Water-Cycle Management Report

230 Sixth Avenue, 50 & 60-80 Edmondson Avenue,
Austral

04 November 2016

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Issue and Revision Record

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A	24/10/16	J Mail	J Taylor	C Avis	DRAFT for Coordination
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Information class: Standard

Contents

1 Introduction

Mott MacDonald has been commissioned by Vantage Property Group to investigate existing services infrastructure in the vicinity of a proposed residential subdivision at 230 Sixth Avenue, 50 and 68 Edmondson Avenue, Austral. The land is situated within the Liverpool City Council Local Government Area.

This report is supplementary to the *Infrastructure Report – 230 Sixth Avenue, 50 & 68 Edmondson Avenue, Austral (November, 2016)* prepared by Mott Macdonald and should be read in conjunction as an accompanying document. The analyses documented in this report support the DA Documentation and provide Council with the necessary details of the stormwater quantity, quality and flooding regimes in order to enable informed decisions on future development.

1.1 Scope of Work

1.1.1 Flooding

The following tasks have been completed in the analyses of potential flooding events in the vicinity of the development.

- Review of previous hydrological and hydraulic studies
- Review of available modelling data for suitability in current analyses

Local context

- Constraints and opportunity investigation with regard to the preservation and treatment of overland flow paths
- Modelling of the floodplain in a pre to post manner to determine the effect of building on local overland flow paths
- Identification of key locations in the flow regime and the investigation of options to mitigate against negative impacts to flooding behaviour in these key areas
- Recommendations into the built form in order to integrate flood hazard management principles into the development proposal
- Documentation of the analysis and flooding outcomes in terms of clear directions for the developer, designers and Council in preparing and assessing the proposal

Regional Context

- Review of Council's plans for the regional water-cycle management with particular focus on the flood hazard management
- Determination of the requirements for flood hazard management within the regional water-cycle management scheme
- Modelling of worst case regional flooding to inform the developer, designers and Council in the provision of appropriate development in the area conforming with the relevant standards and guidelines, and in line with best practice

1.1.2 Stormwater

- Catchment analysis of the existing site and of the proposed developed site
- Design of formal drainage network including pit and pipe specification for the capture of minor system runoff to Council standards
- Identification of key overland flow routes for further examination in the flooding analysis of the local road network
- Major event hydraulic hazard analysis to complement the local flooding analysis
- Development of concept engineering plans for the proposed development indicating the required stormwater infrastructure to meet Council specifications

1.1.3 Water Quality

- Catchment analysis of the existing site and of the proposed developed site
- Review of Council planning documentation including the Water Sensitive Urban Design guidelines
- Classification of the proposed site to Council specifications
- Development of a treatment train of water quality improvement devices for treatment of runoff
- Coordination of engineered water quality solutions with the earthworks, site grading and stormwater design

1.2 Guiding Documentation

1.2.1 Australian Rainfall and Runoff, 2016 (AR&R)

Prepared by the Institution of Engineers, Australia Australian Rainfall and Runoff – *A Guide to Flood Estimation* was written to "provide Australian designers with the best available information on design flood estimation". It contains procedures for estimating stormwater runoff for a range of catchments and rainfall events and design methods for urban stormwater drainage systems.

According to the document, good water management master planning should take into account:

- hydrological and hydraulic processes;
- land capabilities;
- present and future land uses;
- public attitudes and concerns;
- environmental matters;
- costs and finances; and legal obligations and other aspects

1.2.2 NSW Floodplain Development Manual, 2005 (FDM)

The recommendations detailed in this report are made in line with the FDM guidelines on floodplain risk management. Reference to flood hazard is built upon the established hydraulic categorisation of overland flow paths provided in the FDM guideline and summarised in the velocity-depth product graph below.

Figure 1: Hazard Categorisation

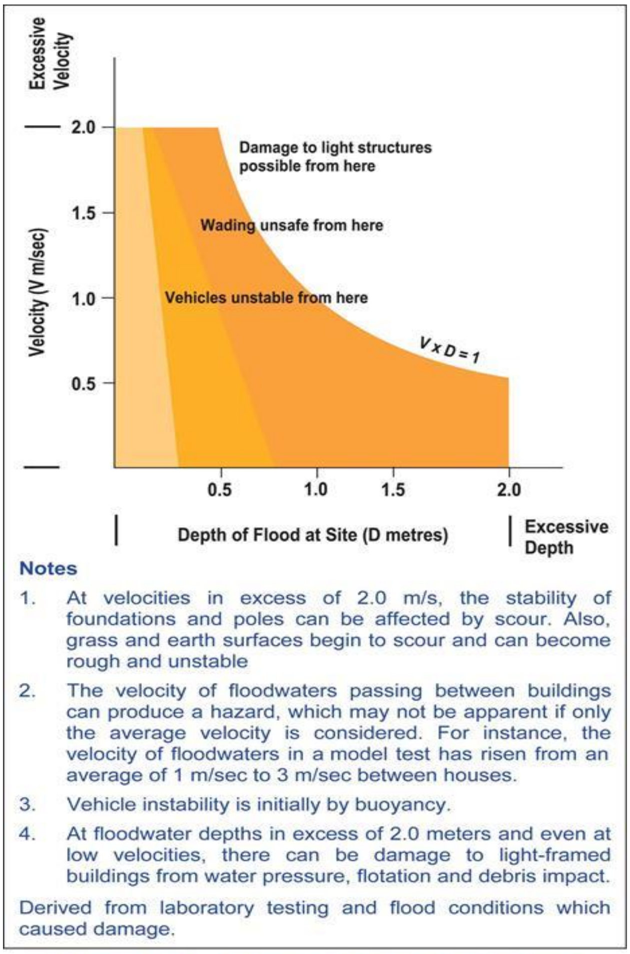


FIGURE L1 - Velocity & Depth Relationships

Source: NSW Floodplain Development Manual, 2005

1.2.3 Liverpool Development Control Plans

An integral part of the Development Application process, Development Control Plans (DCP) provide the necessary controls for the development of the site. Relevant Liverpool Council DCPs include:

- Liverpool City Council Development Control Plan (2008)
  a) Part 1 – General Controls for all Development;
- Liverpool Growth Centre Precincts Development Control Plan (2014)
  a) Schedule 1 – Austral and Leppington North Precincts

1.2.4 Handbook for Drainage Design Criteria– Liverpool City Council, 2003

This guideline sets out design criteria to assist developers and designers in providing civil infrastructure to Council's expected standard. It is applied as an overarching document to be used in concert with regulatory requirements and industry best practice.

1.2.5 NSW Development Design Specification D5 - Stormwater Drainage Design, Liverpool City Council, 2003

Council's *Stormwater Drainage Design Guidelines* sets out the requirements for the design of stormwater drainage for urban and rural areas. The Design Guidelines outline a broad strategy for the design and development of land within the LGA including:

b) Providing clear guidelines for the requirements of stormwater drainage and civil works;
c) Ensuring that developments meet all relevant standards for the disposal of stormwater and that developments do not increase the hazard to persons or property; and
d) Catering for minor and major stormwater systems.

The policy also provides detailed requirements for the hydrologic and hydraulic design and analyses of the proposed water management system including standard calculation factors.

1.2.6 WSUD Technical Guidelines, Liverpool City Council

Council's WSUD Technical Guidelines outlines a broad strategy for the implementation of WSUD principles within the LGA including compliance with Council's target water quality pollutant removal rates as summarised below:

1. *Reduction in annual average suspended solids (SS) export load of 85%*
2. *Reduction in annual average total phosphorus (TP) export load of 65%*
3. *Reduction in annual average total nitrogen (TN) export load of 45%*

1.2.7 NSW Department of Environment and Heritage

The NSW Department of Environment and Heritage, formerly the Department of Environment and Climate Change (DECC), has developed a set of guidelines known as the Managing Urban Stormwater (MUS) series. The set of guidelines includes:

e) Managing Urban Stormwater: Council Handbook
f) Managing Urban Stormwater: Source Control
g) Managing Urban Stormwater: Soils & Construction

Managing Urban Stormwater: Soils and Construction

Managing Urban Stormwater – Soils and Construction (4th edition, March 2004) are guidelines produced by the NSW Department of Housing to help mitigate the impacts of land disturbance activities on landforms and receiving waters by focusing on the removal of suspended solids in stormwater runoff from construction sites.

According to the guide, effective soil and water management during construction involves the following key principles:

h) Assess the soil and water implications of development at the subdivision or site planning stage (including salinity and acid sulphate soils);
i) plan for erosion and sediment control concurrently with engineering design and before the land disturbance begins;
j) minimise the area of soil disturbed;
k) conserve topsoil for subsequent rehabilitation/revegetation;
l) control surface runoff from upstream areas, as well as through the development site;
m) rehabilitate disturbed lands as quickly as possible; and

n) maintain soil and water management measures appropriately during, and after the construction phase until the disturbed land is fully stabilised.

2 Subject Site

The site consists of approximately 4.61Ha of land adjacent Edmondson Ave and between Fifth and Sixth Avenues, Austral, indicated in Figure 2 below and identified as:

- Lot A, DP416093;
- Lot B, DP416093; and
- Lot 1067, DP2475

Currently occupying the site are rural residential properties, with the land subject to the Precinct Plan for the Liverpool Growth Centre and a potential dwelling density of 25/ha.

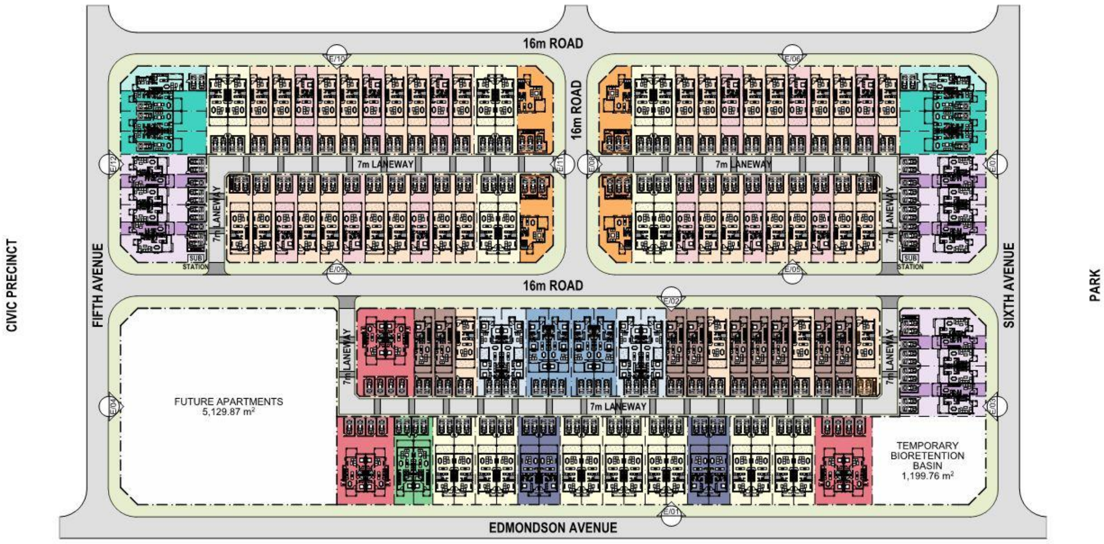
Figure 2: Site Location

Source: Sixmap imagery 2016

3 Development Proposal

The development proposal is for residential land uses distributed across three blocks as indicated in the architectural plan below. The buildings are surrounded by at grade pavements and landscaped areas providing pedestrian access to the buildings.

Figure 3: Development Layout



Source: MPS Architects (2016)

The site interfaces a number of existing streets, with the following interface works proposed:

- Sixth Ave - the civil design interfaces with the existing Sixth Ave road reserve by matching the existing road centreline with a proposed new half road pavement. It should be noted that due to the planned upgrade of Edmondson Avenue by the Roads and Maritime Services (RMS), the section of Sixth Avenue between Edmondson Avenue and Road Number 2 is proposed to be left as existing. This is to enable flexibility in the future upgrade and avoid potential abortive works;
- Fifth Ave – the civil design interfaces with the existing Fifth Ave road reserve by matching the existing road centreline with a proposed new half road pavement;
- Road Number 1 (16m Local road to western boundary) – the civil design includes a half road construction (4.5m) along a new road alignment. The interface with existing land uses will match as close as possible to existing levels at the boundary to minimise the need for works on the neighbouring property. Road Number 1 will be a temporary one-way road until future development to the west of the site completes construction of the other half road, interfacing with the design levels of Road Number 1.
- Edmondson Ave – the civil design interface proposes to provide temporary batter slopes from the new lot boundaries into the verge area of Edmondson Road. These temporary works within the Edmondson Ave road reserve are an interim measure until such time that

Edmondson Road receives a planned upgrade from the RMS. The future upgrade of Edmondson Road shall include verge works and match into the finished lot levels at the site boundary.

