CLIMATE INDICATORS FOR THE OKANAGAN

KEY FINDINGS

August 2024

Okanagan Basin
WATER BOARD

Contents

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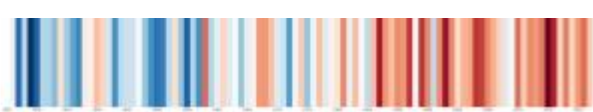
Land Acknowledgment

We acknowledge this work was done on the traditional, ancestral, and unceded tmx̌ʷúlaʔxʷ (land) of the syilx (Okanagan) people who have resided here since time immemorial. The Okanagan Basin Water Board recognizes, honours, and respects the syilx lands upon which we live, work, and play, and the siwɬk (water) which flows through the valley and connects us all.

Cover Art

Annual temperature anomaly for Kelowna from 1915 to 2023



This graphic was inspired by the climate stripes developed by Ed Hawkins, National Centre for Atmospheric Science, UoR #ShowYourStripes

> "It is *unequivocal* that human influence has warmed the atmosphere, ocean and land. Widespread and rapid changes in the atmosphere, ocean, cryosphere and biosphere have occurred." – IPCC AR6, 2021
>
> Although weather and climate have always been variable throughout Earth's history and natural climate variability is still an important part of determining local weather conditions, the scale and speed of the changes seen in recent decades make this different.

Purpose: This document presents the key findings of the Okanagan Climate Indicators Project up to 2023. Methods and decision-making processes are available on the Okanagan Basin Water Board (OBWB) website. The indicators are based on observed historical data and do not include projections or modelled data. The full set of indicators are presented on the OBWB climate indicators dashboard to inform the public and decision-makers about climate change in the Okanagan.

Background: Since the 1970s, the OBWB has identified and addressed water-related issues throughout the Okanagan Basin. The effects of climate change are becoming increasingly apparent through increased temperatures, changing precipitation patterns, changes in spring runoff events, increasing droughts, and the occurrence of other types of extreme events. The valley must take rapid and comprehensive action on adaptation and mitigation measures. To facilitate a sustainable and climate-resilient watershed, we need to know what changes have occurred, the pace of that change, and to systematically be able to track change moving forward.

This project monitors and reports on the extent of changes in the Okanagan's climate using over 30 indicators. It was inspired by the 2020 *Climate Projections for the Okanagan Region*[i] report, developed by the Okanagan regional district governments. Each indicator monitors a specific climate variable, such as the daily mean temperature or the timing of the freshet (i.e., spring runoff). The indicators cover a large variety of weather and hydrology information, looking at shifts in average conditions and the frequency and intensity of extreme events.

Methods

Temperature and precipitation indicators for the valley's lower elevation were available from 1915 to 2023 with data from Environment and Climate Change Canada, from weather stations at the cities of Vernon at Coldstream Ranch (henceforth referred to as Vernon), Kelowna, and Penticton. Okanagan Lake inflows were acquired from the B.C. River Forecast Center, who provided weekly measures from 1922 to 2023. Streamflow data were acquired from the Water Survey of Canada, which collected measurements over different time spans for each stream. Locations for the indicators are shown in Figure 1.

For temperature, precipitation, and Okanagan Lake inflows, we used a baseline period from 1951 to 1980 to establish a historical baseline or 'normal conditions'—a 30-year average condition to compare against current patterns (Figure 2). For stream flows, we used 1971 to 2000 for the baseline due to data limitations. It is common for indicator studies to compare against a 30-year average baseline, but there is no universal standard. In each case, the baseline period is chosen, based on the quality (accuracy) of the observations, and the length of time the measurements have been gathered. In the Okanagan, weather observations taken earlier in the 20th Century were measured with less accurate instruments. So although the climate began changing measurably in the 1970s, we used the 1950-1980 baseline as a conservative compromise, using the highest quality data available before the climate changed too drastically. For stream flow indicators, the baseline we used was 1971 to 2000 because most data was only available starting in the 1970s. The detailed methods for how each indicator is calculated are given on the [OBWB climate indicators webpage].

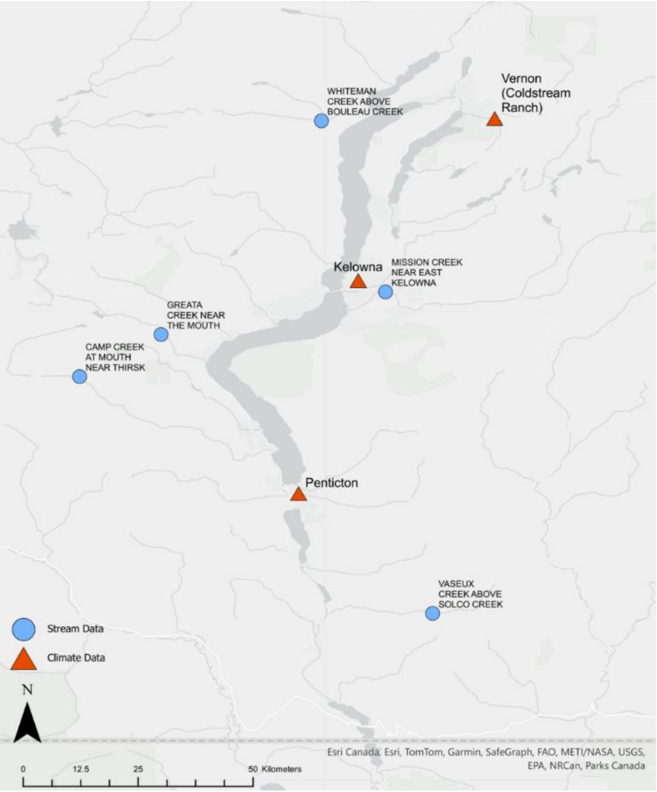


Figure 1 Okanagan climate indicator locations.

Indicators are assessed in one of two ways. 1) each individual year is compared to the baseline to see if it is above, below, or at normal. 2) using a 30-year average (Figure 3). The 30-year average is taken the average of the most recent 30 years. It moves forward by one year each year. Thus, for 2023, the 30-year average is 1994 to 2023. 30-year averages are used to account for year-to-year variability in weather and provide a more holistic and conservative estimate of current and past conditions.

Note

Many indicators show clear long-term changes, and some do not. Both results are valuable since indicators that do not show clear trends may begin to show trends in the future, and it is also useful to know when a weather variable is consistently erratic. As a result, ongoing monitoring is an important part of the project. All indicators from the project, including those in this report, are available on the OBWB climate indicators dashboard, which is updated regularly.

