To:	Dan Repay – Executive Director Little Calumet River Basin Development Commission
From:	Peggy Shepherd, PE - Burke
Subject:	Summary of Findings from Additional Projects Identification and Evaluation
Date:	November 15, 2024
Project Name:	Deep River Watershed Modeling (Burke Project No. 16-0588.00006)

After completion of the Deep River Watershed Modeling, the Commission asked that Burke provide some additional information to help them make decisions about flood reduction possibilities. The modeling extended all the way to Lake Michigan but the additional information is only noted in this memo for areas upstream of the I-65 crossing of Burns Dith. This memo summarizes the data compiled for the Commission in the October 16, 2024 memo outlining findings as of that date plus additional analysis to summarize all of the promised information listed below.

1) Identify extent of 10- and 100-year floodplains and associated flood depths at structures and streets
2) Provide initial ranking of severity of impacts to identified structures and streets
3) Show extent of impact to structures and streets by proposed projects already evaluated
4) Provide at least two options for reducing the impacts at the top five areas of severity of impact
5) Identify important storage areas directly connected to the streams modeled

Floodplain Extent and Flood Depth Identification

Burke developed a series of maps and a spreadsheet to summarize the location, extent, and severity of various flood-vulnerable areas based on our previous study. The maps showed the flood extents and depths at structures and road segments for the 10- and 100-year floods. Flood depth ranges at buildings and streets were computed based on 2018 topography from the LiDAR mapping and the results of the Burke modeling for the 10- and 100-year existing conditions. The spreadsheet summarizes the number of flooded structures and road segments as **Table 1**. The ground elevations at structures used to determine flood depths are only as good as the 2018 LiDAR data. Several structures were close to high ground so may not actually be flooded but have been included based on our desktop level analysis. Other structures may have walkout basements that were not apparent based on the LiDAR so may not have been identified as a flooded structure or shown to have flood depths that are not determined based on the walkout basement elevation for flooding.

Groups of flooded structures were outlined and given a random number for easy reference in discussions. Some areas with a single structure impact were outlined but not all of them. The **Exhibit 1** series of maps show the locations of these areas. More detailed mapping for the top 5 flood areas is included as **Exhibits 2 – 4**. Each of these exhibits includes version A for the 10- year flood and B for the 100-year flood.

Flooded road segments and structures were counted in each flood area and used to rank the severity of the flood issues. The results are summarized in Table 1. Severity of flooding in each area was ranked based on the number of structures in the 10-year floodplain (since these would be areas that would experience more frequent flooding) as well as the number of structures likely impacted by faster flowing flood waters.

Significant Flood Storage Area Identification

The locations of important flood storage areas are provided as **Exhibits 5A** and **5B**. Parcel numbers and landowner information in these areas has been included in a chart with a reference number to match a number provided for each parcel on the map. In the process of evaluating a location for the addition of detention to address flooding along Turkey Creek, an additional significant flood storage area was identified and has been shown on **Exhibit 5C**. All these flood storage areas are connected to the stream either by a small channel or by low points in the berm separating the channel from the overbank. The tributaries that provide significant storage were modeled as storage areas. Additional significant areas were delineated based on backwater from the main stream.

Impacts of Additional Potential Flood Reduction Projects Investigated

Structure and road information was combined with the floodplains from the modeling completed in July 2024 to identify the flood impacts. 264 structures flooded in the 100-year floodplain were identified in the Lake Station area (Flood Areas 1, 2, 23, 24, and 26) near the confluence with Little Calumet River. Another 71 structures are scattered along the remaining reaches of Deep River, Turkey Creek, Duck Creek, and Main Beaver Dam Ditch. Of the 112 flooded road segments identified in the 100-year flood event, 60 are within the same Lake Station Flood Areas noted for the structures. The remaining 52 flooded road segments are along the remaining studied reaches of stream.

In the July 2024 report, Burke investigated the impacts of widening of the Lake George outlet, detention or larger opening at the railroad upstream of Harrison Road on Turkey Creek, I-65 culvert addition on Little Calumet River, and proposed Stinky Creek project, with flood elevation reductions summarized in that report. An additional alternative was also identified and analyzed as part of the current study. The impacts of these alternatives on flooded structures and road segments are summarized below. No information is provided for the detention option at the railroad upstream of Harrison Road, Stinky Creek Diversion, and I-65 culvert addition on Little Calumet River as they showed no decrease in water surface elevations at locations where there were flooded structures.

Lake George Outlet Widening

The widening of the Lake George outlet was investigated as part of the July 2024 report. To more clearly evaluate its impact, the number of structures benefitted by the widening were identified. The existing condition results compared to the results for doubling the outlet length showed that nine structures were located from the Lake George outlet structure upstream to I-65 on Turkey Creek and upstream on Deep River to a little upstream of 61st Avenue (flood areas 6, 13, and 14). Of these nine identified structures, two structures would be removed from the 10-year floodplain by the project but not from the 100-year floodplain. Three that are not in the 10-year floodplain would be removed from the 100-year floodplain and one would have its 100-year flood depth reduced to less than a half foot. The cost of this improvement would be much more than the damage prevented for so few structures. There would have to be other environmental or recreational benefits to the project to make it worthwhile. It should be noted that there is a slight increase (<0.1 ft) in downstream 100-year flood elevations due to the widening. While this would have little impact downstream, cumulative impacts from other future projects would need to be monitored.

Taft Street Area Detention

Because there were several flooded structures located just downstream of the old railroad upstream of Taft Street at the upper end of Turkey Creek (flood areas 8, 9, and 16), a detention pond was evaluated at the old railroad. The assumed outlet was two 7ft X 3 ft (span X rise) box culverts at the channel invert and a 10 ft X 5 ft box culvert about 3 feet above the stream invert. This option removes 4 structures from the 100-year floodplain and reduces the flooding at another 9 to less than a half foot. It does, however, increase elevations upstream enough to add at least 2 structures and a segment of Hendricks Street into the 100-year floodplain.

Lake Station Levee Protection

A levee to protect homes in the Lake Station area along Deep River had been investigated by the Commission earlier. Patrick Engineering informed the Commission that even with a costly addition of levees and a pump station, the existing interior drainage infrastructure was not adequate to prevent flooding of structures from interior drainage flooding. A small berm to at least reduce the flood damages in smaller floods was constructed by the Commission but that was determined to be the extent of protection that could be provided.

Replacement of Restrictive Stream Crossings

There do not appear to be many flooded structures located upstream of restrictive stream crossings within the reaches investigated. Also, the stream crossings do not restrict flow enough that even their removal would significantly reduce the flooding of few, if any, structures.

Floodproofing and Buyouts

Approximately 347 structures along the studied streams and the associated backwater along tributaries were identified as flood prone in the 100-year flood event. For the Lake George outlet and Taft Street area detention flood reduction alternatives only seven structures could be removed from the 100-year floodplain. Construction projects do not, therefore, appear to provide meaningful solutions. The flood damage potential could still be reduced by floodproofing or buyouts of the vulnerable properties. **Table 2** includes the number of structures in each Flood Area that could be candidates for floodproofing or buyout based on the expected flood depths. Most floodproofing options are appropriate for flood depths less than 3 feet. Structures with higher flood depths would likely not be candidates for floodproofing but could be bought out to remove from the flood hazard area.

Floodproofing options could include raising the structure, increasing the amount of flood-resistant materials in the structure to reduce the amount of damage when flooded, installing check valves to prevent water from backing up into the structure, elevating utilities and other equipment above the flood elevation to reduce damage, creating a berm/floodwall as part of landscaping close to the structure with closures to protect from flooding, and having sufficient sand bags or other barriers on site (along with training in their use) to use if flooding is forecasted. Floodproofing options are site specific and can have a wide range in cost.

A floodproofing assistance cost share program could be established if desired to assist homeowners in floodproofing their property. Should this alternative be implemented, additional analysis will be needed to prioritize the structures for voluntary acquisition or floodproofing assistance and to estimate the costs needed to implement such an undertaking over time.

Due to the high number of Lake Station area flood impacted structures, a flood response plan should be created for the area if it does not already exist. Such a plan would include detailed guidance for advance flood detection, communications, response actions, event termination, and post-flood follow-up activities. The plan will help emergency personnel to respond in an efficient way to reduce the negative impact to residents' lives.

The number of structures from each Flood Area that are in the existing and with-project floodplains for various alternatives are summarized in **Table 2**. This table uses the same Flood Area numbers as **Table 1**.