With regard to the water-cycle, interfaces with upstream catchments occur at two key locations are described below:

- Western catchment (across the 16m Road Number 1 shown above) – This catchment contributes runoff to Sixth Avenue. The half road upgrade of Sixth Avenue incorporates stormwater provisions for the minor flow runoff from the site catchments, with the civil design providing safe flow paths during the major storm event making allowances for all major flows from the upstream catchment. Refer section 5.2.3 for the analysis of overland flows.
- Southern catchment (across Fifth Ave shown above) – The civic precinct identified in the above architectural plan contributes overland flow to Fifth avenue. This overland flow has been considered through the analyses informing this report to ensure the safety of pedestrians and vehicles through design storm events

A key flooding interface occurs at the northern boundary, where the 100 year flood extents encroach on the site under existing conditions. The development proposal includes filling of the site to achieve a greater development potential, with the treatment of flood affects to offset the site filling discussed in section 4.2 of this report.

4 Council Directions

A meeting was held with Council on the 22nd September 2016, and as a result of discussions regarding the water quality and quantity management strategies specific to the development we note the following design directions:

4.1 Water Quantity Measures

Detention Basins temporarily detain stormwater runoff from urbanised catchments with the aim of reducing and attenuating the peak discharge at the outlet location to reduce any increases in flood risk to downstream areas as a result of a development. The required storage volume is typically located above ground with discharge flow rates accurately controlled via a throttled outlet pipe / orifice and staged overflow weir.

In accordance with Council's *Liverpool Growth Centre Precincts DCP* (2014), it is our understanding that water quantity requirements for the development area are to be accommodated in a future regional basin strategy. As such, provision of ***permanent*** stormwater detention facilities is not required as part of this proposal. However temporary measures for the management of stormwater flows will be required and Council has agreed to in-principle support of a temporary above ground detention basin to achieve attenuation of flows.

4.2 Flooding performance

Similarly to the regional management of stormwater quantity, the management of flood hazards is being undertaken on a regional basis. Council has advised that due to the future regional works the impact assessment of the development on mainstream flooding is not required for DA submission.

The development involves filling within areas currently susceptible to inundation in the 100 year flood event. This filling will result in a reduction of flood storage available within the floodplain during a major storm event. Council's direction on flooding is that the development is to provide offset flood storage to compensate for this lost storage volume due to development in the interim scenario, until such time that the wider strategy for flood hazard management is in place. Council has provided in-principle support of a combined storage volume for the attenuation of stormwater flows from the site and offset flood storage provided that it is demonstrated that the single facility adequately provides both functions.

Separately to the mainstream flooding, Council indicated that an assessment of the overland flows from upstream catchments will be required at the DA stage, including an analysis using 2-dimensional flood modelling. This analysis is documented in section 5.2.3 of this report.

4.3 Water Quality Targets

As outlined in Council's *Liverpool Growth Centre Precincts DCP* (2014), it is our understanding that future water quality requirements for the development area are to be accommodated in a regional "bioretention" treatment facility which is to be located downstream of the subject site. However, Council have also advised that, as the proposed works are to take place prior to the construction of the downstream basin, provision of a separate on-site water quality treatment device will need to be included as part of the proposal to treat the site in the interim until the regional works have been finalised.

Through discussions with Council it was noted the following approach to the modelling of water quality measures would be appropriate for DA documentation:

a) A pre-post comparison of pollutant loads would be appropriate for the assessment of the interim scenario with the aim being that the development presents a negligible impact on downstream water quality; and
b) The target pollutants for the interim scenario are sediments and gross pollutants.

Mott MacDonald note that Liverpool City Council agreed in-principal to the above items subject to review and approval of the proposal as part of the DA application.

Based on the above, we note that the site can subsequently be separated into two (2) main scenarios with respect to water quality as follows:

- ***Interim Scenario*** – which covers the subdivision of the land up until the construction of the regional facilities; and
- ***Final Scenario*** – which follows completion of the downstream regional basin and full compliance with Council's statutory requirements for target pollutant removal rates.

It should be noted that the stormwater quality assessment as covered as part of this proposal considers the interim scenario only with the design and calculations for the future regional works to be undertaken by others.

5 Model Development

To fully appreciate the local and regional water-cycle characteristics a number of analyses were performed during DA documentation. The following breakdown of technical studies into the various aspects of the water-cycle indicates the key parameters used in the generation of models which informed civil design.

5.1 Hydrologic Model Schematisation

The catchments contributing runoff to the subject site and surrounds were modelled in DRAINS. Impervious fractions for each catchment were applied in accordance with Council's handbook on drainage design and are summarised in the Table 1 below:

Table 1: Impervious fractions for catchments

Land Use	Fraction Impervious (f)
Residential – torrens	0.75
Residential – medium density, townhouses	0.90
Business/Commercial area	1.00
Industrial area	0.90
Road reserves	0.95
Public Recreation areas – reserves etc	0.50
Rural areas	Site measure

Source: LCC Handbook for Drainage Design

The losses applied through the model were in accordance with the following criteria:

- Paved (impervious) area depression storage = 1 mm
- Supplementary area depression storage = 0 mm
- Grassed (pervious) area depression storage = 5 mm
- Soil type = 3

The DRAINS user guide describes soil type 3 as *Type 3 (or C) slow infiltration rates (may have layers that impede downward movement of water).* AMC = 3 will generate higher runoff rates due to lower infiltration to soil compared to lower AMC numbers, therefore aiding in a conservative approach to inlet structure, pipe and stormwater detention design.

5 year, 20 year and 100 year ARI events were considered for the standard durations from 5min through to 3 hour storms, with additional 6 hour and 9 hour events considered for sensitivity of regional flooding affects.

5.1.1 Catchment Analysis

Existing Catchments

Detailed site survey and visual site inspections indicate that stormwater runoff generated from the existing site is currently conveyed overland within Fifth Ave, Sixth Ave and Edmondson Ave via informal flowpaths to the existing downstream culvert beneath Sixth Ave. From here, flows discharge to a table drain situated adjacent Edmondson Avenue before draining to the downstream side of the Edmondson Ave culverts.

The total catchment area being conveyed downstream of the site in the current scenario is approximately 12.09Ha. This catchment includes 5.02Ha generated from within the subject site boundary (referred to as the “Site Catchment”) as well as 7.07Ha of contributing flows from the existing upstream rural residential properties immediately to the west and south of the site (referred to as the “Upstream Catchment” – see Existing Catchment Plan in Appendix A for details).

In order to calculate the flow rates from the pre-developed site, nodes were included in the DRAINS model to represent the current catchment scenario as described above. These nodes were than assigned a sub-catchment (including area, flow path length, slope, roughness, pervious and impervious areas and the like) which is representative of the total existing area which lies within the catchment boundary. By keeping areas consistent, the pre-post discharge rates of the main catchments can then be directly compared.

In accordance with general engineering practice, the flow path slope for each sub-catchment was determined using the equal area method, while the percentage impervious was estimated from site measurements of aerial imagery as outlined in Council’s *Handbook for Drainage Design Criteria.*

Proposed Catchments

For the purposes of this study, two (2) separate DRAINS models were developed for the post-developed site as follows:

a) ***Final Developed Scenario*** – which allows for the developed catchment areas upstream and downstream of the subject site once the temporary detention facilities have been removed; and
b) ***Interim Scenario*** – this model incorporates the undeveloped catchments upstream and downstream of the site in order to mirror the current scenario as well as provision of a temporary detention basin on-site to ensure the developments impact on downstream properties is negligible.

5.2 Hydraulic Model Schematisation

5.2.1 Formal network design

The pit and pipe network has been designed in accordance with Council’s Handbook for Drainage Design using DRAINS hydraulic analysis software. The pit and pipe system has been designed for the 5 year ARI using a combination of methods as indicated in Table 2 following.

Table 2: Hydraulic design methods

Drainage aspect	Analysis Method
Pit and pipe system	DRAINS
Minor event overland flow for pit spacing	DRAINS
Major event overland flow	TUFLOW (refer section 5.2.3 below)

The DRAINS model for this scenario was developed based on the following methodology:

- Stormwater flows from the site are proposed to drain to a new trunk stormwater line crossing Sixth Avenue. From here, flows are to be conveyed (by existing channel) to the downstream creek to mirror the existing flow regime;
- Tailwater levels at the downstream headwall adjacent Edmondson Ave have been set according to the surface level of the lowest pit in the drainage design at the sag in Sixth Avenue. Matching the existing profile of Sixth Avenue results in the existing sag point experiencing surcharge flows once the capacity of the Edmondson Road open channel is met. These levels have been specified to simulate a charged system downstream and to verify the capacity of the proposed piped network for stormwater flows generated during the design storm events;
- In accordance with Council's *Handbook for Drainage Design Criteria*, an impervious fraction of 90% was adopted for the medium-density residential lots within the development area and 95% for the road reserves;
- The upstream catchments draining to Fifth and Sixth Ave from the future lots were also considered in the model to verify the capacity of the downstream stormwater network and minimise the number of future connections to the system. The catchment division for the upstream lots was based generally on the current Growth Centre ILP layout, with the overall impervious percentage based on the recommended values for different land use categories outlined in Table 1. Due to the position of the western upstream catchment within the wider topography it has been assumed that future piped networks shall include a more direct connection to the future regional basin to the north west of the site. Should;
  a) development of the western upstream catchment occur prior to construction of the regional basin, and;
  b) the development relies on the pipe network in Sixth Ave in the interim scenario for the minor event drainage, then;

  The western upstream catchment will need to provide attenuation of flows to the existing scenario flow rates. Refer section 6.2.3.
- 5 year, 20 year and 100 year ARI events were considered for the standard durations from 5min through to 3 hour storms, with additional 6 hour and 9 hour events considered for sensitivity of regional flooding affects.
- For the major system (100 year ARI storm event), a conservative blockage factor of 50% has been applied to all stormwater pits within the development area in accordance with general engineering practice.

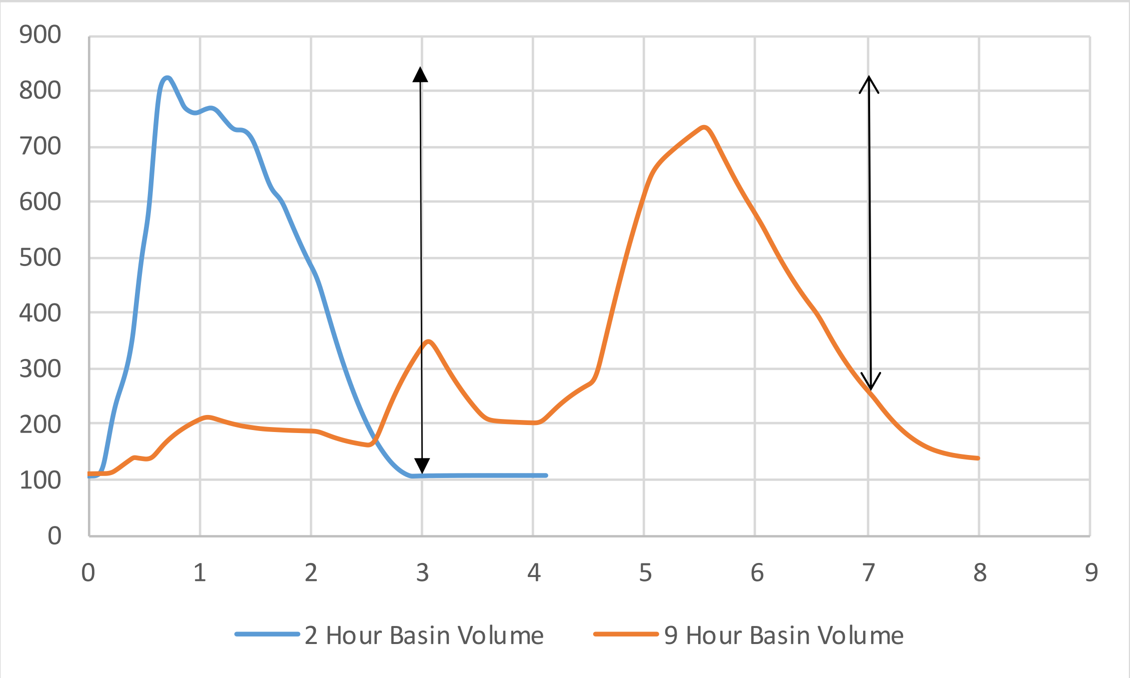
5.2.2 Interim design approach

A separate DRAINS model was than created to assess the performance of the proposed temporary stormwater basin. This design forms the basis of the stormwater design in the DA documentation as it reflects the infrastructure to be constructed at the time of the development rather than the future case. The DRAINS model for the interim scenario was developed based on the same methodology as the final developed scenario with the following modifications:

- A temporary stormwater tail out line and surcharge pit is proposed to discharge flows from the site to the proposed permanent pit and pipe network in Sixth Avenue to suit the interim scenario and mirror the existing flow regime (refer to DA civil engineering plan MMD-369954-C-DR-AB-XX-0073 for details);
- An above-ground detention basin was also incorporated into the model to control flows from the site to the discharge point in accordance with Council requirements. The location of the basin has been proposed in order to maximise contributing flows and allow easy access for maintenance;
- Tailwater levels at the downstream connection to the channel adjacent Edmondson Road have been modelled as per the permanent design case above;
- 5 year, 20 year and 100 year ARI events were considered for all standard durations.

