Oil Sands Monitoring Program:

Summary of 2019 Hydrologic Conditions in the Alberta Oil Sands Area

Oil Sands Monitoring Program
Technical Report Series

Canada

OIL SANDS MONITORING PROGRAM

Alberta

Summary of 2019 Hydrologic Conditions in the Alberta Oil Sands Area

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

2019 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 2019. This report is the second annual publication intended to provide the public with an understanding of the hydrologic conditions that were present in the Oil Sands area in 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 Alberta 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 75 data requests received by WSC for OSM funded hydrometric stations between January 1st and December 31st of 2019. Of those data requests approximately 47% came from Consultants, 29% from Government/Utility Corps, 8% from Industry, 7% came from Academics, with the remaining 9% being of unknown affiliation.

There were 48 hydrometric gauging stations operated by WSC in the Oil Sands area in 2019 (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 2019 is provided in Appendix B, and annual hydrographs are provided for all active hydrometric stations in Appendix C.

Athabasca River at Athabasca (07BE001)

The hydrometric data for this station (Figure 1) indicates that ice break-up began in late March and ended in late April, with new maximum mean daily flows observed for March 27 through to April 12. This was the earliest spring peak on record for this station. The highest flow in 2019 occurred at the start of July due to a large precipitation event coinciding with glacial meltwater, and this peak was in the upper quartile for this time of year based on the historical record. For more than two thirds of the year, the measured flow was in the upper quartile of flows for this station. The 2019 mean flow of 608 m^3/s was nearly 50% higher than the historical mean annual flow of 423 m^3/s over this station's period of record (from 1913-2019). Precipitation measured in 2019 at the nearby Athabasca Climate Station was also greater (130%) than the historical mean annual precipitation.

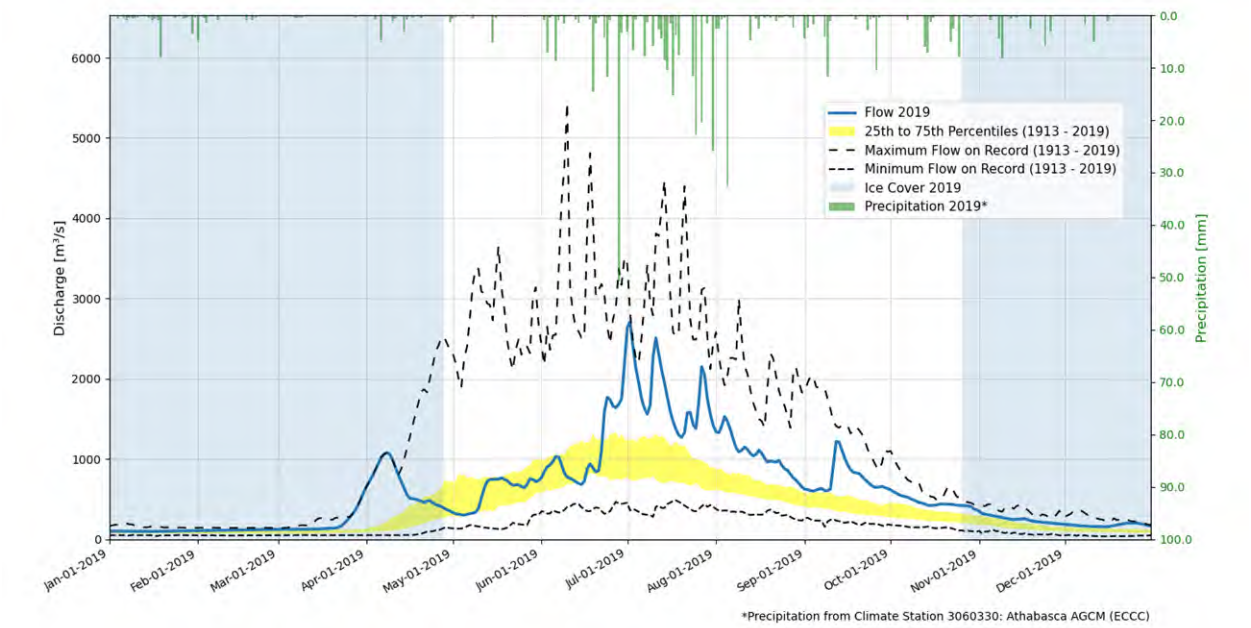

Figure 1: Annual Hydrograph for Station 07BE001 Athabasca River at Athabasca

Clearwater River above Christina River (07CD005)

Hydrometric data from this station can be used as an indicator station for tributary contributions to the Athabasca River upstream of Fort McMurray. The 2019 hydrometric data for this station (Figure 2) shows that ice break-up began in late March and ended in late April. The peak flow for 2019 was experienced in late August due to a large precipitation event and was in the upper quartile for that date based on the historical record. Between the ice break-up and August peak, flows were in the lower quartile; and after the recession of the August peak, the flow remained within the normal range for this station. The 2019 mean flow of 76.2 m^3/s is comparable to the historical mean annual flow of 73.8 m^3/s over this station's period of record (from 1966-2019). Precipitation measured in 2019 at the nearby Gordon Lake Lookout Climate Station was slightly less (94.0%) than the historical mean annual precipitation.

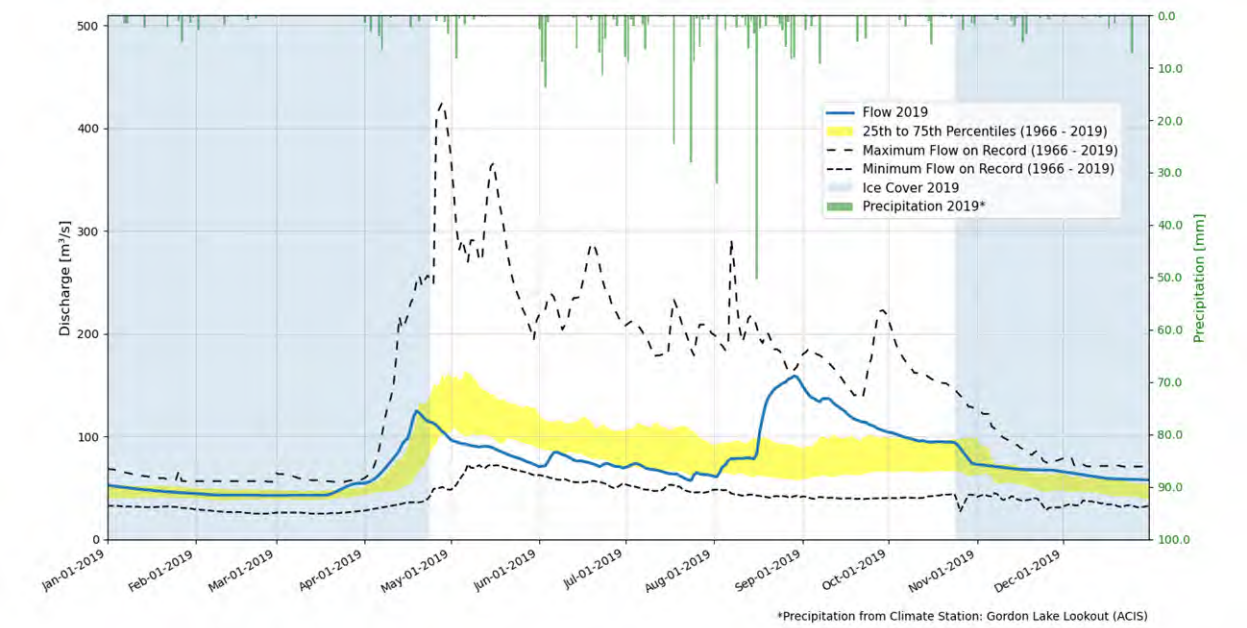

Figure 2: Annual Hydrograph for Station 07CD005 Clearwater River above Christina River

Athabasca River below Fort McMurray (07DA001)

The hydrometric data for this station (Figure 3) indicates that ice break-up began in late March and ended in early May, the earliest spring peak on record for this station. The peak flow for 2019 occurred at the start of July due to precipitation coinciding with glacial meltwater, and was in the upper quartile based on the historical record. For most of the year, the flow was in the upper quartile range of flows for this station. The 2019 mean flow of 795 m^3/s was nearly 30% higher than the historical mean annual flow of 620 m^3/s over this station's period of record (from 1957-2019). Precipitation measured in 2019 at the nearby Fort McMurray Climate Station was also greater (113%) than the historical mean annual precipitation.

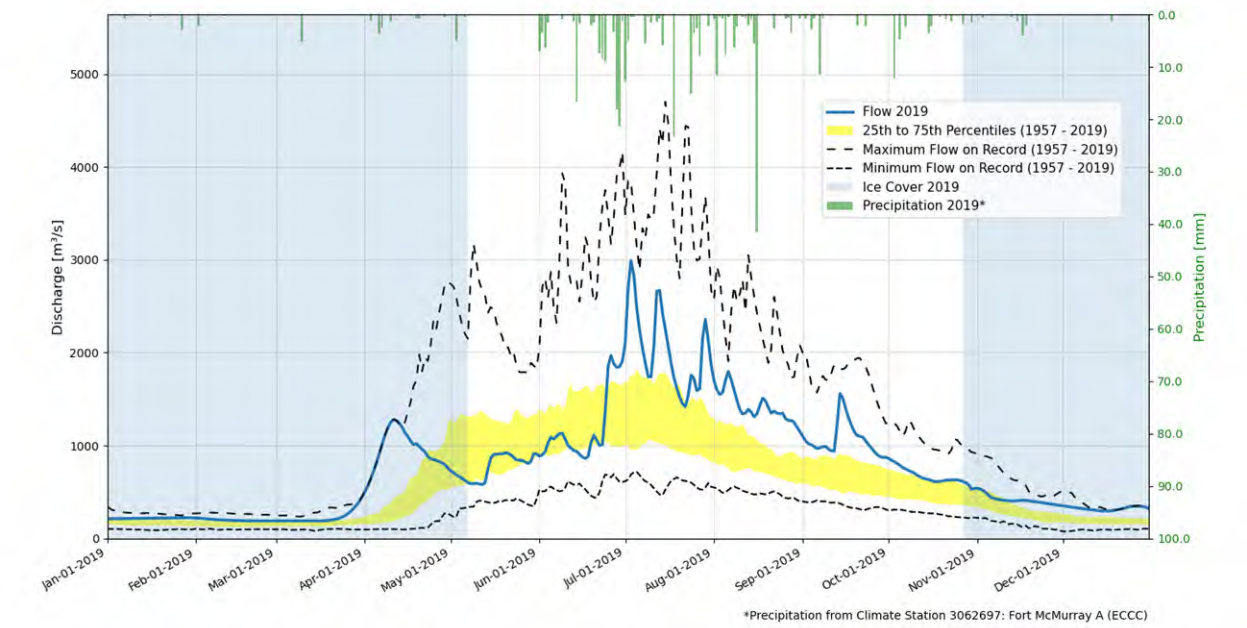

Figure 3: Annual Hydrograph for Station 07DA001 Athabasca River below Fort McMurray

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 2019. Annual hydrographs for these individual gauging stations are included in Appendix C.

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)

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

The majority of the eastern tributaries in the Oil Sands area experienced normal discharges at breakup compared to previous years on record. These tributaries also all recorded low to normal discharges throughout the year, other than in late August where they experienced their peak flows due to precipitation. Overall, the 2019 mean discharge in the eastern tributaries downstream of Fort McMurray was less than the historical mean annual discharge (88.7%, on average).

The majority of western tributaries also experienced normal discharges at break-up compared to previous years on record. The western tributaries recorded low to average discharge throughout most of 2019 and, with the exception of the Calumet River, in late August and September experienced higher than average discharge due to precipitation. Overall, the 2019 mean discharge in the western tributaries was lower than the historical mean annual discharge (88.1%, on average).

Athabasca River at Embarras Airport (07DD001)

The hydrometric data for this station (Figure 4) indicates that spring break-up of ice began late March and ended mid April, the earliest spring peak on record for this station, setting several new maximum mean daily flows between March 31 and April 15 . Between the ice break-up and July, flows were low to normal for this station; however, due to precipitation coinciding with glacial meltwater, high peaks were observed in July and the flow remained in the upper quartile for the remainder of the year. The 2019 mean flow of 879 m^3/s is 20% higher than the historical mean annual flow of 714 m^3/s over this station's period of record (from 1971-2019). Precipitation measured in 2019 at the nearby Meteorological Tower 1007 was lower than average at 90.1% of the historical mean annual precipitation.

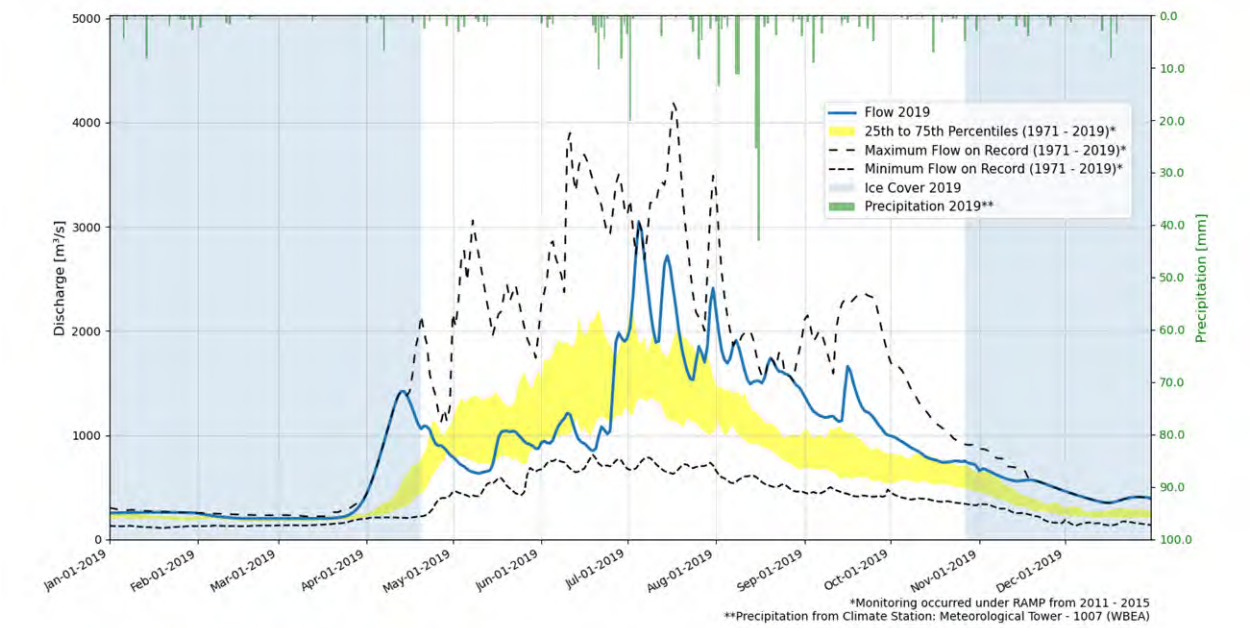

Figure 4: Annual Hydrograph for Station 07DD001 Athabasca River at Embarras Airport

Summary

In 2019 all four indicator stations measured higher than average spring flows in mid to late April, with the Athabasca River stations having the earliest spring peaks on record. Following ice break-up, the discharge measured at these stations followed low to normal variability until July (August for Clearwater River), when precipitation events caused high peaks in discharge and the discharge to remain mostly in the upper quartile range for the remainder of the year.

Local contributions downstream of Fort McMurray were separated into the eastern and western tributaries. The eastern and western tributaries showed normal spring breakup, with lower than average discharge through the remainder of the year. The majority of the eastern and western tributaries also saw higher than average summer peaks due to precipitation. Overall, the 2019 mean discharge in the eastern and western tributaries was less than the mean annual discharge over the period of record, 88.7% and 88.1% on average respectively.

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/.

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

Appendix A:
Overview Maps – Alberta Oil Sands Area

Figure A1 shows all active hydrometric monitoring stations operated by WSC in 2019. Figure A2 shows all climate stations used to represent precipitation on the annual hydrographs included in the main body of this report and in Appendix C. Climate data was obtained from a number of sources, including Environment and Climate Change Canada (ECCC), Alberta Climate Information Service (ACIS), the Wood Buffalo Environmental Association (WBEA), and the Regional Aquatics Monitoring Program (RAMP).

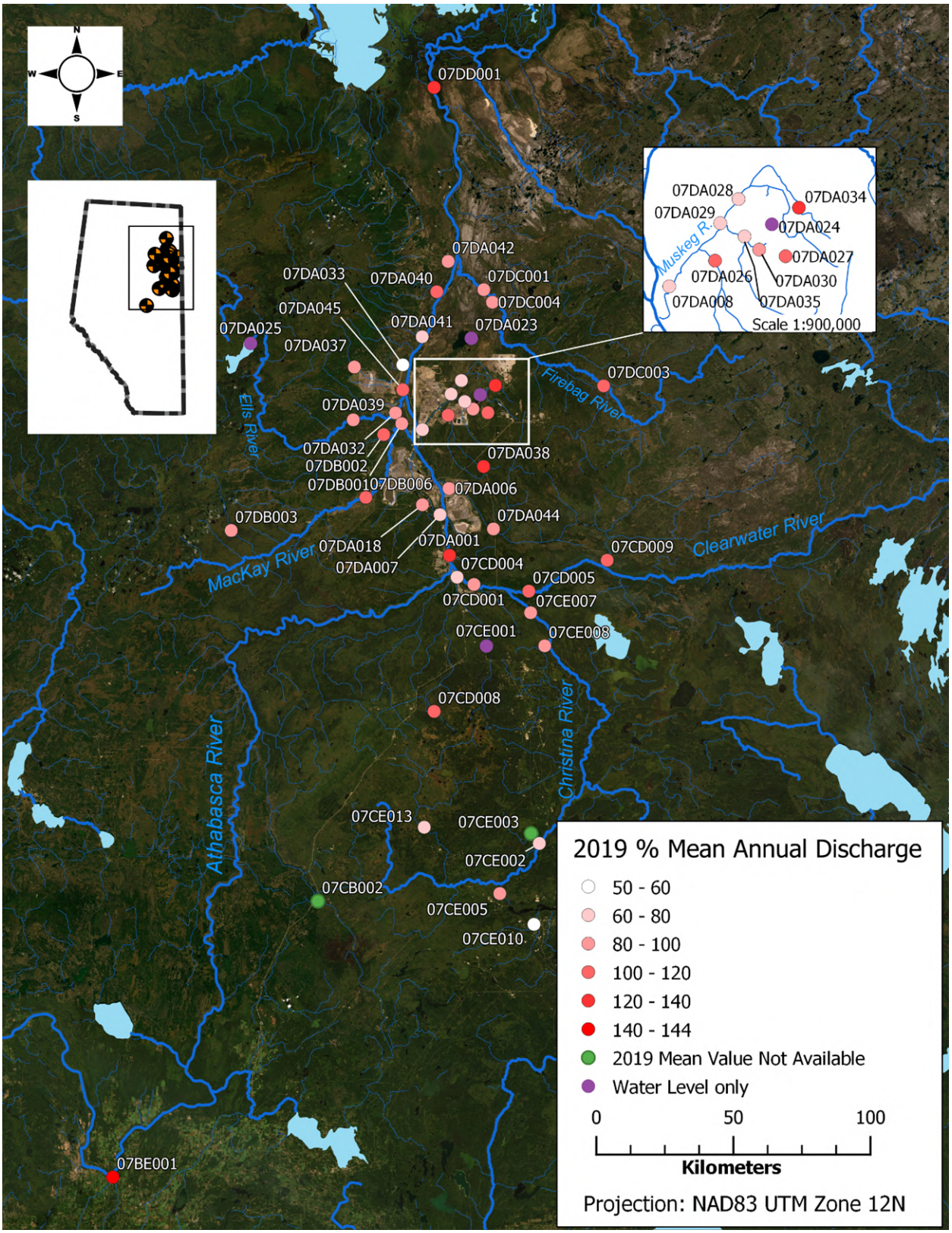

Figure A1: Active Hydrometric Stations in the Alberta Oil Sands Area in 2019

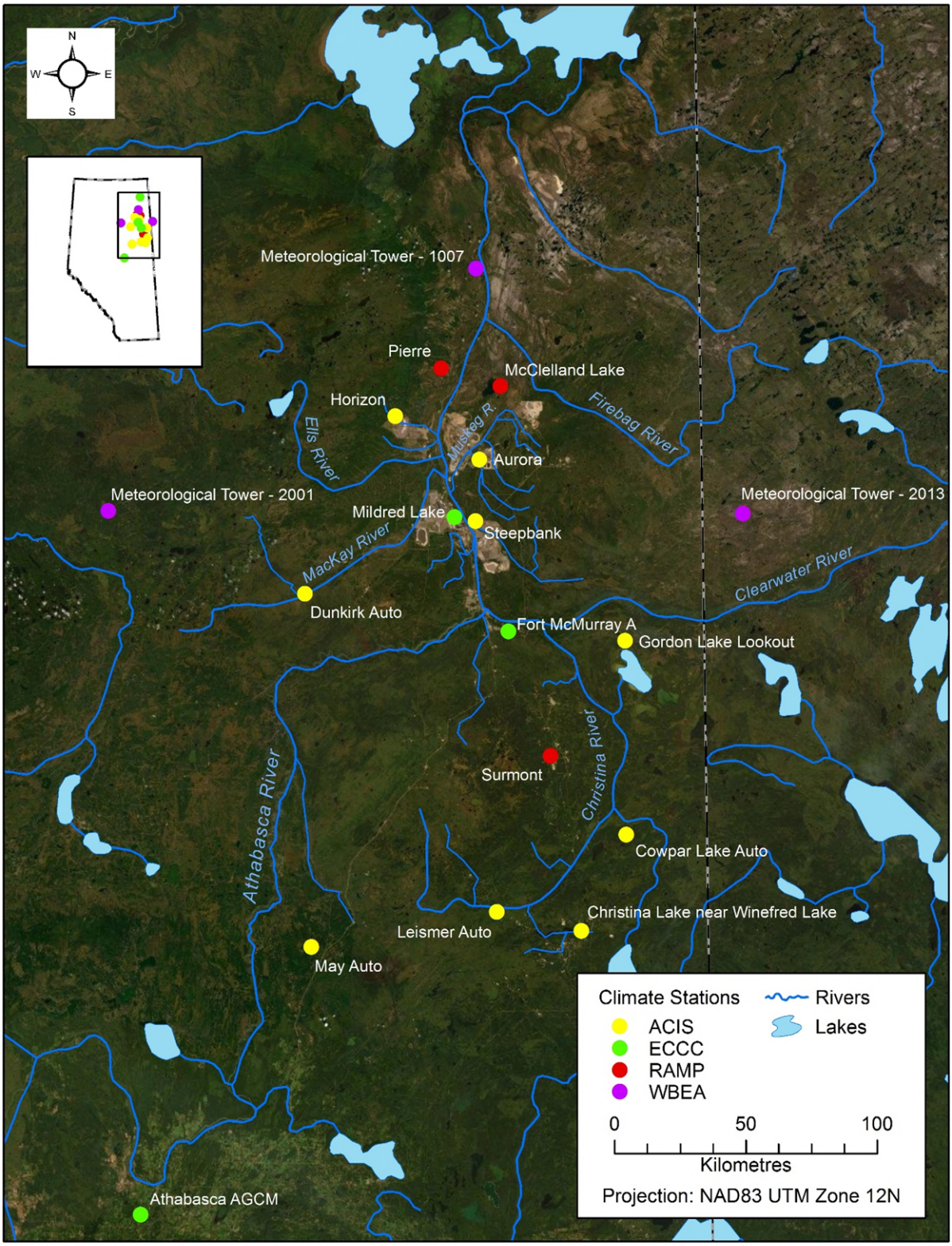

Figure A2: Climate Stations in the Alberta Oil Sands Area used in producing this Annual Report

Appendix B:
Summary – All Hydrometric Stations

The following tables summarize all active WSC hydrometric stations within the Oil Sands area in 2019. 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 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 Station Summary

