NORTH AREA DRAINAGE STUDY

WAHOO, NEBRASKA

JEO PROJECT #211821.00
JUNE 2022

PREPARED BY JEO CONSULTING GROUP FOR
THE CITY OF WAHOO, NEBRASKA

Wahoo, NE
North Area Drainage Evaluation
May 2022

BACKGROUND

The North Area Drainage Study encompasses a drainage area of 381 acres in northwest Wahoo Nebraska. This drainage area was originally studied by JEO consulting group in 2008 as an investigation into potential flooding impacts to some residential properties along North Walnut Street. The 2008 report outlined that for future developed conditions, approximately five properties were at risk of flooding impacts for the 100-year event and outlined three basic improvements to mitigate the risk in this area.

Project MR-01 – Open Channel Improvements Upstream of Chestnut Street

This recommended project included the construction of an improved drainage ditch west of chestnut Street. The proposed ditch was estimated to be a trapezoidal channel with a 20-foot bottom and 2:1 side slope. A change in flowline of 0.5 feet at the upstream end of the proposed grading was anticipated. Since completion of this study, preliminary utility investigation determined that several sanitary mains exist within the alignment of the proposed channel which resulted in this recommendation never being constructed.

Project MR-03 – Culvert Improvements

To reduce backwater effects upstream of Chestnut Street, this project recommended construction of a dual span 6 ft x 6 ft box culvert. The report noted that this proposed structure was not intended to provide conveyance for 50-year peak flows or prevent overtopping of Chestnut Street, as at the time of the study the structure size to achieve that level of overtopping was not deemed to be cost-effective. Instead, the intent of these culvert improvements was to lower the 100-year backwater effect enough to reduce impacts to upstream properties.

Since the study was concluded this structure was replaced with a dual 5' x 10' concrete box culvert as part of the 2012 Chestnut Street Paving Improvement project.

Project UR-01 – Regional Detention Basin East of 23rd Street

To reduce existing and future peak flows the 2008 study recommended construction of a regional detention cell upstream in the study area. This detention cell was recommended to have approximately 19 acre-ft of storage with and concrete weir outlet structure 20ft wide by 5ft tall.

Since completion of the study, a detention cell upstream of 23rd street has been constructed. Though during design, the outlet structure was changed to be a combination of a 36" RCP main flow pipe, with a 5ft x 10ft Reinforced Concrete Box Culvert with an offset flowline to allow for high flows.

SITE CONDITIONS

Drainage catchments throughout the study area were estimated using a combination of engineering judgement, available LiDAR, and available storm sewer utility drawings. In total, nine catchments comprising a total drainage area of 381 acres were developed as part of this project.

Existing land use on site was determined using aerial photography, and proposed land use was taken from the Wahoo's future land use map. Since completion of the study in 2008 several developments have been constructed within the study area including the Sycamore Hills residential development and the construction of a new JEO Consulting Group office. Both developments included the construction of a lot-level detention cell which reduced proposed peak flow runoffs to at or below existing conditions. Existing Site Conditions are depicted in Figure 1.

HYDROLOGY

Peak flow rates for existing and proposed conditions were modeled using HEC-HMS. Peak flow rates for the 2-year, 10-year and 100-year events were modeled for both existing and proposed conditions using a 24-hour type II storm distribution. 24-hour design rainfall values were obtained from NOAA Atlas 14, Volume 8, Version 2 and are summarized in Table 1.

Table 1 – Design Rainfall Depths

Design Storm	Rainfall Depth (in)
2-year	3.02
10-year	4.35
100-year	6.93

Rainfall Loss Method

The SCS curve number method was used for this analysis. Runoff curve numbers were estimated using the reference tables provided within the USDA NRCS National Engineering Handbook Part 630. Existing condition land uses were estimated using aerial photography.

To estimate the impact of future development, curve numbers and time of concentrations were adjusted based on the Future Land Use map for the City of Wahoo. Where future changes were anticipated, the Curve Numbers were adjusted to reflect the proposed land use.

Time of Concentration

The SCS-TR55 method was used to find the lag time of the drainage areas for both existing and proposed conditions. This method uses the longest flow path, runoff curve number, and average watershed gradient to calculate the time of concentration. The time of Concentration (TOC) for the existing conditions were estimated and outlined in Table 3.