The following figure indicates the basin storage in use by site runoff during the worst case 100 year storm event at the site (2hr) and regionally (9hr). The vertical black arrows indicated the flood storage available at the timing of the regional flood peak during the 2 hr and 9 hr storm events, ie. min 550m³. The timing of the flood peaks can be observed from the hydrographs in Figure 5 below.

Figure 4: Provision of Storage (m³) for Regional Flood Peak



Source: MM DRAINS Hydraulic Design

5.2.3 Overland flow analysis

Council has indicated their preference for the overland flow analysis to be completed using a full1D/2D approach to best represent the numerous overland flow paths and the complex flooding behaviour at the interface of these flows. The following is a list of parameters and description of the technical modelling approach adopted to enable a full understanding of the floodplain and interrogation of the affects of the development on flooding:

- Digital Terrain Model (DTM)

  The DTM was produced by creating a base surface with lidar information. Where detailed survey for the site was available, the lidar was supplemented with this additional data to best represent surface levels around the site.

- Grid Size

  The grid used in the modelling was a 1.0m x 1.0m grid based on the DTM, selected to give a good representation of the urban areas including road reserves and other overland flow paths

- Embedded Culverts

  The culvert information from the detailed survey and DA design documentation was modelled as 1D elements in ESTRY, linked to the 2D surface at the openings to the hydraulic structures

- Buildings

  Buildings and other permanent objects were introduced to the model as obstructions to represent blockages in local flow paths through the urbanised portion of the model

- Hydraulic Roughness

  Aerial photography was used to determine different hydraulic properties for the model area dependent on the ground surface, ie. roads, paved areas, grassed areas, riparian vegetation etc.

- Model Extent

  The model area was extended upstream and downstream in order to ensure localised flow nuances associated with model boundary conditions are located away from the site under investigation

- Flow from Upstream Catchments

  Overland flow paths were introduced as surface flows in order to account for the full flow generated from upstream catchments, not just portions of the runoff concentrated in the major channels and hydraulic structures.

Calibration

Council's adopted flood model for the wider catchment was supplied in order to ensure that the development was designed to the surrounding flooding regime. The 1D/2D model provided by Council provides information on the wider catchment response to major rainfall events and allowed informed decision making regarding new infrastructure.

The table below indicates some flood levels at key locations through the 100 year ARI flood scenario extracted from Council's model, highlighting the relevant water levels used for calibration of the hydraulic design models. These flood levels were introduced to the models as tailwater levels to represent worst case flooding situations for the design case. By designing to the worst case event it can be assured that the infrastructure has sufficient capacity through the all storm durations for the specified design ARI.

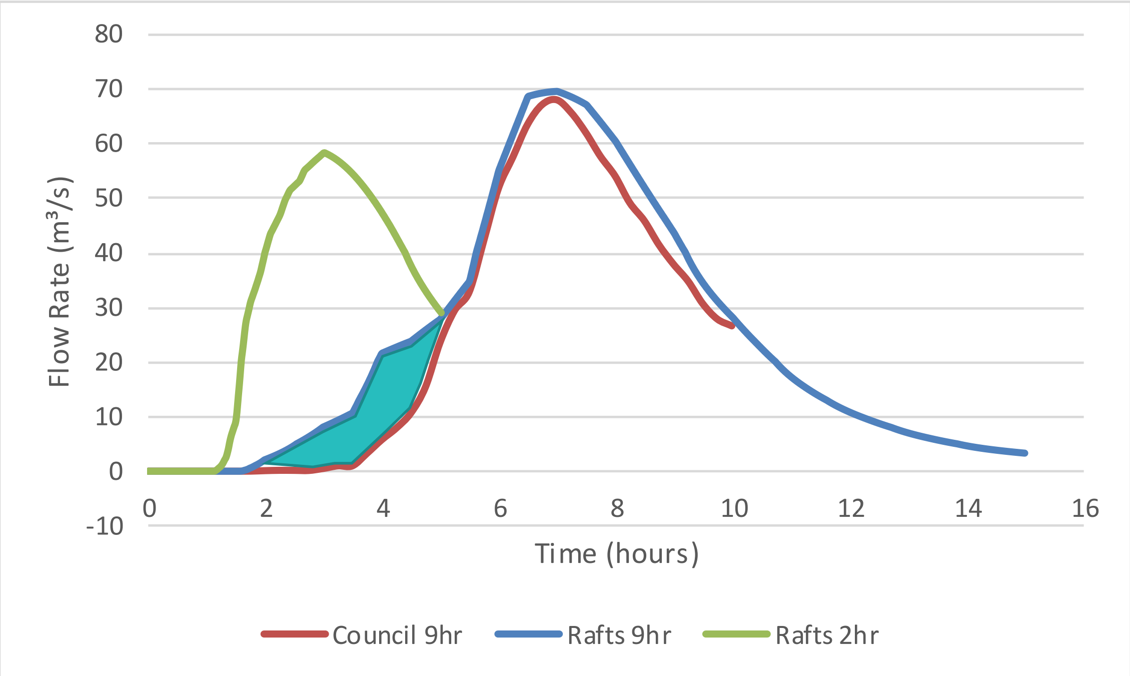
Table 3: Regional Flood Levels

Location	Water Level (m AHD) 100yr 2hr storm	Water Level (m AHD) 100yr 9hr storm
Creek, downstream of Edmondson Avenue	68.15	68.28
Overbank areas, downstream of Edmondson Avenue	68.26	68.32

Source: MM Catchment Analysis

It should be noted that Council's adopted flood model supplied for the purpose of DA documentation included hydrological information for only the worst case flood event, the 9 hour storm. The levels anticipated during the 2hr storm duration (worst case for site runoff only) were extracted by examining the stage discharge relationship of the floodplain both upstream and downstream of the Edmondson Road culvert. The discharge hydrograph during a 2hr storm event was calculated based on a single node XPRAFTS catchment calibrated from the 9hr 1D2D flooding results. The following graph provides the hydrographs extracted from catchment models, indicating the calibrated flow rates for different duration flood events the adjacent floodplain.

Figure 5: XPRAFTS 2hr Regional Storm Generation



Source: MM Catchment Analysis

The rising limb gradient, timing, and peak flow rate of the XPRAFTS hydrograph (blue) was tuned to the Council adopted TUFLOW model results (red) by means of adjustments to the initial and continuing losses and lag times of the catchment. It can be observed that the hydrograph from the XPRAFTS catchment is conservative in that the model does not account for storage upstream (cyan shading) of the catchment node, resulting in slightly higher peak runoff rates and slightly extended peak compared with the TUFLOW result. The green hydrograph indicates the 2hr storm result used to calibrate the overland flow model and basin designs through direct comparison of the stage-discharge relationship of the Council adopted TUFLOW modelling result.

Offset Storage

In the interim scenario offset storage will be provided by means of additional volume in the detention basin above ground. The volume of offset storage was determined by means of examining the results from Council's adopted flood model for the wider catchment to establish the extent of storage provided within the site during the existing scenario 100 year ARI flood. The volumes required for offset storage was determined to be 550m³. As indicated in Figure 4 above, this 550m³ is available at the peak of the mainstream flooding events.

5.3 Water quality model schematisation

In order to assess the effectiveness of the temporary stormwater quality systems that are to be included as part of the subdivision, the existing (un-developed) site was compared directly against the proposed (developed) site. To enable this comparison, two (2) separate MUSIC models were created, one representing the existing scenario and the other the post-developed site as follows:

5.3.1 Developed Site

The following methodology and parameters were incorporated into the MUSIC modelling for the post-developed site:

- Rainfall data sourced from the Liverpool pluviograph (67035 – 6 minute interval) was utilised within the model;
- The post-developed site was consolidated into two sub-catchment area based on the proposed drainage system and lot layout as follows:

Table 5.4: Area Breakdown per MUSIC Sub-Catchment

MUSIC Sub-Catchment	Area (Ha)
M1	3.540
M2	0.800
Total	4.340

Source: MM Catchment Analysis

a) The catchment area draining to the water treatment measures is defined as catchment M1, with the remaining catchment M2 bypassing the water treatment. A total fraction impervious of 90% was adopted for the new residential areas in accordance with Council requirements.

- The pollutant concentration parameters used within the model were based on the recommended model defaults for different land use categories as specified in Council's *WSUD Technical Guidelines*. These are summarised in the following tables;

Table 5.5: Post-Development Areas – MUSIC Node Classification

MUSIC Node	Classification
Lot	"Residential"

Source: Liverpool City Council *WSUD Technical Guidelines* (2015)

Table 5.6: MUSIC Node – Rainfall Runoff Parameters

		TSS		TP		TN	
Classification		Mean	Std Dev	Mean	Std Dev	Mean	Std Dev
"Residential"	Base Flow	1.20	0.17	-0.85	0.19	0.11	0.12
	Storm Flow	2.15	0.32	-0.60	0.25	0.30	0.19

Source: Liverpool City Council *WSUD Technical Guidelines* (2015)

- The soil properties for the pervious areas of the catchment were defined based on the recommended default parameters listed in Council's *WSUD Technical Guidelines* and are summarised below:

Table 5.7: MUSIC Soil Parameters

Soil Properties	Lot
Impervious threshold (mm)	1
Soil storage capacity (mm)	187
Initial storage (% of capacity)	30
Field capacity (mm)	127
Infiltration coefficient 'a'	135
Infiltration coefficient 'b'	4
Initial groundwater depth (mm)	10
Daily recharge rate (%)	10
Daily base flow rate (%)	10
Daily deep seepage rate (%)	0

Source: Liverpool City Council *WSUD Technical Guidelines* (2015)

5.3.2 Un-Developed Site

The MUSIC model for the existing scenario was developed based on the following methodology:

- The impervious area for the existing site was based on site measurements in accordance with Council requirements. From here, the catchment was classified as "General Urban", with the pollutant concentration parameters used within the model based on the recommended model defaults from Council's *WSUD Technical Guidelines* as follows:

Table 5.8: MUSIC Node – Rainfall Runoff Parameters

	TSS		TP		TN	
Classification	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev

		TSS		TP		TN	
"General Urban"	Base Flow	1.20	0.17	-0.85	0.19	0.11	0.12
	Storm Flow	2.15	0.32	-0.60	0.25	0.30	0.19

Source: Liverpool City Council *WSUD Technical Guidelines* (2015)

- The soil properties for the pervious areas of the catchment were defined based on the recommended default parameters listed in Council's *WSUD Technical Guidelines* and are summarised below:

Table 5.9: MUSIC Soil Parameters

Soil Properties	
Impervious threshold (mm)	1
Soil storage capacity (mm)	187
Initial storage (% of capacity)	30
Field capacity (mm)	127
Infiltration coefficient 'a'	135
Infiltration coefficient 'b'	4
Initial groundwater depth (mm)	10
Daily recharge rate (%)	10
Daily base flow rate (%)	10
Daily deep seepage rate (%)	0

Source: Liverpool City Council *WSUD Technical Guidelines* (2015)

- As per the post-developed scenario, pluviograph data from Liverpool (67035 – 6 minute interval) was utilised within the model.

5.3.3 Management Strategies

The following summaries of measures for improving water quality have been integrated into the music model for the developed case, providing water quality improvements in order to satisfy Council requirements.

5.3.3.1 Bioretention "Raingarden"

A Bioretention "Raingarden" has been proposed as an end-of-line treatment within the temporary stormwater basin, and is proposed to treat stormwater runoff from MUSIC sub-catchment M1. The location of the temporary bioretention system has been proposed to maximise flows and allow easy access for maintenance.

In developing the MUSIC model for the post-developed site, the following assumptions have been made regarding the bioretention system:

- Filter area = 630m^2
- Extended detention depth = 0.2m;
- Filter depth = 0.3m; and
- Saturated hydraulic conductivity = 180mm/hr.

We note that the remaining bioretention parameters are as per the recommended model defaults outlined in Council's *WSUD Technical Guidelines.*

5.3.3.2 Rainwater Tanks

We note that Rainwater Re-Use tanks may be incorporated in the individual dwellings to provide at source treatment and supply water for internal re-use on site. However, for the purposes of this study, rainwater tanks have been excluded from the proposed treatment train – this was considered appropriate as it assumes the worst-case scenario for the site.

