F Flood Mapping Report

Flood Study Report Preferred Scenario 3B, Revision 0, 11 September 2014, Irwinconsult

Whitehorse Centre

Preferred Scenario 2B Flood Study Report

11 September 2014

revision 0

job no: 12ME0460

Irwinconsult Pty Ltd Level 3, 289 Wellington Parade South, East Melbourne VIC 3002 Australia ABN 89 050 214 894
t +61 3 9622 9700 f +61 3 9650 6664 mlb@irwinconsult.com.au www.irwinconsult.com.au

irwinconsult

shape the present — enrich the future

document control

project name Whitehorse Centre – Preferred Scenario 2B Flood Risk Assessment Report

project number 12ME0460

Revision	Date	File name 12ME0460-RPT-pm1-FRA-Development Report-R0.docx			
0	11/09/2014	Description	Interim Draft Report		
			Prepared	Checked	Approved
		Initial	PM1	LOT	PG
		File name			
		Description			
			Prepared	Checked	Approved
		Initial			
		File name			
		Description			
			Prepared	Checked	Approved
		Initial			
		File name			
		Description			
			Prepared	Checked	Approved
		Initial			
		File name			
		Description			
			Prepared	Checked	Approved
		Initial			

contents

contents

Glossary of Terms

Annual Exceedance Probability (AEP)	Refers to the probability or risk of a flood of a given size occurring or being exceeded in a given year.
Average Return Interval (ARI)	The average or expected value of the periods between exceedances of a given rainfall total accumulated over a given duration. Eg. 100 year ARI flood is expected to be exceeded every 100 years (taken to be equivalent to 1% AEP). It is implicit in this definition that the periods between exceedances are generally random.
Australian Height Datum (AHD)	A common national surface level datum approximately corresponding to mean sea level.
Catchment	Area draining to a site. It always relates to a particular location and may include the catchment of tributaries as well as main stream.
Design flood	The design is the probabilistic or statistical estimate, being generally based on some form of probability analysis of flood or rainfall data.
Discharge	The rate of flow of water measured in terms of volume over time.
Digital Terrain Model (DTM)	Is the digital representation of ground surface topography.
Flood	A relatively high stream flow which overtops that natural or constructed watercourse or drainage system such as a stream, river, estuary, lake, canal or pipe drainage network.
Flood damage	The tangible or intangible cost of flooding.
Flood hazard	Potential risk to life or property caused by flooding. Flood hazard is often evaluated in terms of flood depth and velocity.
Flood mitigation	Works to prevent or reduce the impact of flooding.
Flood plain	Area of land which is subject to inundation by floods up to the probable maximum flood event. i.e. flood prone land.
Flood storage	Refers to the volume of a flood plain that flood water occupies. May be natural storage of the flood plain our constructed storages like detention or retardation basins.
Freeboard	A factor of safety above design flood levels typical used to define floor levels of building or bridge decks. Freeboard is usually expressed as height above the design flood level.
Geographical Information Systems (GIS)	A system of software and procedures designed to support the management, manipulation, analysis and display of spatially referenced data.
Hydraulics	Is the topic in civil engineering dealing with the mechanical properties water flow through such things as pipe drainage networks, dams rivers, stream and across land.

Hydrograph	A graph that shows the discharge to time relationship of a hydraulic flow at a particular location.
Hydrology	The term given to the study of the rainfall and runoff processes as it relates to the derivation of hydrographs for given floods.
Intensity Frequency Duration (IFD) Analysis	Statistical analysis, describing the rainfall intensity (mm/hr), frequency (probability measured by the AEP), duration (hrs). This analysis is used to generate design rainfall estimates.
Peak flow	The maximum discharge occurring during a flood event.
Runoff	The amount of rainfall that actually ends up as stream or pipe flow, also known as rainfall excess.
Topography	A surface that describes the ground profiles of a chosen land area.
XP-SWMM	The hydrological and hydraulic model used in this study to simulate the site catchments runoff and flow of water through the pipe drainage network.
XP-2D	The hydraulic modelling tool used in this study to simulate the flow of flood water through the floodplain. The model uses numeric equations to describe the water movement in two dimensions (2D).

Executive Summary

Flood Assessment Summary

Flood assessment was undertaken during the study to evaluate existing flood circumstances and the impact of flooding on the preferred Scenario.

The existing centre floor level is approximately 126.3 AHD (Australian Height Datum) at the foyer, with the theatre stage and Sound Shell about a metre higher, and orchestra pit and basement storage lower. The flood assessment of the existing site shows that the centre is impacted by flood water for storm events of 10% AEP (10 year ARI) storm event and greater. For the 10% AEP event modelling shows water to lap up to the south east corner of the building. For the 1% AEP (100 year ARI) storm event the existing centre is significantly impacted by flood with water levels estimated to reach 126.5m AHD on the east side of the building. This flood level being 200mm above the existing floor level.

The draft recommendation for the new building height is 127.5 AHD, that is 1.2m higher than the existing main floor level.

This will require design resolution and substantial civil engineering works to the entrance of the new centre to achieve an integrated universal design to centre entry. The levels in the entry area are constrained by the heights and extent of existing trees and their root zones.

Existing Flood Assessment

The existing centre site is known to be affected by overland flood flows that pass through the site from the south of the site to the north. The major contributing catchments to the overland flows include commercial developed land to the south including part of Whitehorse Road, Nunawading football oval to the east and residential land to the west of the site. Development on the Whitehorse Centre site itself includes the City of Whitehorse council offices, existing arts centre, access roads, car parking, gardens and park land. The total contributing catchment to the drainage and overland flow system is approximately 22 hectares.

There is an 800mm diameter trunk drain that passes through the centre of the site that runs from Whitehorse Rd on the south side of the site to the north. This drain passes directly to the west of the existing arts centre building. Other minor pipe drains connect laterally to the trunk drain along its length that serve the surrounding catchment.

Flood assessment of the existing site has been using 2-Dimensional flood modelling software XP-2D. The flood model hydraulically analyses both the below ground pipe network running through the site and surface overland flow mapping. Analysis has been completed for the 10 year and 100 year ARI storm events. Critical time peak flows for the catchment were found to result from the 20 minute storm duration.

The flood modelling completed shows the minor pipe drainage system to surcharge for lesser 10 year ARI storm event resulting in minor overland flows through the site. The 100 year ARI event was found to produce significant flooding through the site that converges on the existing arts centre building. Major flow paths were identified along the low land line through the centre of the site and also overland flood flows from residential areas and car parking on the east side of the site. The depth of flood water around the existing arts building is estimated to be in the order of 100 to 400mm.

Proposed Facility Flood Assessment

The proposed Whitehorse Centre Scenario 2B has a larger footprint than the existing arts centre building and creates a greater obstacle to flood flows. Significantly, the building extends further to the east than the existing building by approximately 15m and into the path of the existing overland flood flow. The effect of this building shift is to displace the overland flood flows to the east and causing increase in flow depth and increase in velocity of the flood water for the 1% AEP storm event.

The nominated FFL of the building is 127.5m AHD with flood water freeboard level set 300mm lower than the FFL at 127.2m AHD. The freeboard level is observed to be exceeded in the model only on the southern side of the building. The flood water at this location is only minor sheet flows from the adjacent park land and not from the major overland flow path. Defence of the building from flooding at this location may be achieved by providing a small diversion drain or building a flood barrier into the building terrace wall. Floodwater elsewhere around the building is below the building freeboard level and not considered to place the building at risk of flood.

Flood modelling completed has not identified a significant increase in flood levels across the existing car parking spaces. Hence the increased flood risk to the car parking is considered to be negligible.

The overall increase in flood depth to the east of the building has been observed in the model to me relatively minor with increases in flood profile in the order of 50 to 150mm. These increases in flood levels are not observed to impact on other properties and the afflux affects in terms of flood risk are considered negligible.

The Scenario 2B development proposal has resulted in increased flow depths and velocities on the east side of the building for the critical 1% AEP storm event modelled. The maximum flood water depth increase has been relatively minor, however in some localised areas east of the building the flood water does exceed the nominated safe depth of 0.35m with water depths observed in the flood model up 0.44m.

The increase on flood flow velocity to the east of the building has been quite significant with the peak flow velocity increasing from max value of 1.15m/s for the existing scenario to approximately 2.2m/s for the developed Scenario 2B, which exceeds the nominated acceptable level of 1.5m/s

The proposed resultant increase in depth and velocity to the east side of the building for the developed Scenario 2B produces an increase in the relative hazard. As measured by the product of velocity and depth (VxD) the maximum observed value is $0.55m^2/s$, which exceeds the nominated acceptable level of $0.35m^2/s$.

To mitigate the excessive depth and flow velocities observed in the developed scenario model it is proposal to re-profile the access road and car parking areas directly east of the building to be better disperse the flood flows in this area. This remodelling work has not yet been completed and will be completed in the next stage of design work.

The Scenario 2B development proposal will need to consider access and egress in the building design to ensure that people attempting to enter or leave the building during a flood event are not endangered by deep or fast flowing water. The area of hazardous flood flows has been identified on the eastern side of the building. These hazardous areas should be considered in the design of the building to ensure there are alternative entrance and exit points to the building away from the identified hazardous flood area on the east side of the building.

It is considered that the Whitehorse Centre Scenario 2B development proposal can be managed in terms of flood risk. The flood study has identified that the development will result in increased maximum depth and flow velocities to flood flows on the east side of the new building. It is considered that this change in flow dynamics can be largely mitigated by re-grading the access roads and car parking this area to better disperse the flows.

1 Introduction

1.1 Background

The proposed Whitehorse Centre development is to be located at the existing City of Whitehouse civic centre grounds at 379-399 Whitehorse Road (aka Maroondah Highway), Nunawading. The new Whitehorse Centre building will replace the existing arts centre building located on the site. The development site lies within an area known to be flooded from overland stormwater flows from the surrounding catchment. Irwinconsult have been commissioned by the City of Whitehorse to undertake the flood study into the overland flows to support the development.

This flood study has considered both pre and post development scenarios and makes recommendations on flood mitigation options and finished floor levels of the proposed new building. The post-development option considered in the flood study is Scenario 2B as provided by Williams Ross Architects.

This report documents the flood risk assessment findings in relation to the Whitehorse Centre development.

1.2 Pre-Development

For the pre-developed site the existing flood regime has been modelled to estimate flood levels and flows for the critical 1% Annual Excedence Period (AEP) storm event. Through this modelling estimates of flood flows have been completed that includes mapping of existing flood extents, flood depths, evaluation contours and hazard assessment.

The pre-developed site flood assessment is discussed thoughout this report and findings summarised in Section 6.