Figure 1 – Existing Site Conditions

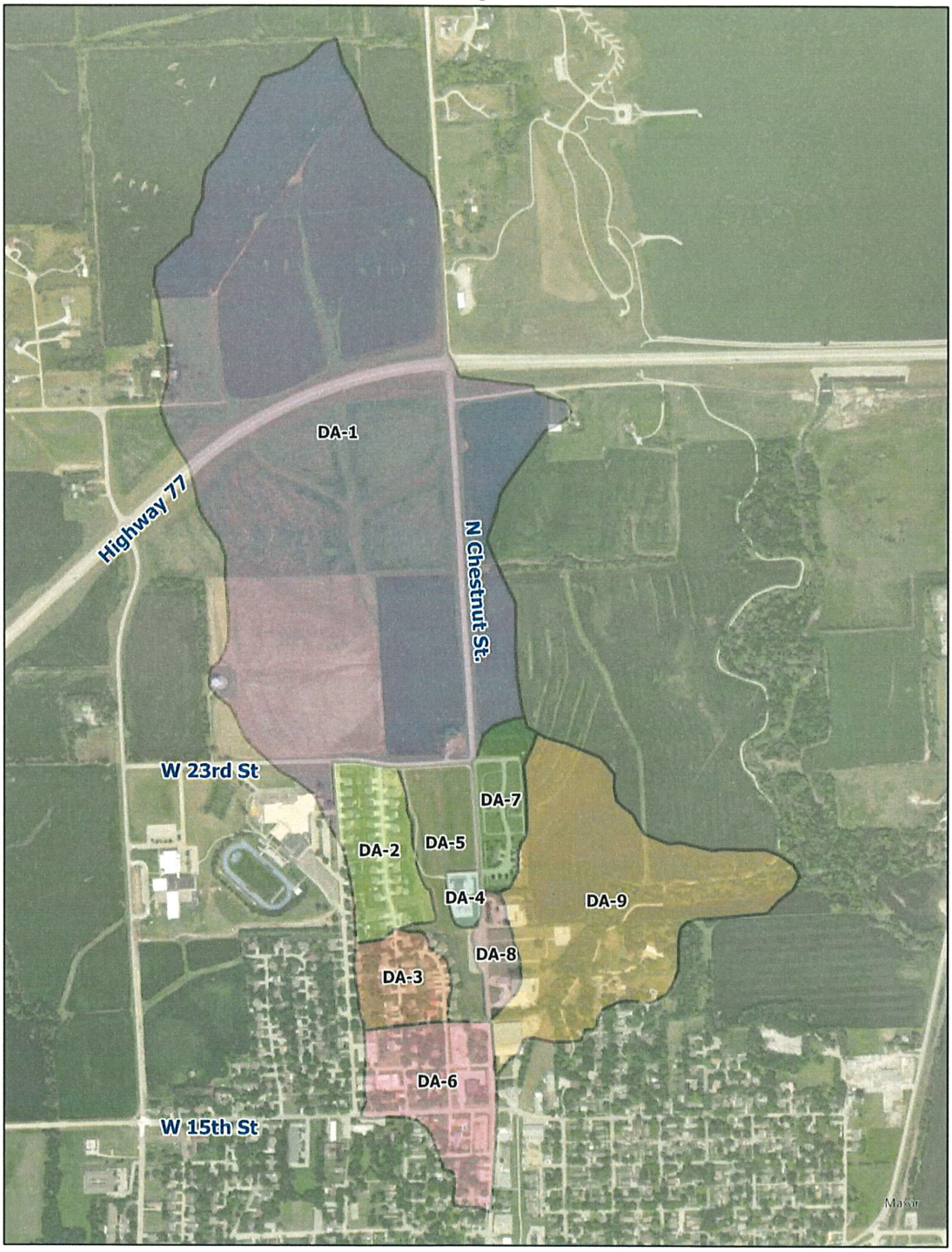

Table 2 – Curve Number Comparisons

Catchment	Drainage Area (Acres)	Existing Curve Number	Proposed Curve Number
DA-1	240.7	81.0	83.5
DA-2	15.8	82.0	82.0
DA-3	10.1	82.0	82.0
DA-4	2.2	91.0	91.0
DA-5	15.4	74.0	83.2
DA-6	21.8	90.0	90.0
DA-7	10.0	90.0	90.0
DA-8	5.1	85.0	85.0
DA-9	59.9	85.0	83.2

Table 3 – Time of Concentration Comparison

Drainage Area	Travel Distance (ft)	Average Slope (%)	Time of Concentration (Min)	SCS Lag Time (Min)
DA-1	7960	.47	35.1	21.1
DA-2	1357	1.27	15.0	20.0
DA-3	1190	1.41	15.0	9.0
DA-4	1368	0.60	15.0	9.0
DA-5	1429	1.93	16.0	9.6
DA-6	725	2.78	15.0	9.0
DA-7	2060	1.50	15.0	9.0
DA-8	1300	2.17	15.0	9.0
DA-9	1092	1.24	18.0	10.8

Three Detention Cells were included within the hydrologic model to represent the large detention cell upstream of 23rd Street as well as the two detention cells located on the Sycamore Hills development and the JEO Consulting Group corporate offices. Stage storage and outlet structures for these structures were taken from both grading or as-built plans for these respective developments.

Runoff Summary

Existing design storm hydrographs for the 2-, 10-, and 100-year events were modeled in HEC-HMS using the SCS Curve Number Methodology (TR-55) and the data outlined in the previous sections. A summary of estimated peak flows for existing conditions are provided in the following section.

