Upper Turtle River Watershed Dam #9, Larimore Dam

Appendix D-7: Accumulated Sediment

Grand Forks County Water Resource District
USDA - NRCS

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Introduction

Background

Larimore Dam (also known as Upper Turtle River Dam No. 9) is located on the South Branch of the Turtle River in Grand Forks County, North Dakota, approximately 3½ miles northeast of the city of Larimore. It was constructed in 1979 under the Watershed Protection Program (PL 83-566) of the USDA-NRCS (formerly known as the USDA-SCS) as a multi-purpose structure with the primary functions of flood risk reduction and recreation. Larimore Dam is one of eight (8) PL 83-566 flood risk reduction structures in the Upper Turtle River Watershed and is in series with three (3) of those structures separately. Those three structures are Upper Turtle River Dams 6 (Kolding Dam), 7, and 8.

Sediment delivery rates are critical to assess the long-term viability of the reservoir formed by the dam. There are various methods of estimating and measuring the quantity of sediment delivered to, and retained in, the reservoir. Two separate efforts were utilized in analyzing this important factor: a bathymetric survey of the reservoir and an estimate of sediment delivery to the reservoir via an empirical equation (RUSLE).

In addition, heavy metal composition of the sediment is important to assess, so two sediment samples were collected and analyzed in a laboratory. These results are also shared in this appendix.

Bathymetric Survey

Data Collection

Bathymetric survey data for Larimore Dam was gathered by the U.S. Geological Survey (USGS). Data collection took place August 3-7, 2020. Bathymetric data was collected using a boat with a multibeam echosounder and manually using a Real-time Kinematic (RTK) GPS rover. Over 117,000 data points were collected using the multibeam echosounder and an additional 726 Global Navigation Satellite System (GNSS) points were collected manually using the RTK GPS rover.

The reservoir elevation was 1069.31 (NAVD88) at the time of the bathymetric survey data collection.

Data Collection Highlights

- Heavy aquatic vegetation was present at the lake, especially the western third of the reservoir. Photos were taken to document the conditions.
- Even with a gas-powered outboard (an exemption was granted), there were areas where aquatic vegetation was so thick that the motor could not push the boat through the water.
- Data was collected on/near the shore and shallow water portions of transects that would be too shallow for the boat using an RTK GPS rover. All of transects 1 and 2 were

collected with RTK, as these areas were not boatable. Transects 3 through 6 were collected by a combination of wading (where possible) and from the boat.

- GNSS data were collected in pairs - one point on top of the sediment, then a second point after the RTK pole had been pushed in until a firm bottom was felt to estimate sediment thickness.
- Elevation data was tied into existing benchmarks in the area.

Data Processing

The raw data was processed to remove bad data points and make any corrections needed. Data editing was complicated on many of the transects due to the amount of vegetation that was present. Northing and Easting corrections were applied to the location data in the edited echosounder dataset and Northing, Easting, and elevation corrections were applied to the GNSS data sets.

Data sets included in the data release are:

- Shapefile of the data collection transects
- Shapefile of the RTK GNSS data collected
- Shapefile of the edited echosounder data
- *.csv file of the raw echosounder data collected.

The metadata for the data collection transects, the RTK GNSS data, and the edited echosounder data were completed September 10, 2020.

Figure 1 - Bathymetric Survey Transects

Figure 2 – Bathymetric Survey Points

Sediment volume based on the bathymetric survey was calculated to the be approximately 45 acre-ft of sediment retained in the reservoir. Calculation of sediment volume was accomplished by creating a top of sediment surface and bottom of sediment surface across the entire reservoir and delta area and determining the volume between the two surfaces.

At the time of preparing the original watershed work plan, the expected submerged and total sediment (submerged + aerated) was 292 ac-ft over the first 50 years of the reservoir, or an approximate retainage of 5.8 ac-ft per year. Based on the bathymetric survey, the first 41 years (1980-2020) of the reservoir life experienced a retainage of approximately 1.1 ac-ft per year, or 19% of the predicted amount.

RESERVOIR CAPACITY TABLE

	ELEV.	AREA ACRES	ACRE FEET	ACCUMULATED ACRE FEET
	1032.0	0.00	0.0	0.0
	1040.0	—	1.4	1.4
	1050.0	17.79	93.7	95.1
	1060.0	45.36	315.8	410.9
PERMANENT POOL	1067.2	72.00	—	823.0
	1070.0	85.61	654.9	1065.8
	1080.0	181.51	1335.6	2401.4
CREST OF 2ND STAGE	1082.0	210.00	—	2850.0
CREST OF EMERG.SPLWY.	1089.3	375.00	—	5003.0
	1090.0	397.17	2893.4	5294.8
	1099.6	650.0	—	10410.0
TOP OF DAM	1100.0	668.62	5328.9	10623.7

Figure 3 - Design Reservoir Capacity Table, Larimore Dam

TABLE 3 – STRUCTURE DATA

FLOODWATER RETARDING STRUCTURES

Upper Turtle River Watershed
Grand Forks and Nelson Counties, North Dakota

Item	Unit	Structure Number No. 1	No. 2	No. 4	No. 5	No. 6	No. 7	No. 8	No. 9	TOTAL
Class of Structure		b	b	b	b	b	b	b	b	
Drainage Area	Sq.Mi.	17.2	12.0	16.0	12.1	11.2	5.4	5.3	42.7	121.9
Controlled	Sq.Mi.	-	-	-	-	-	-	-	21.9	21.9
Curve No. (1-day) (AMC II)		82	82	80	80	80	80	80	76	xxxxx
Tc	Hrs.	6.5	6.7	10.9	6.4	7.7	4.0	4.5	13.3	xxxxx
Elevation Top of Dam	Ft.	1215.5	1339.0	1274.0	1299.0	1296.0	1227.2	1241.5	1095.0	xxxxx
Elevation Crest Emergency Spillway	Ft.	1209.8	1334.0	1269.5	1294.0	1291.0	1222.7	1237.0	1090.2	xxxxx
Elevation Crest High Stage Inlet	Ft.	1200.9	1330.8	1259.5	1278.8	1277.0	1218.5	1232.1	1084.0	xxxxx
Elevation Crest Low Stage Inlet	Ft.	1189.0	1304.2	1236.9	1250.2	1247.8	1207.6	1218.0	1067.2	xxxxx
Maximum Height of Dam	Ft.	33.0	55.0	55.0	71.2	70.0	20.2	33.5	65.0	xxxxx
Volume of Fill	Cu.Yds.	235,600	213,500	250,200	366,700	433,600	68,400	85,300	349,400	2,002,700
Total Capacity	Ac.Ft.	2927	960	1974	1696	1597	694	628	5730	16,206
Sediment Submerged 1st 50 Years	Ac.Ft.	110	77	102	77	72	40	40	273	791
Sediment Submerged 2nd 50 Years	Ac.Ft.	-	-	-	-	-	-	-	-	-
Sediment Aerated	Ac.Ft.	8	5	7	5	5	3	3	19	55
Beneficial Use (recreation)	Ac.Ft.	-	-	-	-	-	-	-	527	527
Retarding	Ac.Ft.	2809	878	1865	1614	1520	651	565	4911	14,833
Between High and Low Stage	Ac.Ft.	1790	167	917	897	857	332	272	2381	7,613
Surface Area										
Sediment Pool	Acres	37	45	16	10	9	10	9	35	171
Beneficial Use Pool (recreation)	Acres	-	-	-	-	-	-	-	76	76
Retarding Pool	Acres	255	52	120	70	82	102	66	410	1,157
Principal Spillway										
*Detention Volume (snowmelt runoff)	In.	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	xxxxx
Capacity of Low Stage (maximum)	Cfs.	32	22	24	23	21	10	10	121	xxxxx
Capacity of High Stage (maximum)	Cfs.	97	380	280	152	135	94	105	1178	xxxxx
Frequency Operation - Emer. Spillway	% Chance	2	2	2	2	2	2	2	2	xxxxx
Size of Conduit	Dim.	2.5'	4.0'	3.5'	2.5'	2.5'	2.5'	2.5'	6.0'x6.0'	xxxxx

