# APPENDIX A

COPY OF LETTER TO PLANNING WORKSHOP AUSTRALIA
DATED 30TH OCTOBER 2006

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consulting engineers

Mr Charles Hill
Planning Workshop Australia
GPO Box 3275
SYDNEY NSW 2001

lt5319_00jmh061025-Response to Sainty Report.doc

30th October 2006

Dear Charles,

**SANDY BEACH NORTH DEVELOPMENT**
**RESPONSE TO ENVIRONMENTAL CONSTRAINTS ANALYSIS LOT 22 DP 1070182, PACIFIC HIGHWAY, SANDY BEACH NORTH (SAINTY AND ASSOCIATES, 2006)**

As requested, we have reviewed the *'Environmental Constraints Analysis Lot 22 DP 1070182, Pacific Highway, Sandy Beach North'* prepared by Sainty and Associates Pty Ltd in September 2006 (*Sainty, 2006*). In particular, we have reviewed those sections of the report recommending the minimum level of potentially suitable areas of the site for development as 3.5 mAHD (*namely Sections 3.1 and 4.2 of the report*).

Sainty *(2006)* has not carried out any flood analysis and proposes a minimum development level of RL 3.5mAHD based on the following assumptions:

1. an arbitrary increase in the beach berm height at the mouth of Hearns Lake from an assumed RL 2.0 mAHD to RL 3.0 mAHD.
2. an allowance of 0.5m on top of this due to sea level rise by the year 2050.

**Entrance Breakout Regime of Hearns Lake**

Aerial photographs of the entrance to Hearns Lake over the period 1943 to 2004 confirm that the entrance is not prone to significant dune buildup. A saddle or pilot channel in the beach berm facilitates natural breakout during years of normal rainfall. WBM *(2005)* indicates that the entrance has an annual opening regime, viz:

"..... Hearns Lake may open a number of times during the year, as the total average annual water level rise in the lagoon is about 18 metres *(which is significantly greater than the rise required to overtop the entrance berm, thus multiple breakouts)*. The majority of breakouts would occur during the dominant wet season, between January and May."

This natural propensity for the Lake to open on an annual basis stems from the relatively small size of the lake. Even modest rainfall on the catchment can lead to substantial rise in the lake level.

A detailed survey of Hearns Lake was undertaken by Surveyors Asquith and de Witt in June 2004. They determined the invert of the pilot channel in the beach berm to have a level of RL 1.6 mAHD and the average level of the beach berm was approx RL 2.0 mAHD. These values are compatible with an entrance which has an annual break regime ie. breakout will be initiated by a lake rise of the order of only 1 to 1.5 metres.

Given the natural, annual opening regime of the Lake and the absence of substantial sand buildup in the entrance over the last 60 years of air photo record, it is considered that the Asquith and de Witt survey is typical of the natural berm state of the entrance, between annual openings. Hence we consider that the invert of the pilot channel in the beach berm varies between limits of RL 1.6 mAHD to RL 2.0 mAHD. There is no evidence to support the RL 3.0 mAHD assumed by Sainty *(2006)*.

**Impact of Greenhouse Scenarios on Breakout Regime**

The International Panel on Climate Change (*IPPC, 2001*) currently recommends a mid range sea level rise, over the next 50 years, of 0.2m. A mid range level of 0.2m is widely used in floodplain management practice to consider the implications of sea level rise under a 2050 sea rise scenario.

The nexus between mean sea level and the average height of the natural beach berm is unlikely to change. As sea level rises, it is considered that the beach berm will maintain the same height above ambient sea level. Hence under a 2050 sea level rise of 0.2m, the average level of the wave berm is likely to increase to approximately RL 2.2 mAHD. This level will not have a significant impact on entrance breakout processes, particularly in relation to the larger flood events.

**100 yr Recurrence Flood Level**

It is noted that Sainty *(2006)* has not carried out a flood study. Our Flood Impact Assessment *(PBP, 2005)* is based on rigorous hydrological modelling and hydrodynamic modelling incorporating entrance scouring. The methodology used in PBP *(2005)* is consistent with that recommended by the Department of Natural Resources, the State's floodplain management authority, in its *'Floodplain Risk Management Guideline No. 5 Ocean Boundary Conditions' (Draft, November 2004)*.

Guideline No. 5 provides advice on deriving appropriate ocean tailwater levels for the hydraulic modelling of coastal lakes, such as Hearns Lake. The guideline also provides recommendations on the method of analysis that should be used to determine the design flood levels at the site.

As discussed in our report, Hearns Lake is an Intermittently Closed and Open Lake Lagoon (*ICOLL*), which is typically closed at the ocean entrance at the northern end of Hearns Lake. Based on the definitions provided in Guideline No. 5, the lake is classified as *"Class 4 – Closed Entrances"*. The guideline provides the recommended methodology for the analysis of flood behaviour within coastal lakes with closed entrances (*Class 4*) as being the development of an upper limit envelope curve of design flood levels based on unsteady hydraulic modelling of the lake with a normal tidal cycle, and the combination of elevated ocean levels and a small flood such as the 5 year recurrence flood (*refer Attachment A to Guideline No. 5*). The guideline

also specifies the adoption of a 100 year recurrence ocean level of 2.6 mAHD (*refer Figure A1 of Guideline No. 5*) as an elevated ocean level.

As documented within Sections 3.3.4 and 3.3.5 of our report, the two-dimensional RMA-2 hydrodynamic model developed for the flood impact assessment of the development was used to simulate a number of flooding scenarios based on combined catchment and ocean storm events for various ocean entrance conditions. Based on an analysis of the results of these simulations, our report recommends that a peak design 100 year recurrence flood level of 2.6 mAHD be adopted for the development site. This level corresponds to the peak flood level that would arise should the design 100 year recurrence flood coincide with a 20 year recurrence ocean storm.

Guideline 5 points out that the flood levels determined by these methods are conservative. Guideline 5 notes that there is little correlation between storm surge and flood levels and hence the coincidence of 1 in 100 year storm surge and 20 year recurrence flood events *(or vice versa)* in the methodology, yields a flood level which has an annual recurrence which is much less than the stated 1%, ie. a conservative result.

In accordance with Council's Flood Policy, the proposed development will have a freeboard of 500mm above the 100 year recurrence flood level ie. minimum floor level of RL 3.1 mAHD. Because of the conservatism built into the design 100 year recurrence flood level, it is considered that the 500mm freeboard appropriately caters for sea level rise. This approach is supported by Guideline 5 which indicates that in relation to Greenhouse Effects "the elevated ocean levels recommended ..... are conservative and a freeboard of 0.5m is generally applied to flood level estimates". The sensitivity analyses carried out in our Flood Impact Assessment indicate that a freeboard of 500mm will be more than adequate to cope with the potential variation in the 100 year recurrence flood level due to Greenhouse Effects.

In summary, we consider that the Sainty *(2006)* minimum development level is unsubstantiated. In contradistinction, the 100 year recurrence flood level of RL2.6 mAHD plus 500mm freeboard, giving a minimum floor level of RL 3.1 mAHD, have been determined in accordance with accepted engineering practice and Council's Flood Policy. PBP strongly recommends the adoption of these levels for this development

Yours faithfully
**PATTERSON BRITTON**

for Chris Thomas
Principal

Review / Verification by Date

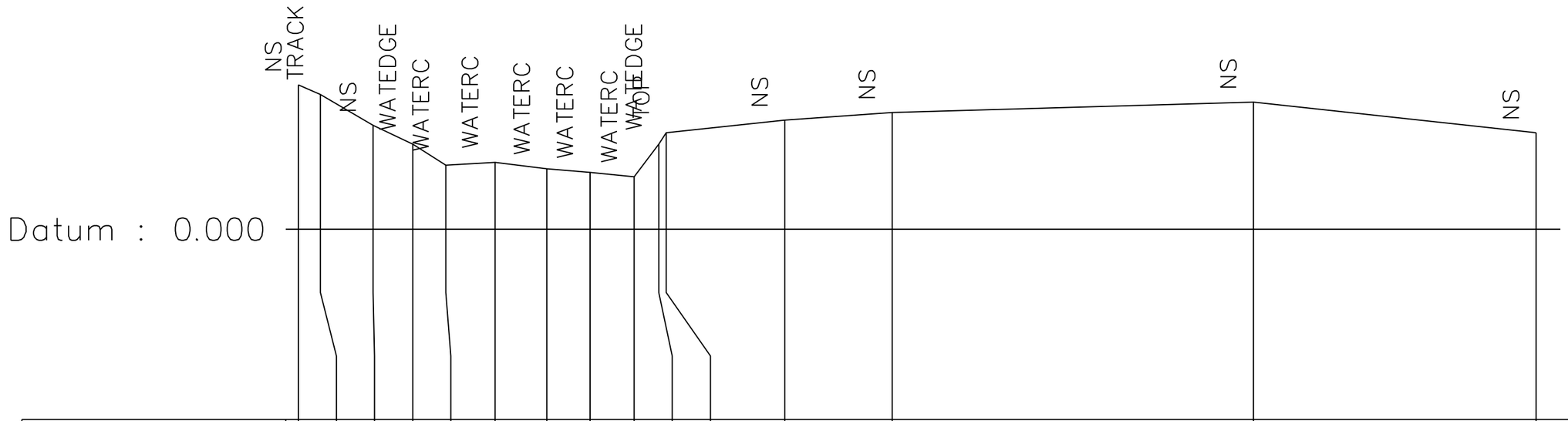
30/10/06

# APPENDIX B

COPY OF DRAWINGS PREPARED BY ASQUITH & DE WITT SHOWING THE ENTRANCE BERM PROFILE IN JUNE 2004


**Patterson Britton**
& Partners Pty Ltd
rp5319 - Sandy Beach Entrance BErm
fig-survey_berm.dgn

# LOCATION AND EXTENT OF SURVEY CROSS-SECTIONS




| | | | | | | | | | | | | | | | | |
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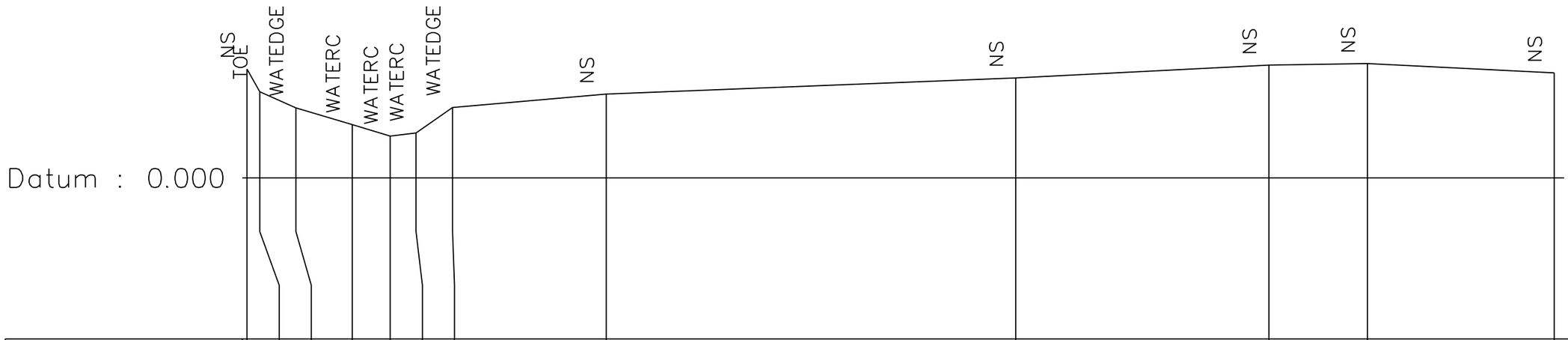
| Chainage | −9.011 | −7.267 | −3.119 | 0.000 | 2.614 | 6.490 | 10.567 | 13.970 | 17.454 | 19.394 | 19.970 | 29.318 | 37.772 | 66.236 | 88.513 |

