Oil Sands Monitoring Program:

Summary of 2022 Hydrologic Conditions in the Alberta Oil Sands Area

Oil Sands Monitoring Program
Technical Report Series

OIL SANDS MONITORING PROGRAM

Canada

Alberta

Summary of 2022 Hydrologic Conditions in the Alberta Oil Sands Area

(Based on hydrometric data collected by Environment and Climate Change Canada, National Hydrological Service)

Acknowledgements:

This work was funded under the Oil Sands Monitoring (OSM) Program. It is independent of any position of the OSM Program.

2022 Overview

This annual report presents a summary of hydrometric data collected by the Water Survey of Canada (WSC) in the Alberta Oil Sands area in 2022. This report is the fifth annual publication intended to provide the public with an understanding of the hydrologic conditions that were present in the Oil Sands area during each year and how they compared with historical conditions. This report is a deliverable produced by Environment and Climate Change Canada (ECCC) as part of the Surface Water Quantity Monitoring services provided by ECCC to support the Oil Sands Monitoring Program.

The ongoing collection of high-quality surface water quantity data by the WSC, as part of the national surface water monitoring network, supports scientific efforts to address several of the Oil Sands Monitoring (OSM) program key questions, including those regarding establishment of baseline data, monitoring for change, and integration of environmental monitoring data to support scientific investigation into other themes (e.g., water quality, benthos, fish, etc.). All data collected by the WSC in the Oil Sands area are publicly available on the Environment and Climate Change Canada Wateroffice website in near real time for both viewing and download (https://wateroffice.ec.gc.ca/). In addition to users accessing data online, there were 22 data requests received by WSC for data from OSM funded hydrometric stations between January 1st and December 31st of 2022. This was a significant decline over previous years, almost three times lower than 2021 data requests. Of the requests for data from the OSM gauges in 2022, no request came from Academia, 68% from Consultants, 27% from Government/Utility Corps, none from Industry, and the remaining approximately 5% had unknown affiliation. Some examples of scientific studies that were published in 2022, and relied in part on hydrometric data, include an analysis of long-term climate patterns and river flow in Northern Canada (Zaghloul et al., 2022), assessment of weather network suitability for gathering wind data in the Athabasca Oil Sands Region (Deshmukh et al., 2022), and an examination of river flow in frigid and unmonitored areas (Belvederesi et al., 2022).

There were 48 hydrometric gauging stations operated by WSC in the Oil Sands area in 2022 (shown on the map provided in Appendix A). Conditions at four key stations are discussed in the main body of this report and are presented from upstream to downstream as follows: Athabasca River at Athabasca, Clearwater River above Christina River (a major tributary to the Athabasca River), Athabasca River below Fort McMurray, and Athabasca River at Embarras Airport. The local contributions from the western and eastern tributaries to the Athabasca River main stem are also discussed. A summary table of all active WSC hydrometric stations within the Oil Sands area in 2022 is provided in Appendix B, and annual hydrographs are provided for all active hydrometric stations in Appendix C.

Athabasca River Basin natural variability

A study was published last year assessing the impact of anthropogenic changes on the Athabasca River Basin hydrology (Saunchyn et al., 2022). By reconstructing annual streamflow going back 900 years using a tree-ring data assimilation method, they were able to identify decade-long low and high river flows cycles, that current climate models do not necessarily capture very well due to a lack of available observation data. This leads to a substantial uncertainty of the projections of future climate and hydrology of the basin. However, a few trends of hydrological changes can still be extracted from the different climate models for the future period (2021-2100) compared to the recent past (1985-2014): an increase in the 90-days average minimum flow, increase in the number of flow reversals, an earlier date of daily maximum flow, a later date of daily minimum flow, and higher daily maximum flow, especially in the upstream part of the River.

Key stations summary

Based on the historical record, the three stations on the Athabasca River main stem recorded average spring flow in late April following ice break-up, with average, to below average, flow throughout the remainder of the year. The fourth key station, Clearwater River above Christina River, had above average spring flow and below average flow after mid-June.

The eastern and western tributaries downstream of Fort McMurray experienced above average flow around spring breakup, and low flow through the remainder of the year. Overall, the 2022 mean discharge in the eastern and western tributaries was lower than the mean annual discharge over the period of record.

Detailed hydrometric records for all stations operated by WSC in the Oil Sands area are publicly available on the Environment and Climate Change Canada Water Office website at https://wateroffice.ec.gc.ca/. More information about the RDPA is available from the Meteorological Services of Canada open data documentation at https://eccc-msc.github.io/open-data/.

Athabasca River at Athabasca (07BE001)

The hydrometric data for this station (Figure 1) indicates an increase in flow, from below 25th percentile to above 75th percentile, following ice break-up. The 2022 hydrometric data for this station shows that ice breakup occurred in late April. The highest flow in 2022 at this station occurred in early June, following a series of precipitation events. Moreover, the basin mean areal precipitation for 2022, calculated using precipitation data available from the RDPA, was shown to be 80% of the historical mean based on records from 2002 to 2022. The measured flow has a peak higher than the interquartile range (25th-75th percentiles) of flows for this station for the year; however, most flows were within the interquartile range throughout the year. The 2022 mean flow of 413 m^3/s was approximately 2.6% lower than the historical mean annual flow of 424 m^3/s over the station's period of record.

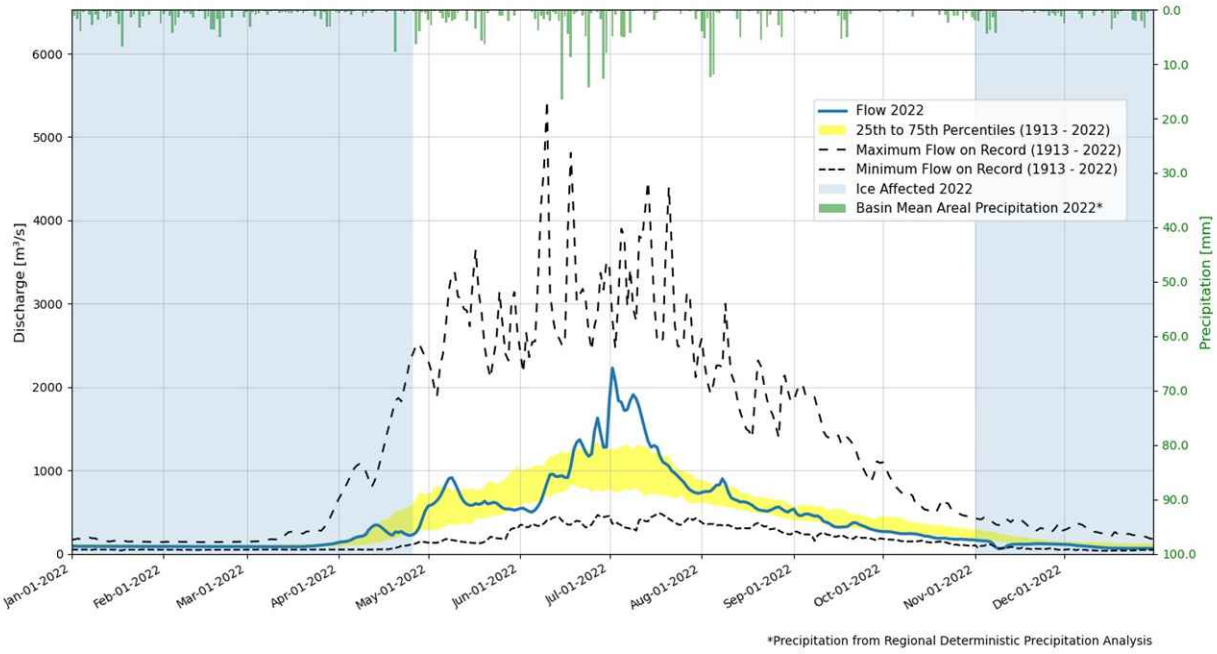

Figure 1: Annual Hydrograph for Station 07BE001 Athabasca River at Athabasca

Clearwater River above Christina River (07CD005)

Hydrometric data from this station is presented as an indicator of tributary contributions to the Athabasca River from the Clearwater River basin. The hydrometric data for 2022 from this station (Figure 2) shows that ice break-up occurred in late April, simultaneously with discharge higher than normal. Flow peaked in mid-May at 182 m^3/s, remaining above the upper quartile range until mid-June. The 2022 mean flow of 73.6 m^3/s was 3.9% lower than the historical mean annual flow of 76.6 m^3/s over the station's period of record. The calculated basin mean areal precipitation for 2022, using precipitation data available from the RDPA, was shown to be 72% of the historical mean based on records from 2002 to 2022.

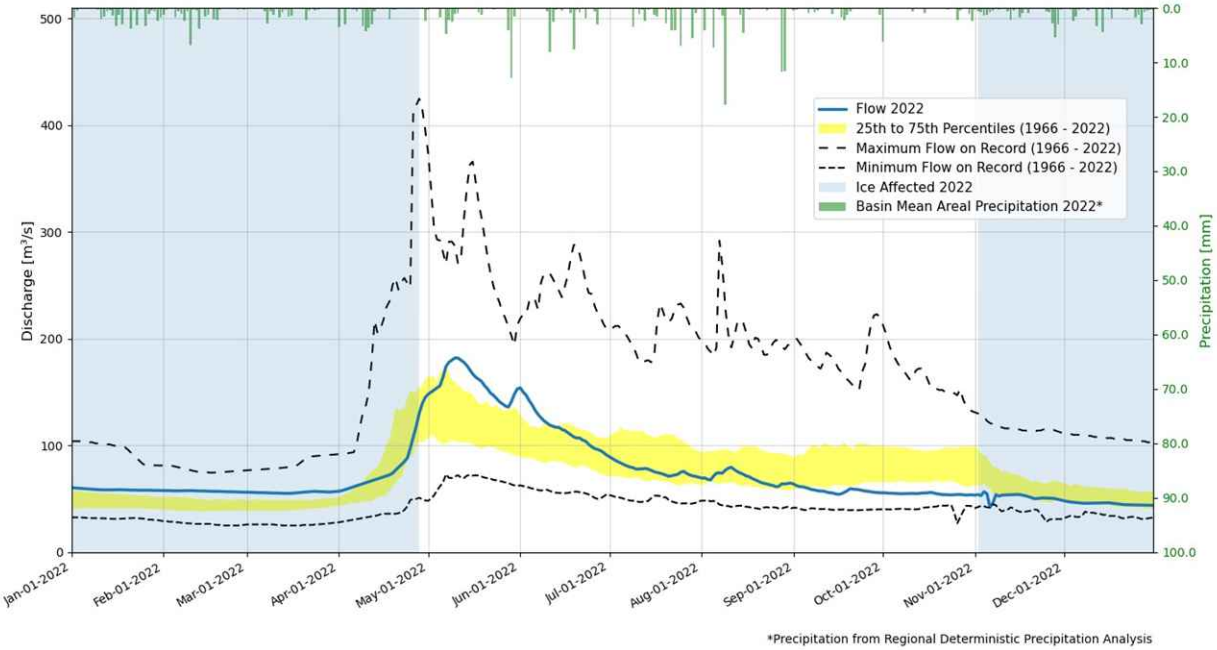

Figure 2: Annual Hydrograph for Station 07CD005 Clearwater River above Christina River

Athabasca River below Fort McMurray (07DA001)

The hydrometric data for this station (Figure 3) indicates that ice break-up occurred in late April. The measured flow peaked higher than the interquartile range (25th-75th percentiles) of flows for this station in mid-May and early July, and it fell below the lower quartiles after mid-September. The peak flow for 2022 occurred at the start of July following several precipitation events. The 2022 mean flow of 592 m^3/s was 4.4% lower than the historical mean annual flow of 619 m^3/s over the station's period of record. Basin mean areal precipitation for 2022, calculated using precipitation data available from the RDPA, was also found to be 82% of the historical mean based on records from 2002 to 2022.

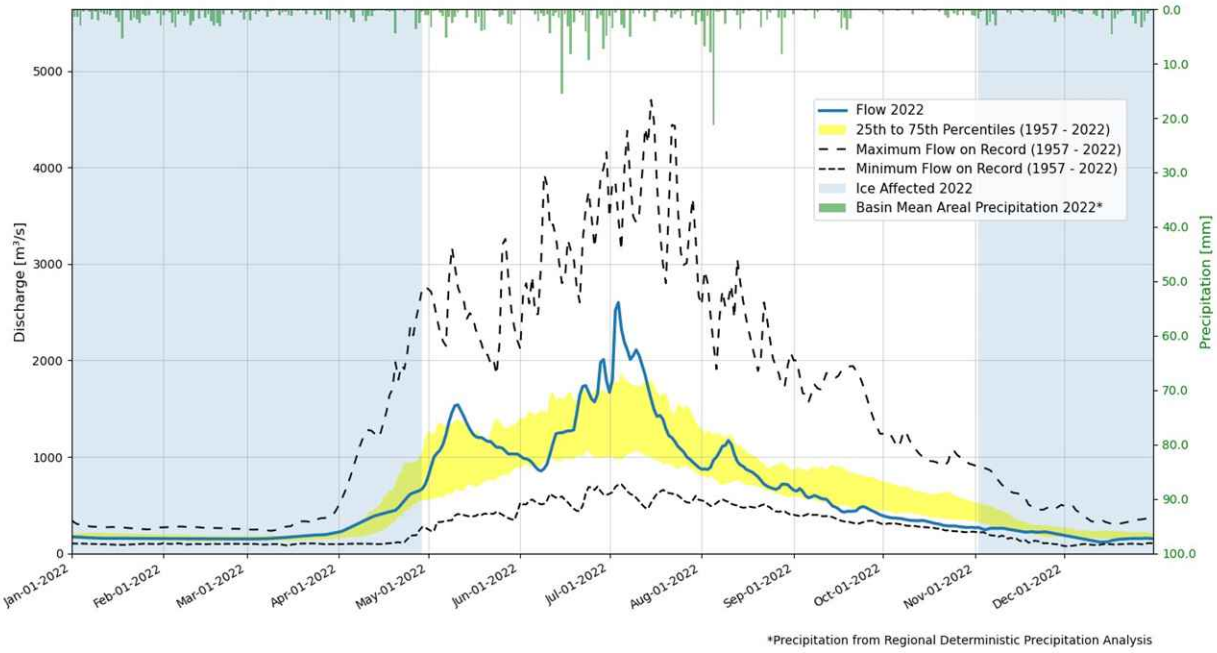

Figure 3: Annual Hydrograph for Station 07DA001 Athabasca River below Fort McMurray

Tributary Contributions to the Athabasca Main Stem

A subset of tributary hydrometric stations located downstream of Fort McMurray (listed in Table 1) were assessed to determine the significance of contributions of sub basins lying to the east and west of the Athabasca River main stem in 2022. Annual hydrographs for these individual gauging stations for 2022 are included in Appendix C.

Table 1: Hydrometric stations used to assess contributions from eastern and western sides of the Athabasca River downstream of Fort McMurray

Eastern Tributaries	Clearwater River at Draper (07CD001)
	Hangingstone River at Fort McMurray (07CD004)
	Steepbank River near Fort McMurray (07DA006)
	Muskeg River near Fort MacKay (07DA008)
	Firebag River near the Mouth (07DC001)
Western Tributaries	Poplar Creek near Fort McMurray (07DA007)
	Beaver River above Syncrude (07DA018)
	MacKay River near Fort MacKay (07DB001)
	Ells River at Canadian Natural Resources Limited Bridge (07DA032)
	Tar River near the Mouth (07DA045)
	Calumet River near the Mouth (07DA033)
	Eymundson Creek near the Mouth (07DA041)
	Big Creek near the Mouth (07DA040)

The eastern tributaries in the Oil Sands area experienced upper quartile flows following ice break-up, with 21 record daily high discharge values set for Hangingstone River, which then fell from late April to June. The eastern tributaries went on to have normal to low flows for the remainder of the year and collectively set 35 record daily low discharge values. Overall, the 2022 mean discharge in the eastern tributaries downstream of Fort McMurray was lower than the historical mean annual discharge (87%, on average).

Almost all of the western tributary indicator stations also experienced upper quartile flows from mid-spring to mid-summer with annual peak flows in May coincident with precipitation, collectively setting 151 record daily high discharge values. These stations then went on to collectively set 609 record daily low discharge values for the remainder of the year. Overall, the 2022 mean discharge in the western tributaries was lower than the historical mean annual discharge (80%, on average).

Athabasca River at Embarras Airport (07DD001)

The hydrometric data for this station (Figure 4) indicates that the period of ice-affected data ended in early May. The peak flow for 2022 occurred in early July following a series of precipitation events. The 2022 mean flow of 664 m^3/s was 5% lower than the historical mean annual flow of 699 m^3/s over this station's period of record. Basin mean areal precipitation for 2022, calculated using precipitation available from the RDPA, was also shown to be 83% of the historical mean based on records from 2002 to 2022.

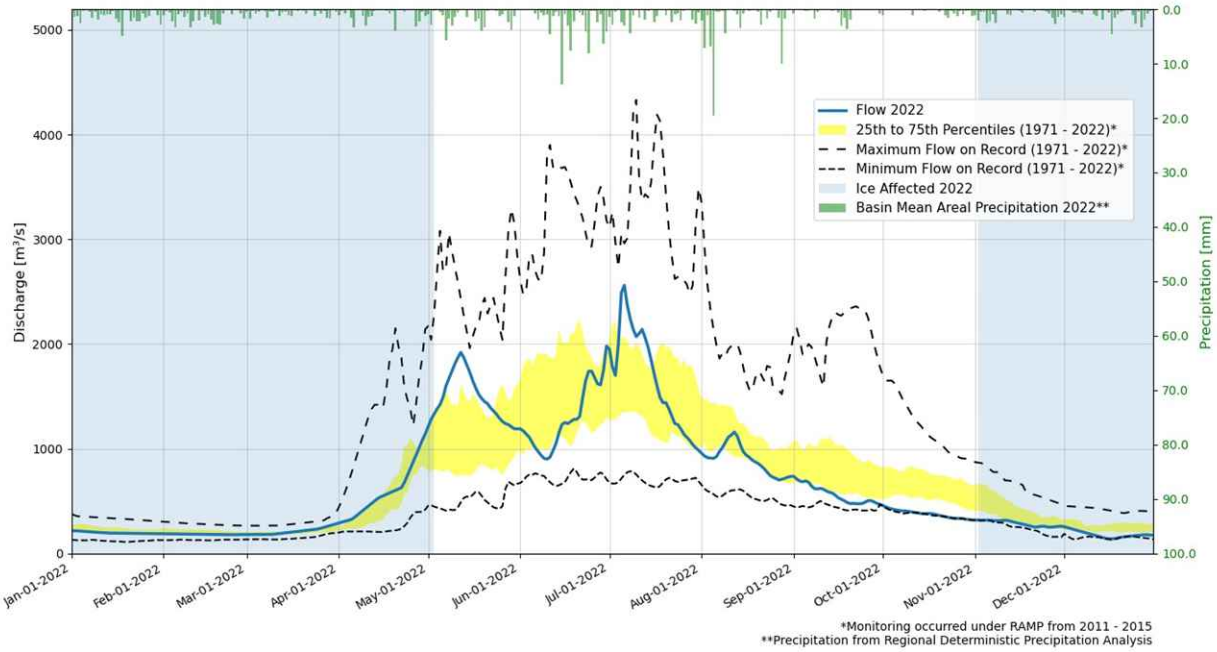

Figure 4: Annual Hydrograph for Station 07DD001 Athabasca River at Embarras Airport

References

Zaghloul, M. S., Ghaderpour, E., Dastour, H., Farjad, B., Gupta, A., Eum, H., Achari, G., and Hassan, Q. K. 2022. Long Term Trend Analysis of River Flow and Climate in Northern Canada. *Hydrology, 9*(11), 197. doi: 10.3390/hydrology9110197

Deshmukh, D., Ahmed, M. R., Dominic, J. A., Gupta, A., Achari, G., and Hassan, Q. K. 2022. Suitability Assessment of Weather Networks for Wind Data Measurements in the Athabasca Oil Sands Area. MDPI. *Climate, 10*(2), 10. doi: 10.3390/cli10020010

Chiara, B., Zaghloul, M. S., Achari, G., Gupta, A., and Hassan, Q. K. 2022. Modelling river flow in cold and ungauged regions: a review of the purposes, methods, and challenges. *Environmental Reviews, 30*(1): 159-173. doi:10.1139/er-2021-0043

Sauchyn, David, Muhammad Rehan Anis, Soumik Basu, Sheena Stewart and Mohammad Zare (2022) Natural Variability versus Anthropogenic Forcing of Hydrological Change, Athabasca River Basin, Report to Alberta Environment and Parks, 30 September 2022

Appendix A:
Overview Maps – Alberta Oil Sands Area

Figure A1 shows all active hydrometric monitoring stations operated by WSC in 2022. Figure A2 shows all the Regional Deterministic Precipitation Analysis (RDPA) grids within the Athabasca River at Embarras Airport (07DD001) contributing area and their 2022 annual precipitation. The daily precipitation at each of these grid points was spatially averaged over each monitoring station's contributing area and used to represent the basin mean areal precipitation on the annual hydrographs included in the main body of this report and in Appendix C. Daily RDPA data can be accessed through Meteorological Services of Canada Datamart (https://dd.weather.gc.ca/). Additional information about RDPA is available from the Meteorological Services of Canada open data documentation (https://eccc-msc.github.io/open-data/) which will also direct those interested to the online archives and re-analysis archives of RDPA data (available from January 2002 onward).

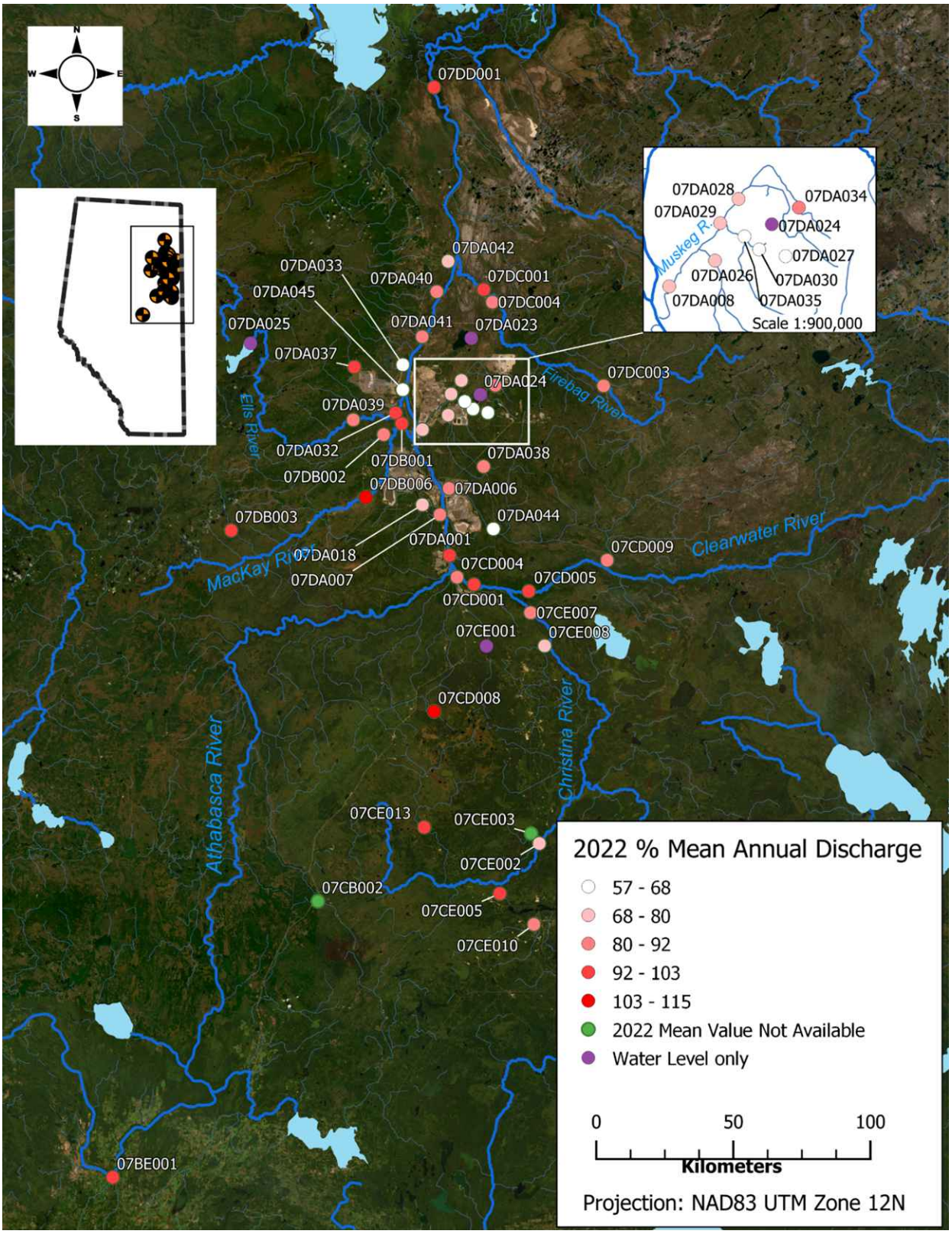

Figure A1: Active Hydrometric Stations in the Alberta Oil Sands Area in 2022

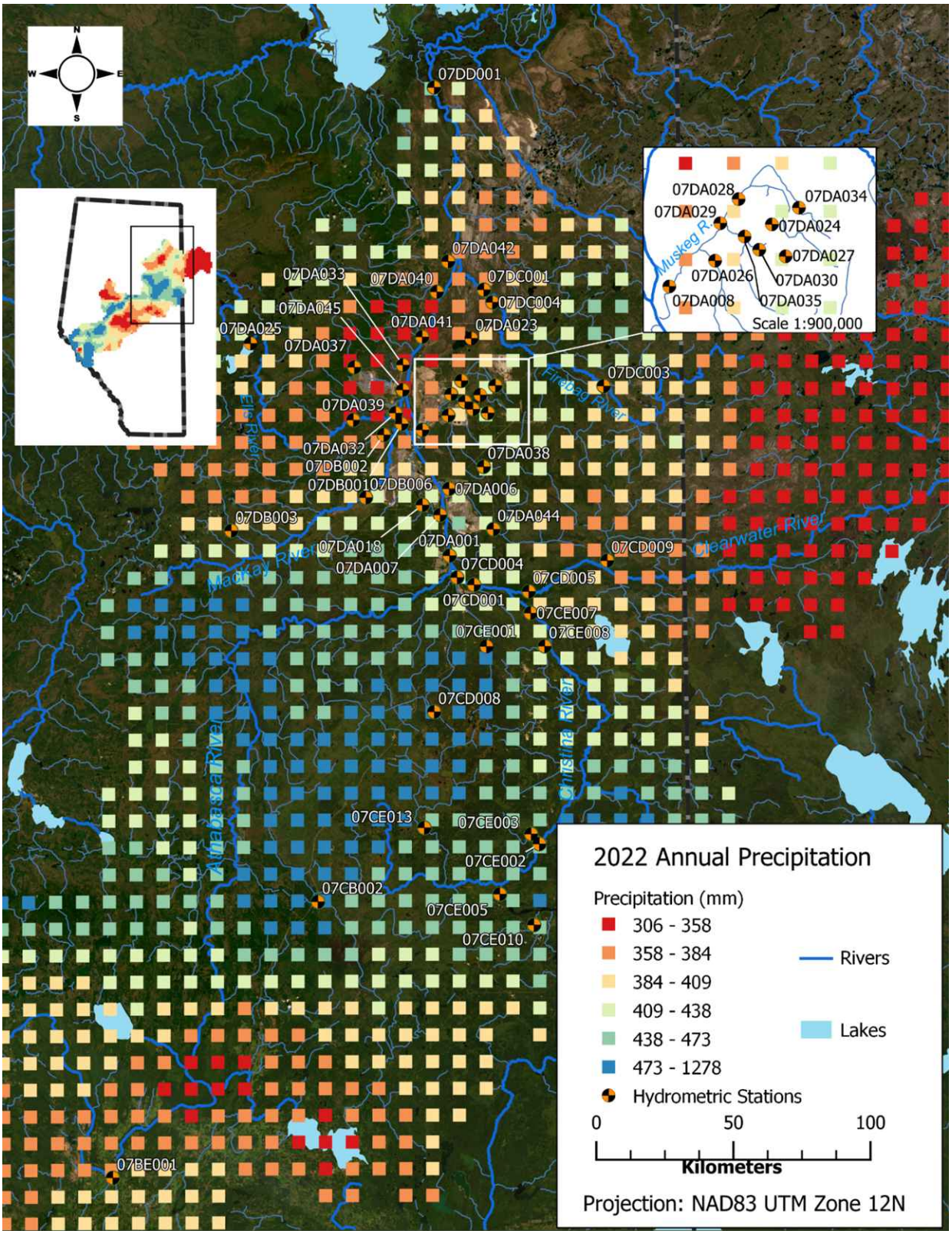

Figure A2: Regional Deterministic Precipitation Analysis (RDPA) gridded annual precipitation over the Alberta Oil Sands Area (Contributing area to Athabasca River at Embarras Airport - 07DD001) used in producing this Annual Report

Appendix B:
Summary – All Hydrometric Stations

The following tables summarize all active WSC hydrometric stations within the Oil Sands area in 2022. Table B1 provides a summary of all discharge stations, and Table B2 provides a summary of all level stations.

