Upper Maple River Watershed Plan

Appendix D-5

Alternative 2A – Upper Maple River Tributary Main Stem Dams Environmental Quality Account Benefits Analysis

Cass County Joint Water Resource District

Picture of Wetland 14 (Site 2A) during delineation

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1 INTRODUCTION

Alternative 2A – Upper Maple River tributary Main Stem dams (project) are on-channel, multipurpose water storage facilities primarily located in Section 21 of Minnie Lake Township of Barnes County, North Dakota. The project is intended to provide flood prevention, wildlife habitat, enhance and restore wetlands, and improve downstream water quality. As outlined in economics guidance prepared for the Red River RCPP PL-566 projects by NRCS (2019), the Economics and Environmental Principles and Guidelines for Water and Related Land Resource Implementation Studies (P&G) of 1983 was utilized to evaluate alternatives under this plan. Flood prevention benefits of the proposed project were monetized under the P&G National Economic Development Account, as documented in the Economics Evaluation Technical Memorandum. The purpose of this report is to summarize the computation of benefits for the P&G Environmental Quality Account, following the general guidance provided by NRCS (2019) for computing non-monetized water quality and wetland functional benefits.

More information on the design of the project is available in the conceptual design report (Appendix D-1).

2 WATER QUALITY BENEFITS

As outlined in Sections 2, 4.2.14 of the Plan/EA, water quality concerns within the Upper Maple River Watershed, and in relation to downstream waterbodies, and related regional and international agreements, are a significant issue. Driven by eutrophication of Lake Winnipeg over the last two decades, research specifically related to phosphorus transport in the Red River Basin has been completed. The findings document why the form and seasonality of phosphorus transport from cropland in this watershed is uniquely difficult to address.

- Total dissolved phosphorus (DP) accounts for an average of 85% of total phosphorus (TP) on tributary rivers and 81% of TP on the mainstem Red River (McCullough, 2012). DP is comprised of 85-93% highly bioavailable inorganic orthophosphate derived from common agricultural fertilizers.
- Rattan et al (2017) found that 62% of annual TP was transported during the 12-18 day snowmelt period, and several studies determined that floods derived from snowmelt tend to have higher concentrations of DP due to the combination of frozen soils and contribution of dead vegetation (Kieta et al, 2018) (McCullough et al, 2012).
- Mobilization of phosphorus is more strongly correlated to peak flow events than to mean discharge. Several studies have shown that the highest TP concentrations are recorded on the falling limb of the hydrograph (McCullough, 2012), which indicates that initial surface runoff and channel erosion are on the main transport mechanisms.
- Soils consist largely of very fine silt and clay lacustrine sediments, therefore even particulate form phosphorus tends to remain suspended in the water column at relatively low velocity flows (Paakh et al, 2006).

Both crops and perennial vegetation actively incorporate dissolved inorganic phosphorus into above and below ground plant tissue via uptake of DP from the soil pore water during the growing season (Curie, 2017). Prior to winter die off, a substantial percentage is translocated to below-ground plant tissue, but the residual above-ground biomass is deposited on the soil surface where TP may be retained as it is incorporated into soil organic matter (Curie et al, 2017). In addition, during leaf senescence, phosphorus solubilizing exudates can be responsible for generation of soluble phosphorus as well as the freezing process itself causing intracellular phosphorus release from biomass within shoots (Kieta et al, 2018).

During the long duration flood inundations typical in this watershed, labile phosphorus from dead vegetation is converted to DP in the overlying water. The uniquely high volumes of DP, compared to particulate bound phosphorus, severely limits the effectiveness of conservation practices that are successful elsewhere in the Midwest due to their ability to intercept soil bound phosphorus. For example, filter strips and riparian buffers typically remove DP through plant and microbial uptake, as well as infiltration driven soil geochemical processes such as adsorption and immobilization. Vanrobaeys et al (2019) completed a study in the Manitoba portion of the Red River Basin utilizing three, 20-meter wide vegetative filter strips downstream of cropland. Data was taken for TP and DP above and below the strips for 22 runoff events that occurred over the course of two years. The mean DP/TP for all events and sites was 0.71, the mean TP reduction was 9% for growing season events (summer), and there was no TP reduction found for non-growing season (spring) events. Conservation tillage, reduced tillage, and cover crops that increase soil organic matter serve to increase infiltration rates thereby reducing overall runoff and creating an armor on the soil surface that reduces soil erosion from fields. However, the stratification of the crop residue and associated nutrients has been shown to be a source of dissolved nutrients in spring runoff events over frozen soils and has the effect of increasing downstream phosphorus loads (Baulsh, 2019) (Haque, 2018).

One of few conservation practices that has been proven to be effective for phosphorus reductions in the Red River Basin are constructed temporary detention structures, such as that proposed with this project, with incorporated depressional areas or water management "biomass harvesting cells" dedicated to growing and removing wetland vegetation. The function of wetland biologic and soil geochemical phosphorus cycling is similar to that of filter strips and riparian buffers, however the addition of 1-2 ft of temporary retention allows those processes to work over a longer time period, after spring runoff and into the growing season. Water quality, soils, and vegetation monitoring at the North Ottawa impoundment, a 16,000 ac-ft multicell detention structure constructed on the MN side of the Red River Basin found an annual TP reduction of 66%, Total Nitrogen (TN) reduction of 73%, and Total Suspended Solids (TSS) reduction of 42% (Guzner, 2017) in the first three years after construction. To ensure that the portion of the impoundment bottom dedicated to wetlands does not become a source of DP over time, it is managed to optimize biomass production and that is then harvested, baled, and removed off site in the late summer. Manitoba has also been engaged in large scale "cattail farming" to reduce phosphorus deliveries to Lake Winnipeg and has developed production facilities and governmental imposed market drivers for processed fuel pellets from that biomass (Svedarsky et al, 2016). The Pelly Lake Project in Manitoba is a 1,200 ac-ft detention structure built in 2015 and managed with the goal of maximizing phosphorus removal by growing and harvesting cattails. Results indicated phosphorus removal rates of 27-53 lbs/acre of cattail biomass removed (Grosshans, 2011).

The biomass harvest area size (264.3 acres) is designed based on estimated phosphorus load to the site and observed content of TP in biomass. The regional curve (Figure 9) identifies TP load rate is 103.5 lb/year/mi^2. The lower range of TP content is 27 lb/ac (Grosshans, 2011). Therefore, the minimum biomass harvest area is ~4 acres/ mi^2.; which for 59.7 mi^2 catchment requires 239 acres. The final BH cell areas were upsized slightly to 264.3 acres for resiliency and fit into available spaces. This report goes on to calculate actual TP load at the site, which varies slightly from the regional curve. Also, the five-site average TP content in late summer cattail harvest is at the upper end the range at 45 lbs/acre (Grosshans, 2011). The final design may differ based on calculated load at this site (Tables 3 & 4), diversion amounts, monitoring results, and if further research verifies the 45 lbs/acre TP content can be obtained with optimal timing of biomass harvest (i.e. August). The Upper Maple River TP loads were above the regional curve, but assuming the average TP to biomass content compensates; the biomass harvest area size is expected to stay similar to these assumed areas to obtain documented benefits. The final design and Operation and Maintenance Plan for the Upper Maple River sites will be developed to ensure that the capacity for biomass harvesting and related soil/vegetation monitoring is incorporated. The O&M Plan will allow flexibility to allow the Sponsor to attempt trials with different types of vegetation for TP removal, with prior NRCS approval and monitoring plan. The rate of TP in alternative vegetation will need to meet the final assumed value, i.e. 27 lb/ac, 45 lb/ac, or other intermediate value.

The proposed project will generate water quality improvements through the following processes:

- Transport of sediment and nutrients (DP most critically) from cropland downstream of the proposed structure is proportional to the acreage of cropland inundated by the river at flood stage. The water quality analysis was based on empirical equations developed specifically for the Upper Maple River Watershed. USGS Gages 05059600 Maple River near Hope, ND and 05059700 Maple River near Enderlin were utilized to develop nutrient-discharge relationships for the Upper River Watershed. Those relationships were then used to obtain nutrient loadings at specific locations for existing and proposed (with project) conditions.
- Reduction of sediment and nutrients from the watershed upstream of the proposed structure through wetland biologic and soil geochemical phosphorus cycling, and biomass removal, in the temporary flood pool area of the detention structure. Nutrient loads were determined from the empirical equations noted above, and reductions applied based on the North Ottawa project research.

Two downstream reporting locations, besides project outlets, were analyzed for water quality benefits. One of the locations analyzed was at the Maple River crossing with 34th Street SE, approximately 2 miles west of Buffalo, ND. The second location analyzed is at the Maple River USGS gauge site near Enderlin, North Dakota (05059700). The project location and three reporting locations existing, and proposed nutrient projections are shown on Figure 1.

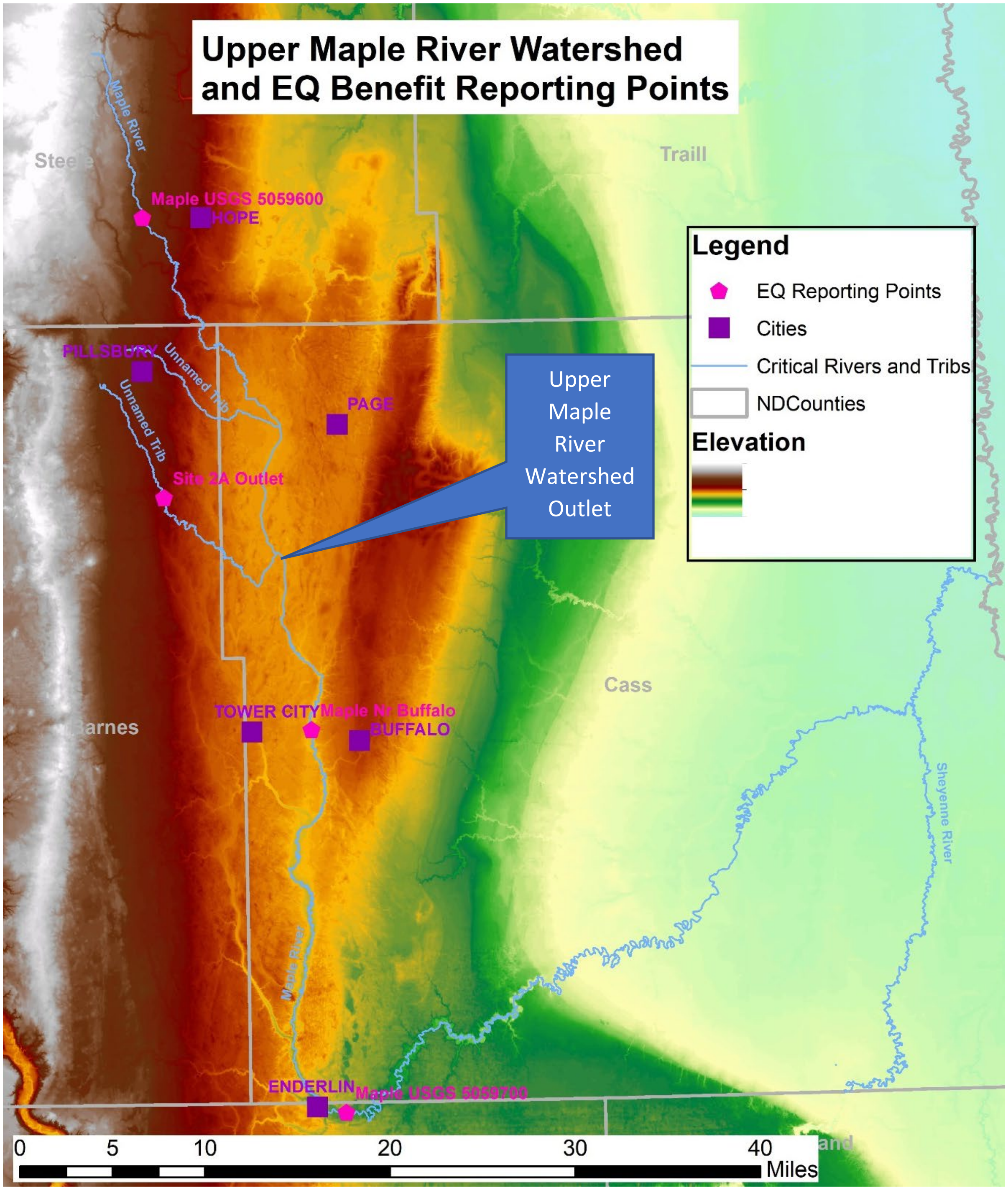

Figure 1: Maple River Watershed and EQ benefit reporting points

2.1 Streamflow Gauge Records

There are two gauge in the Upper Maple River with sufficient nutrient and discharge measurements, which include USGS Gauge 05059600 (Maple River Nr Hope, ND) and 05059700 (Maple River Nr Enderlin, ND). The total drainage area to the Hope gauge is 20.2 mi^2, while contributing drainage area is 17.4 mi^2. The gauge flood of record occurred on 8/1/2011, for which the instantaneous flow rate was 1,340 cfs. The daily discharge plots for 1991-2020 are shown in Figure 2; the dates along x-axis represent month and year, i.e. M-91 represent March of 1991. A noteworthy limitation of daily flow at Hope gauge is that recording stops on September 30 of each year, which underpredicts annual loads due to discounting late fall flows. However, late fall flows are not common, as noteworthy flows only occurred in 2019. These late fall flow rates are much smaller than annual peaks, and with limited occurrences, are not considered to significantly affect the 30-year nutrient loading averages.

The total drainage area to the Enderlin gauge is 843 mi^2, while contributing drainage area is 796 mi^2. The gauge flood of record occurred on 6/30/1975, for which the instantaneous flow rate was 7,610 cfs. The daily discharge plots for 1991-2020 are shown in Figure 3.

