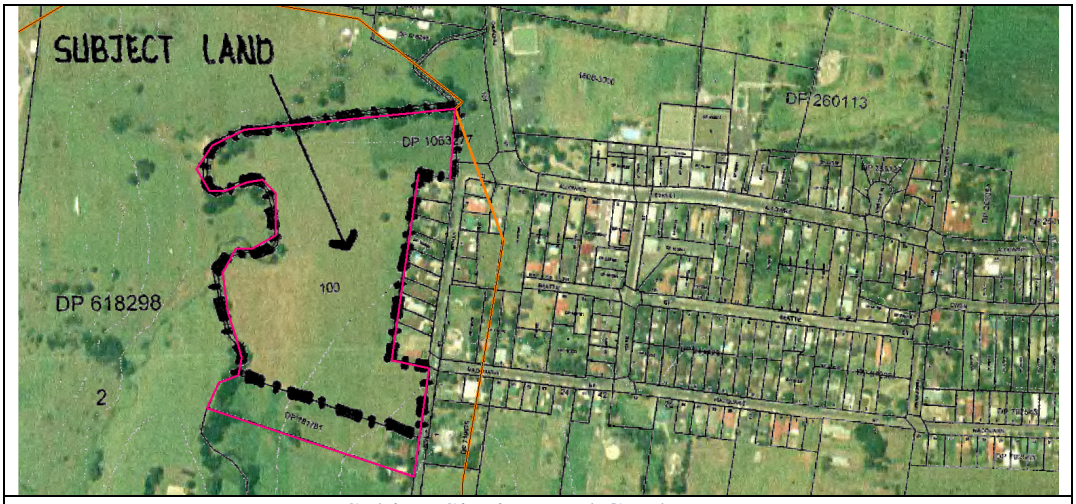
Flood Level Assessment at

Lot 100 DP 1063277 & Lot 1 DP 781781

Whyalla Rd. Jamberoo

For Huntingdale Developments P/L

And Colleen Camarda



Subject Site in Local Catchment

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COMMERCIAL IN CONFIDENCE

CONTENTS:

0.0 EXECUTIVE SUMMARY:

It is understood that this report will accompany a "planning proposal" to Kiama Council regarding a proposed residential and seniors living development on the site.

The site contains a watercourse and as such it is required to identify the flood extent to determine the developable portion of land. This report provides hydrologic analysis of the catchment to determine the flow crossing the site in both a 1:100 year event and a PMF event. This information along with site specific survey (used to create a 3D terrain model of the site) has been used in conjunction with the ANUGA model (a 2D hydrodynamic model).

The results indicate that in a 1:100 year event a portion of the site is currently inundated.

However the balance of the site is free of flooding and therefore suitable for development.

In undertaking the analysis for the site and the watercourse it was found that the impact of blockage of bridge has limited impact due primarily terrain features that impact flow behaviour. This is justified by exhaustive analysis contained within this report and more than 50 figures.

It is recommended that this report be adopted as a description of the flood behaviour at the subject site in its current condition.

Further it is recommended that the impact of any development on this site be assessed with regard to potential to change flood behaviour. Within that review climate change impacts should also be reviewed and considered.

1.0 INTRODUCTION:

It is understood that Huntingdale Developments P/L and Colleen Camarda (clients) requires an assessment of the 1 in 100 year flood level in order to provide information to Kiama Council regarding the rezoning of the site at Whyalla Road Jamberoo for future residential use.

2.0 LOCATION:

The subject site is on Whyalla Rd. Jamberoo approximately 70m west of the Churchill St roundabout. The site is around 450m N-S and 250m E-W.

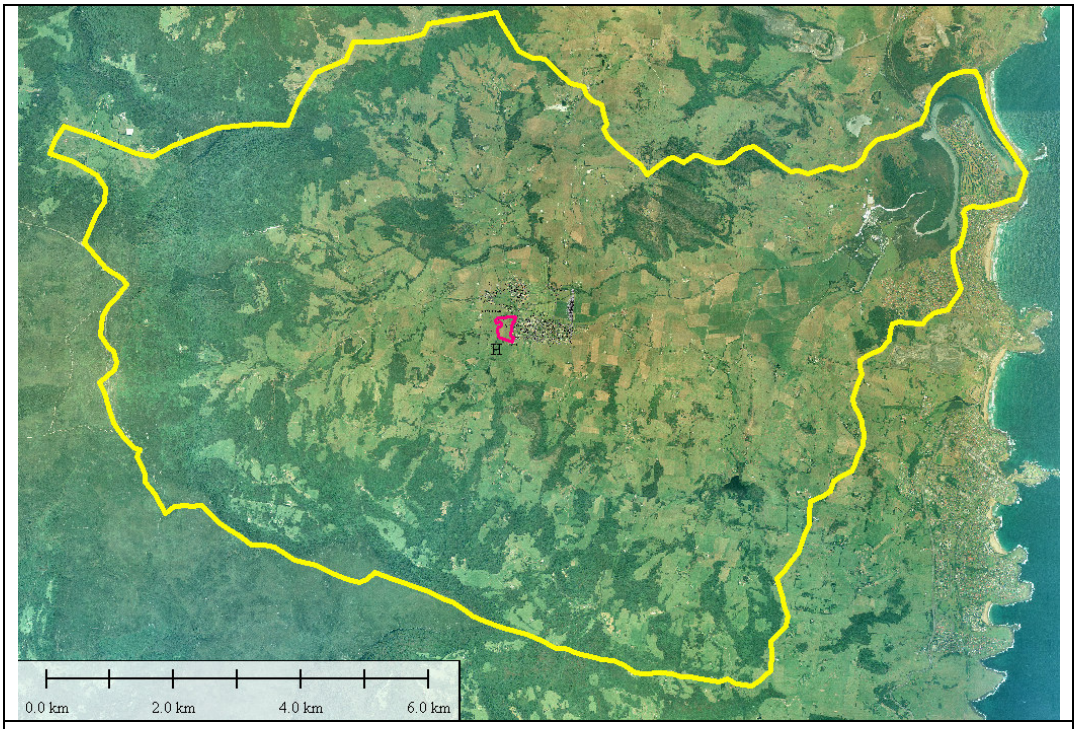
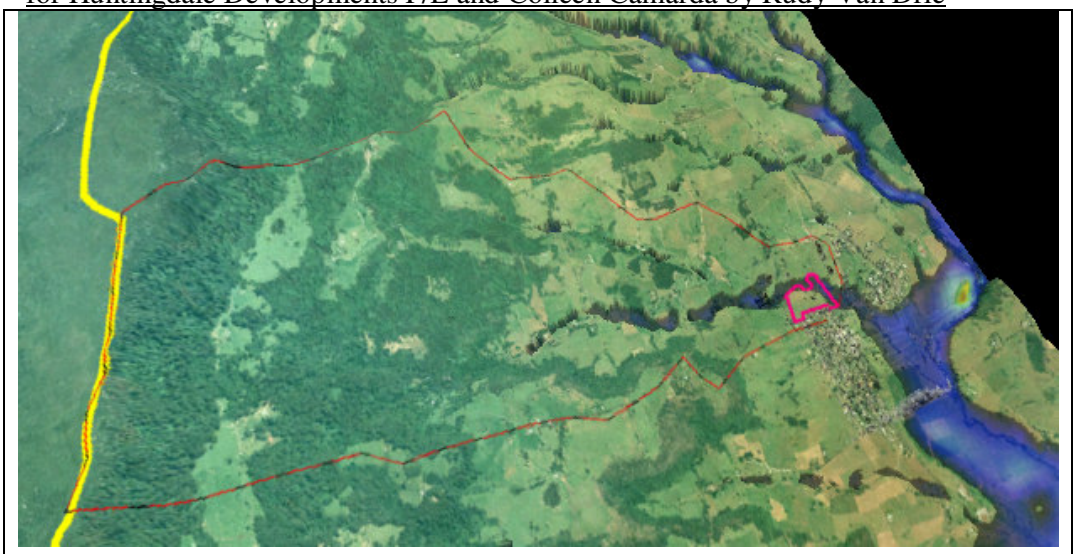


Figure 1. Location of Site Regional Context (Centre of image in Pink)

The site is located with the Hyams Creek catchment (770 hectares), which is a tributary of the Minnamurra River (9600hectares).



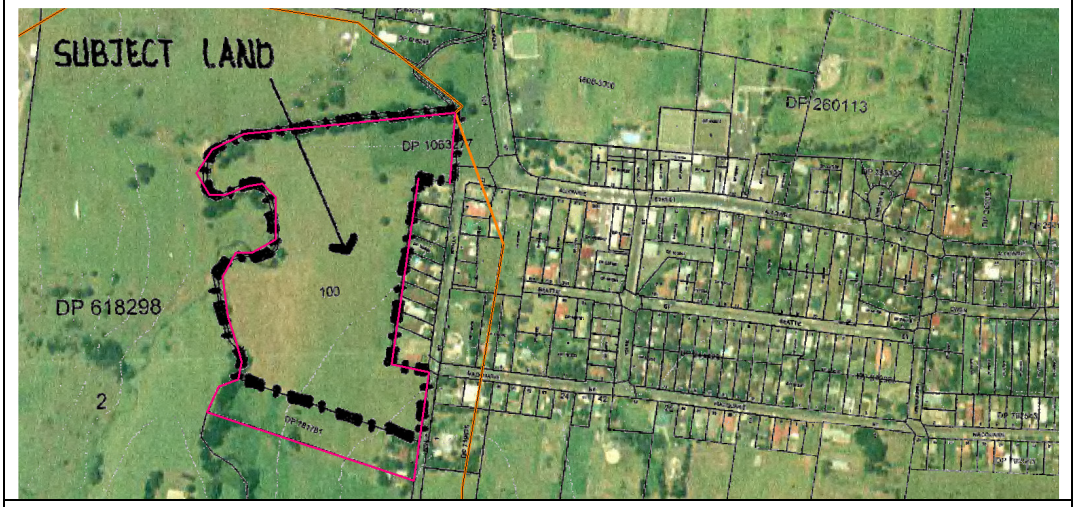


Figure 2. Location of Subject Site (in Pink) Local Context, and the local catchment

3.0 OBJECTIVES:

The objective is to determine the 1:100 year flood level in order to evaluate the constraints to the development potential of the site and further to determine minimal habitable floor levels for any future habitable structures on the site. Further the potential impact to safety as a result of the PMF event will be determined.

4.0 METHODOLOGY:

In undertaking an assessment of the likely 1:100 year flood level at the subject site it is required to establish the quantity of flow first, followed by establishing the water height as a result of that flow. As such a hydrologic analysis will be undertaken of the contributing up stream catchment to determine flow to the site. The site is upstream of potential controls such as the bridge on Churchill St: this also needs to be taken into account.

Therefore Hydrologic Analysis will include the catchment at least to Churchill Street. The local catchment upstream of the site is of the order of 700 hectares.

To determine the flood level detailed topographic data is required of the watercourse and any other significant low point (where the water flows) on the site or adjoining it. Ideally this data should extend up stream and down stream to ensure coverage of the extent of analysis. However considering contour data is available regionally it is likely that this data can be augmented with locally derived site survey data to create a suitable Digital Terrain Model which will be used to set up and run a 2-D Hydrodynamic Model.

The model to be used is the 2D-Finite Volume, unstructured grid shallow water wave equation solver known as ANUGA. This is known to be an extremely robust flexible and accurate 2D flow solver. It operates on a flexible triangular grid which allows refinement of flow details where required.

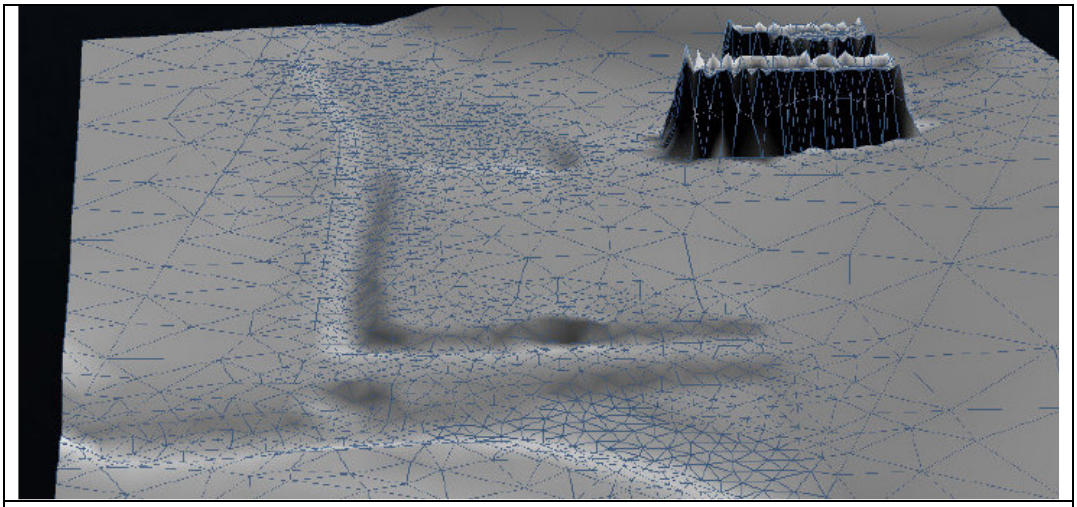


Figure 3. Typical flexible triangular mesh making up a 2D flood model

The flood model is capable of providing flood levels and momentum at all locations where significant flow (greater than say 50mm depth) occurs.