Table 4 – Summary of Existing Runoff

Drainage Area	Existing Peak Flow (cfs)			Future Peak Flow (cfs)		
	2-Year	10-Year	100-Year	2-Year	10-Year	100-Year
DA-1	243.8	451.3	878.9	277.8	492.2	924.1
DA-2	17.3	31.4	60.5	17.3	31.4	60.5
DA-3	15.9	28.9	55.6	15.9	28.9	55.6
DA-4	5.2	8.2	14	5.2	8.2	14
DA-5	15.3	32.1	68.7	25.6	44.9	83.9
DA-6	49.7	79.7	137.6	49.7	79.7	137.6
DA-7	22.8	36.6	63.2	22.8	36.6	63.2
DA-8	9.3	16.1	29.8	9.3	16.1	29.8
DA-9	105.2	180.3	329.2	96.6	170.5	318.9
Upstream of 23rd Street	243.8	451.3	878.9	277.8	492.2	924.1
Downstream 23rd Street	160.4	287.6	515.3	183.0	312.2	531.3
N. Chestnut	195.6	349.1	638.9	220.6	376.0	658.2

DETENTION POND PERFORMANCE

The existing detention pond is very effective at reducing peak flow rates and preventing damage to downstream facilities. It provides a significant amount of attenuation to the downstream system (between 34 to 41 percent). In Tables 5 and 6 below the existing conditions peak inflows, peak outflows, and peak elevation can be seen for the retention pond. A mapped extent of these modeled high water surface elevations is provided in Figure 2. Results indicate that with future conditions peak flows through the study area will be increased slightly downstream of 23rd Street unless upstream detention is required for proposed developments.

Table 5 - Performance of the Detention Pond Under Existing Conditions

Design Storm	Peak Inflow (CFS)	Peak Outflow (CFS)	Reduction (CFS)	Peak Elevation (ft)
2-Year	243.8	160.4	83.4 (34%)	1233.6
10-Year	451.3	287.6	163.7 (36%)	1235.1
100-Year	878.9	515.3	363.6 (41%)	1237.6

Table 6 - Performance of the Detention Pond under Future Conditions

Design Storm	Peak Inflow (CFS)	Peak Outflow (CFS)	Reduction (CFS)	Peak Elevation (ft)
2-Year	277.8	183.0	94.8	1233.9
10-Year	492.2	312.2	180.0	1235.4
100-Year	924.1	531.3	392.8	1238.0

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HYDRAULICS

Hydraulic performance of the existing system was analyzed using two-dimensional modeling in HEC-RAS version 6.2. Culvert crossings were included into the hydraulic model using the survey data collected as part of this project and from as-built plans. Boundary conditions were inserted based on their apparent outfall locations within the survey data. The goal of the Hydraulic Evaluation is to examine the effectiveness of steps already taken within the watershed, and to evaluate the potential for future flooding issues within the watershed.

Effectiveness of Implemented Projects

The purpose of evaluating past conditions is to evaluate the reduction in flood risk which has been achieved through the construction of the new culvert along Chestnut and the 23rd street detention cell. This condition was modeled using the existing conditions peak flow rates assuming no attenuation at the 23rd Street Detention Cell, and the old 6'x6' concrete box culvert along North Chestnut.

These results were overlayed with the hydraulic model for the current conditions to provide a qualitative evaluation as to the effectiveness of the implemented projects. In all cases, the implemented improvements have shown a significant improvement in flood risk throughout the study area. Modeling predicted that on average water surface elevations between 23rd street and North Chestnut were reduced by 0.4 ft for the 10-year event, and 0.7 feet for the 100-year event. Despite those reductions, under existing conditions, modeling indicates that the 100-year event throughout this area has the potential to impact adjacent private property though the severity and extent of these impacts have been reduced.

Comparison Figures for the 10-Year and 100-Year storms are provided in Appendix A.

Future Conditions

Future condition modeling provides an estimate of what future flood risk could be like within the study area if no mitigation actions to prevent peak flow increases are taken as development occurs. This was modeled in HEC-RAS by using the current conditions on site but updating the flow rates to reflect the full build out conditions.

Hydrologic results indicate that through the reach between 23rd Street and North Chestnut, full build out will only minimally affect peak flow rates, however this results in minor water surface elevation rises along the corridor and could result in adverse impacts to adjacent landowners.

