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Our Ref: DJL: L.N20202.005.docx

28 March 2017

Pheonix Builders Pty Ltd
PO Box 342
Earlwood NSW 2206

Attention: Chris Xistouris

Dear Chris,

RE: FLOOD ASSESMENT 251 ADELAIDE ST, RAYMOND TERRACE

This letter report provides a review of the existing flood conditions and identifies risks associated with flooding which may pose constraints on the potential for development of the disused quarry site at 251 Adelaide St, Raymond Terrace. The assessment updates previous reporting investigating different potential development footprints.

Background

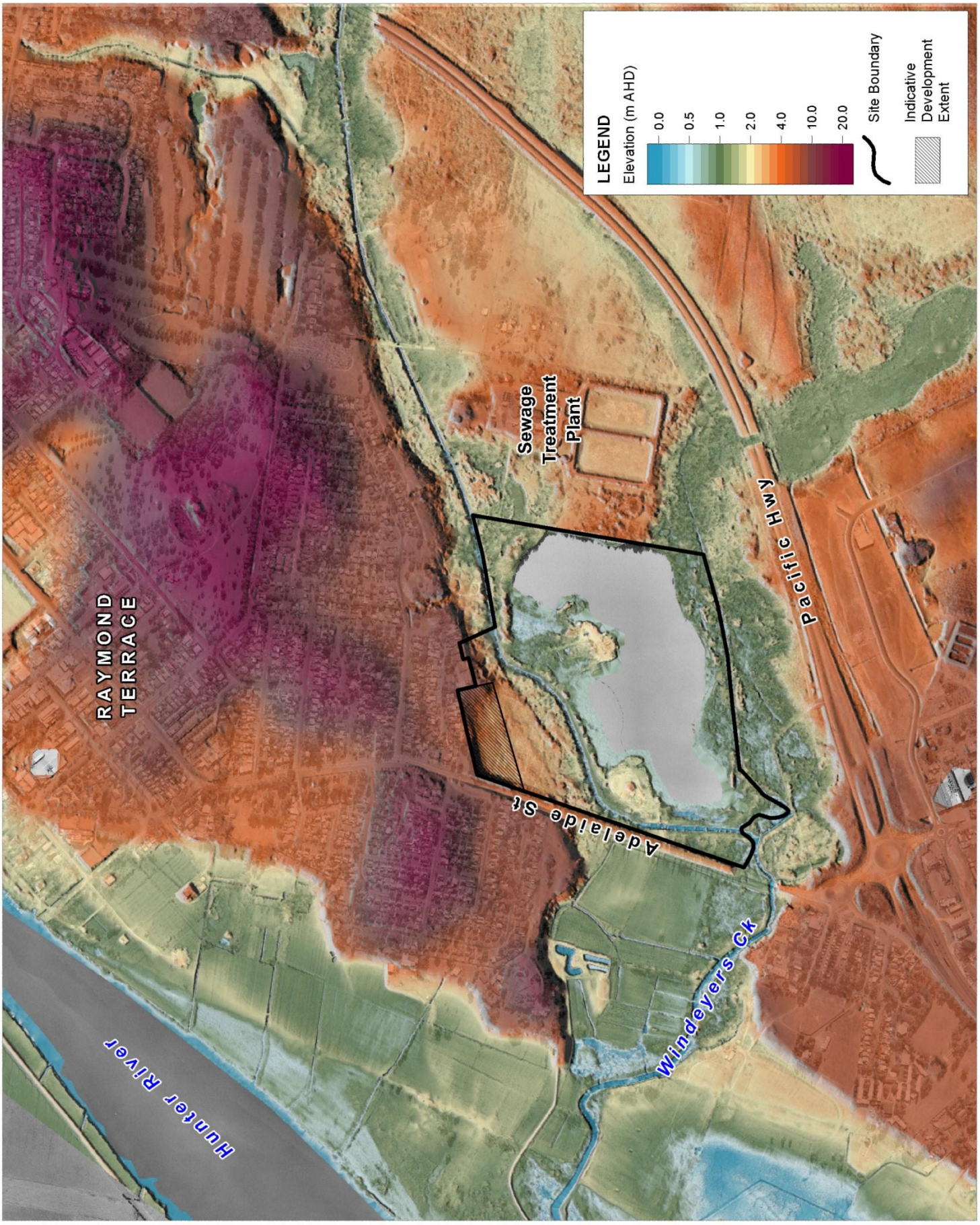
The disused quarry site at 251 Adelaide St, Raymond Terrace is located on the low-lying floodplain of Windeyers Creek, just upstream of the Hunter River. The site is positioned just south of the Raymond Terrace township and is bounded by the elevated road embankments of Adelaide Street and the Pacific Highway. A sewage treatment plant adjacent to the site is raised well above the floodplain.

Windeyers Creek is characterised by wide, low-lying swamp areas where ground levels are typically 1.0-1.5m AHD. Within the site boundary, the creek separates into two branches. The northern creek branch has been realigned into a well-defined channel running along the north and west boundaries of the site. Across the remaining site, elevations are generally below 2.5m AHD, with the exception of the north western corner of the block which is raised to around 3.0m AHD. The site boundary and local topography of the area is presented in Figure 1.

The site is subject to two flooding mechanisms:

- Backwater inundation from the wider Hunter River system; and
- Local flooding of Windeyers Creek catchment.