6 Civil Design Outcomes

6.1 Sediment and Erosion Control

Prior to any earthworks commencing on the site, erosion and sediment control measures will be put in place generally in accordance with Managing Urban Stormwater: Soils and Construction 4th Edition, March 2004. These measures include:

- Installation of a 1.8m high chain wire fence covered with geo-textile filter fabric, to the perimeter of the work site area, where required;
- The use of sediment diverting methods to minimise sediment in Council's stormwater drainage using sandbags around kerb inlet pits and geo-textile filter fabric around drop inlet pits;
- The provision of a sediment basin towards the perimeter of the site for which stormwater runoff shall be channelled and treated during construction;
- Indicative locations for stockpiling; and
- Provision of a temporary truck wash-down facility to service vehicles exiting the site during the construction stage.

Please refer to Sediment and Erosion Control Plans MMD-369954-C-DR-AB-XX-0030 and 0031.

6.2 Stormwater Quantity

6.2.1 Major / Minor Drainage System

The major/minor approach to stormwater drainage is the recognised drainage concept for urban catchments within the Liverpool City Council local government area.

The minor drainage system is comprised of the below ground pit and pipe network and has been designed to control nuisance flooding and enable effective stormwater management for the site. Council's DCP required that the minor system be designed for a minimum 5 year ARI for urban residential areas.

The major drainage system incorporates overland flow routes through proposed road, hardstand and landscaped areas and was assessed against the 100 year ARI design storm event. The major system also exists to cater for minor system failures. In accordance with council's requirements, the major drainage system was designed in a manner that ensures that personal safety is not compromised. As such, all overland flow routes for the site were designed so that the maximum velocity-depth product did not exceed $0.4m^2/s$ in accordance with standard engineering practice.

Please refer to Stormwater Management Plans MMD-369954-C-DR-AB-XX-0073 through 0111.

6.2.2 Detention Basins

Liverpool City Council have indicated that provision of a ***temporary*** detention basin will be required as part of the proposal to manage the flood risk impact on existing downstream properties in the interim until the future regional detention facilities have been developed.

As such, a temporary detention basin has been introduced to the hydrological model of the developed scenario to ensure that the peak maximum post-developed flows are not in excess of peak pre-development levels for all storms up to and including the 100 year ARI in accordance with Council requirements.

Iterations were performed in the DRAINS model to determine the temporary detention basin volume and overflow weir size in order to satisfy Council's pre-post requirements.

The proposed basin has the following parameters:

- The temporary detention basin is situated at the north-east corner of the development area and has been sized to capture runoff from the new local access roads and medium-density residential lots;
- Storage volume provided is approximately 825m^3 (100yr TWL = RL68.7m AHD) which is contained within the above-ground system (Note: storage volume excludes extended detention zone of bioretention system);
- Discharge is controlled via a 525mm dia downstream pipe installed as the outlet of the discharge control pit in order to satisfy pre-post conditions;
- A 15m wide overflow weir at RL 68.60m AHD is also proposed as a secondary stage outlet in major storm events; and
- Due to the depth of ponding, safety fencing has been provided around the perimeter of the basin in accordance with Liverpool Council requirements.

Results of the DRAINS analysis are summarised in the following table:

Table 10: Basin Performance

ARI Event	Pre-Developed Peak Discharge (m^3/s)	Post-Developed Peak Discharge with no OSD (m^3/s)	Post-Developed Peak Discharge with OSD (m^3/s)	Basin TWL (AHD)	Basin Volume (m^3)
5yr	2.12	2.85	1.77	RL68.34	450
20yr	3.10	3.81	2.71	RL68.66	810
100yr	4.02	4.80	3.62	RL68.68	825

Results of the DRAINS analysis indicate that the temporary basin provides sufficient flow retardation and attenuation to ensure that the downstream peak post-developed discharges do not exceed those of the pre-developed scenario for the worst case storm duration.

6.2.3 Provisions for Upstream Catchments

Southern Catchment

This catchment currently contributes runoff to the road reserves of Fifth Avenue and Edmondson Avenue. Minor event flows predominantly follow these road reserves, east along Fifth Ave and North along Edmondson Ave. It is anticipated that the future upgrade of Edmondson Road will provide stormwater infrastructure to cater for the future developed land upstream of the site. In the interim, pits within the section of Fifth Ave upgraded as part of the civil works will convey upstream minor event flows to the Edmondson Ave Road reserve. The temporary pipe within Edmondson Road allows surcharge of these upstream flows into the channel drain alongside the road pavement. A 525mm dia pipe stub has been allowed for underneath the upgraded Fifth Avenue to provide a future crossing for the pipe network of the upstream catchment.

Western Catchment

Currently the catchment contributes runoff to the Sixth Ave Road reserve. Due to the generally flat topography this results in sheet flow/overland flows across Sixth Ave and the properties to the north of Sixth Ave to the creek beyond. The design allows for the existing runoff volumes in the minor event by providing an inlet pit on the western side of the half road construction of Road No.1.

Providing box culverts for the minor system drainage of this western catchment is not an economical approach to the management of stormwater. Upon review of the DA documentation it is recommended that Council review the need for minor system drainage from this western catchment to be routed east along Sixth Avenue to the drainage channel in Edmondson Ave. The very shallow grade that these culverts must be laid in order to suit the existing ground levels results in large span structures which are costly and have implications on the space available for the reticulation and serviceability of other underground services. To achieve economical design and maintain space in the Sixth Ave road reserve for services the future drainage layout and connections to the downstream regional basin should consider an alternate route for the runoff from this western catchment. (Refer to catchment plan MMD-369954-C-DR-AB-XX-0111)

6.3 Local Flooding

6.3.1 Safety of Overland Flow Paths

The TUFLOW analysis has indicated that the overland flow provisions across the site are generally within the acceptable 0.4m²/s limit for the safety of pedestrians. One location which required further investigation was at the sag point of the central 16m road. At this location the gutter flows within the 16m road reserve meet slow moving ponding from the wider downstream floodway. The hazard category indicates a short run of higher hazard classification indicating the velocity transition from faster moving shallow gutter flows to slow moving deeper ponding from the downstream conditions. This area is not considered to pose significant hazard to people and vehicles and is considered acceptable as a transition area of two different flow regimes.

A series of TUFLOW model outputs including the hazard classification discussed above have been included as Appendix C.

6.4 Stormwater Quality

6.4.1 Music Modelling Results

Results of the MUSIC analysis are summarised in the following table:

Table 6.11: MUSIC Model Results

Pollutant	Existing Pollutant Load (kg/yr)	Post-Developed Pollutant Load with no WSUD measures (kg/yr)	Post-Developed Pollutant Load with WSUD measures (kg/yr)	Removal Rate (Post-Developed Scenario)
Total Suspended Solids	1,380	5,550	1,410	74.6%
Total Phosphorus	2.24	9.03	2.89	68.0%
Total Nitrogen	16.3	66.3	35.0	47.2%

Note: The “Removal Rate” as shown in this table is the comparison of the Post-Developed pollutant load with no WSUD measures compared to the post-developed pollutant load with WSUD measures

Results of the MUSIC analysis indicate that, by including the nominated treatment train as described in this report, the post-developed water quality improvement objectives set out in Council’s DCP are achieved for phosphorus and nitrogen.

Similarly, while the removal rate for suspended solids is slightly less than the 85% total specified in the DCP, we note that the total post-developed pollutant load is similar in comparison to the existing scenario. As such, given the temporary nature of the proposed treatment devices, we believe that the water quality improvement objectives for suspended solids have been achieved for the site as the development will present a negligible impact on downstream water quality prior to construction of the future regional facilities.

7 Summary and Recommendations

Based on the analyses undertaken for the subject site, the proposal as documented for this DA submission incorporating the civil design outcomes is considered to adequately meet the requirements of Council in terms of the management of the water-cycle. The design case for the interim scenario includes the combined water quantity, quality and offset storage functions in the interim scenario. Once the regional approach to water-cycle management has been implemented in the area, these site-specific facilities can be decommissioned and the stormwater detention, water quality and flood risk mitigating functions transferred to the regionally applied strategy.

Provision for stormwater flows from upstream catchments have been made in the design of infrastructure for the proposed development at 230 Sixth Ave. Upon analysis of the catchments and runoff volumes it is evident that due to the existing topography, the civil works for 230 Sixth Ave can provide for upstream runoff to varying degrees of efficiency. Most notably, the catchment to the west of the site fronting Sixth Ave has been highlighted in this report as potential formal drainage infrastructure for this catchment running east along Sixth Ave does not perform well in terms of a benefit cost ratio. This is due to the very flat grades of Sixth Ave, with underground culverts required to be very large structures to accommodate peak flow rates. The recommendation made in this report is to review the downstream discharge of runoff from this western catchment to determine a more appropriate and efficient use of infrastructure. In light of Council's earlier indications of the likely location of the future regional basin, a solution including a more direct link to the creek/future basin traversing the future open space to the north is the ideal discharge point for stormwater runoff.

Appendices

A. Catchment Plans

Preliminary - Not for Construction

Rev	Date	Drawn	Description	Ch'k'd	App'd
P2	04.11.16	DRC	Issued for Development Application	DR	AC
P1	01.11.16	DRC	Issued for Information	DR	AC

1:1000 0 50m 100m

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Client: Vantage Property Group Pty Ltd

Title: 230 Sixth Avenue and 38 Edmondson Avenue, Austral
Catchment Plans
DRAINS

Designed	P.Cavanagh		Eng check	D.Reilly	
Drawn	D.Chapman		Coordination	J.Taylor	
Dwg check	A.Singh		Approved	A.Cameron	

Scale at A1	Status	Rev	Sec
1:1000	PRE	P2	STD

Drawing Number
MMD-369954-C-DR-AB-XX-0111

This plan may be prepared using COLOUR and may be incomplete if copied to black and white.

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B. Drains Results

DRAINS results prepared from Version 2016.14

PIT / NODE DETAILS Version 8

Name	Max HGL	Max Pond HGL	Max Surfac Flow Arrivi (cu.m/s)	Max Pond Volume (cu.m)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint	DESIGNER NOTES
B1/1	69.62		0.013		1.45	0	None	2.5m flow checked
B1/2	69.63		0		0.87	0	None	2.5m flow checked
B1/3	69.62		0		0.64	0	None	2.5m flow checked
B1/4	69.57		0.014		0.09	0	None	2.5m flow checked
B/6	69.56		0.07		0.08	0.014	Inlet Capac	2.5m flow checked
B/7	69.29		0.061		0.33	0.011	Inlet Capac	2.5m flow checked
B/8	68.92		0.014		0.73	0	None	2.5m flow checked
B/9	68.6		0		1		None	2.5m flow checked
A/1	67.82	68.79	0.039	0.6	0.93	0	Inlet Capacity	
A/2	67.69		0.006		0.48	0	None	2.5m flow checked
A/3	67.5		0					2.5m flow checked
B2/1	73.35		0.013		1.43	0	None	2.5m flow checked
B2/2	71.44		0.017		1.21	0	None	2.5m flow checked
B2/3	71.42		0.027		0.89	0.001	Inlet Capac	2.5m flow checked
B2/4	71.12	71.89	0.014	0.7	0.76	0	Inlet Capacity	
B/4	70.77		0		1.35	0	None	2.5m flow checked
B/5	70.06		0.065		0.71	0.013	Inlet Capac	2.5m flow checked
B3/1	73		0.022		1.78	0	Inlet Capac	2.5m flow checked
B/2	72.99		0.074		1.7	0.015	Inlet Capac	2.5m flow checked
B/3	71.43		0.092		1.57	0.021	Inlet Capac	2.5m flow checked
B4/1	69.85		0.068		3.35	0.013	Inlet Capac	2.5m flow checked
B4/2	69.78		0.074		2.11	0.015	Inlet Capac	2.5m flow checked
B4/3	69.6		0.072		1.05	0.014	Inlet Capac	2.5m flow checked
B6/1	74.52		0.05		1.99	0.007	Inlet Capac	2.5m flow checked
B6/2	73.25		0.056		1.66	0.009	Inlet Capac	2.5m flow checked
B6/3	71.91		0.066		1.08	0.013	Inlet Capac	2.5m flow checked
B6/4	71.76	72.27	0.035	0.5	0.47	0	Inlet Capacity	
B6/5	71.68		0.004		0.59	0	None	2.5m flow checked
C1/1	69.58		0.057		1.25	0.01	Inlet Capac	2.5m flow checked
C1/2	68.7		0.069		0.56	0.013	Inlet Capac	2.5m flow checked
C1/3	68.15	68.23	0.013	0.3	0.05	0	Inlet Capacity	
C/3	68.1		0		0.31	0	None	2.5m flow checked
C/4	67.98		0.037		0.33	0.004	Inlet Capac	2.5m flow checked
C/5	67.88		0.041		0.28	0.005	Inlet Capac	2.5m flow checked
C/6	67.82		0.021		0.24	0	None	2.5m flow checked
C/7	67.74	68.11	0.054	0.8	0.31	0	Inlet Capacity	
C2/1	67.86		0.04		0.32	0.005	Inlet Capac	2.5m flow checked
C2/2	67.84		0.02		0.33	0	None	2.5m flow checked
D/1	70.94	72.42	0.02	0.3	1.45		Inlet Capacity	
D/2	70.7	72.14	0.006	0.1	1.43		Inlet Capacity	
D/3	70.59	72.01	0.007	0.1	1.4		Inlet Capacity	
D/4	70.32	71.75	0.007	0.1	1.42		Inlet Capacity	
D/5	70.09	71.5	0.007	0.1	1.39		Inlet Capacity	
D/6	69.86	71.26	0.007	0.1	1.38		Inlet Capacity	
D/7	69.68	71.05	0.007	0.1	1.36		Inlet Capacity	
D/8	69.54	70.9	0.007	0.1	1.34		Inlet Capacity	
D/9	69.39	70.74	0.007	0.1	1.33		Inlet Capacity	
D/10	69.24	70.58	0.007	0.1	1.32		Inlet Capacity	
D/11	69.1	70.4	0.007	0.1	1.29		Inlet Capacity	
D/12	69.05	70.17	0.007	0.1	1.11		Inlet Capacity	
D/13	69.01	69.83	0.007	0.1	0.81		Inlet Capacity	
D/14	68.96	69.59	0.007	0.1	0.62		Inlet Capacity	
D/15	68.91	69.45	0.007	0.1	0.53		Inlet Capacity	
D/16	68.85	69.4	0.007	0.1	0.53		Inlet Capacity	
D/17	68.79	69.04	0.007	0.1	0.24		Inlet Capacity	
D/18	68.73	68.91	0.007	0.1	0.17	0	Inlet Capacity	
D/19	68.65	68.86	0.007	0.1	0.19	0	Inlet Capacity	
D/20	68.58	68.69	0.007	0.1	0.1	0	Inlet Capacity	
D/21	68.49	68.5	0.007	0.2	-0.01	0	Outlet System	
D/22	68.37	68.46	0.02	0.3	0.06	0	Inlet Capacity	
E/1	75.72		0.038		1.35	0.004	Inlet Capac	2.5m flow checked
E/2	75.55		0.041		1.29	0.005	Inlet Capac	2.5m flow checked
E/3	75.69		0.005		0.35	0	None	2.5m flow checked
E/4	75		0.015		0	0.09	Outlet Syst	Ex channel
E/5	74.58		0.096		0.01	0.042	Inlet Capac	Ex channel
E/6	73.18		0.141		0	0.126	Inlet Capac	Ex channel
E/7	71.12		0.141		0	0.125	Outlet Syst	Ex channel
E/8	69.11		0.137		0.41	0.039	Inlet Capac	Ex channel