Preservation of Existing Flood Storage

As stated in the July 2024 report of the modeling, 100-year flood elevations would increase over 5 feet in the vicinity if the flood storage areas along Main Beaver Dam Ditch were lost, tapering to zero increase at the Lake George outlet. Increases in water surface elevations on Turkey Creek would also occur and stream velocities would be increased in these reaches. Loss of the storage in the floodplain and a tributary along the upper end of Turkey Creek could increase the 100-year flood elevation by up to almost a half-foot in the reach upstream of I-65. These areas are therefore important to preserve as replacing them would be very costly.

There are already several parks within the identified significant storage areas. Partnership opportunities to expand those or add to the park systems may exist. Other opportunities could include partnership with The Nature Conservancy, Indiana Department of Natural Resources, wetland preservation or creation groups, and Natural Resources Conservation Service to either acquire outright or purchase conservation easements to make sure these flood storage areas remain intact.

The Commission should engage with the entities having regulatory jurisdiction over these flood storage areas to avoid issuing permits for any action that may reduce the existing flood storage and exacerbate flooding in downstream reaches.

Summary of Findings and Options for Flood Damage Reduction

The following is a summary of findings and recommendations from the above additional evaluations:

- Potential projects of widening the Lake George outlet and construction a retention pond upstream of the railroad upstream of Taft Street on Turkey Creek could only remove 7 structures from the 100-year floodplain. The cost of these projects is expected to be much larger than the benefit derived.

- Prevention of increased flooding due to loss of existing storage areas was shown to be important with the finding that loss of storage along Main Beaver Dam Ditch could increase flood elevations by 5 feet and loss of storage along Turkey Creek upstream of I-65 could increase flood elevations by almost a half-foot. Pursuing various opportunities to ensure preservation of flood storage areas within the watershed is believed to be one of the most crucial steps the Commission can take to keep the existing flooding vulnerabilities from getting much worse.

- Floodproofing and buying out structures does have the potential to reduce flood damages. Approximately 234 structures have flood depths conducive to floodproofing while another 113 have flood depths for which buyouts are recommended. If desired, Burke can help with developing a program for cost sharing of floodproofing measures and prioritizing properties for buyout.

- Development of a Flood Response Plan is recommended for Lake Station to streamline flood response to future flood events to help the emergency personnel response to flooding and to reduce pain and suffering of impacted residents as a result of flooding. If desired, Burke can help develop such a plan in coordination with emergency response agencies.

Table 1: Ranking of Deep River Floodprone Areas

Area Number	No. of Structures in Floodplain		Range of Flood Depths at Structures, ft.		No. of Stuctures in Areas of Higher Velocity[a]	No. of Road Segments[b] in Floodplain		Scores		
	10-Year	100-Year	10-Year	100-Year		10-Year Floodplain	100-Year Floodplain	10-Year[c]	100-Year[c]	Overall[d]
26	50	107	0.05-4.2	0-6.8	2	19	28	71	137	208
1	40	96	0.6-2.3	0-4.2	15	12	23	67	134	201
3	5	9	0.1-2.6	1.4-4.6	5	3	3	13	17	30
2	4	43	0.8-1.6	0.7-4.6	5	1	6	10	54	64
24	6	17	0.04-0.4	0.2-2.9	2	1	3	9	22	31
4	3	3	0.3-4.2	2.4-6.3	2	2	2	7	7	14
6	3	7	0.7-5.4	1.0-7.7	1	0	0	4	8	12
17	2	2	0.02-1.7	3.1-4.7	2	0	0	4	4	8
9	0	10	0	0.1-2.0	0	2	2	2	12	14
8	1	10	0.5	0.5-2.6	1	0	0	2	11	13
5	1	1	0.6	3.4	1	0	2	2	4	6
12	2	4	1.6-3.8	0.7-4.9	0	0	0	2	4	6
7	2	2	0.4-1.2	2.6-3.3	0	0	0	2	2	4
11	2	2	0.1-3.4	0.9-4.3	0	0	0	2	2	4
15	1	1	2.5	4.5	1	0	0	2	2	4
21	1	1	4.7	6.7	1	0	0	2	2	4
22	1	1	2.2	4.2	1	0	0	2	2	4
10	1	6	0.3	0.4-1.9	0	0	0	1	6	7
19	1	3	0.2	1.5-2.9	0	0	0	1	3	4
13	1	1	2.1	4.3	0	0	0	1	1	2
18	1	1	2	4.7	0	0	0	1	1	2
20	1	1	1.6	4	0	0	0	1	1	2
25	0	4	0	0.2-3.0	0	0	0	0	4	4
14	0	1	0	1.3	0	0	0	0	1	1
16	0	1	0	0.6	0	0	0	0	1	1
23	0	1	0	0.2	0	0	0	0	1	1

[a] determined based on topography and direction of main flow.

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[b] the stretch of a road between intersections with other roads was selected as one road segment

[c] score based on sum of structures in respective floodplain plus road segments plus structures in higher velocity areas

[d] sum of 10-year and 100-year scores

Additional structures were identified in the floodplain but were not given a flood area number. These structures are shown on the overall maps however.

Table 2 Existing and With Project Benefit Summary

Existing Condition Summary									Project Option Benefits						
Flood Area Number	General Location	No. of Structures in Floodplain		Range of Flood Depths at Structures, ft.		No. of Stuctures in Areas of Higher Velocity[a]	No. of Road Segments[b] in Floodplain		Widen Lake George Outlet (double the length)*			Detention 1,500 ft. Upstream of Taft Street**		Floodproof Potential	Buyout Potential
		10-Year	100-Year	10-Year	100-Year		10-Year Floodplain	100-Year Floodplain	No. of Structures Removed from 10-Year	No. of Structures Removed from 100-Year	Additional No. of Structures reduced to < 0.5 ft 100-Year Flood Depth	No. of Structures Removed from 100-Year	Additional No. of Structures reduced to < 0.5 ft 100-Year Flood Depth	No. of Structures w/ <3.0 ft 100-Year Flood Depth	No. of Structures w/ >3.0 ft 100-Year Flood Depth
1	Deep River near Little Calumet River confluence	40	96	0.6-2.3	0-4.2	15	19	28	-	-	-	-	-	78	18
2	Deep River near Little Calumet River confluence	4	43	0.8-1.6	0.7-4.6	5	12	23	-	-	-	-	-	10	33
3	eastern end of Lake Station	5	9	0.1-2.6	1.4-4.6	5	3	3	-	-	-	-	-	8	1
4	eastern end of Lake Station	3	3	0.3-4.2	2.4-6.3	2	1	6	-	-	-	-	-	1	2
5	Hobart, downstream of Lake George	1	1	0.6	3.4	1	1	3	-	-	-	-	-	-	1
6	Lake George near outlet	3	7	0.7-5.4	1.0-7.7	1	2	2	2	3	1	-	-	4	3
7	Turkey Creek upstream of I-65	2	2	0.4-1.2	2.6-3.3	-	0	0	-	-	-	-	-	1	1
8	Turkey Creek upstream of I-65	1	10	0.5	0.5-2.6	1	0	0	-	-	-	-	5	10	-
9	Turkey Creek upstream of I-65	-	10	0	0.1-2.0	-	2	2	-	-	-	3	4	10	-
10	Deep River near I-65	1	6	0.3	0.4-1.9	-	0	0	-	-	-	-	-	6	-
11	Deep River near I-65	2	2	0.1-3.4	0.9-4.3	-	0	2	-	-	-	-	-	1	1
12	Deep Rivernear US 30 and county boundary	2	4	1.6-3.8	0.7-4.9	-	0	0	-	-	-	-	-	2	2
13	Deep River just upstream of Lake George	1	1	2.1	4.3	-	0	0	-	-	-	-	-	-	1
14	Deep River just upstream of Lake George	-	1	0	1.3	-	0	0	-	-	1	-	-	1	-
15	Turkey Creek upstream of I-65	1	1	2.5	4.5	-	0	0	-	-	-	-	-	-	1

