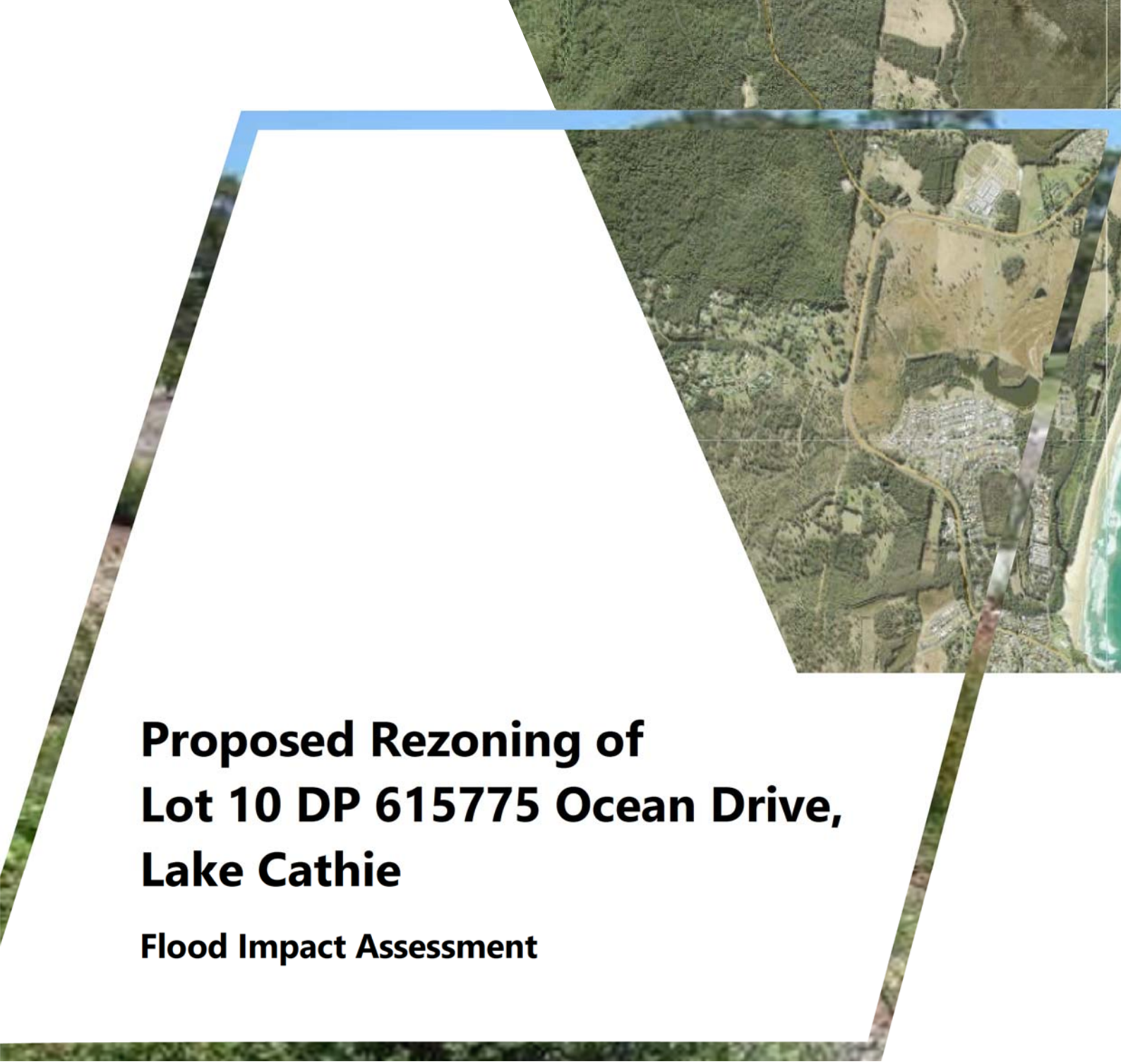

Proposed Rezoning of Lot 10 DP 615775 Ocean Drive, Lake Cathie

Flood Impact Assessment

Level 17, 141 Walker St
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Australia

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Advisian
WorleyParsons Group

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Project: Proposed Rezoning of Lot 10 DP 615775 Ocean Drive, Lake Cathie Flood Impact Assessment

Rev	Description	Author	Review	Advisian Approval	Date
A	Draft Report – Issued for Review	ARM A Morris	CRT C Thomas		30/07/2009
B	Final Report	ARM A Morris	CRT C Thomas	CRT C Thomas	10/9/2010
C	Updated Report for modified development layout and revised Council policies	AJD A Dunphy	CRT C Thomas	 C Thomas	19/02/2019

Table of Contents

1 Introduction

SJ Mifsud Insulation Pty Ltd (*Mifsud*) plans to develop a parcel of land that is referred to as Lot 10 DP 615775 Ocean Drive, Lake Cathie. As shown in **Figure 1**, the land is located along the western frontage of Ocean Drive and extends south from its intersection with Houston-Mitchell Drive. It is currently zoned *RU1 Primary Production* under the *Port Macquarie - Hastings Local Environmental Plan 2011*.

The site is located near the downstream end of a 252 ha catchment that drains to an undeveloped area on the eastern side of Ocean Drive. The extent of the catchment and the location of the site within it is shown in **Figure 2**.

The western boundary of the site adjoins dense bushland. The area to the east of the site has been cleared for grazing and drains to a series of constructed wetlands that are situated along the northern limit of the urban precinct of Bonny Hills.

As shown in **Figure 1**, an ephemeral stream that drains the catchment traverses through the Mifsud Site. The Ocean Drive roadway embankment (*refer* **Figure 1**) presents as a barrier to the easterly discharge of floodwaters, but incorporates three triple cell culvert systems that concentrate runoff and discharge it to the east of the site. The locations of the three culvert systems are highlighted in **Figure 1**.

