Opus International Consultants Ltd
Wellington Environmental Office
L10, Majestic Centre, 100 Willis St
PO Box 12 003, Thorndon,
Wellington 6144
New Zealand

t: +64 4 471 7000
f: +64 4 499 3699
w: www.opus.co.nz

To	Palmerston North City Council
Copy	
From	Matt Balkham
Date	15 March 2016
Attached	Initial pier geometry assessment.xls
Subject	Manawatu Cycle bridge - Pier & abutments initial hydraulic considerations

Background

This note should be read in conjunction with the Preliminary Hydraulic Report. It provides initial consideration of the likely hydraulic effect of the incorporation of piers and raised abutments/approach ramps.

A meeting was held on 29th February 2016 and attended by Palmerston North CC, Horizon RC and Opus at which the implication of incorporation of piers as part of the design of the Manawatu cycle bridge was discussed.

Piers are likely to reduce the construction cost of the bridge superstructure (effectively reducing the span of sections of the deck). However their incorporation has the potential to cause a restriction to flow which could result in a local elevation in upstream water levels. Furthermore the incorporation of piers also increases the propensity to collect debris which could lead to further increase in upstream levels (and/or increased velocities which increase the risk of scour).

Palmerston North City benefits from the Lower Manawatu River scheme which includes stopbanks in the vicinity of the proposed cycle bridge. These stopbanks have been designed and constructed and are maintained by Horizons RC. Any change in peak water level resulting from the construction of the cycle bridge could affect the performance (level of service) of the stopbanks. Horizons RC suggested at the meeting that any increase could be accepted without compromise to the Lower Manawatu scheme provided it was limited to approx. 50mm increase in upstream peak water levels (in the 0.2%AEP flood event). This equates to less than 10% of the freeboard included on design water levels in determining the height of the stopbanks.

It was suggested by Horizon RC that for other projects a pier ratio (area of the proposed piers / total flow area) of 0.1 has yielded an increase in upstream water levels of less than 50mm. Opus has undertaken an initial assessment of the likely geometry of the bridge to check the likely ratios of the concept design.

Initial geometric assessment

Figure 1 provides the geometry of the bridge which assumes:

- Pier diameter of 1200mm

- 2 no. piers in the river
- Abutment slopes of 1v:2h
- Approach ramp width (at crest) of 5m

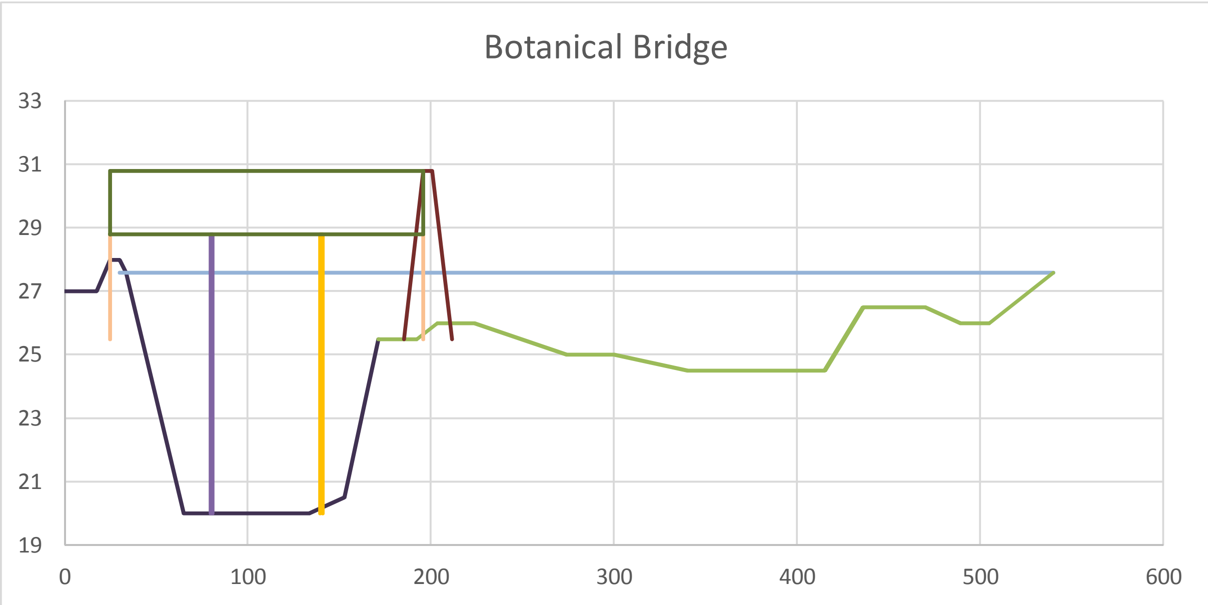

Figure 1 - Indicative Bridge Geometry

Using the above geometry we have estimated the pier ratio using the design peak water level (27.6m) from the preliminary hydraulic report. This assessment is shown in the attached spreadsheet (Initial pier geometry assessment.xls) and summarised below. To simplify the assessment we have undertaken the assessment initially on the botanical bridge location only.

Results of initial assessment

The other important factor to consider is the difference in flow velocity between the main river channel and the left bank floodplain. Afflux is proportional to flow velocity squared.

The piers will occupy approximately 2.2% of the flow area (i.e. have a ratio of 0.022 below the Horizon RC 0.1 ratio). With this pier width to channel width ratio, even though flow velocities are likely to be in the order of 2-5-3 m/s, we would anticipate the resulting afflux to be very small and within acceptable bounds.

The abutment on the Massey University side floodplain will occupy approx. 7.1% of the floodplain flow area (i.e. have a flow ratio of approx. 0.07 also below the 0.1 figure). Even though floodplain velocities are likely to be much lower (~1 m/s), we would be more concerned about the effect of the much larger abutment width to floodplain channel width ratio (0.071). We suspect this is likely to have a greater effect on total afflux of the bridge.

The combination of piers and abutment occupies 4.5% of the total flow area (that is the combined channel and floodplain). This would equate to a net flow area ratio of 0.045 which is below the Horizon RC 0.1 figure.

The other point worth noting is the ability of flow transfer between the main channel and left bank floodplain and *vice versa* to compensate for the partial blockage of flow channels by the bridge piers and left bank abutment. The local topography needs to be checked to ensure that this transfer can occur and minor earthworks may be required to facilitate such a transfer should it not be currently possible.

Next steps

The next stage is develop either a linked 1d/2d Mike model based on the Horizons RC model or develop a new HEC-RAS model of the concept design to determine the likely effect on upstream peak water levels. This increase would be considered in an unblocked and blocked (by debris) scenario and the resulting water level be compared to the height of the upstream stopbanks.

It is important that this model represents the mechanisms by which water is transferred between the channel and the floodplain.

Should this increase exceed the 50mm threshold, the design would need to be further refined to reduce this afflux. Measures to reduce the effect could include:

- Reduce diameter of piles (possibly having different piles above and below bed level)
- Streamline shape of piles (circular is usually the best shape and this factor is likely to have the least impact on afflux)
- Increase spacing of piles (noting that there is a balance between span and pier diameter)
- Reduce footprint of approach ramp (perhaps using soil improvements or retaining walls)

We feel that the last of these options is likely to have the most significant impact on reducing bridge afflux but the likely optimal solution might include each of these measures.