STATION NAME	STATION ID	PERIOD OF RECORD	GROSS DRAINAGE AREA [km²]	2019 WATER YIELD [mm]	HISTORICAL MEAN ANNUAL WATER YIELD [mm]	2019 MEAN DISCHARGE [m³/s]	HISTORICAL MEAN ANNUAL DISCHARGE[1] [m³/s]	2019 AS A PERCENT OF HISTORICAL MEAN ANNUAL DISCHARGE [%]
ATHABASCA RIVER AT ATHABASCA	07BE001	1913 – 2019	74600	257	179	608	423	144
ATHABASCA RIVER AT EMBARRAS AIRPORT	07DD001	1971 – 2019 [1]	155000	179	145	879	714	123
ATHABASCA RIVER BELOW FORT MCMURRAY	07DA001	1957 – 2019	133000	189	147	795	620	128
BEAVER RIVER ABOVE SYNCRUDE	07DA018	1975 – 2019	165	99.8	101	0.522	0.529	98.7
BIG CREEK NEAR THE MOUTH	07DA040	2011 – 2019 [2]	323	38.8	33.6	0.397	0.344	115
CALUMET RIVER NEAR THE MOUTH	07DA033	2001 – 2019 [2]	175	5.86	11.7	0.0325	0.065	50.0
CHRISTINA RIVER ABOVE STATOIL LEISMER	07CE013	2013 – 2019 [2]	1030	96.2	120	3.14	3.93	79.9
CHRISTINA RIVER NEAR CHARD	07CE002	1982 – 2019	4860	89.0	134	13.7	20.7	66.2
CHRISTINA RIVER NEAR THE MOUTH	07CE007	2011 – 2019 [2]	13200	90.8	103	38.0	43.1	88.2
CLEARWATER RIVER ABOVE CHRISTINA RIVER	07CD005	1966 – 2019	17000	141	137	76.2	73.8	103
CLEARWATER RIVER AT DRAPER	07CD001	1930 – 2019	30800	123	123	120	120	100
DOVER RIVER NEAR THE MOUTH	07DB002	1975 – 2019 [3]	963	47.8	42.3	1.46	1.29	113
DUNKIRK RIVER NEAR FORT MACKAY	07DB003	1975 – 2019 [3]	1570	66.5	75.4	3.31	3.75	88.3
EAST JACKPINE CREEK NEAR THE 1300 FT CONTOUR	07DA038	2007 – 2019 [2]	45	168	129	0.239	0.184	130
ELLS RIVER ABOVE JOSLYN CREEK DIVERSION	07DA039	2009 – 2019 [2]	2260	75.4	88.9	5.40	6.37	84.8
ELLS RIVER AT CANADIAN NATURAL RESOURCES LIMITED BRIDGE	07DA032	2004 – 2019 [2]	2430	72.1	84.8	5.55	6.53	85.0
EYMUNDSON CREEK NEAR THE MOUTH	07DA041	2011 – 2019 [2]	319	31.5	39.5	0.318	0.399	79.7
FIREBAG RIVER NEAR THE MOUTH	07DC001	1971 – 2019	5980	132	134	25.1	25.3	99.2
FIREBAG RIVER UPSTREAM OF SUNCOR FIREBAG	07DC003	2009 – 2019 [2]	2420	125	119	9.58	9.11	105
GREGOIRE RIVER NEAR THE MOUTH	07CE008	2012 – 2019 [2]	1000	111	113	3.53	3.59	98.3
HANGINGSTONE RIVER AT FORT MCMURRAY	07CD004	1965 – 2019	962	94.8	124	2.89	3.79	76.3
HANGINGSTONE RIVER AT NORTH STAR ROAD	07CD008	2002 – 2019 [2]	113	151	148	0.541	0.531	102
HIGH HILL RIVER NEAR THE MOUTH	07CD009	2012 – 2019 [2]	1360	104	103	4.47	4.43	101
HOUSE RIVER AT HIGHWAY NO. 63	07CB002	1982 – 2019 [5]	781	-	-	-	-	-
IYINIMIN CREEK ABOVE KEARL LAKE	07DA027	1989 – 2019 [2]	43	149	128	0.203	0.175	116
JACKFISH RIVER BELOW CHRISTINA LAKE	07CE005	1982 – 2019 [3]	1290	94.9	115	3.88	4.70	82.6
JACKPINE CREEK AT CANTERRA ROAD	07DA026	1995 – 2019 [2]	343	105	94.8	1.14	1.03	111
KEARL LAKE OUTLET	07DA030	1989 – 2019 [2]	83	53.2	58.2	0.140	0.153	91.5

Table continued on next page…

STATION NAME	STATION ID	PERIOD OF RECORD	GROSS DRAINAGE AREA [km²]	2019 WATER YIELD [mm]	HISTORICAL MEAN ANNUAL WATER YIELD [mm]	2019 MEAN DISCHARGE [m³/s]	HISTORICAL MEAN ANNUAL DISCHARGE[1] [m³/s]	2019 AS A PERCENT OF HISTORICAL MEAN ANNUAL DISCHARGE [%]
MACKAY RIVER AT PETRO-CANADA BRIDGE	07DB006	2008 – 2019 [2]	4130	71.3	68.7	9.33	8.99	104
MACKAY RIVER NEAR FORT MACKAY	07DB001	1972 – 2019	5570	62.9	74.8	11.1	13.2	84.1
MCCLELLAND LAKE OUTLET ABOVE FIREBAG RIVER	07DC004	2008 – 2019 [2]	359	49.4	49.8	0.562	0.566	99.3
MUSKEG CREEK NEAR THE MOUTH	07DA035	1989 – 2019 [2]	322	63.6	80.6	0.649	0.822	79.0
MUSKEG RIVER ABOVE MUSKEG CREEK	07DA029	1995 – 2019 [2]	567	42.9	67.9	0.771	1.22	63.2
MUSKEG RIVER ABOVE STANLEY CREEK	07DA028	2003 – 2019 [2]	440	47.0	65.8	0.656	0.918	71.5
MUSKEG RIVER NEAR FORT MACKAY	07DA008	1974 – 2019	1460	56.4	76.9	2.61	3.56	73.3
MUSKEG RIVER UPLAND	07DA034	2001 – 2019 [2]	150	83.7	68.0	0.398	0.323	123
PONY CREEK NEAR CHARD	07CE003	1982 – 2019 [5]	279	-	-	-	-	-
POPLAR CREEK NEAR FORT MCMURRAY	07DA007	1972 – 2019 [4]	151	154	194	0.738	0.929	79.4
RED CLAY CREEK NEAR THE MOUTH	07DA042	2011 – 2019 [2]	N/A	N/A	N/A	0.521	0.521	100
STEEPBANK RIVER BELOW NORTH STEEPBANK RIVER	07DA044	2014 – 2019 [2]	1180	114	120	4.25	4.50	94.4
STEEPBANK RIVER NEAR FORT MCMURRAY	07DA006	1972 – 2019	1320	115	121	4.79	5.07	94.5
SUNDAY CREEK ABOVE CHRISTINA LAKE	07CE010	2012 – 2019 [2]	365	86.2	147	0.997	1.70	58.6
TAR RIVER ABOVE CANADIAN NATURAL RESOURCES LIMITED LAKE	07DA037	2005 – 2019 [2]	143	66.0	81.0	0.299	0.367	81.5
TAR RIVER NEAR THE MOUTH	07DA045	2007 – 2019 [2]	320	37.9	33.4	0.384	0.339	113

[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] Seasonally operated

Table B2: Level Stations

STATION NAME	STATION ID	RECORD	DATUM	2019 MEAN LEVEL [m]	HISTORICAL MEAN ANNUAL LEVEL [m]	DIFFERENCE [m]
GREGOIRE LAKE NEAR FORT MCMURRAY	07CE001	1969 – 2019 [3]	Geodetic Survey of Canada	-	-	-
KEARL LAKE AT CANTERRA ROAD[1]	07DA024	2017 – 2019	Assumed	99.519	99.519	0
MCCLELLAND LAKE AT EAST END	07DA023	1997 – 2019 [2]	Assumed	N/A	294.564	N/A
NAMUR LAKE NEAR THE OUTLET	07DA025	2012 – 2019 [2]	Assumed	N/A	97.817	N/A

[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

Appendix C:
Annual Hydrographs – All Hydrometric Stations

The following figures show the annual hydrographs for all active stations within the Oil Sands area in 2019. Each figure includes the measured discharge or level for 2019, the maximum and minimum discharge or level on record for each station, and the interquartile range of discharge or 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, this record includes monitoring that occurred under the Regional Aquatics Monitoring Program (RAMP). Data included from RAMP has not been verified by WSC.

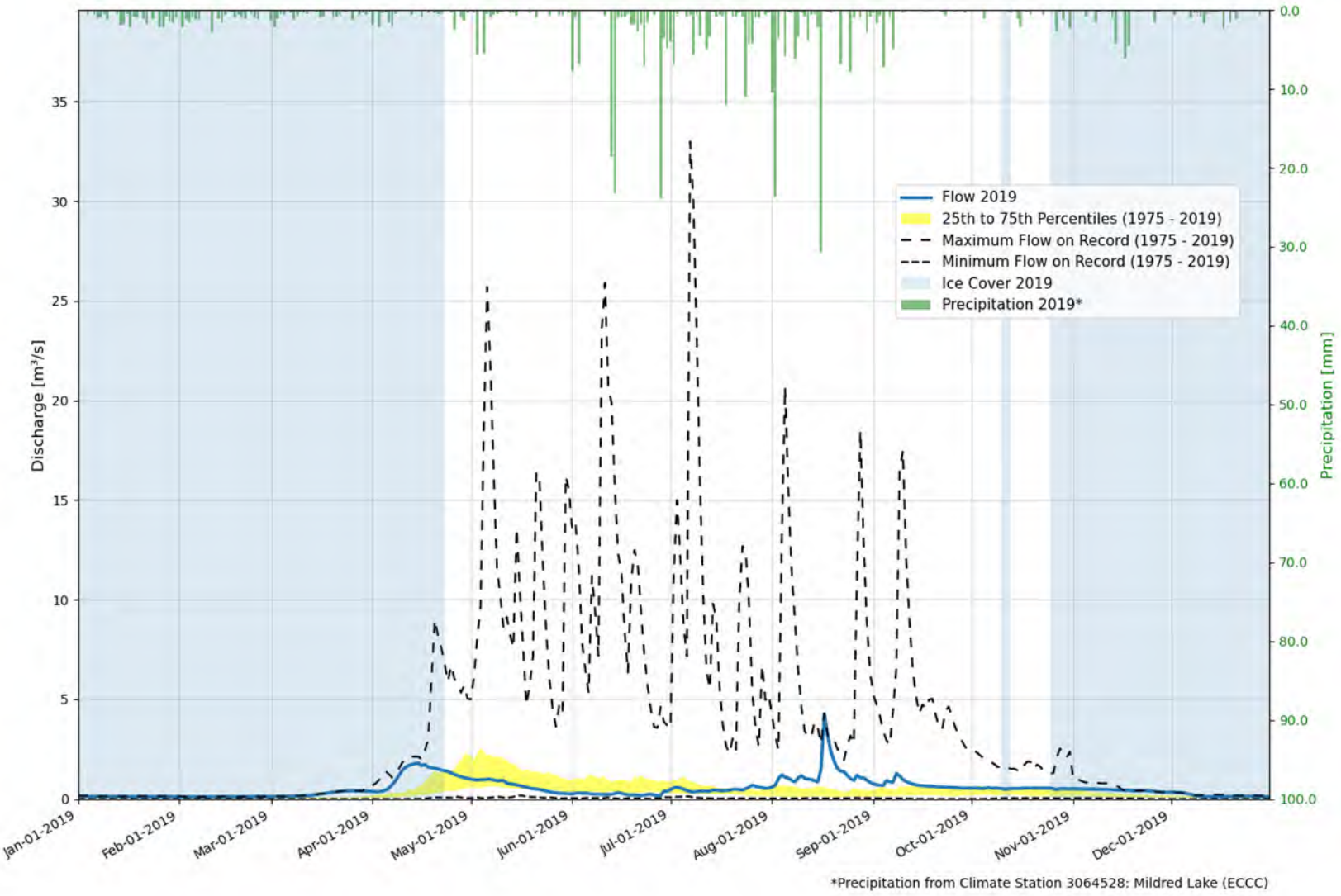

Figure C1: Beaver River above Syncrude (07DA018)

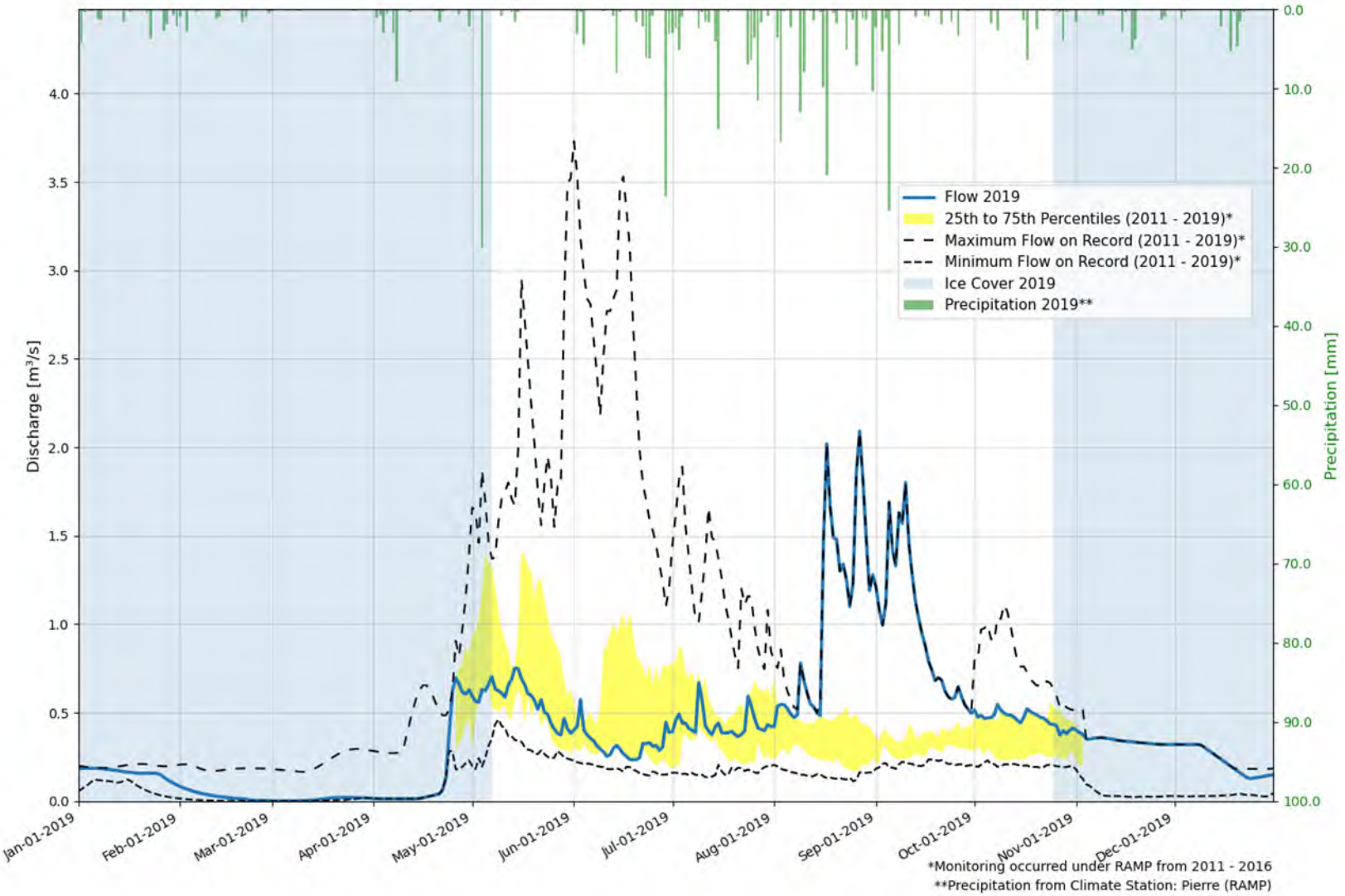

Figure C2: Big Creek near the Mouth (07DA040)

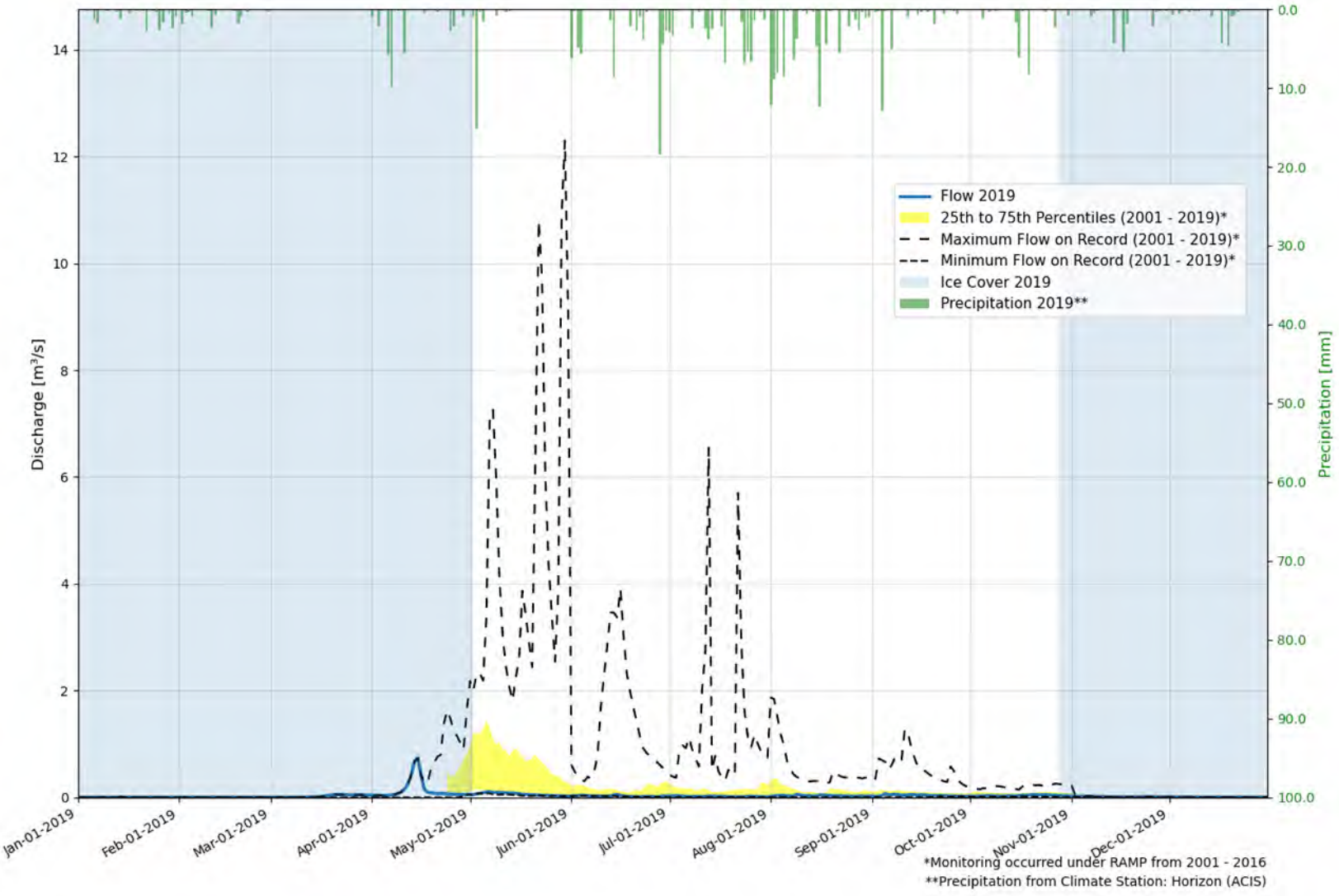

Figure C3: Calumet River near the Mouth (07DA033)

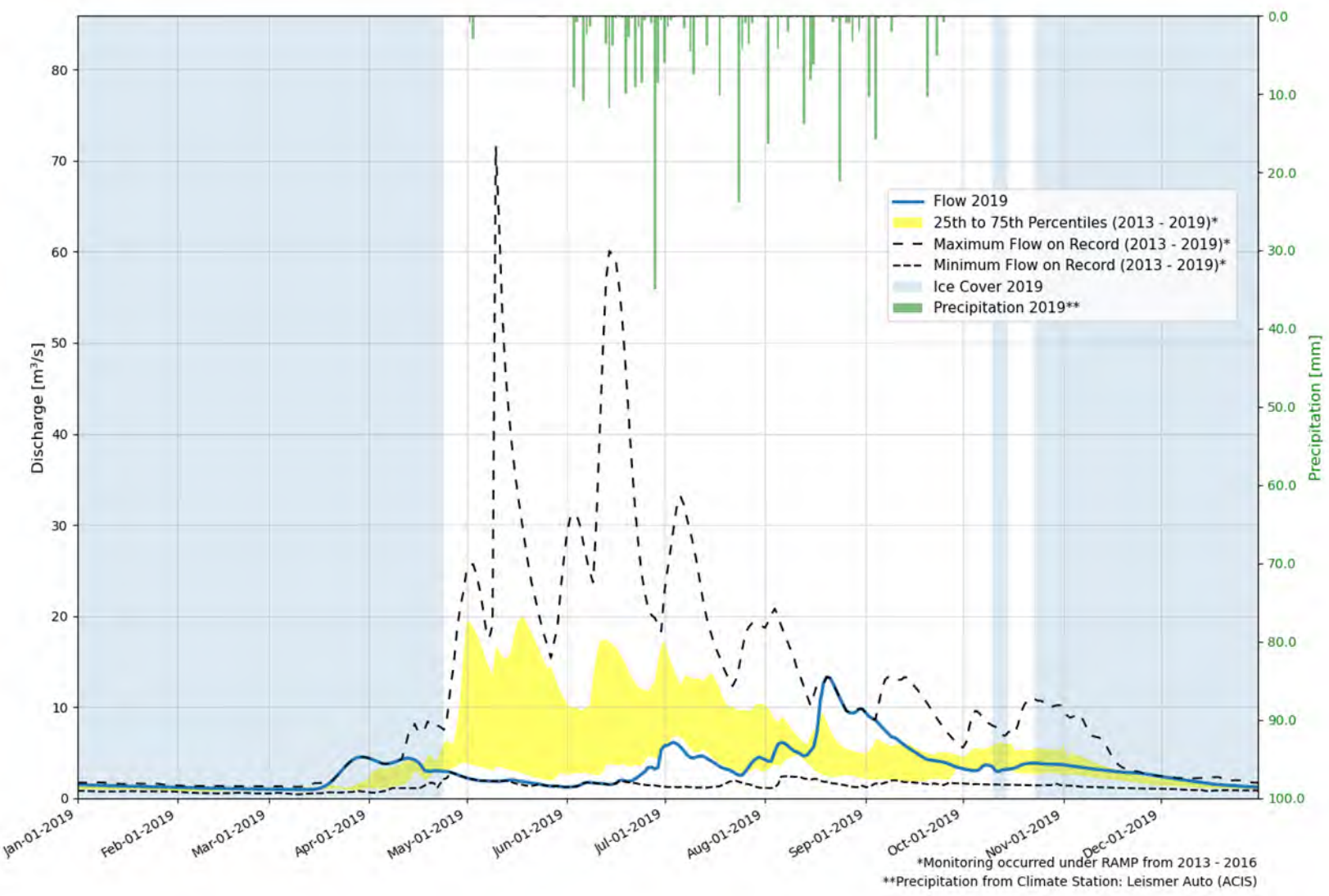

Figure C4: Christina River above Statoil Leismer (07CE013)

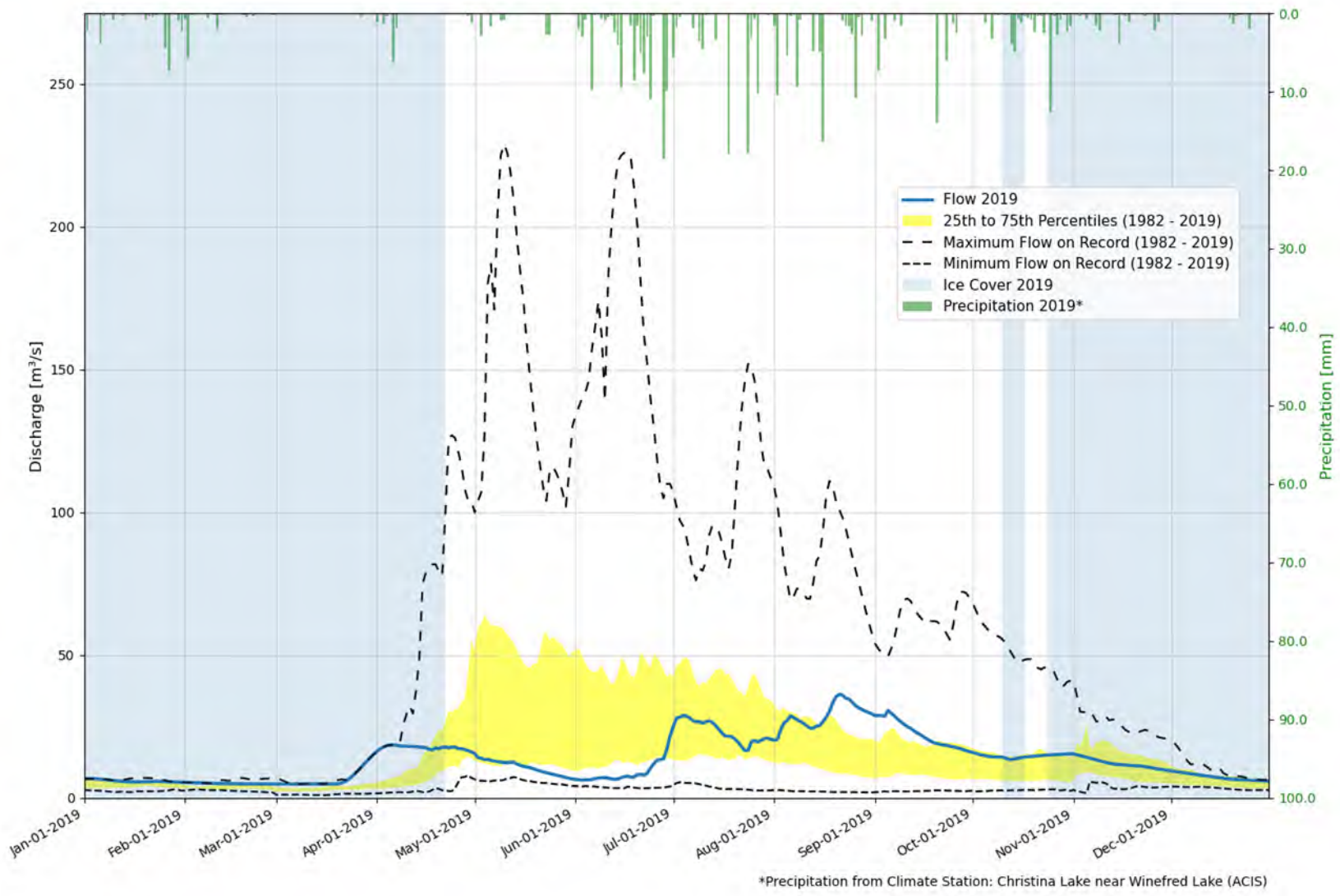

Figure C5: Christina River near Chard (07CE002)