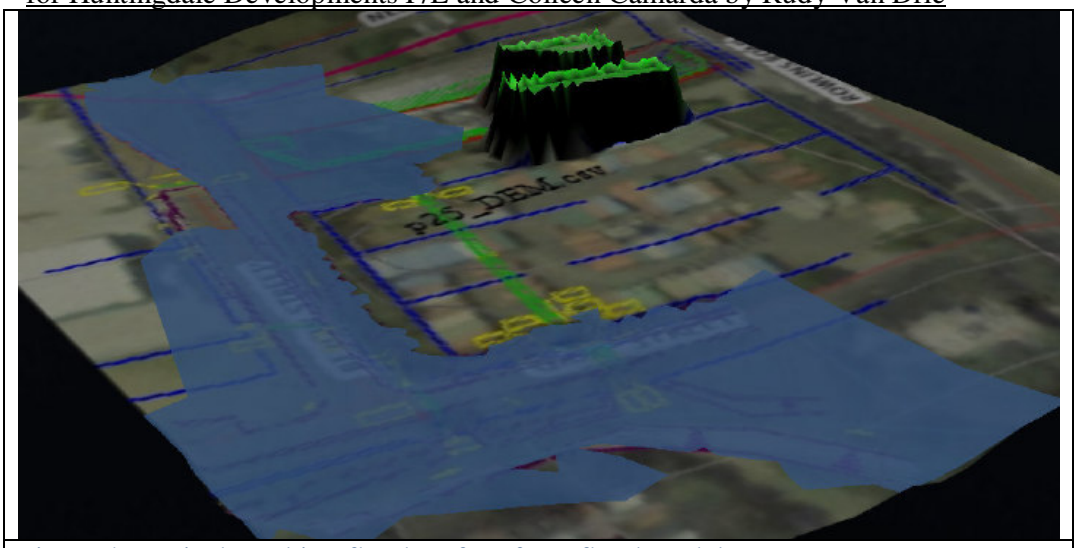


Figure 4. Typical resulting flood surface from flood model

5.0 DATA REQUIREMENTS:

In order to undertake a hydraulic analysis of the watercourse at the site, detailed survey of the watercourse is required.

The extent of survey required should not only include the full extent of the watercourse on the site but also extend up stream and down stream. The extent of survey down stream should include the nearest down stream control, in this case the bridge at Churchill Street (including at least 20m down stream of the bridge).

The extent up stream should ensure capture of the full width as the flood flow enters the site and any significant upstream controls.

The size of all culverts/bridges, including invert levels and effective overtopping levels is required.

In order to determine the catchment hydrology details of the catchment terrain is require. This allows for the determination of the catchment boundary extent and as required delineation of sub catchment. To enable this, a mix of 5m DEM and 25m DEM has been used.

Further details of the bridge over Hyams Creek is required to determine the throttling effect (if any) of the bridge over the creek. These details have been acquired from the regional RTA office.

Finally in order to determine a design flood level, design rainfall is required. This data is derived from Australian Rainfall and Runoff.

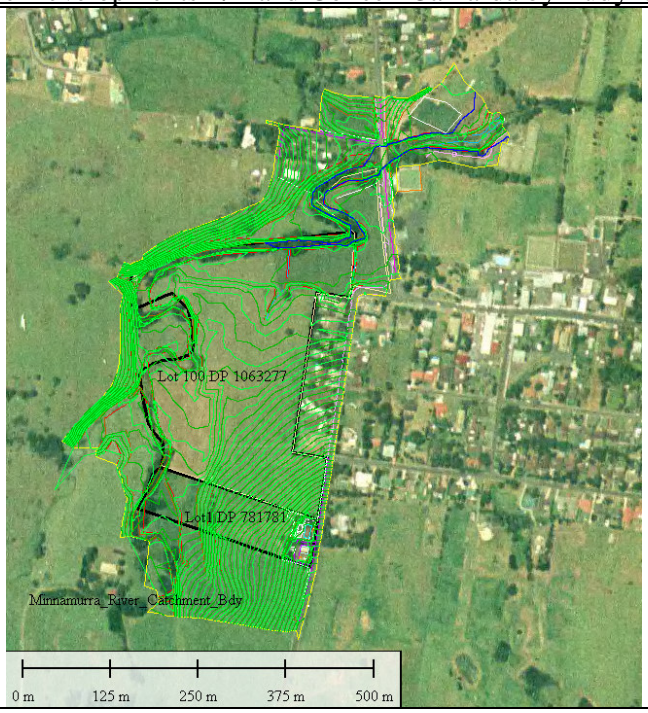


Figure 5. Extent of survey undertaken (Lot extent in Black)

5.1 SUMMARY OF SURVEY:

The final extent of survey is shown below. This survey was used to construct a 3-Dimensional model of the terrain.

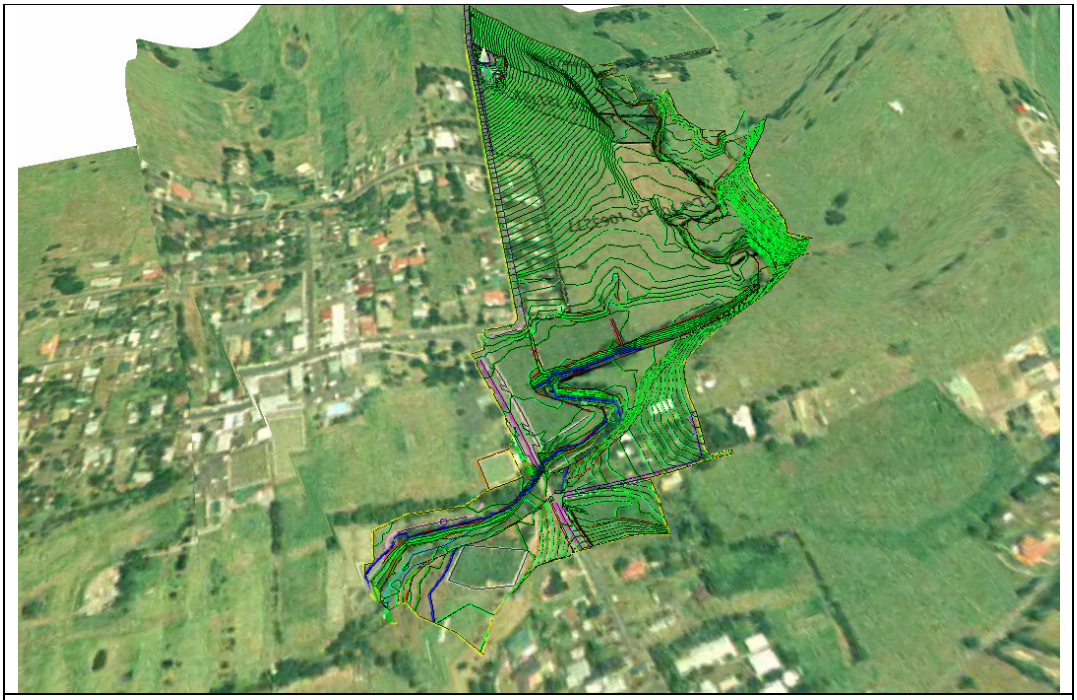


Figure 6. Extent of Survey in the context of the surrounding area (in perspective)

5.2 Catchment DEM:

The extent of catchment contributing to flow at the site has been determined from wider catchment terrain data. The watershed (catchment boundary) is shown below. It is clear that there are two tributaries directing flows to the site.

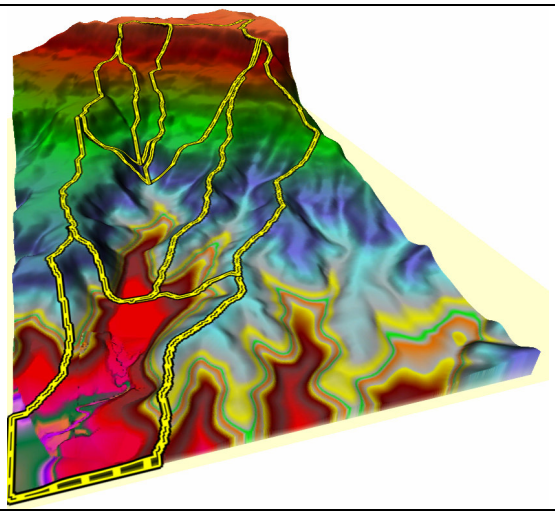


Figure 7. Catchment extent from DEM.

5.3 BRIDGE DATA:

The Hyams Creek bridge at Churchill Street was built in 1938. Details are contained in plans held by the regional RTA office in Wollongong.

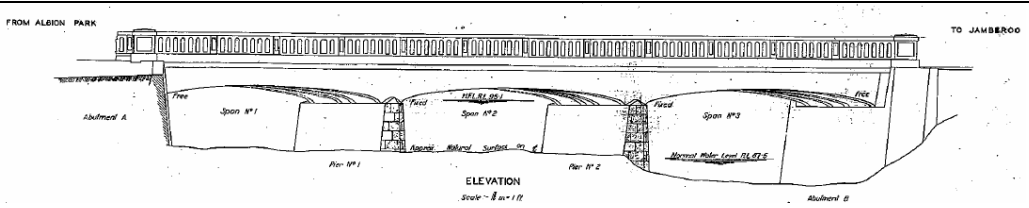


Figure 8. Extract from 1938 DMR Design Plan 3 x 9.8m Spans

Figure 9. Hyams Creek bridge viewed looking toward the north (Albion Park)

Figure 10. Hyams Creek bridge viewed looking toward the south (Jamberoo)

Details of the terrain beneath the bridge have been determined by survey.

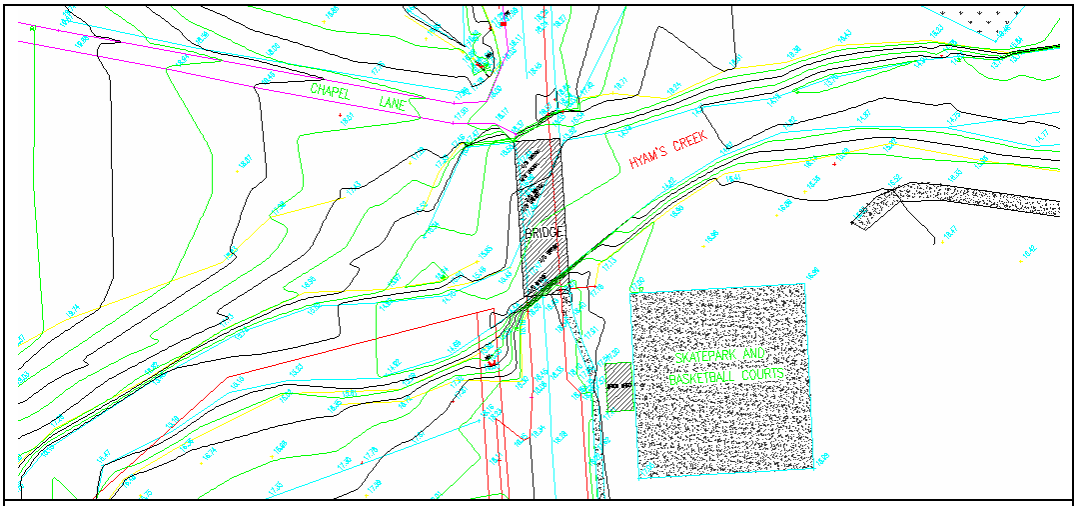


Figure 11. Survey including terrain beneath the Hyams Creek bridge

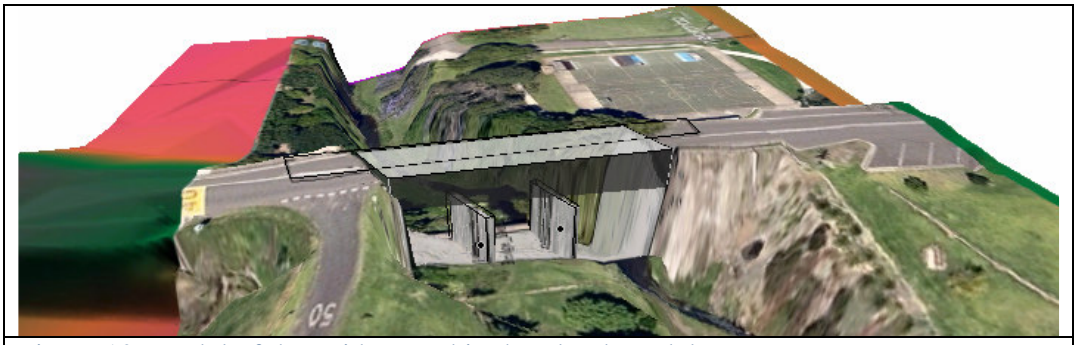


Figure 12. Model of the Bridge used in the Flood Model

Potential for overtopping:

If the bridge opening becomes blocked or if flow exceeds the capacity of the bridge flow will overtop the bridge or roadway. Detail in the survey indicates that overflow would occur initially approximately 70m south of the bridge.