RECOMMENDATIONS

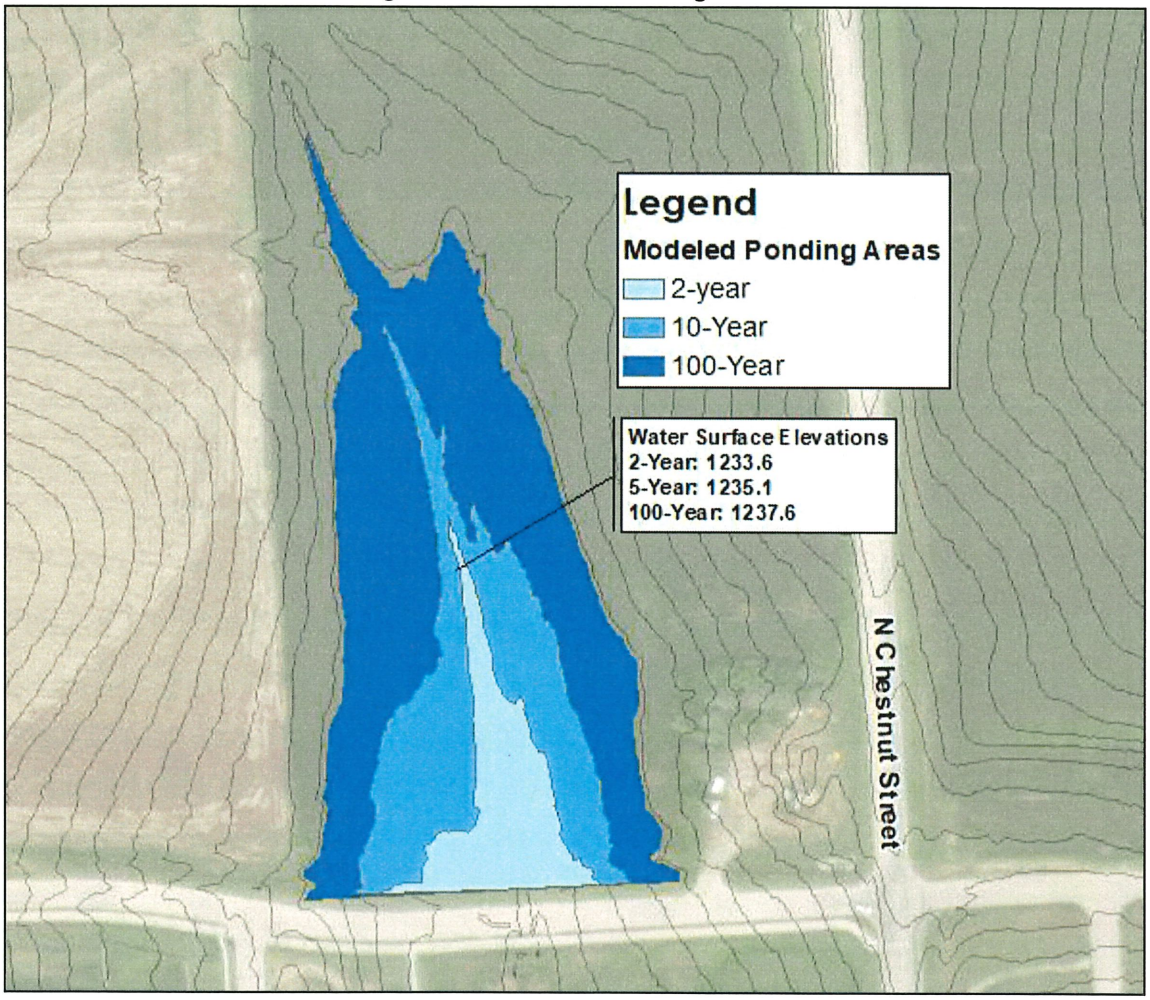
Based on the results of the Hydraulic Model some residual flood risk still exists within the study area. Under current conditions approximately four homes appear to be at risk of flooding impacts for the 100-year event, and two homes for 10-year event. As mentioned, the previously constructed project has a significant impact on reducing flood risk throughout the study area.

Recommendation 1 – Maintain Flood Easement at the 23rd Street Detention Structure

As tabulated in Tables 5 and 6, the 23rd Street Detention Structure significantly reduces peak flows downstream of 23rd street for all design storms. It is recommended that the flood pool of this structure be maintained as a flood easement. During our site design, it was noted that the flood pool is being used as agricultural land and as a result, areas of the initial flood pool appear to have been filled or silted in.

It is recommended that the city plant this area in a grass and maintain it on a regular basis through mowing and trash/sediment removal as warranted. In addition to maintaining this flood easement, its also recommended that future development within the watershed adhere to the drainage criteria standards set forth by Wahoo, namely that proposed development must demonstrate that peak flows after development do not exceed pre-development conditions. Figure 2 depicts the high-water elevations for the 2-year, 10-year, and 100-year events.