Horizontal Scale 1 : 500

Vertical Scale 1 : 100

XS1

Source: Asquith & de Witt survey undertaken in June 2004.




| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
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| Chainage | -4.554 | -3.368 | -0.000 | 5.267 | 8.801 | 11.202 | 14.611 | 28.944 | 67.128 | 90.734 | 99.928 | 117.330 |

Horizontal Scale 1 : 500

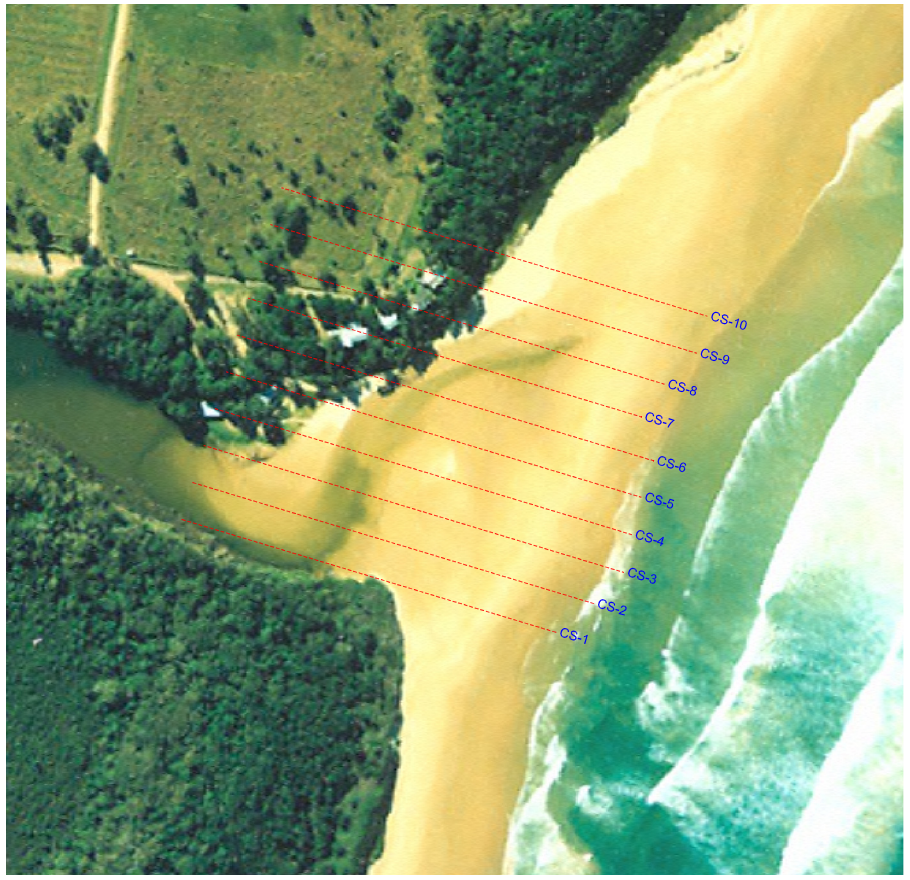
Vertical Scale 1 : 100

XS1A

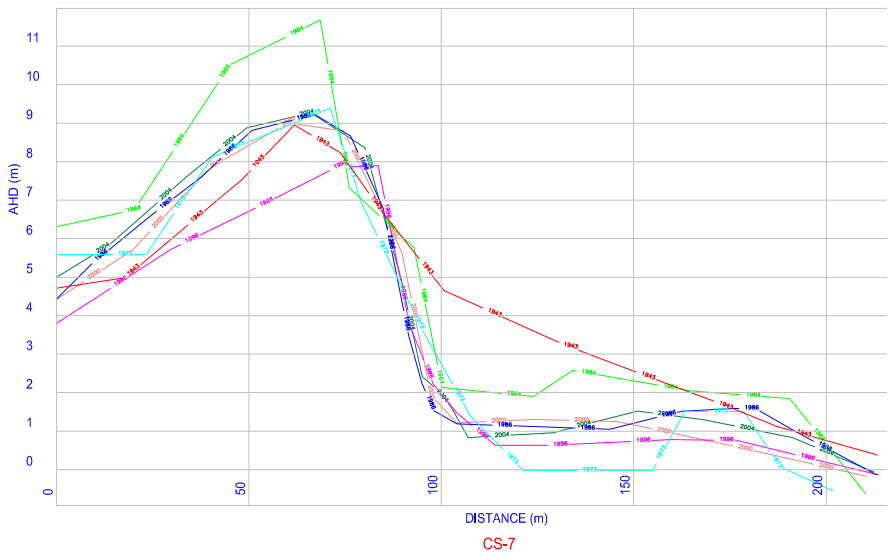
Source: Asquith & de Witt survey undertaken in June 2004.

# APPENDIX C

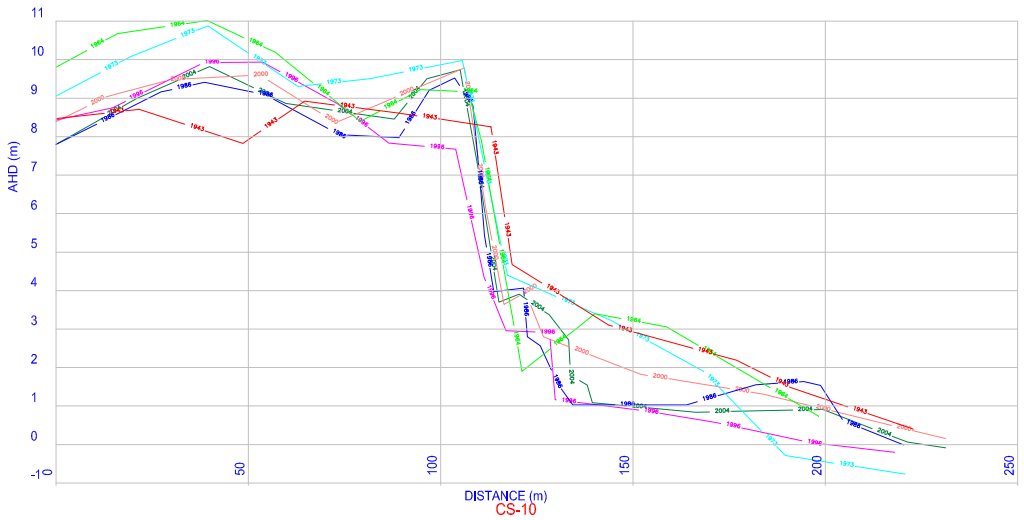
COPY OF CHCC DRAWING NO 2060101 SHOWING HISTORIC BEACH PROFILES DERIVED FROM PHOTOGRAMMETRY




PLAN
1:2000



CS-7



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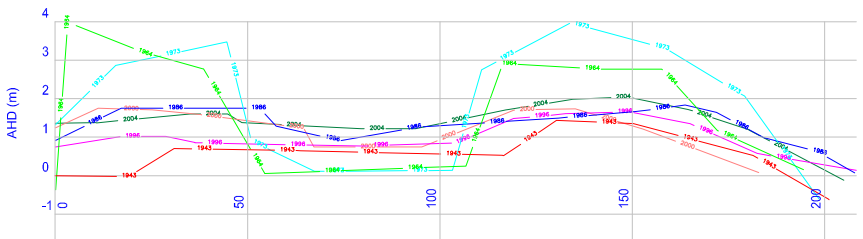

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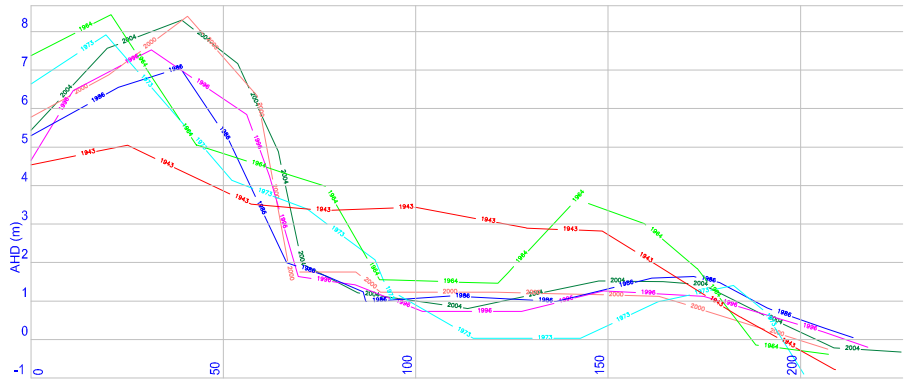

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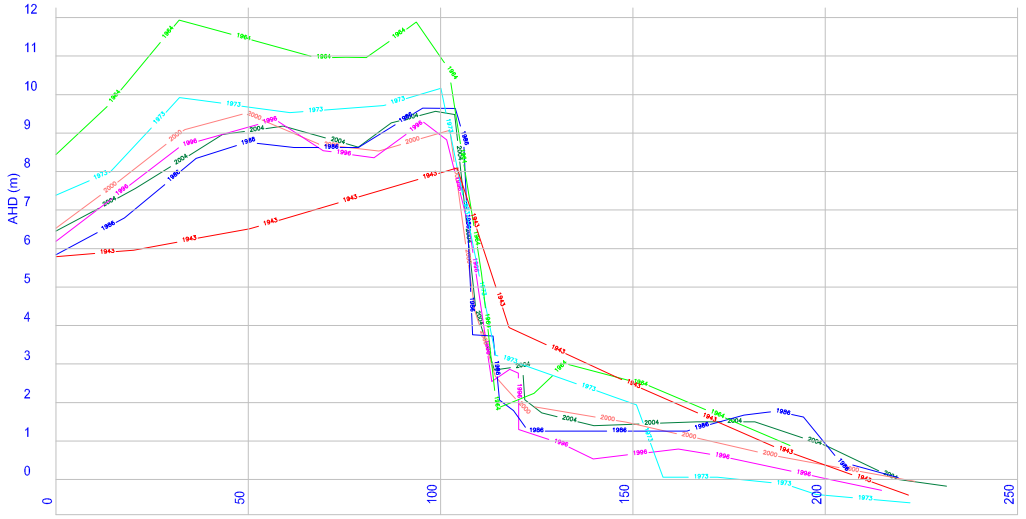