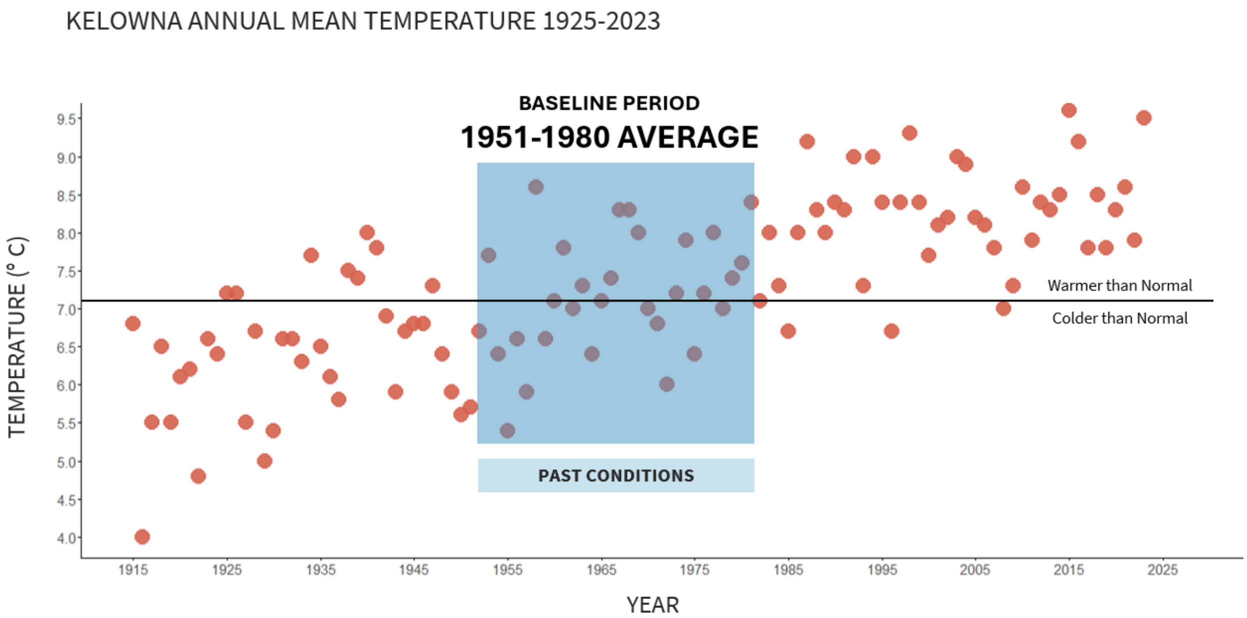


Figure 2 Demonstration of how the baseline period was calculated for mean annual temperature in Kelowna. The average from 1951-1980 was taken and used to compare each year to that value to see if it was warmer or colder.

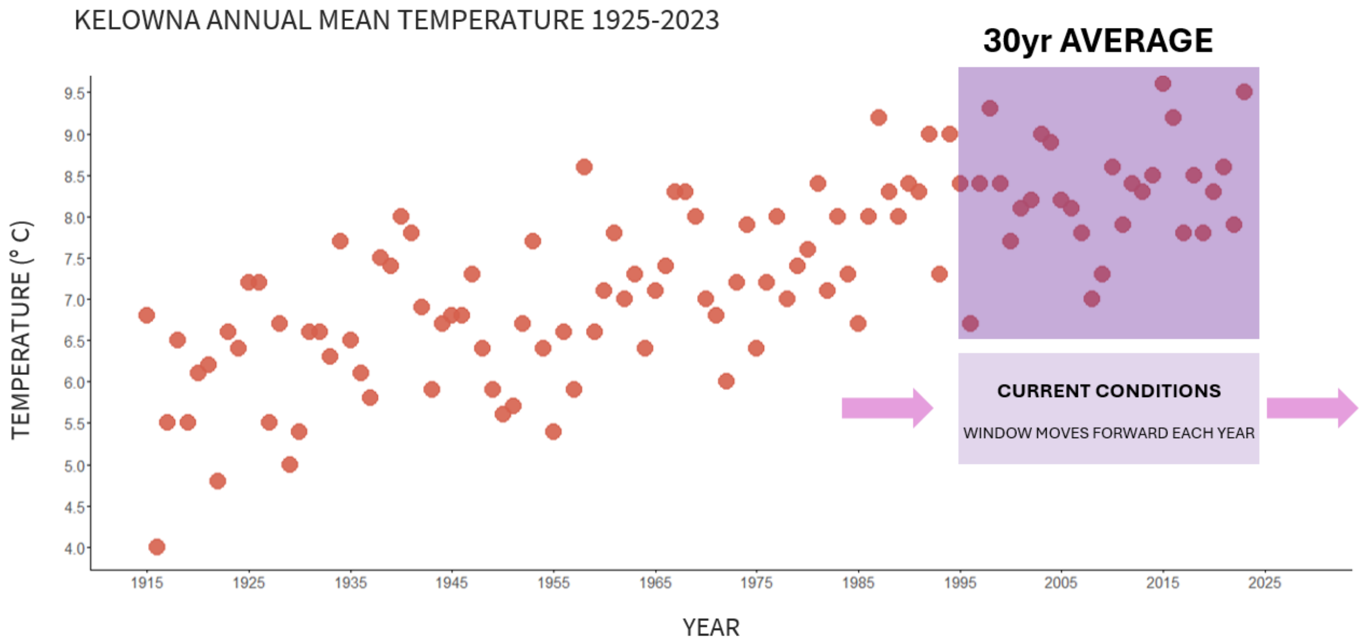


Figure 3 Demonstration of how the 30-year average was calculated for mean annual temperature in Kelowna. The average from the most recent 30 years was taken and compared to the baseline period to see if the long-term trend is for Kelowna to be warmer or colder and get an understanding of current conditions. Thanking a 30-year average accounts for variability from year to year.

Temperature

Compared to historical averages (1951-1980), all temperature indicators show a marked increase in mean temperature and high heat temperature events across all locations. At the same time, cold events still occur, but indicators show fewer cold events overall (Table 1).

- **Compared to the historical average of 1951-1980, mean daily temperatures have increased across the Okanagan, with a substantial shift occurring since 2000 (Figure 4).** Compared to the baseline, the 30-year average for temperature is warmer by 1.3 °C in Vernon, 1.2 °C in Kelowna, and 0.8 °C in Penticton.

- **Temperatures are consistently warmer in the southern part of the Okanagan and cooler in the north.** Penticton is typically the warmest, while Kelowna and Vernon are cooler but similar to each other.

- **Vernon typically saw the most temperature increases across different indicators, while Penticton saw the smallest increases.** Across the valley, colder-than-normal years have rarely occurred since the 1990s and have not occurred since the 2010s. These changes have several effects, such as a 2-week increase in the growing season length. Warmer than normal years have also started to occur in La Nina years, which were historically colder in the Okanagan.

