SANDY SHORES DEVELOPMENT PTY LTD

SANDY BEACH NORTH RESIDENTIAL DEVELOPMENT

FLOOD IMPACT ASSESSMENT

Issue No. 5
FEBRUARY 2009

WorleyParsons
resources & energy

Patterson Britton
& Partners Pty Ltd
consulting engineers

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Document Amendment and Approval Record

Issue	Description of Amendment	**Prepared by** [date]	**Verified by** [date]	**Approved by** [date]
1	Draft Report - Issued for Client Review	JMH (*21/4/04*))		
2	Final Draft Report	JMH/CRT (*24/1/05*)	CRT (*31/1/05*)	
3	Final Report	CRT (*18/10/05*)	BMD [*20/10/05*]	CRT [*2/11/05*]
4	Amended to incorporate revised development layout and to address climate change issues	CRT/WJH [10/10/08]		Chris Thomas [31/10/08]
5	Amended Final Report to address editorial comments raised in DoP letter dated 4/2/09	CRT [22/2/09]		Chris Thomas [22/2/09]

Note: This document is preliminary unless it is approved by a principal of Patterson Britton & Partners.

Document Reference: rp5319_00crt_wjh081010-Sandy Beach Nth FIA
Time and Date Printed: **2:25 pm 31st October 2008**

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1 INTRODUCTION

Sandy Shores Development Pty Ltd (*Sandy Shores*) plans to develop a 49 hectare (*ha*) parcel of land near Sandy Beach on the North Coast of New South Wales. The site is located adjacent to the Pacific Highway, about 20 kilometres north of Coffs Harbour. It is referred to as Lot 22 in DP 1070182 and adjoins the northern boundary of the existing residential area of Sandy Beach. As shown in **Figure 1**, the site also adjoins the southern shoreline of Hearns Lake and extends to the rear of the back beach dune along Hearns Lake Beach.

Hearns Lake is an Intermittently Closed and Open Lake or Lagoon (*ICOLL*) which drains to the ocean at the northern end of Hearns Lake Beach. An oblique aerial view of the lake showing the ocean entrance in its partially 'closed' state is shown overleaf in **Plate 1**. The lake has a surface area of about 15 hectares and is fed by catchment runoff that is discharged to the lake via Double Crossing Creek (*refer* **Figure 1**). The lake is usually closed to the ocean but opens following significant rainfall in the catchment.

The development site extends around the southern shoreline of Hearns Lake and comprises coastal heath that is currently used for grazing and which has previously been mined for rutile. Sandy Shores plans to develop the land and create up to 280 residential lots within an integrated landscape comprising a balanced mix of open space, leafy streetscapes and gardens, and set within a restored coastal landscape.

As shown in **Figure 2**, Double Crossing Creek and Hearns Lake form the northern boundary of the site. Double Crossing Creek drains a 526 ha catchment that extends to the west of the Pacific Highway and discharges into Hearns Lake.

During major storms, there is potential for floodwaters to overtop the banks of Double Crossing Creek and Hearns Lake, and inundate low lying areas of the development site. The potential for inundation varies as a function of one or a combination of the following:

- the frequency of the storm that causes flooding of Double Crossing Creek;
- the entrance conditions at the mouth of Hearns Lake; and,
- the ocean water level at the time of catchment flooding.

Coffs Harbour City Council's *Flood Policy* is outlined in a document titled, *'Potentially Flood Prone Land Information Sheet'* (*October 2002*). This is available from Council's website and indicates that each of the floodplains within the local government area can be divided based on differing levels of flood hazard. Low, medium and high Flood Risk Precincts have been determined for the floodplain of Coffs Creek. However, Flood Risk Precincts have not been defined for other areas within the LGA.

Notwithstanding, the Information Sheet indicates that, in the interim, the controls specified for the Coffs Creek floodplain should be applied elsewhere within the LGA.

