# 4.0 CLIMATIC AND HYDROLOGIC CHARACTERIZATION OF THE ATHABASCA OIL SANDS REGION IN 2008

The following description of the 2008 climate and hydrology of the Athabasca oil sands region and comparison with long-term values provides a context for the results of the 2008 RAMP monitoring program. The comparison is based primarily on federal and provincial hydrologic monitoring stations because of the long data record available at those stations.

Total precipitation in 2008 at Fort McMurray was below the median value for the fifth consecutive year, but was near the long-term annual average (since 1944, Figure 4.1-1). Precipitation amounted to 413 mm during the water year (November 1, 2007 to October 31, 2008) and 422 mm during the calendar year. For comparison, the long-term annual average precipitation at Fort McMurray is 438 mm (Figure 4.1-1). The monthly precipitation is compared to average and extreme historical monthly values in Figure 4.1-2. With the exception of November 2007 and August and October 2008, total monthly precipitation was below average throughout the entire water year. For the second consecutive year, August precipitation was above average and in 2008 was near the maximum recorded value.

A more detailed view of the distribution of precipitation throughout the calendar year and across the region is shown in Figure 4.1-3. Lower than average precipitation was recorded throughout almost all of the calendar year and throughout most of the Fort McMurray area with the exception of the area around Mildred Lake which had higher than average precipitation up to late June. The largest rainfall event of the year occurred from July 27 to August 3, when 55 mm of rain was recorded at Fort McMurray A, and 76 mm at RAMP Station C1 – Aurora Climate Station. Precipitation at Fort McMurray was higher than at stations north of Fort McMurray from September through December. Through the summer, the rainfall recorded at the Mildred Lake station was less than the surrounding RAMP stations. From May through September Mildred Lake recorded 100 mm less rainfall than Fort McMurray. The 2008 spring snowpack was comparable to that in 2005 and was arguably the heaviest in the past five years (Table 4.1-1).

The annual runoff and maximum and minimum daily discharge at selected regional Water Survey of Canada (WSC) streamflow stations are compared with historical values. The stations are selected to represent four main areas of interest: the Athabasca River itself; the Muskeg River, representative of watersheds east of the Athabasca; the MacKay River, representative of watersheds west of the Athabasca; and the Christina River, representative of conditions south of Fort McMurray. Total runoff volume in the Athabasca River measured at the WSC station 07DA001 (Athabasca River below McMurray) was 20% less than the long-term average (Table 4.1-2), and has been below average in 14 of the past 17 years (Figure 4.1-4). The spring runoff flow peaked in the upper quartile on three occasions in 2008 due to heavy snowpack (Figure 4.1-5). Although the Fort McMurray area experienced very little precipitation in May, the runoff resulted in river flow which was above the median value from early May to mid June. Flow then subsided and was within the lower quartile by the end of June. For the remainder of the year, flow was near or within the lower quartile, peaking once in August as a result of the intense rainfall event. The 2008 maximum daily discharge of 1,726 $m^3/s$ was 30% less than the mean annual flood (i.e. the mean of the series of annual maximum daily discharges) of 2,502 $m^3/s$ and the 2008 March to October minimum daily discharge of 129 $m^3/s$ was 13% below the historical average of 149 $m^3/s$ (Table 4.1-2).

The 2008 runoff volume was within the median flow in the Muskeg River basin (Figure 4.1-6). The March to October runoff was 86.3 mm compared to the historical average value of 81.1 mm. The discharge was consistently within the upper quartile throughout May, but decreased to median range levels by mid-June. Flow in July was near the lower quartile range, but increased after the late July and early August precipitation to median flows for the remainder of the monitored year (Figure 4.1-7). The annual maximum daily discharge of 35.7 $m^3/s$ was 39% greater than the mean annual flood of 25.6 $m^3/s$, while the minimum March to October discharge of 0.26 $m^3/s$ was slightly below the average of 0.28 $m^3/s$ (Table 4.1-2).

The seasonal runoff in the MacKay River basin measured at WSC station 07DB001 (MacKay River near Fort McKay) was 94.4 mm (Table 4.1-2), the highest runoff since 1997 and approximately 23% greater than the historical average of 76.5 mm (Figure 4.1-8). Flow throughout May and June was in or near the upper quartile, while flows in July decreased to near the lower quartile. The precipitation event at the beginning of August caused a large increase in flow to near maximum recorded values for August followed by a decrease to upper quartile flows for the remainder of the monitored year (Figure 4.1-9). The maximum daily discharge of 106 $m^3/s$ was slightly below the average mean annual flood of 122 $m^3/s$ while the minimum March to October discharge of 0.41 $m^3/s$ was 21% greater than the historical average of 0.34 $m^3/s$ (Table 4.1-2).

