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Your Ref:
Our Ref: J6607f

5 October 2020

Peet Golden Bay Pty Ltd and Housing Authority
c/o Cossill & Webley
PO Box 680
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Dear Aaron,

GOLDEN BAY – LOT 3 LOCAL STRUCTURE PLAN AMENDMENT
REVISED STORMWATER DRAINAGE DESIGN FOR STAGE 5C PUBLIC OPEN SPACE – LWMS ADDENDUM

Please find below JDA's report detailing the stormwater drainage design criteria, modelling parameters and results to support the amendment to the Local Structure Plan (LSP) for Lot 3 within the Golden Bay Development (herein referred to as the Study Area).

This report is presented in the following sections:

1) *Introduction*
2) *Site Characteristics*
3) *Landscape Design and Groundwater Licence*
4) *Revised Stormwater Modelling*
5) *Conclusion*

1) INTRODUCTION

Golden Bay is located approximately 60 km south of Perth, within the City of Rockingham (CoR) (Figure 1). Lot 3 covers approximately 26.8 ha of the 156.7 ha Golden Bay Comprehensive Development Plan Update (GBCDPU) area. The proposed land use is for residential development consistent with the current Metropolitan Regional Scheme (MRS) and the City of Rockingham Town Planning Scheme No.2 (CoR, 2015).

In 2011, Emerson Stewart prepared a Local Water Management Strategy (LWMS) to support the Golden Bay Development Local Structure Plan. It provided guidance on water management objectives and constraints for future development of land within the Study Area, consistent with Better Urban Water Management (WAPC, 2008) and State Planning Policy 2.9: Water Resources (WAPC, 2006). The LWMS presents concept design details for stormwater management, including drainage volumes and areas required for the 1yr, 5yr and 100yr ARI rainfall events from infiltration modelling.

In 2018 the subdivision layout and subsequent drainage catchments for the Lot 3 LSP were revised. Specifically, Catchments S3 and P3 of the previous Lot 3 LSP were excluded in the amendment. JDA

(2018) performed infiltration modelling using INFIL to determine revised flood storage volume requirements.

In June 2019, additional infiltration testing and permeability assessment was undertaken by Douglas Partners (Attachment A) at the base of two proposed drainage basins within the Golden Bay Stage 5C area. Based on the results a revised permeability of 10 m/d (up from 5 m/d) was recommended and included in the modelling presented in this report.

2) SITE CHARACTERISTICS

The Study Area is generally described as having the following pre-development characteristics:

- Land use comprised of undulating dunes, with vegetated coastal grass and shrub.
- Topography of Study Area ranges from 8 mAHD in the centre to 40 mAHD in the south eastern boundary (Figure 1).
- The 1:50,000 Environmental Geology mapping (DMP, 2010) indicates the Study Area comprises Safety Bay Sand. Safety Bay Sand is composed of fine to medium grained white shelly sand of eolian origin and has a high infiltration rate and is mainly alkaline and deficient in nutrients and trace elements due to its calcareous nature.
- No Conservation Category Wetlands (DEC, 2012) or Bush Forever sites within the Study Area.
- Swan Coastal Plain Acid Sulphate Soils (ASS) Risk Mapping (DER, 2014) classifies the Study Area as having little to no known risk of ASS occurring within 3 m of natural soil surface.
- Post development Average Annual Maximum Groundwater Levels (AAMGL) for the Study Area vary from 1.75 m AHD to ~2 m AHD from the western to eastern boundary of the Study Area (see Figure 1) (JDA, 2010). Separation to groundwater thus ranges from 6 m to 38 m across the site. Groundwater levels will fluctuate approximately 1 m from winter maximum levels to summer minimum levels.

3) LANDSCAPE DESIGN AND GROUNDWATER LICENCE

JDA prepared the "*Golden Bay Development – Groundwater Licence Operating Strategy – GWL172019*" in January 2012 to outline proposed irrigation water use for the Golden Bay Development associated with Licence to Take Water GWL172019.

Water abstraction from the groundwater aquifer was calculated based on proposed irrigation areas. It identified the area requiring irrigation in Lot 9028 as being 5.66 ha, equivalent to an allocation of 42,480 kL/yr by adopting DWER's standard irrigation application rate of 7,500 kL/ha/yr for POS areas.

Current irrigation areas proposed by the landscape architect (EPCAD) indicate irrigation area of 5.07 ha, requiring an allocation of 38,025 kL/yr (Table 1)(see Attachment B). This is similar to the area and allocation presented in the Operating Strategy. Note that this does not include temporary irrigation areas such as rehabilitation areas.