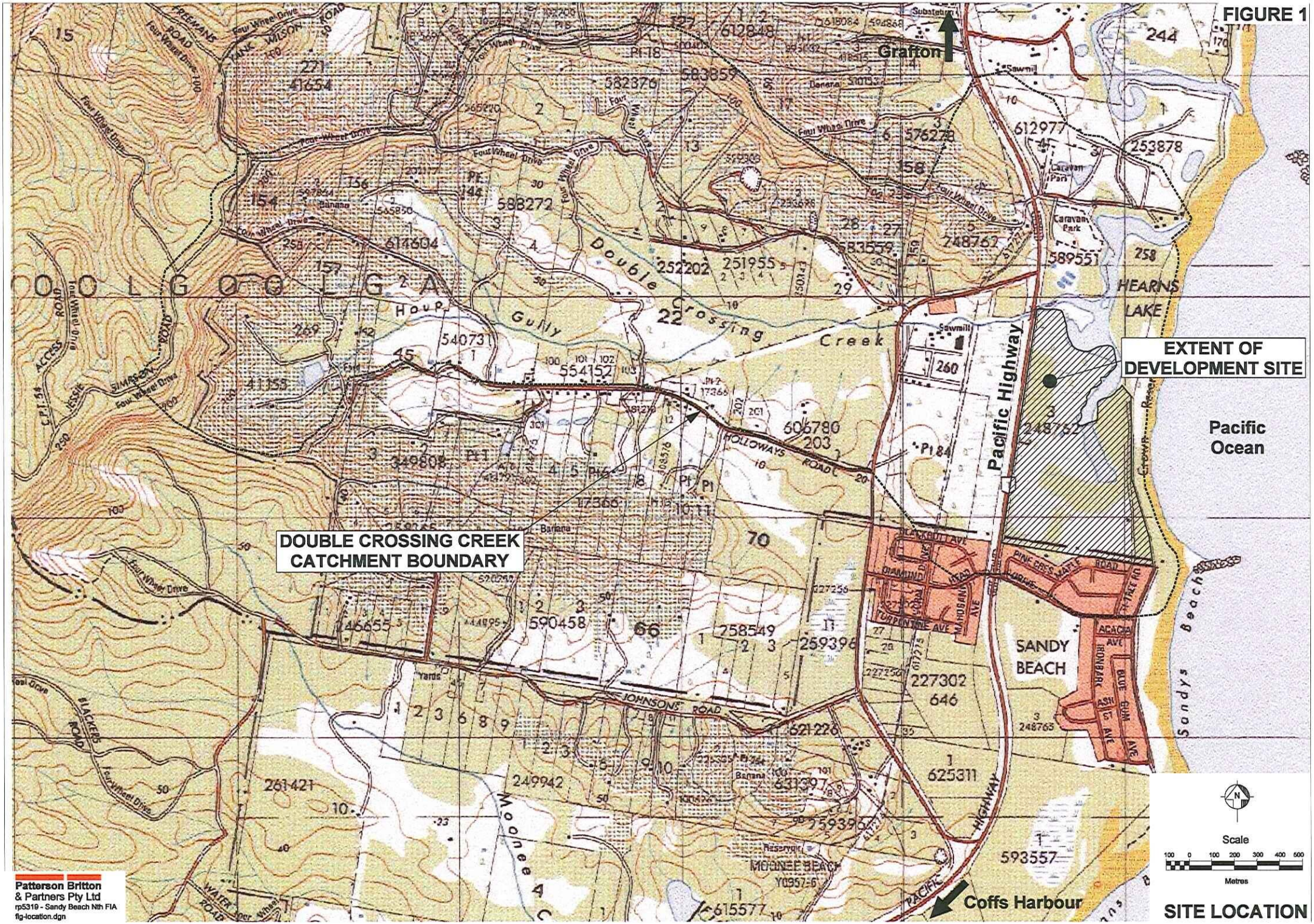

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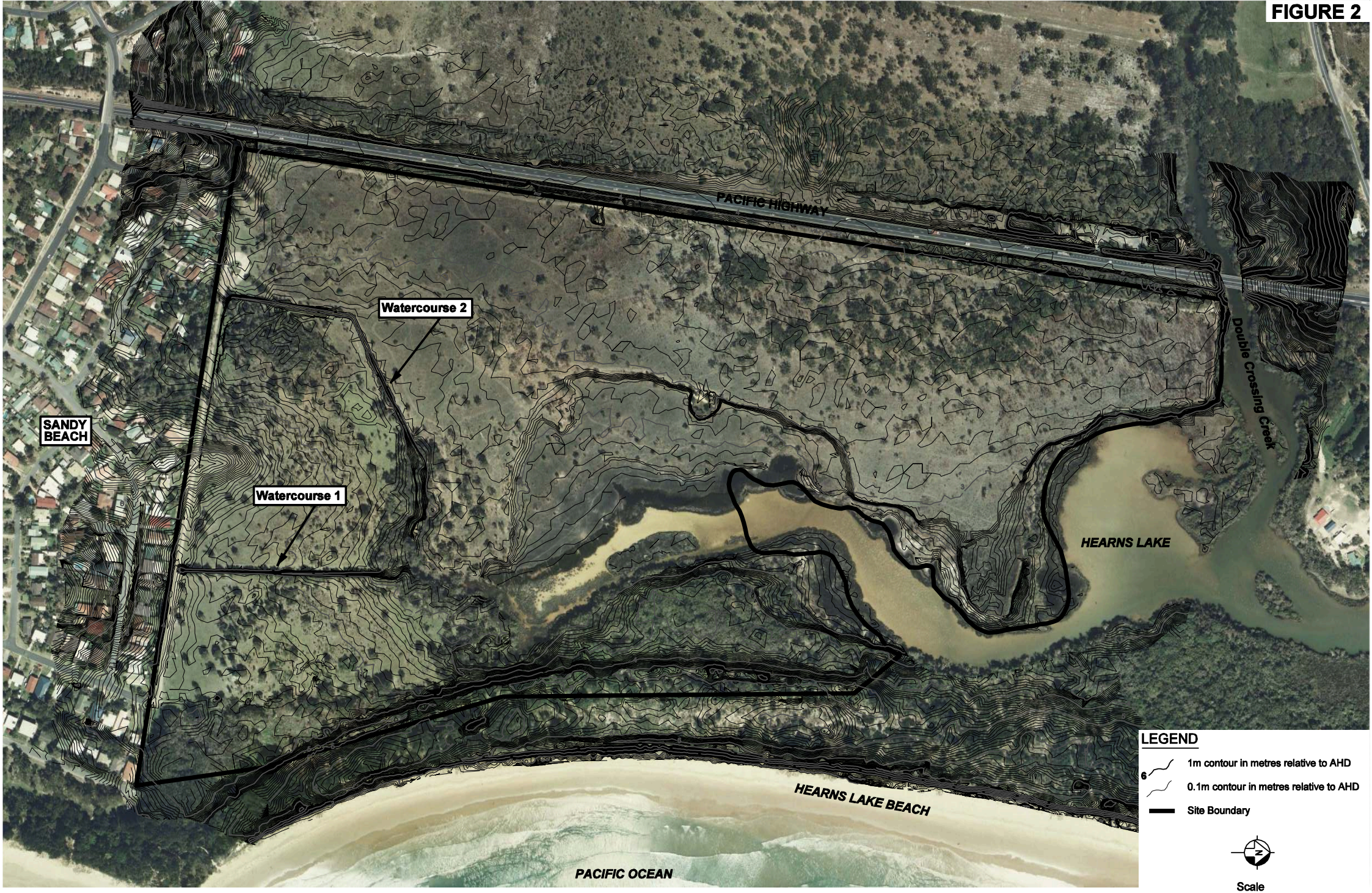
FIGURE 2



