Final Report

HEC-RAS Two-Dimensional Modeling: Lake Wausau, Wisconsin River and Tributaries Big Rib River and Eau Claire River

City of Schofield, City of Wausau, Town of Rib Mountain, and Village of Rothschild, in Marathon County, Wisconsin

US Army Corps of Engineers
St. Paul District

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Executive Summary

The Lake Wausau Association has been working on ways to improve the water quality and fish habitat of the lake. The Corps of Engineers agreed to analyze the flow in Lake Wausau and model alternatives to increase flows in some of the backwater channels in an effort to reduce the growth of invasive species and algae. The LWA is working on the final steps in development of a Lake Wausau Management Plan.

Lake Wausau is formed by blocking flow of the Wisconsin River by the Domtar Paper Mill Dam at Rothschild, WI. The dam is used for hydroelectric power generation for the paper mill. Flows into the lake come from the Wisconsin River, Big Rib River and the Eau Claire River Flowage. The Wisconsin River has 25 hydroelectric dams with the Wausau Dam located just upstream of the modeled area. The Brooks and Ross Dam is located on the Eau Claire River Flowage immediately upstream of the modeled area.

One specific concern is the fish habitat at the upper end of Lake Wausau above and below the County Road N Bridge over the Big Rib River. This habitat has been degrading since the replacement of the bridge in 2004 due to the change in location of the northern end of the bridge and the extension of the causeway on the southern end of the bridge that cut off one of the flow channels.

A second concern that LWA wanted examined with the hydrodynamic model was the water quality in the small channels near the golf course where the nutrient loading is high. Increased water velocity in historic backwater channels can increase the dissolved oxygen levels and potentially reduce aquatic vegetation growth due to the moving water.

The 2D modeling was performed using HEC-RAS version 5.0.3. Hydrographic survey data was received from the University of Wisconsin Steven's Point and the Wisconsin Department of Transportation and its contractors. Marathon County, WI LiDAR data was obtained and used for above water elevations. A digital elevation model was created from the bathymetric and topographic data and used for the terrain of the 2D model. Manning's n values were based on Wiscland 2 land cover data from the Wisconsin Department of Natural Resources and aquatic plant mapping data provided by the LWA.

Hydrographic flow data was obtained from the USGS for the gaging station upstream of Lake Wausau on each river and transferred downstream using appropriate methods detailed in the report. The hydraulic model was unable to be calibrated to water surface elevation data at the Domtar Dam downstream boundary (Wisconsin River at Rothschild) because the stage data was made available too late into the project. This modeling and results are intended to look at relative differences between existing conditions and the modeled scenarios. In an attempt to reduce model run times, the transferred hydrographs were spliced down to a shorter time window by removing parts of the hydrograph data from September 2016. A rating curve at the Domtar Dam was used for the downstream boundary.

The model was built only using 2D geometry components. Lake Wausau was modeled as one large 2D area with a maximum cell size of 50 feet. Near any proposed project features a smaller cell size was used to capture the detail and the complex hydrodynamics near abrupt changes in flow patterns.

There were four 2D area connections defined in Lake Wausau. The 2D area connections served like weirs and represented the Country Club with 5 existing, un-gated culverts; Country Road N over the Big Rib River, a proposed jetty alongside the Eau Claire River as it enters Lake Wausau; and high ground on the right (south) bank immediately downstream of the US Hwy 51 bridge over the Big Rib River.
The modeling was broken up into two main areas; the Big Rib River area and the Eau Claire River and Country Club area.

Proposed alternatives at the Big Rib River area included placing a box culvert through the County Road N

embankment to connect a historic flow path that was cut off when the bridge was reconstructed. A box culvert was also modeled through the high ground just downstream of US Hwy 51 to provide flow to backwater channels. Dredging options were also modeled in the backwater channels and the main Big Rib River channel.

Proposed alternatives at the Eau Claire River area included the construction of a 1,400 feet long jetty along the Eau Claire River channel following naturally high ground along the left (south) bank as it makes its way towards the centerline of the Wisconsin River. Different culvert options and an open channel through the jetty were modeled to look at maintaining flow in the backwater channel along the Lake Wausau shoreline between the Eau Claire River and the Country Club Road. Dredging options were also modeled of the Eau Claire River and specific backwater channels between the Eau Claire River and the Country Club Road.

The modeled scenarios show the relative impacts of the proposed alternatives for habitat and water quality improvement in Lake Wausau specifically for the areas where the Big Rib River and the Eau Claire River enter Lake Wausau. Overall the velocities from both existing conditions and the scenarios modeled were quite low and in many cases less than 1 ft/sec.

The scenarios modeled for the Big Rib River area reflected positive impacts in regards to increasing flows through the backwater channels referred to as upper slough, middle slough and even lower slough. Placement of the box culvert through the County Road N embankment did show flow being conveyed through the pipe however, the flows were lower than hoped and with the very low velocities may not be able to maintain a channel.

The scenarios modeled for the Eau Claire River area showed some positive impacts in terms of increasing flows through the larger backwater channels between the Eau Claire River and the Country Club Road. Flows through the smaller backwater channels closer to the Country Club had minor increases. Placing the jetty with culvert alongside the Eau Claire River where it enters Lake Wausau resulted in retaining most of the flow in the Eau Claire River compared to existing conditions. Once through the culvert in the jetty the flows dropped off along the shoreline channel indicating that the flows were spreading out across the shallower water areas. It is anticipated that rate of sediment deposition in the Eau Claire River channel will decrease with a jetty in place since the jetty would block lateral transport of sediment into the channel from the south due to the blocking of wave action and prevent the Eau Claire River flows from spreading out across the shallow water towards the Country Club Road with increased velocity even though the larger velocity is still too low to transport much sediment.

Readers are reminded that the model is un-calibrated and can be used to compare relative differences between existing and proposed conditions only. The Lake Wausau system is dynamic and has a lot of factors that can change results depending upon the timing and details of a specific climatological event. The 2D hydrodynamic model is not a sediment transport or water quality model.

A holistic approach would be the best method when looking for solutions to water quality issues in Lake Wausau. Besides using the 2D model to refine alternatives and make construction decisions; a major issue that needs to be kept in mind is looking at ways to decrease nutrient load to Lake Wausau, which will be especially important in the area near the golf course and downstream of the Eau Claire River where potential changes to velocity are extremely difficult due to the nearly flat pool created by the Domtar Dam at the downstream end of Lake Wausau.

The 2D model could be converted into a sediment transport model in the future if sufficient sediment load data can be collected over a few years. A sediment transport model could examine deposition trends, evaluate impacts of dredging, and develop better informed solutions.

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CHAPTER 1.

1. Introduction

1.1 Background

Lake Wausau is formed by blocking flow of the Wisconsin River by the Domtar Paper Mill Dam at Rothschild, WI. The Domtar Dam is used for hydroelectric power generation for the paper mill. Flows into the lake come from the Wisconsin River, Big Rib River and the Eau Claire River Flowage. The Wisconsin River has 25 hydroelectric dams and the Wausau Dam is located just upstream of the modeled area. The Brooks and Ross Dam is located on the Eau Claire River Flowage immediately upstream of the modeled area.

Lake Wausau covers 1,971 acres (including 157 acres of islands) and has a volume of 12,994 acre-feet at the full pool elevation of 1160.7 ft. The maximum depth is 35.4 feet, however; the average depth is only 6.7 feet. There are many shallow areas within the lake such that 24.4 percent of the lake is less than 3 feet deep at the full pool elevation. A common circumstance of shallow lake areas are the areas of algae, emergent, submergent and floating leaf vegetation.

The longest wind fetch in the north-south direction is about 3,800 ft long and the longest wind fetch is about 7,800 ft long in the northwest to southeast direction. Longer wind fetches generally produce larger wave, results in loss of shoreline, and can affect emergent, submergent and floating leaf vegetation.

The Lake Wausau Association (LWA) works to protect, maintain, and enhance Lake Wausau and its surrounding area. Lake Wausau is a multiple use lake which includes boating and swimming recreation, hunting and fishing, hydropower generation, fish habitat and scenic appreciation.

The Wisconsin River Basin is part of a water quality improvement project being conducted by the Wisconsin Department of Natural Resources (DNR) in partnership with many organization. As part of the water quality study, Total Maximum Daily Load (TMDL) criteria is being developed. Water quality issues in Lake Wausau include high phosphorus levels, suspended solids, areas of low dissolved oxygen and algal blooms, which contribute to concerns for human health, damaged fish and aquatic life, impaired water quality, and decreases in tourism.

The LWA is leading an evaluation project of the lake with plans to complete the project and develop a management plan by early 2018. Other project partners are the DNR, University of Wisconsin - Steven's Point (UW-StP), Golden Sands Research Conservation and Development, USACE, and local municipalities.

The role of USACE in this project was to conduct two-dimensional hydrodynamics modeling of Lake Wausau to look at velocities within different areas of the lake and develop alternatives for improvement of fish habitat and water quality. One specific concern is the fishery habitat at the upper end of Lake Wausau above and below the County Road N Bridge over the Big Rib River. This habitat has been degrading since the replacement of the bridge in 2004 due to the change in location of the northern end of the bridge and the extension of the causeway on the southern end of the bridge that cut off one of the flow channels. A second concern that LWA wanted examined with the hydrodynamic model was the water quality in the small channels near the golf course where the nutrient loading is high. Increased water velocity in historic backwater channels can increase the dissolved oxygen levels and potentially reduce aquatic vegetation growth due to the moving water.

1.2 Project Location and Study Area

The study area is within Lake Wausau. The southern end of the modeling is at the Domtar Dam on the Wisconsin River in Rothschild. The eastern end of the model is immediately downstream of the Brooks and Ross Dam on the Eau Claire River Flowage at Schofield. The western limit of the model is on the Big Rib River at the US Hwy 51 Bridge near Rib Mountain and Wausau. The northern limit of the model is just downstream of the Wausau Dam and Whitewater Park in Wausau. The study area is shown in Figure 1-1.

Figure 1-1 – Overview of the Modeling Study Area

1.3 Purpose and Need

The role of USACE in this project was to conduct two-dimensional hydrodynamics modeling of Lake Wausau to look at velocities within different areas of the lake and develop alternatives for improvement of fish habitat and water quality. One specific concern is the fishery habitat at the upper end of Lake Wausau above and below the County Road N Bridge over the Big Rib River. This habitat has been degrading since the replacement of the bridge in 2004 due to the change in location of the northern end of the bridge and the extension of the causeway on the southern end of the bridge that cut off one of the flow channels. A second concern that LWA wanted examined with the hydrodynamic model was the water quality in the small channels near the golf course where the nutrient loading is high. Increased water velocity in historic backwater channels can increase the dissolved oxygen levels and potentially reduce aquatic vegetation growth due to the moving water.

CHAPTER 2.

2. Methods

2.1 Data Collection

2.1.1 Flow and Stage Gage data

Water surface elevation data and flow records are important pieces of data for both the construction and calibration of a hydraulic model. The United States Geological Survey (USGS) collects water surface elevation at established gaging stations which can be converted to a continuous record of discharge or streamflow by maintaining a stage-discharge relationship for each gage location through the periodic measuring of discharge at that location (Olson & Norris, 2007). A summary of the available gage locations operated by the USGS within the model study area is shown in Table 2-1. The table summarizes the gage ID, gage title, river and location description, the types of available data, and the years of record for the gage. Figure 2-1 shows the locations of the USGS gages available for the modeling.

Table 2-1 – Streamflow Gages utilized in the Project Area

USGS Gage	Gage Description	Drainage Area (Sq. Mi.)	Period of Record
05395000	Wisconsin River at Merrill, WI	2,760	1902-Present
05396000	Big Rib River at Rib Falls, WI	303	1925-1957, 2009-Present
05397500	Eau Claire River at Kelly, WI	375	1914-1926, 1939-Present
05398000	Wisconsin River at Rothschild, WI	4,020	1944-Present

The USGS gage on the Big Rib River at Rib Falls is the closest gage to the project area however, it is located about 20 miles upstream of Lake Wausau. The USGS gage on the Wisconsin River at Merrill is the USGS gage upstream of the project are however, that gage is also located about 20 miles upstream of Lake Wausau. The USGS gage on the Eau Claire River at Kelly is only 4.5 miles upstream from the mouth (Lake Wausau). The USGS gage at Rothschild is at the very downstream end of the modeling area and can be used to check the model calibration of flows through Lake Wausau. Table 2-2 below shows the locations of the rivers at the upstream modeling limits and the drainage area for comparison to the gages shown above. These inflow locations can be seen at the northern, western and eastern limits of the modeling area shown in Figure 1-1 and correspond to the Wisconsin River, Big Rib River, and Eau Claire River, respectively. The gage locations in relation to the modeled area can be seen in Figure 2-1.

