Our Ref NA50613038

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Attention: Mr Bob Welsh

Via email - welshproperty@bigpond.com

Dear Bob,

RELOCATION OF MOUNT CARMEL ROAD FROM WINDSOR ROAD TO KILLARNEY CHAIN OF PONDS DA – FLOOD ASSESSMENT

This flood assessment report has been prepared to support the Development Application for the proposed relocation of Mount Carmel Road from Windsor Road to Killarney Chain of Ponds on behalf of the Mogul Jundu property owner.

Hydraulic modelling has been conducted for two alternative concept bridge designs which are proposed. These two design options are:

- Option 1: A bridge consisting of three 15m spans (as shown in design drawing no. X11295.01/DA/901)
- Option 2: A bridge consisting of seven 16m spans (as shown in design drawing no. X11295.01/DA/902)

The objective of this assessment is to determine the following:

- If the relocation of the Killarney Chain of Ponds crossing, as shown in **Figure 1**, has an impact on the hydraulic performance of the developed Box Hill precinct; and,
- If the two concept bridge designs proposed within this DA satisfy all relevant design criteria.

1. Box Hill Development Context

In 2013, the NSW Department of Planning and Infrastructure released the Box Hill DCP (DP&I, 2013) which established development controls for the Box Hill precinct within The Hills Shire Council Local Government Area (LGA). To support this DCP, a Water Cycle Management (WCM) Strategy Report (JWP, 2013) was prepared outlining a precinct wide strategy to ensure the development did not result in adverse flooding and WSUD outcomes.

In preparation of the Creek Rehabilitation and Earthworks DA for the Mogul Jundu property, Cardno found a number of issues and limitations with the modelling methodology adopted in the Box Hill WCM Strategy. As a result, a Revised Box Hill WCM Strategy (Cardno, 2014) was prepared which resolved these issues with the modelling. In addition revisions to the original precinct-wide strategy were proposed that were shown to have improved outcomes for Council, other developers in the precinct, and the Mogul Jundu property owner.

The design scenario modelling in the Revised WCM Strategy did not account for the hydraulic impact of the proposed Mount Carmel Road crossings of the Killarney Chain of Ponds or Northern Tributary. This essentially assumed that the eventual designs of the two Mount Carmel Road crossings, for Killarney Chain of Ponds and Northern Tributary, have negligible impact on the hydraulic performance of the Box Hill precinct.

However, a sensitivity analysis was conducted as part of the revised WCM incorporating 50% blockage of riparian corridors for the crossing locations shown in the Box Hill Indicative Layout Plan (DP&I, 2013). The sensitivity analysis showed the northern tributary crossing had negligible flooding impacts, however the Killarney Chain of Ponds crossing had significant (>0.5m) localised water level increases upstream for the 100yr event. Importantly the modelling of the original crossing locations were found not to have a significant impact on discharges from the Box Hill precinct.

2. Relevant Design Criteria

2.1 Cumulative Opening Width

Control 17 of Section 6.11 of the Box Hill DCP (DP&I, 2013):

> *Waterway crossings are required to have a minimum opening width equating to 50% of the width of the relevant riparian corridor*

The proposed relocation of the Killarney Chain of Ponds crossing has an approximate riparian corridor width of 85m, this equates to a minimum opening width of 42.5 metres. The two designs options have cumulative opening widths of 45 metres, and 128 metres, for Option 1, and Option 2, respectively, meaning they both satisfy this criteria.

2.2 Underside of Structure

Section 4.21 of Councils *Design Guidelines Subdivision / Developments* (THSC, 2011):

> *Bridges and major culverts shall be designed for the major storm event (100yr ARI) general with afflux in urban areas. A minimum clearance of 0.3 metres should be provided between the major flow level and the underside of a major structure to allow for passage of storm debris.*

The performance of the two design options is discussed in **Section 4.2**.

3. Hydraulic Modelling

The fully developed scenario Tuflow hydraulic models from the Revised Box Hill WCM Strategy (Cardno, 2014) have been adopted in this assessment as the ‘base case’. The following section outlines the changes to the model accounting for the inclusion of the two design options. Refer to the Revised Box Hill WCM Strategy Report (Cardno, 2014) for details of model methodology.

