Wanganui Rd Flood Modelling Investigation

Wanganui Road Flood Investigation

Greater Shepparton City Council

July 2017
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27 July 2017

Eric Frescher  
Design Engineer  
Greater Shepparton City Council  
Locked Bag 1000  
SHEPPARTON, VICTORIA 3632

Dear Eric

Wanganui Flood Modelling Investigation

Please find the report below detailing the flood modelling investigation of the proposed upgrade to Wanganui Road as part of the Shepparton bypass project.

Yours sincerely

[Signature]

Lachlan Inglis  
Project Engineer  
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WATER TECHNOLOGY PTY LTD
EXECUTIVE SUMMARY

Greater Shepparton City Council are investigating the proposed design of the Shepparton Bypass Link along Wanganui Road. Much of this alignment is prone to flooding and currently sits within the 1% AEP flood extent as shown in Figure 1-1. An upgrade of the road to Austroads/VicRoads standards requires the roadway (proposed 3 lane upgrade compared to existing 2 lanes) to be raised above the 1% AEP flood level.

The flood mapping undertaken has found that a peak flow rate of approximately 170 m$^3$/s overtops Wanganui Road in a 1% AEP event, with the majority of that flow being conveyed through a floodway between Kittles Road and Freemans Road. The floodway collects flow that breaks out of the Goulburn River to the south of Wanganui Road and is activated once the Goulburn River reaches a level of 11.0 m at the Shepparton streamflow gauge. This is considered a Major Flood event, similar to the floods experienced in 1974, 1993 and 2010. Under existing conditions, the flood level in a 1% AEP event is 111.3 m AHD, with depths close to one metre across the roadway. A number of roads in the area including Numurkah Road are inundated in a 1% AEP flood event.

Several mitigation options involving large banks of box culverts with up to 113 culverts were modelled, however the results showed the culverts were not able to convey the large flow efficiently, and resulted in significant increases in flood levels up to 2 km upstream of the roadway. It does not appear that box culverts alone will be suitable to convey the 1% AEP flow through the upgraded raised Wanganui Road without having adverse impacts on flood levels upstream of the roadway.

An alternative approach which used an extended floodway at Wanganui Road was modelled and showed that maintaining or improving the conveyance through the road was achievable without increasing flood levels upstream. This would however require either Wanganui Road to the west of the southbound onramp to be bridged or to be inundated and closed in a 1% AEP flood event. Further investigation into a suitable bridge or floodway design should be undertaken. Consultation with VicRoads to incorporate all proposed road alignments including entry and exit ramps is recommended given the extensive nature of flooding along the proposed bypass route.
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1 INTRODUCTION

The proposed road upgrade along Wanganui Rd is still in the feasibility study stage, but will likely be a three-lane road (one lane either direction with centre median turning lanes), compared with the current two lane configuration. The road upgrade assumes raising of the road to be above flood level requirements for VicRoads. The length of road for the study area is approximately 3,230 m from the north bound off ramp at the most westerly location through to the Numurkah Road intersection in the east.

The design will also be required to provide adequate freeboard above the 1% AEP flood level and have appropriate drainage capacity to ensure no detrimental impacts on surrounding properties during a 1% AEP flood event. The AustRoads/VicRoads Guidelines are provided in Section 3.3.

Flood mapping was undertaken to assess Wanganui Road under existing conditions and the impact of the proposed upgrade on flooding conditions.
2 BACKGROUND

Shepparton and Mooroopna have a long history of flooding, with a number of significant historic flood events and subsequent flood mapping studies resulting in the flood behaviour being well documented and understood.

2.1 Current Planning Scheme

The Shepparton Mooroopna Floodplain Management Study\(^1\) was undertaken in 2002 by Sinclair Knight Merz in conjunction with Lawson and Treloar Pty Ltd. This study used a MIKE 21 flood model to calibrate the flood events of 1974 and 1993 to within +/- 500 mm. The model topography utilised photogrammetry flown in September 1999 and a model grid resolution of 12.5 m for the ‘inner area’ and a 25 m grid resolution in the ‘outer area’. The Wanganui Road area sits in the ‘inner area’.

