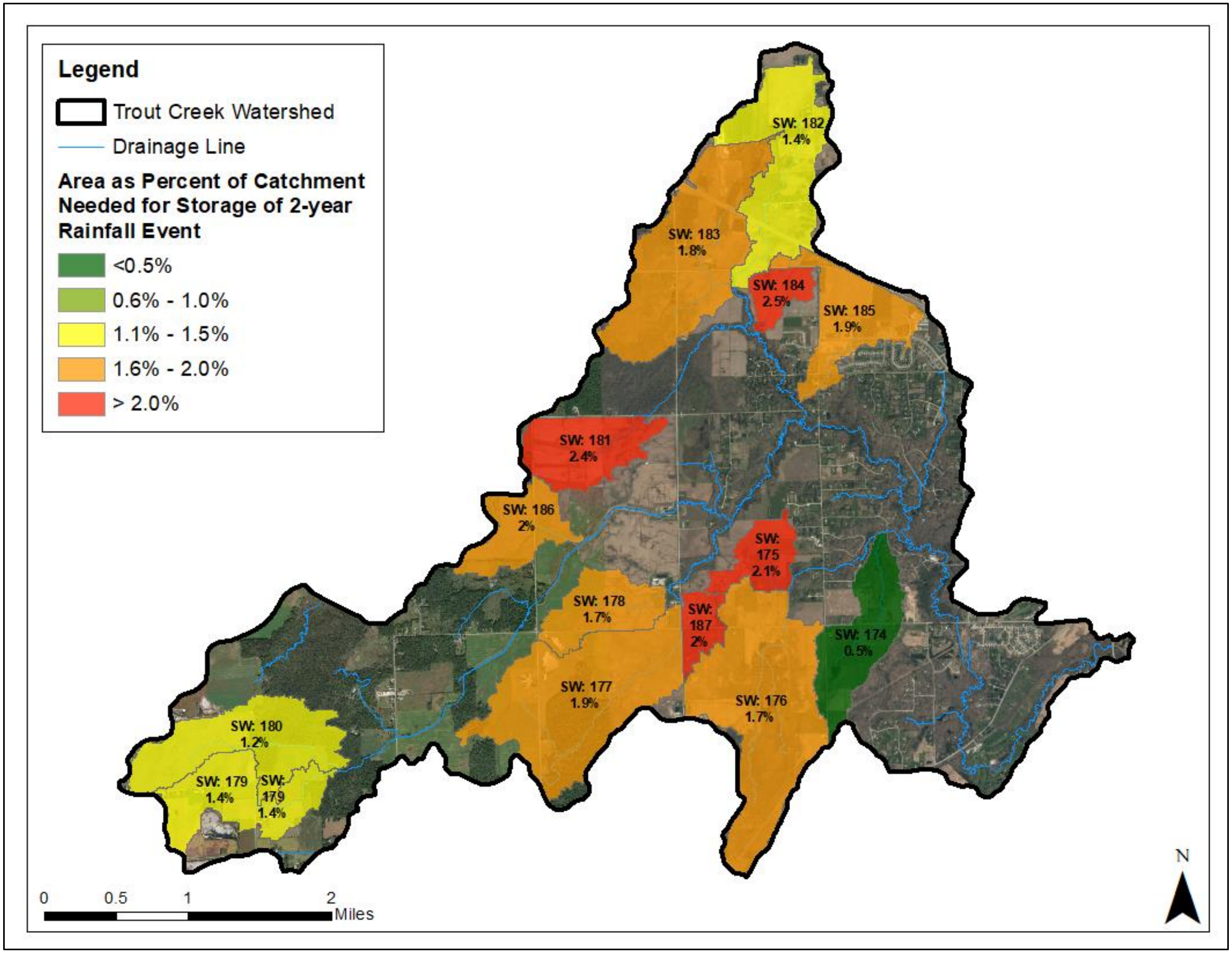

Figure B-28. Trout Creek percent of catchment needed for 2-year rainfall event.

