Flood Impact Assessment

1BBoat House, Palm Beach

59916081/R005

Prepared for

London Lakes Partnership

2 August 2021

Cardno

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1 Introduction

1.1 Background

Cardno (NSW/ACT) Pty Ltd have been engaged by London Lakes Partnership (LLP), who plan to undertake refurbishment and renovations to the restaurant, boat-hire facilities and deck areas (The Superstructure), on their leased property at the Barrenjoey Boat House, Palm Beach. They also plan to upgrade the marina facilities under a separate application. The work will involve an almost complete demolition of the Superstructure and pier replacement under it as required, other than a few piers that are in sound condition.

Figure 1 provides a locality plan of the site and its surrounds.

An annotated survey is given in **Appendix A.** As described by Cardno, 2021b:

> *This survey includes beach levels, which will be needed for design and construction of replacement works, including below and along parts of the building. Note that Council has recently constructed a cut sand-stone block seawall near the back beach area to the south – extending south about 20m from the edge of the southern deck area.*

As described by Cardno, 2021b:

> *Appendix B of Cardno (2021a) provides some history of the site and includes condition reports prepared by Blue Pacific Constructions Pty Ltd – before June 2016. The building is old and was developed in a piece-meal fashion. The seaward deck level is 1.8 m AHD and hence is currently not affected by the 50-years average recurrence interval (ARI) storm tide level of 1.47m AHD; but occasionally by high tides and ocean swell, such as in June 2016, when some damage to the structure, together with shoreline erosion, occurred. Deck boards have been loosened by wave action in the past – they are currently nailed to the deck beams/bearers below; with some nails obviously lifted. A higher upper-deck at 2.5m AHD and closer to the restaurant and along the southern side to the back of the building is accessed from the lower, seaward deck by steps and also the arrival area.*

1.2 Natural Environment Referral Response – Flood (DA2021/0669)

It is proposed under DA2021/0669 to undertake development on:

> Lot 7005 DP 1117451, 1193 Barrenjoey Road PALM BEACH NSW 2108
>
> Lot 7002 DP 1117592, 1193 Barrenjoey Road PALM BEACH NSW 2108
>
> Lot 298 DP 721522, 1191 Barrenjoey Road PALM BEACH NSW 2108

In its Natural Environment referral response, Council advised, in part:

> *The Avalon to Palm Beach Floodplain Risk Management Study and Plan, 2017 identifies the catchment flood regime for the site. The following non-compliances have been identified*
>
> - *A flood management report considering catchment flooding and the impacts of the development on flooding has not been provided*
> - *The finished floor level of the proposed restaurant needs to be set at or above the Flood Planning Level of 3.05m AHD*
> - *The proposed ancillary building housing toilets, bin room and utilities is below the Flood Planning Level of 3.05m AHD*
> - *Potentially hazardous substances are stored below the Flood Planning Level of 3.05m AHD, namely the location and level of the sewer tank*

There is potential for reduction of flood storage in a 1% AEP event.

1.3 Approach

To assess the merit of Council's catchment flooding non-compliances the following tasks were undertaken:

(i) Create a local 1D/2D floodplain model to run to estimate flood levels, velocities, depths and hazards based on a Rain on Grid modelling approach,

(ii) Modify the local 1D/2D floodplain model to represent the planned development on the site;

(iii) Run the post-development model and assess the impacts of the development on flooding.

The selection of design floods was informed by consideration of the following:

1.3.1 Pittwater LEP 2014

7.3 Flood planning

…… flood planning level means the level of a 1:100 ARI (average recurrent interval) flood event plus 0.5 metres freeboard, or other freeboard determined by an adopted floodplain risk management plan.

7.4 Floodplain risk management

(2) This clause applies to land between the flood planning level and the level of the probable maximum flood, but does not apply to land subject to the discharge of a 1:100 ARI (average recurrent interval) flood event plus 0.5 metre freeboard, or other freeboard determined by an adopted floodplain risk management plan.

1.3.2 Pittwater 21 DCP Section B

B3.12 Climate Change (Sea Level Rise and Increased Rainfall Volume)

When this control applies:

This control applies where 'intensification of development' is proposed. 'Intensification of development' includes but may not be limited to:

- *an increase in the number of dwellings (but excluding dual occupancies and secondary dwellings);*
- *an increase in commercial or retail floor space.*

Climate Change Scenarios

The following climate change scenarios shall be considered:

***Scenario 1:** Impacts of sea level rise only:*

***Scenario 2:** Impacts of sea level rise combined with increased rainfall volume:*

1.3.3 2017 Avalon to Palm Beach FRMS&P

14.1.3 NSW and Pittwater Council Approaches

Pittwater Council has adopted a climate change scenario including 0.9 m sea level rise and a 30% increase in design rainfall intensity for considering the possible implications of climate change on floodplain risk management activities. While these values lie at the upper end of projections for the period to 2100, it is noted that climate change and sea level rise are likely to continue for many centuries beyond 2100 (e.g. IPCC 2014).

14.2 Impact of Climate Change on Local Flood Behaviour and Impacts

It is noted that a 1% AEP ocean water level boundary of 1.45 m AHD was adopted for modelling of the 1% AEP flood event in this study, representing quite severe conditions in Pittwater in itself. Together with 0.9 m sea level rise this ocean water level condition would produce significant inundation of the Pittwater foreshore, and much of the climate change impact observed in this analysis can be attributed to ocean storm-driven inundation rather than catchment-driven flooding.

Based on these considerations the following design floods were assessed:

(i) 1% AEP combined with an estuary water level = 1.45 m AHD;

(ii) 1% AEP + 30% increase in Rainfall combined with an estuary water level = 2.35 m AHD; and

(iii) PMF combined with an estuary water level = 2.35 m AHD

2 Previous Studies

2.1 Coastal Processes and Estuarine Flooding

Coastal processes and estuarine flooding are addressed in Cardno (2021a, b).