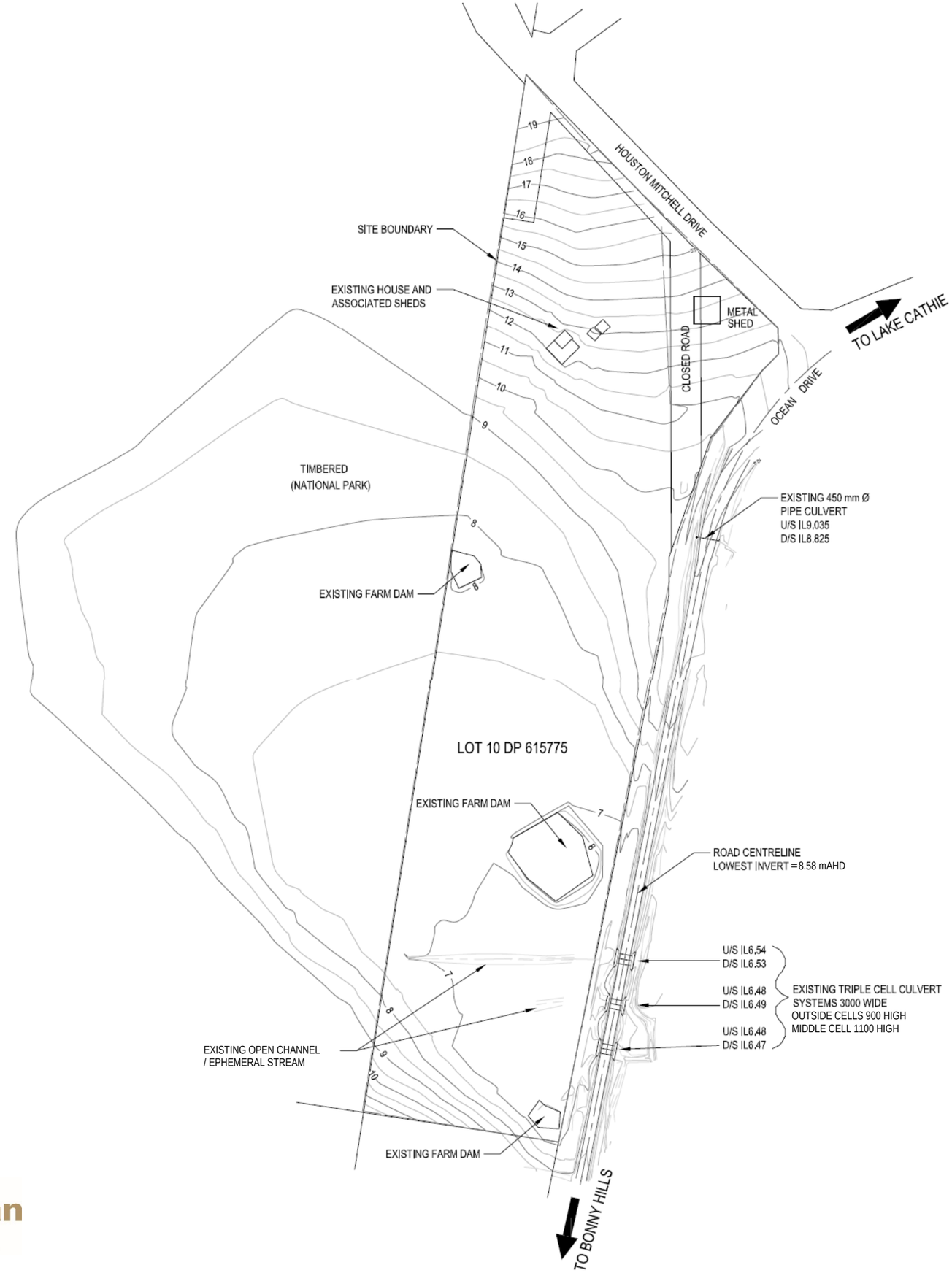
Notwithstanding, there is potential for floodwaters to pond in the area upstream from the roadway embankment leading to inundation of a large proportion of the Mifsud Site.

Accordingly, King and Campbell Pty Ltd, acting on behalf of Mifsud, engaged Advisian (*operating as WorleyParsons*) to undertake flood investigations aimed at determining the 100 year average recurrence interval (ARI) flood level at the site. The results of these investigations are discussed in a draft Site Flood Assessment Report that was issued to King & Campbell in January 2009. The Site Flood Assessment Report established that the estimated peak 100 year ARI flood level at the site was 7.6 mAHD for a "no-blockage scenario". The findings of the Site Flood Assessment Report (2009) are re-stated in this document in **Section 2**.

Following submission of the Site Flood Assessment Report, King & Campbell provided Advisian (*operating as WorleyParsons*) with a plan showing the layout for the proposed development of the site. The plan included a lot layout and an indicative extent of proposed fill. The fill is required to raise the level of the terrain where development is being proposed and is necessary in order for the land to be rezoned for industrial development.

However, the proposed filling has the potential to reduce the available flood storage and could lead to an increase in peak 100 year ARI flood levels across areas upstream from the site. This could also increase the peak flood discharge through the culvert system located underneath Ocean Drive, potentially creating adverse conditions for properties located downstream.

In addition, the proposed development will result in an increase in stormwater run-off from the site itself, which has the potential to increase the peak discharge entering the flood storage area extending upstream from Ocean Drive.



LEGEND

IL 6.54	INVERT LEVEL OF CULVERT IN METERS RELATIVE TO AHD
10	ELEVATION OF NATURAL SURFACE IN METERS RELATIVE TO AHD

NOTES

1. CONTOUR INTERVAL = 0.5m
2. ALL DIMENSIONS ARE IN mm
3. SURFACE ELEVATIONS SHOWN RELATIVE TO METRES ABOVE AHD
4. ORIGIN OF LEVELS -
   PM 71722
   RL 19.163 AHD
5. SURVEY COORDINATED TO SSM16940
6. SOURCE DRAWING REFER KING & CAMPBELL DRAWING No. - 14661S_DET3D_DETAIL SURVEY FOR FLOOD IMPACT STUDY