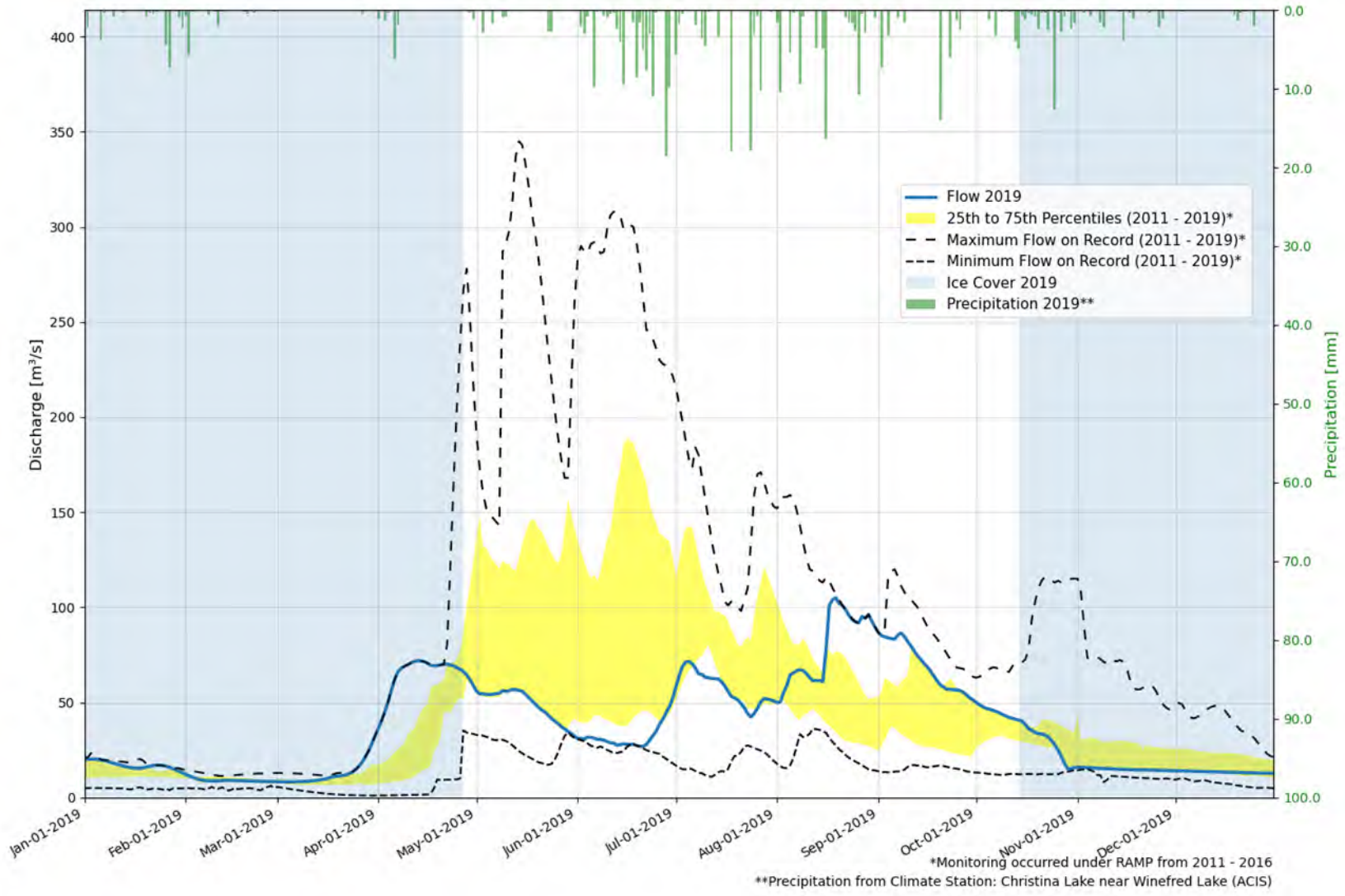

Figure C6: Christina River near the Mouth (07CE007)

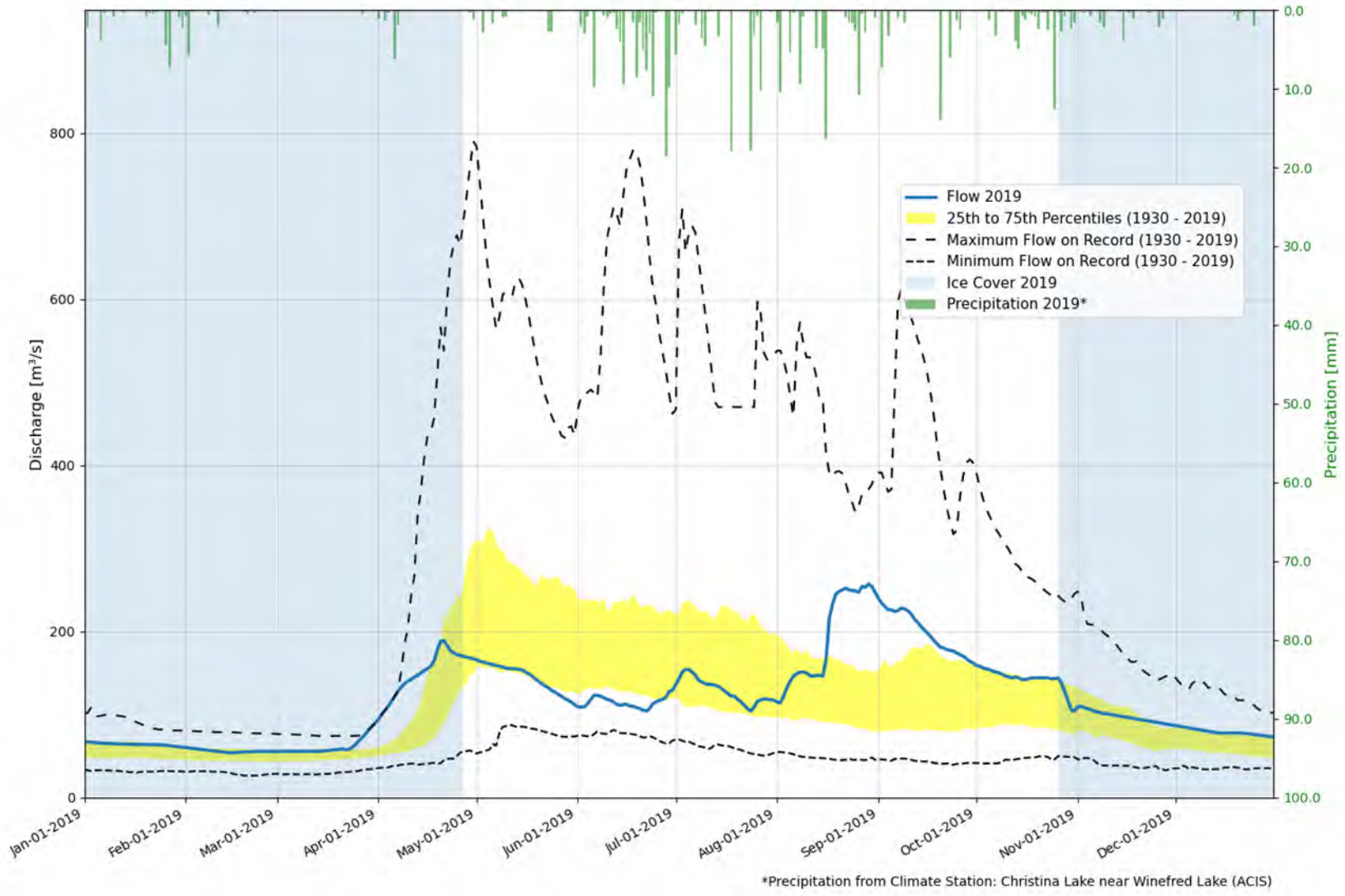

Figure C7: Clearwater River at Draper (07CD001)

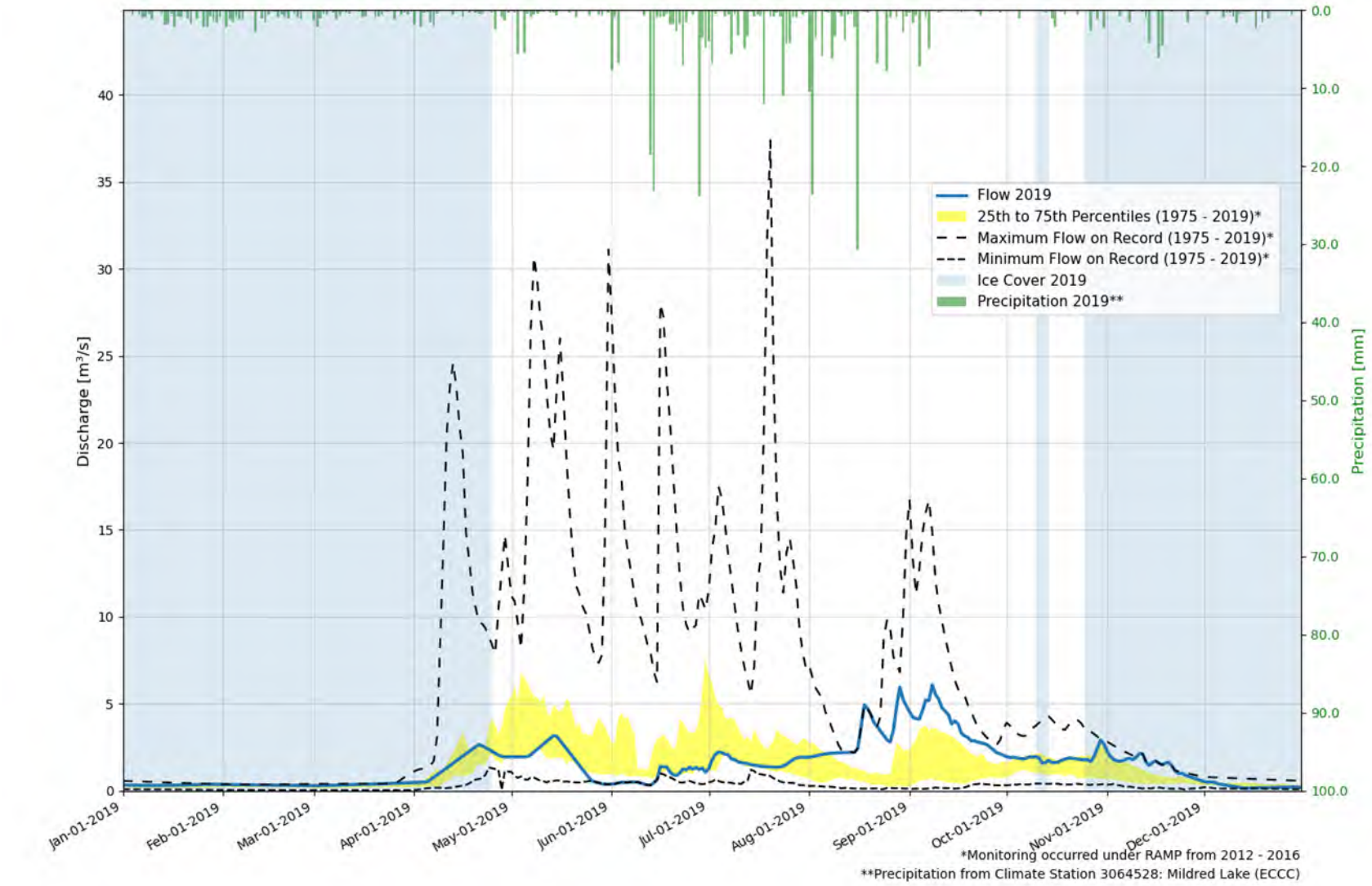

Figure C8: Dover River near the Mouth (07DB002)

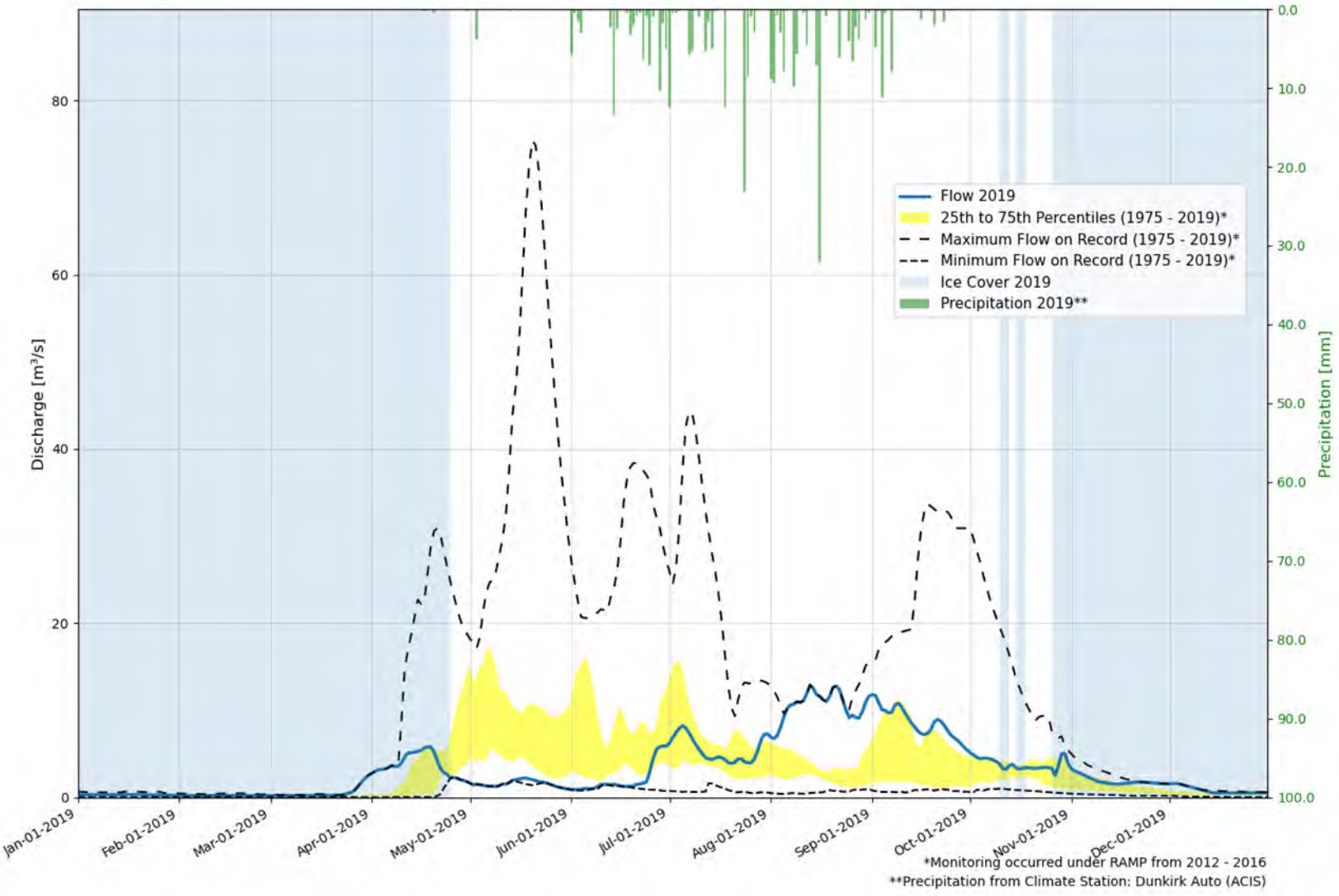

Figure C9: Dunkirk River near Fort MacKay (07DB003)

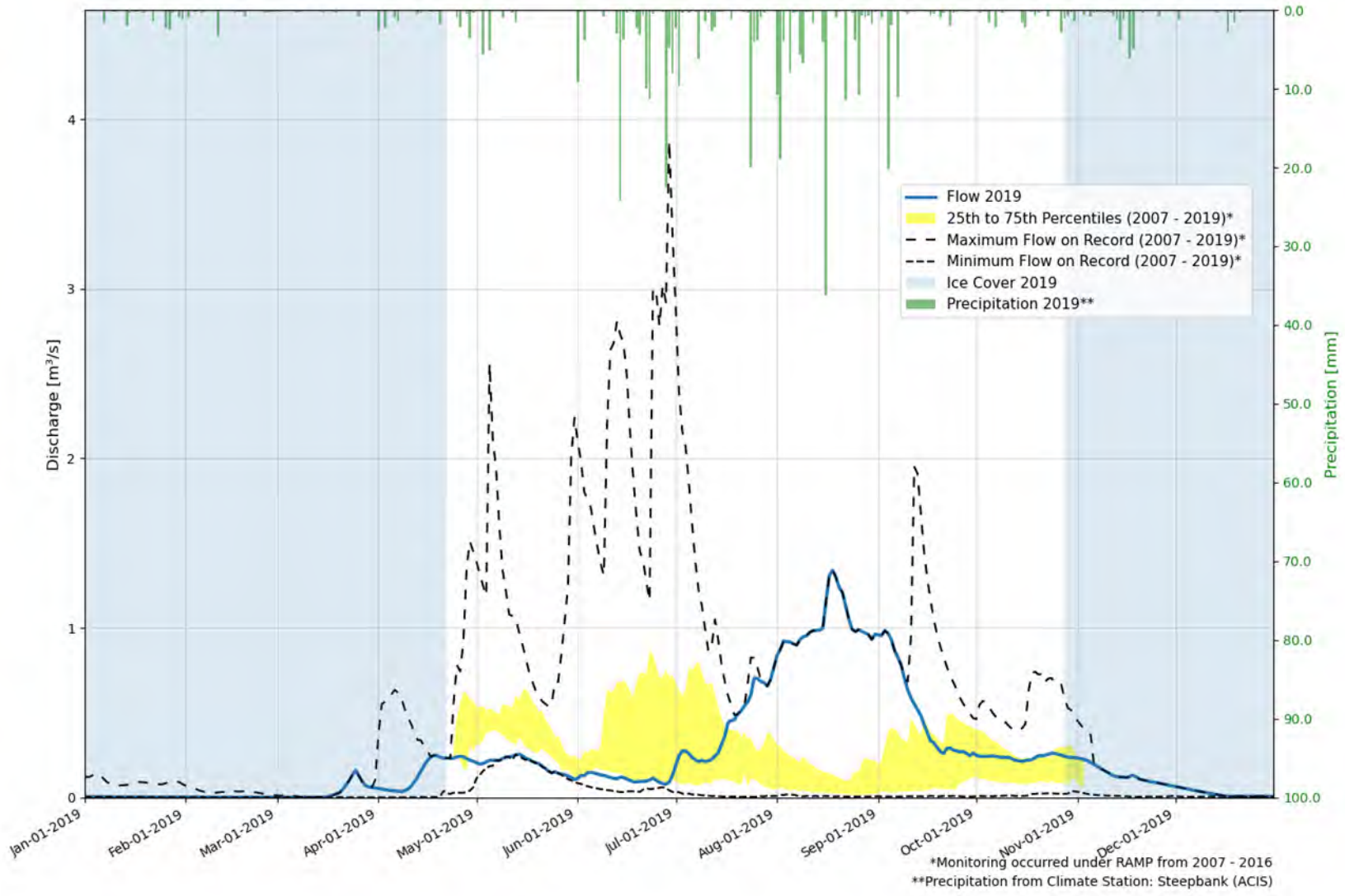

Figure C10: East Jackpine Creek near the 1300 FT Contour (07DA038)

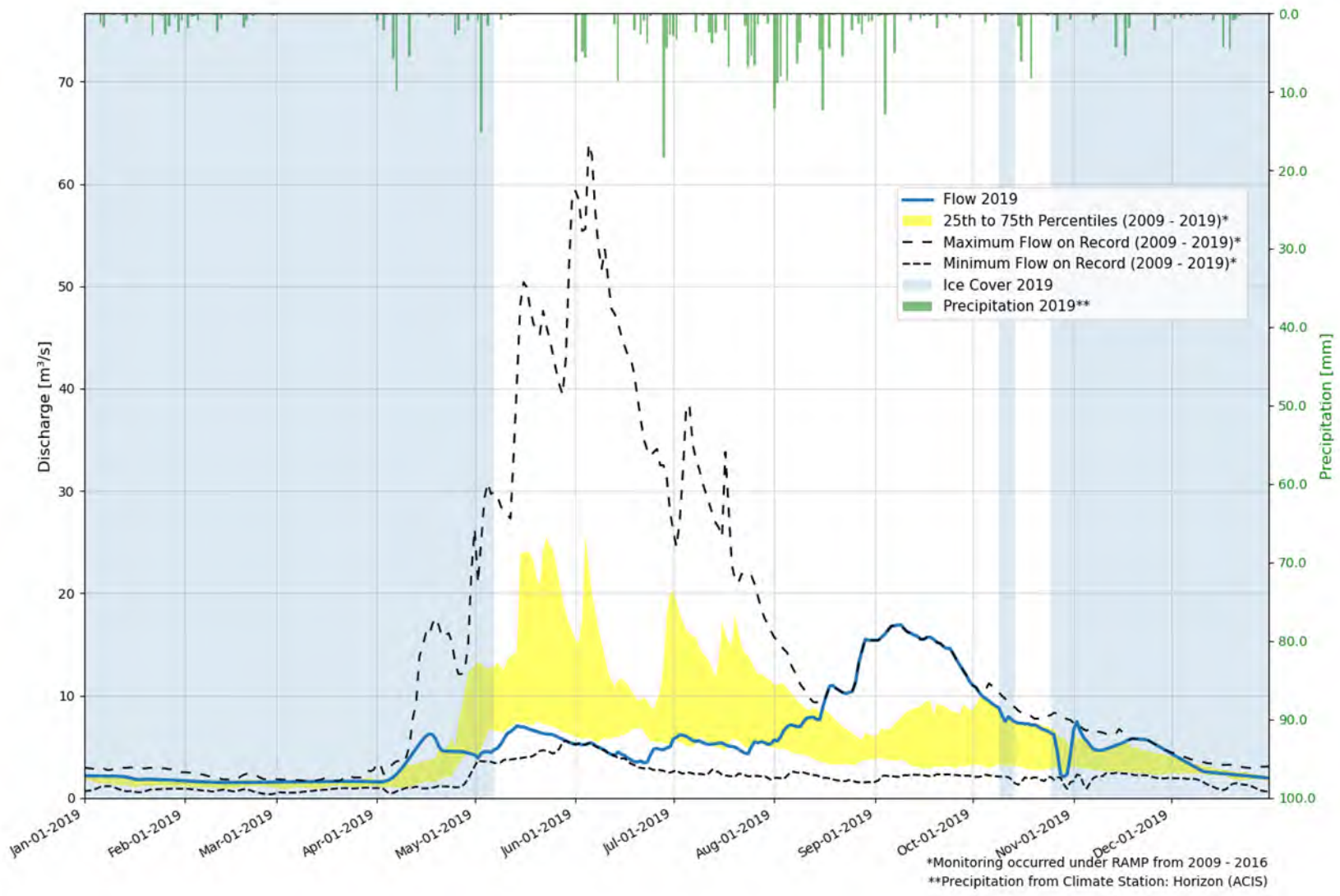

Figure C11: Ells River above Joslyn Creek Diversion (07DA039)

