Molecular and Life Science Building

Flood Study

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Contact Information

Cardno South Coast
Trading as Cardno (NSW/ACT) Pty Ltd
ABN 95 001 145 035

Level 1, 47 Burelli Street
PO Box 1285
Wollongong NSW 2500

Telephone: 02 4228 4133
Facsimile: 02 4228 6811
International: +61 2 4228 4133

southcoast@cardno.com.au
www.cardno.com.au

Author(s):

Nathan Pomfret
Water Engineer

Approved By:

Alex Facchin
Manager - Water

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Table of Contents

1 Introduction **1**
- 1.1 Background 1
- 1.2 Site Description 1

2 Available Data **2**
- 2.1 Topographic Data 2
  - 2.1.1 Aerial Laser Survey 2
  - 2.1.2 Detailed Site Survey 2
  - 2.1.3 Site Inspection 2
- 2.2 Previous Studies 3
  - 2.2.1 Fairy and Cabbage Tree Creeks Flood Study, F&CTCFS 3
  - 2.2.2 Fairy and Cabbage Tree Creeks Floodplain Risk Management Study and Plan 3

3 Hydrological Modelling **4**
- 3.1 Catchment Description 4
- 3.2 Hydrological Model Selection 4
- 3.3 Model Inputs 4
  - 3.3.1 Sub-Catchment Topology 4
  - 3.3.2 Impervious Fractions 4
  - 3.3.3 Hydrological Parameters 5
- 3.4 Design Storm Events 5
  - 3.4.1 Critical Duration 5

4 Hydraulic Modelling **6**
- 4.1 Selection of Hydraulic Model 6
- 4.2 Model Geometry, Boundary Conditions and Roughness 6
  - 4.2.1 Existing Scenario 6
  - 4.2.2 Proposed Scenario 6
- 4.3 Simulation Results 7
  - 4.3.1 Existing Scenario 7
  - 4.3.2 Model Calibration 7
  - 4.3.3 Climate Change 7
  - 4.3.4 Proposed Scenario 7

5 Discussion **8**
- 5.1 Hydraulic Hazard Categorisation 8
- 5.2 Flood Risk Precincts 9
- 5.3 Floodplain Management 9
  - 5.3.1 Finished Floor Levels 9
  - 5.3.2 Flood Compatible Buildings Materials and Structural Soundness 9
  - 5.3.3 Evacuation and Safe Access 9
- 5.4 Flood Affectation 9
  - 5.4.1 100 Year ARI 9
  - 5.4.2 PMF 9
  - 5.4.3 Floodplain Storage 9
- 5.5 Trafficability 10
  - 5.5.1 Carparking Areas 10
  - 5.5.2 Access 10

6 Conclusions **11**

Appendices

Appendix A CATCHMENT MAP
Appendix B HYDROLOGICAL ASSESSMENT
Appendix C HYDRAULIC ASSESSMENT
Appendix D SITEWORKS PLAN

Tables

Table 3-1 WBNM Hydrological Parameters 5
Table 4-1 Manning's 'n' Roughness Values 6
Table 5-1 Council DCP 2009 Risk Precinct Definitions 9

Figures

Figure 2-1 Detailed Site Survey 2
Figure 5-1 Velocity & Depth Relationships (FDM, 2005) 8
Figure 5-2 Provisional Hydraulic Hazard Categories (FDM, 2005) 8

1 Introduction

1.1 Background

The University of Wollongong (UOW) has engaged Cardno (NSW/ACT) Pty Ltd to undertake a flood study for the proposed Molecular and Life Science (MLS) building located at UOW's Wollongong campus. This report presents the outcome of the assessment to demonstrate that the proposal is in accordance with the relevant floodplain management policies.

This flood study has been prepared by a suitably qualified civil engineer in accordance with Chapter E13 – Floodplain Management of Wollongong Development Control Plan 2009 (WDCP 2009) Clause 73 of The Local Environmental Plan 2009, and the NSW Floodplain Development Manual (2005).

1.2 Site Description

The site is situated in the east of the UoW main campus on Northfields Avenue in Keiraville. The site fronts a carparking area and has direct access to the Ring Road. The proposed building is to replace an existing building and ground level carpark area.

An overland flowpath is located to the south of the proposed building boundary, the ring road to the north also acts as an overland flow path. Both flow paths convey flows to the east to a swale within the UoW campus before discharging into the Cabbage Tree Creek Tributary.

The site will be referred to as 'MLS' in this report.

