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City of Greater Geelong Planning Scheme Amendment C375 Expert Witness Statement Flood and Stormwater

1900 Barwon Heads Road, Barwon Heads

Report Reference : R.M00186.001.00.docx
Date: 14 August 2018

Prepared for: Barwon Heads Lifestyles Pty Ltd
Instructed by: Best Hooper Lawyers

Contents

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1 Summary of Opinion

I am of the opinion that development of the site at 1900 Geelong Road, Barwon Heads:

- Will not be constrained by regional flood levels;
- Will not be constrained by local catchment flood levels;
- Will not be constrained by the effects of climate change;
- Can be designed with wetlands and water bodies to prevent increased stormwater runoff volumes and peak flow rates to Murtnaghurt Lagoon and to manage stormwater quality in accordance with Clause 56.07 of the Victorian Planning Provisions.

2 Introduction

2.1 Background

Planning Scheme Amendment C375 to the City of Greater Geelong Planning Scheme seeks to implement the key land use planning direction of the City of Greater Geelong (Council) as contained within the Barwon Heads Structure Plan August 2107.

Barwon Heads Lifestyles Pty Ltd are the land owners of a 49.63 ha site located at 1900 Barwon Heads Road, Barwon Heads (the site). The site is currently in a Farming Zone and Dominion Property Group prepared a submission to the amendment that seeks to have the site included within a revised settlement boundary as contained with Barwon Heads Structure Plan Map No. 2, and to have the site designated as suitable for a future rezoning.

The Preliminary Master Plan provided in Appendix A was the basis of the assessment in this statement.

2.2 Scope of Works

This expert witness statement was prepared at the request of Best Hooper Lawyers. I was instructed to assesses the amendment relative to the site and its position as expressed in the submission to the planning authority in relation to the matters of local and regional flooding, stormwater management and climate change and to review other submission relevant to these matters. I was instructed to prepare a statement of evidence and present my evidence in chief at the panel hearing.

2.3 Details of Expert Witness

I have been a Director at Venant Solutions Pty Ltd since October 2013. Previously I was an Associate of BMT WBM and the Manager of BMT WBM's Water and Environment Group in Melbourne since January 2003. Prior to January 2003 I was a Senior Hydraulics Engineer in BMT WBM's Brisbane office. I previously prepared an expert witness statement pertaining to the site for Amendment C159 (Jempson, 2009).

My qualifications include a Bachelor of Engineering (Civil) degree from the Queensland University of Technology, and Master of Engineering Science and Doctor of Philosophy degrees from the University of Queensland. The degrees at the University of Queensland were undertaken through the Department of Civil Engineering and focussed on hydraulic engineering and fluid mechanics. My curriculum vitae is in Appendix C.

I have 29 years of experience as an engineer, 27 of these in the field of hydrology and hydraulics. My areas of expertise include hydrologic and hydraulic modelling of rural and urban catchments, floodplain risk management, and stormwater management. I have personally undertaken or project managed analyses on well over 300 catchments throughout Victoria, Tasmania, New South Wales and Queensland.

I was assisted in the preparation of this Statement by Dr Dale Brown and Aaron Dowling who are Senior Engineers at E2DesignLab. Our curricula vitae are provided in Appendix A.

Witness Statement

I have made all the inquiries that I believe are desirable and appropriate and no matters of significance which I regard as relevant have to my knowledge been withheld from the Panel.

Dr Mark Jempson

3 Site Location and Characteristics

Barwon Heads is located on Bellarine Peninsula about 11 km west of the entrance to Port Phillip Bay (Figure 3-1). The township is bounded to the north and east by the Barwon River with settlement along the shoreline (Figure 3-2). The Property at 1920 Barwon Heads Road abuts the western extent of the township to the south of Barwon Heads Road (Figure 3-3).

Ground levels on the property range from about 1.0m to 4.5 m AHD, with the majority of the site being above 1.5 m AHD. The majority of the site generally slopes to the west and south resulting in rainfall runoff draining towards Murtnaghurt Lagoon which is a RAMSAR listed wetland. The Lagoon is a terminal water body and hence the water is stored and over time evaporates and/or infiltrates into groundwater. The balance of the site naturally drains to localised depressions in the landscape within the site boundary. It is expected that the stormwater disperses though a combination of infiltration into groundwater (and eventually discharging into the Lagoon) and evaporation.