In addition to irrigation water requirement, GWL172019 also includes an allocation of 35,660 kL/yr for the taking of water for Dust Suppression for Earthworks and Construction purposes.

The current licensed groundwater allocation for GWL172019(3) of 140,660 kL/yr, expiring on 8 Aug 2028, is therefore sufficient to satisfy water demand for irrigation of Lot 9028 and for dust suppression and construction purposes.

TABLE 1. Irrigation Area and Water Requirements

Description	Irrigation Area (ha)	Water Requirement (kL)
Stage 5 Dampier Drive verge	0.28	2,100
Stage 5A POS 'P' and 'S'	0.19	1,425
Stage 5A basin	0.08	600
Stage 5D - Central POS LPS	1.26	9,450
Stage 5C – POS 4	0.32	2,400
Stage 5F	0.77	5,775
Stage 5H	1.79	13,425
Stage 5i	0.08	600
Streetscape / Roundabout	0.30	2,250
TOTAL	5.07	38,025

4) REVISED STORMWATER MODELLING

Catchments & Modelling Assumptions

The Study Area is divided into two drainage catchments as shown in Figure 2. These catchments include the road network and lots which drain towards infiltration areas within POS. Contributing catchment areas are detailed in Table 2.

TABLE 2. Catchment Area Details

Catchment	Catchment Area (ha)			
	Lots <300 m²	Lots >300 m²	Road	Total Area
A	0.19	0.91	0.89	2.00
B	1.58	9.4	6.09	17.06
Total	1.77	10.31	6.98	19.06

- *Lot Runoff*

Due to the presence of sandy soils, soakwells are used to contain runoff from all Lot areas up to the 20% AEP storm event. For storm events greater, lot runoff flows overland into the road drainage system. A Proportional Loss of 50% is used for Lots <300 m², and a Proportional Loss of 90% for Lots >300 m².

These lot runoff proportional losses were also adopted in the approved Golden Bay Development Stage 4 Foreshore Catchment UWMP (JDA, 2016). Stage 4 Example Building plans are attached in Attachment B demonstrating that the residential lots have sufficient outdoor area to accommodate a soakwell within required setbacks. Approval letter from City of Rockingham for the acceptance of the lot runoff coefficients is also attached in Attachment C.

- *Road Runoff*

Road areas generate stormwater runoff that is conveyed by underground pipe system to the infiltration basins in the POS. A Proportional Loss of 20% is used for road areas.

Initial losses of 1.4 and 0.5 mm were also included to represent the storage volume of the "trapped" manhole component (0.6 m depth) of the SEPs located within the road reserves for Catchments A and B respectively. This value was calculated based on the standard City of Rockingham soakwell design (Attachment D) and number of proposed SEPs in each catchment (Attachment E).

Runoff from small event rainfall (15 mm) is to be treated in bio-retention areas that contain amended soil with a minimum hydraulic conductivity of 5 m/d. Further detail design of the bio-retention is to be presented in the UWMP.

The loss model adopted for each of the land use types in PC-SUMP modelling is shown in Table 3. Continuing losses via the 600 mm diameter open area in the base of the manholes is incorporated into the Proportional Loss of 20% for road areas.

TABLE 3. Loss Model

Land Use	Catchment A		Catchment B	
	Initial Loss (mm)	Proportional Loss (%)	Initial Loss (mm)	Proportional Loss (%)
Lots <300 m^2	15	50	15	50
Lots >300 m^2	15	90	15	90
Road	1.4	20	0.5	20

The infiltration model PC-SUMP (JDA, 2019) was used to calculate the peak storage volume, level and area requirements for each infiltration area for the 1 EY 1 hr, 20% AEP and 1% AEP rainfall events based on ARR 2019 (Ball et al., 2019) methodology and the Bureau of Meteorology 2019 Intensity-Frequency-Distribution (IFD) rainfall data. PC-SUMP calculates various AEP storms for storm durations ranging from 30 min to 168 hrs.

For Catchment A, a rectangular basin was assumed with basin base widths and lengths iterated to identify the smallest basin size that will contain the critical storm durations for each AEP storm event.

For Catchment B a tiered basin was assumed with basin base area of 570 m^2 with surface area increasing at 0.5 m (start of tier) to 1,610 m^2.

Modelling design assumptions are as follows:

- Hydraulic conductivity of 10 m/d
- Basin side slopes of 1:6 (v:h)
- Maximum depth of 1.2 m
- Post Development AAMGL of 1.9 mAHD
- Soil suction of -5 and porosity of 0.2
- Initial degree of saturation at 20%

Modelling Results

The results of the revised infiltration modelling for the Study Area including volumes and required flood management areas are detailed in Table 4 and Figure 3. Modelling outputs are provided in Attachment F.