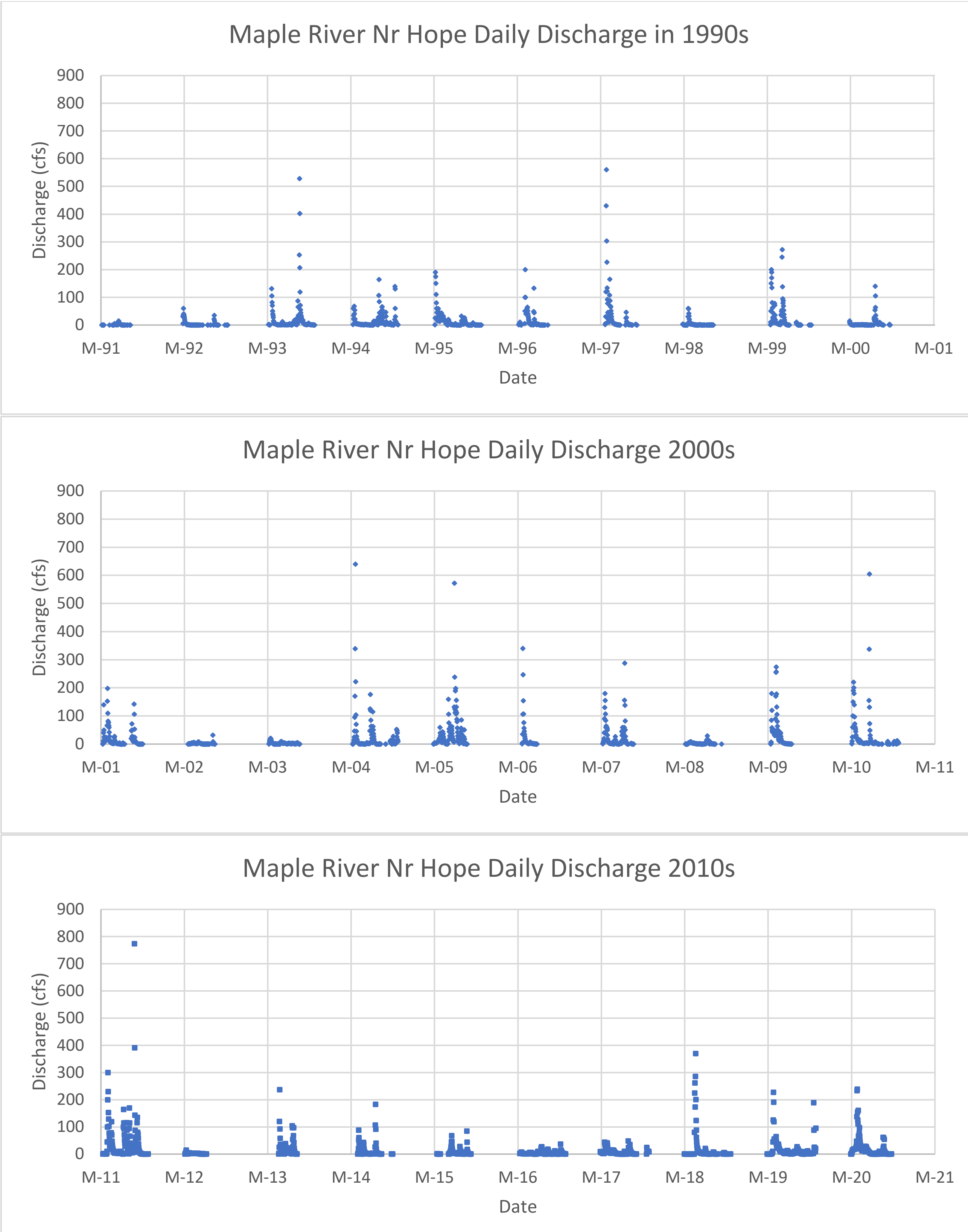

Figure 2: Maple River Near Hope daily average flows

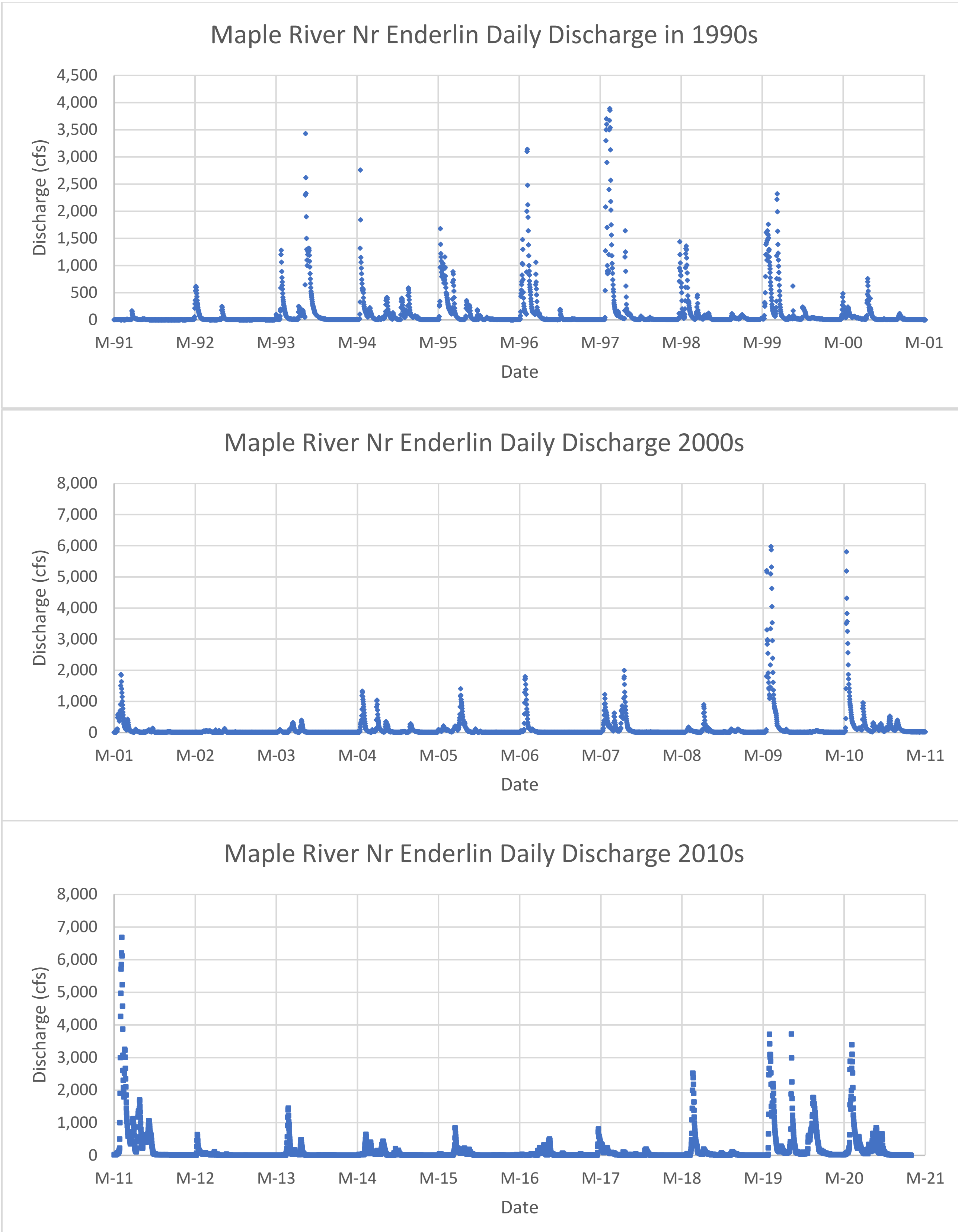

Figure 3: Maple River Near Enderlin daily average flows

2.2 Nutrient-Discharge Relationships

All available total phosphorus, nitrogen, and suspended solids concentrations in the Maple River Near Hope and Enderlin were obtained on specific dates and times from the North Dakota Department of Environmental Quality (ND DEQ, 2021) Water Quality Data Portal, which were from the years 2006, 2007, and 2020. The DEQ measurements near Hope included 45 TP and TN, and 17 TSS. The DEQ measurements near Enderlin included 88 TP, 85 TN, and 82 TSS; three TN measurements were not used as the concentration and load were extreme outliers from other site and regional data. Discharges at USGS Gage 05059600 Maple River Near Hope, ND and 05059700 Maple River Near Enderlin, ND were obtained at the same date and time that each of the concentration values were obtained to develop correlation between flow and nutrient concentration. The maximum flow related to these ND DEQ measurements near Hope was 283 cfs, and near Enderlin was 2,810 cfs. Concentrations for the same parameters and at the same location were investigated from USGS water quality data, however no water quality data is available at the USGS Hope gauge, but 55 TP and TN were available and used from the USGS Enderlin gauge.

The total phosphorus, nitrogen, and suspended solids loading relative to discharge at the respective gauges are shown in the following charts. Empirical equations specific to the Maple River Watershed were developed based on this data. The empirical or best-fit equations can then be used to predict annual nutrient and sediment loading at the gage site based on specific daily discharges. The best-fit equations for each of the relationships are displayed on the charts that follow, including all the data points and best fit lines for each constituent (Figures 4, 6, and 8). Best fit equations were chosen based on validation from other similar gauge analyses in the Red River Basin (Figures 5 and 7) based on findings by USGS SIR 2012-5216 (USGS, 2016). Total Suspended Sediment (TSS) was not part of several gauges listed in USGS SIR 2012-5216, therefore validation is not evaluated for TSS due to limited data. The TP and TN best fit lines are very similar for Hope and Enderlin, however TSS varies considerably; this could be due to less data or physical parameters of the watershed and drainage sizes at each gauge.

An analysis was also completed on the proportion of phosphorus by form based on 55 water quality samples at USGS Gage 05059700 for the 2012-2021 time period. The average ratio of dissolved phosphorus to total phosphorus was 66%, with the median value at 69%. From a seasonal perspective, DP are generally below the average in fall and winter months, where flows are generally less; DP are generally above the average in spring and summer months, where flows are generally higher.

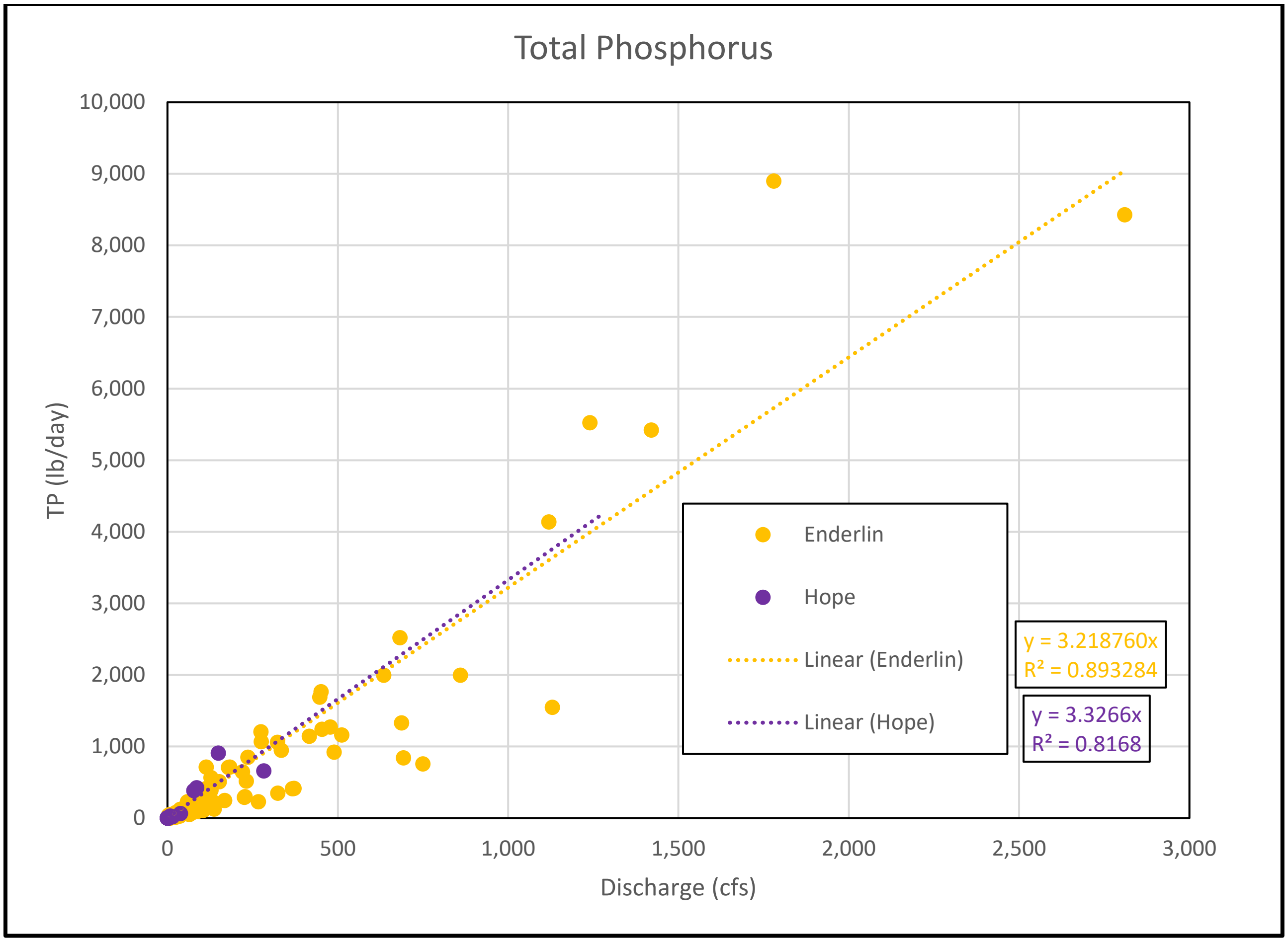

Figure 4: Maple River Near Hope and Enderlin Discharge vs. Total Phosphorus measurements and relationship

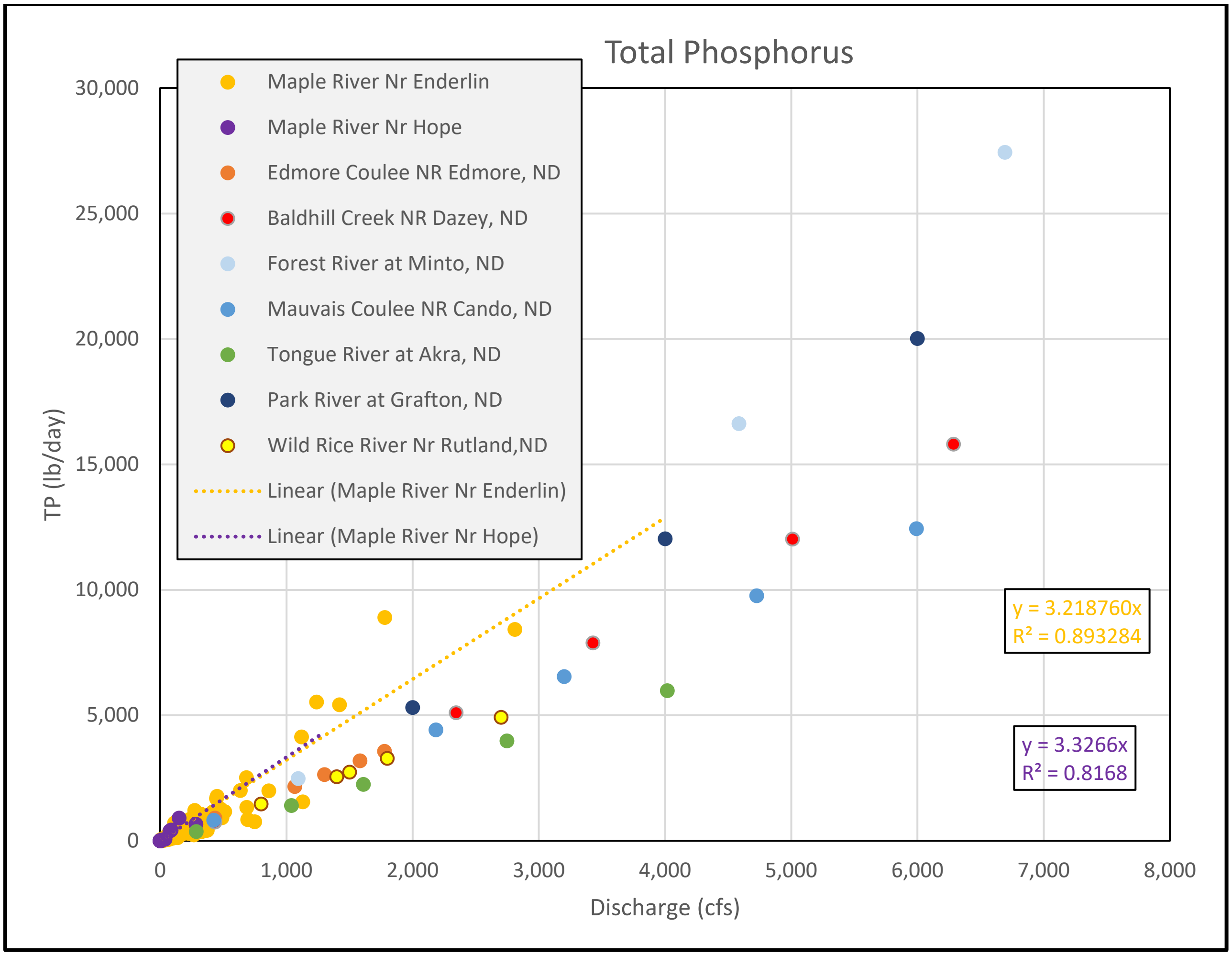

Figure 5: Maple River Near Hope and Enderlin Discharge vs. Total Phosphorus measurements and relationship; plus validation based on nearby gauge estimates