- **Both maximum and minimum daily temperatures have increased.** *Compared to the baseline, the 30-year averages for maximum and minimum temperatures* in Vernon were (1.2 °C and 1.2 °C warmer), in Kelowna (0.9 °C and 1.6 °C warmer), and in Penticton, (0.7 °C and 0.9 °C warmer). **In all cases, the minimum temperatures (likely nighttime temperatures) increased more than the maximum temperatures. This increase occurred across all seasons.**

- **Mean daily temperatures have increased across all seasons (Figure 5).** The greatest increases occurred in summer (Vernon 1.5 °C, Kelowna 1.3 °C, and Penticton 1.1 °C) and spring (Vernon 1.4 °C, Kelowna 1.3 °C, and Penticton 0.7 °C), winter temperatures increased by (Vernon 1.4 °C, Kelowna 1.3 °C, and Penticton 0.7 °C) and the smallest changes were observed in fall (Vernon 0.9 °C, Kelowna 0.8 °C, and Penticton 0.5 °C). These values represent the difference between the 1951-1980 average to the most recent 30-year average.

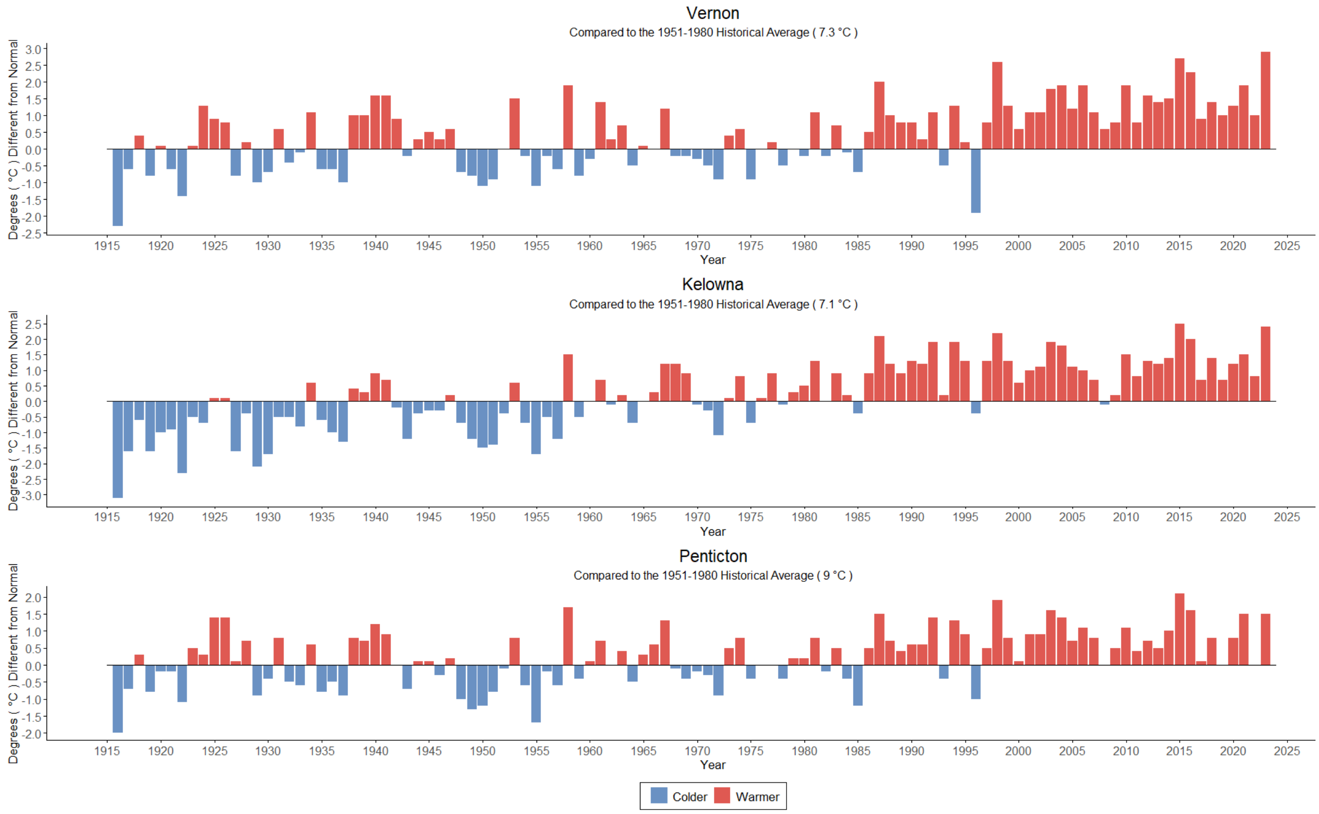


Figure 2 Annual mean temperature (°C) from 1915 to 2023 in Vernon (Coldstream Ranch), Kelowna, and Penticton. Each year indicates if the total number of days was above or below the 1951-1980 historical average.

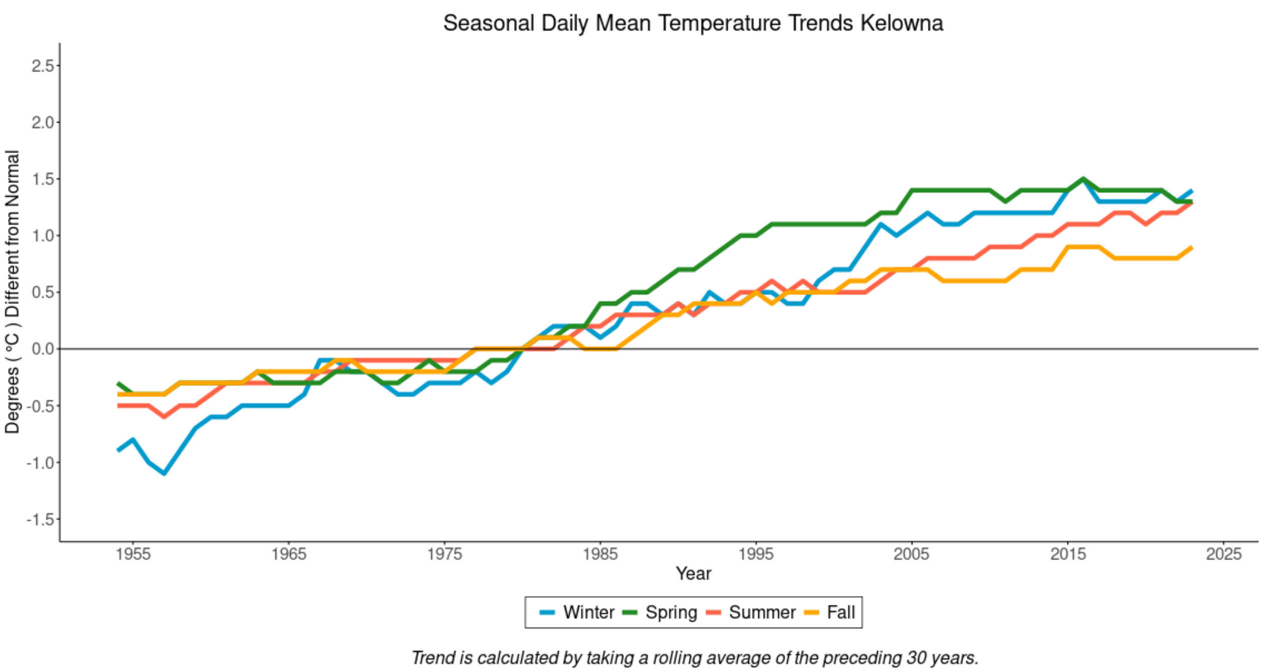


Figure 5 Seasonal daily mean temperature (°C) trend from 1955 to 2023 for Kelowna. The lines represent the 30-year rolling average for each year compared to the 1951-1980 historical average.