The provided mean annual discharge, mean annual yield, and mean annual level are calculated from historical water level or discharge at the selected hydrometric monitoring station over the entire period of record. This record includes monitoring that occurred under the Regional Aquatics Monitoring Program (RAMP), for which data is publicly available on the RAMP website at http://www.ramp-alberta.org/ramp.aspx. Data included from RAMP has not been verified by WSC.

For a given year in the record, the annual mean water level or discharge value is calculated by averaging all the daily water level or discharge values for that year. For consistency with data published on the Environment and Climate Change Canada Water Office website, the annual mean is not calculated when one or more daily mean values are missing, either because of operational problems, or where a seasonal operating schedule is in place. In those instances of operational problems, the data has been listed as N/A in the table, while a dash has been used for the stations with a seasonal operating schedule.

Table B1: Discharge Stations Summary

STATION NAME	STATION ID	PERIOD OF RECORD	GROSS DRAINAGE AREA [km²]	2022 WATER YIELD [mm]	HISTORICAL MEAN ANNUAL WATER YIELD [mm]	2022 MEAN DISCHARGE [m³/s]	HISTORICAL MEAN ANNUAL DISCHARGE[1] [m³/s]	2022 AS A PERCENT OF HISTORICAL MEAN ANNUAL DISCHARGE [%]
ATHABASCA RIVER AT ATHABASCA	07BE001	1913 – 2022	74600	175	179	413	424	97.4
ATHABASCA RIVER AT EMBARRAS AIRPORT	07DD001	1971 – 2022 [1]	155000	135	142	664	699	95
ATHABASCA RIVER BELOW FORT MCMURRAY	07DA001	1957 – 2022	133000	140	147	592	619	95.6
BEAVER RIVER ABOVE SYNCRUDE	07DA018	1975 – 2022	165	83.4	110	0.436	0.573	76.1
BIG CREEK NEAR THE MOUTH	07DA040	2011 – 2022 [2]	323	51.5	61.4	0.527	0.628	83.9
CALUMET RIVER NEAR THE MOUTH	07DA033	2001 – 2022 [2]	175	24.3	37.7	0.135	0.209	64.6
CHRISTINA RIVER ABOVE STATOIL LEISMER	07CE013	2013 – 2022 [2]	1030	135	139	4.4	4.55	96.7
CHRISTINA RIVER NEAR CHARD	07CE002	1982 – 2022	4860	101	133	15.6	20.5	76.1
CHRISTINA RIVER NEAR THE MOUTH	07CE007	2011 – 2022 [2]	13200	103	113	42.9	47.3	90.7
CLEARWATER RIVER ABOVE CHRISTINA RIVER	07CD005	1966 – 2022	17000	137	142	73.6	76.6	96.1
CLEARWATER RIVER AT DRAPER	07CD001	1930 – 2022	30800	121	125	118	122	96.7
DOVER RIVER NEAR THE MOUTH	07DB002	1975 – 2022 [3]	963	57.7	65.2	1.76	1.99	88.4
DUNKIRK RIVER NEAR FORT MACKAY	07DB003	1975 – 2022 [3]	1570	98.9	96.3	4.92	4.79	103
EAST JACKPINE CREEK NEAR THE 1300 FT CONTOUR	07DA038	2007 – 2022 [2]	45	154	171	0.219	0.244	89.8
ELLS RIVER ABOVE JOSLYN CREEK DIVERSION	07DA039	2009 – 2022 [2]	2260	102	115	7.28	8.24	88.3
ELLS RIVER AT CANADIAN NATURAL RESOURCES LIMITED BRIDGE	07DA032	2004 – 2022 [2]	2430	97.4	103	7.5	7.95	94.3
EYMUNDSON CREEK NEAR THE MOUTH	07DA041	2011 – 2022 [2]	319	64.9	77.9	0.656	0.787	83.4
FIREBAG RIVER NEAR THE MOUTH	07DC001	1971 – 2022	5980	130	141	24.7	26.8	92.2
FIREBAG RIVER UPSTREAM OF SUNCOR FIREBAG	07DC003	2009 – 2022 [2]	2420	115	138	8.83	10.6	83.3
GREGOIRE RIVER NEAR THE MOUTH	07CE008	2012 – 2022 [2]	1000	96.6	126	3.06	4	76.5
HANGINGSTONE RIVER AT FORT MCMURRAY	07CD004	1965 – 2022	962	113	126	3.44	3.84	89.6
HANGINGSTONE RIVER AT NORTH STAR ROAD	07CD008	2002 – 2022 [2]	113	179	167	0.64	0.598	107
HIGH HILL RIVER NEAR THE MOUTH	07CD009	2012 – 2022 [2]	1360	108	127	4.64	5.46	85
HOUSE RIVER AT HIGHWAY NO. 63	07CB002	1982 – 2022 [6]	781	-	-	-	-	-
IYINIMIN CREEK ABOVE KEARL LAKE	07DA027	1989 – 2022 [2]	43	96.9	150	0.132	0.205	64.4

JACKFISH RIVER BELOW CHRISTINA LAKE	07CE005	1982 – 2022 [3]	1290	109	119	4.47	4.87	91.8
JACKPINE CREEK AT CANTERRA ROAD	07DA026	1995 – 2022 [2]	343	89.7	120	0.975	1.3	75
KEARL LAKE OUTLET	07DA030	1989 – 2022 [2]	83	55.9	84.8	0.147	0.223	65.9

Table continued on next page…

STATION NAME	STATION ID	PERIOD OF RECORD	GROSS DRAINAGE AREA [km²]	2022 WATER YIELD [mm]	HISTORICAL MEAN ANNUAL WATER YIELD [mm]	2022 MEAN DISCHARGE [m³/s]	HISTORICAL MEAN ANNUAL DISCHARGE[1] [m³/s]	2022 AS A PERCENT OF HISTORICAL MEAN ANNUAL DISCHARGE [%]
MACKAY RIVER AT PETRO-CANADA BRIDGE	07DB006	2008 – 2022 [2]	4130	94.7	82.5	12.4	10.8	115
MACKAY RIVER NEAR FORT MACKAY	07DB001	1972 – 2022	5570	80.5	81	14.2	14.3	99.3
MCCLELLAND LAKE OUTLET ABOVE FIREBAG RIVER	07DC004	2008 – 2022 [2]	359	54.8	66.4	0.623	0.755	82.5
MUSKEG CREEK NEAR THE MOUTH	07DA035	1989 – 2022 [2]	322	68.9	106	0.703	1.08	65.1
MUSKEG RIVER ABOVE MUSKEG CREEK	07DA029	1995 – 2022 [2]	567	50.8	73.5	0.912	1.32	69.1
MUSKEG RIVER ABOVE STANLEY CREEK	07DA028	2003 – 2022 [2]	440	55.9	73.2	0.779	1.02	76.4
MUSKEG RIVER NEAR FORT MACKAY	07DA008	1974 – 2022	1460	64.2	82.4	2.97	3.81	78
MUSKEG RIVER UPLAND	07DA034	2001 – 2022 [2]	150	90.5	107	0.43	0.507	84.8
PONY CREEK NEAR CHARD	07CE003	1982 – 2022 [6]	279	-	-	-	-	-
POPLAR CREEK NEAR FORT MCMURRAY	07DA007	1972 – 2022 [4]	151	189	226	0.906	1.08	83.9
RED CLAY CREEK NEAR THE MOUTH	07DA042	2011 – 2022 [5]	N/A	N/A	N/A	0.551	0.732	75.3
STEEPBANK RIVER BELOW NORTH STEEPBANK RIVER	07DA044	2014 – 2022 [2]	1180	103	157	3.87	5.86	66
STEEPBANK RIVER NEAR FORT MCMURRAY	07DA006	1972 – 2022	1320	104	130	4.37	5.43	80.5
SUNDAY CREEK ABOVE CHRISTINA LAKE	07CE010	2012 – 2022 [2]	365	112	137	1.3	1.58	82.3
TAR RIVER ABOVE CANADIAN NATURAL RESOURCES LIMITED LAKE	07DA037	2005 – 2022 [2]	143	95.3	103	0.432	0.469	92.1
TAR RIVER NEAR THE MOUTH	07DA045	2007 – 2022 [2]	320	45.4	80.2	0.46	0.813	56.6

[1] Monitoring occurred under RAMP from 2011-2015.
[2] Monitoring occurred under RAMP prior to 2017.
[3] Monitoring occurred under RAMP from 2012 – 2016.
[4] Monitoring occurred under RAMP from 1996 – 2016.
[5] Monitoring occurred under RAMP prior to 2017. ECCC operation started in May 2018.
[6] Seasonally operated

Table B2: Level Stations

STATION NAME	STATION ID	RECORD	DATUM	2022 MEAN LEVEL [m]	HISTORICAL MEAN ANNUAL LEVEL [m]	DIFFERENCE [m]
GREGOIRE LAKE **NEAR FORT** MCMURRAY	07CE001	1969 – 2022 [3]	Geodetic Survey of Canada	-	-	-
KEARL LAKE AT CANTERRA ROAD [1]	07DA024	2017 – 2022	Assumed [4]	N/A	99.547	N/A
MCCLELLAND LAKE AT EAST END	07DA023	1997 – 2022 [2]	Assumed [4]	294.625	294.593	0.032
NAMUR LAKE **NEAR THE** OUTLET	07DA025	2012 – 2022 [2]	Assumed [4]	97.896	97.874	0.022

[1] Water level data collected prior to October 21, 2017 at hydrometric station KEARL LAKE AT CANTERRA ROAD is not included in this assessment due to a shift in the assumed datum used for monitoring.

[2] Monitoring occurred under RAMP prior to 2017.

[3] Seasonally operated

[4] Conversion to CGVD 2013 Datum available on Wateroffice.

Appendix C:
Annual Hydrographs – All Hydrometric Stations

The following figures show the annual hydrographs for all active stations within the Oil Sands area in 2022. Each hydrograph includes the measured discharge/level for 2022, the maximum and minimum discharge/level on record for each station, and the interquartile range of flow/level (between the 25th and 75th percentiles) based on daily mean measurements over the entire period of record. Note that percentiles are not shown when the period of record does not include at least 5 years of data for a given day. As noted in Appendix B, the statistical record used includes monitoring that occurred under the Regional Aquatics Monitoring Program (RAMP). Data included from RAMP has not been verified by WSC.

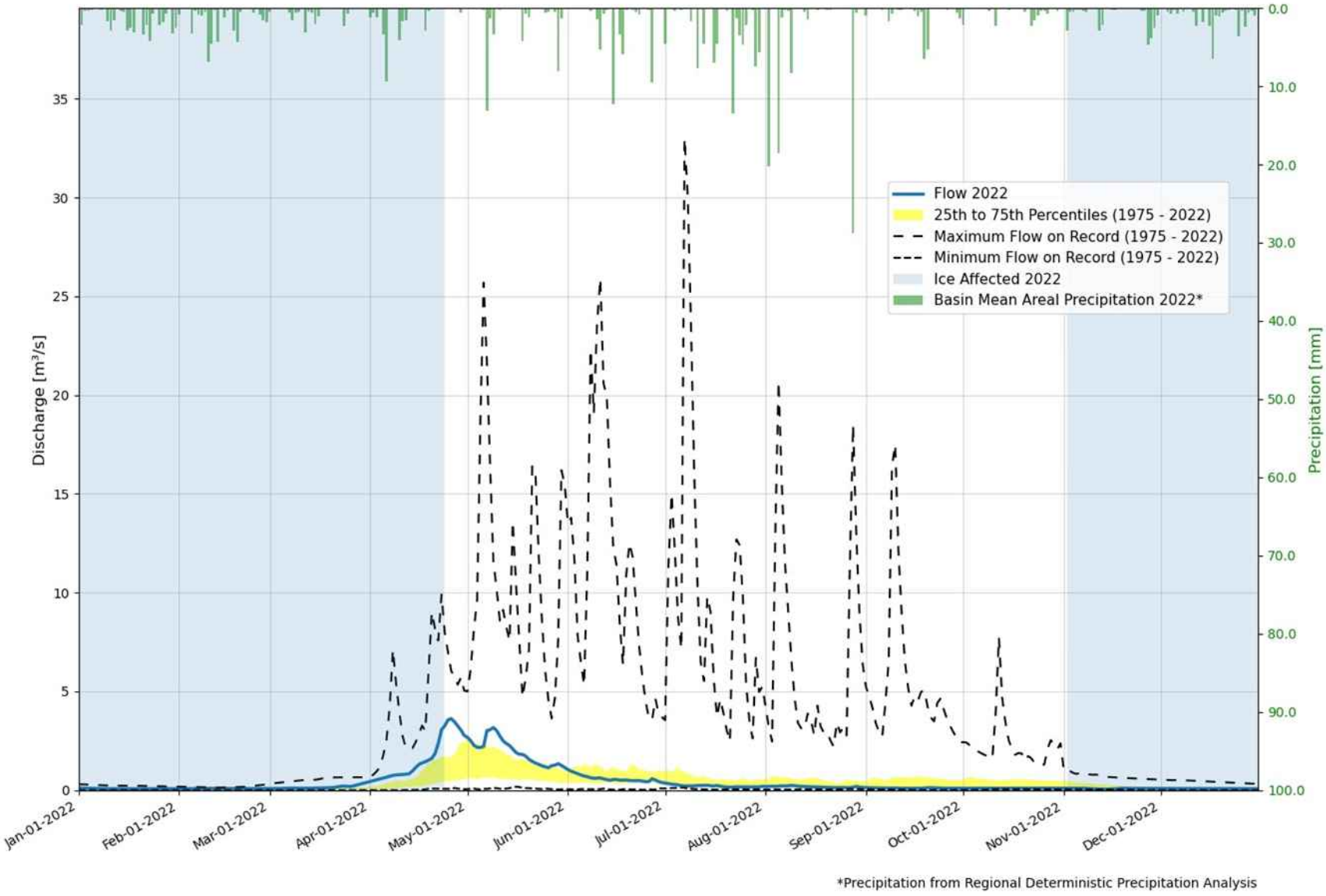

Figure C1: Beaver River above Syncrude (07DA018)

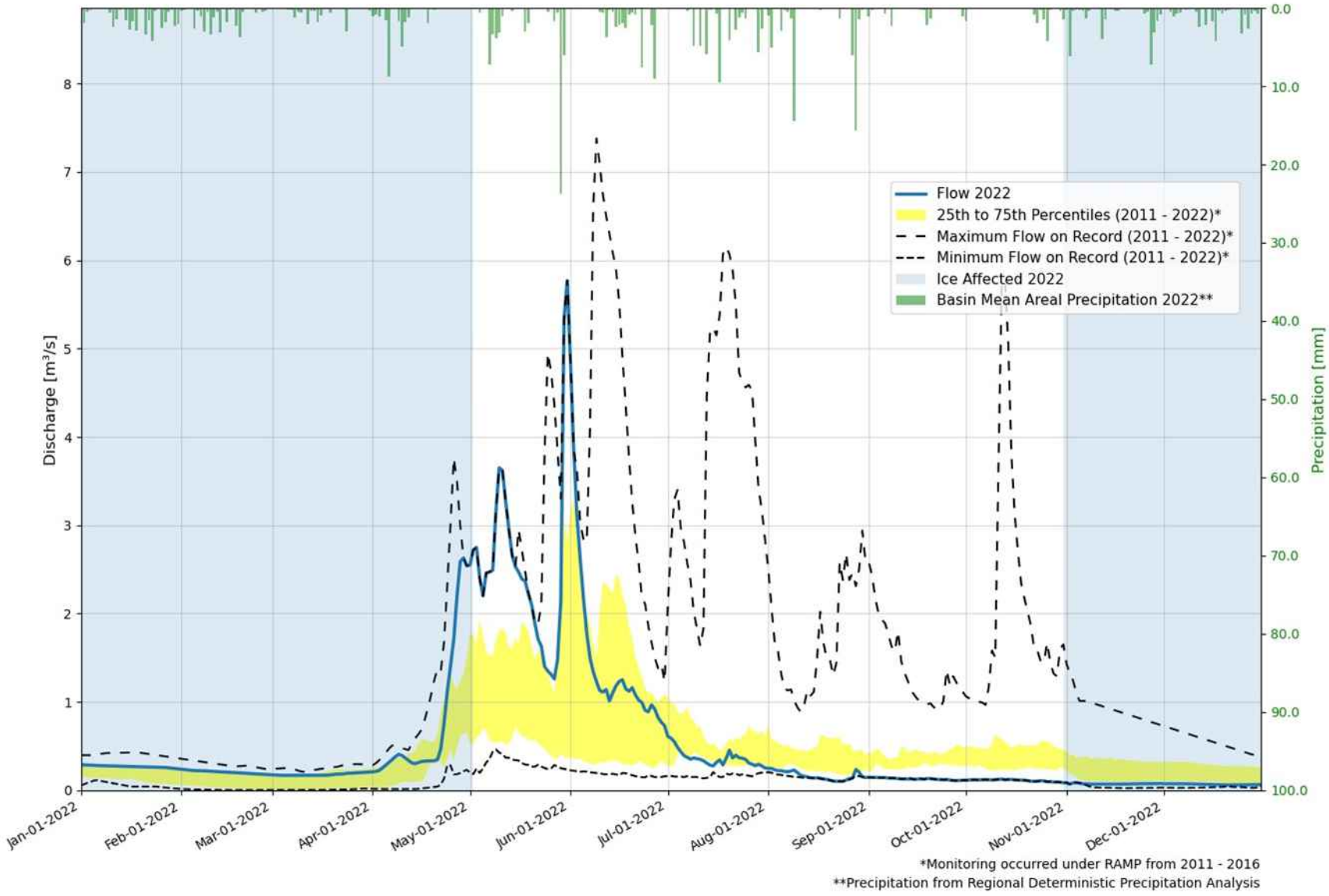

Figure C2: Big Creek near the Mouth (07DA040)

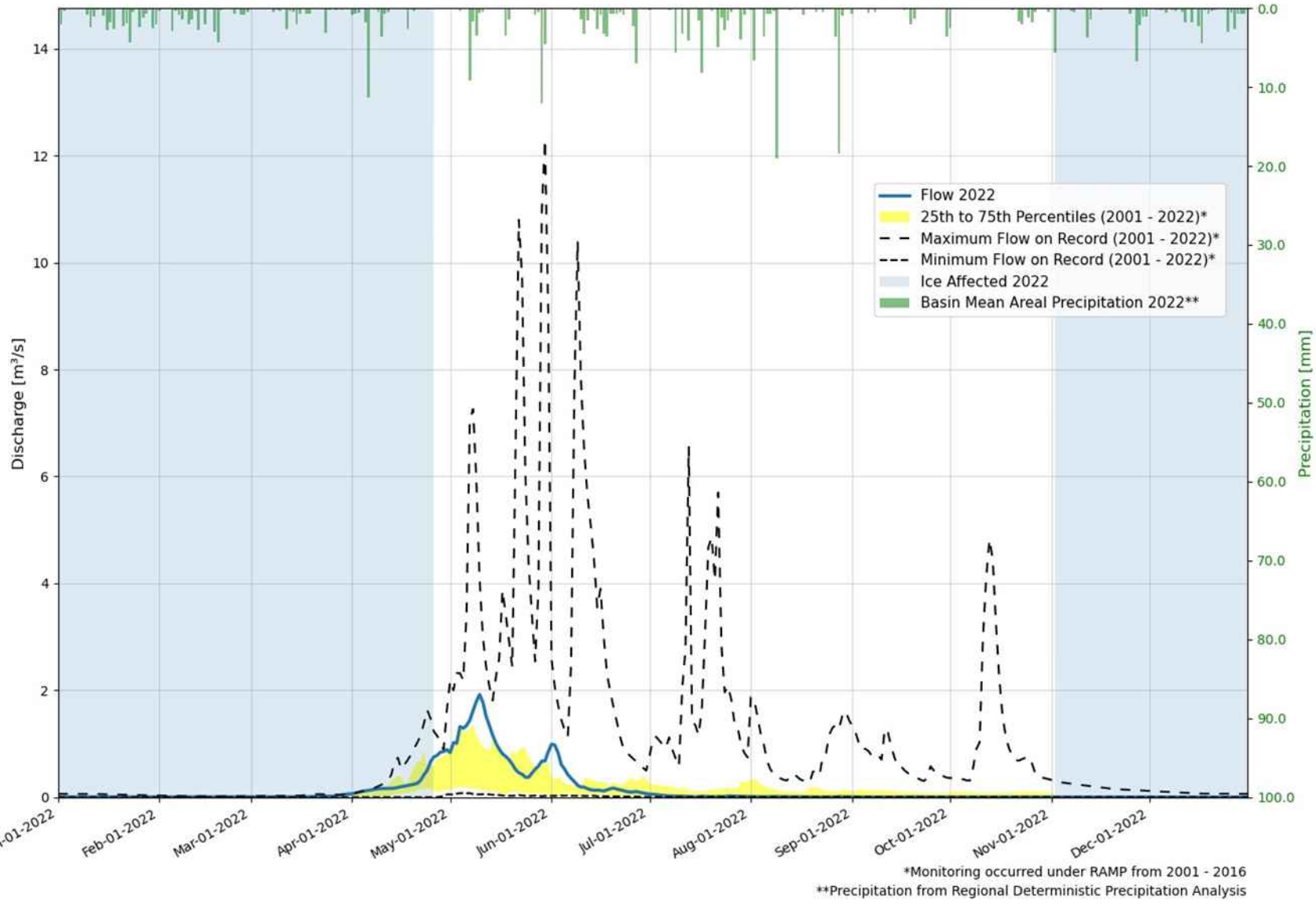

Figure C3: Calumet River near the Mouth (07DA033)