The 2008 seasonal runoff measured at WSC station 07CE002 (Christina River near Chard) was 115 mm (Table 4.1-2), above average for the fifth consecutive year (Figure 4.1-10). Spring runoff peaked in early May near the maximum recorded flow for that period. Flow in June was near median values and decreased in July to the lower quartile range (Figure 4.1-11). The August precipitation event increased the flow to its annual maximum daily value, and it remained in the upper quartile until the end of the monitoring period. The maximum daily discharge of 99.5 $m^3/s$ was above the mean annual flood of 80.7 $m^3/s$ by 23% and the minimum seasonal discharge of 3.39 $m^3/s$ was above the historical average of 2.31 $m^3/s$ by 47% (Table 4.1-2).

In summary, 2008 was characterized by:

- A freshet in May with flows in the upper quartile throughout the Athabasca oil sands region;
- A significant decrease in flow in June and July due to low precipitation throughout May to July;
- Increased flow, especially south of Fort McMurray, due to the large precipitation event in early August, initiating a recovery in flow in the major rivers for the remainder of the open water season; and
- Overall, runoff volumes slightly above the median values except for the Athabasca River, which continued an almost two decade-long period of below average annual flows.

**Figure 4.1-1 Historical annual precipitation at Fort McMurray (1946 to 2008).**

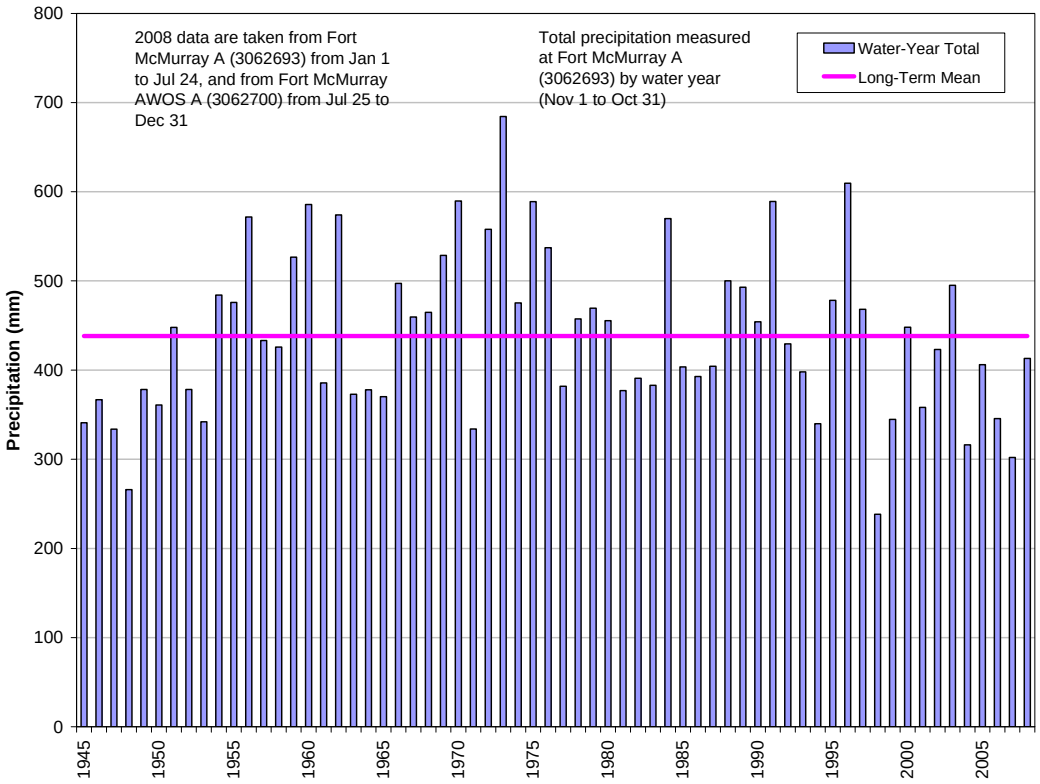


**Figure 4.1-2 Monthly precipitation at Fort McMurray in the 2008 water year (November 1, 2007 to October 31, 2008).**

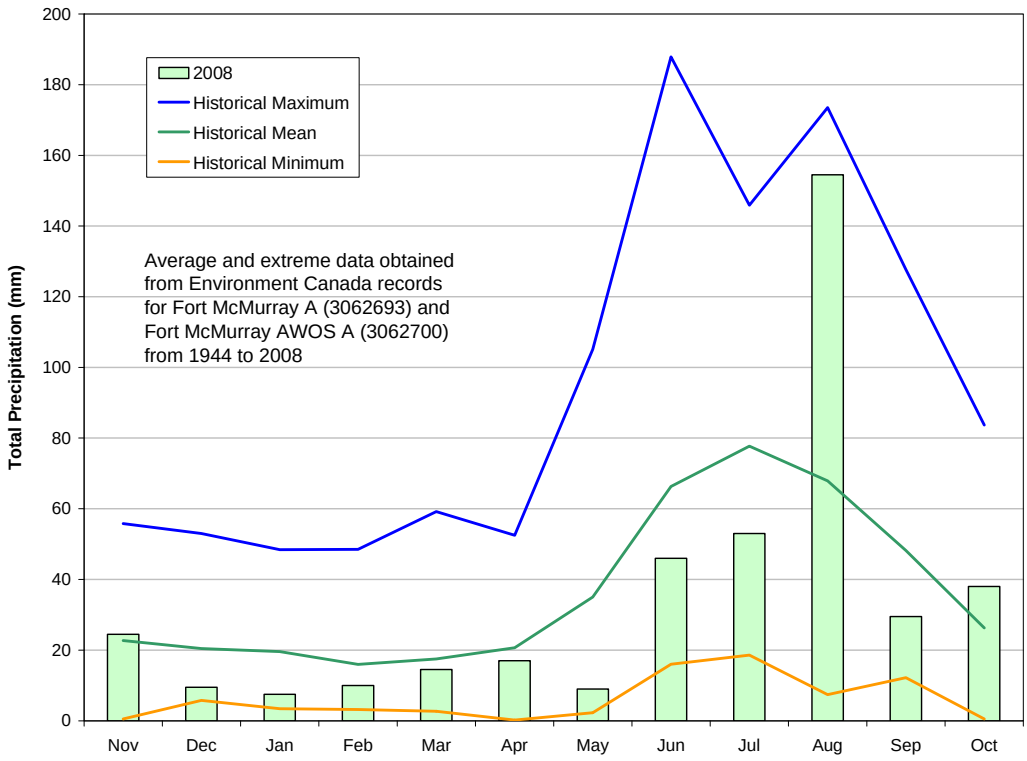

**Figure 4.1-3 Cumulative total precipitation at climate stations in the Athabasca oil sands region in 2008.**

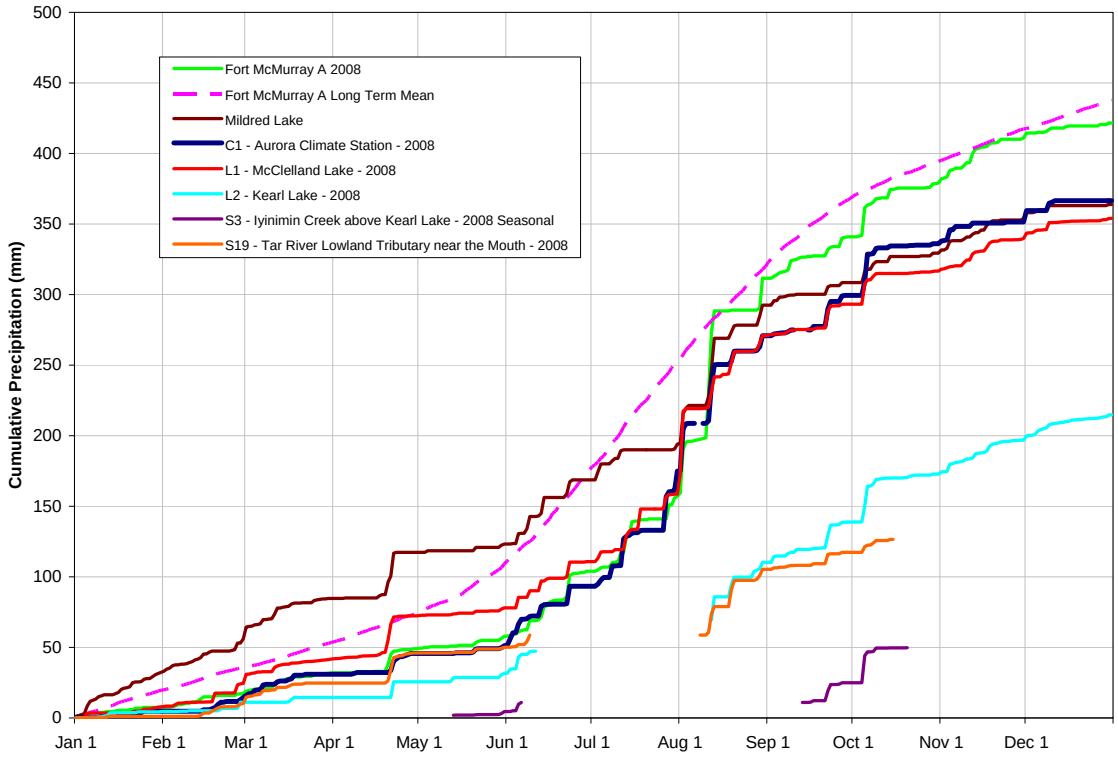


**Table 4.1-1 Historical maximum measured snowpack.**

| Year | Maximum Measured Snowpack* (mm water equivalent) | | | |
|---|---|---|---|---|
| | Jack Pine | Mixed Deciduous | Flat Low Lying | Open Land/Lake |
| 2004 | 71 | 58 | 71 | 57 |
| 2005 | 108 | 102 | 112 | 75 |
| 2006 | 48 | 49 | 49 | 45 |
| 2007 | 92 | 98 | 98 | 104 |
| 2008 | 102 | 100 | 112 | 91 |
| Average | 84 | 81 | 88 | 74 |

