4 April 2025

WRL Ref: WRL2025023 LR20250404 JTC VMM

Ms Jessica Watson
Jorge Hrdina Architects
10/38 Manning Road
Double Bay NSW 2028

By email: jessica@jorgehrdina.com.au;

Dear Jessica,

Re: 325 Whale Beach Road, Palm Beach - coastal hazard assessment

1. Introduction

The Water Research Laboratory (WRL) of the School of Civil and Environmental Engineering at UNSW Sydney was engaged by Jorge Hrdina Architects (JHA, the Client) to provide a coastal engineer's coastal hazard assessment for the proposed works on 325 Whale Beach Road, Palm Beach (Figure 1-1). This report addresses the coastal hazards in accordance with Northern Beaches Council (ex-Pittwater Council) policy and the NSW Coastal Management Act 2016. The site was visited by WRL's Principal Coastal Engineer on Wednesday 26 March 2025.

Figure 1-1 Location (Source: Google Earth ©)

2. Executive summary

A summary of the location's coastal hazard assessment in accordance with Northern Beaches Council (ex-Pittwater Council) policy and the NSW Coastal Management Act 2016 is shown in Table 2-1, with details outlined in the following sections.

Table 2-1 Summary of the coastal hazard assessment

Coastal hazard	Summary	WRL comments
(a) Beach erosion	Not applicable	Rocky foreshore. Subject only to geotechnical assessment
(b) Shoreline recession	Not applicable	Rocky foreshore. Subject only to geotechnical assessment
(c) Coastal lake or watercourse entrance instability	Not applicable	Hazard is not present at this site
(d) Coastal inundation	Property above runup level	The R2% wave runup level is approximately 4 m below the lowest part of the property and 9 m below the lowest floor level. Refer to Section 7
(e) Coastal cliff or slope instability	Subject to geotechnical assessment	Subject to geotechnical assessment with further discussion in Section 8
(f) Tidal inundation	No hazard	Hazard is not present at this site Lowest point is 25 m AHD (above mean sea level)
(g) Erosion and inundation due to tidal waters	No hazard	Hazard is not present at this site Lowest point is 25 m AHD (above mean sea level)

3. Proposed works and available information

JHA, the Client proposes to alter the swimming pool near the seaward boundary of the subject property, with an option to alter the internal configuration of the house, without any lowering of floor levels. Information provided to WRL at the time of this report is shown in Table 3-1. The lowest floor level of the existing and proposed house is 29.66 m AHD. The lowest surveyed ground level on the subject property is 24.35 m AHD.

Table 3-1 Information provided to WRL

Source	Description or title	Drawing number	Rev	Date
CMS Surveyors	Site survey	18080Bdetail 4.dwg	4	21/02/2025
JHA	Site plan - Existing	1000	-	31/01/2025
JHA	Site plan - Option B	1001	B	27/02/2025
JHA	Site plan - Option B – Site areas	1001	B	18/03/2025
JHA	Plan – Measured drawings	2200	-	16/01/2025
JHA	Plan – Sketch design option B - Reno	2212	B	18/03/2025

4. Site geometry and bathymetry

4.1 Site visit

The site was visited by WRL's Principal Coastal Engineer James Carley on Wednesday, 26 March 2025. Photos from the site visit are shown in Figure 4-1 to Figure 4-4. As stated above, a site survey was provided to WRL from CMS Surveyors.

Figure 4-1 View from existing house

Figure 4-2 Cliff face

Figure 4-3 Boulder armour at the cliff toe

Figure 4-4 Rock platform

4.2 Bathymetry and topography

The NSW Department of Planning, Industry and Environment (NSW DPIE), provides topographic and bathymetric data based on Airborne LiDAR Bathymetry (ALB) technology conducted by Fugro Pty Ltd from July to December 2018. The bathymetric data was accessed through the ELVIS portal (https://elevation.fsdf.org.au/) and downloaded at a resolution of 5 m.

