TO: Bryan Carey, PE
FROM: Andrew Johnson, PE; Nash Greenfield, EI; Russ Reed, PE, BC.WRE
DATE: 3/5/2025
PROJECT: Dixon Diversion Conceptual Study
SUBJECT: Update to the 2023 Hydrology Report with 2024 Data – Revised

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The 2023 Hydrology Report introduced three area exponents computed using the first year of streamflow measurements on the Martin River to refine the simple synthetic record (translating the extensive Upper Bradley River record to the previously ungagged Martin River) originally established in 2022. This memorandum documents the 2024 update of the synthetic discharge record that accounts for the additional year (2024) of streamflow measurements on the Martin River.

STREAMFLOW DATA

2024 was the second year DOWL performed streamflow measurements on the Martin River. Figure 1 presents the locations and drainages of the stream gaging stations. The 2024 Streamflow Data Technical Memorandum (Attachment 4) describes the methodology, details of the discharge measurements, development of the rating curves, and rating shifts. Streamflow was measured at the following locations:

- Martin River at the Constriction
- Red Lake Basin Outlet
- Mid-Reach Lake Basin Outlet

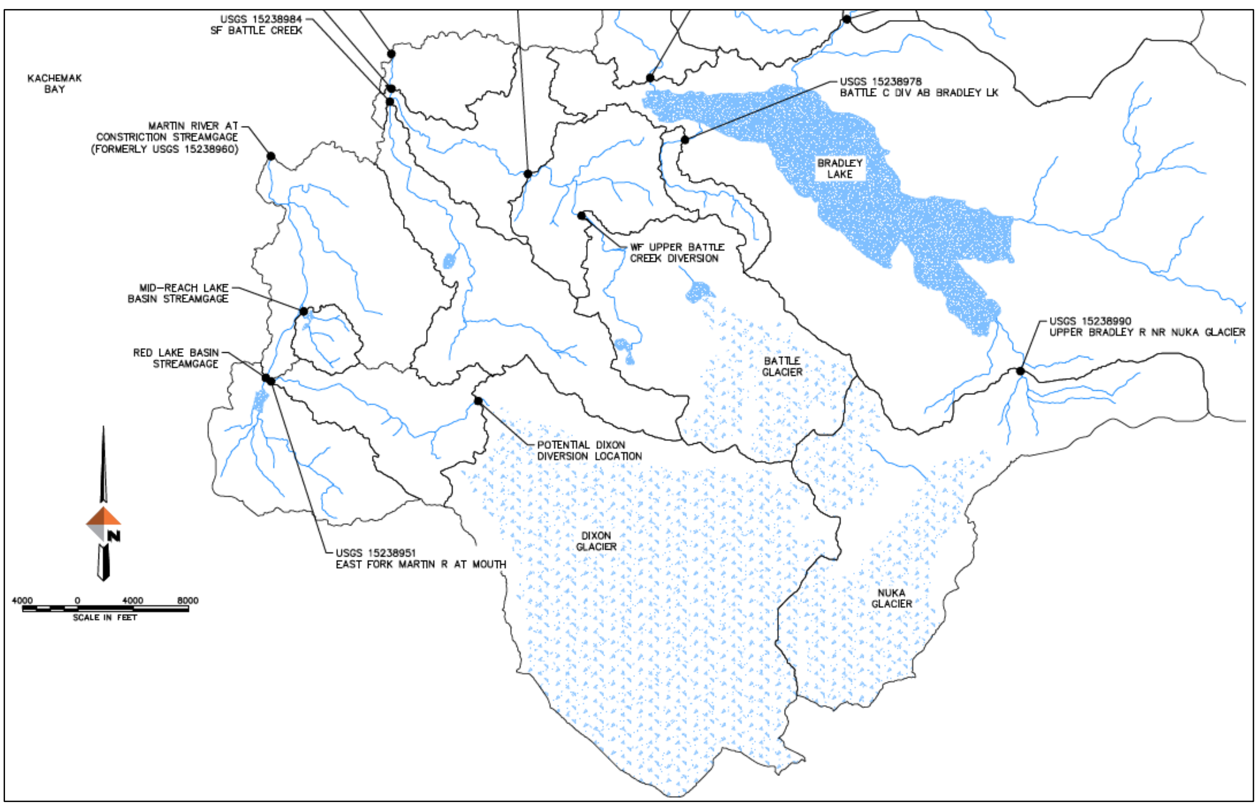


Figure 1: Streamgages along the Martin River Watercourse

Building on the initial work in 2023, the USGS is continues to establish the streamgage record for the East Fork Martin River at the Mouth (USGS 15238951). Note: subsequent to issuing the 2023 Hydrology Report, the stream name changed from “Dixon Creek” to the “East Fork Martin River.” Although preliminary stage data and occasional discharge measurements are available, continuous streamflow data are not available for the USGS gage station. However, DOWL created an approximate discharge hydrograph for the Dixon basin by subtracting the discharge measured at Red Lake and Mid-Reach Lake from the Martin River at the Constriction. The unaccounted-for area between the proposed diversion and the Mouth is about 3.13 mi^2 (~16% of the Dixon diversion basin area), but is believed to not significantly affect the discharge estimates at the diversion because the runoff would only be from early season snowmelt (as opposed to glacier melt throughout the summer) and precipitation. The calculated discharge at the Mouth was validated by point discharge measurements by DOWL and the USGS (USGS 15238951). Figure 2 presents the 2024 average daily Martin River hydrograph at the Mouth.

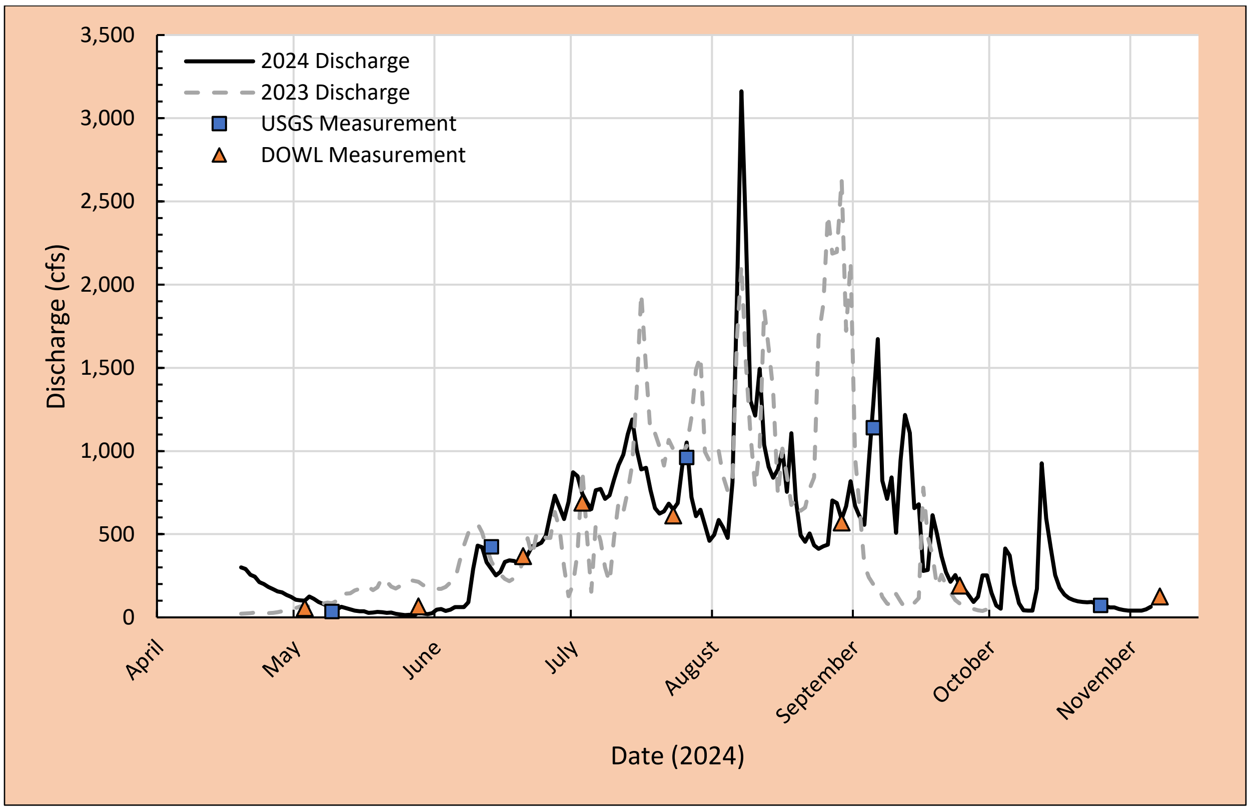


Figure 2: East Fork Martin River Calculated Hydrograph

The USGS has been measuring streamflow on the Upper Bradley River near the Nuka Glacier (USGS 15238990) for over 40 years. As in 2023, DOWL used the extended record of the Upper Bradley River as the basis for the synthetic hydrograph at the proposed Dixon diversion site. Figure 3 shows the 2023 and 2024 discharge on the Upper Bradley River. Based on review of the complete period of record for the Upper Bradley River, both 2023 and 2024 (apart from the early August flood in 2024) appear to be near the mean discharge and are believed to be appropriate for establishing the synthetic record on the Martin River.