* Data source: RAMP regional snowcourse surveys. Multiple snowcourses were sampled in each terrain type, three times during the winter (usually in February, March and April). The values shown in the table were obtained by averaging the measurements obtained for each terrain type during each month, and then selecting the values for the month with the greatest average water equivalent.

**Table 4.1-2 A summary of 2008 streamflow variables compared to historical values measured in the Athabasca oil sands region.**

| | Athabasca River below McMurray (07DA001) | Muskeg River near Fort McKay (07DA008) | MacKay River near Fort McKay (07DB001) | Christina River near Chard (07CE002) |
|---|---|---|---|---|
| **Effective Drainage Area ($km^2$)** | 131,000 | 1,460 | 5,570 | 4,851 |
| **Period of Record** | 1957 - 2008 | 1974 - 2008 | 1972 - 2008 | 1982 - 2008 |
| **Annual Runoff Depth** | | | | |
| Historical mean (mm) | 151 | 81.1[1] | 76.5[1] | 86.1[1] |
| 2008 (mm) | 122 | 86.3[1] | 94.4[1] | 115[1] |
| **Annual Maximum Daily Discharge** | | | | |
| Historical mean ($m^3/s$) | 2,502 | 25.7 | 122 | 80.7 |
| 2008 ($m^3/s$) | 1,726 | 35.7 | 106 | 99.5 |
| **Annual Minimum Daily Discharge[1]** | | | | |
| Historical mean ($m^3/s$) | 149 | 0.28 | 0.34 | 2.31 |
| 2008 ($m^3/s$) | 129 | 0.26 | 0.41 | 3.39 |