0 30 60 90 120 150m

1 : 1500

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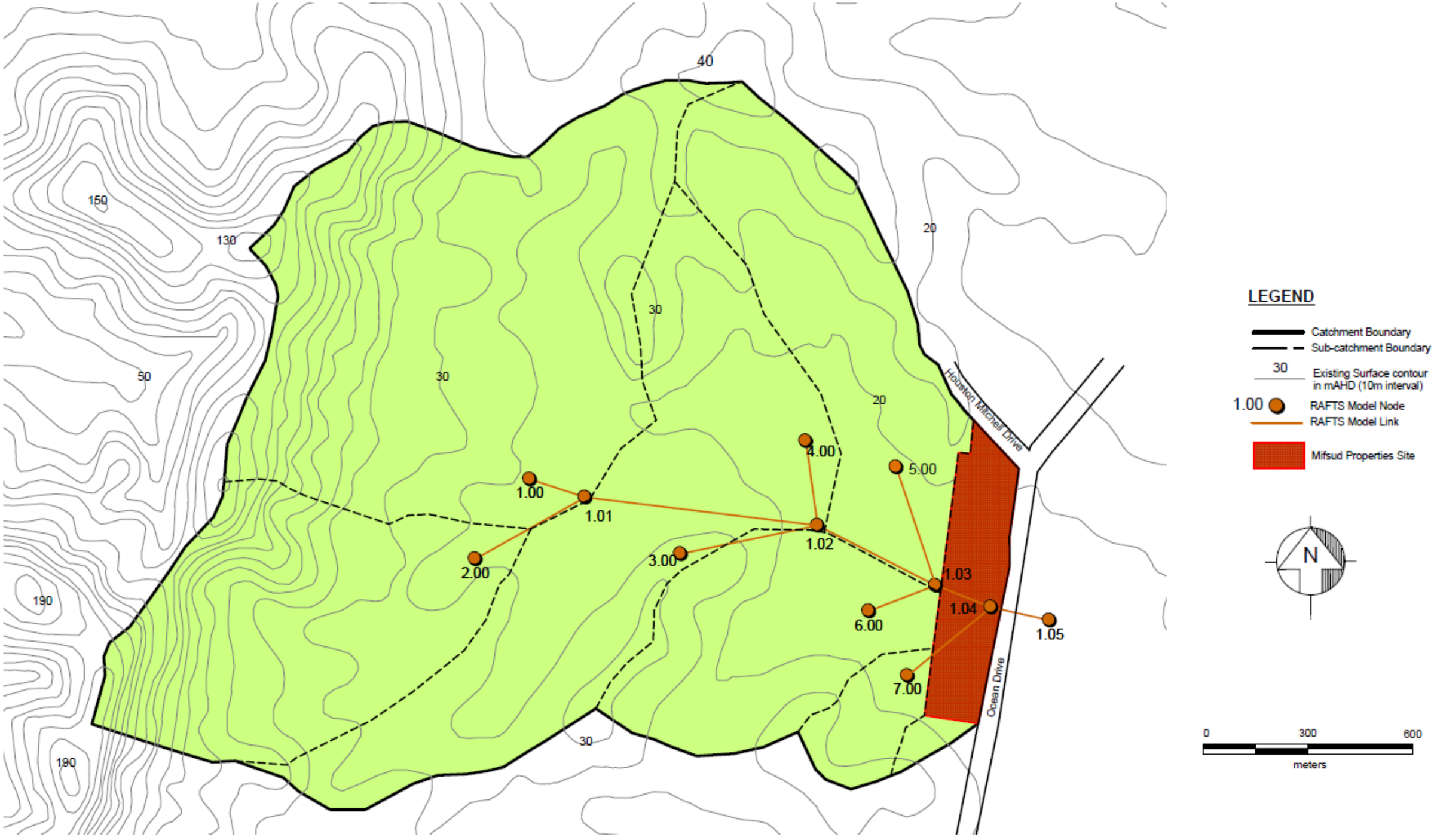
LOCATION AND EXTENT OF SITE PROPOSED FOR REZONING

FIGURE 2



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301015-04004 FIA Figure 2.doc

NODE AND LINK ARRANGEMENT FOR RAFTS HYDROLOGIC MODEL

In 2010 WorleyParsons submitted a previous version of this Flood Impact Assessment Report (*Revision* B) which documented the results of investigations that were undertaken to characterise existing flood conditions at the site. The report also documented the magnitude and extent of the impact that the proposed filling of the land could have on existing flood characteristics.

Since submission of the 2010 Report (*Rev B*), the concept layout plan has been revised. In addition, Port Macquarie-Hastings Council (*Council*) has requested an update of the report to align the proposed development with Council's updated policies, including the *Port Macquarie-Hastings Council Flood Policy*, which was adopted by Council in October 2015 and the AUSPEC D5 design guidelines. In addition, Ocean Drive was upgraded in 2012 and therefore the investigations need to consider the latest road crest levels.

Accordingly, King and Campbell, acting on behalf of Mifsud, engaged Advisian to update the flood investigations that were completed in 2009/10 to account for the requirements of Council's updated policies, the current concept layout plan and the latest road levels for Ocean Drive. The results of these investigations are outlined in this report.

2 Site Flood Assessment

2.1 Hydrologic Analysis

The catchment draining to the Mifsud Site extends 2 kilometres to the west of Ocean Drive and rises to an elevation of 190 mAHD. It has an area upstream of Ocean Drive of 252 ha. Almost all of this area is densely vegetated.

In order to determine peak flood flows that could potentially be discharged to the site, a hydrologic model of the catchment was developed. The hydrologic model was developed using the Runoff Analysis and Flow Training Simulation (*RAFTS-XP*) software package.

RAFTS-XP is a deterministic runoff routing model that simulates catchment runoff processes. It is recognised in *'Australian Rainfall and Runoff – A Guideline to Flood Estimation'* (*ARR 1987*), as one of the available tools for use in flood routing within Australian catchments. The layout of the RAFTS model is shown in **Figure 2** superimposed over a plan of the catchment.

As shown in **Figure 2**, the upper catchment has been subdivided according to drainage lines interpreted from available aerial photography and topographic mapping. Catchment subdivision also considered the homogeneity of existing land use and vegetation cover. Subcatchment characteristics such as area, slope, percentage imperviousness and roughness, were extracted from the mapping and incorporated within the model data-set.