The modelling undertaken in the 2002 flood study formed the basis for the current planning scheme. The existing 1% AEP flood level along Wanganui Road is 111.2 m AHD. The existing flood level contours show a head drop of up to 0.40 m across the roadway. This highlights the road is acting as a hydraulic control across the floodplain in a 1% AEP flood event.

The current planning scheme (Figure 2-1) shows two sections of Urban Floodway Zone (UFZ) directly to the South of Wanganui Road, the western section measuring around 1.5 km along Wanganui Road while the eastern section is approximately 450 metres in length. North of Wanganui Road there is around 550 metres of Floodway Overlay (FO). The entirety of the Wanganui Road proposed for upgrade is within a Land Subject to Inundation Overlay (LSIO) on both the northern and southern sides of Wanganui Road.

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\(^1\) Sinclair Knight Merz (2002), Shepparton–Mooroopna Floodplain Management Strategy, prepared for the Greater Shepparton City Council and the Goulburn Broken Catchment Management Authority
2.2 Shepparton-Mooroopna Flood Mapping and Intelligence Investigation

Water Technology are currently undertaking flood modelling of the Shepparton-Mooroopna area; this is currently the best available flood information for Shepparton and Mooroopna including the Wanganui Road site. The modelling for the Shepparton-Mooroopna Flood Mapping and Intelligence Study\(^2\) used high resolution Light Detection and Ranging (LiDAR) survey, resampled to a 10 m grid resolution. The flood model extent for the Shepparton-Mooroopna Flood Mapping and Intelligence Study along with the model extent for the Wanganui Road model are shown in Figure 2-2. The model was calibrated using surveyed flood height marks from the 1993, 2010 and 1974 floods and further validated using aerial imagery from these events. Calibration of water levels for these events was aimed at within +/- 200 mm. Local drainage issues were not addressed as part of this study. At the time of the investigation, the calibration of the model to the historical events had been undertaken along with design modelling.

The modelling undertaken for the Wanganui Road Flood investigation replicated the modelling being undertaken for the ongoing flood mapping and intelligence study. This involved utilising the same model parameters as used in the Shepparton-Mooroopna Flood Mapping and Intelligence Study and ensuring existing conditions flood levels matched the ongoing flood study results.

\(^2\) Water Technology (2017), Shepparton-Mooroopna Flood Mapping and Intelligence Study, prepared for the Greater Shepparton City Council
Figure 2-2  Flood Model Extents for Shepparton-Mooooroonpa Flood Mapping and Intelligence Study and the Wanganui Road Flood Modelling Investigation
3 METHODOLOGY

The TUFLOW flood model from the Shepparton-Moorooropna Flood Mapping and Intelligence Study was trimmed to a smaller model of the Wanganui Road area, with the results validated back to results of the larger model.

3.1 Model Schematisation

The cut down TUFLOW model begins around 6 km upstream of Wanganui Road and incorporates inflows from the Shepparton-Moorooropna hydraulic model from the Broken River and Goulburn River at the upstream boundary inflow locations. The model extends 4 km downstream of Wanganui Road and uses tailwater data extracted from the Shepparton-Moorooropna hydraulic model. The model roughness parameters adopted in the Shepparton-Moorooropna hydraulic model were used in this model and are shown in Figure 3-1. A summary of the Mannings n values used are shown in Table 3-1.

<table>
<thead>
<tr>
<th>Land Type</th>
<th>Roughness (Manning’s ‘n’)</th>
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</thead>
<tbody>
<tr>
<td>Roads</td>
<td>0.015</td>
</tr>
<tr>
<td>Crops</td>
<td>0.05</td>
</tr>
<tr>
<td>Medium Density Vegetation</td>
<td>0.07</td>
</tr>
<tr>
<td>High Density Vegetation</td>
<td>0.10</td>
</tr>
<tr>
<td>Stagnant Water Bodies</td>
<td>0.03</td>
</tr>
<tr>
<td>Industrial</td>
<td>0.06</td>
</tr>
<tr>
<td>Cleared Land/Open Space</td>
<td>0.04</td>
</tr>
<tr>
<td>1D River Channel</td>
<td>0.06</td>
</tr>
<tr>
<td>Broken River</td>
<td>0.10</td>
</tr>
<tr>
<td>Railway</td>
<td>0.10</td>
</tr>
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</table>
Figure 3-1  Cut down TUFLOW Model – Roughness Schematisation
3.2 Existing Conditions (Base Case)