Earthworks design and conceptual cross section of the stormwater infiltration Basins A and B with modelling results are shown in Attachment G. These designs can be further refined at detail design during subdivision in the UWMP.

Attachment G also demonstrates minimum finished floor level in adjacent lots provide minimum 500mm freeboard above the 1% AEP rainfall event top water level.

TABLE 4. Infiltration Modelling Results

	Catchment A	Catchment B
Invert (mAHD)	6.8	6.6
Base Length (m)	8	30
Base Width (m)	5	19
Base Area (m^2)	40	570
Side Slopes	1:6	1:6
Depth (m)	1.2	1.2
Infiltration Rate (m/d)	10	10
Small Event - 1 EY		
Connected Impervious Area (ha)	0.71	4.87
Storm Rainfall (mm)	15	15
Runoff Volume (m^3)	110	735
Water Depth (m)	0.5	0.5
Top Water Level (mAHD)	7.3	7.1
TWL Surface Area (m^2)	155	890
Peak Storage Volume (m^3)	46	350
Minor Event – 20% AEP		
Tiered Base Area (m^2)	-	1,610
Connected Impervious Area (ha)	0.71	4.87
Critical Storm Duration (hrs)	1	1
Storm Rainfall (mm)	25.9	25.9
Runoff Volume (m^3)	185	1,265
Water Depth (m)	0.8	0.8
Top Water Level (mAHD)	7.6	7.4
TWL Surface Area (m^2)	255	1,875
Peak Storage Volume (m^3)	105	815
Stored Volume/ Runoff Volume (%)	57	65
Major Event - 1% AEP		
Connected Impervious Area (ha)	0.90	6.60
Critical Storm Duration (hrs)	2	2
Storm Rainfall (mm)	55.0	55.0
Runoff Volume (m^3)	495	3,630
Water Depth (m)	1.15	1.2
Top Water Level (mAHD)	7.95	7.8
TWL Surface Area (m^2)	405	2,335
Peak Storage Volume (m^3)	215	1,690
Stored Volume/ Runoff Volume (%)	43	47

5) CONCLUSION

Infiltration modelling has been performed using PC-SUMP to reassess the flood storage requirements for Catchments A and B of Stage 5C, following field investigation with a higher permeability of 10 m/d, and incorporation of updated modelling methodology consistent with ARR 2019 guidelines. Revised modelling results indicate both Catchment A and B drainage basin sizes have reduced in size compared to previous JDA 2018 modelling.

Further detail design and refinement of this conceptual stormwater drainage modelling will be presented in the next stage of subdivision in the Urban Water Management Plan.

REFERENCES

Ball J, Babister M, Nathan R, Weeks W, Weinmann E, Retallick M, Testoni I, (Editors) (2019) *Australian Rainfall and Runoff: A Guide to Flood Estimation,* Commonwealth of Australia (Geoscience Australia), 2019.

Cossill and Webley (2018) *Golden Bay – Lot 3 Proposed Drainage Catchment Plan*, May 2018.

Department of Environment and Conservation (2012) *Geomorphic Wetland Dataset*.

Department of Environment Regulation (2014) *Acid Sulphate Soil Risk Map.*

Department of Mines and Petroleum (2010) *Geological Survey of WA (1985) 1:50,000 Environmental Geology Map – Rockingham (2033-II, 2033-III).*

Emerson Stewart Consulting (2011) *Golden Bay LWMS*, April 2011.

JDA Consultant Hydrologists (2010) *AAMGL Mapping for Golden Bay*, prepared for Department of Housing, Perth, Western Australia.

JDA Consultant Hydrologists (2016) *Golden Bay Development, Stage 4 Foreshore Catchment Urban Water Management Plan*, prepared for Peet Limited & Department of Housing, Perth, Western Australia.

JDA Consultant Hydrologists (2018) *Golden Bay – Lot 3 Local Structure Plan Amendment: Revised Stormwater Drainage Design*, prepared for Peet Golden Bay Pty Ltd and Housing Authority, Perth, Western Australia.

JDA Consultant Hydrologists (2019) *PC-SUMP.*

Western Australian Planning Commission (2006) *Stage Planning Policy 2.9.*

Western Australian Planning Commission (2008) *Better Urban Water Management,* October 2008.