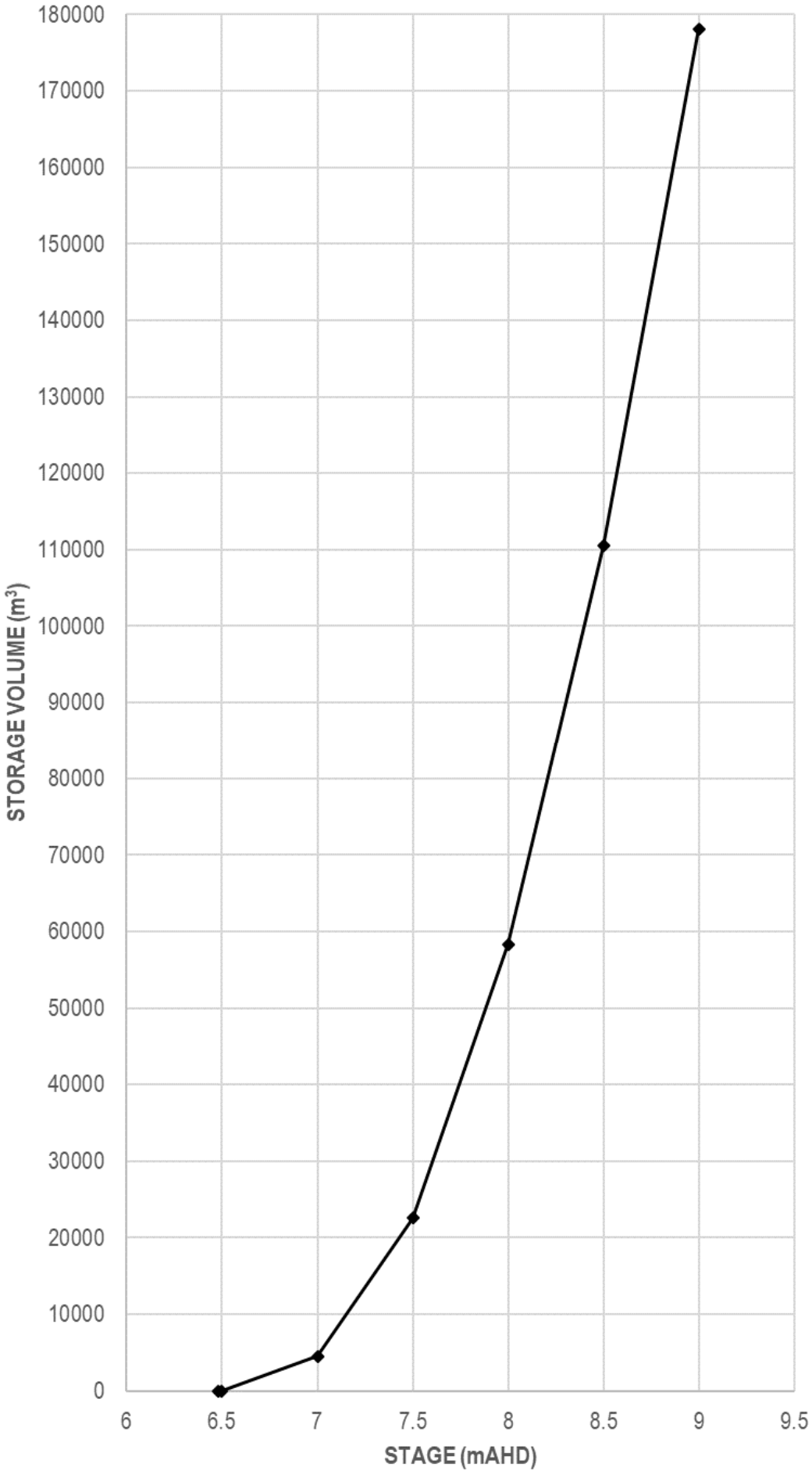
As outlined in **Section 1**, the Ocean Drive roadway embankment effectively "blocks" the free discharge of overland flows and in conjunction with the culvert system, acts as a hydraulic control. As a result, areas of the Mifsud Site upstream from the culverts act as a flood storage area in a similar manner to a detention basin.

Accordingly, the RAFTS model was developed to incorporate the storage afforded by these areas and created by the roadway embankment. The storage was quantified by analysis of the topographic data shown in **Figure 1**, which resulted in determination of the stage-storage relationship presented in **Figure 3**.

In addition, hydraulic analyses were undertaken to determine the flow that would be discharged through the culvert system at different levels of storage. This resulted in development of the stage-discharge relationship shown in **Figure 4**.

The stage-discharge relationship indicates that a sharp reduction in the discharge capacity occurs as the upstream water level reaches the obvert of culverts within the three culvert systems. At this point, the culverts are predicted to be "drowned out". The increase in friction causes a reduction in discharge capacity. The relatively large reduction is due to the number of culverts and the relatively large ratio of width to depth.

FIGURE 3



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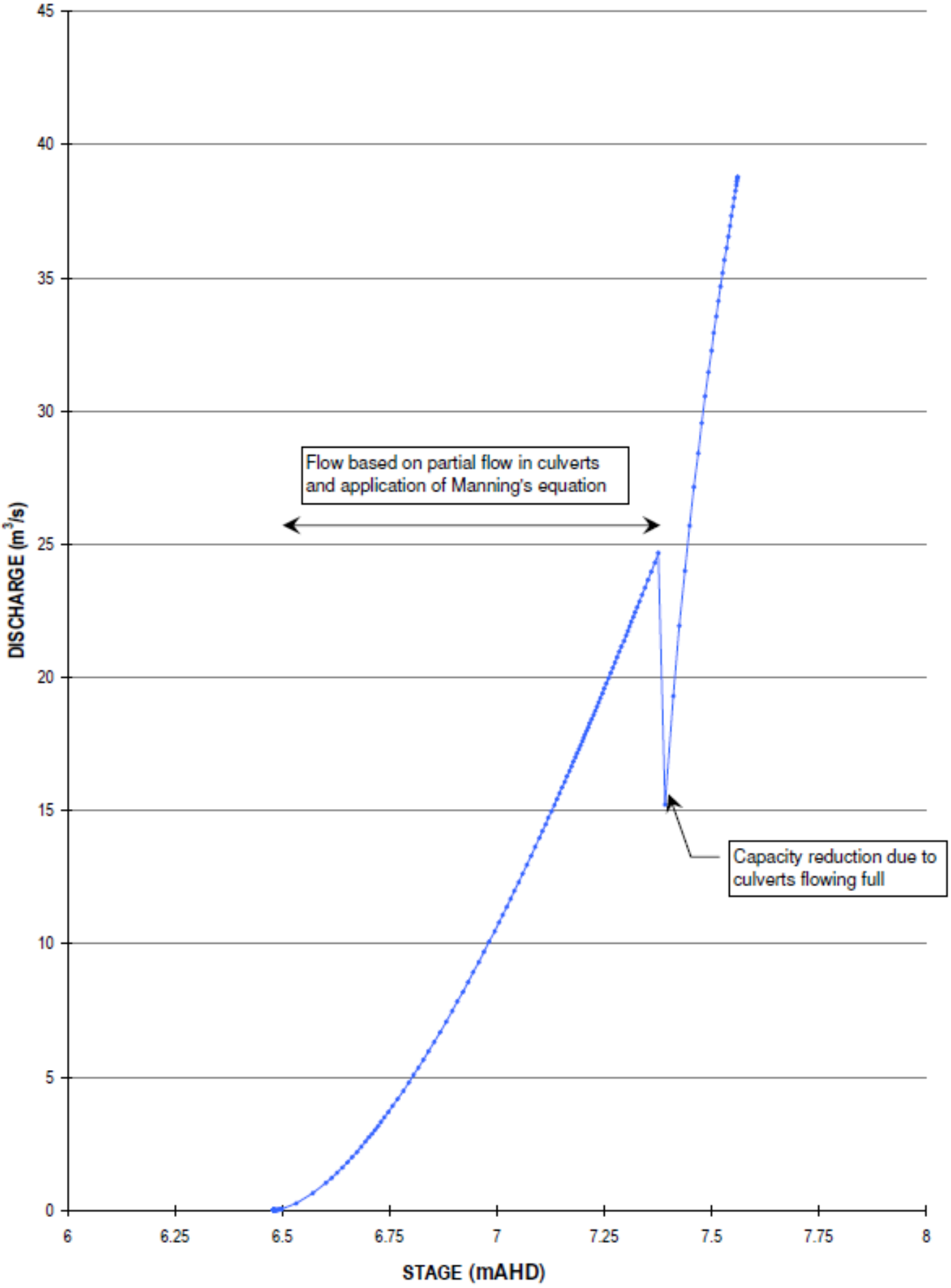
STAGE-STORAGE RELATIONSHIP FOR MIFSUD INDUSTRIAL SITE

FIGURE 4



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STAGE-DISCHARGE RELATIONSHIP FOR MIFSUD INDUSTRIAL SITE

The RAFTS model was used to simulate the design 100 year ARI storm event for the full range of standard storm durations defined in ARR 1987. The 1987 Intensity-Frequency-Duration (IFD) data were adopted as the Council has chosen to retain the procedures and IFD data associated with ARR 1987 for other projects within the local government area, including several government funded flood studies. Hence, we opted to retain the previously adopted 1987 IFD data for the catchment. The results of the analysis were interrogated to determine the critical storm duration for the catchment draining to Ocean Drive.