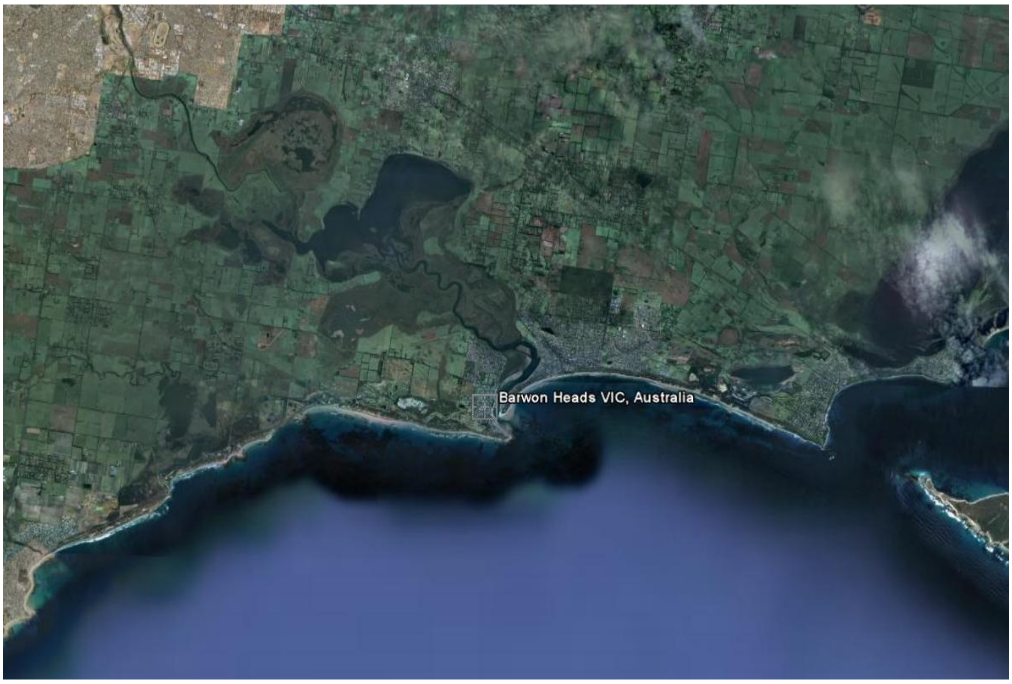

Figure 3-1 Barwon Heads Location

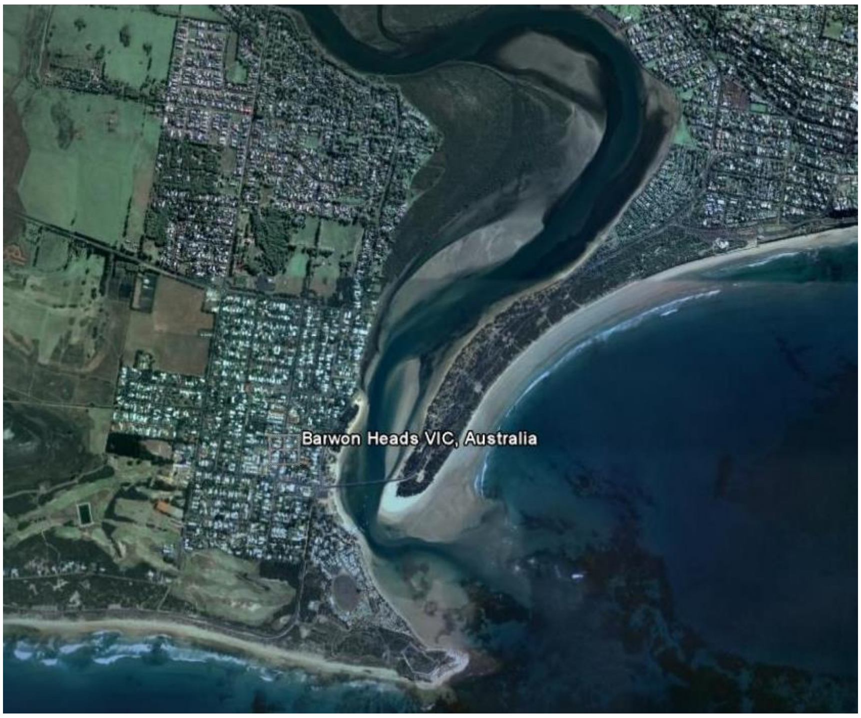

Figure 3-2 Barwon Heads

Figure 3-3 Site Location

4 Regional and Local Catchment Flooding

4.1 Regional Flooding

The Site is located on the floodplain of the Barwon River. However, data provided in GHD (1997) and CCMA (2005) indicates that the Site would be unaffected by flooding from the Barwon River because of the protection offered by a levee at the northern end of the Murtnaghurt Lagoon channel (see Figure 4-1). The levee has a top level of 4.25 m AHD and provides for 1.75 m freeboard against the estimated Barwon River 1% AEP (annual exceedance probability) flood level of 2.5 m AHD. Therefore the Site will not be flooded during a Barwon River flood event. In the event of a levee failure there would be backwater flooding into Murtnaghurt Lagoon at a level of up to 2.5 m AHD. This could result in inundation of the lower parts of the developed Site depending on the finished surface levels. Ongoing maintenance of the levee would be required if house floor levels do not provide a 0.3 m freeboard, i.e., a level of 2.8 m AHD.

It is concluded that river flooding will not provide a constraint for development of the site.

Figure 4-1 Barwon River Levee

4.2 Local Catchment Flooding

As discussed above, the Site is located behind the levee that separates the Murtnaghurt Lagoon from the Barwon River. This stormwater generated from the local area behind the levee drains to Murtnaghurt Lagoon where it is evaporated or infiltrated away. Because the local catchment runoff drains to a terminus system, it is runoff volume rather than peak flow rate which will determine the peak flood level.

Inspection of the ground levels in the Murtnaghurt Lagoon show that there are three relatively distinct terminus waterbodies. The largest of these is located to the west of the site, whilst the central and northern lagoons are relatively similar in total area. The three lagoons and their respective catchment areas are presented below in Figure 4-2. During small rainfall events runoff will terminate in the respective lagoons, however, during large floods there is the potential for cross-catchment flooding between these terminus lagoons. Between the northern and central areas the expected spill level which would allow cross-catchment flooding is approximately 1.2 m AHD, whilst the spill level between the western and central lagoons is estimated to be at or around 1.4 m AHD. To determine the runoff from the catchments runoff volume for each area was assessed individually and as a collective.

Being a runoff volume dependent system, the assumed loss rates in the hydrological modelling can be influential on the assessment outcome. Loss rates account for rainfall that is infiltrated into the soil profile or trapped in the catchment and hence does not contribute to surface runoff. Ideally a hydrological model is calibrated to historical rainfall events which can assist in establishing appropriate loss rates. There are no rainfall gauges or water level recording gauges in this catchment and hence calibration of the hydrological model to historical rainfall events was not possible. Where historical data is not available to establish loss rates, the modeller relies on experience from other similar catchments and the Australian Rainfall & Runoff (2016), hereafter referred to as ARR2016, datahub. Two rainfall losses were adopted in the modelling; the initial loss which is the rainfall at the start of the event from which no runoff is generated, and continuing loss which is the on-going loss through the duration of the rainfall event.

The predominate soil type is sand which can lead to high infiltration rates. Jempson (2009) adopted and initial loss of 5 mm and a continuing loss of 20 mm/hr for these catchments for the pervious surfaces. The ARR2016 datahub suggests an initial loss of 19 mm and continuing loss of 3 mm/hr for perviouis surfaces. The ARR2016 datahub results are regionally based and may not properly account for the local conditions, particularly on small catchments. A continuing loss rate of more than 3 mm/hr would normally be expected in a predominantly sandy area. Both loss rate data sets were analysed to provide an indication of the sensitivity of the flood level to this assumption and the consequences for the development of the Site. For both assessments the adopted initial and continuing loss rate for impervious surfaces was 1 mm and 0 mm/hr respectively. For the purposes of the assessment it was assumed that the waterbodies in the lagoons were effectively impervious surfaces. The adopted fraction impervious for landuse types is summarised in Table 4-1.

ARR2016 1% AEP design event rainfall and ensemble temporal patterns were adopted for this assessment. Temporal patterns describe the variation in rainfall intensity across the duration of the storm. The design rainfall and temporal patterns from ARR2016 were supplied by the Bureau of Meteorology. Storm durations ranging from the 5 minute to the 168 hour were investigated to determine peak flood volumes and hence peak flood levels. A level-volume relationship was determined for each terminus lagoon using the digital elevation model (DEM) shown in Figure 4-2; the DEM was derived from State Government LiDAR data which is the best available data for this area. The level-volume relationship was used to establish a 1% AEP flood level for the corresponding flood volume output from the hydrological model.