LEGEND

- 6 — 1m contour in metres relative to AHD
- 0.1m contour in metres relative to AHD
- Site Boundary

Scale

25 0 25 50 75 100 125

Metres

EXISTING SITE TOPOGRAPHY

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Plate 1 OBLIQUE AERIAL VIEW OF HEARNS LAKE SHOWING THE PARTIALLY CLOSED OCEAN ENTRANCE AND EXTENT OF THE DEVELOPMENT SITE.

Therefore, based on the Policy, residential dwellings can only be constructed on land that has a low or medium flood risk. In addition, all habitable rooms must be constructed with floor levels that are a minimum of 500 mm above the predicted peak 100 year recurrence flood level.

Accordingly, Sandy Shores engaged Patterson Britton & Partners (*now WorleyParsons*) to undertake the necessary investigations required to determine the 100 year recurrence flood level at the site and to identify the associated flood extent.

Sandy Shores also plans to fill selected areas of the development site that are subject to Low Flood Risk and thereby increase the area of land that is available for dwelling construction. Filling of the site will effectively eliminate the potential for inundation from floodwaters that would currently overtop the banks of Hearns Lake and Double Crossing Creek. It would therefore reduce the flood risk and allow development in accordance with Council's *Flood Policy*.

However, the proposed filling will also remove a proportion of the flood storage currently afforded by the low lying areas that adjoin the lake. Therefore, the proposed development has the potential to increase peak flood levels and could adversely impact on adjacent properties.

Accordingly, Sandy Shores requested that Patterson Britton & Partners investigate the potential for the proposed filling to adversely impact on flood behaviour and to determine the optimal fill for areas of the site proposed for development.

The results of these investigations were documented in an earlier version of this report (*Issue No.3, November 2005*). The previous report was incorporated into an Environmental Assessment Report (*EA*) for the residential development that is proposed for the site. The EA was prepared to address the requirements of the Director General of the NSW Department of Planning which were issued on 20th October 2006.

In March 2008, the Department of Planning issued a Supplementary Director-General's Requirement. The supplementary DGR is referred to as Item 7.7 and states that:

> A risk management assessment of climate change impacts to the year 2100 is to be undertaken using the latest available information from the International Panel on Climate Change (*IPCC*), the Department of Environment and Climate Change (*DECC*) and the CSIRO. This should include sensitivity analyses for low level, mid range and high level ocean impacts as set out in the DECC Floodplain Risk Management Guideline titled *'Practical Consideration of Climate Change'*.

In recognition of this, Sandy Shores requested that additional investigations be undertaken to address the Supplementary DGR. The results of these additional investigations are documented in a report prepared by Patterson Britton & Partners (*now a part of WorleyParsons*) titled, *'Climate Change Assessment for Proposed Development at Sandy Beach North'* (*Issue No.3, February 2009*).

The key findings from that report are documented in **Section 4**. They indicate that the peak 100 year recurrence flood level at Hearns Lake could increase by up to 350 mm by the Year 2100 due to climate change impacts.

Accordingly, the proposed Sandy Shores development has been modified to incorporate a design layout and fill scenario based on the adoption of a Year 2100 design 100 year recurrence flood level that incorporates the projected increase in peak flood level due to climate change.

The following report is based on the Flood Impact Assessment that was prepared in 2005, but incorporates the findings of additional modelling to assess the potential for the revised development layout and site filling to adversely impact on flood behaviour.

2 PREVIOUS INVESTIGATIONS

A previous investigation into the potential for flooding of Hearns Lake and Double Crossing Creek was undertaken in 1982 by Antony Tod & Partners (Mid North Coast) Pty Ltd. The investigation led to the production of a flood study which was incorporated within a local environmental study for the area. The flood study is documented in a report titled, *'Hearns Lake / Double Crossing Creek Local Environment Study – Flood Investigation and Report on Water Supply, Sewerage and Water Pollution'* (*1982*).