3.1 Digital Elevation Model (DEM)

The bridge openings have been modelled in the 2D component of the Tuflow model with existing ground surface conditions maintained for the 45 metre and 128 metre openings proposed for Option 1 and Option 2 respectively. This assumes that the proposed designs would not alter the riparian corridor terrain significantly outside of the abutments.

Road embankments adjacent to the bridge opening have been raised in the model DEM above 100yr ARI water levels, creating a constriction in flow within the riparian corridor.

Intermediate bridge piers have not been elevated in the model DEM. These have been incorporated through roughness (refer to **Section 3.3** for further details).

3.2 Design Events

The 100yr event has been run as part of this assessment as all design criteria and objectives for the proposed bridge designs relate to this design event.

3.3 Surface Roughness

A mannings value of 0.07 has been maintained within the bridge sections, which is equivalent to fully vegetated riparian corridor in the hydraulic model. While it is assumed that the vegetation under the bridge structure will be significantly less than the surrounding riparian corridor, this is a composite roughness value accounting for the hydraulic roughness associated with the bridge piers.

Further assessment of this composite roughness is summarised in **Section 6.3** of this report.

Note that it is assumed that, in accordance with the design criteria in **Section 2.2**, that the underside of the bridge designs will lie above the 100yr water level and therefore will not have an impact on hydraulic behaviour.

4. Hydraulic Performance

4.1 Water Level Impacts

Water level impacts resulting from the inclusion of bridge Option 1, and Option 2, in the revised developed model are shown in **Figure 2**, and **Figure 3**, respectively.

Note that there are water level impacts (0.2 – 0.35m) upstream of the proposed bridge for Option 1. As these impacts are quite localised (within 60 metres upstream of bridge structure) the hydraulic impact is considered negligible. However these water level increases will need to be incorporated into future detailed fill designs in this area immediately upstream of the crossing.

It is worth noting these impacts are less than those resulting from the sensitivity analysis conducted for the original Killarney Chain of Ponds crossing from the Revised WCM Strategy Report (Cardno, 2014). The water level impacts resulting from the original crossing location exceeded 0.5m for the 100yr event.

Design Option 2 shows peak water level increases upstream of 0.06 metres which are within the vicinity upstream of the bridge. The reduced impacts for Option 2 compared to Option 1 are due to the cumulative opening width of this option being significantly wider, meaning the constriction of flow is less.

Note that the water level impacts for both design options are contained within the Mogul Jundu property.

4.2 Underside of Bridge

As outlined in **Section 2.2**, Council's design guidelines require that undersides of all bridges have a minimum freeboard of 0.3m to the peak 100yr water level. Hydraulic model results show that on the upstream side of the bridge there are variations in peak water levels across the span, particularly for Option 1. Similarly the elevation of the underside of the bridges varies along the length of the bridge.

Therefore five recording locations have been adopted on the upstream side of the bridge to determine the 100yr ARI peak water levels and compare them to bridge underside levels. These recording locations are shown in **Figure 4**.

The assessment of underside of bridge levels at these five locations is summarised in **Table 1** below.

Table 1 – Assessment of Bridge Options for Underside Freeboard Design Criteria

Location ID	Design Option 1				Design Option 2			
	Peak 100yr WL	Min. Underside Level*	Design Underside Level	Design Acceptable	Peak 100yr WL	Min. Underside Level*	Design Underside Level	Design Acceptable
A**	21.95	-	-	-	21.63	21.93	22.57	Yes
B	21.87	22.17	22.63	Yes	21.62	21.92	22.63	Yes
C	21.87	22.17	22.7	Yes	21.62	21.92	22.7	Yes
D	21.87	22.17	22.72	Yes	21.62	21.92	22.72	Yes
E**	21.92	-	-	-	21.62	21.92	22.63	Yes

*In accordance with Section 4.21 of Council's design guidelines for subdivisions / developments which applies a 0.3m freeboard to all bridge undersides.
**Note Location A and E for Option 1 lie adjacent to embankment and not bridge sections and therefore minimum underside levels do not apply.

As can be seen in the table above, the underside bridge levels proposed within both design options lie well above the minimum requirements specified in Council's design guidelines. Therefore both design options satisfy this design criteria.