FIGURES

Figure 1: Location Plan

Figure 2: Post-Development Catchments

Figure 3: Stormwater Management Plan

ATTACHMENTS

Attachment A: Infiltration Testing Report (Douglas Partners, 2019)

Attachment B: Conceptual Landscape Plan for Catchment A Stormwater Drainage Basin

Attachment C: Stage 4 Example Building Plan and City of Rockingham Approval Letter on Lot Runoff Coefficients

Attachment D: City of Rockingham Standard SEP Drawing (Cossill and Webley, 2018)

Attachment E: Drainage Layout Plan (Cossill and Webley, 2019)

Attachment F: PC-SUMP Outputs

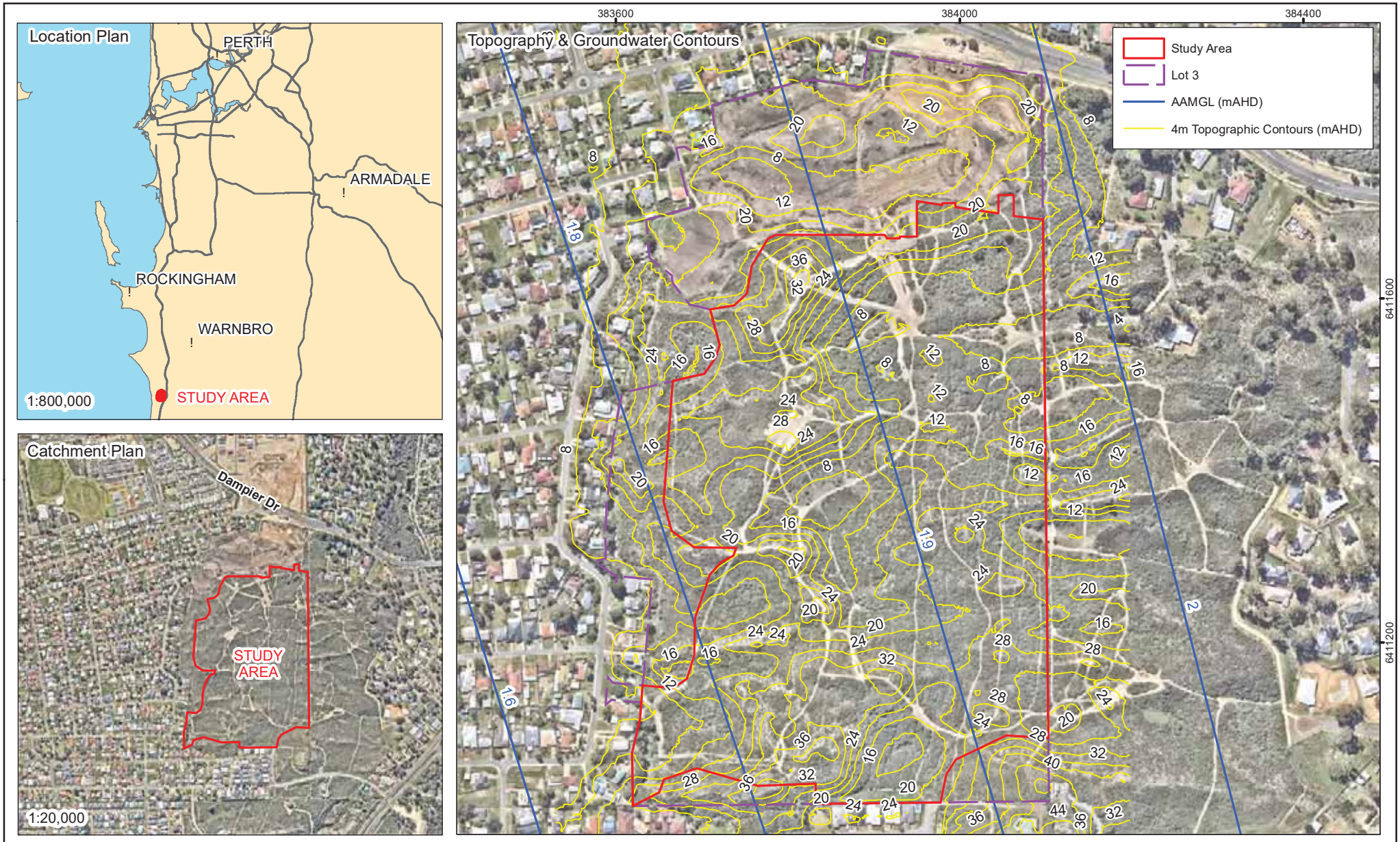
Attachment G: Earthworks Plan and Conceptual Cross Sections for Catchments A and B Stormwater Drainage Basins

If you have any queries, please do not hesitate to contact Matthew Yan (matt@jdahydro.com.au).