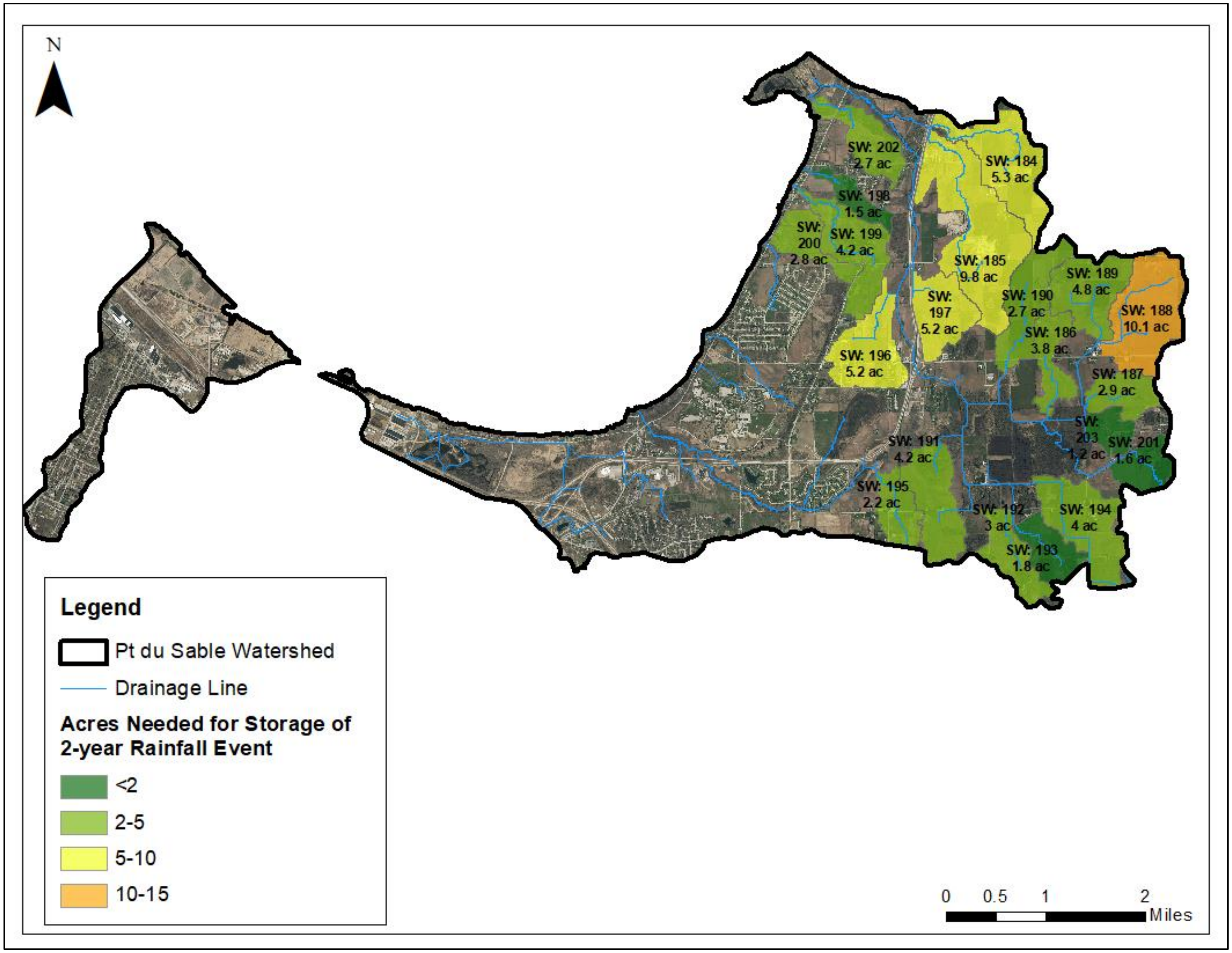

Figure B-29. Point du Sable acres of storage needed for 2-year rainfall event.