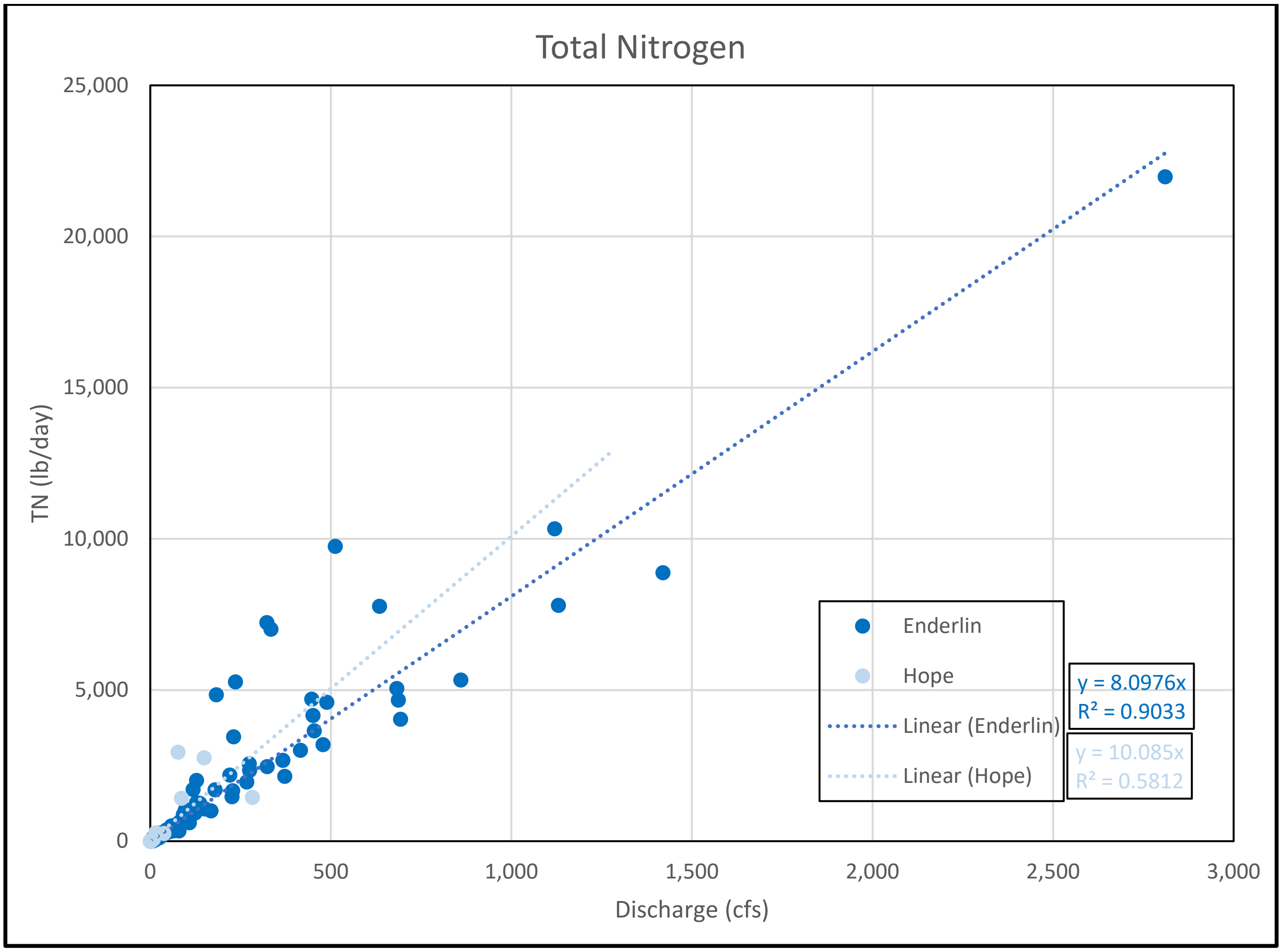

Figure 6: Maple River Near Rutland Discharge vs. Total Nitrogen measurements and relationship

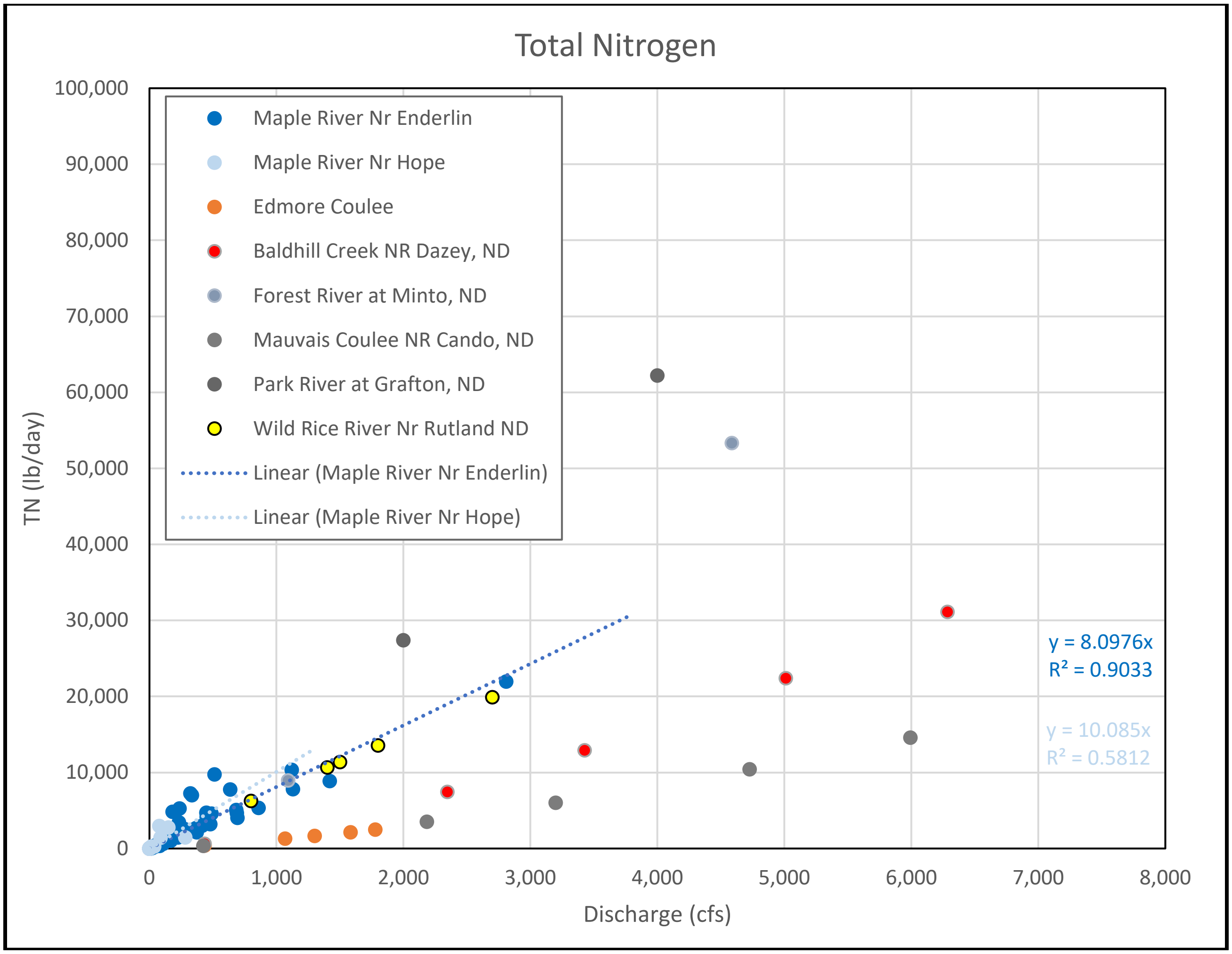

Figure 7: Maple River Near Rutland Discharge vs. Total Nitrogen measurements and relationship; plus validation based on nearby gauge estimates

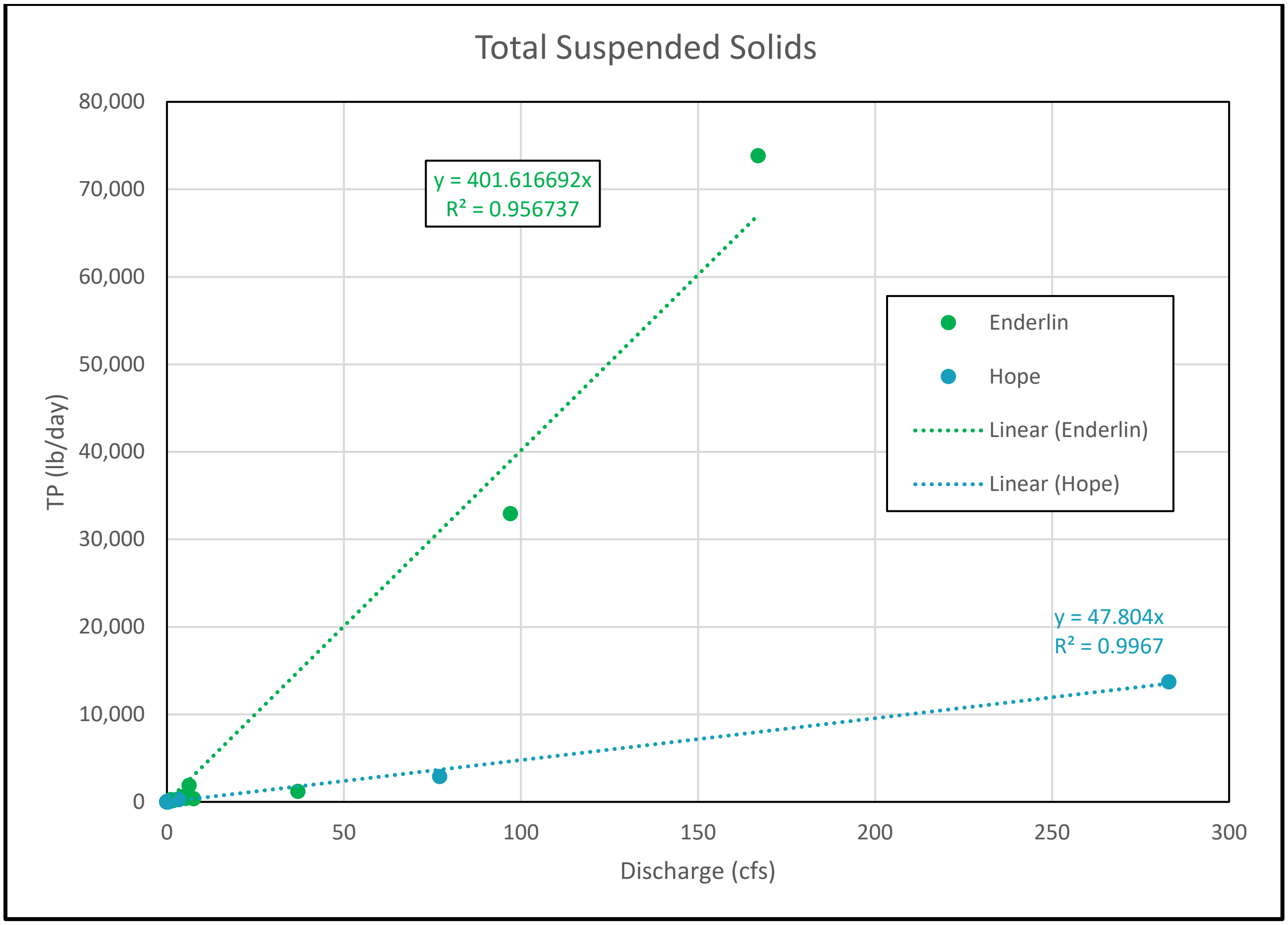

Figure 8: Maple River Near Rutland Discharge vs. Total Suspended Solid measurements and relationship

2.3 Annual Water Quality Benefits

Daily discharges at USGS Gage 05059600 Maple River Near Hope, ND and 05059700 Maple River Near Enderlin, ND were obtained from 1991 through 2020. The empirical equations discussed in Section 2.2 were then used to compute a daily load of TP, TN, and TSS. All daily loads were summed for each year to get an annual sediment loading at the gage site in pounds or tons. The resulting annual nutrient and sediment loads from 1991 through 2020 are shown in Table 1 and 2. Some simple statistics are included at the bottom of the tables to show minimum, maximum, and average annual nutrient and sediment deliveries during the time period analyzed. Additionally, the final value listed in tables were calculated by taking the average annual loading to the gage site and dividing by the contributing drainage areas (17.4 and 796 square miles, respectively). This value represents the average annual nutrient or sediment loading per square mile of drainage area to the USGS gage and can be used to determine nutrient and sediment loading at other locations within the watershed.

Table 1: Annual nutrient and sediment loading for daily discharge at Maple River Near Hope, ND

Year	*Annual Loading Based on Data from 1991 to 2020*		
	Total Phosphorus (lb)	*Total Nitrogen (lb)*	*Total Suspended Sediment (tons)*
1991	408	1,237	3
1992	1,493	4,528	11
1993	10,295	31,221	74
1994	7,253	21,996	52
1995	7,507	22,767	54
1996	4,904	14,871	35
1997	10,953	33,218	79
1998	1,210	3,671	9
1999	9,796	29,710	70
2000	2,445	7,414	18
2001	8,116	24,613	58
2002	792	2,402	6
2003	1,326	4,023	10
2004	11,394	34,556	82
2005	16,343	49,565	117
2006	4,697	14,244	34
2007	9,025	27,372	65
2008	1,114	3,377	8
2009	10,531	31,937	76
2010	12,516	37,958	90
2011	22,331	67,723	160
2012	676	2,052	5
2013	5,416	16,427	39
2014	3,732	11,318	27
2015	2,523	7,650	18
2016	2,369	7,185	17
2017	4,447	13,487	32
2018	7,694	23,334	55
2019	9,859	29,899	71
2020	10,364	31,431	74
Minimum:	408	1,237	3
Maximum:	22,331	67,723	160
Average:	6,718	20,373	48
Average Annual Yield per Sq. Mile	**386**	**1171**	**2.8**

Table 2: Annual nutrient and sediment loading for daily discharge at Maple River Near Enderlin, ND

Year	*Annual Loading Based on Data from 1991 to 2020*		
	Total Phosphorus (lb)	*Total Nitrogen (lb)*	*Total Suspended Sediment (tons)*
1991	7,007	17,737	440
1992	33,029	83,604	2,073
1993	194,641	492,685	12,214
1994	132,309	334,907	8,302
1995	155,452	393,488	9,755
1996	163,133	412,932	10,237
1997	283,463	717,517	17,787
1998	116,384	294,597	7,303
1999	211,868	536,290	13,295
2000	60,647	153,514	3,806
2001	105,302	266,546	6,608
2002	13,576	34,365	852
2003	32,296	81,750	2,027
2004	113,712	287,834	7,135
2005	92,415	233,926	5,799
2006	71,863	181,904	4,509
2007	158,536	401,295	9,948
2008	51,507	130,376	3,232
2009	354,788	898,057	22,263
2010	309,903	784,442	19,446
2011	582,045	1,473,303	36,523
2012	31,095	78,708	1,951
2013	70,247	177,812	4,408
2014	69,773	176,612	4,378
2015	52,748	133,517	3,310
2016	46,248	117,066	2,902
2017	68,808	174,169	4,318
2018	123,230	311,925	7,733
2019	476,486	1,206,104	29,899
2020	281,754	713,191	17,680
Minimum:	7,007	17,737	440
Maximum:	582,045	1,473,303	36,523
Average:	148,809	376,672	9,338
Average Annual Yield per Sq. Mile	**187**	**473**	**12**

Total Phosphorus (TP) and Total Nitrogen (TN) average annual loads from Tables 1 and 2 generally fit the scatter of estimated loads based on findings by USGS SIR 2012-5216 (USGS, 2016) and Total Maximum Daily Load (TMDL) reports for Eastern North Dakota (ND DEQ, 2021). Similar analyses completed on gauges on the Park River and Wild Rice River are also included on the plots. The TP correlation is strong with R^2 of 0.93, while TN correlation is not as strong with R^2 of 0.85. The Maple River points are above the trendline for TP, while on or below regional curve for TN. TP and TN annual load estimates are summarized in figure 9 and 10, respectively. TP and TN annual load rate (total loads divided by contributing drainage area) estimates are summarized in figure 11 and 12, respectively.