[1] March 1 to October 31

**Figure 4.1-4 Historical annual runoff in the Athabasca River basin (1970 to 2008).**

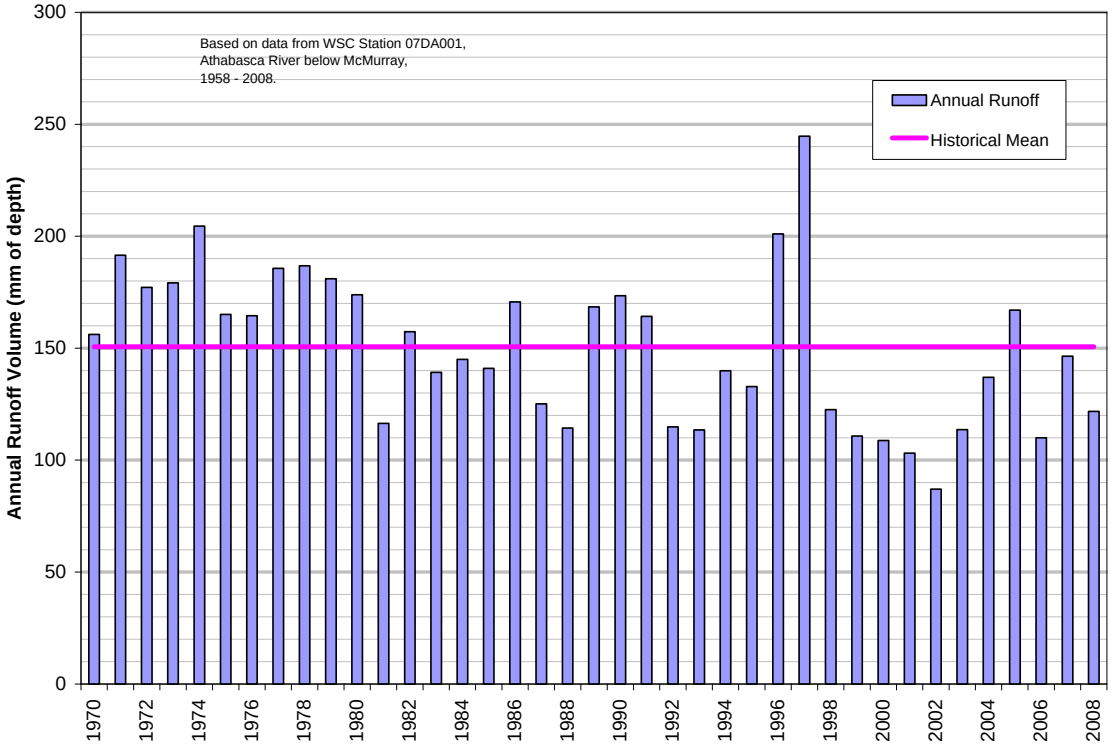


**Figure 4.1-5 The 2008 Athabasca River hydrograph compared to historical values.**

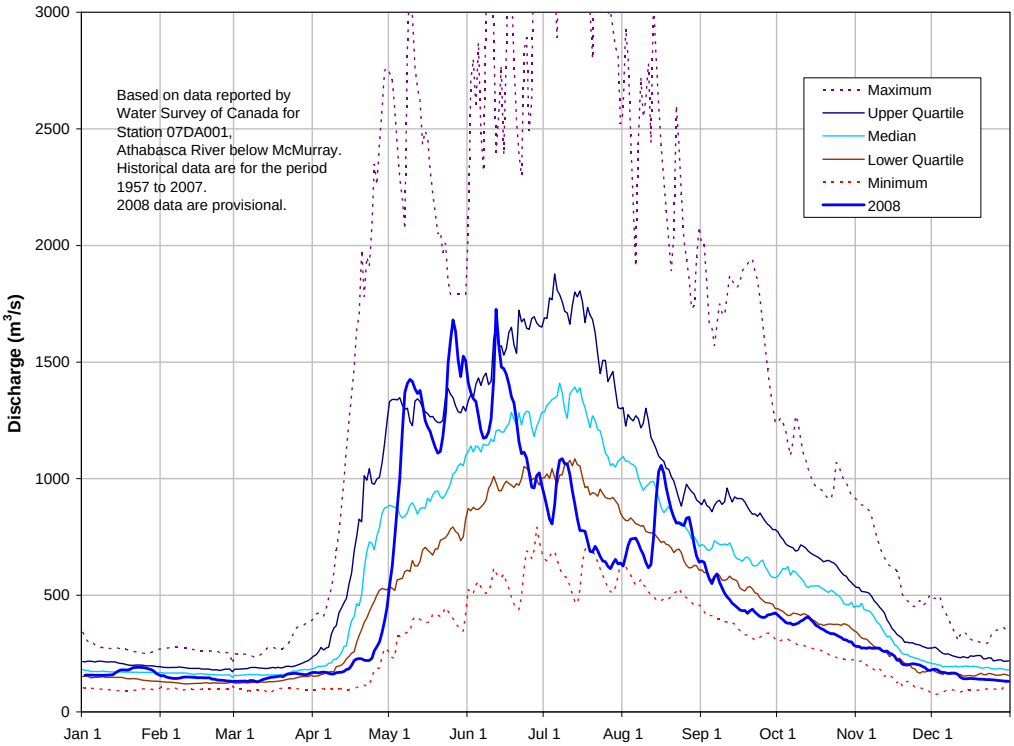