E/9	68.13		0.044		0.49	0.006	Inlet Capac	Ex channel
F/1	70.41		0.028		2.03	0.001	Inlet Capac	2.5m flow checked
F/2	68.63		0.015		2.27	0	None	2.5m flow checked
C/1a	72.05	73.41	0.144	1.1	1.26	0	Inlet Capacity	
C/1b	68.29	68.66	0.422	2.4	0.19	0	Inlet Capacity	
G/1	75.23	75.35	0.228	3.1	-0.04	0	Outlet System	
B5/1	71.14	71.92	0.049	0.7	0.73	0	Inlet Capacity	
B/1	74.1		0.041		1.34	0.005	Inlet Capac	2.5m flow checked

SUB-CATCHMENT DETAILS

Name	Max Flow Q (cu.m/s)	Paved Max Q (cu.m/s)	Grassed Max Q (cu.m/s)	Paved Tc (min)	Grassed Tc (min)	Supp. Tc (min)	Due to Storm
C B1/1	0.013	0.012	0.001	5	10	0	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
C B1/4	0.014	0.014	0	5	10	0	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
C B/6	0.057	0.055	0.003	5	10	0	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
C B/7	0.047	0.044	0.002	5	10	0	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
C B/8	0.014	0.014	0.001	5	10	0	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
C A/1	0.039	0.037	0.002	5	10	0	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
C B2/1	0.013	0.012	0	5	10	0	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
C B2/2	0.017	0.016	0	5	10	0	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
C B2/3	0.027	0.026	0.001	5	10	0	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
C B2/4	0.013	0.012	0.001	5	10	0	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
C B/5	0.065	0.062	0.003	5	10	0	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
C B3/1	0.022	0.021	0.001	5	10	0	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
C B/2	0.069	0.065	0.003	5	10	0	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
C B/3	0.078	0.074	0.004	5	10	0	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
C B4/1	0.068	0.065	0.003	5	10	0	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
C B4/2	0.061	0.058	0.003	5	10	0	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
C B4/3	0.057	0.054	0.003	5	10	0	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
C B6/1	0.05	0.047	0.003	5	10	0	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
C B6/2	0.049	0.046	0.003	5	10	0	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
C B6/3	0.057	0.055	0.003	5	10	0	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
C B6/4	0.023	0.022	0.001	5	10	0	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
C B6/5	0.004	0.004	0	5	10	0	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
C C1/1	0.057	0.054	0.003	5	10	0	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
C C1/2	0.059	0.056	0.003	5	10	0	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
C C/4	0.037	0.036	0.002	5	10	0	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
C C/5	0.037	0.035	0.002	5	10	0	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
C C/6	0.017	0.016	0.001	5	10	0	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
C C/7	0.054	0.052	0.002	5	10	0	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
C C2/1	0.026	0.025	0.001	5	10	0	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
C C2/2	0.01	0.009	0.001	5	10	0	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
C D/1	0.02	0.019	0.001	5	10	0	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
C D/2	0.006	0.006	0	5	10	0	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
C D/3	0.007	0.006	0	5	10	0	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
C D/4	0.007	0.007	0	5	10	0	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
C D/5	0.007	0.007	0	5	10	0	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
C D/6	0.007	0.007	0	5	10	0	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
C D/7	0.007	0.007	0	5	10	0	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
C D/8	0.007	0.007	0	5	10	0	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
C D/9	0.007	0.007	0	5	10	0	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
C D/10	0.007	0.007	0	5	10	0	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
C D/11	0.007	0.007	0	5	10	0	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
C D/12	0.007	0.007	0	5	10	0	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
C D/13	0.007	0.007	0	5	10	0	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
C D/14	0.007	0.007	0	5	10	0	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
C D/15	0.007	0.007	0	5	10	0	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
C D/16	0.007	0.007	0	5	10	0	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
C D/17	0.007	0.007	0	5	10	0	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
C D/18	0.007	0.007	0	5	10	0	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
C D/19	0.007	0.007	0	5	10	0	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
C D/20	0.007	0.007	0	5	10	0	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
C D/21	0.007	0.007	0	5	10	0	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
C D/22	0.02	0.019	0.001	5	10	0	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
C E/1	0.038	0.036	0.002	5	10	0	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
C E/2	0.037	0.036	0.001	5	10	0	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
C E/3	0.005	0.005	0	5	10	0	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
C E/4	0.015	0.014	0	5	10	0	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
C E/5	0.009	0.009	0	5	10	0	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
C E/6	0.125	0.019	0.119	5	10	0	AR&R 5 year, 2 hours storm, average 25.76 mm/h, Zone 1
C E/7	0.034	0.033	0.001	5	10	0	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
C E/8	0.031	0.03	0.001	5	10	0	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
C E/9	0.018	0.017	0	5	10	0	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1

C F/1	0.028	0.027	0.001	5	10	0	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
C F/2	0.013	0.013	0	5	10	0	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
Ex Remainc	1.826	0.439	1.559	10	15	0	AR&R 5 year, 2 hours storm, average 25.76 mm/h, Zone 1
Pr Byp	0.438	0.075	0.422	10	15	0	AR&R 5 year, 2 hours storm, average 25.76 mm/h, Zone 1
Ex Edmond	0.285	0.271	0.015	5	10	0	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
C C/1a	0.144	0.021	0.129	5	10	0	AR&R 5 year, 2 hours storm, average 25.76 mm/h, Zone 1
C C/1b	0.422	0.06	0.381	5	10	0	AR&R 5 year, 2 hours storm, average 25.76 mm/h, Zone 1
C G/1	0.228	0.033	0.205	5	10	0	AR&R 5 year, 2 hours storm, average 25.76 mm/h, Zone 1
C B5/1	0.028	0.027	0.001	5	10	0	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
C B/1	0.036	0.034	0.002	5	10	0	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
Pr Bypass	0.438	0.075	0.422	10	15	0	AR&R 5 year, 2 hours storm, average 25.76 mm/h, Zone 1
Pr Site	2.414	2.414	0.108	10	15	0	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1

Outflow Volumes for Total Catchment (16.4 impervious + 20.0 pervious = 36.4 total ha)

Storm	Total Rainf cu.m	Total Runo cu.m (Runc	Impervious cu.m (Runc	Pervious Runoff cu.m (Runoff %)
AR&R 5 yea	5842.21	3306.05 (5	2468.44 (9	837.62 (26.1%)
AR&R 5 yea	7311.85	4503.73 (6	3130.67 (9	1373.07 (34.2%)
AR&R 5 yea	3816.59	1723.75 (4	1555.77 (9	167.99 (8.0%)
AR&R 5 yea	8480.78	5423.29 (6	3657.33 (9	1765.96 (37.9%)
AR&R 5 yea	9462.67	6151.28 (6	4099.74 (9	2051.54 (39.5%)
AR&R 5 yea	10315.11	6692.38 (6	4483.85 (9	2208.53 (39.0%)
AR&R 5 yea	12389.53	8196.91 (6	5418.56 (9	2778.36 (40.8%)
AR&R 5 yea	14030.76	9354.83 (6	6158.01 (9	3196.82 (41.5%)
AR&R 5 yea	16643.57	11112.52 (	7335.31 (9	3777.22 (41.3%)
AR&R 5 yea	18741.63	12543.98 (	8280.13 (9	4263.85 (41.4%)
AR&R 5 yea	22132	14917.10 (	9808.33 (9	5108.77 (42.0%)

PIPE DETAILS

Name	Max Q (cu.m/s)	Max V (m/s)	Max U/S HGL (m)	Max D/S HGL (m)	Due to Storm
P B1/1	0.023	0.21	69.617	69.626	AR&R 5 year, 1.5 hours storm, average 30.5 mm/h, Zone 1
P B1/2	0.034	0.3	69.624	69.617	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
P B1/3	0.042	0.38	69.615	69.566	AR&R 5 year, 1.5 hours storm, average 30.5 mm/h, Zone 1
P B1/4	0.046	0.42	69.564	69.562	AR&R 5 year, 1.5 hours storm, average 30.5 mm/h, Zone 1
P B/6	0.685	1.55	69.319	69.286	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
P B/7	0.883	2	68.983	68.921	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
P B/8	0.896	2.03	68.817	68.599	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
P B/9	0.933	2.04	68.362	68.36	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
P Basin/1	0.389	1.76	68.144	67.815	AR&R 5 year, 1.5 hours storm, average 30.5 mm/h, Zone 1
P A/1	0.398	1.84	67.75	67.686	AR&R 5 year, 1.5 hours storm, average 30.5 mm/h, Zone 1
P A/2	1.317	1.22	67.54	67.5	AR&R 5 year, 1.5 hours storm, average 30.5 mm/h, Zone 1
P B2/1	0.013	1.34	73.293	71.437	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
P B2/2	0.033	0.3	71.436	71.424	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
P B2/3	0.334	1.54	71.25	71.115	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
P B2/4	0.389	1.8	70.876	70.766	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
P B/4	0.562	3.1	70.502	70.061	AR&R 5 year, 2 hours storm, average 25.76 mm/h, Zone 1
P B/5	0.605	2.14	69.944	69.562	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
P B3/1	0.022	0.2	72.996	72.994	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
P B/2	0.112	2.6	72.845	71.432	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
P B/3	0.179	2.8	71.335	70.766	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
P B4/1	0.053	0.89	69.787	69.776	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
P B4/2	0.113	1.02	69.755	69.601	AR&R 5 year, 15 minutes storm, average 80.4 mm/h, Zone 1
P B4/3	0.17	1.54	69.553	69.286	AR&R 5 year, 15 minutes storm, average 80.4 mm/h, Zone 1
P B6/1	0.043	2.84	74.421	73.254	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
P B6/2	0.088	2.27	73.199	71.91	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
P B6/3	0.248	1.15	71.81	71.762	AR&R 5 year, 1.5 hours storm, average 30.5 mm/h, Zone 1
P B6/4	0.28	1.29	71.72	71.676	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
P B6/5	0.283	1.31	71.546	71.424	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
P C1/1	0.047	2.09	69.484	68.7	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
P C1/2	0.101	1.43	68.517	68.153	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
P C/2	0.11	0.78	68.145	68.104	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
P C/3	0.501	0.93	68.04	67.978	AR&R 5 year, 2 hours storm, average 25.76 mm/h, Zone 1
P C/4	0.532	0.99	67.954	67.879	AR&R 5 year, 2 hours storm, average 25.76 mm/h, Zone 1
P C/5	0.55	0.68	67.844	67.823	AR&R 5 year, 2 hours storm, average 25.76 mm/h, Zone 1
P C/6	0.604	0.75	67.769	67.744	AR&R 5 year, 2 hours storm, average 25.76 mm/h, Zone 1
P C/7	0.638	0.6	67.719	67.686	AR&R 5 year, 2 hours storm, average 25.76 mm/h, Zone 1
P C2/1	0.034	0.31	67.857	67.845	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
P C2/2	0.052	0.47	67.835	67.823	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
P D/1	0.02	1.65	70.915	70.699	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
P D/2	0.026	1.22	70.678	70.616	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
P D/3	0.032	1.79	70.557	70.337	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
P D/4	0.04	1.9	70.284	70.091	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1