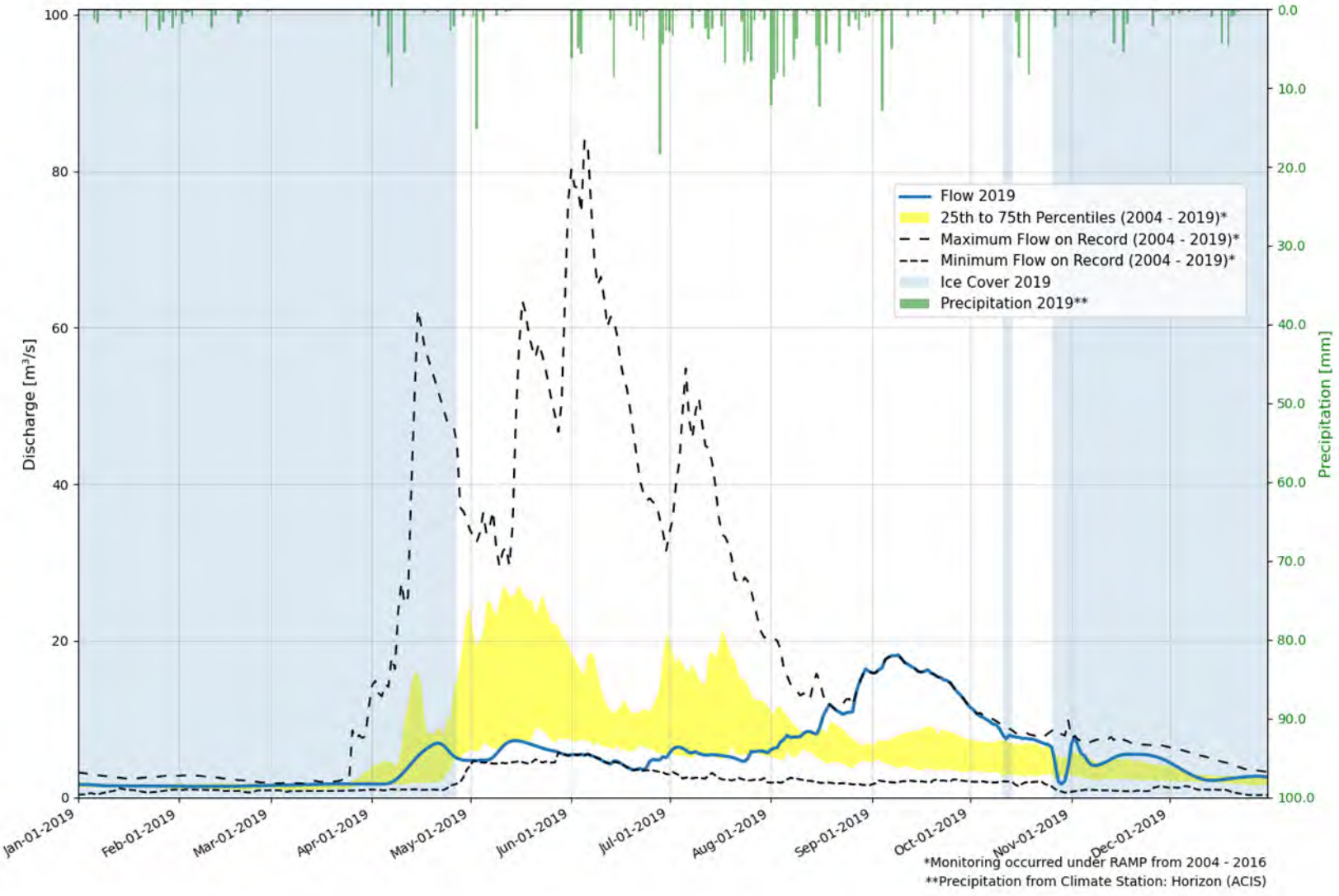

Figure C12: Ells River at Canadian National Resources Limited Bridge (07DA032)

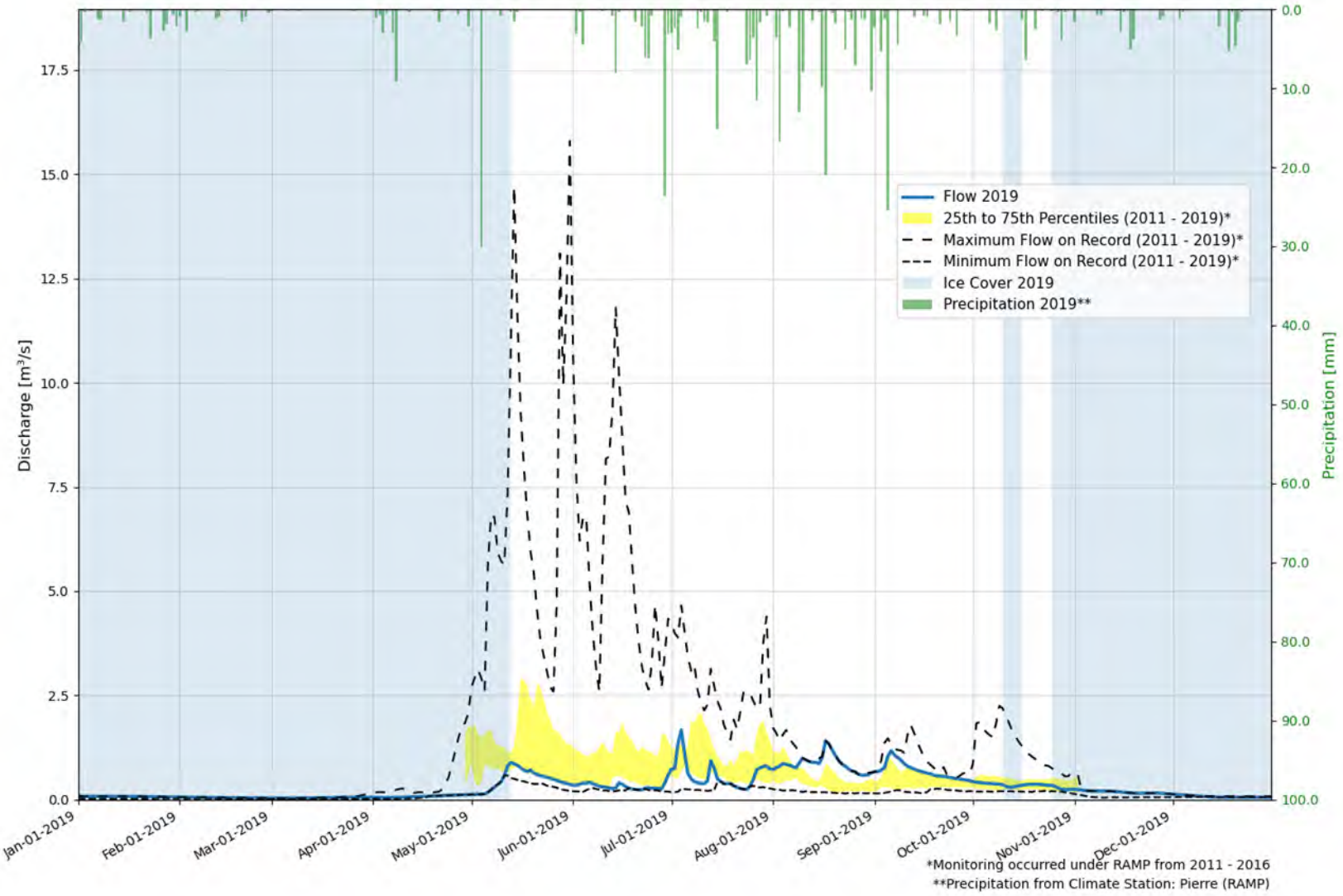

Figure C13: Eymundson Creek near the Mouth (07DA041)

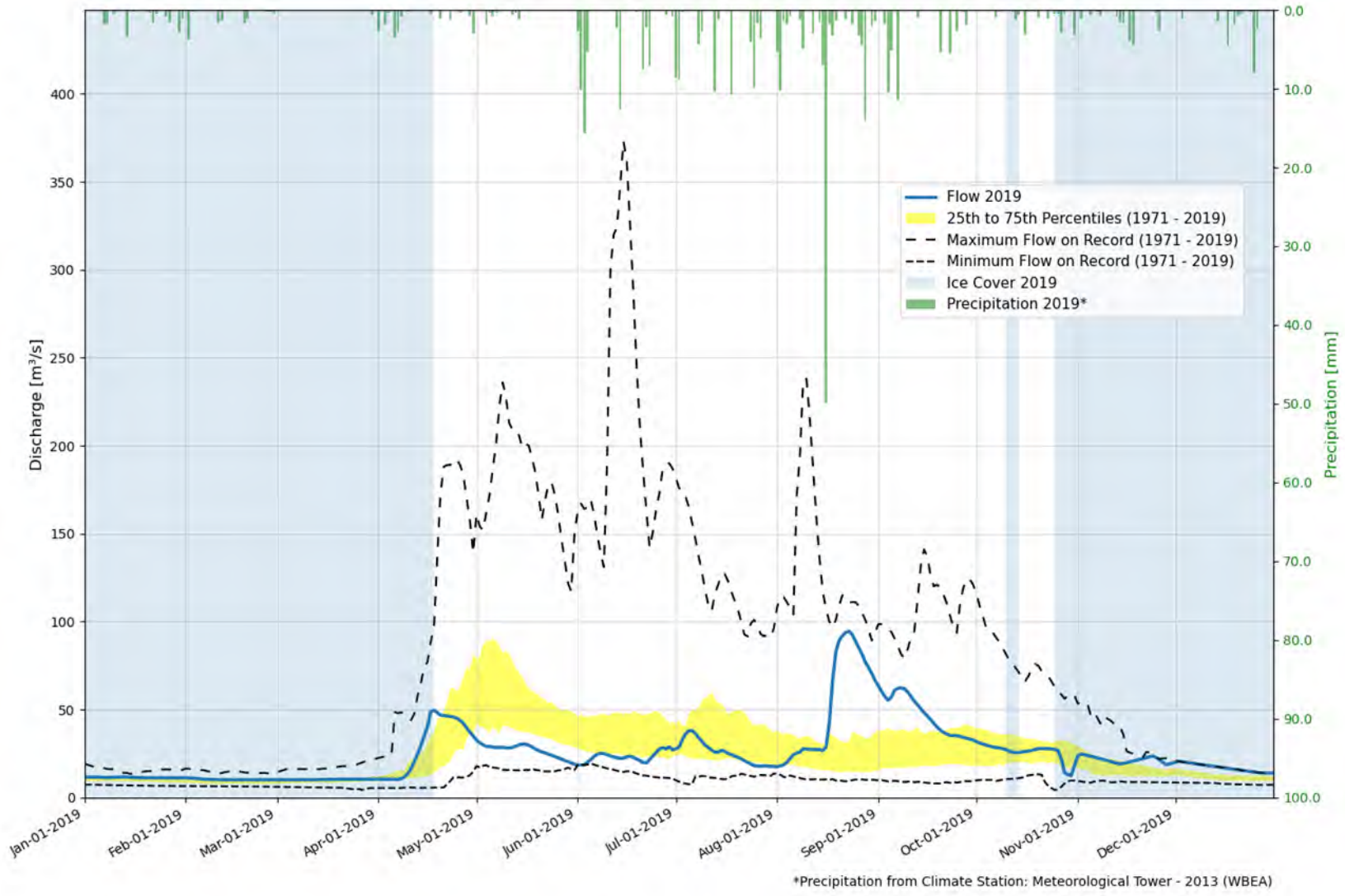

Figure C14: Firebag River near the Mouth (07DC001)

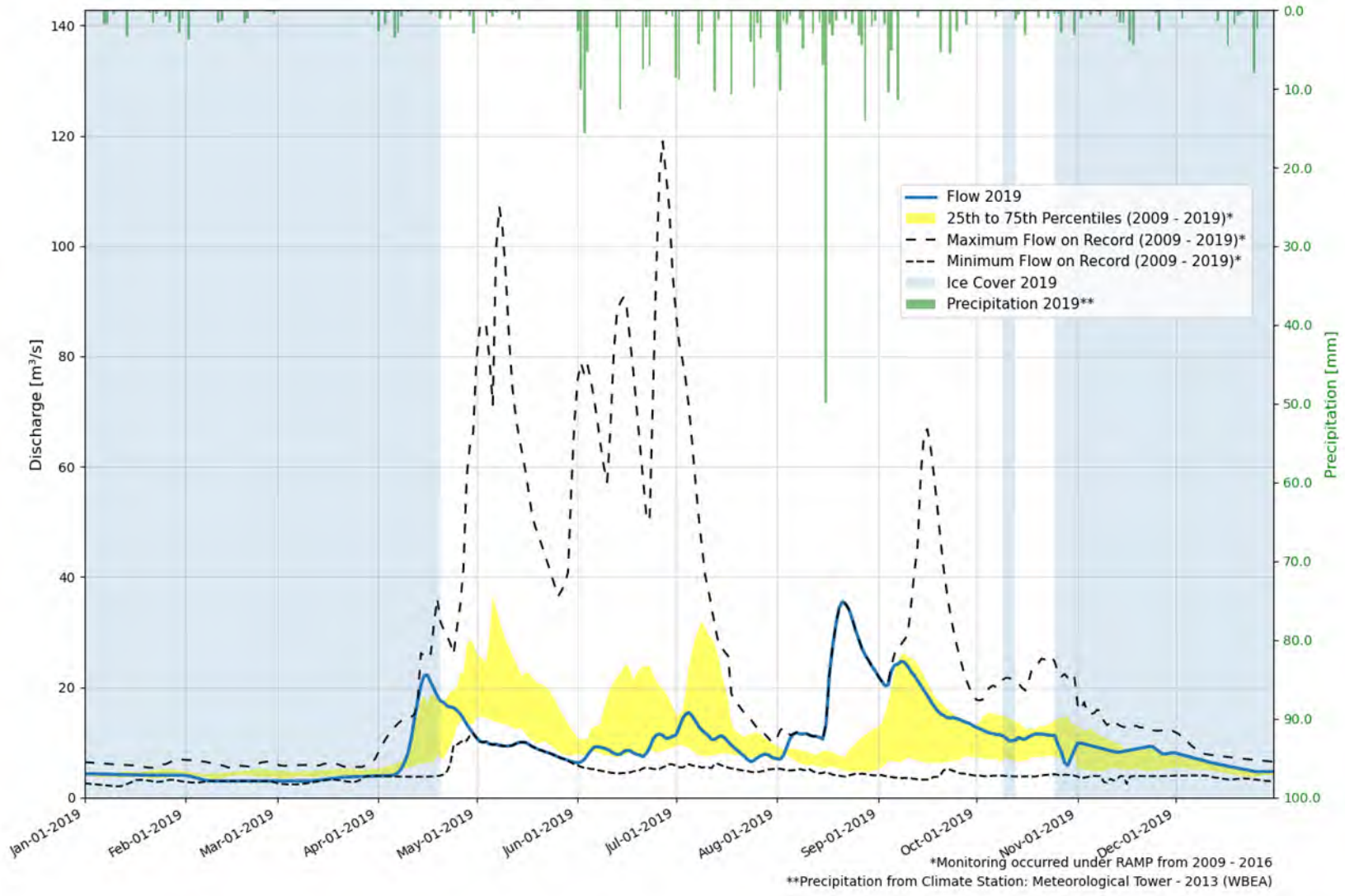

Figure C15: Firebag River upstream of Suncor Firebag (07DC003)

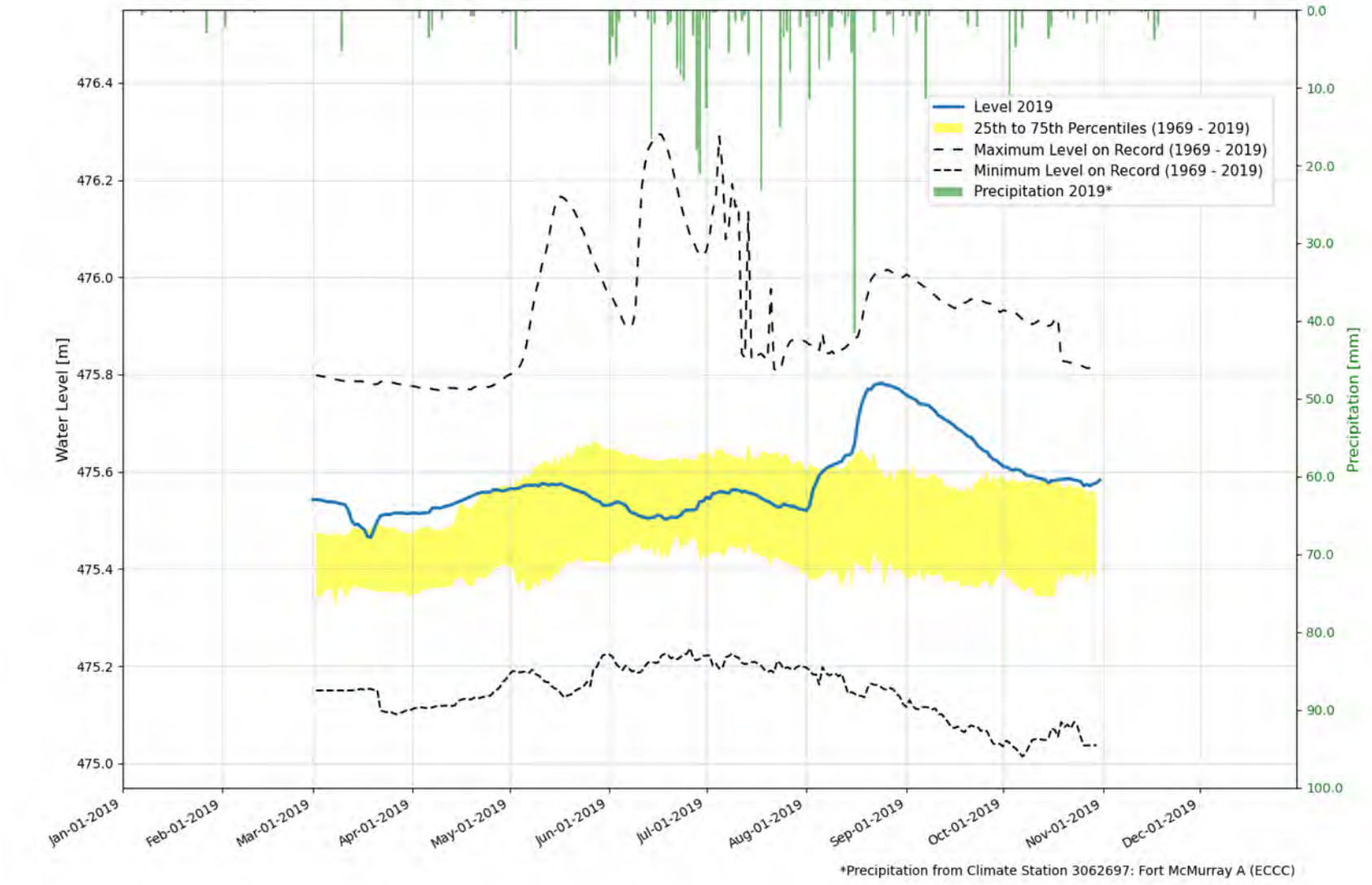

Figure C16: Gregoire Lake near Fort McMurray (07CE001)

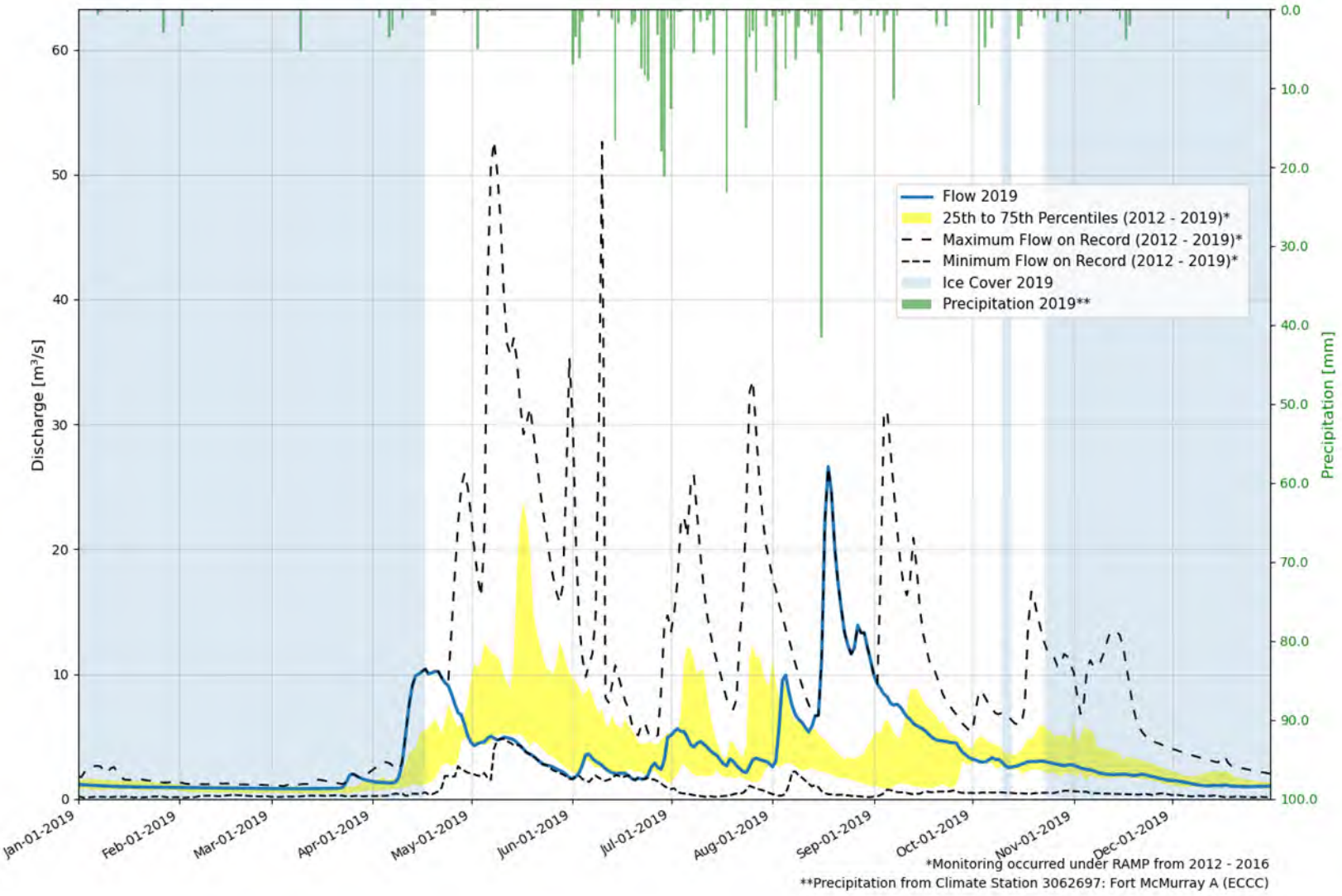

Figure C17: Gregoire River near the Mouth (07CE008)

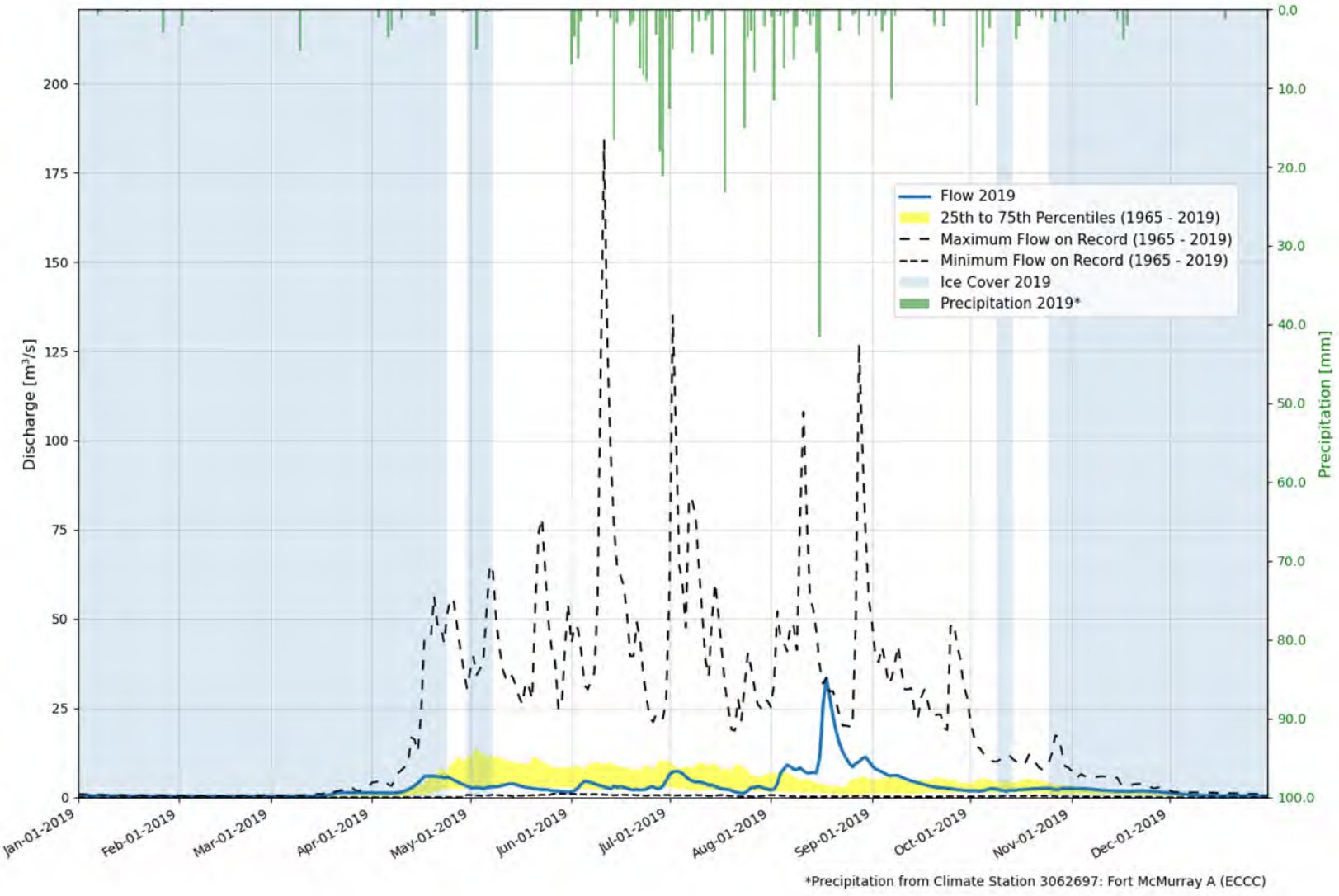

Figure C18: Hangingstone River at Fort McMurray (07CD004)

