PERFORMANCE MEASURE INFORMATION SHEET #5

KINBASKET RESERVOIR: VEGETATION

Objective / Location	Performance Measure	Units	Description	MSIC
Vegetation/ Kinbasket Reservoir	Vegetation	Flooded weeks	Reports on number of flooded weeks that each 2-m elevation band is inundated	10%

Description

A change over time in the composition and spatial extent of riparian vegetation (i.e., vegetation around the reservoir in the zone that is periodically inundated) is an indicator of the potential effects of BC Hydro operations on wildlife, aesthetics, and littoral productivity. Because valley bottom habitat is limited in the Columbia River system, riparian vegetation is viewed as important to a wide variety of wildlife including birds, ungulates, bears, furbearers, reptiles and amphibians, some of which are red- and blue-listed species. Vegetation also improves aesthetic quality, helps to control dust, and may serve to protect cultural sites from erosion and human access.

Establishment of vegetation communities occurs to varying extents around the perimeter of Kinbasket Reservoir depending on substrate, slope, aspect and elevation. Given the large licensed drawdown of Kinbasket (~47 m), a key factor in vegetation establishment is the inundation regime of the reservoir. The specific effects of inundation on vegetation are thought to depend on the depth, duration, and timing, in addition to daily water level changes throughout the growing season. The stress on vegetation communities within the drawdown zone of Kinbasket Reservoir is exacerbated by high rates of deposition and erosion, which are atypical of shoreline flooding events associated with unregulated lakes or rivers. The degree of exposure and the slope of a flooded site largely determine if plants and substrates remain on site or are eroded away.

The WUP Consultative Committee made several assumptions regarding vegetation tolerances to inundation and responses to changes in the hydrologic pattern, based on information gained from studies in the Arrow Lakes Reservoir (AIM and Carr 2002, Moody 2002). Specifically, it was assumed that a change in hydrology (relative to historic) should dictate trends in vegetation by affecting the amount of land that is vegetated at lower elevations within the drawdown zone, or by affecting the amount of plant growth produced per unit area (biomass) and the number of species in the area (diversity) at upper elevations within the drawdown zone. Given differences in the elevation, climate and operating regime of the two reservoirs (Kinbasket and Arrow), the Committee recognized the inherent uncertainties of applying any findings related to the response of vegetation to reservoir operating conditions based on the Arrow Lakes Reservoir study to the Kinbasket Reservoir, and acknowledged the importance of longer-term data collection for assessing the effects of the Kinbasket operating regime on vegetation at multiple spatial scales.

Long-term monitoring programs being undertaken through BC Hydro's Water License Requirements (WLR) Program have shown that vegetation communities, particularly those in the higher elevation bands (e.g., > 749 m), have developed over a number of years when Kinbasket Reservoir did not reach full pool. That is, vegetation communities that span the higher elevation bands experience less inundation and consequently have had more time to develop compared to communities in lower elevation bands. However, vegetation communities in Kinbasket Reservoir appear to be fairly dynamic, with species composition changing from one year to the next (Hawkes et al. 2008, 2009). Preliminary results from WLR studies suggest there have been subtle impacts to the spatial extent, structure and composition of existing vegetation communities resulting from reservoir operations. Since 2007, notable reductions have occurred in species diversity and richness for communities occurring at the highest elevation of the drawdown zone, and increases in diversity and richness for certain communities occurring lower down in the drawdown zone. It is postulated that the lower species diversity at higher elevations is linked to a full pool event in the summer of 2007. However, when considering the vegetation communities overall (i.e., across all elevations and sites), the distribution and extent of those communities has not changed markedly since 2007. To draw conclusions about the impact of the operating regime, further investigation is required, particularly across years where a time series analysis may provide better insight regarding the relationships between environmental conditions and species community richness.

In this analysis, the potential impacts of the NTS scenarios on vegetation in Kinbasket Reservoir were evaluated based on inundation statistics for a 10-year simulation period (1964-1973).

Calculations

Inundation statistics for the NTS scenarios were computed for the periods May 1 – Aug 31 and Sep 1 – Sep 30 (representing the early and latter part of the growing season), as well as the entire period based on reservoir elevation data from the GOM model. Unlike the modeling completed for Arrow Reservoir vegetation, these statistics were computed based solely on the GOM results, as a HEC RAS model for predicting water surface elevation was not available for Kinbasket Reservoir.

Using the simulated results for Kinbasket Reservoir elevations over the 10-year simulation period (1964-1973), the number of weeks over the growing season that each 2-meter elevation band is inundated was computed for each year.

Key Assumptions and Uncertainties

- Each scenario is simulated using the same set of system constraints, input assumptions (e.g., load forecasts) and historic basin inflows (1964-1973).
- Assumes frequency, duration and extent of inundation (timing, duration and depth) of inundation are the only drivers of vegetation survival/establishment
- Assumes all vegetation types are equally affected by the three drivers

Results

Tables 1 and 2 provide the flooding statistics for the upper 20 m of Kinbasket Reservoir over the early and latter part of the growing season. All of the four NTS scenarios have similar characteristics, although there is a marginal increase in the number of flooded weeks under Scenario D (no NTS), mostly due to a more rapid rise in reservoir water levels in the first half of the growing season. While this pattern is apparent over a range of elevation bands, it is most important at elevations greater than 749 m (2444 ft), where vegetation communities have become established in the drawdown zone (749-754 m).