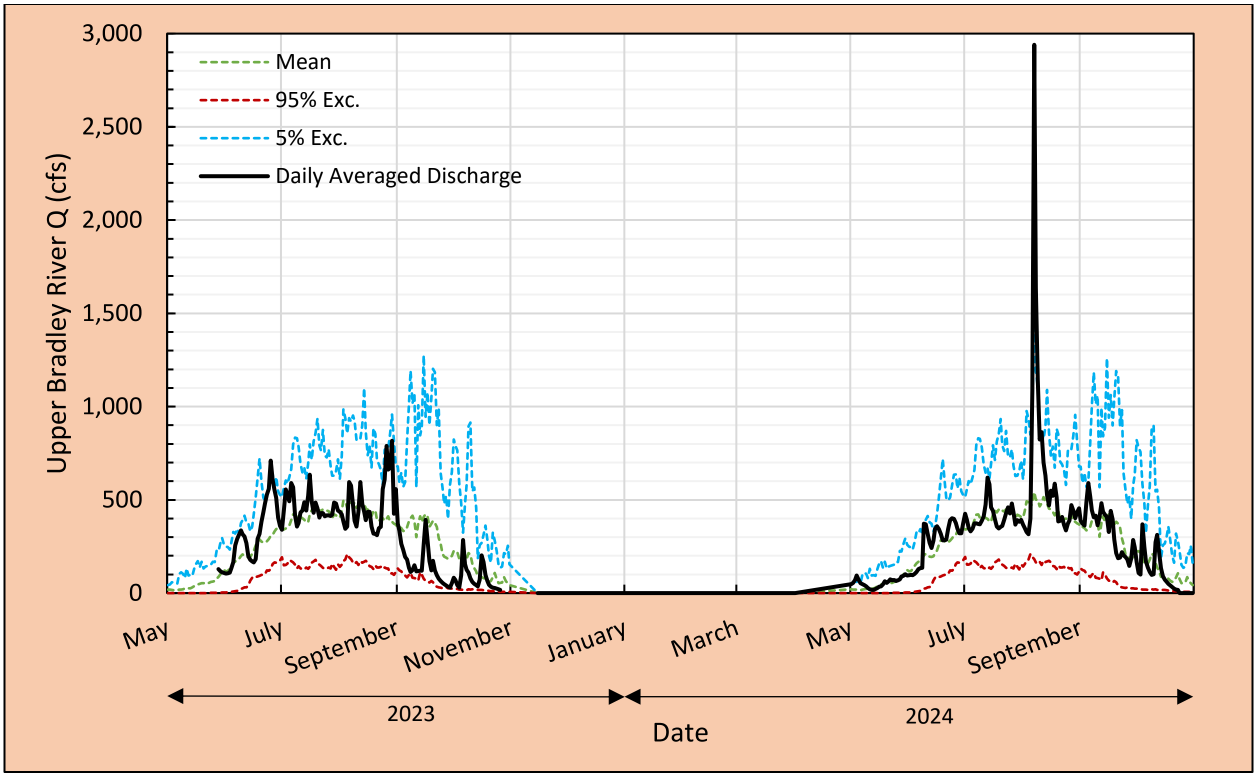


Figure 3: Upper Bradley River Streamflow Statistics and Measured Discharge

AUGUST 2024 FLOOD

As shown in Figure 3 (above), a significant flood occurred in early August of 2024. The flood was a precipitation-driven event lasting a few days beginning on August 5th with an estimated recurrence interval of ~10+ years. The flooding on the Upper Bradley River caused the channel to migrate such that the streamgage (USGS 15238990) no longer accurately records streamflow measurements, and the rating relationship needs to be redeveloped. However, the USGS publishes frequent (although not continuous) approved discharge estimates for the Upper Bradley River with the peak of the flood estimated at 3,400 cfs; after August 5, 2024, the estimates are considered less reliable than the measurements before the flood. The USGS streamgage on the East Fork Martin River (USGS 15238951) also washed out during the August flood and the streamgage may need to be relocated before the rating relationship can be developed. DOWL streamflow measurements on the Martin River at the Constriction are continuous through the flood and were corrected using rating shifts. Based on these observations, the estimated discharge at the Mouth during the August flood have a higher level of uncertainty and were excluded from the area coefficient update described below.

AREA COEFFICIENT UPDATE

As discussed in the 2023 Hydrology Report, DOWL established the following relationship to estimate discharge at the proposed Dixon Diversion location based on discharge measured at the Upper Bradley River near Nuka Glacier (USGS 15238990):

$$Q_{Dixon} = Q_{Bradley}\left(\frac{A_{Dixon}}{A_{Bradley}}\right)^{\alpha} = Q_{Bradley} \times Factor$$

In the above equation, $Q =$ discharge, $A =$ area, and $\alpha =$ an area exponent. The discharge estimated using this equation is termed "synthetic discharge" and can be applied to the extensive record on the Upper Bradley River. When the relationship was initially developed in 2022, no discharge data were available for Dixon Creek at the Mouth, and a constant area exponent was assumed based on "normal" meteorological conditions. However, following a season of Martin River streamflow measurements, the 2023 Hydrology Report presented three area exponents to characterize different runoff periods during the summer. Refer to the 2023 Hydrology Report for a complete discussion of the regression performed on the gage records to determine the appropriate area exponents. Since the area exponents modify two unchanging areas (Martin River drainage area = 22.26 mi^2, Upper Bradley River drainage area = 11.15 mi^2), the resultant term is a constant factor applied to the measured discharge of the Upper Bradley River.

The 2024 streamflow measurements of the Martin River were used to update the synthetic hydrograph record. There is less confidence in the streamflow measurements during the August flood, so DOWL removed measurements during the flood (August 5 to 9, 2024). Figure 4 presents the 2024 measured and synthetic discharge hydrographs. The vertical gold bars delineate the three periods for which each area exponent is applied.

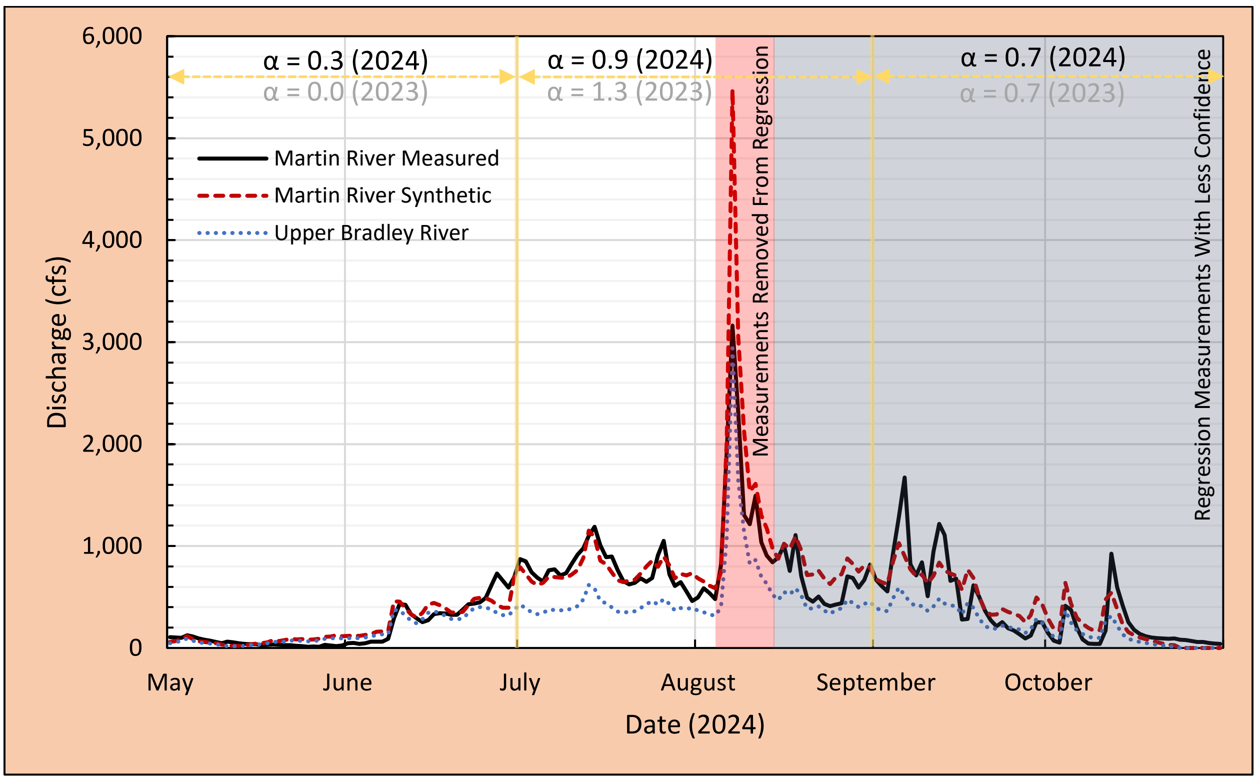


Figure 4: 2024 Measured and Synthetic Discharge

The average of the 2023 and 2024 area exponents is the best estimate for creating the daily synthetic hydrograph. Table 1 presents the area exponents and the resultant factors to build the synthetic discharge record. The 2024 area exponents are similar to the 2023 estimates but result in a net decrease in the best estimate (average) of synthetic record volume.

Table 1: Area Exponent Comparison

Period	Area Exponent (Factor)		
	2023	2024	Best Estimate (Average)
May 1 through June 30	0.0 (1.0)	0.3 (1.2)	0.1 (1.1)
July 1 through August 31	1.3 (2.5)	0.9 (1.9)[1]	1.1 (2.1)
September 1 through October 31	0.7 (1.6)	0.8 (1.7)[2]	0.7 (1.6)

Note 1: Exponent computed based on measurements from the first half of the period (i.e., before the flood).

Note 2: The Upper Bradley River measurements are based on USGS-approved estimates, so there is less confidence in the resultant exponent.

DIVERSION OPERATIONS MODEL UPDATE

Figure 5 presents the average of the historical synthetic hydrographs using the area exponents in Table 1. The period from July 1 to August 31 is the most sensitive to the factors because that is when the greatest runoff volume occurs. Note that the synthetic hydrograph daily averages are shown in Figure 5 to illustrate the general magnitude of runoff in the Martin River. Based on review of the complete precipitation record at the Upper Bradley River, the data reveal a trend of increasing annual precipitation. To reflect the current climate condition, the updated operations model is based on a synthetic hydrograph from 2003 through 2022 (while the full synthetic record could reach back to 1980), with daily average transformations from the Upper Bradley River to the Martin River.