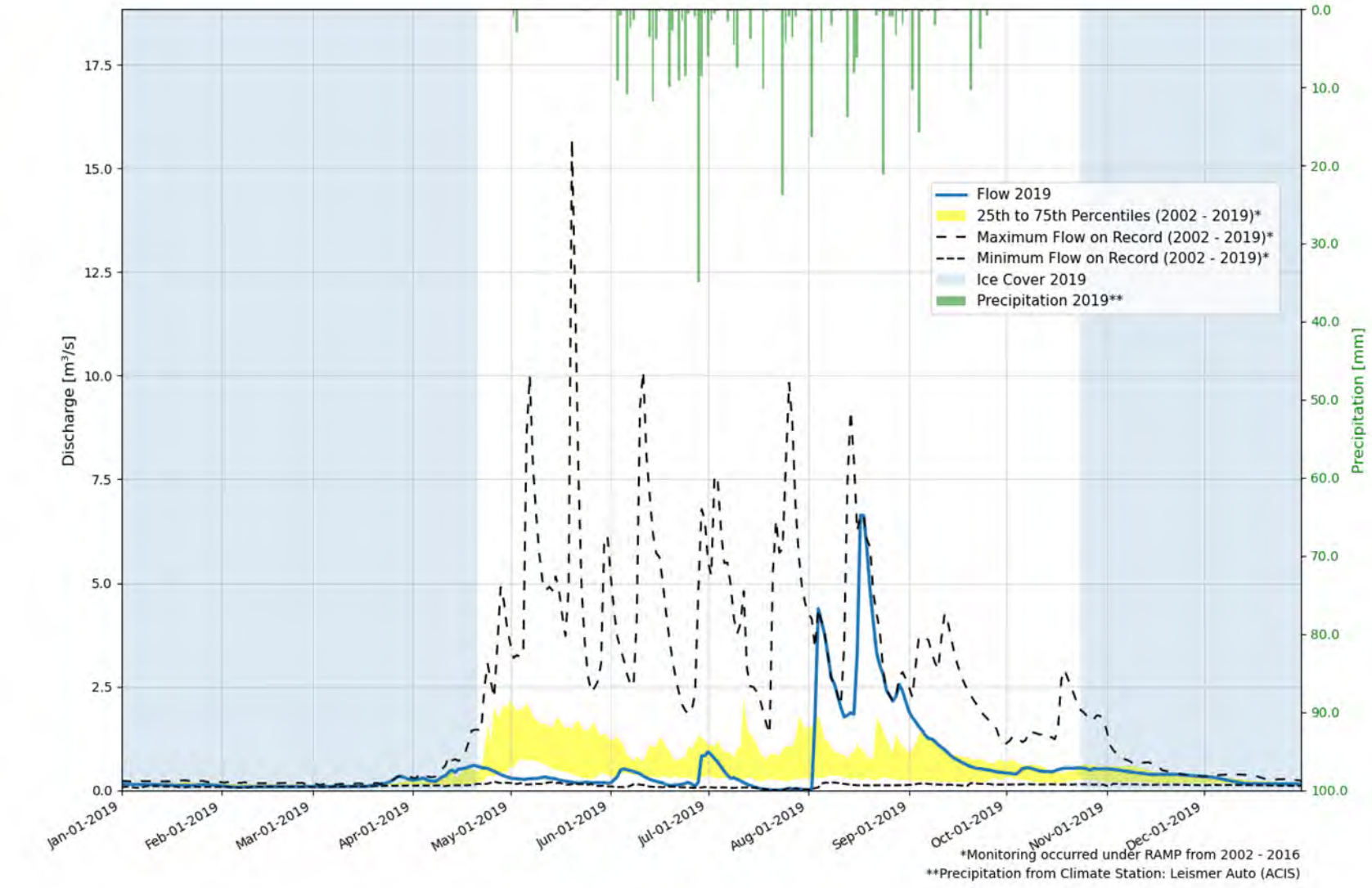

Figure C19: Hangingstone River at North Star Road (07CD008)

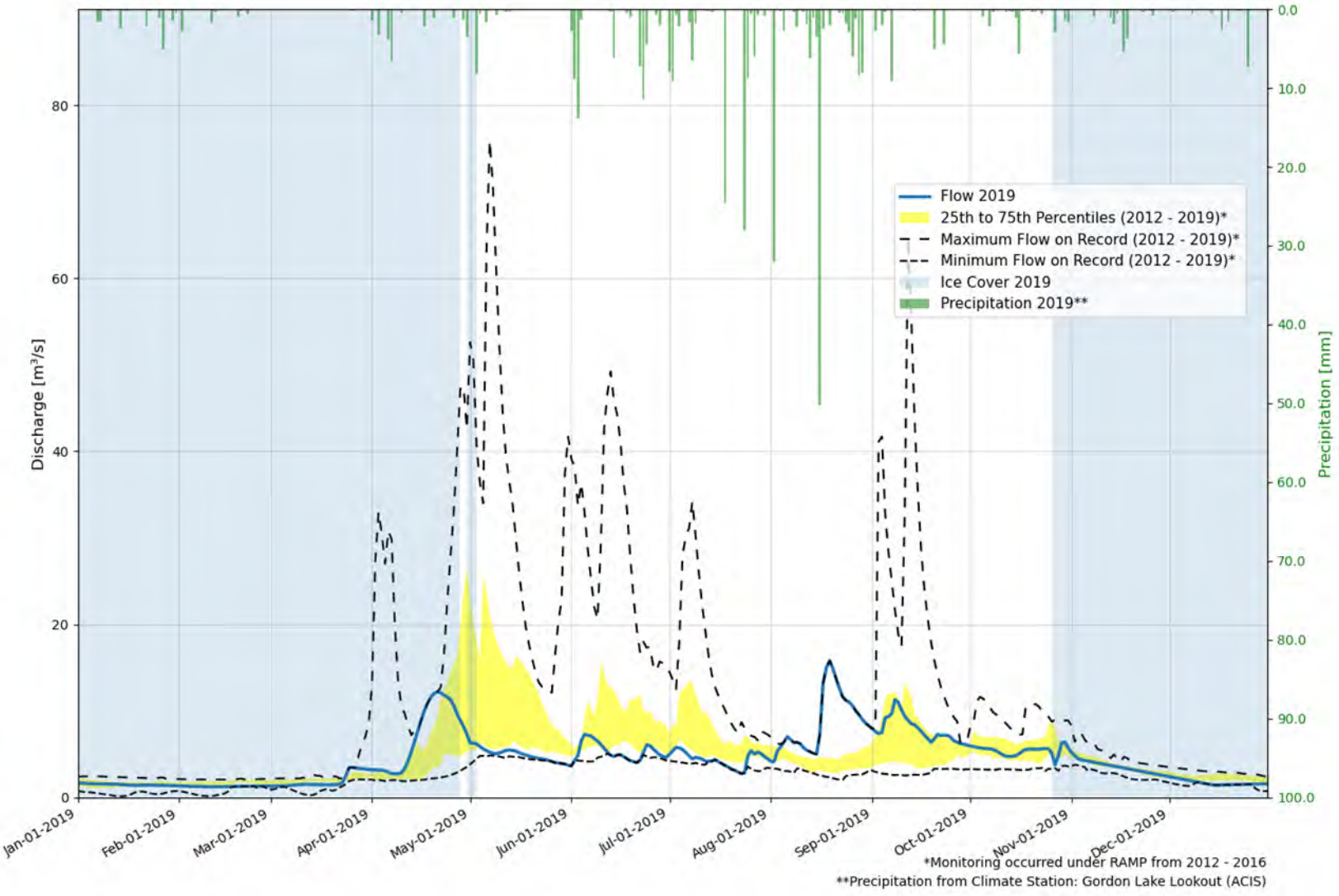

Figure C20: High Hill River near the Mouth (07CD009)

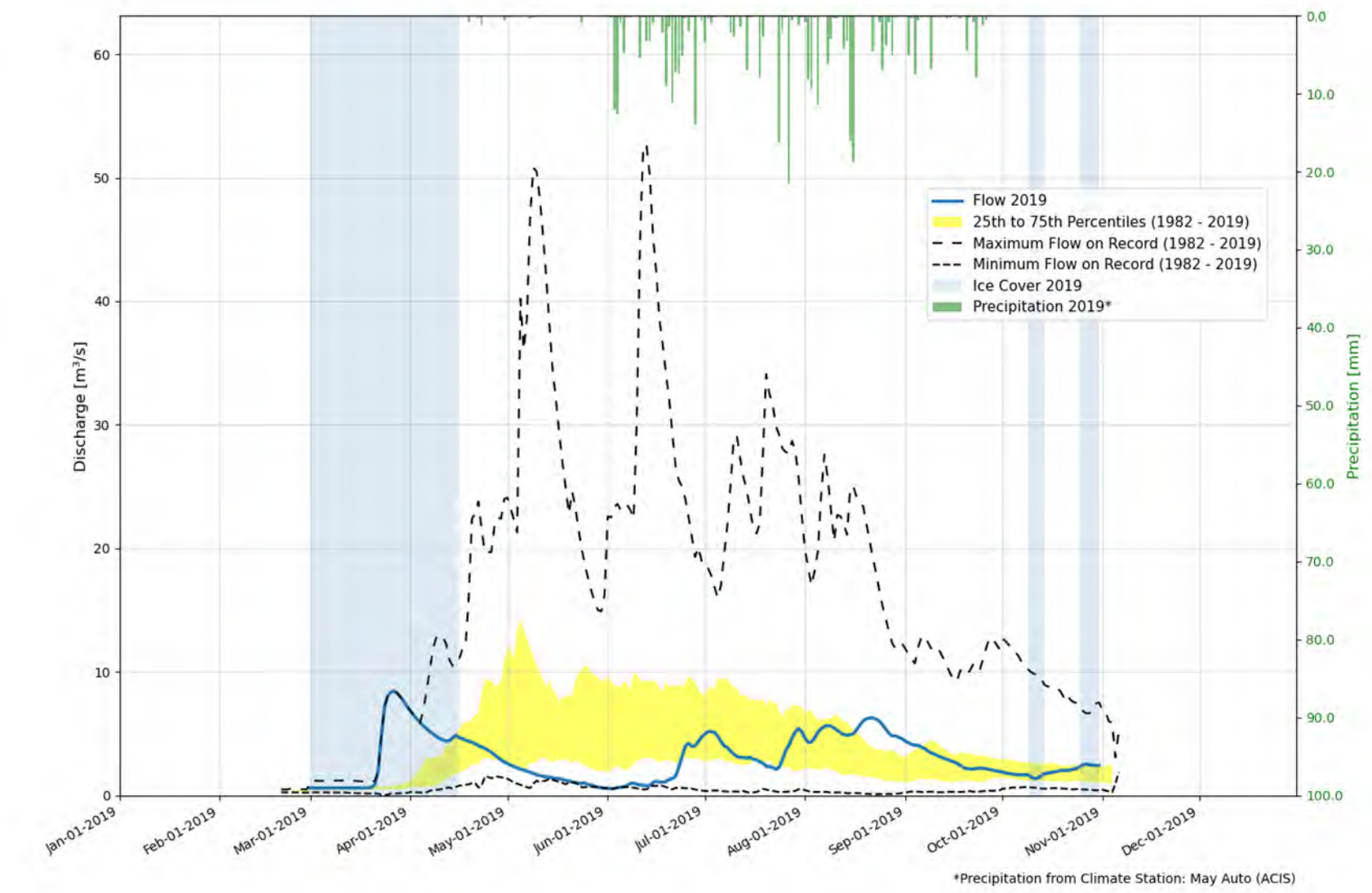

Figure C21: House River at Highway No. 63 (07CB002)

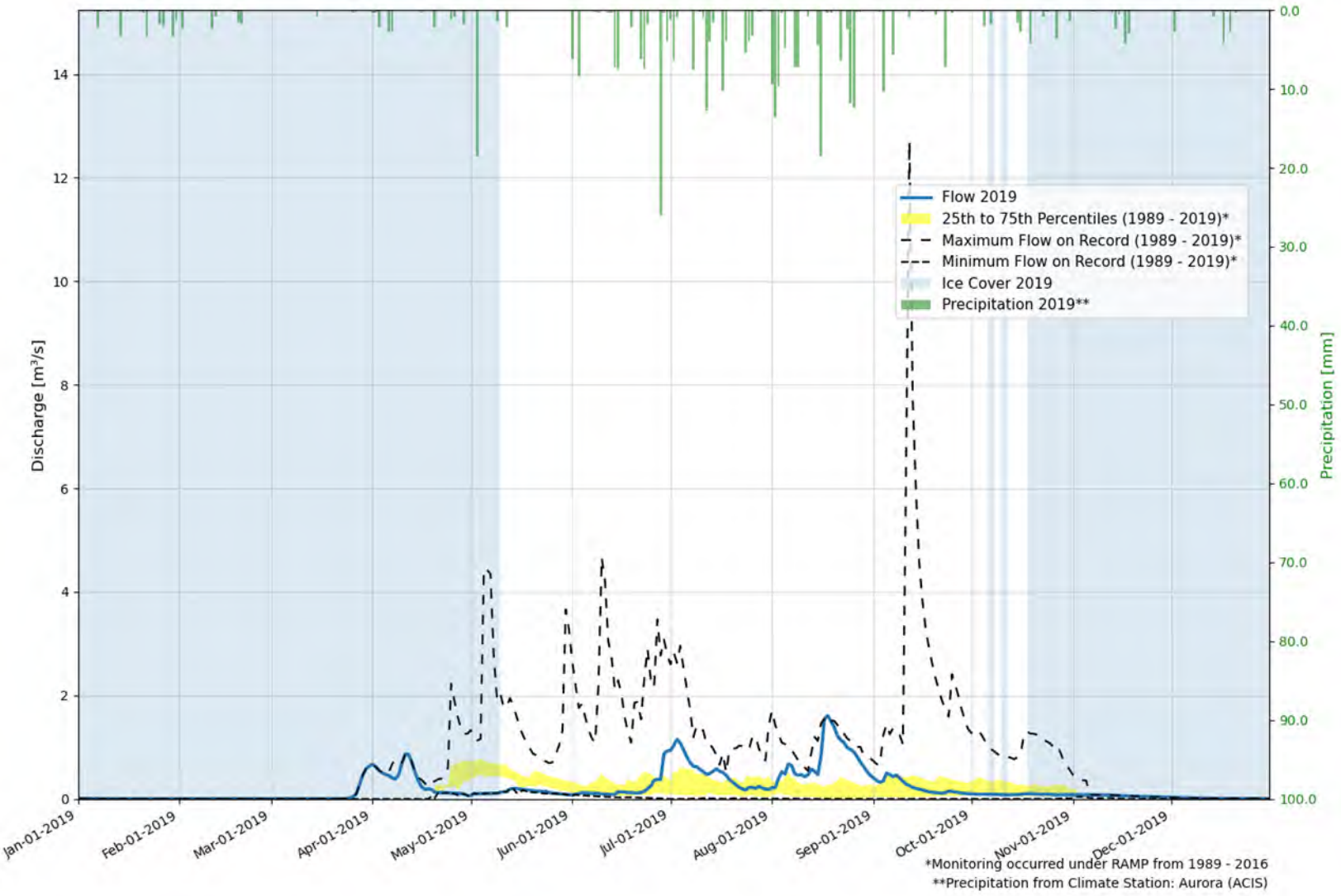

Figure C22: Iyinimin Creek above Kearl Lake (07DA027)

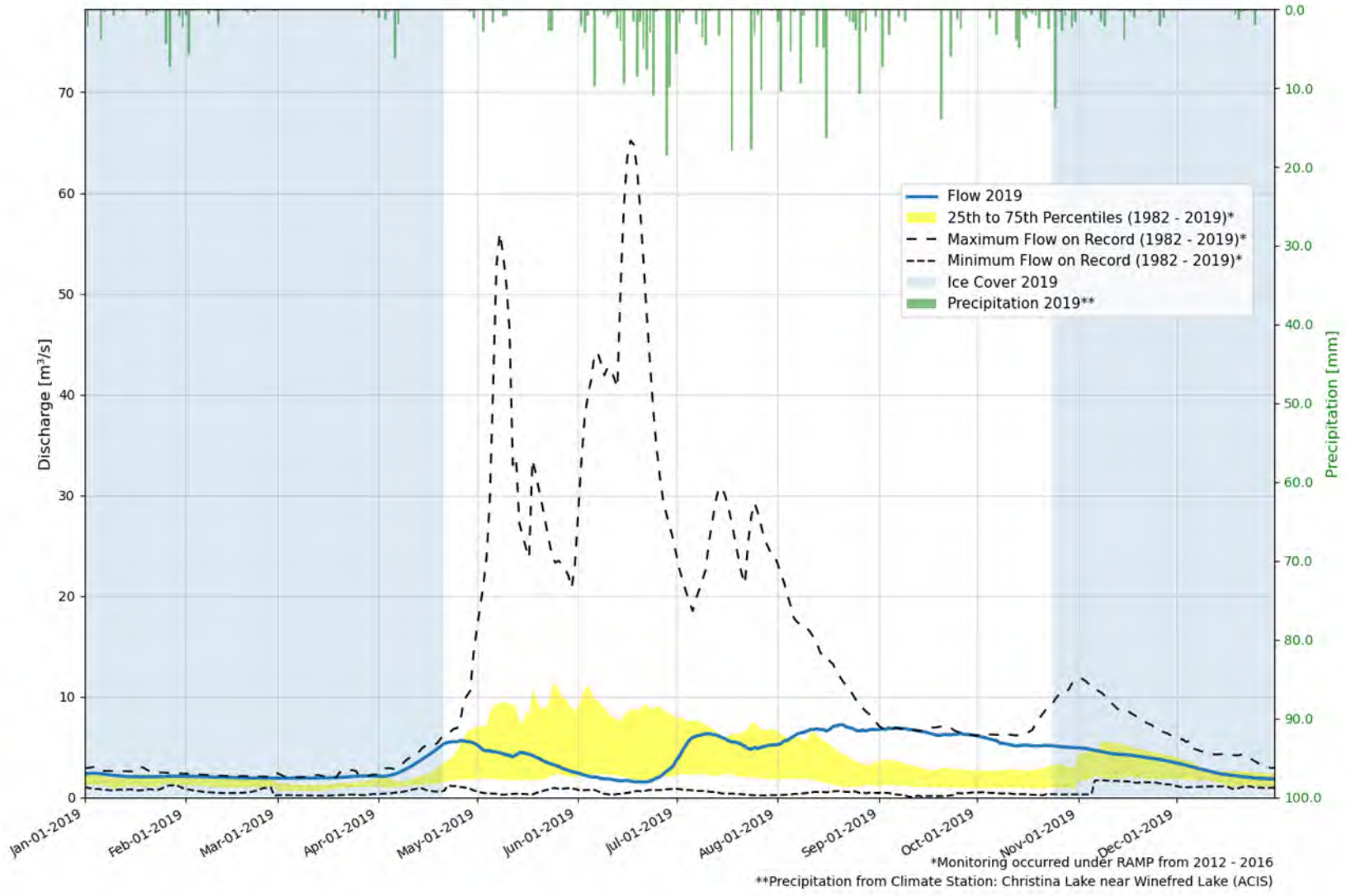

Figure C23: Jackfish River below Christina Lake (07CE005)

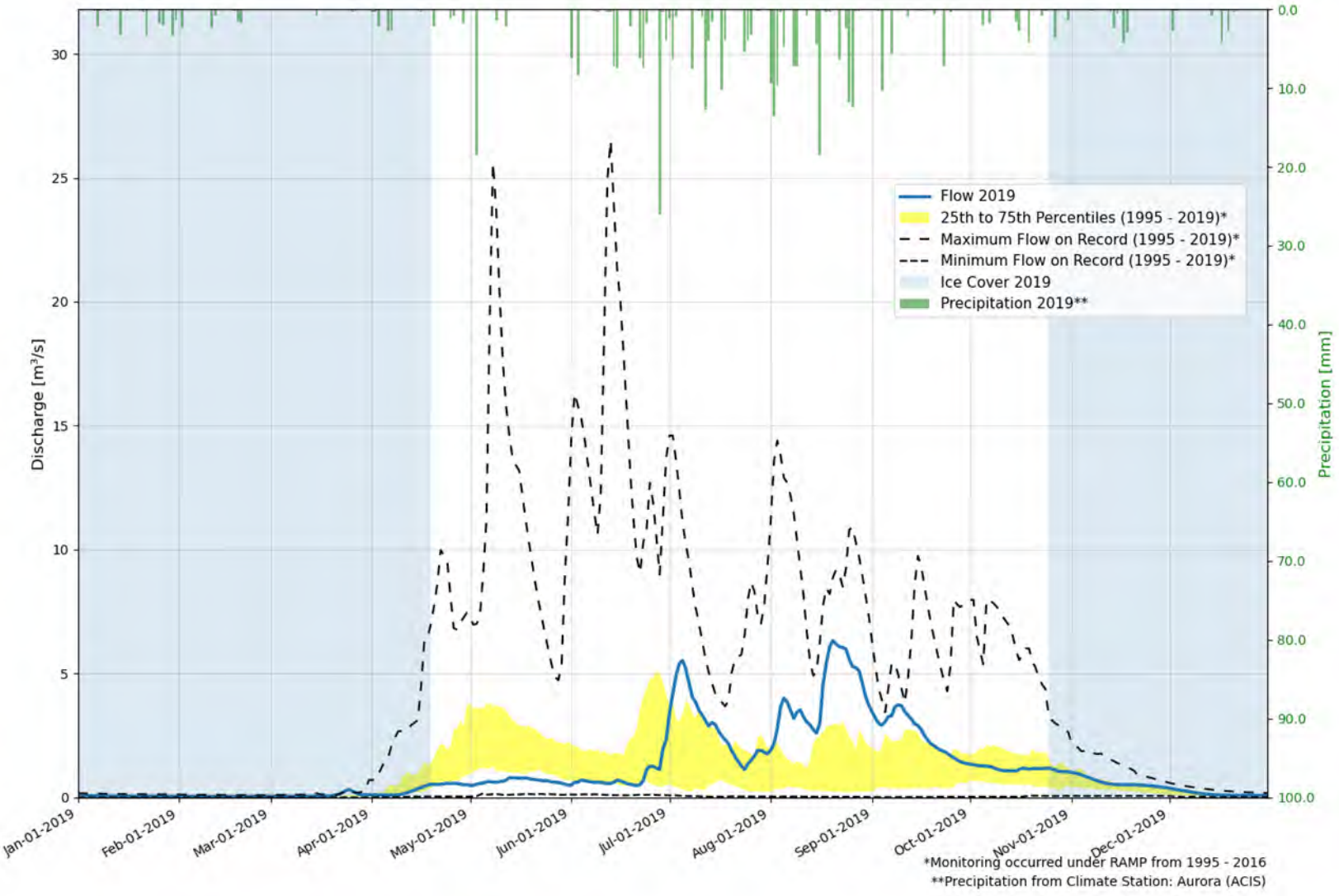

Figure C24: Jackpine Creek at Canterra Road (07DA026)