The site is located within the low-lying floodplain area bounded by Adelaide Street and the Pacific Highway, and provides major storage area for flooding of both Windeyers Creek and the Hunter River. There are two major flood flow paths either side of the disused quarry, being the main Windeyers Creek channel running around the north and west perimeter of the quarry lake and a secondary tributary channel along the southern perimeter. A levee is constructed along the Hunter River floodplain offering some protection from elevated water levels associated with Hunter River flood events. The proposed development at the site will be concentrated to the north-western corner, as indicated on Figure 1.



Title:
Local Topography

Figure: 1

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Model Development

The flooding constraints applicable to the site have been defined through computer modelling of typical flood behaviour. Modelling was completed for the 1% AEP event (100yr ARI), which is typically used to define flood planning levels. The lower Hunter River model (developed by BMT WBM on behalf of Port Stephens Council) defines Hunter River design flood conditions and was utilised for this assessment.

To simulate local catchment flooding of Windeyers Creek, separate hydrologic and hydraulic models were developed.

An XP-RAFTS hydrological model was developed to simulate the rate at which rainfall runs off the catchment. The amount of rainfall runoff and the attenuation of the flood wave as it travels down the catchment are dependent on:

- The catchment slope, area, vegetation and other characteristics;
- Variations in the distribution, intensity and amount of rainfall; and
- The antecedent conditions (dryness/wetness) of the catchment.

Catchment properties were determined from the high resolution (2m grid size) Digital Elevation Model (DEM) derived from LiDAR data and aerial photography. Rainfall intensity-frequency-duration values and temporal patterns were adopted in accordance with the standard procedures outlined in AR&R (2001). An initial loss of 20mm and a continuing loss of 2.5mm/hr were adopted for this study and are within the limits recommended by AR&R for a catchment in eastern NSW.

In developing the hydraulic model, BMT WBM has applied the fully 2D software modelling package TUFLOW. The 2D model has distinct advantages over 1D and quasi-2D models in applying the full 2D unsteady flow equations. This approach is necessary to model the complex interaction between rivers, creeks and floodplains and converging and diverging of flows through structures.

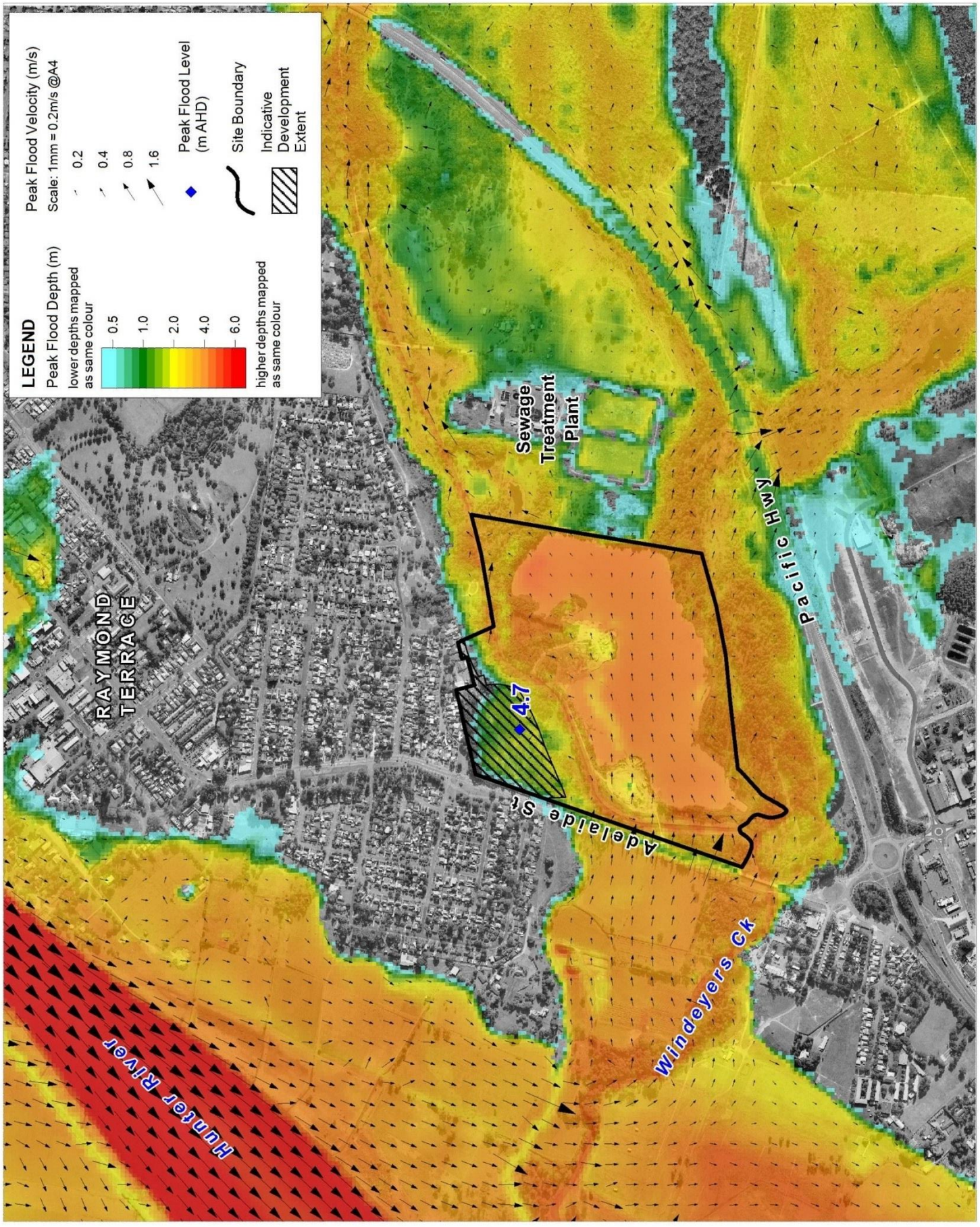
As the study area is relatively small, a high resolution model cell size (5m) was adopted, providing for an accurate representation of flow distribution over the floodplain. Key hydraulic control structures including the Pacific Highway and Adelaide Street bridges were represented as layered flow constrictions where the flow impediment influence of the abutments, piers and bridge deck is modelled. Culverts within the study area (under the Pacific Highway and through the Hunter River levee) were also included within the 2D domain as 1D structures.