Figure 2 – Modeled Ponding Areas



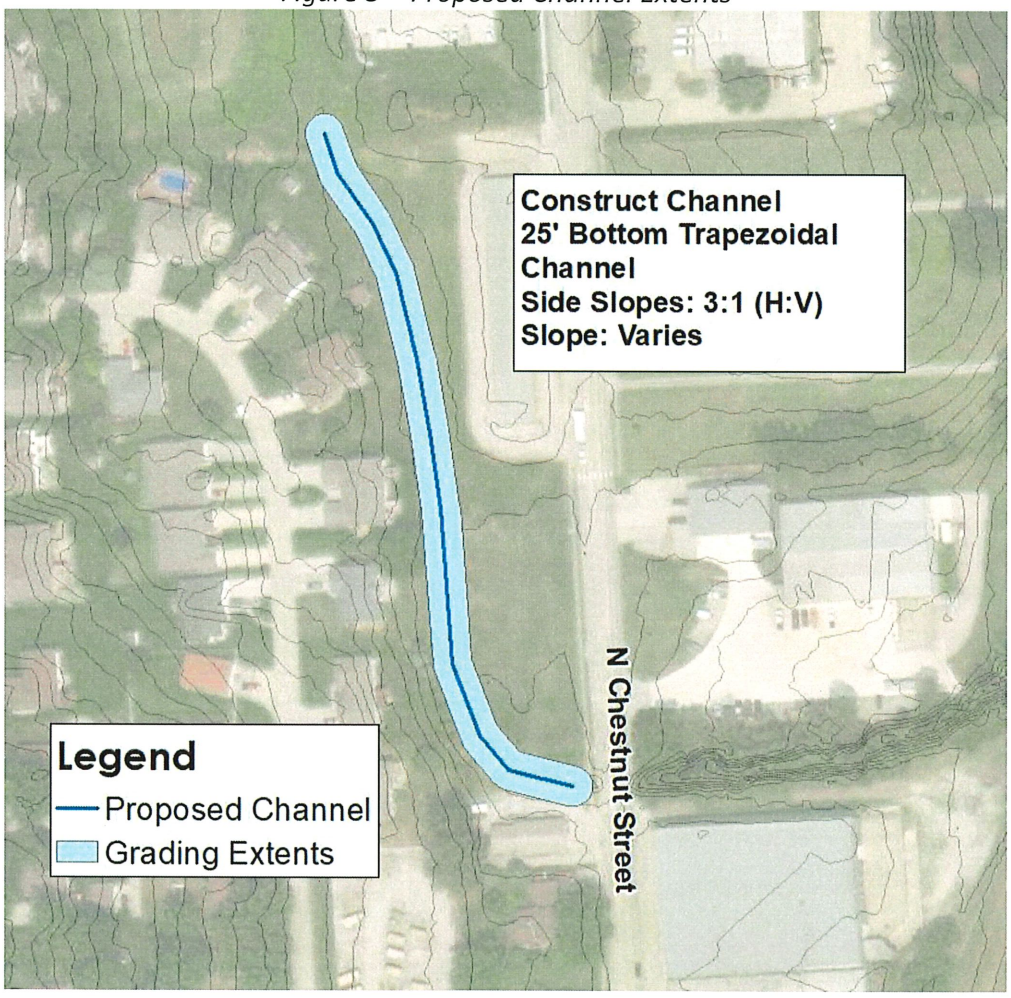
Recommendation 2 – Construct Drainage Swale Upstream of Chestnut St.

The recommended channel is a 25-foot bottom trapezoidal channel with 3:1 side slopes and a longitudinal slope that varies. At the upstream extent of the project, the flowline should be dropped approximately 0.5 ft. Due to an existing sanitary sewer, care should be taken to ensure that operating of this sewer be maintained and protected from adverse impacts in the future. The cost opinion for this project includes costs for Sewer Main Grade Protection as well as Grade Control Structures along the proposed alignment.

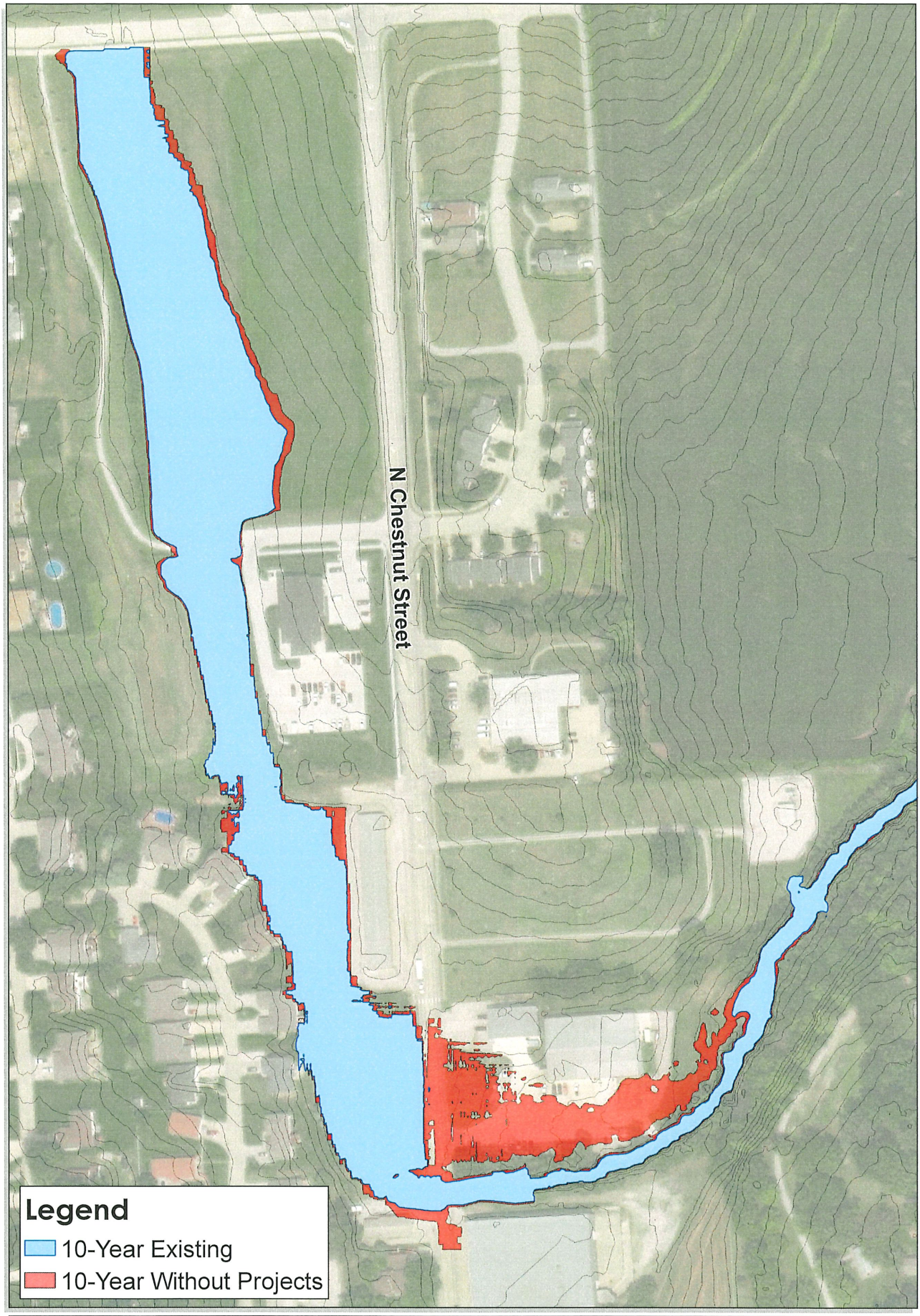
If constructed this project results in significantly less ponding area for the 10-year event and eliminates structural flooding for the 100-year event. Figure 3 depicts the extent of the Proposed Grading. Detailed Cost Opinion is in Appendix C.