Figure 4 – Watershed Work Plan Structural Data

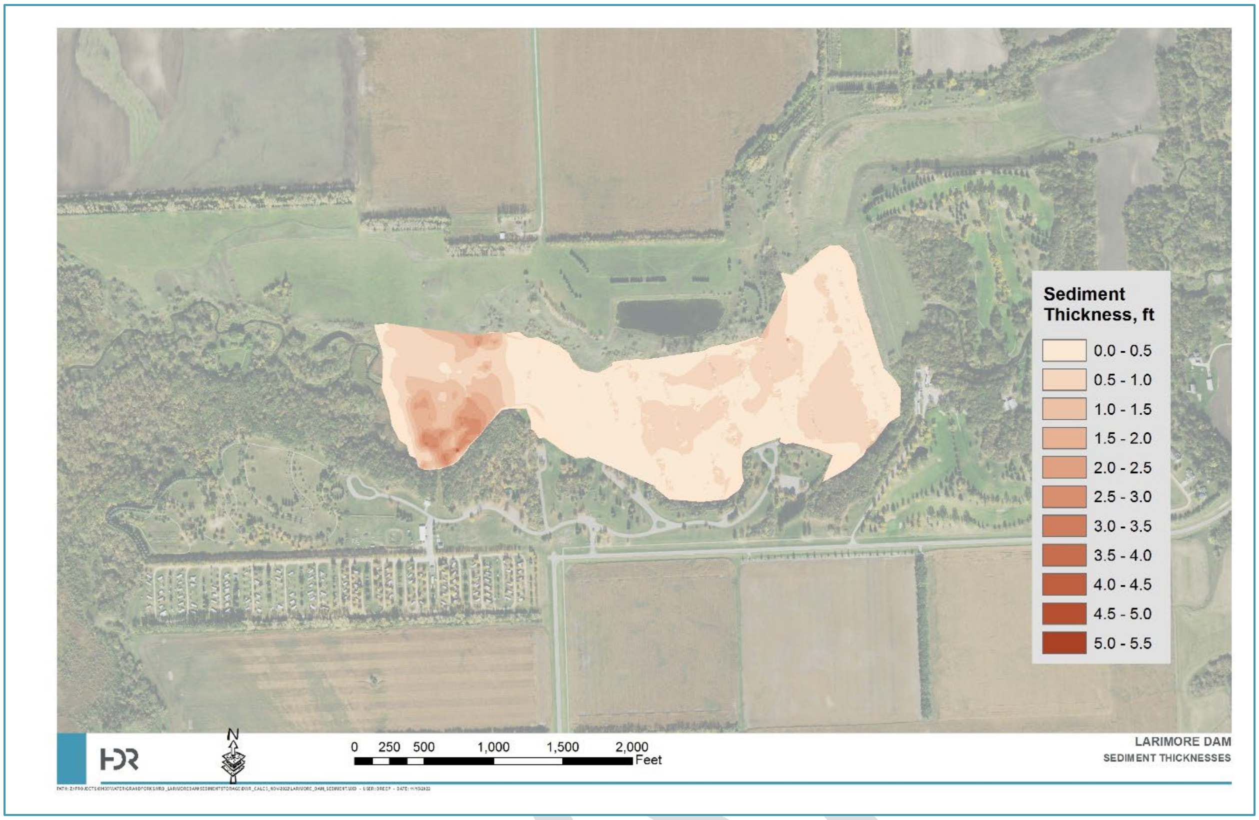


Figure 5 – Sediment Thicknesses at Larimore Dam

PTMAPP

Background

The Interactive Map option of the Prioritize, Target, and Measure Application (PTMApp) was utilized to estimate sediment loading at Larimore Dam. PTMApp utilizes the Revised Universal Soil Loss Equation (RUSLE), developed by USDA-NRCS, as a computation engine to estimate sediment yield from watersheds. RUSLE is calculated as follows:

$$A = R \times K \times LS \times C \times P$$

where, R is the Rainfall and Runoff Factor, K is the Soil Erodibility Factor, LS is the Length-Slope Factor, C is the Cover and Management Factor, and P is the Support Practice Factor.

Sediment yield from a watershed is then converted to an estimated sediment delivery by use of a sediment delivery ratio (SDR). Ultimately this SDR is applied to the sediment yield to estimate the actual amount of sediment delivered to an area of interest.

Analysis

PTMApp was accessed via the interactive map option on the International Water Institute web site. Two separate resource locations associated with Larimore Dam were readily available to estimate sediment delivery to the reservoir utilizing RUSLE. The figures below show the Turtle River Watershed, precalculated resource locations for Larimore Dam (site 25 at the dam and site 26 at the inlet to the reservoir), and resultant calculations of various parameters associated with the sediment delivery from the watershed.

As can be seen from the figures that follow, the predicted sediment delivery rate to Larimore Dam using PTMApp is approximately 21.5 ac-ft per year. However, there is a wide range of values within the watershed, ranging from approximately 4 ac-ft per year to over 50 ac-ft per year.

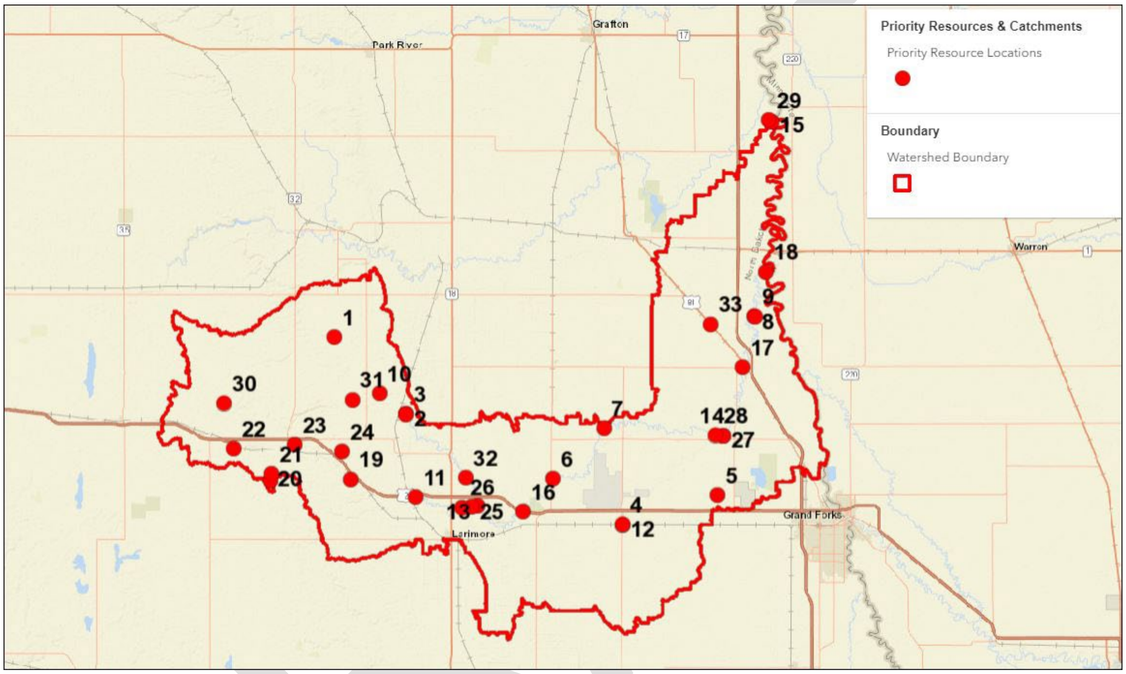


Figure 6 – PTMApp Priority Resource Locations, Turtle River Watershed

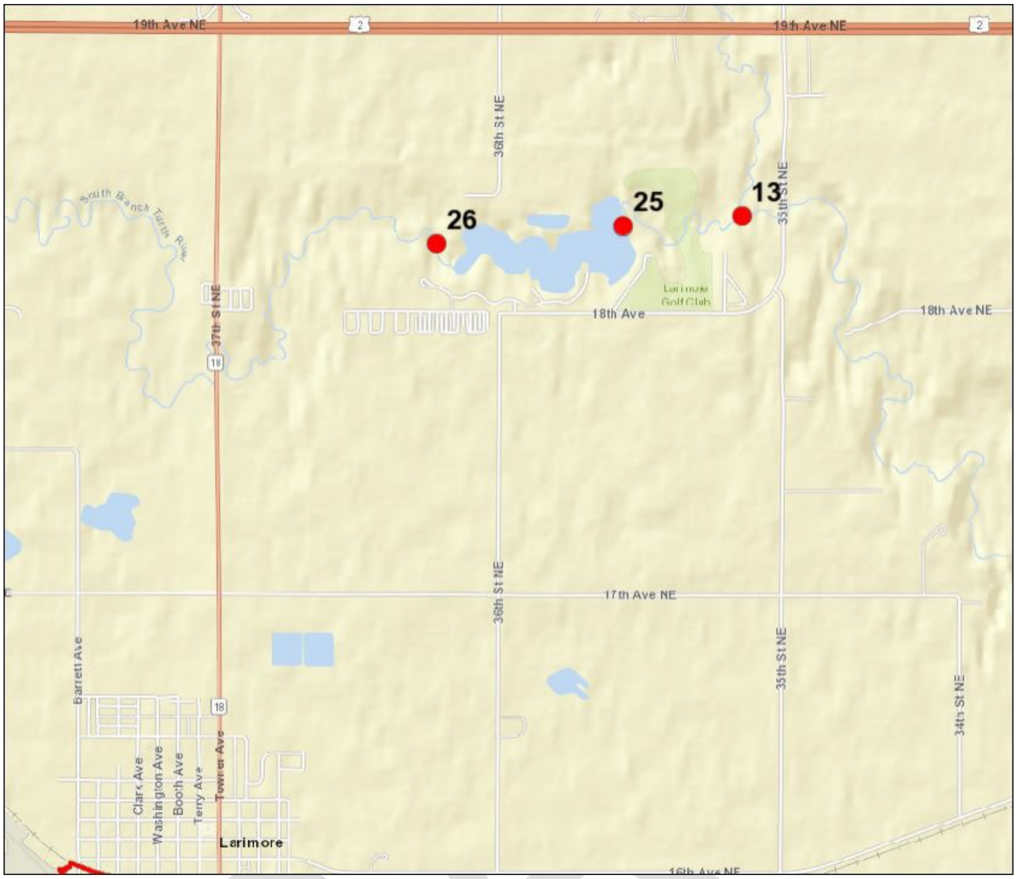


Figure 7 – PTMApp Priority Resource Locations, Larimore Dam

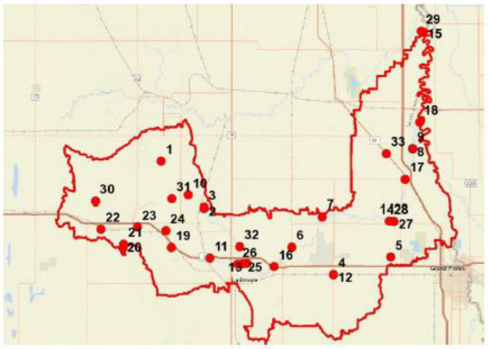
Larimore Dam

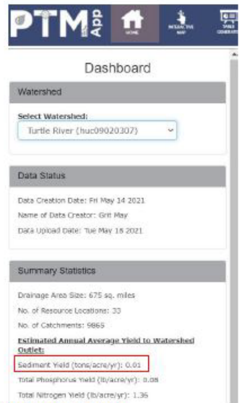
PTMApp
https://nd.ptmapp.iwinst.org/Watershed/InteractiveMap