Table 2-2 – Upstream River Inflow Locations utilized in the Project Area

Model Limit	Drainage Area (Sq Mi.)
Wausau River at Wausau Dam	3,060
Big Rib River at Wausau / Rib Mountain	495
Eau Claire River at Schofield	431

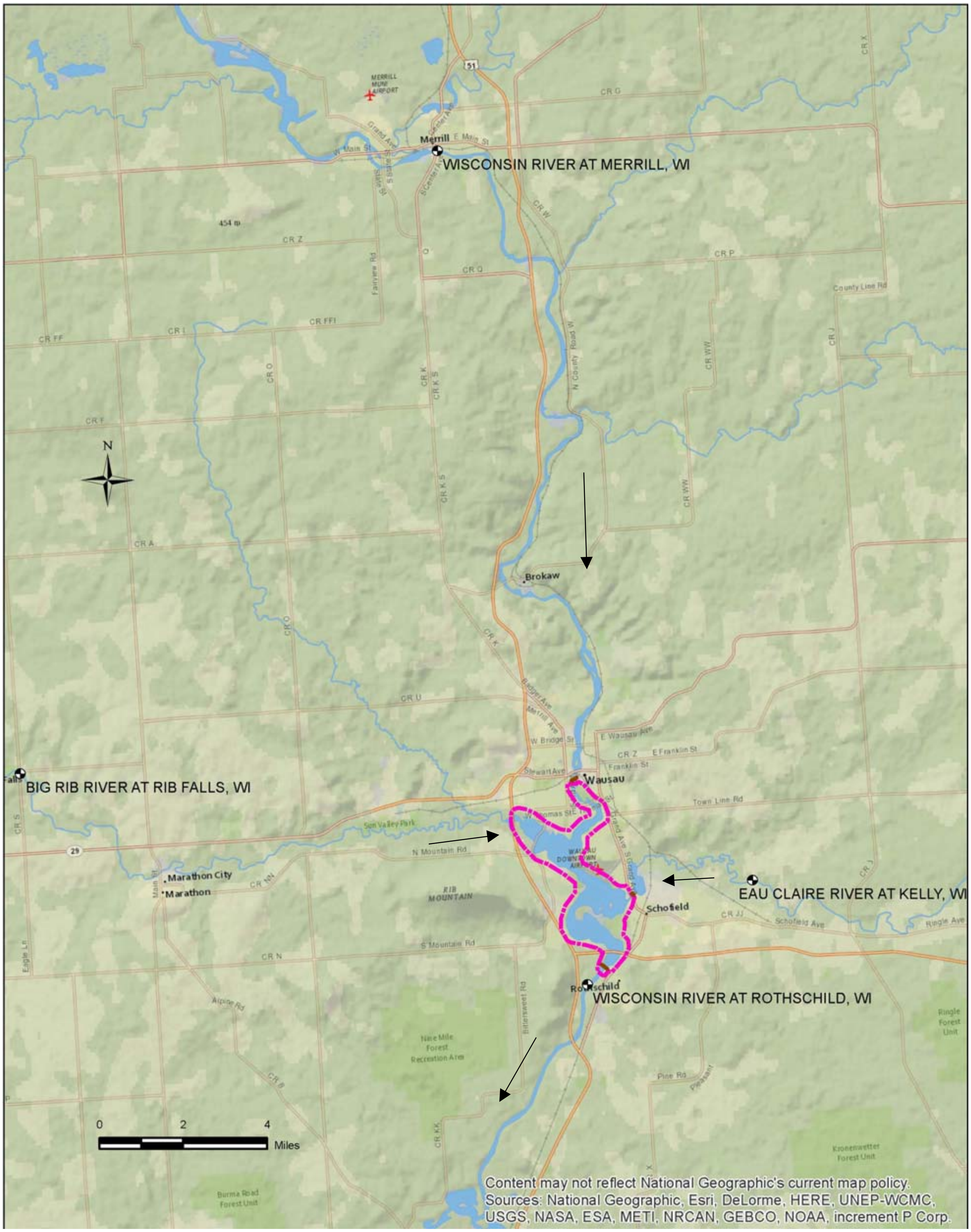

Figure 2-1 – USGS Gages near the Modeling Study Area

The flow data obtained from the upstream USGS gages had to be transferred downstream to Lake Wausau. The USGS report, Flood-Frequency Characteristics of Wisconsin Streams (Walker and Krug, 2003) was consulted to determine the appropriate drainage area transfer relationships. The state of Wisconsin is divided into five flood-frequency areas based on the appropriate regression equations for different basin characteristics. The Big Rib River watershed was located in area in Area 2 where the parameters in the regression equations were only drainage area, soil permeability and slope. The Eau Claire River watershed was located in Area 3 where the parameters in the regression equations were drainage area, soil permeability, percent storage and the precipitation index.

Table 2-3 (Walker p. 10) shows the regression equations, where Q is flow in cfs for the recurrence interval (subscript), A is the drainage area (square miles), SP is soil permeability (inches/hour), S is main-channel slope (feet/mile), ST is storage (percent), and I is the precipitation index, calculated as the 25-year, 24-hour precipitation intensity in inches minus 4.2.

Table 2-3 – Regression Equations for Flood-Frequency Estimates

Best-fit equation						SE	ESE	Eq. no.
Area 2 (36 stations)								
Q_2	=	$13.0\,A^{0.884}$	$SP^{-0.630}$	$S^{0.382}$		.1091	25	2-1
Q_5	=	$15.4\,A^{0.900}$	$SP^{-0.682}$	$S^{0.486}$		.1086	25	2-2
Q_{10}	=	$16.3\,A^{0.910}$	$SP^{-0.710}$	$S^{0.541}$		.1086	25	2-3
Q_{25}	=	$17.3\,A^{0.922}$	$SP^{-0.740}$	$S^{0.600}$		.1100	26	2-4
Q_{50}	=	$17.9\,A^{0.929}$	$SP^{-0.758}$	$S^{0.636}$		.1118	26	2-5
Q_{100}	=	$18.3\,A^{0.936}$	$SP^{-0.775}$	$S^{0.669}$		.1153	27	2-6
Area 3 (57 stations)								
Q_2	=	$36.5\,A^{0.832}$	$SP^{-0.614}$	$ST^{-0.143}$	$I_{25}^{0.124}$	.1591	37	3-1
Q_5	=	$61.6\,A^{0.827}$	$SP^{-0.683}$	$ST^{-0.169}$	$I_{25}^{0.133}$	.1470	34	3-2
Q_{10}	=	$80.6\,A^{0.825}$	$SP^{-0.713}$	$ST^{-0.186}$	$I_{25}^{0.135}$	.1449	34	3-3
Q_{25}	=	$107.0\,A^{0.821}$	$SP^{-0.743}$	$ST^{-0.204}$	$I_{25}^{0.136}$	.1439	34	3-4
Q_{50}	=	$127.0\,A^{0.819}$	$SP^{-0.761}$	$ST^{-0.215}$	$I_{25}^{0.136}$	.1446	34	3-5
Q_{100}	=	$149.0\,A^{0.818}$	$SP^{-0.775}$	$ST^{-0.227}$	$I_{25}^{0.136}$	.1466	34	3-6

Flood-frequency statistics and basin characteristics at the four USGS gage sites were provided in tables of the report. The drainage area transfer method consisted of solving the regression equations for the downstream site (at Lake Wausau) and the gaged site. Then an adjustment ratio was calculated based on a comparison relationship between the actual flood-frequency statistics at the gage and the regression equation values. As long as the size of the drainage area between the downstream site and the gage did not differ by more than 150% then the adjustment ratio was used. Note that for the Big Rib River at Lake Wausau the drainage area of 495 square miles was more than 150% of the gage drainage area of 303 square miles so the regression equation values could be used without applying the adjustment ratio.
The Wisconsin River has 25 hydroelectric dams that regulate the flow on the river. The report provided tables of the flood-frequency statistics for both of the Wisconsin River gages. The report also included a graph showing the relationship between drainage area and flood-frequency data on the Wisconsin River. Because of the regulated nature of the Wisconsin River, the normal regression equations were not applicable to the Wisconsin River below the Wausau Dam. The graph was used to determine the flood-frequency data for the Wisconsin River below the Wausau Dam.

Table 2-4 provides the flood-frequency data at the gages and Lake Wausau locations, note that the data for the gages are highlighted. Whereas the non-highlighted gages are located at the inflow locations to Lake Wausau.

Table 2-4 – Flood-Frequency Data for Gage Sites and at Lake Wausau

	Drain Area (sq. mi.)	Flows for Percent Chance Exceedance (cfs)					
		50%	20%	10%	4%	2%	1%
Wisconsin River at Merrill	2,760	13,600	18,800	21,900	25,500	28,000	30,400
Wisconsin River - Wausau Dam	3,060	16,600	22,900	26,600	30,800	33,700	36,400
Wisconsin River at Rothschild	4,020	27,900	38,300	44,200	50,500	54,700	58,400
Rib River at Rib Falls	303	6,950	11,800	15,200	19,400	22,400	25,400
Big Rib River at Lake Wausau	495	10,835	18,038	22,997	29,028	33,297	37,528
Eau Claire River at Kelly	375	3,180	4,740	5,780	7,100	8,070	9,030
Eau Claire River at Lake Wausau	431	3,216	4,727	5,722	6,976	7,896	8,796

The graph from the USGS report (Walker p. 12) showing the relationship between drainage area and flow for flood-frequency data is shown below in Figure 2-2. The flow values for the Wisconsin River below Wausau Dam was determined by estimating the value from the graph below and then plotting the estimated value and adjusting so that the line for that flood frequency is a straight line between the values for Merrill (2,760 sq mi) and Rothschild (4,020 sq mi).

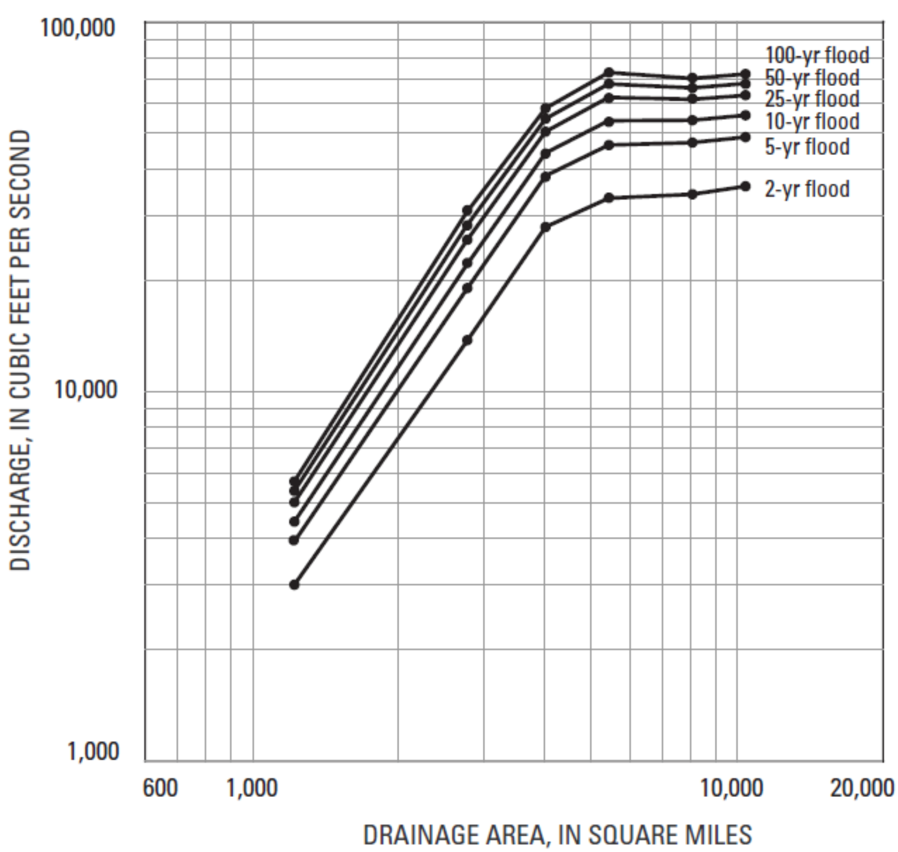

Figure 2-2 – Relationship of discharge to drainage area for selected flood frequencies along the Wisconsin River

The USGS Stream Stats online application was used to determine drainage area and basin characteristics of ungauged sites. The application was also used to obtain flow-duration data for the four USGS gages. Since the most critical time for water quality issues happens during times of low flow, the flood-frequency data wouldn't be very useful for actual 2D modeling of Lake Wausau. Flow-duration data calculates the percent of time that a specific flow is equaled or exceeded.

Flow duration statistics for the gage locations were calculated using the Stream Stats online application through the USGS website (see references). As a rough estimate of flows at the inflows to Lake Wausau the flow-frequency data was examined to determine the factor that was used to multiply the gage data by to transfer downstream for the specific stream. In general for the tributaries (Big Rib River and the Eau Claire River) the proportion of the flow that came from the tributaries increased as the total amount of flow decreased and the duration of time increased. For the lower discharges, it was assumed that the inflows could be summed to equal the flow at the Rothschild Dam. The flow-duration data is shown in Table 2-5 below.

Table 2-5 – Flow-Duration Data for Gage Sites and at Lake Wausau

	Drain Area	Flow Duration (Annual)				
	(Sq. Mi.)	95%	75%	50%	20%	10%
Wisconsin River at Merrill	2,760	1,030	1,600	2,040	3,000	4,320
Wisconsin River at Wausau Dam	3,060	1,073	1,672	2,162	3,267	4,817
Wisconsin River at Rothschild	4,020	1,200	1,900	2,500	4,100	6,420
Rib River at Rib Falls	303	18	40	67	293	688
Big Rib River at Mouth	495	46	94	157	495	1,060
Eau Claire River at Kelly	375	51	88	124	294	519
Eau Claire Flowage at Mouth	431	81	130	181	338	544

The Domtar Paper Mill Dam at Rothschild, WI is used to generate hydropower for the paper mill. There has been very limited data found regarding the operation of the dam. An internet search found an order issued September 22, 2016 by the Federal Energy Regulatory Commission (FERC) authorizing a draw down plan for a 5-week period in the fall (September to November time frame) of 2016 so that Domtar could make concrete repairs to the dam. In that order it states the normal operating parameters for background information. "Article 402 requires the licensee to operate the project in a run-of-river mode in which the reservoir surface elevation remains between 1,160.6 and 1,160.8 feet National Geodetic Vertical Datum. The author assumes this is the same as NGVD29.

There is a USGS gaging station (05398000 Wisconsin River at Rothschild, WI) located near the Domtar Dam however, it is located 0.5 miles downstream of the dam. A flow record is available from October 1944 to present. Only the most recent gage heights are available online however since these are from the downstream side of the dam they are not applicable to this study. A request for pool stage data (Lake Wausau elevations) was sent to the Domtar Dam operators, however the requested data was received in December 2017 too late to be incorporated into the project.

2.1.2 Digital Elevation Model (DEM)

The depths in Lake Wausau were surveyed with GPS tracking and sonar equipment by staff from the UW-StP in May through October 2012. Depths obtained from the surveys were subtracted from surveyed surface water elevations to obtain elevations of the bottom of the lake. This data was provided as GIS point shapefile data in the Marathon County projected coordinate system in US survey feet with a vertical datum of NAVD88 ft. ArcGIS was used to reproject the data to the Albers Equal Area projection (horizontal coordinate system), which is a USACE standard.