Estimated Cost: $634,000

Figure 3 – Proposed Channel Extents



APPENDIX A
PAST PROJECT PERFORMANCE



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Revised: 03/09/2022
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Past Project Effectiveness - 10-Year

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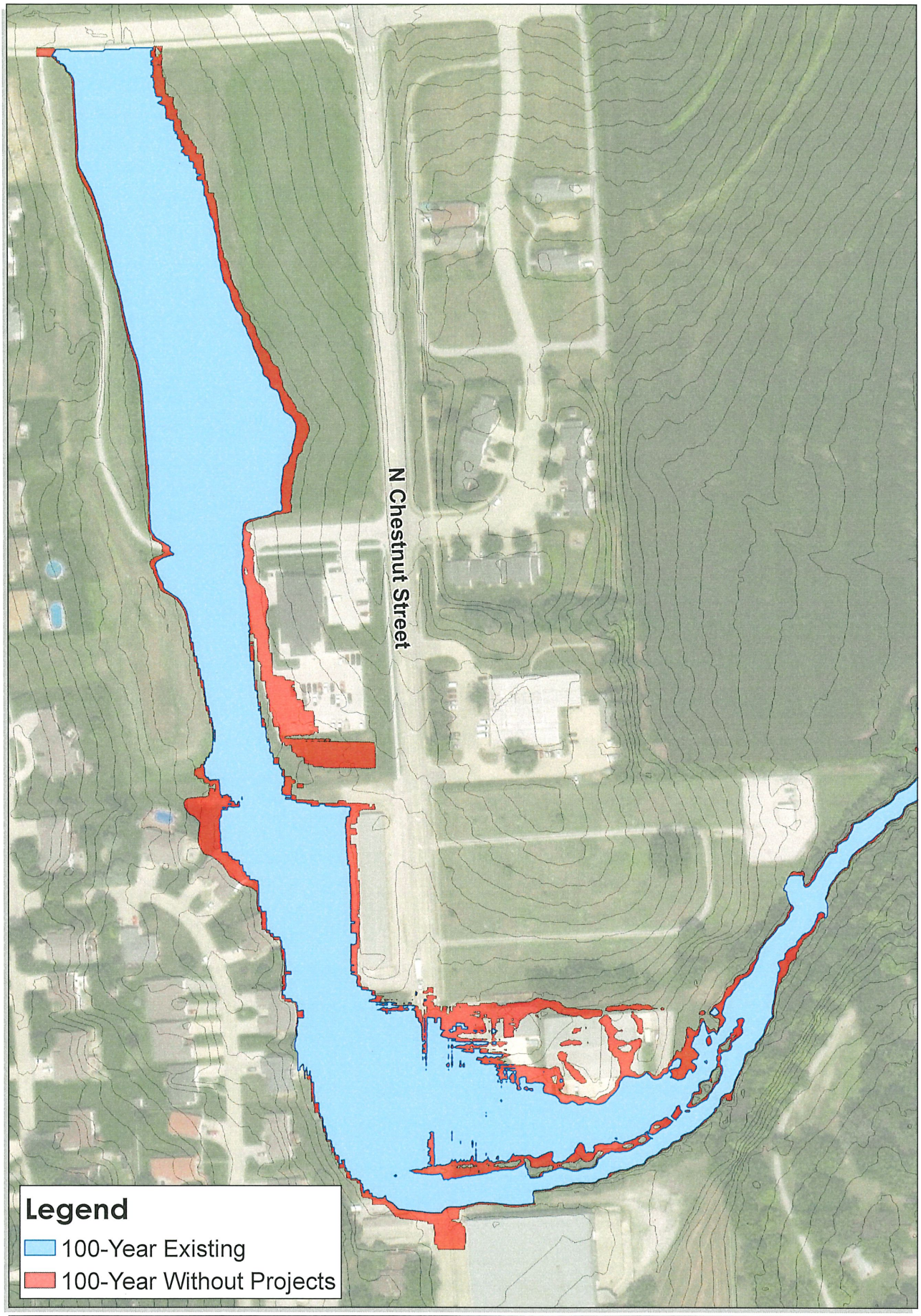