The site's topography features a cliff face, rock platform and nearshore slope. The transect line (Figure 4-5) and transect section (Figure 4-6) taken from the widest part of the property and shows a near vertical steep cliff from 23 m AHD to 0 m AHD, with an approximately 70 m wide rock platform located at 0 m AHD (excluding toe rock boulders) continuing with a 1V:5H slope from to -10 m AHD and a 1V:30H slope further seaward.

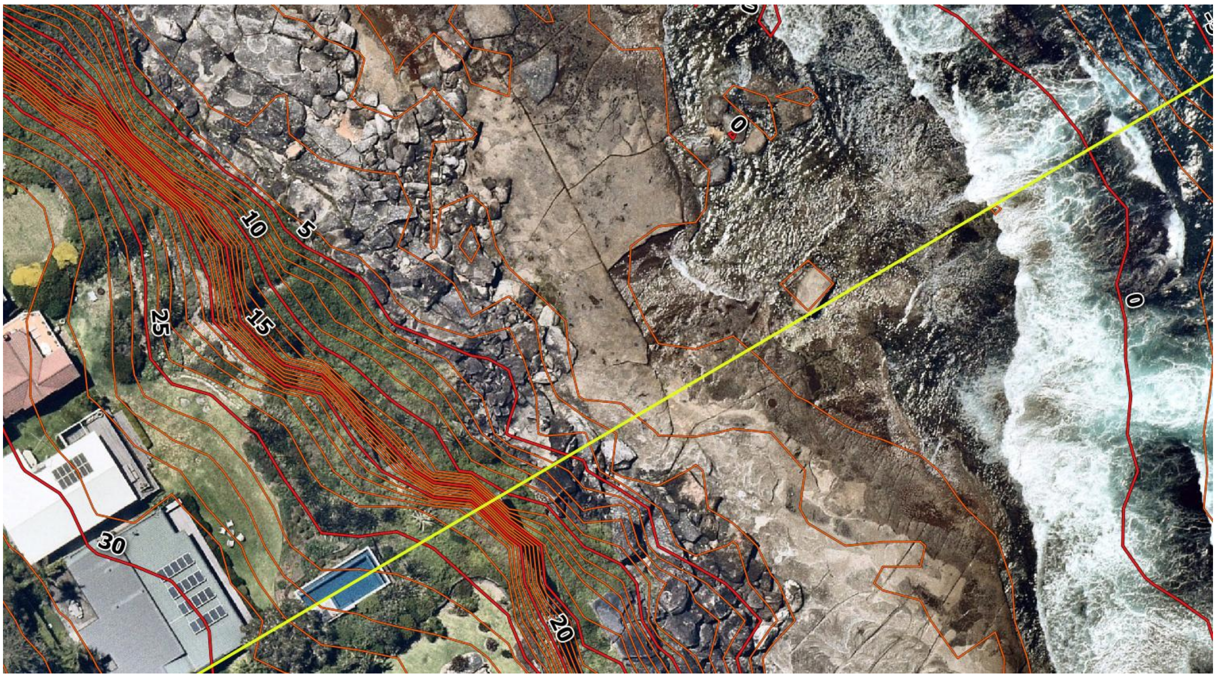

Figure 4-5 Transect and NSW marine LiDAR bathymetry and topography data 2018

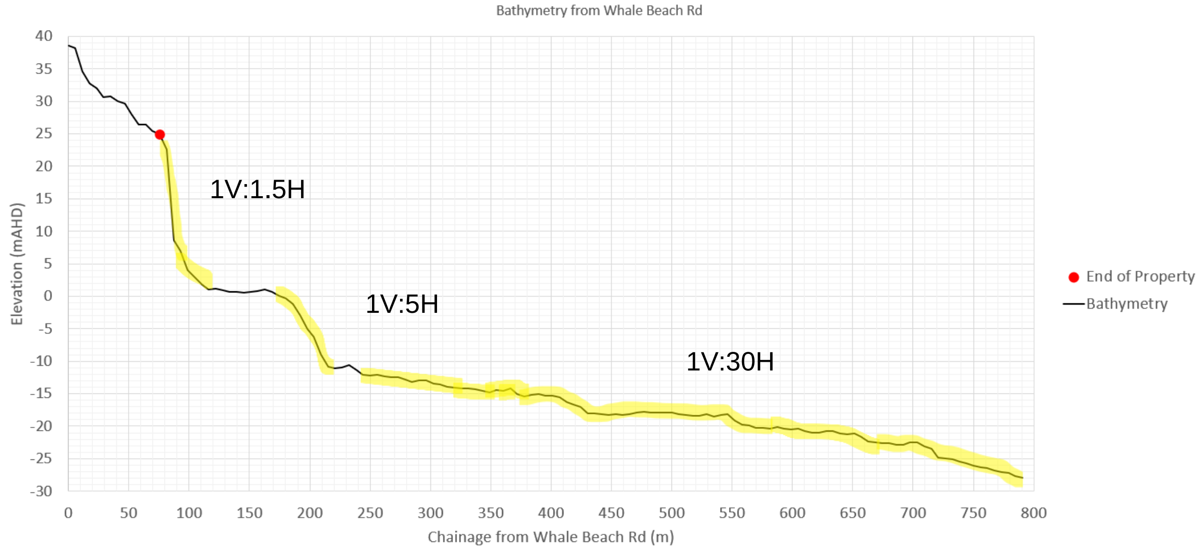

Figure 4-6 Bathymetry and topography transect

5. Water levels and waves

5.1 Water levels

The water levels used are shown in Table 5-1, with the earlier studies corrected for historical sea-level rise (taken as 2 mm/year) at Fort Denison based on the work of Watson (2020). Note that these values exclude wave setup and runup effects. Wave setup is not important for the subject site due to the cliff geometry, while wave runup is calculated separately.

Table 5-1 Design water levels (Sydney) excluding wave setup and wave runup

ARI (years)	2008 water level (m AHD) (NSW DECCW, 2010)	2017 water level (m AHD) (MHL, 2018)	2025 design still water level (m AHD)(2)
100	1.44	1.42	1.46
500	1.54(1)	1.51(1)	1.55

(1) These water level values were extrapolated by WRL using a log-linear fit.

(2) The 2025 design water levels were derived from (NSW DECCW, 2010) and (MHL, 2018) adjusted to 2025 using a constant historical SLR rate of 2 mm/year. The proposed 2025 design still water levels are an average of the adjusted NSW DECCW and MHL water levels.