2 Available Data

2.1 Topographic Data

2.1.1 Aerial Laser Survey

ALS survey data provides complete coverage of the study area and catchments, and has been purchased from LPI. The ALS survey data was captured in 2013. This ALS digital elevation model (DEM) data was used to define catchment boundaries and to represent the existing surface in the hydraulic model where detailed survey or DA approved design was not available. The DEM has been used in the development of the ground surface in the TUFLOW hydraulic model as discussed in **Section 4**.

2.1.2 Detailed Site Survey

Detailed site survey was obtained on 20 December 2016 by Project Surveyors Pty Ltd. The survey contains topographic information of the existing site.

Detailed topographic survey of areas surrounding the subject site were also used in this study. The surveyed area including details of the survey are presented in **Figure 2-1**.

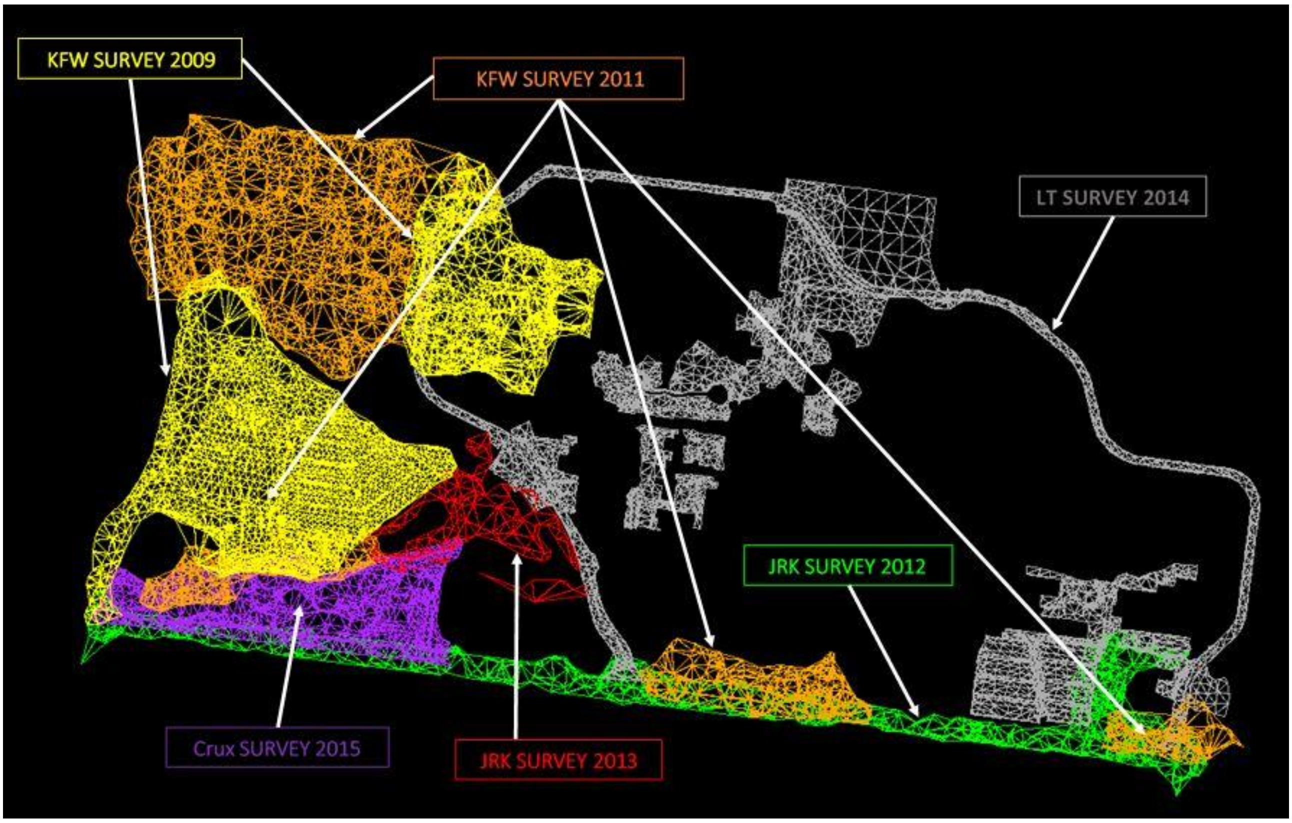

Figure 2-1 Detailed Site Survey

2.1.3 Site Inspection

A number of site inspections have been undertaken by Cardno to confirm catchment boundaries, flow paths, basin configurations and culvert sizes.