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Past Project Effectiveness - 100-Year

Wahoo North Basin Evaluation

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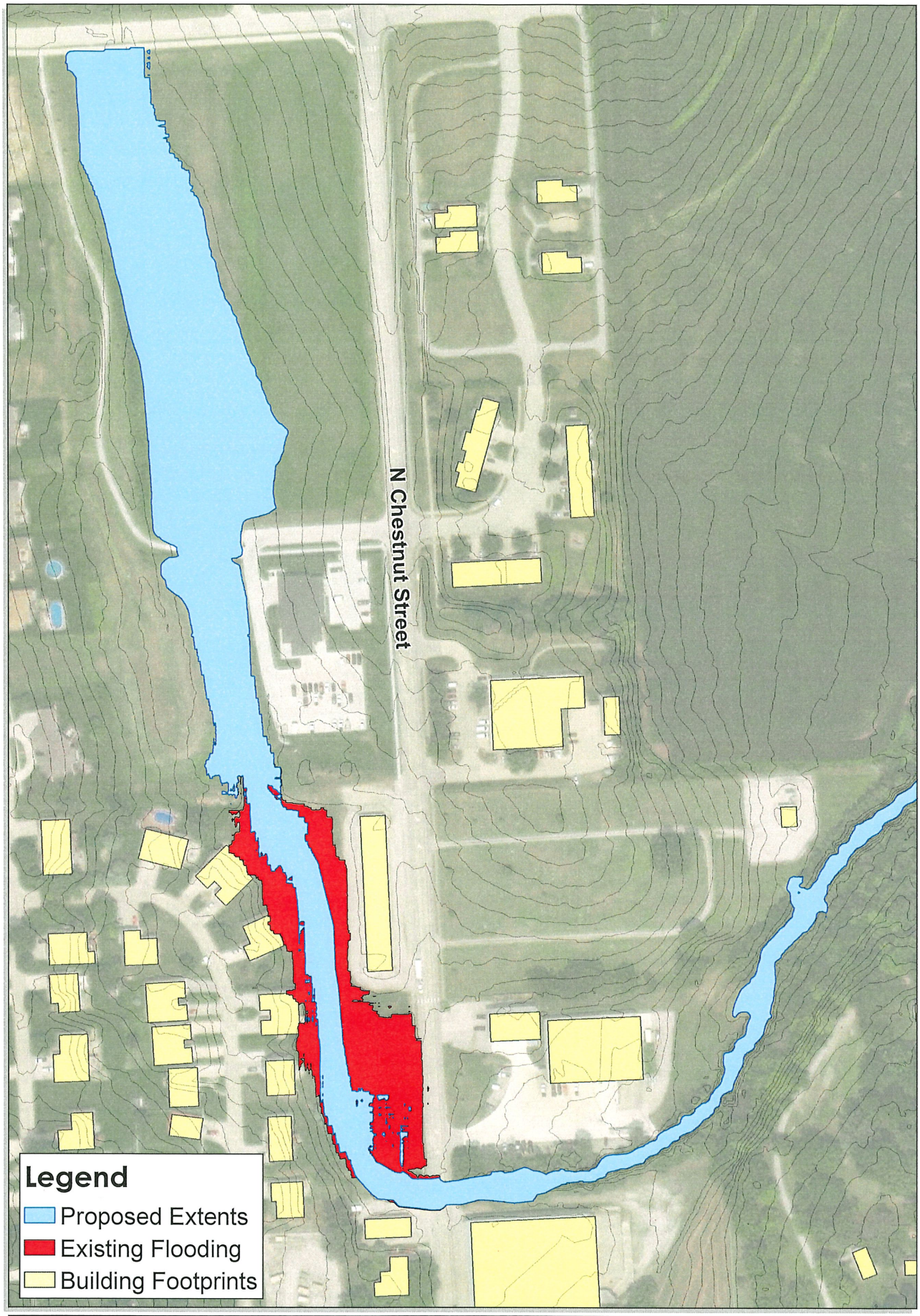
APPENDIX B
PROPOSED PROJECT CONDITIONS



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Proposed Conditions - 10-Year