**Figure 4.1-6 Historical seasonal runoff in the Muskeg River basin (1974 to 2008).**

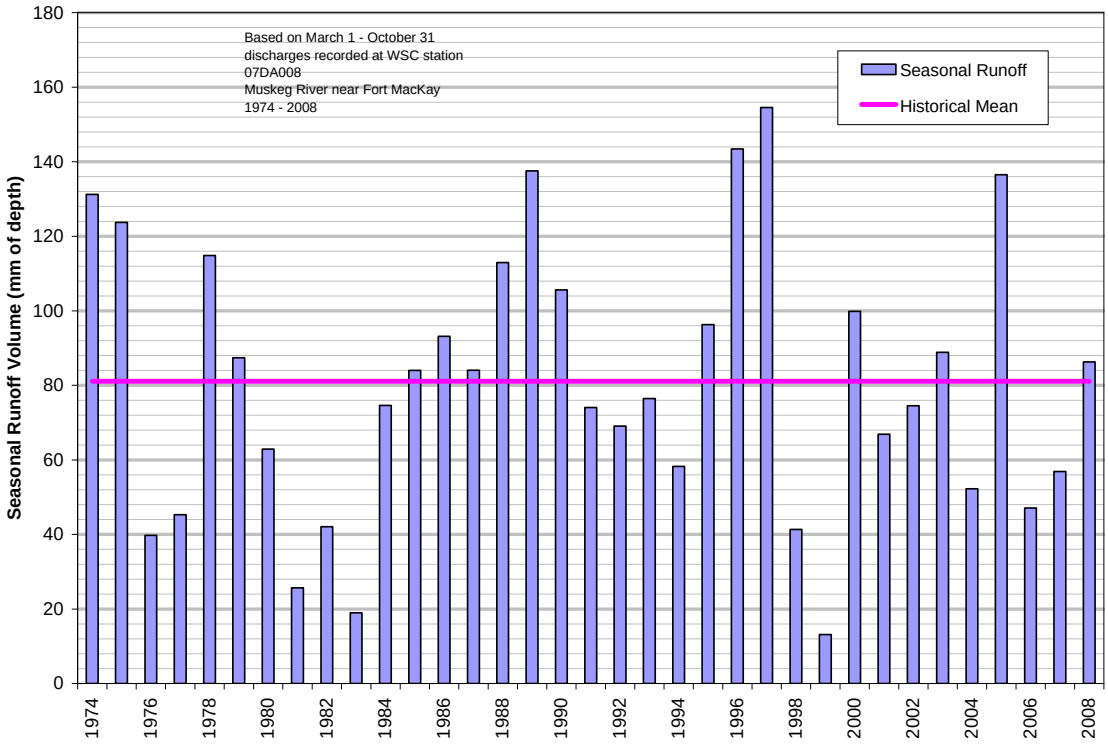


**Figure 4.1-7 The 2008 Muskeg River hydrograph compared to historical values.**

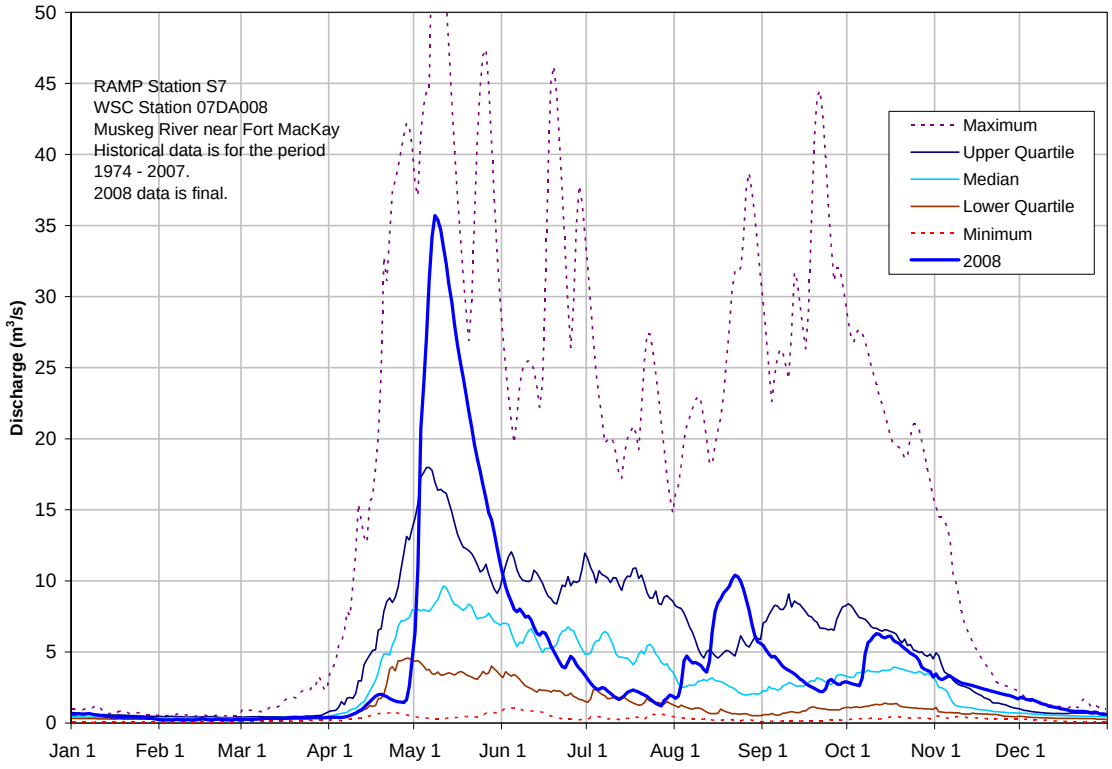

