Climate in the Lake Winnipeg Watershed and the Level of Lake Winnipeg

Prepared for the Manitoba Clean Environment Commission

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This document has been prepared at the request of the Clean Environment Commission. The main objective are 1) to describe climatic patterns and inflow history to Lake Winnipeg over the 100 years since widespread, continuous meteorological and hydrometric records were initiated in the early 20th century, and to describe climate patterns predicted for the 21st century, and 2) to describe the effects of trends and variability in climate over the watershed on the water level record in the lake. Finally, there is a brief summary of how regulation since the late 1970s has interacted with these historical relationships.

Disclosure

In my current employment at the University of Manitoba, I conduct scientific research that is partially funded by Manitoba Hydro, including research related to the effects of climate change and hydro-electric regulation on Hudson Bay. However, none of the research described below was supported by funding from Manitoba Hydro.

Executive summary

Over the last century, the total annual inflow to Lake Winnipeg has ranged by almost 4X from 35,000 to 136,000 cfs. The variability of tributary discharge and underlying climate in the watershed happens at four scales: seasonal, year-to-year, multi-decadal, and long term trends. The level of the lake has varied at all of these scales in rough synchrony with the supply of water from its watershed.

Based on analyses reported in scientific literature, over the last century, precipitation has increased in the watersheds of the Winnipeg and Red Rivers. No significant trend has been identified in the precipitation record for the Saskatchewan watershed. Annual discharge of the Winnipeg and Red Rivers has also increased significantly. The discharge of the Saskatchewan River has decreased, partly due to increasing consumptive use of water in the South Saskatchewan watershed.

Based on the median output of multiple global climate models, precipitation over the southeastern half of the watershed is likely to increase by of the order of 10% over the next century, although based on the wide range of model results among many different models and future climate scenarios, it is apparent that there is a very great uncertainty the prediction of regional precipitation. Modeling studies in the Lake Winnipeg watershed, produce widely varying runoff responses, from increases of a few percent to over 100% depending on the watershed studied. However, modelling results published in the literature do agree that higher precipitation will produce higher runoff, in spite of the higher evapotranspiration that will accompany warming. The exception is the Saskatchewan watershed, where there is no consensus as to whether either precipitation or runoff will increase or decrease through the next century.

Because the Winnipeg and Red Rivers supply over half the total inflow to Lake Winnipeg, that inflow also increased through the last century. The peak decadal mean inflow is currently about 107,000 cfs, almost 50% higher than the peak of 73,000 cfs in another relatively wet period at the beginning of the 20th century. If predicted increases in runoff in the Winnipeg and Red River watersheds are borne out, then total inflow to Lake Winnipeg will increase considerably, perhaps as much again as through the 20th century, though that is far from certain. Regardless, it is unlikely that the 21st century will see a continuous progression of increasing runoff. It is reasonable to assume that the wet/dry cycle evident in historical records will continue, so that the current high flow period will likely be succeeded by a drier one. And even in a wetter climate, there will be dry years when the amount of water delivered to the lake is not far off the low flow years in the historical record.

Over the last century, the multi-decadal pattern water levels in Lake Winnipeg has tended to follow the pattern in inflow, with three extended periods of predominantly low stands separating periods of higher water, with each successive high water period tending to be higher than the last. The decadal mean lake level from 2002–2011 was 714.1 feet above mean sea level (ft MSL), 1.1 ft higher than the decadal mean level at the beginning of the period of record—713.0 ft MSL from 1913–1922. Without regulation, the lake would have averaged another foot higher over the recent decade.

Measured in the south basin, daily mean water level has ranged from 709.1 to 719.4 ft MSL. The 3-day mean level (averaged between stations in both the north and south basins to exclude short-term setup) has ranged from 709.2 to 717.7 ft MSL. Prior to regulation, the seasonal and annual lake level record also followed total inflow, with slightly lagging seasonal peaks, but largely synchronous individual high inflow/high lake level years (and vice versa). Setup events superimpose abrupt, brief surges in level measured at either end of the lake. Along the south shore, the water level change can exceed 4 ft in hours to days, but most setup events are smaller. In general, they appear to have become slightly less frequent, and smaller, over the last century.

Regulation has affected water level differently in dry compared to wet periods. In the drier 1980s/early 1990s, the annual mean lake level tended to be increased by regulation and the seasonal peak was shifted from May or June to late summer or fall. In the wetter years since 1996, the annual mean level has tended to be reduced but the timing of the spring peak has not been shifted by regulation.

Both precipitation and tributary discharge are at, or nearing century-long peaks in the southeastern watershed of Lake Winnipeg, as is the total tributary inflow to the lake. Historically, each succeeding wet period has generated higher decadal mean total inflow into Lake Winnipeg. The watershed and lake may return to drier conditions, lower inflow and lower lake stands if the present wet period is succeeded by a dry spell. However, any near term dry spell is equally likely to be followed by another wet period. Both historical and predicted climate trends suggest that future wet periods will produce more runoff than previous ones. If so, then increasing inflow will make it increasingly difficult to maintain Lake Winnipeg below 715 ft MSL.

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