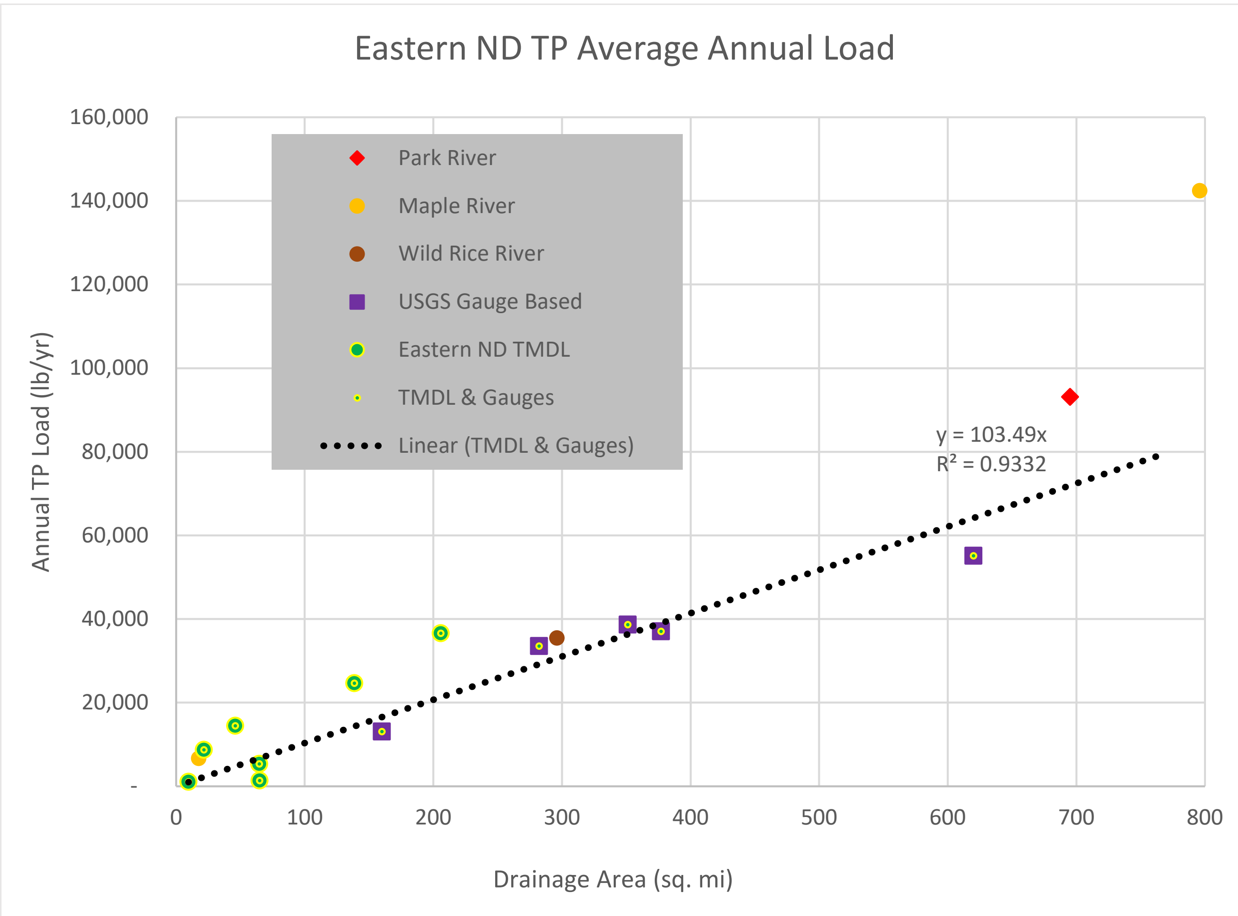

Figure 9: Average Annual TP Load Regional Curve

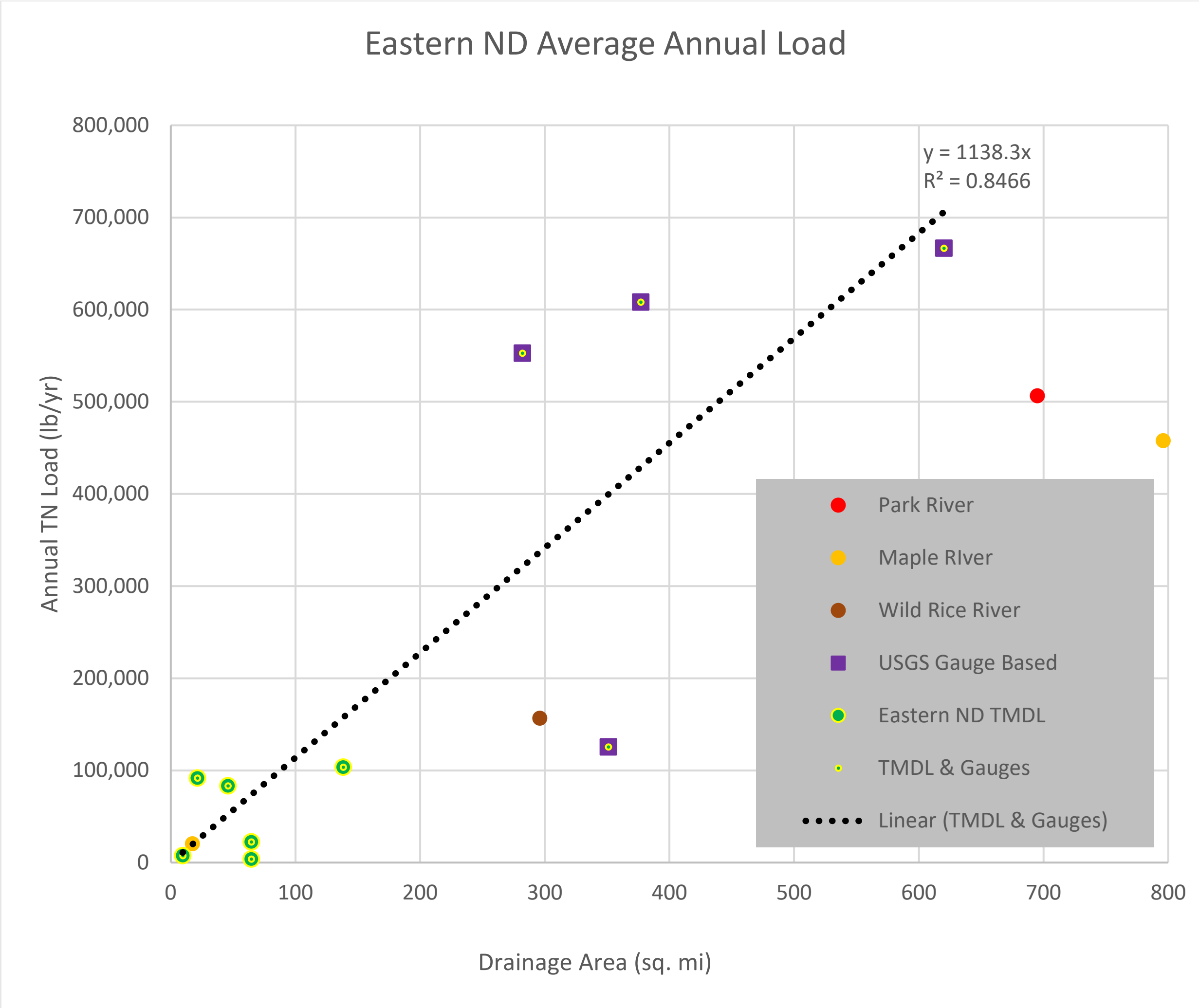

Figure 10: Average Annual TN Load Regional Curve

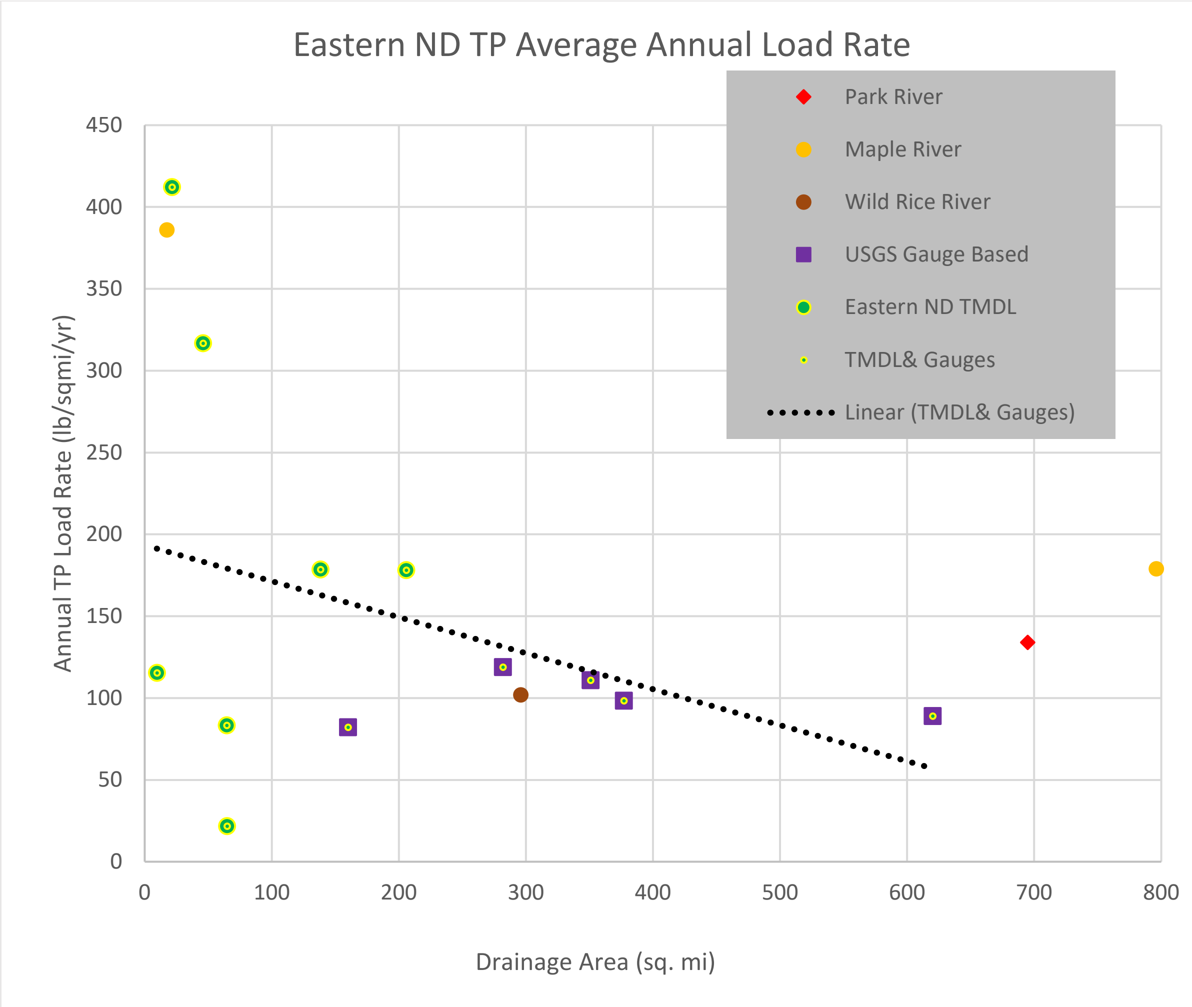

Figure 11: Average Annual TP Load Rate Regional Curve

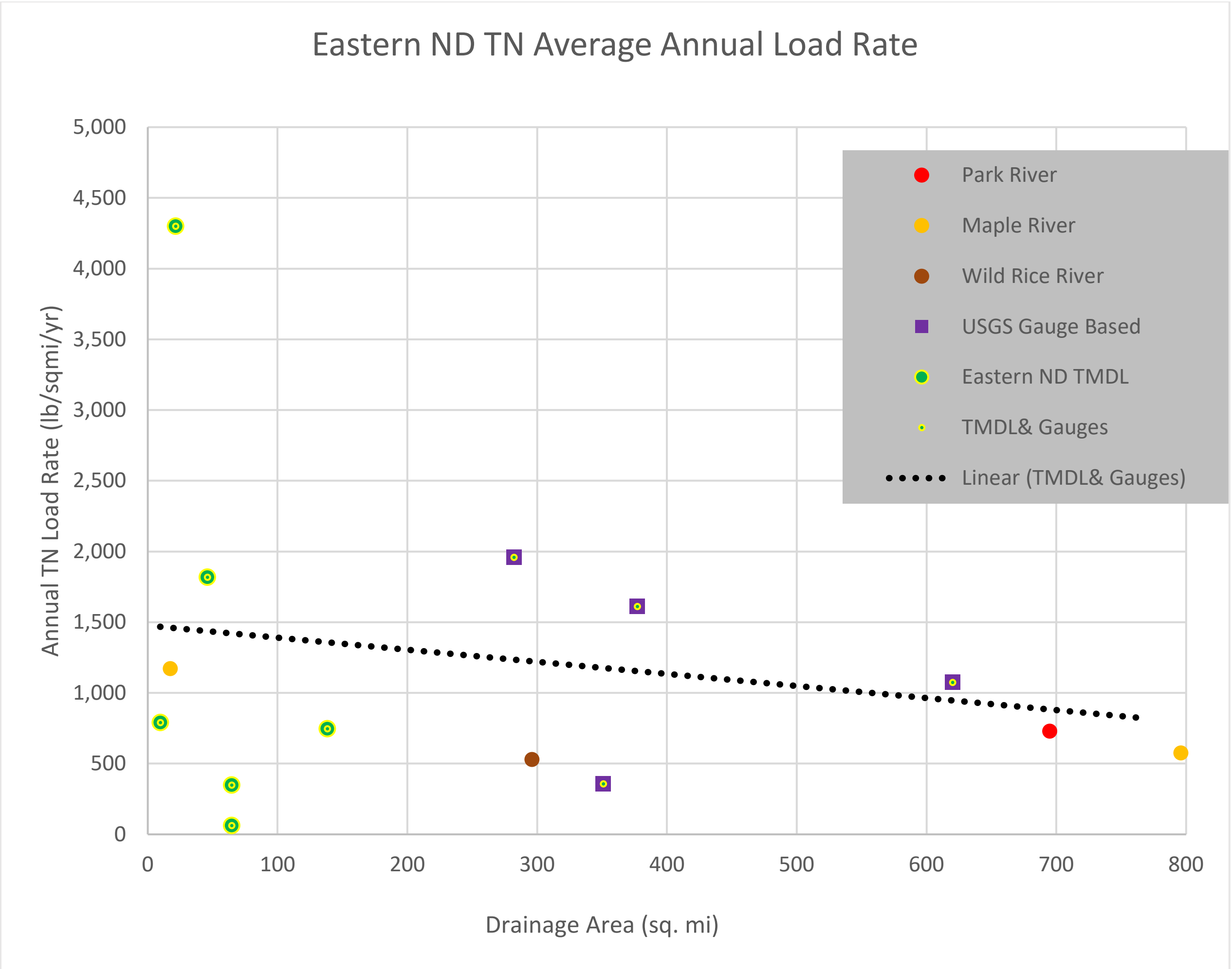

Figure 12: Average Annual TN Load Rate Regional Curve

The load rates have more scatter and weaker correlation, however do show a trend for lower load rates for larger catchments. These lower rates can occur from nutrient and sediment loss from physical, chemical, and biological processes, and are expected to occur throughout the system. For this reason, first order loss equations were used to estimate the nutrient and sediment delivery ratios to the USGS gages using a program called PTMApp (Houston Engineering Inc., 2016). PTMapp provides detailed output information at several priority resource points within the watershed. Output information on nutrient and sediment delivery ratios are available at the USGS Gage, and near the reporting locations shown on Figure 1. The nutrient and sediment delivery ratios at the proposed sites, near Buffalo, ND, and USGS gauge near Enderlin were used to obtain average annual delivery per square mile at each location. The Hope gauge catchment is smaller than project sites, therefore values are ratioed up; while Enderlin gauge catchment is larger than project sites, therefore values are ratioed down. For example, the average annual phosphorus loading found from empirical data at the Hope USGS gage is approximately 386 pounds per square mile. The TP nutrient delivery ratio at that location (from PTMApp outputs) is approximately 0.8, or 80% of the original loading rate. Therefore, the average annual phosphorus loading per square mile for all individual catchments upstream of the USGS gage is approximately 482.5 pounds per square mile. That rate can then be used at a different location in watershed, such as the project site. If the project site 2A has a TP delivery ratio of 0.63, that would then be multiplied by the TP delivery rate (482.5) and then multiplied by the drainage area (59.7 square mile) to the site to get total annual mass of TP delivered (18,151 lb/yr). The same is done at Enderlin gauge (16,950 lb/yr) and average (17,550 lb/yr) used for further analysis.

The drainage area to dam site is approximately 59.7 square miles. The average annual TP, TN, and TSS loadings per square mile were multiplied by the drainage area to the dam and then by the appropriate delivery ratios to obtain the values in the fifth columns of Table 3, which represent the nutrient and sediment loadings entering the site. To compute the water quality benefits at the site, nutrient and sediment reductions were estimated based on the North Ottawa impoundment study discussed previously (Guzner, 2017). For the North Ottawa impoundment, annual reductions of 66%, 73% and 42% were estimated for TP, TN, and TSS, respectively. The annualized nutrient and sediment loadings entering the site were then reduced by the percentages determined for the North Ottawa impoundment study. The results are shown in Table 3. Verification that the phosphorus load retained within the site (~11,200 lb/year) can be harvested is critical. Assuming approximately the average content value of 47 lb/acre phosphorus in harvested biomass, range is 26 – 53 for cattails (Grosshans, 2011), and preliminary 264.3 acre biomass harvest areas, the 11,200 lb/year retention calculation is justified. The Upper Maple River TP loads were above the regional curve, but assuming the average TP to biomass content compensates; the biomass harvest area size is expected to stay similar to these assumed areas to obtain documented benefits in final design.

Table 3: Annualized Nutrient Reduction at Upper Maple Alternative 2A Dam Site

Parameter	Annual Yield/Sq. Mile at Site 2A (DA = 59.7 mi^2)			Incoming Nutrient/ Sediment Delivery	% Reduction (Guzner, 2017)	Nutrient/ Sediment Loading Retained within the Site	Nutrient/ Sediment Loading Leaving the Site
	Scaled up from Enderlin (CDA = 796 mi^2)	Scaled down from Hope (CDA = 17.4 mi^2)	Average (Enderlin & Hope)				
Total Phosphorus (lb/year)	296	304	300	17,921	66%	11,828	6,093
Total Nitrogen (lb/year)	776	954	865	51,634	73%	37,693	13,941
Total Suspended Solids (ton/year)	47	2.5	25	1,464	42%	615	849

Values for the with-project scenario at locations downstream of the proposed site were computed by removing the drainage area upstream of dam sites and adding the nutrient and sediment loading leaving the site to get the total annual mass. Nutrient and sediment loadings leaving dam sites can be found in last column of Table 3.

Beyond water quality improvements related to biomass harvesting cells at site 2A, there are also improvements due to flood control features and reduced flows in the Upper Maple River watershed below the dam. Flow reductions are based on scaled daily flows from the Enderlin gauge to consider volume of non-flood events, historic hydrographs are extremely variable, and many years have multiple separate events. For example, historic flood events have lasted only a few days to over a month, and 2019 had a spring, summer, and fall high flow events. Modeled synthetic frequency based rainfall and runoff estimates, from economics analysis, are based in the summer time and don't consider the annual runoff volume or water quality constituent annual volumes. However, frequency-precipitation based peak runoff flows from modeling allow for suitable scaling of USGS gauge data.

The USGS gauge (05059700 Maple River Near Enderlin, CDA of 796 mi^2) is used for scaling as it better represents historic flood events at the Upper Maple River watershed outlet location (291 mi^2); the Hope gauge CDA is only 17.4 mi^2. The Upper Maple River Watershed Outlet (UMRWO) is scaled down from the Enderlin gauge by a factor of 7.5, which is the average increase between 2 and 50-year events. The modeled existing conditions peak flows, proposed (Alt. 2A), Enderlin USGS gauge, scaled daily UMRWO, and differences between estimates are summarized in Table 4. The differences between modeled and scaled values are generally small, with an average difference of -2%. The outlier is 500-year event, however is not critical as the largest flood in period of record analyzed (1991-2020) equates to a 25-year event. The daily flow records at Enderlin USGS gauge were shown in figure 3.

Table 4: Peak discharges from hydrologic modeling compared to scaled daily flows from USGS gauge

Modeled Peak Discharge (cfs) at the Upper Maple River Watershed Outlet (UMRWO)						
Event	**Existing Conditions**	**Alternative 2A**		Enderlin USGS Gauge	Scaled Daily UMRWO Discharge	Difference (Scaled to modeled)
2-yr	215	215		1,094	215	0%
5-yr	434	400		3,181	433	0%
10-yr	581	501		4,805	614	6%
25-yr	773	633		6,780	884	14%
50-yr	1,020	804		8,084	1212	19%
100-yr	1,320	1,073		9,212	1362	3%