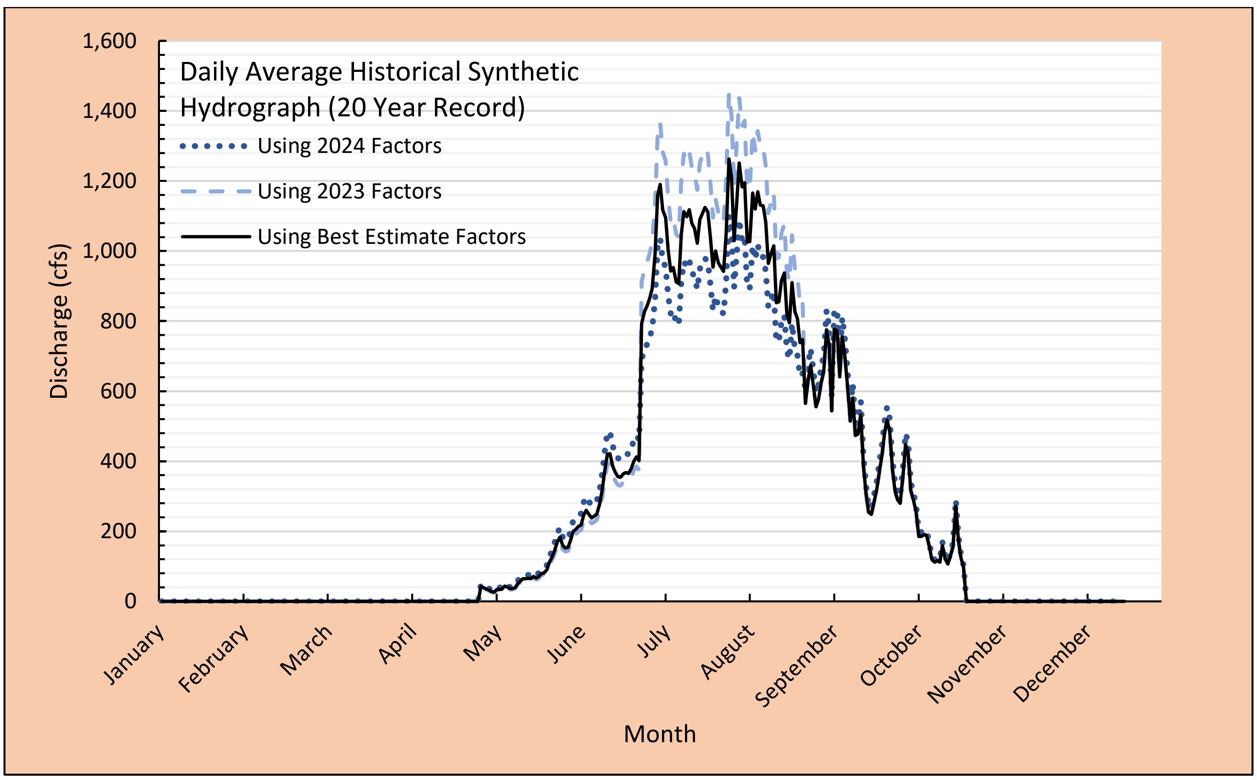


Figure 5: Average Historical Synthetic Hydrograph

Following the same model and methodology as the 2023 Hydrology Report, DOWL ran the operations model using the updated synthetic hydrograph. The 2024 estimated historical runoff volumes decreased by approximately 10%, and the "historical" diverted volumes decreased by about 6% compared to the 2023 estimates. In short, the change in the best estimate for diverted runoff volume is less than 10% of what was estimated in 2023. Attachment 1 presents the computed volumes.

FLOOD-FREQUENCY & FLOW-EXCEEDANCE

Using part of the available synthetic hydrograph record and the two years of streamflow measurements (for a 20-year record to best represent current climatic conditions), DOWL performed flood-frequency and flow-exceedance analyses.

Flood-frequency was estimated following the USGS's *Guidelines for Determining Flood Flow Frequency – Bulletin 17C* (Bulletin 17C). To simplify the operations model, daily average discharges were used instead of instantaneous flow measurements; the same daily average hydrograph was used in the Bulletin 17C flood-frequency analysis for consistency. Unlike a traditional Bulletin 17C analysis that is based on water year (i.e., October 1st – September 30th), DOWL used the calendar year (i.e., January 1st – December 31st) because the expected operating season goes through October. A weighted (of station and regional) skew was used to help fit the log-Pearson Type III distribution. The station skew was computed using HEC-SSP (v2.3); the regional skew was assigned based on the USGS's *Estimating Flood Magnitude and Frequency at Gaged and Ungaged Sites on Streams in Alaska and Conterminous Basins in Canada – SIR 2016-5024* that recommends a regional skew of 0.18 and the average variance of prediction (which was substituted for Mean Standard Error (MSE)) of 0.12. The results of the flood-frequency analysis (based on the average daily flow values) are presented in Attachment 2 and summarized in Table 2. Note that the daily averaged annual flood peaks have a smaller estimated return interval than would be computed using the instantaneous flood peaks.

Table 2: Flood-Frequency Results

Return Interval (years)	Average Daily Discharge (cfs)
50	5,490
25	4,840
20	4,630
15	4,350
10	3,970
5	3,310
4	3,090
3	2,790
2	2,340
1.5	1,960
1.1	1,190
1.0	910

Like the other analyses discussed in this memorandum, the flow-exceedance analysis is based on the daily averaged synthetic hydrograph record. Here, DOWL evaluated how often, or rather how frequently, does the flow in the East Fork Martin River exceed a given discharge rate. The average yearly exceedance values are reported for the synthetic hydrograph record. The two years of measured (2023 and 2024) exceedances plot above (for part of the curve) and below the synthetic average, respectively, as expected (even though 2024 had a greater individual flood event (August 2024), 2023 had a greater overall runoff volume). Attachment 3 presents the flow-exceedance results.

Attachment 1: Operational Model Results

OPERATIONAL MODEL

USING 2024 MEASUREMENTS

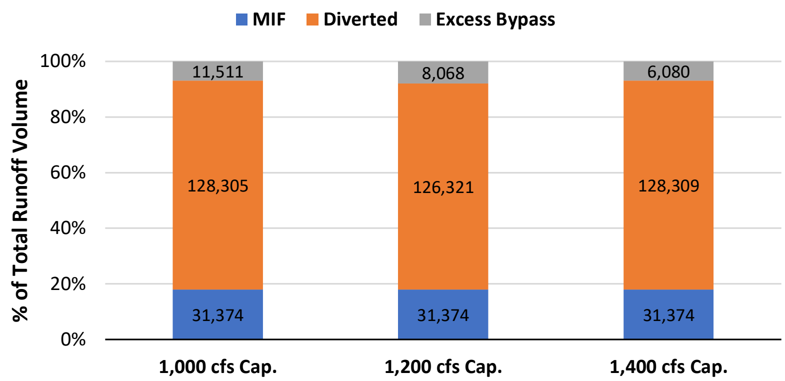
INPUT

Minimum Instream Flow (MIF)

May:	100	cfs
June:	100	cfs
July:	100	cfs
August:	100	cfs
September:	100	cfs
October:	100	cfs

Diversion Tunnel Capacity

Scenario 1:	1,000	cfs
Scenario 2:	1,200	cfs
Scenario 3:	1,400	cfs



OUTPUT

Scenario 1: 1,000 cfs Tunnel Capacity							
Month	Volume (acre-ft)				Percentage		
	Total Runoff	MIF	Diverted	Bypass in Excess of MIF	MIF	Diverted	Bypass in Excess of MIF
May	3,034	2,942	92	0	97%	3%	0%
June	19,619	5,273	14,346	0	27%	73%	0%
July	48,086	6,147	41,758	180	13%	87%	0%
August	55,864	6,147	40,174	9,544	11%	72%	17%
September	34,230	5,934	26,508	1,787	17%	77%	6%
October	10,357	4,930	5,427	0	48%	52%	0%
Total	171,190	31,374	128,305	11,511	18%	75%	7%

Scenario 2: 1,200 cfs Tunnel Capacity							
Month	Volume (acre-ft)				Percentage		
	Total Runoff	MIF	Diverted	Bypass in Excess of MIF	MIF	Diverted	Bypass in Excess of MIF
May	3,034	2,942	92	0	97%	3%	0%
June	19,619	5,273	14,346	0	27%	73%	0%
July	48,086	6,147	41,938	0	13%	87%	0%
August	55,864	6,147	42,396	7,321	11%	76%	13%
September	34,230	5,934	27,548	747	17%	80%	3%
October	10,357	4,930	5,427	0	48%	52%	0%
Total	171,190	31,374	126,321	8,068	18%	74%	8%

Scenario 3: 1,400 cfs Tunnel Capacity							
Month	Volume (acre-ft)				Percentage		
	Total Runoff	MIF	Diverted	Bypass in Excess of MIF	MIF	Diverted	Bypass in Excess of MIF
May	3,034	2,942	92	0	97%	3%	0%
June	19,619	5,273	14,346	0	27%	73%	0%
July	48,086	6,147	41,938	0	13%	87%	0%
August	55,864	6,147	43,979	5,738	11%	79%	10%
September	34,230	5,934	27,954	342	17%	82%	1%
October	10,357	4,930	5,427	0	48%	52%	0%
Total	171,190	31,374	128,309	6,080	18%	75%	7%

OPERATIONAL MODEL

USING SYNTHETIC RECORD

INPUT

Minimum Instream Flow (MIF)

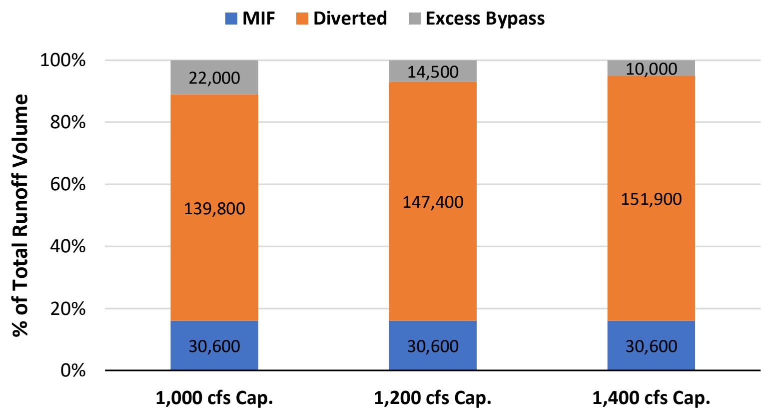
May:	100	cfs
June:	100	cfs
July:	100	cfs
August:	100	cfs
September:	100	cfs
October:	100	cfs