1.3 Post-Development

Flood mapping for the Whitehorse Centre development Scenario 2B has been undertaken to determine the impacts of the proposed development on flood flows together with developing flood risk mitigation options to protect the building and users. The assessment has considered flood levels around the proposed build for the 1% AEP storm event to fix final floor levels. Floor levels will be set a minimum of 300mm above the 1% AEP (100 year ARI) flood level. Additional the flood study will consider and recommend mitigation options in relation to:

- Impacts on car park areas to ensure cars will not be damaged by flooding
- Complete hazard assessment of flood flows in terms of depth to velocity relationship to ensure people can move safely about the building during a flood event are not endangered by deep or fast flowing water. Referring to Melbourne Water Guidelines safety is defined in terms of the depth and velocity of water over the area in question as follows:
  - Depth should be no more than 0.35m
  - Velocity should be no more than 1.5m/s, and
  - The product of depth and velocity should be no more than $0.35m^2/s$
- Afflux affects (i.e. increased flood levels) caused by the development and possible impacts upstream, and
- Safe access and egress routes from the building during flood.

Summary details of the post-development flood risk assessment are provided in Section 7.

2 Available Information

2.1 GIS Layer of Council Drainage Assets

The City of Whitehorse provided Irwinconsult access to the GIS information on the council's drainage networks. The GIS drainage model was assembled from the Councils historical asset records including as-built and construction drawings. The GIS layer provides information on the councils drainage network layout and information on pipe diameters. This information was used by Irwinconsult to construct the XP-SWMM model of the pipe drainage network.

2.2 Topographical Feature Survey

The feature survey, prepared by Brown Consulting in December 2012 & February 2013, was provided by the City of Whitehorse. The feature survey covers the study area and includes details of all site features such as kerb lines, trees, site levels, buildings and service pits. All level information has been included in 3D triangulated model that was used to create the Digital Terrain Model (DTM) in the XPSWMM model. All levels at the Australian Height Datum (m AHD).

The Brown Consulting 2012/2013 survey did not include complete information on below ground drainage and services across the study area. Build-up of the existing below ground drainage model was encompassed with earlier survey information provided, notably feature survey from 2009. The 2009 survey was prepared by the City of Whitehorse and includes more comprehensive information on below ground drainage across the study area that was augment base information.

2.3 As-built Drawing Information

Various as-built drawings provided by the City of Whitehorse of drainage, sewer and other building information across the study area was used to verify and inform details of the XPSWMM drainage model including information on pipe sizes and invert levels. Engineering judgement exercised by Irwinconsult engineers on the extent that as-built information was to be used in the model.

2.4 Site Inspection

The study area was inspected by Peter Munzel and Gervaise Christie of Irwinconsult in April 2014. The purpose of the inspection was for Irwinconsult engineers to familiarise themselves with the site and to verify, where possible, the details of feature survey and some assumptions made on the below ground drainage model.

3 Study Area

3.1 Development Site

The Whitehorse Centre development is proposed on the grounds of the City of Whitehorse Civic Centre. The study area is as defined in Figure 3-1 below. The overall area of the study area is 5.7 hectares. Existing development across the site includes the City of Whitehorse council offices, existing arts centre, access roads, car parking, gardens and park land.

Figure 3-1 City of Whitehorse Civic Centre Grounds

3.2 Stormwater Catchment

The overall area of the flood study encompasses the total stormwater drainage total catchment for the site. This overall catchment is 22.3 hectares in area, capturing commercial developed land to the south including part of Whitehorse Road, Nunawading football oval to the east and residential land to the west of the site. The overall catchment plan for the site is presented in Figure 3-2.

Figure 3-2 Existing Catchment Plan

3.3 Topography and Floor Levels

A full feature survey of the site is included in Appendix A that depicts the topography of the site.

The topography of the study area falls longitudinally from south to the north with levels ranging from 132.2m AHD at the Whitehorse Road and 123.2m AHD adjacent to Carter Avenue. The profile of the site grades toward the centre forming a gentle valley through the site. The valley line closely follows the west edge of the central car park and just east of the existing arts building. It is along this valley line the majority of overland flows pass through the site.

The existing centre floor level is approximately 126.3m AHD (Australian Height Datum) at the foyer, with the theatre stage and sound shell about a metre higher, and orchestra pit and basement storage lower.

3.4 Existing Drainage

Existing drainage through the site is shown on the feature survey plan included in Appendix A.

There is an 800mm diameter trunk drain that passes through the centre of the site in a south to north direction. This trunk drain collects stormwater from subject site and surrounding area by a series of minor lateral pipe drains that are sized in the order of 300mm diameter or less. The existing drainage has been mapped from available information provided included as-built drawings, survey, GIS data base.

4 Hydrology

4.1 General

Hydrological modelling of the stormwater drainage system has been undertaken using the computer software XP-SWMM by WP Software. The software is recommended in AR&R Volume 1 Book VIII Urban Stormwater for modelling of complex drainage systems and is considered suitable for this project.

4.2 Rainfall Intensity-Frequency-Duration

Rainfall Intensity Frequency (IFD) data has been generated from the website Bureau of Meteorology website using data 1987 Australian Rainfall & Runoff Volumes 1 and 2. Refer Table 4-1 for IFD rainfall values.

Table 4-1 Rainfall IFD Table (Rainfall Intensities in mm/hr)

DURATION	1 Year	2 years	5 years	10 years	20 years	50 years	100 years
5Mins	47.7	63.4	86.5	102	123	153	178
6Mins	44.6	59.3	80.7	95.4	115	143	166
10Mins	36.3	48.2	65.0	76.4	91.7	114	132
20Mins	26.2	34.5	46.0	53.7	64.0	78.6	90.6
30Mins	21.2	27.8	36.8	42.7	50.7	62.1	71.3
1Hr	14.3	18.7	24.4	28.2	33.2	40.3	46.1
2Hrs	9.54	12.4	15.9	18.2	21.3	25.6	29.0
3Hrs	7.52	9.72	12.3	14.0	16.3	19.5	22.0
6Hrs	5.00	6.41	7.99	8.97	10.3	12.2	13.7
12Hrs	3.29	4.20	5.18	5.79	6.64	7.81	8.73
24Hrs	2.11	2.70	3.34	3.75	4.31	5.08	5.70
48Hrs	1.29	1.67	2.10	2.38	2.76	3.29	3.72
72Hrs	.951	1.22	1.56	1.77	2.06	2.47	2.80

4.3 Hydrological Model

The catchment model used is presented in Figure 4-1 below.

Figure 4-1 XP-SWMM Catchment Model

The hydrological model used is the SWMM Non-linear Runoff Routing Method utilising the Horton Infiltration model.

Parameters adopted in the model are summarised below:

- Horton Infiltration Model (values estimated for dry loamy soils)
  - Max Infiltration Rate (Fo): 75mm/hr
  - Min (Asymptotic) Infiltration: 5mm/hr
  - Decay rate of infiltration: 1.18×10^{-3} 1/sec
  - Max Infiltration volume 0mm

- Pervious Area
  - Manning's n: 0.035
  - Depression storage: 2.5mm

- Impervious
  - Catchment impervious fraction 75%
  - Manning's n: 0.03
  - Depression storage 1mm
  - Zero Detention (%) 25

The maximum or initial infiltration capacity, mm/hr. This parameter depends primarily on soil type, initial moisture content and surface vegetation conditions. The values adopted are typical for moist loamy soils as recommended by Akan (1993) – Refer XP-SWMM User Manual for further information.

5 Hydraulics

5.1 1D Hydraulic Model

5.1.1 XP-SWMM Hydraulic Module Overview

1D Hydraulic modelling of the of the stormwater drainage system has been undertaken using the Hydraulic module of XP-SWMM.

Hydraulically, flows are simulated in 1D pipes. The model is created using a link-node representation of the stormwater drainage network. The XP-SWMM hydraulics engine solves the St Venant (Dynamic Flow) equations for gradually varied, one dimensional, unsteady flow through the drainage network.

The calculation accurately models backwater effects, flow reversal, surcharging, pressure flow, tidal flow and interconnected ponds. The model allows for looped networks, multiple outfall and accounts for storage in conduits. Refer to www.wpsoftware.com for full technical details of the XP-SWMM hydraulic model.

5.1.2 Boundary Conditions

1D boundary conditions were input for the following:

- Outfall control – Critical depth y_c used

The outfall boundary was set approximately 100m downstream of the development site to ensure the backwater did not affect the flows in the pipes within the area of interest.

5.1.3 Pit Inlet Capacities

Pit inlet capacities have been calculated from equations provided in AR&R Volume 1 as follows.

For grated pits

$$Q_i = 1.66PD^{1.5}$$

For kerb inlet pits

$$Q_i = 1.66LD^{1.5}$$

The following choke factors have been applied to pits to take account of potential blockages: :

- Sag pits 50% efficiency
- On grade pits 80% efficiency

5.1.4 Pre-Developed 1D Drainage Model

Link-node representation of the pre-developed stormwater drainage system has been presented in Figure 5-1. Reference should be made to these diagrams when interpreting the hydraulic analysis data and results that will be discussed in the following sections.

Figure 5-1 Pre-Development 1D Drainage Model

The 1D hydraulic model of the existing site drainage network has been constructed from the available information including GIS, feature survey, and as-built drainage information provided by the City of Whitehorse. Engineering judgement was used by Irwinconsult engineers when interpreting available information together with verification of information on site. There were some gaps in information on pipe diameters and invert levels from the information provided that were filled with the assumed pipe diameters and interpolated invert levels as best as possible.

Excluded from the 1D model were minor drainage systems typically less than 300mm diameter. There is little information available in these small pipes systems and their absence will not significantly affect the overall flood model results.

The hydraulic modelling data inputs include pit data that is input into the XPSWMM Nodes. This information includes pit cover levels, pit base level, detention storage (if required) and inlet capacity.

Conduit data is input into the XPSWMM links. This information includes full details of all pipes and open channels. Data inputs include:- upstream and downstream IL's, conduit length and slope, mannings 'n' roughness, pipe diameter's or channel shapes as appropriate. Special multi links are used where multiple conduits exist in a single link, such as pipe and kerb a channel profiles.

Full data set of the hydraulic model including conduit data is presented in Appendix C.

5.1.5 Post-Developed 1D Drainage 1D Model

For the post-development site the 1D drainage model has been amended to allow for proposed changes to the drainage network include diversion of the 800mm diameter drain around the proposed Whitehorse Centre building.

Link-node representation of the post-developed stormwater drainage system has been presented in Figure 5-2. Reference should be made to these diagrams when interpreting the hydraulic analysis data and results that will be discussed in the following sections.

Figure 5-2 Post-Development Drainage Model

5.2 2D Flood Modelling

5.2.1 XP-2D Model Overview

XP-2D is an overland flow module that forms part of the XPSWMM software. XP-2D models full dynamic 2D overland flow and interfaces directly with the 1D hydraulic model of XPSWMM that allows simulation of flows in and out of urban drainage networks and river systems. It provides a very accurate tool to predict the extent, depth, velocity and duration of flooding to evaluate flood mitigation technologies and management practices. Features supporting structural failures (dams, levees, floodwalls, etc.) allow detailed analysis of emergency response scenarios.