The overall Lake Wausau surveys conducted by UW-StP did have some missing data at the bridges over Lake Wausau. The Wisconsin Department of Transportation (DOT) was contacted to obtain bathymetric survey data collected as part of the bridge inspection program to fill in the bathymetric data gaps. Some of the bridge data sets were obtained from Ayres and Associates as contractors for the DOT. The bridge inspection bathymetric data used to supplement the bathymetry is summarized and compared to the UW-StP data in table 2-3 below. Where there was overlap in the data sets the most recent data was used. Refer to Figure 1-1 for a review of the bridge locations.

Table 2-6 – Bathymetric Data Availability at bridges in the Project Area

Bridge Location	UW-StP WSEL & Date	WI DOT WSEL & Date	Ayres WSEL & Date
WI Hwy 29 Bridge on Wisconsin River 0.5 miles US of Domtar Dam	1160.562 ft 2012		1160.36 ft 8/25/2016
Co N Bridge on Wisconsin River 6.0 miles US of Domtar Dam	1160.504 ft 2012		1160.5 ft * 8/25/2016
Co N Bridge on Big Rib River 5.0 miles US of Domtar Dam	1160.45 ft 2012	1160.47 ft 8/20/2014 1160.79 ft 8/14/2012	
US 51 / Hwy 29 Bridge on Big Rib River 5.4 miles US of Domtar Dam	1160.452 ft 2012		1163.12 ft** 9/5/2012
Business US 51 Bridge on Eau Claire River 3.9 miles US of Domtar Dam	1160.50 ft 2012	1159.86 ft 8/18/2014 1160.33 ft 8/13/2012	

* The actual water surface elevation measured at the Co N Bridge on the Wisconsin River by Ayres was 1166.13 ft. Further investigation has revealed that the benchmark elevation used to determine the water surface elevation at the Co N (Thomas St) Bridge on the Wisconsin River is erroneous resulting in all of the depth data being off. A tail water elevation of 1164.02 ft from the Wausau Dam upstream of the Co N Bridge was recorded by the dam operators on the date of Ayres' survey. The Wisconsin River flow on the date of survey was used in the preliminary FIS model for Lake Wausau (1D, steady-state) model obtained from the DNR to generate water surface profiles. The modeled water surface profiles were compared to the water surface elevation from the WI Hwy 29 Bridge survey downstream (also surveyed by Ayres on 8/25/2016) for verification. The water surface elevation on 8/25/2016 would have likely been approximately 1160.5 ft and this value was used to adjust the elevations of the survey data points.

The lake-wide UW-StP sonar and bridge inspection datasets were merged with above-low-water Light Detection and Ranging (LiDAR) data collected by Wisconsin DNR in Marathon County. These datasets have been merged for this study and a triangulated irregular network (TIN) created. This TIN was converted to a raster (grid data) using natural neighbors to create a single Digital Elevation Model (DEM) with a 5 ft grid size as shown in Figure 2-3. This DEM is used to attribute elevation data to the hydraulic model features.

The vertical datum for the DEM and hydraulic model is NAVD88, ft. The horizontal projection for the DEM and hydraulic model is USA Contiguous Albers Equal Area Conic USGS Version, GCS North American 1983 datum. The Albers projection is a USACE standard.

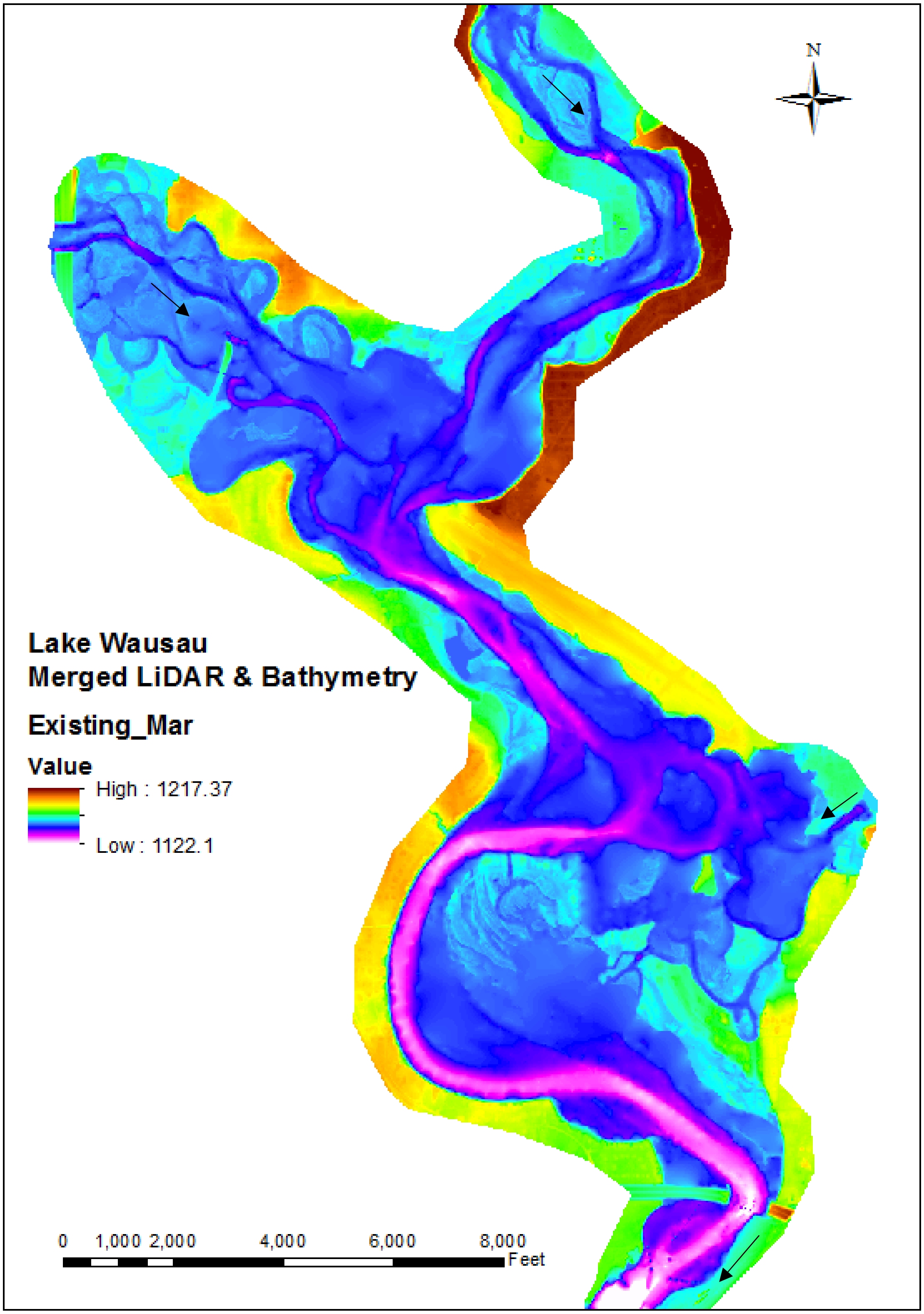

Figure 2-3 – Merged Digital Elevation Model (DEM) Constructed for the Hydraulic Model

2.2 Model Construction

The selected software for the modeling effort is HEC-RAS version 5.0.3 (USACE, 2016). This software, originally developed as a one-dimensional (1D), steady-flow hydraulic modeling software package, now has capabilities for unsteady flow, sediment modeling, and two-dimensional (2D) flow. For this effort, the software is used to construct a 2D, unsteady-flow, hydraulic river model; develop alternatives for improving velocities in backwater channels; and provide recommendations. Due to the fact that since Lake Wausau is formed by a dam across the Wisconsin River at Rothschild, WI it behaves much like a lake in terms of flow patterns. The head differential from the northern end of Lake Wausau to the southern end is very small. Therefore, a 2D model was built for the lake to look at flow currents throughout the lake instead of a 1D model of the Wisconsin River.

The terrain of the 2D mesh was taken directly from the DEM shown in Figure 2-3 in HEC-RAS. Mesh cell size was 10 feet. Boundary condition lines were created at the upstream limits of the model on the Wisconsin River (below Wausau Dam), Big Rib River (at US Hwy 51 / WI Hwy 29), and the Eau Claire River (just below the Brooks and Ross Dam). The downstream boundary condition was set at the Domtar Dam. Existing ungated culverts under Country Club Road were included in the model. Since the model was looking at lower flow ranges the large bridges across Lake Wausau were not included in the model.

2.2.1 Manning's n Values

The Wisconsin Department of Natural Resources has land cover data available online for the State of Wisconsin. From the User Guide (WDNR 2016), "*The Wiscland 2 land cover project was a collaborative effort of the Wisconsin Department of Natural Resources (WDNR), University of Wisconsin-Madison (UW), and the Wisconsin State Cartographer's Office (SCO) conducted between the fall of 2013 and August 2016.*" The database has geometric accuracy of 12 to 30-50 meters. Manning's n values were obtained by using the Wiscland 2 Land Cover data and defining corresponding Manning's n values. The land classifications found within the Lake Wausau project area are listed below. The 2D Modeling User's Manual (USACE 2016) provides guidance on Manning's n values to use for different land classifications. Table 2-7 below lists the land classification and the Manning's n values used.

Table 2-7 – Land Cover and Manning's n Values

Classification Level 2	Description	Manning's n Value
1100	Developed, High Intensity	0.15
1200	Developed, Low Intensity	0.1
2100	Crop Rotation	0.06
3100	Forage Grassland	0.06
3200	Idle Grassland	0.05
4100	Coniferous Forest	0.12
4200	Broad-leaved Deciduous Forest	0.1
5000	Open Water	0.03
6100	Floating Aquatic Herbaceous Vegetation	0.035
6200	Emergent / Wet Meadow	0.08
6300	Lowland Scrub / Shrub	0.08
6400	Forested Wetland	0.12
7000	Barren	0.04

In places where the modeling scenario had to reflect either plant harvesting or dredging, those locations were given the open water Manning's n value of 0.03. Dredging scenarios also had the actual bathymetry elevations changed to reflect the dredging. The final layout of the 2D model is shown in Figure 2-.

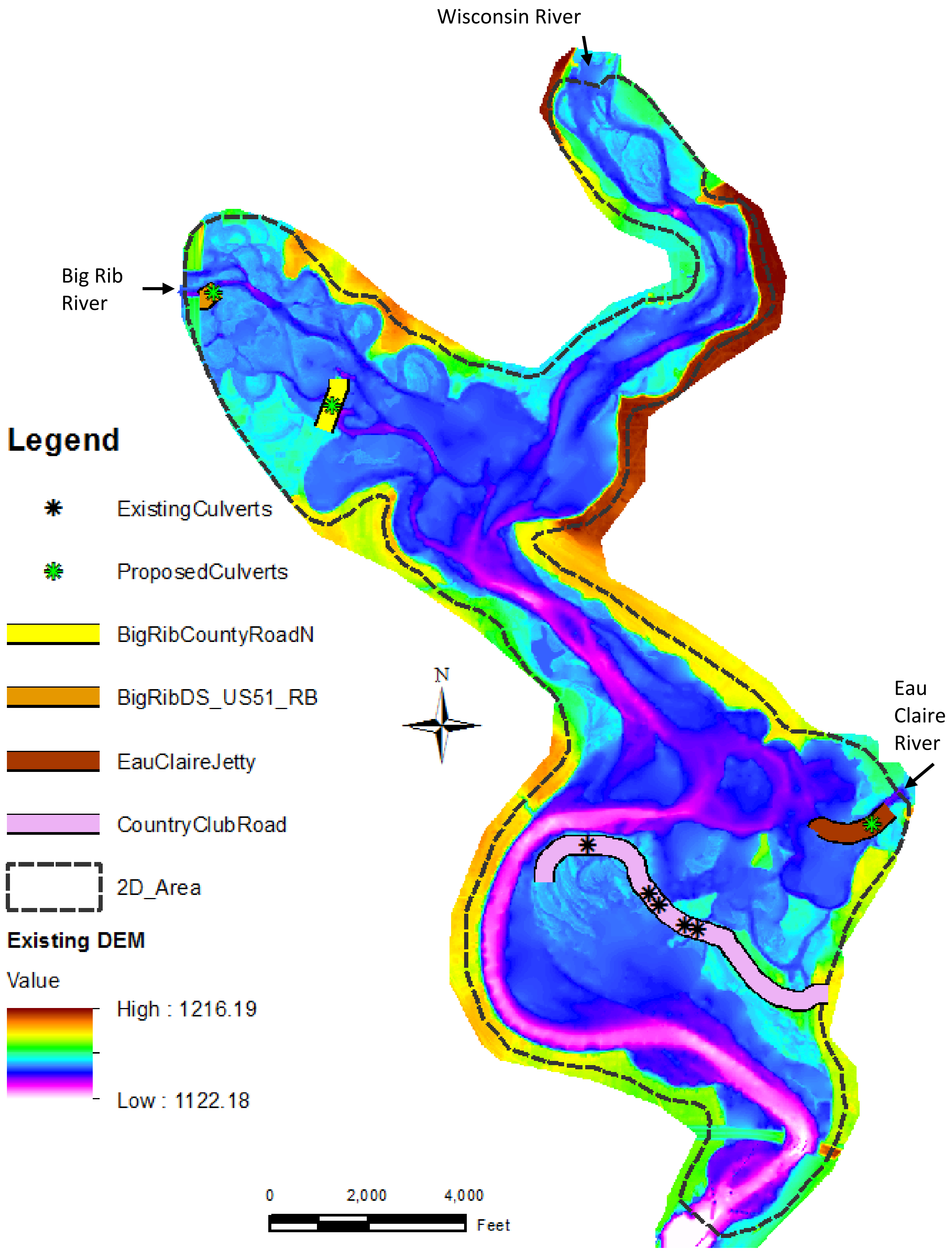

Figure 2-4 –Layout of 2D Hydraulic Model Geometry

All elevations used in the modeling effort and presented in this report are in North American Vertical Datum of 1988 (NAVD88). The conversion from the National Geodetic Vertical Datum of 1929 (NGVD29) to NAVD88 is only 0.04 feet.