16	Turkey Creek upstream of I-65	-	1	0	0.6	-	0	0	-	-	-	1	-	1	-
17	Duck Creek near mouth	2	2	0.02-1.7	3.1-4.7	2	0	0	-	-	-	-	-	-	2
18	Duck Creek near mouth	1	1	2	4.7	-	0	0	-	-	-	-	-	-	1
19	Hobart, downstream of Lake George	1	3	0.2	1.5-2.9	-	0	0	-	-	-	-	-	3	-
20	Hobart, downstream of Lake George	1	1	1.6	4	-	0	0	-	-	-	-	-	-	1
21	eastern end of Lake Station	1	1	4.7	6.7	1	0	0	-	-	-	-	-	-	1
22	eastern end of Lake Station	1	1	2.2	4.2	1	0	0	-	-	-	-	-	-	1
23	Deep River near confluence with Little Calumet River	-	1	0	0.2	-	0	0	-	-	-	-	-	1	-
24	Deep River near confluence with Little Calumet River	6	17	0.04-0.4	0.2-2.9	2	0	0	-	-	-	-	-	17	-
25	Burns Ditch near I-90	-	4	0	0.2-3.0	-	0	0	-	-	-	-	-	3	1
26	Deep River near confluence with Little Calumet River	50	107	0.05-4.2	0-6.8	2	0	0	-	-	-	-	-	67	40

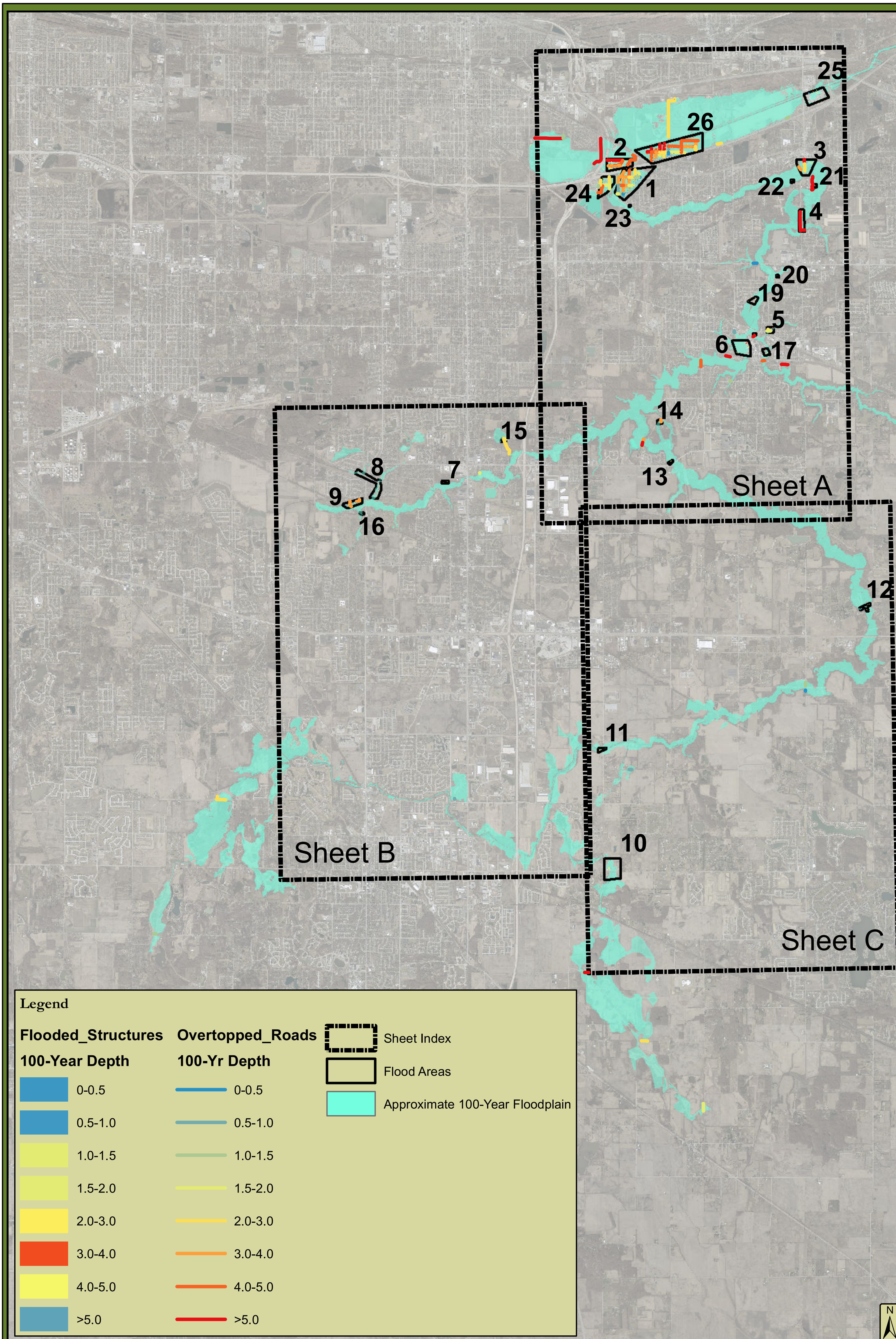
* 2 road segments are removed from the 100-year floodplain by the Lake George Outlet widening.

** 2 structures are added to the 100-year floodplain and 2 road segments are flooded to higher depths by the Taft Road Detention. No road segments are removed.

[a] Determined based on topography and direction of main flow.

[b] The stretch of a road between intersections with other roads was considered as one road segment. There are additional flooded road segments that were not included in a numberd Flood Area

Additional structures and roads were identified in the floodplain but were not given a flood area number. These structures and road segments are shown on the overall maps however.



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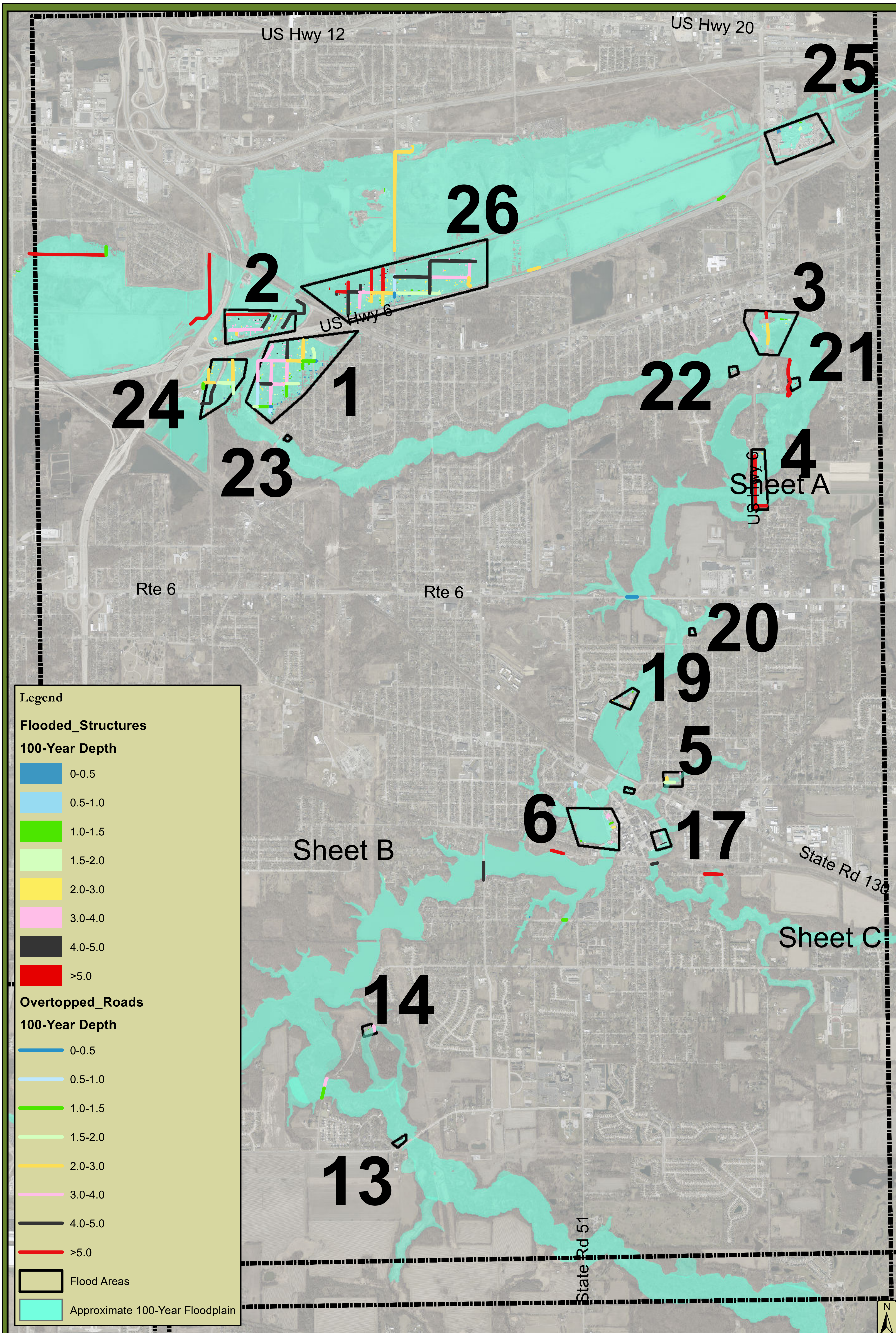
PROJECT:	PROJECT NO.	APPROX. SCALE
Deep River Watershed Modeling	16-0588 .00006	DATE: 10/2024
TITLE: Flood Prone Areas - Sheet A		EXHIBIT 1