Existing Flood Conditions

The inundation extents for 1% AEP flooding events including peak flood depths and velocities in the vicinity of the site are shown in Figure 2 and Figure 3 for Hunter River and Windeyers Creek flooding respectively.

The relative impacts at the site of local flooding of Windeyers Creek are far outweighed by mainstream Hunter River flooding. For the 1% AEP Hunter River flood event, there is extensive overtopping of the levee protection system, with large scale inundation extending upstream into the Windeyers Creek floodplain.

Being the dominant mechanism in terms of peak flood levels, the Hunter River flooding condition would be adopted in the derivation of flood planning levels (FPLs).



Title:

Hunter River 1% AEP Design Flood Conditions: Peak Flood Depths, Velocities and Water Levels

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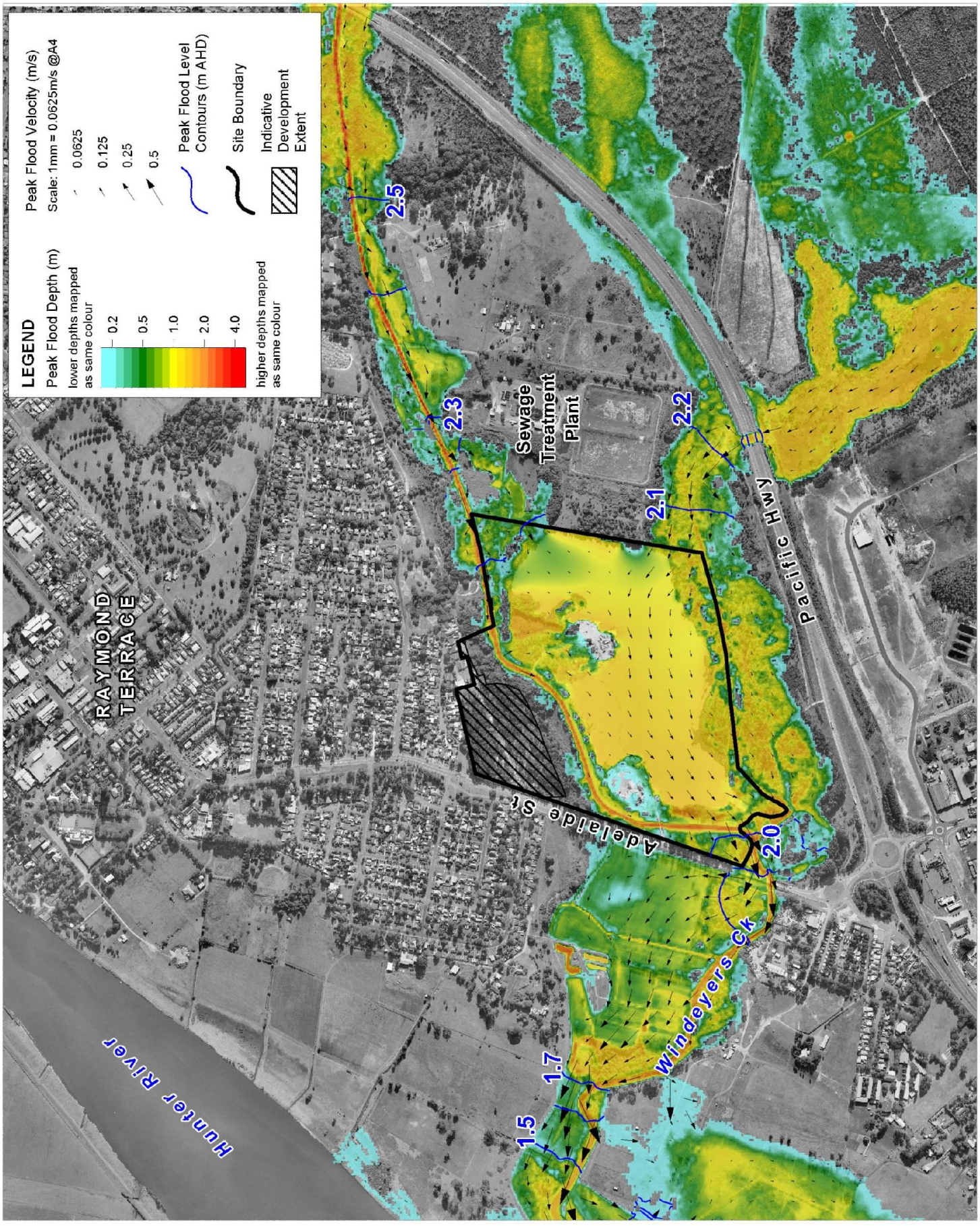

Title:

Winderyers Creek 1% AEP Design Flood Conditions: Peak Flood Depths, Velocities and Water Levels

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Existing design flood conditions for each flooding mechanism are detailed below.