**Figure 4.1-8 Historical seasonal runoff in the MacKay River basin (1973 to 2008).**

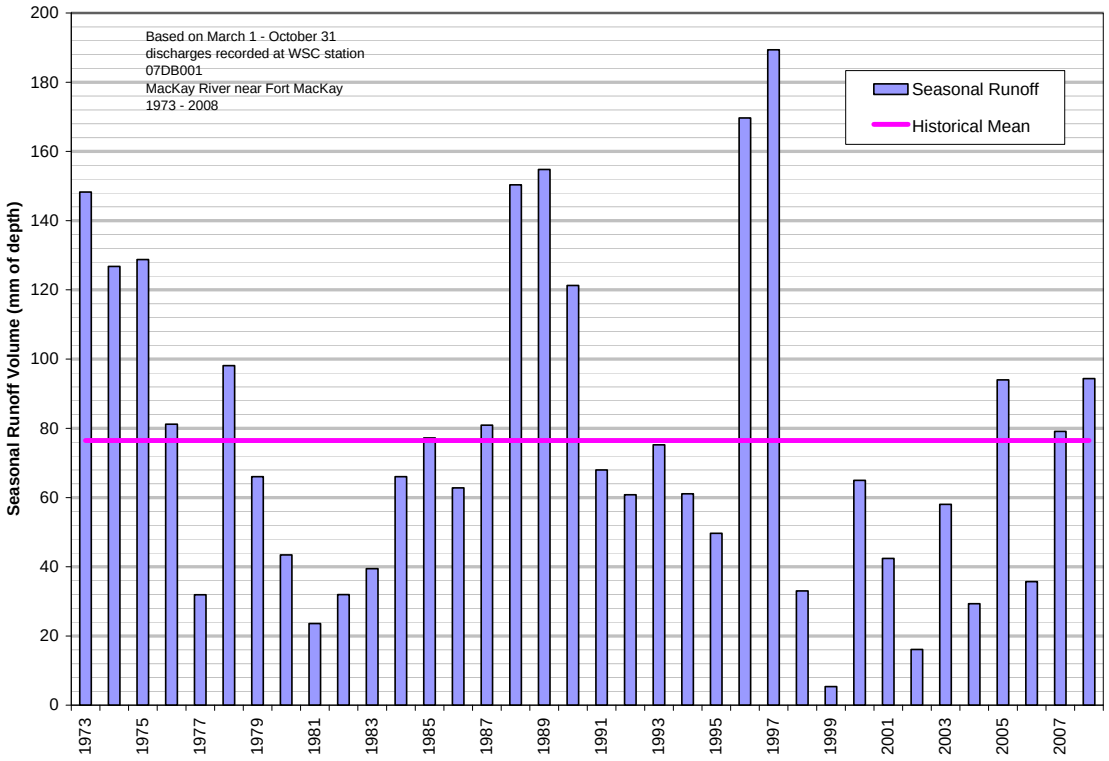


**Figure 4.1-9 The 2008 MacKay River hydrograph compared to historical values.**

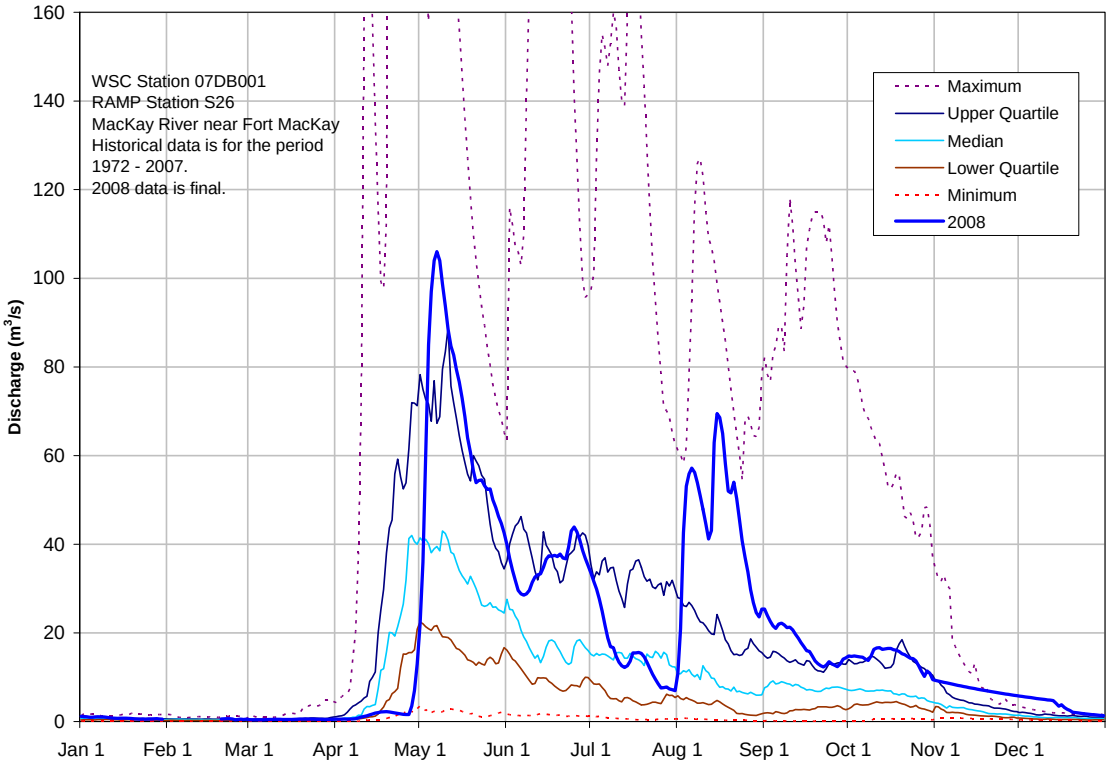