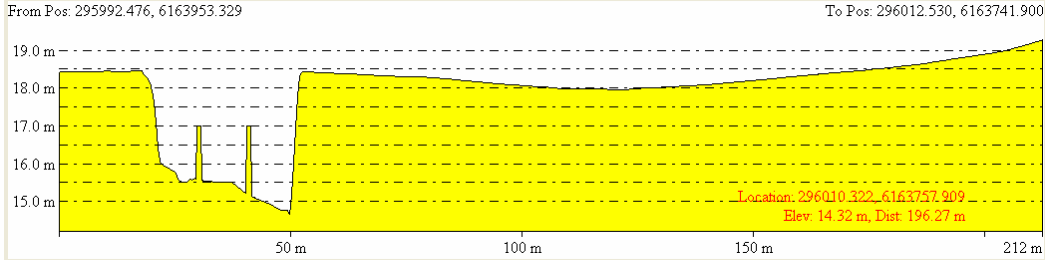


Figure 13. Profile along Churchill road through bridge N - S

5.4 DESIGN RAINFALL DATA:

The rainfall data for DESIGN flood determination is derived from Australian Rainfall and Runoff 1987 (Volume 2.) This source provides the basic data and methods to determine DESIGN rainfall for any duration and frequency. Hence it is known as I-F-D (Intensity-Frequency-Duration) data.

Careful scrutiny of this data reveals that for catchment contributing to flow at this site there is considerable variation in rainfall intensity due mainly to topographic effects. This variation is included in the hydrologic analysis.

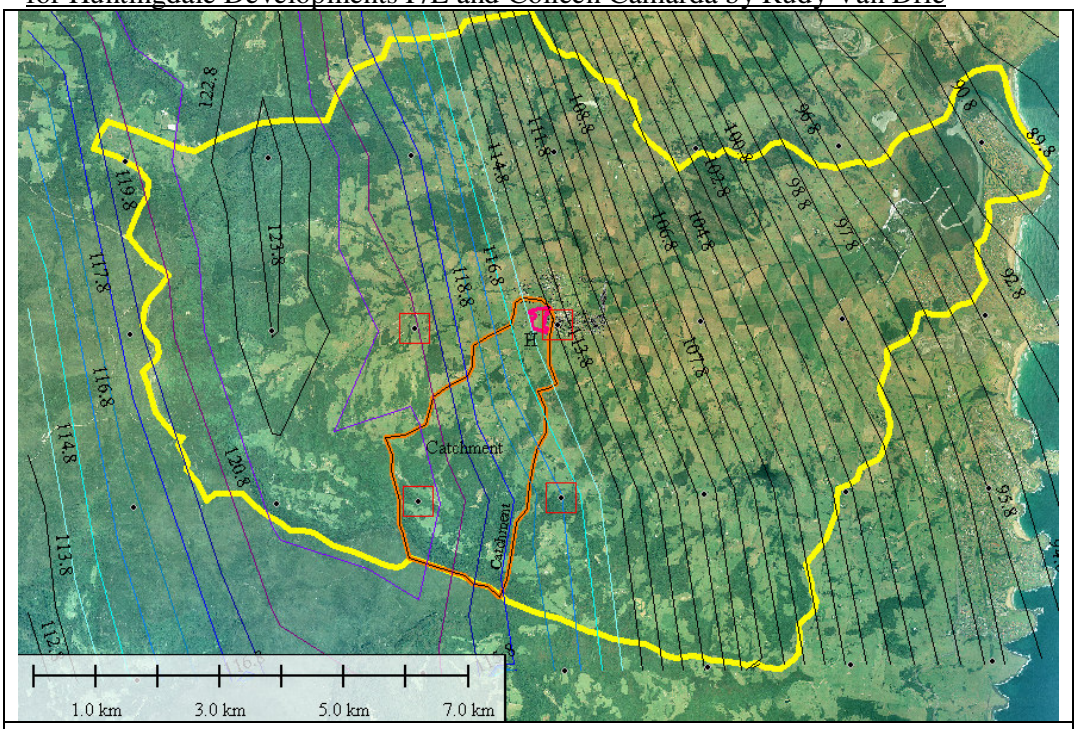


Figure 14. Variation in Design Rainfall intensity (from ARR 1987 Vol 2.)

5.5 PREVIOUS STUDIES:

In 2005 consultants KF Williams prepared a flood study for this site. The hydrologic model used was WBNM. The catchment was determined as 715 hectares with a peak 1:100 year flow of 168m3/s resulting from adopting two design rain gauges.

The hydraulic analysis was based on using HEC-RAS

6.0 TERRAIN MODEL:

The survey data has been merged with regional contour data to construct a full 3D model of the site and catchment. This model will form the basis of the flood analysis model.

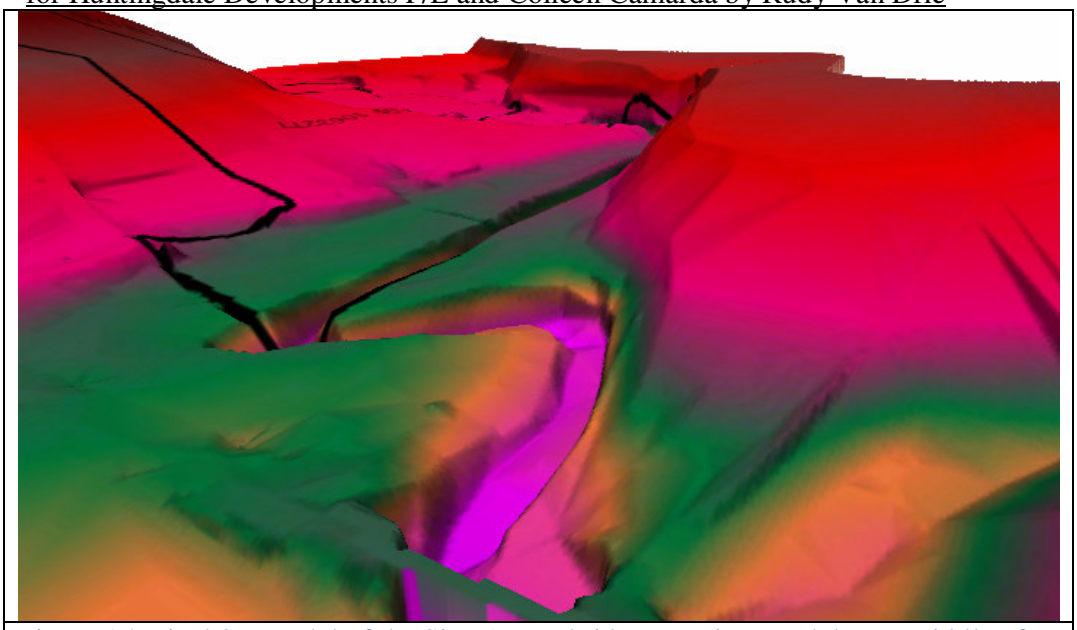


Figure 15. Final 3D model of the Site. (Note bridge crossing creek lower middle of image)

7.0 CATCHMENT HYDROLOGY:

Catchment Hydrology has been developed using WBNM (Boyd etal 1989-2010). This is a well known, accurate and easy to apply hydrologic simulation tool. The model requires sub division of the catchment into sub areas. The catchment has been divided into 6 sub catchments for this analysis. The total catchment area is around 770 hectares.

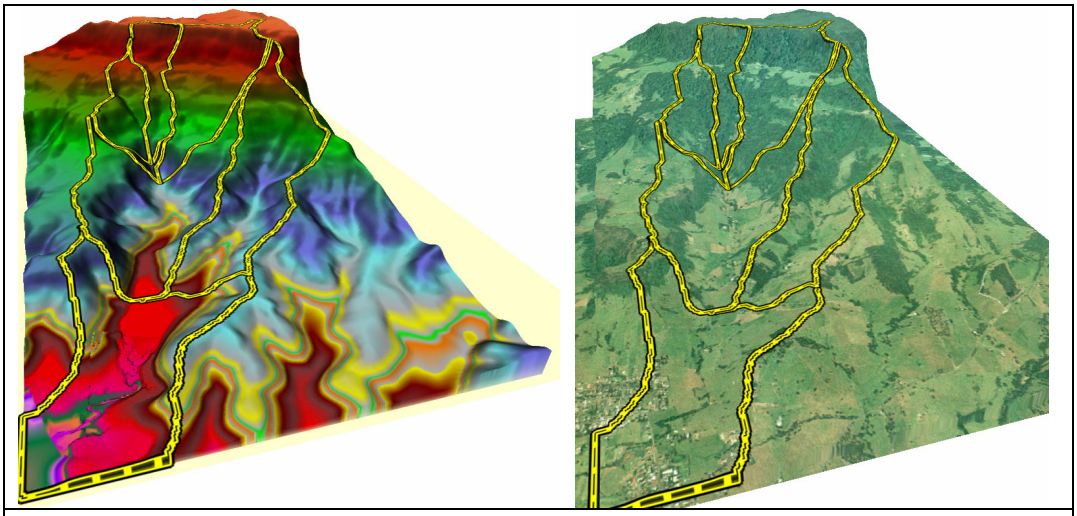


Figure 16. WBNM sub catchment boundaries

There are essentially two points of inflow at the site boundaries:

- Eastern tributary (larger)

- Western tributary (smaller)

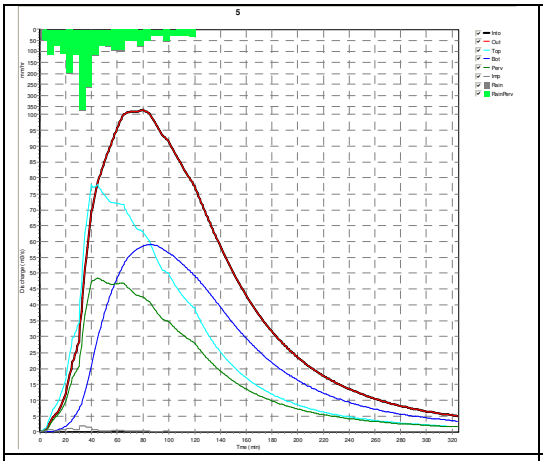


Figure 17. Tributary from the East

101.5m3/s @ 80 min

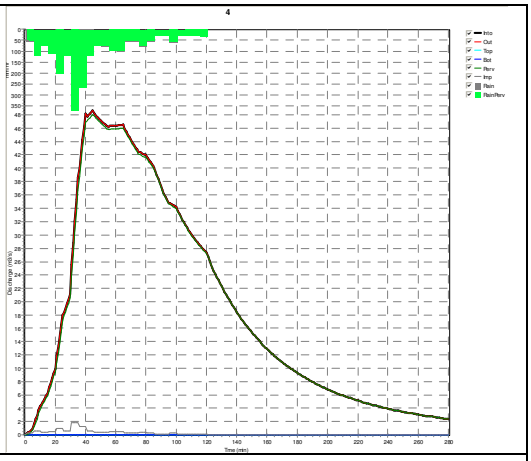


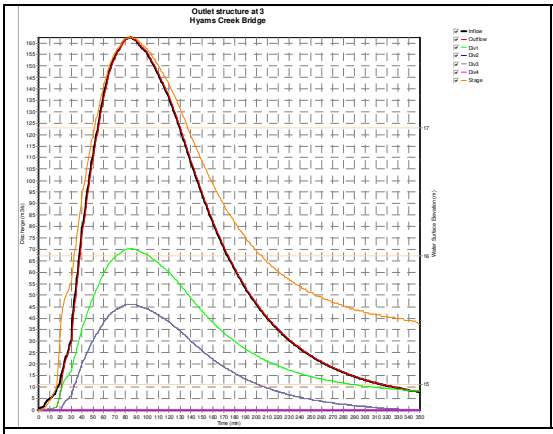
Figure 18. Tributary from the West

48.2m3/s @ 45 min

These flows combine with site derived flow to direct a total of around 162.6m3/s to the bridge at Hyams Creek in a 1:100 year 2 hour design event.