Hunter River Flooding

Design flood conditions were developed for the Lower Hunter and Williams River System in the Williamtown / Salt Ash Flood Study Review (BMT WBM, 2012). Following on from the flood study, the Williamstown / Salt Ash Floodplain Risk Management Study (BMT WBM, 2017) was completed. The study involved further updates and refinement to modelling and provides the most recent definition of design flood conditions at the site.

The 1% AEP design conditions for Hunter River flooding were derived from adopting the following boundary conditions:

- Hunter River flow at Raymond Terrace, just downstream of the confluence with the Williams River. The Williams River inflow components were scaled to produce a peak flood level for the 1% AEP of ~4.8m AHD – consistent with the Flood Frequency Analysis for Raymond Terrace.
- Water level time series at the downstream boundaries of Newcastle Harbour and Tilligerry Creek. The time series are representative of 50% AEP design conditions.
- Local catchment inflows into the Hunter River, including the Windeyers Creek catchment, derived from 10% AEP design rainfall conditions. A 48 hour duration design storm was adopted as it was found to be the critical event for the catchment.

A water level time series along the Hunter River was extracted from the Williamtown / Salt Ash model and was applied at the boundary of the local model developed for this study. The finer cell resolution adopted in this study (5m grid compared to 40m grid in the former study) provided the necessary detail to compare development impacts as a result of filling the site.

For the 1% AEP flooding condition, inundation across the floodplain is extensive. Both the levee protection system and Adelaide Street are significantly overtopped. The storage area is filled and floodwaters breach over sections of the Pacific Highway. Typical depths across the site are within the order of 3.0-4.0m (refer to Figure 2), with the peak water level at approximately 4.7m AHD. The broader low-lying floodplain of Windeyers Creek provides for an extensive storage area of Hunter River derived floodwater. The elevated road embankments of both Adelaide Street and the Pacific Highway provide some level of control, however, extensive overtopping of both roads are expected at the 1% AEP Hunter River flood magnitude.

The main flow path traverses through the centre of the site across the lake, as indicated by the velocity vectors shown on Figure 2.

Local Catchment Flooding of Windeyers Creek

In order to gain a full appreciation of catchment derived flooding conditions, the local Windeyers Creek model was run without influence from Hunter River tailwater conditions. Past studies including the Williamtown / Salt Ash Flood Study adopted a tailwater condition of~ 1.2m AHD which is representative of the 50% AEP (2yr ARI) Hunter River water level. During coincident flooding events of the Hunter River and Windeyers Creek, the levee system offers significant protection against backwater inundation from Hunter River water levels up to around 2.0m AHD. Accordingly, the simulated flood conditions shown in Figure 3 are largely derived from the local Windeyers Creek catchment.

The Adelaide St road embankment acts as a major control for Windeyers Creek flooding with flow confined to the existing bridge opening (i.e. no local overtopping of Adelaide St). The resulting flood levels at the proposed development site are influenced by the backwater from the Adelaide St bridge. Upstream of the development site, the elevated Pacific Highway embankment also provides for a significant hydraulic control, particularly on the southern tributary of Windeyers Creek.

The extent of overbank inundation within the site boundary is generally maintained within the disused quarry lake area between the two Windeyers Creek branches, to the west of the elevated sewage treatment plant. Typical depths across the site are within the order of 0.5-1.5m, with the peak water level at 2.1m AHD. Velocity of floodwaters are generally less than 0.3m/s, with higher velocities (up to 1m/s) contained within the realigned Windeyers Creek channel along the northern boundary of the site. Due to the poorly defined nature of the southern creek branch, the main flood path along the southern boundary of the site is less distinct. Modelled floodwaters spill out of the natural creek channel onto the disused quarry area. The preferential flow path across the lake is indicated on Figure 3.