The 120 minute storm was identified as the critical storm duration for the design 100 year ARI event. This event generated a peak flow of 41.8 m^3/s at the western boundary of the site (*no blockage scenario*). The simulation also showed that the storage afforded by the roadway embankment and culvert system led to an 8.4% attenuation of the peak flow. The 100 year ARI flood discharge at the downstream side of Ocean Drive is estimated to be 38.3 m^3/s.

2.2 Predicted Peak Flood Level

The catchment draining to the Mifsud Site, and ultimately to the culvert system, forms part of the Queens Lake State Conservation Area and is densely vegetated. There is potential for vegetative debris from this area to travel downstream and become lodged within the culverts or across their face. This debris may block the passage of flow through the culverts and impact on predicted upstream flood levels. A photograph of one of the culvert systems is shown in **Plate 1**.

Plate 1 Three Cell Culvert System Beneath Ocean Drive

It was agreed with the Council (*refer email correspondence from Council (Jesse Dick) to King & Campbell (Kylie Moore) on 11th December 2018*) that the blockage factor that should be applied in the current flood impact assessment should be derived using the methodology outlined in the 2016 edition of *Australian Rainfall and Runoff* (*ARR 2016*). A summary of the considerations made when deriving the blockage factor is provided in the following.

- Based on the ARR 2016 methodology, the debris potential (*average exceedance probability (AEP) adjusted*) at the culverts along Ocean Drive would be classified as "High". This is because of the presence of the natural forested area (*i.e., an area of high debris availability*) and because the creek traverses through a forested area (*i.e., an area of high debris mobility*).

- The blockage level (*or percentage blockage*) is then selected by considering the ratio of the culvert opening (*defined as W and equal to 3 metres at the site*) to the average length of the longest 10% of the debris that could make its way to the culverts (*defined as L_{10}*).
- The vegetation upstream of the site is very tall and therefore there is potential for a tree of significant size to block the culverts. However, the clear distance between each of the three culvert banks is approximately 20 metres. Therefore, it is highly unlikely that all three culvert banks will be blocked simultaneously.
- In recognition of this, and for the purpose of this flood impact assessment, it has been assumed that "blockage" corresponds to one culvert bank being 50% blocked and the other two 20% blocked. The scenario where all culvert banks are 20% blocked ($L_{10} <= W <= 3 * L_{10}$) has also been considered for comparison.
- The blockage factor was applied by reducing the culvert width by the percentages outlined above. The RAFTS model was then used to simulate the 100 year ARI event and estimate the maximum impact on culvert performance over a range of storage elevations.

Table 1 lists the results of the design flood simulations for existing conditions.

Table 1 100 year ARI Flood Levels for Existing Conditions

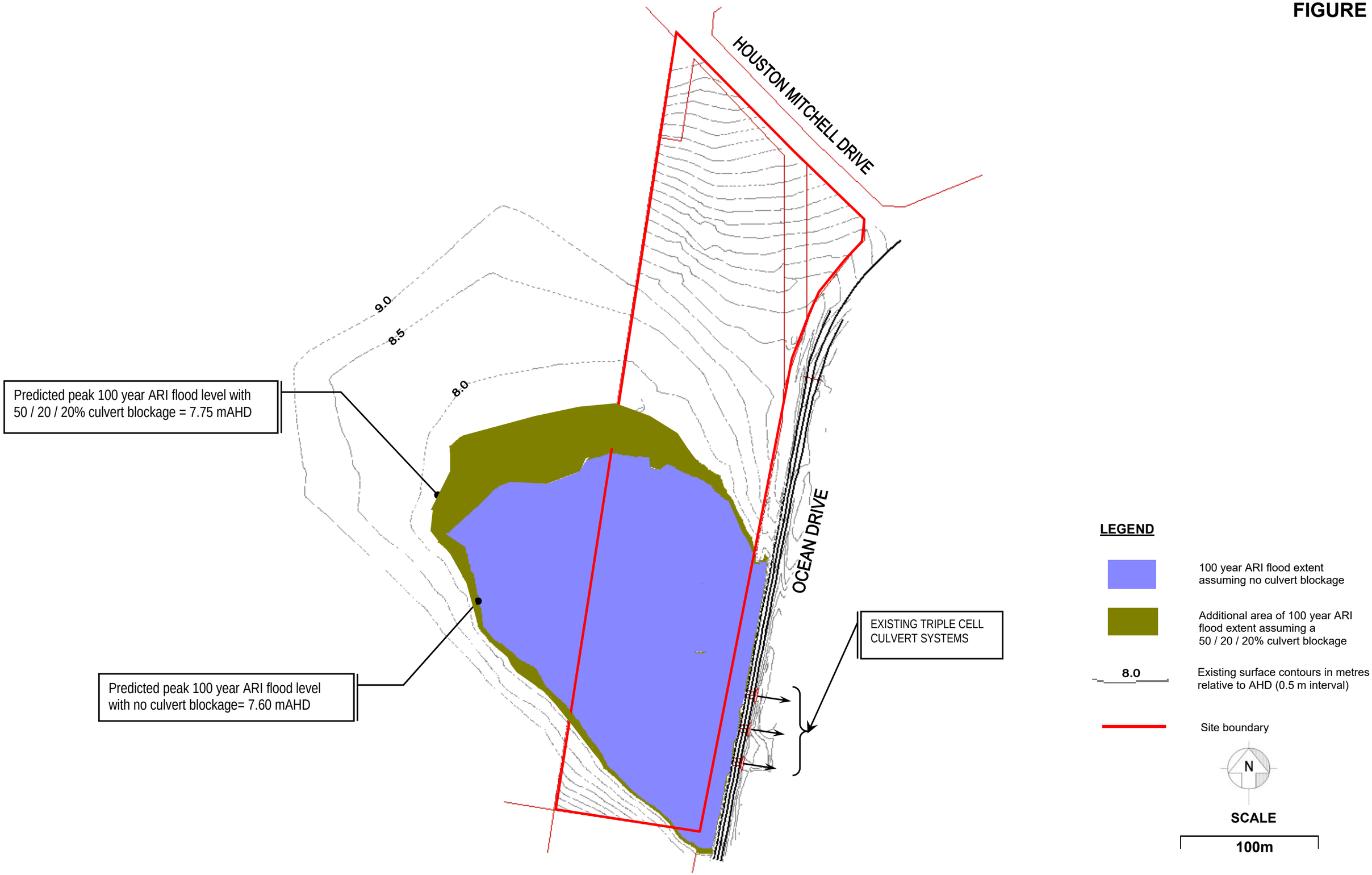
Blockage (%)	Existing 100 year ARI Flood Level (mAHD)
0	7.598
20	7.686
50 / 20 / 20	7.752

Note: Peak Flood Levels are shown to 3 decimal places to allow comparison to post-development levels only. Absolute peak flood levels should be determined based on rounding to 2 decimal places in all cases.