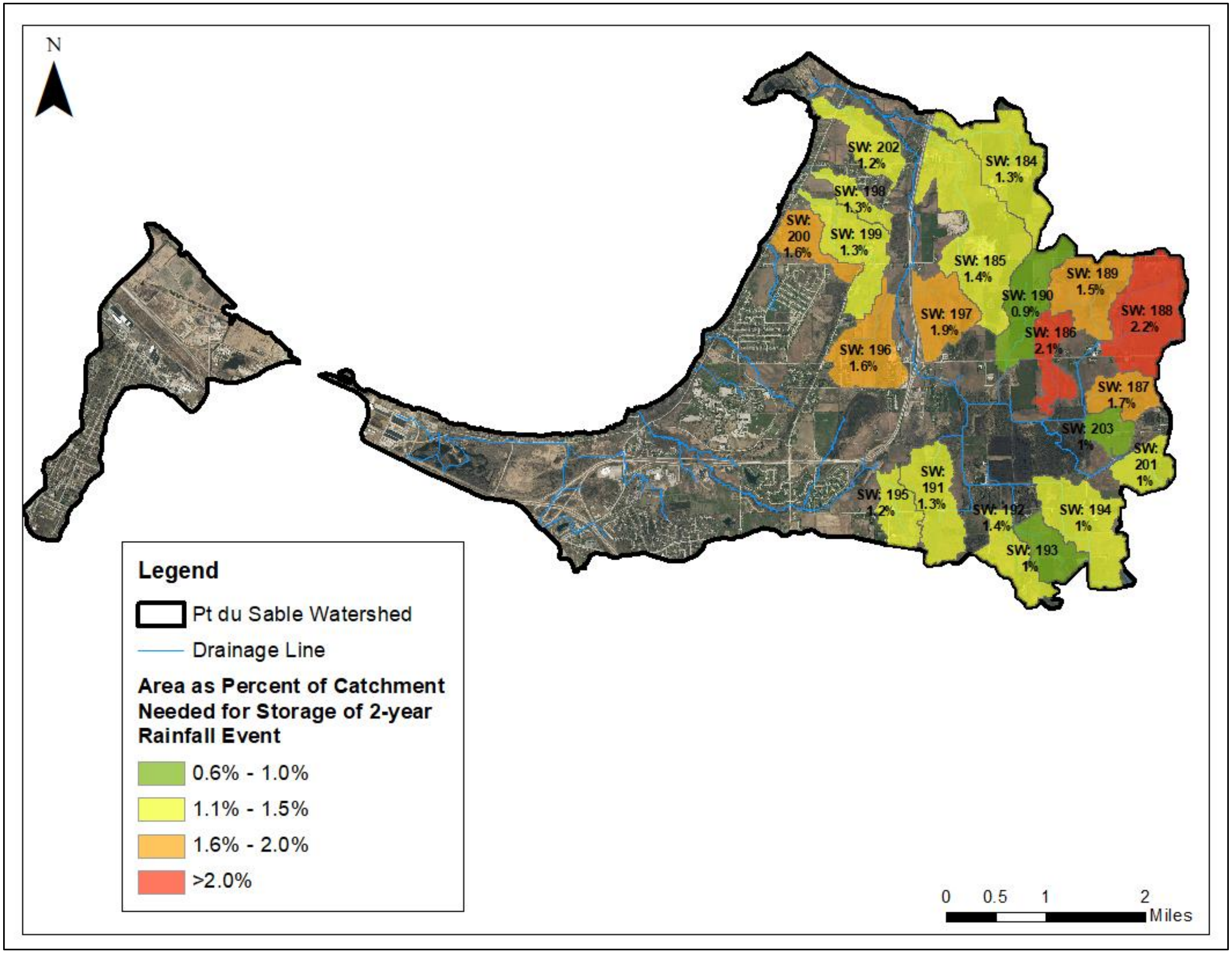

Figure B-30. Pt du Sable percent of catchment needed for 2-year rainfall event.