Table 4-1 Adopted Fraction Impervious for Flood Modelling

Landuse	Fraction Impervious
Rural	0.02
Open Space	0.05
Aged Car Facility	0.7
Retirement Facility (includes open space & gardens)	0.4
Mixed Commercial	0.8
Residential (~800m^2 lots)	0.6

Table 4-2 presents the key inputs and results of the local catchment flood assessment. Results are presented assuming no cross-catchment flow between the terminus lagoons and with cross-catchment flows. The results assuming no cross-catchment flow gives levels above the cross-catchment spill levels which indicates that the with cross-catchment flows should be adopted. The flood level assuming cross-catchment flow is 1.4 m AHD using the ARR 2016 losses and 1.2 m AHD using the Jempson (2016) losses. The lower bound estimate of 1.2 m AHD is consistent with the previously reported level (Jempson, 2009).

From the assessment it has been estimated that the peak 1% AEP flood level for the site is likely to be in the range of 1.2 to 1.4 m AHD depending on rainfall losses assumptions and the spill level between the western and central lagoon. Levels from the DEM indicates that existing grounds levels on the site typically vary between 1.5 and 4.5 m AHD. **Therefore it is concluded that the local catchment flood level would not present a constraint on the development of the site.**

It should be noted that the determination of catchment area that will flow to the Murtnaghurt Lagoon and hence the runoff volume is conservative as there exists considerable depression storages in the existing dune system. For the purposes of this assessment it was assumed that rainfall in these depressions would reach the lagoons.

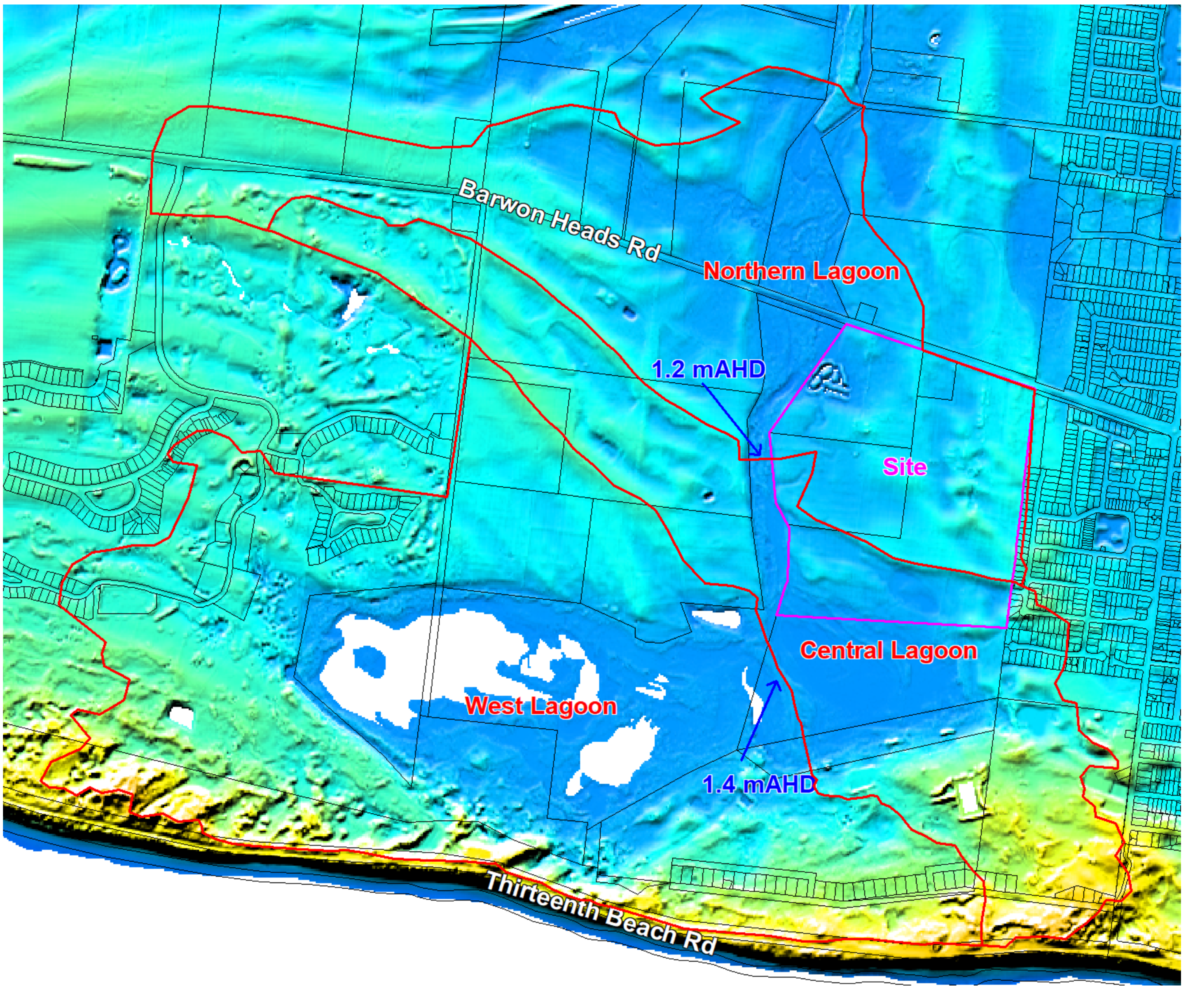

Figure 4-2 Local Catchment Breakup

Table 4-2 Local Catchment Flooding Assessment

Scenario	IL	CL	Subarea	Total Area (ha)	Peak Volume (m^3)	Peak Flood Level No Cross-Catchment Flows (m AHD)	Ave. Level - With Cross-Catchment (m AHD)
ARR 2016 Losses	19	3	Centre	119	89,000	1.46	-
			North	130	107,000	1.53	-
			West	240	177,000	1.2	-
			North & Centre	249	196,000	-	1.5
			Total	489	373,000	-	North and Central - **1.4** West - 1.18
Jempson (2009) Losses	5	20	Centre	119	31,000	1.16	-
			North	130	37,000	1.26	-
			West	240	62,000	0.9	-
			North & Centre	249	68,000	-	**1.2**
			Total	489	130,000	-	-

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5 Stormwater Management

The majority of rainwater falling on the site drains naturally to the south and west into the existing Murtnaghurt Lagoon, where the water is stored and over time evaporates and / or infiltrates into groundwater. The balance of the property naturally drains to localised depressions in the landscape within the property boundary. It is expected that the stormwater disperses though a combination of infiltration into groundwater (and eventually discharging into the Lagoon) and evaporation.

Development of the site will increase the quantity and decrease the quality of stormwater reaching the Lagoon if stormwater management techniques are not used to mitigate these impacts. The Lagoon contains flora that may be sensitive to decreased salinity so an increase in freshwater runoff to the Lagoon may not be desirable. Development of the Site will potentially increase the nutrient, sediment and gross pollutants entering the Lagoon. Stormwater management techniques can be adopted to mitigate the changes to the water quantity (stormwater harvesting) and quality (Water sensitive urban design (WSUD)). Often assets can be designed which will provide mitigation for both stormwater quantity and quality.