- **The number of days with a maximum temperature over 30 °C is frequently more than double the historical average number of days (Figure 6).** Although hot weather was always common in the Okanagan – especially during El Nino events - in individual years, an additional month of this extreme weather is now common.

- **Historically, in many years there were days with a maximum temperature over 35 °C, but recent years have had up to three times more days over 35 °C than baseline each year.**

- **Cold events still happen, but all three indicators for cold weather showed less cold weather.**
    - There were over two weeks fewer frost days (days with a minimum temperature below 0 °C) in all locations: 19 days fewer in Vernon, 23.7 days fewer in Kelowna, and 18.3 days fewer in Penticton.
    - Ice Days (days with a maximum temperature below 0 °C) were fewer by about a week: 10.4 days fewer in Vernon, 7.4 days fewer in Kelowna, and 7 days fewer in Penticton.
    - Days with a minimum temperature below -20 °C, important for crop mortality, were historically rare but are now even fewer by 3.3 days in Vernon, 3.1 days in Kelowna, and 0.4 days in Penticton. However, they still occur, as observed in January 2024.

- **The length of the growing season**—the number of days between the last spring frost and the first fall frost—has increased by about two weeks. The 30-year average shows 16.1 additional days in Vernon, 13.6 additional days in Kelowna, and 13.9 additional days in Penticton.

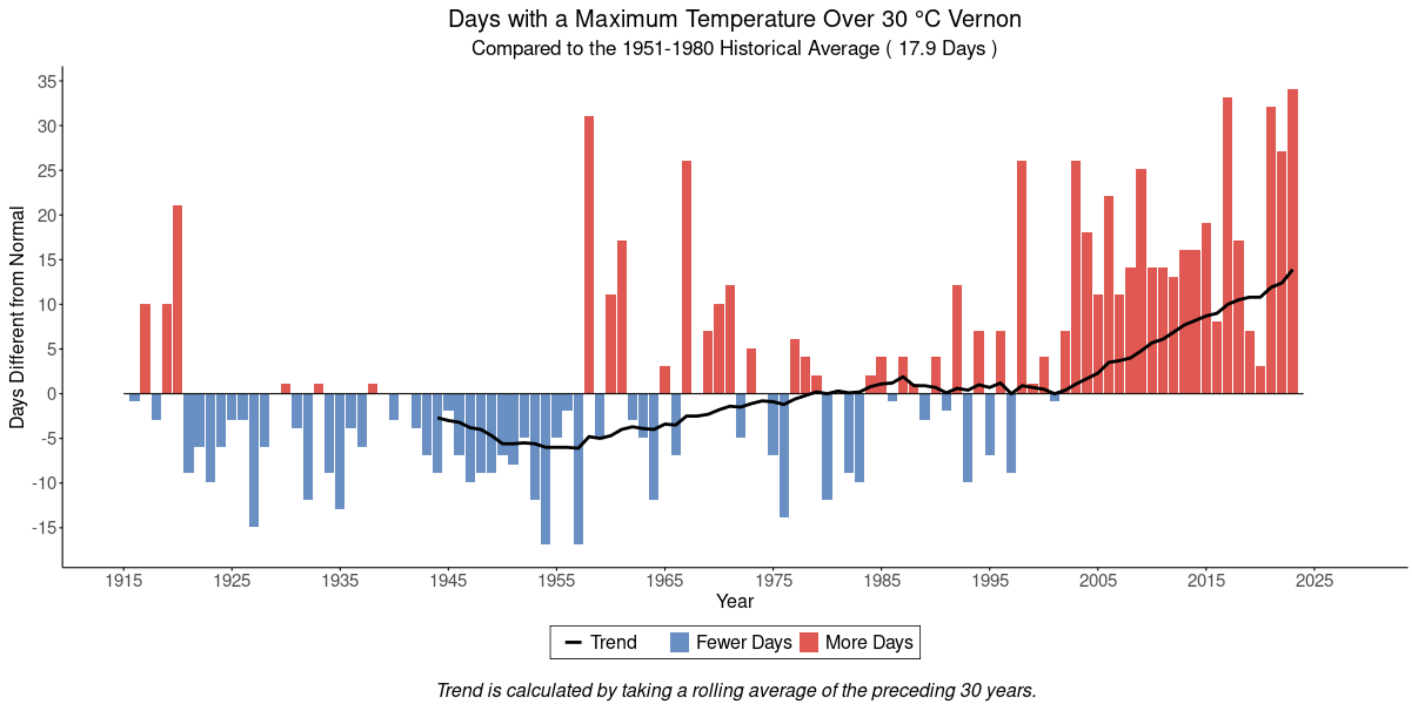


Figure 5 The number of days over 30 C 1915 to 2023 In Vernon. Each year indicates if the total number of days was above or below the 1951-1980 historical average of 25.5 days. The line represents the 30-year rolling average for the preceding 30 years.

Table 1 Summary of temperature indicators for Vernon (Coldstream Ranch) (Coldstream Ranch), Kelowna, and Penticton. The baseline is the average from 1951 to 1980, the Trend is the average for the last 30 years, 1994 to 2023, and the change is the difference between those two. Blue cells mark a decrease while orange an increase. A note that a decline in the number of cold days means that there are more warm days.