7.1 BRIDGE PERFORMANCE (HYDROLOGY):

As mentioned the primary control downstream is the bridge on Churchill St. The performance of this structure can be estimated by several methods. The initial method is within the hydrologic model. The hydrologic model WBNM can model bridges, however there is accuracy of the downstream backwater impacts are limited.



Bridge:~3x 9.8m x 2.2m

Invert: 14.8m AHD

Total Flow: 162.6m3/s

Bridge Flow: 162.6m3/s

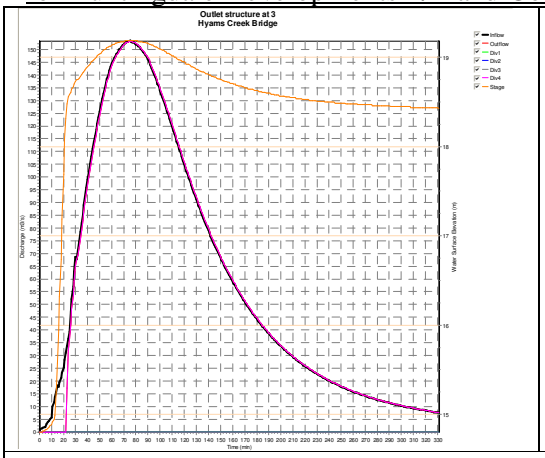
Overtopping Flow: 0.0m3/s

Peak Flood Level: 17.71m AHD

Figure 19. 100 year 2 Hour Design Event, Churchill St Bridge

The WBNM model estimates that the bridge is capable of passing the 1:100 year design flood event without overtopping.

IMPACT OF BLOCKAGE:



Bridge:~3x 9.8m x 2.2m

Invert: 14.8m AHD

Total Flow: 162.6m3/s

Bridge Flow: 0.0m3/s

Overtopping Flow: 162.6m3/s

Peak Flood Level: 19.19m AHD

Figure 20. Bridge Fully Blocked from Hydrologic Model

The usual problem with a hydrologic model assessment of bridge hydraulics is that the user is required to make assumptions and estimates regarding the available overflow weir width.

7.2 SUMMARY OF HYDROLOGY:

The hydrologic model has been run for a range of storm event durations for the 1:100 year and PMF simulations. The peak for the 1:100 year event results from the 2 hour event whilst for the PMF the 2 hour (120min) event also produces the peak at the site.

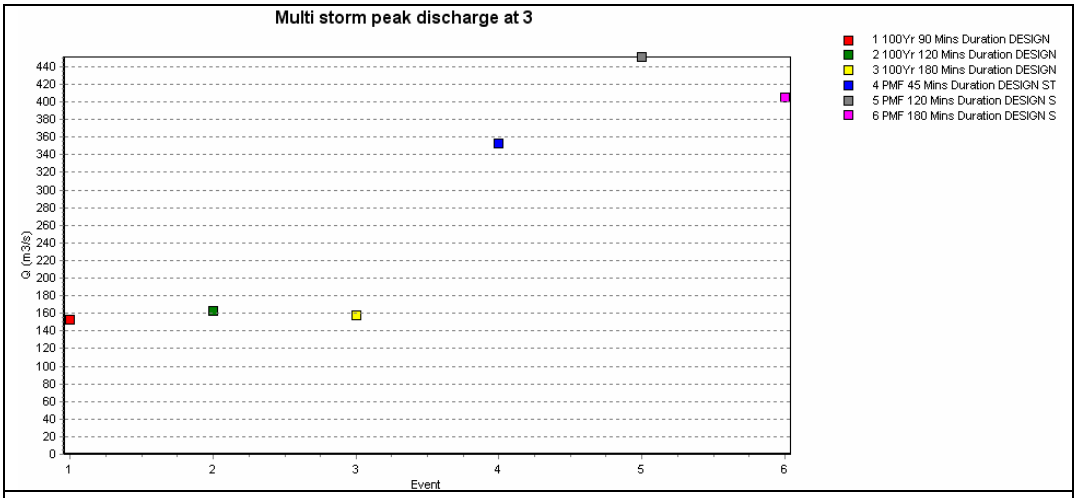


Figure 21. Summary of hydrologic model results

8.0 SITE HYDRAULIC ANALYSIS:

Kiama Council (KC) require that the site inundation be determined in order to evaluate the site constraints on development potential.

The determination of the 1:100 year flood levels on the subject site requires as input a detailed topographic model (as described above) and the inflow hydrographs from the hydrologic analysis.

These are used in a 2D hydrodynamic model to determine the flow behaviour on the site terrain.

The model of choice is the relatively new but extremely robust and accurate ANUGA model developed by the Australian Government. Refer to Geoscience Australia for details of the model and ongoing development.

8.1 1:100 year Flow ANALYSIS (Existing Site):

Application of hydrographs from the two tributaries in addition to local site runoff results in well defined flow path. However it is noted that the 1:100 year design flood overtops Churchill St. This may in part be due to the very distinct meander immediately up stream. This is clearly visible in the plot of momentum.

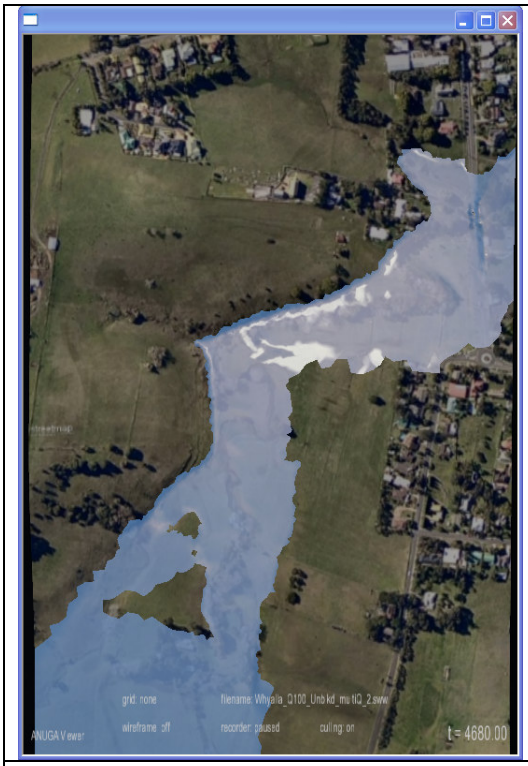


Figure 22. Q100 Flood Extent

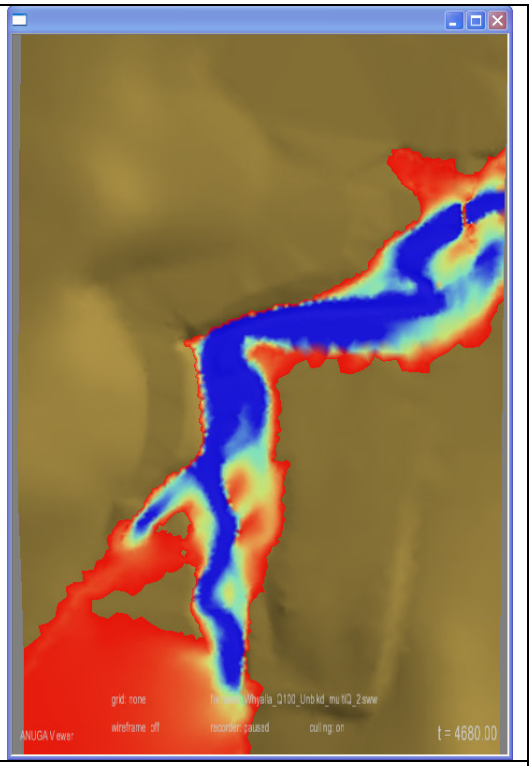


Figure 23. Q100 Momentum plume

The ANUGA model shows the momentum plume (VxD) of the deepest fastest flowing water. The momentum plume leaving the bridge is also clearly visible.