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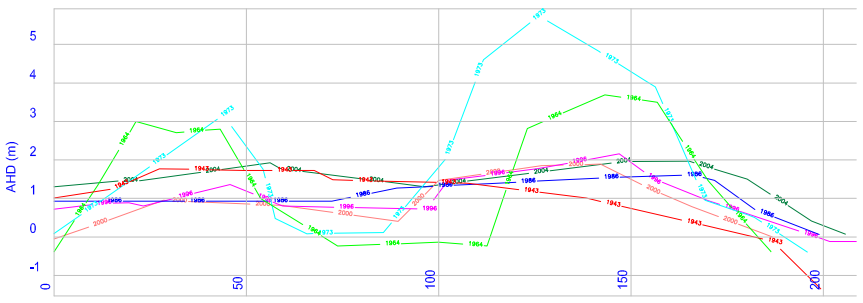

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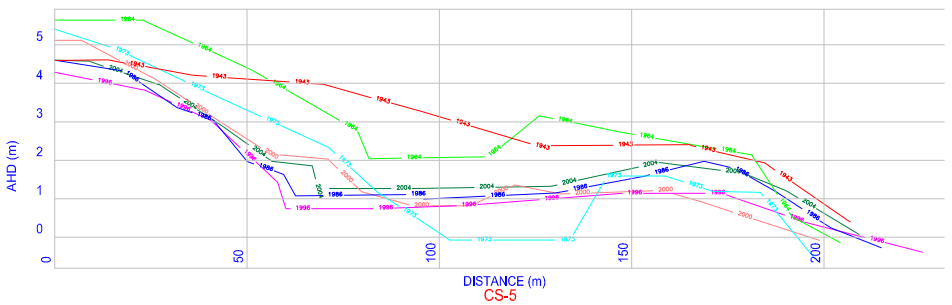

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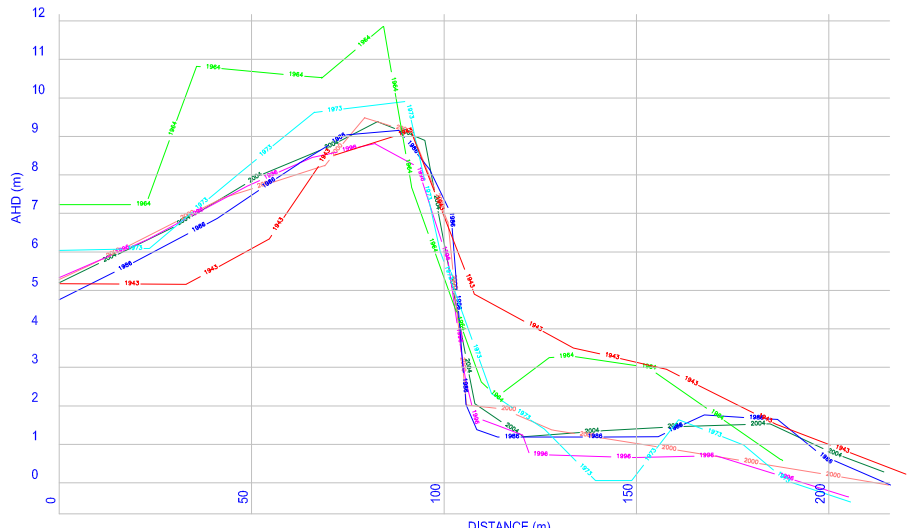

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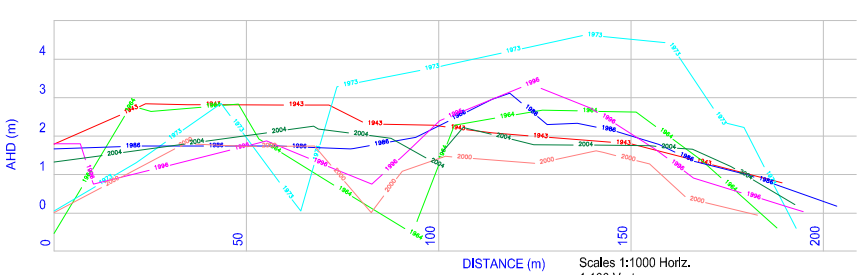

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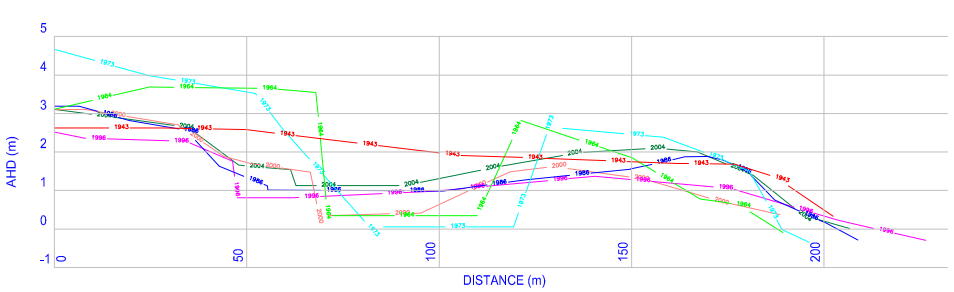
Scales 1:1000 Horiz.
1:100 Vert.



CS-4

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SCALES

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| DESIGN | | | | |
| DRAWN | REF | JAN 06 | | |
| CHECKED | | | CONST'N ENGINEER | DATE |
| STATUS | | | WORKS No. | |

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SURVEY AND DESIGN BRANCH

# HEARNES LAKE

## PLAN AND SECTION HEARNES LAKE ENTRANCE FROM 1943 to 2004 WOOLGOOLGA

| COUNCIL PLAN No. | |
|---|---|
| 2060101 | |
| SHEET 1 OF 1 | |
| SIZE A1 | REVISION |

PDF ARCHIVE DATED:

# APPENDIX D

HISTORICAL AERIAL PHOTOS OF HEARNS LAKE ENTRANCE


Patterson Britton & Partners Pty Ltd

Sandy Beach North
Appendix Jan 07.wor

N

Note: Aerial photo is sourced from Department of Lands and was taken on 11th March 1943 at a stated scale of 1:18,900.

NOT TO SCALE

## 1943 AERIAL PHOTOGRAPHY


Patterson Britton & Partners Pty Ltd

Sandy Beach North
Appendix Jan 07.wor

N

Note: Aerial photo is sourced from Department of Lands and was taken on 26th April 1956 at a stated scale of 1:32,230

NOT TO SCALE

# 1956 AERIAL PHOTOGRAPHY


Note: Aerial photo is sourced from Department of Lands (with permission from Dept. of Lands) and was taken on 7th February 1966 at a stated scale of 1:15,980.

NOT TO SCALE

**1966 AERIAL PHOTOGRAPHY**

Patterson Britton & Partners Pty Ltd

Sandy Beach North
Appendix Jan 07.wor


Patterson Britton & Partners Pty Ltd

Sandy Beach North
Appendix Jan 07.wor

N

Note: Aerial photo is sourced from Department of Planning & Natural Resources and was taken on 6th April 1969 at a stated scale of 1:58,590

NOT TO SCALE

# 1969 AERIAL PHOTOGRAPHY


Patterson Britton & Partners Pty Ltd

Sandy Beach North
Appendix Jan 07.wor

N

Note: Aerial photo is sourced from Roads & Traffic Authority and was taken on 8th October 1972 at a stated scale of 1:18,400

NOT TO SCALE

# 1972 AERIAL PHOTOGRAPHY


Note: Aerial photo is sourced from Department of Lands and was taken on 3rd May 1973 at a stated scale of 1:26,460

NOT TO SCALE

# 1973 AERIAL PHOTOGRAPHY

Patterson Britton & Partners Pty Ltd

Sandy Beach North
Appendix Jan 07.wor


Patterson Britton & Partners Pty Ltd

Sandy Beach North
Appendix Jan 07.wor

Note: Aerial photo is sourced from Department of Lands and was taken on 23rd June 1974 at a stated scale of 1:40,250

NOT TO SCALE

## JUNE 1974 AERIAL PHOTOGRAPHY


Patterson Britton & Partners Pty Ltd

Sandy Point
Photogrammetry Analysis Jan 07.wor

N

Note: Aerial photo is sourced from Department of Lands and was taken on 18th August 1974 at a stated scale of 1:44,280

NOT TO SCALE

# AUGUST 1974 AERIAL PHOTOGRAPHY


Patterson Britton & Partners Pty Ltd

Sandy Beach North
Appendix Jan 07.wor

N

Note: Aerial photo is sourced from Roads & Traffic Authority and was taken on 19th March 1980 at a stated scale of 1:10,150

NOT TO SCALE

## 1980 AERIAL PHOTOGRAPHY


Patterson Britton & Partners Pty Ltd

Sandy Beach North
Appendix Jan 07.wor

N

Note: Aerial photo is sourced from Department of Lands and was taken on 22nd June 1986 at a stated scale of 1:9,954

NOT TO SCALE

## 1986 AERIAL PHOTOGRAPHY


Patterson Britton & Partners Pty Ltd

Sandy Beach North
Appendix Jan 07.wor

N

Note: Aerial photo is sourced from Department of Lands and was taken on 17th June 1993 at a stated scale of 1:10,280

NOT TO SCALE

## 1993 AERIAL PHOTOGRAPHY


Patterson Britton & Partners Pty Ltd

Sandy Beach North
Appendix Jan 07.wor

N

Note: Aerial photo is sourced from Department of Lands and was taken on 17th May 2000 at a stated scale of 1:9,950

NOT TO SCALE

## MAY 2000 AERIAL PHOTOGRAPHY

SANDY SHORES DEVELOPMENTS PTY LTD

# SCIENTIFIC ASSESSMENT OF ENTRANCE BERM ELEVATION FOR HEARNS LAKE, SANDY BEACH NORTH

**Issue No. 2**
**JANUARY 2007**

Patterson Britton
& Partners Pty Ltd
consulting engineers

## SANDY SHORES DEVELOPMENT PTY LTD

# SCIENTIFIC ASSESSMENT OF ENTRANCE BERM ELEVATION FOR HEARNS LAKE, SANDY BEACH NORTH

## Issue No. 2
## JANUARY 2007

Document Amendment and Approval Record

| Issue | Description of Amendment | **Prepared by** [date] | **Verified by** [date] | **Approved by** [date] |
|---|---|---|---|---|
| **1** | Draft Report – Issue for client review | CRT (*10/1/07*)) | BMD (*10/1/07*) | |
| **2** | Final Report | CRT (*15/1/07*) | | Chris Thomas (*15/1/07*) |

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

Document Ref: rp5319_00crt070102-Hearns Lake Entrance Berm
Time and Date Printed: 4:35 pm 15th January 2007



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Patterson Britton & Partners Pty Ltd
consulting engineers

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# 1 BACKGROUND

Sandy Shores Developments 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. The site also adjoins the southern shoreline of Hearns Lake and extends to the rear of the back beach dunes along Hearns Lake Beach.