2.3 Hydraulic Model Unsteady Flow Data

The hydraulic model was unable to be calibrated to water surface elevation data at the Domtar Dam downstream boundary (Wisconsin River at Rothschild) because the stage data was made available too late into the project. This modeling and results are intended to look at relative differences between existing conditions and the modeled scenarios.

Flow hydrographs were obtained online from the USGS for the four gaging stations in the project area. These flows were transferred downstream using the factors developed for the flow-duration data. The time period chosen for the 2D hydraulic model was September 2016 because in November 2016 there was a drawdown of Lake Wausau to facilitate repairs to the Domtar Dam. Possible compaction of the soils on the bottom of Lake Wausau could affect the bathymetry data used for the model.

Due to the recent flow data the values obtained were in 30 minute increments. In addition the upstream and downstream boundary conditions on the Wisconsin River are dams which don't reflect open river conditions. There is also a dam at Merrill. Because of this, a 5-period moving average was applied to the the upstream inflow hydrograph to smooth out the flows on the Wisconsin River just downstream of the Wausau Dam. The Merrill Gage is located about 20 miles upstream of Lake Wausau. By doing a visual comparison of hydrograph peaks a 1/2 day lag time was used in transferring the hydrograph downstream. The hydrographs of the Merrill Gage and just downstream of the Wausau Dam are plotted below in Figure 2-3.

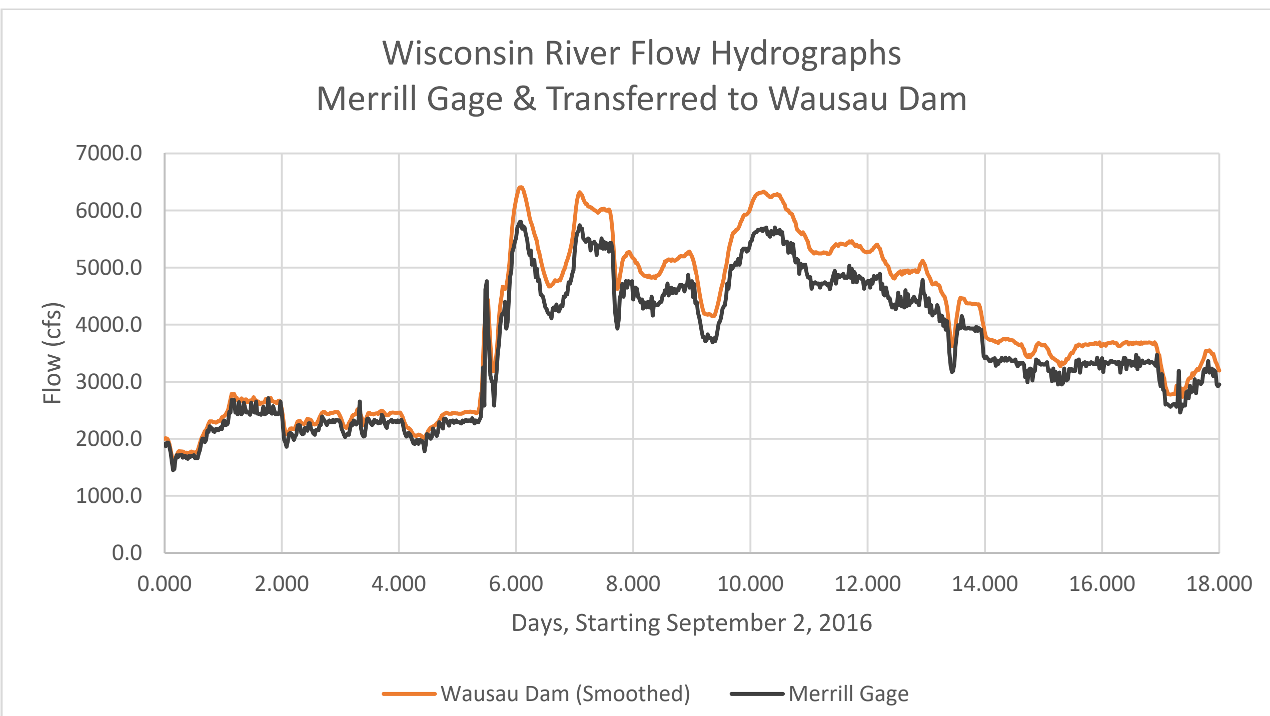

Figure 2-5 – Wisconsin River Hydrographs

The Rib Falls gage on the Big Rib River is located about 20 miles upstream of Lake Wausau. By doing a visual comparison of hydrograph peaks a 1/2 day lag time was used in transferring the hydrograph downstream. The hydrographs of the Rib Falls Gage and just downstream of the US Hwy 51 Bridge are plotted below in Figure 2-4.

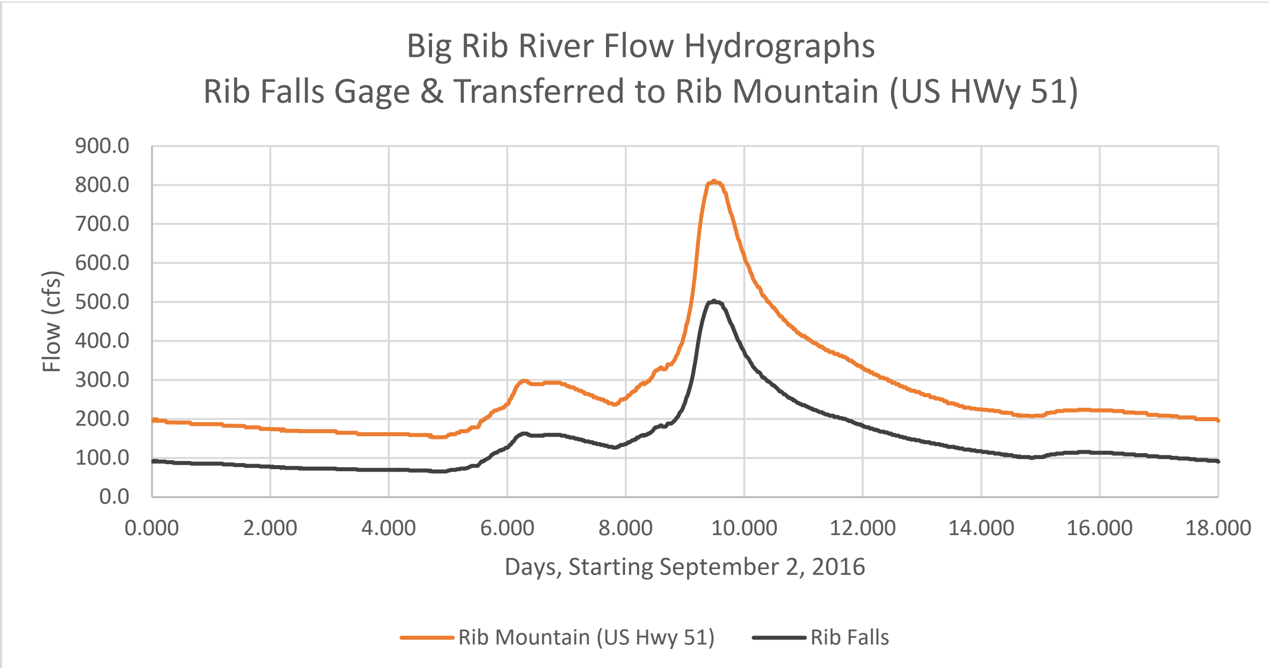

Figure 2-6 – Big Rib River Hydrographs

The Kelly gage on the Eau Claire River is only 4.5 miles upstream from the mouth at Lake Wausau. The hydrographs of the Kelly gage and just downstream of the Brooks and Ross Dam are shown in Figure 2-5.

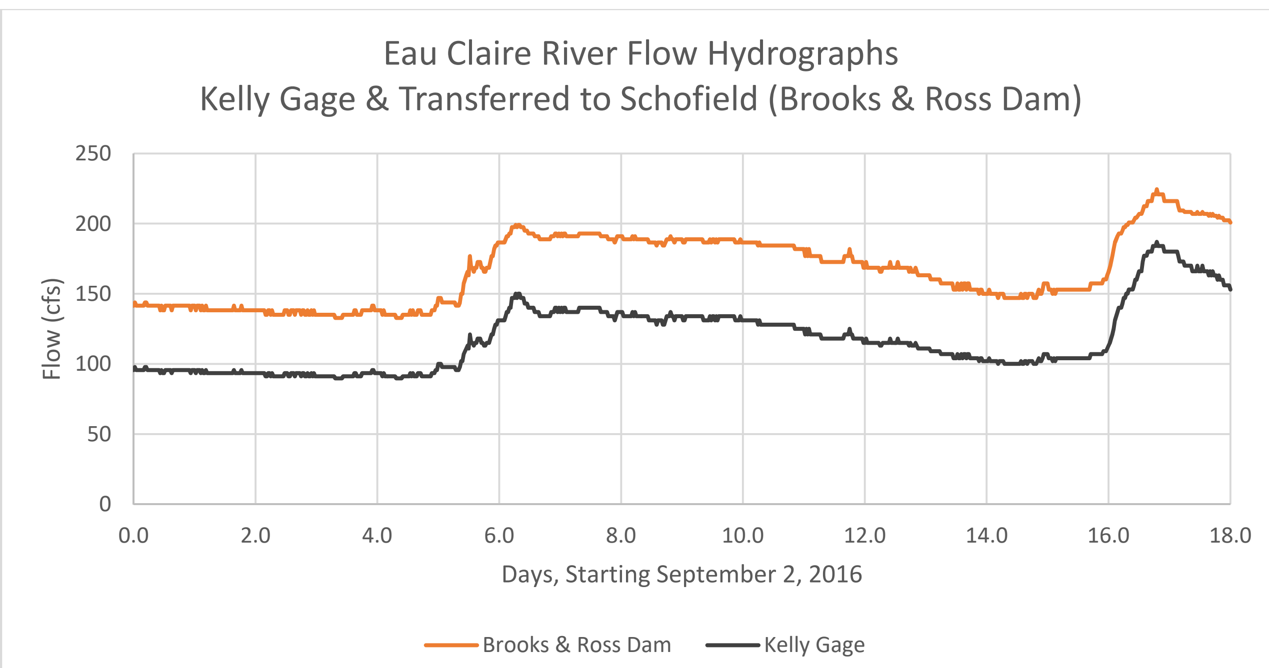

Figure 2-7 – Eau Claire River Hydrographs

Determining the impacts of alternatives proposed to alleviate the habitat and water quality problems in Lake Wausau was the focus of the modeling. September was chosen because typically the lowest flows and poor water quality in Midwestern lakes occur at the end of summer. Keeping run times reasonable in 2D modeling can be difficult depending upon the complexity of the model. The initial run times for the 18 day simulation took over 2 hours.

Since the modeling is only looking at relative impacts of the alternatives the 18 day hydrographs were cut down to 4.5 days, thereby reducing model run time to around 30 minutes. The shape of parts of the hydrograph was kept and spliced together for each inflow hydrograph and the spikes in flows were removed to improve model stability. Actual flows in each river are variable depending upon the current climatic factors and dam operation so these flows are just an example. The comparison of the full hydrograph and the spliced hydrograph for each river is shown in Figures 2-6, 2-7, and 2-8.