As described by Cardno, 2021b, in part:

> *LLP, through Blue Pacific Constructions, have requested that the EPL for re-design and re-construction of the Superstructure at the Boat House Wharf be based on 2070, including projected sea level rise. This has been interpolated from the 2050 and 2100 data presented in Cardno (2012). This planning period is based on the likely design life of some of the proposed marine works. Design principals have been based on AS 4997-2005 for Design of Maritime Structures because the Superstructure is seaward of the gazetted MHWM and is classified as a normal commercial wharf struc*ture.
>
> *…. Note also that the rebuilt Superstructure could be raised after 50 years, above the new piers, bearers and joists that would be installed – if the building is still in use at 2070.*
>
> *… The EPL assessed above complies with Appendix 7 of Pittwater 21 DCP. Note that:*
>
> - *This is not a residential development under Appendix 7 and Pittwater 21 DCP clauses 3.8 and 3.9.*
> - *The storage of dangerous goods and sewerage systems are all above the EPL.*

2.2 Flooding

2.2.1 2013 Pittwater Overland Flow Mapping and Flood Study

As described by Cardno, 2013, in part:

> *Cardno was commissioned by Pittwater Council to undertake Pittwater Overland Flow Mapping and* Flood *Study. This study aims to identify properties and areas potentially affected by overland flow rather than "mainstream" flooding identified by Pittwater Council as Category 1.*
>
> *A full dynamic two-dimensional (2D) SOBEK hydraulic model has been developed in this study to define the overland flow behaviour under existing conditions and climate change scenarios. A range of flood events have been considered, including the 5 year ARI, 20 year ARI, 100 year ARI and PMF events.*
>
> *A detailed flood model was established on a pilot site to undertake a sensitivity analysis on the impact of the key assumptions of the modelling. The sensitivity analysis included the impact of assumption on pipe blockage, grid size and on the modelling of buildings on the floodplain.*
>
> *The sensitivity analysis results are summarised as follows:*
>
> - *An alternative approach to modelling buildings as blocked would significantly impact on flowpaths immediately adjacent to buildings, but not on flowpaths away from the buildings; and*
> - *Incorporation of drainage system in the model would decrease water levels in general. The results indicate that the model without blockage of stormwater infrastructure for 100 year ARI event generates a similar flood extent generated by the model with blockage of stormwater infrastructure for 20 year ARI event. This suggests that 20 year ARI (with blockage) in the larger models may by a more realistic representation of the 100 year ARI, if no pit blockage is assumed.*
>
> *Preliminary validation was undertaken to test the robustness and reliability of the hydrological component of the model. The validation results suggest that the SOBEK model is capable of simulating hydrological processes for the study area and the hydrological parameters applied in the SOBEK model are reasonable.*

The results from the modelling have been provided in a number of forms:

- *Peak depths and water levels;*
- *Overland flow extents;*
- *Provisional flood hazard, which is a measure of the risk to life from the overland flow;*
- *Hydraulic categories, including floodway, flood storage and flood fringe.*

A 0.15m filter was selected to represent significant overland flow as this is generally the standard height of most kerb and gutters within the LGA. Depths in excess of this are likely to represent a reasonable proportion of flow, particularly within the steep terrain of the Pittwater LGA.

…. Climate change is predicted to influence both sea levels and rainfall intensities during infrequent storm events. An analysis has been undertaken on the likely impact of climate change on overland flow within the LGA.

…. For planning purposes overland flow for the Pittwater LGA was categories into two severities:

- *Overland Flow Path – Major: is defined as land that has a depth of overland flow greater than 0.3m.*
- *Overland Flow Path – Minor: is defined as land that has a depth of overland flow greater than 0.15m and less than 0.3m.*

Flood Planning Level (FPL) mapping across the Pittwater LGA has been based on the above two overland flow categories.

2.2.2 2017 Avalon to Palm Beach FRMS&P

As described by MHL, 2017, in part:

Pittwater Council commissioned NSW Public Works, with financial assistance from the NSW State Government, to prepare the Avalon to Palm Beach Floodplain Risk Management Study and Plan. The study area extends from Bilgola Beach in the south to Palm Beach in the north, and includes Avalon town centre and Careel Creek, which have experienced serious flooding in the past.

…. The principal outcomes of this study include:

- *A consolidated Flood Study (Chapter 7), with estimates of flood extents, levels, depths and velocities for the 20% Annual Exceedance Probability (AEP), 5% AEP, 1% AEP, 0.5% AEP, 0.2% AEP and probable maximum flood (PMF) events;*
- *Mapping of the high, medium and low Flood Risk Precincts and of Flood Life Hazard categories used for applying Pittwater 21 DCP (Chapter 7);*
- *Definition of the flood problem by construction of a property database and assessment of building inundation, road inundation, evacuation 'hot spots' and flood damages; about 219 dwellings and 101 other buildings would be flooded above floor in the 1% AEP event, though generally to shallow depths (median < 0.2m); the estimated average annual damages is $5.2 million and the net present value of damage is $77.1 million (Chapter 8);*
- *Further definition of the flood problem by a formal risk assessment; this shows that catastrophic damage to houses is largely confined to very rare events (medium risk) but moderate damage is expected in frequent events (high risk); areas of pronounced risk in the study area include Pittwater Palms retirement village, the Avalon town centre and the Elaine Avenue precinct (Chapter 9);*

- *An assessment of potential floodplain management measures (Chapter 10) and detailed evaluation of flood modification options (Chapter 11), property modification options (Chapter 12) and response modification options (Chapter 13);*
- *An assessment of the potential impacts of climate change (Chapter 14);*
- *A recommended Floodplain Risk Management Plan (FRMP) for the Avalon to Palm Beach study area (Chapter 15).*

…. As part of the current Floodplain Risk Management Study it was determined that it would be advantageous to update previous modelling, essentially through extension of the existing Careel Creek TUFLOW model to include those parts of the Avalon to Palm Beach study area previously modelled using SOBEK (assembled for the 2013 Pittwater Overland Flow Mapping and Flood Study). …..

The model development, calibration and validation, and result processing are described in detail in Appendix B, with floodplain mapping presented in Appendix C. In summary:

- *The extended TUFLOW model was adequately calibrated against surveyed flood levels for the February 2008 flood event, and verified against simulated flood levels and flows from the 2013 Careel Creek TUFLOW model.*
- *Flood conditions for the PMF, 0.2%, 0.5%, 1%, 5% and 20% AEP design events have been investigated in this study. Critical design storm durations were adopted as per the Careel Creek Catchment Flood Study (WMA Water 2013) and comprise a 120 minute duration for the 0.2%, 0.5%, 1%, 5% and 20% AEP events, and a 60 minute duration for the PMF.*
- *Flood levels in low lying foreshore areas of the study area as well as discharge from Careel Creek are influenced by the coinciding water level in Pittwater and the ocean. A 1% AEP ocean water level boundary (1.45 m AHD) was adopted for the PMF, 0.2%, 0.5% and 1% AEP events, while for the smaller AEP events a tailwater of 0.95 m was adopted (mean Highest High Water Solstice Springs for Sydney). These tailwater levels were determined with reference to Development of Practical Guidance for Coincidence of Catchment Flooding and Oceanic Inundation (Toniato et. al 2014).*
- *The use of the direct rainfall method in TUFLOW results in all active model cells being 'wet' or inundated. Filtering is therefore required to improve interpretation of flooding. A filtering methodology was developed and applied to all mapping consisting of velocity and depth thresholds and removal of small isolated 'ponds' of inundation.*
- *A suite of flood maps was produced including peak flood depths, peak flood levels, peak flood velocities, hydraulic flood hazard and hydraulic categories.*

3 Flooding Assessment

As outlined in **Section 1.3**, a local TUFLOW model of the site and its surrounds was assembled.