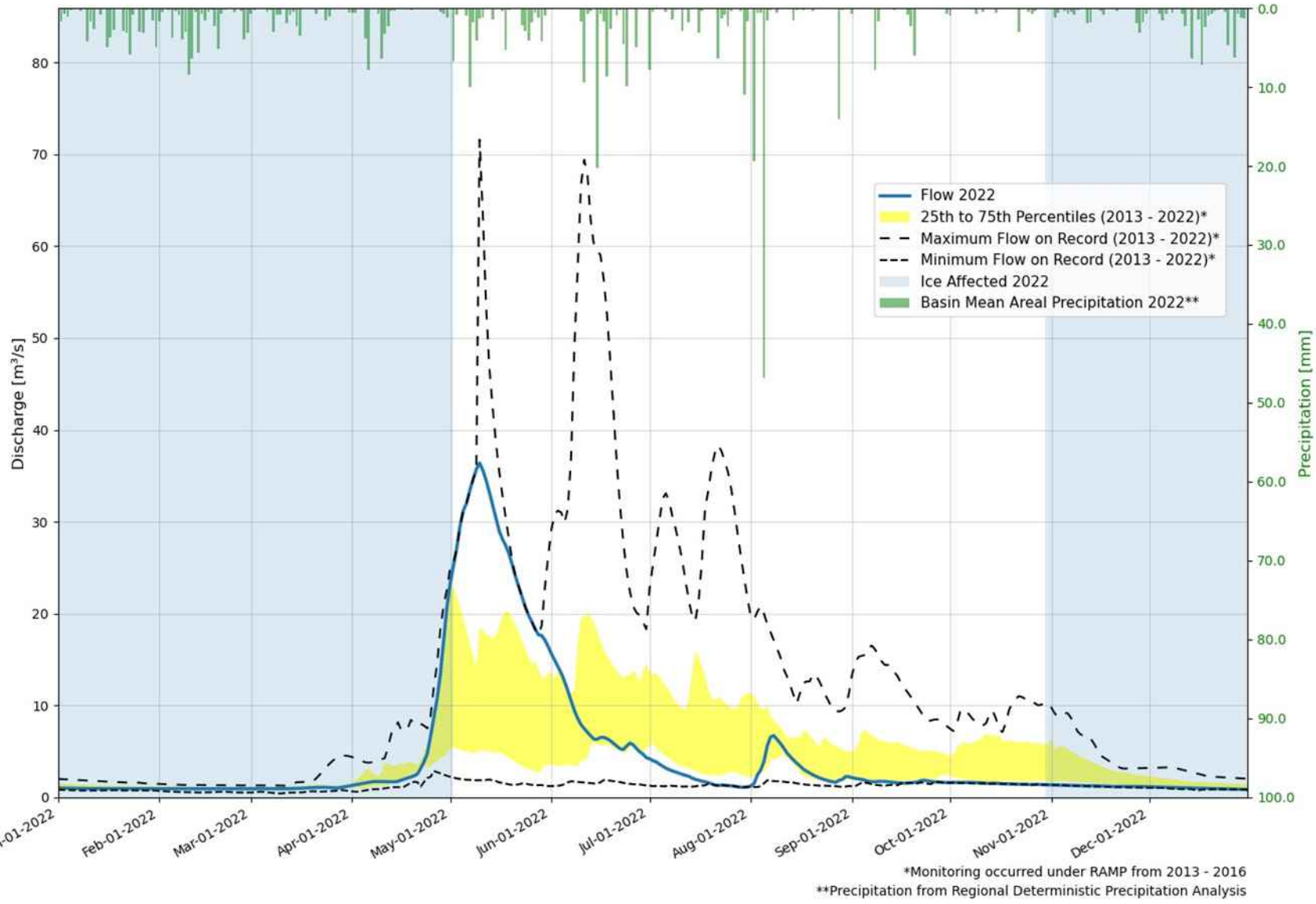

Figure C4: Christina River above Statoil Leismer (07CE013)

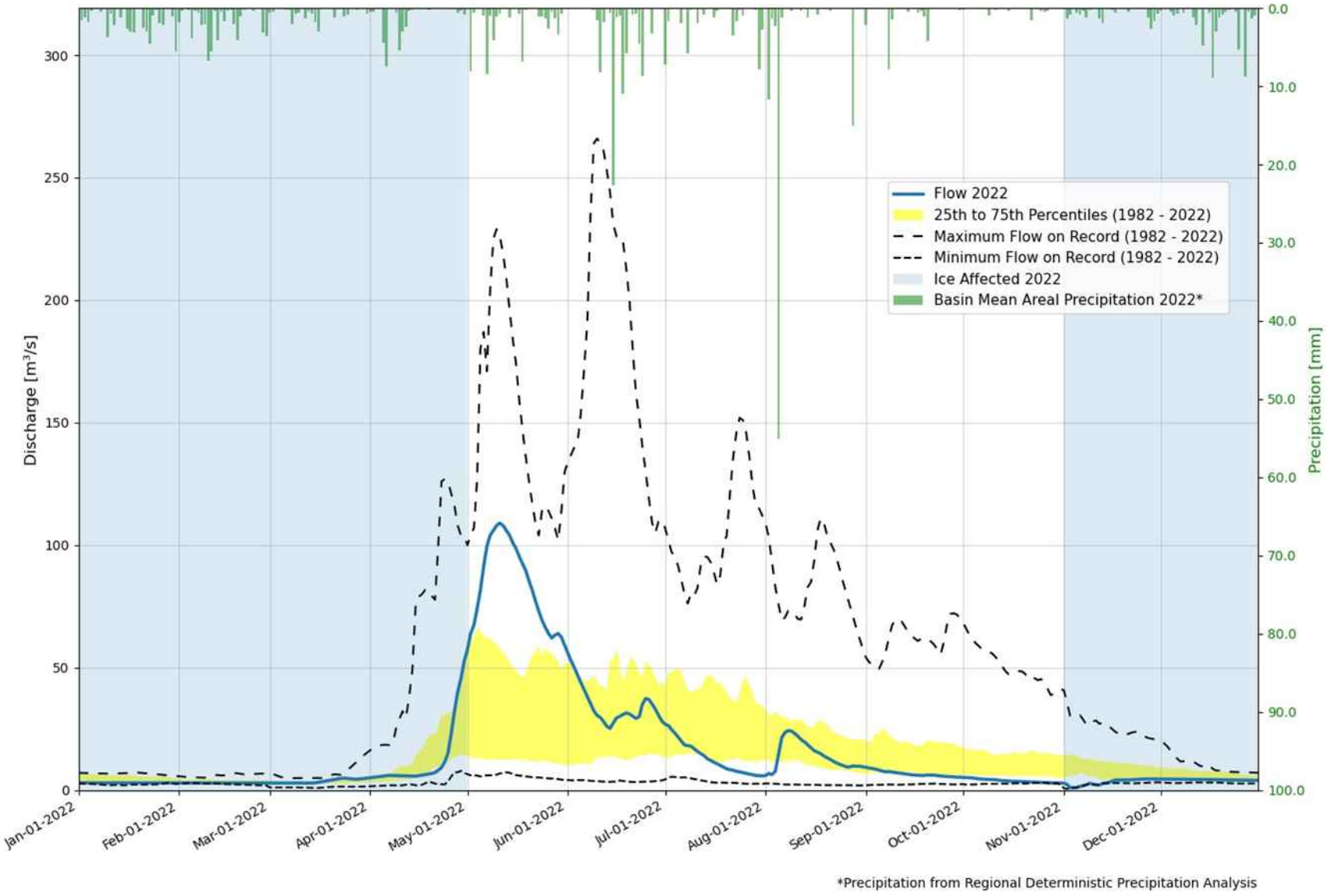

Figure C5: Christina River near Chard (07CE002)

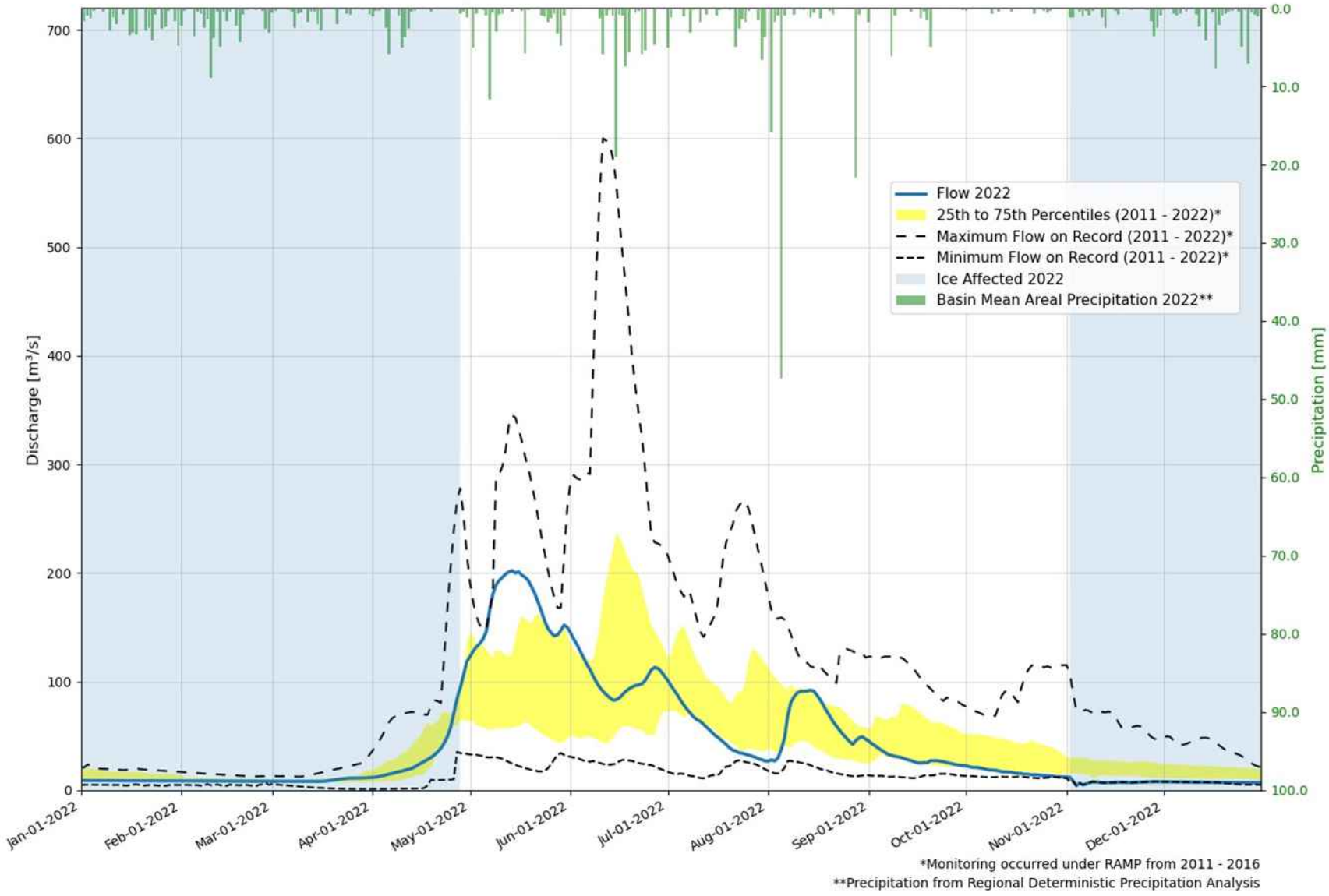

Figure C6: Christina River near the Mouth (07CE007)

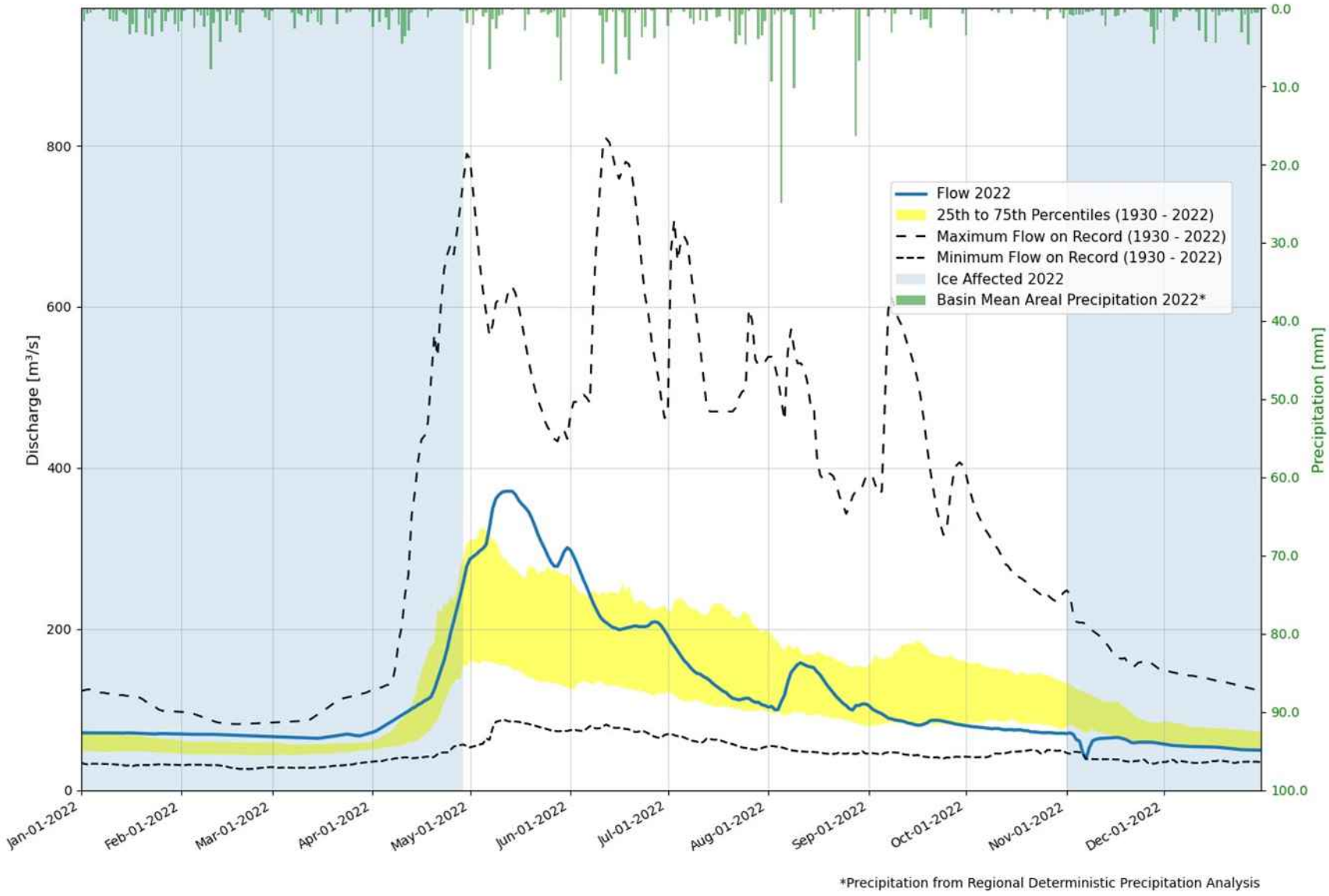

Figure C7: Clearwater River at Draper (07CD001)

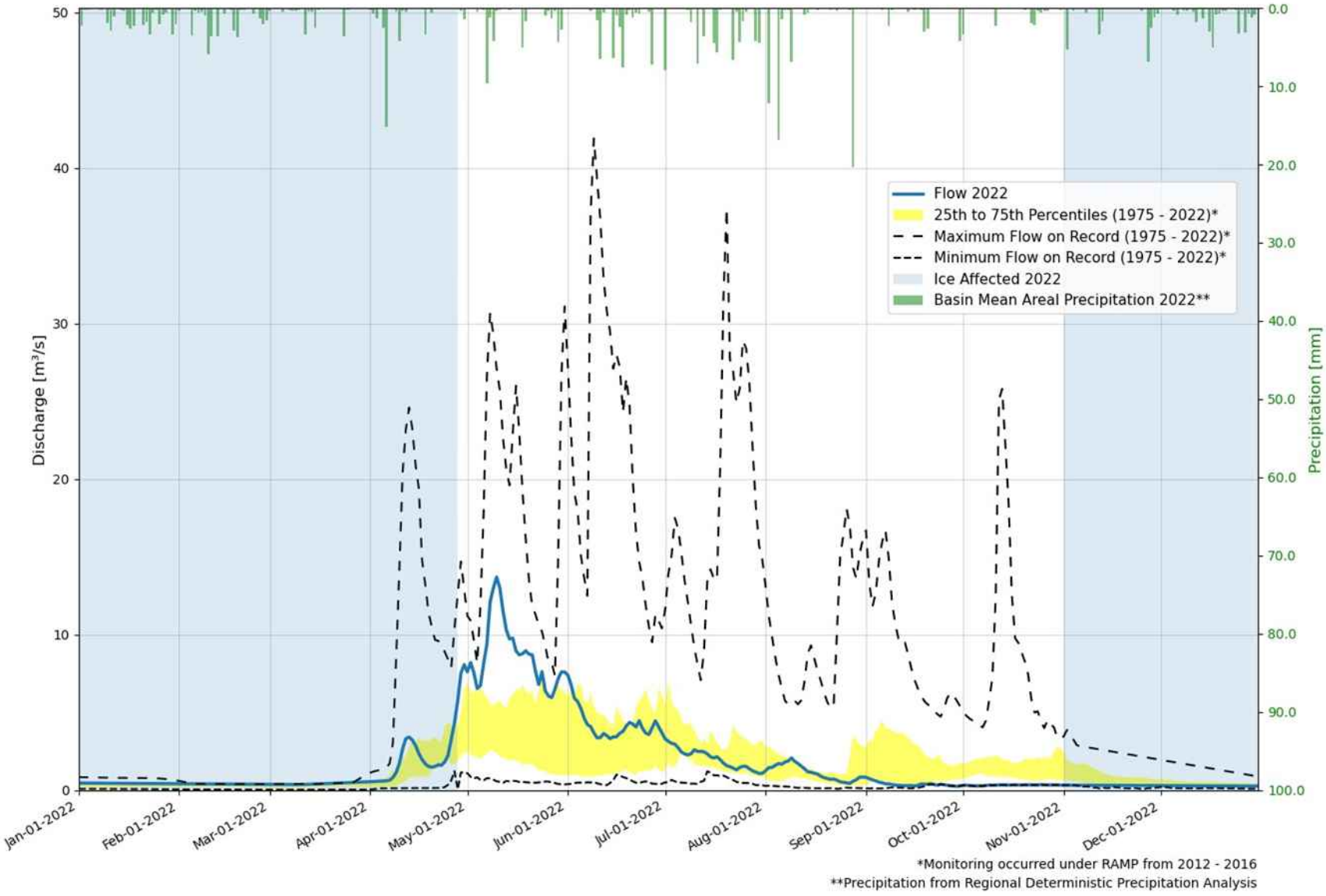

Figure C8: Dover River near the Mouth (07DB002)

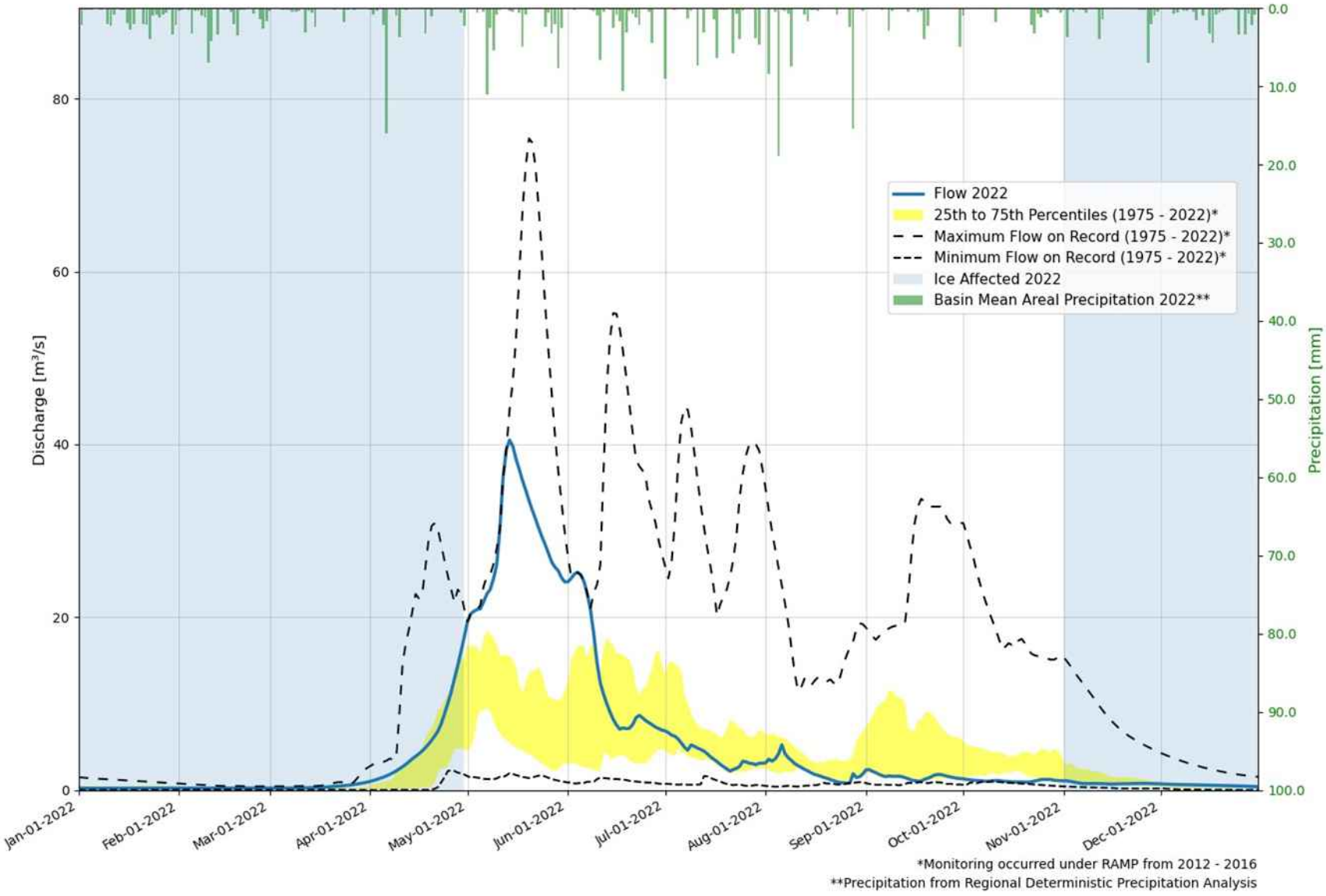

Figure C9: Dunkirk River near Fort Mackay (07DB003)

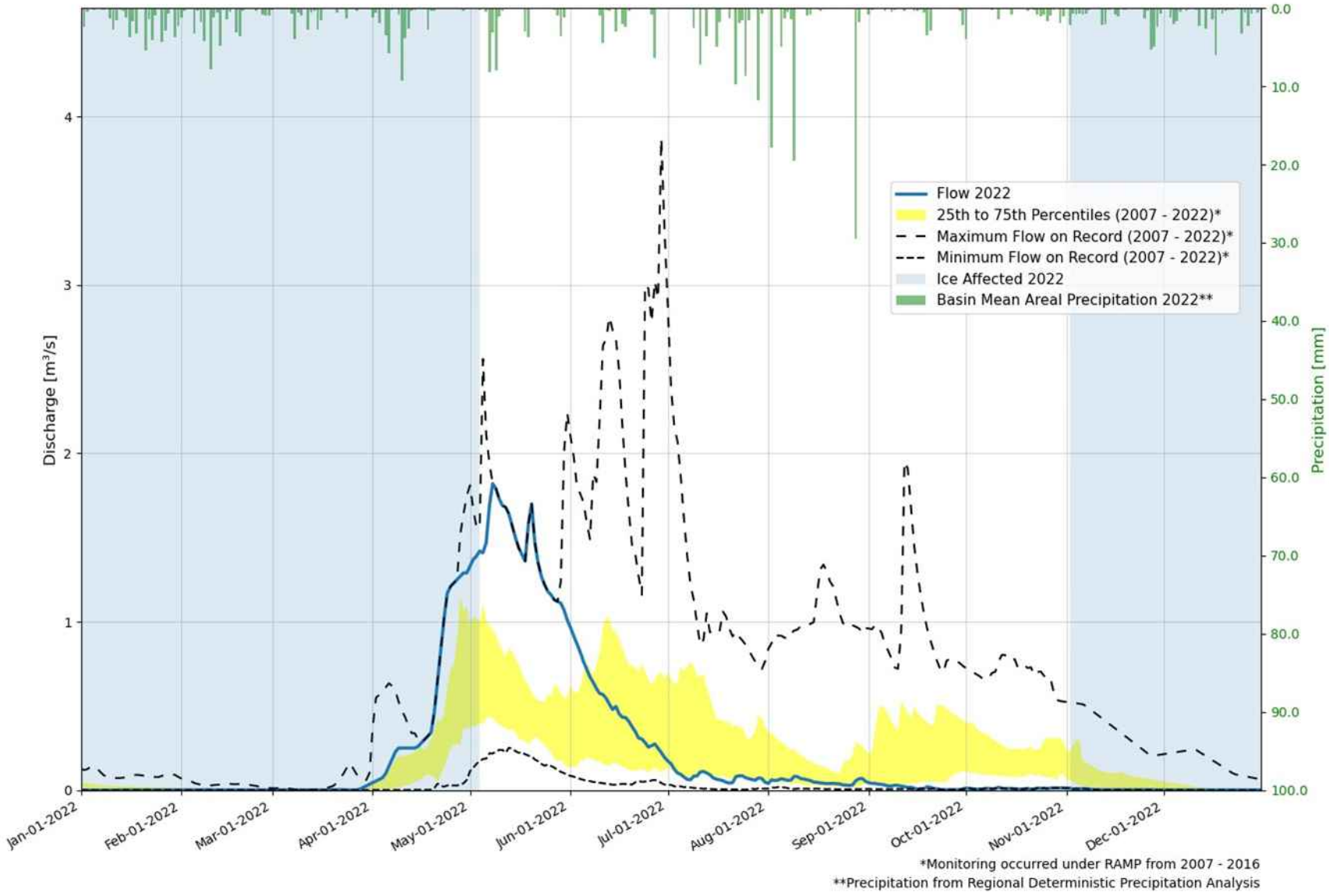

Figure C10: East Jackpine Creek near the 1300 Ft Contour (07DA038)

