Responses to Additional Questions posed by Mr. Bruce Webb, Manitoba Conservation and Water Stewardship, Nov 18, 2013, with respect to UNIES Ltd. report entitled: **Fork River Low-level Crossing Replacement, NW 27-29-20W, R.M. of Mossey River, Report on Hydrologic and Hydraulics Design Assistance**, June 21, 2012.

Q.1. What is the frequency of event where the crossing is overtopped and what is the velocity in the culverts at this discharge?

Q.2. What is the frequency of event where the velocity of flow in the culverts is 1.0 m/s?

Responses: The attached **Figures 1** and **2** show estimated hydraulic behaviour for the proposed low-level crossing replacement configuration over a range of discharges that may be expected to occur during the operating life of the project. Unresolved, unresolvable, and unknown differences between the physical situation at the site and the idealized representation discussed here should, of course, be expected.

The original report dated June 21, 2012 included description of the annual flood frequency distribution adopted for design at the ungauged project site based on earlier recorded daily discharges at relevant gauged locations in the same region. **Figure 1** includes the adopted flood frequency distribution as an indication of the range of discharges that the crossing might see. For the range of discharges expected, the right hand side of the figure compares the estimated values of three hydraulic parameters:

(a) head loss at the crossing – difference in estimated water surface elevation between a point several metres upstream of the structure and a point several metres downstream of the structure;

(b) average velocity in the culverts – average of velocity just inside the entrance and velocity just inside the exit (these are equal for culverts flowing full, unequal for culverts not flowing full); and

(c) average velocity overtop of the roadway – water surface is higher near the upstream edge of the structure and lower near the downstream edge; an average value is given.

At the estimated 3dQ10 discharge of 16 cu m/s, it is estimated that 10.2 cu m/s would be passing through the ten proposed culverts and 5.8 cu m/s would be going over the road. Average velocity in the culverts under these conditions is estimated at 1.64 m/s. Average velocity above the active part of the road at the upstream edge with this conceptualization of flow conditions is estimated to be about 0.74 m/s from an average flow depth of 0.28 m and flow width of 28 m, while at the downstream edge it is 1.11 m/s from a flow depth of 0.13 m and a 40-metre flow width.

A.1 The roadway is estimated to be overtopped at a discharge of just greater than 10 CMS, with velocities at that time in the culverts estimated at just over 1.60 m/s. At the point of overflow, the water surface on the downstream side of the road crossing would be about 0.40 m below the assumed roadway crest at elevation 294.65 m ASL. The culvert velocities and culvert discharge are estimated to peak at about 1.68 m/s and 10.50 CMS, respectively, at a total Fork River discharge of about 12 CMS. Above about 12 CMS, the culvert flows start to decline as the overflow begins to dominate and begins to reduce the overall head loss across the structure. The annual probability of the road overtopping is estimated to be about 50 to 60 percent.

Timing during the year, persistence, and rates of change of the various hydraulic conditions all interact in a complex manner with the physical setup to affect possible fish movements. **Figure 2** provides an example of what typically may happen in a year. The year 1976 included a fairly typical spring melt runoff together with the largest rainfall runoff event in the modern record of the Fork River. The stream flow recessions following the two largest events were typical, as were the extended periods of low flow.

The estimated discharge hydrograph used in the example shown in **Figure 2** is constructed from the 1976 record of daily mean discharges at the Water Survey of Canada hydrometric gauging station #05LJ016, Fork River near Ethelbert. That station ceased operation in 1994. Actual discharges reaching the low-level crossing site downstream of the gauge have not been recorded, and would not likely match the constructed hydrograph presented here. However, the pattern of daily discharges may be considered reasonable for purposes of looking at the possible performance of the proposed crossing replacement project.

A,2. The flow simulation illustrated in **Figure 2** indicates that the roadway would have been expected to overtop for 5 days during the spring melt in 1976 and for 5 days in response to a storm similar to the June storm in 1976. Streamflows would be expected to rise quickly, and overtop and then soon inundate the structure within the first day of events such as the two depicted in the figure. Quieter water adjacent to the river banks and on the floodplain and over the road outside of the low water channel area would be available for species passage without much delay during the rising limb of the runoff event. Water would also recede from the structure over a short period.