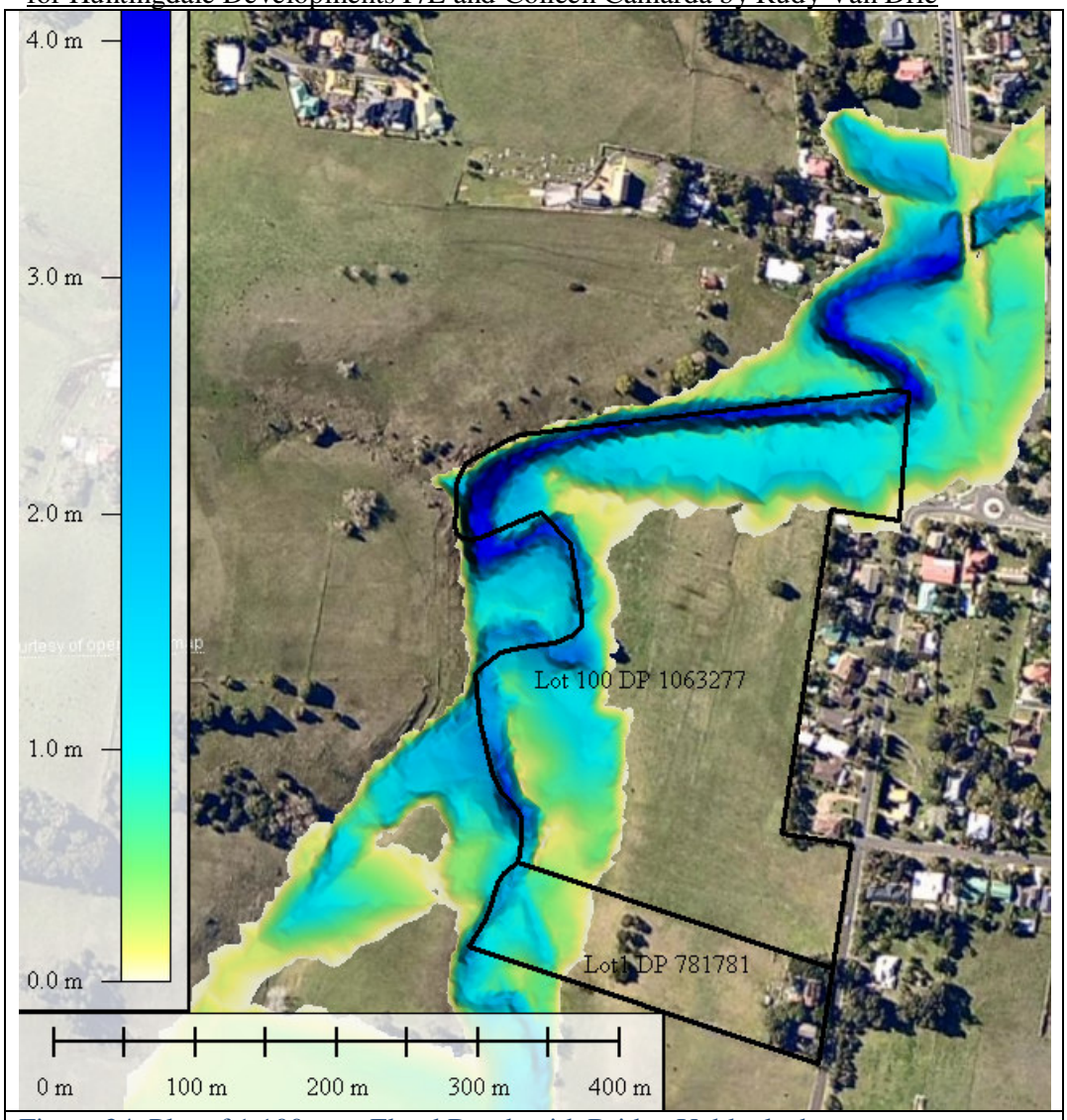


Figure 24. Plot of 1:100 year Flood Depth with Bridge Unblocked

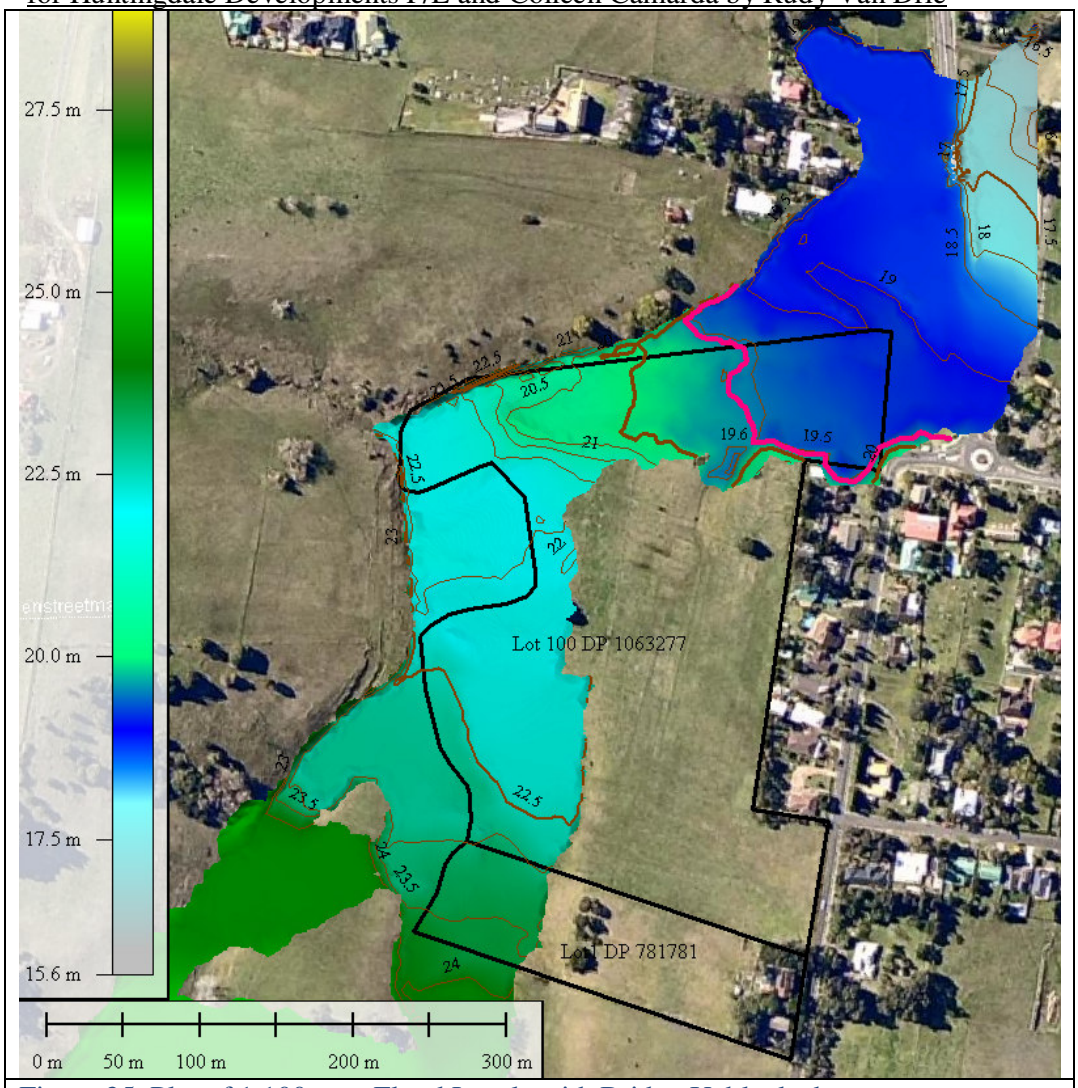


Figure 25. Plot of 1:100 year Flood Levels with Bridge Unblocked

In order to determine the plausible maximal flood extent a second analysis has been carried out this time assuming the bridge is 100% blocked with debris.

8.2 Blocked Bridge 1:100 year Flow ANALYSIS (Existing Site):

In order to model the bridge fully blocked the bridge opening has been replaced by a solid embankment. The resulting analysis shows a stronger momentum plume crossing to the south of the bridge over the low point in Churchill Street. The flood level has risen around 300mm.

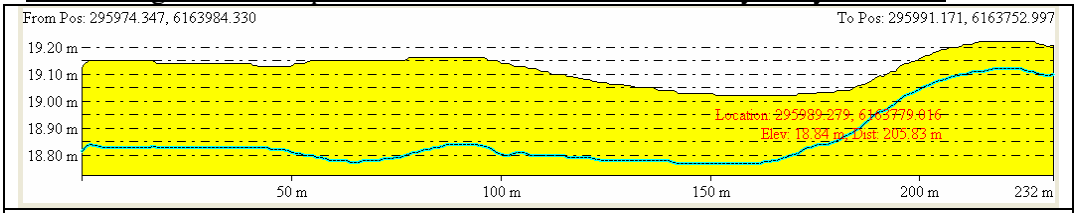


Figure 26. Comparison of Unblocked (Green) and Blocked (Yellow) Flood Levels just upstream of the bridge

Once again a plot of flood extent and momentum provides details of flood behaviour. As expected the momentum plume through the bridge is weaker and crossing Churchill Street stronger.

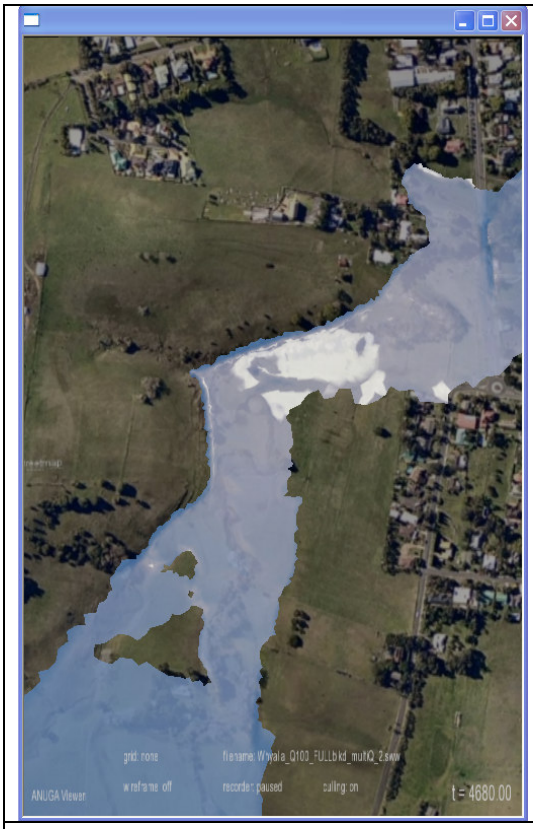


Figure 27. Q100 Flood Extent (Bridge Blocked)