The study area for the investigation was bound by the village of Sandy Beach to the south, the sand dunes to the east, Graham Drive (*referred to in the report as the 'Old Pacific Highway'*) and Flat Top Point. This area includes the Sandy Beach North development site.

A hydrologic analysis was undertaken as part of the investigation to determine peak design flows for the Double Crossing Creek / Hearns Lake system for the 20 and 100 year recurrence design storm events. The analysis was based on the Cordery Webb Method which was used to derive unit hydrographs and subsequent design flood hydrographs at the Graham Drive and Pacific Highway crossings of Double Crossing Creek. The peak flow at the Pacific Highway Crossing was determined to be 67 m^3/s and 92 m^3/s for the 20 and 100 year recurrence floods, respectively.

A hydraulic model of Double Crossing Creek was also developed using the HEC-2 software package. The model was based on cross-sections of Double Crossing Creek and extended along the lower reaches of the creek from the Graham Drive crossing to the ocean entrance. Ocean levels at the mouth of Hearns Lake were adopted as the downstream boundary conditions for the hydraulic model. Ocean levels of 1.8 and 2.4 mAHD were used for the 20 and 100 year recurrence catchment events, respectively.

The hydrologic and hydraulic models were used to estimate peak flood levels within Hearns Lake. The 20 and 100 year recurrence flood levels were determined to be 2.2 and 2.6 mAHD, respectively.

The results of the modelling indicated that flooding due to a design 100 year recurrence storm over the catchment would generally be limited to the creek channel. Notwithstanding, some minor inundation was predicted in low lying overbank areas around Hearns Lake.

However, the hydrologic analysis was based on rainfall data that pre-dates the 2nd edition of *'Australian Rainfall & Runoff – A Guide to Flood Estimation'*. This document was published in 1987 and outlines procedures for flood estimation and defines design rainfall intensities across Australia. It replaced the 1st edition which was published in 1977.

The design rainfall intensities published in *Australian Rainfall & Runoff* are based on extensive recorded rainfall data. The additional data gathered over the 10 years between the 1st and 2nd editions indicated a general trend for design rainfall intensities across eastern Australia to be higher than those published in 1977. As a result, the application of procedures outlined in the 2nd edition typically results in higher design rainfall intensities than for the 1st edition.

Therefore, the Antony Tod & Partners report is based on hydrologic analysis that used design rainfall intensity data that is outdated.

More importantly, as design rainfall intensities have increased, it was considered that the Antony Tod & Partners Report is likely to underestimate peak flood discharges entering Hearns Lake. Accordingly, it is considered appropriate to revisit the catchment hydrology to establish peak design flood levels for the lake.

3 ASSESSMENT OF EXISTING FLOOD BEHAVIOUR

3.1 DESCRIPTION OF THE EXISTING DEVELOPMENT SITE

The development site is located on the eastern side of the Pacific Highway about 3 kilometres south of the North Coast town of Woolgoolga (*refer* **Figure 1**). It is situated immediately north of the village of Sandy Beach and covers all of the land between the Pacific Highway and Hearns Lake Beach. As shown in **Figure 2**, the southern shoreline of Hearns Lake effectively forms the northern boundary of the site.

Hearns Lake is an Intermittently Closed and Open Lake or Lagoon (*ICOLL*) which drains to the ocean at the northern end of Hearns Lake Beach (*refer* **Plate 1** *on page 2*). The lake has a surface area of about 15 hectares and is fed by catchment runoff that is discharged to the lake via Double Crossing Creek (*refer* **Figure 1**).

The development site has a total area of 49 ha. It's current zoning varies and includes areas zoned 2A Residential (*low density*), 2E Tourist, 7A Environmental Protection Habitat and Catchments, and 7B Environmental Protection / Scenic Buffer.

The existing vegetation across the site varies from open pasture to more densely vegetated creek and lake shorelines. There is also a corridor of dense vegetation that extends along the back of the dune system that adjoins Hearns Lake Beach.