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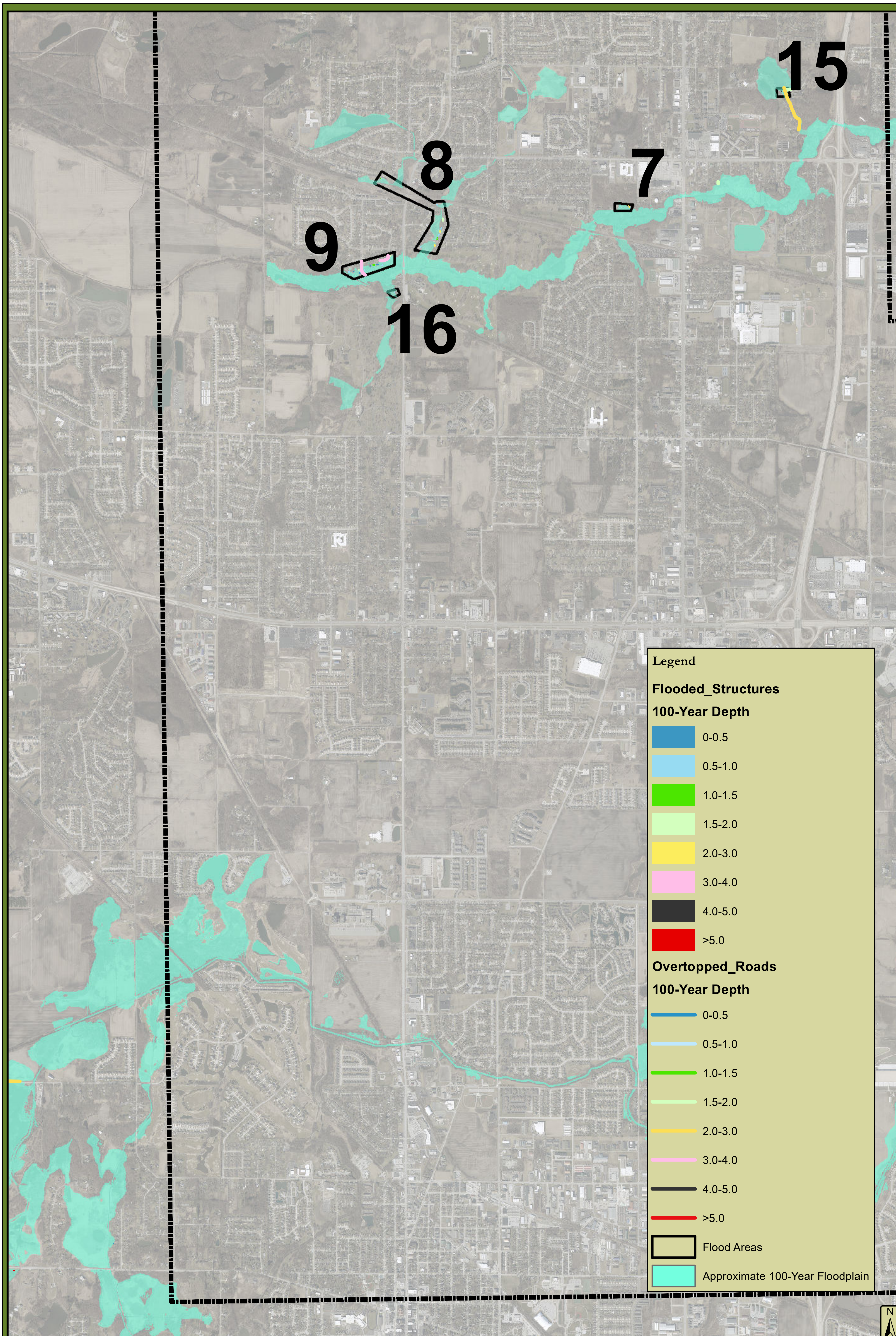
PROJECT: Deep River Watershed Modeling		PROJECT NO. 16-0588 .00006	APPROX. SCALE
TITLE: Flood Prone Areas - Sheet A			DATE: 11/2024
			EXHIBIT 1A



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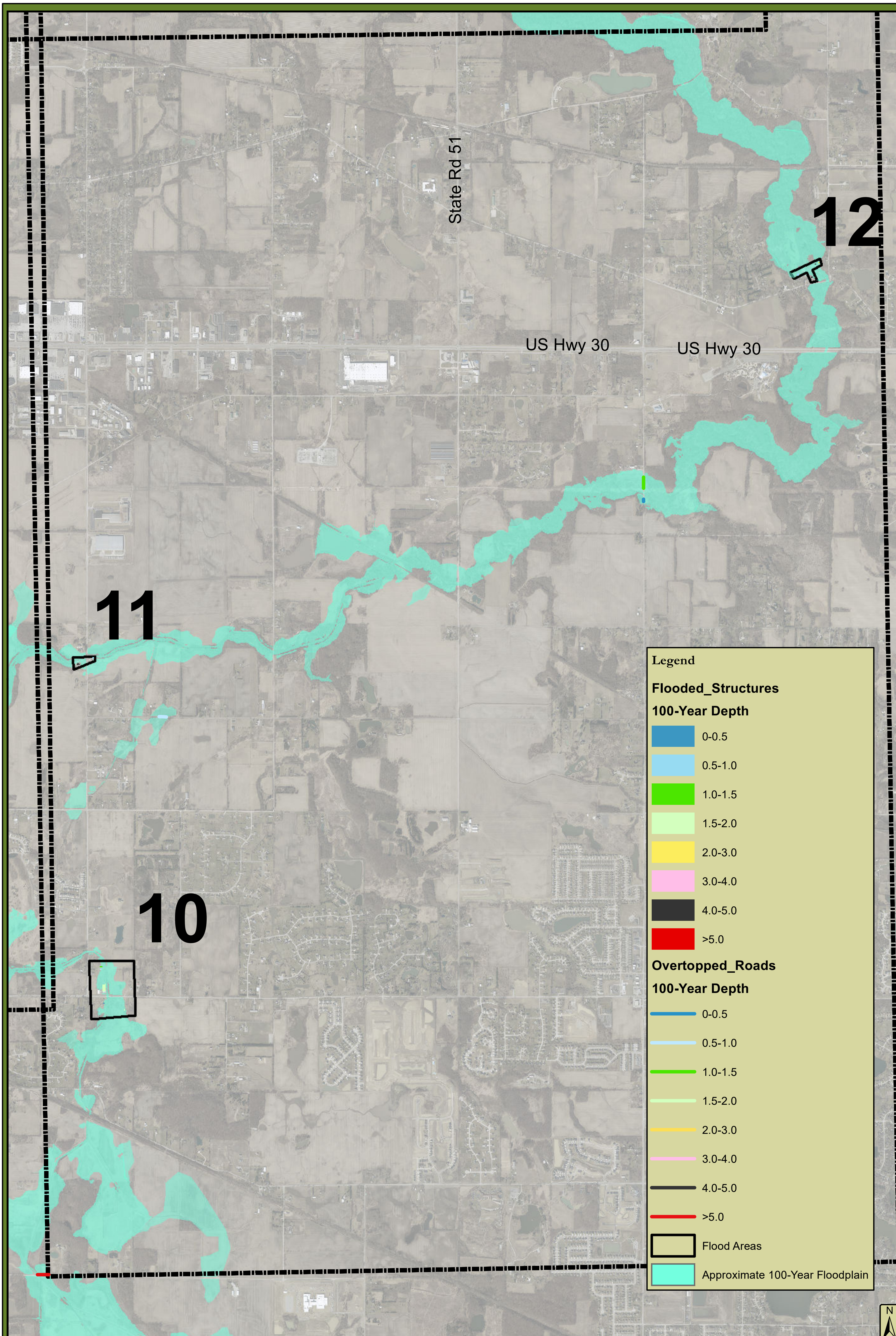
PROJECT: Deep River Watershed Modeling	PROJECT NO. 16-0588 .00006	APPROX. SCALE
		DATE: 11/2024
TITLE: Flood Prone Areas - Sheet B		EXHIBIT 1B