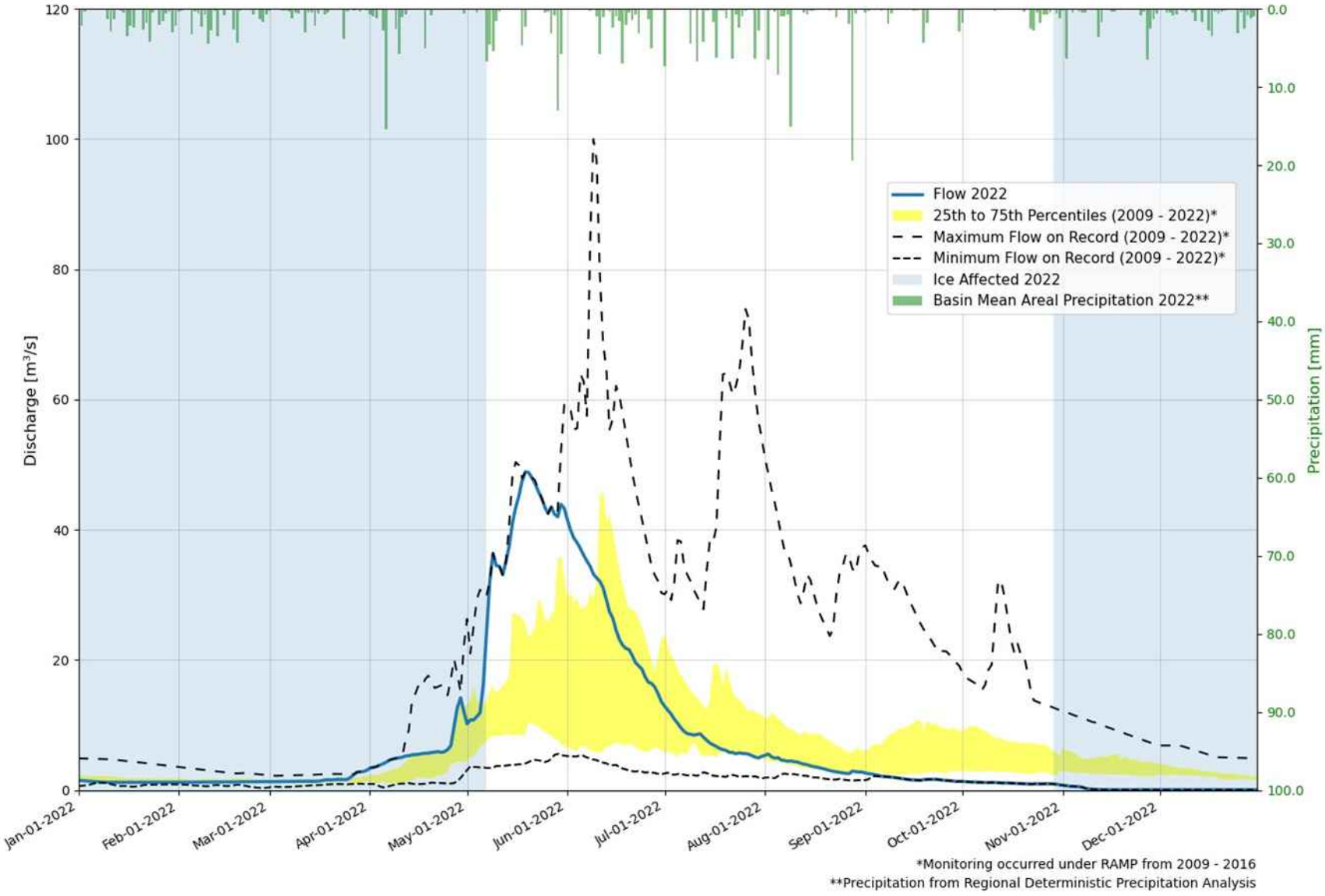

Figure C11: Ells River above Joslyn Creek Diversion (07DA039)

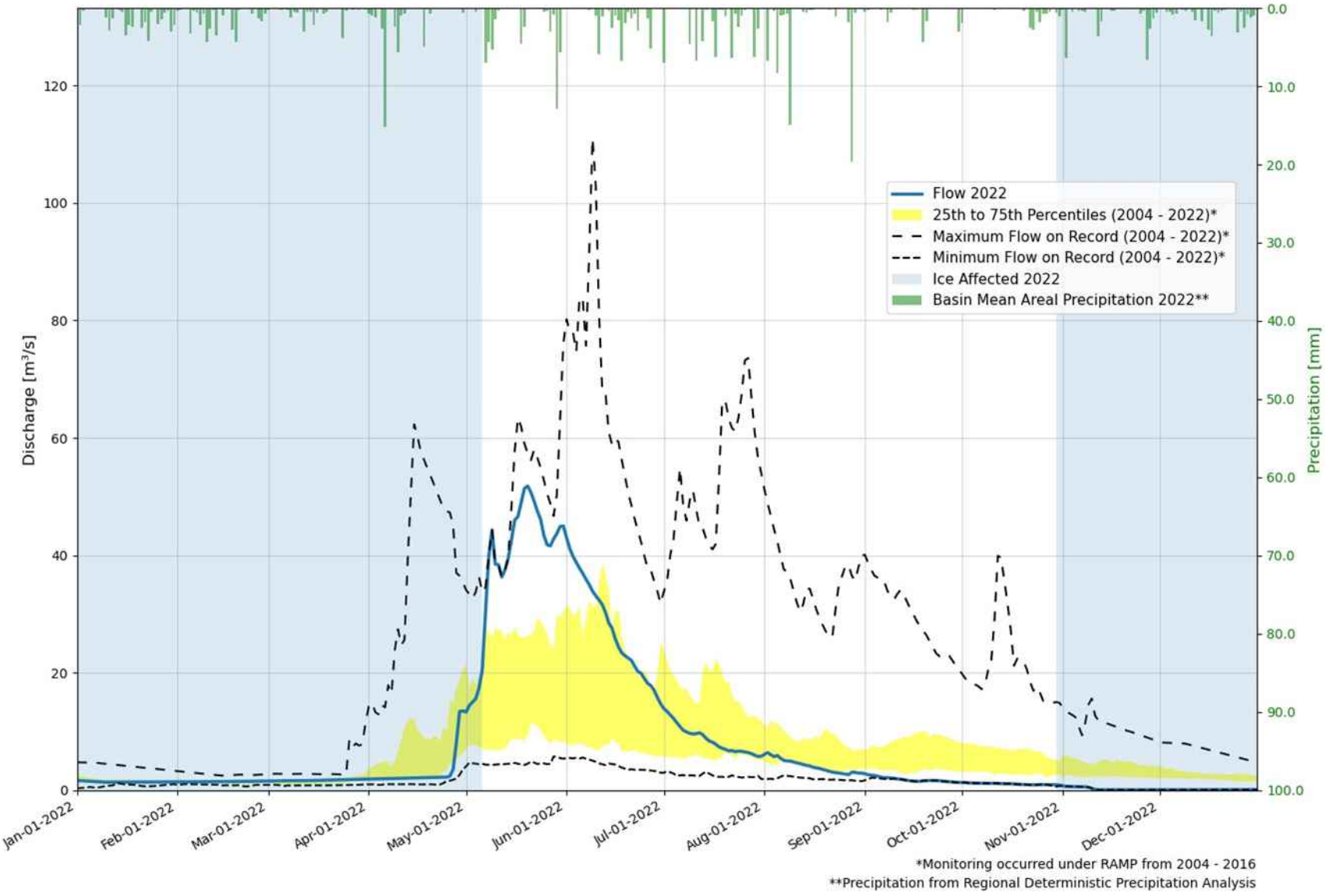

Figure C12: Ells River at Canadian Natural Resources Limited Bridge (07DA032)

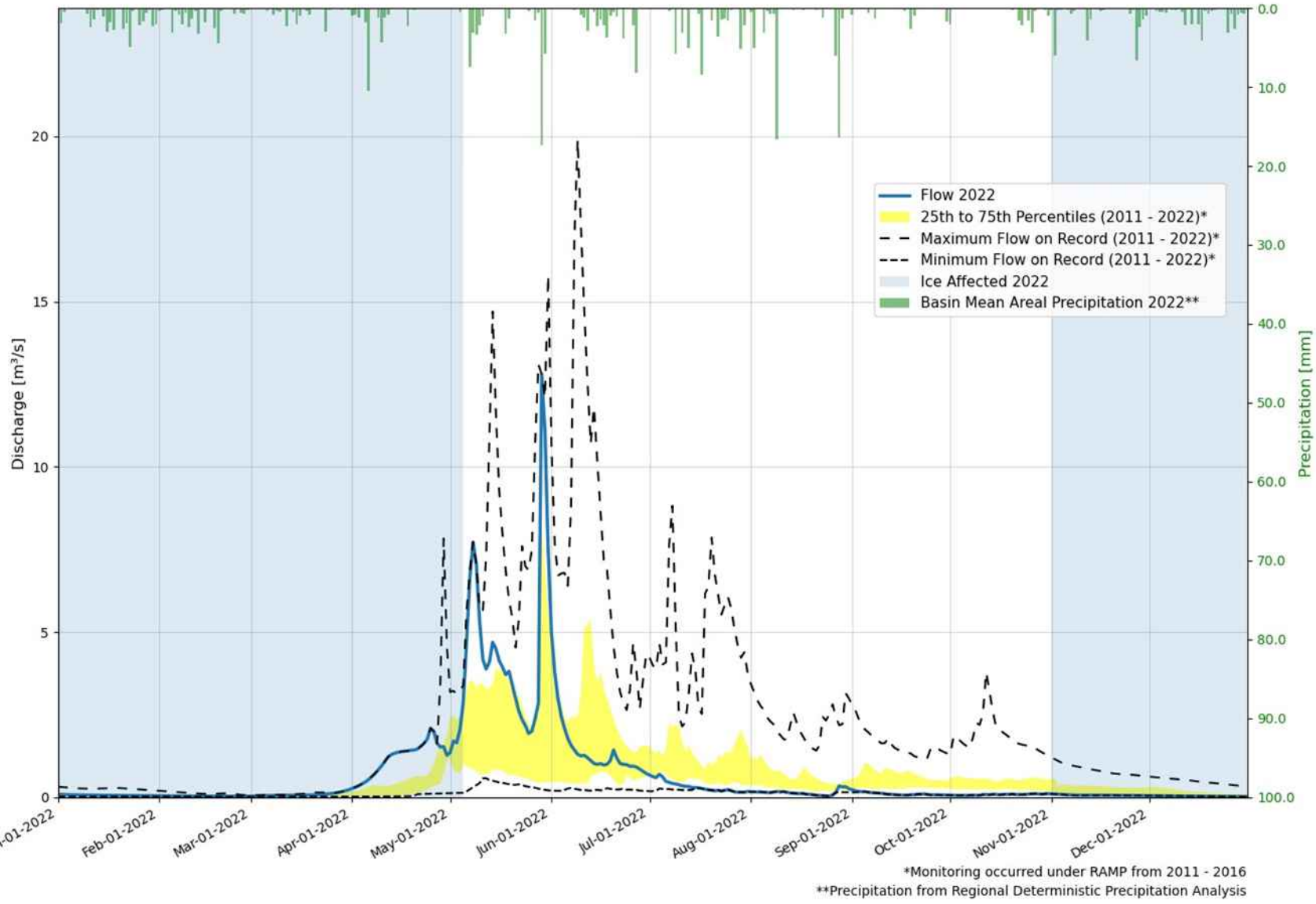

Figure C13: Eymundson Creek near the Mouth (07DA041)

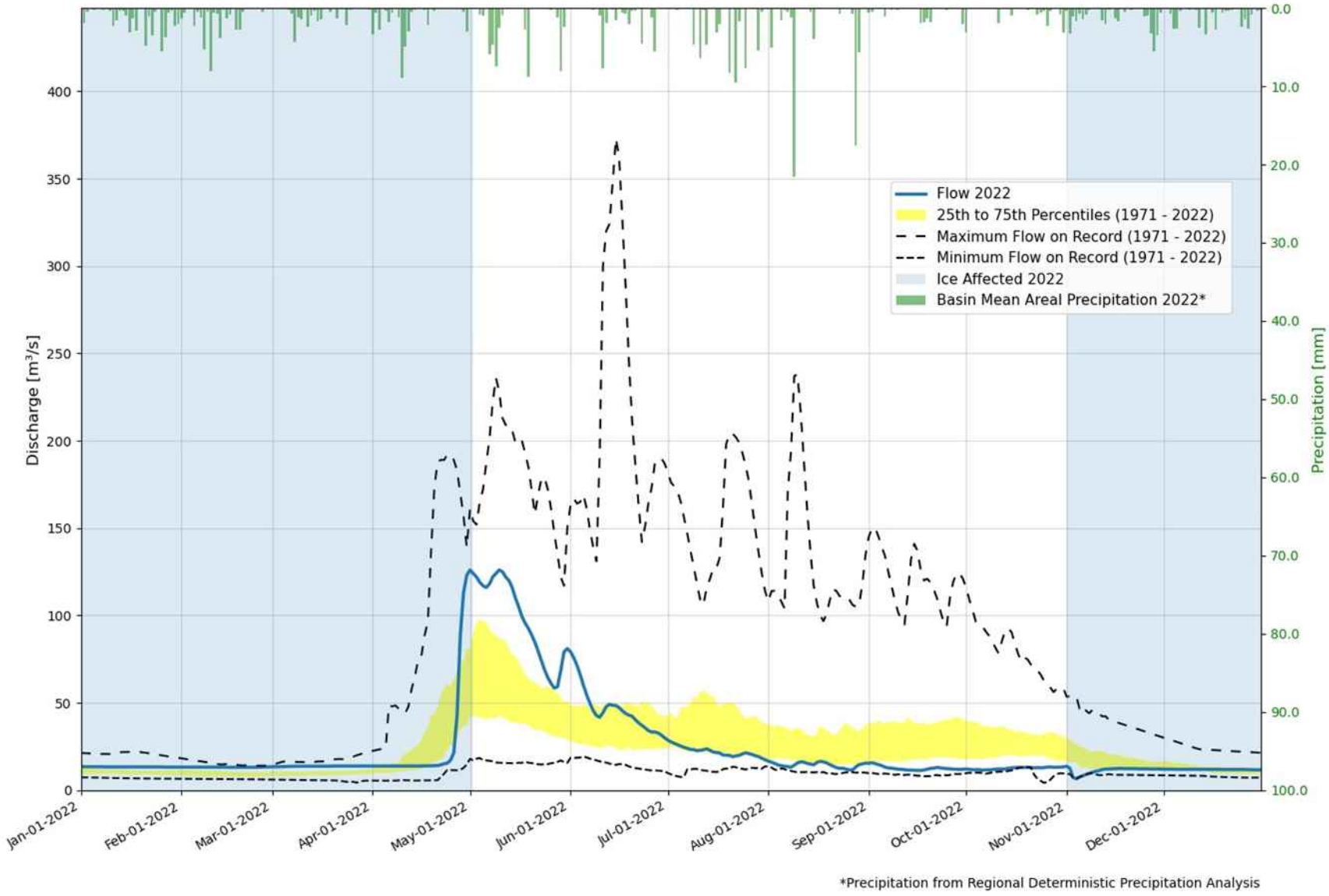

Figure C14: Firebag River near the Mouth (07DC001)

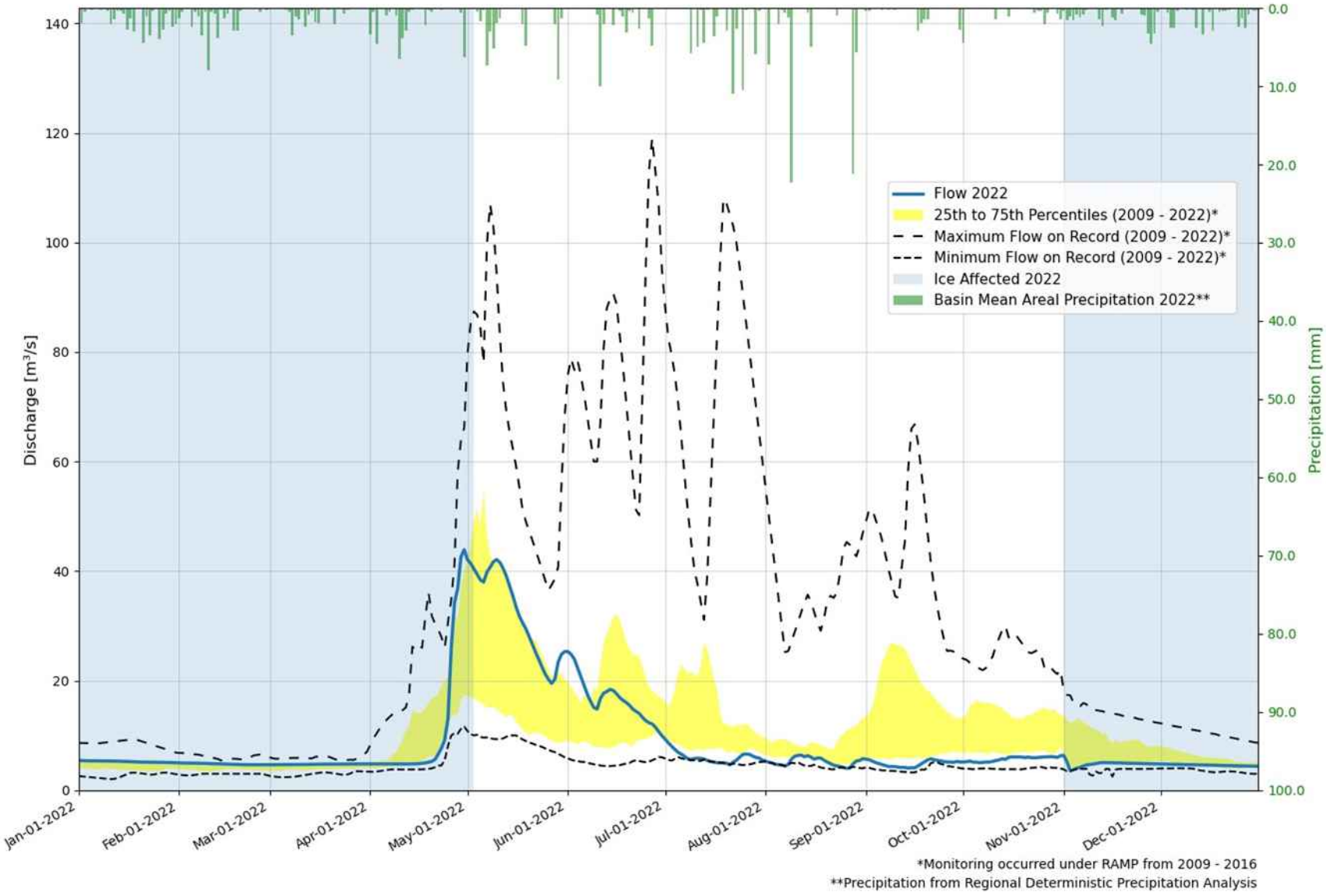

Figure C15: Firebag River upstream of Suncor Firebag (07DC003)

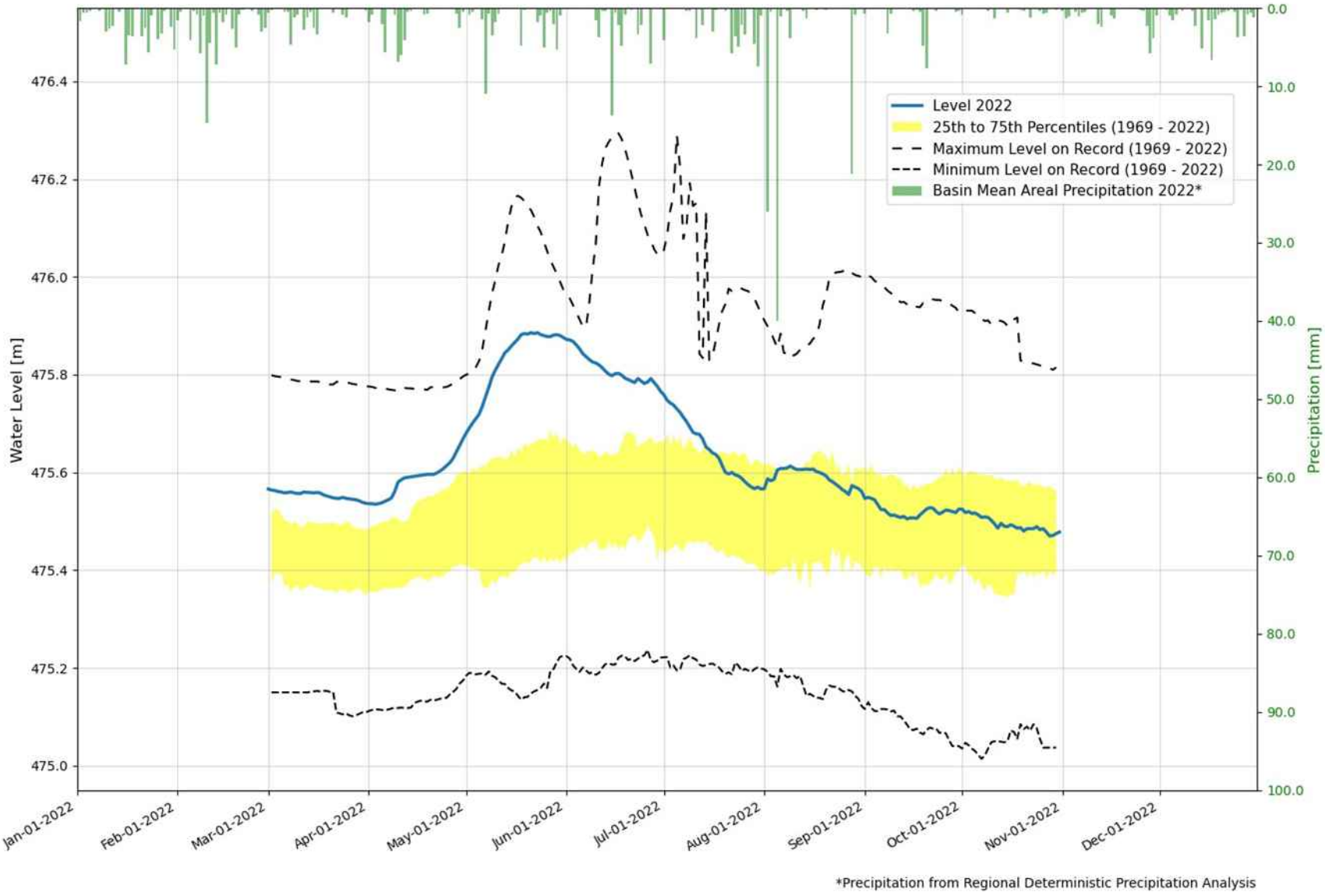

Figure C16: Gregoire Lake near Fort Mcmurray (07CE001)

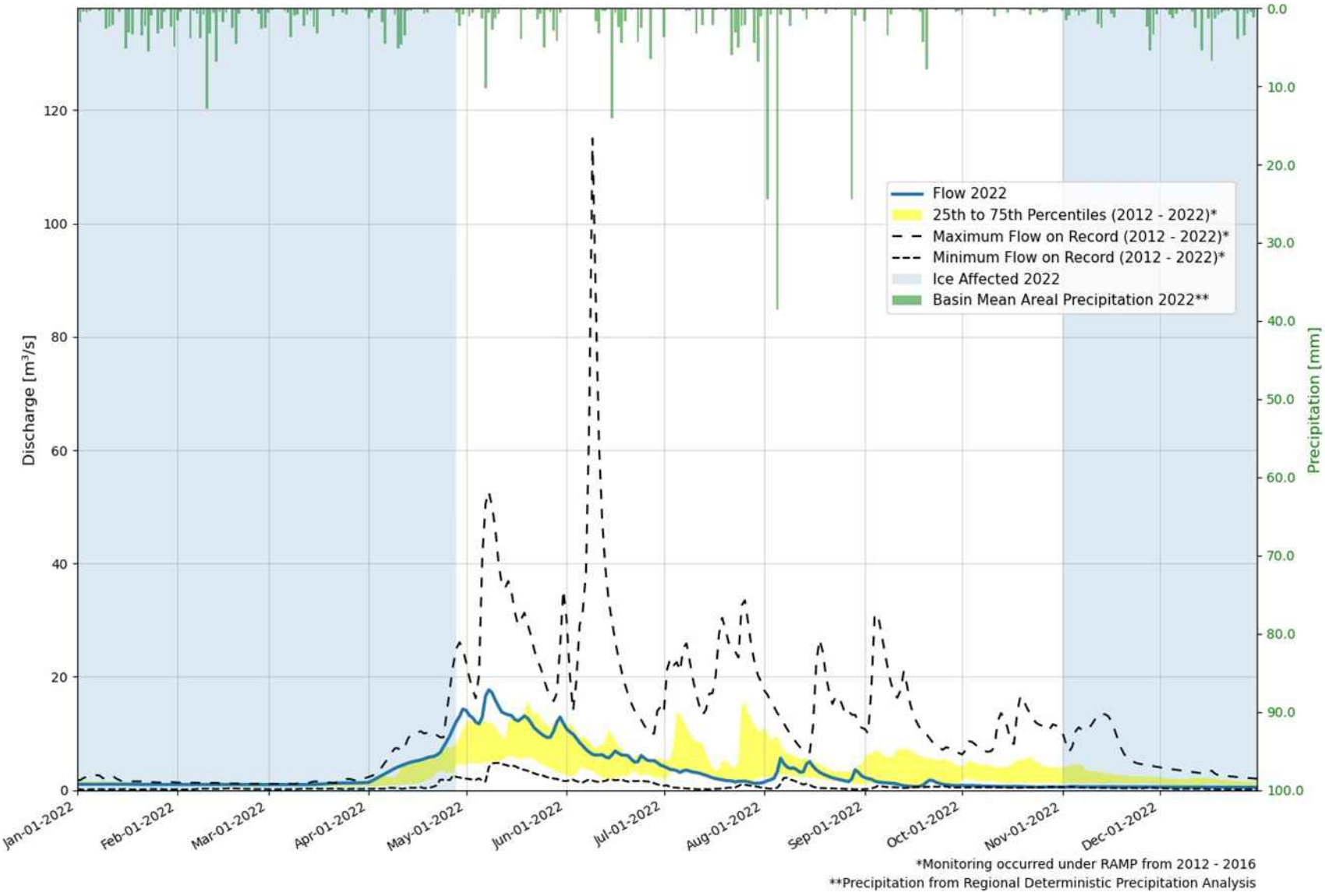

Figure C17: Gregoire River near the Mouth (07CE008)