Temperature Indicators										
	Vernon			Kelowna			Penticton			
Indicator	Baseline	Trend	Change	Baseline	Trend	Change	Baseline	Trend	Change	Unit
Daily Mean Temperature	7.3	8.6	1.3	7.1	8.3	1.2	9	9.8	0.8	°C
Daily Maximum Temperature	12.8	14	1.2	13.6	14.5	0.9	14.6	15.3	0.7	°C
Daily Minimum Temperature	1.8	3.2	1.4	0.5	2.1	1.6	3.4	4.3	0.9	°C
Days Over 30°C	17.9	31.8	13.9	25.1	32	6.9	25.5	34.3	8.8	Days
Days Over 35°C	0.9	4.7	3.8	2.7	4.4	1.7	2.9	5.1	2.2	Days
Frost days	150.9	131.9	-19	172.1	149	-23.1	121.9	103.6	-18.3	Days
Ice Days	49.1	38.7	-10.4	37.3	29.9	-7.4	30	23	-7	Days
Sub -20°C	5.3	2	-3.3	5.7	2.6	-3.1	0.6	0.2	-0.4	Days
Growing Season Length	153.8	169.9	16.1	128.1	141.7	13.6	148.4	162.3	13.9	Days
Last Spring Frost	07-May	26-Apr	-11	19-May	13-May	-6	08-May	01-May	-7	Date
First Fall Frost	08-Oct	13-Oct	5	24-Sep	01-Oct	7	03-Oct	10-Oct	7	Date

Increase	Decrease

Precipitation

Results were quite variable and inconclusive for precipitation indicators. Precipitation is typically a more complex and regional process than temperature, so inconclusive results are common in this type of study. Many projections, such as the 2020 Okanagan Climate Projections study, predict an increase in precipitation. What is clear from our findings is that at the bottom of the valley, the increase has not started yet. Furthermore, as temperatures increase, evapotranspiration increases, so more precipitation is needed to maintain soil moisture,

- **Precipitation trends vary throughout Okanagan (Figure 7).** The Okanagan has a north-south precipitation gradient, getting progressively drier as you move south. The 1951-1980 average for total precipitation was 411.6 mm in Vernon, 348.2 mm in Kelowna, and 330.4 mm in Penticton.

- Historically, the early 20th century had consistently low precipitation, while the 1980s to mid-2000s saw a consistent wet period across the Okanagan. Although no consistent trend is present in the recent data, the past few years (i.e., since 2015), were drier.

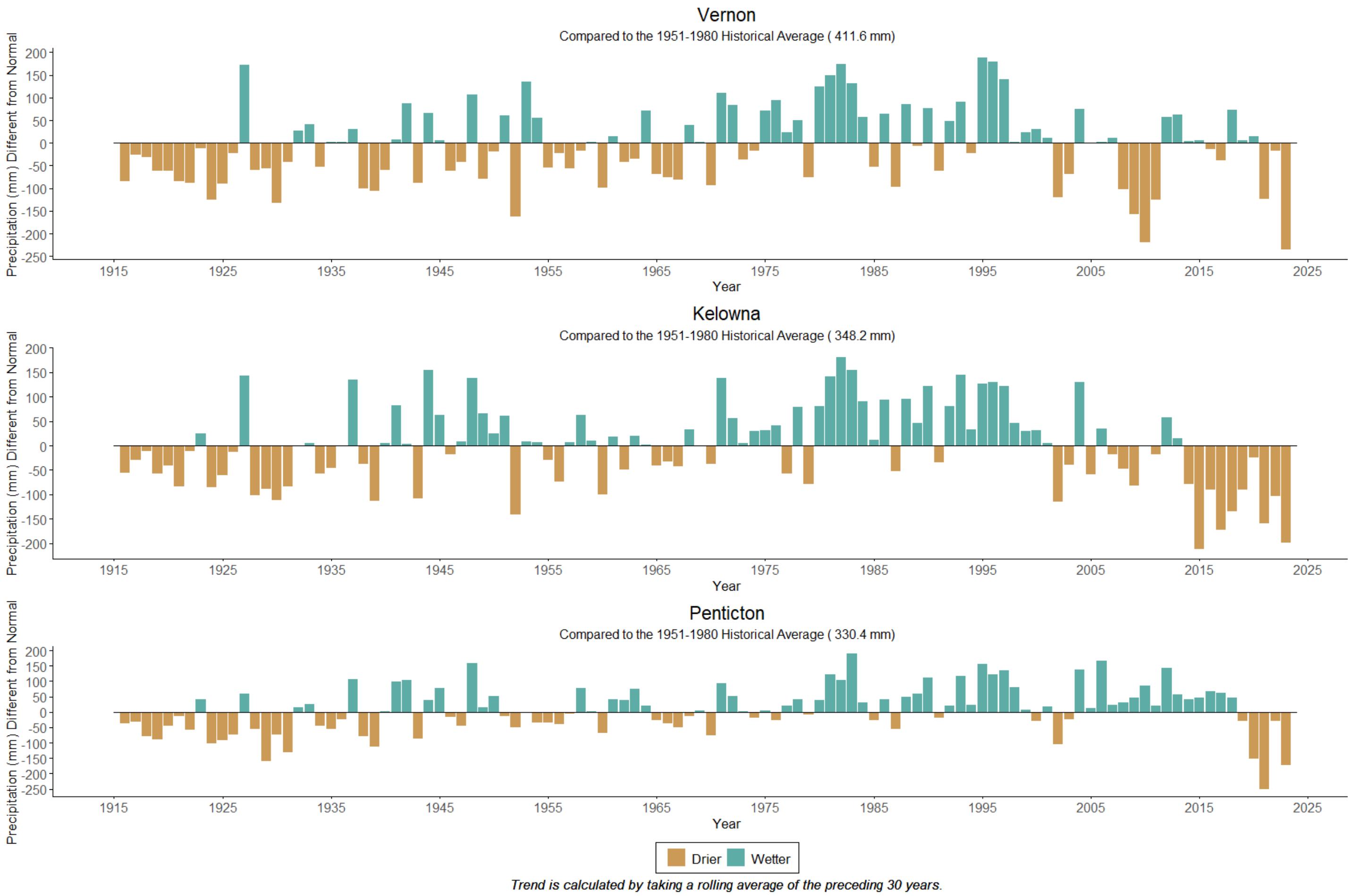


Figure 7 Total annual precipitation (mm) from 1915 to 2023 in Vernon, Kelowna, and Penticton. Each year indicates if the total number of days was above or below the 1951-1980 historical average.

- No clear change was observed in the volume of water (rain/snow-water equivalent) that fell on the day with the most precipitation.

- **Total precipitation has decreased in the winter and increased in spring and fall.** These trends began in the 1980s and have remained steady.

- **Although not yet long enough to be a trend recent year have had many seasons that are drier than normal, some considerably so.** If this drier weather persists, this may mark the beginning of a departure from the water conditions of the past 30 years. However, it is too soon to say, and even seasonal precipitation remains variable from year to year.

- **There is a shift in precipitation type, with more precipitation falling as rain and less as snow at the valley bottom**

Streams

Unregulated streams included in the study were Whitman Creek, Greta Creek, Camp Creek, and Vaseux Creek. To assess changes in streamflow across the Okanagan watershed, in hydrological and engineering studies, the focus is usually placed on unregulated streams, since dams and control structures mask many of the changes in flows that might come due to climate change. However, even for unregulated streams, there are other factors, such as land use change, that can also influence flows. Each stream time-series has a different start date, based on data availability, and all are compared to a 1971-2000 historical average. Most streams have data that begins in the 70s, and although this may seem like a long record when looking at long-term trends, it is barely enough for examining long-term trends. It is possible that shifts had already begun prior to when measurements started.