500-yr	4,952	3,222		11,212	2030	-59%

The scaled UMRWO daily flows are applied to TP, TN, and TSS rating curve lines from Enderlin gauge and summed similar to the gauge analysis described at the beginning of this section. The average annual flood control applied water quality benefits are 734 lb for TP, 1,859 lb for TN, and 46 tons for TSS; the annual tables are summarized in Table 5. A key takeaway from results is that there is no flow reduction for 2-year runoff events and lower; therefore there are no water quality load reductions during years with peak flow lower than 215 cfs, i.e. 1991, 1992, and etc..

Table 5: Annual nutrient and sediment loading for daily discharge at Upper Maple River Watershed Outlet, existing and proposed condition comparison

Year	***Existing Conditions Annual Loading Based on Data from 1991 to 2020***		
	Total Phosphorus (lb)	*Total Nitrogen (lb)*	*Total Suspended Sediment (tons)*
1991	934	2,365	59
1992	4,404	11,147	276
1993	25,952	65,691	1,628
1994	17,641	44,654	1,107
1995	20,727	52,465	1,301
1996	21,751	55,058	1,365
1997	37,795	95,669	2,372
1998	15,518	39,280	974
1999	28,249	71,505	1,773
2000	8,086	20,468	507
2001	14,040	35,540	881
2002	1,810	4,582	114
2003	4,306	10,900	270
2004	15,162	38,378	951
2005	12,322	31,190	773
2006	9,582	24,254	601
2007	21,138	53,506	1,326
2008	6,868	17,383	431
2009	47,305	119,741	2,968
2010	41,320	104,592	2,593
2011	77,606	196,440	4,870
2012	4,146	10,494	260
2013	9,366	23,708	588
2014	9,303	23,548	584
2015	7,033	17,802	441
2016	6,166	15,609	387
2017	9,174	23,223	576
2018	16,431	41,590	1,031
2019	63,531	160,814	3,987
2020	37,567	95,092	2,357
Minimum:	934	2,365	59
Maximum:	77,606	196,440	4,870
Average:	19,841	50,223	1,245
Average Annual Yield per Sq. Mile	**68**	**173**	**4**

Year	***Proposed Annual Loading Based on Data from 1991 to 2020***		
	Total Phosphorus (lb)	*Total Nitrogen (lb)*	*Total Suspended Sediment (tons)*
1991	934	2,365	59
1992	4,404	11,147	276
1993	25,435	64,382	1,596
1994	17,484	44,257	1,097
1995	20,670	52,320	1,297
1996	21,192	53,643	1,330
1997	35,087	88,813	2,202
1998	15,518	39,280	974
1999	27,854	70,507	1,748
2000	8,086	20,468	507
2001	13,858	35,079	870
2002	1,810	4,582	114
2003	4,306	10,900	270
2004	15,162	38,378	951
2005	12,322	31,190	773
2006	9,404	23,803	590
2007	20,950	53,029	1,315
2008	6,868	17,383	431
2009	42,556	107,720	2,670
2010	39,003	98,727	2,447
2011	71,737	181,584	4,501
2012	4,146	10,494	260
2013	9,366	23,708	588
2014	9,303	23,548	584
2015	7,033	17,802	441
2016	6,166	15,609	387
2017	9,174	23,223	576
2018	15,914	40,283	999
2019	61,085	154,623	3,833
2020	36,380	92,086	2,283
Minimum:	934	2,365	59
Maximum:	71,737	181,584	4,501
Average:	19,107	48,364	1,199
Average Annual Yield per Sq. Mile	**66**	**166**	**4**

The resulting annual nutrient and sediment delivery for both existing and proposed conditions, including biomass harvesting and flood control applied water quality improvements, are shown in Table 6.

Table 6: Annualized Nutrient Reduction at and Downstream of Upper Maple Dam Sites

Location	*Drainage Area (Square Miles)*	*TP Delivery Ratio*	*TN Delivery Ratio*	*TSS Delivery Ratio*	*Scenario*	*Annual TP Delievery (lb/year)*	*Annual TN Delivery (lb/year)*	*Annual TSS Delivery (Ton/year)*
Site Outlet 2A	59.7	**0.63**	**0.65**	**0.39**	Existing	17,921	51,634	1,464
					Proposed	6,093	13,941	849
					% Reduction	66%	73%	42%
Maple River Near Buffalo, ND	377.4	**0.56**	**0.56**	**0.15**	Existing	99,232	201,883	3,466
					Proposed	86,670	162,331	-46
					% Reduction	13%	20%	101%
USGS Gage (Enderlin)	843 CDA: 796	**0.40**	**0.40**	**0.10**	Existing	148,809	376,672	9,338
					Proposed	136,247	337,121	8,677
					% Reduction	8%	11%	7%

2.4 Water Quality Benefit Summary

Water quality benefits are expected because of pollutant capture in the site with associated biomass removal to maintain capacity, and decreased extents and frequency of inundation in downstream agricultural fields during large runoff events. Pollutant capture within the site is estimated based on the study of the North Ottawa impoundment which is also located in the Red River Basin. Removal or retention of phosphorus, nitrogen, and suspended solids within the site is estimated to be 11,828 pounds per year, 37,693 pounds per year, and 615 tons per year, respectively. The average annual flood control applied reduction of downstream transported phosphorus, nitrogen, and suspended solids are 734 lb, 1,859 lb, and 46 tons, respectively. The total project water quality benefits for phosphorus, nitrogen, and suspended solids are 12,562 lb, 39,552 lb, and 661 tons, respectively.

Reductions to nutrient loading immediately downstream of the proposed site is expected because of the pollutant capture within the site is based on optimal sizing of 4:1 (acres/square mile), which is 239 acres (of biomass harvesting areas for the 59.7 square mile 2A catchment. The final BH cell areas were upsized slightly to 264.3 acres for resiliency and fit into available spaces. As the Upper River progresses downstream and eventually flows into the Sheyenne River, the relative water quality benefits will begin to diminish because of the accumulated discharge. Lower in the Maple River Watershed the water quality benefits are significantly lower in terms of percent reduction than the benefit immediately downstream of the site.

3 WETLAND BENEFITS

The Preferred Alternative will involve a net positive impact on wetland functions and wildlife habitat, as a result of planned constructed wetlands and restoration features. It does, however, result in loss of wetland acreage and function from filling and drainage in some locations. Calculation of Environmental Quality (EQ) account wetland benefits for existing and proposed project alternatives was completed utilizing the NRCS Hydrogeomorphic Functional Assessment Model for

- Prairie Potholes, Low Permeability Substrate, Temporary and seasonal, dominantly recharge, depressions, and

- Riverine.

EQ benefits calculate both wetland area gains and losses, as well as functional habitat improvements and losses. Functional improvements are based on wetland indices, which measure the ability of a wetland to perform a specific function relative to a regional reference standard; indices are then multiplied by the wetland area to generate Functional Capacity Units (FCU) (USDA-NRCS, 2008).

3.1 Existing Wetland Extents

The project area includes 53 existing wetlands totaling 237.6 acres; see Wetland Delineation Report in Appendix D-5 for more details on this process. The existing land use of the conservation easement area includes 497 acres of annual crops and 541 acres of perennial vegetation (figure 13). Some of the wetlands are affected by ditches. However, upstream of these ditches some portions retained hydric indicators and still meet wetland criteria. Appendix D-4 (Wetland Delineation Report), figures 5.1, 5.2, and 5.3 are wetland delineation maps completed using USACE Regional Supplement/NEPA criteria.