3.1 Local Overland Flow Model

The Digital Elevation Model (DEM) was created by combining detailed survey (attached in **Appendix A**) and ALS data external to the site that was collected in 2013. Across reference Locations 1 – 8 (refer **Figure 19**) the survey ground level was found to vary from 0.14 m lower (P6) to 0.23 m higher (P3) than the ALS level. Immediately east of the Boathouse the survey ground level was 0.02 m lower than the ALS level.

The adopted grid size was 1 m x 1 m.

Any drainage system is very limited or not present given the sandy soils and lack of kerb and gutter. No drainage was included in the model.

The roughness zones for the floodplain are mapped in **Figure 3**.

A “rain on grid” approach was adopted for combined hydrological and hydraulic modelling based on the following:

To be consistent with the approach adopted in the 2017 Avalon to Palm Beach FRMS the IFD and storm burst temporal patterns were obtained for the 1987 edition of Australian Rainfall and Runoff (ARR1987).

The adopted rainfall losses for impervious surfaces were an initial loss = 1 mm and a continuing loss = 0 mm/h.

The adopted rainfall losses for pervious surfaces were an initial loss = 0 mm and a continuing loss = 10 mm/h. This initial loss was consistent with the initial loss adopted in the 2017 Avalon to Palm Beach FRMS. The continuing loss reflected the very sandy soils, as evidenced by the historical image of Palm Beach below, and was guided by the continuing loss adopted for assessments on the Kurnell peninsula on similar sandy soils.

Palm Beach Camping Ground in 1955

Based on the considerations outlined in **Section 1.3**, the following design floods and estuary levels were assessed:

(i) 1% AEP combined with an estuary water level = 1.45 m AHD;

(ii) 1% AEP + 30% increase in Rainfall combined with an estuary water level = 2.35 m AHD; and

(iii) PMF combined with an estuary water level = 2.35 m AHD

3.2 Benchmark Conditions

An initial assessment of 1% AEP storm burst of 60 mins, 90 mins and 120 mins determined that in the vicinity of the Boathouse the 90 mins storm burst is critical. For the PMF a 60 mins storm was adopted in accordance with the 2017 Avalon to Palm Beach FRMS.

3.2.1 Flood Levels and Depths

The overall 1% AEP, 1% AEP under climate change and PMF flood extents and depths under Benchmark Conditions are plotted in **Figures 4, 8** and **12** respectively.

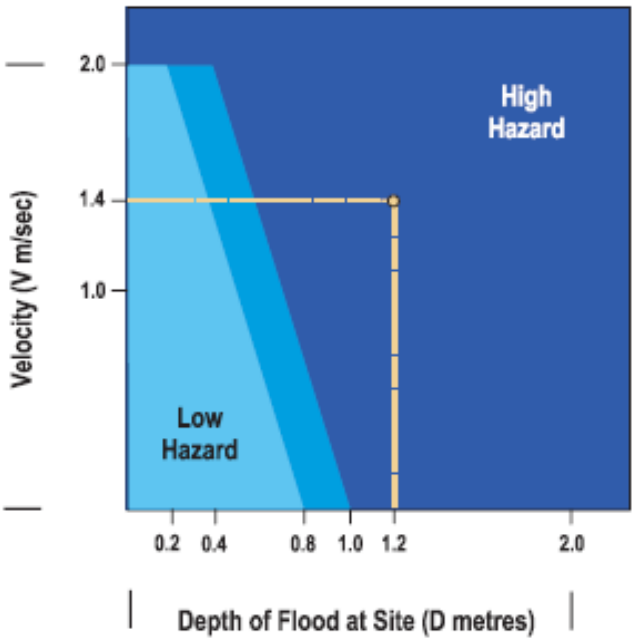
In the vicinity of the Boathouse, the 1% AEP, 1% AEP under climate change and PMF flood extents and depths under Benchmark Conditions are plotted in **Figures 5, 9** and **13** respectively. The flood depths at the reference locations identified in Figure 19 are summarised in **Table 1**.

3.2.2 Flood Velocities

In the vicinity of the Boathouse, the 1% AEP, 1% AEP under climate change and PMF flood velocities under Benchmark Conditions are plotted in **Figures 6, 10** and **14** respectively.

3.2.3 Flood Hazard

As described in the 2005 NSW Floodplain Development Manual, experience from studies of floods throughout NSW and elsewhere has allowed authorities to develop methods of assessing the hazard to life and property on floodplains. This experience has been used in developing the 2005 NSW Floodplain Development Manual to provide guidelines for managing this hazard. These guidelines are shown schematically below.



Provisional Hazard Categories
(after Figure L2, NSW Government, 2005)

Table 1 Flood Levels (m AHD) and Depths (cm) under Benchmark Conditions

Point	Ground Level in Local Model (mAHD)	1%AEP 90mins		1%AEP 90mins + 30% Increase		PMF 60mins	
		Flood Level (mAHD)	Depth (cm)	Flood Level (mAHD)	Depth (cm)	Flood Level (mAHD)	Depth (cm)
P1	2.53	2.54	1	2.55	2	2.58	5
P2	2.76	2.80	4	2.84	8	2.92	16
P3	2.69	2.81	12	2.84	15	2.92	23
P4	2.64	2.80	16	2.84	20	2.92	28
P5	2.68	2.80	12	2.84	16	2.92	24
P7	2.67	2.76	9	2.80	13	2.89	22
P6	2.13	2.17	4	2.44	31	2.44	31
P8	2.67	2.79	12	2.83	16	2.91	24
P9	2.65	2.78	13	2.82	17	2.90	25
P10	2.64	2.74	10	2.77	13	2.84	20
P11	2.58	2.67	9	2.70	12	2.76	18
P12	2.53	2.59	6	2.61	8	2.66	13
P13	2.55	2.57	2	2.59	4	2.62	7
P14	2.52	2.57	5	2.59	7	2.63	11
P15	2.55	2.70	15	2.73	18	2.78	23
P16	2.58	2.70	12	2.73	15	2.79	21
P17	2.68	2.80	12	2.84	16	2.91	23
P18	2.66	2.80	14	2.84	18	2.92	26
P19	2.70	2.80	10	2.84	14	2.92	22
P20	2.64	2.81	17	2.84	20	2.92	28
P21	2.64	2.80	16	2.83	19	2.91	27
P22	2.75	2.80	5	2.84	9	2.91	16
P23	2.75	2.79	4	2.82	7	2.88	13
P24	2.73	2.80	7	2.84	11	2.91	18
P25	2.64	2.80	16	2.84	20	2.92	28
P26	2.64	2.80	16	2.84	20	2.92	28
		Fixed Tailwater = 1.45mAHD		Fixed Tailwater = 2.35mAHD		Fixed Tailwater = 2.35mAHD	

To use the diagram, it is necessary to know the average depth and velocity of floodwaters at a given location. If the product of depth and velocity exceeds a critical value (as shown below), the flood flow will create a **high hazard** to life and property. There will probably be danger to persons caught in the floodwaters, and possible structural damage. Evacuation of persons would be difficult.