5.2.2 Digital Terrain Model

The XP-2D model uses the Digital Terrain Model (DTM) of the site to form a 2D surface model. For the DTM was generated by the triangulated topographical feature survey provided by the City of Whitehorse. Figure 5-3 below shows the DTM used in the XP-2D model.

Figure 5-3 DTM Generated for the Study Area

A four meter grid size was chosen to accurately model surface flows in XP-2D. This cell size proved to be sufficiently small to accurately model terrain of the study area.

5.2.3 Surface Roughness

Within XP-2D a land use layer is utilised to import surface roughness information into the model. This defines how surface water travels over the various land types in the catchment. The following Manning's 'n' values were used:

- 0.016 Roads and car parks
- 0.030 Open grassed areas (regularly mowed) – Default Setting
- 0.050 Grassed areas with trees

5.2.4 Boundary Conditions

2D boundary condition was applied where the modelled overland flow exits the study area. The headwater depth applied at this boundary was 100mm.

5.2.5 Durations Modelled

1% AEP design storms ranging in duration from 10 minute to 2 hours were run for the XP-2D model. Analysis of the results showed that the 20 minute storm produced the greatest flood depths. This time of concentration is in line with expected values for a catchment of this size.

5.2.6 Post Development Model

The XP-2D model has been modified to include the new Whitehorse Centre building footprint and set as an inactive area in the model.

6 Flood Mapping and Flow Results

6.1 Overview

Flood assessment of the existing site has been completed using 2-D flood modelling software XP-2D. The flood model hydraulically analyses both the below ground pipe network running through the site and surface overland flow mapping. Analysis has been completed for the 1% AEP and 10% AEP storm events. Critical time peak flows for the catchment were found to result from the 20 minute storm duration.

6.2 Pre-Development Mapping

6.2.1 General

Flood mapping for the pre-development site has been produced from the XP-2D model for the 1% AEP storm events and presented in Figures 6-1 to 6-4, including:

- Figure 6-1 Maximum Flood Water Depths
- Figure 6-2 Maximum Water Surface Contours
- Figure 6-3 Maximum Velocity and Depth Product Contours
- Figure 6-4 Maximum Velocity Contours

Larger A3 prints of the flood maps are reproduced in Appendix D.

Presentation of maps together discussion of finding is provided in the follow sections

6.2.2 Existing Flood Depth

Mapping of maximum flood depths for the critical 1% AEP storm event is provided in Figures 6-1 below.

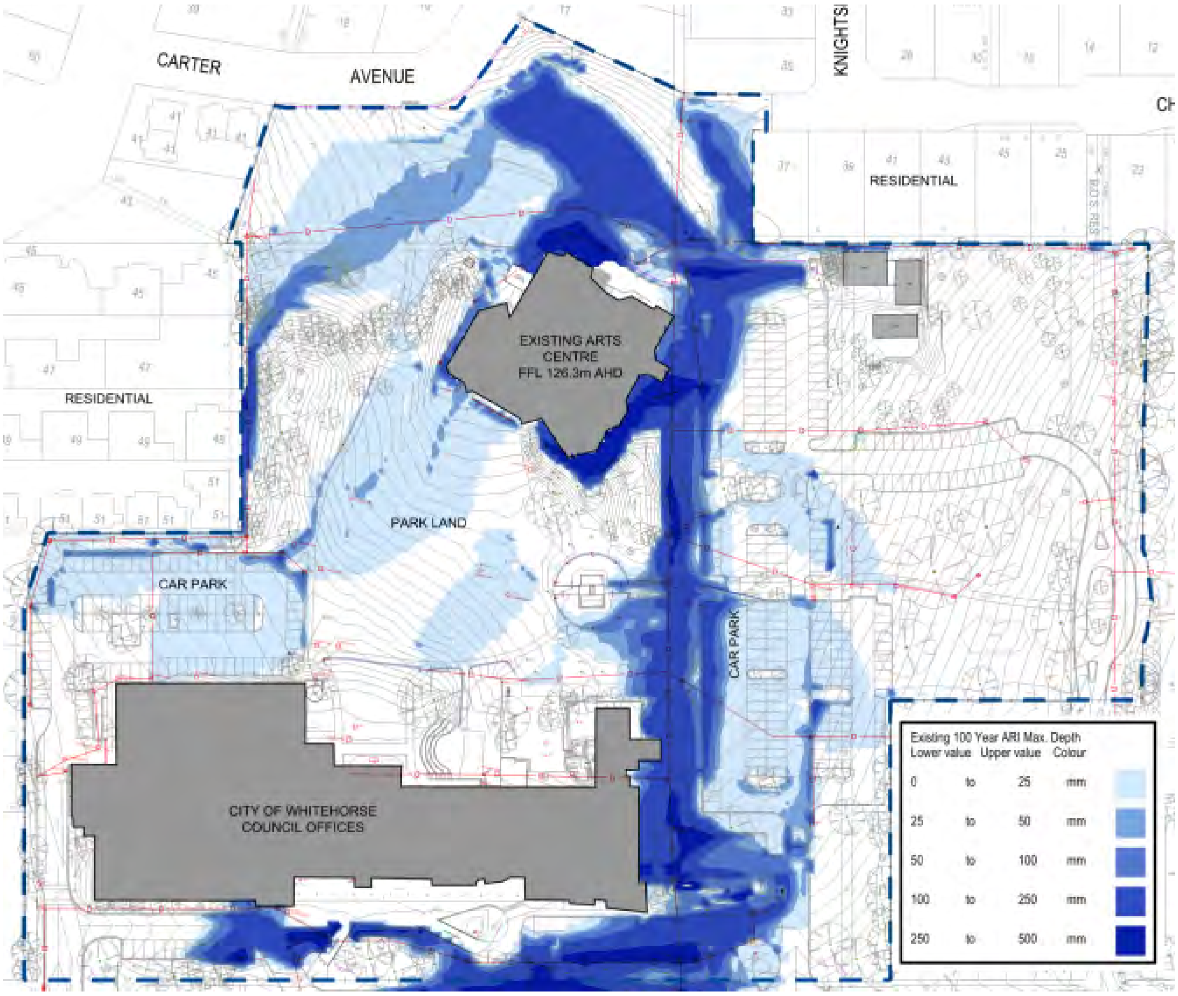


Figure 6-1 Pre-Developed Site Maximum Flood Depth Map

For the 1% AEP critical storm event the depth of flood water around the existing arts building is estimated to be in the order of 100 to 400mm.

The flood modelling completed shows the minor pipe drainage system to surcharge for events less than 10 year ARI storm event (10% AEP) resulting in minor overland flows through the site. The 100 year ARI event (1% AEP) was found to produce significant flooding through the site that converges on the existing arts centre building. Major flow paths were identified along the low land line through the centre of the site and also overland flood flows from residential areas and car parking on the east side of the site.

6.2.3 Existing Surface Water Contours

Mapping of maximum flood surface water elevations for the critical 1% AEP storm event is provided in Figures 6-2 below.

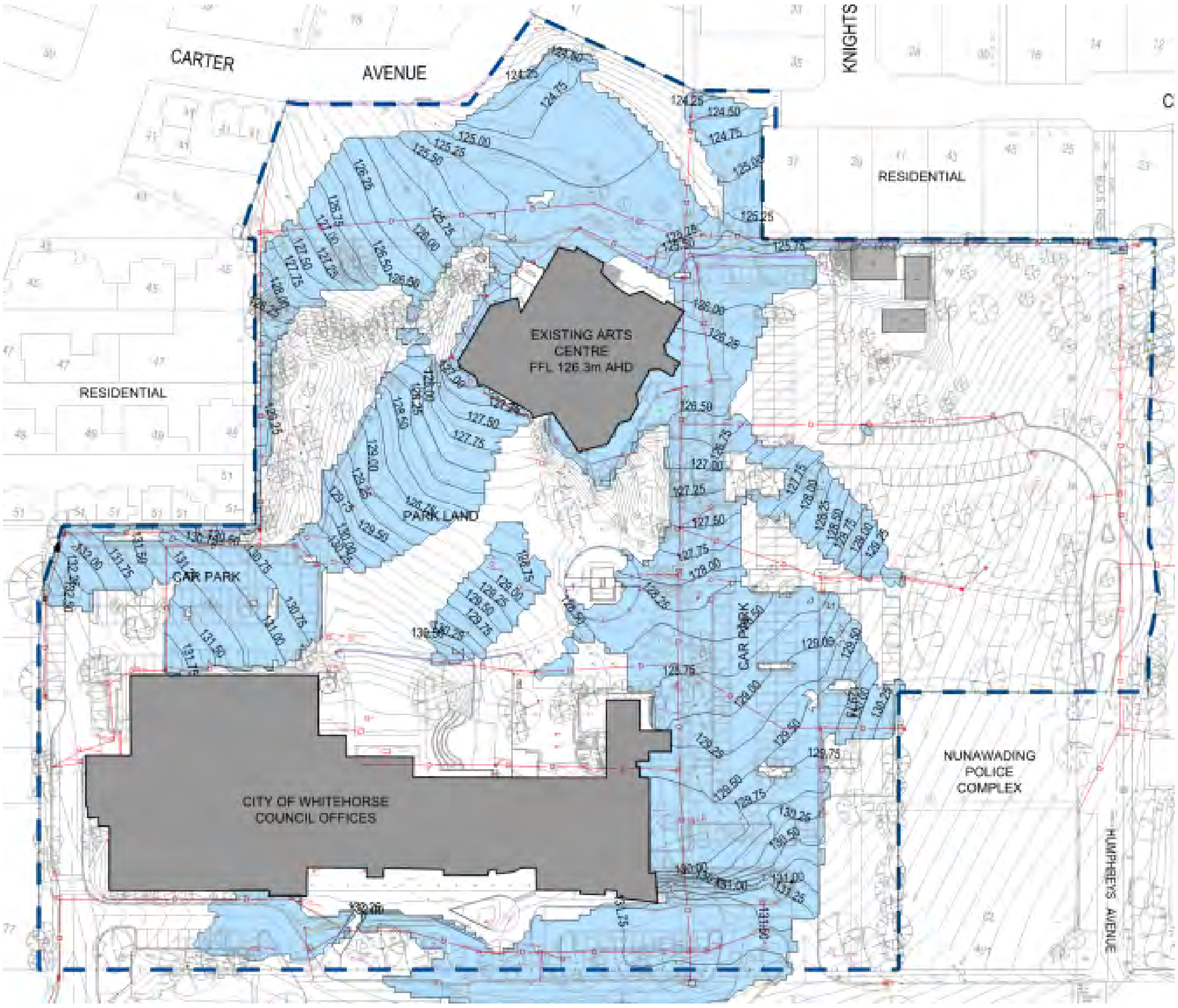


Figure 6-2 Pre-Developed Site Water Surface Contours

The surface water contour mapping shows the existing arts centre to be impacted by flood water for storm events of 10 year Annual Return Interval (ARI) and greater. For the 10 year ARI event (10% AEP) modelling shows water to lap up to the south east corner of the building. For the 100 year ARI storm event (1% AEP) the existing centre is significantly impacted by flood with water levels estimated to reach 126.5m AHD on the east side of the building. This flood level being 200mm higher than the existing floor level of 126.3m AHD.