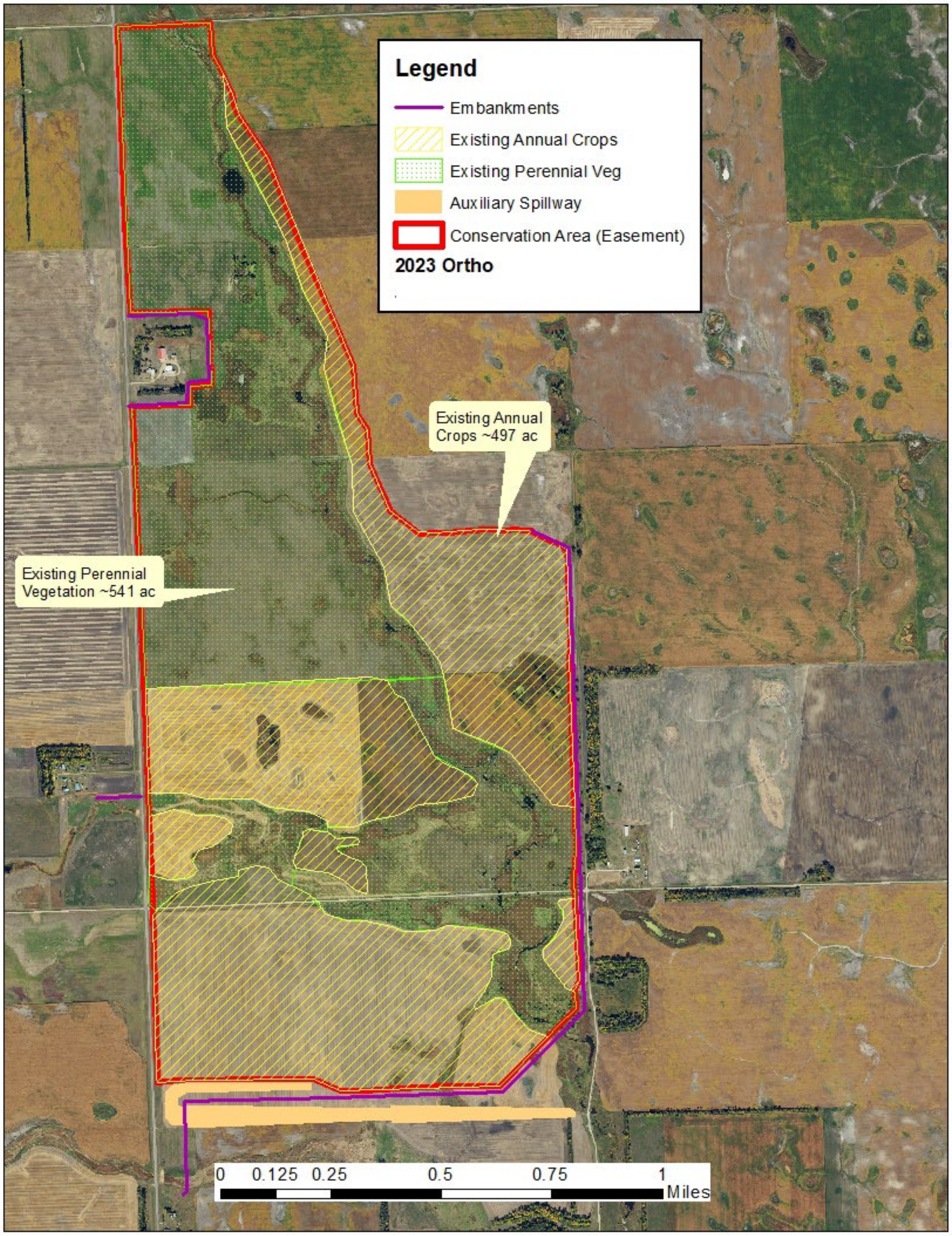

Figure 13: Alternative 2A land use map

3.2 Permanently Impacted Wetlands

The proposed project is multipurpose water storage structure that includes a dam embankment and related features, including principal and auxiliary spillways. Also included in this site are upland areas to be restored to native grassland and biomass harvesting wetlands. Wetlands are impacted through placement of fill or excavation occurring within wetland boundaries. The principal spillway is expected to incorporate an on-channel grade culvert to limit affecting wetlands beyond the embankment footprint and principal spillway extents. The principal spillway excavation extends ~1,000 feet, in order to provide straight flowpath through the embankment, and direct exit flows away from 129th Ave SE. Fourteen of the fifty-three wetlands will be affected by the embankment footprints or will have hydrology cutoff by the embankments or auxiliary spillway and completely lost (figure 15). Eighteen of the fifty-three wetlands will be affected by the biomass harvest features and loose some functions due to modified hydroperiod and management, but retain wetland designation (figure 15). Six wetland plugs within 14D labeled P2-P7 are accounted for in wetland losses as they are in delineated wetland areas. The wetland area lost sums to 29.27 acres (25.71 acres of Potholes and 3.56 acres of riverine).

The embankment and excavation areas cause negative impacts to existing wetland functions and area. The overall goal of "avoid, minimize, and mitigate" is best served with the combined approach of minimize and mitigate within the project site. There are two wetland areas avoided with project features, including culvert through embankment at station 122+17 and backwater connection at the primary spillway exit channel; see Appendix D-7 (Preliminary Plans) for project details. Backwater connections provide highly permeable path for water to connect from river channel to wetland, while maintaining desired channel dimensions and erosion protection, see figure 14 for cross section details. The oxbow wetland retains groundwater connection to the channel, and mimic similar natural wetlands that form these types of wetlands due to channel meander migration. These backwater connections avoid significant wetland impacts while lowering erosion risk to infrastructure. Wetland impact summaries are documented in tables 7 and 8; individual lost wetland areas and functions are identified in Table 9, while gains are identified in Table 10.

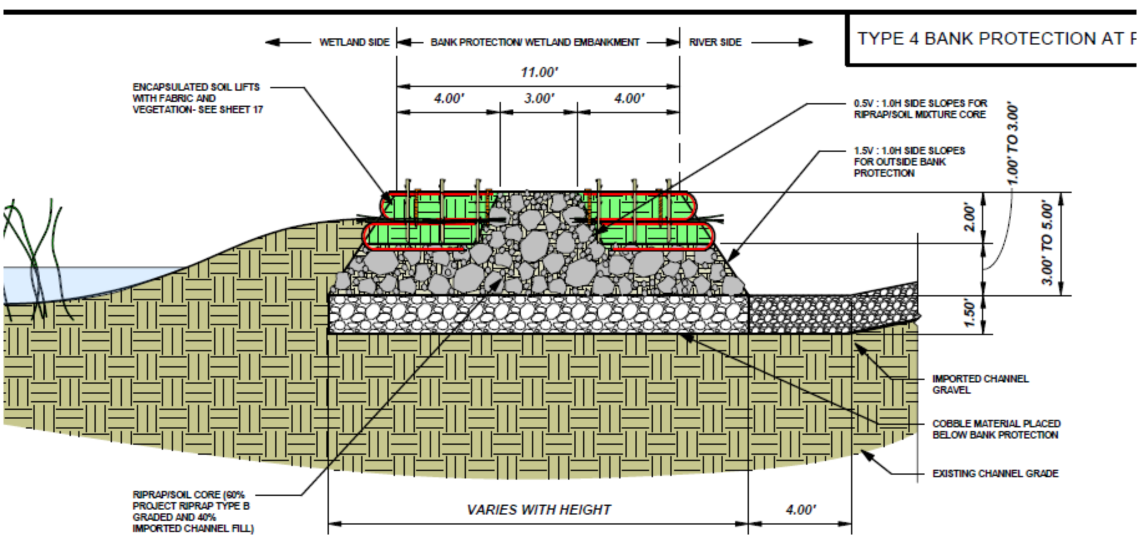

Figure 14: Backwater Connection Cross Section

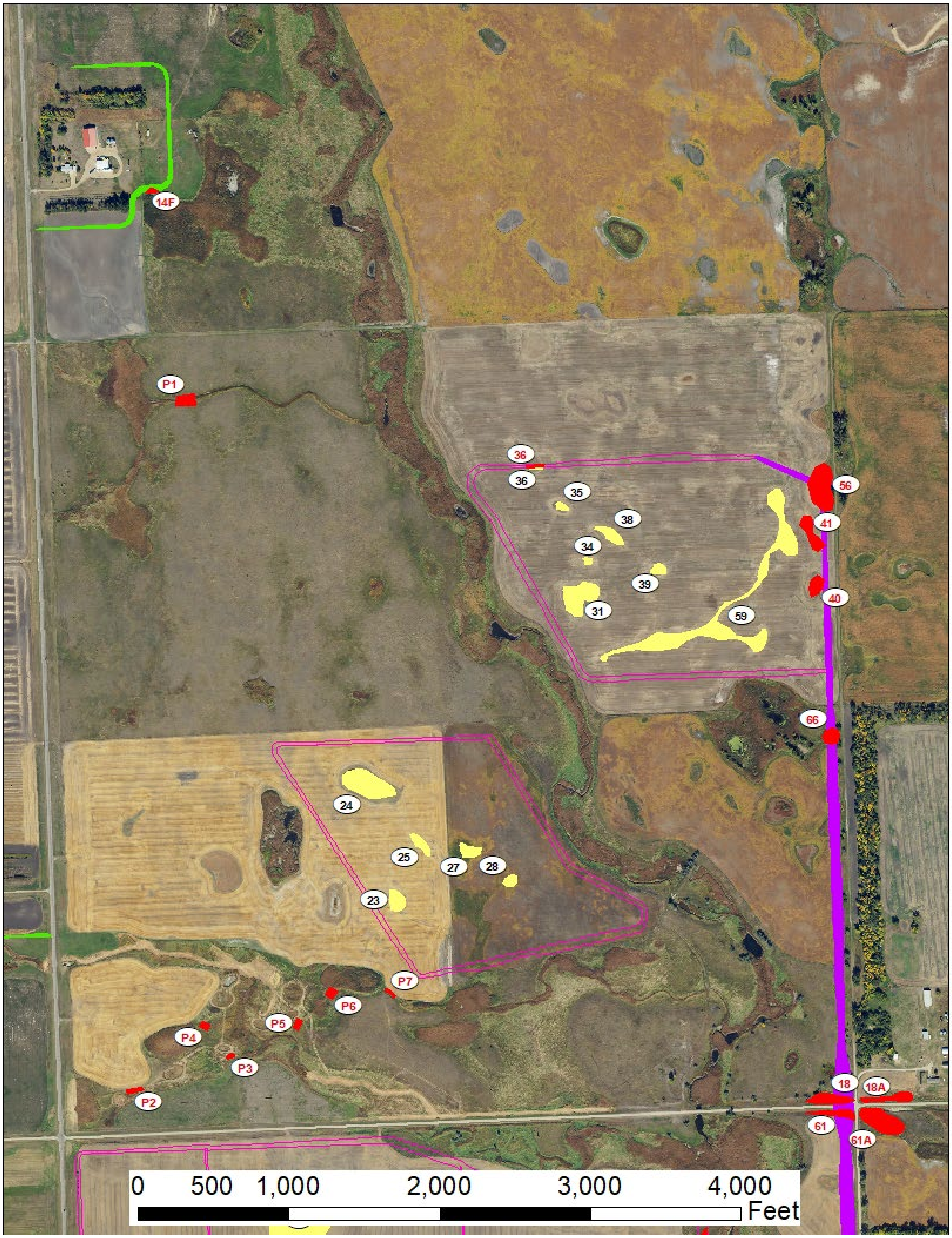

Figure 15A: Wetlands lost due to project features (North)

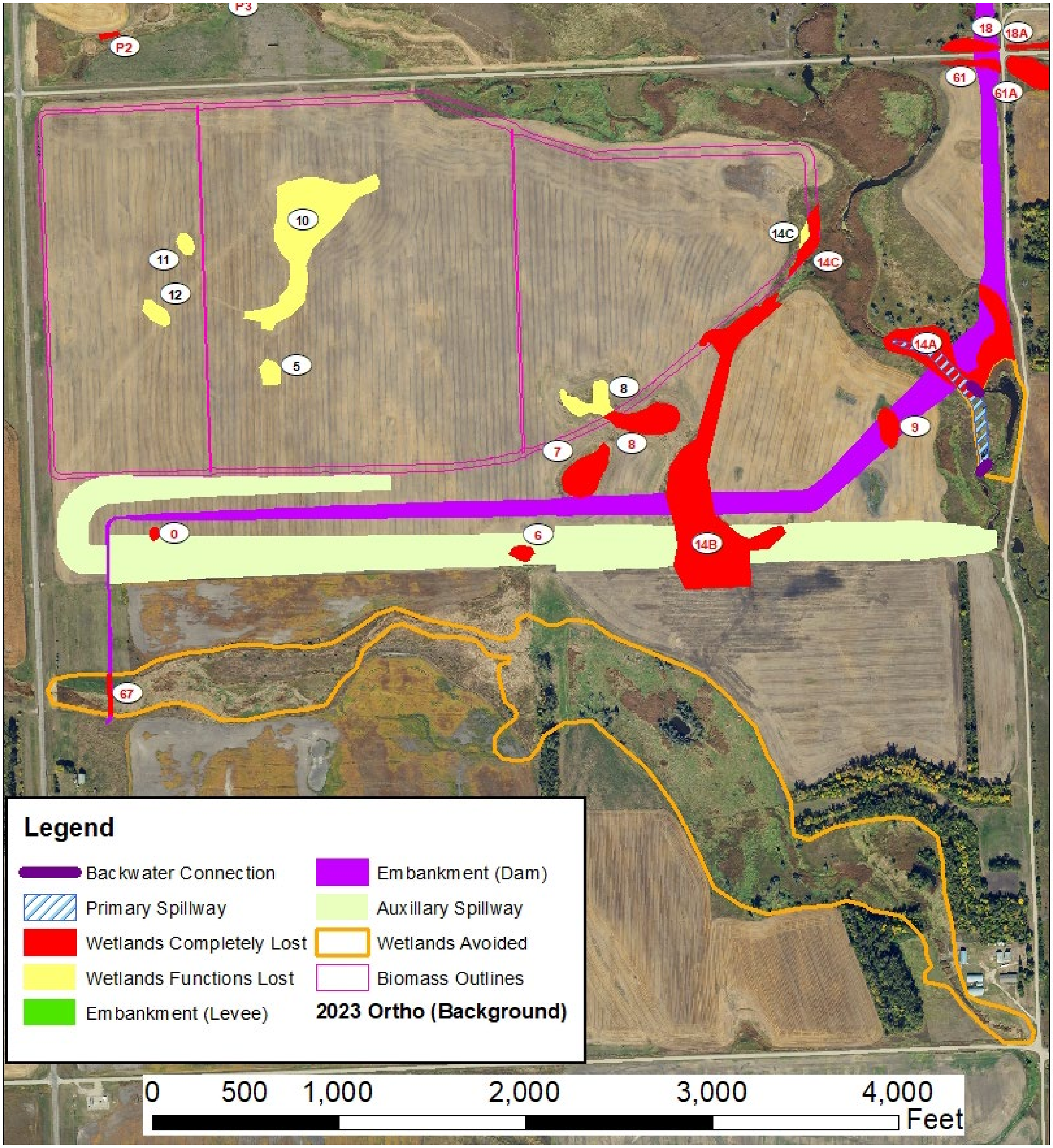

Figure 15B: Wetlands lost due to project features (South)

3.3 Wetland Area and Functional Improvements

Multiple wetland improvements will be made to the project area, including wetland restorations and constructed wetlands. Wetland restoration will include restoration of hydrology by filling existing ditches and channels. Pothole restorations will include ditch fill to the wetland boundary or to the landscape level to attain dynamic storage functions, perennial vegetation, buffer and uplands to improve functions. Riverine and floodplain wetlands will be restored by filling excavated channels and re-creating natural riverine and floodplain conditions. Pothole wetland restoration will include restoring natural spillout levels to retain runoff hydrology. This site includes pothole and riverine wetlands partially and completely ditched. The final wetland improvements will significantly increase area and functional benefits from restoring the natural hydrology, vegetation, and soils. Natural hydrophytic vegetation will be planted or seeded in areas outlined. Soils will develop hydric indicators resulting from restored hydrology.

Constructed wetlands, described as biomass harvesting (BH) cells are designed into this project improve water quality of Maple River and further downstream rivers as described in Section 2. The critical water quality nutrient in the Red River of the North is phosphorus, which is dominant in the dissolved form. Effective conservation practices are very limited to treat Total Dissolved Phosphorus (TDP). However, BH cells have been shown to work well in the basin to reduce downstream TDP by using hydrophytic plant uptake followed by harvesting and removing the plant material annually prior to first heavy freeze. The preliminary ideal ratio of BH cell size to drainage area is 4 acre/square mile (see Section 2); therefore the ideal BH site size at Alternative 2A sites is 239 acres. The final BH cell areas were upsized slightly to 260.2 acres for resiliency and fit into available spaces. The BH cell requires hydrophytic vegetation, therefore needs to have annual shallow inundation or saturation for a minimum of 14 days, but preferably for several months. A BH cell is limited at lower portion of project area due to expansive existing wetlands.