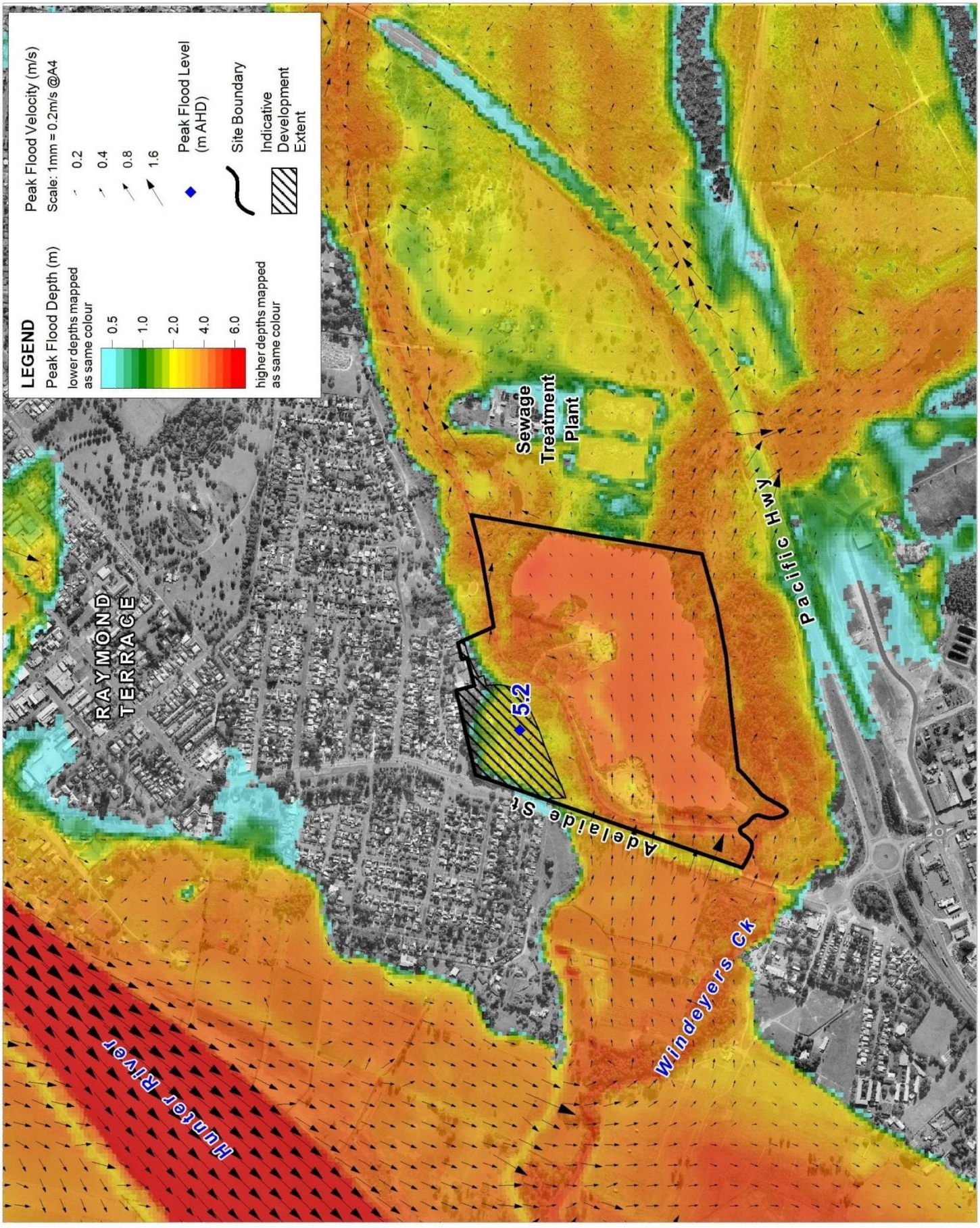
There is notable attenuation of floodwaters over the wider catchment due to the flat topography and remnant sand dunes. The local hydraulic model was developed by applying inflow boundary conditions derived from the XP-RAFTS hydrological model at selected locations. Due to the flooding behaviour of the wider floodplain, the inflows derived from the XP-RAFTS model are expected to be slightly higher than what would realistically occur as some attenuation outside the model domain is not explicitly accounted for. The results found in this study are conservative and would represent the maximum peak flood level likely across the site. Previous model results from the Williamtown Salt Ash Flood Study (WBM Oceanics, 2004) indicated that 1% AEP flooding of Windeyers Creek resulted in peak flood levels at the site of 1.9m AHD. Therefore, it is appropriate to assume that peak flood conditions in the order of 1.9-2.1m AHD should be expected at the site for the 1% AEP event.

Development Potential

In considering the impact of flood conditions on potential development, the Hunter River conditions will drive the required flood planning level (FPL). The Williamtown / Salt Ash FRMS (BMT WBM, 2017) was in part prepared to inform Council of the likely changes in flood behaviour within the study area that may arise through future climate change conditions, particularly in relation to flood planning levels. Following completion of the study, Council has adopted the 1% AEP Hunter River design event including a 0.9m sea level rise allowance and 20% increase in flow (indicative 2100 planning horizon) to define flood planning levels. A similar 20% increase in design rainfall intensity is applied to the local Windeyer's Creek catchment.

The peak flood inundation extents and depths for the 1% AEP flood planning event for Hunter River and Windeyers Creek flooding are shown in Figure 4 and Figure 5 respectively.

A summary of the simulated peak water levels for existing and flood planning conditions (2100 planning horizon) is shown in Table 1. At the site, the peak flood level for the appropriate flood planning event is 5.2m AHD. An additional allowance for freeboard is required for certain types of development. For residential development, a freeboard of 0.5m is typically required. This would provide for a FPL of 5.7m AHD for habitable floor levels at the site.