From PTMApp		
	Priority Resource Location	
	25	26
Watershed Area (acres)	36,094	35,600
Average runoff depth (in) 2yr, 24hr event	0.43	0.43
Average runoff depth (in) 10yr, 24hr event	1.09	1.09
Runoff volume (ft^3) 2yr, 24hr event	56,962,172	56,202,223
Runoff volume (ft^3) 10yr, 24hr event	143,808,527	141,906,735
Sediment load (t/yr) at priority resource location	5,805	6,211
Average sediment yield (t/ac/yr) leaving landscape	1.18	1.19
Average sediment yield (t/ac/yr) leaving landscape & delivered to catchment outlets	0.77	0.77
Sum of sediment load (t/yr) leaving landscape	40,867	40,554
Sum of sediment load (t/yr) leaving landscape & delivered to catchment outlets	26,016	25,832
Total N load (lb/yr) at priority resource location	131,067	134,748
Average Total N yield (lb/ac/yr) leaving landscape	5.39	5.41
Average Total N yield (lb/ac/yr) leaving landscape & delivered to catchment outlets	5.38	5.40
Sum of Total N load (lb/yr) leaving landscape	197,436	195,055
Sum of Total N load (lb/yr) leaving landscape & delivered to catchment outlets	196,867	194,494
Total P load (lb/yr) at priority resource location	7,198	7,583
Average Total P yield (lb/ac/yr) leaving landscape	0.30	0.30
Average Total P yield (lb/ac/yr) leaving landscape & delivered to catchment outlets	0.30	0.30
Sum of Total P (lb/yr) leaving landscape	11,118	10,980
Sum of Total P load (lb/yr) leaving landscape & delivered to catchment outlets	11,087	10,950
Sum of sediment load (ac-ft/yr) delivered to reservoir (use 0.00083 ac-ft/ton):	21.6	21.4
Total Sediment Delivery from construction (1979), 43 Years, ac-ft	929	922

Figure 8– PTMApp Results, Larimore Dam

PTMApp
https://nd.ptmapp.iwinst.org/Watershed/InteractiveMap





	Priority Resource Location						
	25	**26**	**11**	**32**	**19**	**2**	**Turtle River**
Watershed Area (acres)	36,094	35,600	32,739	89,435	5,490	64,745	432,000
Average runoff depth (in) 2yr, 24hr event	0.43	0.43	0.45	0.51	0.48	0.53	
Average runoff depth (in) 10yr, 24hr event	1.09	1.09	1.13	1.22	1.17	1.25	
Runoff volume (ft^3) 2yr, 24hr event	56,962,172	56,202,223	54,208,645	167,341,474	9,686,107	125,581,916	
Runoff volume (ft^3) 10yr, 24hr event	143,808,527	141,906,735	135,266,030	400,014,115	23,685,464	297,692,656	
Sediment load (t/yr) at priority resource location	5,805	6,211	12,055	6,845	2,998	12,369	
Average sediment yield (t/ac/yr) leaving landscape	1.18	1.19	1.22	1.05	1.30	1.11	
Average sediment yield (t/ac/yr) leaving landscape & delivered to catchment outlets	0.77	0.77	0.80	0.68	0.85	0.72	0.01
Sum of sediment load (t/yr) leaving landscape	40,867	40,554	38,243	88,258	6,862	67,209	
Sum of sediment load (t/yr) leaving landscape & delivered to catchment outlets	26,016	25,832	24,600	56,926	4,409	43,333	4,320
Total N load (lb/yr) at priority resource location	131,067	134,748	150,010	292,851	22,627	268,217	
Average Total N yield (lb/ac/yr) leaving landscape	5.39	5.41	5.43	5.75	4.56	5.77	
Average Total N yield (lb/ac/yr) leaving landscape & delivered to catchment outlets	5.38	5.40	5.42	5.74	4.55	5.76	
Sum of Total N load (lb/yr) leaving landscape	197,436	195,055	179,882	527,519	26,191	382,460	
Sum of Total N load (lb/yr) leaving landscape & delivered to catchment outlets	196,867	194,494	179,375	525,941	26,131	381,344	
Total P load (lb/yr) at priority resource location	7,198	7,583	8,325	15,510	1,242	14,178	
Average Total P yield (lb/ac/yr) leaving landscape	0.30	0.30	0.30	0.31	0.26	0.31	
Average Total P yield (lb/ac/yr) leaving landscape & delivered to catchment outlets	0.30	0.30	0.30	0.31	0.26	0.31	
Sum of Total P (lb/yr) leaving landscape	11,118	10,980	10,028	27,979	1,465	20,182	
Sum of Total P load (lb/yr) leaving landscape & delivered to catchment outlets	11,087	10,950	10,000	27,897	1,462	20,124	
Sum of sediment load (ac-ft/yr) delivered to reservoir (use 0.00095 ac-ft/ton):	**24.7**	**24.5**	**23.4**	**54.1**	**4.2**	**41.2**	**4.1**

Figure 9 – PTMApp Results, Turtle River Watershed Selected Locations

Trap Efficiency

Retainage of the sediment in the reservoir as compared to the amount delivered is called the Trap Efficiency. A couple of different calculations estimating trap efficiency were made, with significant variations in the results. Using the method prescribed by Brune, trap efficiency is estimated at ~ 90 percent, while the method developed by Brown results in a trap efficiency of approximately 25 percent. The figures below show the computations.

Larimore Dam
Trap Efficiency - Brune

Brune 1953 Reference: https://agupubs.onlinelibrary.wiley.com/doi/abs/10.1029/TR034i003p00407

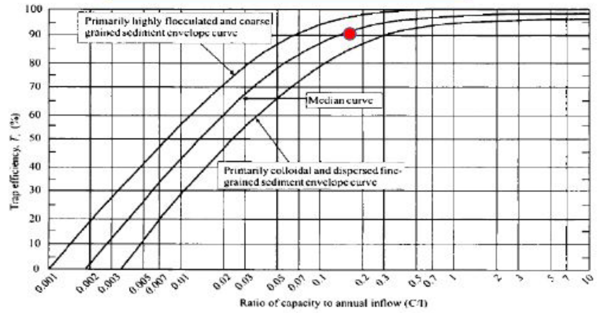
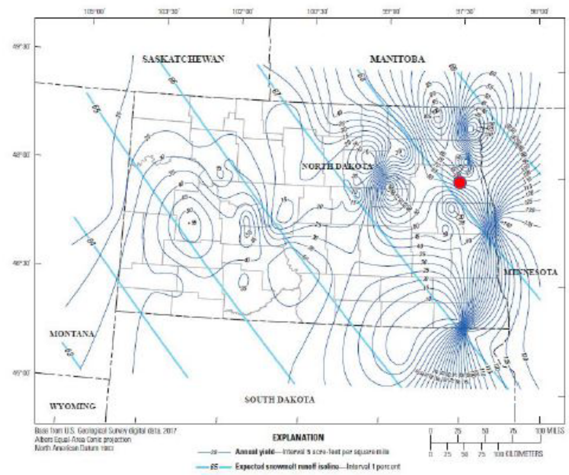


Fig.1 sediment trapping efficiency as per Brune (1953)



I (ac-ft)	4,725	USGS RO (50%)
C: storage capacity (perm pool)		
C/I	0.174	
TE (%)	**~90**	

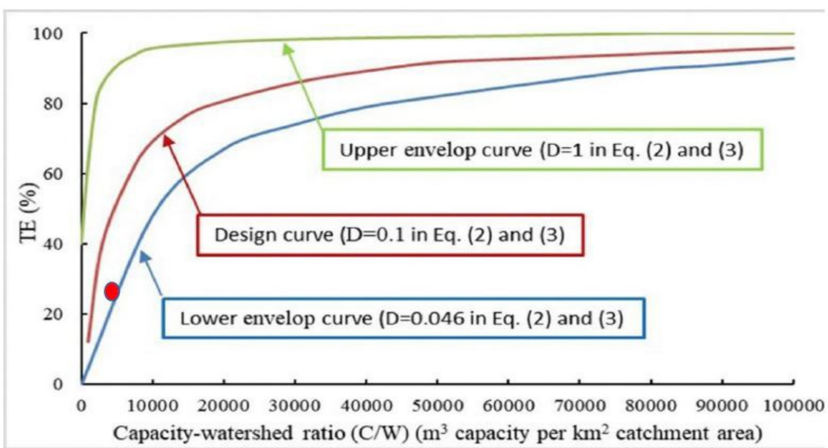
RESERVOIR CAPACITY TABLE

	ELEV.	AREA ACRES	ACRE FEET	ACCUMULATED ACRE FEET
	1032.0	0.00	0.0	0.0
	1040.0	—	1.4	1.4
	1050.0	17.79	93.7	95.1
	1060.0	45.36	315.8	410.9
PERMANENT POOL	1067.2	72.00	—	823.0
	1070.0	85.61	654.9	1065.8
	1080.0	181.51	1335.6	2401.4
CREST OF 2ND STAGE	1082.0	210.00	—	2850.0
CREST OF EMERG.SPLWY.	1089.3	375.00	—	5003.0
	1090.0	397.17	2893.4	5294.8
TOP OF DAM	1099.6	650.0	—	10410.0
	1100.0	668.62	5328.9	10623.7

Figure 10 – Trap Efficiency, Larimore Dam, Brune

Larimore Dam
Trap Efficiency - Brown

Brown 1944 Reference: Could not find, but referenced in validation



C=	823	ac-ft
	1,015,156	m^3
W=	67.5	mi^2
	175.0	km^2
C/W=	5,802	unitless
TE~	**25**	**%**

assume fine sediment, therefore blue curve

watershed area in km², and D is factor determined by detention time and sediment particle size which varies between 1, 0.1 and 0.046 for coarse, medium and fine sediment respectively (Fig. 1) (Brown, 1944).

Figure 11 – Trap Efficiency, Larimore Dam, Brown

Summary – Sediment Volume

Estimates of sedimentation volume in Larimore Dam reservoir and in the delivery rates to the reservoir were prepared from a couple of different approaches. Empirical analyses were prepared via the PTMApp utility which utilizes the RUSLE predictive equation. Retainage (Trap Efficiency) of these predictive delivery rates were then estimated via methods based on historical resource studies.

Additionally, a bathymetry survey was conducted which collected data on a grid basis across the entirety of the reservoir and the sediment volume calculated from that survey data.

The tables that follow document the predictive and measured sediment volumes and delivery rates. As discussed, prior, there is a wide variability in the rates and volumes when comparing the predictive approach to the measured approach. An emphasis on using the actual measured volumes in the reservoir (and correspondingly the delivery rates) is suggested to be utilized.