- **Data for streamflow was limited, and results varied from location to location.** The short data time range makes it difficult to assess trends, and many low-flow indicators are designed for streams and rivers that do not commonly dry out in the summer (as do many Okanagan streams).

- **Overall, it was difficult to draw conclusions about Okanagan-wide trends from these streams.** However, continuing to monitor streamflow indicators moving forward will be useful in identifying if a consistent shift does begin to occur.

- **The date of freshet has been shifting earlier by about five days across most streams (Figure 8).**

- Results for indicators of the amount of streamflow were inconclusive and varied between locations. Camp, Greta, and Vaseux creeks all have slightly fewer days with high flows, while Whitman Creek is around normal.

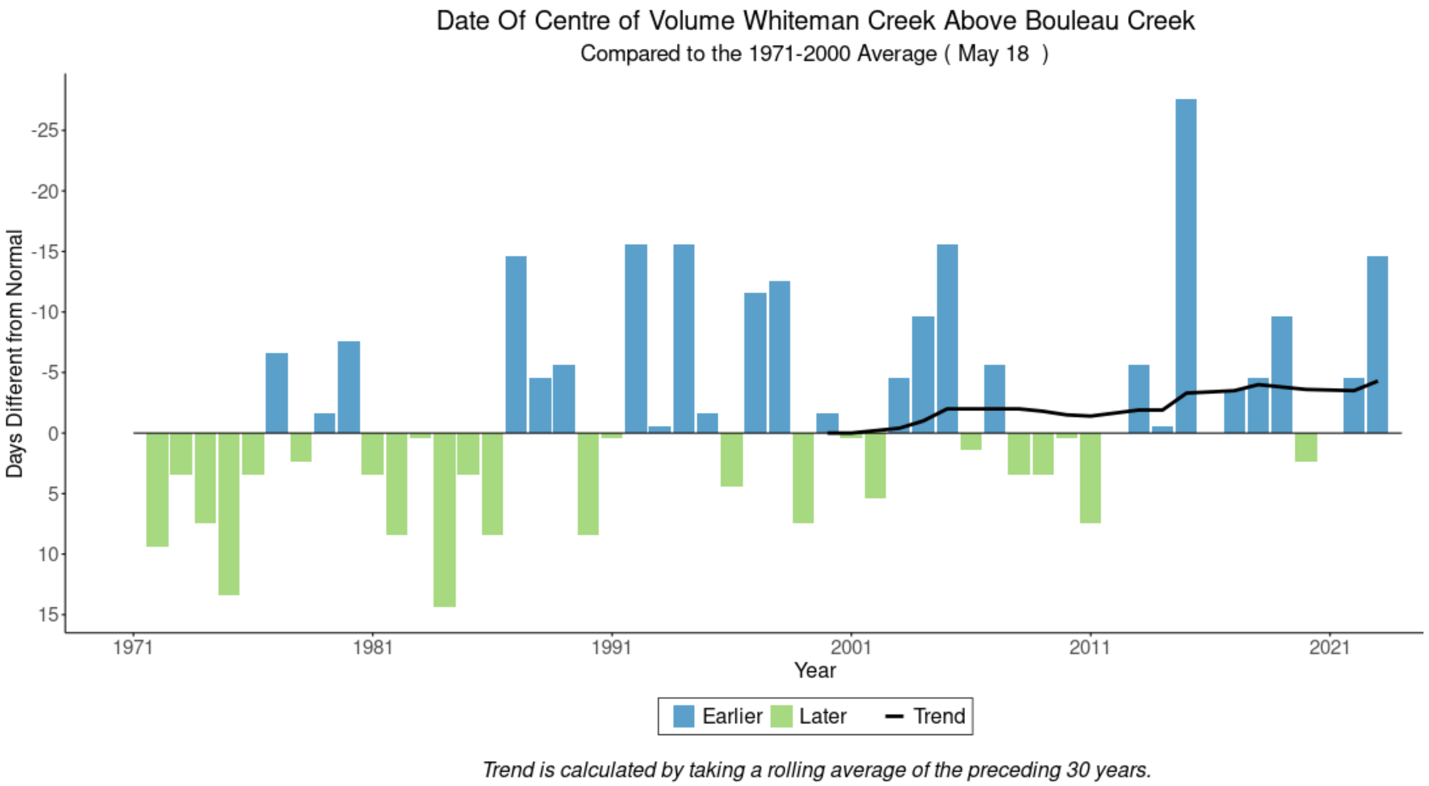


Figure 8 The date of freshet in Whiteman Creek 1971-2023 compared to the 1971-2000 historical average of May 18th.

Mission Creek

In addition to the unregulated streams, we assessed Mission Creek since it is the largest tributary to Okanagan Lake. Mission Creek is managed quite extensively, and its lower reaches are channelized with little natural riparian area. These conditions should be kept in mind while interpreting any information from Mission Creek, as changes may not be the result of climate change. The data for Mission Creek starts in 1967, and indicators are compared to the 1971-2000 historical average.

- Historically, the 30-year average date of freshet was May 23rd. Most recent years had an earlier freshet, but in the 20 years before that, most years were later (Figure 9).
- The number of days below critical flows—an important threshold for ecosystem health—are related to known region-wide drought years. Historically, the 30-year average number of days below critical flows was 22.4, and recently, the 30-year average is 29.2 days (Figure 10).