Title:

Hunter River 1% AEP 2100 SLR & 20% Rainfall Increase: Peak Flood Depths, Velocities and Water Levels

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Approx. Scale

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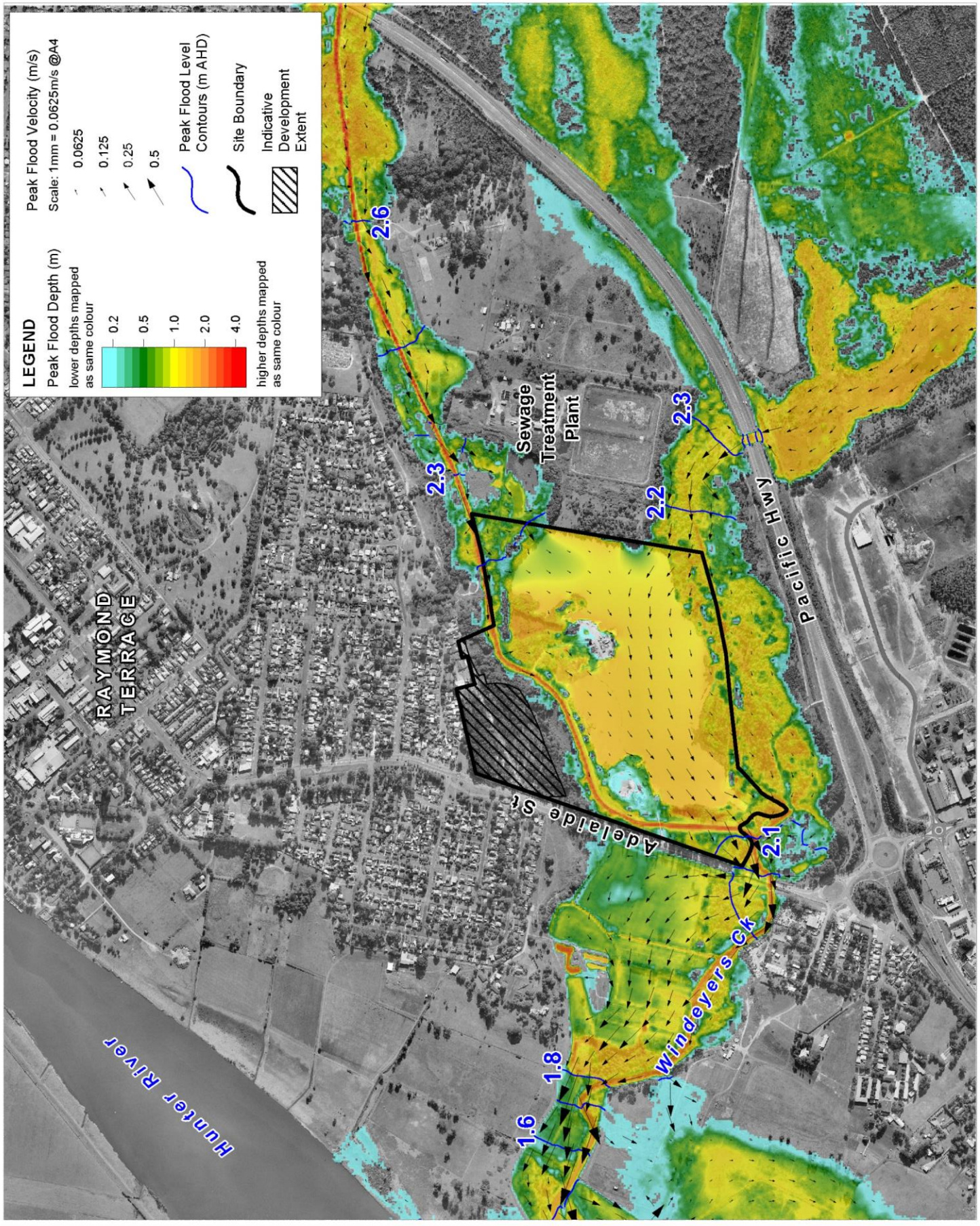

Title:

Winderyers Creek 1% AEP 20% Rainfall Increase: Peak Flood Depths, Velocities and Water Levels

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Table 1 Peak Flood Levels at 251 Adelaide St, Raymond Terrace

Flooding Mechanism	Peak flood level (m AHD)
Hunter River 1% AEP (BMT WBM, 2017)	4.7
Hunter River 1% AEP 2100 planning horizon w/ 0.9m SLR and 20% increase in flow (BMT WBM, 2017)	5.2
Windeyers Creek 1% AEP	2.1
Windeyers Creek 1% AEP 2100 planning horizon with 20% increase rainfall	2.2

As the majority of the site is elevated below 2.5m AHD, an extensive amount of fill would be required to provide flood immunity to the 1% AEP flood level and is indicative of the severity of flooding affecting the area and suggests that stringent controls would apply to any proposed development in this location. Preliminary investigation into flood constraints at the site indicated that filling of a large, central portion of the site was not viable due to potential for changes to existing flood conditions through:

- Redistribution of flow arising from works on the floodplain;
- Concentrated discharges and subsequent impact on downstream areas; and
- Increase in flood levels through impedance of overland flow paths and loss of temporary flood storage.