6.2.4 Existing Hazard Assessment

Mapping of maximum velocity to depth product contours for the critical 1% AEP storm event is provided in Figures 6-3 below.

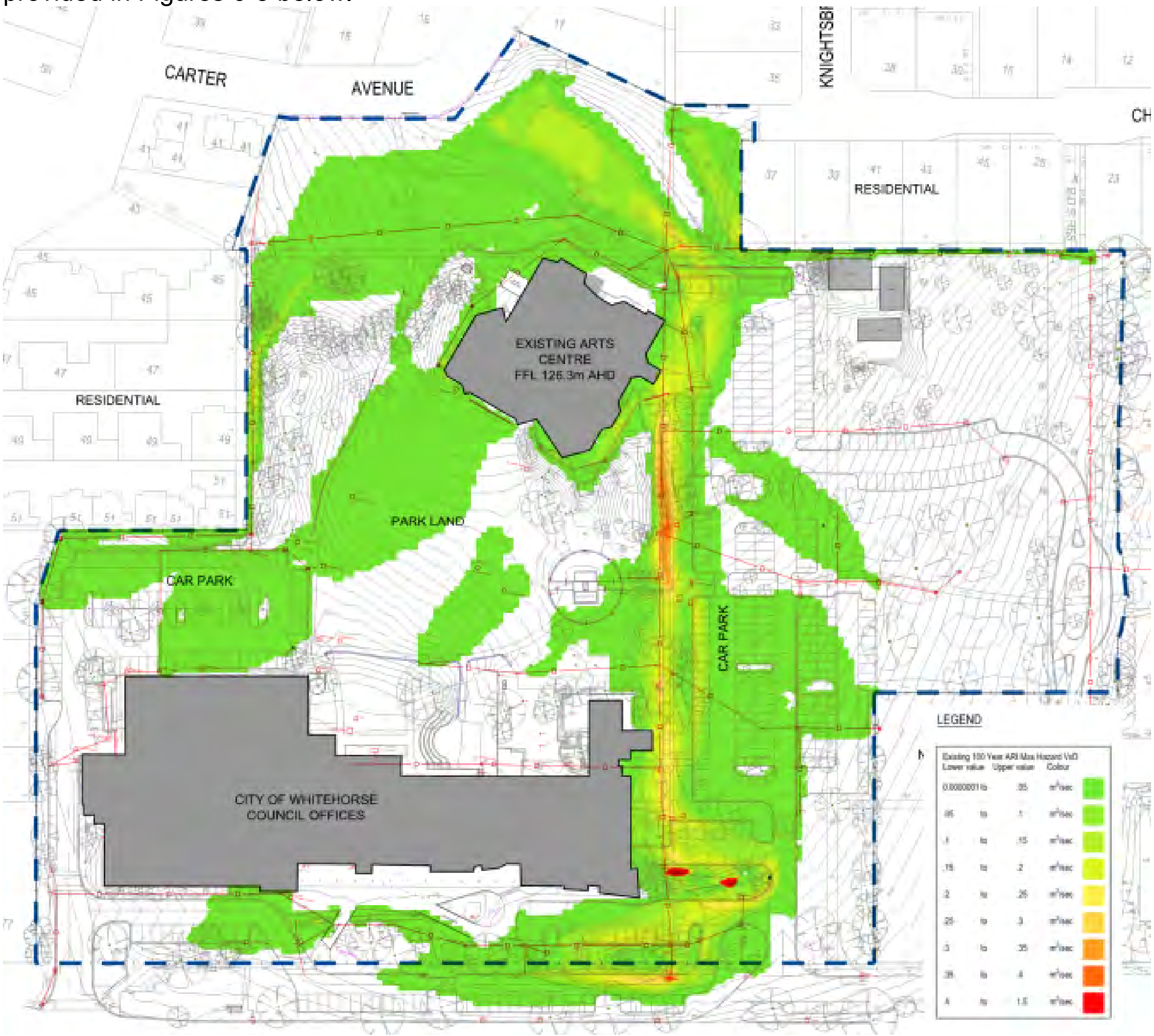


Figure 6-3 Pre-Developed Velocity and Depth Product Contours

The relative hazard of flood flows across the site is generally considered to be low with product of flow velocity by depth typically (DxV) below 0.35m^2/s. The exception to this is the area in the flood plain just south of the existing arts building where there is a hot spot where DxV are recorded in the order of 0.4m^2/s.

6.2.5 Existing Flow Velocity

Mapping of maximum velocity vectours for the critical 1% AEP storm event is provided in Figures 6-4 below.

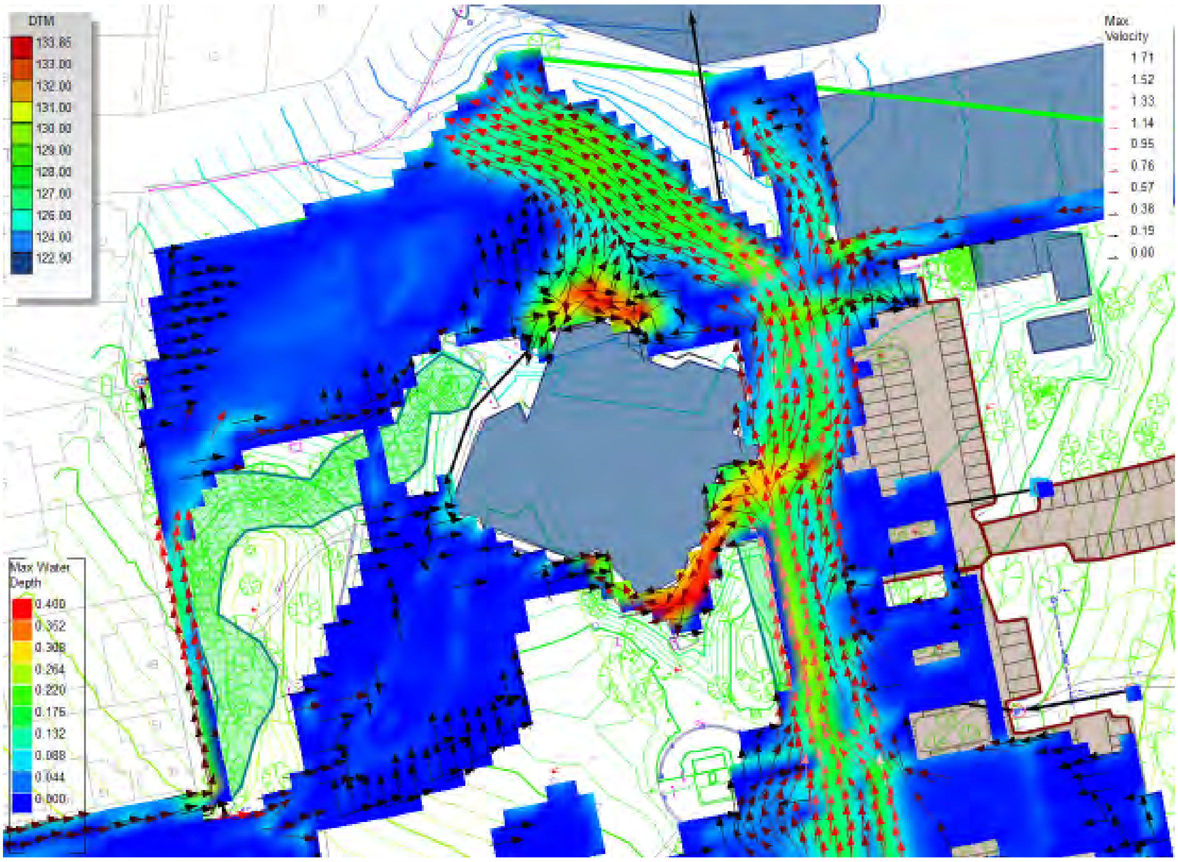


Figure 6-4 Pre-Developed Site Max Water Depth with Velocity Vectors – 100 yr 20 min Storm Event

The maximum velocities of flows through the site are generally quite low with typical values along the main flow path of the flood less than 1 m/s. The highest flow velocities have been observed in the model directly to the east of the existing arts building values as high as 1.15m/s. This value is still relatively low and would not be considered hazardous or damaging.

6.3 Post-Development Mapping

Flood mapping for the post-development site has been produced from the XP-2D model for the 1% AEP storm events and presented in Figures 6-5 to 6-8 below, including:

- Figure 6-5 Maximum Flood Water Depths
- Figure 6-6 Maximum Water Surface Contours
- Figure 6-7 Maximum Velocity and Depth Product Contours
- Figure 6-8 Maximum Velocity Contours

Larger A3 prints of the flood maps are reproduced in Appendix D.

Presentation of maps together discussion of finding is provided in the follow sections

6.3.1 Post-Development Flood Depth

Post-development flood mapping of maximum flood depths for the critical 1% AEP storm event is provided in Figures 6-5 below.