Diversion Tunnel Capacity

Scenario 1:	1,000	cfs
Scenario 2:	1,200	cfs
Scenario 3:	1,400	cfs

Statistical Range

Start Year:	2003
End Year:	2022



○ All Data ○ 40-yr Record ○ 30-yr Record ◉ 20-yr Record ○ 10-yr Record

OUTPUT

Scenario 1: 1,000 cfs Tunnel Capacity

Month	Volume (acre-ft)				Percentage		
	Total Runoff	MIF	Diverted	Bypass in Excess of MIF	MIF	Diverted	Bypass in Excess of MIF
May	3,900	2,700	1,200	0	69%	31%	0%
June	17,700	5,700	12,000	0	32%	68%	0%
July	62,200	6,100	48,200	7,800	10%	77%	13%
August	62,000	6,100	46,200	9,700	10%	75%	15%
September	32,500	5,700	23,600	3,100	18%	73%	9%
October	14,300	4,300	8,600	1,400	30%	60%	10%
Total	192,600	30,600	139,800	22,000	16%	73%	11%

Scenario 2: 1,200 cfs Tunnel Capacity

Month	Volume (acre-ft)				Percentage		
	Total Runoff	MIF	Diverted	Bypass in Excess of MIF	MIF	Diverted	Bypass in Excess of MIF
May	3,900	2,700	1,200	0	69%	31%	0%
June	17,700	5,700	12,000	0	32%	68%	0%
July	62,200	6,100	51,500	4,600	10%	83%	7%
August	62,000	6,100	49,100	6,800	10%	79%	11%
September	32,500	5,700	24,600	2,200	18%	76%	6%
October	14,300	4,300	9,000	900	30%	63%	7%
Total	192,600	30,600	147,400	14,500	16%	77%	7%

Scenario 3: 1,400 cfs Tunnel Capacity

Month	Volume (acre-ft)				Percentage		
	Total Runoff	MIF	Diverted	Bypass in Excess of MIF	MIF	Diverted	Bypass in Excess of MIF
May	3,900	2,700	1,200	0	69%	31%	0%
June	17,700	5,700	12,000	0	32%	68%	0%
July	62,200	6,100	53,200	2,900	10%	86%	4%
August	62,000	6,100	51,000	4,900	10%	82%	8%
September	32,500	5,700	25,200	1,600	18%	78%	4%
October	14,300	4,300	9,300	600	30%	65%	5%
Total	192,600	30,600	151,900	10,000	16%	79%	5%

OPERATIONAL MODEL

USING SYNTHETIC RECORD

INPUT

Minimum Instream Flow (MIF)

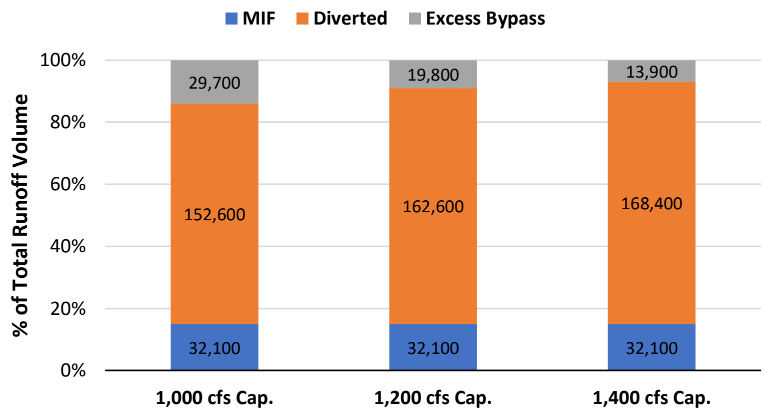
May:	100	cfs
June:	100	cfs
July:	100	cfs
August:	100	cfs
September:	100	cfs
October:	100	cfs

Diversion Tunnel Capacity

Scenario 1:	1,000	cfs
Scenario 2:	1,200	cfs
Scenario 3:	1,400	cfs

Statistical Range

Start Year:	2013
End Year:	2022



○ All Data ○ 40-yr Record ○ 30-yr Record ○ 20-yr Record ◉ 10-yr Record

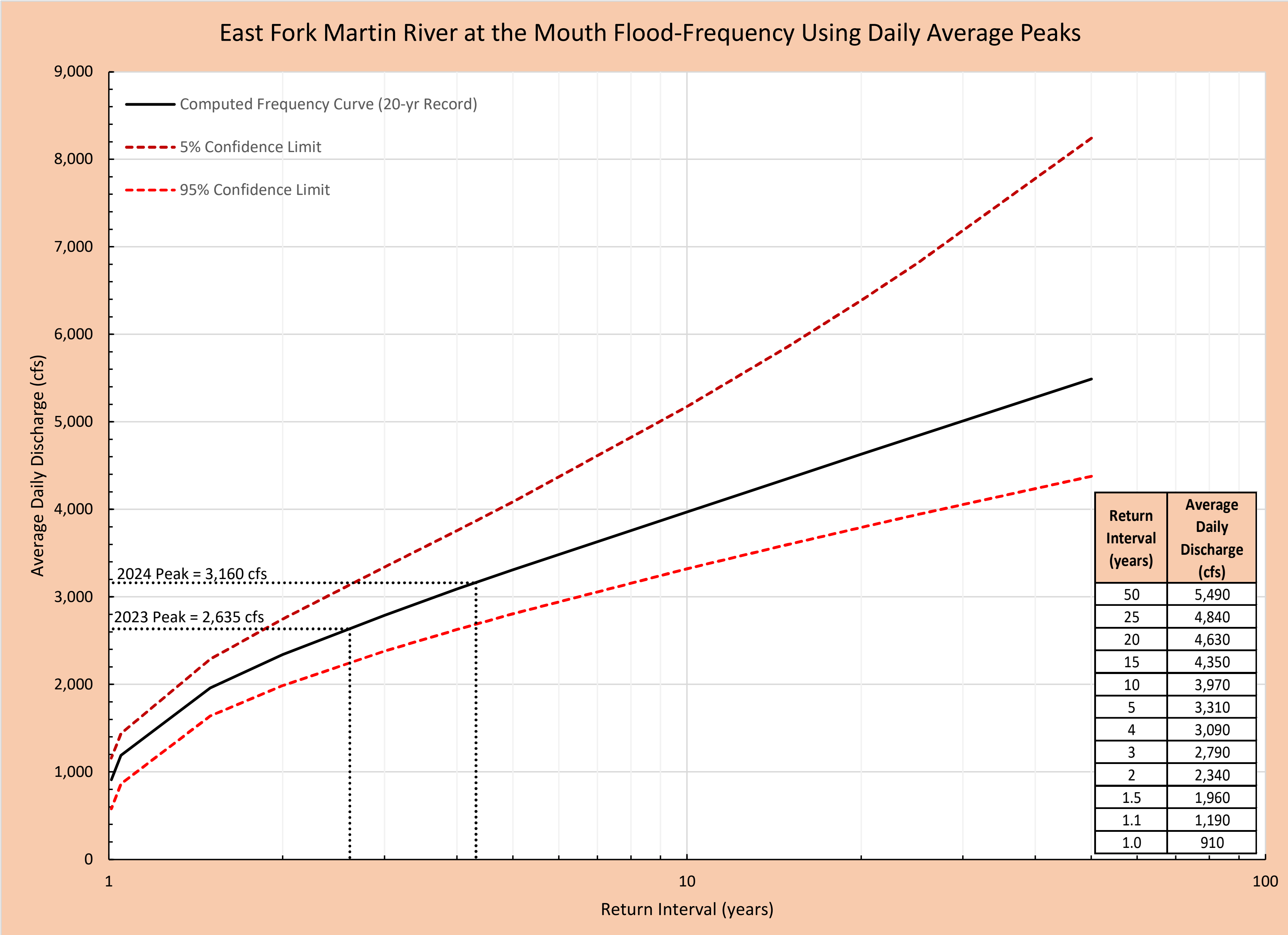
OUTPUT

Scenario 1: 1,000 cfs Tunnel Capacity							
Month	Volume (acre-ft)				Percentage		
	Total Runoff	MIF	Diverted	Bypass in Excess of MIF	MIF	Diverted	Bypass in Excess of MIF
May	5,700	3,800	1,900	0	67%	33%	0%
June	20,300	5,900	14,400	0	29%	71%	0%
July	68,300	6,100	52,000	10,100	9%	76%	15%
August	69,600	6,100	48,400	15,000	9%	70%	21%
September	35,500	5,700	26,000	3,700	16%	73%	11%
October	15,300	4,500	9,900	900	29%	65%	6%
Total	214,700	32,100	152,600	29,700	15%	71%	14%

Scenario 2: 1,200 cfs Tunnel Capacity							
Month	Volume (acre-ft)				Percentage		
	Total Runoff	MIF	Diverted	Bypass in Excess of MIF	MIF	Diverted	Bypass in Excess of MIF
May	5,700	3,800	1,900	0	67%	33%	0%
June	20,300	5,900	14,400	0	29%	71%	0%
July	68,300	6,100	56,300	5,800	9%	82%	9%
August	69,600	6,100	52,400	11,000	9%	75%	16%
September	35,500	5,700	27,300	2,500	16%	77%	7%
October	15,300	4,500	10,300	500	29%	67%	4%
Total	214,700	32,100	162,600	19,800	15%	76%	9%