Table 1 – Accumulated Sediment Loads - 1980-2020

Larimore Dam - Accumulated Sediment (1980-2020)					
	Predicted Sediment Delivery Rate ac-ft/yr	Predicted Sediment Delivery Volume ac-ft (41 yrs)	Retained Sediment Volume ac-ft	Remaining Permanent Pool Volume ac-ft	Remaining Recreation Pool Volume ac-ft
Watershed Work Plan	5.8	239			
PTMApp (Larimore Dam est.)	21.5	882			
Brune Trap Eff (90%)		882	793	30	(266)
Brown Trap Eff (25%)		882	220	603	307
PTMApp (Turtle WS est.)	4.1	168			
Brune Trap Eff (90%)		168	151	672	376
Brown Trap Eff (25%)		168	42	781	485
Bathymetric Survey			45	778	482

Table 2 – Predicted Sediment Loads 100 Years into Future

Larimore Dam - Predicted Sediment (100 years into Future)					
	Predicted Sediment Delivery Rate ac-ft/yr	Predicted Sediment Delivery Volume ac-ft (141 yrs)	Retained Sediment Volume ac-ft	Remaining Permanent Pool Volume ac-ft	Remaining Recreation Pool Volume ac-ft
Watershed Work Plan	5.8	818			
PTMApp (Larimore Dam est.)	21.5	3,032			
Brune Trap Eff (90%)		3,032	2,728	(1,905)	(2,201)
Brown Trap Eff (25%)		3,032	758	65	(231)
PTMApp (Turtle WS est.)	4.1	578			
Brune Trap Eff (90%)		578	520	303	7
Brown Trap Eff (25%)		578	145	678	382
Bathymetric Survey			155	668	372

Possible considerations at Larimore Dam that may validify the differences are listed below:

- Relatively short reservoir, thereby reducing detention time of the inflow before passing downstream.
- There are three (3) dams upstream, increasing the likelihood that some of the sediment is removed from the system prior to reaching Larimore Dam.
- The equations used in predicting sediment delivery rates are empirical in nature.

Below is an updated storage table for Larimore Dam based on the bathymetric survey conducted and corresponding sedimentation calculations. The updated table also adjusts the as-built data by utilizing LiDAR topography that was collected above the permanent pool in 2009-2010 timeframe.

Table 3 – Larimore Dam – Updated Storage

Updated Storage - Adjusted for 2020 Bathymetry Survey and LiDAR		
Elev. (NAVD88)	Area (ac)	LiDAR As-Built Storage and Bathymetry Adjust (ac-ft)
1040.0	0	0
1050.0	16	39
1060.0	42	317
1068.4	67	778
1071.0	81	924
1075.0	106	1,294
1080.0	157	1,940
1085.0	234	2,901
1090.0	356	4,366
1095.0	481	6,458
1100.0	622	9,166
1105.0	942	13,028
1110.0	1,356	18,743

Sediment Sampling

Data Collection

Sediment samples were collected at Larimore Dam reservoir by Minnesota Valley Testing Laboratories, Inc. on October 21, 2020. Two samples were collected and subsequently tested in the laboratory. Approximate locations of the samples taken are shown in the figure below.

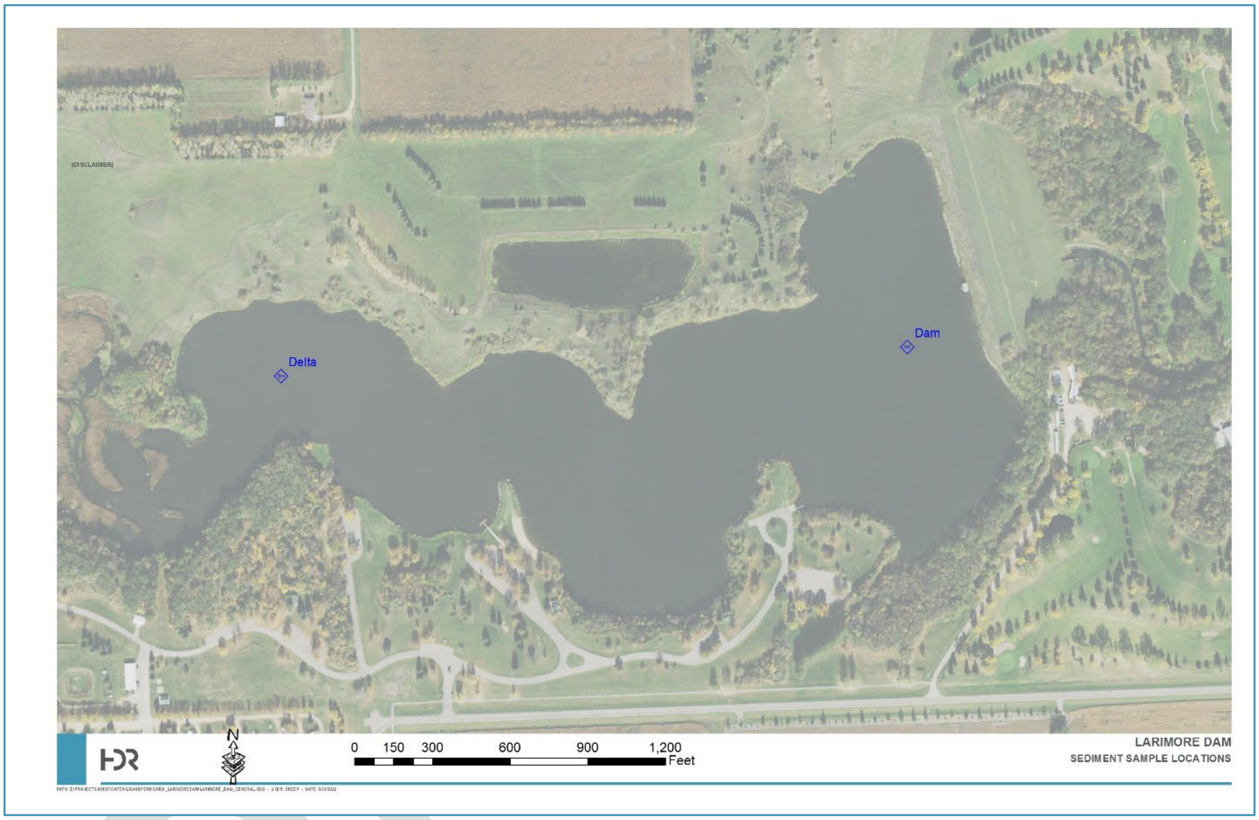


Figure 12– Sediment Sample Locations, Larimore Dam

Laboratory analyses were conducted by Minnesota Valley Testing Laboratories, Inc. in early November 2020. Results of those analyses are shown in the table below. Select elements are shown in the figures following the table.

Table 4 - Sediment Laboratory Results

Analyte	Units	Pool	Inlet
GRO (TPH)	mg/Kg	< 0.2	< 0.2
DRO (TEH)	mg/Kg	52.6	22.7
PCB-1016	ug/Kg	< 60	< 60
PCB-1221	ug/Kg	< 60	< 60
PCB-1232	ug/Kg	< 60	< 60
PCB-1242	ug/Kg	< 60	< 60
PCB-1248	ug/Kg	< 60	< 60
PCB-1254	ug/Kg	< 45	< 45
PCB-1260	ug/Kg	< 30	< 30
PCB-1262	ug/Kg	< 45	< 45
PCB-1268	ug/Kg	< 45	< 45
Total Organic Carbon	wt. %	1.86	1.45
Nitrate-Nitrite as N	ug/g	< 0.5	< 0.5
Phosphorus as P - Total	ug/g	10.2	9.98
Total Kjeldahl Nitrogen	ug/g	1200	783
Mercury	ug/g	0.01	< 0.02
Chromium	ug/g	7.1	5.69
Copper	ug/g	6.45	5.42
Nickel	ug/g	8.11	6.18
Zinc	ug/g	26.3	20.7
Arsenic	ug/g	3.32	2.29
Cadmium	ug/g	0.3	0.248
Lead	ug/g	2.55	2.11
Acenaphthene	mg/Kg	< 0.266	< 0.36
Acenaphthylene	mg/Kg	< 0.252	< 0.34
Anthracene	mg/Kg	< 0.237	< 0.32
Benzo(a)anthracene	mg/Kg	< 0.229	< 0.31
Benzo(a)pyrene	mg/Kg	< 0.281	< 0.38
Benzo(b)fluoranthene	mg/Kg	< 0.259	< 0.35
Benzo(ghi)perylene	mg/Kg	< 0.666	< 0.9
Benzo(k)fluoranthene	mg/Kg	< 0.229	< 0.31
Chrysene	mg/Kg	< 0.252	< 0.34
Dibenzo(a,h)anthracene	mg/Kg	< 0.666	< 0.9
7,12-Dimethylbenz (a) Anthracene	mg/Kg	< 0.333	< 0.45
Fluoranthene	mg/Kg	< 0.296	< 0.4
Fluorene	mg/Kg	< 0.266	< 0.36
Indeno(1,2,3-cd)pyrene	mg/Kg	< 0.592	< 0.8
2-Methylnaphthalene	mg/Kg	< 0.296	< 0.4
Naphthalene	mg/Kg	< 0.244	< 0.33
Phenanthrene	mg/Kg	< 0.259	< 0.35
Pyrene	mg/Kg	< 0.222	< 0.3