By contrast, in **low hazard** areas people and their possessions can be evacuated safely by trucks. Between the two categories a transition zone is defined in which the degree of hazard is dependent on site conditions and the nature of the proposed development. This calculation leads to a provisional hazard rating. The provisional hazard rating may be modified by consideration of effective flood warning times, the rate of rise of floodwaters, duration of flooding and ease or otherwise of evacuation in times of flood.

In the vicinity of the Boathouse, the 1% AEP, 1% AEP under climate change and PMF provisional flood hazards under Benchmark Conditions are plotted in **Figures 7, 11** and **15** respectively.

3.2.4 Flood Profiles

Two 1% AEP flood profiles were also plotted. The alignments of Sections AA and BB through the driveway and the boat ramp and access road respectively are plotted in **Figure 16**. The flood profiles along Sections AA and BB are plotted in **Figures 17** and **18** respectively.

3.2.5 Discussion

It was concluded rom the assessments of flooding in the 1% AEP, 1% AEP under climate change and PMF events that:

(i) The 1% AEP flood depth is shallow (0.09 m – 0.13 m) and is fairly uniform down the driveway and starts getting shallower (down to 0.01 m) once it has an opportunity to spread out in front of and flow under the Boathouse;

(ii) The impact of climate change would be to increase the 1% AEP flood levels by up to 0.04m except of Reference Location 6;

(iii) The impact at reference Location 6 is greater because the tailwater condition in the 1% AEP under climate change and PMF events drowns this location;

(iv) The PMF is up to 0.13 m higher than the 1% AEP flood level (except at Reference Location 6) which indicates that a freeboard of 0.5 m is overly conservative.

3.3 Future Conditions

The assessment of flooding under Future Conditions was undertaken by modifying the local TUFLOW model of Benchmark Conditions to represent the planned development as documented in **Figure 20**.

The DEM as updated based on the proposed levels and building layouts.

The proposed deck was not included on the basis that it is intended the overland flows down the driveway flow under the proposed pervious deck.

The adopted roughness zones under Future Conditions are mapped in **Figure 21.**

3.3.1 Flood Levels and Depths

The overall 1% AEP, 1% AEP under climate change and PMF flood extents and depths under Future Conditions are plotted in **Figures 22, 26** and **30** respectively.

In the vicinity of the Boathouse, the 1% AEP, 1% AEP under climate change and PMF flood extents and depths under Future Conditions are plotted in **Figures 23, 27** and **31** respectively. The flood levels and depths at the reference locations identified in Figures 19 are summarised in **Table 2**. The locations of four additional reference locations (27, 28, 29 and 30) are also identified as follows.