4.3 Impact on Discharges from Precinct

From the Revised Box Hill WCM Strategy there are two flow recording locations downstream of the proposed Killarney Chain of Ponds crossing:

- Node 1.04: First Ponds Creek crossing Boundary Road (the Box Hill precinct discharge point); and,
- Node N9: First Ponds Creek downstream of Boundary Road (downstream of the Box Hill precinct).

An assessment of peak flows at these two locations for the base case (revised fully developed with no bridges modelled for Mount Carmel Road crossings), Option 1, and Option 2, are summarised in **Table 2** below.

Table 2 – Peak 100yr Flow Results for Downstream of Box Hill Precinct (in m^3/s)

Location	Base Case*	Option 1	Option 2
1.04 – Precinct Discharge Point	168.6	168.6	168.8
N9 – Downstream of Precinct	177.8	177.7	178.4

*The base case is the revised fully developed Box Hill precinct scenario from the Revised WCM (Cardno, 2014).

Therefore it can be seen that the two proposed design options have negligible (<0.6m^3/s) impact on the hydraulic performance of the precinct-wide WCM Strategy.

5. Blockage Factors

In February 2013 Australian Rainfall and Runoff (AR&R) released the AR&R Project 11 Stage 2 Report (Engineers Australia, 2013) which looks at blockage of hydraulic structures and in particular providing guidance on accounting for blockage in hydraulic structure design. Importantly the report incorporates catchment dependent variables into blockage factor assessments, making them applicable Australia-wide.

The report details two blockage assessment approaches suggesting that either method can be adopted. As part of this flood assessment, design blockage values have been based on Scheme A.

Scheme A, is a qualitative assessment outlined in Section 3.4 of the AR&R Project 11 Stage 2 report (Engineers Australia, 2013). The procedure requires subjective assessment of the upstream catchment to assign a low, medium, or high categorisation for a number of debris associated variables. The results of the assessment for Killarney Chain of Ponds is listed in **Table 3**. Option 1 has been assessed as it has the smallest opening widths and is therefore the worst case blockage scenario.

Table 3 – Blockage Assessment Scheme A Summary for Option 1

Variable	Appropriate Category	Justification
Debris Availability – What potential volume of debris may be collected by this catchment	Moderate	Rural, grazing land across most of upstream catchment, however extensive stand of casuarinas upstream enhances debris availability
Debris Mobility – Does the catchment have sufficient flow to carry debris	Moderate	Moderately flat upstream catchment, with long response time and moderate annual rainfall
Debris Transportability – Does the creekline have the appropriate geometry to allow debris	Moderate	Flat bed slope (<1%), Narrow streams relative to debris load dimensions, regular rainfall distribution.

In accordance with Table 3.4 of AR&R Project 11 Stage 2 report (Engineers Australia, 2013), this combination results in an “At site base debris potential” of Low.

The final variable that needs to be accounted for in this scheme is the design structures opening width in comparison to the likely size of debris that will pass through the structure.

The minimum opening width proposed is 15 metres for the bridge options. Applying this to Table 3.6 of AR&R Project 11 Stage 2 report (Engineers Australia, 2013) if the L_{10} for the crossing location is less than a third of that width (5 metres) than no design blockage factor needs to be considered.

The L_{10} value is defined in this method as “the length of the longest 10% of debris that could arrive at the site”. There is an extensive stand of casuarinas upstream meaning that tree debris of significant length could be washed down to the proposed crossing location. However it is assumed that the length of 10% of debris would be no more than 3 metres. Therefore no design blockage factors need to be considered as part of this design assessment.

6. Model Validation

To verify the hydraulic modelling of the proposed design bridge options within the Tuflow model, a detailed local HEC-RAS model has been prepared for the proposed crossing. This ensures that the way in which the hydraulic behaviour of the bridge options have been represented in Tuflow is appropriate.

6.1 Model Set-up

Cross sections for the HEC-RAS model were extracted from 250 metres upstream and 250 metres downstream of the proposed crossing location at regular intervals. Cross sections were recorded immediately upstream (KC-1380) and downstream (KC-1430) of the proposed crossing, as well as one within the proposed crossing area (KC-1404).

The cross section locations adopted within the HEC-RAS model are shown in **Figure 5**. Cross sections were interpolated at 10m intervals for the HEC-RAS model.