In the "50 / 20 / 20%" blockage scenario, the 100 year ARI flood is predicted to reach an elevation of 7.75 mAHD. This is about 800 mm below the minimum crest level of the section of Ocean Drive that fronts the eastern side of the site. Accordingly, all runoff from the upstream catchment must be discharged via the three culvert systems shown in **Figure 1**.

The results of the modelling indicate that 50% of the site is estimated to be inundated at the peak of the flood under existing conditions in the "50 / 20 / 20%" blockage scenario. The increase in flood extent between the no blockage scenario and the "50 / 20 / 20%" blockage scenario are shown in **Figure 5**.

FIGURE 5



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301015-04004 FIA Figure 5.doc

PREDICTED 100 YEAR ARI FLOOD EXTENT FOR EXISTING CONDITIONS

3 Flood Impact Assessment

3.1 Description of Proposed Development

The proposed development involves subdivision of the Mifsud Site into twenty-seven separate allotments as shown in **Figure 6**. The lots are arranged on the northern two-thirds of the site. A road extends along the eastern and western boundaries of the site and forms a circular loop around the majority of the lots. The road joins Houston Mitchell Drive near the north-eastern corner of the Site.

The *Port Macquarie-Hastings Council Flood Policy* was adopted by the Council in October 2015. The policy contains guidelines for determining minimum floor levels for developments. For commercial and industrial development, the flood planning level (*FPL*) is defined as the 100 year ARI flood level plus an allowance for climate change; referred to as FPL2 in the Flood Policy. The Flood Policy highlights that flood modelling incorporating an allowance for climate change has not been finalised for the Lake Cathie catchment. The Policy indicates that an 'interim' allowance of 400 mm should be adopted (*based on location of east (downstream) of the Pacific Highway*) where modelling for climate change has not been carried out.

Table 2 lists the FPL2 levels associated with the different blockage scenarios.

Table 2 Flood Planning Levels (FPL2)

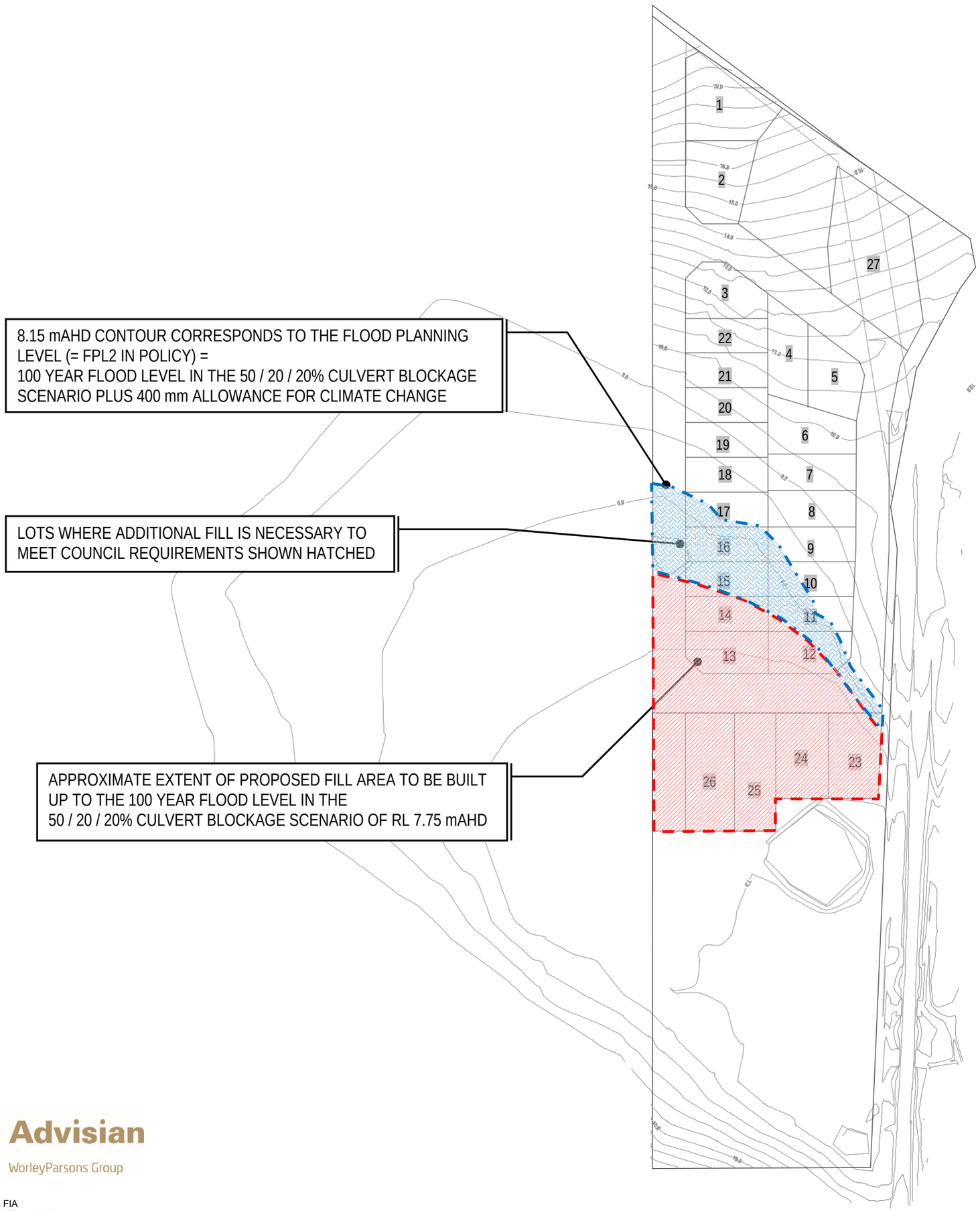
Blockage (%)	Flood Planning Level (FPL2) (mAHD)
0	7.998
20	8.086
20 / 50 / 20	8.152

Note: FPL2 Levels are shown to 3 decimal places to allow comparison to pre-development (or post-development) levels only. Absolute peak flood levels should be determined based on rounding to 2 decimal places in all cases.