Table 1. Statistics on Weeks Flooded for the Early (May 1 – Aug 31) Half of the Growing Season (1964-1973) by 2-m Elevation Band in Kinbasket Reservoir across Four NTSA Scenarios

Elevation	Average				Minimum				Maximum			
(msl)	A	B	C	D	A	B	C	D	A	B	C	D
735-737	7.3	7.2	7.6	8.5	3.8	3.8	6.0	6.8	9.0	9.0	9.3	10.3
737-739	6.6	6.6	7.0	7.7	2.5	2.8	5.3	5.8	8.3	8.0	8.5	9.0
739-741	5.9	6.0	6.3	7.1	1.5	1.5	4.3	5.0	7.8	7.8	8.0	8.5
741-743	5.3	5.2	5.8	6.4	0.0	0.3	3.3	3.8	7.0	7.0	7.0	7.8
743-745	4.6	4.6	4.9	5.7	0.0	0.0	2.0	2.5	6.3	6.3	6.3	7.0
745-747	3.9	4.0	4.2	4.9	0.0	0.0	0.5	1.5	5.8	5.8	5.8	6.0
747-749	3.1	3.2	3.3	4.1	0.0	0.0	0.0	0.0	5.0	5.0	5.0	5.5
749-751	2.2	2.3	2.4	3.1	0.0	0.0	0.0	0.0	4.0	4.0	4.0	4.8
751-753	1.1	1.3	1.4	2.0	0.0	0.0	0.0	0.0	2.8	3.3	3.3	3.5
753-755	0.1	0.2	0.2	0.3	0.0	0.0	0.0	0.0	0.6	0.8	0.8	1.2
	Median				10th Percentile				90th Percentile			
	A	B	C	D	A	B	C	D	A	B	C	D
735-737	7.5	7.5	7.5	8.6	4.0	4.0	6.0	6.8	9.0	9.0	9.2	10.2
737-739	7.0	7.0	7.0	7.9	2.8	3.1	5.3	5.8	8.2	8.0	8.5	9.0
739-741	6.3	6.3	6.3	7.4	1.9	1.9	4.3	5.1	7.7	7.7	8.0	8.5
741-743	5.8	5.5	6.0	6.6	0.5	0.7	3.4	3.9	7.0	7.0	7.0	7.8
743-745	4.9	4.8	5.1	6.0	0.4	0.4	2.2	2.8	6.2	6.2	6.3	7.0
745-747	4.1	4.0	4.6	5.1	0.3	0.4	0.8	1.8	5.7	5.7	5.7	6.0
747-749	3.4	3.1	3.6	4.5	0.2	0.3	0.3	0.4	4.9	4.9	4.9	5.5
749-751	2.4	2.3	2.5	3.3	0.1	0.2	0.2	0.3	3.9	3.9	3.9	4.7
751-753	1.0	1.4	1.4	2.0	0.0	0.1	0.0	0.2	2.7	3.1	3.2	3.4
753-755	0.0	0.1	0.2	0.2	0.0	0.0	0.0	0.0	0.6	0.7	0.7	1.1

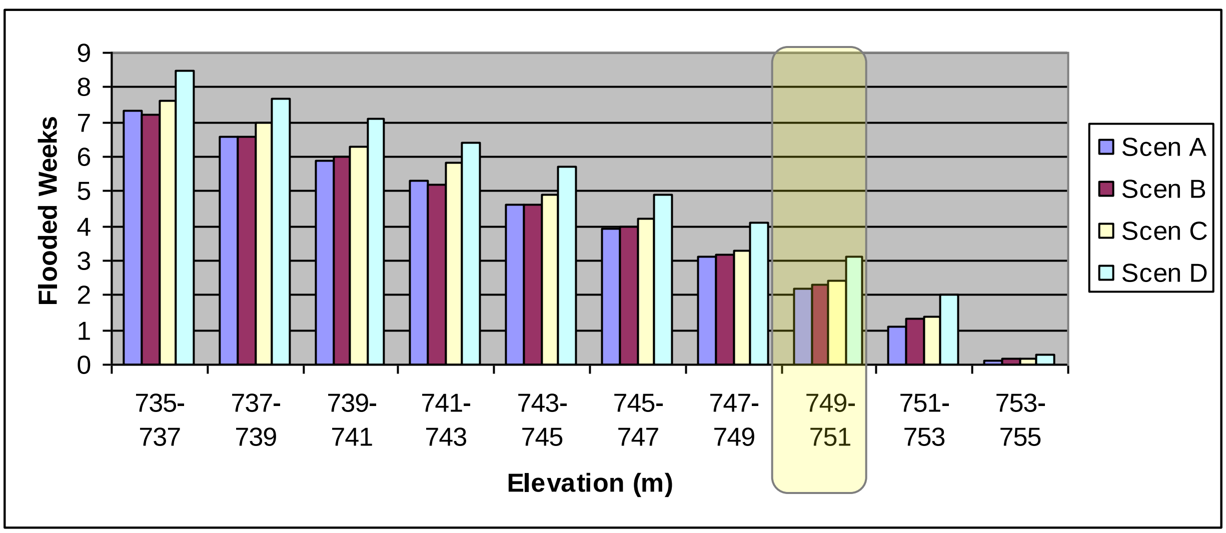

Figure 1. Average Number of Flooded Weeks by 2-m Elevation Bands during the Early Part of the Growing Season for the 10-year (1964-1973) Simulation Period. Yellow-shaded results carried forward into Consequence Table.