2.2 Previous Studies

2.2.1 Fairy and Cabbage Tree Creeks Flood Study, F&CTCFS

A flood study of Fairy Creek and Cabbage Tree Creeks was developed for Wollongong City Council in 2009 by Bewsher Consulting. Hydrologic and hydraulic models in this study were developed to define existing flood behaviour and problems within the study area. The hydrologic and hydraulic models were calibrated to historical flood events to demonstrate the validity of the models, using the August 1998 with the smaller October 1999 flood event used as verification. The study also predicts flood levels for design events up to and including the Probable Maximum Flood (PMF) event, and Provisional Hydraulic Hazard for the 1% AEP flood. The findings provide means for assessing floodplain management measures within the study area. This study is abbreviated and referenced in this report as the F&CTCFS, 2009.

2.2.2 Fairy and Cabbage Tree Creeks Floodplain Risk Management Study and Plan

A Floodplain Risk Management Study and Plan for Fairy Creek and Cabbage Tree Creek (FCTCFRMS) was developed for Wollongong City Council in 2010 by Bewsher Consulting. The study covers the Fairy Creek, Cabbage Tree Creek and Towradgi Arm catchments. The study investigates what can be done to minimise the effects of flooding while the Floodplain Risk Management Plan (FRMP) outlines the best measures to reduce future flood damages, based on consideration of economic, social, ecological and engineering issues.

3 Hydrological Modelling

3.1 Catchment Description

The main University of Wollongong campus contains two major tributaries, which form part of the Fairy Creek catchment to the south and Cabbage Tree Creek catchment to the north (refer to catchment plan in **Appendix A**).

The Fairy Creek tributary headwaters originate at the summit of Mount Keira, and are conveyed down the escarpment which is characterised by steep slopes with minimal urbanisation. The tributary then enters a flatter grazing area before flowing through a culvert under Robsons Road and into the University. The Robsons Road culvert and the storage area immediately upstream provide some degree of (informal) attenuation of peak flows during major storm events.

The catchment for the Cabbage Tree Creek tributary previously extended west of Robson Road. However, following the construction of Robson Road, runoff west of Robsons Road is now redirected to Fairy Creek. The catchment within the University is characterised by large buildings and paved areas set in landscaped gardens on relatively flat grades.

3.2 Hydrological Model Selection

The computer model 'Watershed Bounded Network Model' WBNM2007 v104 (Boyd et al, 2007) was used for hydrological modelling of the study area. WBNM is an advanced storage-routing model that allows simulation of complex catchment behaviour. This particular model was considered most appropriate to the task of modelling the study area, given its ability to model a wide range of catchment characteristics, its local development and its use in the Fairy and Cabbage Tree Creek Flood Study, F&CTCFS (WCC, 2009). The model allowed peak flows to be established at various locations throughout the subject site. Model input and results are provided in **Appendix B**.

The WBNM model was used to derive flows for input to flood model.

3.3 Model Inputs

3.3.1 Sub-Catchment Topology

The site lies within the upper reaches of the Fairy Creek Catchment. A ridgeline which separates the Cabbage Tree & Fairy Creek catchments traverses the campus. This boundary was confirmed during the site visit (2013) and was incorporated in the catchment plan (**Appendix A)**. The catchment plan illustrates the Cabbage Tree Creek catchment which discharges from the site and was further delineated into smaller sub-catchments using:

- Aerial Laser Survey (ALS);
- 2m contours; and
- Site inspection confirmation.

3.3.2 Impervious Fractions

The catchment consists of dense bush, residential lots, paths, roads, car parks, commercial buildings and grassed recreation areas. Within the site, the impervious fraction of each sub-catchment was determined by accounting for each impervious area, as illustrated in **Appendix B**. Impervious fractions we adopted for sub catchments outside the site in accordance with Wollongong City Council's (WCC) Development Control Plan (DCP 2009) as follows:

- Normal Residential Lots - 60% impervious;
- Public Recreation Areas – 25% impervious;

The 25% impervious fraction for public recreation areas was used on areas with short grass and light vegetation. Areas covered in dense vegetation were represented by a 10% impervious fraction (confirmed via site inspection) while buildings, roads and hardstand areas were considered 100% impervious.

3.3.3 Hydrological Parameters

Hydrological parameters incorporated in the WBNM model are listed in **Table 3-1** and were adopted from the Fairy and Cabbage Tree Creeks Flood Study (WCC, 2009).