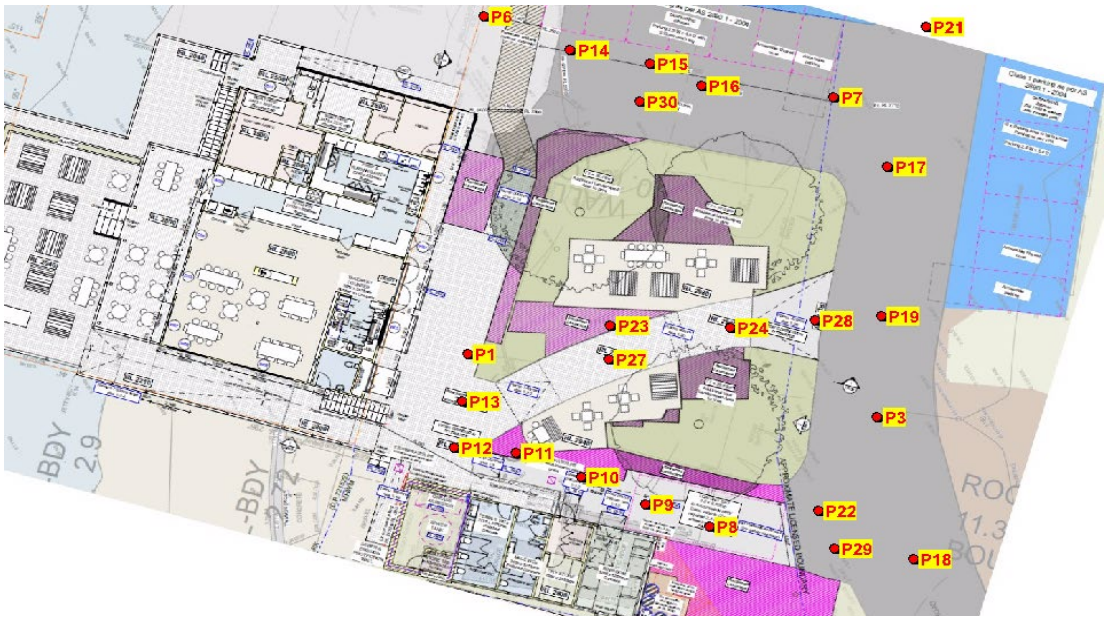


Table 2 Flood Levels (m AHD) and Depths (cm) under Future Conditions

Point	Ground Level in Local Model (mAHD) (d)	1%AEP 90min		1%AEP 90min CC30		PMF 60min	
		Flood Level (mAHD)	Depth (cm)	Flood Level (mAHD)	Depth (cm)	Flood Level (mAHD)	Depth (cm)
P1	2.53	2.53	0	2.53	0	2.54	1
P2	2.76	2.81	5	2.85	9	2.95	19
P3	2.69	2.81	12	2.85	16	2.95	26
P4	2.64	2.81	17	2.85	21	2.94	30
P5	2.68	2.81	13	2.85	17	2.95	27
P7	2.67	2.76	9	2.81	14	2.91	24
P6	2.13	2.17	4	2.44	31	2.44	31
P8	2.67	2.80	13	2.85	18	2.94	27
P9	2.65	2.79	14	2.84	19	2.93	28
P10	2.66	2.77	11	2.80	14	2.87	21
P11	2.74	-	-	-	-	2.79	5
P12	2.53	2.58	5	2.59	6	2.64	11
P13	2.55	2.56	1	2.56	1	2.58	3
P14	2.52	2.57	5	2.60	8	2.65	13
P15	2.55	2.70	15	2.73	18	2.81	26
P16	2.58	2.70	12	2.74	16	2.81	23
P17	2.68	2.80	12	2.84	16	2.94	26
P18	2.66	2.81	15	2.85	19	2.95	29
P19	2.70	2.81	11	2.85	15	2.95	25
P20	2.64	2.81	17	2.85	21	2.95	31
P21	2.64	2.80	16	2.84	20	2.94	30
P22	2.75	2.81	6	2.85	10	2.95	20
P23	2.76	2.84	8	2.84	8	2.84	8
P24	2.98						
P25	2.64	2.81	17	2.85	21	2.95	31
P26	2.64	2.81	17	2.85	21	2.95	31
P27	2.94	2.94	0	2.94	0	2.95	1
P28	2.81	2.82	1	2.85	4	2.95	14
P29	2.74	2.81	7	2.85	11	2.95	21
P30	2.55	2.68	13	2.70	15	2.75	20
		Fixed Tailwater = 1.45mAHD		Fixed Tailwater = 2.35mAHD		Fixed Tailwater = 2.35mAHD	

3.3.2 Flood Velocities

In the vicinity of the Boathouse, the 1% AEP, 1% AEP under climate change and PMF flood velocities under Benchmark Conditions are plotted in **Figures 24, 28** and **32** respectively.

3.3.3 Flood Hazard

In the vicinity of the Boathouse, the 1% AEP, 1% AEP under climate change and PMF provisional flood hazards under Benchmark Conditions are plotted in **Figures 25, 29**and **33** respectively.

4 Flood Impact Assessment

The impacts the proposed development on flood levels and flows down the driveway are described as follows.

4.1 Flood Level Impacts

The estimated impact of the proposed the 1% AEP, 1% AEP under climate change and PMF flood levels are plotted in **Figures 34, 35** and **36** respectively.

The ground level and flood level differences at the reference locations identified in Figures 19 are summarised in **Table 3**.

Table 3 Flood Levels (m AHD) and Depths (cm) under Future Conditions

Point	Ground Level Difference (cm) (d)	1%AEP 90min Differences Flood Level (cm)	1%AEP 90min CC30 Differences Flood Level (cm)	PMF 60min Differences Flood Level (cm)
P1	0	-1	-2	-4
P2	0	1	1	3
P3	0	0	1	3
P4	0	1	1	2
P5	0	1	1	3
P7	0	0	1	2
P6	0	0	0	0
P8	0	1	2	3
P9	0	1	2	3
P10	2	3	3	3
P11	16	-	-	3
P12	0	-1	-2	-2
P13	0	-1	-3	-4
P14	0	0	1	2
P15	0	0	0	3
P16	0	0	1	2
P17	0	0	0	3
P18	0	1	1	3
P19	0	1	1	3
P20	0	0	1	3
P21	0	0	1	3
P22	0	1	1	4
P23	1	5	2	-4
P24	25	-	-	0
P25	0	1	1	3
P26	0	1	1	3

The following was noted from the assessments of impact on flood levels in the 1% AEP, 1% AEP under climate change and PMF events:

(i) The impacts on 1% AEP flood levels are negligible except locally where the proposed development modifies the existing ground level eg. the central path at Reference Locations 23 and 24;

(ii) Any impacts are almost wholly confined to the property and there are no adverse impacts on any adjoining property;

(iii) The impacts on 1% AEP flood levels under climate change are negligible except locally where the proposed development modifies the existing ground level;

(iv) The impacts on 1% AEP flood levels under climate change are minor (up to 0.03 m).

The potential impact of the proposed pervious ramp on flood levels in the driveway in a 1% AEP flood was also estimated based on uniform flow calculations. The assessment was based on an assumed porosity of the ramp of 50% and a further scenario where the porous areas were a further 50% blocked. It was estimated that local increase in 1% AEP flood level in the driveway in the vicinity of the ramp could be 0.015 m and 0.022 m for an unblocked ramp and for a ramp with a further 50% blockage respectively. This is comparable to the local impacts of a 30%increase in 1% AEP rainfall.

4.2 Peak Flow down Driveway

The peak flows down the driveway in the 1% AEP, 1% AEP under climate change and PMF were extracted at Section CC shown below under Benchmark and Future Conditions. These peak flows are summarised in **Table 4**.

Table 4 Peak Flows (m3/s) down the Driveway

	Benchmark Conditions	Future Conditions
1% AEP	0.27	0.15
1% AEP under climate change	0.48	0.25
PMF	1.12	0.64

It is noted that the proposed landscaping works narrow a section of the driveway which reduces the flow down the driveway. This combined with the raising of the central path to a level higher than the PMF leads to a local redistribution of flows and additional storage of runoff which manifests as very small increases in the flood levels.

5 Natural Environment Referral Response

5.1 Floor Levels and Freeboard

Based on issues of concern raised in relation to DA2021/0669, it is proposed that the floor levels be raised as summarised in **Table 5**. The resulting freeboard to the 1% AEP, 1% AEP under climate change and PMF levels is also given in **Table 5.**

Table 5 Amended Floor Levels and Freeboard

		1%AEP 90min		1%AEP 90min CC30		PMF 60min	
	Floor Level (m AHD)	Flood Level (m AHD)	Freeboard (m)	Flood Level (m AHD)	Freeboard (m)	Flood Level (m AHD)	Freeboard (m)
Ground Floor of the Boathouse	2.9	2.53	0.37	2.53	0.37	2.54	0.36
Ancillary Buildings							
Sewer Tank / Grease Arrestor	2.9	2.58	0.32	2.59	0.31	2.64	0.26
Female and Mail Toilets	2.9	2.74	0.16	2.74	0.16	2.79	0.11
Boat Hire General Storage	2.8	2.77	0.03	2.80	0.00	2.87	-0.07
Bin Room	2.8	2.79	0.01	2.84	-0.04	2.93	-0.13

It is concluded that under Future Conditions:

(i) The ground floor level of the Boathouse has freeboard above the PMF level;

(ii) All non-habitable floor levels in the Ancillary buildings have freeboard in the 1% AEP flood;

(iii) The Sewer Tank/Arrestor and Female and Male Toilets have freeboard in the PMF;

(iv) The Boat Hire General Storage would experience shallow inundation in a PMF.