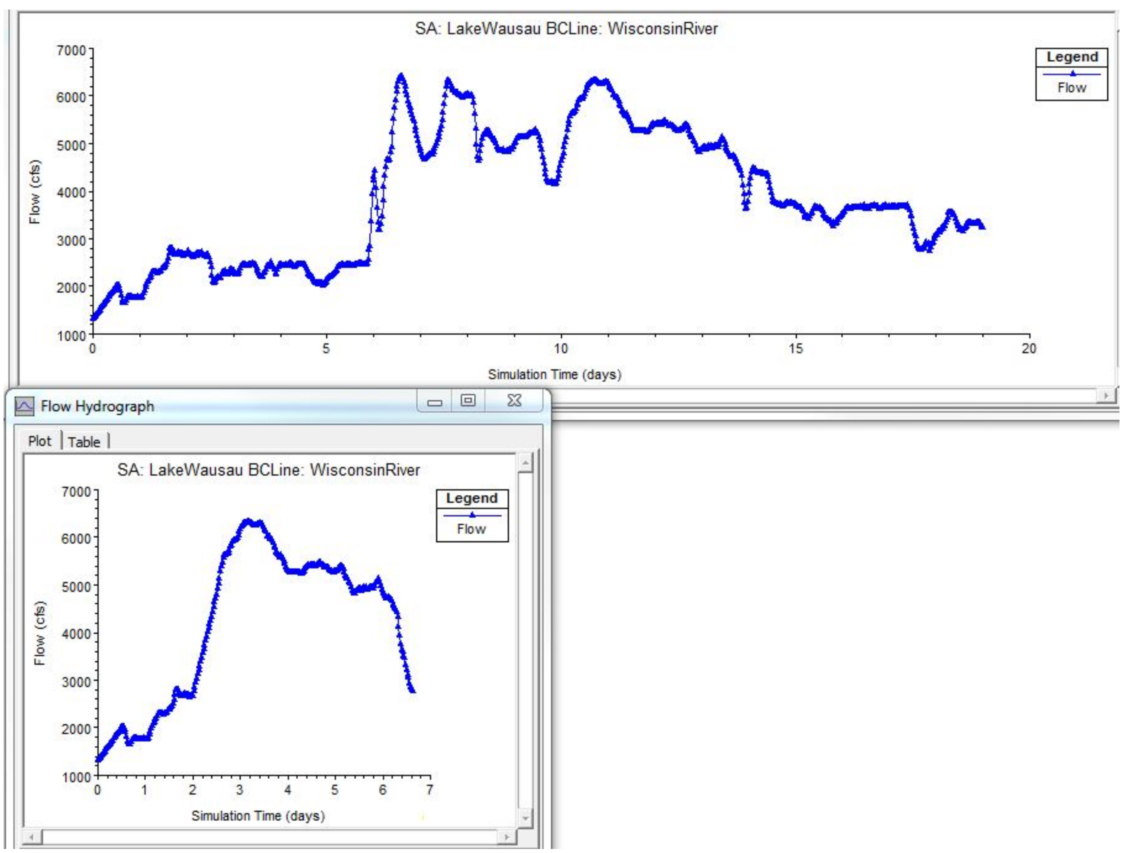

Figure 2-8 – Wisconsin River Full and Spliced Hydrographs

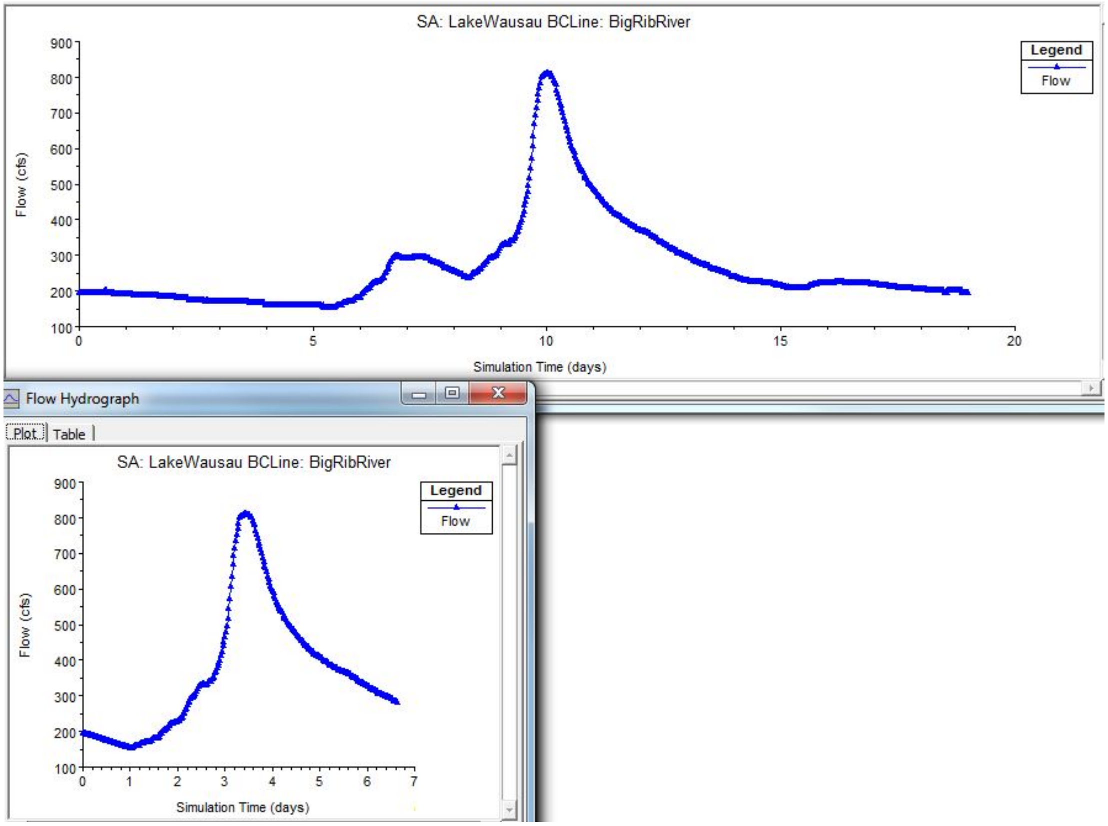

Figure 2-9 – Big Rib River Full and Spliced Hydrographs

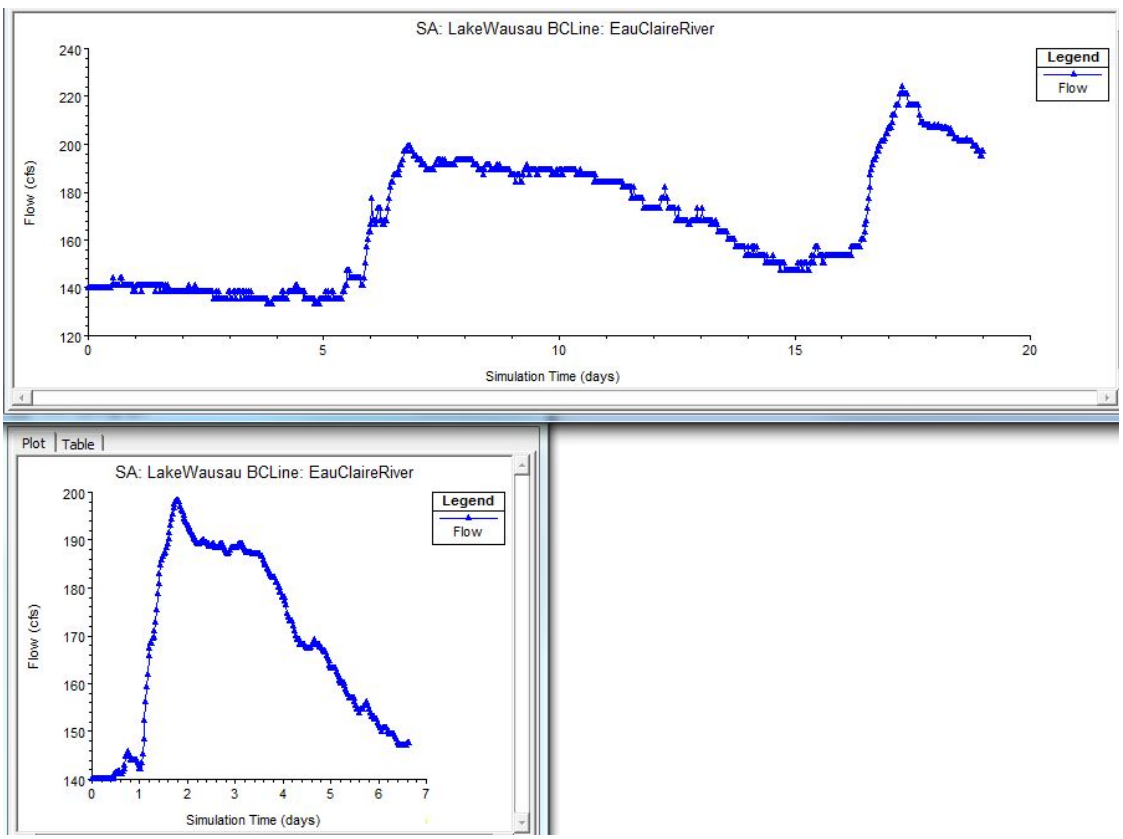

Figure 2-10 – Eau Claire River Full and Spliced Hydrographs

Since the full hydrographs were developed, the model could be calibrated at any time using the full flow hydrographs once the stage hydrograph for the pool elevation at the Domtar Dam is made available.

A rating curve was used for the downstream boundary condition at the Domtar Dam in Rothschild. The upper portion (adopted stages for 10%, 2%, 1%, and 0.2% annual chance exceedance flood events) of the rating curve was taken from the effective Flood Insurance Study (FIS) for Marathon County (FEMA 2010). The Federal Regulatory Energy Commission (FERC) requires the Domtar Paper Company to maintain the pool at the Domtar Dam (FERC Project No. 2212-049) between 1160.6 and 1160.8 ft National Geodetic Vertical Datum (Weyerhaeuser 1996). Figure 2-9 shows the downstream rating curve at the Domtar Dam pool (headwater) level (NAVD88).

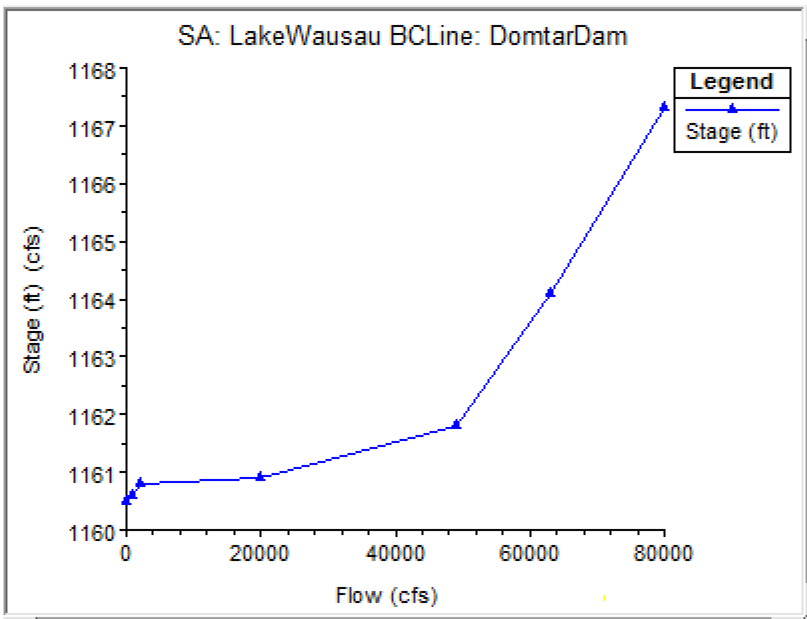

Figure 2-11 – Rating Curve Headwater at the Domtar Dam (Rothschild)

CHAPTER 3.

3. Scenarios Modeled and Results

3.1 Existing Conditions

The existing conditions scenario was the base scenario to which all alternatives were compared. The existing conditions model uses the base DEM described earlier. The goal was to keep the same geometry file for all scenarios as much as possible. During hydrodynamic calculations the terrain (DEM or DEM with dredging) is combined with the geometry data file allowing the same geometry file to be used for different scenarios. The geometry file consists of a 2D mesh (or grid), hydraulic structures (2D area connections), and Manning's n values.

There were four 2D area connections defined in Lake Wausau. The top elevations (called a "weir" in the model) of all four 2D area connections for existing conditions matched the elevations from the LiDAR data and was part of the geometry files. Some of the alternatives looked at adding culverts through embankments to connect backwater areas to each other or a tributary channel. The culverts from these alternatives were included in the embankments of the 2D area connections. The software doesn't allow for culverts to be buried and trenches had to be cut into the existing bathymetry to be able to connect the culverts to their inverts on either end.

The unsteady flow file provides the inflow hydrographs, starting water surface elevation for Lake Wausau and the downstream rating curve. For existing conditions the only culverts modeled the existing culverts under Country Club Road. The top of the "weir" on the 2D area connection filled in the trench where it crossed the connection. The bullets below summarize the scenario.

- Existing bathymetry, except for trenches for the proposed culverts (no proposed culverts)
- 2D Area Connections
    - Country Club Road: existing un-gated 5 culverts are always open
    - Big Rib River: County Road N (southern embankment)
    - Big Rib River: high ground on south side immediately downstream of US Hwy 51
    - Eau Claire River: south side high ground (Jetty) (extends west from the lakeshore)

The overall layout of the 2D Hydraulic Model geometry was provided in Figure 2-2. The following figures provide closer-up views of the 2D Area Connections defined above.