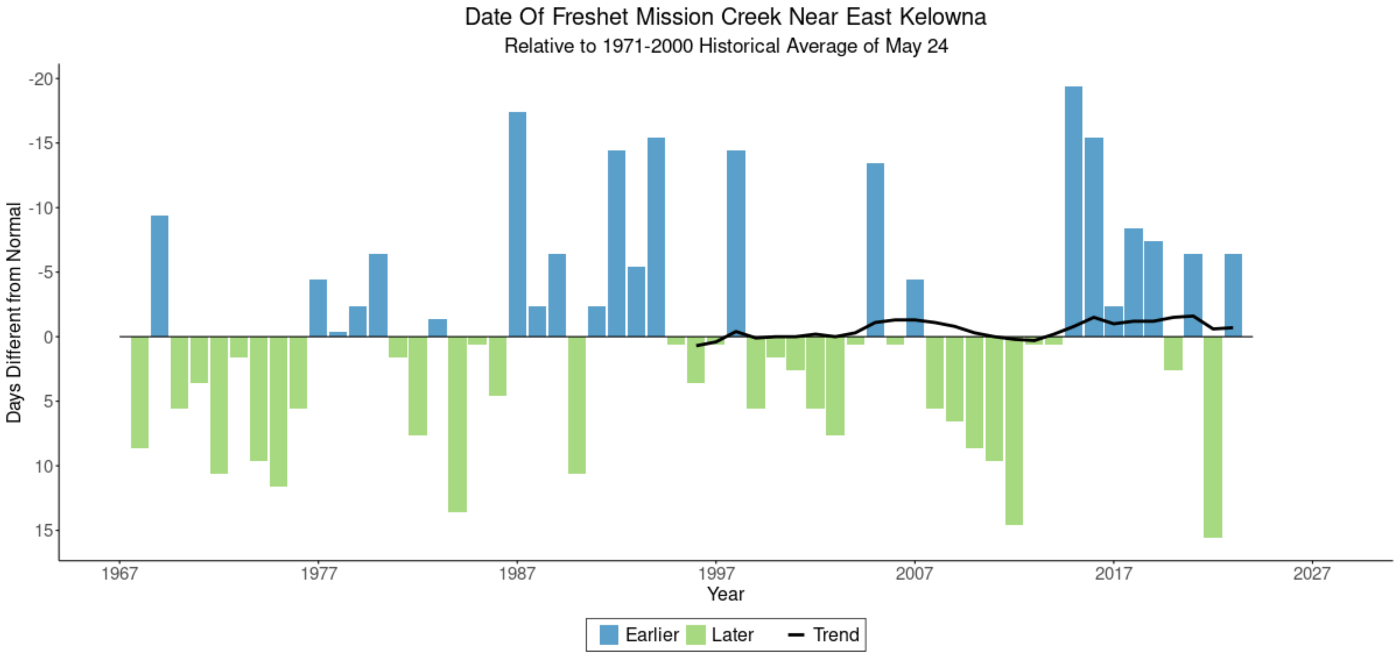


Figure 9 Date of Feshhet Mission Creek from 1967 to 20223 compared to the 1971-2000 historical average of May 24th.

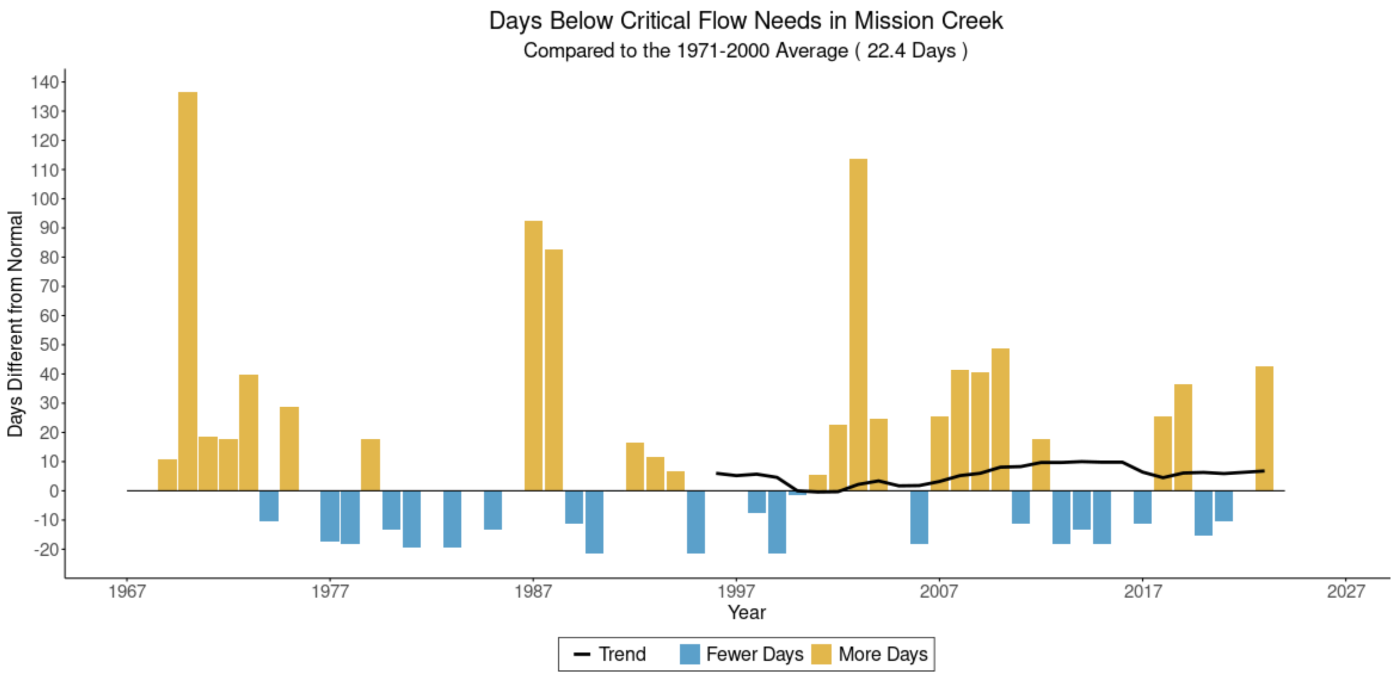


Figure 10 Mission Creek days below critical flows from 1967 to 2023 compared to the 1971-2000 historical average of 22.4 days.

Okanagan Lake

Okanagan Lake weekly inflow data is from the B.C. River Forecast Centre and goes back to 1921. This dataset provides information on the collective runoff from the whole watershed above Penticton.

- **Compared to the 1951-1980 average (479 kdam³), the inflows into the lake have increased, but there is still variability year to year with some drier years (Figure 11).**