A BH cell has wetland area, but some functions score very low due to the early fall harvest 2 out of 3 years, i.e. Vpratio (native plant species) and Vdetritus (dead plant material). The pothole Hydrogeomorphic Model (HGM) was chosen to evaluate functions of BH areas because it most closely fits hydrology, soils, and vegetation. The descriptions of Pothole HGM that meet features of BH areas include northern climatic region, low permeability substrate, temporary or seasonal hydroperiod, and dominantly recharge closed contour depressions. Furthermore, hydrology can be from variety of sources (precipitation, overland flow, or groundwater), and cattails are common hydrophytic plant in North Dakota wetlands. The There is no HGM designed for BH areas as they are constructed wetlands and not natural, other approved HGM's for North Dakota wetland include Slope and Riverine, neither of which matches better than the Pothole HGM. However, the functions that are gained need to be quantified with approved HGM, hence the Pothole HGM is used.

Wetland restoration include ditch plugs for potholes, and floodplain restoration for riverine wetlands, where soils no longer had hydric indicators. Wetland restoration also includes improved functions of existing wetlands. Figure 16 provides an overall map of planned wetland improvements, whiles Tables 7-8 summarize the proposed improvements in both acreage and wetland functional capacity. During the design phase of the project, detailed field work and HGM assessments will be performed for final wetlands constructed/restoration designs. The final design will achieve the minimum FCU scoring presented in the watershed plan, but wetland construction and restorations may have slight changes to the boundaries and design of planned features. Abbreviations utilized in the tables to describe pothole wetland functions are defined as:

- *Static*- capacity of the wetland to sustain the areas surface and groundwater supply

- *Dynamic*- capacity to retain runoff, maintain subsurface recharge, and stable vegetation zone above the more consistent saturated regions.
- *Cycling* - short- and long-term cycling of elements and compounds on site through the abiotic and biotic processes that convert elements from one form to another.
- *Removal* – capacity to remove nutrients and particulates from downstream water bodies
- *Retention* - deposition and retention of inorganic and organic particulate (>45 um) from the water column, primarily through physical processes.
- *Plants*- species composition and physical characteristics of living plant biomass.
- *Structure* – soil structure to store, move, and release water, cycle nutrients and compounds, and support healthy plant communities.
- *Habitat*- myriad of conditions for animals that allows numerous species to coexist in the same area.

Abbreviations utilized in the tables to describe riverine wetland functions are defined as:

- *Velocity reduction surface water*- the capacity of the wetland access floodplain during ~1.5-yr runoff event, in order to dissipate larger flows over broader area with higher roughness.
- *Storage & release subsurface water* - the capacity to maintain baseflow.
- *Removal imported elements & compounds* - capacity to remove nutrients and particulates from downstream water bodies.
- *Elemental and Nutrient Cycling*- short- and long-term cycling and removal of elements and compounds on site through the abiotic and biotic processes that convert elements from one form to another.
- *Retention of Particulates and Organic Materials*- deposition and retention of inorganic and organic particulate (>45 um) from the water column, primarily through physical processes.
- *Organic Carbon Export*- export of dissolved and particulate organic carbon and detritus from the wetland.
- *Maintenance habitat structure*- myriad of conditions for animals that allows numerous species to coexist in the same area.
- *Habitat structure & connectivity among wetlands*- the spatial relationship of an individual wetland with respect to adjacent wetlands in the complex.

3.4 Wetland Benefit Summary

The proposed project has a very large and complex wetland area improvement through restoration and construction, which are estimated at 275.1 acres total, 245.39 acres net. Furthermore, variable Functional Capacity Unit (FCU) increases are generated, primarily from biomass harvest constructed wetlands, restored hydrology to prior converted wetlands, and conversion of existing cropland to perennial vegetation. All wetland acreage lost as the result of the project and each associated function were mitigated for and then the additional wetland restoration and constructed wetlands accounted for gained improvements. Wetland restorations are considered re-establishment when manipulation results in a gain in wetland acres, while considered rehabilitation when the result is a gain of functions but not area. Wetland restoration areas 14D, 14E, 70, 71, and 72 are considered re-establishment. Wetland restoration areas 19-22, 29, 64, and 65 are considered rehabilitation.

The minimum riverine FCU gain is 2.54 FCUs for the Storage & Release Subsurface Water function, while the maximum FCU gain is 6.02 FCUs for the Organic carbon export function. The minimum pothole FCU gain is score of 56.12 (habitat), the maximum FCU gain is 220.49 (Retention), and all other scores range from 140 - 162. The FCU habitat score is lower than others because the large biomass harvest area constructed wetlands will be harvested, as well as reliance on waterfowl breeding density information by US Fish and Wildlife Service (Thunderstorm Map); this area is comparatively lower than areas with more perennial or semi-permanent wetlands.

The project and nearby area have very limited wetlands remaining due to drainage. Remaining wetlands in the local area have low FCUs due to hydrology changes and intensive cropping of wetlands and buffers. The proposed project has great potential to substantially improve wetland area and functions at these sites, which is intertwined with water quality benefits and overall habitat improvements.

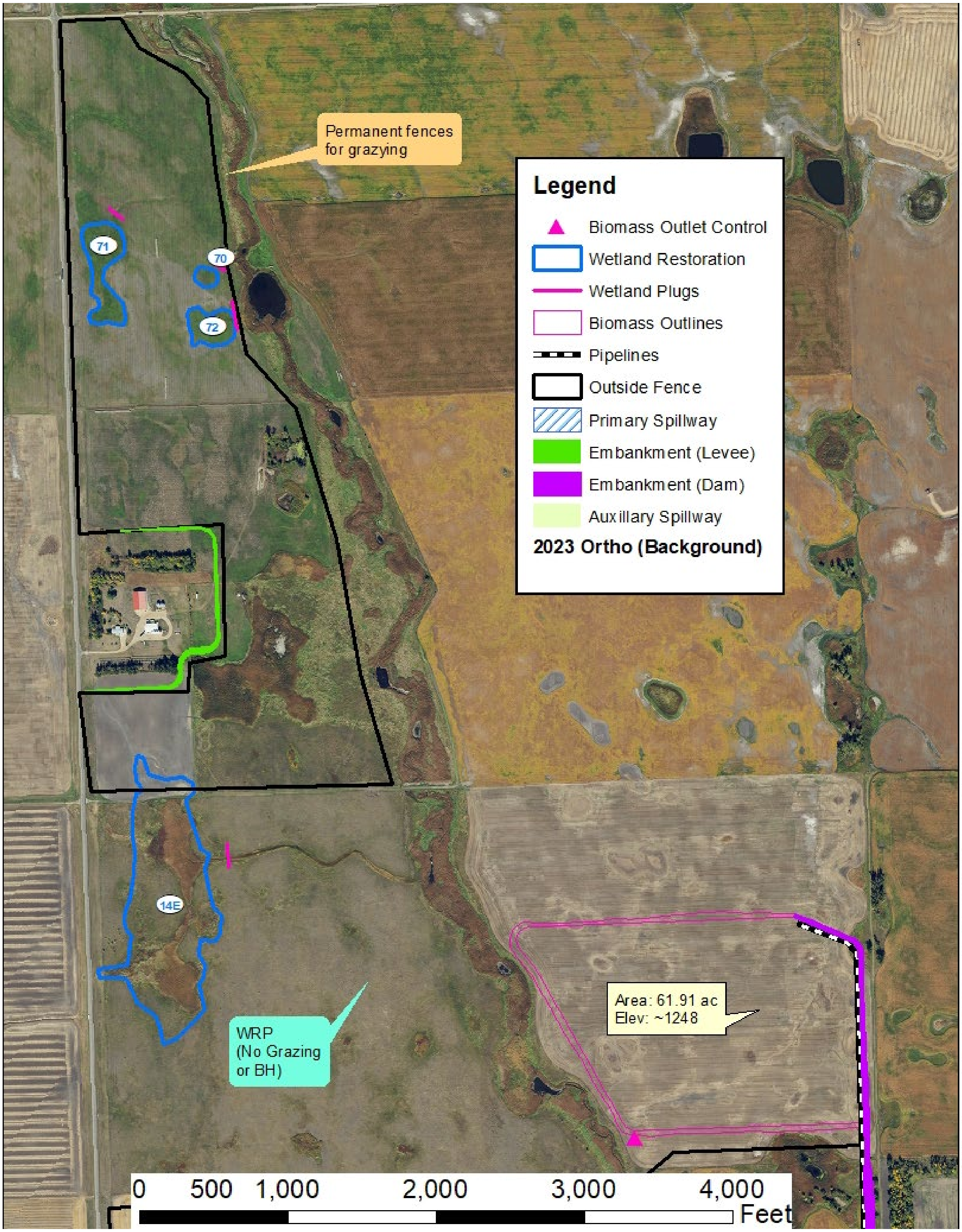

Figure 16: Upper Maple River Project Site EQ Benefit Summary Map (North)

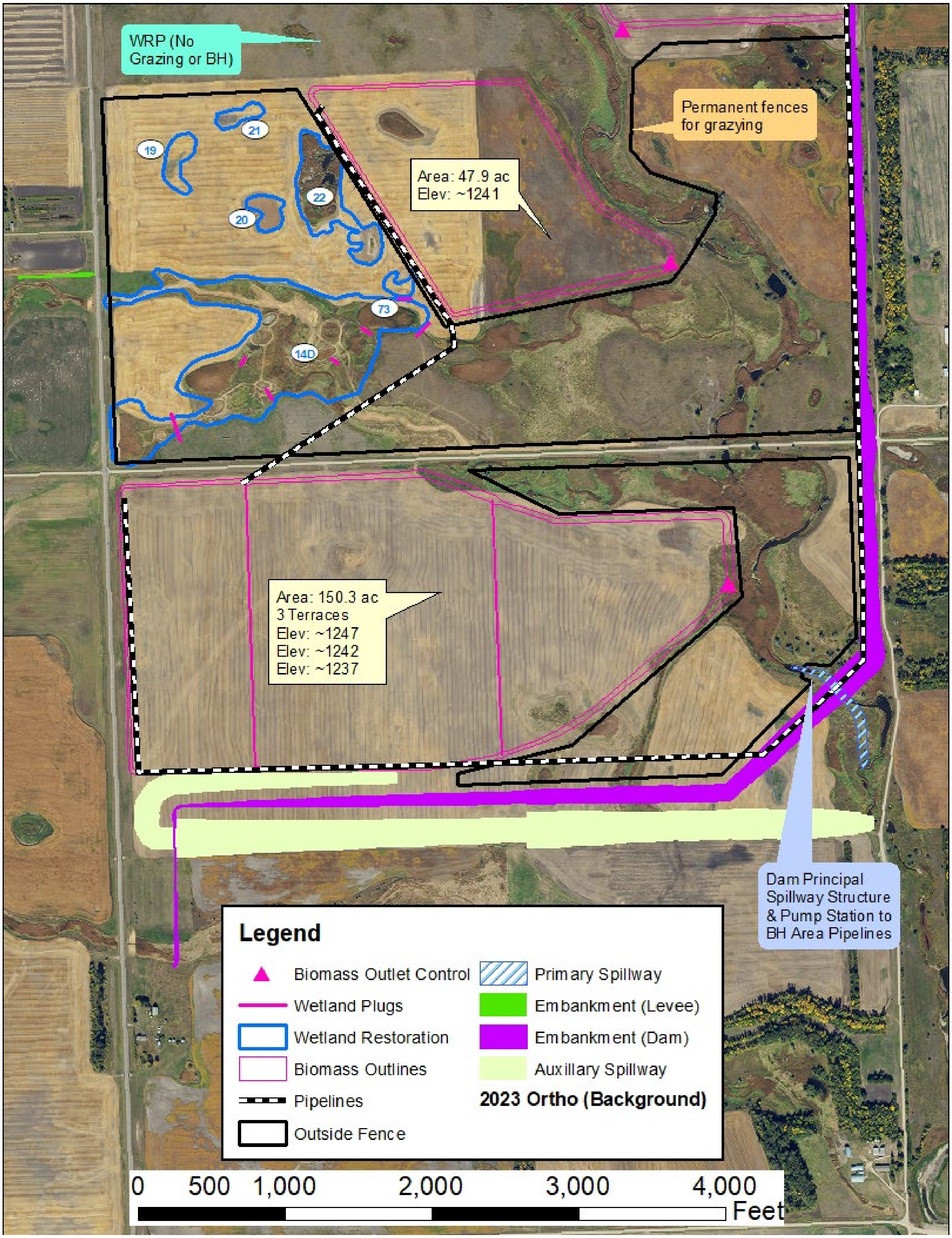

Figure 16 (Continued): Upper Maple River EQ Benefit Summary Map (South)

Table 7: Summary Wetland Acreage Impacts

POTHOLE ACREAGE			
Wetland Numbering or features	Pre-project (ac)	Post-Project (ac)	Total Mitigation Required (ac)
0,6	0.28	0.00	0.28
7,9, 40, 41 56, 66, 67	3.13	0.00	3.41
5, 8, 10, 11, 12	7.11	0.00	10.52
14B, 14F	7.07	0.00	17.59
18,61, 18A, 61A	1.68	0.60	18.67
23, 24, 25, 27, 28	2.06	0.00	20.73
31, 34, 35, 36, 38, 39, 59	4.98	0.00	25.71
14E	13.80	18.80	20.71
Biomass Harvesting	0.00	260.18	-239.47
19-22,29,64-65	15.88	15.88	-239.47
70-72	0.00	4.73	-244.20
Net	55.99	300.19	-244.20

RIVERINE ACREAGE			
Wetland Numbering	Pre-project (ac)	Post-Project (ac)	Mitigation Required (ac)
14A,14C	3.56	0.00	3.56
14D	21.10	25.85	-1.19
Net	24.66	25.85	-1.19

Note: Negative numbers represent gains in terms of wetland acreage, i.e. the result is 245.39 acres.

Table 8: Summary Wetland HGM Function Impacts

POTHOLE FUNCTIONS	Pre-project (FCU)	Post-Project (FCU)	Mitigation Required (FCU)
Dynamic	3.58	159.98	-156.40
Cycling	17.57	158.09	-140.52
Removal	19.19	169.90	-150.72
Retention	17.41	237.89	-220.49
Plants	22.19	184.44	-162.25
Structure	17.96	168.76	-150.80
Habitat	10.52	66.64	-56.12

RIVERINE FUNCTIONS	Pre-project (FCU)	Post-Project (FCU)	Mitigation Required (FCU)
Velocity Reduction Surface Water	18.22	22.74	-4.51
Storage & Release Subsurface Water	16.18	18.71	-2.54
Removal Imported Elements & Compounds	16.98	22.50	-5.51
Retention of Particulates & Organic Materials	17.96	21.67	-3.71
Organic Carbon Export	19.03	25.04	-6.02
Maintains Plant Community	17.54	21.87	-4.34
Maintains Habitat Structure	18.50	24.13	-5.63
Habitat Structure & Connectivity Among Wetlands	17.10	22.21	-5.10

Note: Negative numbers represent gains in terms of wetland functions, i.e. the result of the project is a significant increase in wetland functions in all categories.