P D/5	0.047	1.92	70.052	69.864	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
P D/6	0.054	1.93	69.823	69.681	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
P D/7	0.061	1.77	69.641	69.54	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
P D/8	0.068	1.87	69.497	69.393	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
P D/9	0.075	1.91	69.347	69.241	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
P D/10	0.082	2.05	69.191	69.096	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
P D/11	0.088	1.53	69.058	69.045	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
P D/12	0.093	0.85	69.027	69.006	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
P D/13	0.1	0.9	68.985	68.962	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
P D/14	0.107	0.96	68.938	68.911	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
P D/15	0.113	1.02	68.884	68.853	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
P D/16	0.12	1.08	68.823	68.79	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
P D/17	0.126	1.14	68.76	68.725	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
P D/18	0.133	1.2	68.692	68.654	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
P D/19	0.139	1.26	68.617	68.576	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
P D/20	0.146	1.32	68.537	68.495	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
P D/21	0.153	1.38	68.455	68.37	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
P D/22	0.171	1.55	68.365	68.36	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
P E/1	0.033	1.24	75.668	75.551	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
P E/2	0.077	1.48	75.498	75.687	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
P E/3	0.089	0.81	75.677	74.998	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
P E/4	0.267	2.42	74.775	74.577	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
P E/5	0.269	2.44	74.458	73.177	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
P E/6	0.275	2.49	73.029	71.116	AR&R 5 year, 30 minutes storm, average 56.71 mm/h, Zone 1
P E/7	0.305	2.76	70.954	69.106	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
P E/8	0.374	2.35	68.964	68.129	AR&R 5 year, 2 hours storm, average 25.76 mm/h, Zone 1
P E/9	0.41	2.58	67.966	67.686	AR&R 5 year, 2 hours storm, average 25.76 mm/h, Zone 1
P F/1	0.026	1.82	70.354	69.292	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
P F/2	0.04	0.36	68.615	68.599	AR&R 5 year, 20 minutes storm, average 69.94 mm/h, Zone 1
P C/1a	0.143	1.66	71.89	71.91	AR&R 5 year, 2 hours storm, average 25.76 mm/h, Zone 1
P C/1	0.427	0.79	68.163	68.104	AR&R 5 year, 2 hours storm, average 25.76 mm/h, Zone 1
P G/1	0.216	1	75.027	74.998	AR&R 5 year, 2 hours storm, average 25.76 mm/h, Zone 1
P B5/1	0.046	0.42	71.122	71.115	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
P B/1	0.034	1.66	74.008	72.994	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1

CHANNEL DETAILS

Name	Max Q (cu.m/s)	Max V (m/s)	Due to Storm

OVERFLOW ROUTE DETAILS

Name	Max Q U/S	Max Q D/S	Safe Q	Max D	Max DxV	Max Width	Max V	Due to Storm
F B1/1	0	0	0	0	0	0	0	
F B1/2	0	0	0	0	0	0	0	
F B1/3	0	0	0	0	0	0	0	
F B1/4	0	0	0	0	0	0	0	
F B/6	0.014	0.014	0	0.045	0.05	0.63	1.13	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
F B/7	0.011	0.011	0	0.042	0.04	0.52	1.06	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
F B/8	0	0	0	0	0	0	0	
OF1731	0	0	0	0	0	0	0	
OF8144	0	0	0	0	0	0	0	
F A/2	0	0	0	0	0	0	0	
F B2/1	0	0	0	0	0	0	0	
F B2/2	0	0	0	0	0	0	0	
F B2/3	0.001	0.001	0	0.024	0.01	0.27	0.42	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
F B2/4	0	0	0	0	0	0	0	
F B/4	0	0	0	0	0	0	0	
F B/5	0.013	0.013	0	0.044	0.05	0.58	1.13	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
F B3/1	0	0	0	0	0	0	0	
F B/2	0.015	0.015	0	0.047	0.05	0.71	1.09	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
F B/3	0.021	0.021	0	0.06	0.05	1.12	0.86	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
F B4/1	0.013	0.013	0	0.046	0.05	0.65	1.08	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
F B4/2	0.015	0.015	0	0.047	0.05	0.71	1.1	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
F B4/3	0.014	0.014	0	0.044	0.05	0.6	1.24	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
F B6/1	0.007	0.007	0	0.035	0.03	0.4	0.99	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
F B6/2	0.009	0.009	0	0.038	0.04	0.44	1.02	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
F B6/3	0.013	0.013	0	0.057	0.03	1.03	0.58	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
F B6/4	0	0	0	0	0	0	0	
F B6/5	0	0	0	0	0	0	0	
F C1/1	0.01	0.01	0	0.04	0.04	0.47	1.07	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
F C1/2	0.013	0.013	0	0.056	0.03	1.01	0.62	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
F C/2	0	0	0	0	0	0	0	
F C/3	0	0	0	0	0	0	0	
F C/4	0.004	0.004	0	0.041	0.02	0.5	0.44	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
F C/5	0.005	0.005	0	0.039	0.02	0.45	0.57	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1

F C/6	0	0	0	0	0	0	0	
F C/7	0	0	0	0	0	0	0	
F C2/1	0.005	0.005	0	0.037	0.02	0.43	0.56	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
F C2/2	0	0	0	0	0	0	0	
OF36623	0	0	0	0	0	0	0	
OF36597	0	0	0	0	0	0	0	
OF36581	0	0	0	0	0	0	0	
OF33997	0	0	0	0	0	0	0	
OF34001	0	0	0	0	0	0	0	
F E/1	0.004	0.004	0	0.035	0.02	0.4	0.61	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
F E/2	0.005	0.005	0	0.032	0.03	0.37	0.85	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
F E/3	0	0	0	0	0	0	0	
F E/4	0.09	0.09	0	0.099	0.09	2.44	0.95	AR&R 5 year, 2 hours storm, average 25.76 mm/h, Zone 1
F E/5	0.042	0.042	0	0.077	0.06	1.71	0.84	AR&R 5 year, 2 hours storm, average 25.76 mm/h, Zone 1
F E/6	0.126	0.126	0	0.11	0.11	2.81	1.01	AR&R 5 year, 2 hours storm, average 25.76 mm/h, Zone 1
F E/7	0.125	0.125	0	0.11	0.11	2.81	1.01	AR&R 5 year, 2 hours storm, average 25.76 mm/h, Zone 1
F E/8	0.039	0.039	0	0.076	0.06	1.65	0.83	AR&R 5 year, 2 hours storm, average 25.76 mm/h, Zone 1
F E/9	0.006	0.006	0	0.035	0.03	0.4	0.82	AR&R 5 year, 2 hours storm, average 25.76 mm/h, Zone 1
F F/1	0.001	0.001	0	0.02	0.01	0.24	0.59	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
F F/2	0	0	0	0	0	0	0	
OF22267	0	0	0	0	0	0	0	
F C/1	0	0	0	0	0	0	0	
OF22264	0	0	0	0	0	0	0	
F B5/1	0	0	0	0	0	0	0	
Dummy	0.005	0.005	0	0.009	0	5.16	0.2	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1
F B/1	0.005	0.005	0	0.033	0.03	0.38	0.81	AR&R 5 year, 25 minutes storm, average 62.43 mm/h, Zone 1

DETENTION BASIN DETAILS

Name	Max WL	MaxVol	Max Q Total	Max Q Low Level	Max Q High Level
Basin422	68.36	469.3	0.389	0.389	0

CONTINUITY CHECK for AR&R 5 year, 2 hours storm, average 25.76 mm/h, Zone 1

Node	Inflow (cu.m)	Outflow (cu.m)	Storage Ch (cu.m)	Difference %
B1/1	18.85	18.86	0	-0.1
B1/2	18.86	18.85	0	0
B1/3	18.85	18.9	0	-0.2
B1/4	39.9	40	0	-0.2
B/6	1101.1	1101.39	0	0
B/7	1441.11	1441.19	0	0
B/8	1459.55	1459.9	0	0
B/9	1520.84	1535.31	0	-1
Basin422	1817.39	1913.99	-0.14	-5.3
A/1	1971.12	1983.15	0	-0.6
A/2	3588.96	3583.64	0	0.1
A/3	3583.64	3583.64	0	0
B2/1	18.94	18.92	0	0.1
B2/2	43.84	43.8	0	0.1
B2/3	517.02	516.91	0	0
B2/4	586.31	585.94	0	0.1
B/4	878.97	878.49	0	0.1
B/5	975.1	975.84	0	-0.1
B3/1	32.48	31.96	0	1.6
B/2	187.91	187.84	0	0
B/3	303.18	302.21	0	0.3
B4/1	100.92	100.66	0	0.3
B4/2	191.29	191.17	0	0.1
B4/3	275.66	275.24	0	0.2
B6/1	74.12	74.06	0	0.1
B6/2	146.42	146.28	0	0.1
B6/3	392.9	393.33	0	-0.1
B6/4	427.18	426.83	0	0.1
B6/5	433.02	432.59	0	0.1
C1/1	84.64	84.52	0	0.1
C1/2	172.22	171.35	0	0.5
C1/3	171.35	171.23	0	0.1
C/3	644.64	643.18	0	0.2
C/4	698.55	698.83	0	0
C/5	753.15	753.13	0	0
C/6	837.73	837.7	0	0
C/7	918.08	920.48	0	-0.3
C2/1	43.48	43.38	0	0.2