Scenario 3: 1,400 cfs Tunnel Capacity							
Month	Volume (acre-ft)				Percentage		
	Total Runoff	MIF	Diverted	Bypass in Excess of MIF	MIF	Diverted	Bypass in Excess of MIF
May	5,700	3,800	1,900	0	67%	33%	0%
June	20,300	5,900	14,400	0	29%	71%	0%
July	68,300	6,100	58,400	3,700	9%	86%	5%
August	69,600	6,100	55,200	8,200	9%	79%	12%
September	35,500	5,700	28,000	1,700	16%	79%	5%
October	15,300	4,500	10,500	300	29%	69%	2%
Total	214,700	32,100	168,400	13,900	15%	78%	7%

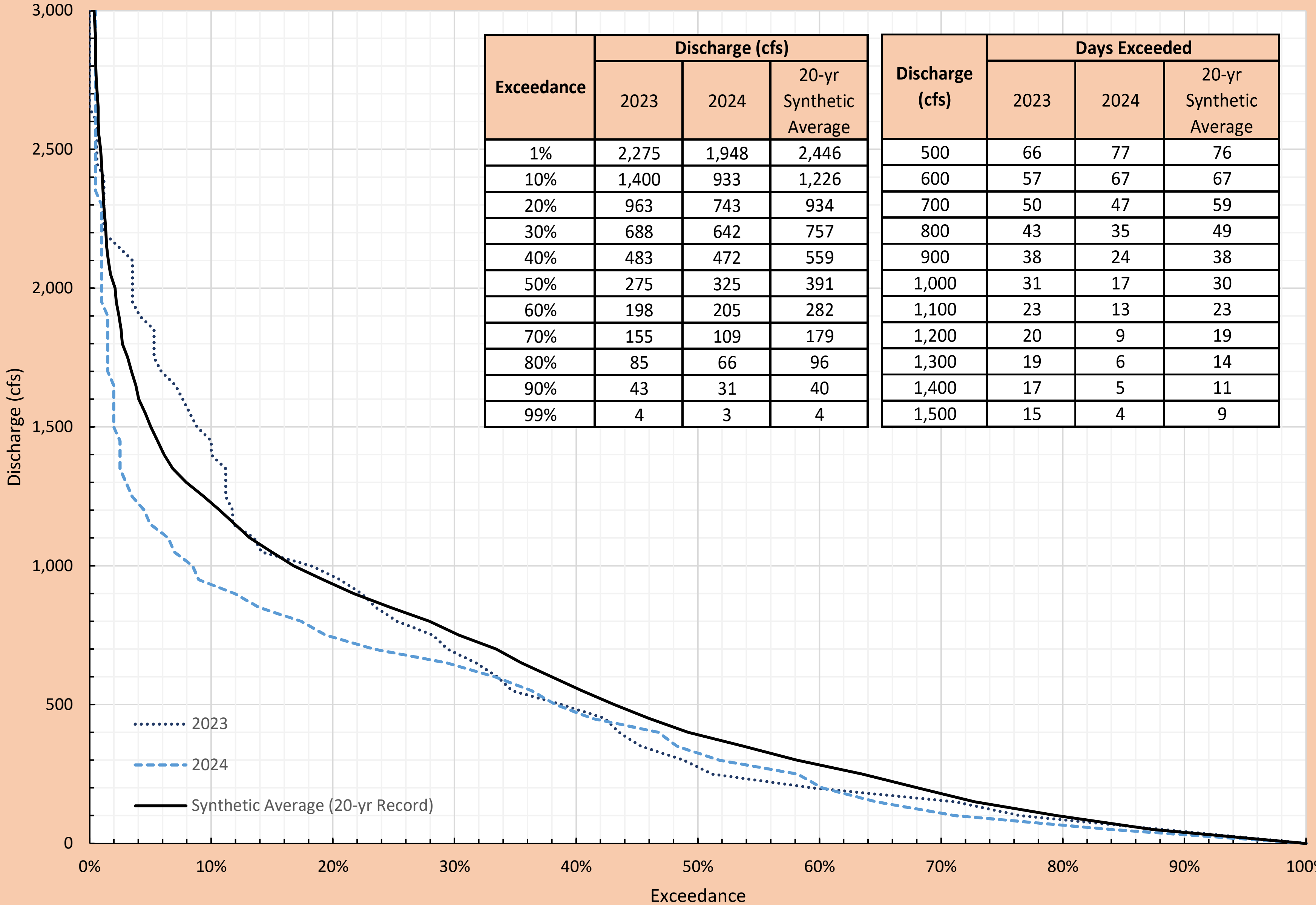
Attachment 2: Flood – Frequency Results



Return Interval (years)	Average Daily Discharge (cfs)
50	5,490
25	4,840
20	4,630
15	4,350
10	3,970
5	3,310
4	3,090
3	2,790
2	2,340
1.5	1,960
1.1	1,190
1.0	910

Attachment 3: Flow – Exceedance Results

Daily Flow Exceedance of the East Fork Martin River at the Mouth



Exceedance	Discharge (cfs)		
	2023	2024	20-yr Synthetic Average
1%	2,275	1,948	2,446
10%	1,400	933	1,226
20%	963	743	934
30%	688	642	757
40%	483	472	559
50%	275	325	391
60%	198	205	282
70%	155	109	179
80%	85	66	96
90%	43	31	40
99%	4	3	4

Discharge (cfs)	Days Exceeded		
	2023	2024	20-yr Synthetic Average
500	66	77	76
600	57	67	67
700	50	47	59
800	43	35	49
900	38	24	38
1,000	31	17	30
1,100	23	13	23
1,200	20	9	19
1,300	19	6	14
1,400	17	5	11
1,500	15	4	9

Attachment 4: Streamflow Data Collection Memorandum

TO: Bryan Carey, PE
FROM: Cameron Brailey, EIT; Euan-Angus MacLeod, PE, PH, CFM
DATE: 2/14/2025
PROJECT: Dixon Diversion Conceptual Study
SUBJECT: 2024 Streamflow Data Collection - Revised

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DOWL collected stage and discharge data at three locations along the Martin River watercourse to support the hydrologic analyses performed for the Dixon Diversion Conceptual Study, listed below:

1. At a constriction in the Martin River near river mile (RM) 1.9 (a.k.a. Martin River at Constriction)
2. Near the outlet of Red Lake (a.k.a. Red Lake Basin Outlet)
3. Near the outlet of Mid-Reach Lake (RM) 4.2 (a.k.a. Mid-Reach Lake Basin Outlet)

DOWL also collected discharge data at the USGS gage, East Fork Martin River at Mouth (USGS 15238951). Figure 1 presents an excerpt of a schematic map showing the general locations of the gage locations. The Dixon Diversion Conceptual Study Hydrology Report includes the full schematic map.

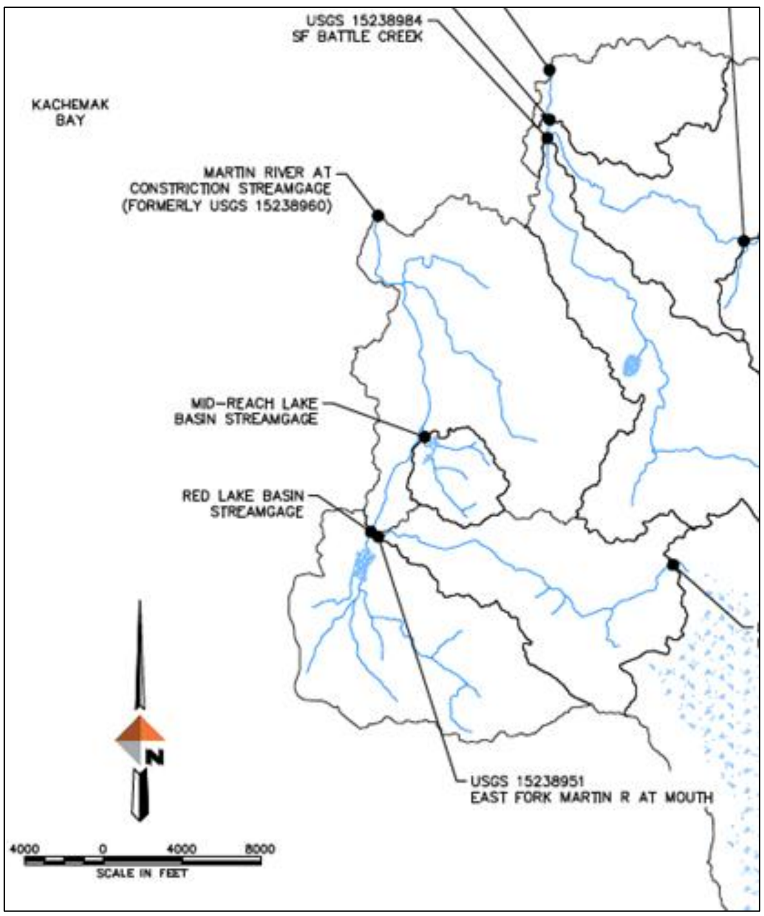

Figure 1. Streamgages along the Martin River Watercourse

MEASUREMENT METHODOLOGY

To measure stage, DOWL used HOBO MX2001 water level data loggers and an OTT radar level sensor (RLS). Once installed, the loggers captured data at a 15-minute interval. The HOBO loggers were secured to a protective casing, either a 1.25-inch stainless steel pipe or a 2-inch aluminum stilling well. In low-velocity locations, the protective casings were attached to dowels driven into the channel bed, and in high-velocity locations, the stilling well was fastened to bedrock using self-tapping rock bolts. An OTT RLS was installed at the constriction on a unistrut lever arm elevated 5-10 feet above the high-water mark.

DOWL deployed the stage data loggers during open-water conditions (approximately April to November) and retrieved the data from the loggers monthly. While retrieving data, DOWL assessed each logger for damage and movement. Stage measurements performed by DOWL used guidance from the USGS methodology Techniques and Methods 3-A7: Stage Measurement at Gaging Stations.