The model was run to simulate a 1% AEP flood event at Shepparton with a streamflow gauge height of 12.3 m. This is above the current classification for a Major Flood Event as defined by the Bureau of Meteorology. The Flood Class Levels along with historical flood heights at the Shepparton streamflow gauge are shown in Table 3-2. The 1% AEP flood extent, depth and water surface elevation for existing conditions are shown in Figure 3-2 to Figure 3-4. A long section of the existing conditions water surface and topography along Wanganui Road is shown in Figure 3-5.

Table 3-2 Key Flood Levels (Shepparton Streamflow Gauge)

<table>
<thead>
<tr>
<th>Flood Event</th>
<th>Gauge Height at Shepparton</th>
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<tbody>
<tr>
<td>Minor Flood</td>
<td>9.50m</td>
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<tr>
<td>2011</td>
<td>9.82 m</td>
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<tr>
<td>Moderate</td>
<td>10.70 m</td>
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<td>Major</td>
<td>11.00 m</td>
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<tr>
<td>2010</td>
<td>11.09 m</td>
</tr>
<tr>
<td>1993</td>
<td>11.71 m</td>
</tr>
<tr>
<td>1974</td>
<td>12.09 m</td>
</tr>
<tr>
<td>1916</td>
<td>12.25 m</td>
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<tr>
<td>1% AEP Flood Event</td>
<td>12.30 m</td>
</tr>
</tbody>
</table>

Figure 3-2 1% AEP Existing Conditions Flood Extent at the Site
Figure 3-3  1% AEP Existing Conditions Flood Depth at the Site
Figure 3-4  1% AEP Existing Conditions Water Surface Elevation at the Site
Figure 3-5 Long Section of Wanganui Road Existing Conditions 1% AEP Flood Levels
3.3 Austroad/VicRoads Guidelines

The following conditions regarding the guidelines for the Wanganui Road upgrade were supplied by GTA consultants and refer to Table 4.3 in the Austroads Guide to Road Design, Part 5: Drainage Design, noting the following:

- 1 in 100 year ARI flood level used as design level for Wanganui Road
- Apply a freeboard of 500 mm on top of design level given the flat terrain in the area
- Water sensitive urban design and retardation of stormwater requirement will be carried out as per VicRoads Water Sensitive Road Design guidelines
- Bridge design – 1 in 100 year ARI flood level

Based on the existing flood information, it is expected that the roadway would have a minimum elevation of 111.4 to 111.9 m AHD based on a minimum of 500 mm freeboard on the 1% AEP level. Given the extremely flat nature of the surrounding terrain, it was anticipated that this would generate higher water levels from ponding against the roadway. This will have significant implications to the residential areas upstream of Wanganui Road.

3.4 Goulburn Broken CMA Guidelines

The Goulburn Broken CMA were initially consulted regarding the upgrade of Wanganui Road and highlighted its concerns around location of the road and its orientation which is perpendicular to the flow path across the floodplain. It noted the roadway in its existing condition (along with a number of GMW irrigation channels) currently act like a levee, ponding flood water behind the roadway. The GBCMA recommended negotiating the level of protection for the roadway given any increase in the road level would likely result in increased flood levels on the upstream (southern) side of Wanganui Road. The GBCMA also recommended the use of a floodway or bridged structure if possible to increase the conveyance of flow across the roadway compared to the use of box culverts. The GBCMA are not likely to support a road design that results in increased flood levels to residential properties that result in above floor flooding.
4 RESULTS

Several design scenarios for the upgraded Wanganui Road were modelled, starting with the initial design of several box culverts, and ending with a floodway or bridged section of roadway to increase the conveyance across Wanganui Road. The results are presented below.