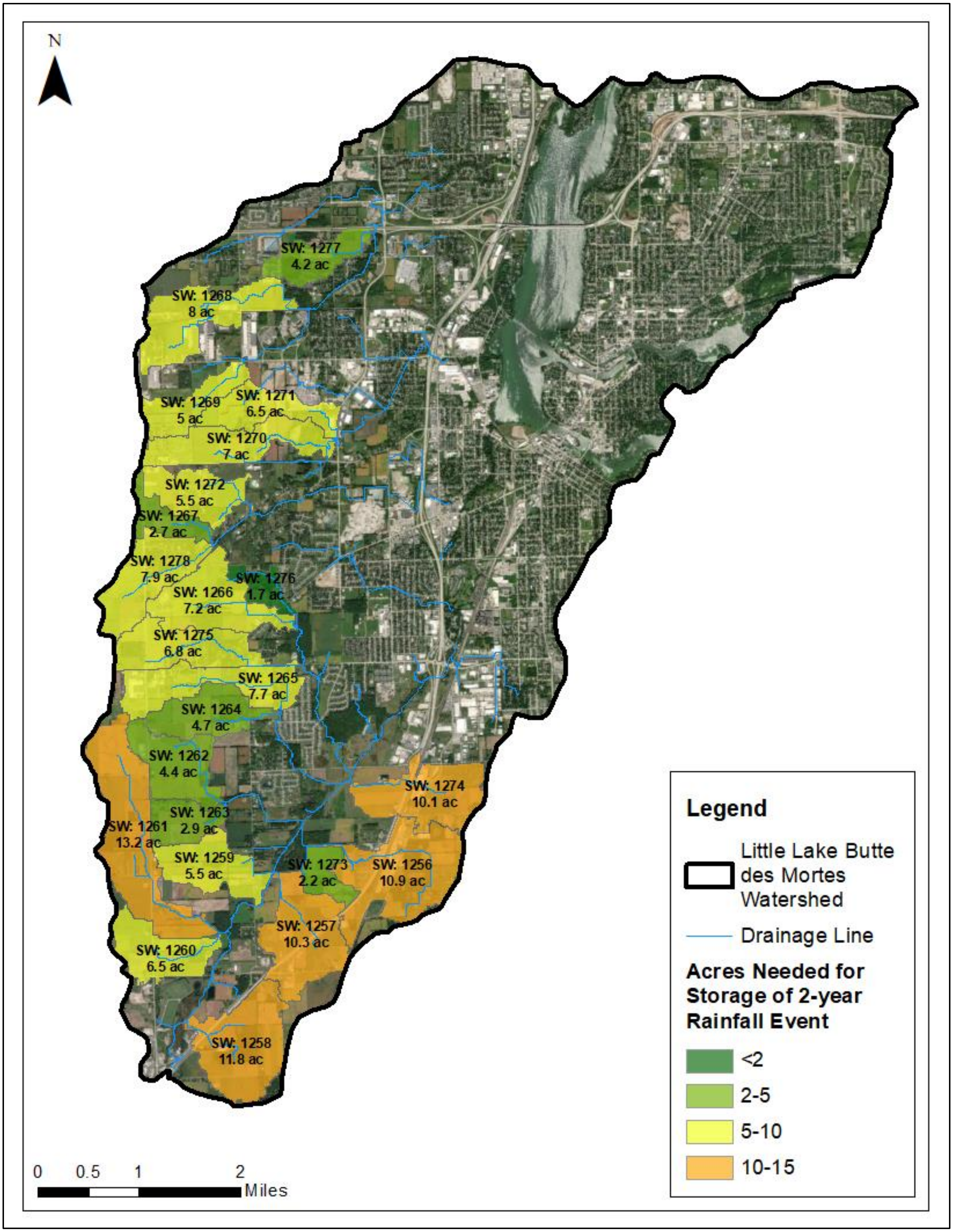

Figure B-31. Little Lake Butte des Mortes acres of storage needed for 2-year rainfall event.