Hearns Lake is an Intermittently Closed and Open Lake or Lagoon (*ICOLL*) which drains to the Pacific 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 relative scale of the entrance berm is evident from **Plates 2** and **3**.

The lake has a surface area of about 15 hectares and is fed by catchment runoff that is discharged to it via Double Crossing Creek and a small catchment that extends south toward the urban area of Sandy Beach (*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 heathland that is currently used for grazing and which has previously been mined for rutile.

In November 2005, Sandy Shores submitted a Masterplan for development of the site to create up to 295 residential lots within an integrated landscape comprising a balanced mix of open space, leafy streetscapes and gardens. The current zoning of the land varies and includes areas zoned 2A Residential (*low density*), 2E Residential (*Residential Tourist*), 7A Environmental Protection Habitat and Catchments, and 7B Environmental Protection / Scenic Buffer. The Masterplan was submitted to the Department of Planning for determination in accordance with Part 3A of the Environmental Planning & Assessment Act.

The Masterplan was accompanied by an array of supporting documentation that addressed a range of key environmental issues. This supporting documentation included a Flood Impact Assessment Report that was prepared in 2005 by Patterson Britton & Partners. The Flood Impact Assessment Report documents the findings from complex two-dimensional flood modelling of Double Crossing Creek and Hearns Lake. The flood modelling considered variable ocean entrance conditions and established a peak 100 year recurrence flood level at the site of 2.6 mAHD.

In mid 2006, the Department of Planning engaged Sainty & Associates Pty Ltd to undertake an environmental assessment of the development site. The assessment was to identify the presence and extent of any high conservation lands on the site. High conservation lands were considered to include:

- existing SEPP 14 Coastal Wetlands and any additional lands identified as satisfying SEPP 14 Coastal Wetland criteria;
- endangered ecological communities; and,
- buffer zones around existing SEPP 14 Coastal Wetlands, Hearnes Lake ICOLL and any endangered ecological communities.

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

Plate 2 VIEW LOOKING SEAWARD FROM NEAR THE MOUTH OF DOUBLE CROSSING CREEK SHOWING THE RELATIVE SCALE OF THE BERM AT THE OCEAN ENTRANCE

Plate 3 VIEW LOOKING SOUTH ALONG HEARNS LAKE BEACH SHOWING THE LIMITED DUNE FORMATION AND LOW ELEVATION IN THE VICINITY OF THE ENTRANCE BERM

In September 2006, Sainty & Associates completed its environmental assessment of the site and published a report titled, *'Environmental Constraints Analysis - Lot 22 DP 1070182, Pacific Highway, Sandy Beach North'*. The report (*herein referred to as the Sainty Report*) documents the findings from the environmental assessment and includes a discussion on the potential impacts of climate change on Hearns Lake. It also considers the need for environmental buffers and argues the case for a "vertical buffer" to protect the ICOLL.

The outcomes from the investigations carried out for the Sainty Report led to the development of an *Environmental Constraints and Development Potential Map*. This map identifies areas of the site that Sainty & Associates considers to be suitable for development. In summary, it recommends that development should be prohibited in all areas of the site below the 3.5 metre contour. Sainty & Associates state that this is required to protect development from predicted sea level rise.

The Sainty Report was reviewed by a number of consultants who had carried out environmental investigations for the Sandy Shores development. Patterson Britton & Partners reviewed those sections of the Sainty Report that argue the basis for recommending that development be restricted to areas above an elevation of 3.5 mAHD (*namely Sections 3.1 and 4.2 of the Sainty Report*). The findings from that review are documented in a letter to Mr Charles Hill of Planning Workshop Australia dated 30th October 2006. A copy of this letter is enclosed within **Appendix A**.

In summary, the letter indicates that it is our professional opinion that the minimum development level of 3.5 mAHD recommended by Sainty & Associates is unsubstantiated.

In this document, we provide the results of additional investigations and analyses which demonstrate further that the 3.5 mAHD elevation recommended by Sainty & Associates is inappropriate for the site.

# 2 REVIEW OF ASSESSMENT BY SAINTY & ASSOCIATES

## 2.1 CRITIQUE OF DOWNSLOPE LIMIT OF DEVELOPMENT DETERMINED BY SAINTY & ASSOCIATES

### 2.1.1 Summary of Sainty & Associates Position

The Sainty Report states that the 3.5 metre contour should define the downslope limit of potential development around the perimeter of Hearns Lake. This recommendation is based on the predicted future extent of Hearns Lake considering "the existing environment and the likely variations in geomorphology over time".

Sainty states that the predicted extent of Hearns Lake is defined as the area up to the 3.5 metre contour. This claim is based on the adoption of a future entrance berm elevation of 3.0 mAHD and the application of a 0.5 metre freeboard to accommodate the predicted maximum sea level rise to 2050. It is also noted that a 0.5 metre freeboard is similar to the projected median increase in sea level of 0.48 metres by 2100 (*IPCC, 2001*).

Therefore, the adopted future extent of Hearns Lake is based on two factors:

- an adopted future entrance berm elevation of 3.0 mAHD; and,
- a 0.5 metre allowance for the projected maximum increase in mean sea level between now and 2050, or the projected median rise in sea level between the present and 2100.

### 2.1.2 Assessment of Sainty & Associates Recommendation

#### Suitability of Key Assumptions

The adoption of a 0.5 metre allowance for sea level rise is consistent with recommendations in the literature. For example, the current projections for global average sea level rise between 1990 and 2100 lie in the range 0.09 to 0.88 metres. The median increase in sea level by 2100 is predicted to be 0.3 to 0.5 metres (*National Committee on Coastal and Ocean Engineering, 2004*). Therefore, the adoption of a 0.5 metre allowance for sea level rise is consistent with the upper bound median value projection to 2100.

However, the adoption of a future entrance berm elevation of 3.0 mAHD is not substantiated.

The Sainty Report acknowledges that the existing entrance berm is typically at an elevation of 2.0 mAHD (*refer paragraph 3 on page 8 of the Sainty Report*). However, it argues that "the berm height could reasonably increase to an elevation of 3.0 mAHD due to tidal surcharge caused by storms and king tides".

Aerial photographs of the entrance to Hearns Lake over the period from 1943 to 2004 indicate that the entrance is not prone to significant dune build-up. A saddle or pilot channel in the beach berm facilitates natural breakout during years of normal rainfall.

WBM Oceanics (*2005*) indicates that the entrance has an annual opening regime, viz:

> *"….. Hearns Lake may open a number of times during the year, as the total average annual water level rise in the lagoon is about 18 metres (which is significantly greater than the rise required to overtop the entrance berm, thus leading to multiple breakouts). The majority of breakouts would occur during the dominant wet season between January and May."*

This natural propensity for opening on an annual basis stems from the relatively small size of the lake. Even modest rainfall on the catchment can lead to a substantial rise in the lake water level, which typically induces entrance breakout.

### Contemporary Entrance Berm Elevation

A detailed survey of Hearns Lake was undertaken in June 2004 by Consulting Surveyors, Asquith & de Witt. This included a topographic survey of the beach and entrance bathymetry. Copies of drawings that were prepared from the survey are enclosed within **Appendix B**.

As shown by the drawings, the invert of the pilot channel in the beach berm had an elevation of 1.6 mAHD (*refer cross-sections XS 1, XS 1A and XS 2 in* **Appendix B**). The average level of the beach berm was approximately 2.0 mAHD. These values are compatible with an entrance which has an annual opening regime; that is, breakout will be initiated by a lake rise in the order of only 1 to 1.5 metres.

Given the natural annual opening regime of the Lake and the absence of substantial sand build-up in the entrance over the last 60 years of air photo record, it is considered that the Asquith & de Witt survey is typical of the natural berm state of the entrance between annual openings.

Therefore, it is our professional opinion that the invert of the pilot channel in the beach berm varies between limits of 1.6 and 2.0 mAHD. There is no evidence to support the 3.0 mAHD elevation assumed by Sainty & Associates.

## 2.2 ADDITIONAL INVESTIGATIONS TO DETERMINE ENTRANCE BERM ELEVATION

Sainty states that the adoption of the 3.5 mAHD contour as the limit of downslope development is supported in the scientific literature. In this regard he quotes a paper by Haines that was presented at the 14th NSW Coastal Conference in November 2005. The main thrust of this paper is to present a suggested policy position for the introduction of "vertical buffers" around ICOLLS.

Haines (*2005*) uses Hearns Lake as a case study for the application of his suggested policy. He suggests the use of a vertical buffer to an elevation of 3.5 mAHD at Hearns Lake, based on an assumed maximum entrance berm crest elevation of 3.0 mAHD, plus a 0.5 metre allowance for future sea level rise. Haines is of the view that the 3.5 mAHD contour defines the future extent of the Hearns Lake ICOLL based on consideration of projections for global warming and tidal surcharges.

Sainty has drawn directly from Haines' paper and recommends that a development buffer based on the 3.5 mAHD contour be imposed on the Sandy Shores development site.

However, it is important to appreciate that the adoption of a vertical buffer defined by the 3.5 mAHD contour is based on an assumed maximum entrance berm crest elevation.

The assumed maximum entrance berm crest elevation has been determined from consideration of the upper end of recorded data for a range of estuary entrances along the NSW coast. These entrances are varied and have different degrees of exposure to coastal processes that cause dune build-up and influence the frequency of entrance closure. The data includes large fully exposed coastal systems with undiminished coastal processes affecting the entrances. Therefore, an entrance berm elevation of 3.0 mAHD could overestimate the average entrance berm condition for a relatively protected estuary entrance like Hearns Lake.

In recognition of this, it is appropriate that the specific data pertaining to the entrance berm elevation at the mouth of Hearns Lake be closely examined. A good understanding of entrance berm behaviour can be obtained by the application of photogrammetric methods.