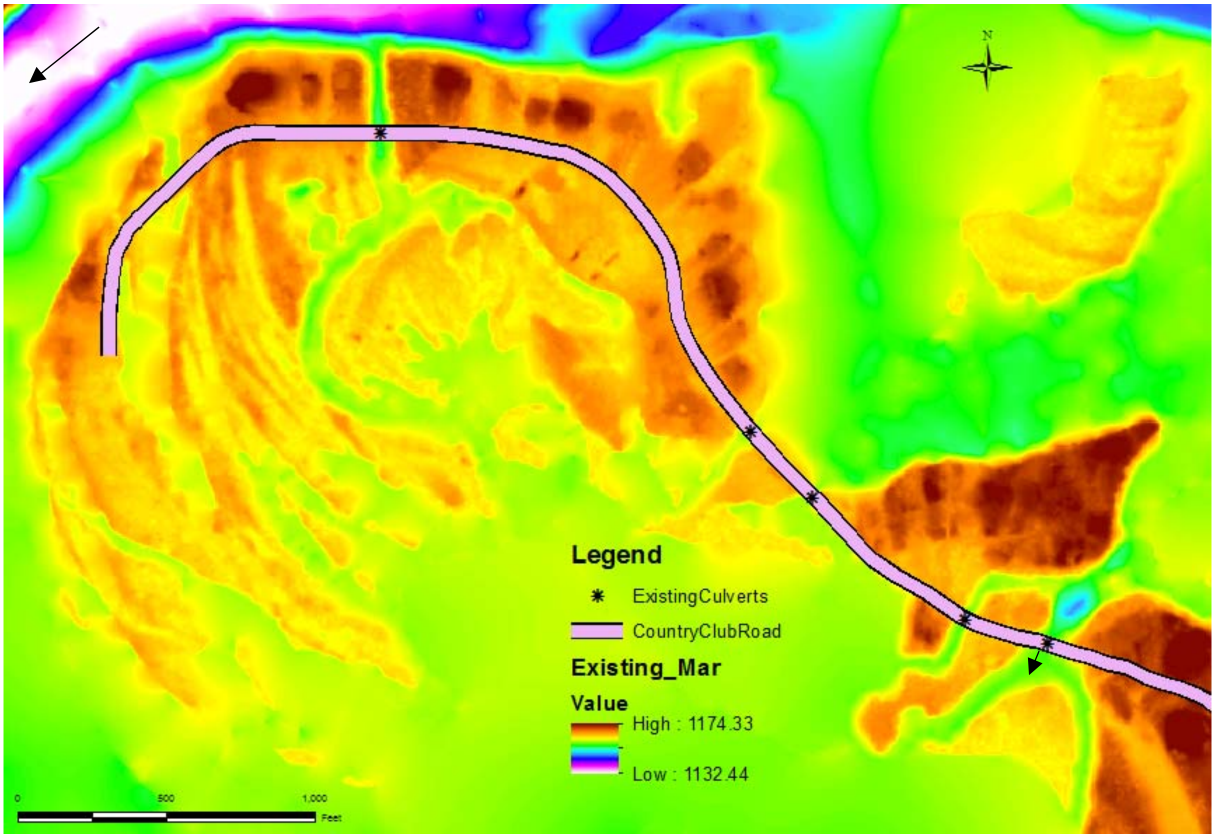

Figure 3-1 – 2D Area Connection: Country Club Road

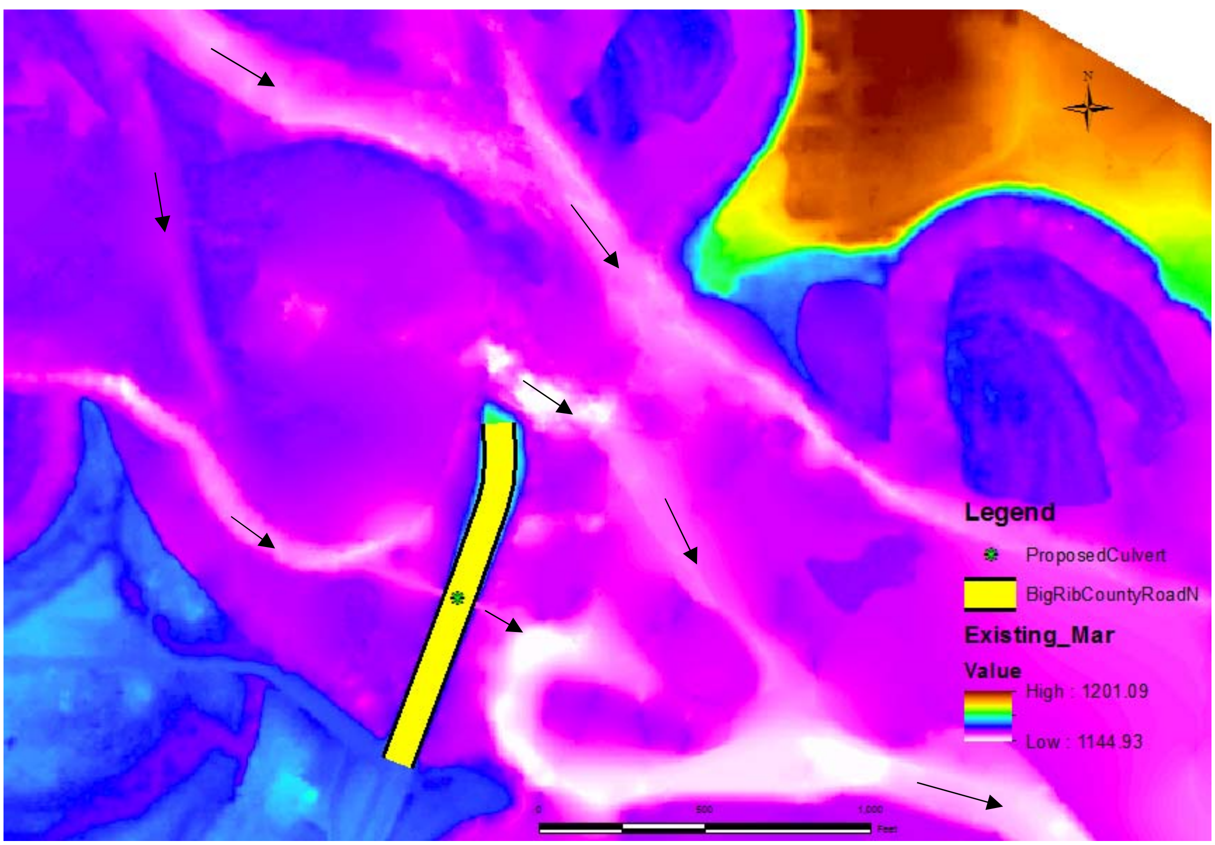

Figure 3-2 – 2D Area Connection: Big Rib River County Road N South Bridge Embankment

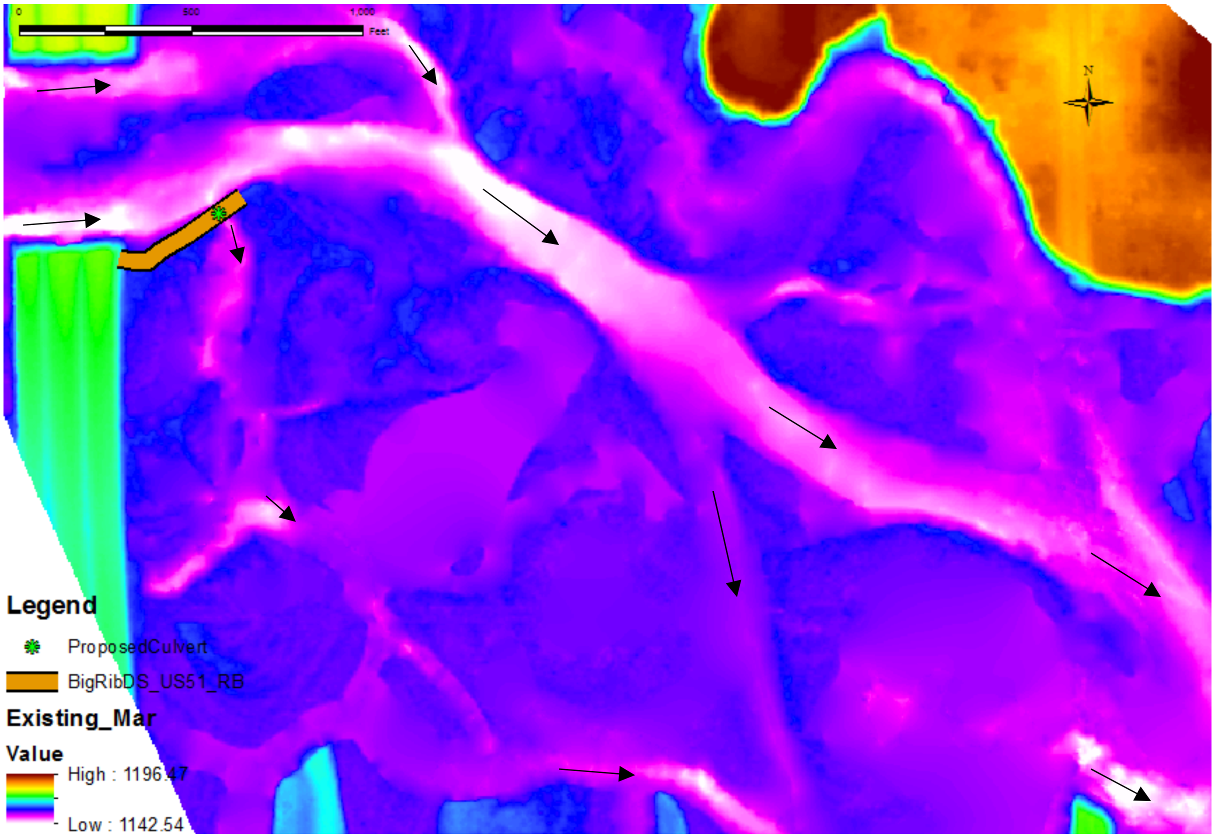

Figure 3-3 – 2D Area Connection: Big Rib River Downstream of US Hwy 51 South Side

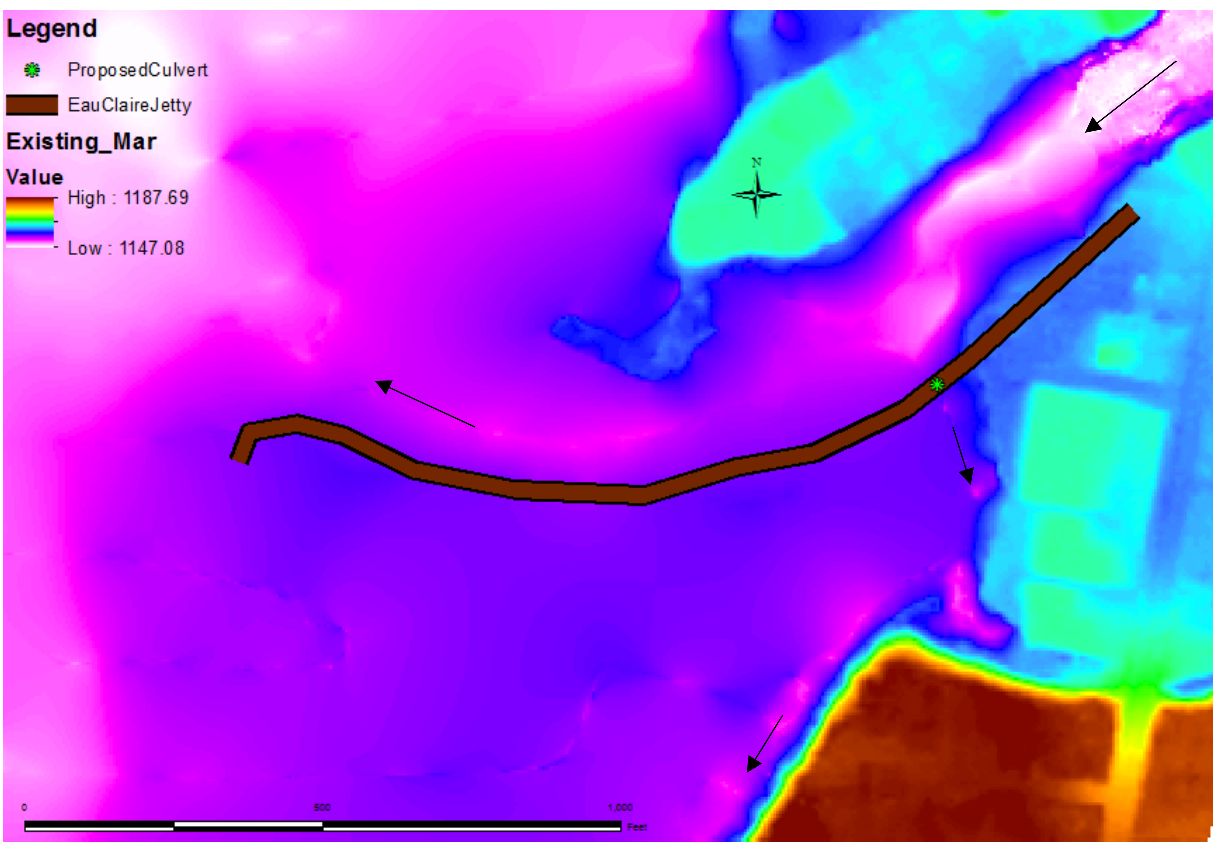

Figure 3-4 – 2D Area Connection: Eau Claire River South Bank

3.2 Modeled Scenarios for the Big Rib River Area

The goal for improvements in the Big Rib River area was to increase velocities in the backwater channels for fish habitat (and improved water quality). Some of the alternatives included placing a culvert through the County Road N embankment on the south side where the 2004 bridge replacement filled in a flow path; dredging of the two main backwater channels on the south side of the river; placing a culvert through high ground on the south side immediately downstream of the US Hwy 51 to reconnect a historic flow path; and dredging deposition from the main Rib River channels upstream, at, and downstream of the County Road N bridge.

The historic flow path on the south side (right bank) immediately downstream of US Hwy 51 is referred to as the “Upper Slough”. The backwater channel located on the south side of the river between US Hwy 51 and Co Rd N is referred to as the “Middle Slough”. The backwater channel downstream of the confluence of the Upper Slough and Middle Slough is referred to as the “Lower Slough”. Two different bottom elevations were considered for the Big Rib River dredging. The minimum dredging elevation for the Big Rib River dredging was 1153.0 ft (NAVD88); compared to the full dredging bottom elevation of 1152.0 ft (NAVD88) .All of the proposed improvements to the Big Rib River Area are shown in Figure 3-5.

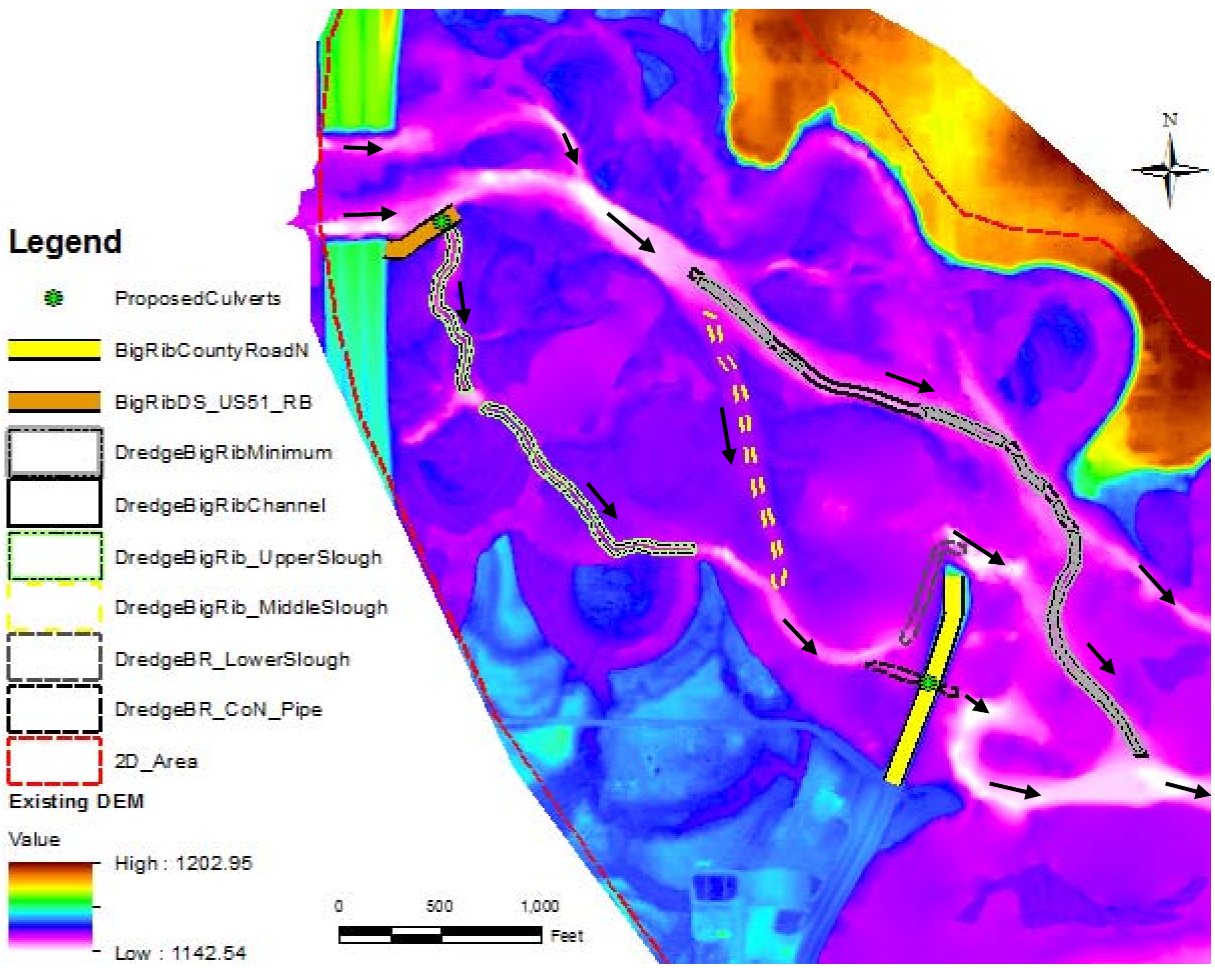

Figure 3-5 – All Modeled Proposed Big Rib River Area Improvements

The LWA indicated that their overall plan for improvements to Lake Wausau will need to be developed in phases due to funding and requested some information about impacts of only doing part of the improvements at a time. Multiple scenarios were run for the Big Rib River area to look at creating the improvements in phases and an initial look at culvert sizes. Note that box culvert sizes are listed as the span (ft) x rise (ft).