5.1 MUSIC Modelling

MUSIC (Model for Urban Stormwater Improvement Conceptualisation) is an industry-standard tool for simulating rainfall and runoff from both a quantity and quality perspective. It is a proven tool for assessing the performance of both WSUD and stormwater harvesting assets and is an effective tool for demonstrating compliance with relevant standards.

The adopted rainfall template uses 123 years of data (1889-2011) run at a 6-minute time step Due to the absence of site-specific geotechnical data, it was assumed that the appropriate soil parameter for Melbourne are applicable here.

5.1.1 Existing Conditions

MUSIC modelling was undertaken to determine flow volumes currently entering the Lagoon under the existing catchment conditions.

Due to the current land uses within the catchment which are almost entirely rural, it was assumed that a fraction imperviousness value of 2% applies. Further, the Lagoon water level was assumed to be at 1 m AHD, therefore resulting in an area of 67 hectares where a fraction imperious of 100% applies. Evaporation from the Lagoon is represented by a pond of surface area 67 hectares.

The results of this model indicate that 659 ML/year may enter the Lagoon under the existing catchment conditions for its full catchment. The site contributes 34 ML/year of the 659 ML/year.

5.1.2 Developed Conditions

The catchment fraction impervious was adjusted to account for the proposed development as shown in the Preliminary Master Plan in Appendix A. A breakdown of the landuse and associated areas and adopted fraction impervious is provided in Table 5-1.

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Table 5-1 Adopted Fraction Impervious for Development Landuses

Landuse Type	Area (ha)	Fraction Impervious
Residential (~800m^2 lots)	21.7	0.02
Open Space	3.5	0.05
Aged Car Facility	2.1	0.7
Retirement Facility (includes open space & gardens)	9.3	0.4
Mixed Commercial	0.9	0.8

The results show that the total volume of stormwater increases to from 659 ML/year to 722 ML/year, if mitigation measures are not implemented. The site contributes 97 ML/year of the 722 ML/year compared with 34 ML/year under existing conditions. Mitigation of the increased runoff volume (63 ML/year) is proposed using evaporation from the proposed linear wetland on the western side of the development and stormwater harvesting.

Stormwater harvesting will require the mandating of rainwater tanks on the residential lots and villa units in the retirement village. It is assumed that each lot has a roof area of 200 m^2 and each villa a roof area of 100m ^{2}. Each house and villa is assumed to have a modestly sized 2KL tank fitted and plumbed into the building for toilet flushing. This results in a daily demand of 0.04 KL per residential dwelling and 0.02 KL per Villa. Tanks are assumed to be 2m high and 1x1m surface area and at half initial capacity. Irrigation demand of private residential yards and gardens is assumed to be 7.82 KL/dwelling/year and 3.91 KL/dwelling/year demand for villas.

The combination of the proposed wetland and the stormwater harvesting will give a resultant annual volume of stormwater runoff from the development of 32 ML/year, which is slightly less than the volume of stormwater entering the Lagoon under existing pre-developed conditions (34 ML/year). Evaporation from the wetland provides 62 ML/year reduction in runoff and the rainwater tanks provide 3 ML/year. The analysis has conservatively assumed no infiltration from the proposed wetland. Infiltration would further reduce the runoff to the Lagoon. It is anticipated that during further development of the design, when assumptions around infiltration can be made, that the size of the wetland could be reduced and/or the requirement for mandating rainwater tanks removed.

The management of stormwater quality has been assessed. The current State Environment Protection Policy require that all new developments treat their stormwater runoff to Best Practice Environmental Management (BPEM) standard. Clause 56.07 of the Victorian Planning Provisions specifies the BPEM standard as 80% reduction in Total Suspended Solids, 45% reduction in Total Phosphorus, 45% reduction in Total Nitrogen and no increase in Gross Pollutants. The wetland is oversized for stormwater quality management purposes and hence the BPEM standards are easily achieved as shown in Table 5-2.

Council may require that the development of the site does not increase the peak flow rate (differing from flow volume discussed above) leaving the developed site compared with existing conditions. It is expected that as the design progresses the wetlands will be design as a multi-purpose facility to provide management of stormwater volume, quality and peak flow. The oversizing of the wetlands to manage runoff volumes will ensure that there is adequate capacity to design for management of peak flow rates if required.

It is concluded that the management of stormwater quantity and quality is not a constraint on the development of the site.

Table 5-2 Water Quality Outcomes

	Inflow	Outflow	Target Reduction	Actual Reduction
Total Suspended Solids (kg/yr)	21.7	0.02	80%	99%
Total Phosphorus (kg/yr)	3.5	0.05	45%	95%
Total Nitrogen (kg/yr)	2.1	0.7	45%	88%
Gross Pollutants (kg/yr)	9.3	0.4	100%	100%

6 Climate Change

Consideration of potential climate change influences on rainfall, evaporation and sea level and their significance to the viability of the development project is provided in this Chapter.

6.1 Rainfall and Evaporation

The most recent scaled-down climate change models for Victoria's south-west region, which includes the site, projected the following conditions, relative to a 1986-2005 baseline (Timbal et al.):

- A change in annual mean runoff -13% to 0% by 2030 and -28% to -5% by 2090;
- A change in cool season mean runoff -11% to +4% by 2030 and -31% to -2% by 2090;
- A change in warm season mean runoff -20% to +1% by 2030 and -33% to -1% by 2090;
- Increase in evaporation by 5% to 20%, the higher increases being in winter.

The above predictions for changes in rainfall indicate that a long-term reduction in in more frequent rainfall events is likely. This would lead to a reduction in the annual and seasonal runoff from the site to Murtnaghurt Lagoon. The site itself is only a small portion of Murtnaghurt Lagoons watershed catchment and hence it is likely that there will be a long-term reduction in the runoff entering the lagoon even if the development were not to proceed. This would lead to reduction in the frequency and duration of inundation in the Lagoon. The expected long-term increase in evaporation rate would further decrease the duration of inundation in the wetland.

Tiebal et al states that "*the frequency of heavy rainfall events and associated flooding is projected to increase across Victoria, despite the overall projected rainfall decline in both cool and warm seasons*". ARR 2016 provides a methodology for estimating potential increases in design event rainfall intensities for using in flood assessments. Applying this methodology projected the following changes to design rainfall intensities:

- An increase in the design rainfall intensity of about 5% by 2030;
- An increase in the design rainfall intensity in the range 10% to 20% by 2030.

An increase in the rainfall intensity would result in a small increase in the local catchment 1% AEP flood level. If at the time of a development application an allowance for climate change adjusted rainfall is required, the flood level would not increase sufficiently to create a constraint on development of the site. Under current rainfall In Section 4.2 the local catchment flood was conservatively calculated to be up to 1.4 m AHD which is well below the level across most of the site.