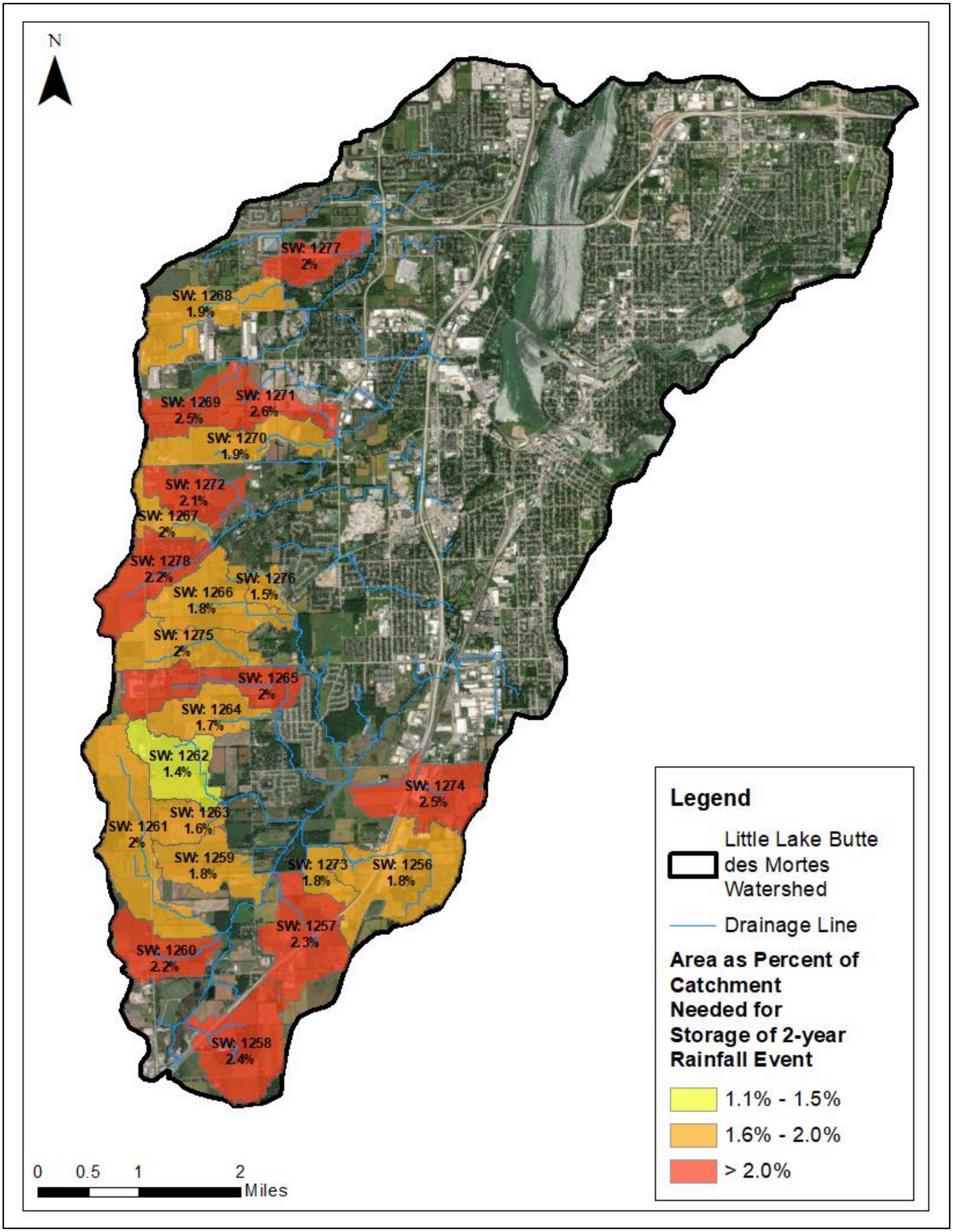

Figure B-32. Little Lake Butte des Mortes percent of catchment needed for 2-year rainfall event.