Depending on flow conditions, DOWL used either a Sontek RS5 Acoustic Doppler Current Profiler (ADCP), a Teledyne RiverPro ADCP or a FlowTracker 2 to measure discharge. Discharge measurements were performed as close to the stage data logger as possible. Discharge measurements were collected every two to four weeks to capture the seasonal discharge variations of the watershed. Discharge measurements performed by DOWL used guidance from the following USGS methodologies:

- Techniques and Methods 3-A8: Discharge Measurements at Gaging Stations
- Techniques and Methods 3-A22: Measuring Discharge with Acoustic Doppler Current Profilers from a Moving Boat

Each ADCP discharge measurement consisted of four to sixteen individual ADCP measurements (i.e., transects). The individual measurements were averaged to provide a single flow measurement for that date and time. DOWL reviewed all ADCP measurements for consistent bottom tracking, estimated flows near banks, percent of flow measured, average water velocity, total flow, and the coefficient of variation. Transects with significant errors or missing data were removed. Low-flow discharge measurements were collected with the FlowTracker 2 using at least twenty discrete sampling stations along a transect and reviewed for appropriate signal-to-noise (SNR) ratios, velocities and depths.

SITE DESCRIPTIONS

MARTIN RIVER AT CONSTRICTION

DOWL collected stage data for the Martin River at the Constriction using two stage data loggers, a HOBO MX2001 and an OTT RLS constriction for redundancy. The streambed within the bedrock constriction is an alluvial braid plain. The high-velocity environment appears to induce varying channel properties such as cross-sectional area, channel orientation, velocity distribution, and bed elevation. Moving beds induced by sediment transport may impact hydroacoustic discharge measurements at this site.

Figure 2 shows the Martin River at Constriction gage location, Figure 3 shows an aerial photograph of the site, and Figure 4 shows photos of the two stage data loggers installed. The gage at the constriction was installed in April 2023. The pressure transducer sensor was removed in November 2023 and reinstalled and operating from 4/18/2024 to 11/7/2024. The radar level sensor was installed on 5/29/2024 and in continuous operation to present day. Check gage heights were collected at the constriction during each measurement using real-time-kinematic global positioning system (RTK-GPS) established gage height reference points.

Figure 2. Martin River at Constriction Gage Location

Figure 3. Martin River at Constriction (Looking Downstream)

Figure 4. Constriction River-Left Gage

RED LAKE BASIN OUTLET

This gage is located near the outlet of Red Lake, in the channel constriction before its confluence with the Martin River. The gage is located between apparently stable grade control features upstream and downstream, consisting of medium-sized boulders. Figure 5 shows the location of the gage, and Figure 6 shows a photograph of the gage.

The Red Lake gage was installed in April 2023. The pressure transducer sensor was removed at the end of the 2023 season and reinstalled 4/18/2024 to 11/7/2024. During the 2024 season the logger was in operation from 4/18/2024 to 7/23/2024 and 8/29/2024 to 11/7/2024. The data logger was lost during the 8/7/2024 storm event and the gage pool was aggregated with cobbles and woody debris. A new pressure transducer was installed 15 feet downstream. The channel at the site appears to be have inflows from the East Fork Martin River, occurring after the 8/7/24 event, during flow events around 1,000 cfs or greater on the Constriction Gage.

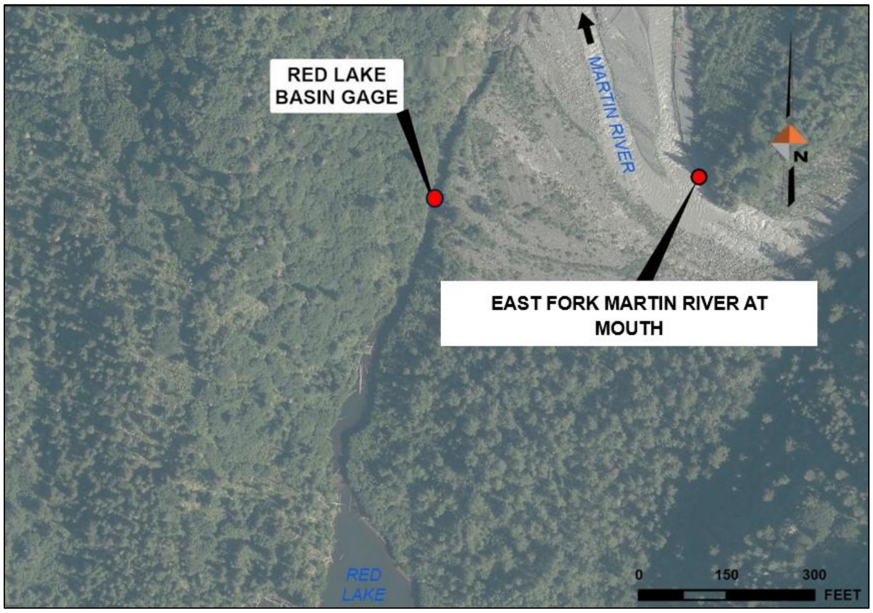

Figure 5. Red Lake Basin Outlet Gage Location

Figure 6. Red Lake Basin Outlet Gage

MID-REACH LAKE BASIN OUTLET

This gage is located near the outlet of a mid-reach lake upstream of the drainage's confluence with the Martin River. Figure 7 shows the location of the gage, and Figure 8 shows a photograph of the gage. The Mid-Reach Lake gage was installed in April 2023. The pressure transducer was removed at the end of the 2023 season and reinstalled and operating from 4/18/2024 to 11/7/2024. The channel at the site appears to have inflows from the Martin River, occurring after the 8/7/24 event, during flow events around 500 cfs or greater on the Constriction Gage.

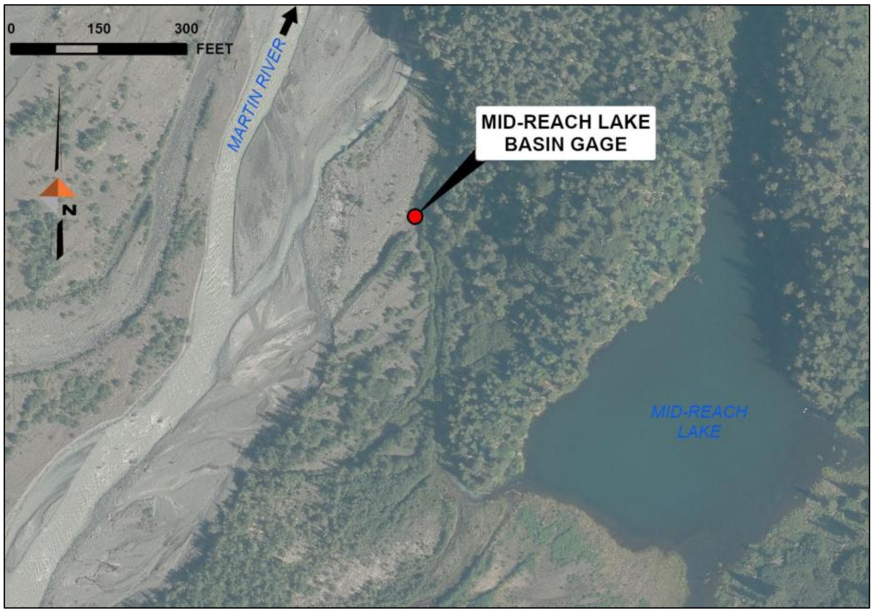

Figure 7. Mid-Reach Lake Basin Outlet Gage Location

Figure 8. Mid-Reach Lake Basin Outlet Gage

EAST FORK MARTIN RIVER AT MOUTH (USGS 15238951)

The USGS has operated a stage gage at Dixon Creek at the Mouth since April 13, 2023. Figure 9 shows the location of the USGS gage, and Figure 10 shows a photograph of the gage. USGS-published continuous discharge data are not yet available for the site because they are still in the process of creating a gage rating curve. Provisional stage data are available on the USGS website, and the USGS has measured discharge 11 times at the site.

Figure 9. East Fork Martin River at Mouth (USGS 15238951) Gage Location

Figure 10. East Fork Martin River at Mouth (USGS 15238951) Gage

2024 DISCHARGE MEASUREMENTS

Table 1 presents the discharge measurements collected along the Martin River watercourse in 2024.

Table 1. 2024 Discharge Measurements

Date	Measured discharge (cfs)			
	Martin River at Constriction	Red Lake Basin Outlet	Mid-Reach Lake Basin Outlet	East Fork Martin River at Mouth[1]
4/2/2024	-	-	-	12.1[1]
4/18/2024	347.5	31.7	13.2	-
5/3/2024	121.0	37.4	-	57.2
5/7/24	-	-	-	35.6[1]
5/28/2024	108.1	28.1	2.0	65.2
6/12/2024	-	-	-	424.0[1]
6/20/2024	334.9	14.2	0.3	367.0
7/3/2024	722.0	7.7	0.6	689.1
7/23/2024	632.3	3.7	0.5	612.8
7/25/2024	-	-	-	960.0[1]
8/9/2024	1206.9	8.2	50.6	-
8/29/2024	600.4	1.3	12.0	570.3
9/4/2024	-	-	-	1140.0[1]
9/24/2024	223.1	14.2	0.4	190.1
10/24/2024	-	-	-	71.0[1]
11/7/2024	279.0	29.5	9.0	126.3

STREAMGAGE RATING CURVES

RATING CURVE METHODOLOGY

Development of the rating curves was guided by USGS methodologies:

Water-Resources Investigations Report 01-4044 "*Standards of the Analysis and Processing of Surface-Water Data and Information Using Electronic Methods*"

Rating curves were developed in excel using a best-fit power equation, measured discharges, gage height measurements and recorded stage from each gage. No hinge points could be determined to distinguish between section control, channel control, or overbank with the small sample size.

MARTIN RIVER AT CONSTRICTION

Figure 11 presents the rating curve for the Martin River at Constriction gage using constriction stage data with the six measurements collected during 2023 and ten measurements collected during 2024 operation. The variability of discharge points relative to the rating curve is attributed to channel aggradation, degradation and migration near the gage location. The changes in the channel are accounted for with rating curve shifts as shown in Figure 14.