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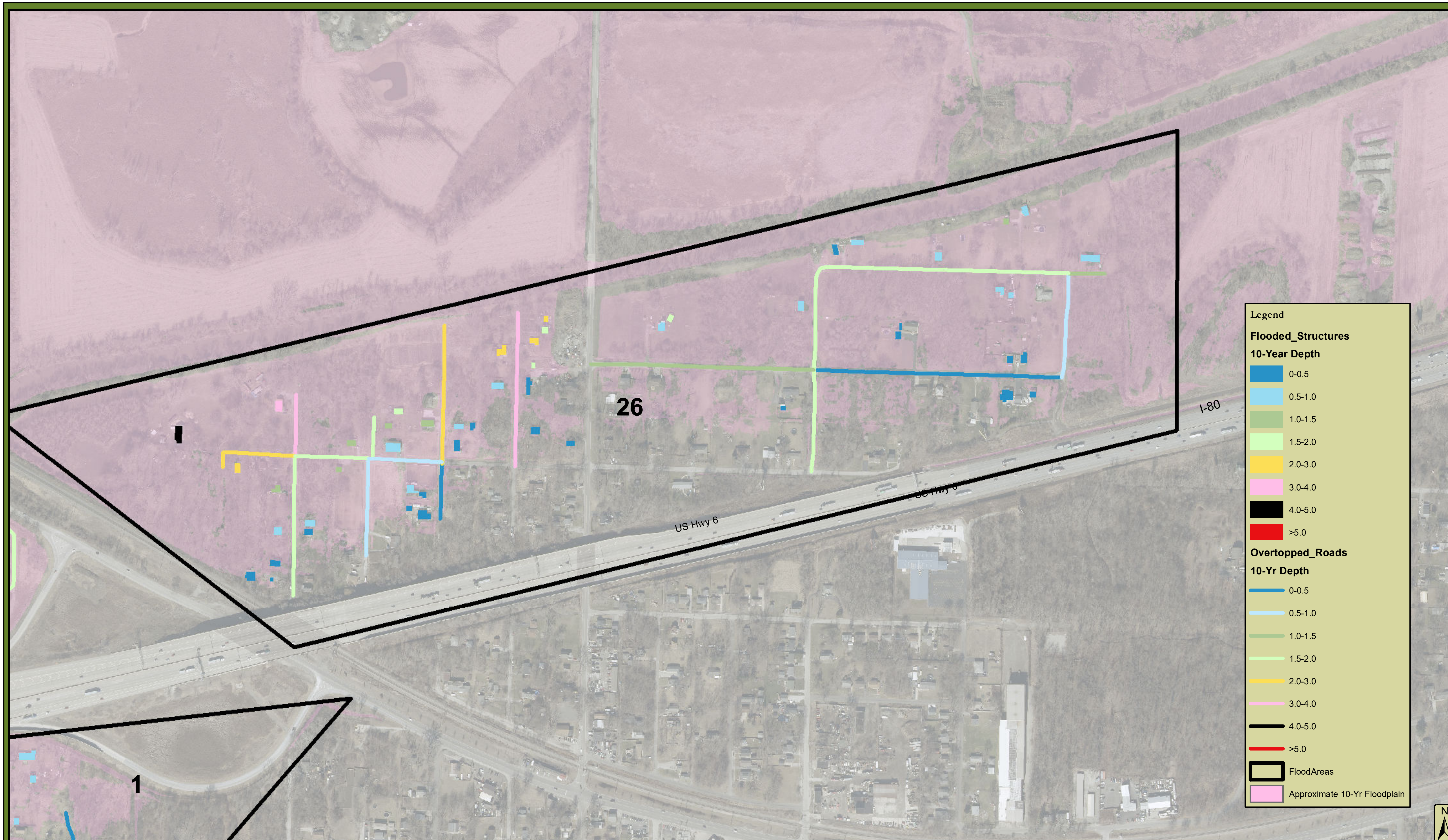
PROJECT: Deep River Watershed Modeling	PROJECT NO. 16-0588 .00006	APPROX. SCALE
TITLE: Flood Prone Areas - Sheet C		DATE: 11/2024
		EXHIBIT 1C



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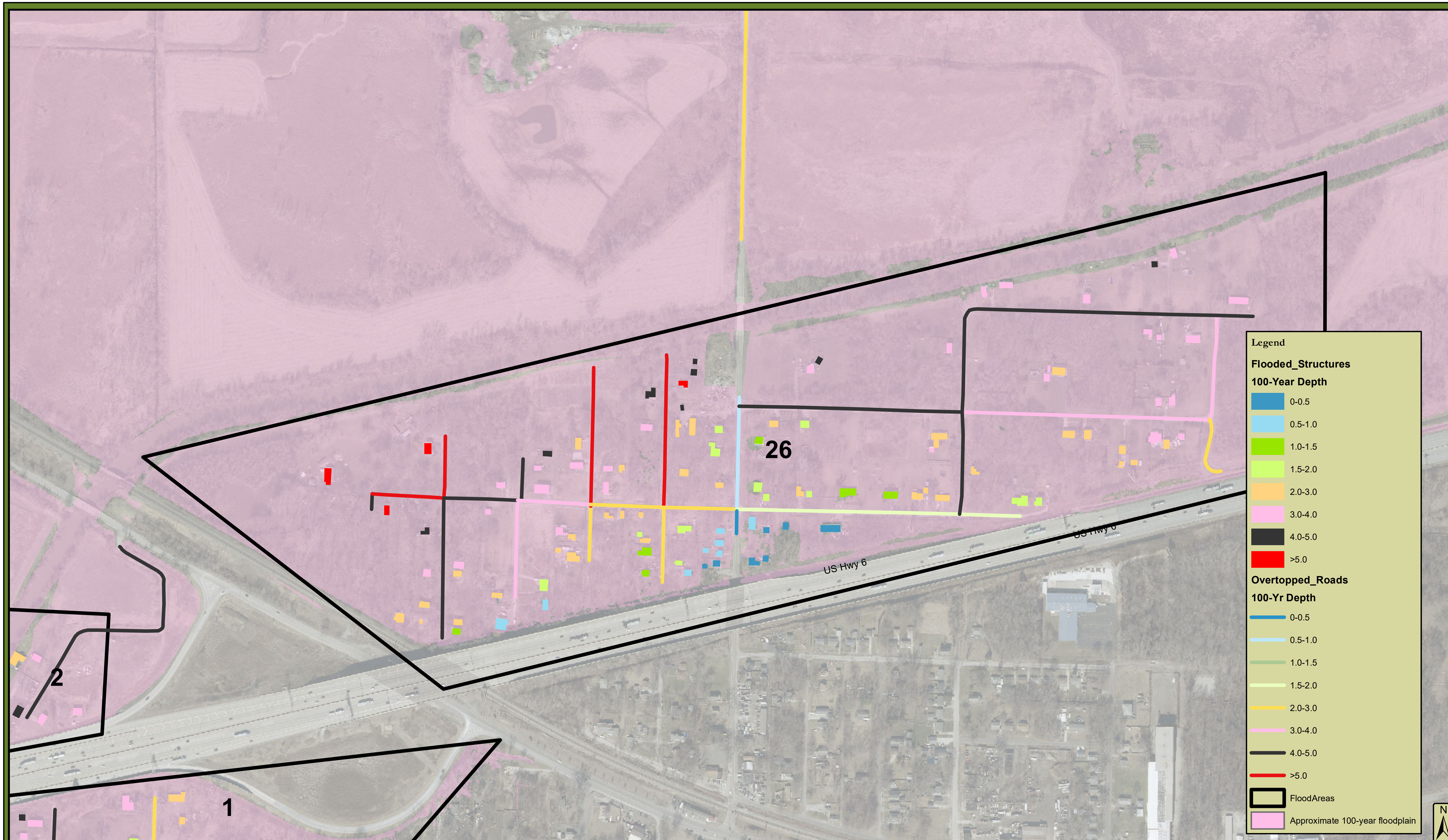
PROJECT: Deep River Watershed Modeling	PROJECT NO. 16-0588 .00006	APPROX. SCALE 1"=400'	
TITLE: Area 26 Flood Depths - 10-Year Flood		DATE: 11/2024	EXHIBIT 2A