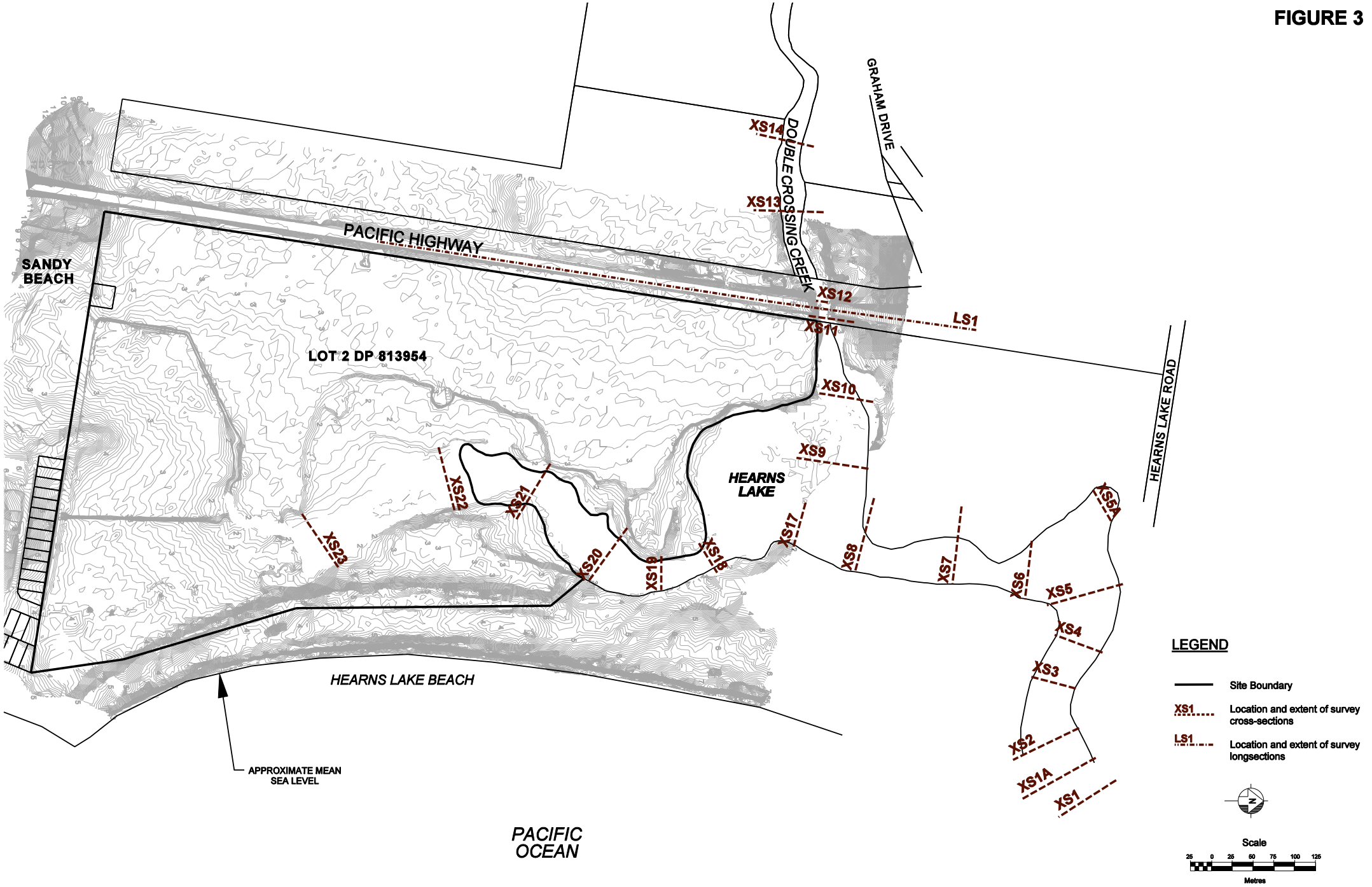
Consulting Surveyors, Asquith & de Witt Pty Ltd, have developed a contour plan of the site based on detailed photogrammetric survey. The contour plan is presented as **Figure 2** and shows contours of natural surface at 0.1 metre intervals. Interpretation of these contours indicates that the existing surface elevation across the development site varies between 0.8 mAHD near the Hearns Lake shoreline to 6 mAHD along the rear of the dunes that adjoin the eastern boundary of the site (*refer* **Figure 2**).

The western portion of the site can be characterised as a sparsely vegetated coastal plain. The land in this area has a typical grade of less than 1% and generally slopes from the Pacific Highway toward Hearns Lake.

The southern area of the site is steeper but only rises to an elevation of about 5.5 mAHD. This area drains to two open channels that flow in a northerly direction and discharge runoff to Hearns Lake. These channels are man made and are understood to have been constructed in the 1980s.

Hydrographic survey of Hearns Lake and Double Crossing Creek was also undertaken by Asquith & de Witt. The location and extent of the surveyed cross-sections are shown in **Figure 3**. Based on this survey, the top-of-bank elevation of Hearns Lake is estimated to be 1.3 mAHD. The data shows that at the time of the survey in June 2004, the lake had a water level of 1.35 mAHD.

FIGURE 3



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LOCATION AND EXTENT OF SURVEY CROSS-SECTIONS

3.2 HYDROLOGIC ANALYSIS

3.2.1 Catchment Description

The catchment draining to Hearns Lake is shown in **Figure 1**. It has an area of 650 ha and extends about 6 kilometres west from the coast to Jessie Simpson Drive. The catchment rises to an elevation of over 230 metres above sea level and is characterised by steeply sloping valley walls in the upper half which give way to a flat valley floor that extends to an estuarine floodplain. The steeper western half of the catchment comprises extensive areas of banana plantations. These areas are typically at grades of 1 (V) in 3 (H).

The catchment is drained by two major watercourses that join approximately midway through the catchment near the 10 metre contour. Houp Gully is the smaller of these tributaries and drains the southern half of the catchment. It flows in an easterly direction from the downstream side of a farm dam that services one of the banana plantations.

Houp Gully is joined by a smaller creek that drains a small sub catchment that extends to the north-western corner of the valley.