Yours sincerely,

JDA Consultant Hydrologists

Figures



Data Source: Nearmap (2017), Cossill & Webley (2018), JDA (2010)

Coordinate System: GDA 94, Zone 50

Job No. J6607

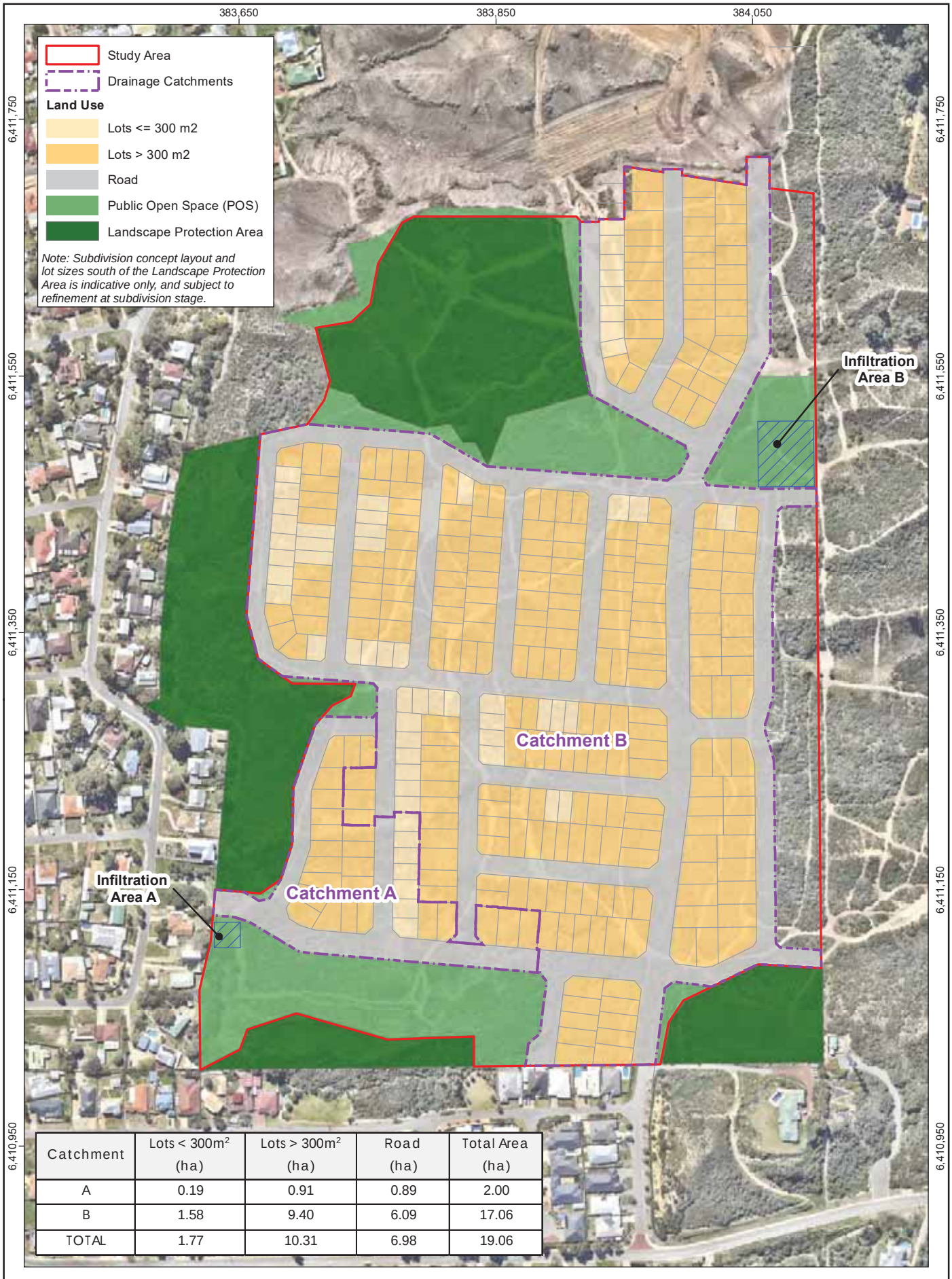
1:6,023

0 62.5 125 250 375 500 Meters

Peet Golden Bay Pty Ltd & Housing Authority

Golden Bay Development, Lot 3

Figure 1: Location Plan



Catchment	Lots < 300m² (ha)	Lots > 300m² (ha)	Road (ha)	Total Area (ha)
A	0.19	0.91	0.89	2.00
B	1.58	9.40	6.09	17.06
TOTAL	1.77	10.31	6.98	19.06