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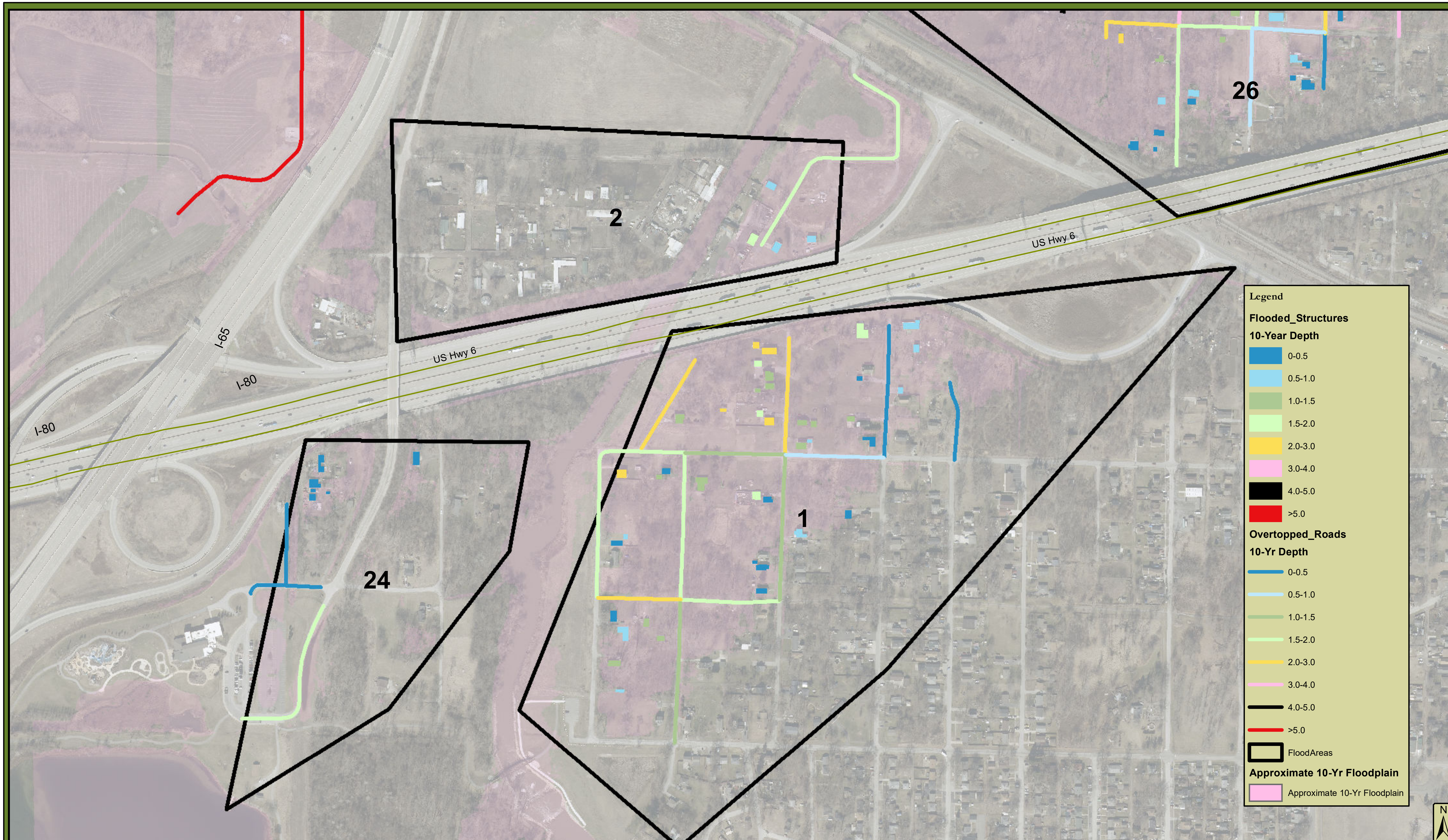
PROJECT: Deep River Watershed Modeling	PROJECT NO. 16-0588 .00006	APPROX. SCALE 1"=400'	
TITLE: Area 26 Flood Depths - 100-Year Flood		DATE: 11/2024	EXHIBIT 2B



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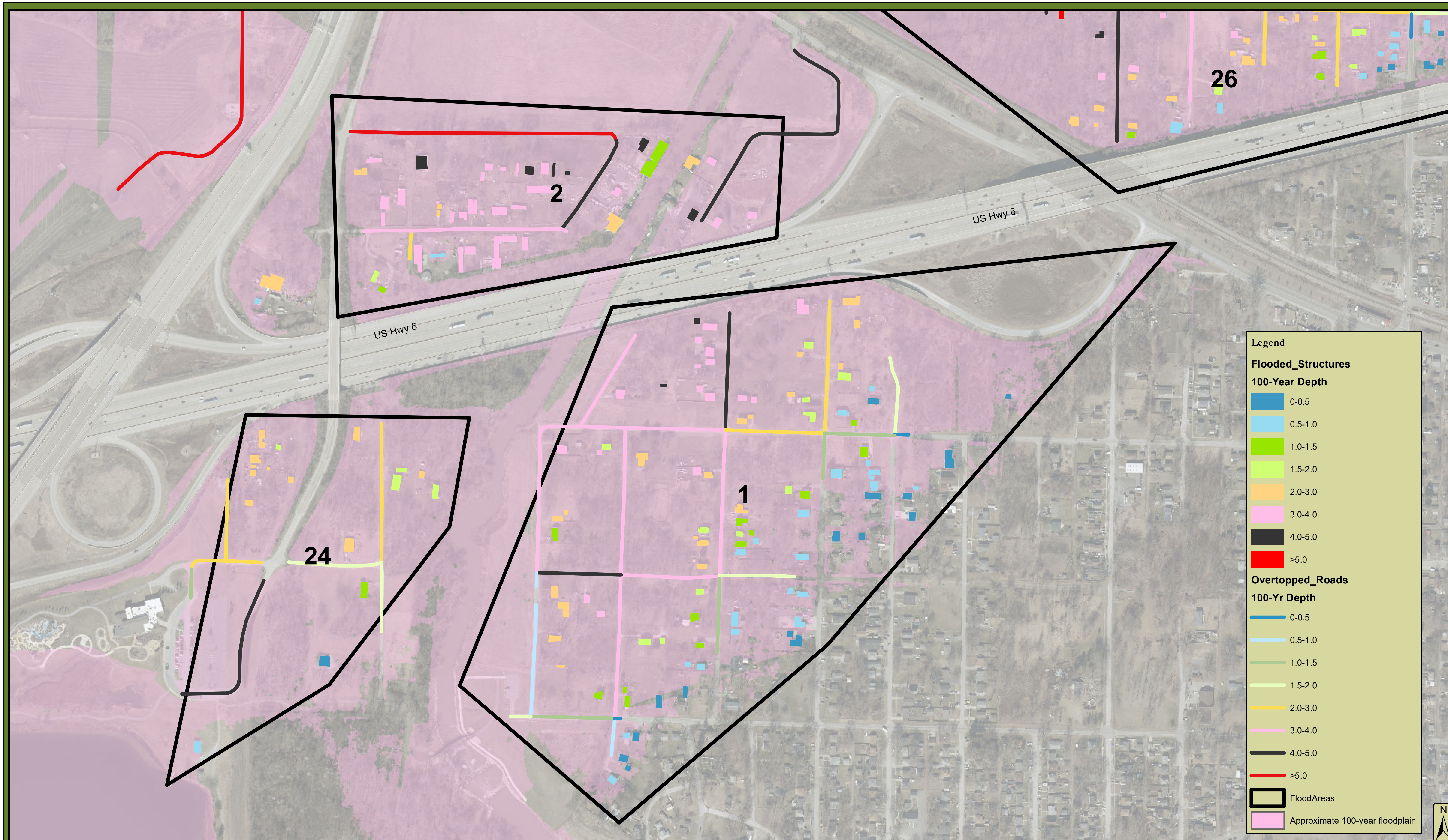
PROJECT: Deep River Watershed Modeling	PROJECT NO. 16-0588 .00006	APPROX. SCALE 1"=400'
TITLE: Area 1, 2, 24 Flood Depths - 10-Year Flood		DATE: 11/2024
		EXHIBIT 3A