Double Crossing Creek is the major tributary in the catchment. It primarily drains the northern section, but as discussed above is joined midway through the catchment by Houp Gully. Below its confluence with Houp Gully, Double Crossing Creek runs across a flat coastal plain before discharging into Hearns Lake just below the Pacific Highway. Between the Houp Gully confluence and Hearns Lake, Double Crossing Creek is crossed by Graham Drive and the Pacific Highway.

Hearns Lake is situated behind the coastal dunes along Hearns Lake Beach. It is orientated approximately north-south and receives runoff from a number of minor tributaries in addition to the larger catchment flows from Double Crossing Creek. Under normal conditions, the entrance to Hearns Lake is closed, being effectively "blocked" by the beach berm.

As shown in **Figure 1**, the development site is situated east of the Pacific Highway and adjoins the southern shoreline of Hearns Lake.

3.2.2 Hydrologic Model Development

The Runoff Analysis and Flow Training Simulation (*RAFTS-XP*) software was employed to develop a hydrologic model of the Double Crossing Creek catchment. The RAFTS model was used to analyse runoff processes and determine an estimate of the peak flow at the development site for the 20 and 100 year recurrence floods.

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'* (*1987*) as one of the available tools for use in flood routing within Australian catchments. Importantly, it can account for the impact of urban development and therefore provides a more reliable estimate of peak discharge than does the more empirical Probabilistic Rational Method.

The RAFTS model was developed using the physical characteristics of the catchment including catchment area, slope, percentage impervious area and extent of vegetation cover.

The catchment was delineated using contours provided in 1:25000 series topographic mapping and the available 1:4000 series orthophoto mapping covering the lower reaches of the catchment. Sub catchment boundaries were determined based on the local topography, alignment of roads and four wheel drive tracks, the position of hydraulic controls such as bridges, and the locations of major creek confluences.

Seventeen sub catchments were identified as contributing inflow into Hearns Lake. These sub catchments and the adopted node and link arrangement for the RAFTS model are shown in **Figure 4**.

Catchment L was further subdivided into 25 smaller sub catchments to enable a detailed assessment of drainage behaviour through the development site. Sub catchments across the site were defined using 0.1 metre contours obtained from the detailed photogrammetric survey undertaken over the site area.

The sub catchments and the RAFTS model layout in the vicinity of the development site are shown in **Figure 5**. A summary of adopted sub catchment parameters is enclosed in **Appendix A**.

Storm rainfall data for design events was generated by applying the principles of rainfall intensity estimation and design temporal distributions outlined in *'Australian Rainfall and Runoff – A Guide to Flood Estimation'* (*1987*). These procedures were used to determine intensity-frequency-duration (*IFD*) data for the Hearns Lake catchment. A summary of the adopted IFD data is enclosed in **Appendix B**.

All standard storm events were analysed to determine the critical duration storm for the catchment. The critical storm duration was assumed to corresponds to the storm that results in the largest peak discharge at the ocean entrance.

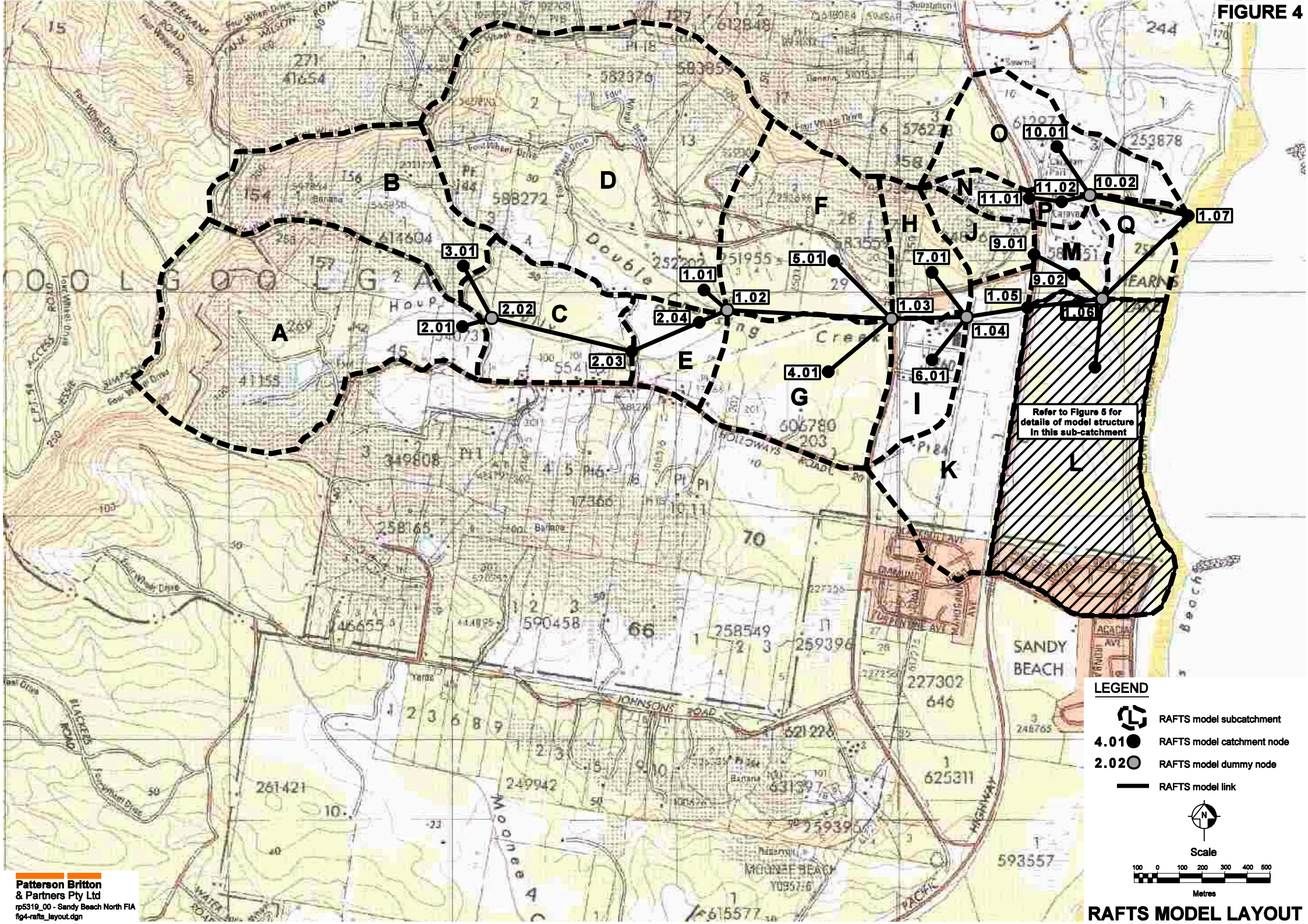
The critical storm duration for all design events was determined to be 120 minutes.