5.2 Comments on Referral Responses

In its Natural Environment referral response, Council advised, in part:

> *The Avalon to Palm Beach Floodplain Risk Management Study and Plan, 2017 identifies the catchment flood regime for the site. The following non-compliances have been identified*
>
> - *A flood management report considering catchment flooding and the impacts of the development on flooding has not been provided*
>
> This report satisfies this non-compliance.
>
> - *The finished floor level of the proposed restaurant needs to be set at or above the Flood Planning Level of 3.05m AHD*
>
> The flooding assessment disclosed that the PMF is up to 0.13 m higher than the 1% AEP flood level (except at Reference Location 6) which indicates that a freeboard of 0.5 m is overly conservative.
>
> Council's nominated Flood Planning Level of 3.05 m AHD is based on a freeboard which is overly conservative when compared the incremental increase in flood level in a PMF.
>
> As identified in Table 5 the amended ground floor level of 2.9 m AHD provides a freeboard over the PMF level in the vicinity of the Boathouse.
>
> It is concluded that the amended ground floor level of 2.9 m AHD is acceptable.
>
> - *The proposed ancillary building housing toilets, bin room and utilities is below the Flood Planning Level of 3.05m AHD*
>
> As identified in Table 5,
>
> - all **non-habitable** floor levels in the ancillary buildings have freeboard in the 1% AEP flood.
> - the Female and Male Toilets have freeboard in the PMF;

- The Boat Hire General Storage would experience shallow inundation in a PMF.

It is concluded that the amended floor levels of the ancillary building rooms are acceptable given the proposed non-habitable uses.

- *Potentially hazardous substances are stored below the Flood Planning Level of 3.05m AHD, namely the location and level of the sewer tank*

  As identified in Table 5, the floor level of the Sewer Tank/Arrestor has freeboard in the PMF.

  It is concluded that the amended floor level of the Sewer Tank/Arrestor is acceptable and exceeds Council's intended level of protection against flooding.

6 References

Cardno (2021a): Coastal Engineering Assessment and Estuarine Risk Management; Boat House, Palm Beach. *Report 59916081, R003*, prepared for London Lakes Partnership, May

Cardno (2021b): Flooding and Estuarine Risk Management and Evacuation Plan; Boat House, Palm Beach. Report 59916081, R004, prepared for London Lakes Partnership, May.

Cardno Lawson Treloar (2013) “Pittwater Overland Flow Mapping and Flood Study”, *Final Report*, Version 4, 2 Vols, prepared for Pittwater Council, October.

MHL (2017) “Avalon to Palm Beach Floodplain Risk Management Study and Plan”, *Final Report,* 2 Vols, prepared for Northern Beaches Council, June

APPENDIX A

SITE SURVEY

A0

ADJOINS SHEET 2

ADJOINS SHEET 2

APPROX TRUE NORTH
MGA NORTH

PITTWATER

PITTWATER

298
D.P.721522
"THE STATE OF NSW"
1887m² DP.721522

"THE BOATHOUSE"
1 & 2 STOREY
CLAD BUILDING
METAL ROOF

COVERED DECKS
(METAL ROOF)

TIMBER JETTY
(DINING AREA)

TIMBER JETTY EDGE

TIMBER STEPS

RAMP-DOWN

JETTY-BOY
0.N

"BARRENJOEY BEACH"
(SANDY BEACH)

"BARRENJOEY BEACH"
(SANDY BEACH)

CONCRETE BOAT RAMP

CONCRETE BOAT RAMP

UPPER BUILDING LINE

CHIMNEY

TIMBER STEP

DRILL HOLE-BDY
(6.5)

MEAN HIGH WATER MARK (D.P.721522)

MEAN HIGH WATER MARK (D.P.721522)

SEAWALL
CONCRETE
STONE

CONCRETE STEPS

CONCRETE BLOCKS

ROCKY GARDEN

SAND

GRAVEL

PAVED

HYDRANT ROOM

TIMBER DECK

ROOF

SANDSTONE PLANTER

CONCRETE

PATH

SANDSTONE TABLE

GRAVEL

BENCH MARK
NAIL IN CONCRETE
RL 2.48 (AHD)

BITUMEN

CONCRETE

EDGING

TIMBER

ROCKY GARDEN

PAVED DINING AREA

TABLE

OVEN

PAVED

PATH

ROCKY GARDEN

DRIVEWAY

DRIVEWAY

BITUMEN

BITUMEN

7005
D.P.1117451
"THE STATE OF NSW"

7005
D.P.1117451
"THE STATE OF NSW"
(GOVERNOR PHILLIP PARK)

LAWN

LAWN

LAWN

"PALM BEACH GOLF COURSE"

METAL CONTAINER SHED (FRIDGE)

METAL STORAGE SHED

TIMBER SHED (STORAGE AREA) PLASTIC ROOF

TIMBER SHED (STORAGE AREA) PLASTIC ROOF

(GAS BOTTLES)

ROCKY GARDEN

PAVED PATH

GOLF PUTTING GREEN

GARDEN

GARDEN

GRAVEL PARKING

GRAVEL PARKING

GRAVEL PARKING

GRAVEL PARKING

GARDEN

BITUMEN ROAD

BITUMEN ROAD

APPROX POSITION OF ROAD BOUNDARY (NOT SURVEYED) (VIDE RI477-1603)

APPROX POSITION OF ROAD BOUNDARY (NOT SURVEYED) (VIDE RI477-1603)

FENCE

CHAINWIRE FENCE

IRREGULAR FENCE

CHAINWIRE FENCE

P1

P2

P3

P4

P5

P6

P7

P8

7006
D.P.1117451
"THE STATE OF NSW"
(GOVERNOR PHILLIP PARK)

0 1 2 3 4 5 6 7 8 9 10
SCALE 1:100

TITLE INDICATES THAT LOT 7005 & 7006 IN D.P.1117451 IS SUBJECT TO:

- THE LAND IS A RESERVE WITHIN THE MEANING OF PART 5 OF THE CROWN LANDS ACT 1989 AND THERE ARE RESTRICTIONS ON TRANSFER AND OTHER DEALINGS IN THE LAND UNDER THAT ACT, WHICH MAY REQUIRE CONSENT OF THE MINISTER.
- LIMITED TITLE. LIMITATION PURSUANT TO SECTION 28T(N) OF THE REAL PROPERTY ACT, 1900, THE BOUNDARIES OF THE LAND COMPRISED HEREIN HAVE NOT BEEN INVESTIGATED BY THE REGISTRAR GENERAL.

- LAND THAT MAY BE THE SUBJECT TO A LICENCE AGREEMENT WITH COUNCIL OR THE CROWN HAS NOT BEEN INVESTIGATED IN THIS SURVEY.