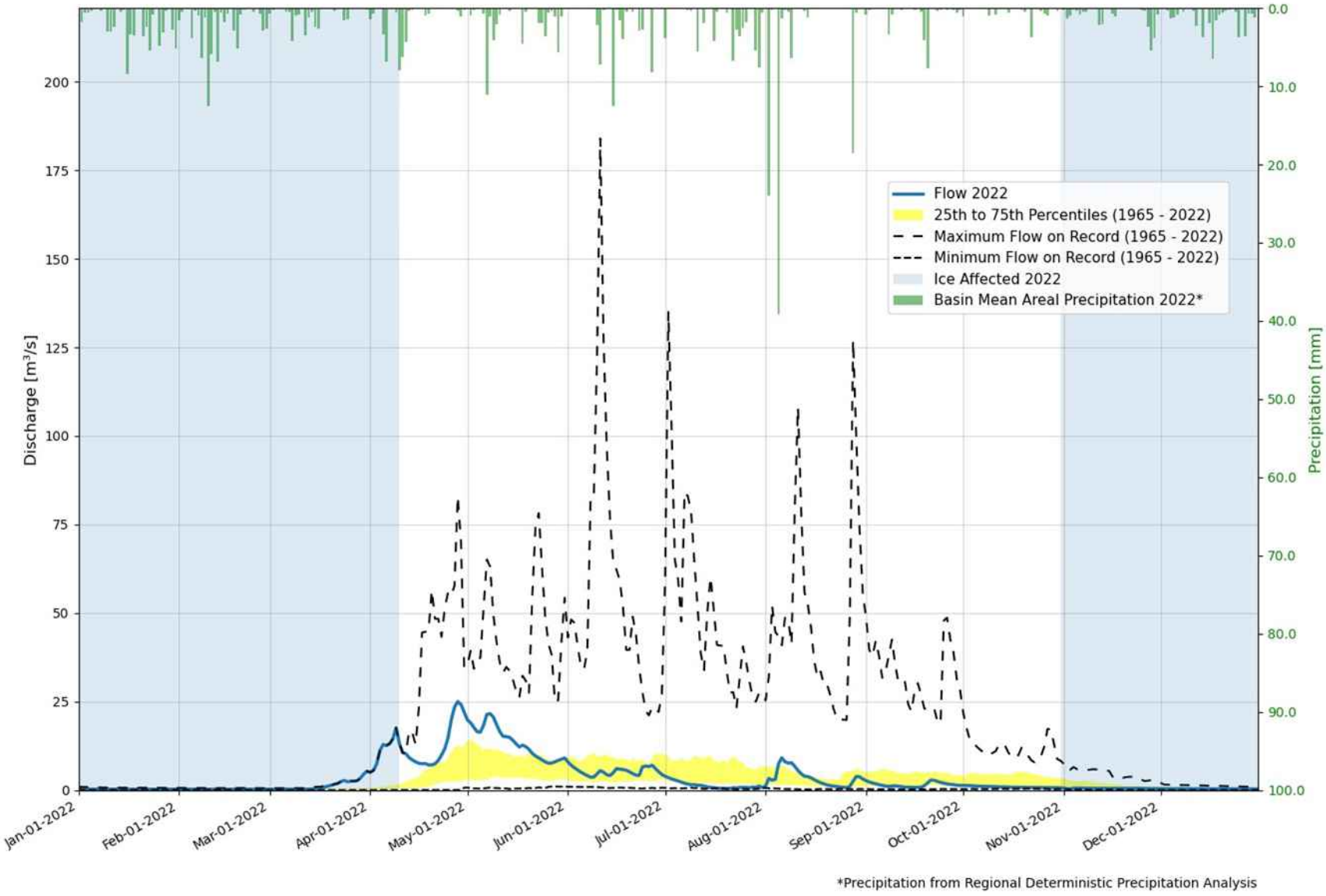

Figure C18: Hangingstone River at Fort Mcmurray (07CD004)

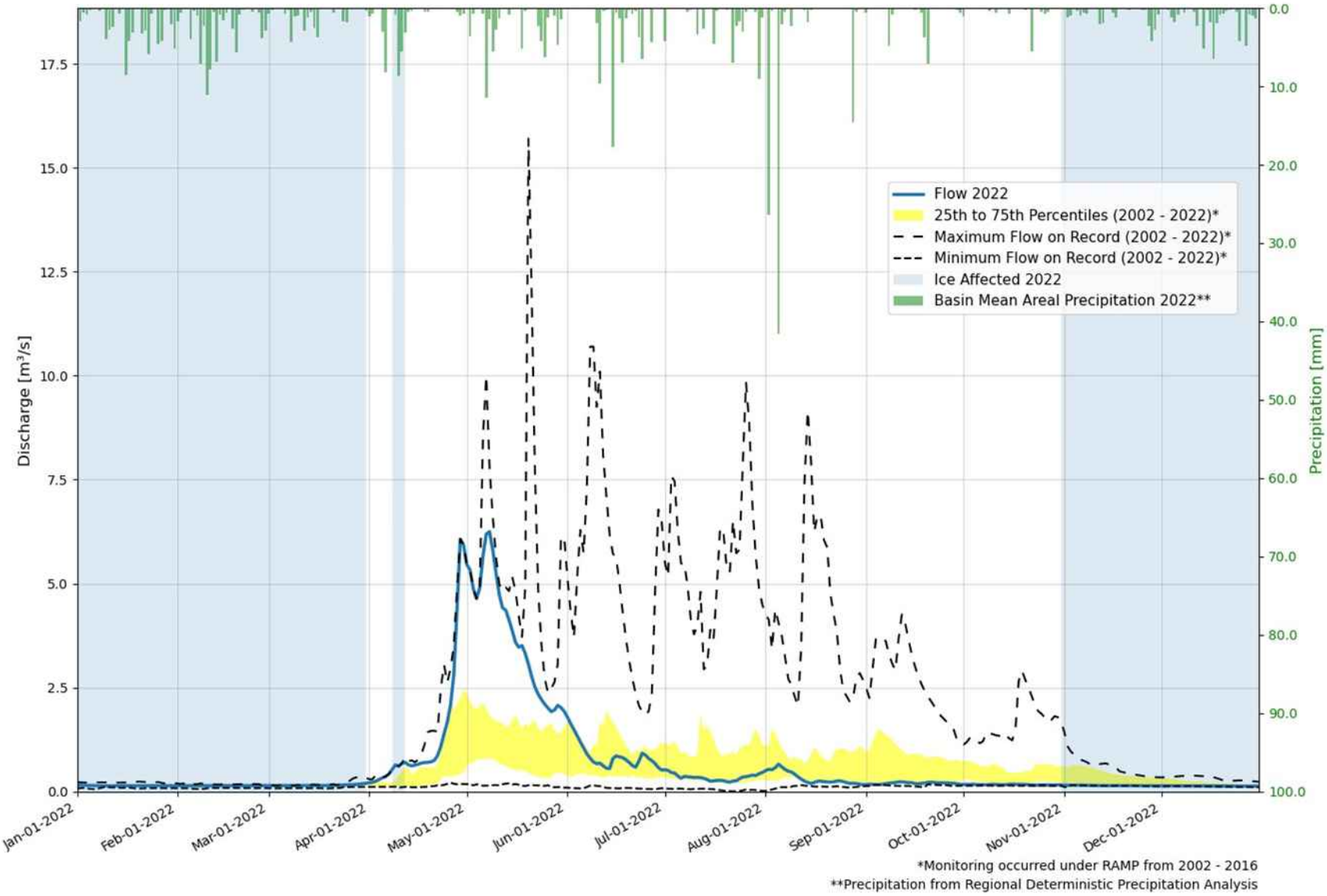

Figure C19: Hangingstone River at North Star Road (07CD008)

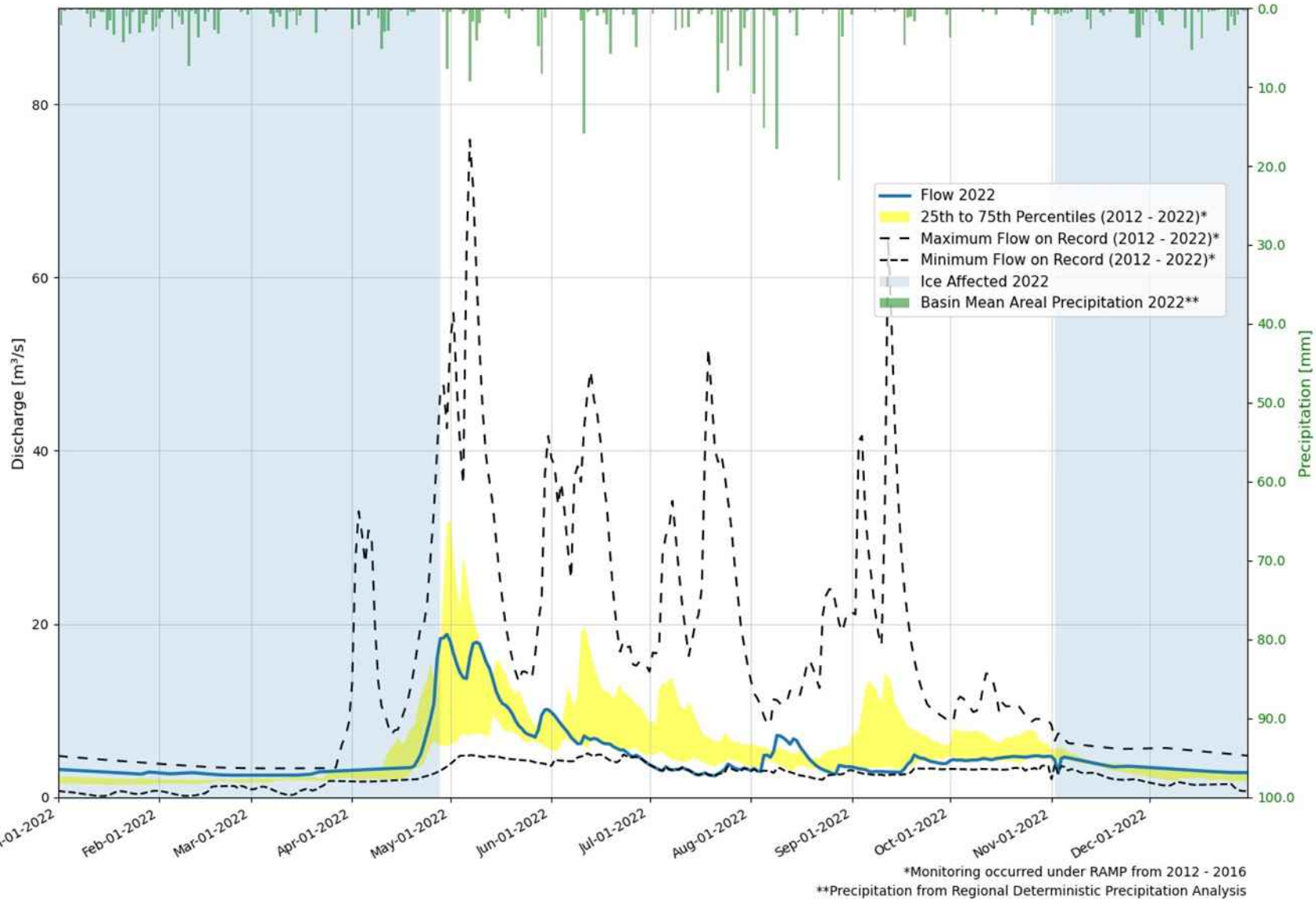

Figure C20: High Hill River near the Mouth (07CD009)

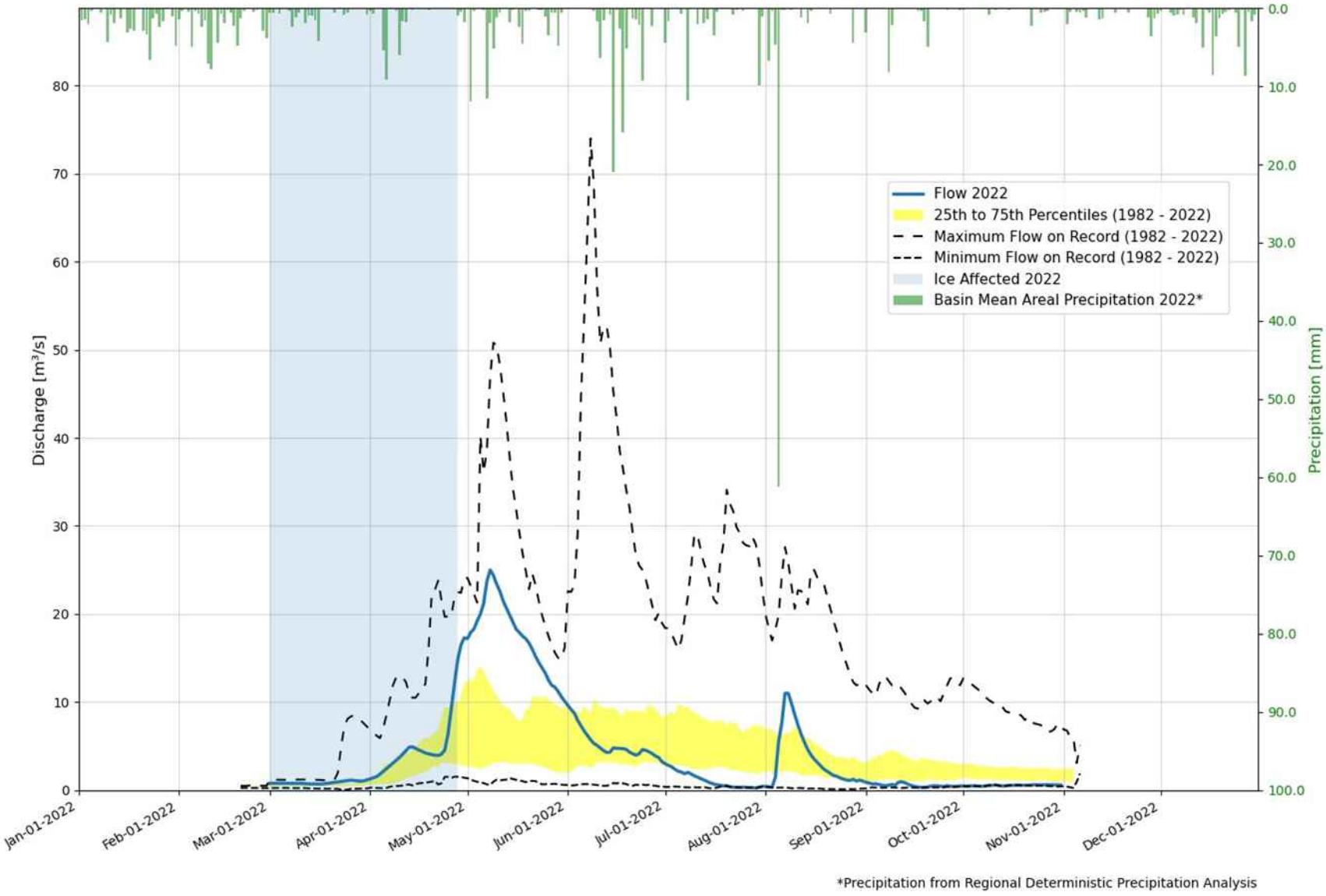

Figure C21: House River at Highway No. 63 (07CB002)

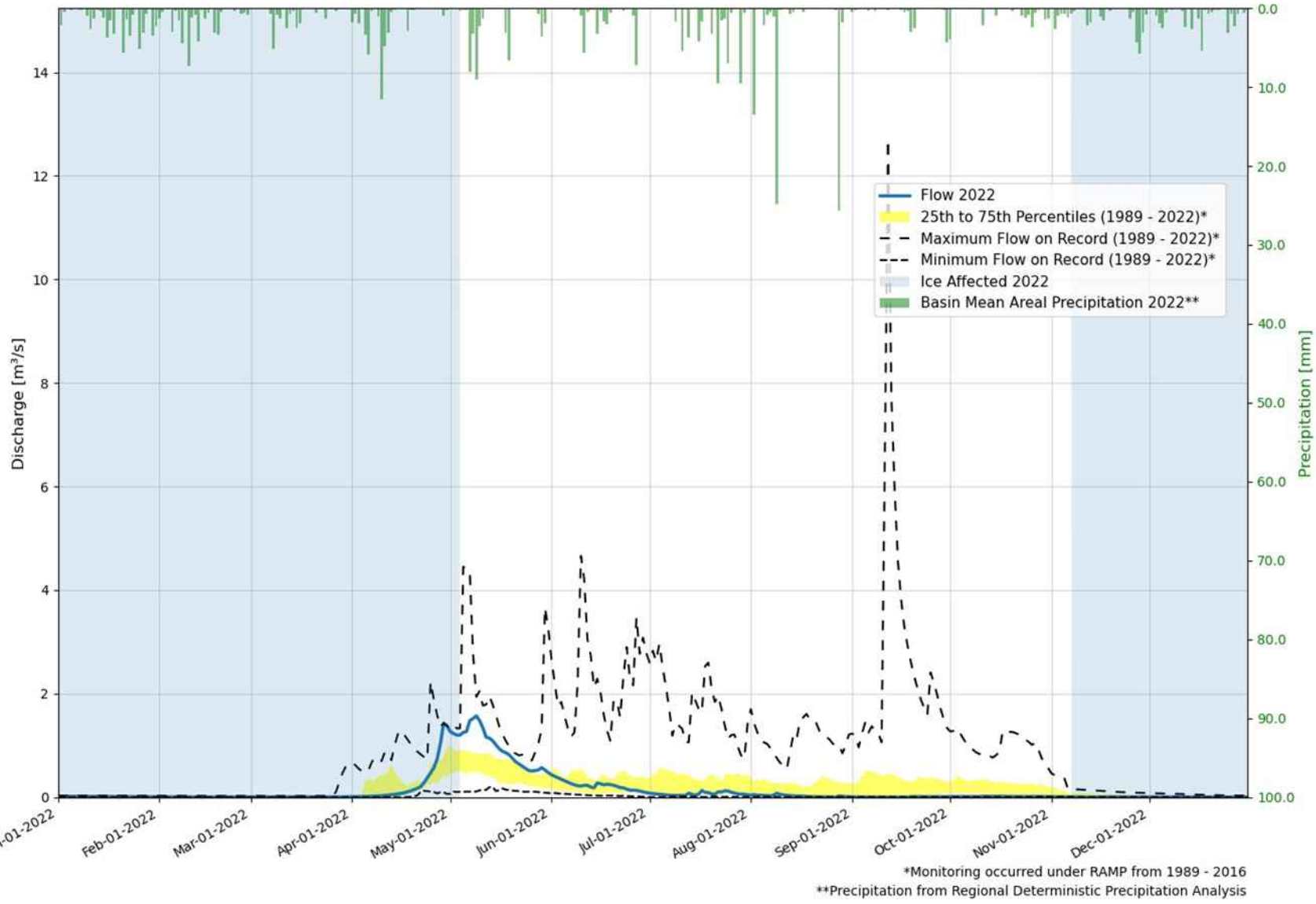

Figure C22: Iyinimin Creek above Kearl Lake (07DA027)

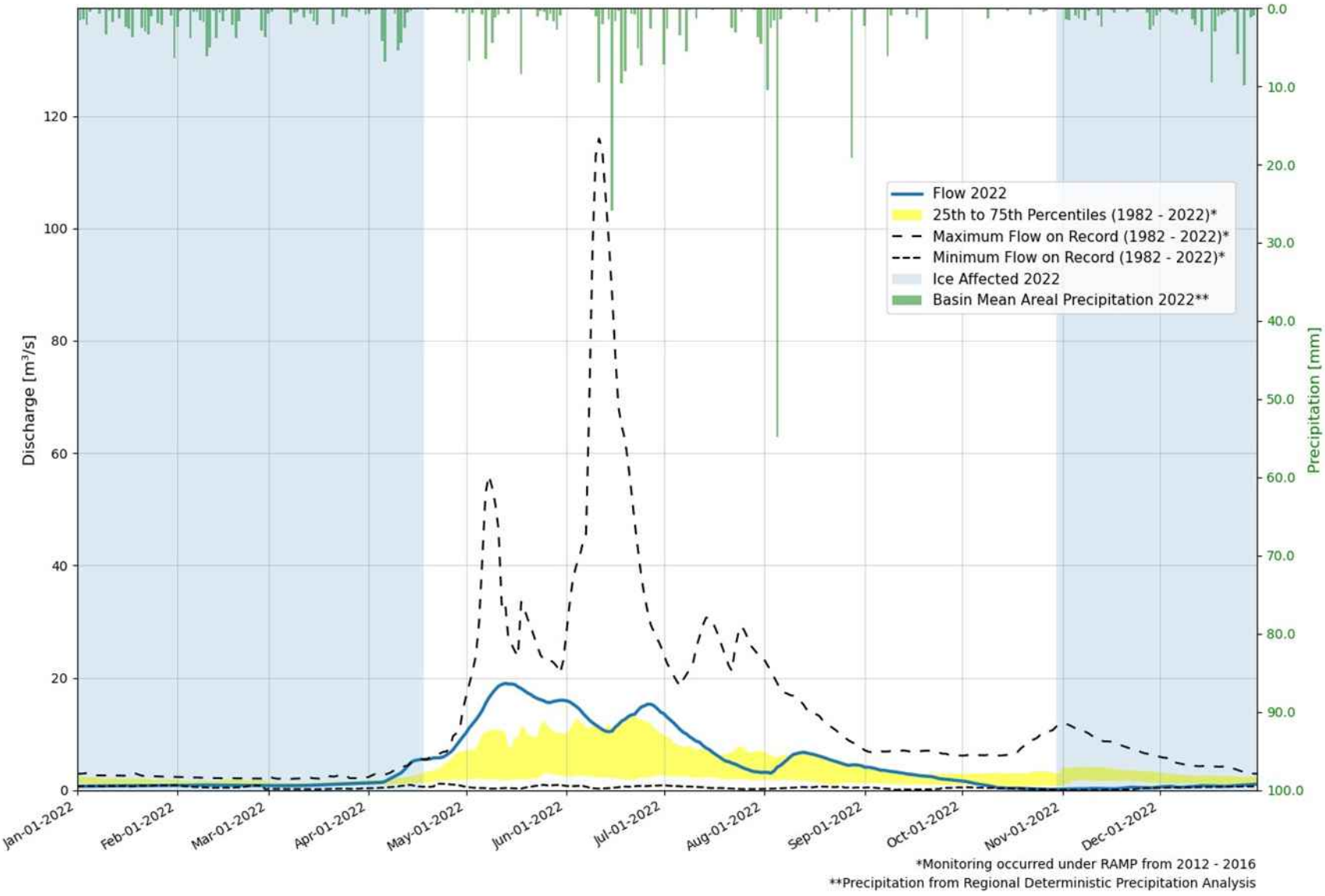

Figure C23: Jackfish River below Christina Lake (07CE005)

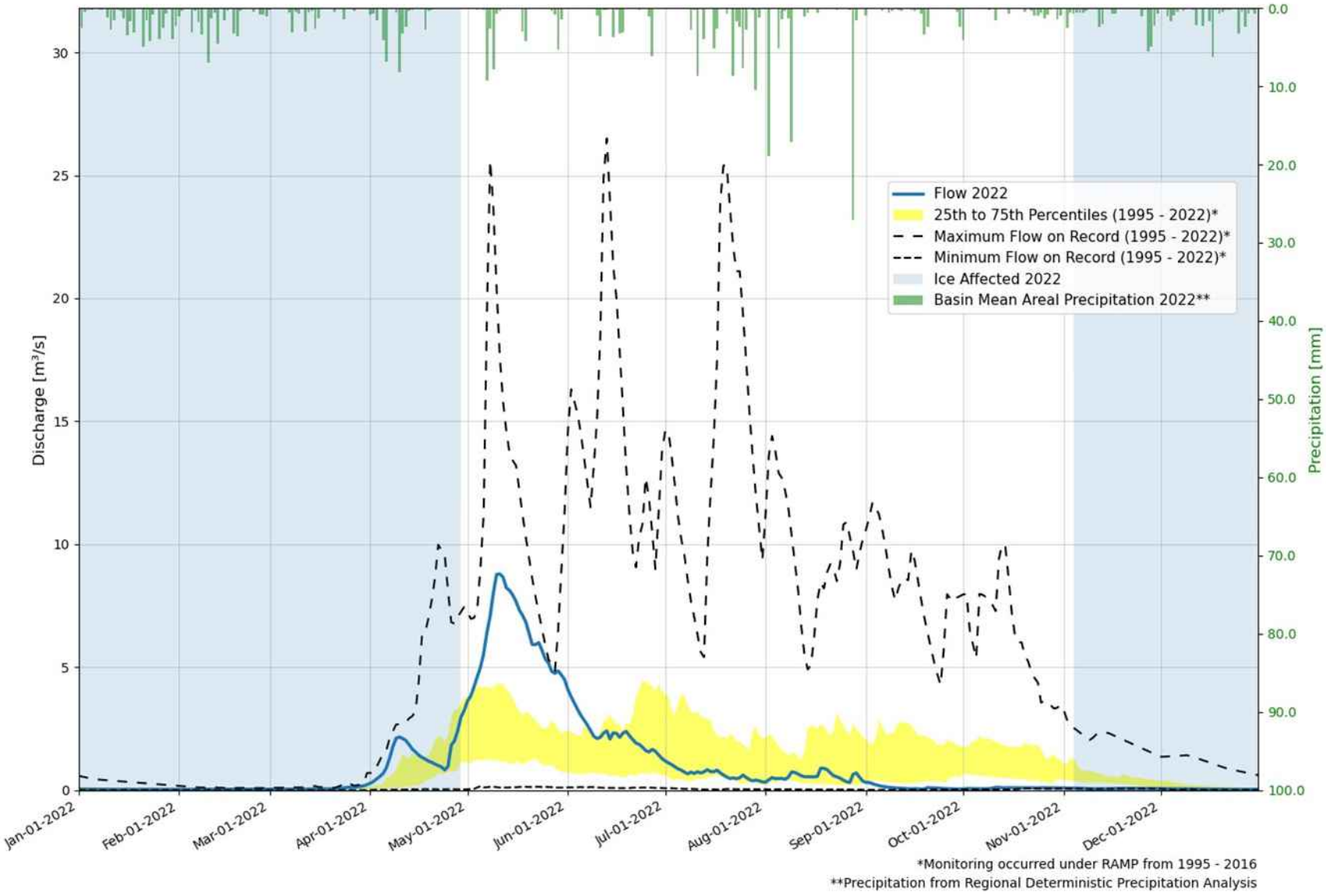

Figure C24: Jackpine Creek at Canterra Road (07DA026)