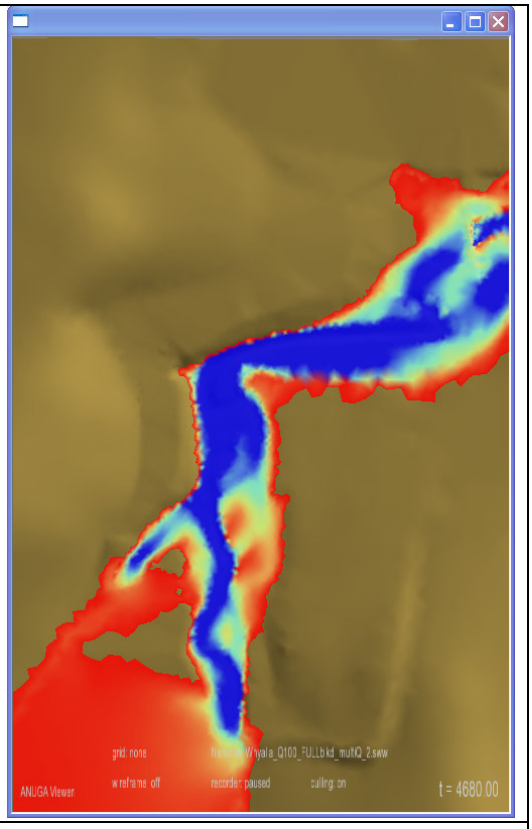


Figure 28. Q100 Momentum plume Blocked

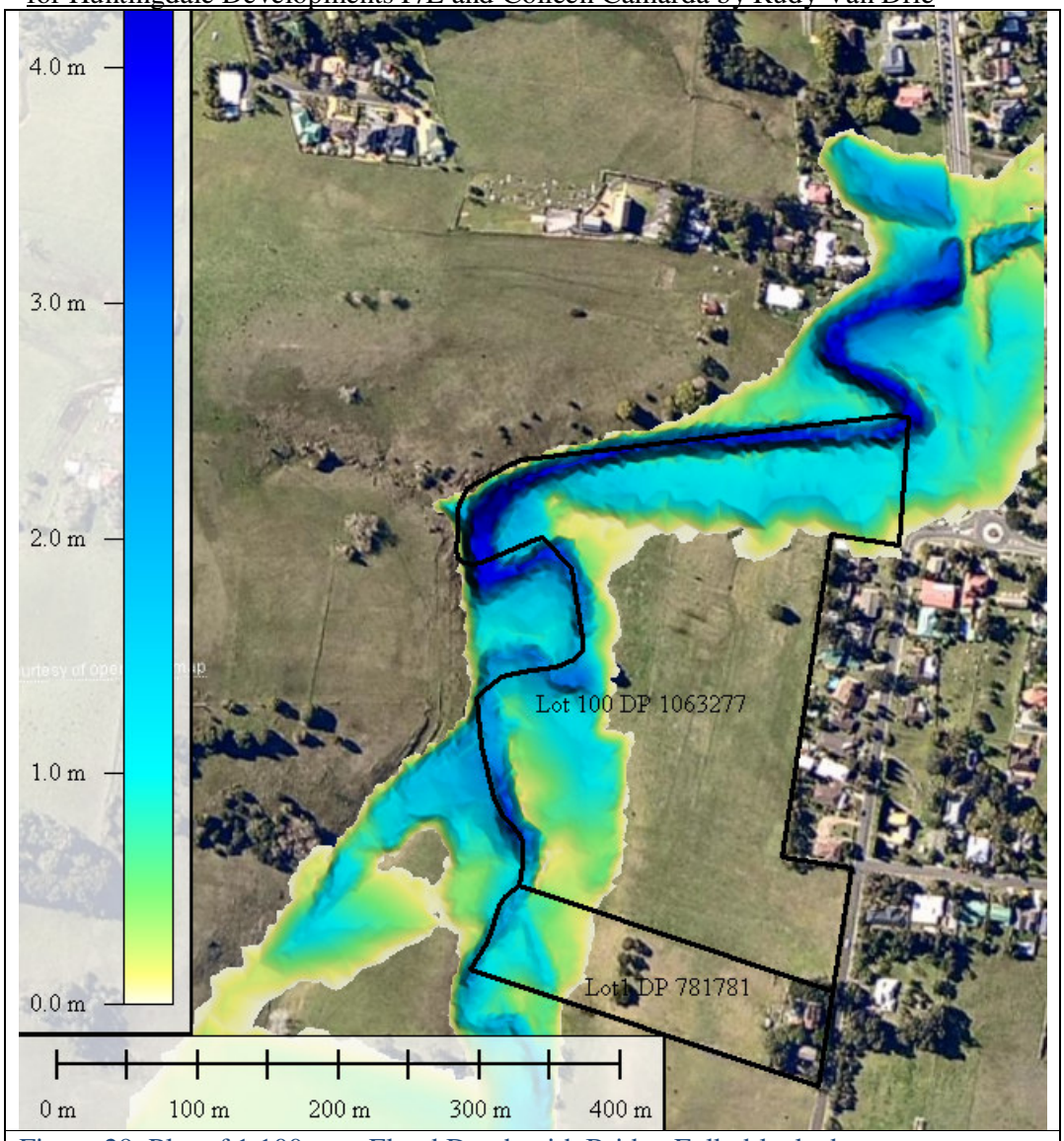


Figure 29. Plot of 1:100 year Flood Depth with Bridge Fully blocked

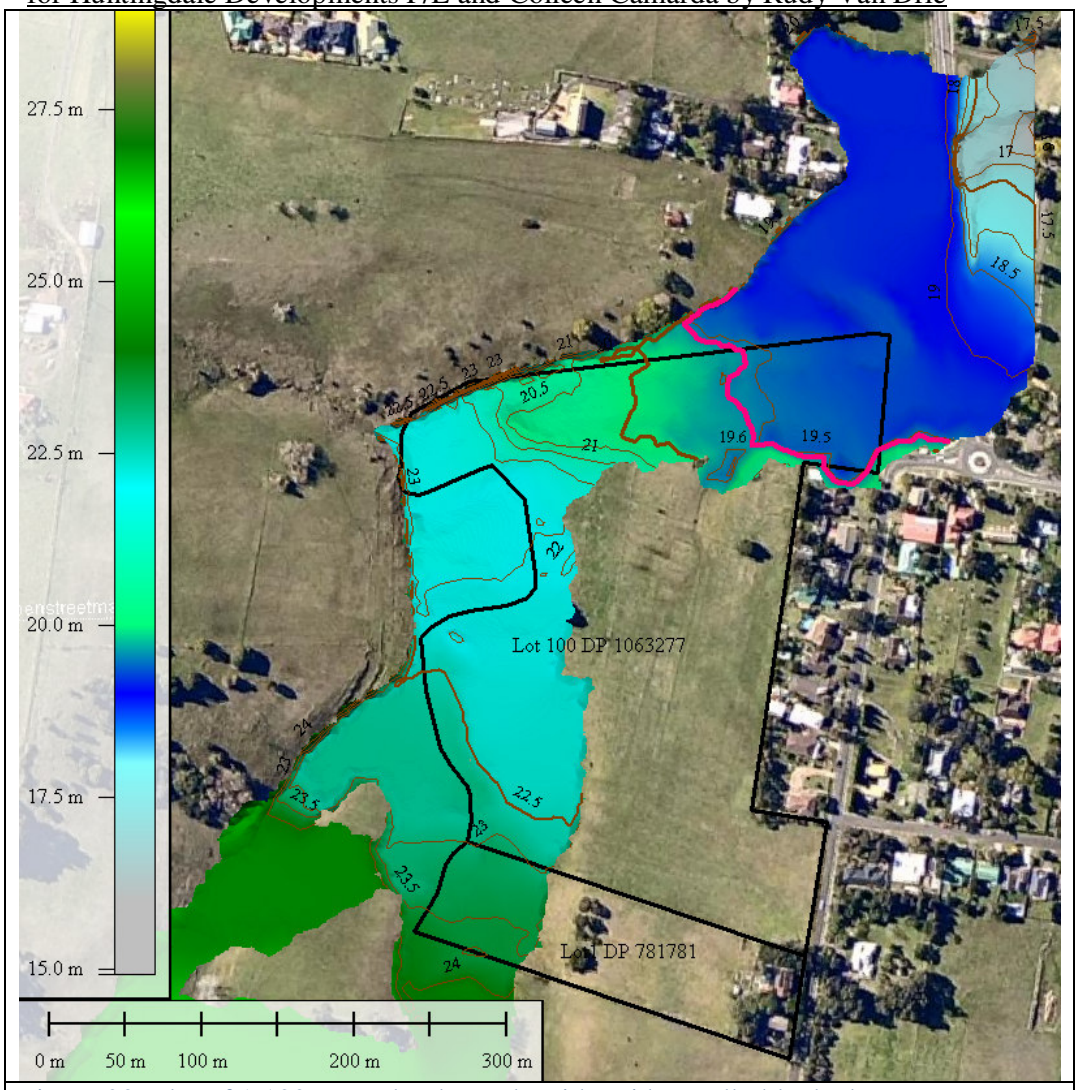


Figure 30. Plot of 1:100 year Flood Levels with Bridge Fully blocked

A comparison profile plot of the Unblocked Bridge case and Fully Blocked Bridge case indicates that the back water influence of the fully blocked bridge only impacts upstream for around 250m. Where the flood level has reached 19.6m AHD both profiles are the same.

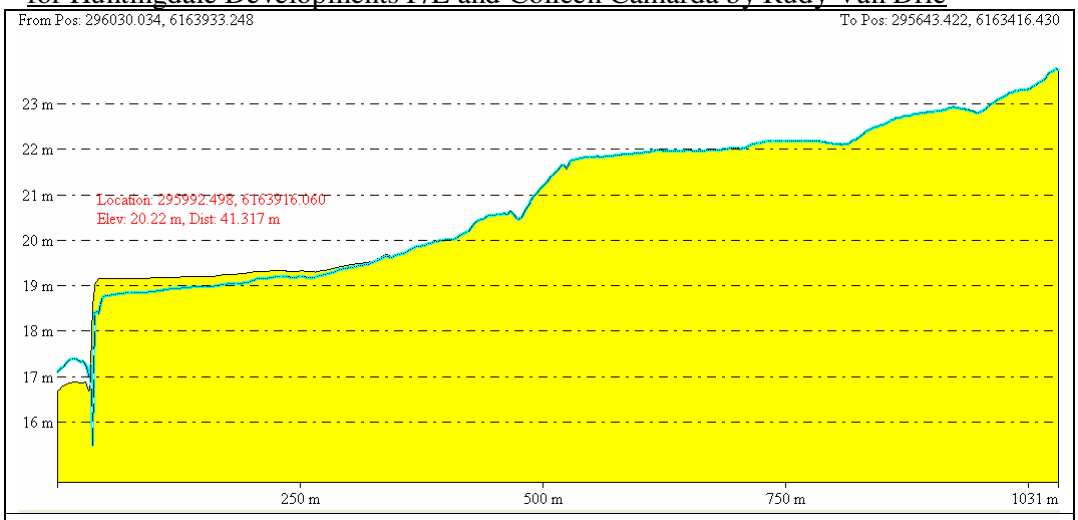


Figure 31. Comparison of Q100 Flood Profiles (Bridge Unblocked {green) and Blocked {yellow})

The 19.6m flood surface contour is shown in the figures below.

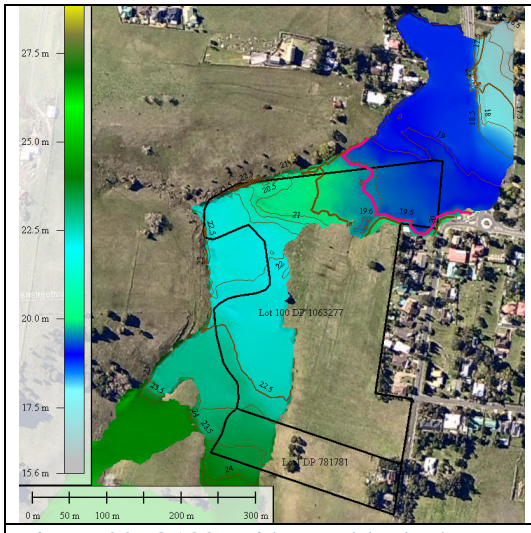


Figure 32. Q100 Bridge Unblocked

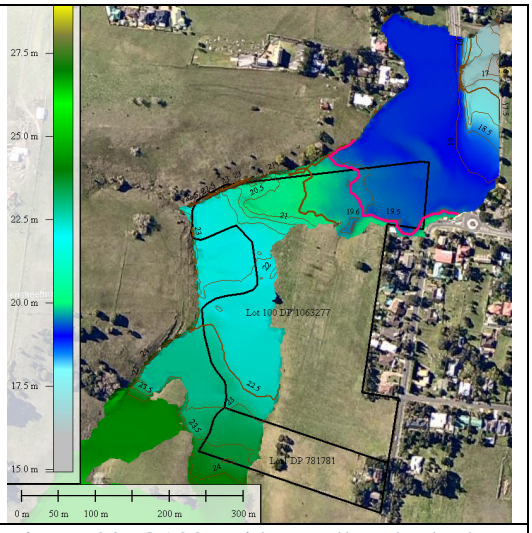


Figure 33. Q100 Bridge Fully Blocked

8.3 DETAILED REVIEW OF BRIDGE PERFORMANCE:

What appears to be the relatively minimal impact of the complete blockage of the bridge, at first glance may be questioned. As such it may be prudent to review the bridge performance to ensure it has been correctly identified. This may identify other control mechanisms acting at this location.

The method of analysis for this approach is to create a highly detailed model of the bridge crossing including the bridge piers. The impact of the bridge deck can be evaluated by removing the deck, and assessing the impact of the piers only.
This is in effect a channel with obstacles (piers).

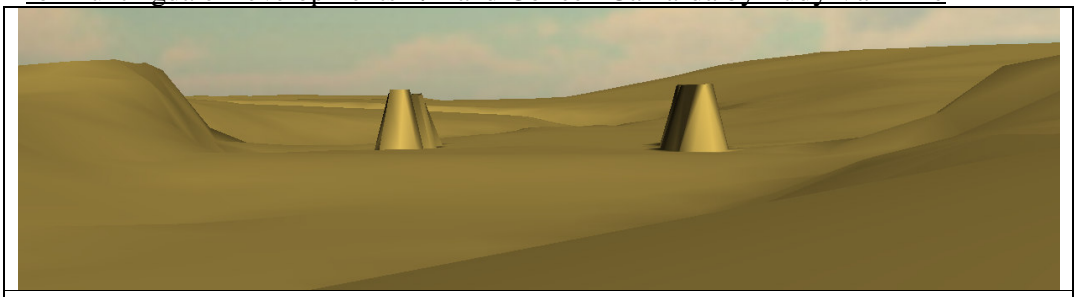


Figure 34. Bridge Piers in the 2D flow model

In the following figure there is a profile plot that lies over a plan view of the flood extent, the bridge is located approximately at 20-30m along the dotted line from Right to Left. The analysis found that the flow profile through the bridge is as one would expect:

- there is a relatively flat profile (18m AHD) upstream of the bridge (40-70m) [Velocity ~ 2m/s]
- there is a distinct draw down into the throat of the bridge as the flow accelerates and contracts (30-40m) to around 17.8m AHD [Velocity ~ 4m/s]
- Flow through the bridge (20-30m) is relatively smooth
- The exit jet or plume results in a drop to around 17.1m AHD with considerable flow expansion [Velocity ~ 3m/s]

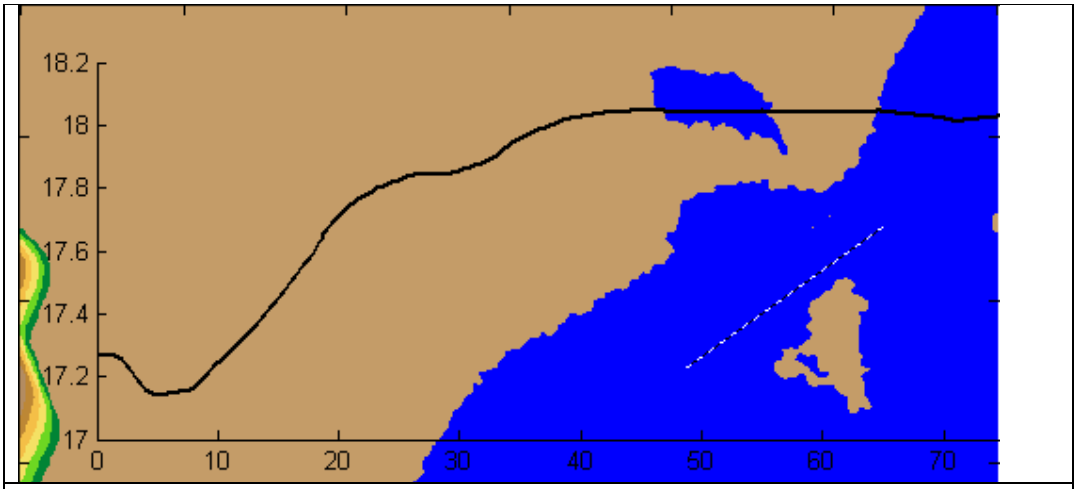


Figure 35. Detail profile through the Bridge (with Deck removed)

The flow width and flood extent for this analysis is not considerably different to the two previous analyses (Bridge with Deck, Bridge Fully Blocked). The reason for this is that the flooding is strongly influenced by the upstream terrain and the very strong meander directly upstream of the bridge. This can best be visualised by plotting momentum. The very distinct 'S' shape in blue below shows the strong influence of momentum.

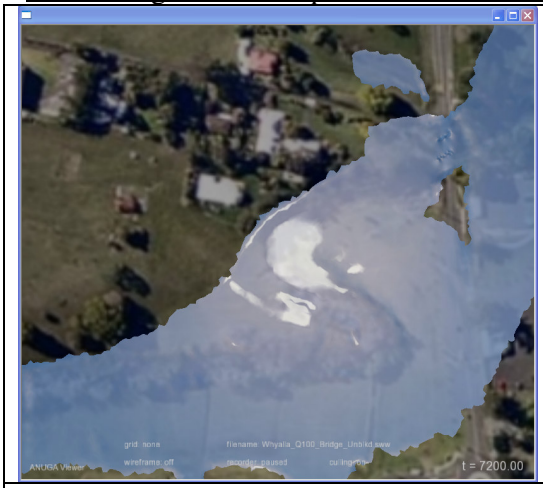


Figure 36. Flood Extent using detailed bridge analysis

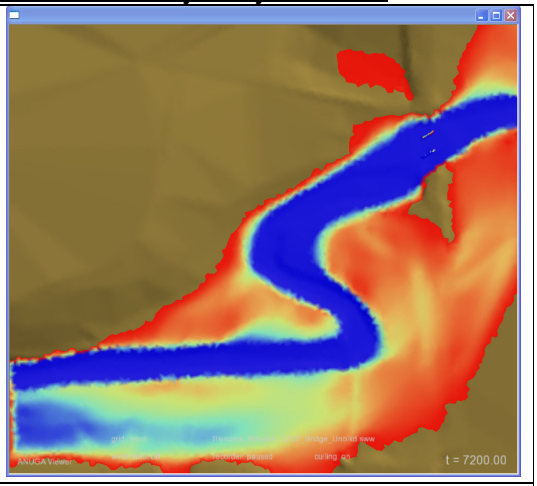


Figure 37. Momentum plume of detailed bridge analysis

Also note that Churchill Street would still overtop if the bridge deck were to be removed. The primary mechanism for this is the restrictive nature of the momentum plume across the main floodplain flow direction. This results in considerably higher water levels at the southern end of Churchill Street. This can be seen in the following plots of Depth and flood level along Churchill Street.