Table 3-1 WBNM Hydrological Parameters

Parameter	Value(s)
Initial loss (pervious surface)	0 mm
Initial loss (impervious surface)	0 mm
Continuing loss (pervious surface)	2 mm/hr
C (Lag parameter)	1.3
Stream routing factor	1.00

3.4 Design Storm Events

3.4.1 Critical Duration

The WBNM hydrological model was simulated for a range of storm durations to determine critical durations for the existing catchment. It was established that for events up to and including the 100 year ARI event, the critical duration is 120 minutes and 60 minutes for the PMF event.

4 Hydraulic Modelling

4.1 Selection of Hydraulic Model

A 2D flood model (TUFLOW) was used to simulate flooding on the site and surrounding area for the 100 year ARI and PMF storm events. The model covers the study area shown in **Appendix C** and extends approximately 500 m upstream of Robsons Road to approximately 200 m downstream of the Southern Freeway. A 2D model was selected in preference over a 1D model to better represent the complex hydraulics associated with this site. The location of the downstream model boundary is shown in the Hydraulic Model Configuration map in **Appendix C**.

4.2 Model Geometry, Boundary Conditions and Roughness

4.2.1 Existing Scenario

The TUFLOW model was established over a 2 m grid with elevations extracted from ALS data. The model grid extent covers the entire UoW Campus and the adjacent sub-catchments.

Hydrographs were extracted from the WBNM model for input to the hydraulic model. The downstream boundary conditions were modelled using a constant tailwater level which was taken immediately downstream of the Southern Freeway. The tailwater levels were adopted from the F&CTCFS (2009) and were identified as 14 m AHD for the 100 year ARI and 16 m AHD for the PMF event.

Culverts and pipes inspected within the study area were modelled in accordance with WCC's new blockage policy as detailed in the Review of Conduit Blockage Policy Summary Report (WMA, May 2016).

Manning's roughness values were assigned to the model based on areas identified from aerial imagery. Values adopted from the F&CTCFS (2009) and included in the model are provided in **Table 4-1**.

Table 4-1 Manning's 'n' Roughness Values

Land Type	Land Type (F&CTCFS, 2009)	Manning's 'n' Values
Ponds	-	0.010
Roads	Road Surface	0.025
Pasture	Grass (un-maintained)	0.045
Buildings	Building	0.500
Short Grass	Grass (maintained)	0.035
Trees	Dense Creek Vegetation	0.080

4.2.2 Proposed Scenario

The TUFLOW model was updated to reflect the proposed development within the MLS site. The proposed building envelope was modelled as an obstruction based on the proposed layout plan. The Proposed Siteworks Plans are provided in **Appendix D**.

The proposed MLS site was found to result in no adverse flooding impacts on adjacent roads and properties. The existing flood training wall to the north of the IMHRI building is proposed to be removed, however the proposed driveway in this area incorporates a ridge designed to the level of the flood training wall result in no change to flooding conditions.

The building pad elevation has been designed to achieve the Flood Planning level (FPL), i.e. 100 year ARI plus 500mm freeboard (refer Section 5.3.1 for details).

The Manning's roughness values within the proposed development areas were updated based on the proposed layout plan. Values adopted from the F&CTCFS (2009) and included in the model are provided in **Table 4-1**.

Hydraulic Model Configuration Plan for the developed scenario is provided in **Appendix C**.

4.3 Simulation Results

4.3.1 Existing Scenario

The hydraulic model was simulated for the 100 year ARI and PMF storm events. Flood maps indicating flood extents, depths, elevations, velocities and hazards were produced from the simulation results and are presented in **Appendix C**.

The hydraulic modelling results show that flooding occurs to the north and south of the site as overland flows. The proposed MLS building pad is not flood affected in the 100 year ARI event. Overland flows will occur immediately adjacent to the proposed MLS building in the PMF event but the building will remain flood free due to the adopted floor levels.

Depth of flow adjacent to the proposed MLS building (south) is generally below 250 mm in the 100 year ARI and 400 mm in the PMF event. Flood velocities are generally less than 2 m/s in both storm events with marginal areas reaching a maximum velocity of 1.9 and 2.2 m/s in the 100 year ARI and PMF events, respectively. Flood maps are provided in **Appendix C**.

4.3.2 Model Calibration

The 100 year ARI results from this assessment were compared against the results from the F&CTCFS (2009). The downstream boundary condition used in the model is adopted and consistent with the level presented in the F&CTCFS (2009).

