Hydrology for the Kutawagan Diversion Project

Introduction

The Quill Lakes basin has no history of natural outflow. The natural spill elevation to Last Mountain Lake is much higher than normal water levels. Evaporation is the only outflow from the lakes and during wet years precipitation exceeds evaporation resulting in above than normal water levels. The gross drainage area to the Quill Lakes is 8,780 km^2 and the natural spill elevation is at 521.47 m. Figure 1 illustrates the drainage area to the Quill Lakes watershed and also the extend of flooded lake area at the current water level of 520.5 m.

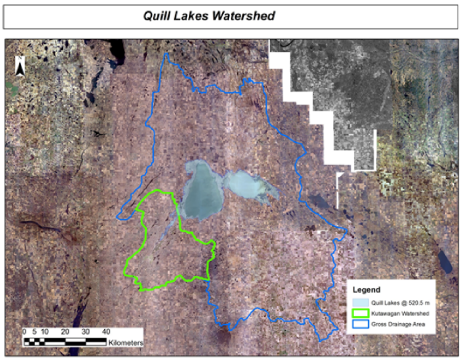

Figure 1: Drainage area to the Quill Lakes, current water level extent, and the Kutawagan watershed.

Historical Water levels of the Quill Lakes

The historical mean water level of the Quills Lake water levels is 515.9 m (1956-2014) . Little Quill Lake and Big Quill Lake become one lake at an estimated elevation of 518.5 m and form one lake. As seen in Figure 2, water levels of Big Quill Lake reached this elevation for the second time since 1919 in 2010. Since 2005 water levels of the Quill Lakes have increased more than 6 meters.

Mean annual precipitation at Wynyard is 405 mm. Precipitation in 2010 exceeded 600 mm and was followed by a couple of years with slightly above normal precipitation.

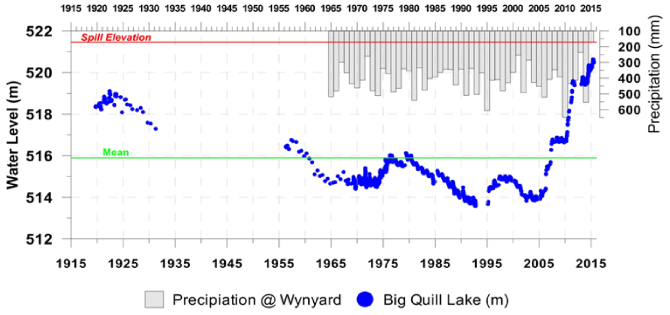

Figure 2: Historical water levels of Big Quill Lake and historical annual precipitation recorded at Wynyard.

Simulated Water levels of the Quills Lakes with the Kutawagan Diversion Project

Simulation of water levels of the Quills Lake for the wet period of 2005-2014 (Figure 3) suggests that if the project was in place at the beginning of the simulation water levels of the Quills Lake would be up to 0.3 m lower from what has been observed during the past ten years.

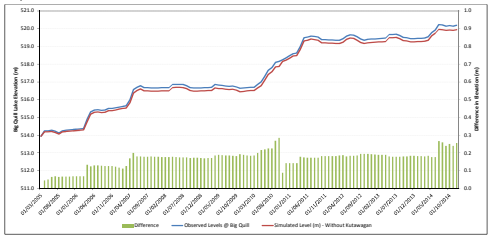

Figure 3: Simulated water levels of Big Quill Lake without the Kutawagan Creek inflow.

Kutawagan Watershed

The Kutawagan Creek is located south of Big Quill Lake with an estimated gross and effective drainage area of 1,210 km^2 and 388 km^2. Within the Creek there are three Ducks Unlimited projects, Kutawagan Lakes A and B, and Pel Lake which have a combined capacity of 10,600 dam^3 at Full Supply Level (FSL) of 521.24 m.

The historical median runoff of the watershed is estimated to be 6,000 dam^3. During the years of 2010, 2011, and 2014 the runoff volume of the watershed was well above normal (Figure 4a).

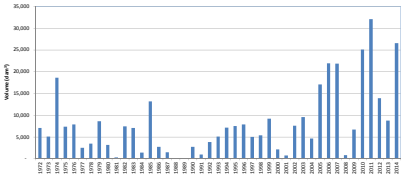

Figure 4a: Estimated annual runoff volumes from the Kutawagan Creek.

In order to simulate water levels of the Kutawagan reservoir, a water balance simulation was carried out for the recent wet period (2005-2014). The simulation considers the storage available in the creek, inflows, net evaporation, and outflows based on an assumed outlet channel with a 3:1 side slope, bottom width of 4 m, and an invert of 519.5 m.

To be able to release water from the reservoir the channel must be free of ice thus, the period in which outflows occur in the simulation is from March 15th to October 31st.

Kutawagan Watershed (Con't.)

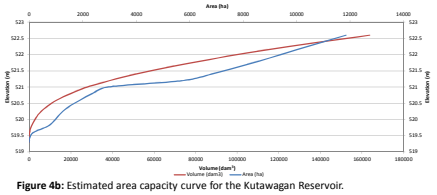

Figure 4b: Estimated area capacity curve for the Kutawagan Reservoir.