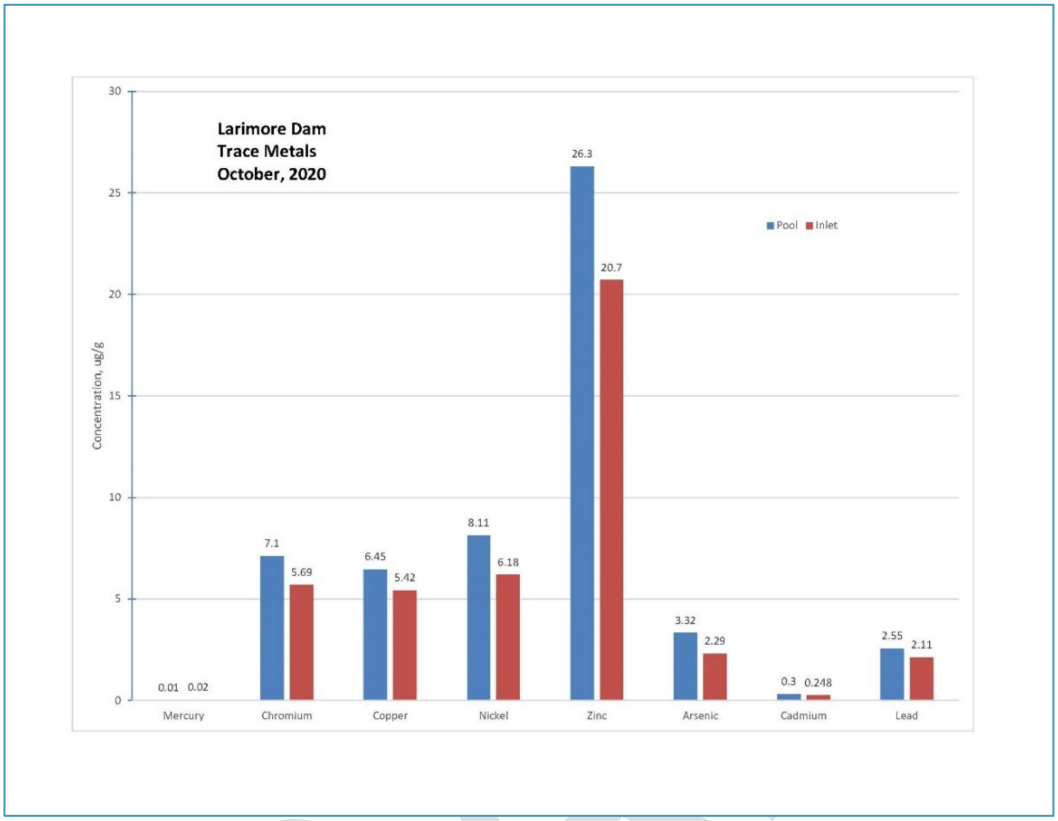


Figure 13 – Trace Metals, Larimore Dam

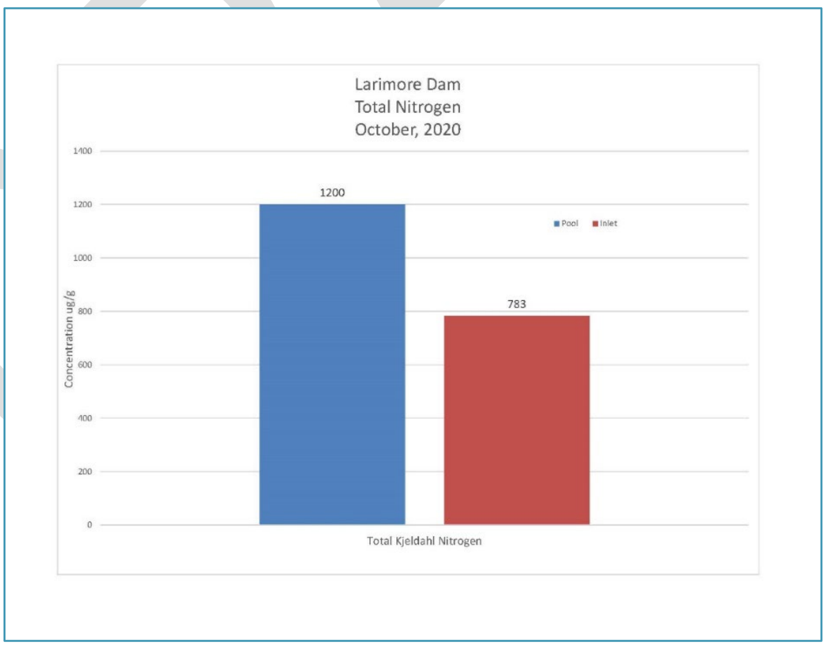


Figure 14 – Total Nitrogen, Larimore Dam

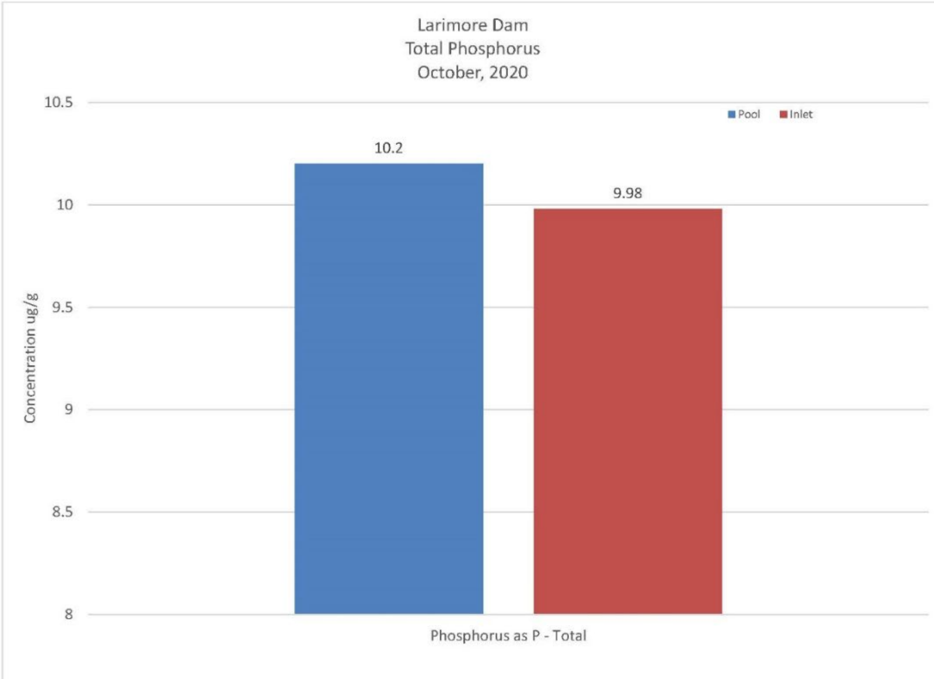


Figure 15 – Total Phosphorus, Larimore Dam

References

International Water Institute (2019), Prioritize, Target, Measure Application (PTMApp) Web User's Guide.

International Water Institute (2016), Prioritize, Target, Measure Application (PTMApp) Theory and Development Documentation.

Vaibhav Garg and V. Jothisprakash (2008) Trap Efficiency Estimate of a Larger Reservoir, ISH Journal of Hydraulic Engineering.

Gunnar M. Brune (1953), Trap Efficiency of Reservoirs.

C.B. Brown (1944), Sedimentation in Reservoirs.

Robert I. Strand and Ernest L. Pemberton (1982), Reservoir Sedimentation, U.S. Bureau of Reclamation, Denver, CO.

Tara Williams-Sether and Spencer L. Wheeling (2019), Small Basin Annual Yield and Percentage of Snowmelt Runoff in North Dakota, U.S. Geological Survey, Bismarck ND.

APPENDIX D-7-A
Bathymetry Data Collection Methods and Documentation

Bathymetric survey of Larimore Dam, August 2020

Project update 9/15/20

Data Collection

Data collection took place August 3-7, 2020. Bathymetric data was collected using a boat with a multibeam echosounder and manually using a Real-time Kinematic (RTK) GPS rover. Over 117,000 data points were collected using the multibeam echosounder and an additional 726 Global Navigation Satellite System (GNSS) points were collected manually using the RTK GPS rover (fig.1).

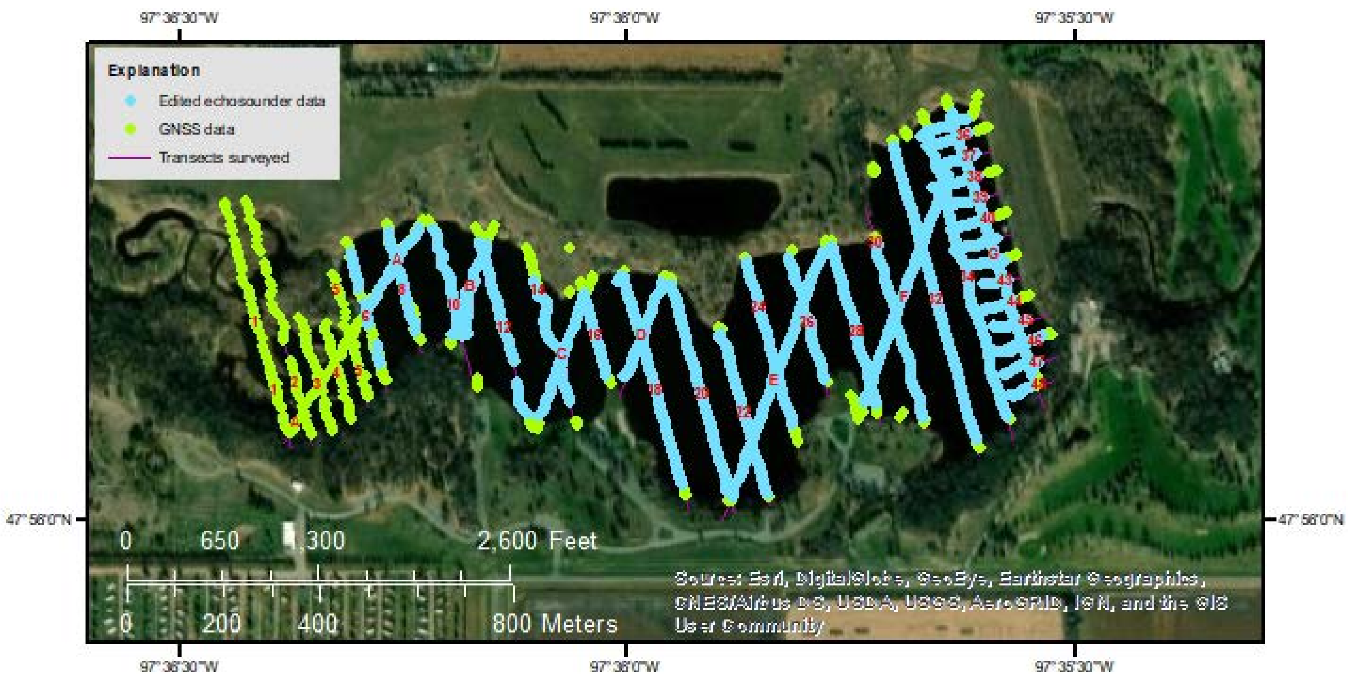


Figure 1. Data collected at Larimore dam, August 3-7, 2020.