6.2 Sea Level Rise

The Planning Practice Note No. 53, *Managing coastal hazards and the coastal impacts of climate change August 2015*, references the *Victorian Coastal Strategy 2008* with regards to planning for sea-level rise. The coastal strategy identifies the need to "*Plan for sea-level rise of note less than 0.8 metres by 2100, and allow for the combined effects of tides, storm surges, coastal process and local conditions such as topography and geology when assessing risks and impacts associated with climate change.*" The State Planning Policy Framework specifies, "*Ïn planning for possible sea level rise, an increase of 0.2 metres over current 1 in 100 year flood levels by 2040 may be used for new development in close proximity to existing development (urban infill).*"

This development cannot be considered as urban infill and hence consideration of a 0.8 m sea level rise is required.

Jempson (2009) with regards to coastal process and storm surge concludes “*The Property is not at risk from coastal processes or storm tide inundation either now or under a future sea level rise scenario of 0.8 m.*”

As noted in Section 4.1 the site is protected from Barwon River flooding by a levee with a 1.75 m freeboard above the 1% AEP level. Sea level rise would likely increase the 1% AEP flood level higher than the current 2.5 m AHD, but by the full 0.8 m. The effects of an increases in the 1% AEP rainfall intensity on the Barwon River catchment because of climate change has not been quantified but may also lift the flood level marginally above the 2.5 m AHD. However, even with the combination of sea level rise and increased rainfall intensity, the levee will continue offer a significant freeboard above the 1% AEP flood level, noting that levees are typically designed with a 0.3 m to 0.6 m freeboard.

It is concluded that the development of the site would not be constrained by the effects of climate change.

7 References

ARR (2016), *Australian Rainfall & Runoff*, *A Guide to Flood Estimation in Australia*, Commonwealth of Australia, 2016.

CCMA (2005), *Barwon River Estuary Flood Study Tidal Surge Analysis for 1% AEP Flood Levels*, Corangamite Catchment Management Authority, May 2005

GHD (1997), *Geelong Flood Mitigation Strategy Final Report*, Report to the City of Greater Geelong, May 1997

Jempson (2009) *1920 Barwon Heads Road Coastal Vulnerability, Flooding and Stormwater Assessment, Expert Report, Amendment C159*, BMT WBM report No. R.M7751.003.00, November 2009

Timbal, B., Ekstrom, M., Fiddes, S., Grose, M., Kirono, D., Lim, E., Lucas, C., and Wilson, L. (2016). *Climate Change Science and Victoria*. Bureau of Meteorology, Melbourne, Victoria, 2016

Appendix A Preliminary Master Plan

0 20 40 60 80m

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Scale 1:2,000 @ A1

Preliminary Master Plan

1900 Barwon Heads Road - Barwon Heads

Appendix B Curricula Vitae

Dr Mark Jempson
Director

Qualifications and Accreditations

PhD in Civil Engineering, Hydraulics, University of Queensland.

Master of Engineering Science, University of Queensland.

Bachelor of Civil Engineering, Queensland University of Technology

Member, Engineers Australia

Chartered Professional Engineer (CPEng)

National Professional Engineers Register (NPER)

Registered Professional Engineer of Queensland, Civil (RPEQ)

Past Chair, Engineers Australia Victorian Water Engineering Branch

Summary

Mark has twenty-eight years industry experience in hydrological, hydraulic and multidisciplinary environmental investigations, construction and bridge design. Mark has worked in both the government and private sectors; 10 and 18 years respectively.

Mark is recognised as one of Australia's leading experts in flood and stormwater modelling, floodplain management and road and bridge hydraulics. He has undertaken studies across Victoria, Queensland, New South Wales, Tasmania, South Australia and the UK involving hydrologic and hydrodynamic modelling and flood management of estuaries, rivers and floodplains, water quality investigations and environmental assessments.

Mark is regularly called on as a peer reviewer and expert witness by government agencies and the private sector in QLD, NSW and Victoria. Mark has excellent communication skills, honed from many years of community consultation, and is able to effectively communicate complex flooding issues and analysis techniques to those without a technical background.

Mark's PhD research topic was *Flood and Debris Loads on Bridges*. Mark was the author of the hydrodynamic and debris load chapters in the Australian Bridge Design Standard.

Mark has hands-on experience in many of the key hydrologic and hydraulic modelling packages including XP-RAFTS, RORB, WBNM, URBS, HEC-RAS, TUFLOW, and MIKEFLOOD / MIKE21 / MIKE11.

Employment History

Current:	Venant Solutions, Director and Founder, Melbourne
2003 – 2013:	BMT WBM Water & Environment Business Unit Manager, Melbourne
1999 – 2002:	BMT WBM Senior Engineer, Brisbane
1988 – 1998:	QLD Department of Main Roads

Areas of Expertise

- Hydrodynamic modelling (1D and 2D)
- Flood hydrology
- Urban and rural flood modelling and mapping
- Floodplain Management
- Expert Witness/Peer Review
- Road and Bridge Hydraulics - author of flood and debris loads in Australian Bridge Design Standard
- Stormwater Quality and Quantity Management
- GIS Mapping

Contact Details

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Key flood management experience

Rural flood and floodplain management studies

These projects typically required the development of a survey brief, hydrologic modelling, two-dimensional hydraulic modelling, hydraulic and economic assessments of structural and non-structural floodplain management options, review of flood warning systems, community and stakeholder consultation, sedimentation assessments, and preparation of floodplain management plans. Following is a list of project in which Mark has been involved either as project manager, project director or technical reviewer.

- Herbert River Flood and Floodplain Management Study (Qld)
- Johnstone River Flood and Floodplain Management Study (Qld)
- River Tamar and North Esk River Flood Study (Tas)
- Mt William Creek Flood Investigation (Vic)
- Upper Wimmera Flood Investigation (Vic)
- Macalister River Flood Study – Stage 1 (Vic)
- Bacchus Marsh Flood and Floodplain Management Study (Vic)
- Yarriambiack Creek Flood Investigation (Vic)
- Lower Kiewa River Flood and Floodplain Management Study (Vic)
- Casterton Flood Intelligence and Warning Improvement Study (Vic)
- Glenelg River Sand Management Hydraulic Modelling Study (Vic)

Urban flood mapping

These studies involve the development of detailed hydrologic and 1D/2D hydraulic models to establish existing flood characteristics, and to provide input into economic and flood damages assessments. Some studies required the assessment of mitigation options and benefit-cost analyses. Clients include Melbourne Water, City of Greater Geelong and City of Greater Dandenong. This list of projects undertaken includes the Western Treatment Plant, Shakespeare Grove and Byron Street Main Drains, Sweetwater Creek, Kilsyth and Bungalook Main Drains, Barwon Heads, Bridge Street and Western Gully, Port Arlington, and Dandenong CBD.