5.2 Future sea level rise

This report is for a design working life of 60 years, assuming the structure is to be built in 2025.

In the absence of official NSW sea level rise (SLR) benchmarks, the SLR values adopted by WRL were based on the more recent IPCC AR6 (2021) report. The IPCC report provides global mean sea level rise projections for five Shared Socioeconomic Pathways (SSPs), with each SSP capturing different emissions scenarios. WRL adopted SLR values for this study were based on SSP5–8.5 (Very High emissions scenario – medium confidence) to account for the highest risk scenario, using the NASA sea level projection tool (NASA, 2025) for the Sydney, Fort Denison location. SLR projections are shown in Table 5-2.

Table 5-2 Sea level rise projection (SSP5–8.5, Source IPCC, 2021)

Planning Period (year)	Sea Level Rise (m)[(1)]
2025	0.00
2050	0.18
2065	*0.33*[(2)]
2080	0.46
2085	*0.53*[(2)]
2090	0.59
2100	0.72
2150	1.30

(1) SLR values were adjusted to 2025 as IPPC (2021) SLR values are relative to 2020.

(2) 2065 and 2085 SLR values were interpolated using a 2nd degree polynomial fit.

5.3 Waves

The location is characterised by a moderate to high energy wave climate as the offshore bathymetry has a moderate gradient and there are no protective offshore reefs. Estimates for 100 year ARI (Average Recurrence Interval) non-directional offshore waves (Glatz et al., 2017) and directional offshore extreme waves (Shand et al., 2011a) in the Sydney region are provided in Table 5-3. For this analysis, unrefracted waves from the east to south-east wave direction H_s were used to quantify wave runup.