For the remainder of the year, while lower flows predominate, only the culverts would be available for passage upstream or downstream. In **Figure 2**, the simulation of 1976 conditions indicates that velocities of flows in the culverts would drop to below 1 m/s in about 3 days following the re-emergence of the roadway at the end of the spring runoff and June storm runoff events. Two other events during the simulated 1976 spring-summer period shown in the figure would be estimated to have culvert velocities exceeding 1 m/s for three and four consecutive days, respectively.

Other flow years would be expected to have different outcomes than the single illustrative example simulated here. The interaction of timing and discharge magnitude is complex, but it appears that the Fork River is quite flashy between its long periods of low flows and very low water depths.

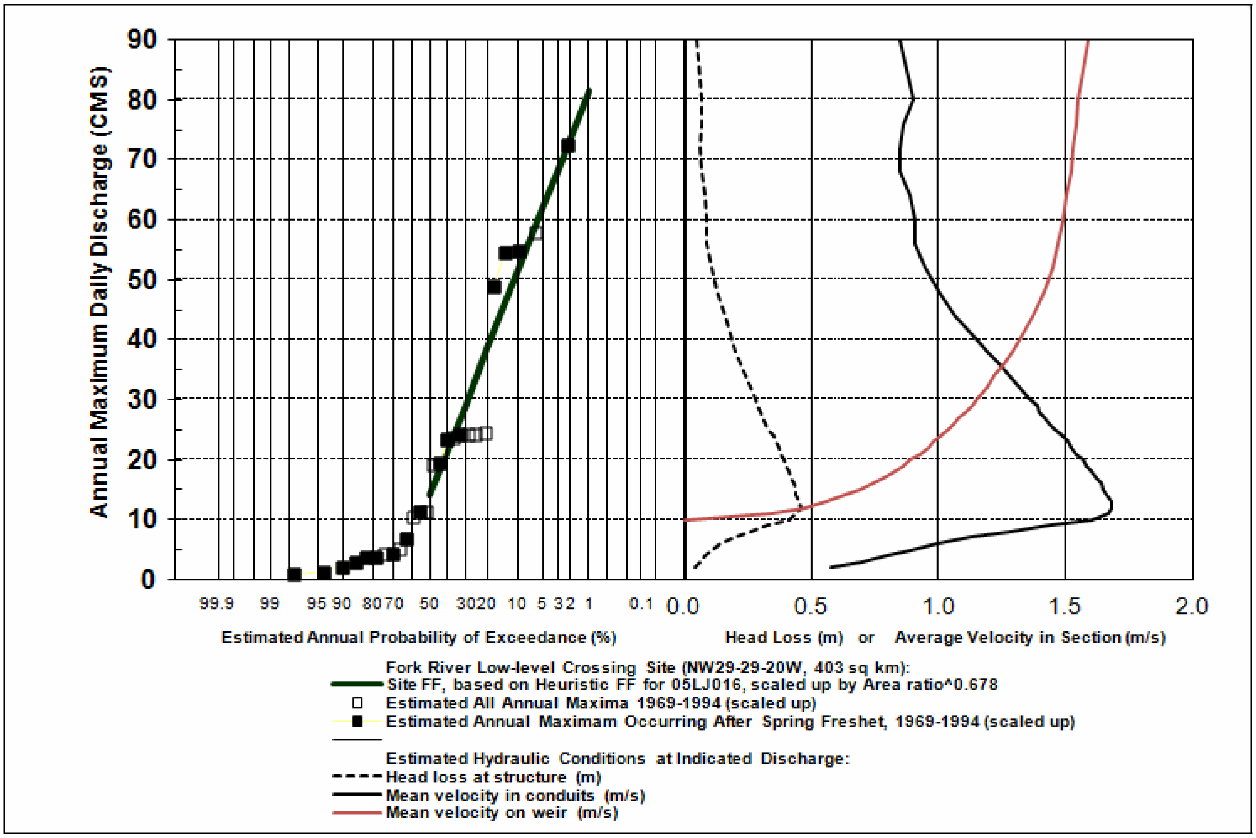

Figure 1. Estimated annual discharge exceedance frequency and estimated hydraulic conditions corresponding to the range of Fork River discharge conditions at RM of Mossey River low-level crossing replacement site, **NW 27-29-20W**.