The flood level at the bridge is around 17.6m whilst further south on Churchill St. the flood level climbs from around 18.0 to 18.5m AHD.

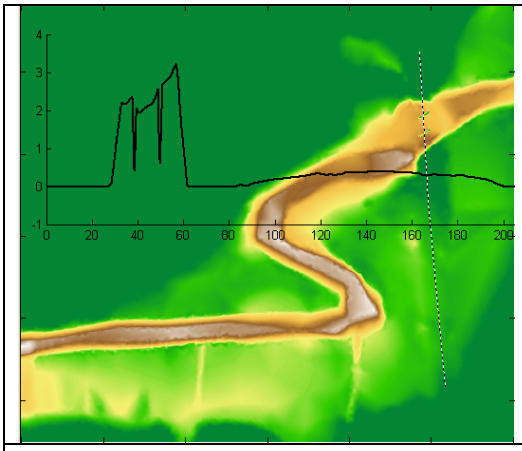


Figure 38. Depth Plot along dotted line (Churchill St.)

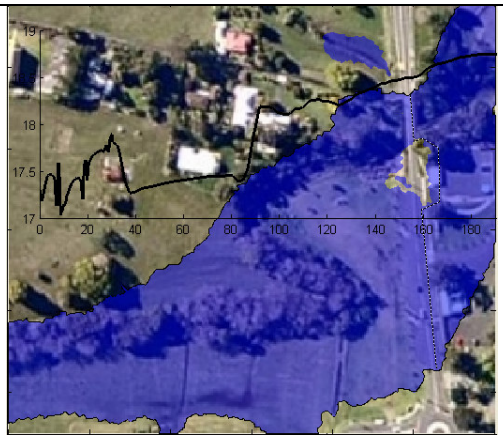


Figure 39. Flood Level Plot along Dotted Line (Churchill St.)

With the bridge deck in place there is a further constriction due to both the loss of waterway area from the portion of bridge below the flood level and the additional friction due to the underside of the bridge being in contact with the flowing water.

When compared to the peak flood level with NO-DECK, the figure below shows that the area in Red is immersed and thus displaced water. However as a result accounting for this the flood level raises hence the influence is heightened as the area in green is immersed and portions of the area in blue.

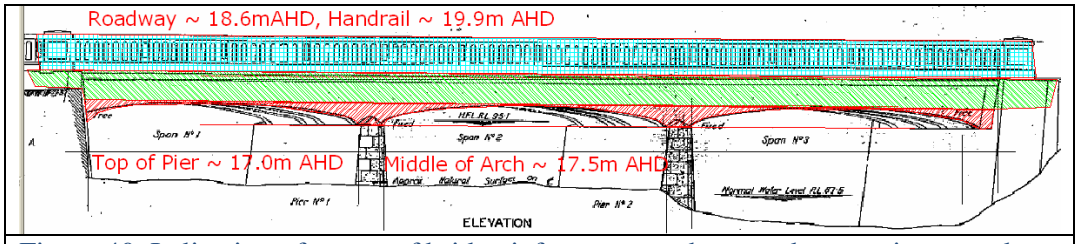


Figure 40. Indication of extent of bridge infrastructure that may become immersed due to flooding

The resulting flood level just up stream of the bridge location shows that with the bridge deck removed the flood level would be around 900mm lower in the channel immediately in front of the bridge but only 200mm lower on the flood plain along the same cross section line. In the following figure chainage 0m is the edge of Chapel Lane increasing heading south.

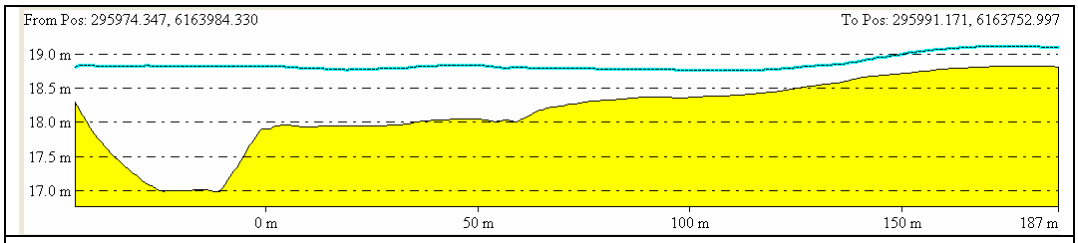


Figure 41. Comparison of No Bridge Deck and Unblocked Bridge Flood Level at section in front of the bridge

Recall that the impact of fully blocking the bridge is to raise the flood level over this section from between 350mm in the channel to 250mm and 100mm on the flood plain heading south (refer Figure 26).

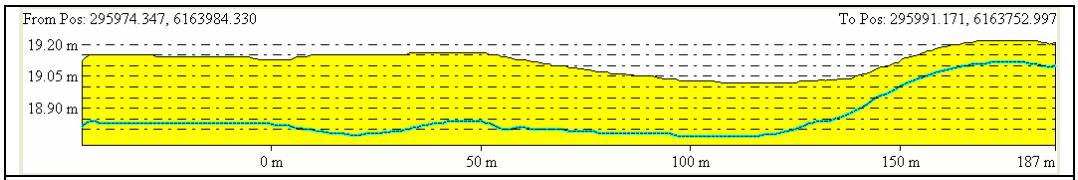


Figure 42. Comparison of Unblocked (Green) and Blocked (Yellow) Flood Levels just upstream of the bridge

8.4 PMF Flow ANALYSIS (Existing Site):

The PMF flood directs around 450m3/s through the site. This is around 2.8 times the 1:100 year flow. Considering the negligible effect of the bridge blockage in establishing the flood levels at the site, only the fully blocked condition is presented, as this is the generally more conservative, but in effect has little adverse impact a short distance upstream of Churchill RD.

The PMF hydrographs have been applied to the same topographic model to simulate the impact of a PMF event at the site. Once again reviewing the flood extent and momentum for the PMF event reveals both the extent and hazard (VxD) plume on the site.

Figure 43. PMF Flood Extent

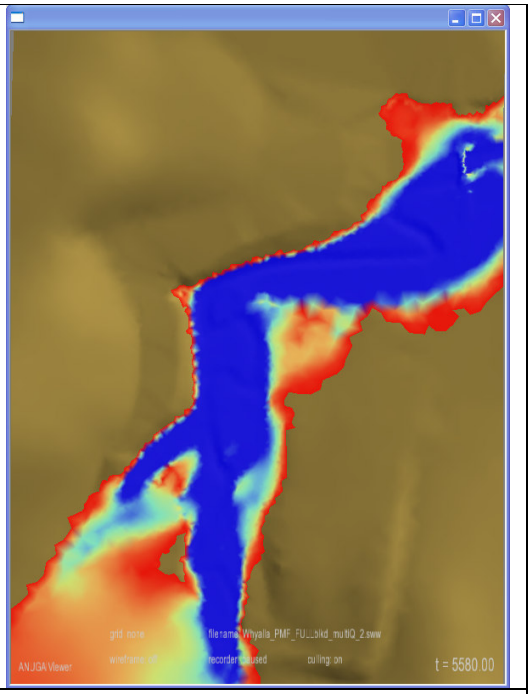


Figure 44. PMF Momentum plume

A comparison of the flood levels for the Q100 event and the PMF event reveals that the PMF is between 400 and 800mm (near the bridge) higher than the Q100 event (refer Figure 45).

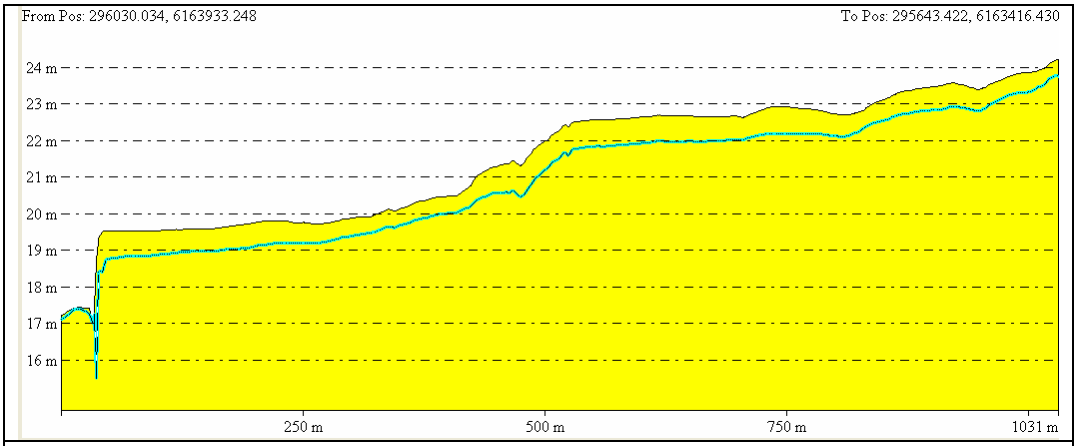


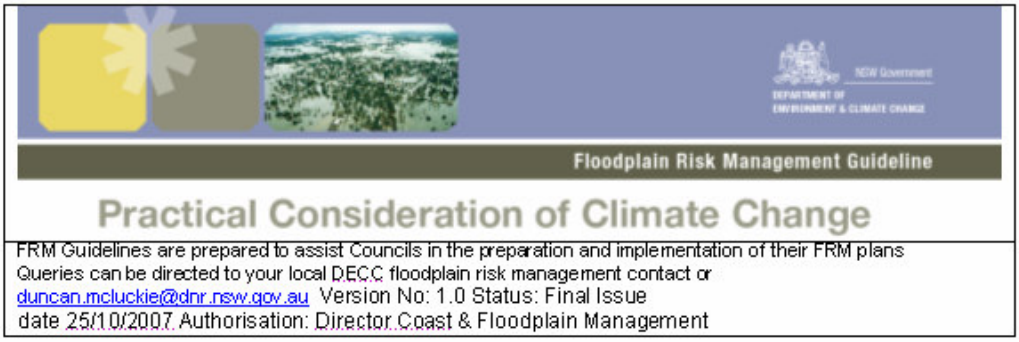
Figure 45. Comparison of the Q100 (green) and PMF (yellow) flood level profiles along the Hyams Creek

9.0 DEVELOPMENT PROPOSED ON SITE:

It is understood that the client has at this stage not finalised the development proposal for this site. A flood impact assessment will be required once the development layout is finalised to ensure no adverse impacts result.

10.0 ASSESSMENT OF CLIMATE CHANGE IMPACTS:

The assessment of potential Climate Change Impacts is reliant on guidance provided by the NSW government in the following document.



Floodplain Risk Management Guideline

Practical Consideration of Climate Change

FRM Guidelines are prepared to assist Councils in the preparation and implementation of their FRM plans
Queries can be directed to your local DECC floodplain risk management contact or
duncan.mcluckie@dnr.nsw.gov.au Version No: 1.0 Status: Final Issue
date 25/10/2007 Authorisation: Director Coast & Floodplain Management

In summary this is what is required:

SEA LEVEL RISE	RAINFALL INCREASES
The following sensitivity analyses are recommended: ▪ for sea level where relevant to the study area: – 0.18m (Low Level Ocean Impacts – 0.55m (Mid Range Ocean Impacts – 0.91m (High Level Ocean Impacts	In addition until more work is completed in relation to the climate change impacts on rainfall intensities the following sensitivity analyses are recommended: ▪ Rainfall Intensities. Increases of: – 10% in peak rainfall and storm volume – 20% in peak rainfall and storm volume – 30% in peak rainfall and storm volume

Figure 46. Summary of Climate Change Assessment requirements

Since the site is removed from Ocean influences only rainfall increases will need to be assessed. Further considering that the hazardous flow during a PMF is almost aligned with the Q100 flood extent (refer below). It is considered of more efficient to report on climate change impacts with the assessment of development impacts.

11.0 CONCLUSIONS:

It is concluded that currently the site is flood affected in a 1:100 year event, and even more so in a PMF event.