The existing site contour information indicates that Lots 13 to 15 and 23 to 26 and sections of Lots 9 to 12 and 17, are located on land that is below the predicted FPL (*8.15 mAHD*) in the "50 / 20 / 20%" blockage scenario. Therefore, filling of these lots up to the FPL is proposed in order to meet the requirements of the Council's Flood Policy.

The fill requirements discussed above are estimated to lead to a reduction in the storage volume of approximately 10,000 m^3 up to the existing 100 year ARI peak flood level at the site in the "50 / 20 / 20%" blockage scenario. The modified stage storage relationship, including a comparison against the existing stage storage relationship is included in **Figure 7**.

FIGURE 6



LEGEND

10 — ELEVATION OF NATURAL SURFACE IN METERS RELATIVE TO AHD

12 — DENOTES LOT NUMBERS

NOTES

1. CONTOUR INTERVAL = 0.5m
2. ALL DIMENSIONS ARE IN mm
3. SURFACE ELEVATIONS SHOWN RELATIVE TO METRES ABOVE AHD
4. ORIGIN OF LEVELS -
   PM 71722
   RL 19.163 AHD
5. SURVEY COORDINATED TO SSM16940
6. SOURCE DRAWING REFER KING & CAMPBELL DRAWING No. 4661P_Rezone_Opt2 Rev C AREA 14 EMPLOYMENT LANDS STRUCTURE PLAN – PROPOSED REZONING – OPTION 2

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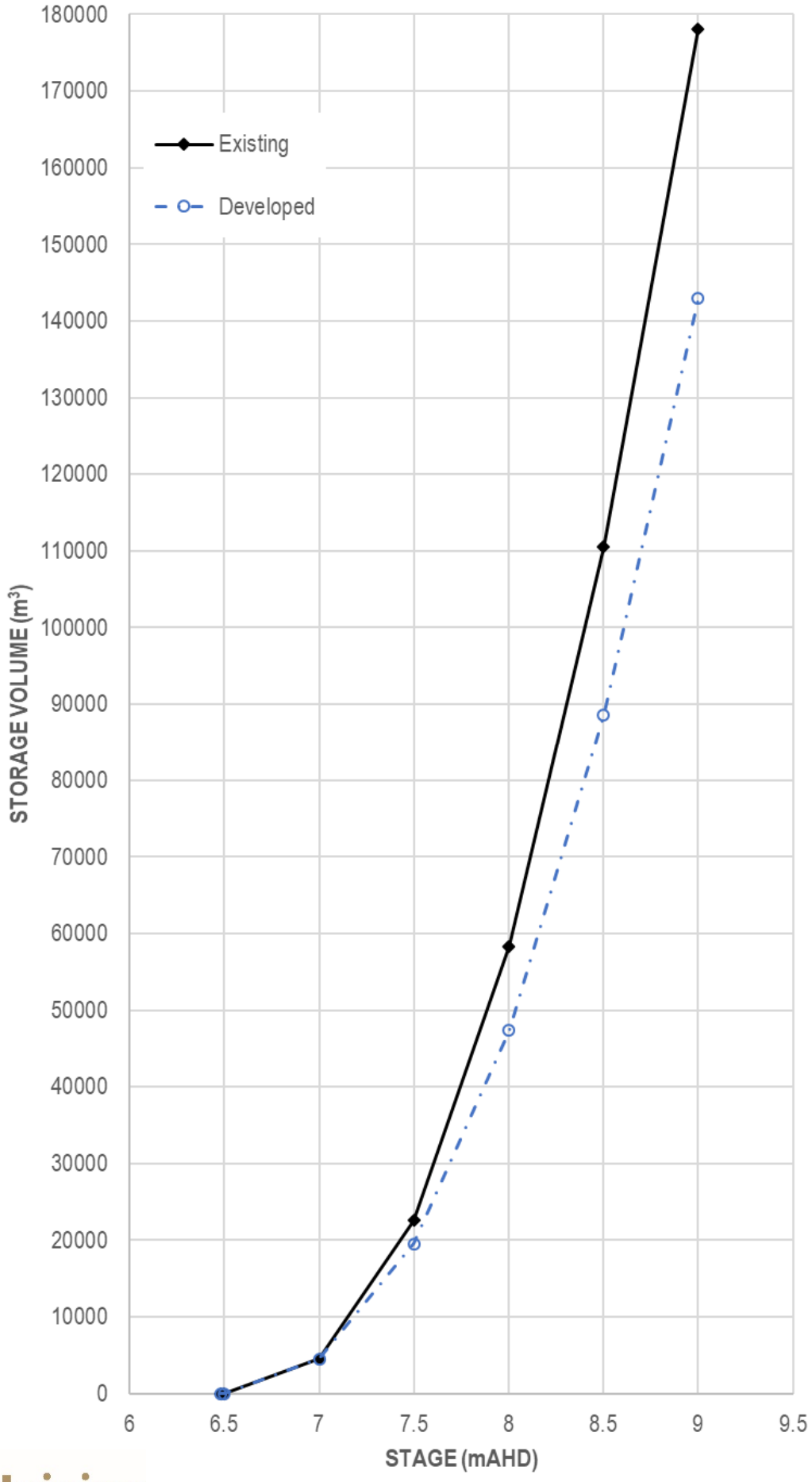
PROPOSED LOT LAYOUT AND EXTENT OF FILLING

FIGURE 7



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STAGE-STORAGE RELATIONSHIP FOR EXISTING CONDITIONS AND POST DEVELOPMENT

3.2 Proposed Development Flood Modelling

The potential impact of the proposed development on the predicted 100 year ARI flood level at the site was determined by simulating flooding under post-development conditions based on the development layout described above. The existing hydrologic model was modified to incorporate the stage-storage relationship shown in **Figure 7** and runoff parameters for the development site were modified to reflect the post development conditions (*i.e. greater imperviousness*). The proposed development has the effect of reducing the perviousness of the land surface due to the construction of roads and buildings.

3.3 Flood Modelling Results

3.3.1 Impact on Upstream Flood Levels

Design flood simulations were completed to determine the impact of the proposed development on the peak 100 year ARI flood level at the site. **Table 3** lists the post-development flood levels, along with the difference between the existing and post-development levels.

Table 3 Post-Development 100 year ARI Flood Levels and Predicted Increase at Upstream Site Boundary

Blockage (%)	Post-Development 100 year ARI Flood Level (mAHD)	Difference Between Existing and Post-Development Levels (mm)
0	7.605	7
20	7.699	13
50 / 20 / 20	7.770	18

Note: Peak Flood Levels are shown to 3 decimal places to allow comparison to pre-development levels only. Absolute peak flood levels should be determined based on rounding to 2 decimal places in all cases.