### 2.2.1 Assessment of Available Photogrammetry

WBM Oceanics Evaluation of Photogrammetric Data for Hearns Lake Entrance

WBM Oceanics was engaged by Coffs Harbour City Council to prepare an Estuary Management Plan for Hearns Lake. The Plan was required to be developed in accordance with guidelines outlined in the NSW Government's *Draft Estuary Management Manual* (*1992*).

In March 2006, WBM Oceanics submitted a draft of the Hearns Lake Estuary Processes Study to Coffs Harbour City Council. In December 2006, a copy of the draft Hearns Lake Estuary Processes Study was made available to Sandy Shores Developments Pty Ltd.

A review of the report shows that it contains a commentary on the condition of the ocean entrance to Hearns Lake (*refer pages 3-5 to 3-9, inclusive*). This commentary includes a discussion of the shape and height of the entrance berm at Hearns Lake, and makes reference to a photogrammetric analysis that was undertaken by the NSW Department of Natural Resources (*DNR*) in December 2005.

The photogrammetric analysis used aerial photographs that were taken in 1943, 1964, 1973, 1986, 1996, 2000 and 2004, to generate 16 cross-section profiles of the beach along the length of the entrance berm. The location and alignment of these cross-sections or beach transects is shown in **Figure 2**.

Beach profiles were generated for each cross-section alignment for each year of photography. These profiles are presented on a drawing that was prepared by Coffs Harbour City Council and which is included as Figure 3-4 within WBM Oceanics' Draft Estuary Processes Study Report. A copy of this drawing is reproduced in **Appendix C**.

WBM Oceanics used this information to record the minimum and maximum beach profile heights for each year of photography. Based on their interpretation of this data, WBM Oceanics concluded that the maximum entrance berm height occurred in 1973 and reached an elevation of 5.7 mAHD. On face value this appears to be extremely high for an entrance berm, particularly for an entrance which WBM Oceanics has identified as being predisposed to annual breakouts.

Closer examination of the data on which this claim is made suggests that WBM Oceanics may have misinterpreted the data derived from the photogrammetric analysis.

In this regard, the data presented in Table 3.2 of the WBM Oceanics Report appears to be presented as a summary of the entrance berm height elevation along each of ten of the cross-sections that were derived from the photogrammetric analysis. However, on closer inspection, these heights include fore dune and some back dune heights, as well as berm levels which are much lower.

Hence, Table 3-2 and the associated commentary provide an erroneous assessment of the entrance berm elevation.

### PBP Analysis of Photogrammetric Data

In order to better understand the data, a copy of the raw photogrammetric data was obtained from the NSW Department of Natural Resources. The raw data was used to develop a digitial terrain model and plot terrain contours of the beach in the vicinity of the entrance to Hearns Lake. Contour mapping was developed for each year in which aerial photography was analysed; that is, for 1943, 1964, 1973, 1986, 1996, 2000 and 2004.

The resultant contour mapping is presented for each year in **Figures 3** to **9** inclusive. The raw spot elevations that were derived by DNR for each transect of the beach are superimposed with individual elevations corresponding to the nearest asterisk.

The contour plans presented in **Figures 3** to **9** identify the relict entrance channel or "saddle" through the beach berm that would form the hydraulic control for entrance breakout. The hydraulic control is defined by the level of the low point or "saddle" at the seaward end of the channel which will provide a pathway for flow connection between the lake and the ocean. The lowest of these saddles defines the controlling entrance berm elevation at the time that the aerial photograph was taken.

Each of **Figures 3** to **9** was interpreted to identify the controlling saddle in the contour maps; that is, the lowest saddle which would trigger breakout when the lake level rose due to rainfall in the catchment. The results of the analysis are summarised by the data presented in **Table 1**.

The results of the analysis indicate that over the 60 years of record, the entrance berm at the mouth of Hearns Lake had an elevation that varied between 0.1 mAHD and 2.6 mAHD. More significantly, the results indicate that the entrance berm elevation exceeded 1.6 mAHD on only one of the seven years for which photogrammetric analysis was undertaken.

The results also suggest that the typical entrance berm elevation lies between 1 and 1.6 mAHD.

**Table 1 SUMMARY OF CONTROLLING ENTRANCE BERM ELEVATIONS BASED ON PHOTOGRAMMETRY**

| YEAR OF PHOTOGRAPHY / PHOTOGRAMMETRY | MINIMUM ELEVATION OF 'SADDLES' IDENTIFIED FROM CONTOUR MAPPING (*mAHD*)† | CONTROLLING ENTRANCE BERM ELEVATION (*mAHD*) |
|---|---|---|
| 1943 | 0.98 | 1.0 |
| 1964 | 2.8<br>2.85<br>2.6 | 2.6 |
| 1973 | 1.31<br>0.22 | 0.1 |
| 1986 | 1.61<br>1.58<br>1.63 | 1.6 |
| 1996 | 1.2<br>0.53 | 0.55 |
| 2000 (May) | 1.55<br>1.1 | 1.1 |
| 2004 | 1.76<br>1.45<br>1.43 | 1.45 |

† The number of elevations shown indicates the number of saddles identified along the beach front that could serve as pathways for estuary waters to discharge to the ocean.

### Comparison with Sainty and WBM Oceanics

The results of this analysis indicate that the entrance berm elevation of 3.0 mAHD adopted by Haines and Sainty & Associates is not representative of actual entrance berm conditions at Hearns Lake, as reflected by 60 years of recorded data. As a result, it is considered that the recommendation that development at the site be restricted to areas above the 3.5 mAHD contour is unjustified.

If the approach adopted by Haines and employed by Sainty & Associates to determine the down slope limit of development is applied using the data derived from the photogrammetric analysis undertaken by DNR, then a vertical buffer corresponding to the 2.1 mAHD contour should apply to the site. This 2.1 mAHD contour is based on the adoption of a typical entrance berm elevation of 1.6 mAHD, plus an allowance of 0.5 metres for sea level rise.

It is noted that Sainty & Associates did not consider the results of the photogrammetric analysis that was completed by DNR in December 2005. This data was available 9 months prior to the Sainty Report being submitted to DoP, and was identified in the draft Estuary Processes Study prepared by WBM Oceanics and submitted to Council in March 2006. It clearly provides evidence of typical entrance berm elevations at the mouth of Hearns Lake. Therefore, it provides data that is specific to Hearns Lake and should override the assumed entrance berm elevation presented by Haines and adopted by Sainty & Associates.

### 2.2.2 Assessment of Available Recorded Water Level Data

As further support for the adoption of a lower entrance berm elevation, a search was undertaken to determine the existence of recorded data defining typical water levels within Hearns Lake that lead to entrance breakout. This search established that a continuous water level recorder was installed in Hearns Lake on 8th December 2004. The water level recorder was installed by MHL on behalf of DNR. It is located about 100 metres from the ocean entrance and records water levels in metres relative to Australian Height Datum.

Recorded water level data was obtained for the period from 8th December 2004 to 14th December 2006. This data is plotted in **Figure 10**, which also shows the corresponding daily rainfall as recorded at Woolgoolga.

**Figure 10** shows that the maximum recorded lake water level over the last 2 years was 2.15 mAHD. This occurred on 30th June 2005 and corresponded to a period of intense rainfall in which 214 mm fell in three days. More than half of this rainfall (*116 mm*) fell on 30th June 2005, and led to the entrance breakout reflected in the water surface profile shown in **Figure 10**.

**Figure 10** shows the correlation between heavy rainfall events and entrance breakout. The rise in water level and the steepness of the profile reflects the extent and intensity of the rainfall, respectively. The subsequent fall in lake water level highlights episodes of entrance breakout followed by tidal intrusion which is evidenced by the harmonic signature in the data record.

The water surface level plot presented in **Figure 10** suggests that entrance breakout occurred on 7 occasions between December 2004 and December 2006. The dates when entrance breakout occurred and the associated rainfall are summarised in **Table 2**.

**Table 2** and **Figure 10** indicate that peak lake water levels prior to entrance breakout ranged between 1.5 mAHD and 2.15 mAHD. This suggests that the entrance berm elevation over this period varied between these levels.

However, the peak lake level would include a dynamic head that would extend above the entrance berm elevation. This dynamic head is required to generate sufficient energy to scour the entrance and initiate discharge from the lake. This is likely to be in the order of 200 mm. Accordingly, it can be concluded that the entrance berm elevation is likely to be about 200 mm lower than the peak lake water level prior to entrance breakout.

Therefore, the peak water level data recorded over the last two years suggest that the contemporary entrance berm elevation varies between 1.3 and 2.0 mAHD. This indicates that the average entrance berm elevation is of the same order as that determined from the photogrammetry; that is, in the order of 1.6 mAHD.

Based on consideration of the peak water level data and the photogrammetric data, it can be concluded that an elevation of 2.0 mAHD should be adopted as a conservative estimate of the maximum contemporary entrance berm elevation for the mouth of Hearns Lake. This is in keeping with the lower bound of the range specified for maximum ICOLL entrance berm heights in New South Wales (*Gordon, 1990; Hanslow et al, 2000*).

**Table 2 SUMMARY OF ENTRANCE BREAKOUTS SINCE DECEMBER 2004**

| DATE WHEN ENTRANCE BREAKOUT OCCURED | RECORDED RAINFALL (*mm*) | PEAK LAKE WATER LEVEL PRIOR TO ENTRANCE BREAKOUT (*mAHD*) |
|---|---|---|
| 28/11/05 | 24/1/05 – 38.2 mm<br>25/1/05 – 49 mm<br>26/1/05 – 8.4 mm<br>27/1/05 - 10.4 mm<br>28/1/05 - 89 mm | 1.58 |
| 30/6/05 | 28/6/05 – 15.2 mm<br>29/6/05 – 56 mm<br>30/6/05 – 116.2 mm | 2.15 |
| 30/11/05 | 30/11/05 – 93.2 mm | 1.97 |
| 15/2/06 | 12/2/06 – 14.2 mm<br>13/2/06 – 16 mm<br>14/2/06 – 2.4 mm<br>15/2/06 – 34.4 mm | 1.48 |
| 29/3/06 | 24/3/06 – 14.2 mm<br>25/3/06 – 16 mm<br>29/3/06 – 3 mm | 1.7 |
| 26/7/06 | 25/3/06 – 18 mm<br>26/3/06 – 13.4 mm<br>27/7/06 – __ mm | 1.72 |
| 30/8/06 | 29/8/06 – 30.6 mm<br>30/8/06 – 44.8 mm | 1.9 |

# 3 CONCLUSIONS

The Sainty Report states that the 3.5 metre contour should define the down slope limit of potential development around the perimeter of Hearns Lake. This is based on the adoption of a future entrance berm elevation of 3.0 mAHD and the application of a 0.5 metre freeboard to accommodate the predicted maximum sea level rise to 2050.