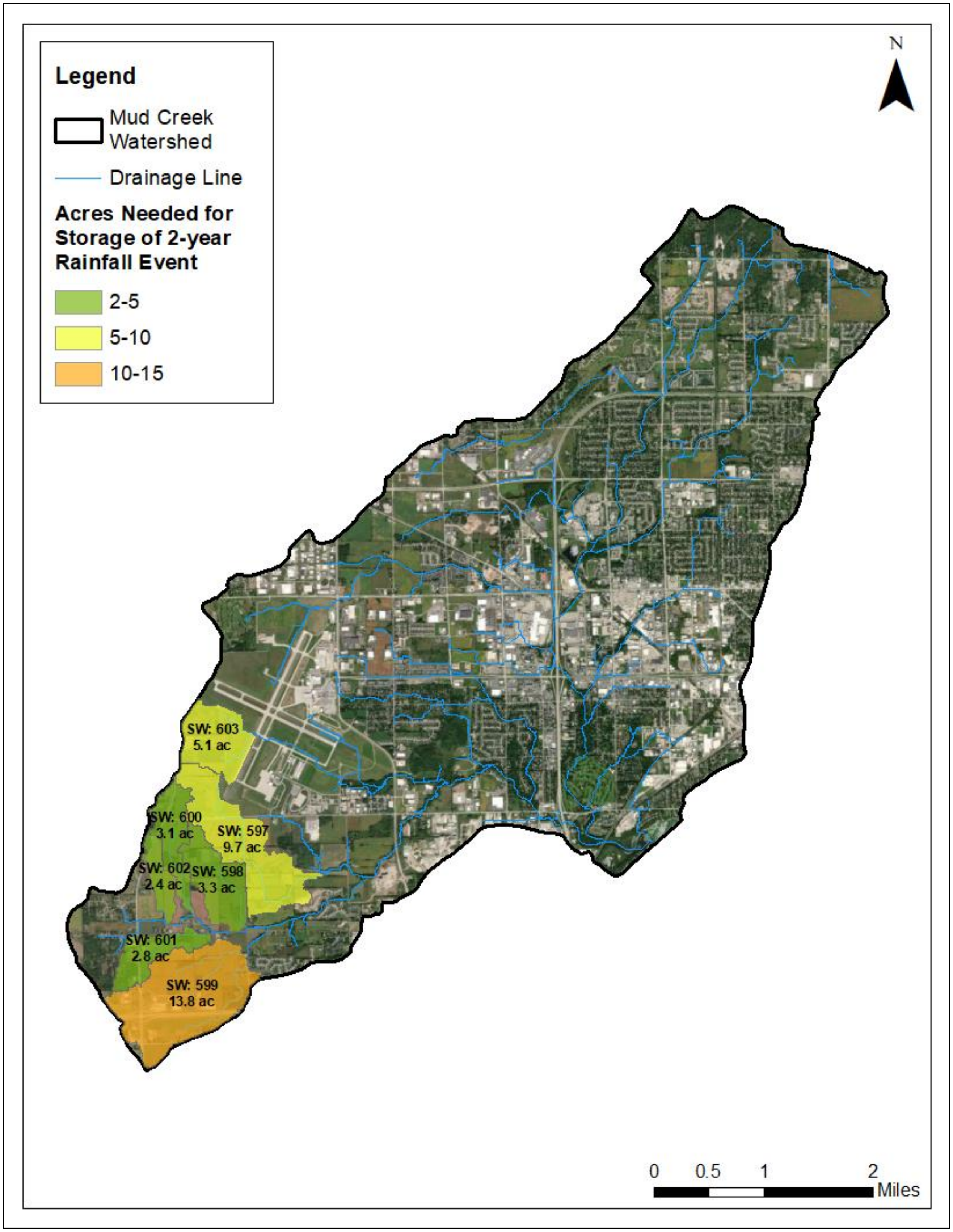

Figure B-33. Mud Creek acres of storage needed for 2-year rainfall event.