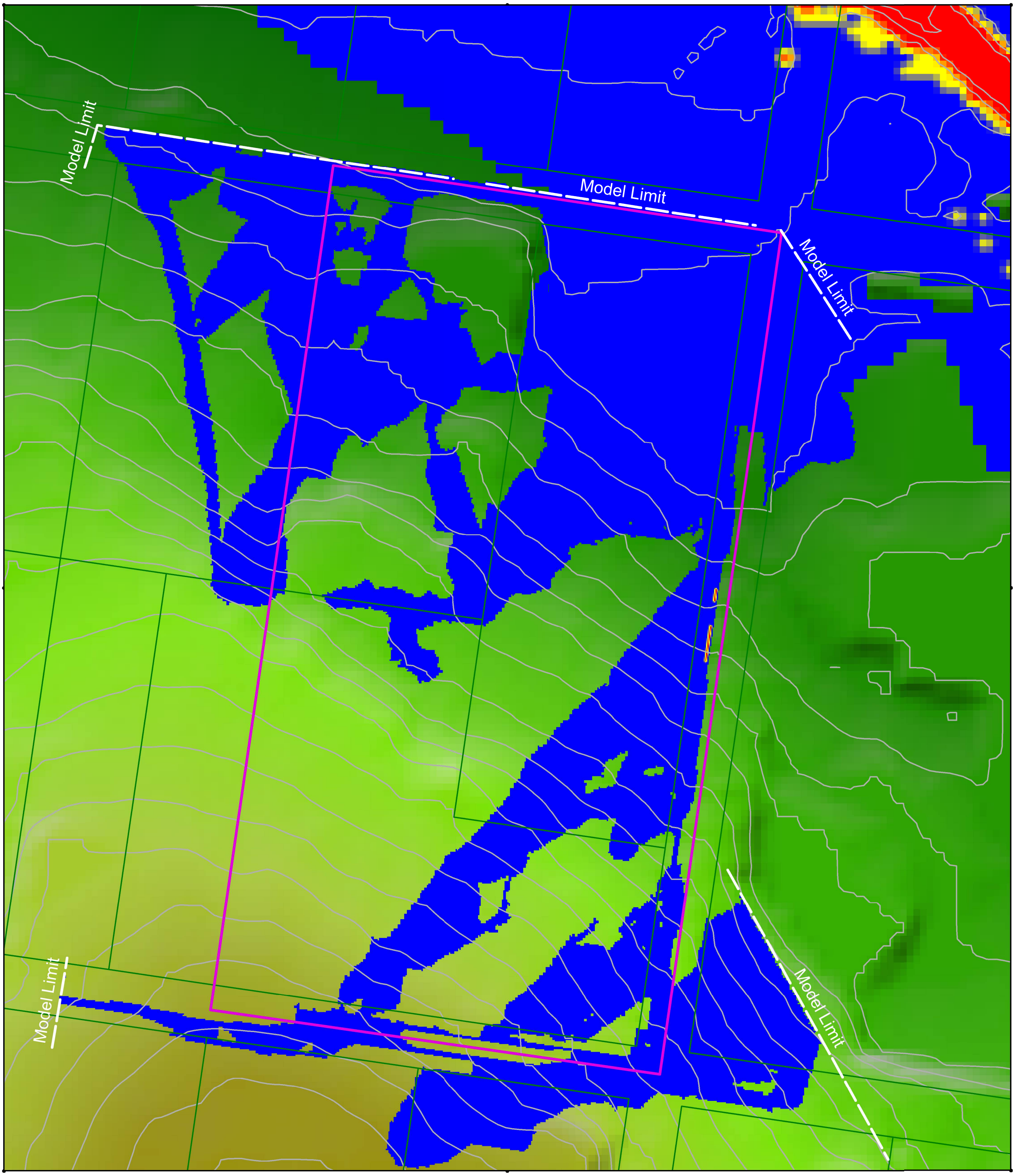
C2/2	59.94	59.72	0	0.4
D/1	29.28	29.24	0	0.1
D/2	38.85	38.83	0	0.1
D/3	48.97	48.93	0	0.1
D/4	59.74	59.72	0	0
D/5	70.53	70.49	0	0.1
D/6	81.29	81.26	0	0
D/7	92.07	92.04	0	0
D/8	102.84	102.8	0	0
D/9	113.61	113.57	0	0
D/10	124.38	124.35	0	0
D/11	135.15	135.12	0	0
D/12	145.93	145.86	0	0
D/13	156.66	156.58	0	0.1
D/14	167.39	167.33	0	0
D/15	178.14	178.13	0	0
D/16	188.93	189.01	0	0
D/17	199.82	199.86	0	0
D/18	210.67	210.71	0	0
D/19	221.52	221.57	0	0
D/20	232.38	232.55	0	-0.1
D/21	243.36	243.42	0	0
D/22	272.7	282.09	0	-3.4
E/1	55.65	55.55	0	0.2
E/2	110.85	109.48	0	1.2
E/3	116.48	117.1	0	-0.5
E/4	394.73	394.2	0	0.1
E/5	407.64	407.52	0	0
E/6	556.09	556.16	0	0
E/7	606.84	607.37	0	-0.1
E/8	653.19	654	0	-0.1
E/9	680.3	685.33	0	-0.7
F/1	41.02	40.96	0	0.1
F/2	60.83	60.94	0	-0.2
O C/2	0	0	0	0
N19530	2880.99	2880.99	0	0
N19531	694.55	694.55	0	0
N22404	423.22	423.22	0	0
C/1a	161.47	161.31	0	0.1
C/1b	474.63	473.41	0	0.3
G/1	256	255.71	0	0.1
B5/1	50.77	50.65	0	0.2
O C/7	0.95	0.95	0	0
O C2/1	0	0	0	0
O B2/2	0	0	0	0
B/1	54.18	54.11	0	0.1
N55997	0.95	0.95	0	0
N56956	694.55	694.55	0	0
N56969	4394.84	4394.84	0	0

Run Log for Untitled run at 09:32:27 on 4/11/2016 DESIGNER NOTES

Upwelling occurred at E/4
Surcharge pit to maintain flows from upstream catchments within the Edmondson Ave open channel
Freeboard was less than 0.15m at G/1 E/7 E/6 E/5 D/22 D/21 D/20 C1/3 B1/4 B/6
G - Upstream catchment future connection point. E - Design for surcharge pit on temporary line in Edmondson Ave. D - Interallotment line to be finalised in CC submission. C, B - Sag pits to be refined with final grading of kerb returns etc in CC submission.

Flows were safe in all overflow routes.

C. TUFLOW Results



Title

230 Sixth Avenue Austral
Flood Analysis
100 year Existing Scenario

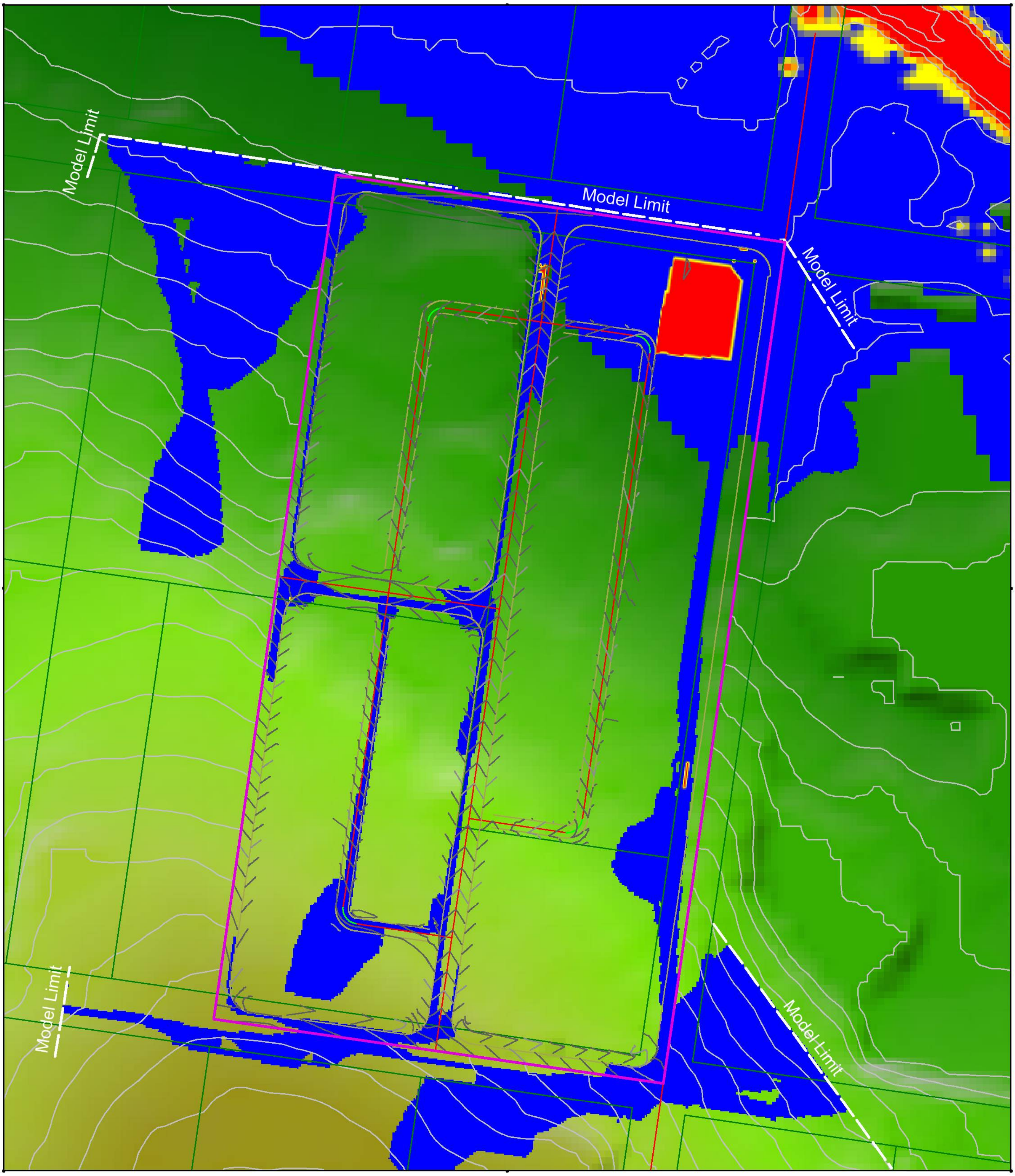
M M
MOTT MACDONALD

N W E S

NSW FDM Hazard Class

- Low
- Intermediate
- High

Date	Drawn	Checked	Approved	Scale at A4	Drawing Number	Status	Rev
02/11/2016	JM	JT	AC	2000	Appendix C - Figure 1	FI	A



Title

230 Sixth Avenue Austral
Flood Analysis
100 year Proposed Scenario

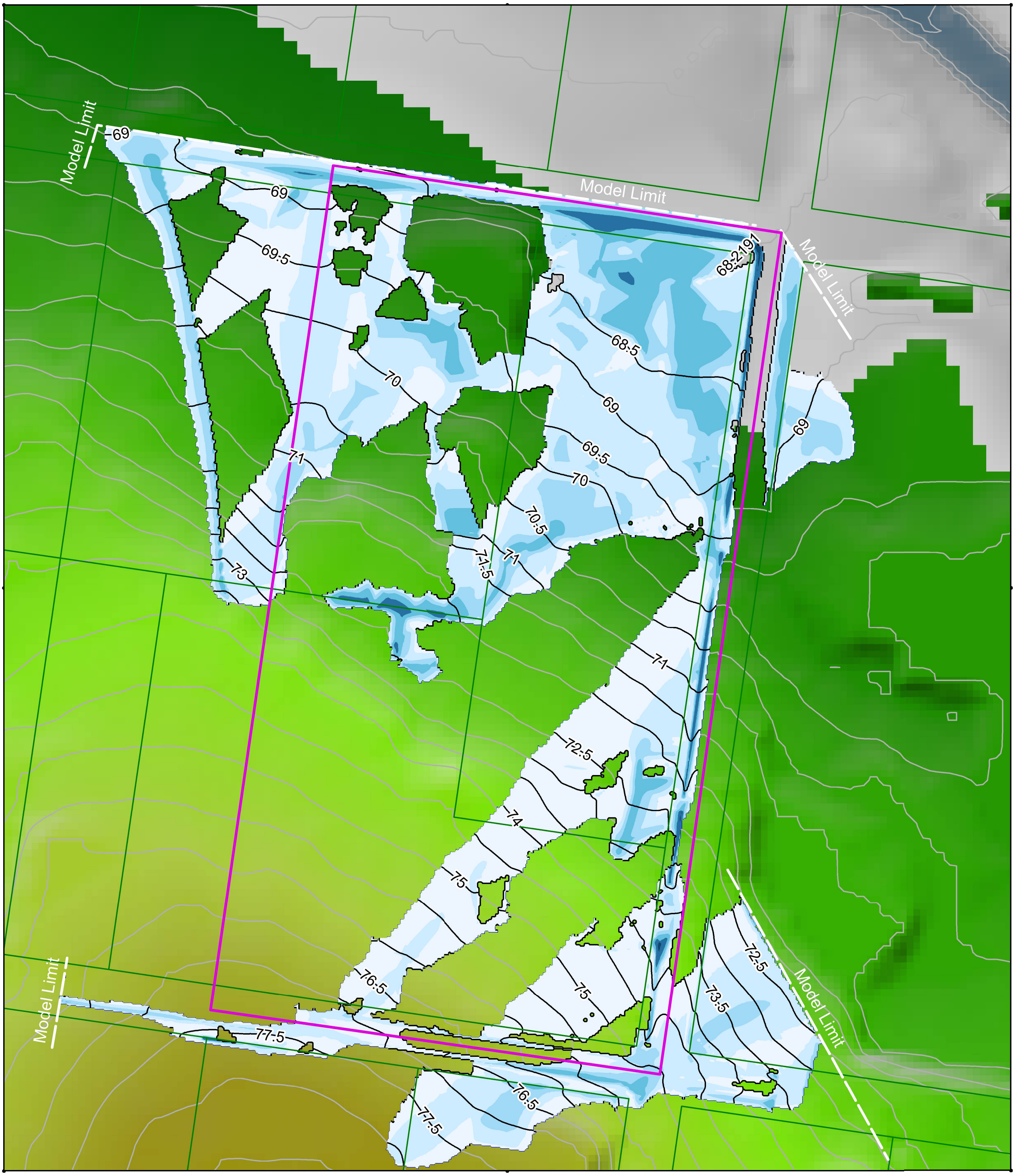
M M MOTT MACDONALD

NSW FDM Hazard Class

- Low
- Intermediate
- High

N W E S

Date	Drawn	Checked	Approved	Scale at A4	Drawing Number	Status	Rev
02/11/2016	JM	JT	AC	2000	Appendix C - Figure 2	FI	A