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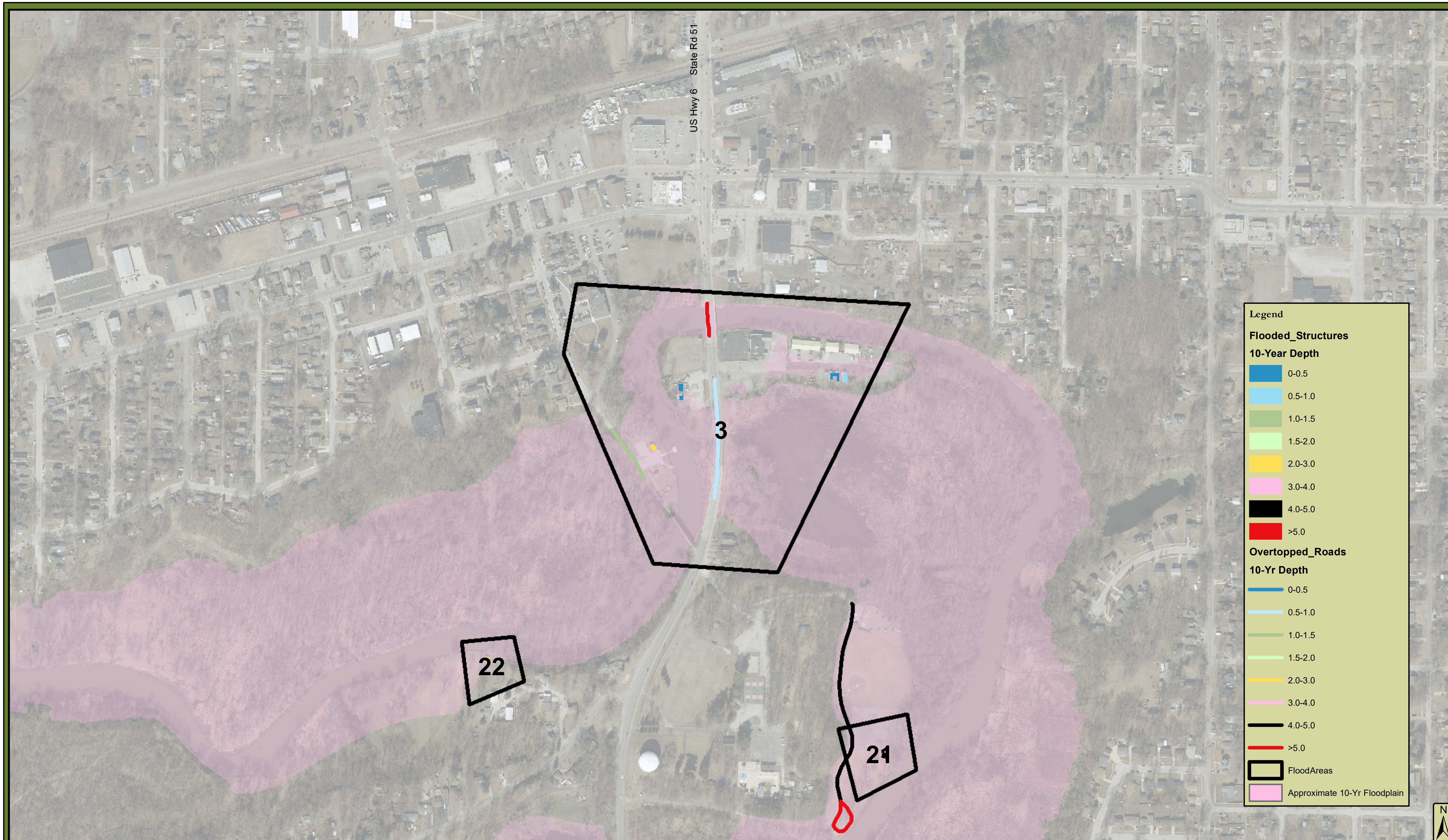
PROJECT:	PROJECT NO.	APPROX. SCALE
Deep River Watershed Modeling	16-0588 .00006	1"=400'
TITLE: Area 1, 2, 24 Flood Depths - 100-Year Flood		DATE: 11/2024
		EXHIBIT 3B



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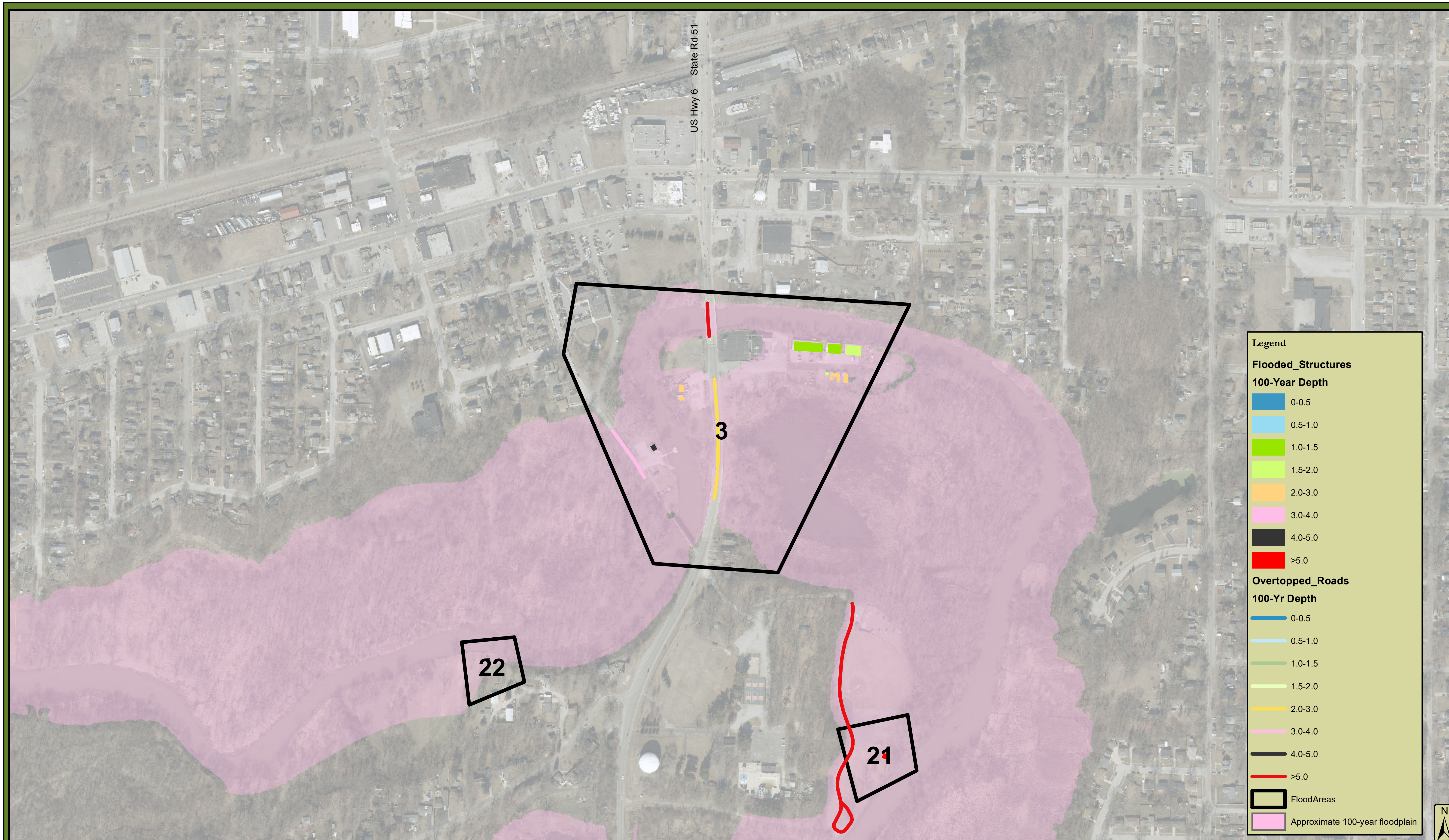
PROJECT:	Deep River Watershed Modeling
PROJECT NO.	16-0588 .00006
APPROX. SCALE	1"=400'
DATE:	11/2024
TITLE:	Area 3 Flood Depths - 10-Year Flood
EXHIBIT	4A