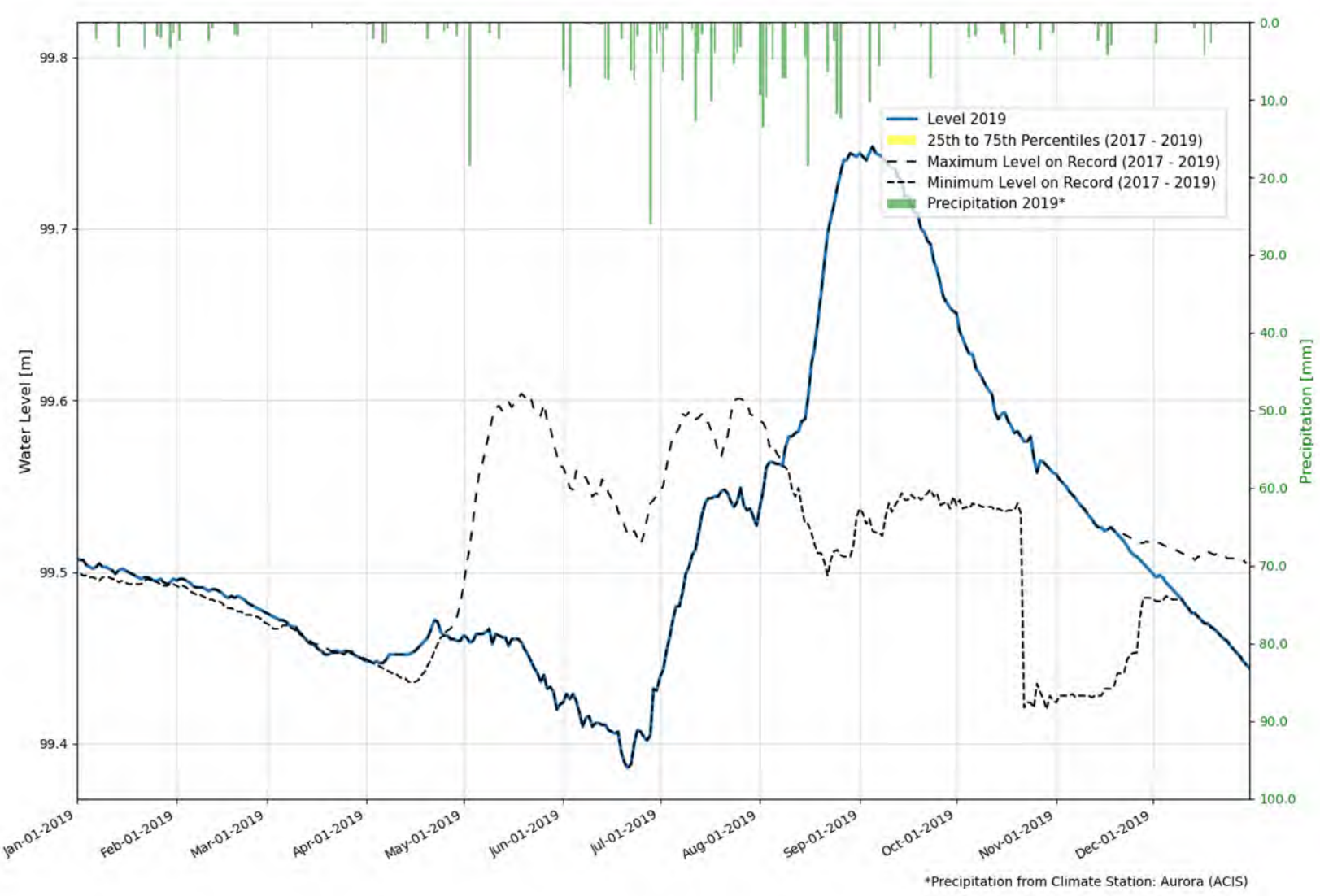

Figure C25: Kearl Lake at Canterra Road (07DA024)

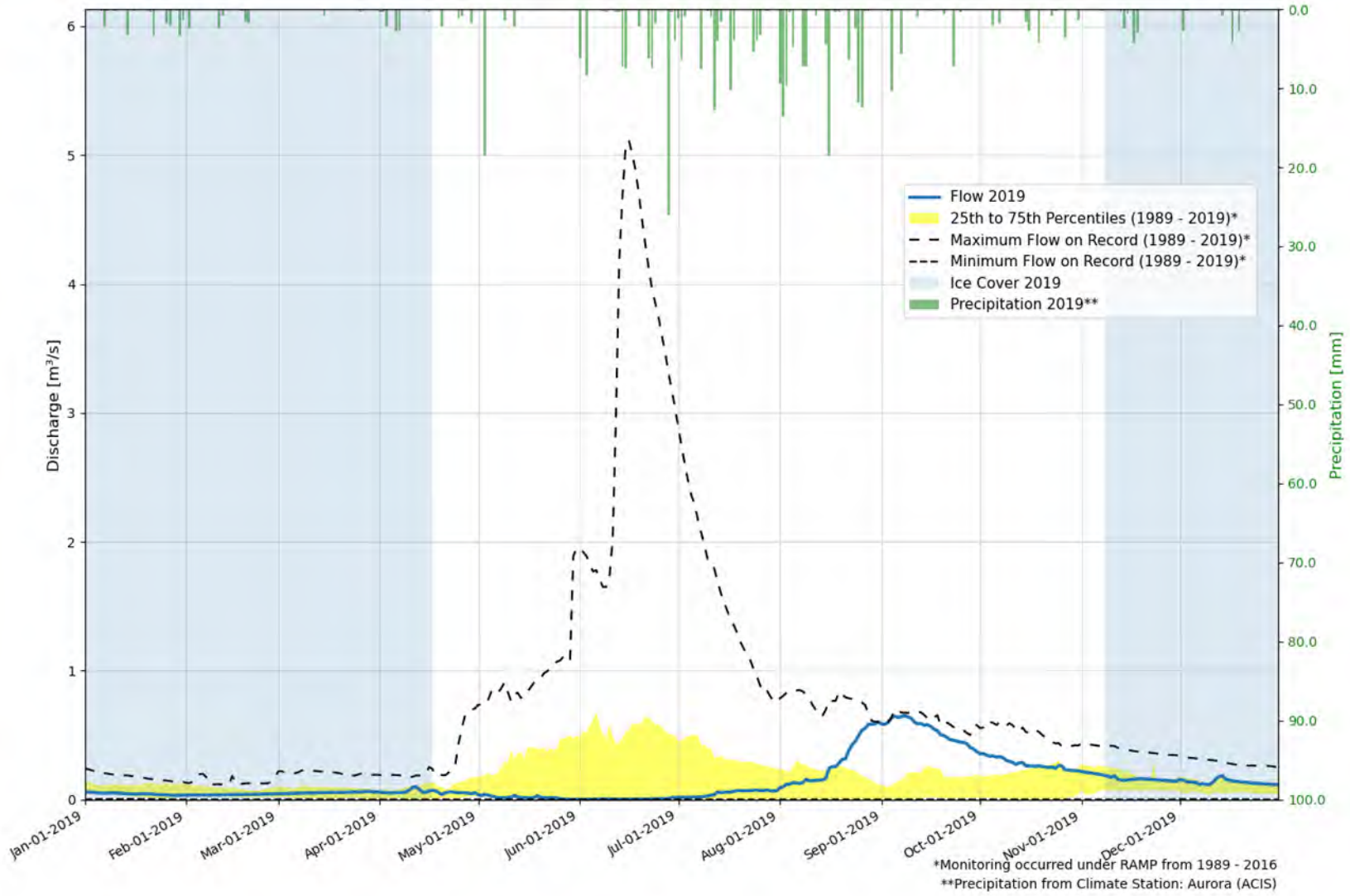

Figure C26: Kearl Lake Outlet (07DA030)

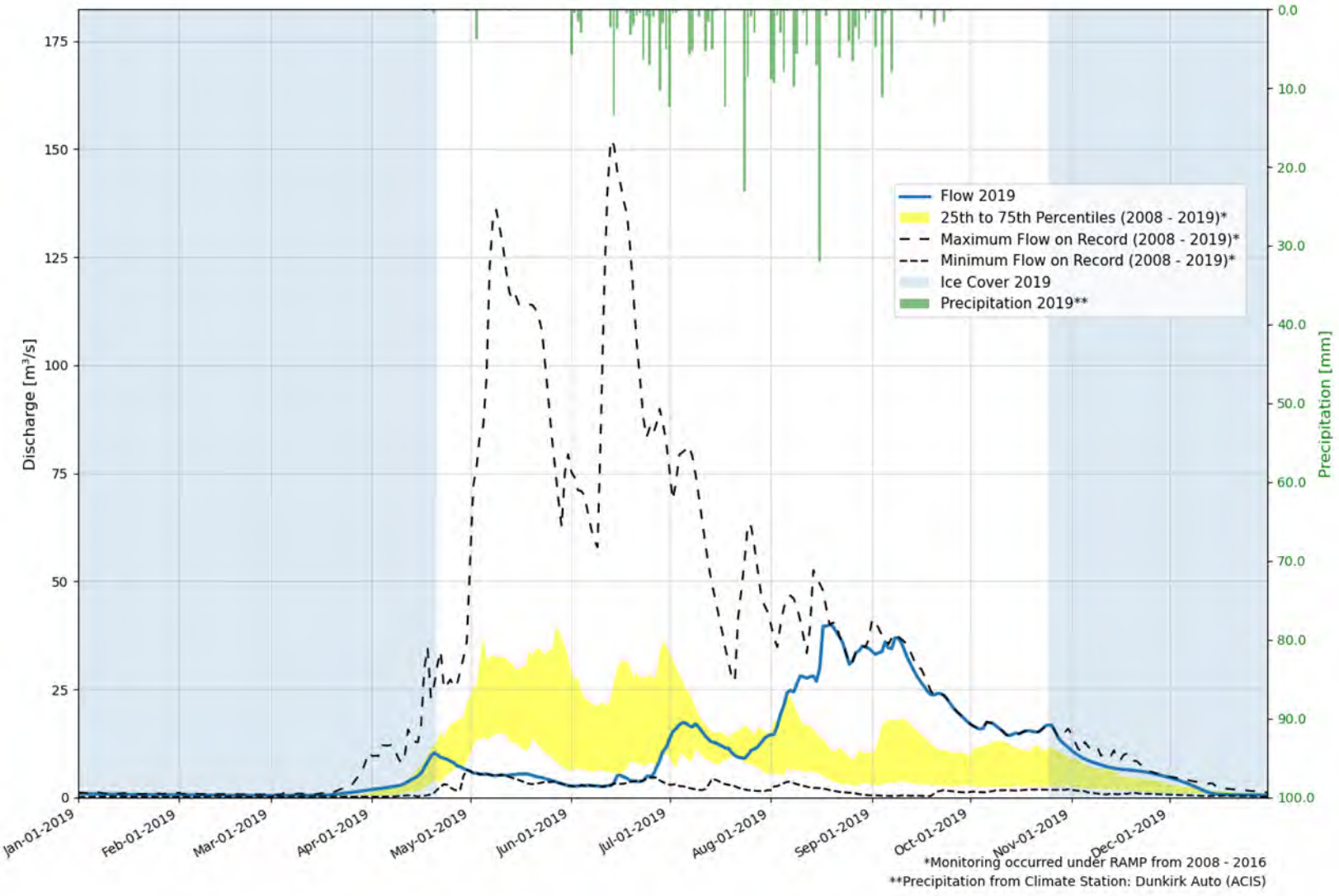

Figure C27: MacKay River at Petro-Canada Bridge (07DB006)

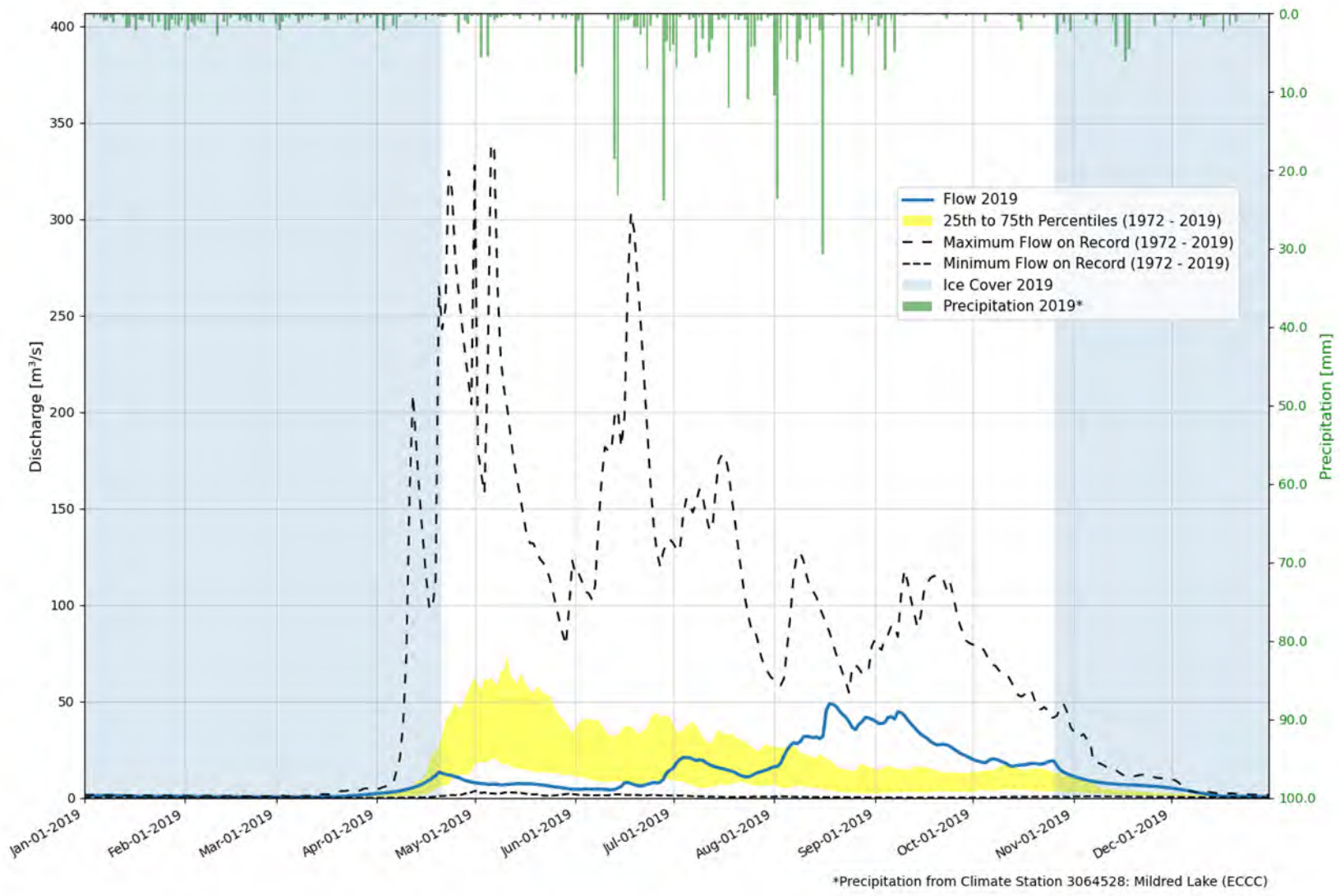

Figure C28: MacKay River near Fort MacKay (07DB001)

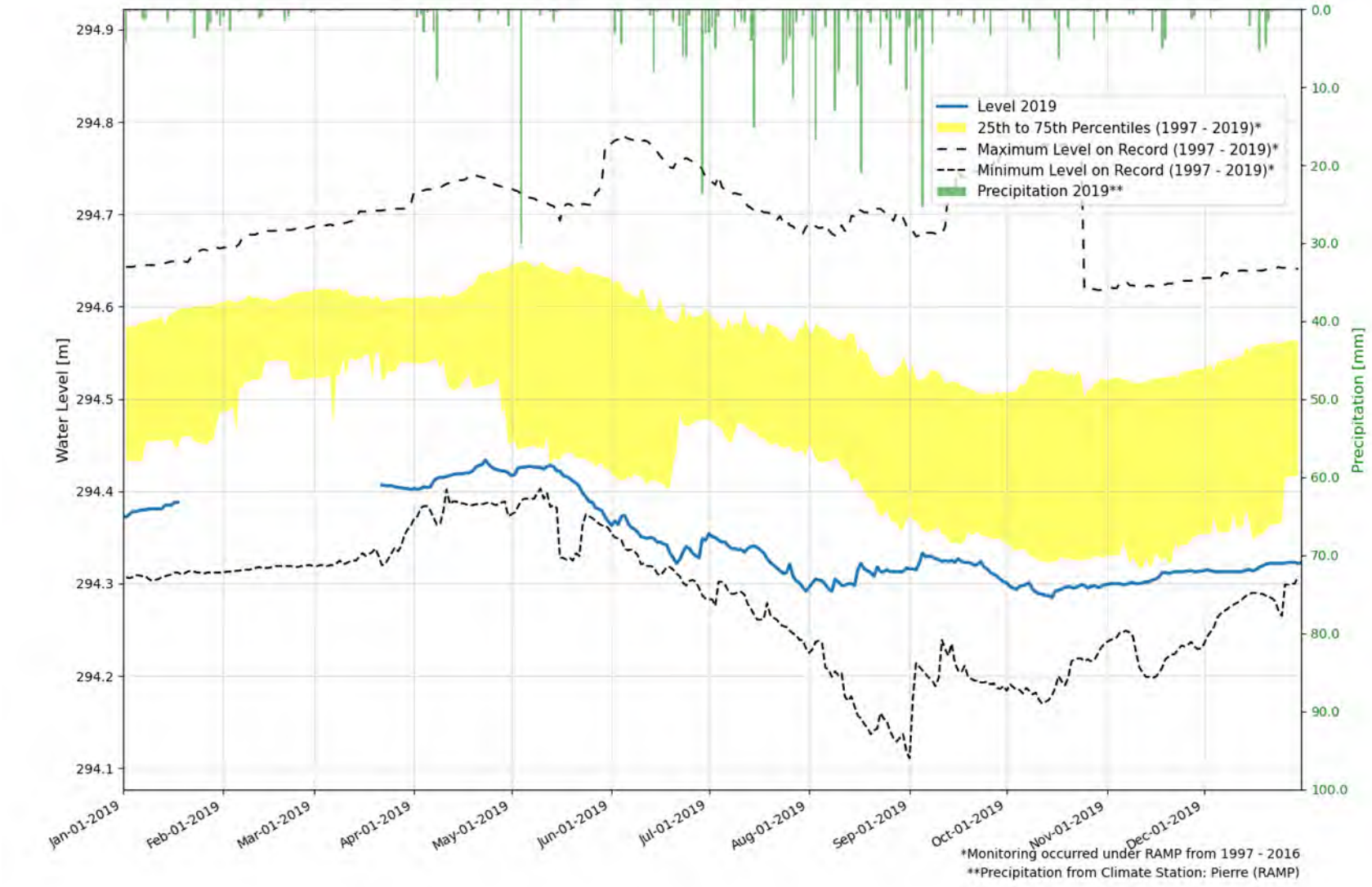

Figure C29: McClelland Lake at East End (07DA023)

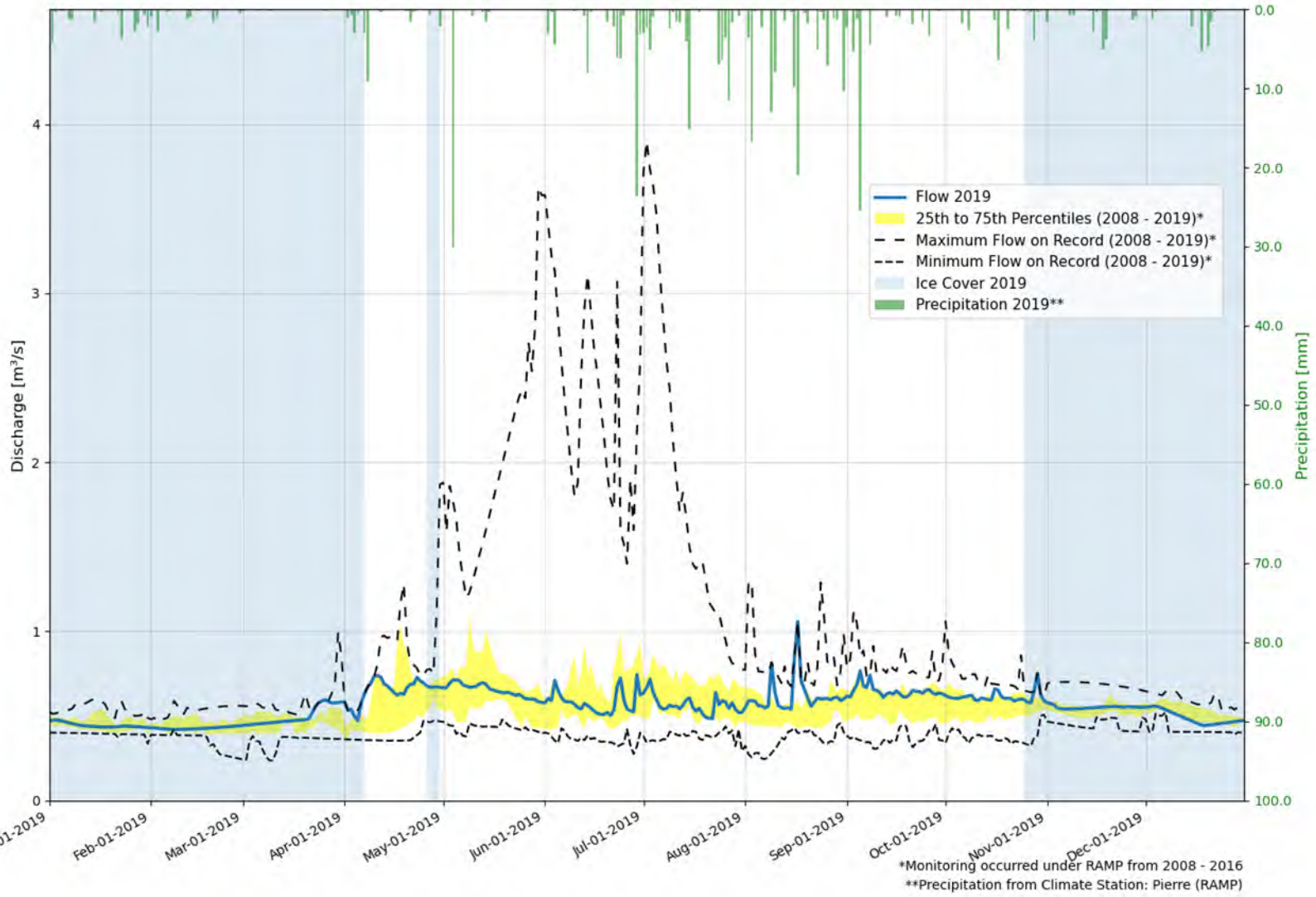

Figure C30: McClelland Lake Outlet above Firebag River (07DC004)

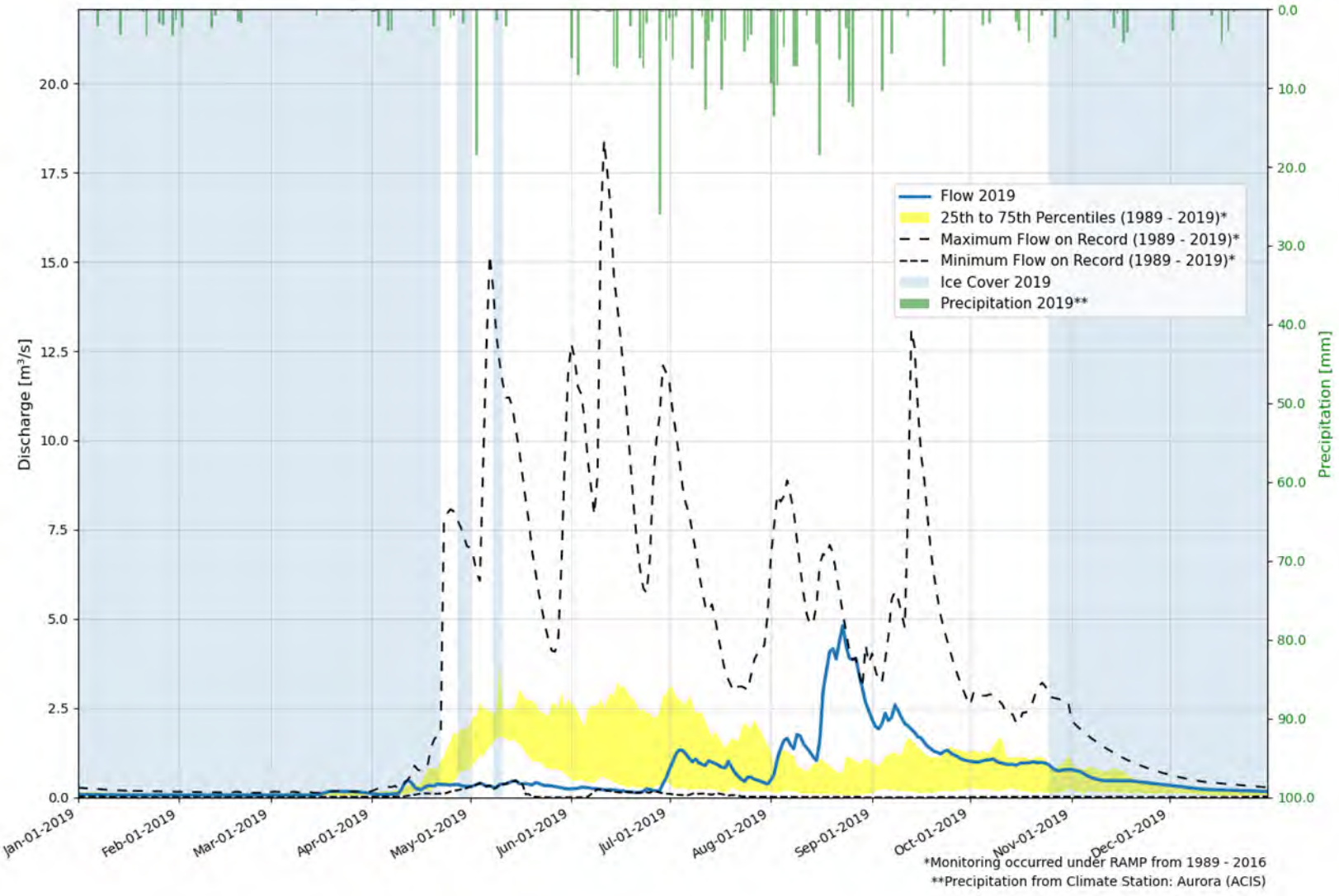

Figure C31: Muskeg Creek near the Mouth (07DA035)