[1] USGS discharge measurements collected at East Fork Martin River at Mouth.

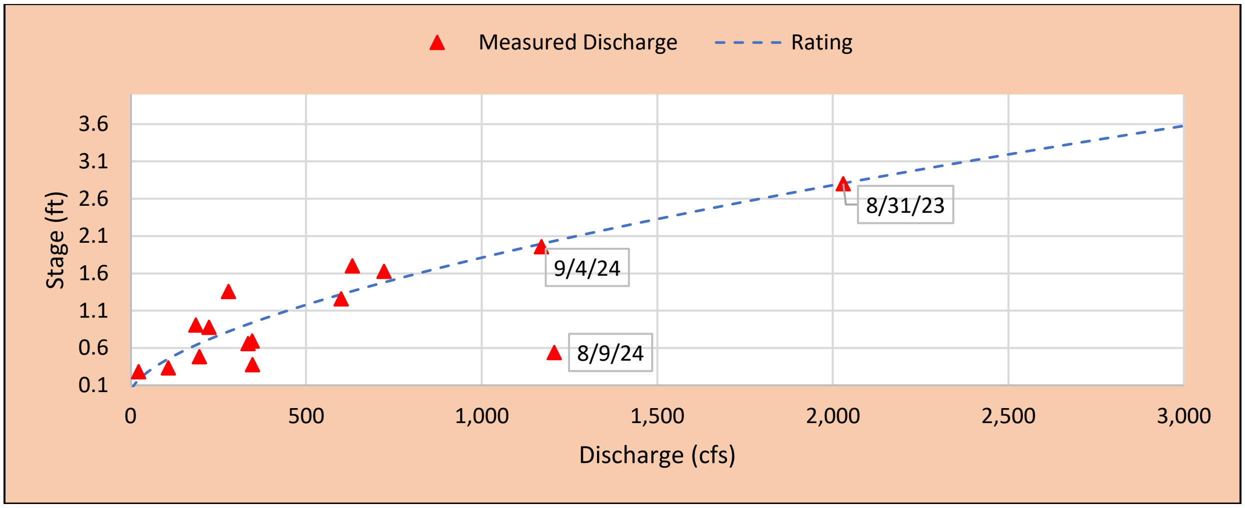

Figure 11. Martin River at Constriction Streamgage Rating Curve

RED LAKE BASIN OUTLET

Figure 12 presents the rating curve for the Red Lake Basin Outlet gage using five data points collected during 2023 operation and 10 measurements collected during 2024 operation. The discharge measurements fit well to the rating curve and no shifts were applied in 2024. The rating curve will be re-evaluated after more discharge measurements are collected since the gage was relocated 15 feet downstream. The rating curve modifications may affect discharge data after the 8/7/24 event.

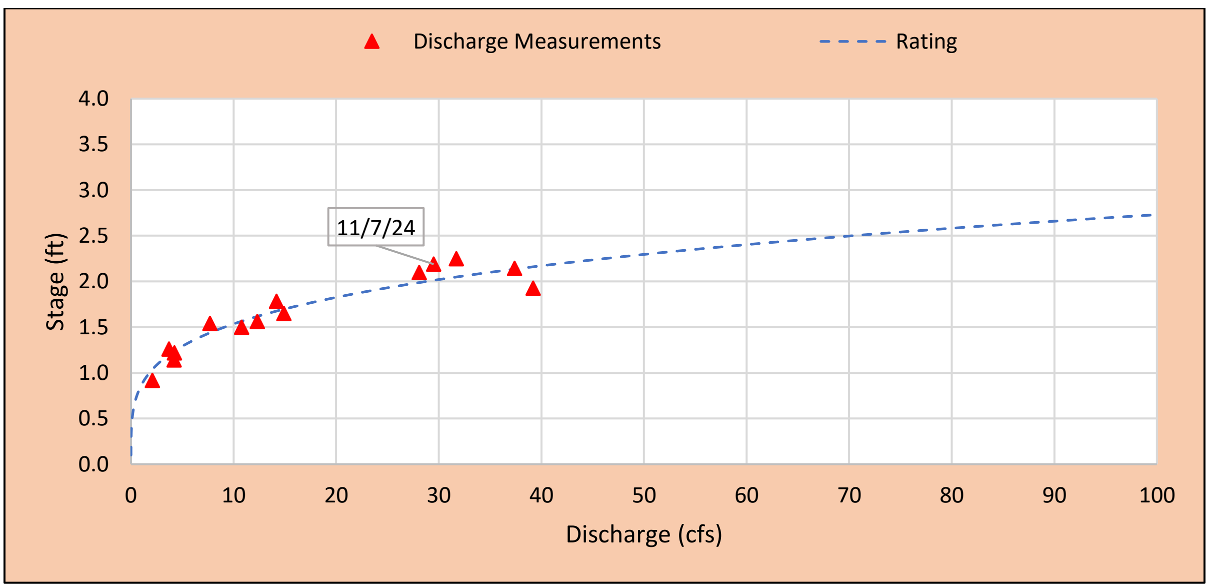

Figure 12. Red Lake Basin Outlet Streamgage Rating Curve

MID-REACH LAKE BASIN OUTLET

Figure 13 presents the rating curve for the Mid-Reach Lake Basin Outlet gage using stage data with 5 measurements collected during 2023 operation and 8 measurements collected during 2024 operation. The discharge measurements fit well to the rating curve and no shifts were applied in 2024.

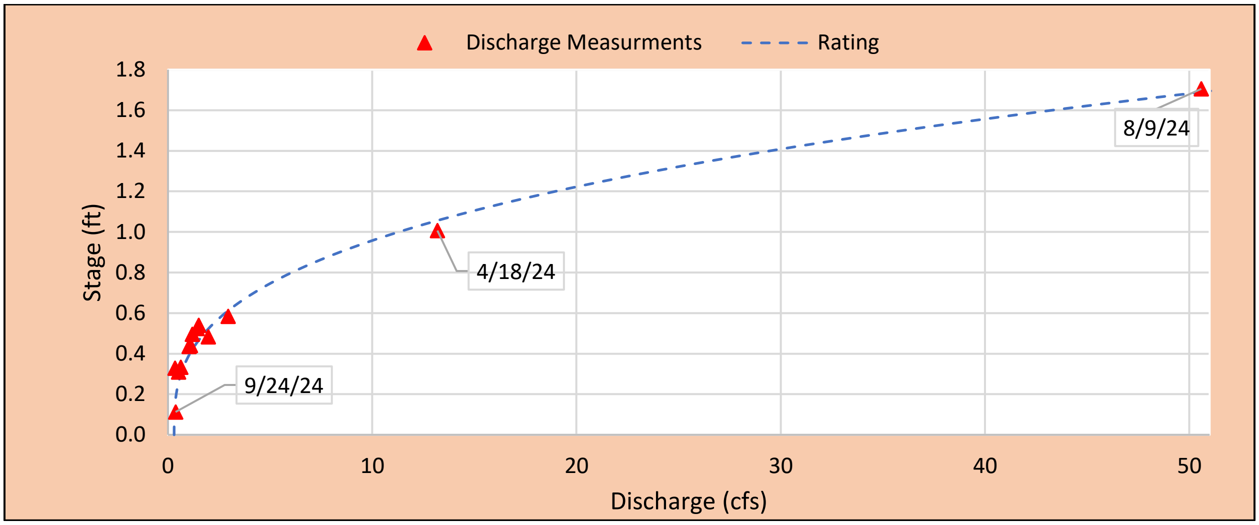

Figure 13. Mid-Reach Lake Basin Outlet Streamgage Rating Curve

EAST FORK MARTIN RIVER AT MOUTH

Fourteen discharge measurements are currently available for East Fork Martin River at the Mouth. A rating curve is not currently available from the USGS. It was assumed that East Fork Martin River at Mouth discharge can be estimated by subtracting Red Lake Outlet and Mid-Reach Lake Outlet daily average discharge from the DOWL-measured Martin River at Constriction discharge. Table 2 presents the measured and estimated discharge.

Table 2. Basis of East Fork Martin River at Mouth Provisional Hydrograph

Date	Measured Discharge (cfs)	Estimated Discharge (cfs)[2]	Difference in Flow Measured vs. Estimated (cfs)	Notes
10/27/2022	66	71	+5	
4/25/2023	14	4	+10	
5/26/2023	139	144	+5	
9/19/2023	377	334	-43	Flow mmt greatest at EFMR
10/20/2023	161	180	+19	
11/17/2023	32	34	+2	
5/3/2024	57	84	+27	
5/28/2024	65	78	+13	
6/20/2024	367	320	-47	Flow mmt greatest at EFMR
7/3/2024	689	713	+24	
7/23/2024	613	627	+14	
8/29/2024	570	587	+17	
9/24/2024	190	208	+18	
11/7/2024	126	240	+114	Rain on snow event

[2] $Q_{East\ Fork\ Martin\ R} = Q_{Constriction} - Q_{Red\ Lake} - Q_{MR\ Lake}$

The difference in flow between measured and estimated flow varies by 47 cfs less than measured and 114 cfs more than measured. This difference is likely due to a number of factors; the time disparity between measurements, unaccounted groundwater and surface runoff between the two locations, and changes in seasonal groundwater and surface runoff. No strong correlations can be made with the small sample group. The estimated discharge method will be reviewed as more data is collected.

CONTINUOUS STREAMFLOW DATA

MARTIN RIVER AT CONSTRICTION

Figure 15 presents the 2024 continuous streamflow record for the Martin River at Constriction gage. DOWL developed the continuous streamflow record by applying the gage rating curve in Figure 11, applying rating curve shifts and filtering erroneous stage measurements from the dataset. The raw water level reading from the OTT radar level sensor collected accurate readings with few outliers. The computed discharge from the gage with rating curve shifts matches well to the plotted discharge measurements. The peak flow for 2024 was estimated to be 4200 cfs on 8/7/24. USGS discharge measurements collected at the East Fork Martin River mouth are included for reference.