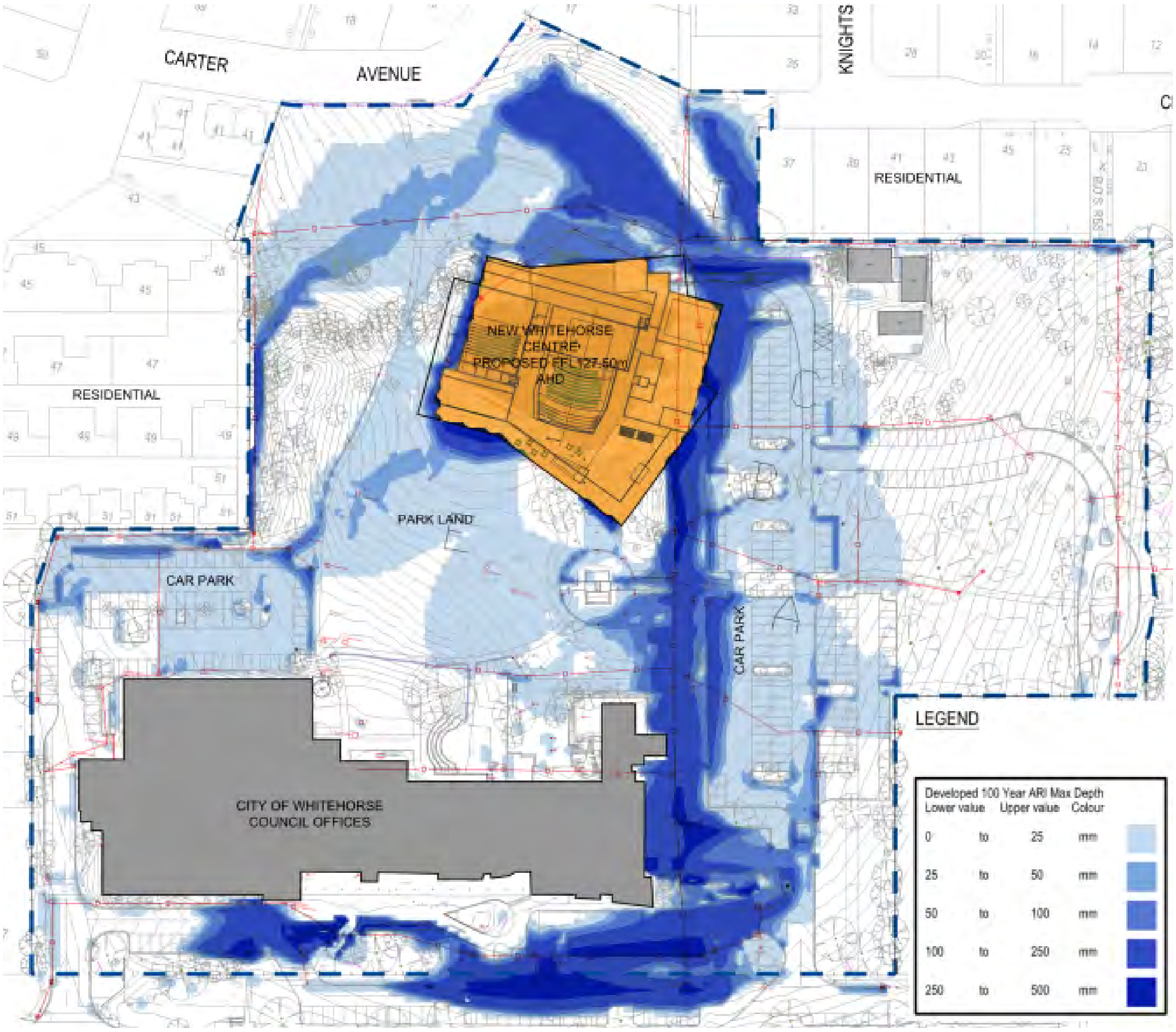


Figure 6-5 Pre-Developed Site Maximum Flood Depth Map

For the 1% AEP critical storm event the depth of flood water around the proposed Whitehorse Centre building is estimated to be in the order of 100 to 400mm. The deepest flooding is observed in the model on the east side of the building with a maximum depth of 0.427m.

6.3.2 Post-Development Surface Water Contours

Post-development flood mapping of maximum flood surface water elevations for the critical 1% AEP storm event is provided in Figures 6-6 below.

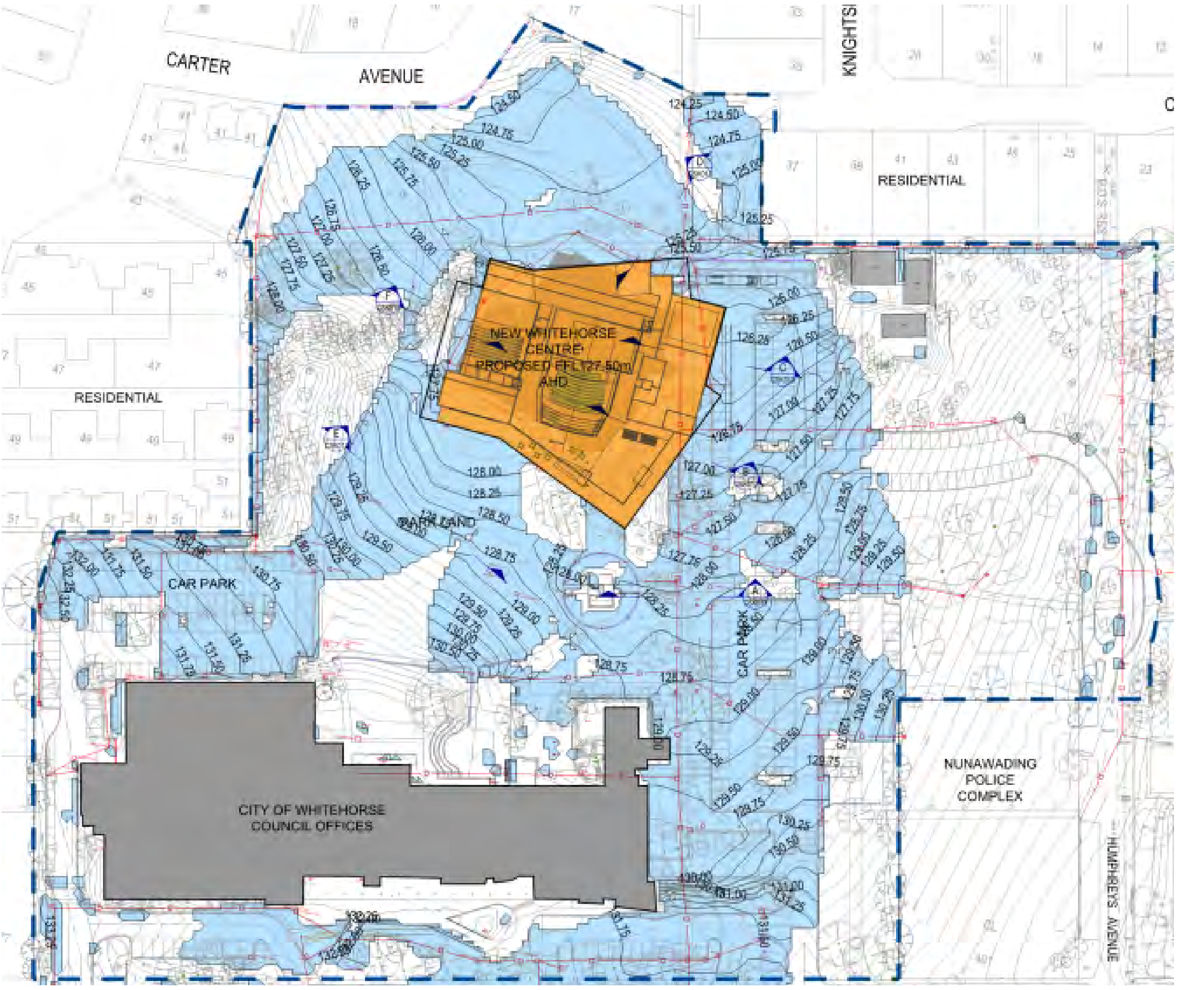


Figure 6-6 Post-Developed Site Water Surface Contours

The surface water contour mapping shows the proposed Whitehorse Centre building to be impacted by flood water for the critical 1% AEP storm event with flood water reaching the building on all four sides. The depth of flood water is considered to be critical where it rises above the FFL freeboard level.

The proposed FFL of the building is 127.5m AHD with flood water freeboard set 300mm lower the FFL at 127.2m AHD. The freeboard level is observed to be exceeded in the model only on the southern side of the building. The flood water at this location is only minor sheet flows from the adjacent park land and not from the major overland flow path. Defence of the building from flooding at this location can be achieved by providing a small diversion drain or building a flood barrier into the building terrace wall.

Floodwater elsewhere around the building is below the building freeboard level and not considered to place the building at risk of flood inundation.

6.3.3 Post Development Hazard Assessment

Post-development flood mapping of maximum velocity to depth product contours for the critical 1% AEP storm event is provided in Figures 6-7 below.

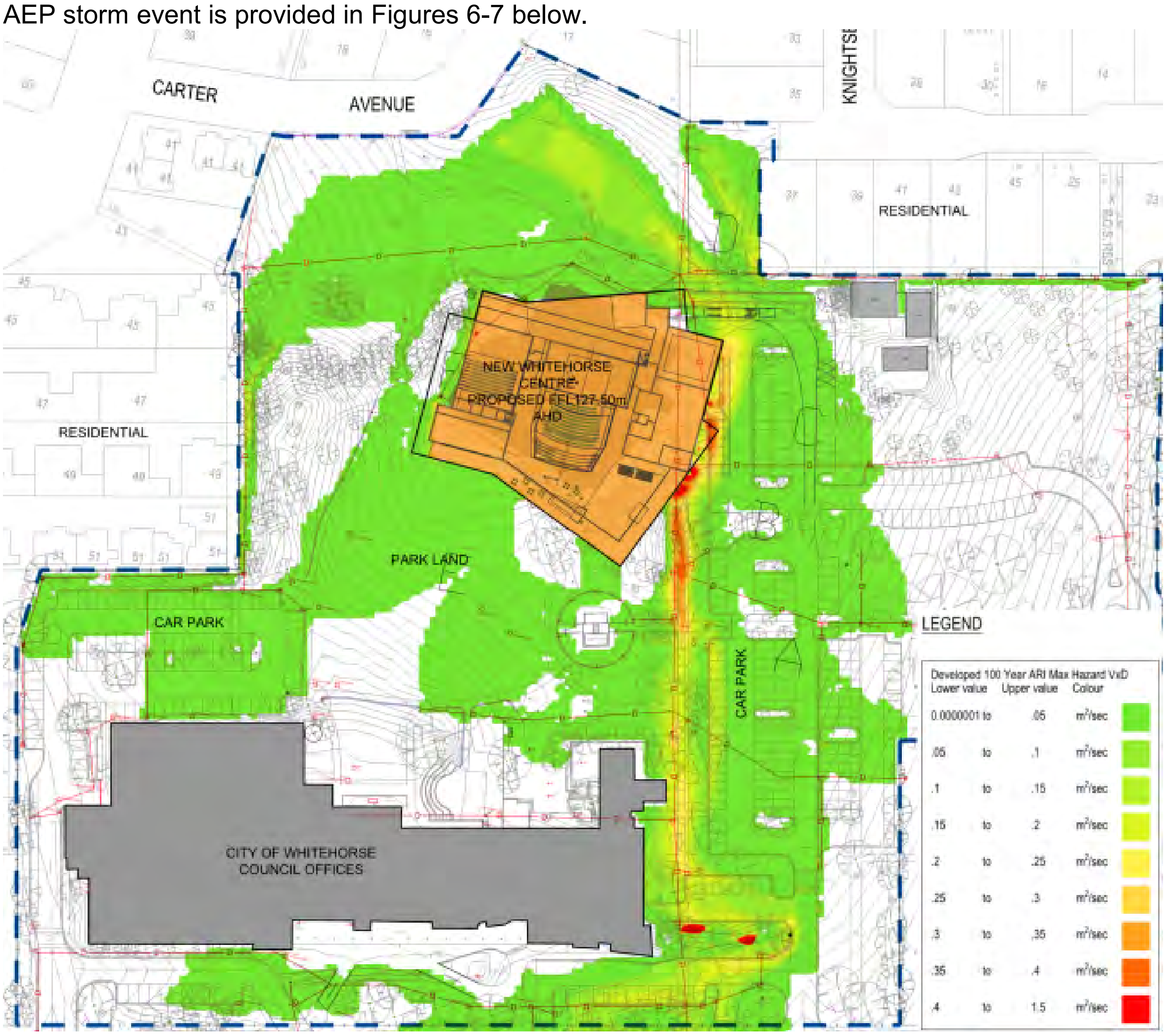


Figure 6-7 Post-Developed Velocity and Depth Product Contours

The relative hazard of flood flows across the site is generally considered to be low with product of flow velocity by depth typically (DxV) below $0.35m^2/s$. The exception to this is the area in the flood water directly to the east of the proposed Whitehorse Centre building with localised values reaching a maximum of $0.55\ m^2/s$. Product of velocity to depth values in excess of $0.35m^2/s$ are considered hazardous to people and may be damaging to property. Consideration to the hazardous flows will be considered in the flood risk mitigation measures discussed in Section 7.