Data Source: Nearmap (2017), Cossill & Webley (2018)

JDA

Job No. J6607
Scale 1:4,000 @A4
Coordinate System: GDA 94, Zone 50

Peet Golden Bay Pty Ltd & Housing Authority
Golden Bay Development, Lot 3 Catchment - LWMS

Figure 2: Post Development Catchments

Land Use

- Lots <= 300 m2
- Lots > 300 m2
- Road
- Public Open Space (POS)
- Landscape Protection Area

Storm Event

- 1 EY
- 20% AEP
- 1% AEP

Note: Subdivision concept layout and lot sizes south of the Landscape Protection Area is indicative only, and subject to refinement at subdivision stage.

Design Specifications

	Catchment A	Catchment B
Invert (mAHD)	6.8	6.6
Base Length (m)	8	30
Base Width (m)	5	19
Base Area (m^2)	40	570
Side Slopes	1:6	1:6
Depth (m)	1.2	1.2
Infiltration Rate (m/d)	10	10
Small Event - 1 EY		
Connected Impervious Area (ha)	0.71	4.87
Storm Rainfall (mm)	15	15
Runoff Volume (m^3)	110	735
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Top Water Level (mAHD)	7.95	7.8
TWL Surface Area (m^2)	405	2,335
Peak Storage Volume (m^3)	215	1,690
Stored Volume/ Runoff Volume (%)	43	47

Data Source: Nearmap (2017), Cossill & Webley (2018)

Coordinate System: GDA 94, Zone 50

Job No. J6607

Peet Golden Bay Pty Ltd & Housing Authority
Golden Bay Development, Lot 3

Figure 3: Stormwater Management Plan

ATTACHMENT A

Infiltration Testing Report
(Douglas Partners, 2019)

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Wormall Civil Pty Ltd
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CARDUP WA 6122

Project 88788.10
13 June 2019
R.001.Rev0
SN

Attention: Catherine Cunningham

Email: ccunningham@wormallcivil.com.au

Dear Catherine Cunningham

Report on Infiltration Testing
Golden Bay Stage 5C Permeability Assessment
Golden Bay Stage 5C, Golden Bay, WA

1. Introduction

This report presents the results of infiltration testing carried out by Douglas Partners Pty Ltd at two locations proposed by Cossill & Webley Consulting Engineers, at the base of two proposed drainage basins within the Golden Bay Stage 5C area in Golden Bay, WA. The locations of the two proposed basins and infiltration tests are indicated on the attached Drawing 1.

It is understood that permeability values are required for the in situ materials at the location of proposed drainage basins to assist with drainage design requirements. Douglas Partners carried out an assessment of the ground conditions at each of the basin locations along with in situ infiltration testing.

2. Field Work Methods

Assessment and testing within the proposed drainage basin locations was undertaken on 6 June 2019.

The existing surface level at the two locations proposed by Cossill & Webley Consulting Engineers, was understood to be near the basins base design levels (approximately RL 6.3 m and RL 7.0 m, at the proposed northern and southern drainage basins, respectively). Field work comprised the drilling of two shallow boreholes using hand tools to assess the ground conditions and to facilitate infiltration testing. Testing was undertaken using the constant head apparatus, with field permeability values estimated using the method outlined in AS 1547-2000 Appendix 4.1F. The locations of the tests are indicated on the attached Drawing 1 identified as Perm 1 and Perm 2.

The ground conditions at each test location were logged in general accordance with test procedure AS 1726–1993, 2017.

3. Field Work Results

3.1 Ground Conditions

The surficial ground conditions observed across the proposed northern basin location (Perm 1) generally comprised dark-brown, fine to medium grained sand, trace silt, while the shallow ground conditions across the proposed southern basin location (Perm 2) generally comprised light brown, fine to medium grained sand, trace silt.

3.2 Groundwater

Groundwater was not observed at any of the test locations during the field work undertaken on 6 June 2019. The boreholes were immediately backfilled following sampling, which precluded longer term monitoring of perched groundwater levels.

It should be noted that groundwater levels are potentially affected by various factors such as climatic conditions and soil permeability and will therefore vary with time.

4. Laboratory Testing

A geotechnical laboratory testing programme was carried out on selected soil samples by a NATA registered laboratory and comprised the particle size distribution of two samples.

Detailed test report sheets are attached to this letter report and the results are summarised in Table 1 below.