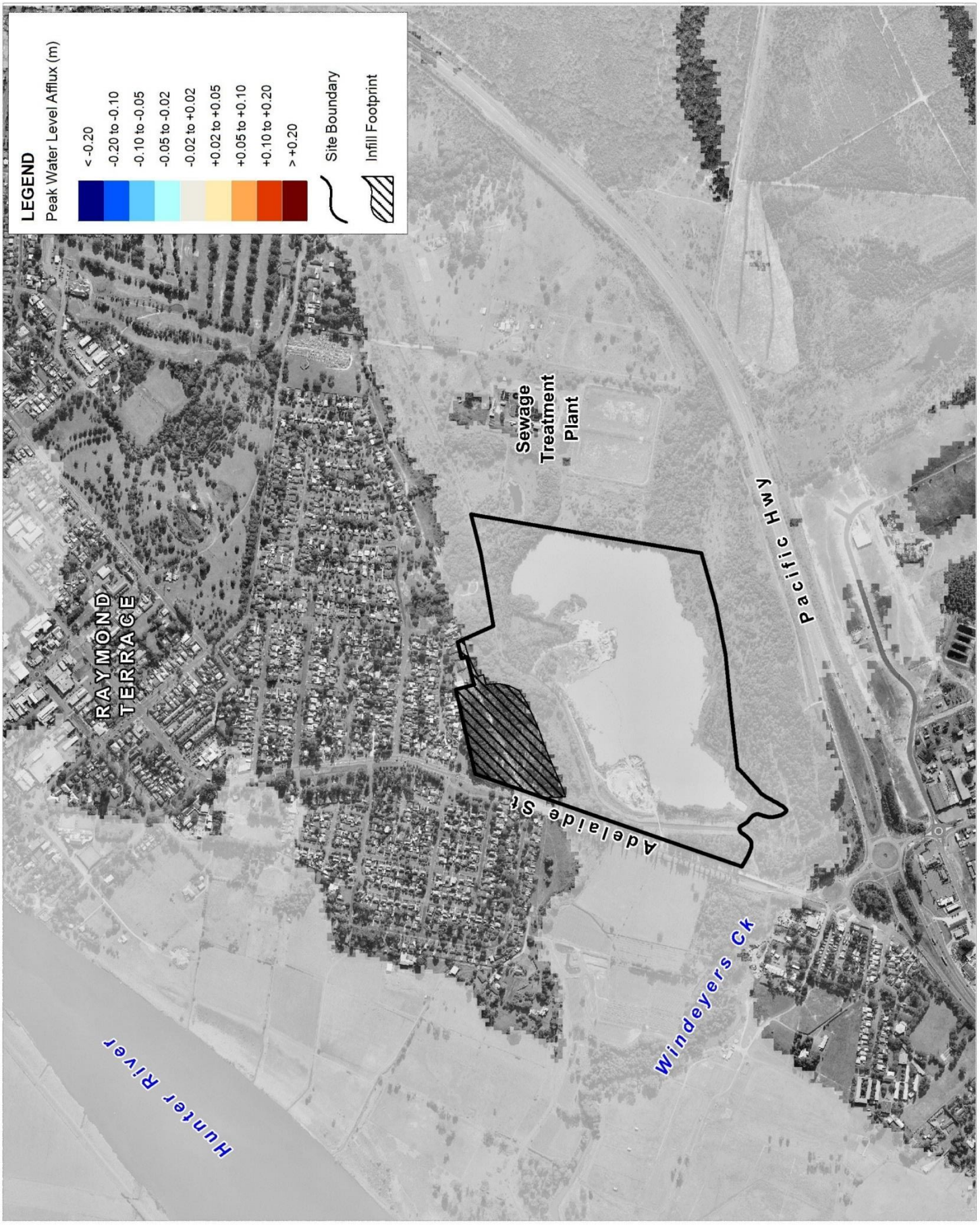
As a consequence of the preliminary investigation, this current study is focused on filling the north-western portion of the site only. The assessment will assume the parcel of land indicated as having development potential to above the peak 1% AEP flood level. This represents the exclusion of all existing flood storage within the fill footprint.

It should be noted that the proposed development extent is outside of the 1% AEP Windeyers Creek flood inundation extent (refer to Figure 5). Therefore, impacts will be assessed for Hunter River derived flooding only. This assessment is focused on identifying the opportunity for development based on the flooding constraints and potential flood impacts. The assessment has not considered other design constraints such as environmental constraints, construction practicalities, planning approvals etc.

Flood Impact Assessment

The proposed development layout is included in Appendix A for reference. Within the model the development footprint area, ground levels have been raised above the adopted FPL for habitable dwellings (i.e. 5.7m AHD).

The simulated change in peak flood level and peak flood velocity for the proposed fill footprint is shown in Figure 6 and Figure 7 respectively. In both instances, there are no significant impacts on existing flood water level and velocity distributions for the proposed fill footprint.



Title:

Flood Impact Assessment - Peak Water Level Afflux: Hunter River 1% AEP 2010 SLR & 20% Rainfall Increase