Data collection highlights:

- Heavy aquatic vegetation was present at the lake- especially the western third or so. Photos were taken to document the conditions and will be shared outside the data release.
- Even with a gas-powered outboard (an exemption was granted), there were areas where aquatic vegetation was so thick that the motor could not push the boat through the water
- Several equipment issues created setbacks and long days - but crew was able to resolve the issues and collect data
- Data was collected on/near the shore and shallow water portions of transects that would be too shallow for the boat using an RTK GPS rover. All of transects 1 and 2 (fig. 1)

were collected with RTK, as these areas were not boatable. Transects 3 through 6 were collected by a combination of wading (where possible) and from the boat.

- GNSS data were collected in pairs- one point on top of the sediment, then a second point after the RTK pole had been pushed in until a firm bottom was felt to estimate sediment thickness.
- Data collection was completed on Friday afternoon and elevation data was tied into existing benchmarks in the area.

Data Processing

The raw data needed to be processed to remove bad data points and make any corrections needed. Data editing was a tedious process on many of the transects due to the amount of vegetation that was present. Northing and Easting corrections were applied to the location data in the edited echosounder dataset and Northing, Easting, and elevation corrections were applied to the GNSS data sets.

The draft data and metadata is available at ftp://ftpext.usgs.gov/pub/cr/sd/huron/Larimore_Bathy/ for preliminary use. The data and metadata will also be posted on Sciencebase for USGS technical review and this platform will be used to access the final dataset and metadata once it has been through the review process. Data sets that will be included in the data release are: a shapefile of the data collection transects, a shapefile of the RTK GNSS data collected, a shapefile of the edited echosounder data, and a .csv file of the raw echosounder data collected. The metadata for the data collection transects, the RTK GNSS data, and the edited echosounder data were completed September 10, 2020. The metadata for the raw echosounder data are expected to be completed and all datasets and metadata will be posted to Sciencebase for review by September 16, 2020.

View looking towards the upstream end of the lake. We found that all areas where algae was visible on the surface actually had algae throughout the water column.

Here is a closer view once we were in the area with floating algae. The RTK rove in the boat was used for collecting water surface elevations, land surface elevations above water, and lake bottom elevations in water too shallow for the bathymetry equipment. In the extreme upper end of the lake that was entirely algae/vegetation choked (and where we couldn't get good data with the bathymetry equipment), the RTK rove was used to collect lake bottom points along the transect. We also pushed the rove pole down into the lake-bottom sediment (to a firm bottom) and collected elevations of what was thought to be the original lake bottom surface prior to sediment deposition.

Closer view of a location where algae growth filled the water column in the upper end of the lake.

Some areas that didn't have much surface algae and (from a distance) appeared to be clear, actually had a lot of algal growth that would interfere with the transducer signal and often would tear free and coat the transducer as we attempted to move along the transects. In much of the upstream end of the lake, the algae was so thick that our motor didn't have enough power to push the boat through it.

Along the legacy channel, there was also macrophyte vegetation mixed in with the algae. Both types of vegetation tended to wrap up around the propeller and made it difficult to wade through without getting tangled.

Cattails were present as islands in the lake, and also some spots along the shore. Often the boat wasn't able to push through them, but wading through cattails was sometimes possible (where depth allowed).

We attempted to get RTK land surface elevation near the shore on transects, but in some areas, it was very steep and difficult to get good footing.

Tree growth near the water edge sometimes interfered with RTK radio signal and adjacent tree canopy sometimes prevented obtaining the full constellation of satellite signal. In a few small areas, we were not able to collect points with RTK because of this.