Table 1: Summary of Laboratory Testing Results for Soil Classification

Test Location		Depth (m)	Fines (%)	Sand (%)	Gravel (%)	D_{10} (mm	D_{60} (mm	Material
Northern	Perm 1	0.00 – 0.20	4	96	0	0.18	0.45	SAND (SP) trace silt
Southern	Perm 2	0.00 – 0.35	3	97	0	0.17	0.38	

Notes: Fines are particles smaller than 75 µm.
Sand is particles larger than 75 µm and smaller than 2.36 mm.
Gravel is particles larger than 2.36 mm and smaller than 60 mm.
A D_{10} of 0.17 mm means that 10% of the sample particles are less than 0.17 mm.
A D_{60} of 0.38 mm means that 60% of the sample particles are less than 0.38 mm.

5. Soil Permeability Results

In situ infiltration testing was carried out within each borehole using the constant head method. Field permeability values were estimated using the method outlined in AS 1547-2000 Appendix 4.1F, and using the laboratory test results included in Table 1 and Hazen's formula, which applies for sand in a loose state. Results of the permeability analysis are summarised in Table 2 below.

Table 2: Summary of In Situ Permeability Testing Results

Test Location		Depth (m)	Measured Permeability		Derived Permeability[1]		In Situ Condition of the Tested Material
			(m/s)	(m/day)	(m/s)	(m/day)	
Northern Basin	Perm 1	0.20	1.9×10^{-4}	16	3.2×10^{-4}	28	SAND (SP) trace silt (loose to medium dense)
Southern Basin	Perm 2	0.35	3.9×10^{-4}	34	2.9×10^{-4}	25	SAND (SP) trace silt (medium dense to dense)

Note: [1]: Hazen's formula applied to laboratory result regarding soil grading.

The above results indicate permeability values greater than 10 m/day for the ground conditions encountered within the proposed northern and southern basins. These values are consistent with our expectations and experience in similar ground conditions. It is recommended that a design value near the lower bound of the above permeability values be adopted, and thus a design value of 1.2×10^{-4} m/s (10 m/day) is suggested. This value takes into account the results of the above testing, along with other relevant considerations such as soil clogging and siltation factors.

Following completion of the excavation of the proposed drainage basins to finished level, should the exposed subgrade comprise any materials other than those mentioned in Section 3.1 (e.g. limestone), Douglas Partners should be contacted for further advice.

It should be noted that density of the sand impacts on soil permeability, and therefore, if compaction during the earthworks operations is anticipated at the base of the proposed basins, then a further adjustment of the above suggested design permeability value is recommended.

6. References

1. AS1289-2000, Methods of Testing Soils for Engineering Purposes, Australian Standard
2. AS1726-2017, Geotechnical Site Investigation, Australian Standard
3. HVORSLEV 1951, Time lag and Soil Permeability in Ground Water Observations, US Army Engineering Waterways, Vicksburg, Bulletin 56, 50pp, 1951

7. Limitations

Douglas Partners has prepared this letter report for this project at Golden Bay Stage 5C in Golden Bay, WA in accordance with Douglas Partners' proposal dated 30 May 2019 and acceptance received from Brent Sanders of Wormall Civil in a purchase order dated 30 May 2019. The work was carried out under Douglas Partners' Conditions of Engagement. This letter report is provided for the exclusive use of Wormall Civil for this project only and for the purposes as described in the letter report. It should not be used by or relied upon for other projects or purposes on the same or other site or by a third party. Any party so relying upon this letter report beyond its exclusive use and purpose as stated above, and without the express written consent of Douglas Partners, does so entirely at its own risk and without recourse to Douglas Partners for any loss or damage. In preparing this letter report Douglas Partners has necessarily relied upon information provided by the client and/or their agents.

The results provided in the letter report are indicative of the sub-surface conditions on the site only at the specific sampling and/or testing locations, and then only to the depths investigated and at the time the work was carried out. Sub-surface conditions can change abruptly due to variable geological processes and also as a result of human influences. Such changes may occur after Douglas Partners' field testing has been completed.

Douglas Partners' advice is based upon the conditions encountered during this investigation. The accuracy of the advice provided by Douglas Partners in this letter report may be affected by undetected variations in ground conditions across the site between and beyond the sampling and/or testing locations.

This letter report must be read in conjunction with all of the attached and should be kept in its entirety without separation of individual pages or sections. Douglas Partners cannot be held responsible for interpretations or conclusions made by others unless they are supported by an expressed statement, interpretation, outcome or conclusion stated in this letter report.