Section 5.4(c) of the *Port Macquarie-Hastings Council Flood Policy* states,

> "*Where development will take place in a designated Flood Storage Area, the applicant must demonstrate that the impact on peak 100 year ARI flood levels is less than 10 mm, and on peak 100 year ARI flood velocities is less than 0.1 m/s*".

The results listed in **Table 3** indicate that the maximum flood level increase requirement is met for the "no blockage" scenario. However, for blockage scenarios involving both uniform 20% blockage and "50 / 20 / 20%" blockage, the post-development 100 year ARI flood levels at the upstream site boundary are predicted to increase by more than the specified 10 mm. Notwithstanding, the predicted increase at the upstream site boundary in both cases is less than 20 mm.

The minor increase in peak flood level can be attributed to the large discharge capacity of the culvert system that drains the catchment extending upstream from the site. The culverts have sufficient capacity to carry the peak 100 year ARI flow without causing substantial backwater flooding.

As the area upstream from the site is a densely vegetated State Conservation Area, the predicted increase in peak 100 year ARI flood level at the upstream site boundary (*i.e., less than 20 mm*) is unlikely to have any impact on flood behaviour or result in any measurable impact on flood damages. Hence, the predicted increases are considered to be acceptable in the context of the intent of the Flood Policy.

3.3.2 Impact on Downstream Flood Levels

The peak 100 year ARI discharge through the culvert system in the post-development no blockage scenario is estimated to be 39.1 m^3/s, which represents a decrease in the peak discharge of 2.7 m^3/s (*from 41.8 m^3/s*). The minor decrease in the peak discharge through the culvert system is not considered to be an issue as it is not anticipated to cause any measurable increase in peak flood levels.

The increase in run-off resulting from the proposed development also makes no difference to the overall inflow hydrograph. In this case, the peak flow from the local catchment does not coincide with the peak of the hydrograph entering the flood storage area from the upstream catchment. This is due to the close proximity of the development area to the culvert outlet, relative to the rest of the catchment.

3.3.3 Impact on Flow Velocities

The total area of the nine culvert cells is 26.1 m^2 and therefore using the estimated flow, the corresponding velocity is 1.5 m/s (= *39.1 m^3/s / 26.1 m^2*) in the post-development scenario. In the existing scenario the velocity is 1.6 m/s (= *41.8 m^3/s / 26.1 m^2*). Therefore, the impact on the velocity is in accordance with the flood policy (*i.e., it does not exceed 0.1 m/s*).

In the "50 / 20 / 20%" blockage scenario the difference between the existing and post-development velocities is 0.15 m/s. This is greater than the maximum allowable velocity increase of 0.1 m/s specified in the Council's Flood Policy, but given the nature of the catchment and the low absolute magnitude of flood flow velocities, it is unlikely to have a significant impact.

3.3.4 Afflux Assessment

In addition to Council's Flood Policy requirements, Council's AUSPEC D5 design guidelines for *Stormwater Drainage Design* require that all major structures be designed for the 100 year ARI storm event with a maximum afflux of no greater than 300 mm. Council' AUSPEC D5 design guidelines for *Stormwater Drainage Design* also require that major culverts be designed with a blockage factor of 50%.

Therefore, a simulation was undertaken assuming 50% blockage of all three culvert systems. The results from this analysis established that the afflux is predicted to be less than 300 mm.

4 Conclusions

Hydrologic modelling of the catchment draining to Lot 10 DP 615775 Ocean Drive, Lake Cathie (referred to as the Mifsud Site), and through the culvert system beneath Ocean Drive, indicates that the peak 100 year ARI flood level at the site for existing conditions in the "50 / 20 /20%" culvert blockage scenario is estimated to be 7.75 mAHD. This level is lower than the road crest elevation of Ocean Drive. Therefore, all runoff from the upstream catchment must be discharged via the three culvert systems that cross Ocean Drive at this location.

As part of a proposal to rezone and develop the site it is proposed that a section of the site be filled as shown in **Figure 6**. The fill is required to allow development to proceed in accordance with the Council's requirements.

Design flood simulations have been completed to assess the impact of the filling proposed as part of development of the site. The findings from the analysis are summarised as follows.

(i) For a "zero culvert blockage" scenario, the filling proposed as part of the development will result in an increase in peak 100 year ARI flood level at the upstream site boundary of less than 10 mm. This increase in 100 year ARI flood level is within the allowable limit specified in the Council's Flood Policy.

(ii) For the "50 / 20 /20% culvert blockage" scenario, the difference in the peak 100 year ARI flood level in existing and post-development conditions is less than 20 mm. This is greater than the 10 mm difference that is noted in the Council's Flood Policy. However, due to the nature of the catchment whereby it is a densely vegetated State Conservation Area the estimated change in the flood level is unlikely to have a significant impact.

(iii) The difference in the 100 year ARI flow velocity between existing and post-development no blockage scenarios is estimated to *be 0.15 m/s* through the culverts. This is greater than the maximum allowable velocity difference of 0.1 m/s specified in the Council's Flood Policy. However, given the nature of the catchment and the low absolute magnitude of flood flow velocities through the culverts, the predicted increase is unlikely to have a significant impact.

(iv) In addition to Council's Flood Policy requirements, Council's AUSPEC D5 design guidelines for *Stormwater Drainage Design* require that all major structures be designed for the 100 year ARI storm event with a maximum afflux of no greater than 300 mm. Council' AUSPEC D5 design guidelines for *Stormwater Drainage Design* also require that major culverts be designed with a blockage factor of 50%. Under this scenario it was found that the afflux is predicted to be less than 300 mm.

5 References

- Port Macquarie – Hastings Council (2008), *'AUSPEC-01 D05 – Stormwater Drainage Design'*
- Port Macquarie - Hastings Council (2015), *'Port Macquarie-Hastings Council Flood Policy'*
- Willing & Partners Pty Ltd (1996), *'RAFTS-XP User Manual'*
- Institution of Engineers (1987), *'Australian Rainfall and Runoff – A Guide to Flood Estimation'*; edited by DH Pilgrim.
- Institution of Engineers (2016), '*Chapter 6. Blockage of Hydraulic Structures'* (Draft) in *'Australian Rainfall and Runoff – A Guide to Flood Estimation'*; W Weeks and T Rigby.
- Port Macquarie - Hastings Council (2011), *'Port Macquarie - Hastings Local Environment Plan 2011'*
- WorleyParsons (2009), '*Proposed Rezoning of Lot 10 DP 615775 Ocean Drive, Lake Cathie - Site Flood Assessment*' (Draft)