The flood extents and water levels along Northfield Avenue show general parity between the 100 year ARI obtained in this assessment and that presented in the F&CTCFS (2009). However, the existing MLS site and surrounding areas are shown as flooded in this study although the F&CTCFS (2009) presents no flood affectation within this area. It should be noted that flood modelling in this study includes detailed site surveys within the vicinity of the UoW Campus. As such, the result obtained in this study establishes a more detailed and accurate representation of the flood behaviour across the subject site.

4.3.3 Climate Change

A climate change assessment was undertaken to assess the flood immunity of the project under a future climate change scenario in accordance with the design criteria. This took into account an estimated 20% increase in rainfall intensity and a 0.91m increase in ocean water levels potentially associated with climate change. These values are identical to the values used in the climate change assessment undertaken by Bewsher for the FCTCFRMS, and are consistent with parameters typically adopted for the assessment of climate change in flood studies. Climate change predictions are based on mid-range estimates provided in the Floodplain Risk Management Guideline titled ‘Practical Consideration of Climate Change’ (DECC, 2007).

Within the site the estimated increase in rainfall intensity is the primary cause of impacts, while the application of increased ocean levels does not substantially impact on flooding for the site. Results from the climate change analysis are provided in **Appendix C**. The FPL proposed for the site accounts for both the increase in levels due to climate change and the required freeboard (**refer Section 5.3.1**).

4.3.4 Proposed Scenario

The hydraulic modelling results in the proposed scenario are essentially unchanged from the existing.

5 Discussion

5.1 Hydraulic Hazard Categorisation

The NSW Floodplain Development Manual (FDM, 2005) provides guidelines to assess the safety and hazard of floodwaters based on the velocity and depth. Appendix L of the FDM (2005) provides two graphs which are used to assess flood waters, as provided in **Figure 5-1** and **Figure 5-2** below.

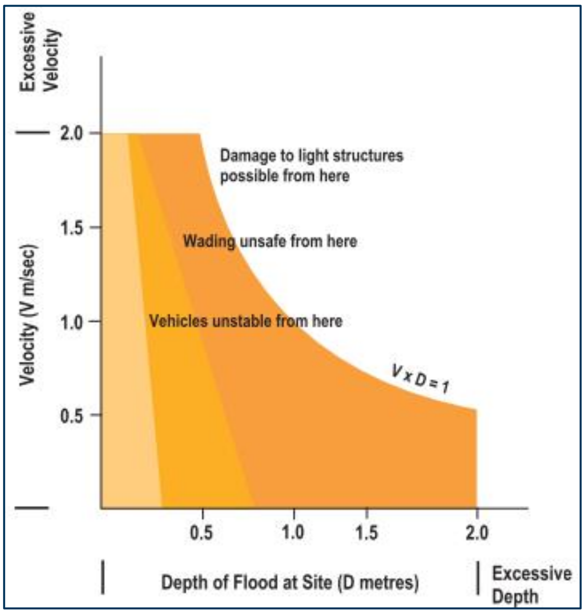

Figure 5-1 Velocity & Depth Relationships (FDM, 2005)

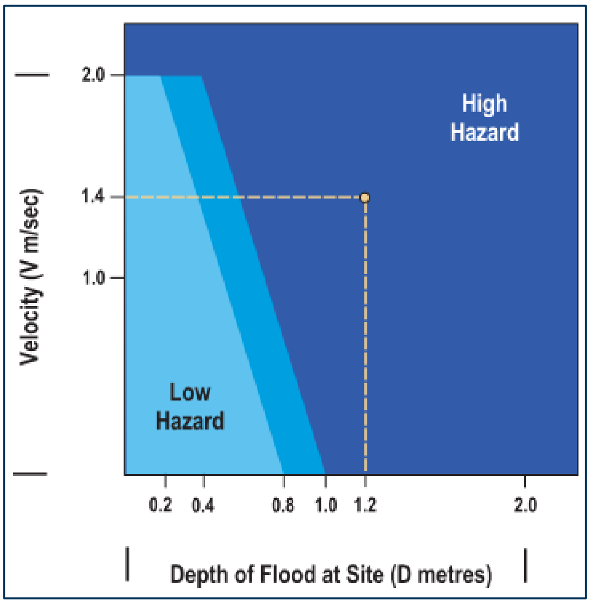

Figure 5-2 Provisional Hydraulic Hazard Categories (FDM, 2005)

FDM (2005) defines the hazard categories as follows:

- ***High hazard**: possible danger to personal safety: evacuation by trucks difficult: able-bodied adults would have difficulty in wading to safety; potential for significant structural damage to buildings;*
- ***Low hazard**: should it be necessary, truck could evacuate people and their possessions; able-bodied adults would have little difficulty in wading to safety.*

Flood maps were derived to demonstrate the flood behaviour exhibited across the site to identify potential safety and hazardous flooding. The flood extents, depths and elevations including velocities and hydraulic hazards are provided in **Appendix C**. All flood model results and observations are based on the major flood event, i.e. the 100 year ARI event, in accordance with the FDM (2005) guidelines.