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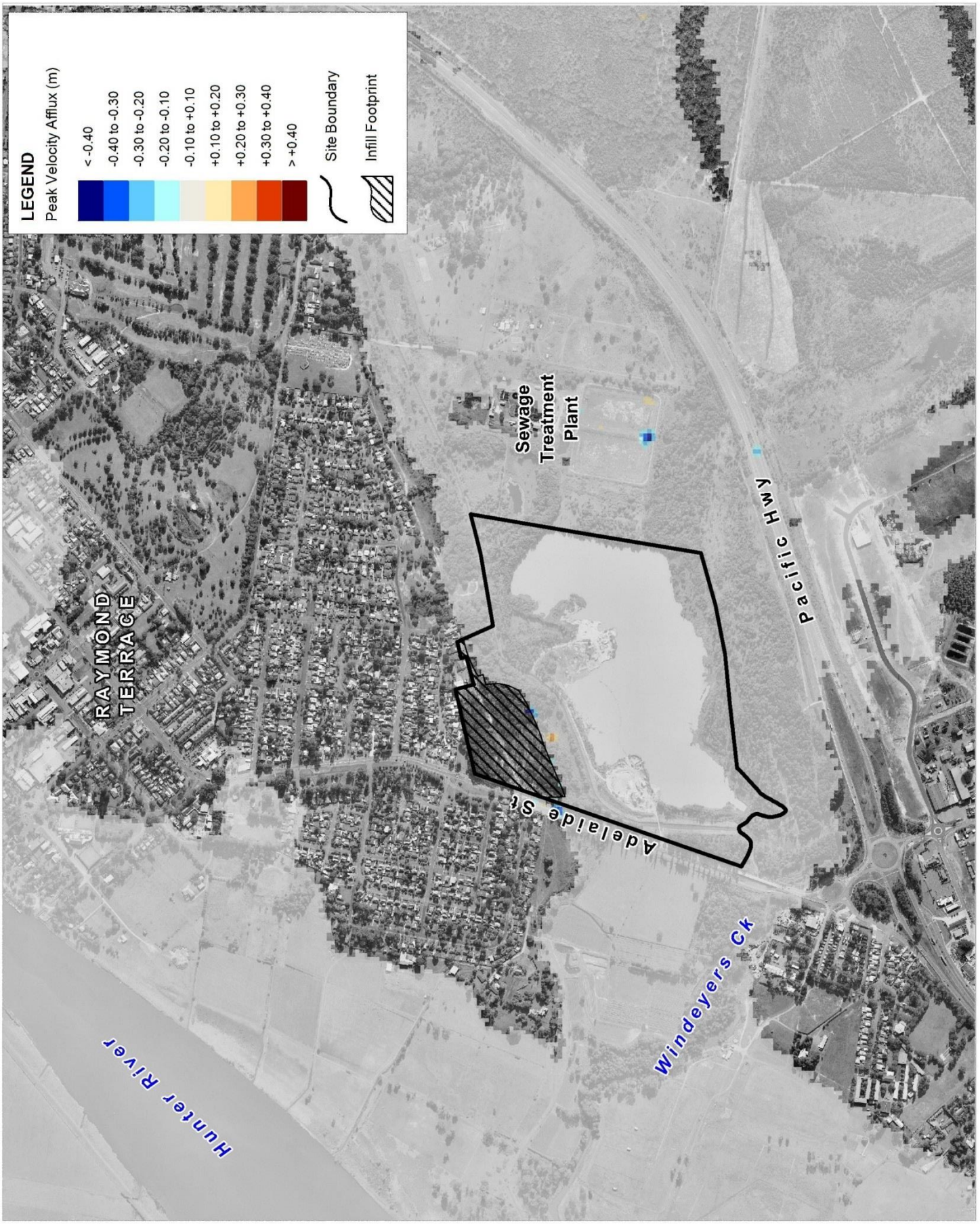

Title:

Flood Impact Assessment - Peak Velocity Afflux: Hunter River 1% AEP 2010 SLR & 20% Rainfall Increase

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The proposed development area is located on the fringe of the 1% AEP Hunter River flood inundation extent, where velocities are minor (less than 0.1m/s) and depths are typically in the order of 1-2m. Residential development located to the north-west of the site on the opposite side of Adelaide Street (Wahroonga Street and Parkway Avenue area) is elevated well above the floodplain and offers protection to the proposed development area from Hunter River flooding. As such, the results of the flood impact assessment show that there will be negligible impact to existing 1% AEP design flood conditions at the site as a result of filling the north-western corner out of the floodplain. Increases in peak flood levels and velocities are less than 5mm and 0.05m/s. respectively.

The flood impact assessment has only considered the proposed fill footprint for the proposed dwellings (raised to the FPL). At this stage of the development design, there is no detail of the proposed access road that runs from Adelaide Street through to the development lots. The access road traverses the flood inundation area under both Hunter River and Windeyers Creek flood conditions (refer to Figure 4 and 5). The road elevations and cross drainage provisions will need to be designed to meet the objectives for access road flood immunity and minimising potential adverse impacts through elevated road profiles.

Other Considerations

In assessing the development potential site there are a number of other considerations with respect to flooding including:

- Risks to life considered for flood events up to the PMF;
- Flood warning; and
- Emergency response and flood access.

Whilst these aspects have not been considered in detail to date, the following comments are offered. The Hunter River flooding is noted as the dominant flooding mechanism and far exceeds the Windeyers Creek flooding in terms of severity. Accordingly, the design standards for any proposed development on the site is based on peak Hunter River flood levels. With regards the other design considerations noted above, it is important to note that flooding of the wider Hunter / Williams River system has a very long warning time (likely to be days), with flood waters rising slowly as a result of the large contributing catchment area. Accordingly, it is envisaged that existing formal flood warning and emergency procedures for the Hunter River would serve proposed development at the site for flood events in excess of the 1% AEP design standard.

I trust the above provides a suitable description of the opportunity and constraints for development at the subject site. Please feel free to contact the undersigned to discuss further as required.

Yours Faithfully
BMT WBM

Darren Lyons
Water & Environment Manager – Newcastle

References:

BMT WBM (2012) Williamtown / Salt Ash Flood Study Review, prepared for Port Stephens Council

BMT WBM (2017) Williamtown-Salt Ash Floodplain Risk Management Study and Plan (in preparation), prepared for Port Stephens Council

Appendix A – Proposed Development Layout