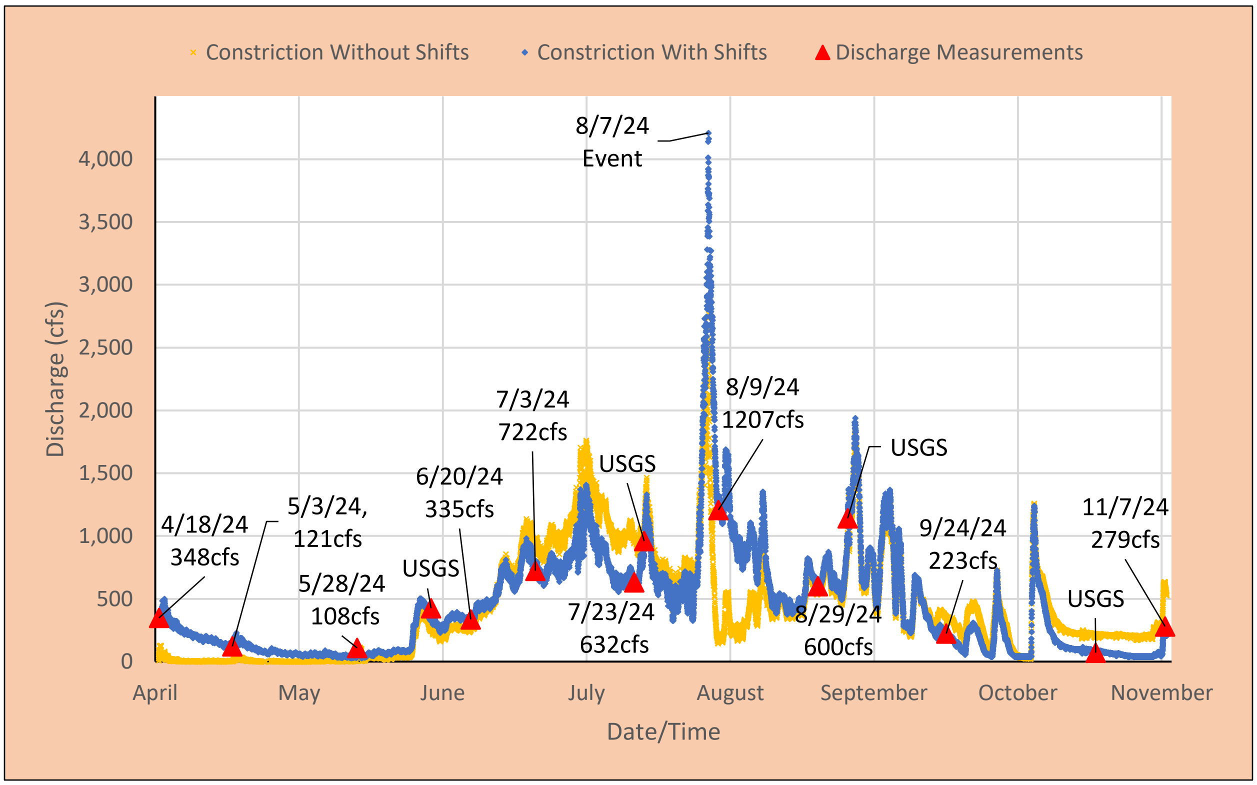

Figure 14. Martin River at Constriction Continuous Streamflow Record

RED LAKE BASIN OUTLET

Figure 16 presents the 2024 continuous streamflow record for the Red Lake Outlet. DOWL developed the continuous streamflow record by applying the gage rating curve in Figure 12 and filtering erroneous stage measurements from the dataset. High flow events recorded on 10/5/24 and 10/12/24 are due to inflows from the Martin River, discharge is estimated during periods of inflow. The estimated peak flows are based on discharge measurements all below 40 cfs. Computed peak flows above 40 cfs will likely be refined after more high-water measurements are collected and the rating curve is refined.

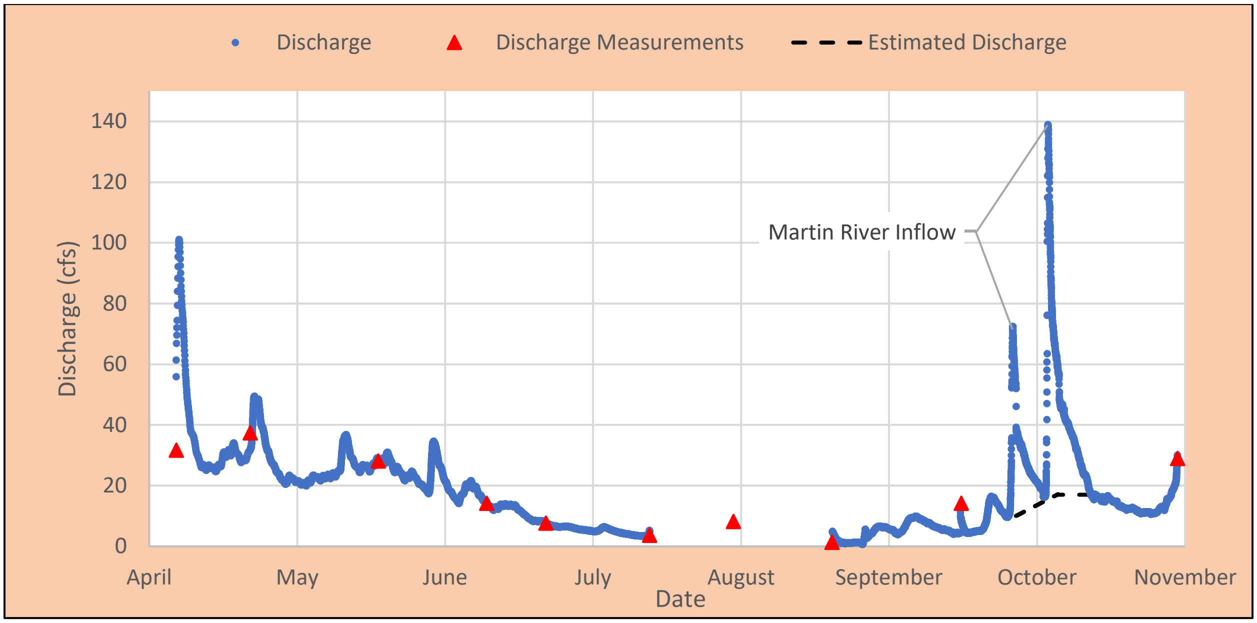

Figure 15. Red Lake Basin Outlet Continuous Streamflow Record

MID-REACH LAKE BASIN OUTLET

Figure 17 presents the 2023 continuous streamflow record for the Mid-Reach Lake Basin. DOWL developed the continuous streamflow record by applying the gage rating curve in Figure 13 and filtering erroneous stage measurements from the dataset. High flow events recorded after spring breakup are due to frequent inflows from the Martin River, discharge is estimated during periods of inflow.

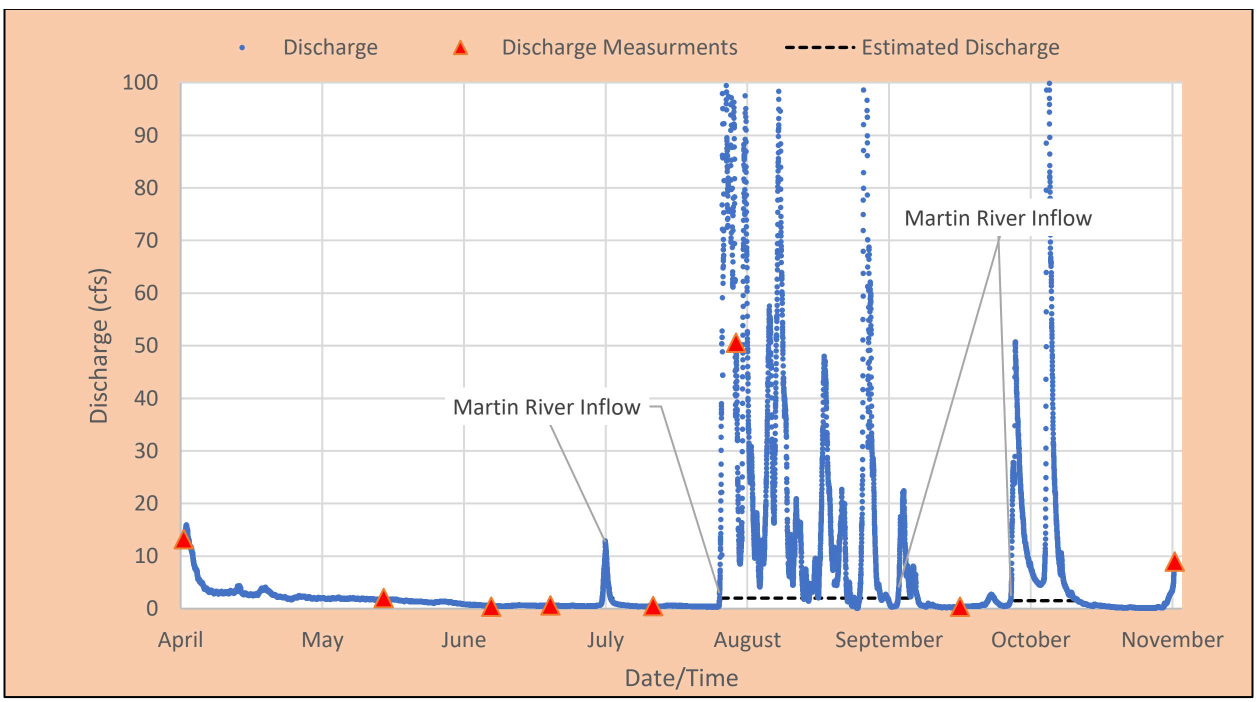

Figure 16. Mid-Reach Lake Basin Outlet Continuous Streamflow Record