4.1 Developed Scenario 1

The initial mitigation option involved locating four sets of culverts at locations along Wanganui Road where the existing conditions modelling results showed high areas of flow. A total of 51 culverts with a combined waterway area of 35.6 m² were placed in the model with downstream invert levels often the limiting factor in providing the initial level at which the culverts will convey flow. The roadway was raised to an elevation of 111.5 m AHD as a conservative approach (this is below the required 500 mm freeboard outlined by GTA consultants). Initial cut and fill calculations which do not take into account batter slopes required for the filled roadway provide were undertaken to provide an estimate of earthworks for the road upgrade. Filling to this level requires approximately 28,000 m³ of fill to be sourced to raise the Wanganui Road surface to 111.5 m AHD.

The model results show Wanganui Road is overtopped despite the increase in elevation to 111.5 m AHD and results in a significant increase in the flood extent to the south of Wanganui Road. The depth plot for this scenario is shown in Figure 4-1, while a flood level difference plot is shown in Figure 4-2. This shows a significant increase in flood levels immediately upstream of Wanganui Road along the length of the road (up to 0.56 m), and extends around 2 km upstream of the roadway along the floodway. This increase is significant and impacts around 2,000 properties, many of which would now be flooded above floor under this scenario.

All culverts modelled are running full and convey a maximum of 73 m³/s, with around 86 m³/s travelling over Wanganui Road. The maximum depth across the road is reduced to around 100 to 150 mm.

This scenario does not meet either Austroads/VicRoads or GBCMA requirements.
Figure 4-1  1% AEP Flood Depth for Developed Scenario 1
4.2 Developed Scenario 2

The second mitigation option involved the addition of two sets of culverts increasing the total culverts to 84 with a combined waterway area of 58.0 m², an increase in conveyance area of 62% compared to scenario 1. The roadway was again raised to an elevation of 111.5 m AHD, same as Scenario 1.

The model results show Wanganui Road is overtopped despite the increase in road elevation to 111.5 m AHD and the increased culvert capacity as compared to Scenario 1. The flood extent upstream of Wanganui Road is significantly increased. The depth plot for this scenario is shown in Figure 4-3, while a flood level difference plot is shown in Figure 4-4. This shows a significant increase in flood levels immediately upstream of Wanganui Road along the length of the road (up to 0.53 m) and extends around 2 km upstream of the roadway along the floodway. This increase is significant and impacts around 2000 properties, many of which would now be flooded above floor under this scenario.

All culverts are running full and convey a maximum of 108 m³/s, with around 50 m³/s travelling over Wanganui Road. The maximum depth across the road is reduced to around 80 to 100 mm.

This scenario does not meet either Austroads/VicRoads or GBCMA requirements.
Figure 4-3  1% AEP Flood Depth for Developed Scenario 2
Figure 4-4  1% AEP Flood Level Change for Developed Scenario 2
4.3 Developed Scenario 3

The third mitigation option increased the total culverts to 121 with a combined waterway area of 82.2 m², an increase in conveyance area of 25% from scenario 2. The roadway was again raised to an elevation of 111.5 m AHD same as Scenario 1 and 2.

The model results show Wanganui Road is overtopped despite the increase in elevation to 111.5 m AHD and the further increases to culvert capacity. The flood extent upstream of Wanganui Road is significantly increased. The depth plot for this scenario is shown in Figure 4-5, while a flood level difference plot is shown in Figure 4-6. This shows a significant increase in flood levels immediately upstream of Wanganui Road along the length of the road (up to 0.49m) and extends around 2 km upstream of the roadway along the floodway. This increase is significant and impacts around 2,000 properties, many of which would now be flooded above floor under this scenario.

All culverts are running full and convey a maximum of 140 m³/s, with only 20 m³/s travelling over Wanganui Road. The maximum depth across the road is reduced to around 50 to 60 mm.