TITLE INDICATES THAT LOT 298 IN D.P.721522 IS SUBJECT TO:

- 3942964 LAND EXCLUDES MINERALS (S.171 CROWN LANDS ACT 1989)
- 3942965 CROWN LEASE TO CARMEL EUGENE WALTON, RUSSELL WALTON, WENDY WALTON, CHRISTOPHER HOGG & JOANNE HOGG (LE 9050(4). EXPIRES: 30/4/2022.
- 3942966 LEASE NO. LE 9050(6 (3942965) MAY NOT BE TRANSFERRED, MORTGAGED, SUB-LEASED OR DEALT WITH IN ANY SPECIFIED MANNER WITHOUT THE CONSENT OF THE MINISTER ADMINISTERING THE CROWN LANDS ACT 1989
- AB365809 LEASE OF LEASE 3942965 TO AIRFOTO PTY LIMITED OF SHOP 3, BARRENJOEY BOATHOUSE, GOVERNOR PHILLIP PARK, PALM BEACH. EXPIRES: 13/9/2009, OPTION OF RENEWAL: FIVE YEARS.
- AB879636 TRANSFER OF LEASE AB365809 LESSEE NOW KRUG AGENCIES PTY. LIMITED.
- AC192396 LEASE OF LEASE 3942965 TO DAWSON BROWN ARCHITECTURE PTY LIMITED OF SHOP 4, BARRENJOEY BOATHOUSE, GOVERNOR PHILLIP PARK, PALM BEACH. EXPIRES: 28/2/2007. OPTION OF RENEWAL: 1 YEAR.
- AC251936 LEASE OF LEASE 3942965 TO BARRENJOEY BOATING SERVICES PTY LIMITED OF SHOP 1, BARRENJOEY BOATHOUSE, GOVERNOR PHILLIP PARK , PALM BEACH. EXPIRES: 28/2/2011. OPTION OF RENEWAL: 5 YEARS.
- AC522166 TRANSFER OF LEASE 3942965 LESSEE NOW ISLAND GETAWAY PTY LIMITED, NITOLA PTY LIMITED & N B T PTY LIMITED
- AF708175 TRANSFER OF LEASE AC251936 LESSEE NOW BIGWEST PTY LIMITED & NORTH SUMMER BAY INVESTMENTS PTY LTD
- AF495746 TRANSFER OF LEASE 3942965 LESSEE NOW ISLAND GETAWAY PTY LTD, NBT PTY LTD, NITOLA PTY LTD & CHAMPAMES LAKES PTY LTD
- AH20977 VARIATION OF LEASE AC251936 EXPIRY DATE NOW 28/2/2016.

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NOTES

- **A BOUNDARY SURVEY HAS BEEN UNDERTAKEN.**
- **THE BOUNDARIES OF THE SITE HAVE BEEN IDENTIFIED BY FIELD SURVEY.**
- **CROWN LAND STATEMENT:**
  THE BOUNDARIES AS SHOWN ON REGISTERED PLAN DP721522 CAN BE CONSIDERED TO BE THE CURRENT BOUNDARY LOCATIONS CONSIDERING DP721522 IS THE CURRENT TITLE DIAGRAM.
- **WALL TO BOUNDARY DIMENSIONS SHOWN HEREON MUST NOT BE USED FOR CONSTRUCTION. IF CONSTRUCTION IS INTENDED TO BE UNDERTAKEN ON OR ADJACENT TO PROPERTY BOUNDARIES THE BOUNDARIES OF THE LAND MUST BE MARKED OR THE BUILDING SETOUT..**
- **AREA HAS BEEN CALCULATED BY TITLE DIMENSIONS.**
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- ONLY VISIBLE SERVICES HAVE BEEN LOCATED. UNDERGROUND SERVICES HAVE NOT BEEN LOCATED. DIAL BEFORE YOU DIG SERVICES (ph 1100) SHOULD BE USED AND A FULL UTILITY INVESTIGATION, INCLUDING A UTILITY LOCATION SURVEY, SHOULD BE UNDERTAKEN BEFORE CARRYING OUT ANY CONSTRUCTION ACTIVITY IN OR NEAR THE SURVEYED AREA.
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- CONTOURS SHOWN DEPICT THE TOPOGRAPHY. THEY DO NOT REPRESENT THE EXACT LEVEL AT ANY PARTICULAR POINT. ONLY SPOT LEVELS SHOULD BE USED FOR CALCULATIONS OF QUANTITIES WITH CAUTION.
- CONTOUR INTERVAL - 0.5 metre. - SPOT LEVELS SHOULD BE ADOPTED.
- POSITION OF RIDGE LINES ARE DIAGRAMMATIC ONLY (NOT TO SCALE).
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-
-
- ANY PERMITTED DOWNLOADING, ELECTRONIC STORAGE, DISPLAY, PRINT, COPY OR REPRODUCTION OF THIS SURVEY SHOULD CONTAIN NO ALTERATION OR ADDITION TO THE ORIGINAL SURVEY.
- THIS NOTICE MUST NOT BE ERASED.

STEPHEN EMERY
REGISTERED SURVEYOR BOSSI NUMBER 1605

LEGEND:

BB = BOTTOM OF BANK
BBQ = BARBEQUE
BIT = BITUMEN
BLD = EXTERNAL BUILDING
BOL = BOLLARD
BW = BOTTOM WALL
CHI = CHIMNEY
CON = CONCRETE
DD = DISH DRAIN
DK = DECK
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S = SEWER UNDERGROUND
TREE SPREAD-DIAMETER-HEIGHT

HORIZONTAL DATUM:
CO-ORDINATE SYSTEM: M.G.A.
MARKS ADOPTED: PM1657 & PM40338

VERTICAL DATUM:
DATUM: AUSTRALIAN HEIGHT DATUM (AHD)
B.M. ADOPTED: PM 1657
R.L. 2.171 (ORDER L2)
SOURCE: S.C.I.M.S. (02/02/18)

3	ADD SIGNATURE & NOTES	24/05/21
1	FIRST ISSUE	21/08/19

CLIENT:
BLUE PACIFIC CONSTRUCTIONS PTY LTD
74 CABARITA ROAD,
AVALON NSW 2108

SURVEY PLAN
SHOWING DETAIL & LEVELS OVER LOT 298 IN D.P.721522 "THE BOATHOUSE" GOVERNOR PHILLIP PARK PALM BEACH NSW 2108

C.M.S. Surveyors Pty Limited
ACN: 096 240 201
PO Box 463 Dee Why NSW 2099
2/394 South Creek Road, Dee Why NSW 2099
Telephone: (02) 9971 4802
Facsimile: (02) 9971 4522
E-mail: info@cmssurveyors.com.au