The bridge structures have been modelled with the bridge piers included within the model, and a mannings roughness value of 0.05 has been adopted under the bridge to account for the reduced vegetation as discussed in **Section 3.3**. This approach is different to that adopted in the Tuflow model where a representative surface roughness of 0.07 has been adopted under the bridge to account for the hydraulic roughness associated with the bridge piers.

HEC-RAS hydraulic models were established for the following three scenarios:

- Base Case - revised fully developed precinct scenario with no bridge,
- Option 1; and,
- Option 2.

6.2 Model Validation Results

General validation of the HEC-RAS and Tuflow models based on peak 100yr levels for the base case model are shown in **Table 4**.

Table 4 – Model Validation Results for Peak 100yr ARI Water Levels for the Base Case

Cross Section	Tuflow Peak WL	HEC-RAS Peak WL	Validation Result
KC-1161	22.3	22.42	0.12
KC-1296	21.87	21.84	-0.03
KC-1380	21.6	21.55	-0.05
KC-1404 (Crossing Location)	21.55	21.47	-0.08
KC-1430	21.5	21.41	-0.09
KC-1513	21.32	21.31	-0.01
KC-1579	21.1	21.11	0.01
KC-1662	20.85	20.85	0

All 100yr water level results are generally within 0.1 metres of Tuflow model results for the base case scenario. This demonstrates a good agreement between the models.

6.3 Bridge Hydraulic Impact Validation

A summary of the water level impacts for Option 1 and Option 2 compared to the base case scenario for the HEC-RAS and Tuflow models are shown in **Table 5** below. As mentioned previously water levels vary across cross sections for the Tuflow models, as such the levels reported below are for channel centrelines.

Table 5 – Validation Results for Bridge Hydraulic Impacts (Design Less Base Case) for 100yr ARI

Cross Section	Design Option 1			Design Option 2		
	Tuflow WL Impacts	HEC-RAS WL Impacts	Validation Result	Tuflow WL Impacts	HEC-RAS WL Impacts	Validation Result
KC-1161	0.05	0.01	-0.04	0	0	0
KC-1296	0.14	0.09	-0.05	0	0.01	0.01
KC-1380	0.3	0.25	-0.05	0.03	0.05	0.02
KC-1404 (Crossing Location)	0.25	0.21	-0.04	0.03	0.08	0.05
KC-1430	0	0	0	0	0	0
KC-1513	0	0	0	0	0	0
KC-1579	0	0	0	0	0	0
KC-1662	0	0	0	0	0	0

The hydraulic impact of the two bridge designs recorded in the Tuflow model shows good agreement with those represented in the HEC-RAS model with validation of impacts within 0.05 metres at all locations. Both the HEC-RAS and Tuflow hydraulic models show significant water level increases resulting from Option 1 immediately upstream of the crossing location (KC-1380) with negligible impacts downstream.

These validation results support the adoption of a representative roughness of 0.07 within the Tuflow model to account for the reduced vegetation under the bridge, combined with the hydraulic behaviour of the piers.

7. Conclusion

The outcomes of this flood assessment are as follows:

- The proposed relocation of the Mount Carmel Road crossing of Killarney Chain of Ponds has negligible impact on the hydraulic performance of the Revised Box Hill WCM Strategy (Cardno, 2014),
- Both Design Option 1 and Design Option 2 for the proposed bridge crossing are appropriate for adoption as they are both shown to meet all design criteria,
- The modelling results suggest that if Option 1 is adopted this may have a minor impact on final fill levels immediately upstream (within 60 metres) of the proposed crossing location; and,
- No consideration of design blockage factors is required within this assessment in accordance with Assessment Scheme A from the AR&R Project 11 Stage 2 Report (Engineers Australia, 2013); and,

Any queries please contact me on 9496 7700 to discuss further.