This scenario does not meet either Austroads/VicRoads or GBCMA requirements.
Figure 4-5  1% AEP Flood Depth for Developed Scenario 3
Figure 4-6  1% AEP Flood Level Change for Developed Scenario 3
4.4 Developed Scenario 4

The fourth scenario involved raising the roadway to a level of 111.6 m AHD to ensure no water was able to overtop the roadway. Furthermore, the floodway to the south of Wanganui Road was extended around 1,200 metres through private property north of Wanganui Road, to provide a more defined flow path. The floodway was extended to flow into a flood runner located north of a GMW drain. The GMW Drain (Drain No. 3) was removed from the topography to allow for additional conveyance. This would require a syphon under the floodway. The extent of the floodway extension and the modified topography of the floodway which ties into the levels south of Wanganui Road and north of GMW Drain No. 3 is shown in Figure 4-7. The number of culverts was increased to 140 with an extra 8 culverts located at the floodway. This provided a combined waterway area of 95.4 m², an increase in conveyance area of 15% from scenario 3. It is estimated around 60,000 m³ of earth would be excavated for the floodway extension while the increased roadway height would require approximately 35,000 m³ of fill, an increase of 7000 m³ compared to the previous three scenarios.

This shows a significant increase in flood levels immediately upstream of Wanganui Road along the length of the road (up to 0.39 m) but still extends around 2 km upstream of the roadway along the floodway. This increase is significant and impacts around 2,000 properties, many of which would now be flooded above floor under this scenario. The increased culvert capacity and floodway extension improved results compared with scenario 3 between 5-10 cm in most areas.

![Figure 4-7 - Scenario 4 – Modified Topography to include floodway extension](image-url)
Figure 4-8  1% AEP Flood Level Change for Developed Scenario 4
4.5 Developed Scenario 5

Based on the improvements shown in Scenario 4, the floodway was shown to be important in ensuring flows were not held up. An approach was taken to remove around 200 m of the roadway at the floodway to provide a free opening. This was considered to be the best case scenario for a bridge structure, given no piers were modelled. The set of culverts at the floodway were removed along with the most westerly bank of culverts leaving four culvert banks with a total of 80 culverts with a combined waterway area of 52.2 m².

The depth plot is provided in Figure 4-9 and the flood level difference plot is provided in Figure 4-10. The results show an improvement not only compared to the other designs but also show a reduction in the existing condition flood levels. There is a reduction of around 4 cm in the 1% AEP flood level compared to existing conditions through the floodway to the south, with the flood extent slightly reduced upstream. There is a minor increase in flood levels to the north of Wanganui Road at a location of one of the culvert banks. This increase is in the order of 3-8 cm, with one property with several buildings having increased flood levels. It is likely that a realignment of the culvert locations or some changes the culvert capacity and/or the local topography levels north of Wanganui Road would remove the increased flood levels at this property. To the south of Wanganui Road, there is a minor increase in the flood extent into the Shepparton Waste Transfer & Recycling Centre. Similar to the increase north of Wanganui Road, this could be resolved easily with minor earthworks.

East of the southbound on ramp, the roadway remains above the 1% AEP Flood level but would rely upon a bridged section of around 400 to 8000 m to be included west of the southbound on ramp as well as excavation works at the floodway.

The most westerly located culvert set flowed at a maximum of 52% of capacity which would suggest a further reduction in the number of culverts could also be achieved, possibly reduced down to a total of 30 to 50 culverts.

This scenario also shows potential for a further reduction in flood extent to the south through refinement of the floodway including a possible extension of the floodway (similar to developed scenario 4). It is estimated around 5,000 m³ of earth would be excavated for the floodway extension while the increased roadway height would require approximately 20,000 m³ of fill (assuming no earthworks west of the floodway).
Figure 4-9  1% AEP Flood Depth for Developed Scenario 5
4.6 Summary

None of the five scenarios modelled were able to meet both the VicRoads requirements to be flood free with appropriate freeboard above the 1% AEP flood level while also ensuring no increased flood levels as a result of the road design. The total flow conveyed through culverts or over Wanganui Road for the five scenarios assessed are summarised in Table 4-1. Developed Scenario 5 was able to show that the roadway east of the southbound on ramp could be raised above the flood level without having significant increases on flood levels. This appears to be the most promising scenario option to pursue further. All developed scenarios did not include the main bypass or on-off ramp alignments. It is anticipated that these alignments will be designed to have no increase in flood levels and maintain existing conveyance across the floodplain up to a 1% AEP flood event by bridging the floodplain.