Each scenario modeled had different combinations of the improvements described above. The scenarios modeled are shown in Table 3-1 below indicating which improvement(s) was part of the scenario.

Table 3-1 – Big Rib River Area Modeled Scenarios

Scenario Name	County Road N Pipe (Dredge Invert 1155)	Upper Slough Pipe & Dredging (Invert 1155.2)	Middle Slough Dredging (Invert 1155.4)	Lower Slough Dredging (Invert 1153)	Big Rib River Channel Dredging
ExistingSpliceHydro	No	No	No	No	No
BigRibCoNonlyNoDredge	Yes 6'x6' Box	No	No	No	No
BigRibNoMainChDredgeUS8x4	Yes 6'x6' Box	Yes 8'x4' Box	Yes	Yes	No
BigRibUS_8x4	Yes 6'x6' Box	Yes 8'x4' Box	Yes	Yes	Yes – Invert 1152
BigRibUS_6x4	Yes 6'x6' Box	Yes 6'x4' Box	Yes	Yes	Yes – Invert 1152
BigRibUS_2-6x4	Yes 6'x6' Box	Yes (2) 6'x4' Box	Yes	Yes	Yes – Invert 1152
BigRibUS_5x5	Yes 6'x6' Box	Yes 5'x5' Box	Yes	Yes	Yes – Invert 1152
BigRibMinMainChDrdgUS5x5	Yes 6'x6' Box	Yes 5'x5' Box	Yes	Yes	Yes – Invert 1153
BigRibMinMainChDrdgUS8x4	Yes 6'x6' Box	Yes 8'x4' Box	Yes	Yes	Yes – Invert 1153

Overall the velocities from both existing conditions and the scenarios modeled were quite low and in many cases less than 1 ft/sec. Examining the flow hydrograph at a specific location provided more information to show where flow was increased or decreased compared to the existing conditions.

Specific profile locations were chosen strategically located upstream and downstream of improvements to evaluate the effectiveness of the improvement. These profile locations for the Big Rib River Area are shown in Figure 3-6 and each location is labeled for easy reference. The total flow across each specific profile location was examined and the peak flow is shown in table 3-2.

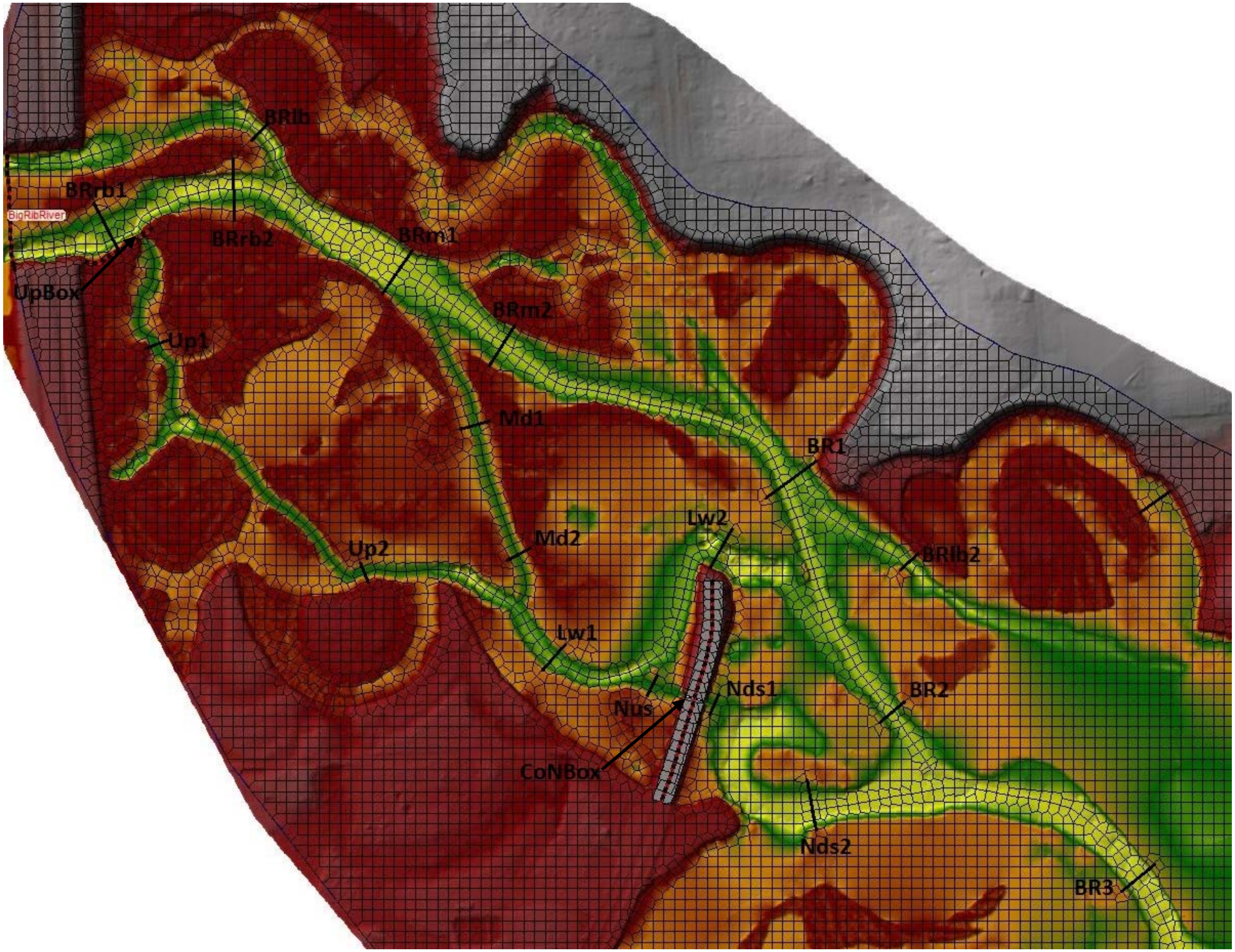

Figure 3-6 – Big Rib River Area Flow Profile Locations

Table 3-2 – Big Rib River Area Flow Profile Peaks By Scenario and Location

Peak Flow At Profile Locations by Scenario (cfs)

	Upper Slough Area						Middle Slough Area			
Scenario Name	Up1	Up2	UpBox	BRlb	BRrb1	BRrb2	Md1	Md2	BRm1	BRm2
ExistingSpliceHydro	0.22	43.04	0.00	127.9	664.8	642.1	33.42	16.97	727.8	605.8
BigRibCoNonlyNoDredge	0.27	42.95	0.00	128.1	665.9	643.2	33.47	16.93	728.7	606.6
BigRibNoMainChDredgeUS8x4	16.78	61.14	17.64	126.3	666.7	627.2	73.96	51.48	714.1	558.5
BigRibUS_8x4	16.29	56.47	17.30	127.2	665.4	627.0	68.75	47.78	720.7	578.5
BigRibUS_6x4	12.59	55.89	13.31	127.8	665.0	630.4	68.78	47.73	723.2	579.1
BigRibUS_2-6x4	23.16	57.42	24.55	126.0	667.4	621.6	68.59	47.81	716.7	577.5
BigRibUS_5x5	13.04	56.17	13.70	126.9	666.4	630.9	68.91	47.80	722.7	578.3
BigRibMinMainChDrdgUS5x5	13.36	59.62	14.04	126.7	666.3	630.3	72.41	50.46	717.7	564.6
BigRibMinMainChDrdgUS8x4	16.58	59.54	17.64	126.4	666.6	627.4	72.38	50.34	716.0	563.8

	Lower Slough Area / Co Rd N						
Scenario Name	Lw1	Lw2	CoNBox	BR1	BR2	BR3	BRlb2
ExistingSpliceHydro	61.01	188.6	0.00	531.2	162.3	444.9	149.1
BigRibCoNonlyNoDredge	61.44	184.4	17.85	529.9	166.6	444.7	150.1
BigRibNoMainChDredgeUS8x4	91.20	229.0	17.39	492.4	178.9	444.9	148.6
BigRibUS_8x4	84.52	212.9	17.06	512.3	240.6	437.7	137.3
BigRibUS_6x4	84.00	212.4	17.27	513.6	244.1	438.5	139.4
BigRibUS_2-6x4	85.00	214.5	17.14	511.1	231.2	439.7	134.4
BigRibUS_5x5	84.29	214.9	17.70	513.3	238.8	439.0	136.6
BigRibMinMainChDrdgUS5x5	89.36	223.9	17.24	499.8	219.2	445.3	143.2
BigRibMinMainChDrdgUS8x4	88.43	223.0	24.50	498.7	217.4	444.7	141.4

One of the considerations was to put the proposed improvements to the Big Rib River area in place in phases due to funding. The first step being considered would be to place the box culvert through County Road N without doing any channel dredging. The box culvert (CoNBox) provides about 17 cfs because the back water from the Wisconsin River results in minimal difference in water surface elevation between the upstream and downstream sides of the County Road N embankment. The only modeled feature that resulted in a higher flow of 24.5 cfs occurred with minimial main channel dredging and the largest box culvert size providing flow to the upper slough.

There was interest in getting flow through the upper slough area for fish habitat. Dredging was modeled for the upper slough, middle slough and lower slough. Different box culvert sizes and even the number of box culverts was examined. There was little variation , 13 to 18 cfs, between the results for the different culvert sizes, however, all culvert options showed a noticeable improvement in the peak flow through the upper slough. Using two box culverts through the high ground leading to the upper slough showed the largest flow increase of 24.55 cfs. Dredging of the middle slough and lower slough showed an increase in flows through these sloughs.

Another location for improvement was to dredge the main channel of the Big Rib River for improved boat access in general from the upstream to the downstream side of County Road N. The initial model runs looked at dredging in the main channel to a bottom elevation of 1152.0 ft. Adding the dredging impacted the flow in the backwater channels by reducing them by 3 percent in the upper slough, 7 percent in the middle slough and 7 percent in the lower slough.

One scenario had the main channel dredging of the Big Rib River minimized by raising the bottom elevation to 1153.0 ft instead of 1152.0 ft. This dramatically reduced the area needing dredging. Minimizing the main channel dredging impacted the flow in the backwater channels by reducing them by 1 percent in the upper slough, 2 percent in the middle slough and 3 percent in the lower slough.

3.3 Modeled Scenarios for the Eau Claire River Area

The goal for the 2D modeling in the Eau Claire River area was to increase velocities in the backwater channels hoping to improve water quality and reduce nuisance aquatic vegetation growth. The improvements consisted of dredging of the Eau Claire River bottom and constructing a jetty approximately 1,400 feet long following natural high ground along the left bank (south side) of the Eau Claire River channel as it makes it way to the centerline of the Wisconsin River through Lake Wausau. Some scenarios placed box culvert(s) through the jetty to allow flow to enter the existing backwater channel along the Lake Wausau shoreline that has been narrowing over time. Another option looked at keeping a 30 feet bottom width channel open through the jetty near the Lake Wausau shoreline. The jetty will help maintain a defined channel for the Eau Claire River by reducing sedimentation from wave action from the south side and help create shallow water mud flats on the south side of the jetty for waterfowl habitat. The top elevation chosen for the jetty was 1162.7 ft NAVD88, which is about 5 to 6 feet above the lake bottom elevation here.

There are many vegetation harvest areas in the backwater areas between the Eau Claire River and the golf course. The proposed scenarios included some dredging of the specific backwater channels. In Lake Wausau aquatic plants are growing in water depths of up to 8 feet. This modeling looked at changes in flows and velocity in the Eau Claire River and backwater channels. Modeling scenarios varied the size and number of culverts through the jetty. Note that box culvert sizes are listed as the span (ft) x rise (ft).

Each scenario modeled had different combinations of the improvements described above and are shown in Figure 3-7. The scenarios modeled are shown in Table 3-3 below indicating which improvement(s) was part of the scenario.

Table 3-3 – Eau Claire River Area Modeled Scenarios

Scenario Name	Jetty	Eau Claire River, Side Channel Dredging & Invert Elevation	Culvert(s) through Jetty	Channel through the Jetty
ExistingSpliceHydro	No	No	No	No
ECjetty8x8	Yes	Yes - Eau Claire 1150, Channel Min 1154, Channels 1153	(1) 8'x8' Box	No
ECjetty2-8x8	Yes	Yes - Eau Claire 1150, Channel Min 1154, Channels 1153	(1) 8'x8' Box	No
ECjetty9x9	Yes	Yes - Eau Claire 1150, Channel Min 1154, Channels 1153	(2) 9'x9' Box	No
ECjettyChannel	Yes	Yes - Eau Claire 1150, Channel Min 1154, Channels 1153	No	Yes

Specific profile locations were chosen strategically located upstream and downstream of improvements to evaluate the effectiveness of the improvement. These profile locations for the Eau Claire River Area are shown in Figure 3-8 and each location is labeled for easy reference.