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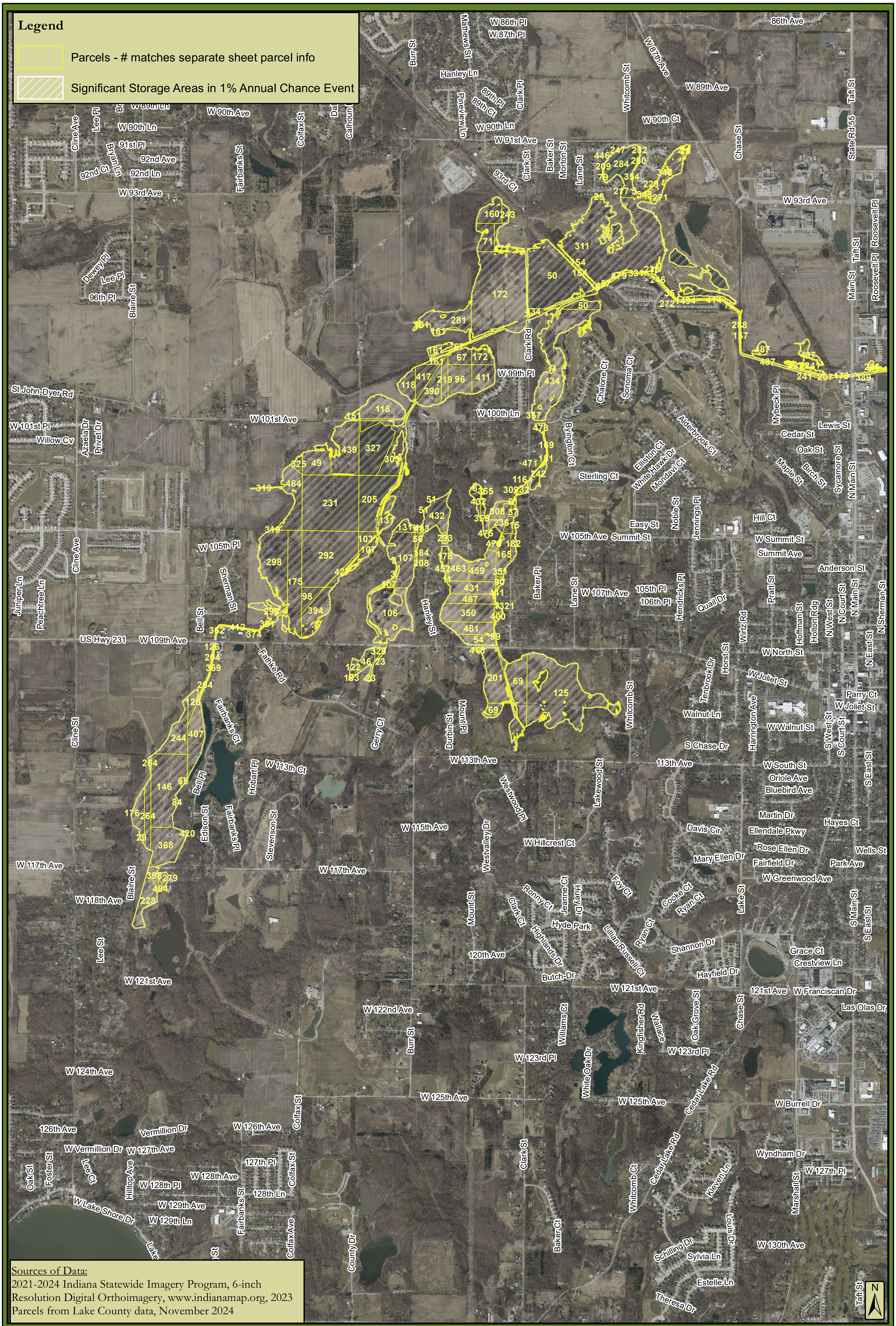
PROJECT: Deep River Watershed Modeling	PROJECT NO. 16-0588 .00006	APPROX. SCALE 1"=400'	
TITLE: Area 3 Flood Depths - 100-Year Flood		DATE: 11/2024	
		EXHIBIT 4B	



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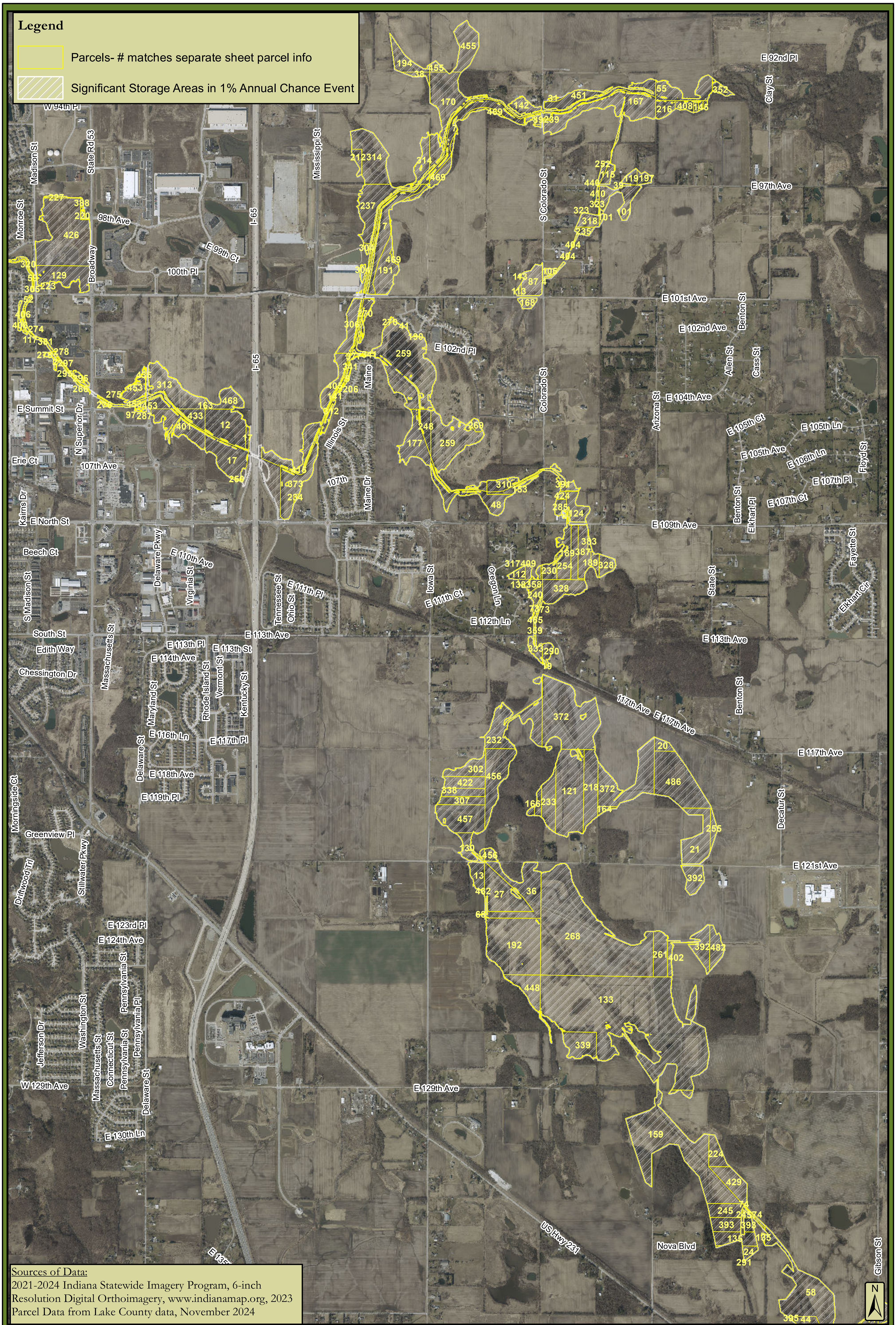
PROJECT: Deep River Watershed		PROJECT NO. 16-0588.00006	APPROX. SCALE 1"=2,000'
			DATE: 11/2024
TITLE: Significant Storage Areas			EXHIBIT 5A

Legend

- Parcels- # matches separate sheet parcel info
- Significant Storage Areas in 1% Annual Chance Event



Sources of Data:
2021-2024 Indiana Statewide Imagery Program, 6-inch Resolution Digital Orthoimagery, www.indianamap.org, 2023
Parcel Data from Lake County data, November 2024

Christopher B. Burke Engineering, LLC PNC Center, Suite 1368 South 115 West Washington Street Indianapolis, Indiana 46204 (t) 317.266.8000 www.cbbel-in.com	PROJECT: Deep River Watershed	PROJECT NO. 16-0588.00006	APPROX. SCALE 1"=2,000'
			DATE: 11/2024
	TITLE: Significant Storage Areas		EXHIBIT 5B

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