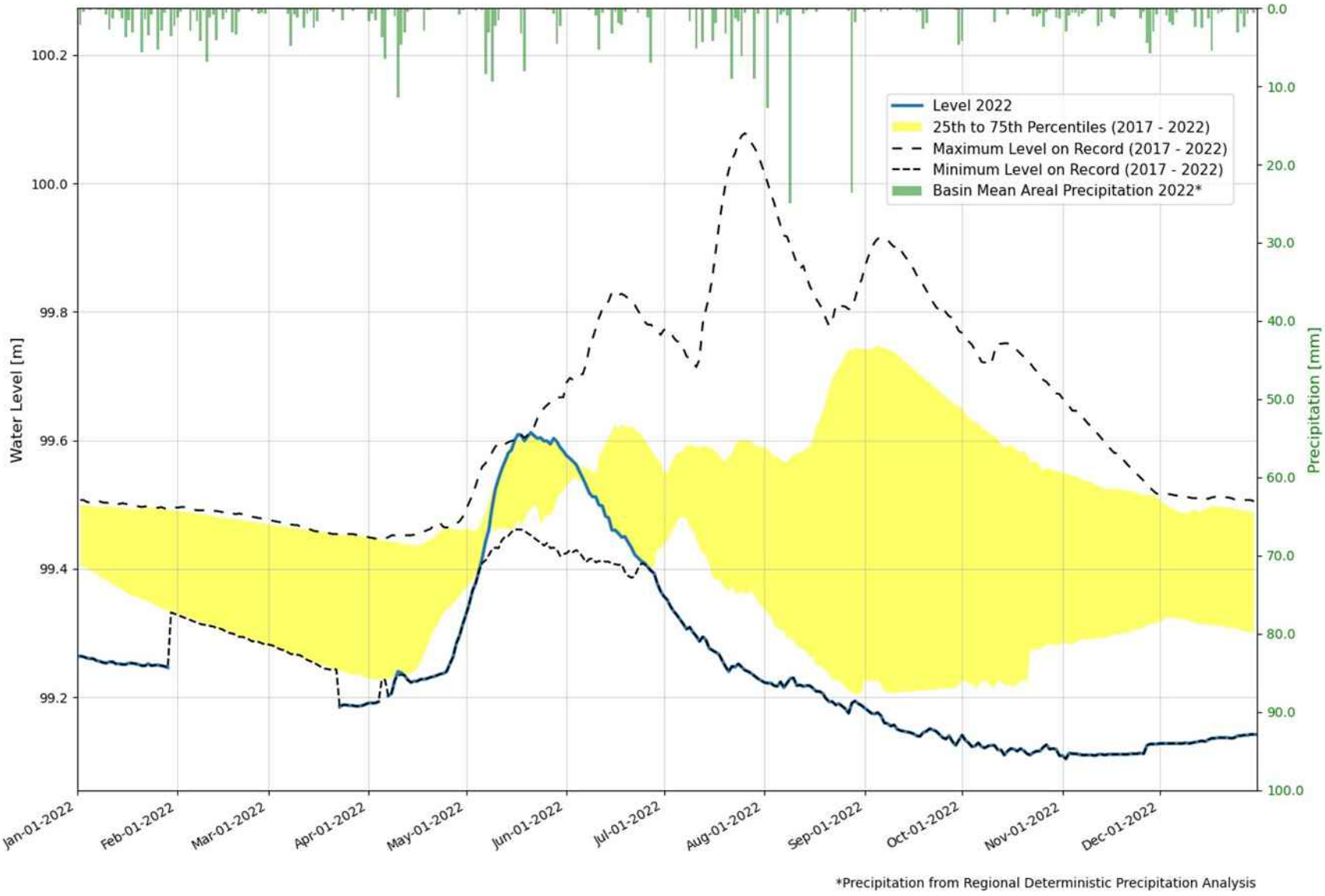

Figure C25: Kearl Lake at Canterra Road (07DA024)

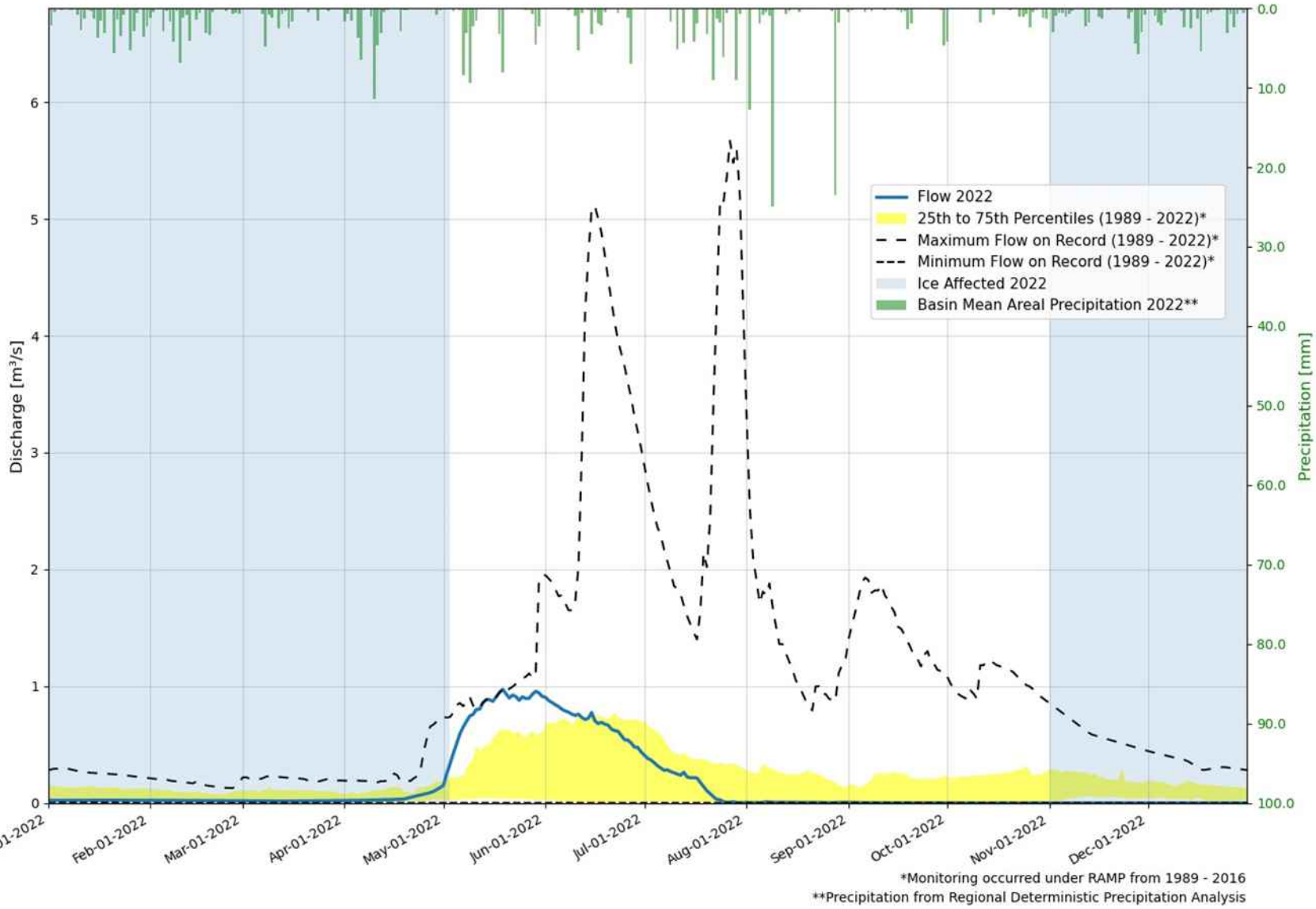

Figure C26: Kearl Lake Outlet (07DA030)

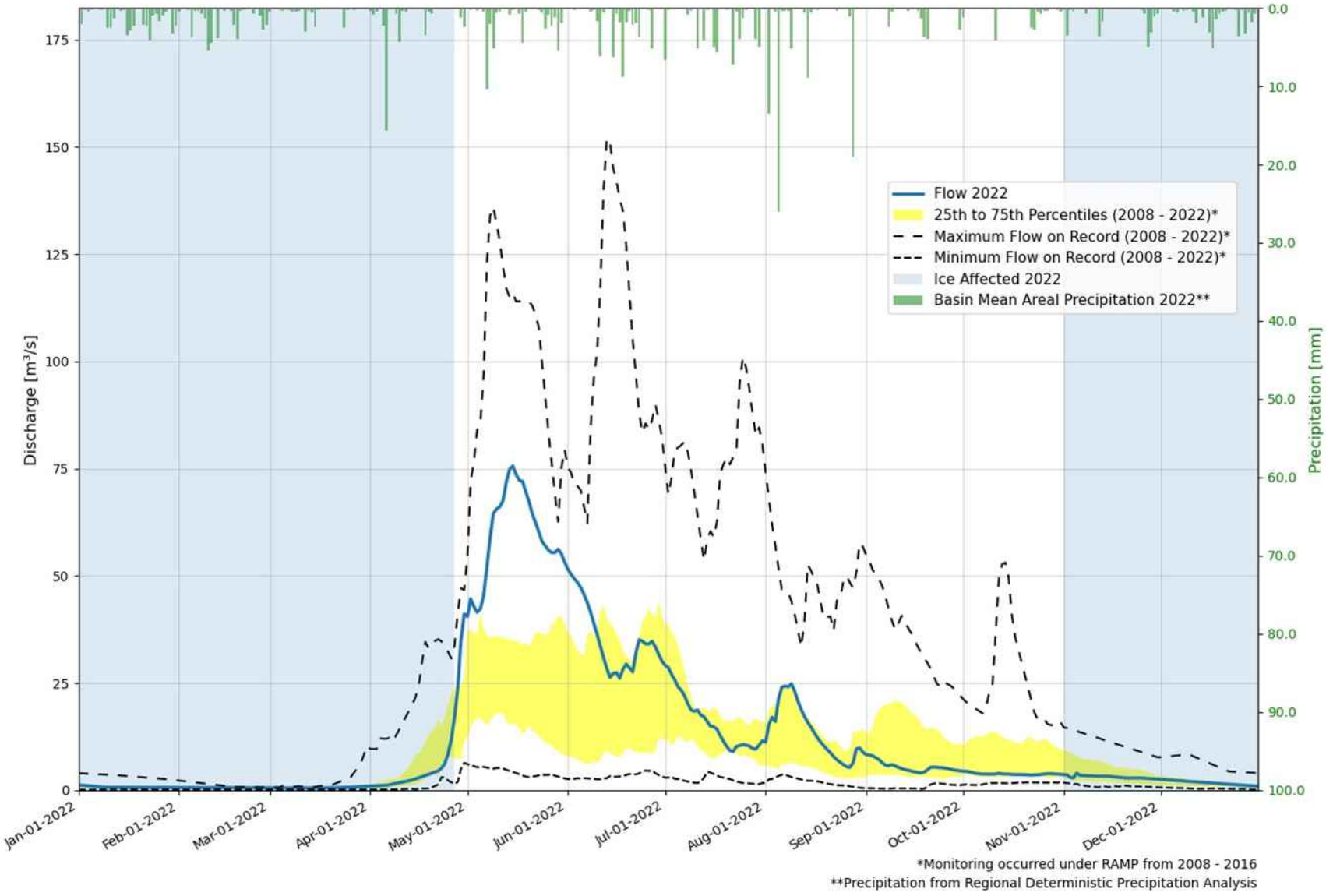

Figure C27: Mackay River at Petro-Canada Bridge (07DB006)

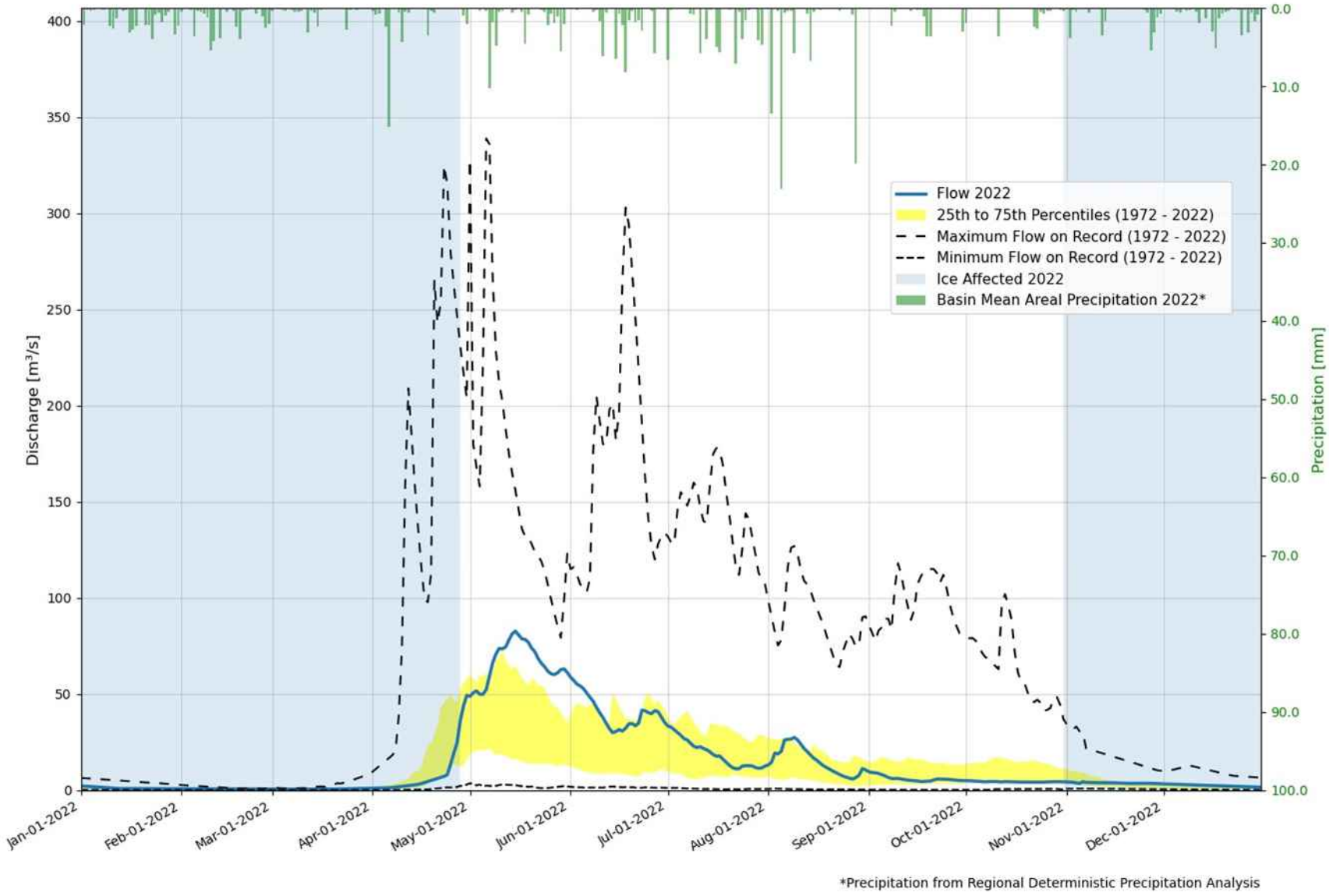

Figure C28: Mackay River near Fort Mackay (07DB001)

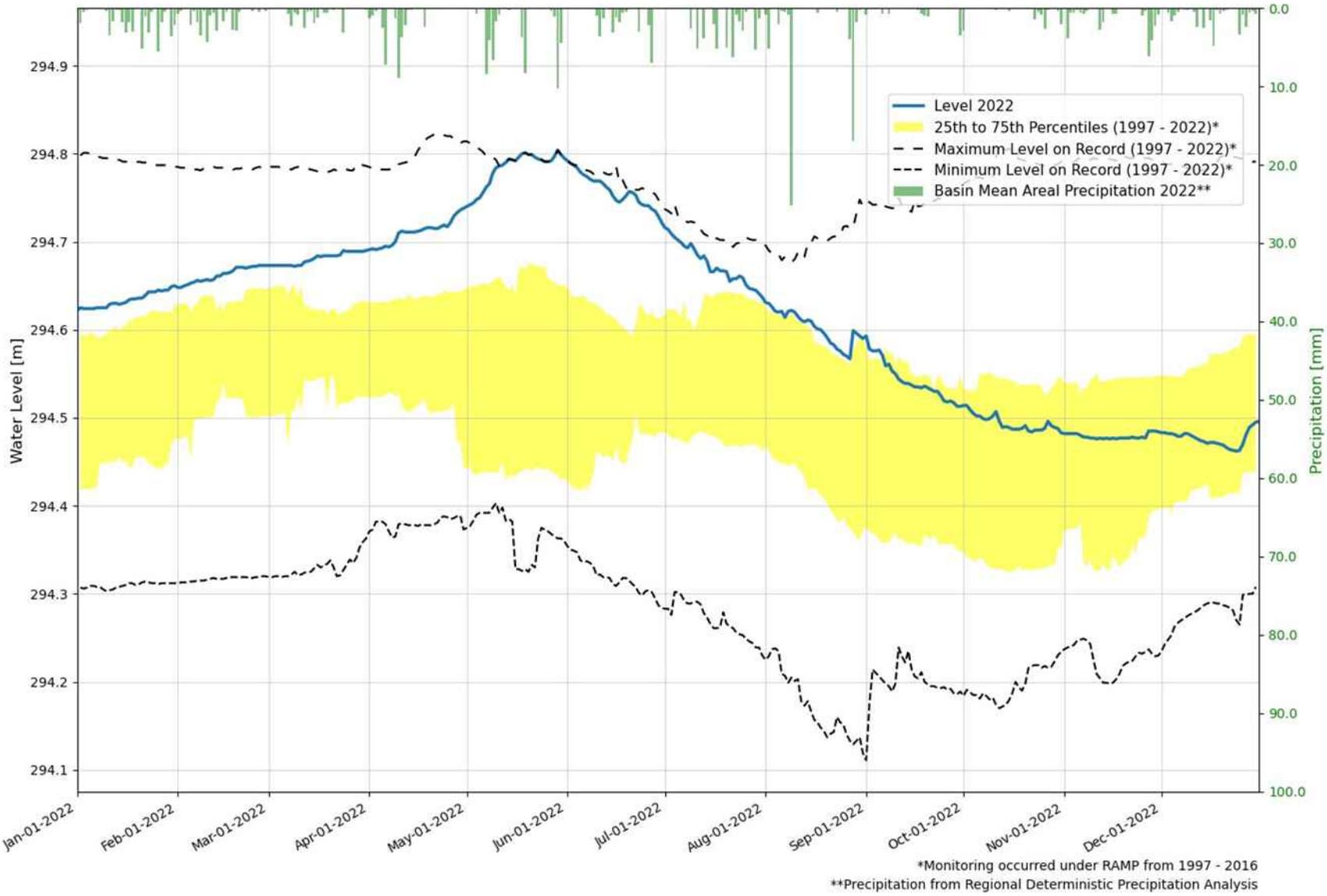

Figure C29: Mcclelland Lake at East End (07DA023)

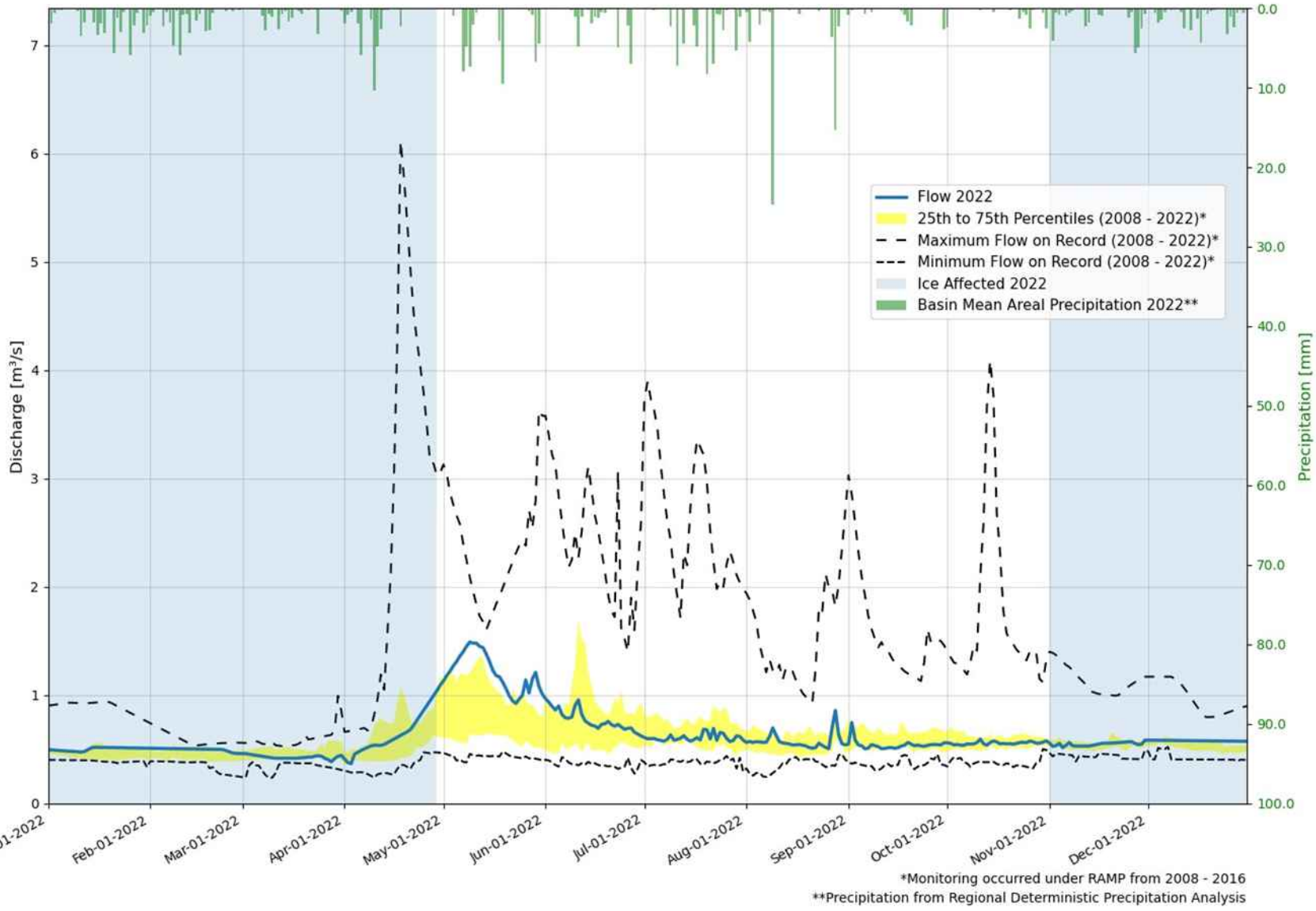

Figure C30: Mcclelland Lake Outlet above Firebag River (07DC004)