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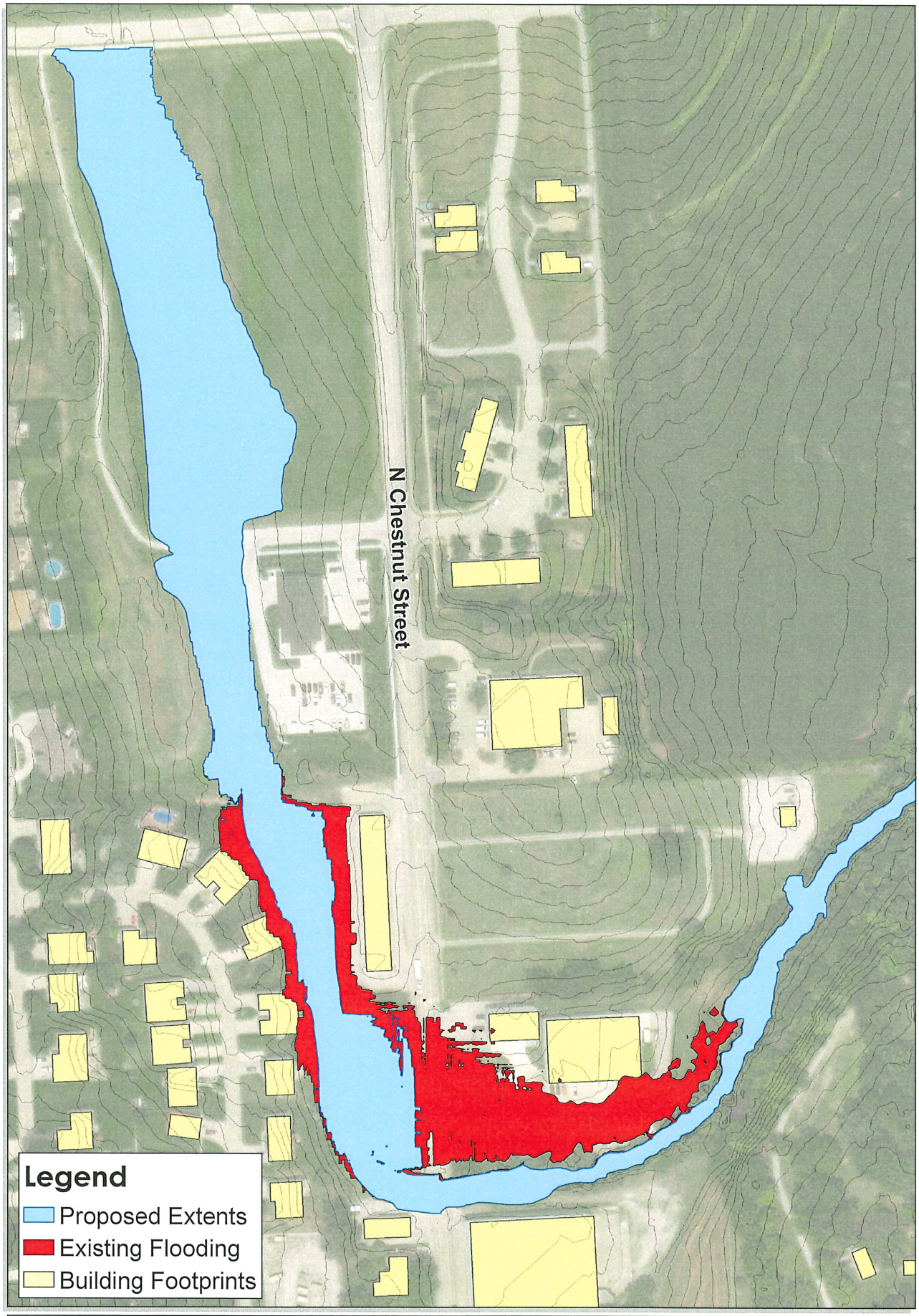

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Proposed Conditions - 100-Year

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APPENDIX C
OPINION OF COST

ENGINEER'S OPINION OF PROBABLE COST - CONCEPTUAL DESIGN

North Study Area Drainage Improvements

Wahoo, Nebraska

Date Prepared:

JEO Project No. 211821.00

June 9, 2022

ESTIMATE OF QUANTITIES

Item #	Description	Unit	Quantity	Unit Price	Total
MR-02					
1.	Mobilization	LS	1	$ 31,000.00	$ 31,000.00
2.	Bonding and Insurance	LS	1	$ 11,000.00	$ 11,000.00
3.	Clearing & Grubbing	LS	1	$ 3,500.00	$ 3,500.00
4.	Channel Excavation	CY	2,700	$ 20.00	$ 54,000.00
5.	Excavation Spoils Disposal	CY	1,500	$ 5.00	$ 7,500.00
6.	Grade Control Structures	EA	1	$ 100,000.00	$ 100,000.00
7.	Sewer Main Grade Protection	EA	2	$ 50,000.00	$ 100,000.00
8.	Storm Sewer Discharge	EA	1	$ 20,000.00	$ 20,000.00
9.	Utility Adjustment or Relocation (Allowance)	LS	1	$ 50,000.00	$ 50,000.00
10.	Rock Rip Rap	TONS	400	$ 130.00	$ 52,000.00
11.	Seeding & Erosion Control	AC	2	$ 7,000.00	$ 14,000.00
			Construction Subtotal	Base Bid	$ 443,000.00
			Contingency	30%	$ 133,000.00
			Total Opinion of Construction Cost		**$ 576,000.00**
NON-CONSTRUCTION ITEMS					
1.	Design Services (Engineering, Survey, Cons. Admin.)			10%	$ 58,000.00
				Subtotal	$ 58,000.00
				Total Opinion of Project Cost	**$ 634,000.00**

JEO Consulting Group Inc.'s (JEO) Opinions of Probable Cost provided for herein are to be made on the basis of JEO's experience and qualifications and represent JEO's best judgment. However, since JEO has no control over the cost of labor, materials, equipment, or services furnished by others, or over the Contractor's methods of determining prices, or over competitive bidding or market conditions, JEO cannot and does not guarantee that proposals, bids, or actual construction cost will not vary from Opinions of Probable Cost prepared by JEO.