However, investigations undertaken for this report highlight that the future entrance berm elevation adopted by Sainty is an assumed value. It appears to be based on applying the upper bound of a 2 to 3 mAHD range suggested by Gordon (*1990*) for New South Wales ICOLL entrances.

However, this range considers all ICOLL entrances irrespective of their exposure to coastal processes that cause dune build-up and influence the frequency of entrance closure. As a result, an entrance berm elevation of 3 mAHD is considered to overestimate of the average entrance berm condition for a relatively protected estuary entrance like Hearns Lake. Available photogrammetric data for Hearns Lake Beach confirms this.

The results of photogrammetry undertaken in December 2005 show that over the last 60 years the entrance berm has had a typical crest elevation of between 1 and 1.6 mAHD. This data indicates that the 3 mAHD entrance berm elevation assumed by Sainty is inappropriate for Hearns Lake.

Water level data recorded over the last two years indicates that peak lake water levels prior to entrance breakout ranged between 1.5 and 2.15 mAHD. If it is assumed that peak water levels must rise 150 to 200 mm above the entrance berm crest elevation to initiate scour and pilot channel formation, then it can be concluded that the available water level data suggests that an entrance berm elevation of between 1.3 and 2 mAHD is appropriate.

Therefore, the available photogrammetric data and the recorded water level data indicate that entrance berm elevations for Hearns Lake range between 1 and 2 mAHD. On this basis, an elevation of 2 mAHD is considered to provide a conservative estimate of the maximum contemporary entrance berm elevation for the mouth of Hearns Lake.

The International Panel on Climate Change (*IPPC, 2001*) currently recommends a mid range sea level rise over the next 50 years of 0.2 metres. A mid range level of 0.2 metres is widely used in floodplain management practice to consider the implications of sea level rise under a 2050 sea level rise scenario.

The nexus between mean sea level and the average height of the natural beach berm is unlikely to change. As sea level rises, the beach berm will maintain the same height above ambient sea level. Hence, under a 2050 sea level rise of 0.2 metres, the average level of the entrance berm at Hearns Lake is likely to increase by 0.2 metres; that is, to approximately 2.2 mAHD.

Therefore, application of the procedures employed by Sainty & Associates indicate that a vertical buffer up to 2.2 mAHD (*not 3.5 mAHD*) would be appropriate for the development site.

# 4 REFERENCES


(1) Antony Tod & Partners (*Mid North Coast*) Pty Ltd, *'Hearns Lake / Double Crossing Creek Local Environment Study – Flood Investigation and Report on Water Supply, Sewerage and Water Pollution'*; prepared for McDonald Cox Corkill Pty Ltd.

(2) Coffs Harbour City Council (*2006, in draft*); *'Hearns Lake Estuary Processes Study'*; prepared by WBM Oceanics Pty Ltd.

(3) Department of Natural Resources [*DNR*] (*December 2005*); Results of Photogrammetric Analysis for Hearns Lake Beach; data supplied on 1st December 2006.

(4) Hanslow DJ, Davis GA, You BZ and Zastawny J (*2000*), *'Berm Height at Coastal Lagoons in NSW, Australia'*; proceedings from the 10th Annual NSW Coastal Conference, Yamba.

(5) Haines PE (*2005*), *'Determining Appropriate Setbacks for Future Development Around ICOLLs'*; presented at the 14th NSW Coastal Conference, Narooma, 8-11th November 2005.

(6) Intergovernmental Panel on Climate Change [IPCC] (*2001*), *'Climate Change 2001: Synthesis Report'*; edited by Robert T Watson and the Core Writing Team, Contribution of Working Groups I, II, and III to the Third Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, ISBN 0 521 80770 0

(7) National Committee on Coastal and Ocean Engineering (*2004*), *'Guidelines for Responding to the Effects of Climate Change in Coastal Engineering Design'*

(8) Patterson Britton & Partners Pty Ltd (*2005a*), *'Sandy Beach North Residential Development – Water Management Strategy'*; Issue No 2, prepared for Sandy Shores Developments Pty Ltd.

(9) Patterson Britton & Partners Pty Ltd (*2005b*), *'Sandy Beach North Residential Development – Flood Impact Assessment'*; Issue No 3, prepared for Sandy Shores Developments Pty Ltd.

(10) Sainty & Associates (*September 2006*), *'Environmental Constraints Analysis - Lot 22 DP 1070182, Pacific Highway, Sandy Beach North'*; prepared for the NSW Department of Planning.