3.2.3 Predicted Peak Discharges

The RAFTS model was used to simulate design 20 and 100 year recurrence storms across the catchment. Selected peak discharges generated from the RAFTS modelling are listed in **Table 1**. These correspond to model nodes located at or near the site (*refer* **Figures 4** *and* **5**). Output files from the RAFTS modelling are enclosed in **Appendix C**.

The Graham Drive and Pacific Highway bridge crossings correspond to RAFTS model nodes 1.03 and 1.05, respectively. The peak flows determined at these locations and the flows determined by Antony Tod & Partners (Mid North Coast) Pty Ltd for 1982 Flood Study are compared in **Table 2**.

FIGURE 4



RAFTS MODEL LAYOUT

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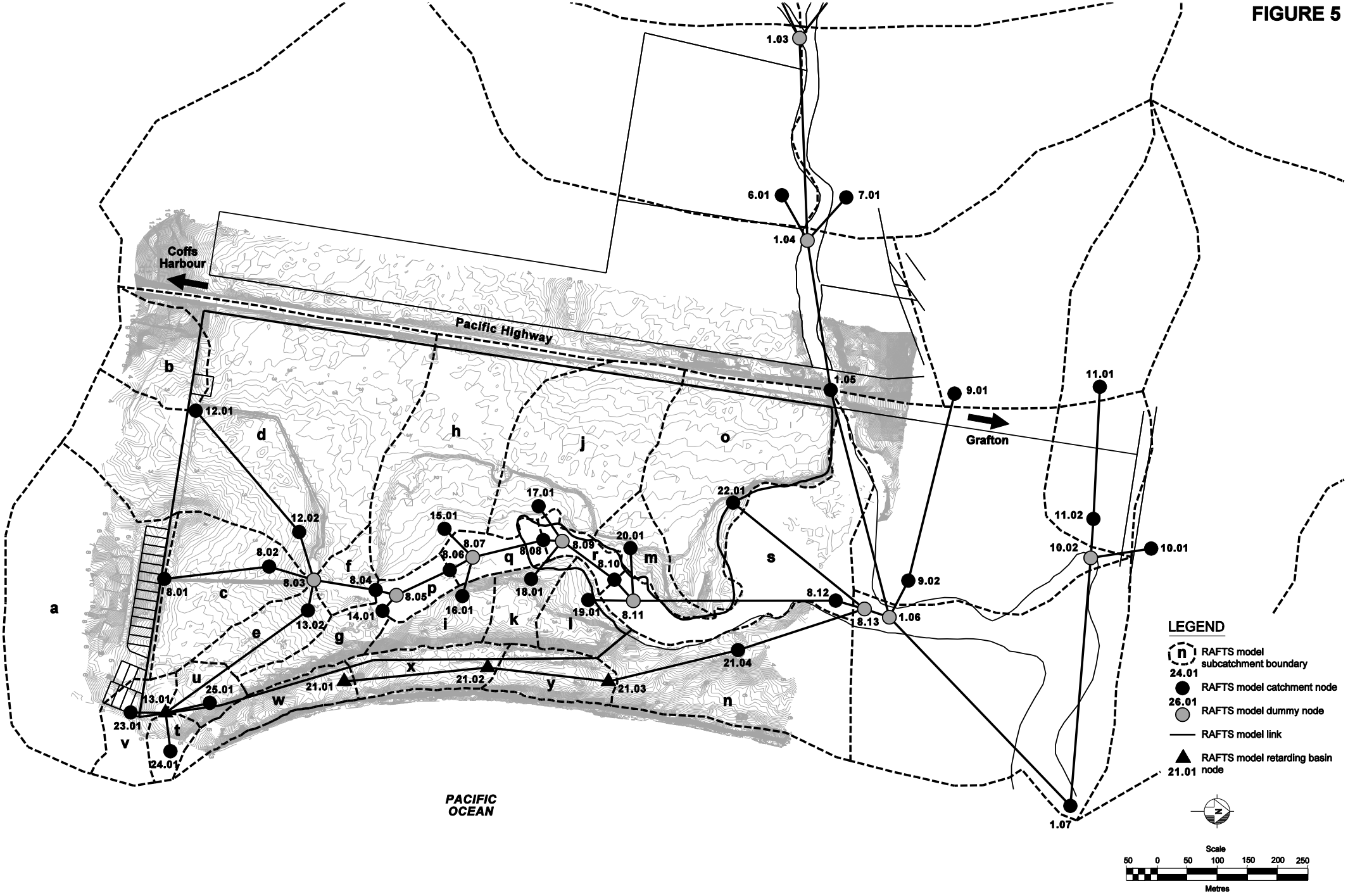
FIGURE 5