The storage capacity of the reservoir is estimated to be 11,000 dam^3 at Full Supply Level of 520.5 m (Figure 4b). This capacity is enough to store slightly above normal runoff volume.

The Ministry of Highways and Infrastructure has requested a maximum water level of the Kutawagan reservoir of 520.47 m which is 1.23 m lower than the top of the highway due to the old highway sub base.

Results

Results of the 10 year period simulation suggest that during most years water levels in the reservoir are below the maximum allowable elevation of 520.47 m (Figure 5). During 2006, 2007, and 2011 water levels exceeded 520.5 m with a maximum elevation of 520.74 m that occurs in 2011. The number of days that the water level is expected to be higher than 520.5 m in 2011 is 48 days. During the 10 years of the simulation, 2011 is the worst case scenario mainly because the reservoir had high water levels before spring runoff and because the annual runoff volume during this year has an estimated return period of 1:100 years.

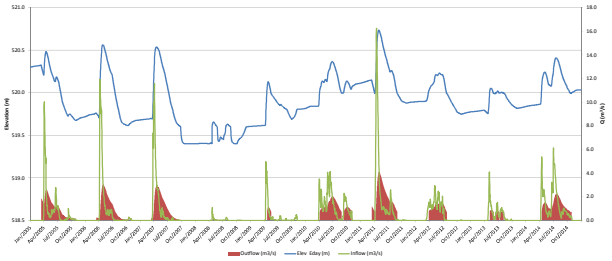

Figure 5: Simulated water levels of the Kutawagan reservoir.

The estimated peak inflow was 16 m^3/s while the maximum outflow is 4.1 m^3/s at the maximum elevation of 520.74 m. Table 1 summarizes the inflow/outflow volumes as well as the percentage of retention, peak water level, and the number of days that the maximum allowable water level was exceeded.

Table 1: Inflow and outflow volume.

Year	Inflow (dam^3)	Outflow (dam^3)	% Retention	Peak Water Level (m)	# Days Peak Above 520.5
2005	17,100	20,300	-19	520.49	0
2006	21,900	19,300	12	520.56	21
2007	21,900	19,400	12	520.54	23
2008	820	260	68	519.66	0
2009	6,700	2,300	65	520.13	0
2010	25,100	21,600	14	520.37	0
2011	32,100	30,000	6	520.74	48
2012	13,900	12,300	12	520.23	0
2013	8,700	4,200	53	520.05	0
2014	26,600	22,700	14	520.41	0
Median	19,500	19,300	1		
Mean	17,500	15,300	13		

Water levels simulation of the Kutawagan reservoir based on the period of 2005-2014 also suggest that there might be some years in which the water levels in the pond will be near minimum such as during 2008.

Overall the mean annual outflow volume expected from the Kutawagan Creek for the 10 year simulation period is just over 15,000 dam^3 with an average volume retention of 13 %.

Impact on Last Mountain Lake and the Qu'Appelle System

Average outflow from the Kutawagan pond would be 1.1 m^3/s during the 2005-2014 period with a peak flow of 4.1 m^3/s. The maximum impact on water levels of the additional outflow from the Kutawagan Creek is estimated to be 0.07 m which would have occurred during the summer of 2011. Figure 5 illustrates the recorded water levels and the simulated water level of Last Mountain Lake during the period 2005-2013.

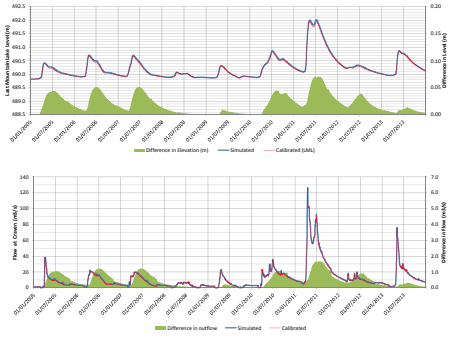

Figure 6: Simulated water levels of Last Mountain Lake (top) and flows of the Qu'Appelle River at Craven (bottom).

The additional inflow to Last Mountain Lake is expected to produce minor impact on the outflows from the Qu'Appelle river. The change in elevation is expected to have an average and maximum increment on outflows of 0.5 m^3/s and 1.7 m^3/s. The increment of 1.7 m^3/s is the result of the 0.07 m increment in water level of Last Mountain Lake Figure 6 illustrate the observed and simulated flows at the Qu'Appelle River at Craven.

Impact on the Qu'Appelle Lakes

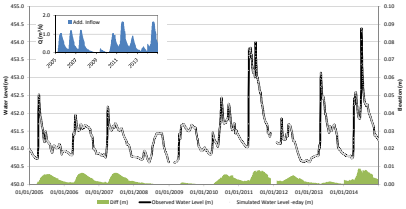

Figure 7: Simulated and observed water levels of Crooked Lake.

The impact on the Qu'Appelle Lakes was assed by adding the additional outflows from Last Mountain Lake to the net inflows of each Lake. Results suggest a maximum increase on water levels of 1 cm at all downstream Lakes.

Figure 7 illustrates observed and simulated water levels of Crooked Lake for the 2005-2014 period. The maximum increment in water levels due to the additional outflow from Last Mountain Lake is expected to be less than 1 cm. This estimate is considered a conservative estimate since it does not account for attenuation of the flows through the lakes.