Yours faithfully,

Martin Griffin
Engineer
for **Cardno (NSW/ACT) Pty Ltd**

REFERENCES

Cardno (2014) *Revised Box Hill WCM Strategy Report*, February

Department of Planning & Infrastructure (2013) *Box Hill & Box Hill Industrial Precinct DCP 2013*, April

Department of Planning & Infrastructure (2013) *Box Hill & Box Hill Industrial Precinct Indicative Layout Plan*

Engineers Australia (2013) *AR&R Project 11 Stage 2 Report – Blockage of Hydraulic Structures*, February

J. Wyndham Prince (2012) *Box Hill & Box Hill Industrial Precincts Post Re-Exhibition WCM Strategy Report*, November

The Hills Shire Council (201) *Design Guidelines Subdivision / Development*, September

Figure 1
Location of Proposed Mount Carmel Road Crossing of KCoP

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Relocation of Mount Carmel Road from Windsor Road to KCoP DA
Flood Assessment

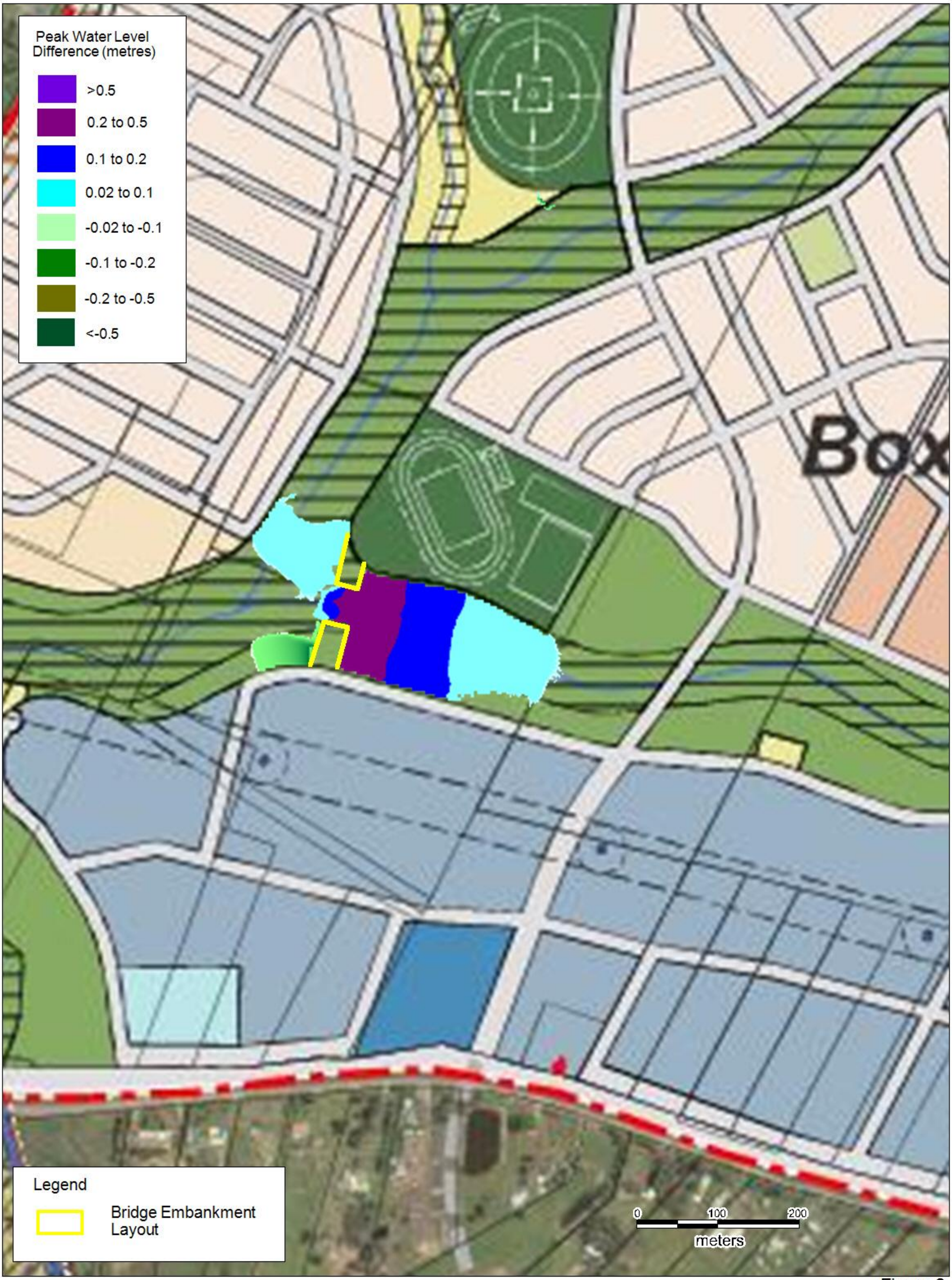

Figure 2
100yr Water Level Differences
Option 1 Less Base Case

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Relocation of Mount Carmel Road from Windsor Road to KCoP DA
Flood Assessment