Table 2. Statistics on Weeks Flooded for the Latter (Aug 31 –Sep 30) Half of the Growing Season (1964-1973) by 2-m Elevation Band in Kinbasket Reservoir across Four NTSA scenarios.

Elevation	Average				Minimum				Maximum			
(msl)	A	B	C	D	A	B	C	D	A	B	C	D
735-737	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
737-739	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
739-741	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
741-743	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
743-745	4.9	4.9	5.0	5.0	3.8	4.0	5.0	5.0	5.0	5.0	5.0	5.0
745-747	4.5	4.5	5.0	5.0	0.3	0.0	5.0	5.0	5.0	5.0	5.0	5.0
747-749	4.5	4.5	4.9	5.0	0.0	0.0	4.3	4.8	5.0	5.0	5.0	5.0
749-751	4.5	4.5	4.6	4.8	0.0	0.0	0.8	2.5	5.0	5.0	5.0	5.0
751-753	4.5	4.5	4.5	4.5	0.0	0.0	0.0	0.0	5.0	5.0	5.0	5.0
753-755	2.2	2.4	2.4	2.6	0.0	0.0	0.0	0.0	3.0	3.0	3.0	3.0
	Median				10th Percentile				90th Percentile			
	A	B	C	D	A	B	C	D	A	B	C	D
735-737	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
737-739	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
739-741	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
741-743	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
743-745	5.0	5.0	5.0	5.0	3.9	4.1	5.0	5.0	5.0	5.0	5.0	5.0
745-747	5.0	5.0	5.0	5.0	0.7	0.5	5.0	5.0	5.0	5.0	5.0	5.0
747-749	5.0	5.0	5.0	5.0	0.5	0.5	4.3	4.8	5.0	5.0	5.0	5.0
749-751	5.0	5.0	5.0	5.0	0.5	0.5	1.2	2.8	5.0	5.0	5.0	5.0
751-753	5.0	5.0	5.0	5.0	0.5	0.5	0.5	0.5	5.0	5.0	5.0	5.0
753-755	2.6	2.8	2.8	2.8	0.1	0.2	0.1	0.3	3.0	3.0	3.0	3.0

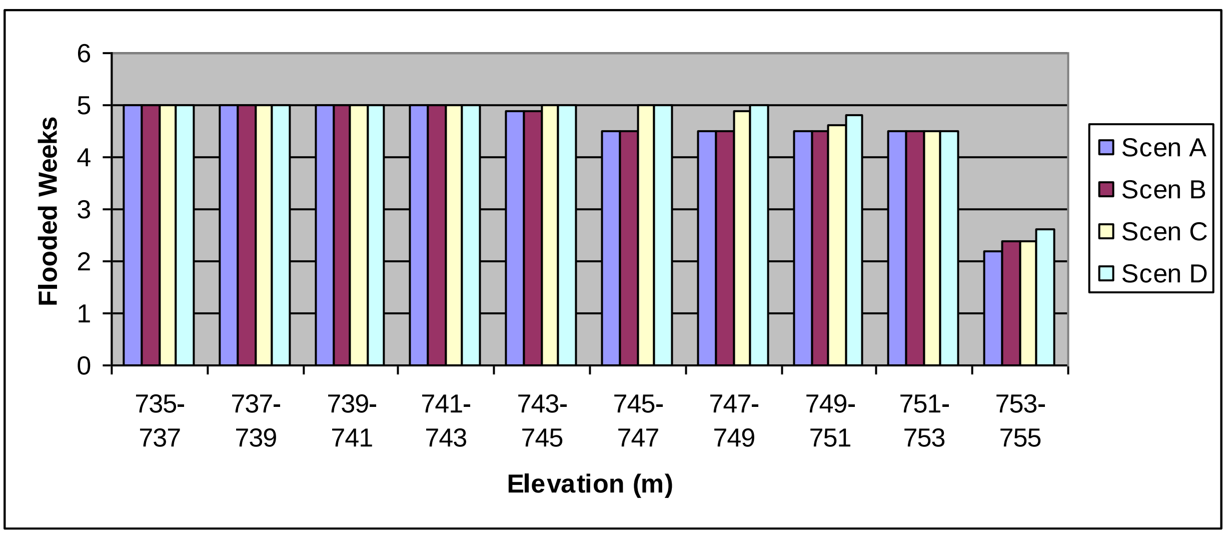

Figure 2. Average Number of Flooded Weeks by 2-m Elevation Bands during the Latter Part of the Growing Season for the 10-year (1964-1973) Simulation Period