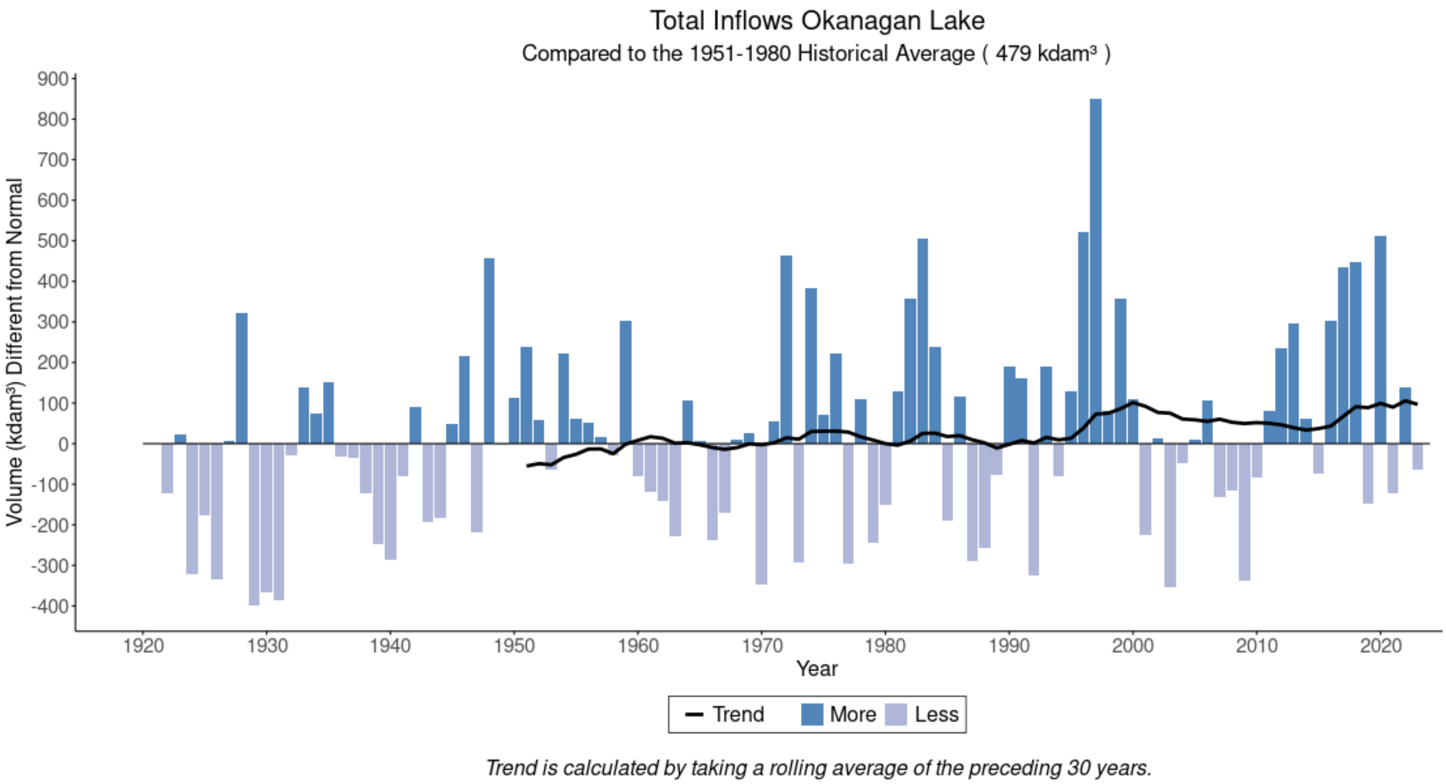


Figure 11 Total annual inflows for Okanagan Lake from 1922 to 20223 compared to the 1951-1980 historical average.

- **The date of freshet has shifted earlier by about a week** on average from the normal date of May 19th. In some years, a freshet of 3-to-4 weeks earlier, or 1-to-2 weeks later can be seen, but the 30-year average pattern is consistently earlier (Figure 12).

- There was a significant multi-year drought in the 1930s, which has not been experienced in recent decades.

- Maximum one-week inflows remain quite variable year to year, and minimum inflows are around normal.

- The number of weeks with net evaporation is around normal (i.e. 14 weeks). The last four years have had slightly more weeks than normal, but nothing like the 1930s drought period, where there were consistent years with 6 – 8 additional weeks.

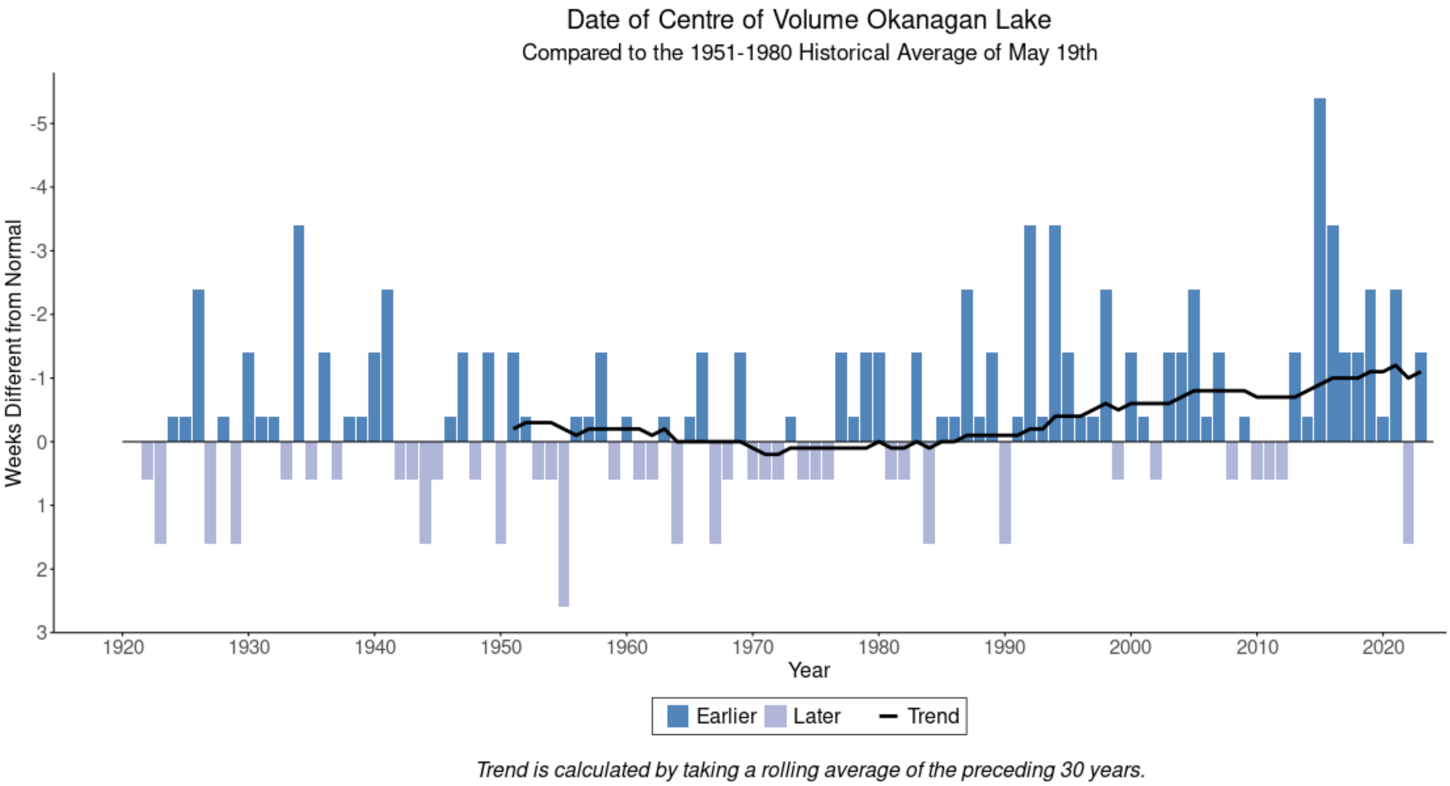


Figure 12 Date for Freshet Okanagan Lake from 1922 to 2023 compared to the 1951-1980 historical average.

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