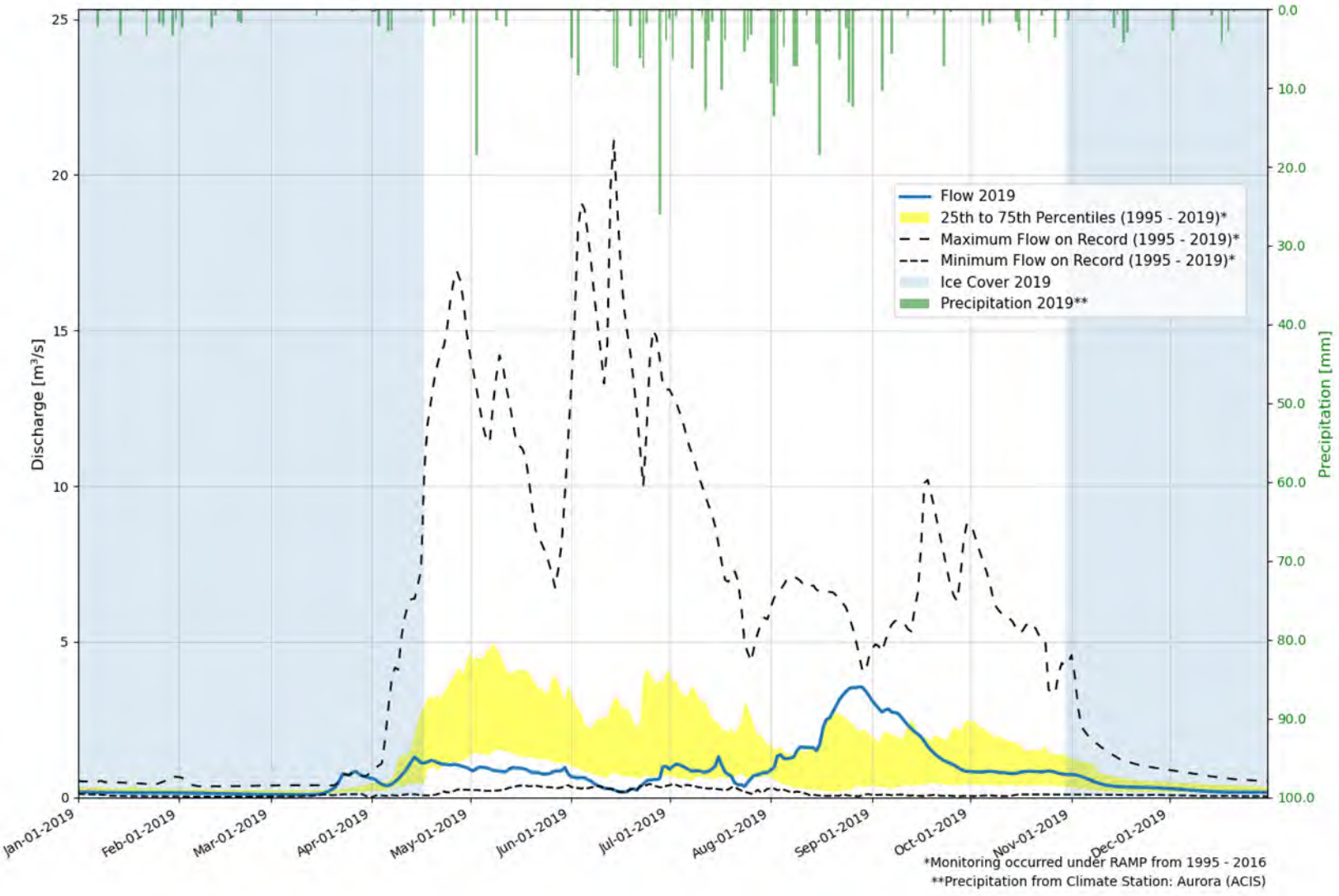

Figure C32: Muskeg River above Muskeg Creek (07DA029)

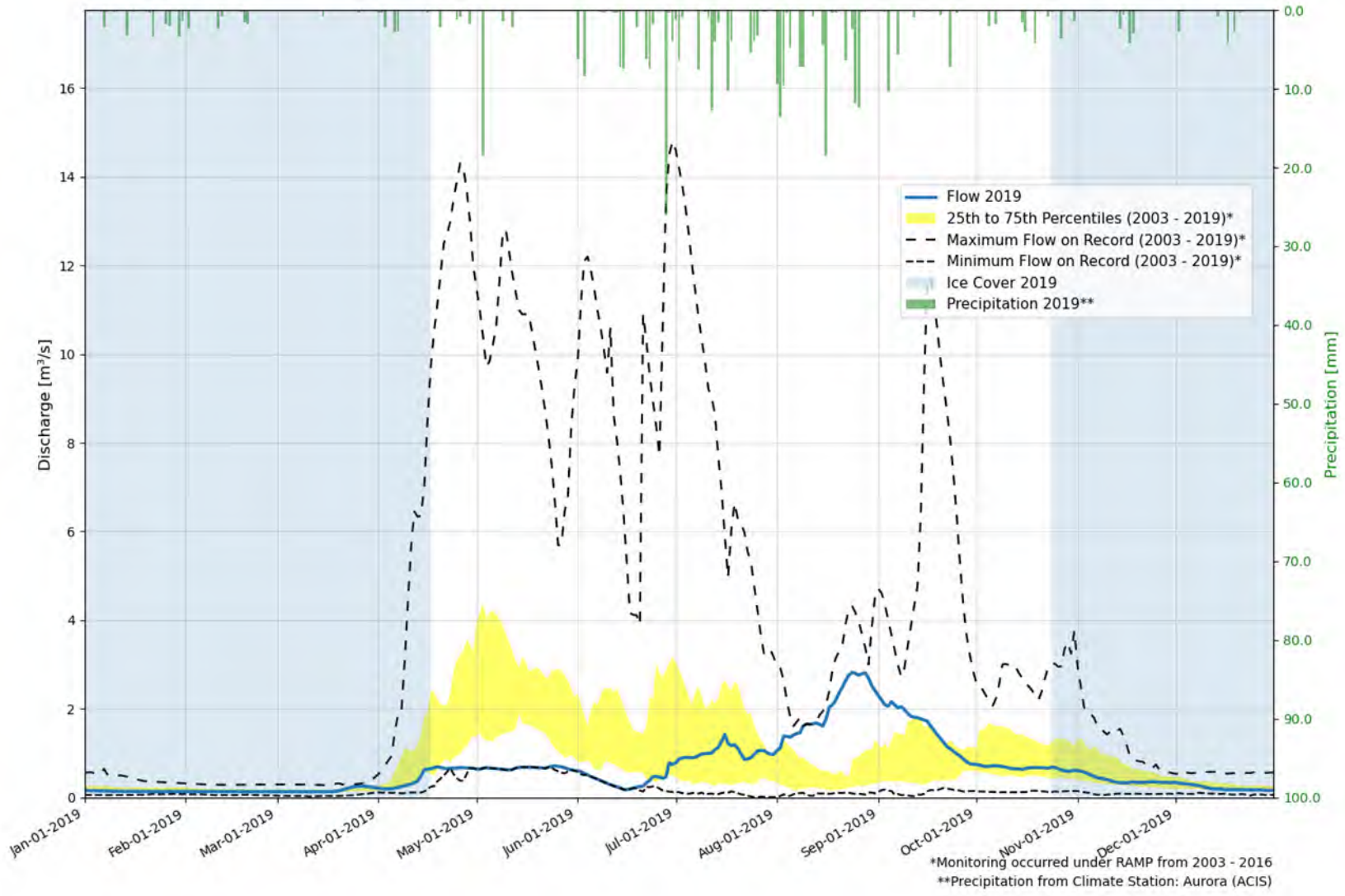

Figure C33: Muskeg River above Stanley Creek (07DA028)

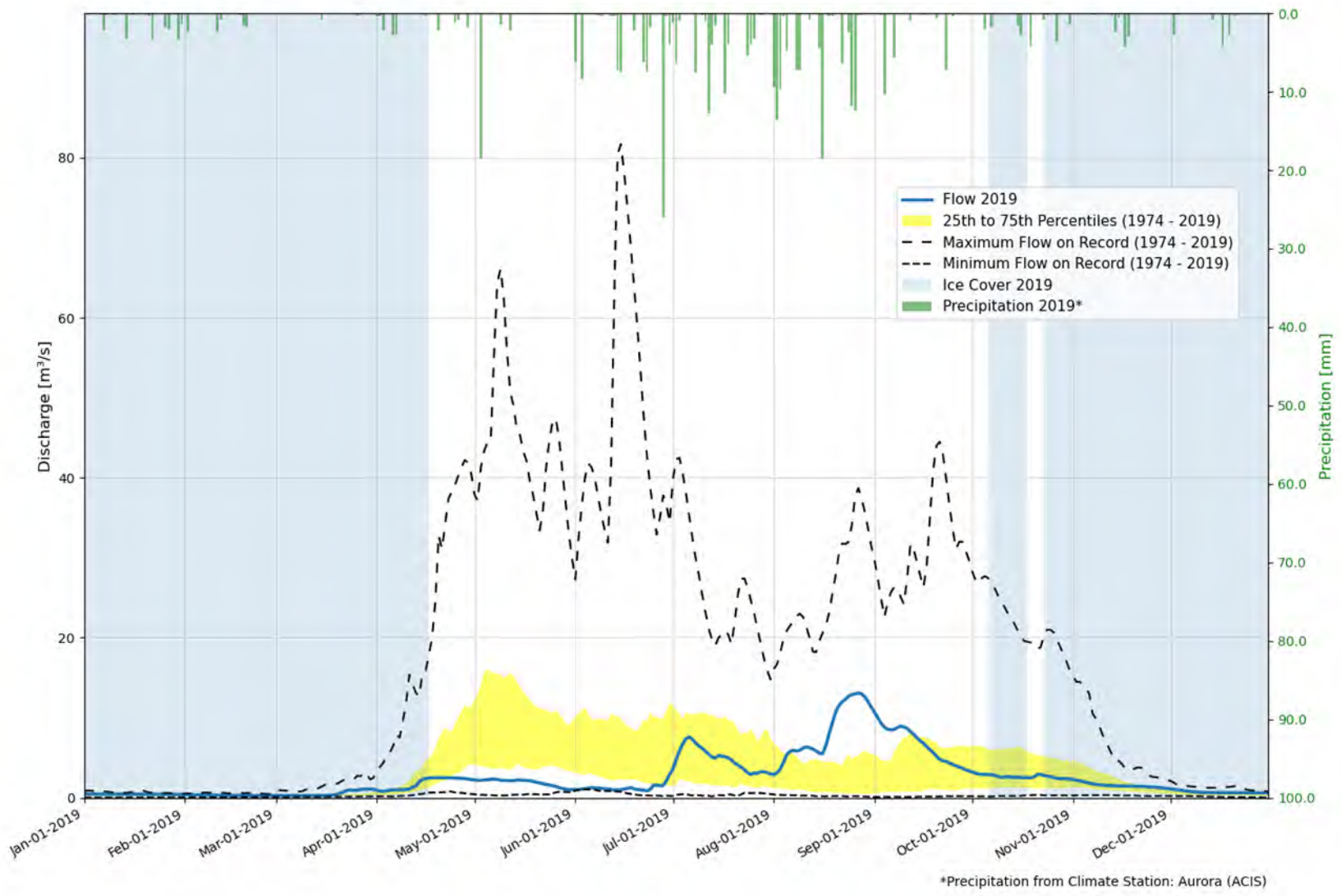

Figure C34: Muskeg River near Fort MacKay (07DA008)

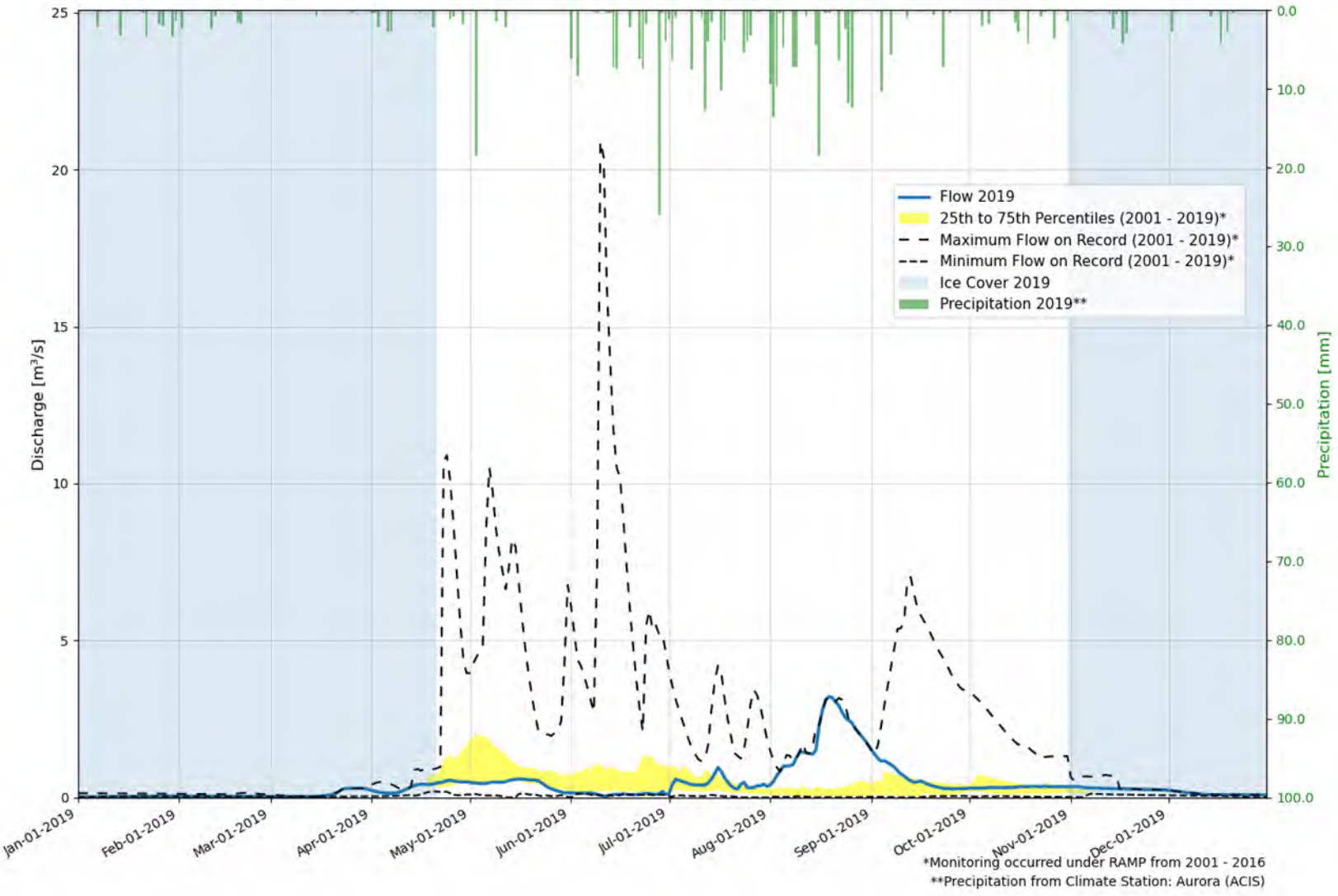

Figure C35: Muskeg River Upland (07DA034)

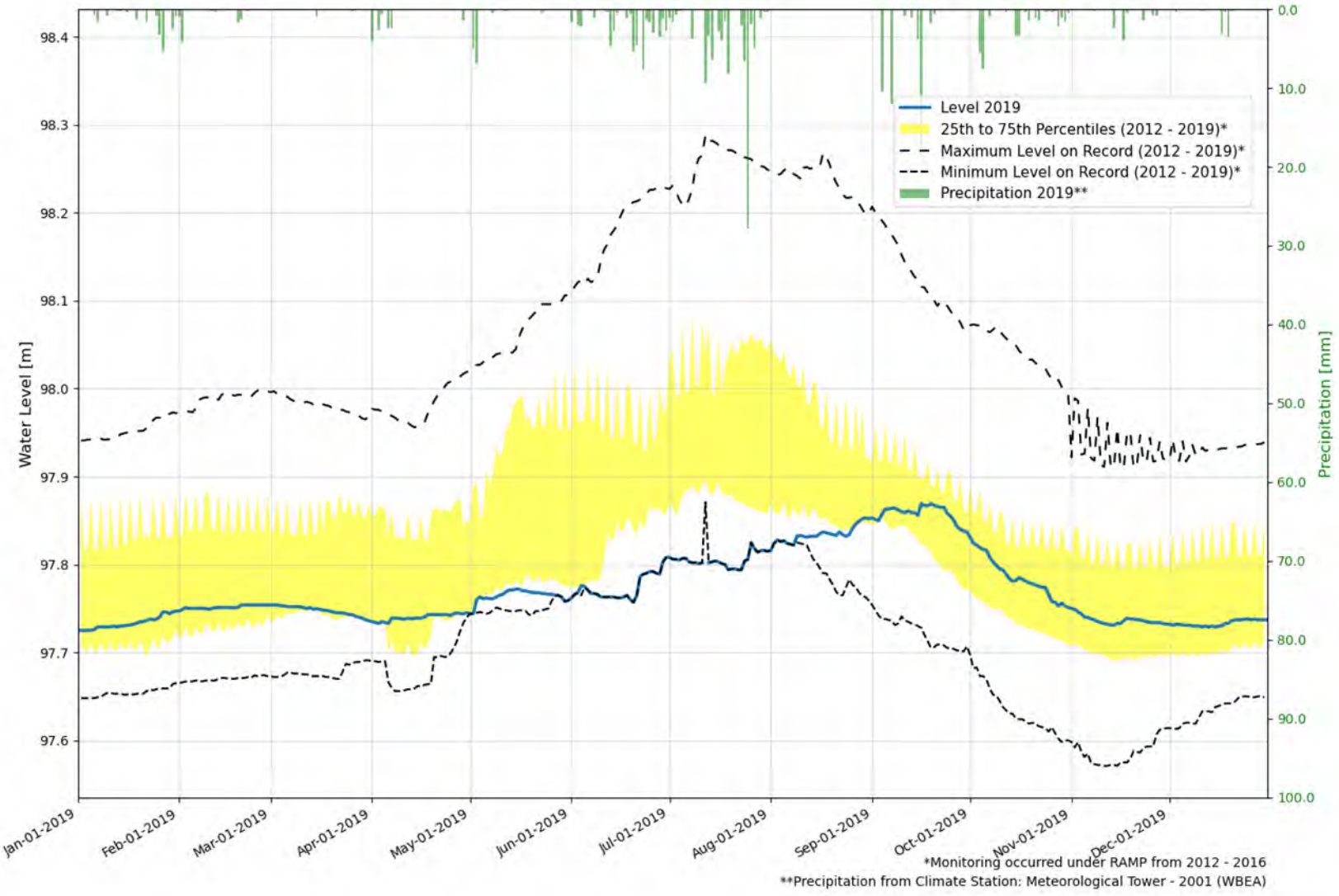

Figure C36: Namur Lake near the Outlet (07DA025)

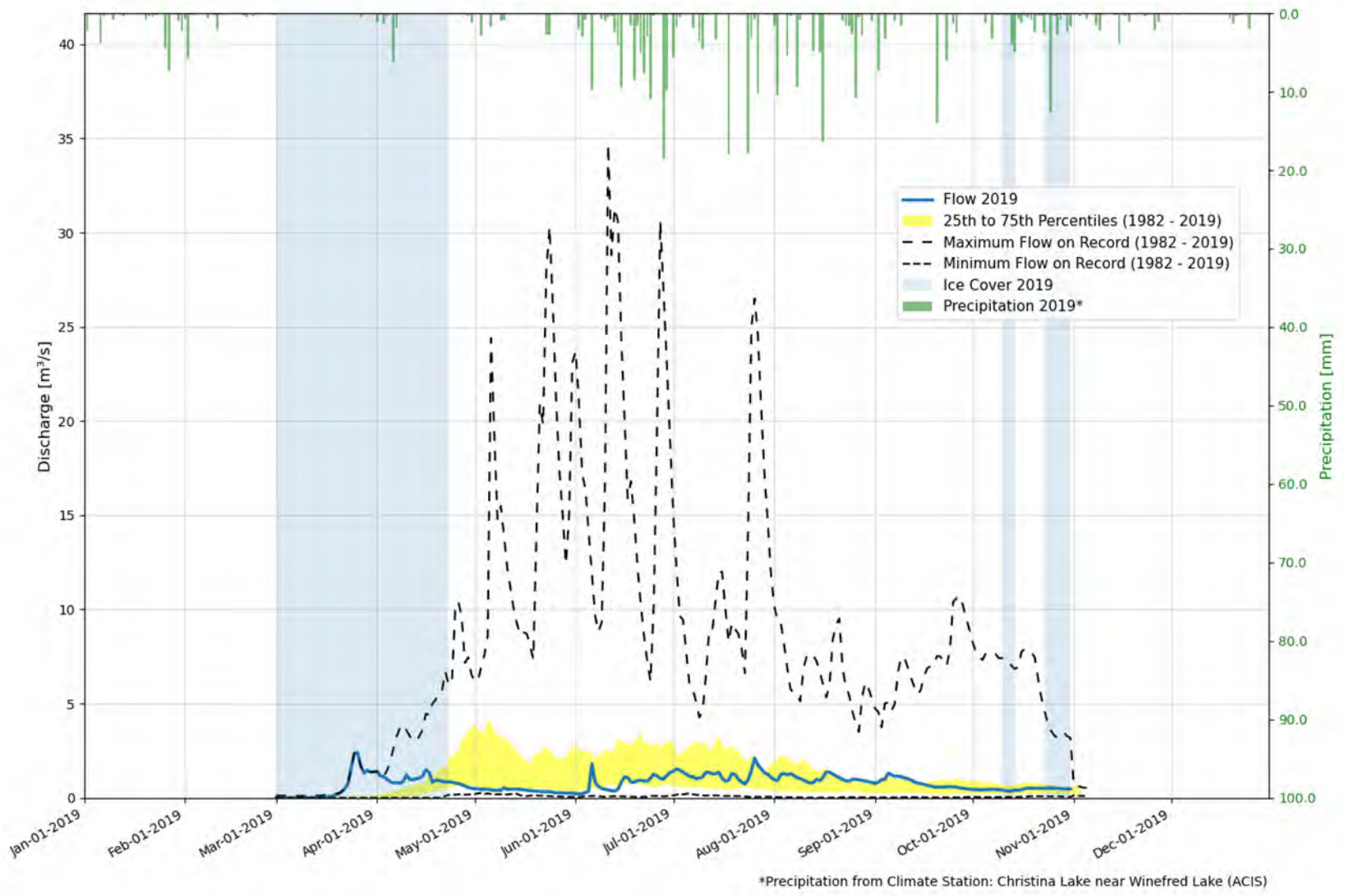

Figure C37: Pony Creek near Chard (07CE003)