Flood model results were assessed to identify hazardous areas. It is demonstrated that the MLS site exhibits primarily low hazard to flood free.

5.2 Flood Risk Precincts

WCC's DCP 2009 states that flood prone land should be divided into three flood risk areas (**Table 5-1**).

Table 5-1 Council DCP 2009 Risk Precinct Definitions

Risk Precinct	Definition
High	The area within the envelope of land subject to a high provisional hydraulic hazard (in accordance with FPDM, 2005) in a 100 year flood event plus all land within 10m from the top of the creek bank.
Medium	Land below the 100 year flood level (plus 500mm freeboard) that is not within the High Flood Risk precinct.
Low	All other land within the floodplain (ie the extent of the PMF) but not defined within either the High or Medium Flood Risk precincts.

The site will be contain a range from medium to no Flood Risk Precinct.

5.3 Floodplain Management

5.3.1 Finished Floor Levels

The proposed MLS building is outside the 100 year ARI flood extents. As such, the habitable floor level for the MLS Building is to be equal to or greater than the 100 year flood level adjacent to the site in the climate change simulation plus 500 mm freeboard.

The hydraulic modelling result shows that the 100 year ARI water level adjacent to the building (upstream extent) in the climate change scenario is approximately 22.0 m AHD. As such, the FPL for the proposed building is 22.5 m AHD.

5.3.2 Flood Compatible Buildings Materials and Structural Soundness

Flood compatible building components would be required for any portion of the building which is below the flood planning level. This includes masonry foundations and other such features. An extensive list of approved materials is available in WCC's DCP (2009) and should be referenced during detailed design.

A structural soundness certificate will be required as part of the Construction Certificate to demonstrate that the proposed works can withstand the force of floodwater, debris and buoyancy up to and including the PMF.

5.3.3 Evacuation and Safe Access

Safe evacuation for pedestrians and vehicles through Northfields Avenue are provided up to the PMF storm event. Details are further discussed in **Section 5.5.**

5.4 Flood Affectation

Changes in flood elevations in the 100 year ARI and PMF storm events as a result of the proposed works were assessed using the hydraulic model. Flood Impact Maps are provided in **Appendix C.** Key findings are discussed in the sections below.

5.4.1 100 Year ARI

Results indicate that the proposed site changes do not result in any detrimental flooding impacts. This is demonstrated in the flood maps provided in **Appendix C**.

5.4.2 PMF

Results indicate that the proposed site changes do not result in any detrimental flooding impacts. This is demonstrated in the flood maps provided in **Appendix C**.

5.4.3 Floodplain Storage

No changes is flood levels occur as a result of the development and hence floodplain storage has been maintained.

5.5 Trafficability

5.5.1 Carparking Areas

The results from the hydraulic flood model demonstrate that the proposed carpark within the site (located to the north of the MLS building) is flood free.

5.5.2 Access

The MLS development proposes pedestrian access to the carpark to the immediate north of the building. The proposed access and carpark areas are flood free, evacuation from this area is not recommended until flood waters recede.

6 Conclusions

It can be concluded that:

> Flooding occurs as overland flows at both the southern and northern extents of the existing and proposed site while the proposed building location is flood free.

> The depth of inundation adjacent to the MLS building (south) is generally below 250 mm in the 100 year ARI and 400 mm in the PMF event in the existing and developed scenarios. Velocities are generally less than 2 m/s in both events.

> The proposed MLS building area is flood free in all storm events up to and including the PMF event.

> The proposed development will not cause any detrimental flooding impacts.

> A climate change assessment has been undertaken and considered when setting the proposed FPL. An increase in ocean levels does not substantially impact flood conditions on site.

> The habitable floor level for the MLS building has been designed above the recommended FPL.

> All proposed carparking areas and accesses are trafficable up to the PMF storm event.

> Safe evacuation is provided up to the PMF event as a result of the proposed development.

> OSD is not required for the proposed development.