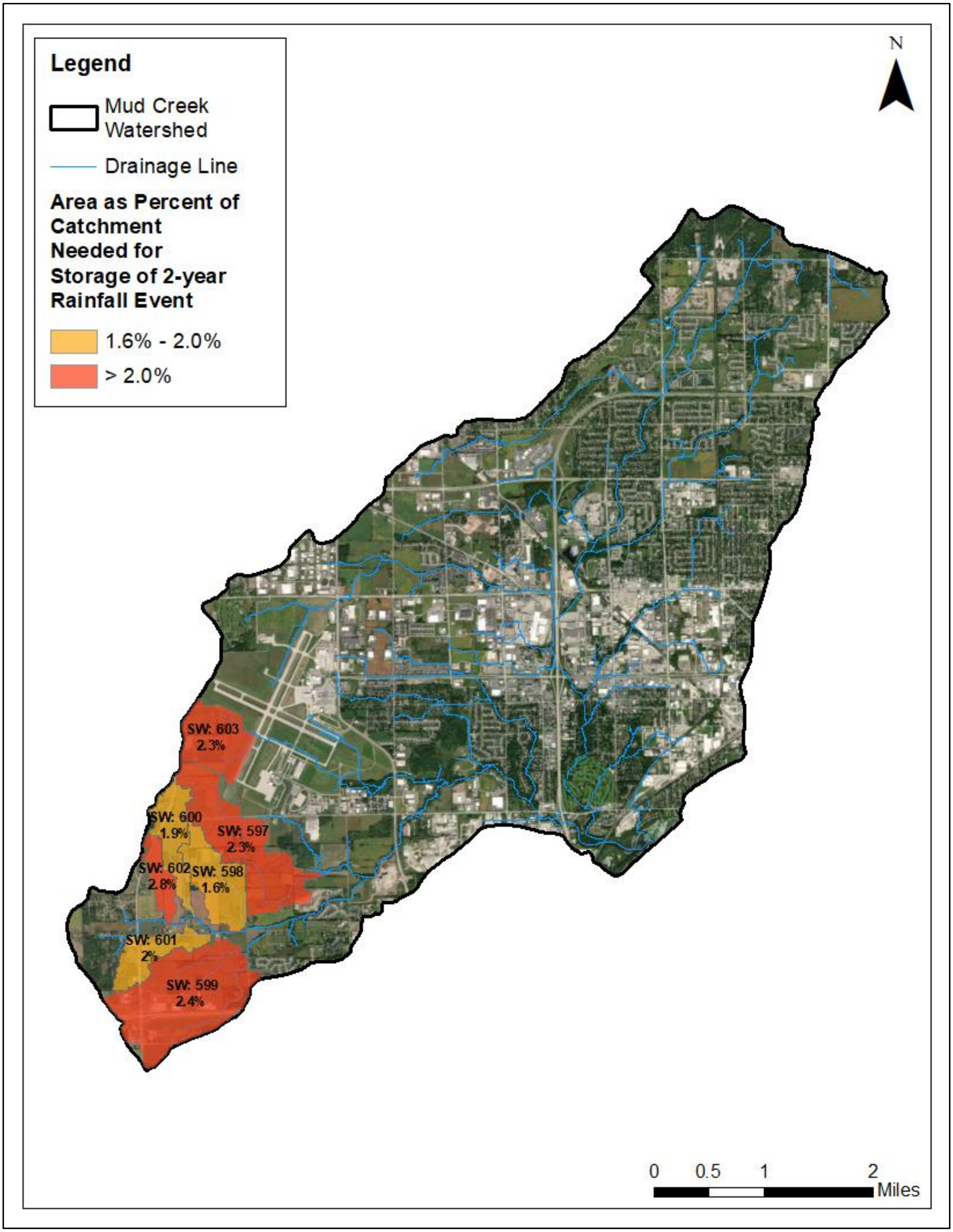

Figure B-34. Mud Creek percent of catchment needed for 2-year rainfall event.

Appendix C. Cost definitions and estimate calculations.

<u>Cost Estimate Definitions:</u>

Subdivision, lease docs- Cost associated with coordinating/drafting legal documents for the purchasing/leasing of land

Design Survey- Cost for topographic survey of the site for design work

Design- Cost to design and generate construction plans for practice

Mobilization- Cost to get equipment/materials to construction site

Excavation- Construction cost associated with earth moving on the project

Restoration/Landscaping- Construction cost to restore landscape after construction (seeding & erosion control)

Erosion Control- Cost of the construction and maintenance of erosion control practices needed during construction.

Land Acquisition- Cost to purchase land

Construction Oversight- Cost for someone to supervise construction (county personnel or consultant) to make sure it is being constructed to design specifications

O&M- Operation and maintenance costs (vegetation management, sediment removal, etc)

Administration- Cost of tracking cost share agreements, lease docs, and implementation, creating project reports

Outreach- Cost of outreach to landowners/public to sell practice on large scale

<u>Cost Estimates Calculations:</u>

Subdivision, lease docs:

If area needed <5 acres, cost is $5,000

If area needed >5 acres, cost is calculated: $5,000 + (acres needed in catchment in catchment/max acres needed in catchment of all catchments in watershed)*$5,000

Design Survey

If area needed <5 acres, cost is $3,000

If area needed >5 acres, cost is calculated: $3,000 + (acres needed in catchment/max acres needed in catchment of all catchments in watershed)*$7,000