A long section shown in Figure 4-11 shows the existing road surface level, the scenario 5 modelled road surface level, and the scenario 5 flood level. A recommended bridge or road deck height is also shown for the floodway area, this has been set at 300 mm above the flood level for scenario 5. Figure 4-11 shows the road levels east of the south bound on ramp that incorporates a 500 mm freeboard above the 1% AEP level. These levels then tie in to the bridge or floodway levels west of the south bound on ramp. It is estimated that this will require an additional 15,000 m$^3$ of fill to raise the roadway to this level of freeboard compared with the scenario 5 fill level. An example of a floodway height is also included in Figure 4-11.

<table>
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<tr>
<th>Scenario</th>
<th>Road Elevation (m AHD)</th>
<th>Number of Culvert Banks</th>
<th>Total Culverts</th>
<th>Total Flow Culverts (m$^3$/s)</th>
<th>Flow Over Wanganui Road (m$^3$/s)</th>
<th>Maximum Depth on Wanganui Road (m)</th>
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<tr>
<td>Existing Conditions</td>
<td>110.2 to 111.5</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>167</td>
<td>0.70</td>
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<td>Scenario 1</td>
<td>111.5</td>
<td>4</td>
<td>51</td>
<td>73</td>
<td>80</td>
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<td>108</td>
<td>60</td>
<td>0.09</td>
</tr>
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<td>Scenario 3</td>
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<td>113</td>
<td>141</td>
<td>31</td>
<td>0.06</td>
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<td>Scenario 4</td>
<td>111.6</td>
<td>6</td>
<td>140</td>
<td>161</td>
<td>1</td>
<td>0.02</td>
</tr>
<tr>
<td>Scenario 5 (East of Sth-Bnd on ramp)</td>
<td>111.6</td>
<td>4</td>
<td>80</td>
<td>33 excluding floodway</td>
<td>135 through floodway</td>
<td>1.40 m through floodway (this section could be bridged)</td>
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</tbody>
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Table 4-1 Summary of Pipe and Overland Flow at Wanganui Road.
Figure 4-11  Wanganui Road Long Section for Developed Scenario 5
5 RECOMMENDATIONS

The project scope was to provide design flood levels, design road level (to cater for a 1% AEP flood event), freeboard design levels, culvert numbers, size and locations.

The road design initially aimed to raise Wanganui Road above the 1% AEP flood level to meet Austroad/VicRoads standards. The modelling found that conveying the extensive floodplain flow rate (approximately 170 m³/s) through banks of culverts is not achievable without significant afflux impacting in excess of 2,000 upstream properties. Raising the road level to a freeboard of 300 mm above the existing 1% AEP flood level as per Austroad/VicRoads standards also does not appear practical or necessary given the surrounding roads (including parts of Numurkah Road) are inundated in a 1% AEP flood level. If designed to this standard, Wanganui Rd would become an island during a 1% AEP flood event.

After discussions with officers from the Greater Shepparton City Council and the Goulburn Broken CMA, Water Technology have developed and tested two alternative recommendations in a bid to proceed with the design of the Wanganui Road upgrade. These recommendations have been developed to balance the initial guidelines set out in the project scope with a feasible engineering outcome, that provides no adverse flood impacts for nearby residents. The recommendations may warrant further investigation or consultation with VicRoads.

The modelling to date has not included the main bypass route which currently travels through significantly flood prone land. The alignment of on and off ramps to the bypass have also not been assessed within this investigation and it is recommended that the full alignment including on and off ramps be incorporated into any future investigation. It is likely that the bypass and the on and off ramps will need to be bridged to result in no adverse impacts on nearby residents.

The two alternative options to maintain flow conveyance across Wanganui Road are discussed in more detail below.
Alternative Option 1

Extend the existing floodway located south of Wanganui Road further north of Wanganui Road. This is similar to Scenario 4 which provided a 150 m wide floodway from Wanganui Road north for 1,200 m to a flood runner located just north of GMW Drain No. 3. It is likely that this floodway would provide a suitable bridge crossing for the main bypass alignment (north of Wanganui Road) and could reduce the flood risk to many areas north and south of Wanganui Road, potentially opening up some land for future development. Modelling of this option with box culverts across the floodway still resulted in significant increases in flood levels upstream of Wanganui Road, however showed some improvement compared to the previous scenarios modelled.