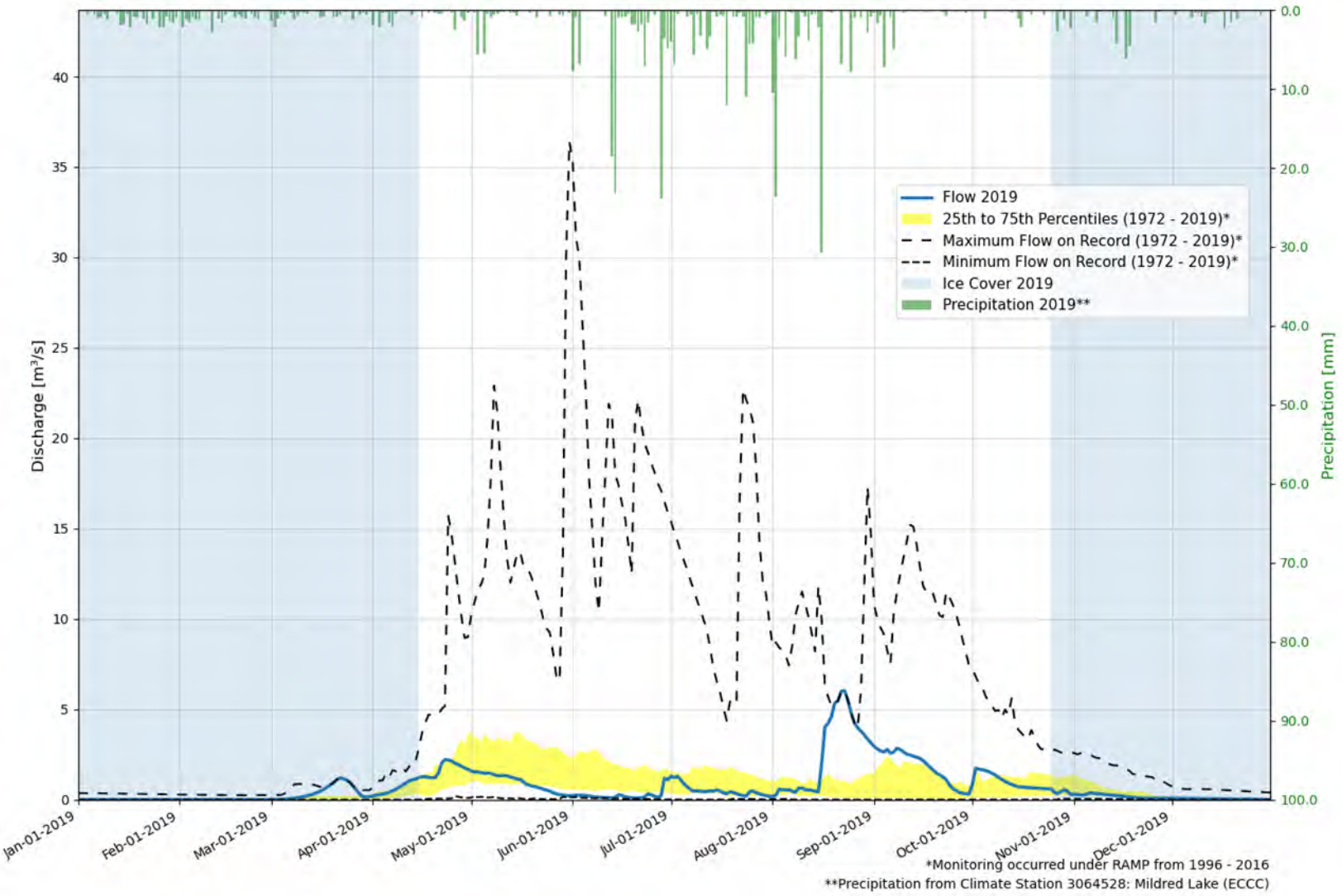

Figure C38: Poplar Creek near Fort McMurray (07DA007)

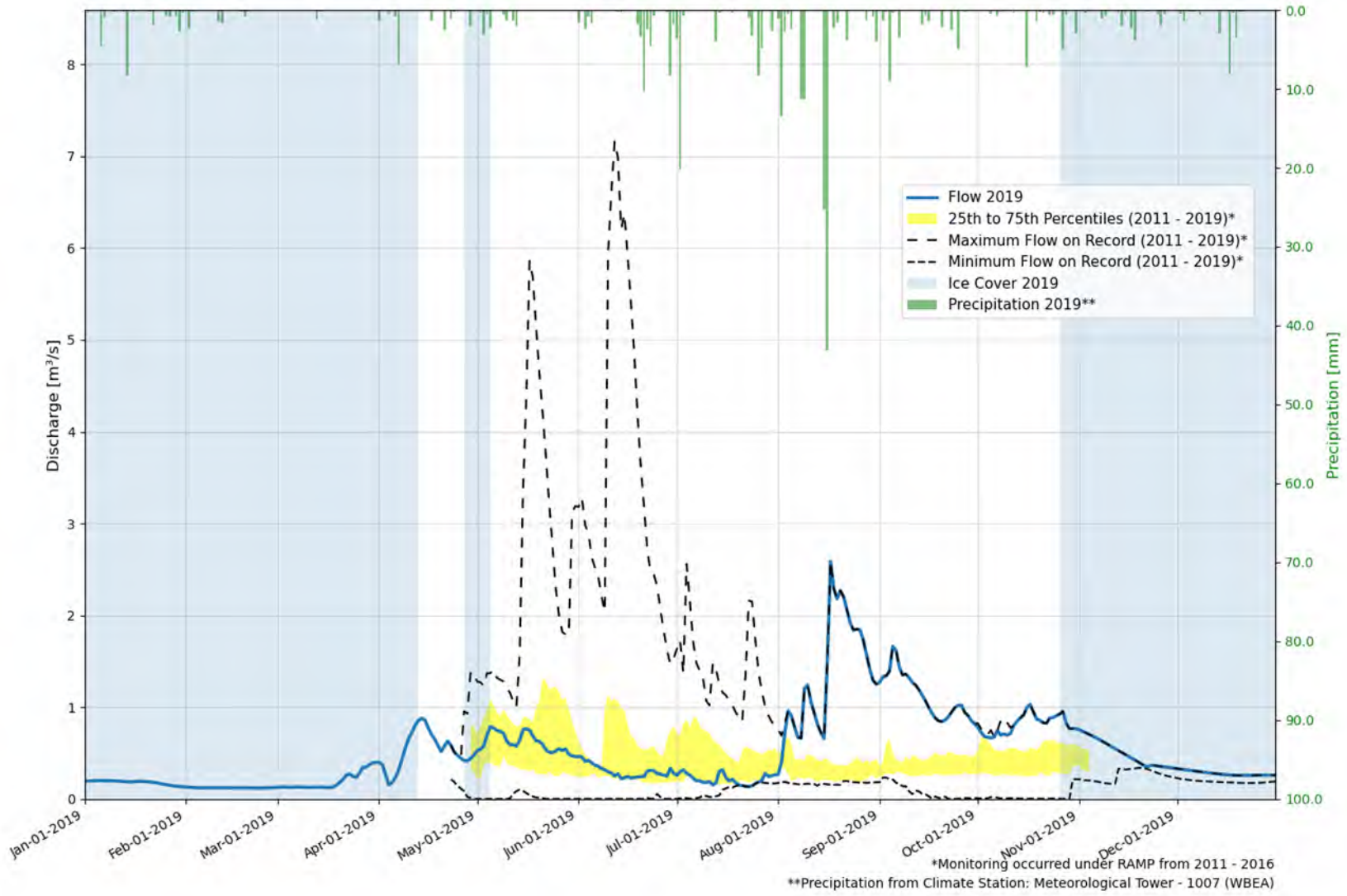

Figure C39: Red Clay Creek near the Mouth (07DA042)

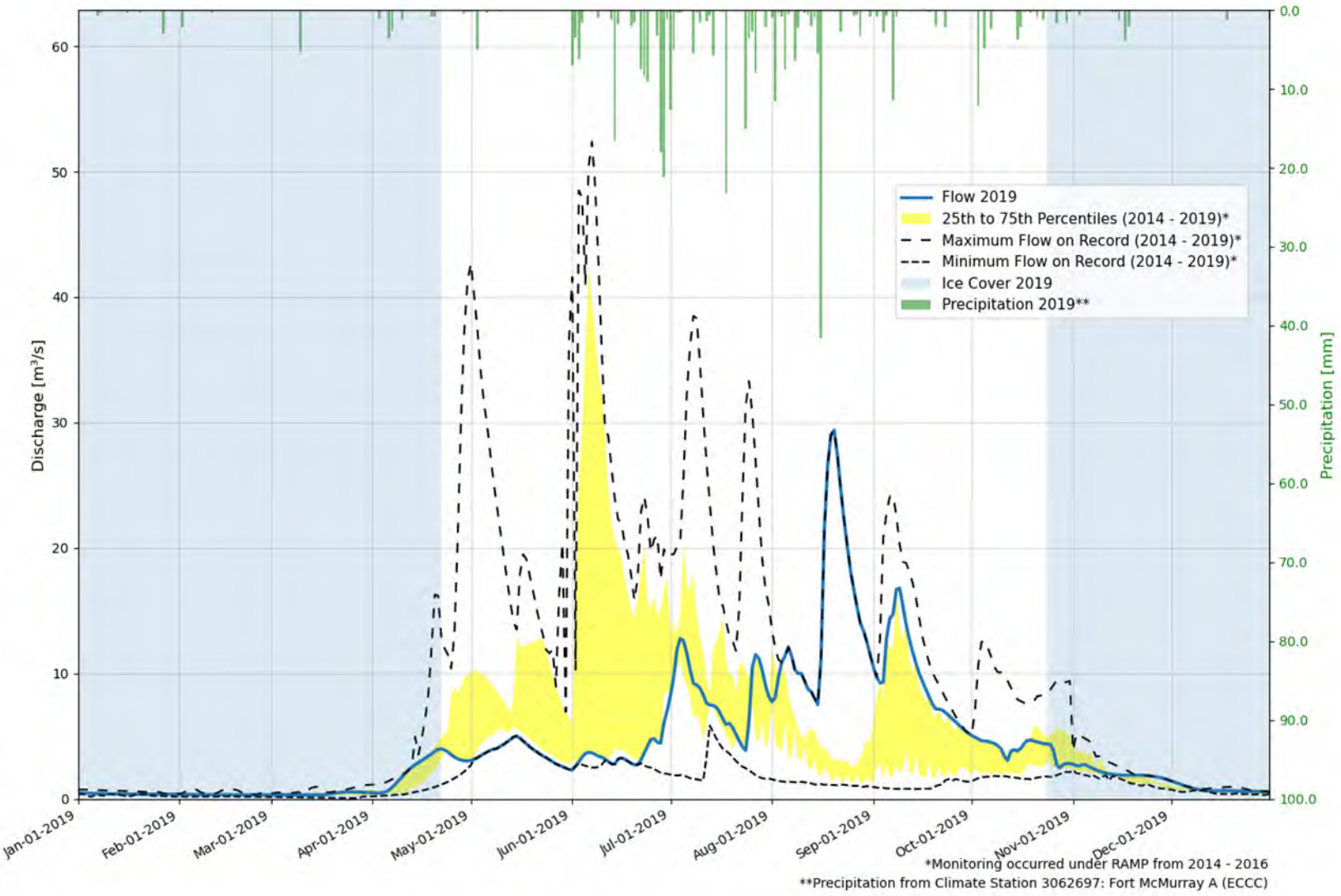

Figure C40: Steepbank River below North Steepbank River (07DA044)

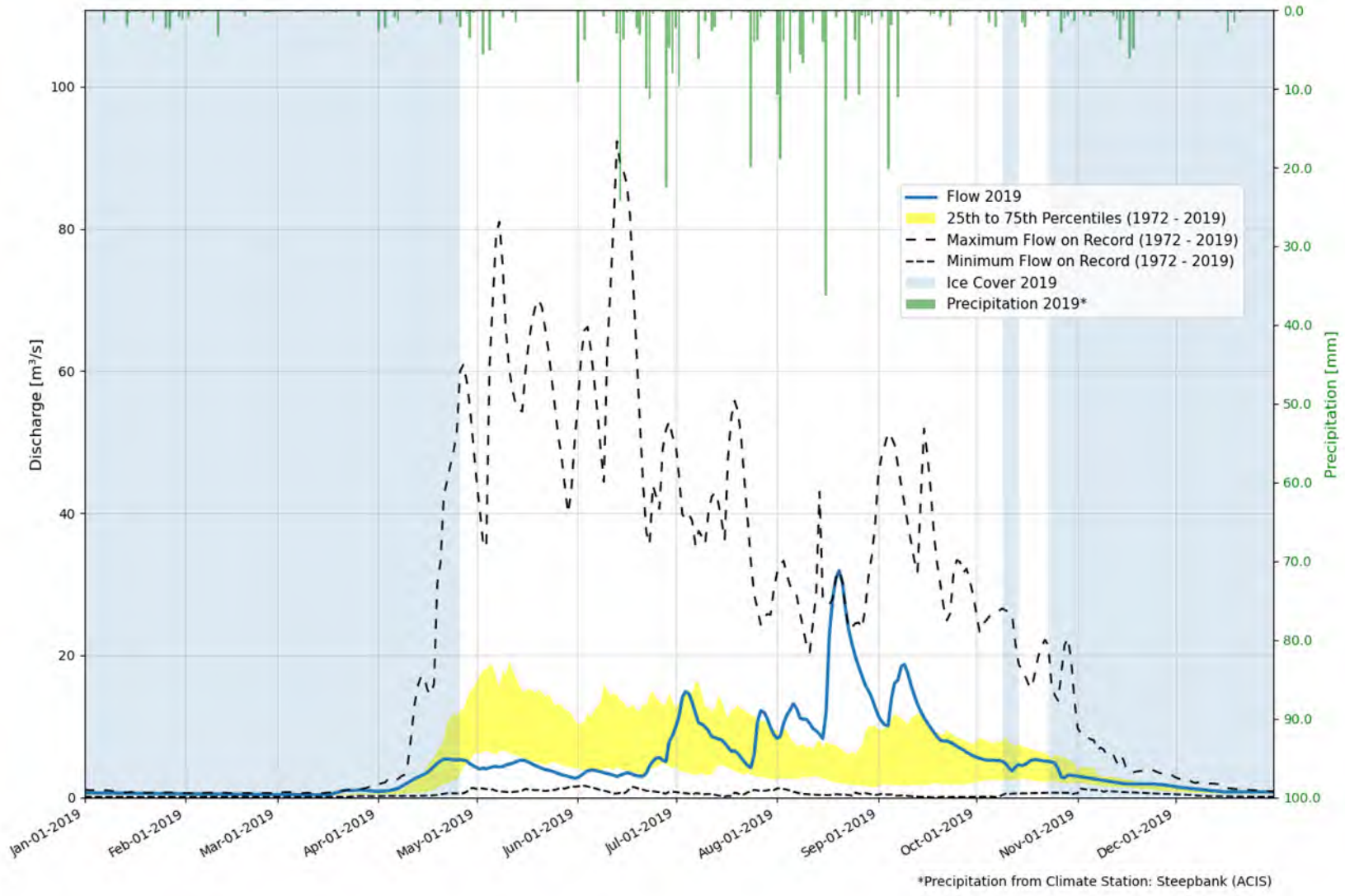

Figure C41: Steepbank River near Fort McMurray (07DA006)

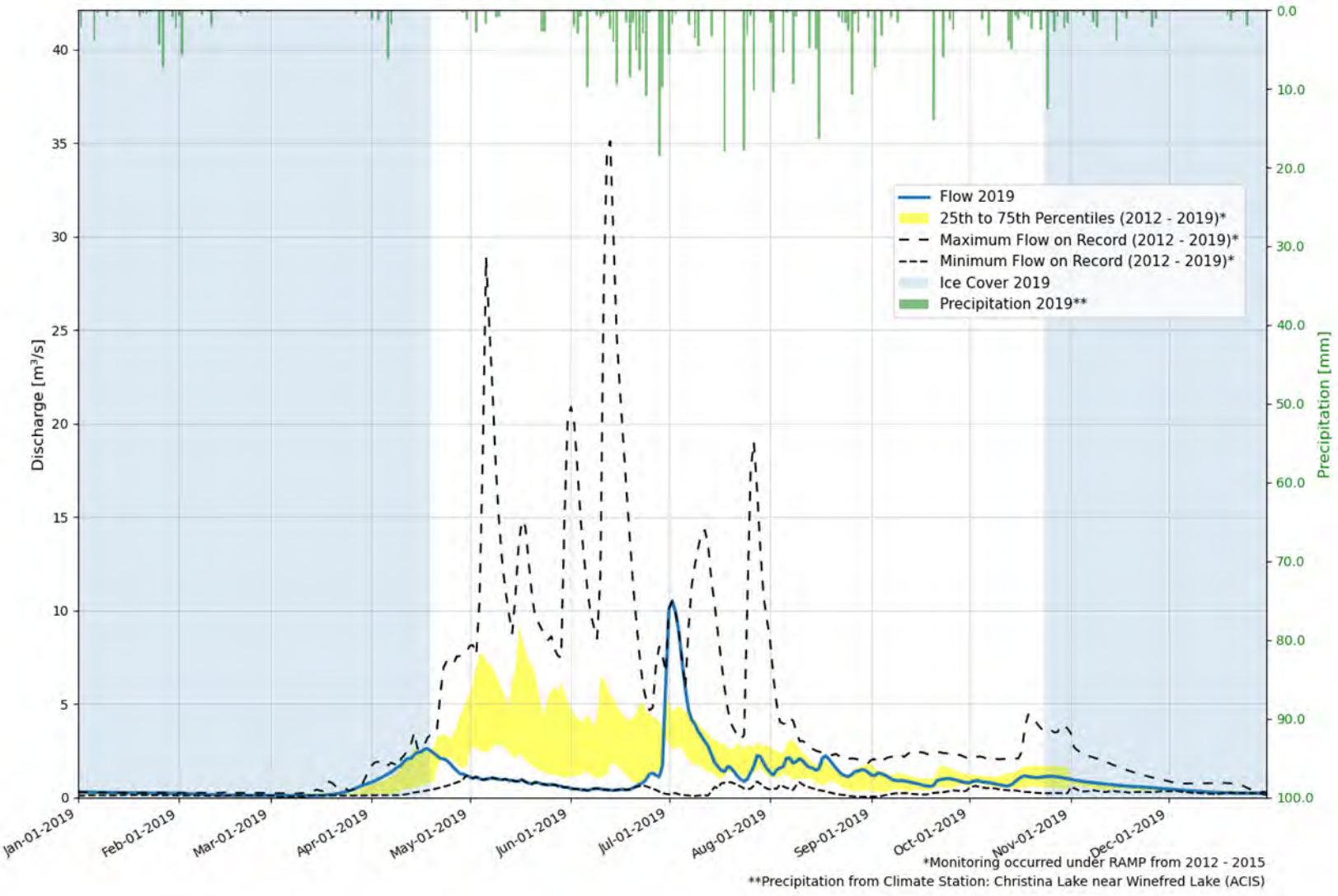

Figure C42: Sunday Creek above Christina Lake (07CE010)

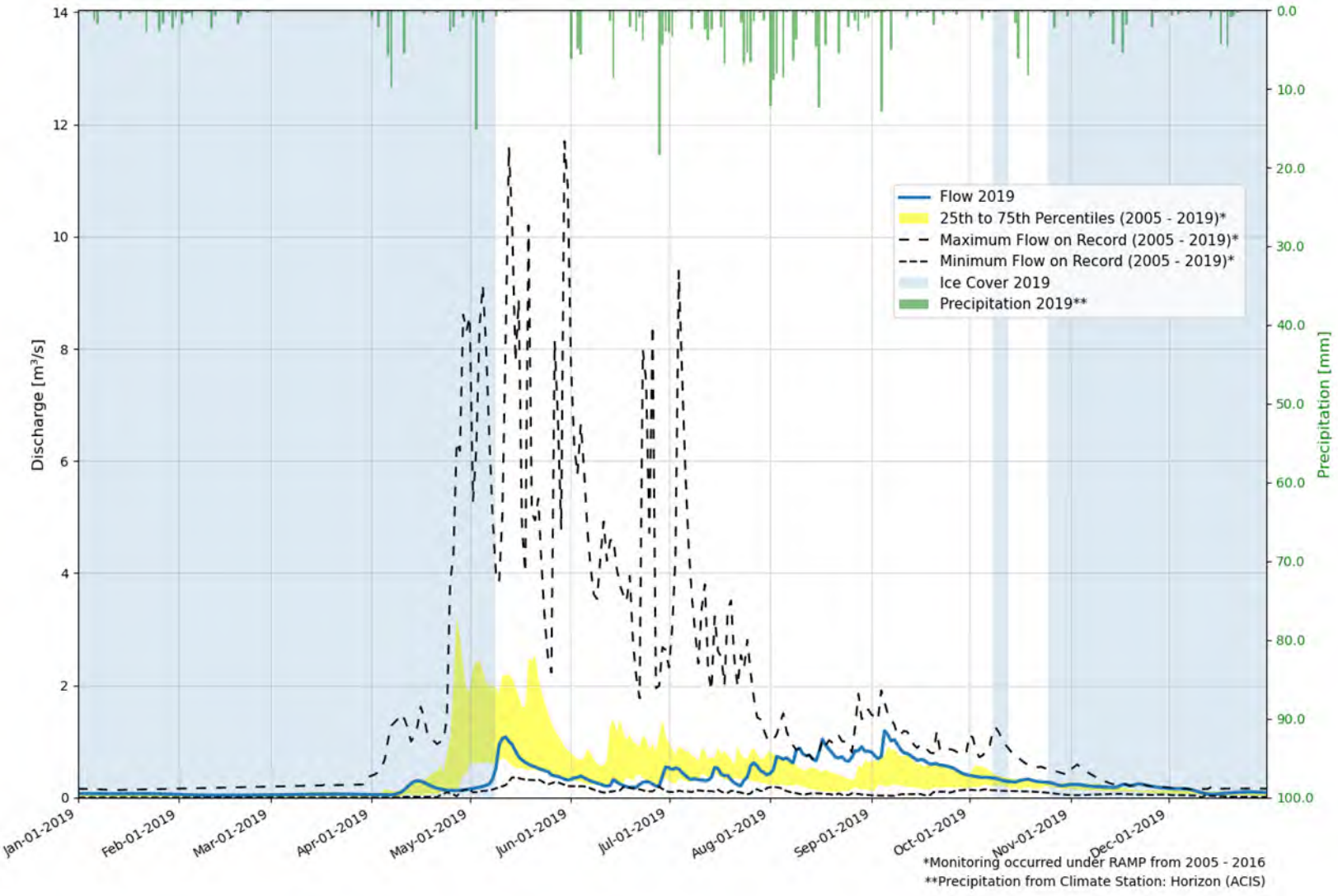

Figure C43: Tar River above Canadian Natural Resources Limited Lake (07DA037)

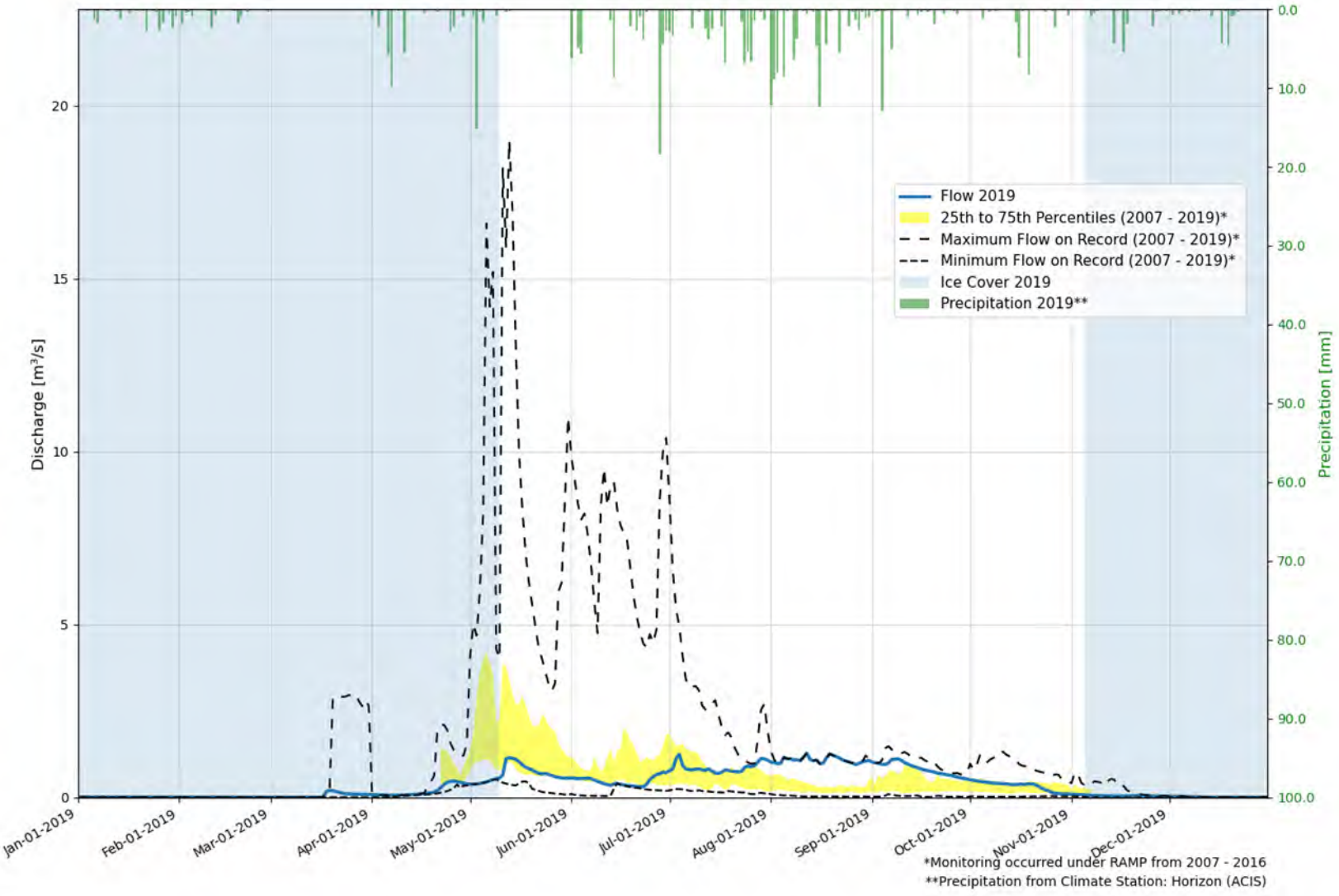

Figure C44: Tar River near the Mouth (07DA045)