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RAFTS MODEL LAYOUT IN THE VICNITY OF THE DEVELOPMENT SITE

Table 1 PEAK DISCHARGES IN THE VICINITY OF THE DEVELOPMENT SITE

RAFTS MODEL NODE (*refer Figures 4 and 5*)	PEAK DISCHARGE	
	20 Year Recurrence Flood (m^3/s)	**100 Year Recurrence Flood** (m^3/s)
1.03	92.7	123.1
1.04	93.9	124.9
1.05	97.0	129.4
8.13	15.9	21.5
1.06	102.2	136.6
1.07	103.5	138.4

Table 2 PEAK DISCHARGES AT GRAHAM DRIVE AND THE PACIFIC HIGHWAY

LOCATION	ANTONY TOD & PARTNERS		ADOPTED FOR THIS INVESTIGATION	
	20 Year Recurrence Flood (m^3/s)	**20 Year Recurrence Flood** (m^3/s)	**20 Year Recurrence Flood** (m^3/s)	**100 Year Recurrence Flood** (m^3/s)
Graham Drive	48	66	**92.7**	**123.1**
Pacific Highway	67	92	**97.0**	**129.4**

The comparison shows that the peak flows calculated for this study are significantly higher than those determined by Antony Tod & Partners.

As expected (*refer* **Section 2**), these differences can be attributed to the fact that the flows determined for the 1982 Flood Study were based on the data and methodologies outlined in 1977 edition of *Australian Rainfall & Runoff* (*i.e., the 1st edition*). Additional data was obtained over the following 10 years and has resulted in revised procedures and higher estimates of design rainfall intensities.

These procedures are presented in the 1987 and 1998 editions of *Australian Rainfall & Runoff* and have been adopted in the hydrologic analysis for this investigation.

3.3 HYDRAULIC ANALYSIS

3.3.1 Model Development

A two-dimensional hydrodynamic model was developed to define flood behaviour in the vicinity of the development site. The model was created using the RMA suite of software, and specifically using RMA-2.

RMA-2 is a finite element software package that employs a variable grid geometry in which elements with irregular and curved boundaries can be modified as required without the need for regeneration of the entire grid. This is particularly advantageous for assessing the impact of a development proposal involving filling, as the model can be easily modified to incorporate changes in model node elevations, thereby allowing the impact of the filling to be quantified.

The RMA-2 model that was developed for this investigation extends over all of the body of the Hearns Lake downstream to the ocean entrance at Hearns Lake Beach. It covers the entire development site and extends upstream along Double Crossing Creek to about 300 metres upstream of the Pacific Highway bridge crossing.

The final adopted RMA-2 model network is shown in **Figure 6**. This shows the density and location of finite elements that have been used to develop the model. Each element (*triangle or rectangle*) represents a lake bed or floodplain surface. As also shown in **Figure 6**, the finite element grid was aligned with the surveyed cross-sections of the lake bed.

The size and location of floodplain elements were determined based on the detail required to reliably represent critical hydraulic controls and the definition required in areas where filling is likely to be proposed within the development site. Ground surface elevations were assigned to corners of individual elements based on a digital terrain model derived from the detailed photogrammetric survey undertaken by Asquith & de Witt. The hydrographic survey was used to define the bathymetry of the bed of Hearns Lake, the ocean entrance and Double Crossing Creek.

3.3.2 Channel and Floodplain Roughness

Main channel and overbank roughness values were determined for the study area based on an analysis of aerial photography of the area and from field observations. The adopted roughness parameters were determined by comparing vegetation density and site characteristics with standard values for stream and floodplain conditions for which Manning's "n" values are documented in the literature.

Most of the development site has been cleared for grazing, although there are some areas of light scrub. There are also some small areas of dense vegetation in the southern section of the site and along the rear of the dune located along the eastern site boundary.

The roughness parameters adopted for the RMA-2 model of Hearns Lake are listed in **Table 3**.