Herbert River Levee Management Study

There has been a significant change in flooding patterns on the Herbert River floodplain since the 1960's as a result of construction of levees by landholders. The construction of the levees, or the expansion of existing levees, continues as landholders respond to increased flooding on their properties. The Herbert River Improvement Trust recognises the need to control future growth of levees if a disaster is to be avoided. This study used flood modelling of future hypothetical levee construction to demonstrate the future impact on flooding. Consultation with landholders and stakeholders was then undertaken to kick start an on-going and long-term education process.

Melbourne Water Development Services Schemes

These projects involve hydrologic, hydraulic and water quality modelling and the preparation of a development services strategy. Functional design of stormwater management measures such as retarding basins and bio-retention systems were undertaken. Quantities and costs of works are determined as input into Melbourne Water's Development charges. Projects undertaken include Central Creek, New Gisborne, Romsey, Riddells Creek, Loch and Nyora.

Impacts of Pontoons and Jetties on Flooding on the Coomera and Nerang Rivers

The Gold Coast City Council was concerned that the on-going construction of pontoons and jetties on the Nerang and Coomera Rivers may impact of flood levels. The Computational Fluid Dynamics (CFD) software Fluent was used to assess the near field effects of the pontoons and jetties. Data obtained from the CFD analysis was used to inform the far-field 2D modelling undertaken using TUFLOW.

Insurance Assessments

Mark worked on hydrology reports for insurance companies following the Victorian floods in 2012 and the Queensland flood in 2013.

Key road and bridge drainage assessments

These studies involved the development of detailed hydrologic and hydraulic models to assist in route selection and the establishment of the road grade and bridge and culvert requirements to meet flood serviceability requirements such as flood impact and time of closure. Bridge scour assessments are sometimes required. Recent major projects include:

- Warrego Highway Upgrade, Gowrie Creek, Detailed Design (Qld)
- Bruce Highway Upgrade, Ingham to Cardwell Range Planning Study (Qld)

- Bruce Highway Upgrade, Frances and Cattle Creeks - Link Study, Business Case and Detailed Design phase
- Bruce Highway Upgrade – Larsens Street to Lannercost Street (Qld)
- Gold Coast Intra-Regional Transport Corridor (Qld)
- Western Highway Duplication – Carpenter Road to Box's Track (Vic)
- Springvale Road - Railway level crossing removal (Vic)

During Mark's 10 years at the QLD Department of Main Roads he spent 8 years working in the flood group undertaking flood assessments on bridge and road project across most parts of Queensland.

Key land development projects

Planning system requirements associated with developing on a floodplain can be complex with regards to flood and stormwater management. Mark has worked for both developers and approval authorities (review and technical advisor role) on many complex development proposals in both Victoria and Queensland from concept through to detailed design and as an expert witness in planning submissions and appeals. A selection of these projects includes:

- Queens Wharf Brisbane (Qld)
- Grand Lakes (Vic)
- Seabank Estate (Vic) – winner of the 2007 UDIA award for WSUD
- Manzeene Avenue (Vic)
- Gold Coast Convention Centre (Qld)
- Pacific View Estate (Qld)
- Gold Coast International Marine Precinct (Qld)

The Queens Wharf Development is a multi-billion dollar redevelopment of the north bank of the Brisbane River in the CBD. The project is a State initiative and Mark worked as a Technical Advisor (flooding) to the State through the 18 month procurement process. This included the preparation of tender documentation, development of a TUFLOW model for use by the Proponents during tendering, assisting with Proponent questions during tendering, technical review of tenders, advising the State on planning matters.

Key environmental modelling projects

River Tamar Estuary Modelling Study

Mark was the Project Manager responsible for the development of a calibrated tidal hydrodynamic, water quality and cohesive sediment transport model of the Tamar River estuary for the Launceston City Council. The modelling was performed using the RMA10S and RMA11 software packages. Cohesive sediment transport and siltation modelling was an important focus of this study which seeks to develop a tool for modelling the ongoing siltation problem within the upper Tamar estuary and for predicting the flood scour which is likely to occur. The model was also used to assess the impact of changes to the Council's wastewater treatment system on the water quality of the Estuary.

Gold Coast International Marine Precinct EIS

An expansion to the marine precinct on the Coomera River is proposed. It is deemed to be a project of state significance by the State. The precinct is in an environmentally sensitive and flood prone area. Mark was responsible for the following assessments: flood and tidal; receiving water quality; sediment accumulation; dredge plume dispersion; sediment impacts on aquatic ecology. The assessments were undertaken on a range of modelling packages including a TUFLOW FV for tide, advection dispersion model (dredge plume dispersion), and sediment accumulation. MIKE21 was used for the flood assessment.

Woollooman Creek Weir

The impact of a proposed weir in combination with an in-stream sand extraction operation on the sediment transport processes within the Creek were assessed. Long-term sediment transport processes, catchment yield and sediment capacity were assessed. Recommendations were developed for mitigating the impacts.

Maroochy River Eutrophication Modelling

The effects on sewage discharges on receiving water quality and estuarine ecological health and proposed plant augmentations were assessed using MIKE11. The eutrophication model investigated nutrient cycling, growth of phytoplankton and zooplankton as well.

Construction and bridge design experience

During his time at QLD Department of Main Roads, Mark spent nearly two years working in road construction and bridge design.

Key peer review experience

Inquiry into Flood Mitigation Infrastructure in Victoria, Parliament of Victoria

Following the Victorian floods of 2010 and of 2011, the Victorian Government established a parliamentary enquiry into flood mitigation infrastructure in Victoria. Mark was the technical adviser for the enquiry report.

Hawkesbury-Nepean Valley Flood Management Strategy

Infrastructure NSW is proposing a significant investment in a range of flood management strategies for the Hawkesbury-Nepean Valley. The NSW State Government requires that the strategic business case for the next phase of the scheme be independently reviewed to satisfy the requirements of its Gateway Review Process. Mark was a member of the Gateway peer review panel established by NSW Treasury.

Brisbane River Pedestrian Riverwalk, Peer Review

The Riverwalk pedestrian bridge on the Brisbane River was washed away during the 2011 floods. To minimise the risk of a future failure, the Brisbane City Council's consultant undertook 3D hydrodynamic modelling to determine flow velocities and physical modelling to determine flood force coefficients; the coefficients were required to establish the flood loads.

Mark's PhD research was in flood and debris loads on bridge structures, and so the Council engaged Mark to review the physical modelling and derivation of the force coefficients.