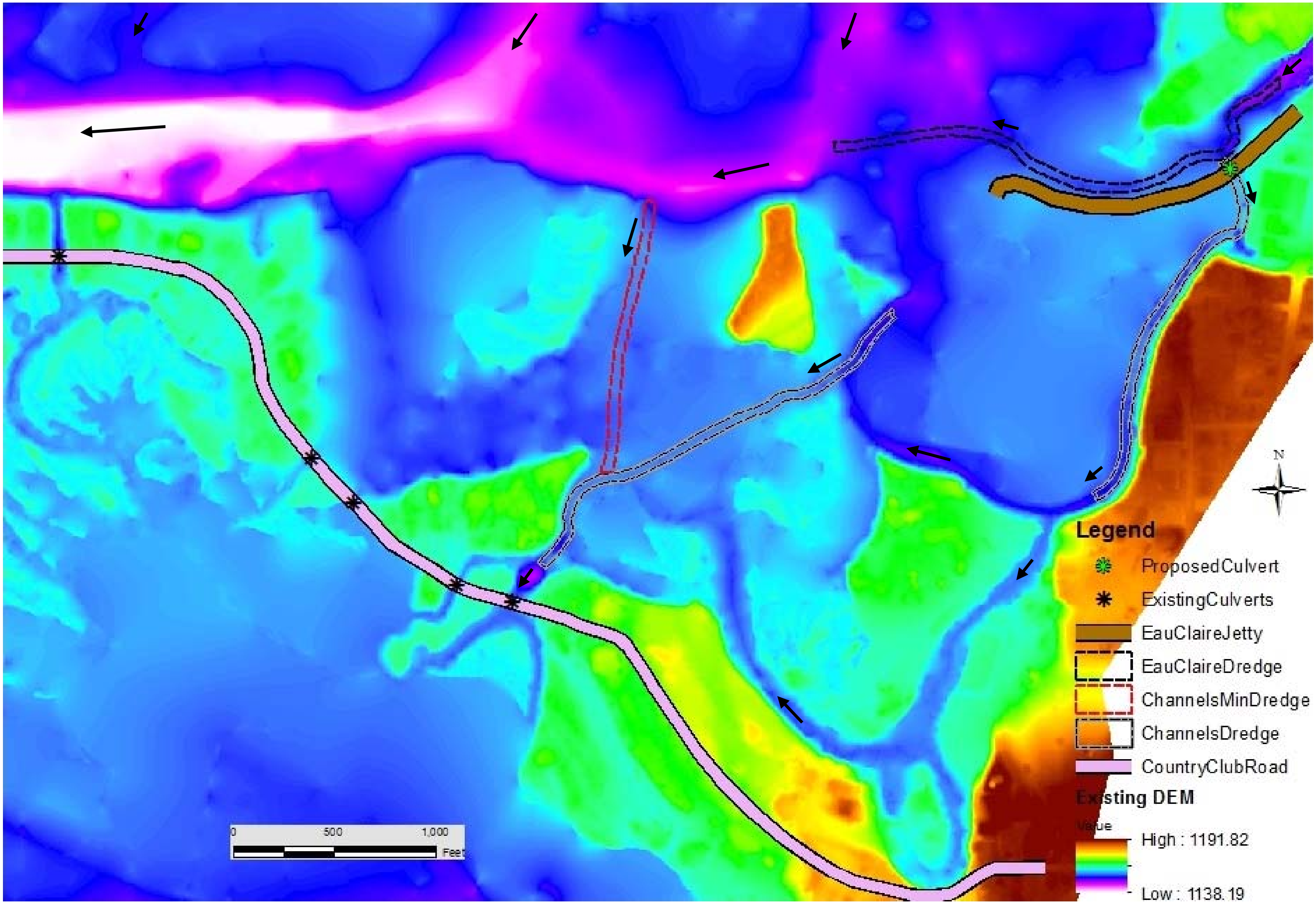

Figure 3-7 – All Modeled Proposed Eau Claire River Area Improvements

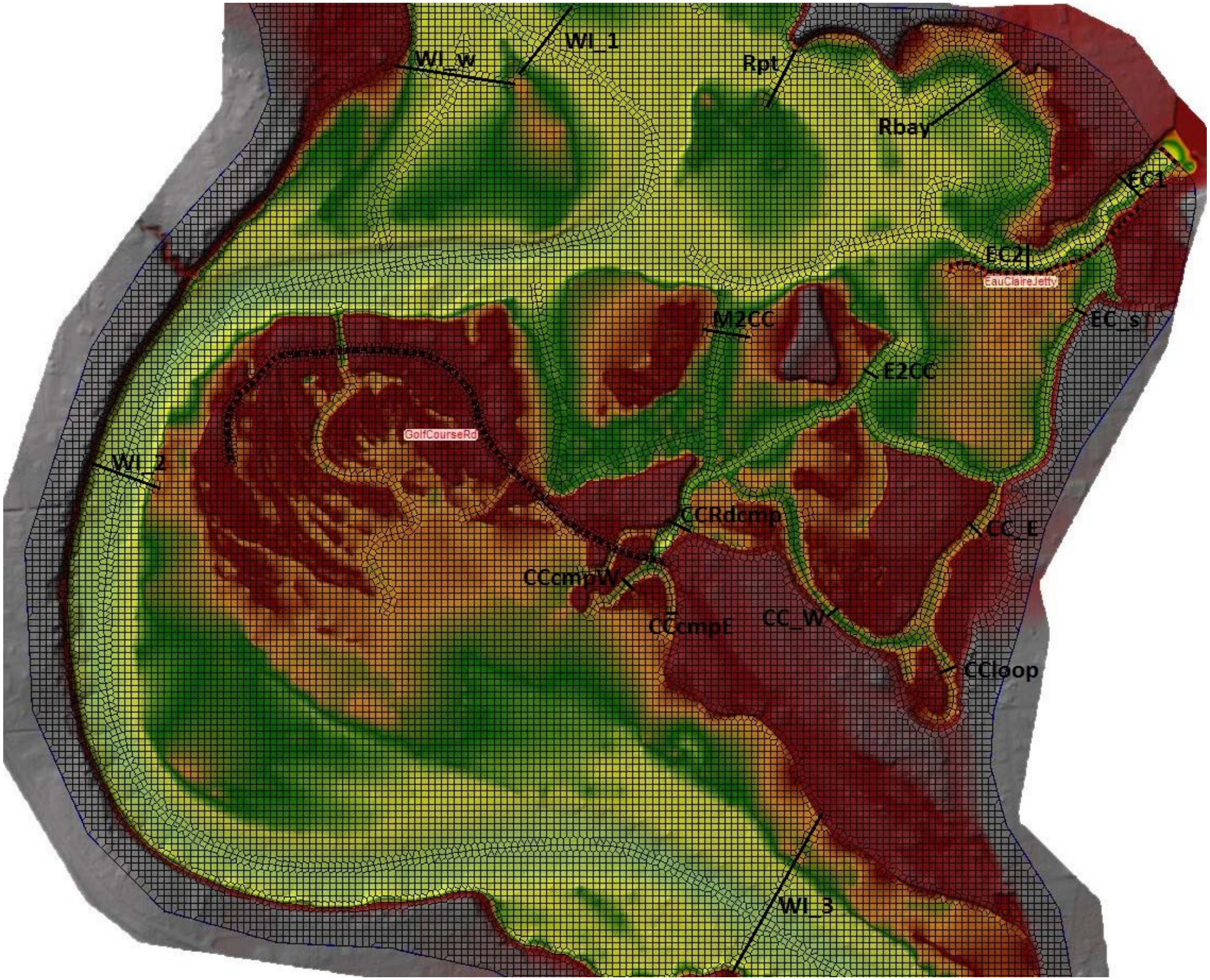

Figure 3-8 – Eau Claire River Area Flow Profile Locations

Overall the velocities from both existing conditions and the scenarios modeled were quite low and in many cases less than 1 ft/sec. Examining the flow hydrograph at a specific location provided more information to show where flow was increased or decreased compared to the existing conditions. The total flow across each specific profile location was examined and the peak flow is shown in table 3-4.

Table 3-4 – Eau Claire River Area Flow Profile Peaks By Scenario and Location

Peak Flow At Profile Locations by Scenario (cfs)

Scenario Name	WI_1	WI_w	WI_2	WI_3	Rpt	Rbay	EC_1	EC_2	JettyBox	EC_s
ECjettyChannel	2,229	3,324	6,903	7,267	705	71.0	198.2	134.4	N/A	24.53
ECjetty9x9	2,229	3,324	6,903	7,267	703	64.1	198.2	188.5	7.13	3.70
ECjetty8x8	2,229	3,324	6,903	7,267	703	64.0	198.2	189.4	5.91	3.37
ECjetty2-8x8	2,229	3,324	6,903	7,267	703	64.6	198.2	185.0	11.81	5.04
ExistingSpliceHydro	2,227	3,327	6,904	7,267	699	72.0	198.2	95.0	N/A	25.27

	Golf Course Area							
Scenario Name	E2CC	M2CC	CC_E	CC_W	CCRdcmp	CCcmpE	CCcmpW	CCloop
ECjettyChannel	21.11	102.3	6.32	6.33	48.21	10.08	19.32	0.08
ECjetty9x9	21.07	103.2	6.22	6.24	48.21	10.08	19.32	0.07
ECjetty8x8	21.07	103.2	6.22	6.23	48.21	10.08	19.32	0.08
ECjetty2-8x8	17.96	103.1	6.23	6.25	48.21	10.08	19.32	0.08
ExistingSpliceHydro	15.33	80.5	7.58	7.58	47.38	9.99	19.14	0.07

Placing the jetty with culvert alongside the Eau Claire River where it enters Lake Wausau resulted in retaining most of the flow in the Eau Claire River compared to existing conditions. The flow going through the culvert was low, 3.37 to 3.7 cfs. Adding a second culvert had a minor increase in flow, up to 5.04 cfs. However, when a 30 foot bottom width channel opening was kept through the jetty opening at the deepest part of the existing slough, then the peak flow increased to 25.27 cfs. Once through the culvert in the jetty the flows dropped off between the culvert and the EC_s shoreline channel indicating that the flows were spreading out across the shallower water areas.

All of the alternative scenarios had a small increase in flow in the dredged backwater channels (E2CC and M2CC) between the Eau Claire River and the Country Club Road compared to the existing conditions. The E2CC profile, representing the eastern-most channel path towards the Country Club Road increased from 15.33 cfs for existing conditions to 17.96 to 21.11 cfs for the alternatives. The M2CC profile, representing the kind of middle channel path towards the Country Club Road increased from 80.5 cfs for existing conditions to about 103 cfs for the alternatives.

None of the scenarios modeled had a dramatic effect on the flows through the large culvert on the Country Club Road (closest to the Country Club). The flows only increase by about 1 cfs through the culvert from 47.38 cfs to 48.21 cfs.

The flows in the loop through the Country Club, CC_E and CC_W decreased from 7.58 cfs for the existing conditions to 6.22 to 6.33 cfs with the alternatives.

The flows in the backwater areas near Radtke Point (Rpt) were very similar for both existing conditions and the proposed alternatives, at about 700 cfs. The flows in Radke Bay (Rbay) were nearly identical for the existing (72 cfs) and jetty with channel (71 cfs) conditions and slightly lower for the alternatives with the jetty and culvert(s) (64 to 64.6 cfs).

CHAPTER 4.

4. Conclusions

4.1 General

The modeled scenarios show the relative impacts of the proposed alternatives for habitat and water quality improvement in Lake Wausau specifically for the areas where the Big Rib River and the Eau Claire River enter Lake Wausau. Overall the velocities from both existing conditions and the scenarios modeled were quite low and in many cases less than 1 ft/sec. Examining the flow hydrograph at a specific location provided more information to show where flow was increased or decreased compared to the existing conditions.

4.2 Comparison of Existing and Proposed Alternatives

The scenarios modeled for the Big Rib River area reflected positive impacts in regards to increasing flows through the backwater channels referred to as upper slough, middle slough and even lower slough. Placement of the box culvert through the County Road N embankment did show flow being conveyed through the pipe however, the flows were lower than hoped and with the very low velocities may not be able to maintain a channel.

The velocity in the Eau Claire River channel downstream of the box culvert / channel (profile EC-2) did show a relatively large increase in velocity, from a peak of 0.079 ft/s to 0.113 ft/s (42 percent increase) with the scenarios that included a box culvert with the jetty. However, these incredibly low velocities will not have an impact on the sediment transport capacity (or lack thereof) of the Eau Claire River channel. It is anticipated that rate of sediment deposition in the Eau Claire River channel will decrease with a jetty in place since the jetty would block lateral transport of sediment into the channel from the south due to the blocking of wave action and prevent the Eau Claire River flows from spreading out across the shallow water towards the Country Club Road.

4.3 Model Limitations

The model is not calibrated due to the stage hydrograph for the pool elevation at the Domtar Dam being provided as the model report was being finalized and modeling complete. The model results are only valid for a “relative” comparison between existing conditions and model scenarios. Actual values should not be expected.

The Lake Wausau system is dynamic and has a lot of factors that can change results. The flow hydrographs were spliced together from actual September 2016 hydrographs. However they imitate just one scenario of conditions. Every climatological event is different and the shape of the hydrographs, values, and timing of flows will vary under actual conditions as precipitation doesn’t fall evenly everywhere.

The model does not include any sediment transport data or water quality data and results were limited to changes in velocity and flow.

4.4 Next Steps

The Lake Wausau Management Plan is being finalized and looks at a holistic solution to water quality issues in Lake Wausau. The results from this 2D modeling can be used to help the LWA make decisions and the model itself modified to refine and add alternatives before construction decisions are finalized. The 2D model should be calibrated to the downstream pool elevation at the Domtar Dam to see if more detailed results can be garnered.

The LWA is pursuing steps to reduce nutrient load to the lake which will be especially important in the area near the golf course and downstream of the Eau Claire River where potential changes to velocity are extremely difficult due to the nearly flat pool created by the Domtar Dam at the downstream end of Lake Wausau.

Other possible future efforts could be the collection of sediment load data by the USGS and adding the sediment data to the 2D model to convert it into a sediment transport model to look at deposition trends and solutions.

These study results could be used to pursue a project aimed at construction features with USACE or by other means to look at refining alternatives.

CHAPTER 5.

5. References

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