**Figure 4.1-10 Historical seasonal runoff in the Christina River basin (1982 to 2008).**

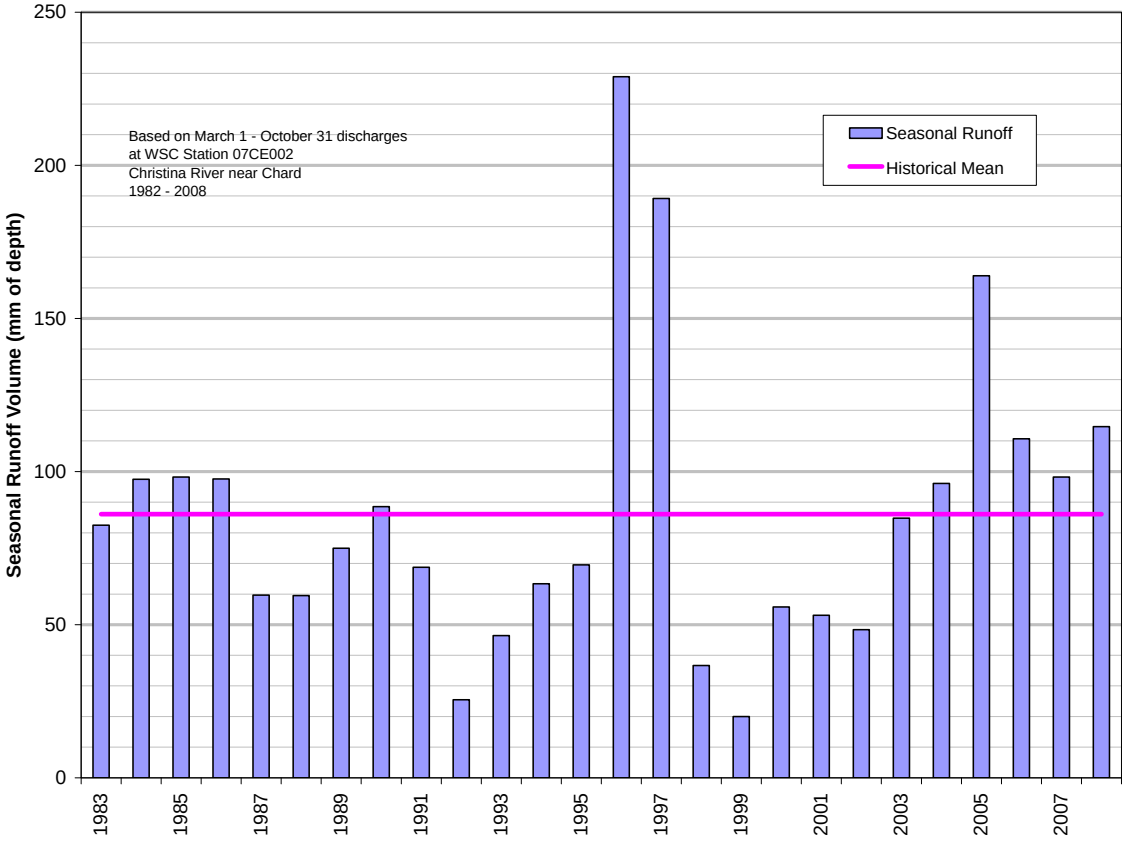


**Figure 4.1-11 The 2008 Christina River hydrograph compared to historical values.**