Table 5-3 Offshore directional extreme wave conditions at Sydney wave buoy
(Source: Glatz et al., 2017 and Shand et al., 2011a)

Offshore Wave Direction		One Hour Exceedance H_S (m) 100 year ARI
All directions [(1)]	-	9.4
N to E [(2)]	0 to 90	5.7
E to SE [(2)]	90 to 135	7.8
SE to SW [(2)]	135 to 225	9

(1) These values were reported in Galtz et al. (2017).

(2) These values were reported in Shand et al. (2011a).

Offshore peak wave period for design conditions from the Sydney wave buoy (Shand et al., 2011b) are provided in Table 5-4.

Table 5-4 Corresponding peak wave period Tp conditions

ARI (years)	Offshore Tp (s)
100	13.0

6. Coastal hazard assessment

The NSW Coastal Management Act 2016 lists the following coastal hazards:

(a) Beach erosion
(b) Shoreline recession
(c) Coastal lake or watercourse entrance instability
(d) Coastal inundation
(e) Coastal cliff or slope instability
(f) Tidal inundation
(g) Erosion and inundation of foreshores caused by tidal waters and the action of waves, including the interaction of those waters with catchment floodwaters

6.1 (a) Beach erosion hazard

Beach erosion is not applicable for this location due to the site not being located on a sandy beach.

6.2 (b) Shoreline recession hazard

Conventional shoreline recession is not applicable for this location due to the site not being located on a sandy beach. Further discussion can be found in the assessment of (e) Coastal cliff or slope instability.

6.3 (c) Coastal lake or watercourse entrance instability

Coastal lake or watercourse entrance instability is not applicable for this location due to the site not being located at coastal lake or watercourse entrance.

6.4 (d) Coastal inundation

Due to its elevation, the site is not subject to conventional coastal inundation. However, it could be subject to wave runup, which is assessed in more detail in Section 7.

6.5 (e) Coastal cliff or slope instability

This hazard is primarily assessed separately by a geotechnical engineer. Additional input from WRL is provided in Section 8.

6.6 (f) Tidal inundation

Tidal inundation is not a hazard for this location due to the site being located above 25 m AHD (mean sea level).

6.7 (g) Erosion and inundation caused by tidal waters

Erosion and inundation caused by tidal waters is not a hazard for this location due to the site being located above 25 m AHD (mean sea level).

7. WRL analysis of wave runup

Wave runup height was estimated for 100 year ARI conditions for 2025, 2065 and 2085 using Equation 6.2 in the EurOtop (2018) Overtopping Manual. The results are shown in Table 7-1. A cross check was made with the method of Mase et al. (2004), which estimated runup levels about 0.5 to 1 m lower than EurOtop (2018). The EurOtop (2018) method was adopted for this study.

Table 7-1 R2% wave runup height (EurOtop, 2018)

ARI (years)	Year	Water level (m AHD)	Wave runup R2% (m AHD)
100	2025	1.46	18.9
100	2065	1.79	20.2
100	2085	1.99	20.5

A visual representation of the EurOtop, 2018 runup extents are shown in Figure 7-1. The wave run up analysis show that even during extreme 100 ARI events the R2% wave runup is more than 4 m below the lowest point of the property and 9 m below the lowest floor level of the house, noting that splash, spray and some individual waves may exceed this design runup level – particularly during strong onshore winds

Figure 7-1 R2% 2085 wave runup extents

8. WRL discussion on cliff erosion/recession

8.1 Geotechnical engineering assessment

Coastal hazard (e) coastal cliff or slope instability requires a specialist geotechnical assessment. Some commentary by WRL on cliff erosion rates is provided below.

8.2 Published cliff erosion/recession rates

Chapman et al. (1982) gave the following commentary on cliff erosion in NSW:

> *"Rates of cliff erosion are highly variable and actual measurements are virtually non-existent. …cliff retreat is highly erratic, with localized and infrequent rock falls separated by long periods of weathering."*

For the purposes of estimating sediment supply to beaches, Chapman et al. (1982) suggested an order of magnitude estimate of cliff erosion rates for Sydney to be 5 mm per year.