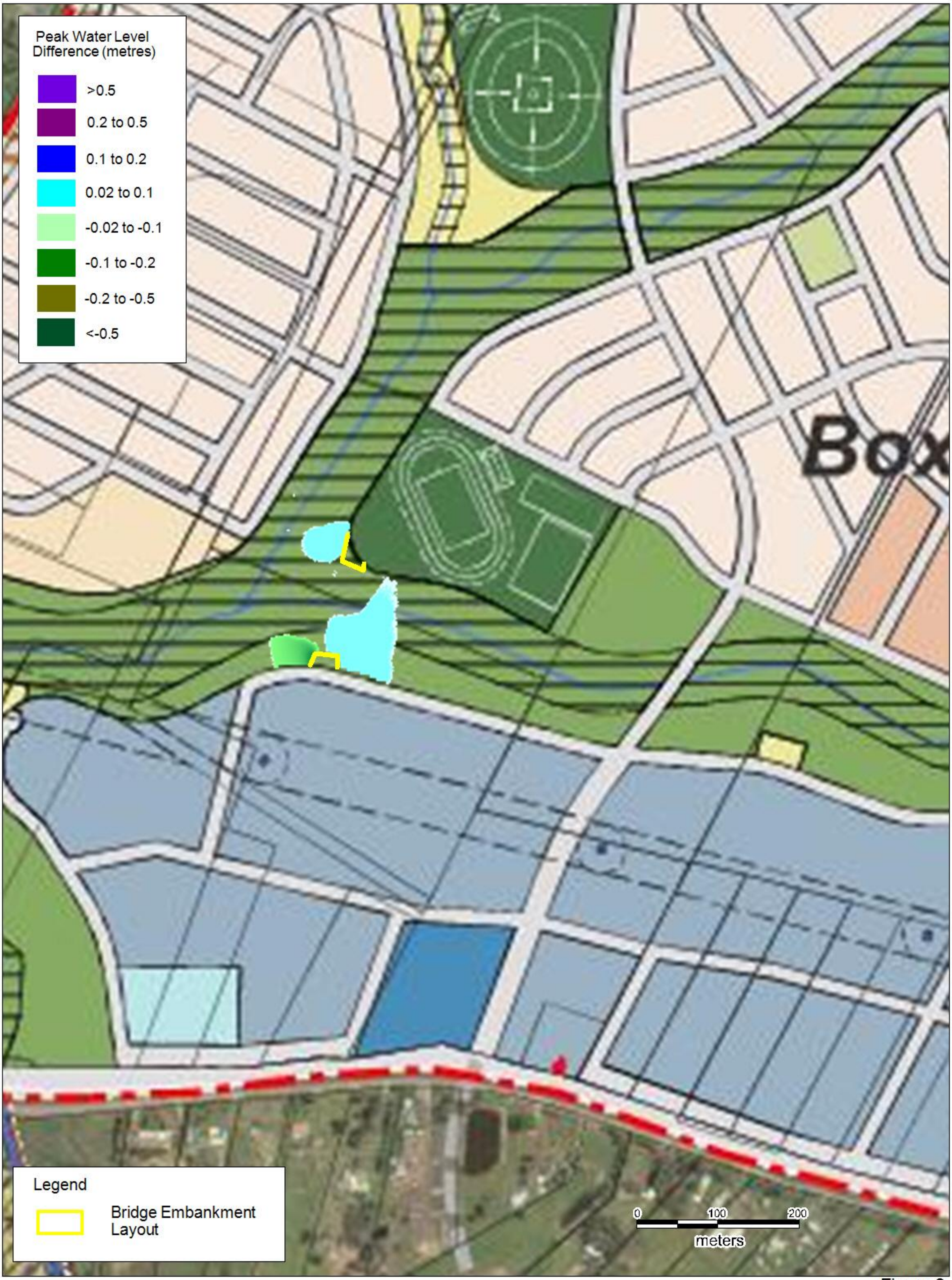

Figure 3
100yr Water Level Differences
Option 2 Less Base Case

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Relocation of Mount Carmel Road from Windsor Road to KCoP DA
Flood Assessment