6.3.4 Flow Velocity

Post-development flood mapping of maximum velocity vectors for the critical 1% AEP storm event is provided in Figures 6-8 below.

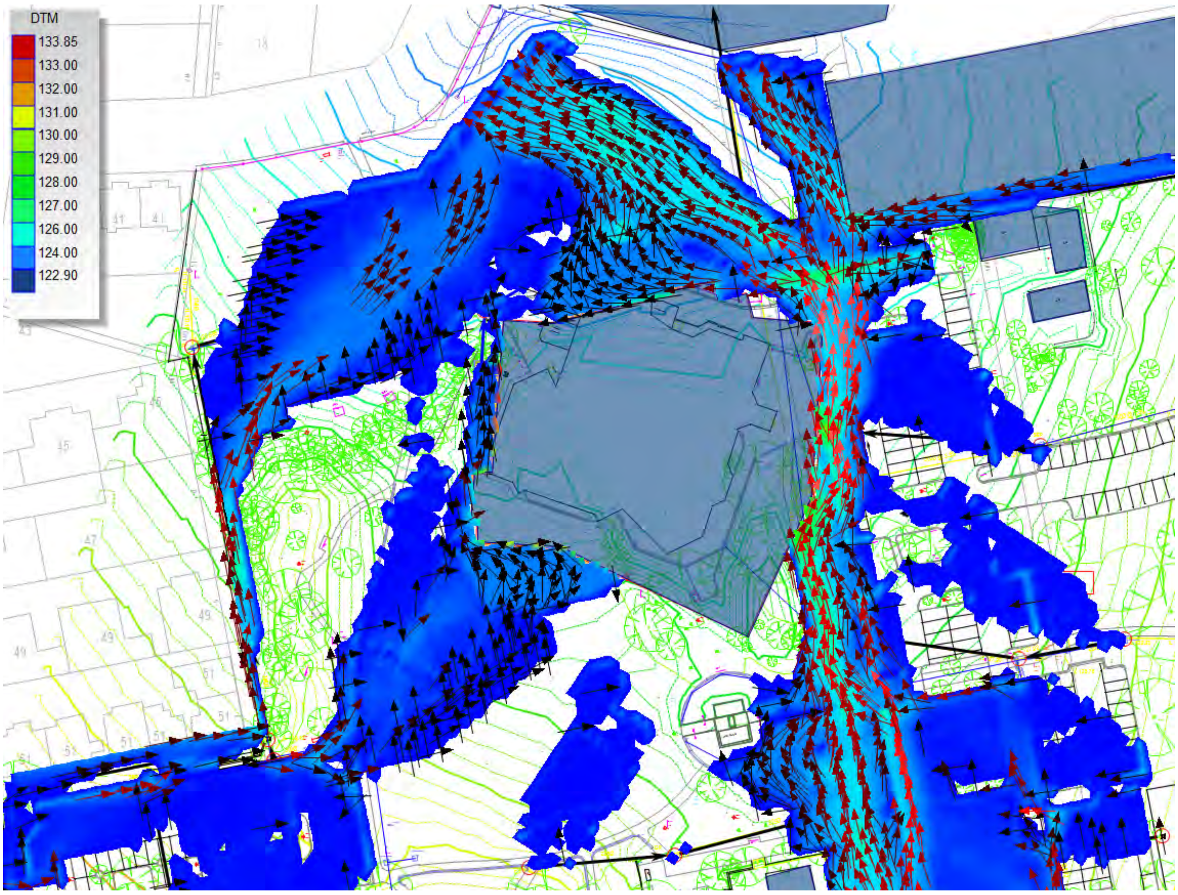


Figure 6-8 Post -Developed Site Max Water Depth with Velocity Vectors – 100 yr 20 min Storm Event

The maximum velocities of flows around the site are generally low with typical values less than 1 m/s. These low velocities are not considered to be hazardous.

However, on the eastern side of the proposed Whitehorse Centre building flow concentrations and elevated velocity values are observed in the model. The flow velocities observed at this location are the range from 1.3 to 2.2m/s. These flow rates are considered to be unacceptably high. It is recommended that ground reshaping to the car park area east of the building be undertaken to better disperse flows and reduce flow velocities.

6.4 Peak Discharge Rates

1% and d10% AEP flow hydrographs have been calculated at Stations 01, 02, 03, 04 and 05 below. Results are presented in Tables 6-1 and 6-2 respectively.

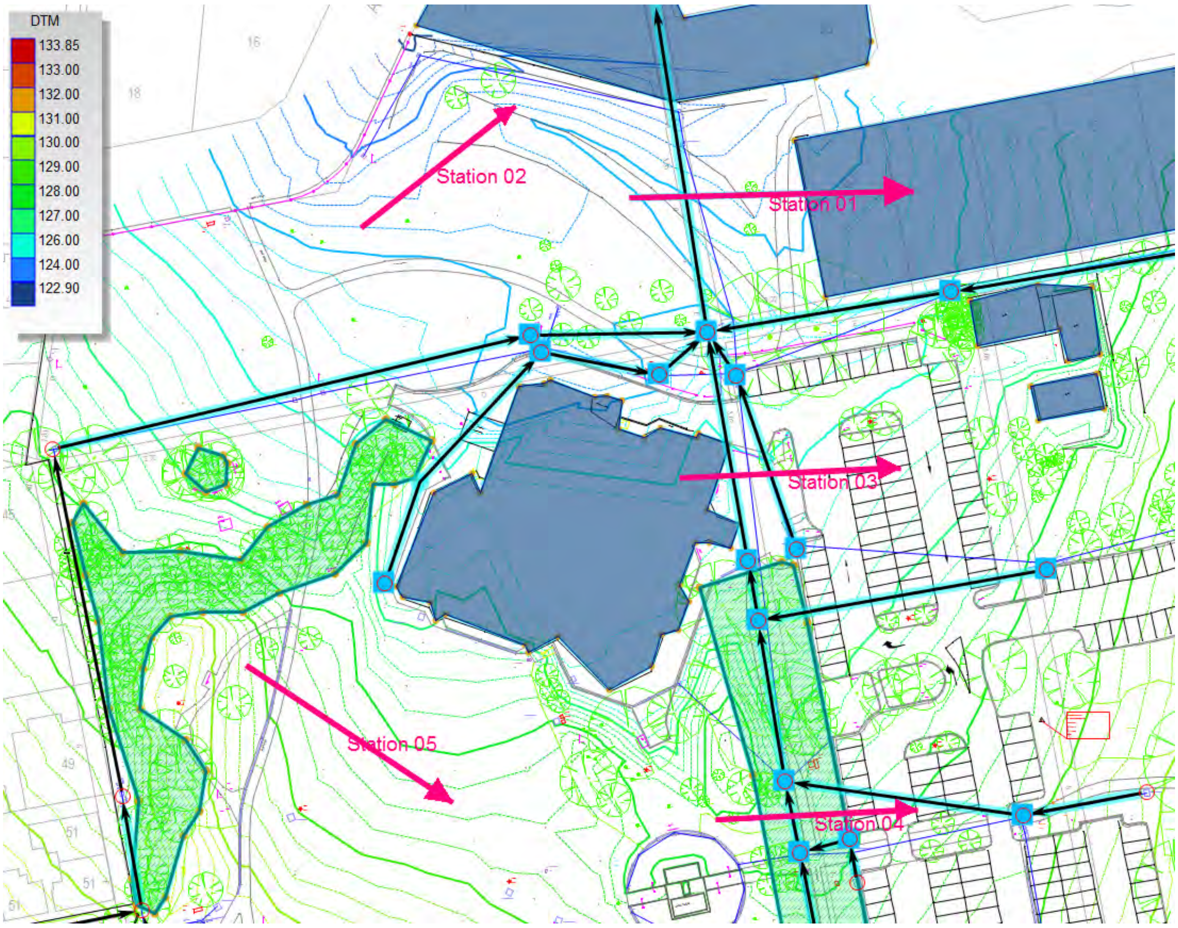


Figure 6-5 Peak Flow Station Locations

Table 6-1 10% AEP Peak Flow Rates (m^3/sec)

Location	Flow Though Pipe	Overland Flow	Total
Station 01	1.30	0.0003	1.30
Station 02	Nil	0.19	0.19
Station 03	0.92	0.24	1.16
Station 04	0.94	0.40	1.34
Station 05	Nil	Nil	Nil

Table 6-2 1% AEP Peak Flow Rates (m3/sec)

Location	Flow Though Pipe	Overland Flow	Total
Station 01	1.48	0.62	2.10
Station 02	Nil	1.82	1.82
Station 03	1.31	1.95	3.26
Station 04	1.09	2.01	3.10
Station 05	Nil	0.07	0.07

7 Flood Risk Summary and Mitigation Options

7.1 General

The proposed Whitehorse Centre Scenario 2B has a larger footprint than the existing arts centre building and creates a greater obstacle to flood flows. Significantly, the building extends further to the east than the existing building by approximately 15m and into the path of the existing overland flood flow. The effect of this building shift is to displace the overland flood flows to the east and causing increase in flow depth and increase in velocity of the flood water for the 1% AEP storm event.