Table 9, HGM Wetland Impacts for Project by Location (Wetland Losses)

Wetland Losses										
		Pre Project Assessment			Post Project Assessment			Gain or Loss		
Wetland ID	Functions	Wetland Acres	FCI	FCU	Wetland Acres	FCI	FCU	FCI	FCU	Rationalle
0,6	Static	0.3	0.23	0.06	0.0	0.00	0.00	-0.23	-0.06	Aux spillway
	Dynamic		0.00	0.00		0.00	0.00	0.00	0.00	
	Cycling		0.24	0.07		0.13	0.00	-0.10	-0.07	
	Removal		0.27	0.08		0.13	0.00	-0.15	-0.08	
	Retention		0.15	0.04		0.08	0.00	-0.08	-0.04	
	Plants		0.30	0.08		0.27	0.00	-0.03	-0.08	
	Structure		0.16	0.04		0.11	0.00	-0.05	-0.04	
	Habitat		0.12	0.03		0.06	0.00	-0.06	-0.03	
7,9, 40, 41 56, 66, 67	Static	3.1	0.23	0.71	0.0	0.00	0.00	-0.23	-0.71	Dam Fill
	Dynamic		0.00	0.00		0.00	0.00	0.00	0.00	
	Cycling		0.24	0.74		0.13	0.00	0.00	0.00	
	Removal		0.27	0.85		0.13	0.00	-0.15	-0.85	
	Retention		0.15	0.48		0.08	0.00	-0.08	-0.48	
	Plants		0.30	0.94		0.27	0.00	-0.03	-0.94	
	Structure		0.16	0.50		0.11	0.00	-0.05	-0.50	
	Habitat		0.12	0.38		0.06	0.00	-0.06	-0.38	
5, 8, 10, 11, 12	Static	7.1	0.18	1.25	0.0	0.00	0.00	-0.18	-1.25	Convert to BH Area
	Dynamic		0.00	0.00		0.00	0.00	0.00	0.00	
	Cycling		0.24	1.68		0.13	0.00	0.00	0.00	
	Removal		0.13	0.91		0.13	0.00	0.00	-0.91	
	Retention		0.15	1.08		0.08	0.00	-0.08	-1.08	
	Plants		0.19	1.34		0.27	0.00	0.08	-1.34	
	Structure		0.16	1.13		0.11	0.00	-0.05	-1.13	
	Habitat		0.12	0.87		0.06	0.00	-0.06	-0.87	
14G (Plugs, P1-P7)	Static	0.4	0.17	0.08	0.0	0.21	0.00	0.04	-0.08	Wetland restoration plugs
	Dynamic		0.00	0.00		0.00	0.00	0.00	0.00	
	Cycling		0.17	0.07		0.17	0.00	0.00	-0.07	
	Removal		0.15	0.06		0.24	0.00	0.09	-0.06	
	Retention		0.15	0.07		0.15	0.00	0.00	-0.07	
	Plants		0.20	0.09		0.30	0.00	0.10	-0.09	
	Structure		0.16	0.07		0.16	0.00	0.00	-0.07	
	Habitat		0.12	0.05		0.12	0.00	0.00	-0.05	
14B, 14F	Static	7.1	0.17	1.22	0.0	0.21	0.00	0.04	-1.22	Aux spillway & Embankment fill
	Dynamic		0.00	0.00		0.00	0.00	0.00	0.00	
	Cycling		0.17	1.20		0.17	0.00	0.00	-1.20	
	Removal		0.15	1.04		0.24	0.00	0.09	-1.04	
	Retention		0.15	1.08		0.15	0.00	0.00	-1.08	
	Plants		0.20	1.41		0.30	0.00	0.10	-1.41	
	Structure		0.16	1.13		0.16	0.00	0.00	-1.13	
	Habitat		0.12	0.87		0.12	0.00	0.00	-0.87	

Table 9 Continued, HGM Wetland Impacts for Project by Location (Wetland Losses)

18,61, 18A, 61A	Static	1.7	0.17	0.29	0.6	0.21	0.13	0.04	-0.16	Dam & Road Fill
	Dynamic		0.00	0.00		0.00	0.00	0.00	0.00	
	Cycling		0.17	0.28		0.17	0.10	0.00	-0.18	
	Removal		0.15	0.25		0.24	0.14	0.09	-0.10	
	Retention		0.15	0.26		0.15	0.09	0.00	-0.16	
	Plants		0.20	0.34		0.30	0.18	0.10	-0.16	
	Structure		0.16	0.27		0.16	0.10	0.00	-0.17	
	Habitat		0.12	0.21		0.12	0.07	0.00	-0.13	
23, 24, 25, 27, 28	Static	2.1	0.68	1.41	0.0	0.94	0.00	0.25	-1.41	Convert to BH Area
	Dynamic		0.51	1.05		0.83	0.00	0.33	-1.05	
	Cycling		0.14	0.28		0.82	0.00	0.68	-0.28	
	Removal		0.36	0.73		0.87	0.00	0.52	-0.73	
	Retention		0.18	0.38		0.94	0.00	0.75	-0.38	
	Plants		0.40	0.82		0.86	0.00	0.46	-0.82	
	Structure		0.25	0.52		0.88	0.00	0.62	-0.52	
	Habitat		0.20	0.41		0.29	0.00	0.09	-0.41	
31, 34, 35, 36, 38, 39, 59	Static	5.0	0.68	3.40	0.0	0.89	0.00	0.21	-3.40	Convert to BH Area
	Dynamic		0.51	2.53		0.79	0.00	0.28	-2.53	
	Cycling		0.14	0.68		0.78	0.00	0.64	-0.68	
	Removal		0.36	1.77		0.85	0.00	0.49	-1.77	
	Retention		0.18	0.91		0.90	0.00	0.71	-0.91	
	Plants		0.40	1.99		0.86	0.00	0.46	-1.99	
	Structure		0.25	1.26		0.85	0.00	0.59	-1.26	
	Habitat		0.20	1.00		0.29	0.00	0.09	-1.00	
14A, 14C	Velocity Reduction Surface Water	3.6	0.67	2.39	0.0	0.18	0.00	-0.49	-2.39	Dam fill and Principle Spillway outlet
	Storage & Release Subsurface Water		0.66	2.34		0.39	0.00	-0.27	-2.34	
	Removal Imported Elements & Compounds		0.69	2.45		0.00	0.00	-0.69	-2.45	
	Retention of Particulates & Organic Materials		0.67	2.39		0.28	0.00	-0.39	-2.39	
	Organic Carbon Export		0.73	2.59		0.09	0.00	-0.64	-2.59	
	Maintains Plant Community		0.71	2.53		0.00	0.00	-0.71	-2.53	
	Maintains Habitat Structure		0.75	2.67		0.20	0.00	-0.55	-2.67	
	Habitat Stucture & Connectivity Among Wetlands		0.63	2.23		0.06	0.00	-0.57	-2.23	
Sum (Wetland Losses)	Static	30.3		8.42	0.6		0.13		-8.30	Dam Fill & Hydrology cut off by Aux Spillway
	Dynamic			3.58			0.00		-3.58	
	Cycling			5.00			0.10		-4.90	
	Removal			5.69			0.14		-5.54	
	Retention			4.29			0.09		-4.20	
	Plants			7.02			0.18		-6.84	
	Structure			4.92			0.10		-4.83	
	Habitat			3.82			0.07		-3.75	

Table 10, HGM Wetland Impacts for Site 2A by Location (Wetland Gains)

Wetland Gains										
		Pre Project Assessment			Post Project Assessment			Gain or Loss		
Wetland ID	Functions	Wetland Acres	FCI	FCU	Wetland Acres	FCI	FCU	FCI	FCU	Rationalle
14D	Velocity Reduction Surface Water	21.1	0.75	15.84	25.9	0.88	22.74	0.13	6.90	Floodplain ditch plugs
	Storage & Release Subsurface Water		0.66	13.84		0.72	18.71	0.07	4.87	
	Removal Imported Elements & Compounds		0.69	14.53		0.87	22.50	0.18	7.97	
	Retention of Particulates & Organic Materials		0.74	15.57		0.84	21.67	0.10	6.10	
	Organic Carbon Export		0.78	16.43		0.97	25.04	0.19	8.61	
	Maintains Plant Community		0.71	15.00		0.85	21.87	0.13	6.87	
	Maintains Habitat Structure		0.75	15.83		0.93	24.13	0.18	8.30	
	Habitat Stucture & Connectivity Among Wetlands		0.71	14.88		0.86	22.21	0.15	7.33	
14E	Static	13.8	0.42	5.81	18.8	0.89	16.73	0.47	10.92	Ditch Plug (Restoration)
	Dynamic		0.00	0.00		0.79	14.88	0.79	14.88	
	Cycling		0.64	8.82		0.78	14.62	0.14	5.81	
	Removal		0.58	7.98		0.85	15.89	0.27	7.90	
	Retention		0.74	10.21		0.90	16.84	0.16	6.64	
	Plants		0.64	8.82		0.86	16.19	0.22	7.37	
	Structure		0.61	8.46		0.85	15.89	0.23	7.43	
	Habitat		0.24	3.33		0.29	5.43	0.05	2.09	
Biomass Harvesting	Static	0.0	0.18	0.00	260.2	0.66	170.86	0.48	170.86	Biomass Harvesting Areas
	Dynamic		0.00	0.00		0.49	127.92	0.49	127.92	
	Cycling		0.24	0.00		0.49	126.48	0.25	126.48	
	Removal		0.13	0.00		0.52	135.91	0.39	135.91	
	Retention		0.15	0.00		0.78	201.64	0.62	201.64	
	Plants		0.19	0.00		0.58	150.33	0.39	150.33	
	Structure		0.16	0.00		0.52	134.74	0.36	134.74	
	Habitat		0.12	0.00		0.21	55.19	0.09	55.19	
19-22,29,64-65	Static	15.9	0.69	10.94	15.9	0.94	14.85	0.25	3.91	Perennial Veg, stop row crops (Restore Functions)
	Dynamic		0.00	0.00		0.83	13.23	0.83	13.23	
	Cycling		0.24	3.75		0.82	13.01	0.58	9.26	
	Removal		0.35	5.52		0.87	13.84	0.52	8.33	
	Retention		0.18	2.91		0.94	14.89	0.75	11.98	
	Plants		0.40	6.35		0.86	13.67	0.46	7.32	
	Structure		0.29	4.57		0.88	13.90	0.59	9.32	
	Habitat		0.21	3.37		0.29	4.58	0.08	1.22	
70-72	Static	0.0	0.42	0.00	4.7	0.94	4.42	0.51	4.42	Ditch Plug (Restoration)
	Dynamic		0.00	0.00		0.83	3.94	0.83	3.94	
	Cycling		0.64	0.00		0.82	3.88	0.18	3.88	
	Removal		0.58	0.00		0.87	4.12	0.29	4.12	
	Retention		0.74	0.00		0.94	4.43	0.20	4.43	
	Plants		0.64	0.00		0.86	4.07	0.22	4.07	
	Structure		0.61	0.00		0.88	4.14	0.26	4.14	
	Habitat		0.24	0.00		0.29	1.37	0.05	1.37	
Sum (Wetland Gains)	Static	50.8		16.75	325.4		206.87		190.11	Restorations and Biomass Harvesting
	Dynamic			0.00			159.98		159.98	
	Cycling			12.57			157.99		145.42	
	Removal			13.50			169.76		156.26	
	Retention			13.12			237.80		224.69	
	Plants			15.17			184.26		169.09	
	Structure			13.04			168.66		155.62	
	Habitat			6.70			66.57		59.87	

4 WILDLIFE HABITAT

Historically, the Prairie Pothole Region (PPR) included large diversity of wildlife habitats. Prior to settlement in the 1890-1930 period, this wide, flat, glacial lake plain was a tallgrass prairie ecosystem consisting of a mosaic of dry prairies, wet meadows, shallow marshes, and riparian wetlands created by high densities of beaver dams on the prairie streams and rivers. However, the RRB is currently one of the largest artificially drained landscapes in the world, with hundreds of miles of publicly owned drainage ditches, privately owned lateral ditches, and thousands of acres of subsurface drain tile installed in crop fields (Carlyle, 1984). Currently, only very small and scattered wetland habitat remains within the row crop dominated landscape of square drained fields and straightened river channels. The remaining wetlands and grasslands of the PPR are one of the most productive areas in the world for breeding waterfowl and are important habitat for migratory grassland and shore birds as well. Between 50 and 80% of North American ducks breed in the PPR, and waterfowl production is closely associated with the number and quality of wetlands and surrounding grasslands. Drainage of remaining wetlands continues in the region. From 1997 to 2009 North Dakota alone lost more than 50,000 individual wetlands through draining, filling, burning, or farming: a -3.3% overall change (Dyke et al, 2015). An ancillary goal of the Red River RCPP watershed dam planning projects was to restore critical wetland functions to this landscape.

Critical PPR habitats include meandering rivers, adjacent floodplains, wetlands of multiple classes, and supporting uplands. Since the PPR is critical to migratory waterfowl, the project will improve nesting and cover habitat for North American ducks and all other waterfowl. In addition to adequate nesting and cover habitat, invertebrate production as a food source for broods is critical to their success. PPR wetlands sustain a wide variety of aquatic and semi-aquatic insects including overwintering residents (snails, mollusks, amphipods, worms, leeches, crayfish), overwintering spring recruits (midges, mayflies, beetles) whose reproduction depends on water availability and overwintering summer recruits (phantom midges, dragonflies, mosquitos). Insect reproduction depends on surface water, and non-wintering spring migrants (water bugs, water beetles) who require water below ice in the winter (Adamus, 1998). Interestingly, PPR studies have examined invertebrate production in natural, restored, and created wetlands, and found them to be comparable; in fact, a study of 20 North Dakota Department of Transportation wetland creations found higher density and diversity in macroinvertebrates than in nearby natural wetlands (Kreil & Crawford, 1986). Therefore, constructed wetlands still have significant potential for variety of habitat improvements. Construction plans will minimize disturbance in this area.

The U.S. Fish and Wildlife Service, NRCS, and Ducks Unlimited often utilize managed grazing of wetlands in the northern PPR to simulate the historic role of bison and elk within the ecosystem. Grazing stimulates root growth, increases vegetal species diversity, and can promote organic matter in the underlying soils of restored or created wetlands. The areas will benefit from management practices such as flash grazing to assure plant diversity and plant vigor are maintained. Therefore, permanent outside fences are included as shown in Figure 16. Temporary portable electric inside fences and livestock water systems will be needed as well to implement flash grazing and added to requirements of the PL-566 Operation and Maintenance Plan. However, the exact locations of temporary fences and water systems will be up to the rancher. The flash grazing paddocks should range from 30 to 40 acres in size. None are currently planned in the WRP easement, given management restrictions with that program, however after the easement expires it would have vegetation management via grazing to optimize wildlife habitat with the remainder of the area. Typical grazing O&M goals involve 50% removal of seasonal growth at 3 to 5-year intervals applied to all of the area excluding the constructed wetland managed with biomass removal. During annual Operation and Maintenance (O&M) inspections of the project, NRCS staff will evaluate vegetative communities and work with the Sponsor on grazing time periods and stocking needed to meet wildlife habitat goals. The Project O&M Plan will outline specific goals for vegetative communities. These practices will also help to promote a healthy upland and wetland plant community needed to meet long-term HGM success criteria. Prescribed fire can also be used for isolated areas where grazing is not feasible. The constructed wetlands will provide open water habitat longer into the summer than surrounding pothole wetlands, which will provide a benefit to wildlife. Ultimately, the project will result in a 1,036.3 acre complex of wetlands (483.0 acres) and upland grassland habitat (553.3 acres). No threatened or endangered species are likely to make use of the area in the near-term, however some more transient individuals may make temporary use of the site.

5 CONCLUSION

The project provides an opportunity to implement a multipurpose project to attain local objectives and provide watershed protection benefits to water quality and wildlife habitat at a scale typically not experienced on other watershed protection initiatives in the planning region.

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