Flemington Racecourse Flood Wall

The Victorian Racing Club proposed the construction of a flood wall around the Flemington Racecourse to reduce the risk of the Melbourne Cup being affected by flooding. Concerns were raised as to the effects of the flood wall on existing developments along the Maribyrnong River floodplain. The City of Melbourne, Moonee Valley City Council and Maribyrnong City Council engaged Mark to complete an independent peer review of the modelling, proposal and mitigation works.

Brisbane Airport Link and Busways, Peer Review of Hydraulic Modelling

The Airport Link and Busways project in Brisbane required the construction of a complex array of bridges/overpasses over Breakfast Creek at Herston. This resulted in a large number of piers in creek and floodplain. With a large number of flood prone houses upstream, it was important that the modelling reliably estimated the impacts of the piers and that appropriate mitigation was implemented. Brisbane City Council engaged Mark to peer review the modelling undertaken by the Proponents' consultants.

Salacia Waters Marina Development, Gold Coast, Qld

Mark undertook an independent peer review of modelling and associated impacts of a proposed marina at Salacia Waters development. The review was done in order to assist in resolving a dispute between Council and the proponent with regards to the representation in the model of hydraulic losses around the marina structures.

Florina Gardens Development, Gold Coast

The Florina Gardens development on the Gold Coast is located on the Nerang River floodplain. Gold Coast City Council engaged Mark to complete a peer review of the hydraulic modelling done by the proponent and an assessment against the planning scheme.

Key expert witness experience

Mark regularly prepares expert witness statements for both government and private sector clients in relation to flooding and Stormwater matters. The list below is a mix of VCAT and Planning Panel work in Victoria, Planning & Environment Court in Queensland and Land and Environment Court in NSW.

- Ibbotson St Development, St Leonards, VIC
- Mills Crescent Development at Port Fairy, VIC
- Implementation of Special Building Overlay into planning scheme, City of Greater Geelong
- Masters Development at Corio, VIC
- Development at San Remo, VIC
- Halcyon Waters, Gold Coast, QLD
- Masters Development at Corio, VIC
- Eastern Golf Course at Yering, VIC
- St Patricks School, Macksville, NSW
- Claremont Street, South Yarra, VIC
- Great Ocean Green, Apollo Bay, VIC
- Grand Lakes Development at Lara, VIC
- Caddys Road Rezoning at Lara, VIC
- Manzeene Ave Development at Lara, VIC
- Subdivision at Metung, VIC
- Subdivision at Aireys Inlet, VIC
- Flooding appeal at Gardiner Rd Hawthorn
- Sheehan & Berry appeal, Gold Coast, QLD
- Dunns Creek Road Dromana, VIC
- Development at Walcourm Court, Launceston, TAS
- Pizzolato Development, Innisfail, QLD
- Celledoni Development, Innisfail QLD
- Barwon Heads Road Development, VIC

Articles, papers and presentations

Jempson, M.A. and Apelt, C.J. (1992), Hydrodynamic forces on partially and fully submerged bridge superstructures, *Proc. 16th ARRB Conference, 9-12 November, Perth, Australia, v3, pp67-82.*

Jempson, M.A. (1994), Hydrodynamic forces on partially and fully submerged bridge superstructures, *Master of Engineering Science Thesis, The University of Queensland*

Jempson, M.A. and Apelt, C.J. (1995), Flood loads on bridge superstructures, *Proc. Bridges into the 21st Century, 2-5 October 1995, Hong Kong*, pp.1025-1032. (Hong Kong Institution of Engineers).

Jempson, M.A. and Apelt, C.J. (1997), Debris loadings on bridge superstructures and piers, *Proc. Bridging the Millennia, AUSTROADS 1997 Bridge Conference, 3-5 December, Sydney, Australia, v2, pp3-17.*

Jempson, M.A. and Apelt, C.J. (1997), Flood loads on submerged and semi-submerged bridge superstructures, *Proc. Bridging the Millennia, AUSTROADS 1997 Bridge Conference, 3-5 December, Sydney, Australia, v2, pp19-33.*

Penfold, P.S and Jempson, M.A. (1997), New Survey Requirements for Bridge Sites, *Proc. Mining in the Third Millennium, 10th ISM and 23 IESMA Conference, 3-6 November 1997, Perth, Australia.*

Jempson, M.A. (1998), Oakey Bypass and La Niña - Mutually Exclusive Events? *Main Roads Department Southern Symposium, October 1998, Roma.*

Jempson, M.A. (2000), Flood and Debris Loads on Bridges, *Institution of Engineers Australia, Technical Seminar, March 2000, Brisbane.*

Jempson, M.A. (2000), Flood and Debris Loads on Bridges, *PhD Thesis, The University of Queensland*

Neilsen, C.F, Barton, C.L., Jempson, M.A. (2001), The Application of Three Dimensional Finite Element Modelling to Flood Flows in a River Channel *6th Conference on Hydraulics in Civil Engineering, Hobart, Tas, 2001.*

Jempson, M.A. and Alam, K. (2003), Flood risk management and community consultation – A Queensland perspective, *43rd NSW Floodplain Management Conference, Forbes.*

Jempson, M.A., Maxwell, N.D., Apelt, C.J. (2004), Application of CFD Modelling to Free Surface Flow Around Bluff Bodies – A Case Study Using a Bridge Superstructure, 8th National Conference on Hydraulics In Water Engineering, Gold Coast, Australia, July 2004.

Gillam, P, Jempson, M.A., Rogencamp, G.J., (2005), The importance of combined 2D/1D modelling of complex floodplains – Tatura Case Study, *4th Victorian Floodplain Management Conference*, Shepparton, Victoria, 2005

Jempson, M.A., Rogencamp, G.J., (2006), The Application and Benefits of 2D/1D Flood Modelling in Urban Developments, 1st *Association of Land Development Engineers Conference*, Gold Coast, Queensland, August 2006

Caddis, B.M, Jempson, M.A, Syme, W.J. and Ball, J.E. (2008) *Incorporating Hydrology into 2D Hydraulic Models – The Direct Rainfall Approach.* Proceedings of Hydraulics in Water Engineering Conference, Darwin, Australia

Leister, J.G. and Jempson, M.A. (2010), *Backwater Effects of Piers and Abutments in a 2D Hydraulic Model*, Victorian Floodplain Managers Conference, Bendigo, November 2010

Leister, J.G. & Jempson, M.A., (2011), *Backwater Effects of Bridge Piers and Abutments in 2D – Replication of Physical Model Tests in a 2D Hydrodynamic Model*, 34th International Association of Hydraulic Research (IAHR) World Congress, Brisbane, Australia, June 2011.