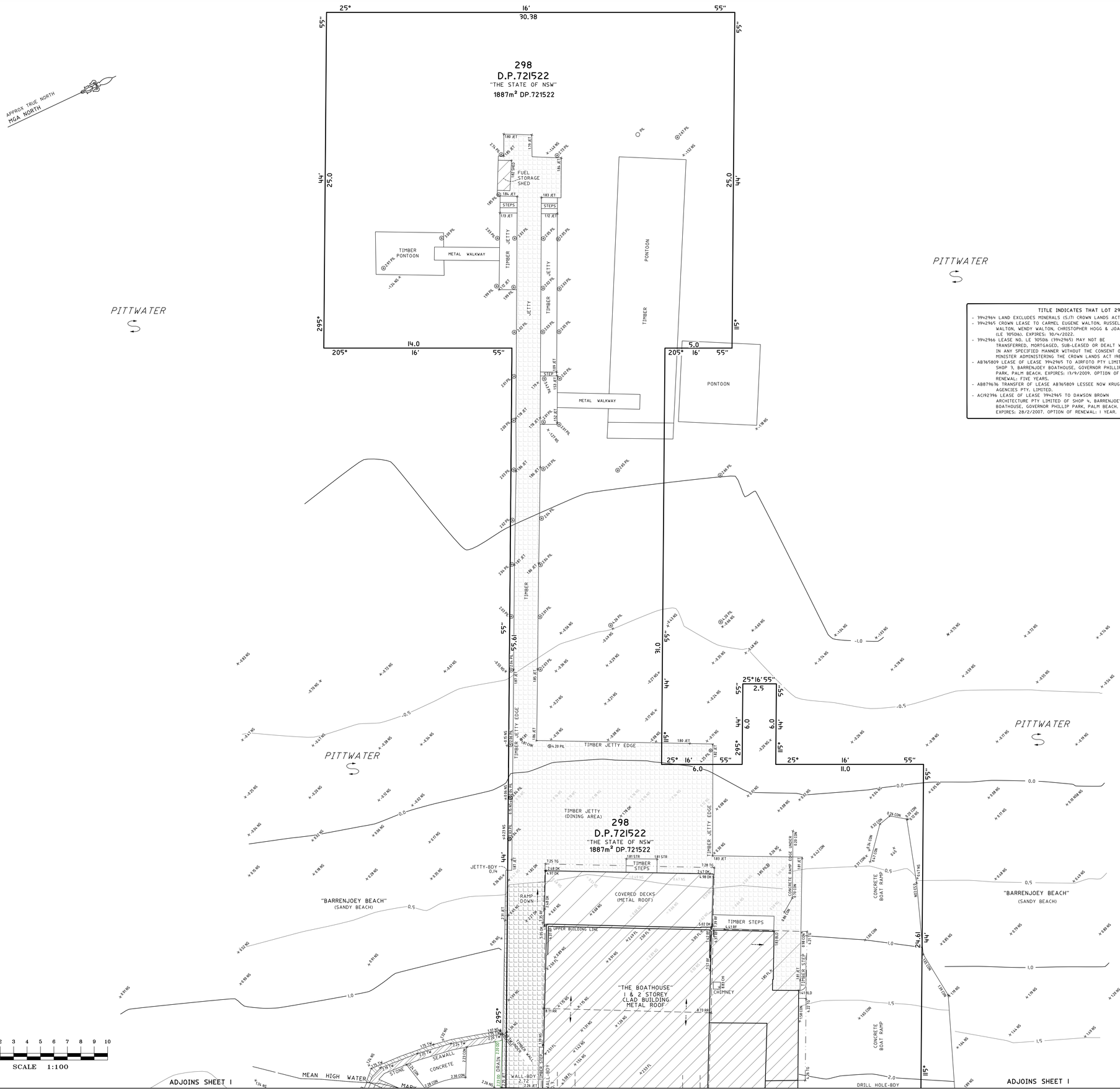
LGA: NORTHERN BEACHES | SHEET 1 OF 2

SURVEYED	DRAWN	CHECKED	APPROVED
L.J.	R.N./GP	L.J.	S.M./MDL

SURVEY INSTRUCTION	SCALE	DATE OF SURVEY
17534C	1:100 @ A0	05/02/18-17/07/18 12/08/19-19/08/19

DRAWING NAME: 17534detail
CAD FILE: 17534detail 3.dwg
ISSUE: 3

A0



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- AB879636 TRANSFER OF LEASE AB365809 LESSEE NOW KRUG AGENCIES PTY. LIMITED.
- AC192396 LEASE OF LEASE 3942965 TO DAWSON BROWN ARCHITECTURE PTY LIMITED OF SHOP 4, BARRENJOEY BOATHOUSE, GOVERNOR PHILLIP PARK, PALM BEACH. EXPIRES: 28/2/2007. OPTION OF RENEWAL: 1 YEAR.
- AC259136 LEASE OF LEASE 3942965 TO BARRENJOEY BOATING SERVICES PTY LIMITED OF SHOP 1, BARRENJOEY BOATHOUSE, GOVERNOR PHILLIP PARK , PALM BEACH. EXPIRES: 28/2/2011. OPTION OF RENEWAL: 5 YEARS.
- AC522166 TRANSFER OF LEASE 3942965 LESSEE NOW ISLAND GETAWAY PTY LIMITED, NITOLA PTY LIMITED & N B T PTY LIMITED
- AF708115 TRANSFER OF LEASE AC259136 LESSEE NOW BIGWEST PTY LIMITED & NORTH SUMMER BAY INVESTMENTS PTY LTD
- AF495746 TRANSFER OF LEASE 3942965 LESSEE NOW ISLAND GETAWAY PTY LTD, NBT PTY LTD, NITOLA PTY LTD & CHAMPAMES LAKES PTY LTD
- AH20977 VARIATION OF LEASE AC259136 EXPIRY DATE NOW 28/2/2016.

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MARKS ADOPTED: PM11657 & PM40338

VERTICAL DATUM:
DATUM: AUSTRALIAN HEIGHT DATUM (AHD)
B.M. ADOPTED: PM 11657
R.L. 2.171 (ORDER L2)
SOURCE: S.C.I.M.S. (02/02/18)

3	ADD SIGNATURE & NOTES	24/05/21
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Telephone: (02) 9971 4802
Facsimile: (02) 9971 4822
E-mail: info@cmssurveyors.com.au

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SURVEYED	DRAWN	CHECKED	APPROVED
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SURVEY INSTRUCTION	SCALE	DATE OF SURVEY
17594C	1:100 @ A0	05/02/18-17/07/18 12/06/19-19/08/19

DRAWING NAME: 17594detail
ISSUE: 3
CAD FILE: 17594Cdetail 3.dwg