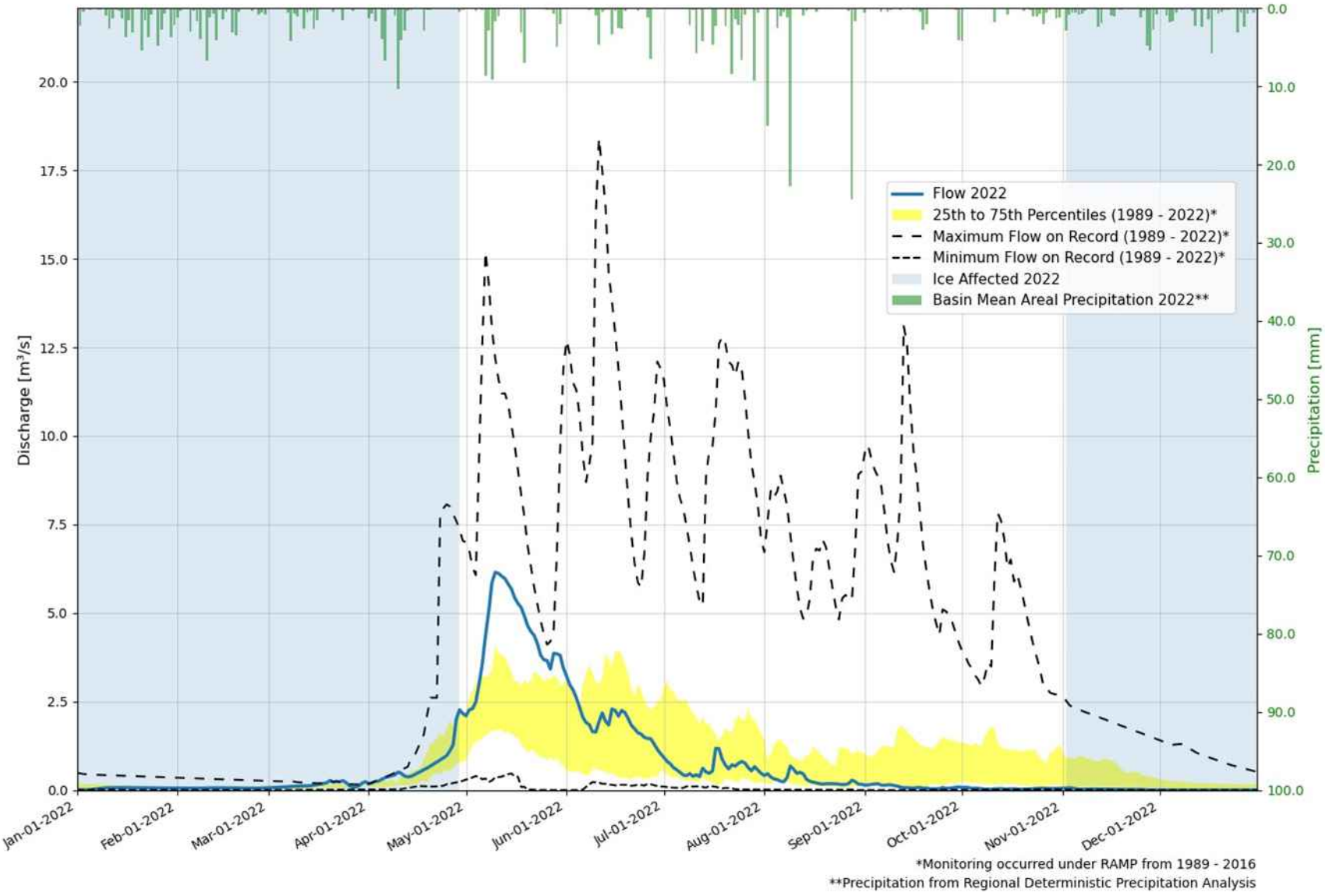

Figure C31: Muskeg Creek near the Mouth (07DA035)

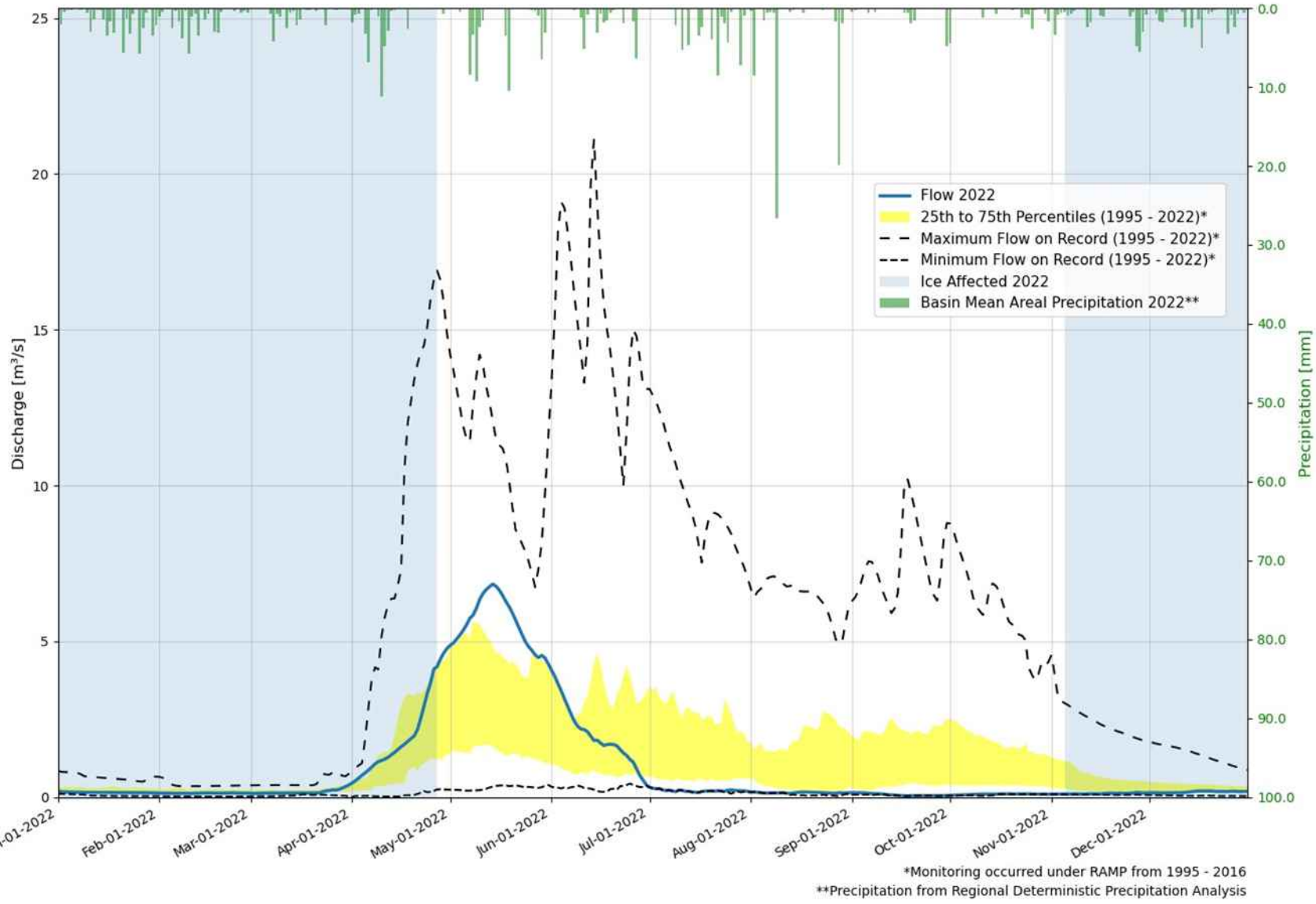

Figure C32: Muskeg River above Muskeg Creek (07DA029)

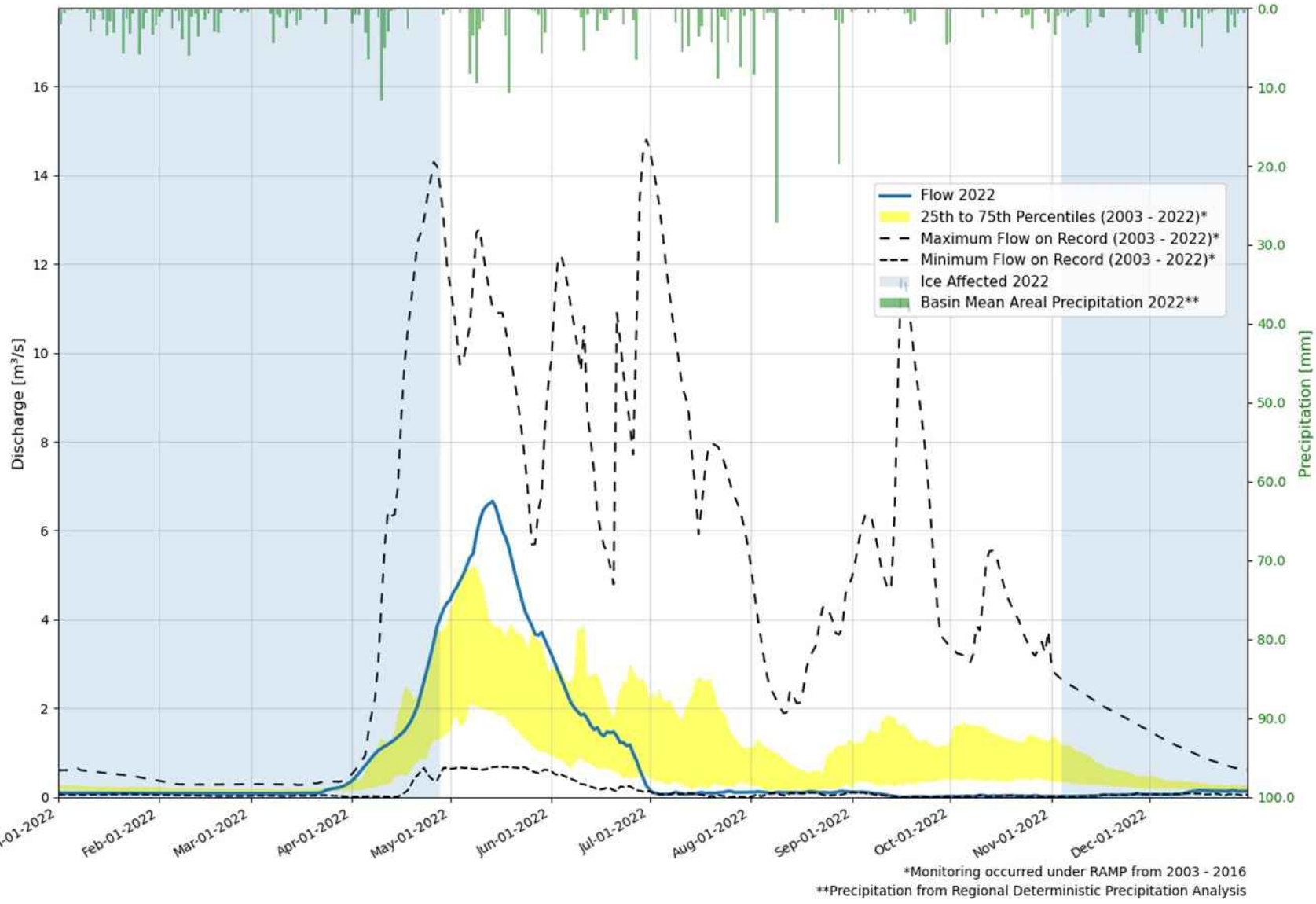

Figure C33: Muskeg River above Stanley Creek (07DA028)

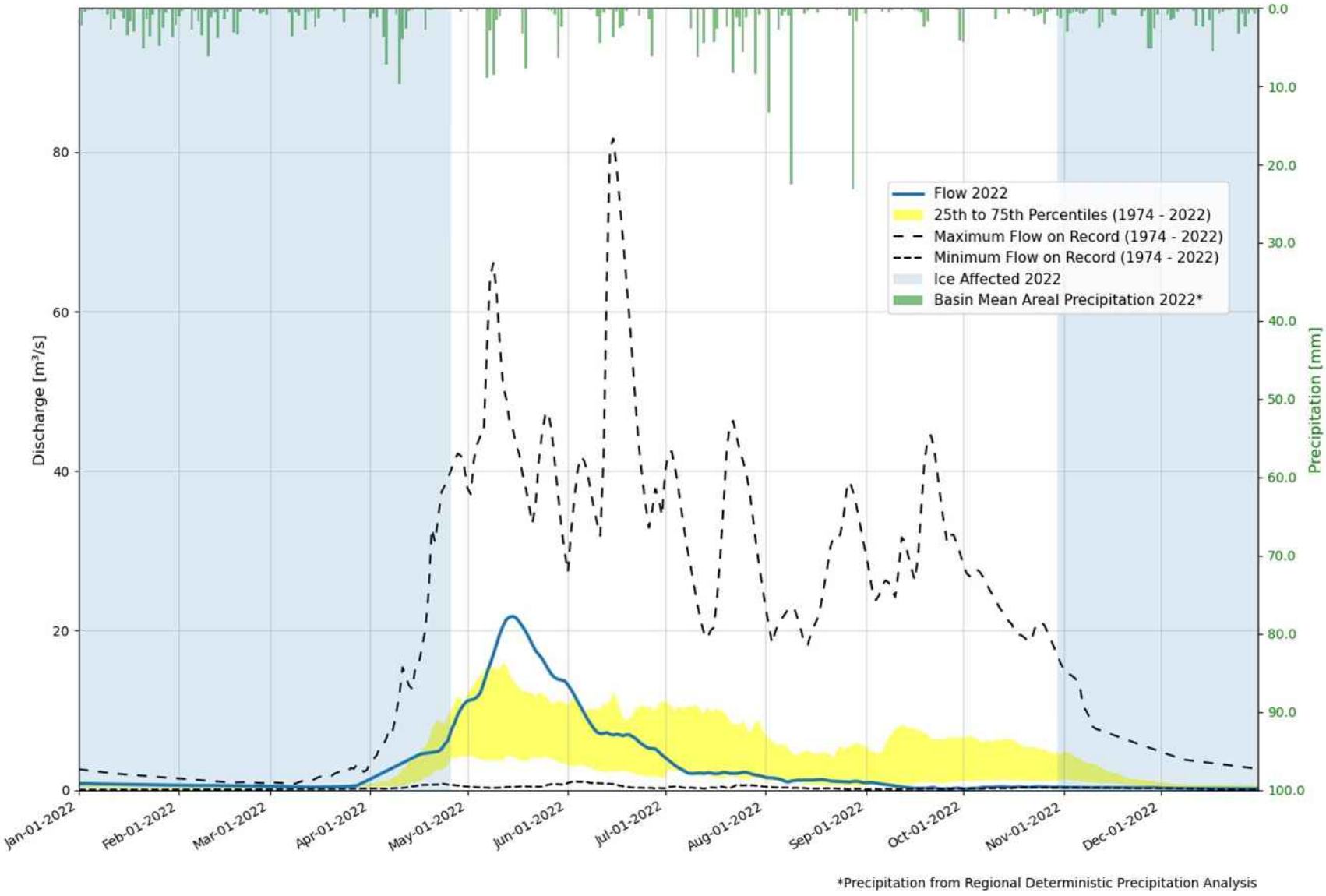

Figure C34: Muskeg River near Fort Mackay (07DA008)

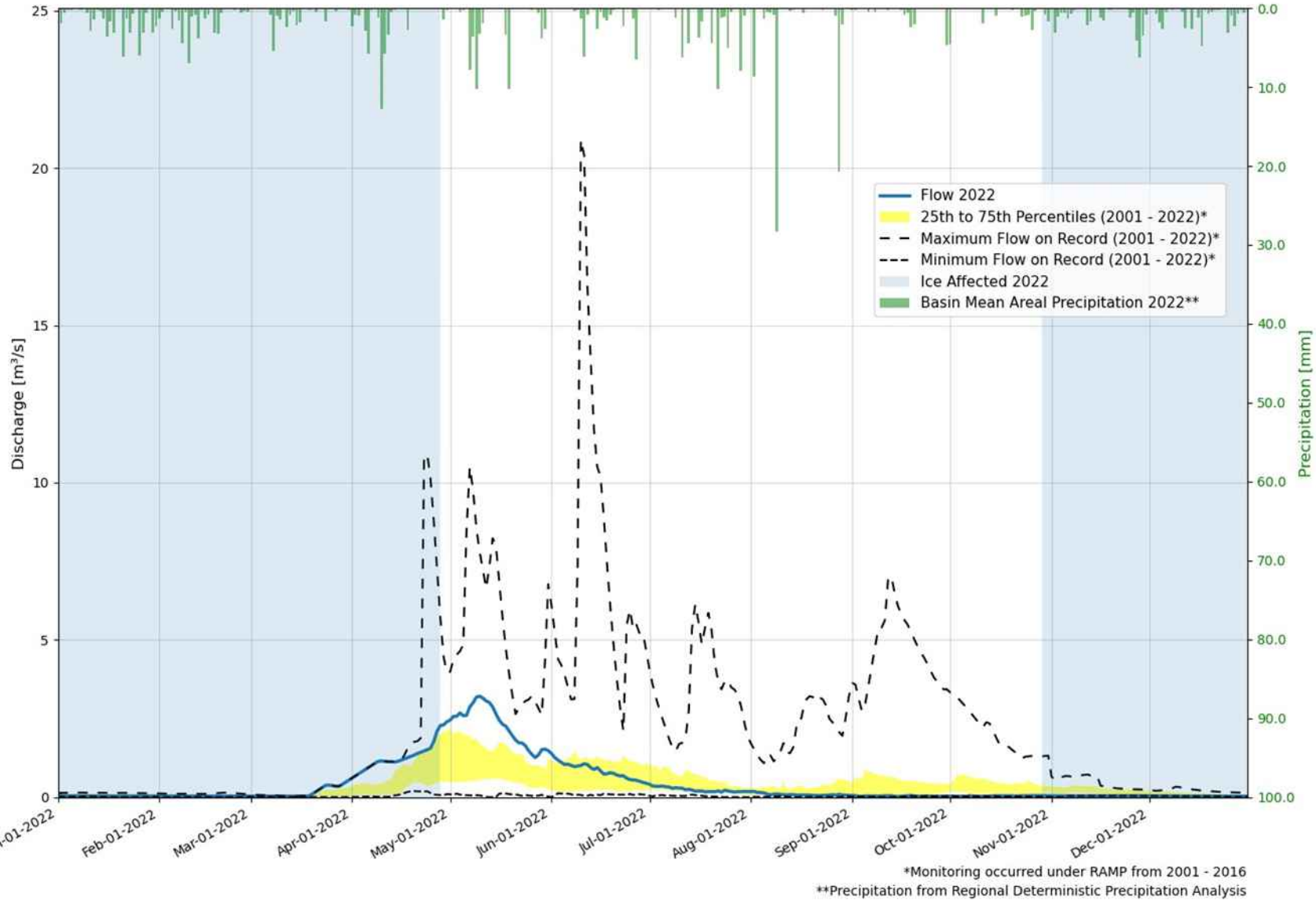

Figure C35: Muskeg River Upland (07DA034)

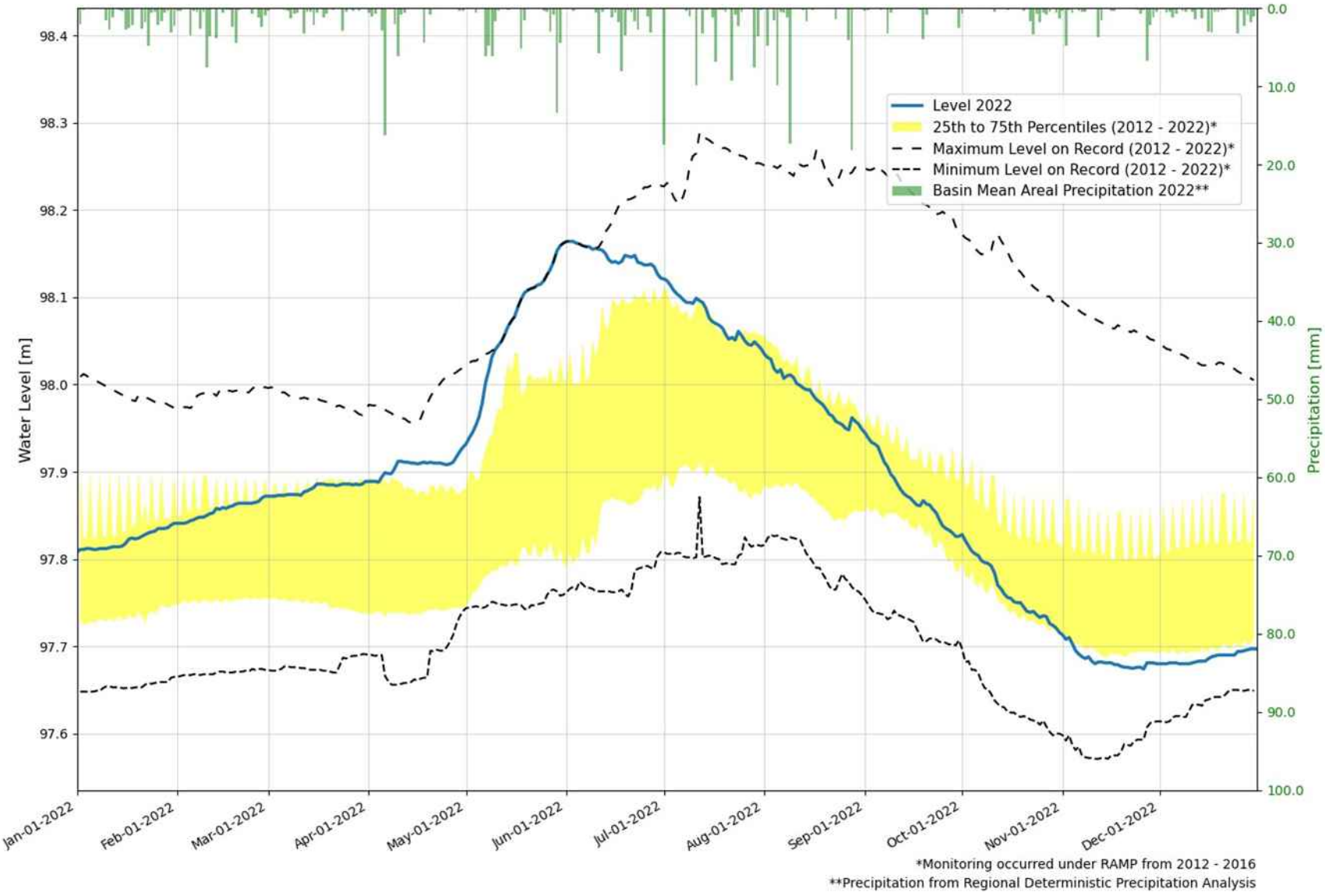

Figure C36: Namur Lake near the Outlet (07DA025)

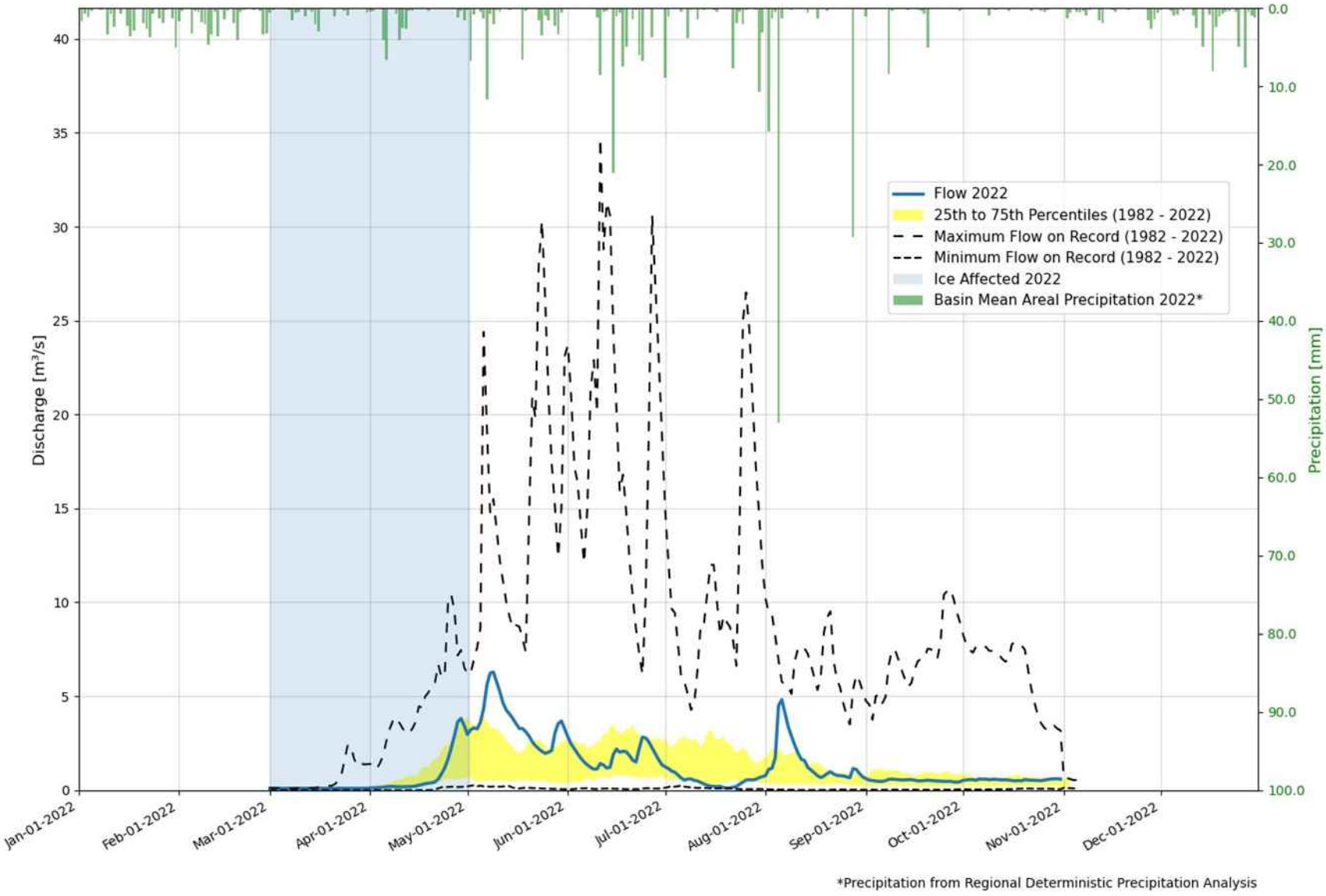

Figure C37: Pony Creek near Chard (07CE003)