This letter report, or sections from this letter report, should not be used as part of a specification for a project, without review and agreement by Douglas Partners. This is because this letter report has been written as advice and opinion rather than instructions for construction.

The contents of this letter report do not constitute formal design components such as are required, by the Health and Safety Legislation and Regulations, to be included in a Safety Report specifying the hazards likely to be encountered during construction and the controls required to mitigate risk. This design process requires risk assessment to be undertaken, with such assessment being dependent upon factors relating to likelihood of occurrence and consequences of damage to property and to life. This, in turn, requires project data and analysis presently beyond the knowledge and project role respectively of Douglas Partners. Douglas Partners may be able, however, to assist the client in carrying out a risk assessment of potential hazards contained in the Comments section of this letter report, as an extension to the current scope of works, if so requested, and provided that suitable additional information is made available to Douglas Partners. Any such risk assessment would, however, be necessarily restricted to the geotechnical component set out in this letter report and to their application by the project designers to project design, construction, maintenance and demolition.

Please contact either of the undersigned for clarification of the above as necessary.

Yours faithfully

Douglas Partners Pty Ltd

Sergio Neves
Associate Geotechnical Engineer

Reviewed by

Dan Reaveley
Senior Associate Geotechnical Engineer

Attachments: Notes About this Report
Test Location Plan
Laboratory Test Results

About this Report

Douglas Partners

Introduction

These notes have been provided to amplify DP's report in regard to classification methods, field procedures and the comments section. Not all are necessarily relevant to all reports.

DP's reports are based on information gained from limited subsurface excavations and sampling, supplemented by knowledge of local geology and experience. For this reason, they must be regarded as interpretive rather than factual documents, limited to some extent by the scope of information on which they rely.

Copyright

Borehole and Test Pit Logs

The borehole and test pit logs presented in this report are an engineering and/or geological interpretation of the subsurface conditions, and their reliability will depend to some extent on frequency of sampling and the method of drilling or excavation. Ideally, continuous undisturbed sampling or core drilling will provide the most reliable assessment, but this is not always practicable or possible to justify on economic grounds. In any case the boreholes and test pits represent only a very small sample of the total subsurface profile.

Interpretation of the information and its application to design and construction should therefore take into account the spacing of boreholes or pits, the frequency of sampling, and the possibility of other than 'straight line' variations between the test locations.

Groundwater

Where groundwater levels are measured in boreholes there are several potential problems, namely:

- In low permeability soils groundwater may enter the hole very slowly or perhaps not at all during the time the hole is left open;
- A localised, perched water table may lead to an erroneous indication of the true water table;
- Water table levels will vary from time to time with seasons or recent weather changes. They may not be the same at the time of construction as are indicated in the report; and
- The use of water or mud as a drilling fluid will mask any groundwater inflow. Water has to be blown out of the hole and drilling mud must first be washed out of the hole if water measurements are to be made.

More reliable measurements can be made by installing standpipes which are read at intervals over several days, or perhaps weeks for low permeability soils. Piezometers, sealed in a particular stratum, may be advisable in low permeability soils or where there may be interference from a perched water table.

Reports

The report has been prepared by qualified personnel, is based on the information obtained from field and laboratory testing, and has been undertaken to current engineering standards of interpretation and analysis. Where the report has been prepared for a specific design proposal, the information and interpretation may not be relevant if the design proposal is changed. If this happens, DP will be pleased to review the report and the sufficiency of the investigation work.

Every care is taken with the report as it relates to interpretation of subsurface conditions, discussion of geotechnical and environmental aspects, and recommendations or suggestions for design and construction. However, DP cannot always anticipate or assume responsibility for:

- Unexpected variations in ground conditions. The potential for this will depend partly on borehole or pit spacing and sampling frequency;
- Changes in policy or interpretations of policy by statutory authorities; or
- The actions of contractors responding to commercial pressures.

If these occur, DP will be pleased to assist with investigations or advice to resolve the matter.

About this Report

Site Anomalies

In the event that conditions encountered on site during construction appear to vary from those which were expected from the information contained in the report, DP requests that it be immediately notified. Most problems are much more readily resolved when conditions are exposed rather than at some later stage, well after the event.

Information for Contractual Purposes

Where information obtained from this report is provided for tendering purposes, it is recommended that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate to prepare a specially edited document. DP would be pleased to assist in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

Site Inspection

The company will always be pleased to provide engineering inspection services for geotechnical and environmental aspects of work to which this report is related. This could range from a site visit to confirm that conditions exposed are as expected, to full time engineering presence on site.