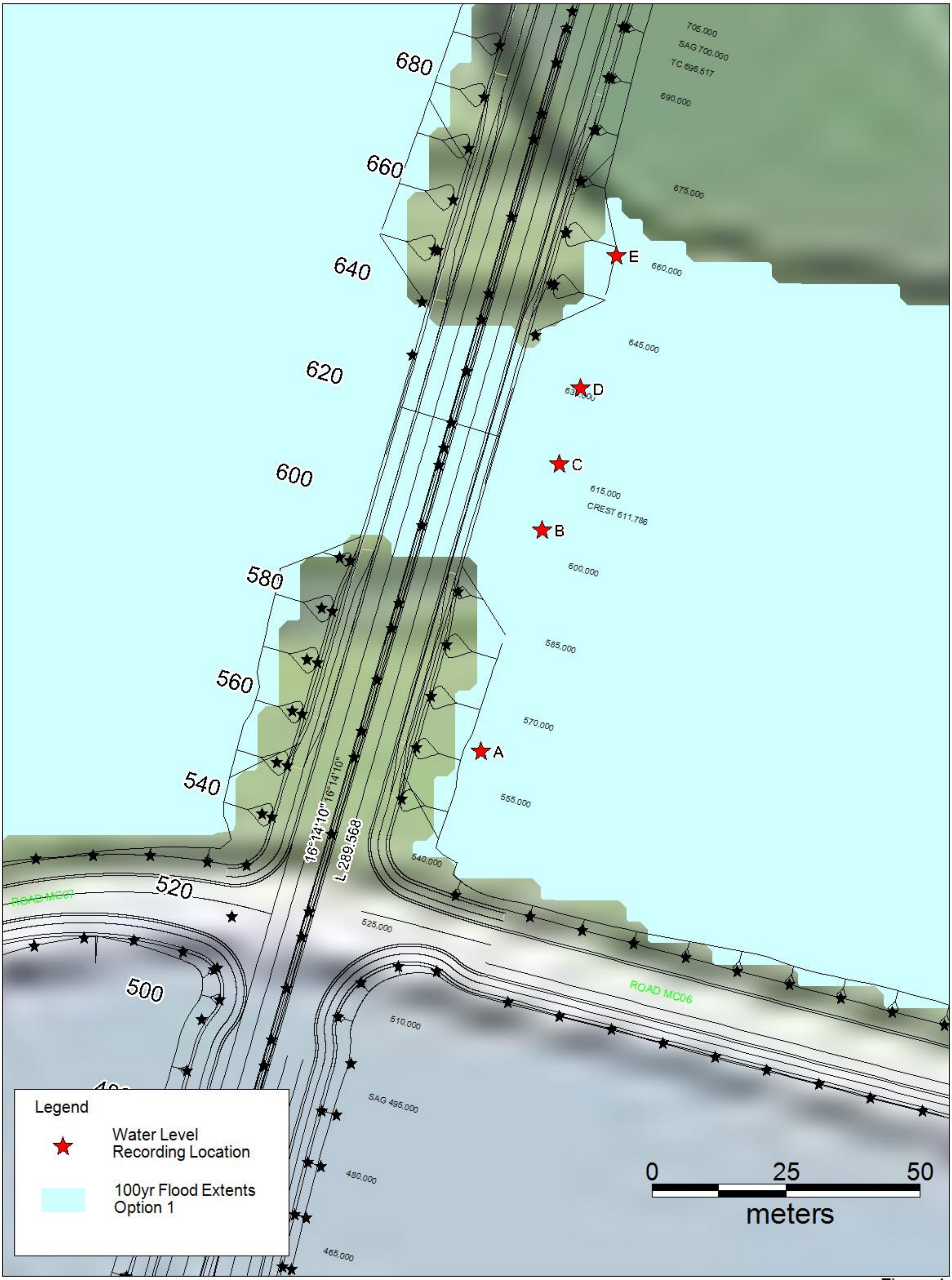

Figure 4
Water Level Recording Locations

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Figure 5
HEC-RAS Hydraulic Model Cross Sections

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