Title

230 Sixth Avenue Austral
Flood Analysis
100 year Existing Scenario

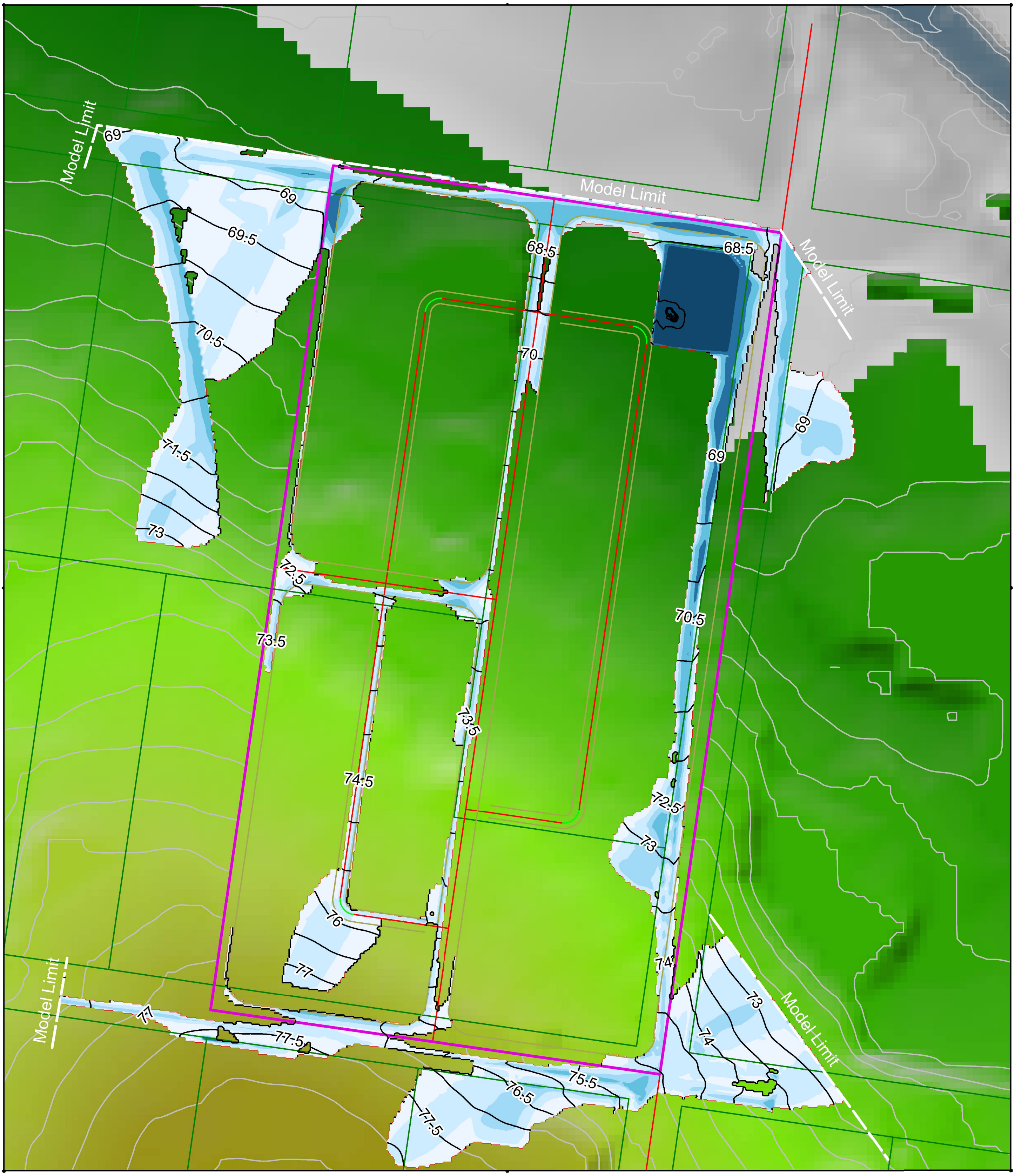
M M
MOTT MACDONALD

Overland Flow Depth (m)

0.00 to 0.01
0.01 to 0.05
0.05 to 0.10
0.10 to 0.20
0.20 to 0.50
0.50 to 0.72

N
W E
S

Date	Drawn	Checked	Approved	Scale at A4	Drawing Number	Status	Rev
02/11/2016	JM	JT	AC	2000	Appendix C - Figure 3	FI	A



Title

230 Sixth Avenue Austral
Flood Analysis
100 year Proposed Scenario

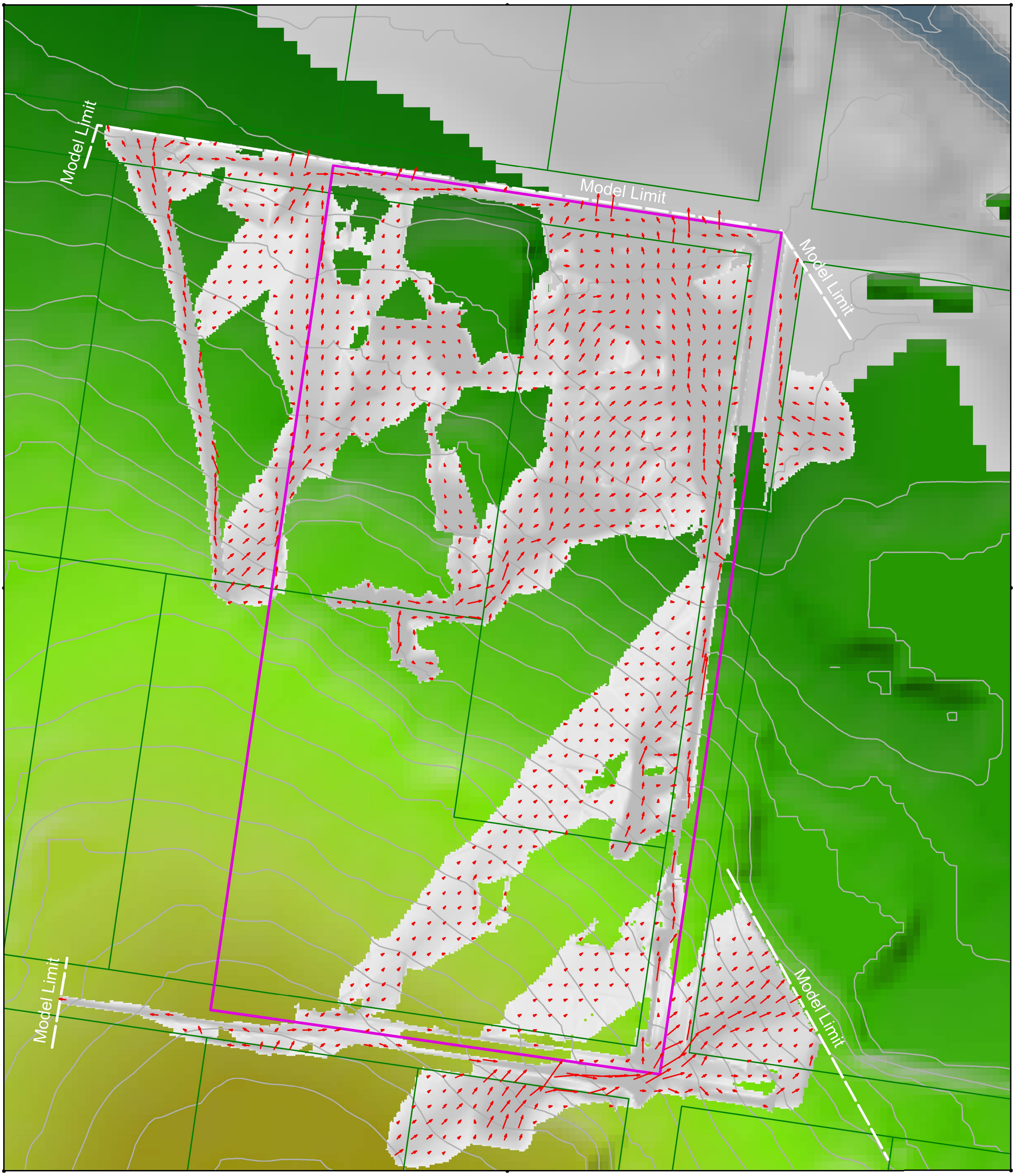
M M
MOTT MACDONALD

N W E S

Flood Depth (m)

0.00 to 0.01	0.10 to 0.20
0.01 to 0.05	0.20 to 0.50
0.05 to 0.10	0.50 to 3.88

Date	Drawn	Checked	Approved	Scale at A4	Drawing Number	Status	Rev
02/11/2016	JM	JT	AC	2000	Appendix C - Figure 4	FI	A



Title

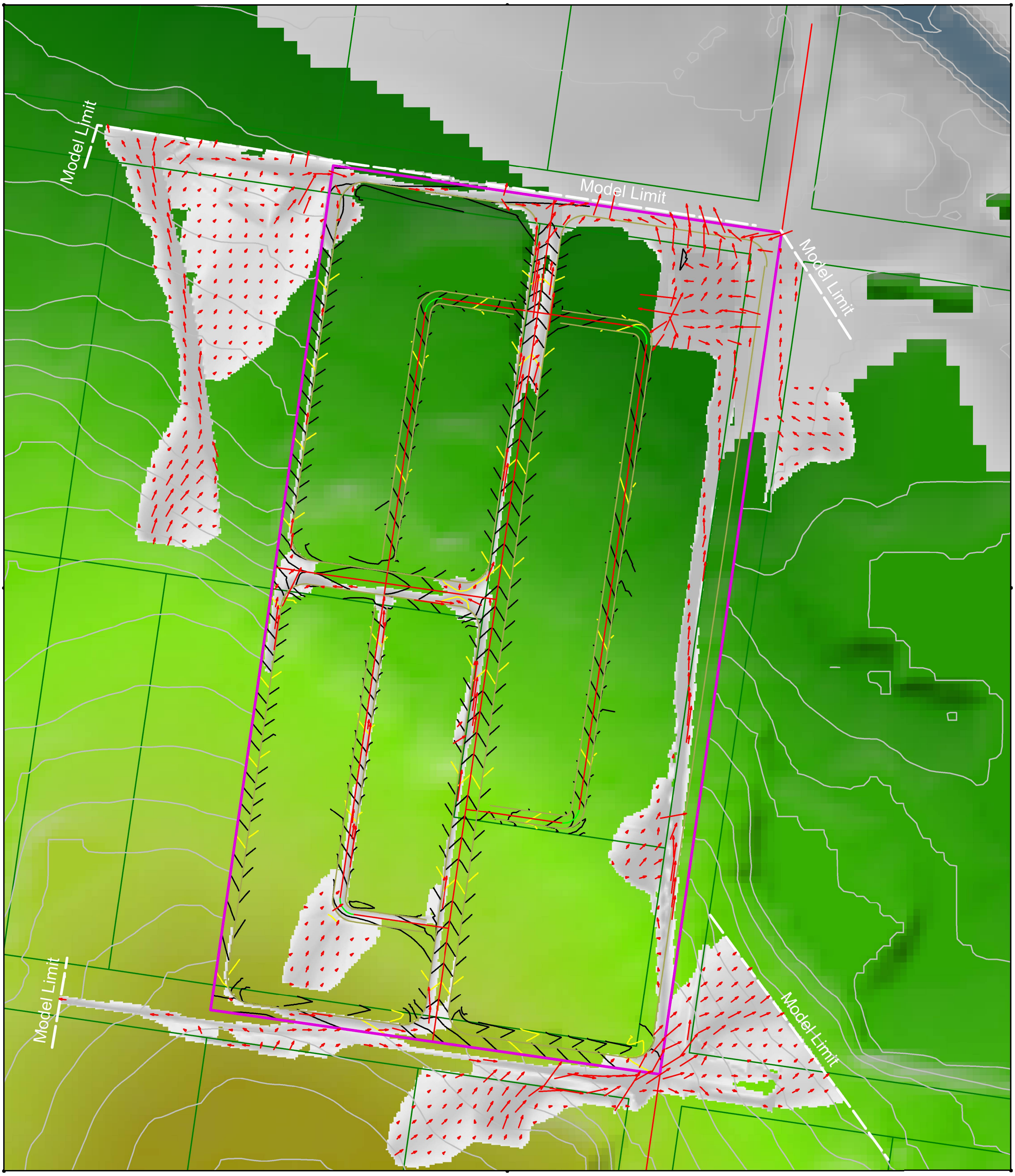
230 Sixth Avenue Austral
Flood Analysis
100 year Existing Scenario

M M
MOTT MACDONALD

Velocity Vectors

N
W E
S

Date	Drawn	Checked	Approved	Scale at A4	Drawing Number	Status	Rev
02/11/2016	JM	JT	AC	2000	Appendix C - Figure 5	FI	A



Title

230 Sixth Avenue Austral
Flood Analysis
100 year Proposed Scenario

M M
MOTT MACDONALD

N W E S

Velocity Vectors

Date	Drawn	Checked	Approved	Scale at A4	Drawing Number	Status	Rev
02/11/2016	JM	JT	AC	2000	Appendix C - Figure 6	FI	A