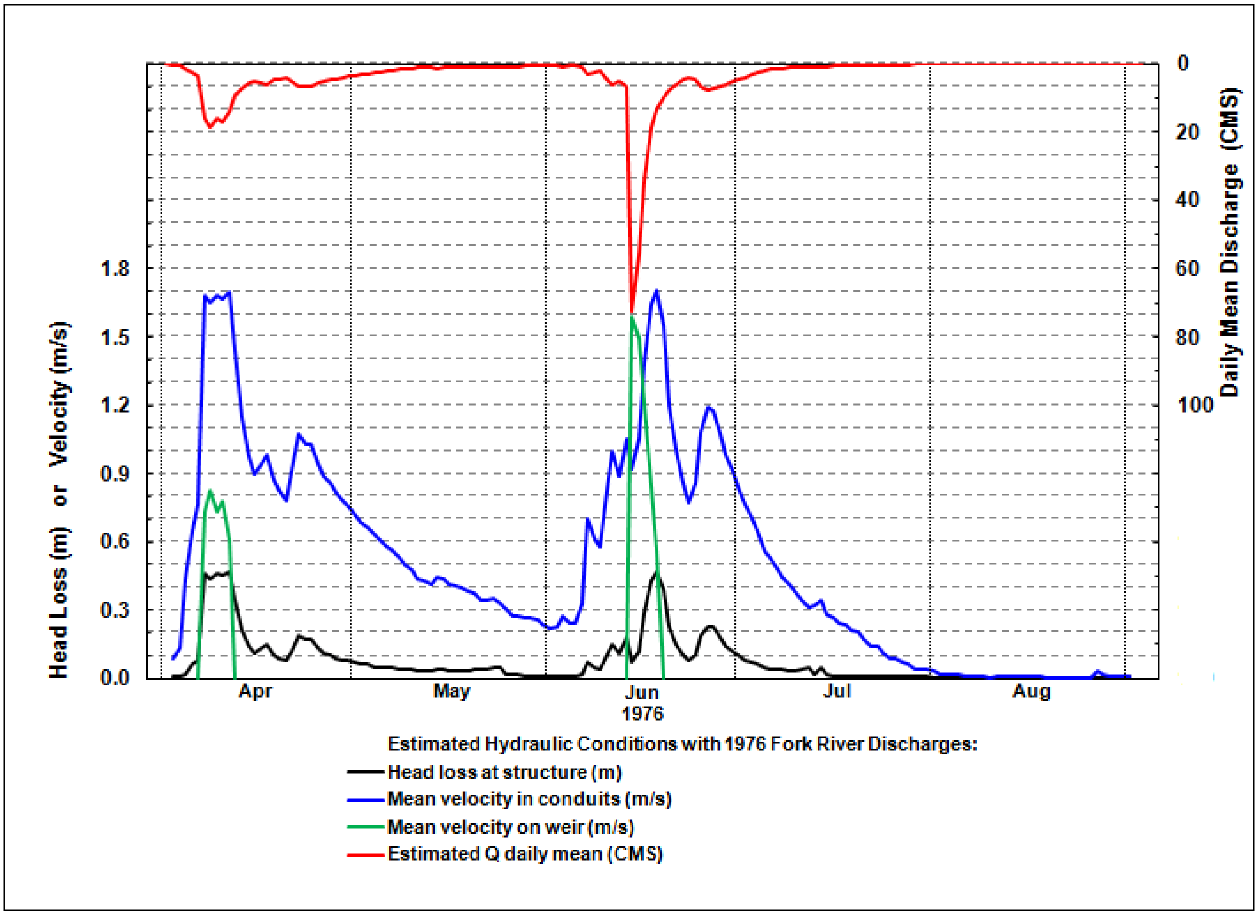

Figure 2. Simulated daily sequence of hydraulic variables at RM of Mossey River low-level crossing site, **NW 27-29-20W,** on basis of proposed crossing replacement geometry and estimated 1976 Fork River discharge hydrograph.