Assessment if the flood risk to the new arts building has been completed in terms of the following consideration that is discussed in the subsequent sections:

- Nominate the proposed floor level to ensure at least 300mm freeboard above the 1% AEP flood level.
- Impacts on car park areas to ensure cars will not be damaged by flooding.
- Complete hazard assessment of flood flows in terms of depth to velocity relationship to ensure people can move safely about the building during a flood event are not endangered by deep or fast flowing water. Referring to Melbourne Water Guidelines safety is defined in terms of the depth and velocity of water over the area in question as follows:
  - Depth should be no more than 0.35m
  - Velocity should be no more than 1.5m/s, and
  - The product of depth and velocity should be no more than 0.35m2/s
- Afflux affects (i.e. increased flood levels) caused by the development and possible impacts upstream, and
- Safe access and egress routes from the building during flood.

7.2 Floor Levels

As discussed in Section 6.3.2, the nominated FFL of the building is 127.5m AHD with flood water freeboard level set 300mm lower than the FFL at 127.2m AHD. The freeboard level is observed to be exceeded in the model only on the southern side of the building. The flood water at this location is only minor sheet flows from the adjacent park land and not from the major overland flow path. Defence of the building from flooding at this location may be achieved by providing a small diversion drain or building a flood barrier into the building terrace wall as illustrated in Figure 7-1 below.

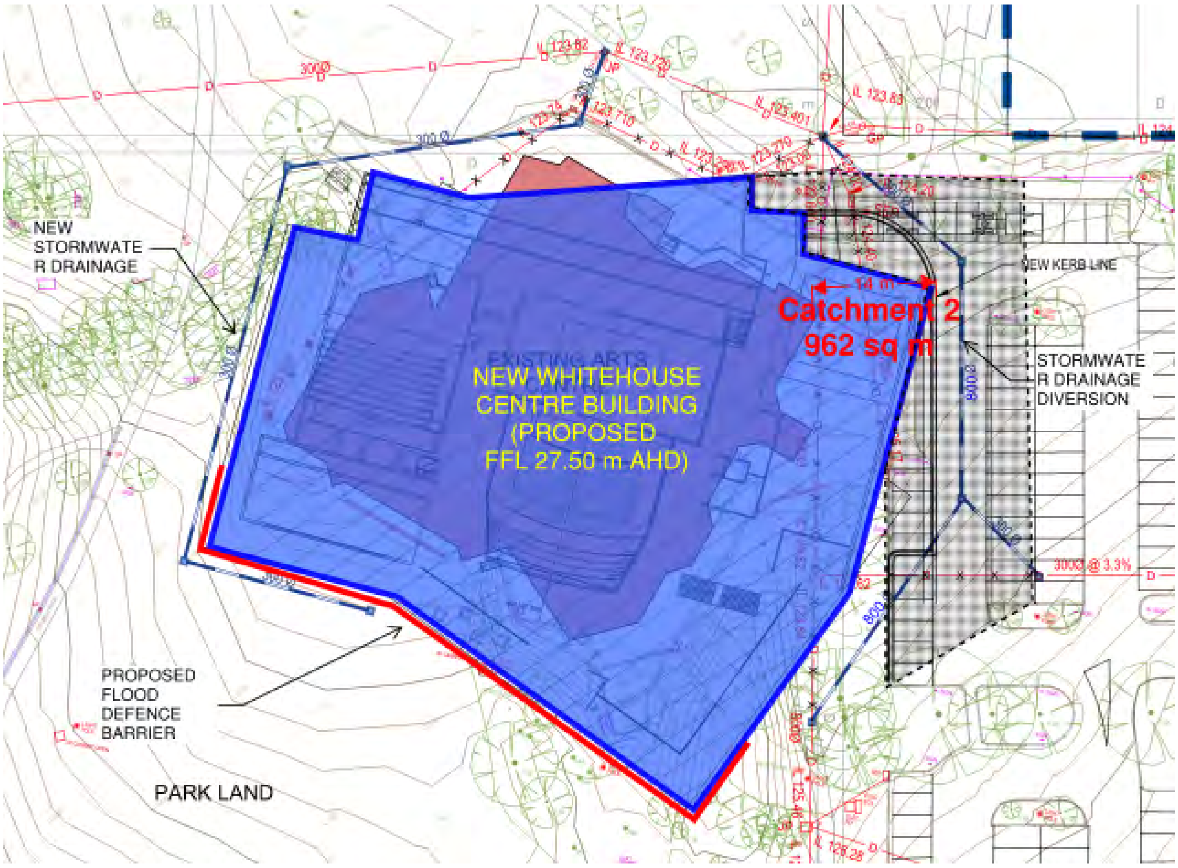


Figure 6-1 Proposed Flood Barrier to Defend Minor Flood Flows to South Side of Building

Floodwater elsewhere around the building is below the building freeboard level and not considered to place the building at risk of flood.

Hence the findings of the flood study support the proposed finished floor level of 127.5 AHD for the new building. It is noted that this floor level is 1.2m higher than FFL of the existing arts centre building.

7.3 Impacts on Car Parking

There has been minor increase in water levels observed in the between the existing and developed site flood levels on the east side of the new arts centre building in the order of the 50 to 100mm. However the flood modelling completed has not identified a significant increase in flood levels across the existing car parking spaces. Hence the increased flood risk to the car parking is considered to be negligible.

7.4 Afflux Effects

The overall increase in flood depth to the east of the building has been observed in the model to me relatively minor with increases in flood profile in the order of 50 to 150mm. These increases in flood levels are not observed to impact on other properties and the afflux affects in terms of flood risk are considered negligible.

7.5 Hazard Assessment

The Scenario 2B development proposal has resulted in increased flow depths and velocities on the east side of the building for the critical 1% AEP storm event modelled.

The maximum flood water depth increase has been relatively minor, however in some localised areas east of the building the flood water does exceed the nominated safe depth of 0.35m with water depths observed in the flood model up 0.44m.

The increase on flood flow velocity to the east of the building has been more significant with the peak flow velocity increasing from max value of 1.15m/s for the existing scenario to approximately 2.2m/s for the developed Scenario 2B, which exceeds the nominated acceptable level of 1.5m/s

The resultant increase in depth and velocity to the east side of the building for the developed Scenario 2B produces an increase in the relative hazard. As measured by the product of velocity and depth (VxD) the maximum observed value is 5.5m^2/s, which exceeds the nominated acceptable level of 0.35m^2/s. These hot spots of high hazard flows are illustrated in Figure 6-7.

To mitigate the excessive depth and flow velocities observed in the developed scenario model it is proposal to re-profile the access road and car parking areas directly east of the building to be better disperse the flood flows in this area. This remodelling work has not yet been completed and will be completed in the next stage of design work.

7.6 Safe Access and Egress

The Scenario 2B development proposal will need to consider access and egress in the building design to ensure that people attempting to enter or leave the building during a flood event are not endangered by deep or fast flowing water.

As discussed in 7.3.2 above, the area of hazardous flood flows has been identified on the eastern side of the building. These hazardous areas should be considered in the design of the building to ensure there are alternative entrance and exit points to the building away from the identified hazardous flood area on the east side of the building.

8 References

Relevant Australian Standards:

- AS3500.3 Stormwater Drainage

Other guidance documents:

- Australian Rainfall and Runoff Volumes 1 & 2
- Melbourne Water Standards and Specifications, Hydrological and Hydraulic Design
- Bureau of Meteorology for Rainfall Data and IFD Charts

9 Limitations of Estimates

Irwinconsult has used its best endeavours to understand the extent and details of the existing stormwater drainage system, and the models developed from this information are as accurate and comprehensive as reasonably possible. We acknowledge that gaps in information have been encountered. To fill these gaps we have used our best judgement on assuming and interpolating data inputs.

We have used our best judgement to estimate hydrological and hydraulic modelling parameter used in the flood models. Were necessary drawn on guidelines from reputable authorities such as Melbourne Water to arrive on parameters used.

APPENDIX A

FEATURE SURVEY AND EXISTING DRAINAGE PLAN

ISSUE	DESCRIPTION	BY	DATE	ISSUE	DESCRIPTION	BY	DATE
P1	DESCRIPTION		DATE				

STATUS

PRELIMINARY ISSUE

NOT TO BE USED FOR CONSTRUCTION PURPOSES

SCALE 15 7.5 0 15 30 45m
H 1:750 AT

SCALE INDICATED FOR REFERENCE ONLY. DO NOT SCALE DRAWING.

irwinconsult
Level 3, 289 Wellington Parade South
East Melbourne VIC 3002
t +61 3 9622 9700 f +61 3 9650 6664
mlb@irwinconsult.com.au ABN 89 050 214 894

PROJECT
WHITEHORSE CIVIC CENTRE

CLIENT
CITY OF WHITEHORSE

TITLE
EXISTING SITE SURVEY PLAN

DATE	DESIGNER	DRAWN	CHECKED	APPROVED
Sep, 2014	PLM	PK	LOT	PLM

SCALE AT A1	JOB No.	DRAWING No.	ISSUE
1:750	12ME0460	CSK001	P1

APPENDIX B

CATCHMENT DATA

Physical Hydrology

Name	Storm	Subcatchm	Node Name	Catchment Nu	Width	Area	Impervious Pe	Slope	Infiltration Ref
P02.07	20 min 100 y		P02.07		0.000	0.000	0.0	0.0000	
P02.06	20 min 100 y	1	P02.06	1	80.000	0.355	85.0	0.0250	grass
P02.05	20 min 100 y		P02.05		0.000	0.000	0.0	0.0000	
P02.04	20 min 100 y		P02.04		0.000	0.000	0.0	0.0000	
P03.01	20 min 100 y	1	P03.01	1	60.000	0.348	90.0	0.0250	grass
P02.02	20 min 100 y	1	P02.02	1	10.000	0.102	0.0	0.0250	grass
P02.02		2		2	20.000	0.102	85.0	0.0250	grass
P02.01	20 min 100 y		P02.01	1	0.000	0.000	0.0	0.0000	
P01.02	20 min 100 y		P01.02		0.000	0.000	0.0	0.0000	
P04.01	20 min 100 y	1	P04.01	1	30.000	0.131	95.0	0.2000	grass
P06.02	20 min 100 y	1	P06.02	1	60.000	1.069	25.0	0.0250	grass
P06.01	20 min 100 y	1	P06.01	1	45.000	0.493	10.0	0.0250	grass
P05.02	20 min 100 y	1	P05.02	1	10.000	0.038	90.0	0.0250	grass
P05.01	20 min 100 y	1	P05.01	1	25.000	0.233	100.0	0.0250	grass
P08.02	20 min 100 y	1	P08.02	1	20.000	0.148	0.0	0.0250	grass
P08.01	20 min 100 y	1	P08.01	1	15.000	0.090	90.0	0.0250	grass
P01.05	20 min 100 y		P01.05		0.000	0.000	0.0	0.0000	
P01.01	20 min 100 y	1	P01.01	1	35.000	0.174	0.0	0.0500	grass
P01.11	20 min 100 y	1	P01.11	1	10.000	0.082	85.0	0.0250	grass
P01.11		2		2	360.000	12.719	90.0	0.0250	grass
P01.10	20 min 100 y	1	P01.10	1	15.000	0.144	90.0	0.0250	grass
P01.09	20 min 100 y	1	P01.09	1	5.000	0.070	0.0	0.0250	grass
P01.09		2		2	5.000	0.017	25.0	0.0250	grass
P01.09		3		3	15.000	0.044	90.0	0.0250	grass
P01.08	20 min 100 y	1	P01.08	1	40.000	0.125	100.0	0.2000	grass
P01.07	20 min 100 y	1	P01.07	1	30.000	0.156	80.0	0.0250	grass
P01.06	20 min 100 y	1	P01.06	1	30.000	0.154	5.0	0.0250	grass
P11.03	20 min 100 y	1	P11.03	1	40.000	0.376	90.0	0.0250	grass
P11.02	20 min 100 y	1	P11.02	1	5.000	0.064	90.0	0.0250	grass
P11.01	20 min 100 y		P11.01		0.000	0.000	0.0	0.0000	
P12.01	20 min 100 y	1	P12.01	1	30.000	0.105	25.0	0.0250	grass
P13.01	20 min 100 y	1	P13.01	1	40.000	0.148	100.0	0.2000	grass
P13.01		2		2	15.000	0.039	80.0	0.0250	grass
P15.05	20 min 100 y	1	P15.05	1	60.000	0.213	100.0	0.2000	grass
P15.04	20 min 100 y	1	P15.04	1	60.000	0.281	60.0	0.0250	grass