Sunamura (1983) presented a model for cliff recession and collated recession rates from numerous locations around the world. The only Australian locations cited were for limestone at Point Peron near Perth (0.2 to 1 mm per year) and aeolianite at Warrnambool Victoria (14 mm per year). Sunamura (1983) also presented results of physical model studies on cliff recession and platform formation.

Crozier and Braybrooke (1992) examined sea cliffs on Sydney's northern beaches. Some of these cliffs are shale, which is softer than sandstone. They estimated that the average rate of sandstone cliff erosion was 4.3 mm per year, and the maximum was 12.1 mm per year. They also published sandstone erosion rates from a range of sources (not sea cliffs) which ranged from 0.012 mm/year to 4.6 mm per year. However, "fine clayey grained sandstone" at Beacon Hill was observed to erode at 10 to 17.4 mm per year over 15 years.

Dragovich (2000) estimated erosion rates of Sydney sandstone in locations with a high salt load to be 1 to 5 mm per year – though this related to dimensioned construction stone rather than sea cliffs subject to wave action. She also quoted Roy (1983) who estimated that the softer beds near the base of sandstone cliffs in the southern Sydney region were weathering at rates of 2 to 5 mm per year.

8.3 Cliff erosion/recession on subject property

The cliff face at the subject property is fronted by a wave cut platform (Figure 4-4 and Figure 8-1) of approximately 70 m width. The landward edge of the platform where it intersects with the cliff base is naturally armoured with an apron fillet of rock boulders from previous cliff face collapses (Figure 4-3). The rock boulders have typical individual rock dimensions of up to 1 to 5 m. The rock boulder apron would provide a degree of armouring protection to the base of the cliff from further wave attack.

Chapman et al. (1982) reported on work from Thom and Chappell (1975) which showed that sea level 10,000 years before present was approximately 30 m below present, however, from approximately 6,000 years before present, sea level has remained roughly constant within an envelope of approximately $\pm$1 m.

On the assumption that the wave cut platform was formed over the duration of this approximately constant sea level, the order of magnitude estimate of the mean rate for formation of the wave cut platform at the cliff base fronting the subject property is estimated to be 12 mm per year.

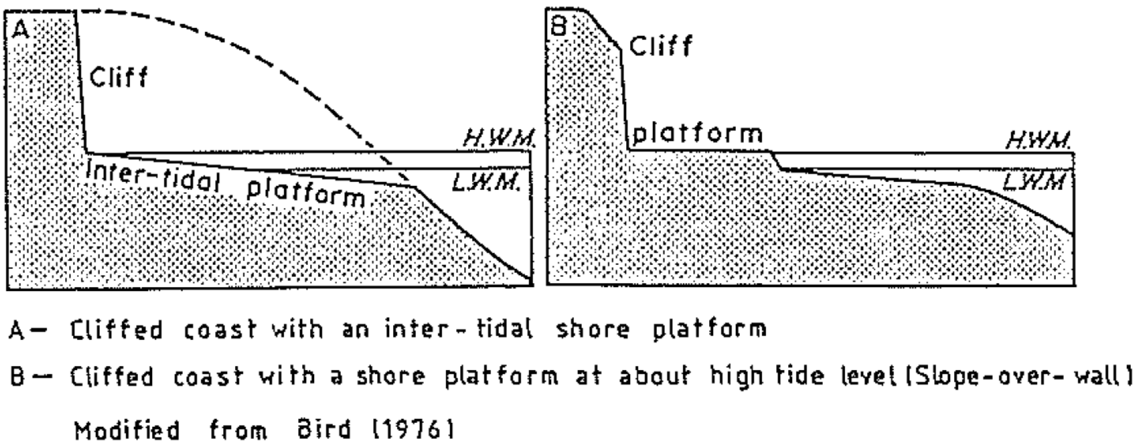

Figure 8-1 Wave cut platform illustration (Crozier and Braybrooke, 1992)

9. Summary

An executive summary is provided in Section 2 of this letter. Please contact James Carley or myself should you require further information.

Yours sincerely,

Dr Francois Flocard
Director, Industry Research

10. References and bibliography

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