FIGURE 1

Grafton

EXTENT OF DEVELOPMENT SITE

DOUBLE CROSSING CREEK CATCHMENT BOUNDARY

Pacific Ocean

Coffs Harbour

LOCATION OF THE DEVELOPMENT SITE

Scale

100 0 100 200 300 400 500

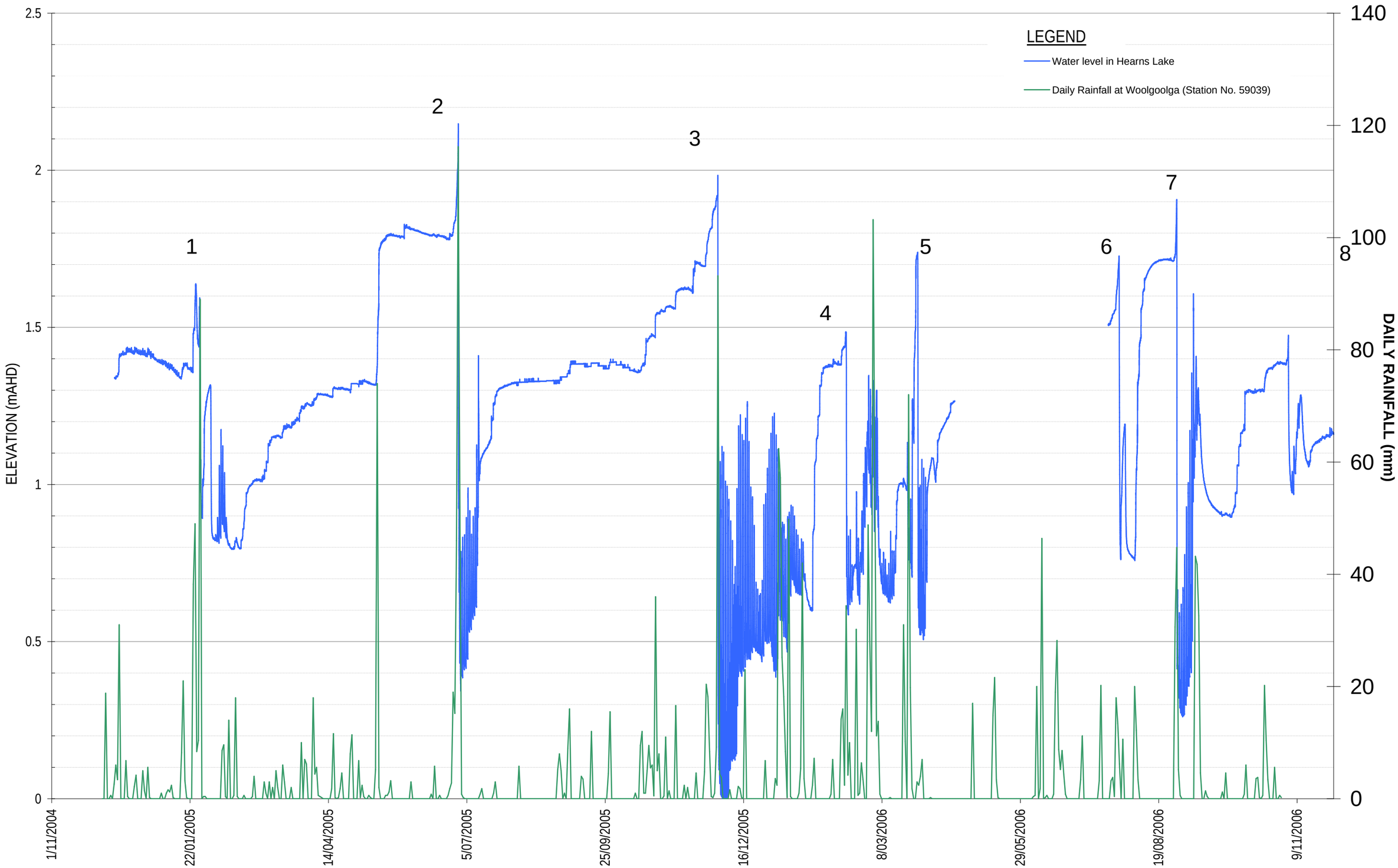
Metres

Patterson Britton & Partners Pty Ltd

rp5319 - Hearns Lake Entrance Berm

fig-location_berm.dgn

**FIGURE 10**

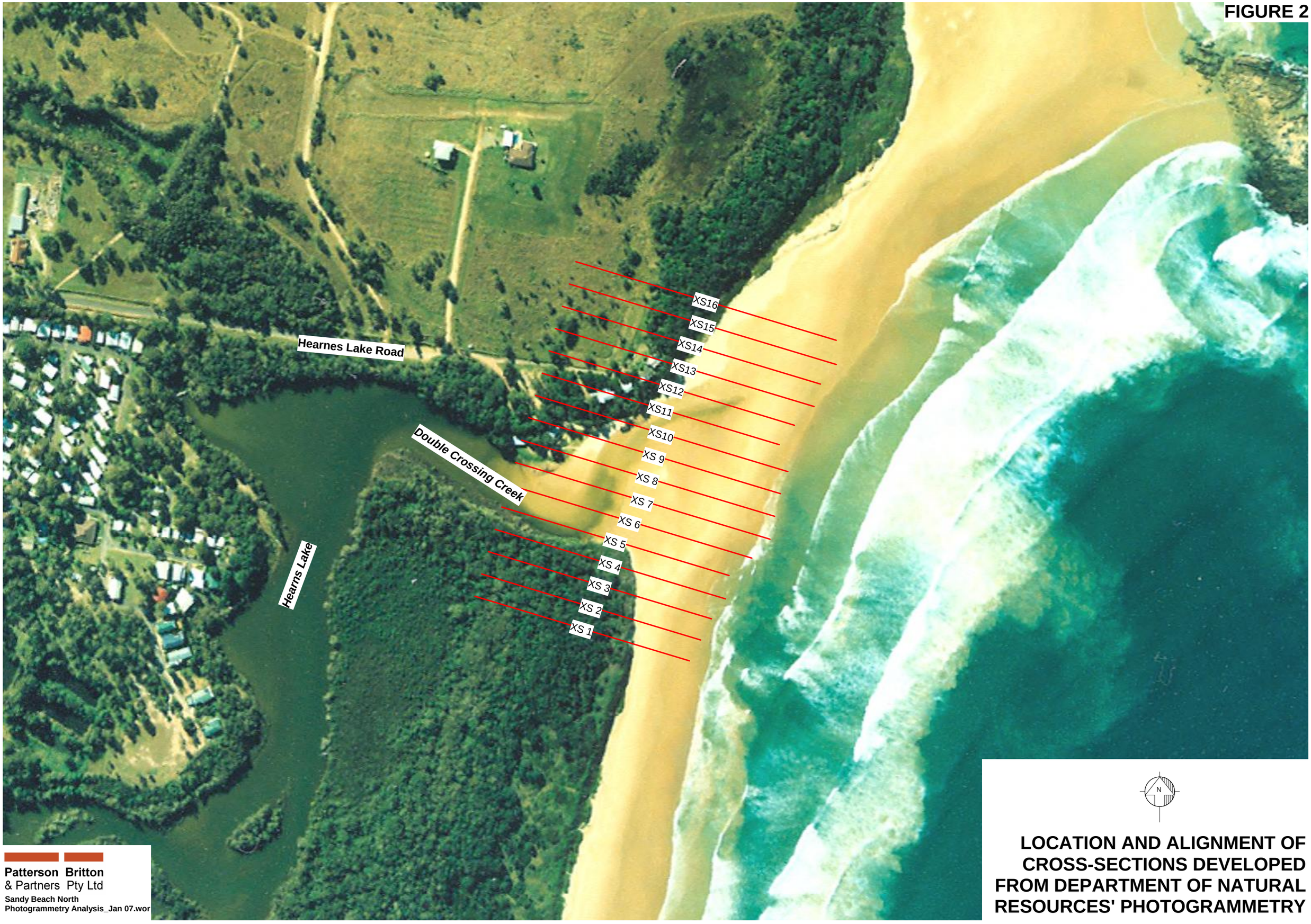



**Patterson Britton**
& Partners Pty Ltd

Water level Data_hearns Lake04_05 Jan 07.xls
Fig 10 - Water Levels

**VARIATION IN LAKE WATER LEVEL AND RECORDED RAINFALL BETWEEN DECEMBER 2004 AND DECEMBER 2006**

FIGURE 2

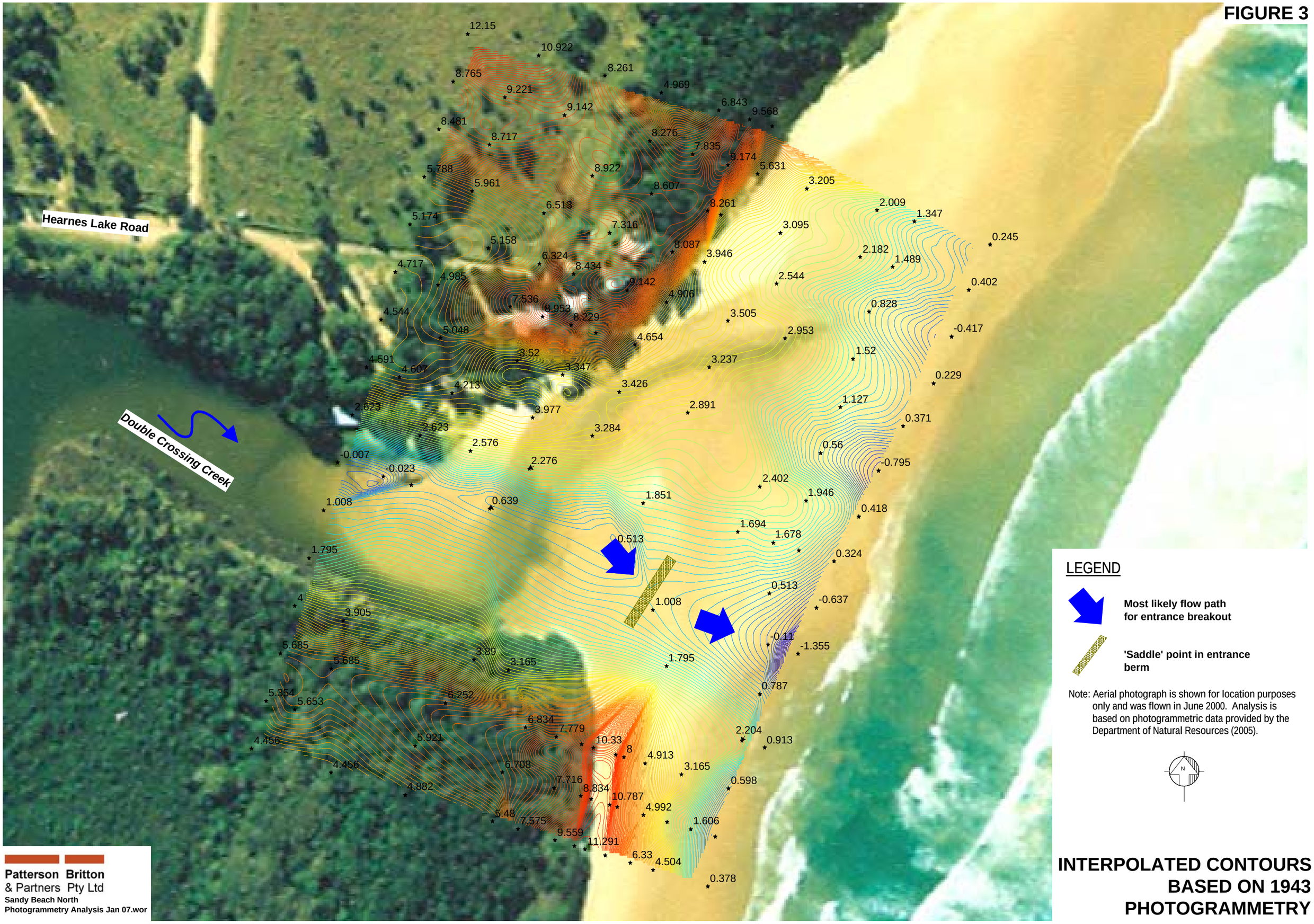



**LOCATION AND ALIGNMENT OF CROSS-SECTIONS DEVELOPED FROM DEPARTMENT OF NATURAL RESOURCES' PHOTOGRAMMETRY**

Patterson Britton & Partners Pty Ltd

Sandy Beach North
Photogrammetry Analysis_Jan 07.wor

FIGURE 3




Patterson Britton & Partners Pty Ltd

Sandy Beach North
Photogrammetry Analysis Jan 07.wor

## LEGEND

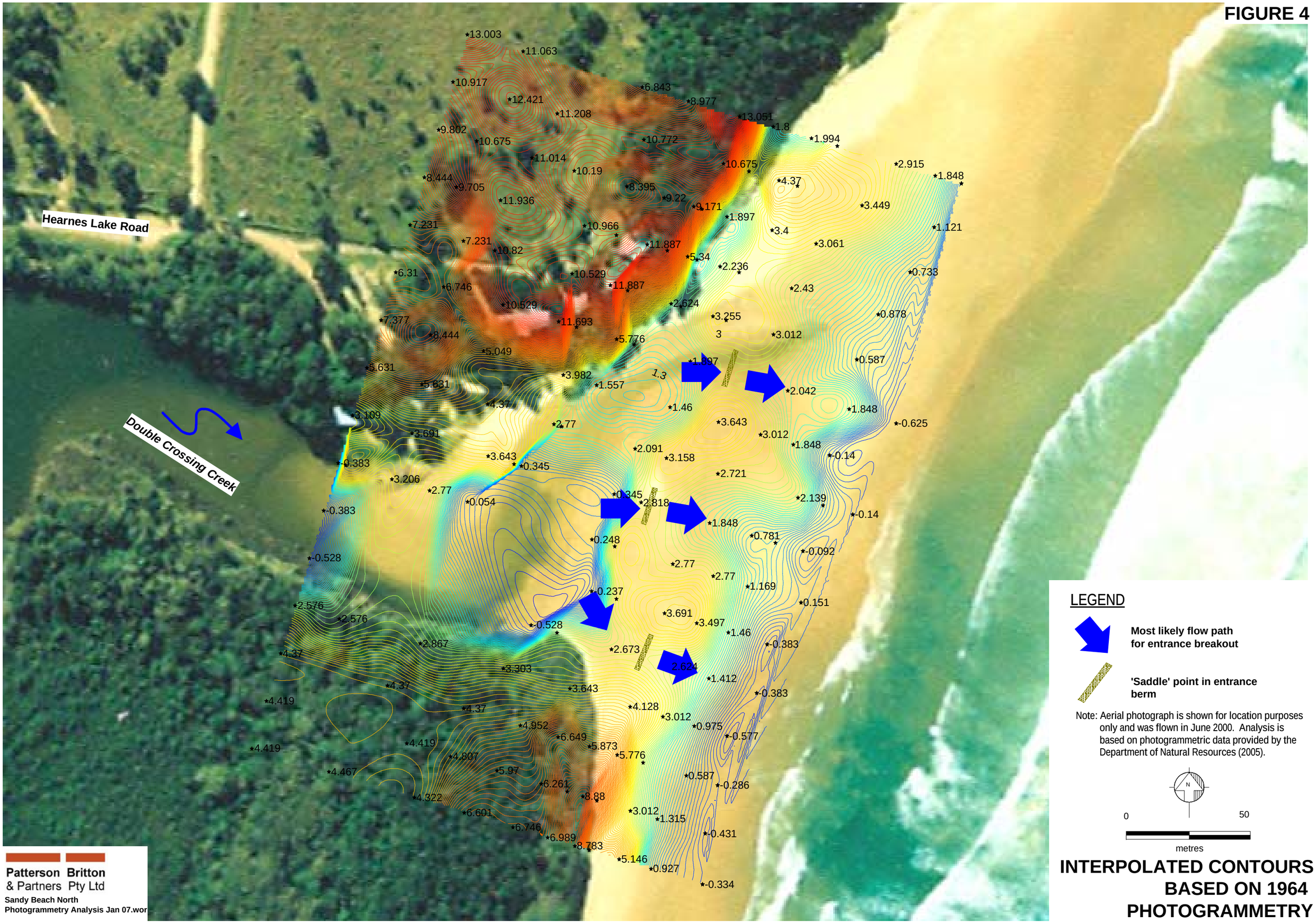
**Most likely flow path for entrance breakout**

**'Saddle' point in entrance berm**

Note: Aerial photograph is shown for location purposes only and was flown in June 2000. Analysis is based on photogrammetric data provided by the Department of Natural Resources (2005).