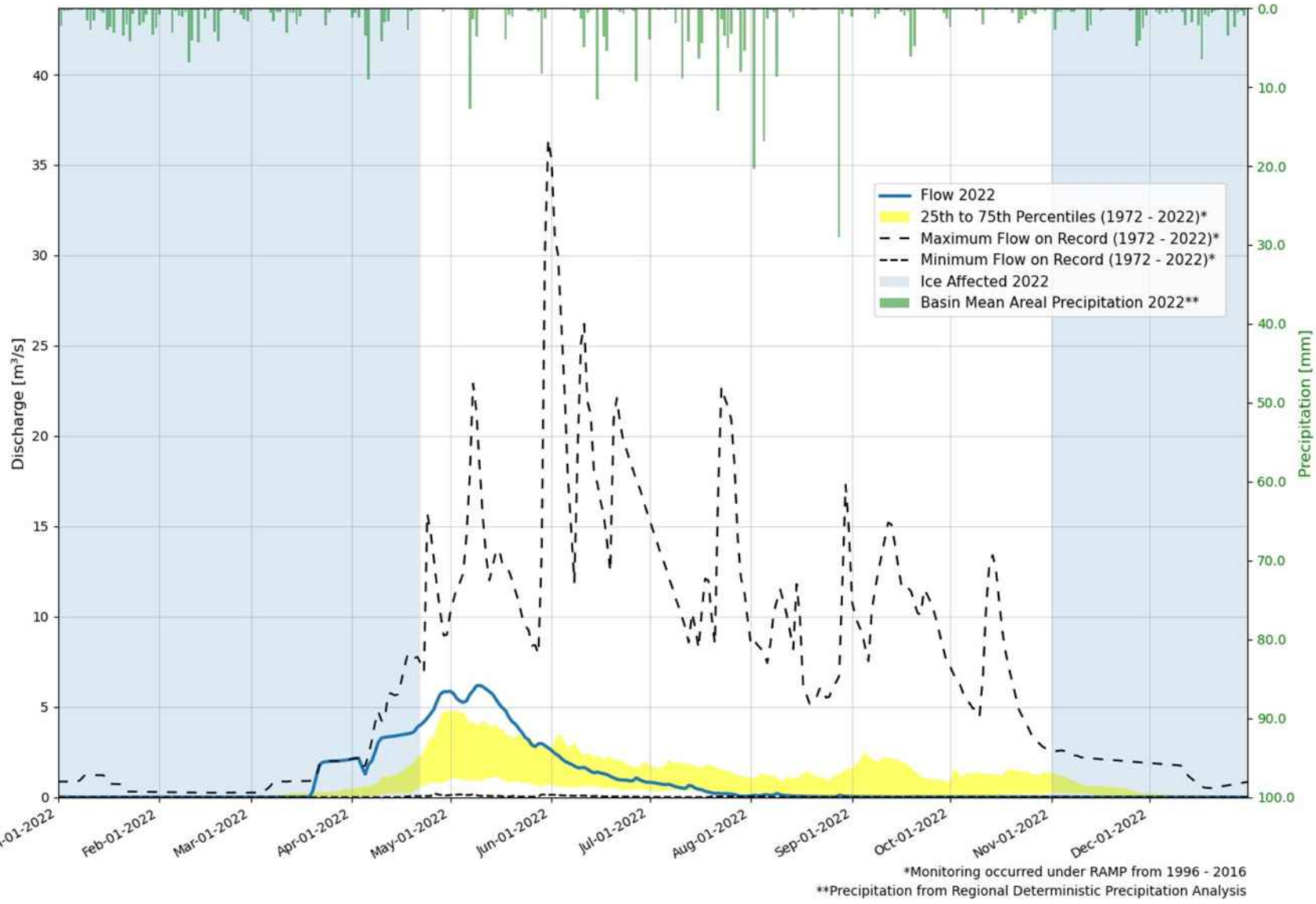

Figure C38: Poplar Creek near Fort Mcmurray (07DA007)

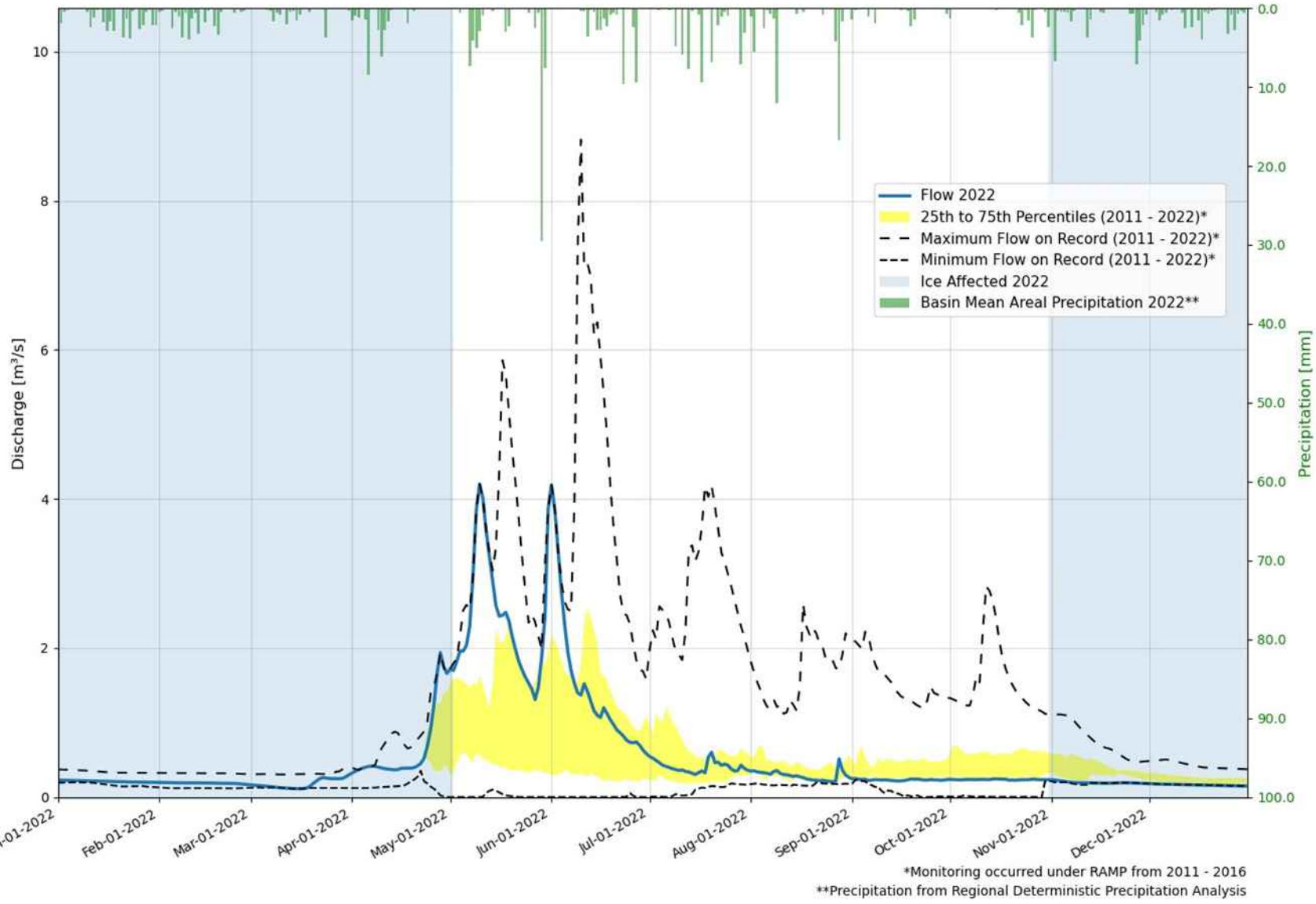

Figure C39: Red Clay Creek near the Mouth (07DA042)

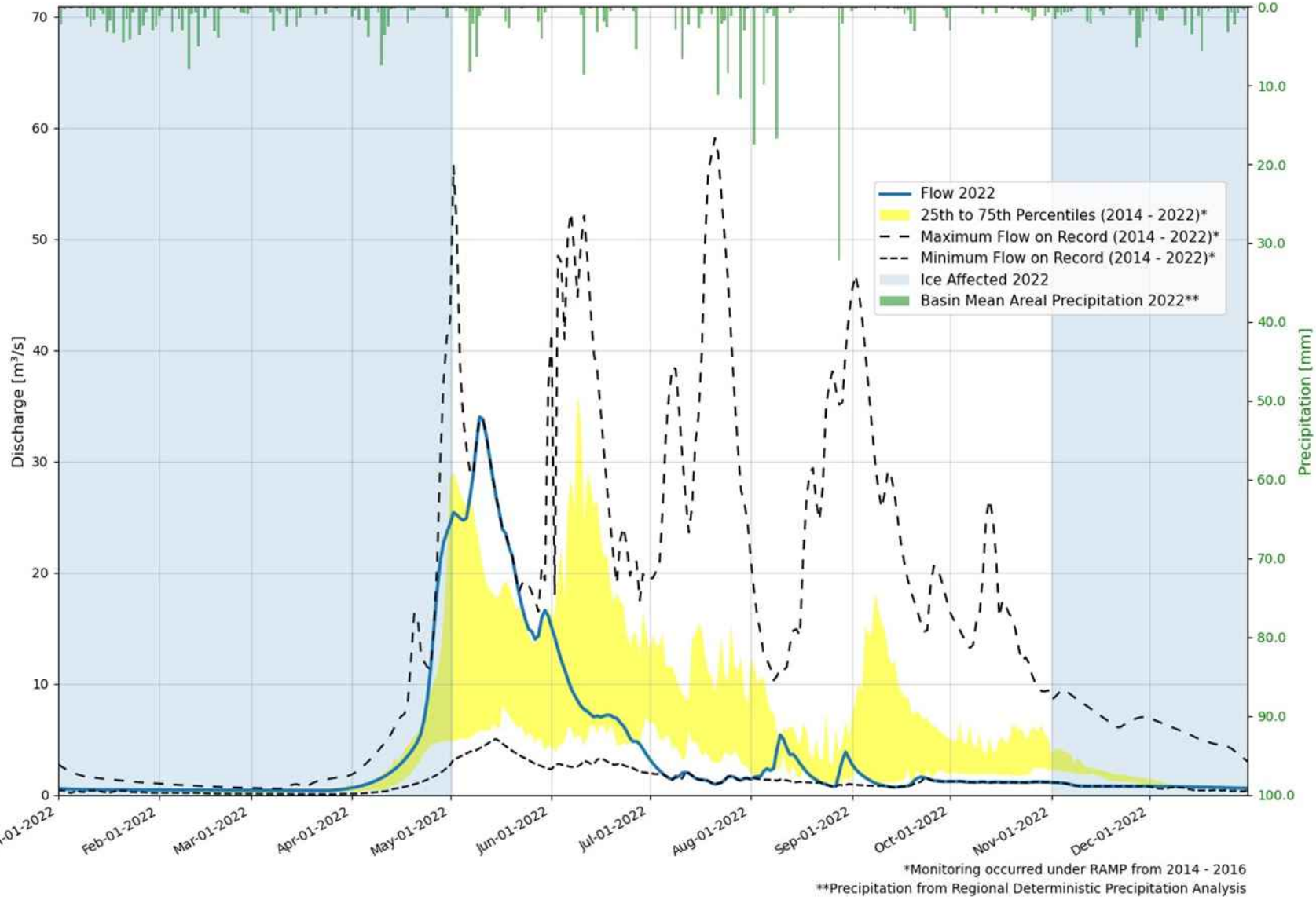

Figure C40: Steepbank River Below North Steepbank River (07DA044)

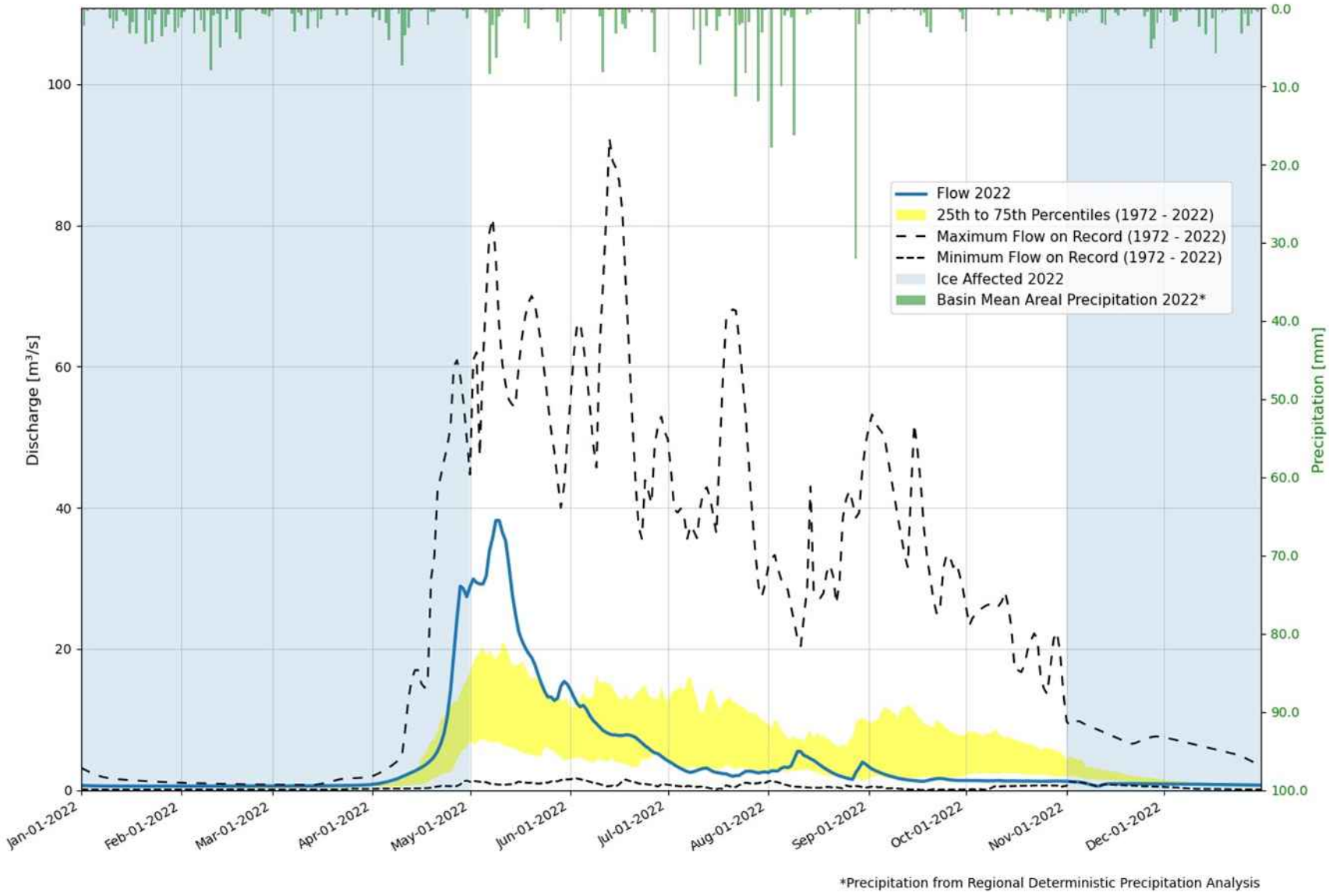

Figure C41: Steepbank River near Fort Mcmurray (07DA006)

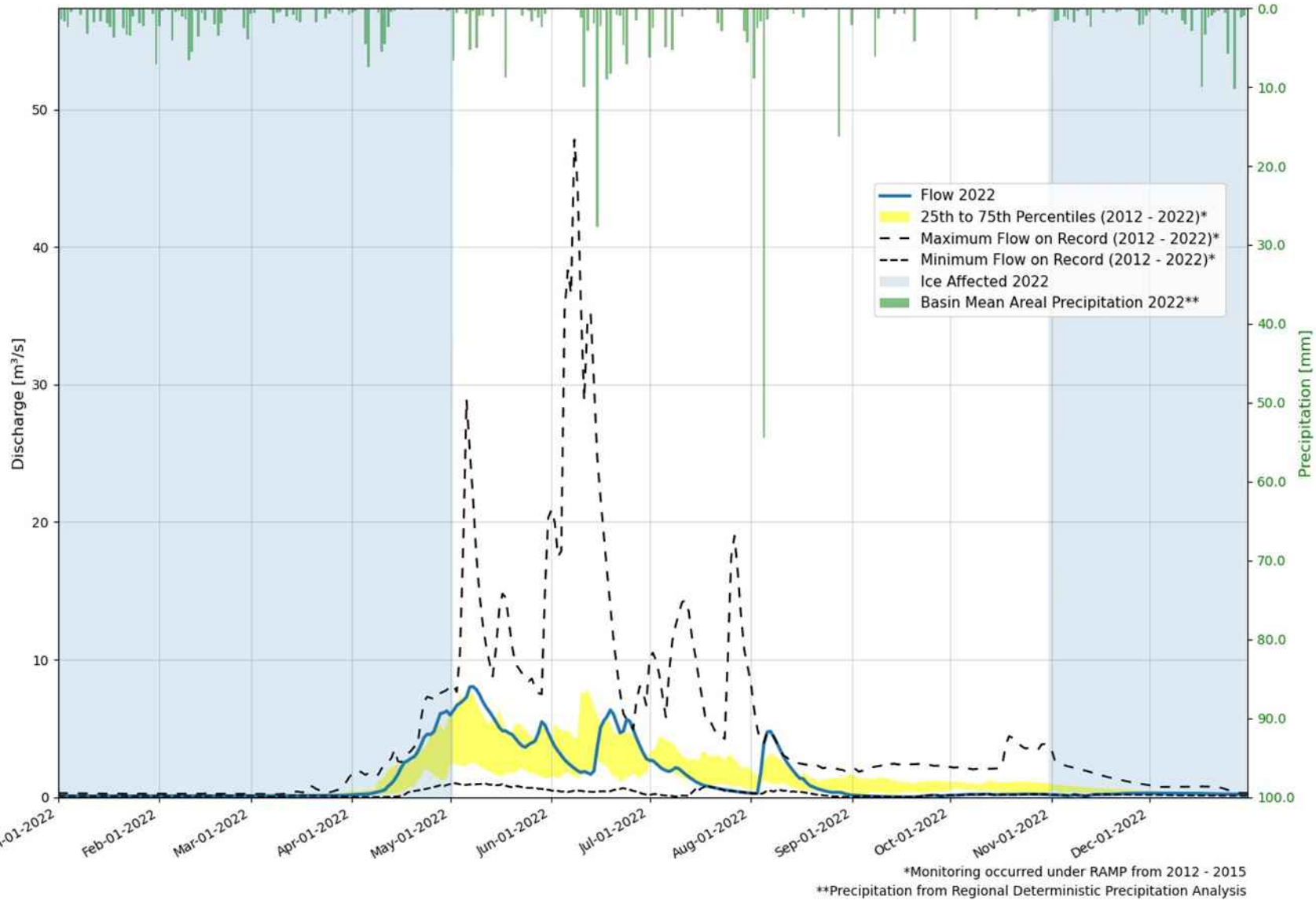

Figure C42: Sunday Creek above Christina Lake (07CE010)

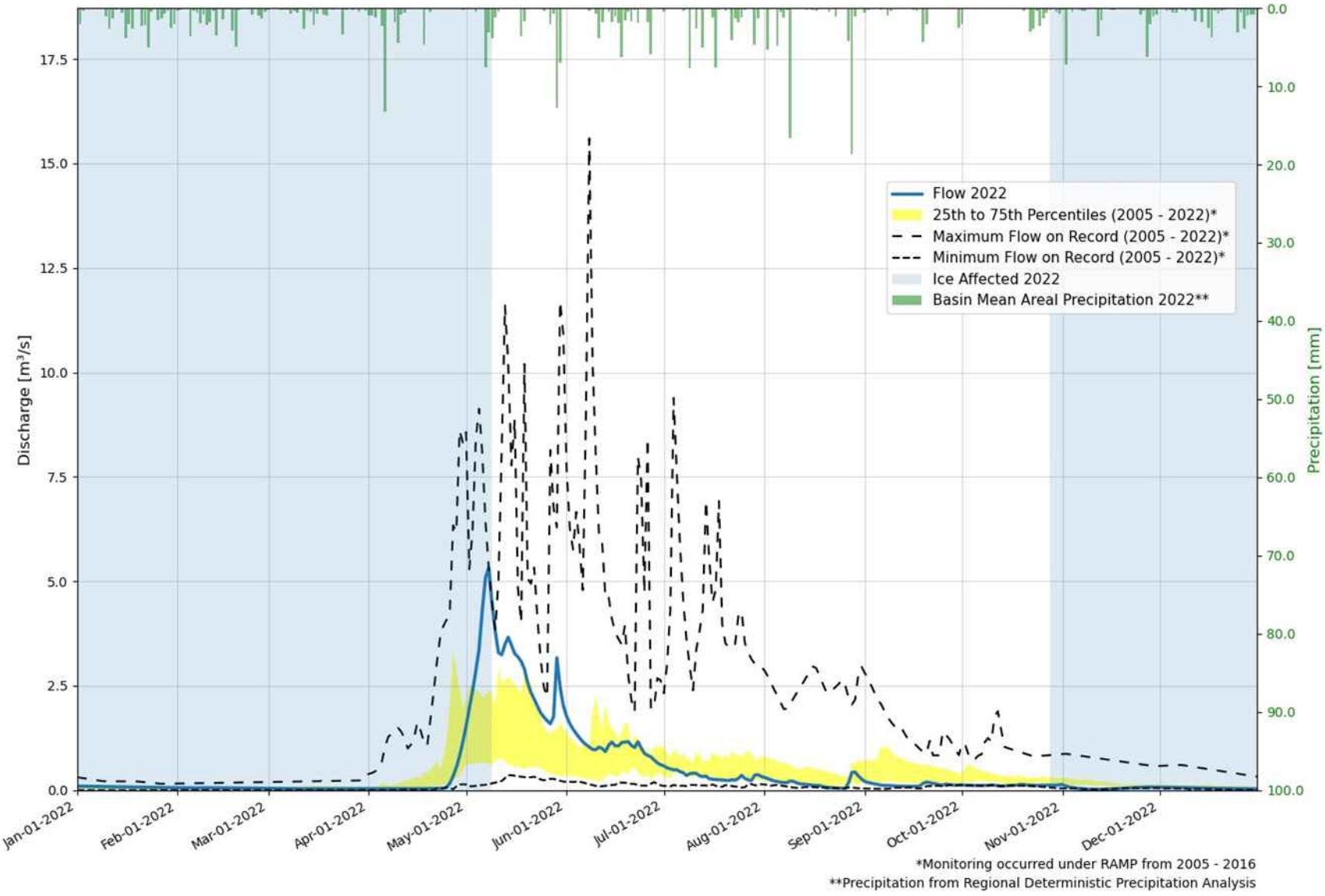

Figure C43: Tar River above Canadian Natural Resources Limited Lake (07DA037)

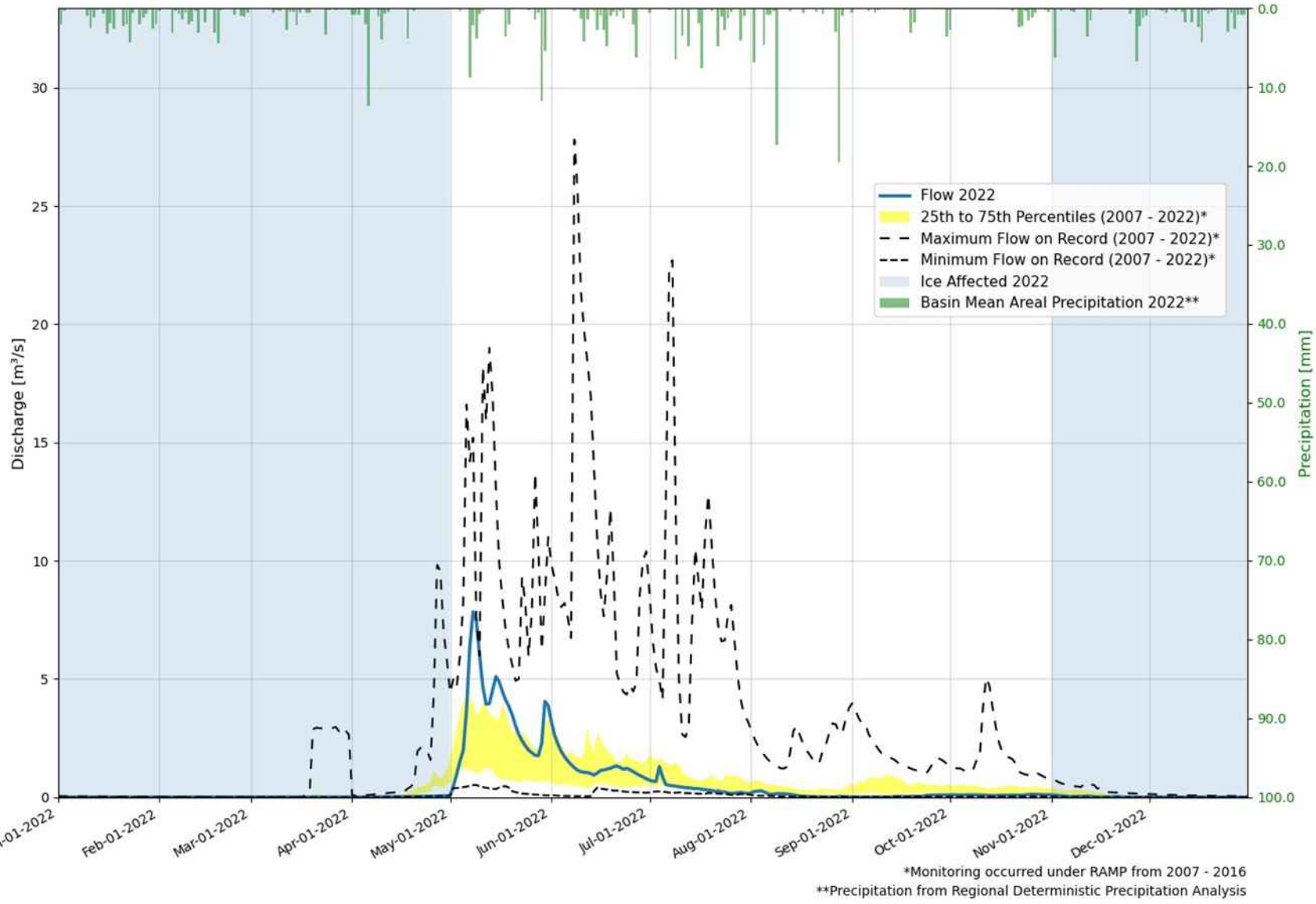

Figure C44: Tar River near the Mouth (07DA045)