Jempson, M.J., Leach, B. and Trotter, D., (2011), *A review of the implementation of floodplain management plans on the Herbert and Johnstone Rivers in North Queensland Australia*, 5th International Conference on Flood Management, Tokyo, Japan, September 2011

Jempson, M.J., Leach, B. and Trotter, D., (2013), *On the implementation of floodplain management plans on the Herbert and Johnstone Rivers*, IAHS Publication No. 357 (2013), ISBN 978-1-907161-35-3

Jempson, M.J., South, M.E., and Kim, Y.J., (2014), *The influence of localised upwelling at a bridge on overtopping and road closure: a case study using vertical 2D CFD and horizontal 2D flood models*, 5th International Symposium on Hydraulic Structures, Brisbane, June 2014.

Dr Dale Browne
Principal Environmental Engineer

Qualifications

> PhD, Monash University, 2011
> Bachelor of Environmental Engineering (First Class Honours), 2000
> Bachelor of Arts (Indonesian), University of Melbourne, 2000

Career Overview

Dale is an Environmental Engineer with over 12 years professional experience in WSUD and integrated water cycle management. He has practical experience in the project management, design and delivery of water sensitive urban design interventions including wetlands, rain gardens and stormwater harvesting locally and internationally.

Dale has worked on and often acted as technical lead for a range of integrated water management strategies at development to municipal and city scales. Dale has expertise in the creation, development and application of models for water sensitive urban design. As a member of the MUSIC development team he contributed to recent versions through research, specifications, implementation and testing.

Dale is committed to training and has taught over 500 industry professionals in Victoria how to use MUSIC over a decade. He also teaches Clearwater's Stormwater Reuse course and lectures in WSUD design and modelling at Monash and Federation Universities and has delivered industry training in Kunshan and Singapore.

Selected Project Experience

WSUD and Integrated Water Management

- WSUD and IWCM Scoping and Prioritisation for Maribyrnong and Koroit Catchment, Brimbank City Council
- Stormwater Quality Strategy, City of Geelong
- Darebin Priority Stormwater Projects
- Ballarat Integrated Water Management Strategy Central Highlands Water, Winner AWA 2018 awards
- WSUD Asset Audit, Cities of Stonnington, Casey and Port Phillip
- ACT Non-Potable Master Plan and Integrated Water Management, ACTPLA
- Sunshine National Employment Cluster Integrated Water Management, City West Water and Melbourne Water
- Black Forest Road Catchment Integrated Water Management Strategy, City West Water and Melbourne Water
- San Remo Integrated Water Management Strategy, Westernport Water
- Effects of WSUD on Flooding in Elizabeth St, City of Melbourne
- Municipal integrated Water Management Strategies - City of
- Integrated Water Management Strategy, City of Casey, Port Phillip and Nillumbik Shire Council
- City West Water Integrated Water Management Strategy and Options Assessment Model, City West Water

WSUD Design and Construction

- Galada Reserve Bioretention Retrofit Works, City of Melbourne
- Western Precinct Rain Garden and Wetland Detailed Design, Monash University
- Sunvale Community Park
- Port Phillip Raingarden Retrofits Project, City of Port Phillip
- Harcrest Residential Development Raingarden and Stormwater Harvesting Scheme Design, Mirvac
- Elsternwick Park Stormwater Harvesting Scheme Detailed Design and Construction, Bayside City Council
- Napier Park Swale and Stormwater Harvesting Scheme Detailed Design and Construction, Moonee Valley City Council
- Design of Biofiltration Systems in the West, Melbourne Water
- Port Phillip Streetscape WSUD Design Options, City of Port Phillip

WSUD Guidelines and Industry Training

- Kunshan Design Studio, CRCWSC
- Kunshan Sponge City Training, CRCWSC
- Singapore MUSIC Calibration Training, NUS/PUB
- Stormwater Retention Guidelines, Sydney Water- WSUD Audit Guidelines, Stormwater, Victoria
- ACT WSUD Guidelines, ACT Government
- Melbourne Water WSUD Guidelines, Melbourne Water
- Melbourne Water MUSIC Guidelines 2016 Revision, Melbourne Water
- Stormwater Harvesting Training, Clearwater
- Wetland training, Water Sensitive SA and Stormwater Australia
- MUSIC Training for Melbourne Water, Clearwater and eWater since 2004
- Raingarden Design Workshops in Collaboration with FAWB to industry in VIC, NSW, SA and WA.

Model Development

- Creation of a model and analysis for stormwater infiltration systems representing 2D variably saturated flows, storage and clogging processes (PhD)
- Revised Melbourne Water MUSIC Auditor and Wetland Spells and Analysis Tool web services
- Member of the MUSIC development team providing technical specifications and testing for upgrades.
- MUSIC Auditor and Wetland Analysis Tool web services - As partner at Microburst Software

Aaron Dowling
Senior Engineer

Qualifications

> Bachelor of Engineering (Civil) (Hons), Swinburne University, 2012

> Bachelor of Business (Management), Swinburne University, 2012

Employment History

> Senior Engineer - E2Designlab (2018 - Current)

> Development Engineer - Melbourne Water (2010-2018)

Career Overview

Aaron is a Civil Engineer with 8 years of experience in WSUD, stormwater management and strategy development. He is passionate about the design and implementation of innovative water servicing solutions that deliver beneficial environmental, social and financial outcomes.

Aaron is a self-motivated, adaptable professional with 8 years' experience in hydrologic and hydraulic engineering, water sensitive urban design and project management. High level of analytical and problem solving skills, and broad knowledge of the development industry standards and practices. Passionate about utilising engineering knowledge and experience to enhance life and the liveability of communities.

Skills

- Specialised in functional design and performance modelling of flood protection, conveyance and stormwater quality treatment assets.
- Proficient and accurate when undertaking GIS, hydraulic and hydrologic modelling tasks.
- Confident and proficient communicator at all levels, from consultation with the general public to representing Melbourne Water at Planning Panel hearings and participation in technical specialist conclaves.
- Strong appreciation of the technical and operational complexities of waterways and stormwater quality assets, including constructed wetlands, sedimentation basins and bio-retention basins.
- Known for attention to detail and logical approach to problem solving, with a passion for innovation and process efficiency.
- Experienced at negotiating complex funding, construction and administration arrangements with a drive to achieve win-win outcomes between parties.
- Excellent resource management skills with significant experience in prioritisation and delegation of tasks whilst affording due consideration of team strengths and capabilities.
- Experience managing multiple highly complex projects across various professional disciplines on time and budget.
- Conscientious outlook toward workplace safety.

Selected Work Experience

Aaron has demonstrated technical and project management capabilities in recent projects such as:

- MUSIC Guidelines Update, Melbourne Water
- Sunbury Stormwater and IWM Plan, Melbourne Water
- Sandown IWM Plan: Regulatory Options to Improve Stormwater Management, South East Water
- Taylors Road Stormwater Management Strategy