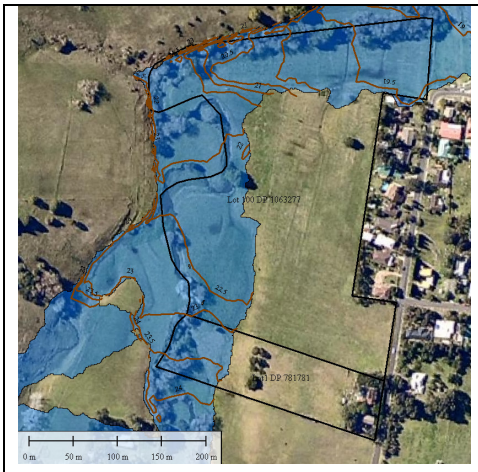


Figure 47. Q100 Flood Levels and Extent

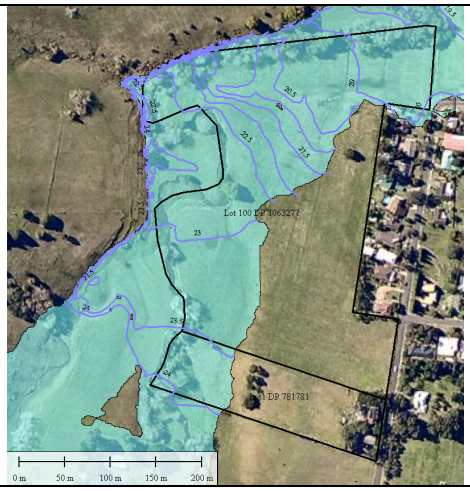


Figure 48. PMF Flood Levels and Extent

However the increase in extent for the PMF event is largely over two distinct areas, one where people could continue to wade through the flood water (yellow to light blue) and one where damage to small structures could be expected (area where green brown and into orange). Note that in the brown to orange; extensive damage may be expected. Considering that generally the PMF is around 0.5m above the Q100 event the usual 0.5m freeboard for habitable floors above the Q100 will be adequate to protect floor levels.

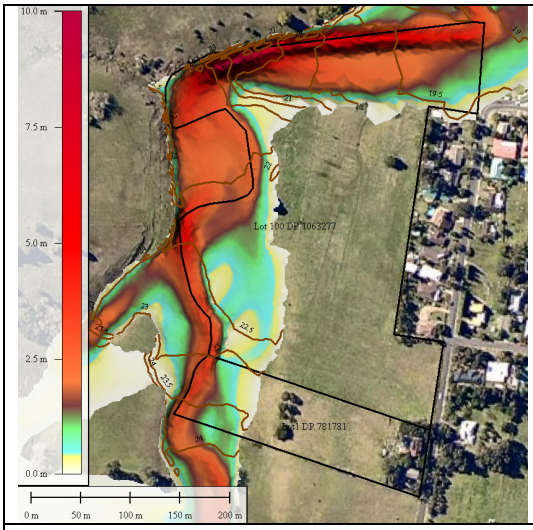


Figure 49. Q100 Flood Levels and Momentum

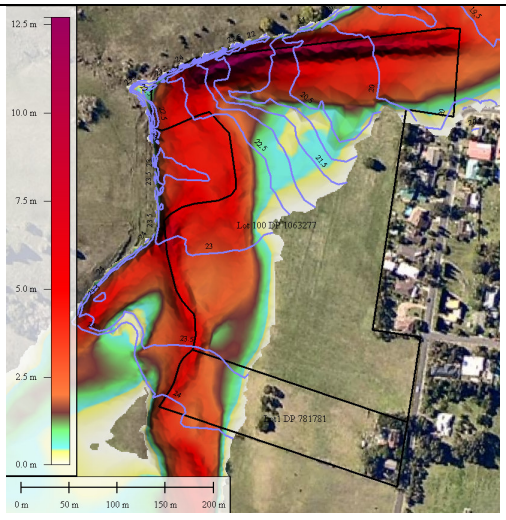


Figure 50. PMF Flood Levels and Momentum

However given that the PMF momentum extent (where momentum exceeds 1.0) generally aligns with the Q100 flood extent it is suitable to use either of these two lines to set the development extent.

Figure 51. Comparison of Q100 flood extents (Blue) with PMF Momentum => 1.0 (brown/orange)

However it is noted that the PMF flood extent (not hazard extent) does cover a greater area particularly in the North West corner of the site.

Refer to the following image for a comparison.

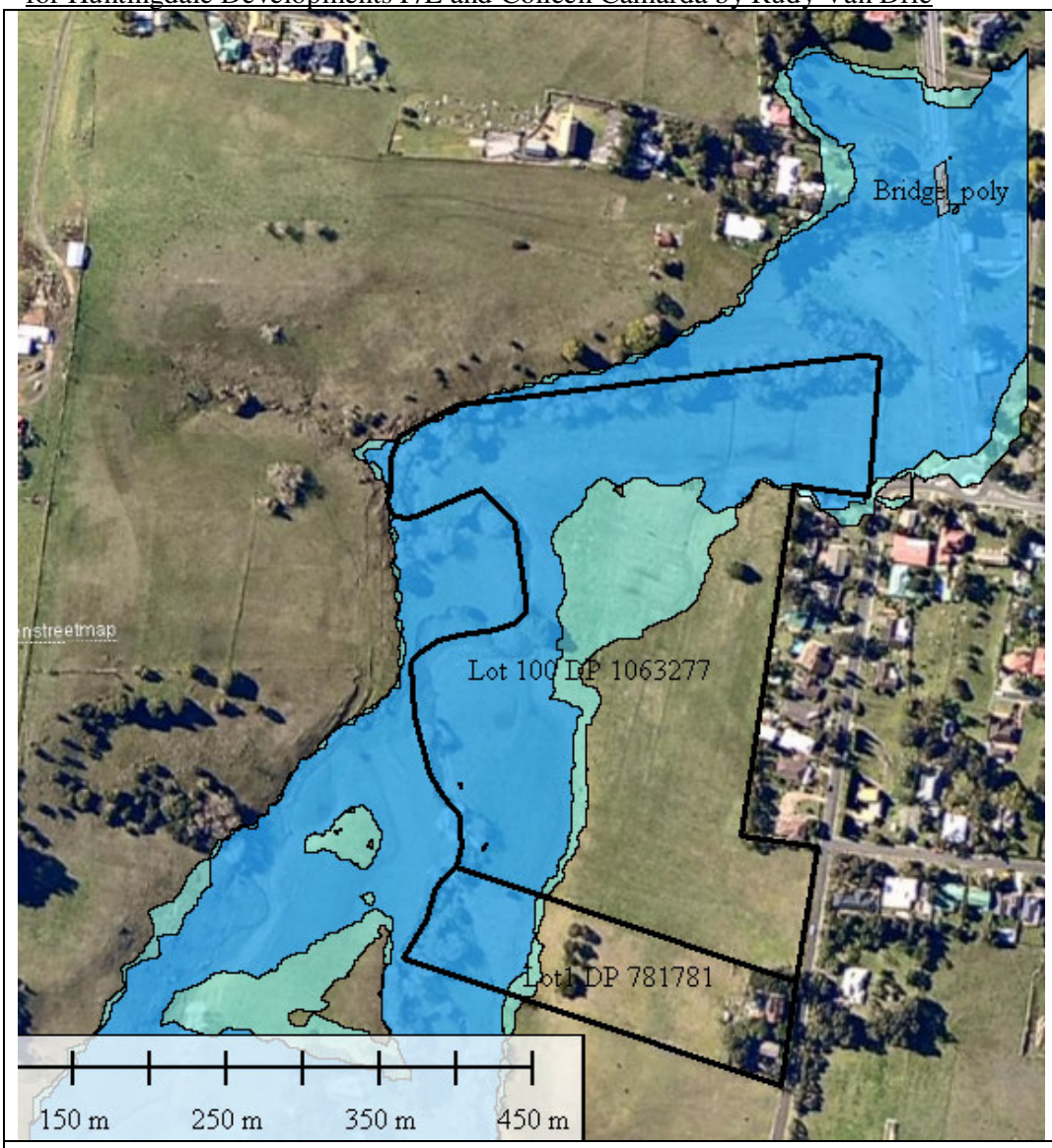


Figure 52. Comparison of Q100 and QPMF Flood extents

12.0 RECOMMENDATIONS:

It is recommended that this report be adopted as a description of the flood behaviour at the subject site in its current condition. It is further recommended that the 1:100 year flood levels provided in this report be utilised to set habitable floor levels and the developable extent determined from the hazard (momentum) present during a PMF event.

It is noted that in Figure 51 the 1:100 year flood extent and PMF hazard extent are very closely aligned. Therefore if development is contained within the extent shown on Figure 51 flood behaviour will remain largely unaffected. On this basis (that hazardous PMF flow coincides approximately with Q100 flood extents) it is likely that Climate Change impacts will not significantly impact the level of hazard within the development, but this will need to be assessed prior to the completion of the final development layout.

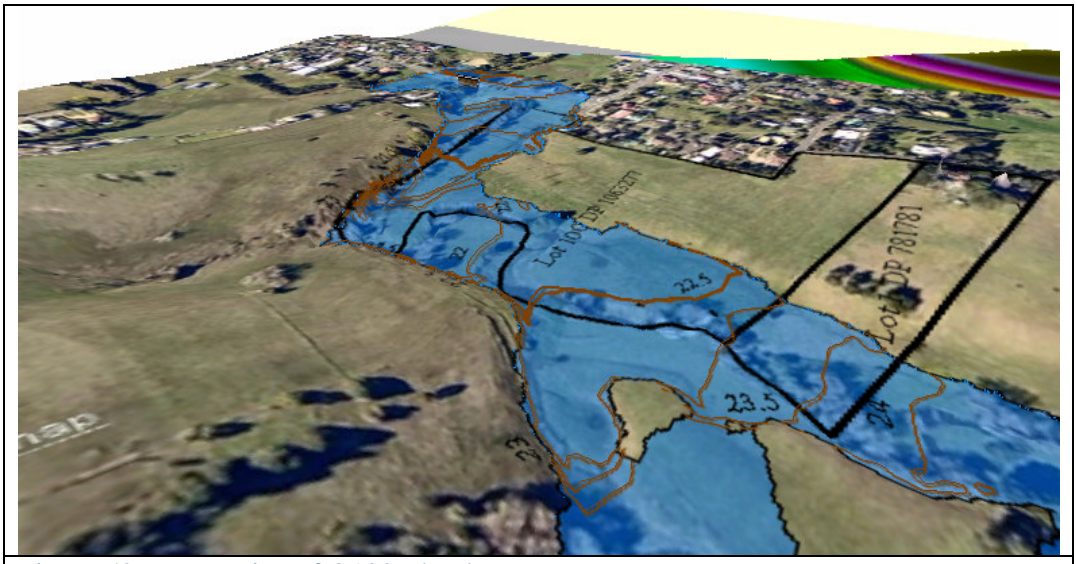


Figure 53. Perspective of Q100 Flood

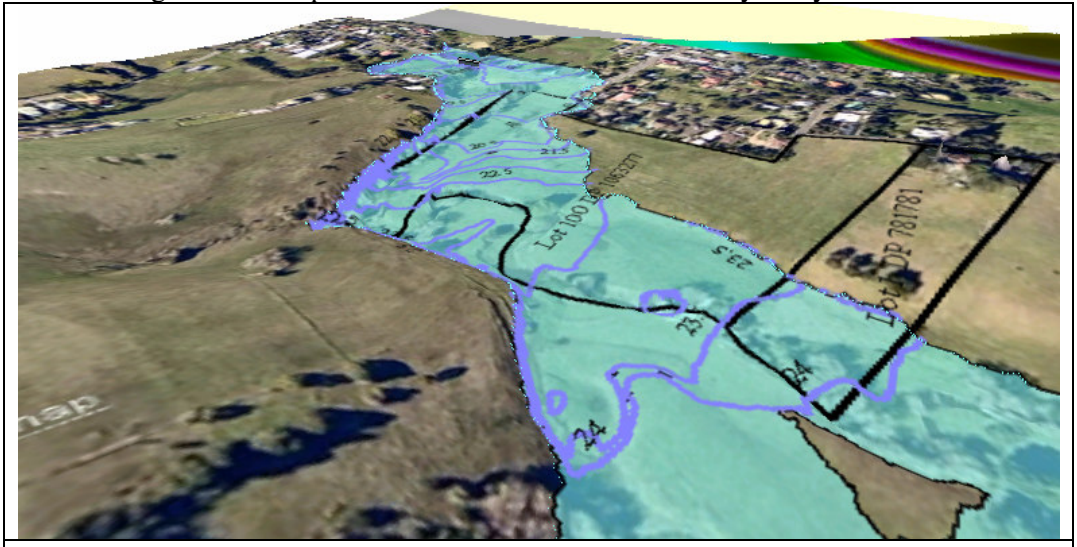


Figure 54. Perspective of QPMF Flood

If any one has any queries regarding any matter raised in this report, please do not hesitate to contact me.

Signed……..
Regards Rudy Van Drie
Dated: 04/11/2011
Updated: 05/06/2012