# INTERPOLATED CONTOURS BASED ON 1943 PHOTOGRAMMETRY

FIGURE 4




LEGEND

**Most likely flow path for entrance breakout**

**'Saddle' point in entrance berm**

Note: Aerial photograph is shown for location purposes only and was flown in June 2000. Analysis is based on photogrammetric data provided by the Department of Natural Resources (2005).

N

0 50

metres

# INTERPOLATED CONTOURS BASED ON 1964 PHOTOGRAMMETRY

Patterson Britton & Partners Pty Ltd

**Sandy Beach North**
**Photogrammetry Analysis Jan 07.wor**

FIGURE 5

Hearnes Lake Road

Double Crossing Creek

LEGEND

Most likely flow path for entrance breakout

'Saddle' point in entrance berm

Note: Aerial photograph is shown for location purposes only and was flown in June 2000. Analysis is based on photogrammetric data provided by the Department of Natural Resources (2005).

0 50

metres

# INTERPOLATED CONTOURS BASED ON 1973 PHOTOGRAMMETRY

Patterson Britton & Partners Pty Ltd

Sandy Beach North
Photogrammetry Analysis Jan 07.wor

FIGURE 6

Hearnes Lake Road

Double Crossing Creek

?

LEGEND

Most likely flow path for entrance breakout

'Saddle' point in entrance berm

Note: Aerial photograph is shown for location purposes only and was flown in June 2000. Analysis is based on photogrammetric data provided by the Department of Natural Resources (2005).

0 50

metres

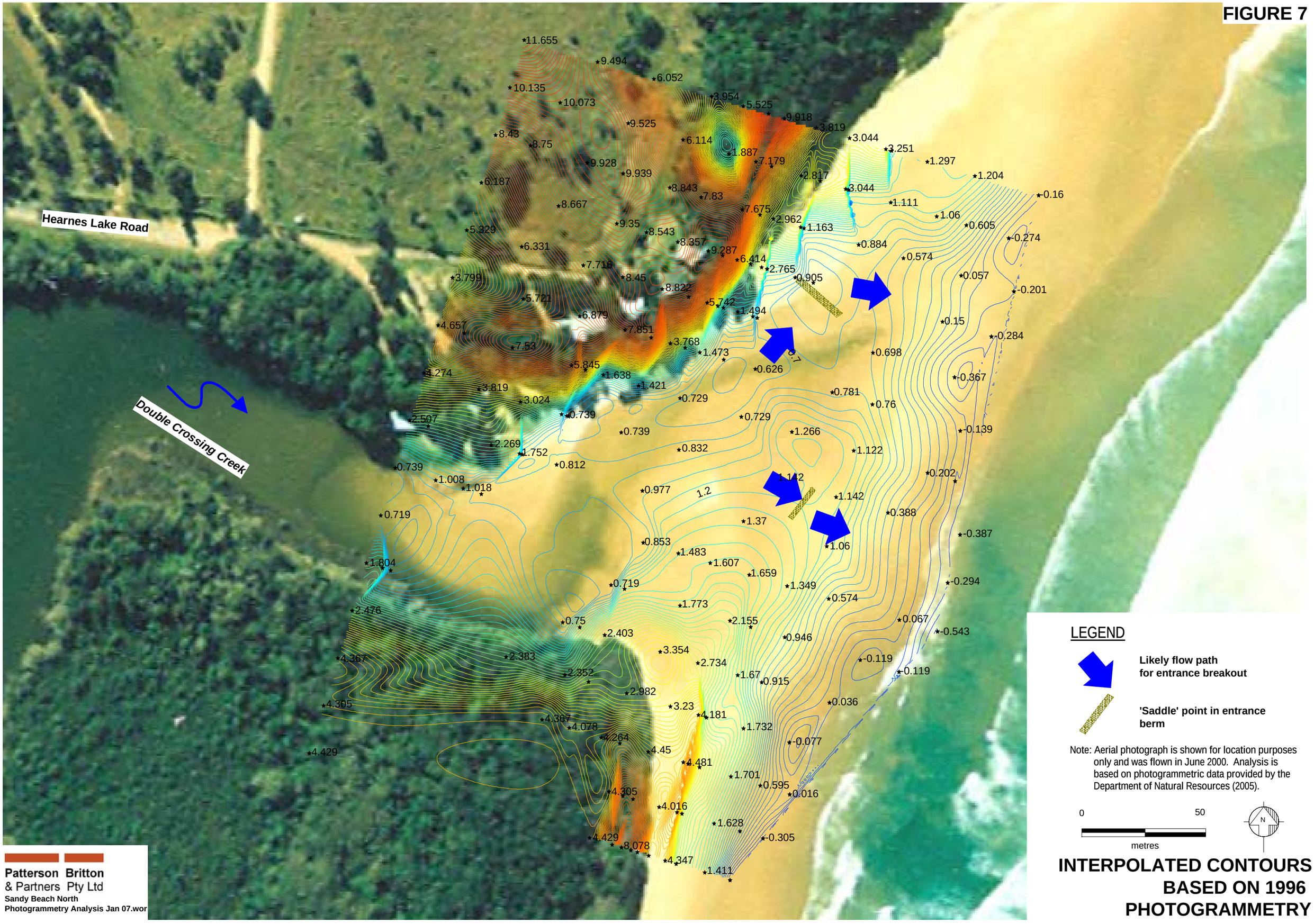
N

# INTERPOLATED CONTOURS BASED ON 1986 PHOTOGRAMMETRY

Patterson Britton & Partners Pty Ltd

Sandy Beach North
Photogrammetry Analysis Jan 07.wor

FIGURE 7




Patterson Britton & Partners Pty Ltd

Sandy Beach North
Photogrammetry Analysis Jan 07.wor

## LEGEND

**Likely flow path for entrance breakout**

**'Saddle' point in entrance berm**

Note: Aerial photograph is shown for location purposes only and was flown in June 2000. Analysis is based on photogrammetric data provided by the Department of Natural Resources (2005).

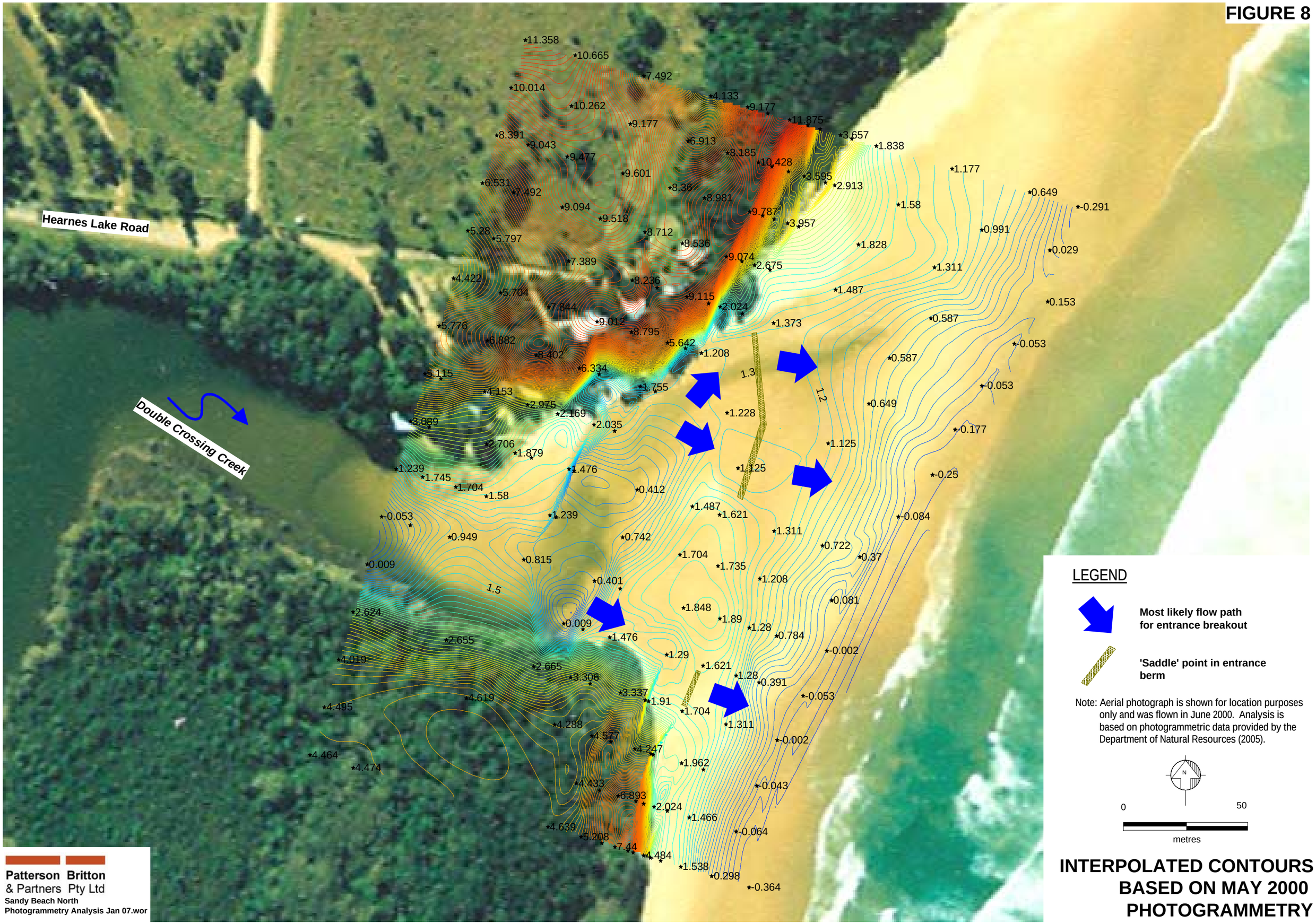
0 50

metres

N

# INTERPOLATED CONTOURS BASED ON 1996 PHOTOGRAMMETRY

FIGURE 8




Patterson Britton & Partners Pty Ltd

Sandy Beach North
Photogrammetry Analysis Jan 07.wor

LEGEND

Most likely flow path for entrance breakout

'Saddle' point in entrance berm

Note: Aerial photograph is shown for location purposes only and was flown in June 2000. Analysis is based on photogrammetric data provided by the Department of Natural Resources (2005).

0 50

metres

# INTERPOLATED CONTOURS BASED ON MAY 2000 PHOTOGRAMMETRY

FIGURE 9

Hearnes Lake Road

Double Crossing Creek

LEGEND

Most likely flow path for entrance breakout

'Saddle' point in entrance berm

Note: Aerial photograph is shown for location purposes only and was flown in June 2000. Analysis is based on photogrammetric data provided by the Department of Natural Resources (2005).

0 50

metres

# INTERPOLATED CONTOURS BASED ON 2004 PHOTOGRAMMETRY

Patterson Britton & Partners Pty Ltd

Sandy Beach North

Photogrammetry Analysis Jan 07.wor