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County, North Dakota on August 4 and August 7, 2020. The data were collected using
two echosounders and a dual frequency transducer. The intent was to collect data
denoting depth to lake bottom using a 200 kilohertz frequency with a 4 degree beam,
and data denoting depth to bottom of sediment using a 24 kilohertz frequency with a
20 degree beam. Widespread dense aquatic vegetation was present in the western end
of the lake, preventing data collection in some areas and degrading data quality in
other areas. Data was collected using Hypack bathymetric software and global
navigation satellite system equipment used in real-time kinematic mode for vessel
guidance on planned data collection transects. Data were also edited in Hypack,
then exported in comma spaced variable file format. These data files were imported
into ESRI ArcGIS software and combined into a single shapefile. Horizontal
corrections were added to the attribute table to correct the raw horizontal
coordinates based on an online positioning user service solution for the base
location. The attribute table was then exported as a dbf file, and opened in ArcGIS
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map of Larimore Dam. Data in the Depth_1 field can be subtracted from the average
water surface elevation (325.927 meters above the national geodetic vertical datum
of 1988) to determine elevation of the lake bottom. Data in the Depth_2 field may
provide an indicator of sediment depth on the lake bottom in some areas. This
information could be used to develop a lake depth map and elevation/area/capacity
curves. Information on sediment thickness can be used to estimate lake volume lost
to sediment buildup.</purpose>
      <supplinf>Aquatic vegetation issues
The western portion of the lake had a great deal of aquatic vegetation. Cattail
rafts and islands were present, and submerged vegetation was present at nearly
every location with a water depth of approximately 2 meters or less. This greatly
impeded the bathymetry data collection. Submerged vegetation was also present at
scattered locations along the edges in the middle section of the lake, although
patches tended to be less thick. In some areas in the western end of the lake,
vegetation was so thick that the motor could not push the boat through it, even
when frequent stops were made to clear the propeller. In areas where vegetation was
too thick for the bathymetry equipment to work, partial data was collected using
```

global navigation satellite system equipment in real-time kinematic mode (RTK), off the side of the boat. One point was collected at what was estimated to be the top of the sediment, then another point (nearby or in the same location) was collected after the pole was pushed down until hitting a firm bottom substrate. Transects 1 and 2 at the upstream end of the lake were collected completely using RTK and wading, as this portion of the lake was not deep enough to boat. Transects 3, 4, 5, and parts of 6 could not be driven with the boat, as the motor was not able to push through the vegetation. Instead, an anchor was thrown out and used to pull the boat ahead on the transect, and points were collected using the RTK with an extended rod height. Please see the GNSS data (GNSS_data.shp within this data release) for additional data.

Echosounder settings
Since echosounders rely on signals passing through the water column, water temperature was recorded each day the echosounders were used, so that the speed of sound in water could be computed. On August 4, the water temperature was 24 degrees Celsius at the bar check location. This corresponds to an approximate speed of sound in water of 1492 meters per second. On August 7, the water temperature was also 24 degrees Celsius, so the same speed of sound in water was used. The two echosounders used for data collection each had power and gain levels that could be adjusted in an effort to optimize clean signal returns. The power level can be increased to help the transducer signal better penetrate submerged vegetation. However, excess power in shallow water can cause signal returns in multiples. This happens when part of the transducer signal bounces off the vegetation, then reflects off the bottom of the boat, then off the vegetation again. Adjusting the signal gain can help reduce noise in the data, but at the expense of sensitivity. Attempts were made to optimize power and gain settings before the bar check was completed at the beginning of the day, and only very minor adjustments were made while surveying. Large changes in power and gain settings made during surveying can affect and possibly invalidate an earlier bar check completed with different settings.

Bar Checks
A bar check was completed each day prior to collecting the first bathymetric data, and after the last data was collected. A bar check places an object below the transducer at a known depth below the water surface to ensure that the transducer is producing accurate data. The depth of the transducer below the water surface (draft) also needs to be measured and taken into account. Prior to collecting data using the E20 echosounder on August 4, a bar check was completed at depths of 1.21, 2.95, 3.99, 5.08, and 5.99 meters. The depth values from the 200 kilohertz frequency with the 4 degree width (Depth_1 in attribute table) averaged 0.04 meters shallower. The transducer draft value was re-measured and a follow-up bar check resulted in only a 2 centimeter difference. While using the E20 echosounder, the 24 kilohertz frequency signal with the 20 degree beam width (Depth_2 in the attribute table) was not able to lock onto the bar check apparatus, but at the bar check location, Depth_2 values were typically within a few centimeters of of Depth_1 values. A second bar check was completed after data collection on August 4, using depths of 5.99, 4.74, 2.68, and 1.63 meters. Depth_1 values averaged 2.5 centimeters shallower. The MKIII echosounder was used for bathymetric data collection on August 7. The Depth_2 signal was able to lock on to the bar check

apparatus with this echosounder. A bar check was completed before data collection on August 7 at 2.20 and 3.00 meters. The Depth_1 signal averaged 3.5 centimeters deeper, while the Depth_2 signal averaged 11.5 centimeters deeper. This echosounder allowed an index value to be applied, which brought the average Depth_1 values within 2 centimeters and the Depth_2 values within 5 centimeters. A bar check after data collection on August 7 had average Depth_1 values within 2 centimeters, and Depth_2 values within 2.5 centimeters.

Data Editing
Raw data includes erroneous depth returns caused by submerged objects such as fish, logs, and aquatic vegetation. Data was edited in an effort to remove erroneous data points from the dataset. Dense vegetation can prevent the transducer signal from reaching the lake bottom. In such areas, data could not be collected with the bathymetry equipment. In areas with moderate to sparse aquatic vegetation, a portion of the transducer signal may reach the lake bottom, so data was edited to remove data points representing vegetation, leaving data points representing the lake bottom. Generally speaking, the 200 kilohertz signal (Depth_1 in the attribute table) was able to successfully identify the lake bottom when sparse vegetation was present. The 24 kilohertz signal (Depth_2 in the attribute table) seemed less able to deal with vegetation. In some locations, vegetation or signal noise caused Depth_2 values to be misinterpreted as slightly above the Depth_1 values. These data points were not deleted so that the valid Depth_1 values associated with the data point could be retained.</supplinf>
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constitute any such warranty, and no responsibility is assumed by the USGS in
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Megabytes) were generated from an echosounder and transducer. The echosounder used
August 4, 2020 was a Teledyne Odom Hydrographic Echotrac E20 (serial number
1220041). The echosounder used August 7, 2020 was an Odom Hydrographic Echotrac
MKIII (serial number 21062). Both echosounders were used in conjunction with a
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Teledyne Odom Hydrographic dual frequency (24/200 kilohertz) transducer with 20 degree and 4 degree beams, respectively (serial number TR9075). Hypack 2019 bathymetric software was used for data collection and navigation. Data editing also took place within the Hypack Single Beam Editor module. Editing was completed to remove erroneous data returns caused by fish, vegetation or other submerged objects. The raw and edited data files were exported as comma spaced variable text file. A personal computer (with an Intel Core i9-9980HK central processing unit running at 2.40 Gigahertz and with 32 Gigabytes of random access memory running a Windows 10 Enterprise operating system) was used to import the file into ESRI ArcGIS 10.7.1 software. This software was also used to export the data into a shapefile format. For additional details on data editing, echosounder settings, and bar checks, please reference the Supplemental Information section of this metadata file.</native>
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    <posacc>
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        <horizpar>The horizontal accuracy of each point has three different components: accuracy of the base coordinates, accuracy of the physical surveying technique, and accuracy of the equipment. The horizontal and vertical coordinates of each point were adjusted to reflect a correction from the autonomous coordinates of the base to the solution determined from a 5 hour, 37 minute static occupation submitted to the Online Positioning User Service. This solution utilized 96 percent of observations and fixed 96 percent of ambiguities, resulting in an overall root mean squared error of 0.014 meters. Estimated error of the Easting is 0.004 meters, and estimated error of the Northing is 0.009 meters. Accuracy of the physical surveying technique is ensured by using a birds-eye level on the rove pole to ensure that the rod is held vertically and plumb. The data collector gives an

audible alarm if motion is detected while a point is being collected. Data
collection stops with the alarm so that the pole can be stabilized before
re-initiating data collection. Manufacturers specifications indicate that the
maximum precision of the Trimble R-8 receiver is 8 millimeters horizontal.
Check-in/check-out procedures (see supplemental information section within this
metadata file) were used to provide a field assessment of horizontal accuracy.
Eight total occupations of a check point are within the dataset. The Northing
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elsewhere within this metadata using Hypack bathymetric software. Following data
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ArcGIS software. The data were then exported in shapefile format. The coll_with
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shapefiles were copied into a single shapefile, and fields were added for northing
and easting corrections. Values for these correction fields were populated using
the field calculator. The contents of the northing and easting fields were copied
into new fields named Raw_North and Raw_East, respectively. The original northing
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considered to satisfy the quality standards relative to the purpose for which the
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APPENDIX D-7-B
Sediment Collection Documentation

Report Date: 17 Nov 20

Dennis Reep
HDR
3231 Greensboro Dr, Suite 200
Bismarck ND 58503

Date Received: 22 Oct 20 16:18
Sampled By: MVTL Field Services

Lab Number: 20-M2073
Work Order #:81-0850
Account #: 69396
Date Sampled: 21 Oct 20 12:00

Project Name: Larimore Dam
Sample Description: Dam

Temp at Receipt: 3.6C

	As Rec			Method RL	Method Reference	Date Analyzed				Analyst
EPA DRO Extraction						23	Oct	20		AK
Microwave Digestion					EPA 3051A	29	Oct	20		RAA
GRO (TPH)	<		mg/Kg	0.20	8015D	30	Oct	20		AK