Figure 5-1 Recommendation 1 – Investigate possibility of extending the floodway North of Wanganui Road

Alternative Option 2

Maintaining the existing level of Wanganui Road between the northbound exit-ramp and the south bound on-ramp to provide similar flow conditions for the ‘high flow zone’. This area, shown in green in Figure 5-2, currently conveys around 90% of the flow across Wanganui Road and is fed by two floodways through Shepparton North, adjacent to the Boulevard precinct. This option would rely upon the southbound on-ramp to be bridged using piers rather than an earthen embankment, it is estimated the bridge may be up to 800 m in length. This was tested as developed Scenario 5, and showed the most suitable results of all scenarios tested. An alternative option would allow the major flow path to be formalised into a floodway, with a ford crossing that would be inundated and closed once the Goulburn River has reached the Major Flood Level at Shepparton (11.0 m gauge height).
**Recommendation 2 - Maintain existing flow conditions west of the Southbound on ramp or provide further flow conveyance through lowering Wanganui Road at the floodway**

Despite there still being a need to investigate further options to refine the drainage design, the following recommendations based on flood modelling have been provided.

- Any design must be able to convey around 170\(\text{m}^3/\text{s}\) of flow across the length of Wanganui Road, with the bulk (85-90%) being conveyed in the area designated as the ‘North Shepparton Floodway’.

- The eastern end of Wanganui Road should be raised to a level of at least 111.6 m AHD to provide a freeboard of 200 to 300 mm above the 1% AEP flood level.

- The western end of Wanganui Road appears to have two options to convey the flow without significant increases in flood levels.
  - Construction of a large bridge section (up to 800 metres in length that will sit above the 1% AEP flood level (AustRoads/ VicRoads Design standards require 1 m freeboard above 1% AEP flood level).
  - Construction of a floodway with a low flow culvert and ford crossing as an alternative to a bridged section between Freemans Road and Kittles Road. This will likely be a much cheaper option, however this section of roadway to the west of the southbound on ramp will be closed during a 1% AEP flood event. The floodway is not engaged until the Shepparton streamflow gauge reaches 11.0 m which is considered a Major Flood with an approximate 10% AEP flood event. A low flow culvert beneath the ford would be recommended to convey local runoff flows from the upstream catchment.

- Further modelling should be undertaken to include the impact of the main bypass alignment as well as the on and off ramp alignments which cross significantly flood prone land.
6 SUMMARY

The flood modelling undertaken shows Wanganui Road is likely to be subject to extensive flooding during a 1% AEP flood event at Shepparton under existing conditions. This has implications for the design of the upgraded roadway to meet AustRoads/VicRoads guidelines which require the road to be above the 1% AEP flood level. Given the current flooding conditions in which close to 170 m$^3$/s travel over Wanganui Road, it does not appear practical to convey this flow through culvert banks without significant increases in flood levels upstream of the road.

Three scenarios which aimed to convey the total flow via banks of box culverts did not achieve either the flood free AustRoads/VicRoads guidelines and resulted in significant increases in flood levels across more than 2,000 upstream properties.

An alternative approach was tested and recommended for further investigation (Scenarios 4 & 5). These options which incorporated an extended floodway through Wanganui Road to convey the majority of the flow appear to be suitable for not increasing flood levels upstream of the road. This option allows for the road to the east of the southbound on ramp to be constructed above the 1% AEP flood level. West of the south bound on ramp there are two main options for the road design; either provide access to the western end of Wanganui Road and the north bound off ramp in a 1% AEP flood through the construction of a large bridge (up to 800 m) or the use of a floodway where this section of road would be closed once the Goulburn River exceeds the Major Flood level at Shepparton.

Further work should be undertaken to investigate the extension of the ‘North Shepparton Floodway’ beyond Wanganui Road as an option to allow the upgrade of Wanganui Road. Any further modelling should include the impact of the main bypass alignment including entry and exit ramps to the north and south of Wanganui Road which crosses significantly flood prone land.
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