Design

If area needed <5 acres, cost is $7,800

If area needed >5 acres, cost is calculated: $7,800 + (acres needed in catchment/max acres needed in catchment of all catchments in watershed)*$72,200

Mobilization

If area needed <5 acres, cost is $3,250

If area needed >5 acres, cost is calculated: $3,250 + (acres needed in catchment/max acres needed in catchment of all catchments in watershed)*$1,750

Excavation

If area needed <5 acres, cost is calculated: acres*2*(43,560/27)*10

If area needed >5 acres, cost is calculated: (10-(acres needed in catchment -5)/(max acres needed in catchment of all catchments in watershed)-5)*5)*acres*2*(43,560/27)

Restoration/Landscaping

If area needed <5 acres, cost is $24,200

If area needed >5 acres, cost is calculated: $24,200 + (acres needed in catchment/max acres needed in catchment of all catchments in watershed)*$287,000

Erosion Control

If area needed <5 acres, cost is $3,250

If area needed >5 acres, cost is calculated: $3,250 + (acres needed in catchment/max acres needed in catchment of all catchments in watershed)*$27,000

Land Acquisition

$15,000/ acre

Construction Oversight

7% of cost sum of Design Survey, Design, Mobilization, Excavation, Restoration/Landscaping and Erosion Control

Operation and Maintenance

3% of cost sum of Design Survey, Design, Mobilization, Excavation, Restoration/Landscaping and Erosion Control

Administration

5% of Total Cost (Subdivision/lease docs, Design Survey, Design, Mobilization, Excavation, Restoration/Landscaping, Erosion Control, Construction Oversight and Operation and Maintenance)

Outreach

Estimated at $1,000,000 for 3 years for all analyzed watersheds in basin.

Appendix D. Glossary of Terms and Acronyms.

Area of Concern (AOC) - Great Lakes Rivers and harbors that have been most severely affected by pollution and habitat loss. They were designated in 1987 as part of an international agreement between the U.S. and Canada known as the Great Lakes Water Quality Agreement

Best Management Practice (BMP) - A method that has been determined to be the most effective, practical means of preventing or reducing pollution from nonpoint sources.

Beneficial Use Impairment (BUI) - An impairment of beneficial uses means a change in the chemical, physical or biological integrity of the Great Lakes system sufficient to cause significant environmental degradation.

Great Lakes Restoration Initiative (GLRI) - The largest funding program investing in the Great Lakes. Currently the Lower Fox River watershed is one of three priority watersheds in the Great Lakes Restoration Initiative Action Plan. Under the initiative nonfederal governmental entities (state agencies, interstate agencies, local governments, non- profits, universities, and federally recognized Indian tribes) can apply for funding for projects related to restoring the Great Lakes.

Hydrologic Unit Code (HUC) - The United States is divided and sub-divided into successively smaller hydrologic units which are classified into four levels: regions, sub-regions, accounting units, and cataloging units. Each hydrologic unit is identified by a unique hydrologic unit code (HUC) consisting of two to eight digits based on the four levels of classification in the hydrologic unit system.

MSE4 - A specific precipitation distribution developed by the United States Department of Agriculture, Natural Resources Conservation Service, using precipitation data from Atlas 14.

Potentially Restorable Wetland (PRW) - Areas that are not currently mapped as wetland, but soil and water pooling data indicate it may be possible to restore them to wetland.

Total Maximum Daily Load (TMDL) - A calculation of the maximum amount of pollutant that a water body can receive and still meet water quality standards.

Total Phosphorus (TP) - Measure of all forms of phosphorus.

Total Suspended Sediment (TSS) - The organic and inorganic material suspended in the water column and greater than 0.45 micron in size.

United States Department of Agriculture (USDA) - The department of the United States government that manages various programs related to food, agriculture, natural resources, rural development, and nutrition.

United States Environmental Protection Agency (USEPA) - Government agency to protect human health and the environment.

Wisconsin Department of Natural Resources (WDNR) – State organization that works with citizens and businesses to preserve and enhance the natural resources of Wisconsin.

Wisconsin Wetland Inventory (WWI) -Graphic representations of the type, size and location of wetlands in Wisconsin developed by WDNR.