DRO (TEH)	52.6		mg/Kg	3.0	8015D	2	Nov	20		AK
PCB-1016	< 60	@	ug/Kg	40.0	SW8082A	12	Nov	20		JTG
PCB-1221	< 60	@	ug/Kg	40.0	SW8082A	12	Nov	20		JTG
PCB-1232	< 60	@	ug/Kg	40.0	SW8082A	12	Nov	20		JTG
PCB-1242	< 60	@	ug/Kg	40.0	SW8082A	12	Nov	20		JTG
PCB-1248	< 60	@	ug/Kg	40.0	SW8082A	12	Nov	20		JTG
PCB-1254	< 45	@	ug/Kg	30.0	SW8082A	12	Nov	20		JTG
PCB-1260	< 30	@	ug/Kg	20.0	SW8082A	12	Nov	20		JTG
PCB-1262	< 45	@	ug/Kg	30.0	SW8082A	12	Nov	20		JTG
PCB-1268	< 45	@	ug/Kg	30.0	SW8082A	12	Nov	20		JTG
Total Organic Carbon	1.86		wt. %	0.50	ASTM D5373	17	Nov	20	12:09	EV
Nitrate-Nitrite as N	<		ug/g	0.50	EPA 353.2	29	Oct	20	8:22	EV
Phosphorus as P - Total	10.2		ug/g	1.58	Olsen/EPA 365.1	30	Oct	20	8:10	EV
Total Kjeldahl Nitrogen	1200		ug/g	5.00	PAI-DK01	3	Nov	20	13:10	BJ
Mercury	0.01		ug/g	0.00	SW846 7471B	3	Nov	20	10:49	MDE
Chromium	7.10		ug/g	4.61	6010D	3	Nov	20	9:23	SZ
Copper	6.45		ug/g	4.61	6010D	3	Nov	20	9:23	SZ
Nickel	8.11		ug/g	3.69	6010D	3	Nov	20	9:23	SZ
Zinc	26.3		ug/g	4.61	6010D	3	Nov	20	9:23	SZ
Arsenic	3.32		ug/g	0.037	6020	30	Oct	20	11:01	MDE
Cadmium	0.300		ug/g	0.0092	6020	30	Oct	20	11:01	MDE
Lead	2.55		ug/g	0.009	6020	30	Oct	20	11:01	MDE

Report Date: 17 Nov 20
Dennis Reep
HDR
3231 Greensboro Dr, Suite 200
Bismarck ND 58503
Date Received: 22 Oct 20 16:18
Sampled By: MVTL Field Services

Lab Number: 20-M2073
Work Order #:81-0850
Account #: 69396
Date Sampled: 21 Oct 20 12:00

Project Name: Larimore Dam
Sample Description: Dam

Temp at Receipt: 3.6C

As Received Result	Method RL	Method Reference	Date Analyzed	Analyst

~~BrFB SURROGATE RECOVERY: 95 % DRO SURROGATE RECOVERY: 96 %~~
2,4,5,6-TETRACHLORO-m-XYLENE (SURROGATE) RECOVERY: 106 %
DECACHLOROBIPHENYL (SURROGATE) RECOVERY: 110 %
DRO(TEH) sample pattern does not match diesel fuel. Unknown hydrocarbons present.
DRO - lab spike and spike duplicate recoveries above acceptable range. EPA DRO method blank concentration = 4.509 mg/Kg.
For questions about organic analyses results please contact our New Ulm organics laboratory at 1-800-782-3557. Organic analyses are performed in the New Ulm laboratory of MVTL; Minnesota Department of Health laboratory certification number is 027-015-125; North Dakota Department of Health laboratory certification number is R-040. Analyses performed by EPA Method 602 and 8021, glycol analyses, light hydrocarbons (methane, ethane, ethylene and propane) or residual hexane are not covered under these certification scopes.

Claudette K. Carroll

Approved by:

Claudette K. Carroll, Laboratory Manager, Bismarck ND

Report Date: 17 Nov 2020
Dennis Reep
HDR
3231 Greensboro Dr, Suite 200
Bismarck ND 58503
Date Sampled: 21 Oct 2020 12:00
Sampled By: MVTL Field Services

Lab Number: 20-M2073
Work Order #: 81-0850
Account #: 69396
Sample Matrix: MISC

Project Name: Larimore Dam
Sample Description: Dam

Date Received: 22 Oct 2020 16:18

Temp at Receipt: 3.6C

	CAS #	As Received Result				Method RL	Method Reference	Date Analyzed			Analyst
625/8270 SVMS Extraction								28	Oc	20	JE
Acenaphthene	83-32-9	<	0.266	@	mg/Kg	0.036	SW8270E	5	No	20	JTG
Acenaphthylene	208-96-8	<	0.252	@	mg/Kg	0.034	SW8270E	5	No	20	JTG
Anthracene	120-12-7	<	0.237	@	mg/Kg	0.032	SW8270E	5	No	20	JTG
Benzo(a)anthracene	56-55-3	<	0.229	@	mg/Kg	0.031	SW8270E	5	No	20	JTG
Benzo(a)pyrene	50-32-8	<	0.281	@	mg/Kg	0.038	SW8270E	5	No	20	JTG
Benzo(b)fluoranthene	205-99-2	<	0.259	@	mg/Kg	0.035	SW8270E	5	No	20	JTG
Benzo(ghi)perylene	191-24-2	<	0.666	@	mg/Kg	0.09	SW8270E	5	No	20	JTG
Benzo(k)fluoranthene	207-08-9	<	0.229	@	mg/Kg	0.031	SW8270E	5	No	20	JTG
Chrysene	218-01-9	<	0.252	@	mg/Kg	0.034	SW8270E	5	No	20	JTG
Dibenzo(a,h)anthracene	53-70-3	<	0.666	@	mg/Kg	0.09	SW8270E	5	No	20	JTG
7,12-Dimethylbenz (a)	57-97-6	<	0.333	@	mg/Kg	0.045	SW8270E	5	No	20	JTG
Fluoranthene	206-44-0	<	0.296	@	mg/Kg	0.04	SW8270E	5	No	20	JTG
Fluorene	86-73-7	<	0.266	@	mg/Kg	0.036	SW8270E	5	No	20	JTG
Indeno(1,2,3-cd)pyrene	193-39-5	<	0.592	@	mg/Kg	0.08	SW8270E	5	No	20	JTG
2-Methylnaphthalene	91-57-6	<	0.296	@	mg/Kg	0.04	SW8270E	5	No	20	JTG
Naphthalene	91-20-3	<	0.244	@	mg/Kg	0.033	SW8270E	5	No	20	JTG
Phenanthrene	85-01-8	<	0.259	@	mg/Kg	0.035	SW8270E	5	No	20	JTG
Pyrene	129-00-0	<	0.222	@	mg/Kg	0.03	SW8270E	5	No	20	JTG

NITROBENZENE (SURROGATE) RECOVERY: 40
2-FLUOROBIPHENYL (SURROGATE) RECOVERY: 53 TERPHENYL-d14 (SURROGATE) RECOVERY: 69

Due to sample matrix interferences the B/N surrogate recoveries were outside the acceptable ranges.
All other QC was within acceptable recovery ranges.

Approved by: R. Dan O'Connell

Dan O'Connell, Chemistry Laboratory Manager New Ulm, MN

RL = Reporting Limit

Analyses performed under our Minnesota Department of Health Accreditation conform to the current TNI standards. The reporting limit was elevated for any analyte requiring a dilution as coded below:

@ = Due to sample matrix # = Due to concentration of other analytes
! = Due to sample quantity + = Due to internal standard response

CERTIFICATION: MN LAB # 027-015-125 WI LAB # 999447680 ND MICRO # 1013-M ND WW/DW # R-040

Report Date: 17 Nov 20

Dennis Reep
HDR
3231 Greensboro Dr, Suite 200
Bismarck ND 58503
Date Received: 22 Oct 20 16:18
Sampled By: MVTL Field Services

Lab Number: 20-M2074
Work Order #:81-0850
Account #: 69396
Date Sampled: 21 Oct 20 13:00

Project Name: Larimore Dam
Sample Description : Upstream

Temp at Receipt: 3.6C

	As Received Result			Method RL	Method Reference	Date Analyzed				Analyst
EPA DRO Extraction						23	Oct	20		AK
Microwave Digestion					EPA 3051A	29	Oct	20		RAA
GRO (TPH)	<		mg/Kg	0.20	8015D	30	Oct	20		AK
DRO (TEH)	22.7		mg/Kg	3.0	8015D	2	Nov	20		AK
PCB-1016	< 60	@	ug/Kg	40.0	SW8082A	12	Nov	20		JTG
PCB-1221	< 60	@	ug/Kg	40.0	SW8082A	12	Nov	20		JTG
PCB-1232	< 60	@	ug/Kg	40.0	SW8082A	12	Nov	20		JTG
PCB-1242	< 60	@	ug/Kg	40.0	SW8082A	12	Nov	20		JTG
PCB-1248	< 60	@	ug/Kg	40.0	SW8082A	12	Nov	20		JTG
PCB-1254	< 45	@	ug/Kg	30.0	SW8082A	12	Nov	20		JTG
PCB-1260	< 30	@	ug/Kg	20.0	SW8082A	12	Nov	20		JTG
PCB-1262	< 45	@	ug/Kg	30.0	SW8082A	12	Nov	20		JTG
PCB-1268	< 45	@	ug/Kg	30.0	SW8082A	12	Nov	20		JTG
Total Organic Carbon	1.45		wt. %	0.50	ASTM D5373	17	Nov	20	12:09	EV
Nitrate-Nitrite as N	<		ug/g	0.50	EPA 353.2	29	Oct	20	8:22	EV
Phosphorus as P - Total	9.98		ug/g	1.54	Olsen/EPA 365.1	30	Oct	20	8:10	EV
Total Kjeldahl Nitrogen	783		ug/g	5.00	PAI-DK01	3	Nov	20	13:10	BJ
Mercury	< 0.02		ug/g	0.02	SW846 7471B	3	Nov	20	10:49	MDE
Chromium	5.69		ug/g	2.22	6010D	3	Nov	20	9:23	SZ
Copper	5.42		ug/g	2.22	6010D	3	Nov	20	9:23	SZ
Nickel	6.18		ug/g	1.78	6010D	3	Nov	20	9:23	SZ
Zinc	20.7		ug/g	2.22	6010D	3	Nov	20	9:23	SZ
Arsenic	2.29		ug/g	0.018	6020	30	Oct	20	11:01	MDE
Cadmium	0.248		ug/g	0.0044	6020	30	Oct	20	11:01	MDE
Lead	2.11		ug/g	0.004	6020	30	Oct	20	11:01	MDE

Report Date: 17 Nov 20

Dennis Reep
HDR
3231 Greensboro Dr, Suite 200
Bismarck ND 58503

Lab Number: 20-M2074
Work Order #:81-0850
Account #: 69396
Date Sampled: 21 Oct 20 13:00

Date Received: 22 Oct 20 16:18
Sampled By: MVTL Field Services

Project Name: Larimore Dam
Sample Description: Upstream Delta

Temp at Receipt: 3.6C

	As Received Result	Method RL	Method Reference	Date Analyzed	Analyst

BrFB SURROGATE RECOVERY: 95 % DRO SURROGATE RECOVERY: 95 %
2,4,5,6-TETRACHLORO-m-XYLENE (SURROGATE) RECOVERY: 116 %
DECACHLOROBIPHENYL (SURROGATE) RECOVERY: 106 %
DRO(TEH) sample pattern does not match diesel fuel. Unknown hydrocarbons present.
DRO - lab spike and spike duplicate recoveries above acceptable range. EPA DRO method blank concentration = 4.509 mg/Kg.
For questions about organic analyses results please contact our New Ulm organics laboratory
at 1-800-782-3557. Organic analyses are performed in the New Ulm laboratory of MVTL; Minnesota Department of Health laboratory certification number is 027-015-125; North Dakota Department of Health laboratory certification number is R-040. Analyses performed by EPA Method 602 and 8021, glycol analyses, light hydrocarbons (methane, ethane, ethylene and propane) or residual hexane are not covered under these certification scopes.

Approved by: Claudette K. Carroll

Claudette K. Carroll, Laboratory Manager, Bismarck, ND

Report Date: 17 Nov 2020

Dennis Reep
HDR
3231 Greensboro Dr, Suite 200
Bismarck ND 58503

Date Sampled: 21 Oct 2020 13:00
Sampled By: MVTL Field Services

Lab Number: 20-M2074
Work Order #: 81-0850
Account #: 69396
Sample Matrix: MISC

Project Name: Larimore Dam
Sample Description: Upstream Delta

Date Received: 22 Oct 2020 16:18

Temp at Receipt: 3.6C

	CAS #	As Received Result				Method RL	Method Reference	Date Analyzed			Analyst
625/8270 SVMS Extraction								28	Oc	20	JE
Acenaphthene	83-32-9	<	0.36	@	mg/Kg	0.036	SW8270E	5	No	20	JTG
Acenaphthylene	208-96-8	<	0.34	@	mg/Kg	0.034	SW8270E	5	No	20	JTG
Anthracene	120-12-7	<	0.32	@	mg/Kg	0.032	SW8270E	5	No	20	JTG
Benzo(a)anthracene	56-55-3	<	0.31	@	mg/Kg	0.031	SW8270E	5	No	20	JTG
Benzo(a)pyrene	50-32-8	<	0.38	@	mg/Kg	0.038	SW8270E	5	No	20	JTG
Benzo(b)fluoranthene	205-99-2	<	0.35	@	mg/Kg	0.035	SW8270E	5	No	20	JTG
Benzo(ghi)perylene	191-24-2	<	0.9		mg/Kg	0.09	SW8270E	5	No	20	JTG
Benzo(k)fluoranthene	207-08-9	<	0.31	@	mg/Kg	0.031	SW8270E	5	No	20	JTG
Chrysene	218-01-9	<	0.34	@	mg/Kg	0.034	SW8270E	5	No	20	JTG
Dibenzo(a,h)anthracene	53-70-3	<	0.9		mg/Kg	0.09	SW8270E	5	No	20	JTG
7,12-Dimethylbenz (a)	57-97-6	<	0.45	@	mg/Kg	0.045	SW8270E	5	No	20	JTG
Fluoranthene	206-44-0	<	0.4		mg/Kg	0.04	SW8270E	5	No	20	JTG
Fluorene	86-73-7	<	0.36	@	mg/Kg	0.036	SW8270E	5	No	20	JTG
Indeno(1,2,3-cd)pyrene	193-39-5	<	0.8		mg/Kg	0.08	SW8270E	5	No	20	JTG
2-Methylnaphthalene	91-57-6	<	0.4		mg/Kg	0.04	SW8270E	5	No	20	JTG
Naphthalene	91-20-3	<	0.33	@	mg/Kg	0.033	SW8270E	5	No	20	JTG
Phenanthrene	85-01-8	<	0.35	@	mg/Kg	0.035	SW8270E	5	No	20	JTG
Pyrene	129-00-0	<	0.3		mg/Kg	0.03	SW8270E	5	No	20	JTG

NITROBENZENE (SURROGATE) RECOVERY: 34
2-FLUOROBIPHENYL (SURROGATE) RECOVERY: 40 TERPHENYL-d14 (SURROGATE) RECOVERY: 72

Due to sample matrix interferences the B/N surrogate recoveries were outside the acceptable ranges.
All other QC was within acceptable recovery ranges.

Approved by: R. Dan O'Connell

Dan O'Connell, Chemistry Laboratory Manager New Ulm, MN

RL = Reporting Limit

Analyses performed under our Minnesota Department of Health Accreditation conform to the current TNI standards. The reporting limit was elevated for any analyte requiring a dilution as coded below:

@ = Due to sample matrix # = Due to concentration of other analytes
! = Due to sample quantity + = Due to internal standard response

CERTIFICATION: MN LAB # 027-015-125 WI LAB # 999447680 ND MICRO # 1013-M ND WW/DW # R-040

United States Department of Agriculture

Addendum to Larimore Dam Rehab Accumulated Sediment Report, Appendix D-7
May 15, 2025

The sediment thickness near the dam is important for determining low-level drawdown pipe connecting the reservoir to the new principal spillway riser tower. The Accumulated Sediment Report Figure 5, shows sediment thickness in the Larimore reservoir. The values near the dam range from 0.0 to 1.0 feet, however the Data Processing section describes collection challenges that resulted in unexpectedly low amounts of sediment in the reservoir (45 ac-ft); this volume is represented in Figure 5 thicknesses and summarized by documentation of 41 years of life and rate of 1.1 ac-ft/year. The Data Processing section goes on to take another approach comparing top of permanent pool volume to top of sediment, resulting in sediment accumulation of 186 ac-ft. This volume is corroborated with the predicted amount as well as regional sedimentation data at other dams. Therefore, 186 ac-ft of sedimentation is utilized for planning the rehabilitation project. In summary, the sediment thicknesses documented in Figure 5 resulted in a volume of 45 ac-ft, while the best estimate for planning is a sediment volume of 186 ac-ft (four times higher than volumes depicted in Figure 5).

The sedimentation thickness near the dam according to data accumulated in August 2020 should be extrapolated by a multiple determined from the best estimate (4). As noted prior, the sediment thickness near the dam ranges from 0.0 to 1.0 feet. Therefore, the most realistic range of sediment thickness near the dam ranges from 0 to 4 feet. In summary, 4 feet is the maximum expected thickness of sediment near the dam.

Update Prepared By: Jon Petersen, ND NRCS H&H Engineer