Physical Hydrology

Name	Storm	Subcatchm	Node Name	Catchment Nu	Width	Area	Impervious Pe	Slope	Infiltration Ref
P15.03	20 min 100 y		P15.03		0.000	0.000	0.0	0.0000	
P15.02	20 min 100 y	1	P15.02	1	25.000	0.179	60.0	0.0250	grass
P15.01	20 min 100 y	1	P15.01	1	10.000	0.131	85.0	0.0250	grass
P14.01	20 min 100 y		P14.01		0.000	0.000	0.0	0.0000	
P03.03	20 min 100 y	1	P03.03	1	50.000	0.119	100.0	0.2000	grass
P03.03		2		2	20.000	0.106	90.0	0.0250	grass
P03.02	20 min 100 y		P03.02		0.000	0.000	0.0	0.0000	
P09.01	20 min 100 y		P09.01		0.000	0.000	0.0	0.0000	
P09.02	20 min 100 y	1	P09.02	1	30.000	0.164	90.0	0.0250	grass
P14.03	20 min 100 y		P14.03		0.000	0.000	0.0	0.0000	
P14.02	20 min 100 y	1	P14.02	1	5.000	0.012	90.0	0.0250	grass
P10.02	20 min 100 y	1	P10.02	1	20.000	0.061	5.0	0.0250	grass
P10.01	20 min 100 y	1	P10.01	1	10.000	0.033	5.0	0.0250	grass
P01.03	20 min 100 y	1	P01.03	1	10.000	0.097	50.0	0.0250	grass
P01.03		2		2	20.000	0.076	95.0	0.2000	grass
P01.03		3		3	36.000	0.274	0.0	0.0250	grass
P04.03	20 min 100 y	1	P04.03	1	20.000	0.066	100.0	0.2000	grass
P04.03		2		2	40.000	0.212	20.0	0.0250	grass
P04.02	20 min 100 y	1	P04.02	1	5.000	0.029	0.0	0.0250	grass
P07.02	20 min 100 y	1	P07.02	1	38.000	0.312	40.0	0.0250	grass
P02.03	20 min 100 y	1	P02.03	1	80.000	0.619	85.0	0.0250	grass
P15.07	20 min 100 y	1	P15.07	1	50.000	0.297	85.0	0.0250	grass
P15.06	20 min 100 y		P15.06		0.000	0.000	0.0	0.0000	
P06.03	20 min 100 y	1	P06.03	1	20.000	0.267	90.0	0.0250	grass
P06.03		2		2	75.000	1.341	60.0	0.0250	grass
P01.04	20 min 100 y		P01.04		0.000	0.000	0.0	0.0000	

APPENDIX C

1D PIPE DATA

Basic Conduit Data

Name	Storm	Link Name	Length m	Shape	Roughness	Diameter (Height) m	Upstream Invert Elevation	Downstream Invert Elevation
C01.01	20 min 100 y	C01.01	67.330	Circular	0.0140	0.800	122.580	122.220
C01.02	20 min 100 y	C01.02	40.880	Circular	0.0140	0.800	123.700	122.600
C01.03	20 min 100 y	C01.03	10.670	Circular	0.0140	0.800	123.820	123.720
C01.04	20 min 100 y	C01.04	28.680	Circular	0.0140	0.800	125.460	123.840
C01.05	20 min 100 y	C01.05	12.820	Circular	0.0140	0.800	126.028	125.480
C01.06	20 min 100 y	C01.06	25.260	Circular	0.0140	0.800	126.616	126.030
C01.07	20 min 100 y	C01.07	28.390	Circular	0.0140	0.800	127.705	126.636
C01.08	20 min 100 y	C01.08	13.170	Circular	0.0140	0.800	127.900	127.725
C01.09	20 min 100 y	C01.09	37.460	Circular	0.0140	0.800	128.700	128.100
C01.10	20 min 100 y	C01.10	8.040	Circular	0.0140	0.800	129.700	128.720
C02.01	20 min 100 y	C02.01	31.070	Circular	0.0140	0.375	123.720	123.407
C02.02	20 min 100 y	C02.02	86.340	Circular	0.0140	0.375	126.688	123.820
C02.03	20 min 100 y	C02.03	60.540	Circular	0.0140	0.300	128.222	127.038
C02.04	20 min 100 y	C02.04	22.040	Circular	0.0140	0.300	128.760	128.322
C02.05	20 min 100 y	C02.05	52.680	Circular	0.0140	0.225	131.115	129.010
C02.06	20 min 100 y	C02.06	17.880	Circular	0.0140	0.225	132.086	131.265
C02.07	20 min 100 y	C02.07	44.510	Circular	0.0140	0.150	132.680	132.132
C03.01	20 min 100 y	C03.01	4.260	Circular	0.0140	0.300	129.222	128.870
C03.02	20 min 100 y	C03.02	25.930	Circular	0.0140	0.300	129.904	129.222
C03.03	20 min 100 y	C03.03	34.420	Circular	0.0140	0.300	130.811	129.904
C04.01	20 min 100 y	C04.01	11.260	Circular	0.0140	0.300	123.270	123.000
C04.02	20 min 100 y	C04.02	21.100	Circular	0.0140	0.300	123.710	123.290
C04.03	20 min 100 y	C04.03	50.340	Circular	0.0140	0.225	125.891	123.740
C05.01	20 min 100 y	C05.01	9.100	Circular	0.0140	0.300	124.200	124.000
C05.02	20 min 100 y	C05.02	32.450	Circular	0.0140	0.225	125.170	124.400
C06.01	20 min 100 y	C06.01	43.370	Circular	0.0140	0.375	124.580	123.830
C06.02	20 min 100 y	C06.02	77.030	Circular	0.0140	0.375	129.090	124.600
C06.03	20 min 100 y	C06.03	67.590	Circular	0.0140	0.375	130.550	129.150
C07.01	20 min 100 y	C07.01	52.330	Circular	0.0140	0.300	126.870	124.620
C08.01	20 min 100 y	C08.01	42.170	Circular	0.0140	0.300	127.900	126.280
C08.02	20 min 100 y	C08.02	22.250	Circular	0.0140	0.225	128.788	127.920
C09.01	20 min 100 y	C09.01	8.990	Circular	0.0140	0.225	126.980	126.040
C09.02	20 min 100 y	C09.02	13.440	Circular	0.0140	0.225	127.430	127.000

Basic Conduit Data

Name	Storm	Link Name	Length m	Shape	Roughness	Diameter (Height) m	Upstream Invert Elevation	Downstream Invert Elevation
C10.01	20 min 100 y	C10.01	38.760	Circular	0.0140	0.225	127.500	127.416
C10.02	20 min 100 y	C10.02	30.160	Circular	0.0140	0.225	129.500	127.520
C11.01	20 min 100 y	C11.01	32.210	Circular	0.0140	0.300	128.100	127.416
C11.02	20 min 100 y	C11.02	10.920	Circular	0.0140	0.225	128.800	128.120
C11.03	20 min 100 y	C11.03	22.770	Circular	0.0140	0.225	129.260	128.840
C12.01	20 min 100 y	C12.01	24.190	Circular	0.0140	0.225	129.260	128.820
C13.01	20 min 100 y	C13.01	52.260	Circular	0.0140	0.225	129.939	128.505
C14.01	20 min 100 y	C14.01	5.380	Circular	0.0140	0.225	130.260	130.000
C14.02	20 min 100 y	C14.02	16.600	Circular	0.0140	0.225	130.400	130.340
C14.03	20 min 100 y	C14.03	7.950	Circular	0.0140	0.225	130.700	130.450
C15.01	20 min 100 y	C15.01	40.710	Circular	0.0140	0.300	130.380	130.250
C15.02	20 min 100 y	C15.02	16.730	Circular	0.0140	0.300	130.600	130.400
C15.03	20 min 100 y	C15.03	21.290	Circular	0.0140	0.300	131.020	130.620
C15.04	20 min 100 y	C15.04	16.790	Circular	0.0140	0.300	131.480	131.040
C15.05	20 min 100 y	C15.05	16.860	Circular	0.0140	0.300	131.600	131.500
C15.06	20 min 100 y	C15.06	64.740	Circular	0.0140	0.300	131.780	131.620
C15.07	20 min 100 y	C15.07	19.870	Circular	0.0140	0.300	132.600	131.800

APPENDIX D

POST-DEVELOPMENT FLOOD MAPS

DATE PLOTTED: 16 September 2014 2:57 PM BY: PETRA KENNA

CAD FILE: 12ME0460-CSK006.DWG

ISSUE	DESCRIPTION	BY	DATE	ISSUE	DESCRIPTION	BY	DATE
P1	DESCRIPTION		DATE				

STATUS

PRELIMINARY ISSUE

NOT TO BE USED FOR CONSTRUCTION PURPOSES

SCALE 10 5 0 10 20 30m
H 1:500 AT

SCALE INDICATED FOR REFERENCE ONLY. DO NOT SCALE DRAWING.

irwinconsult
Level 3, 289 Wellington Parade South
East Melbourne VIC 3002
t +61 3 9622 9700 f +61 3 9650 6664
mlb@irwinconsult.com.au ABN 89 050 214 894

PROJECT
WHITEHORSE CIVIC CENTRE

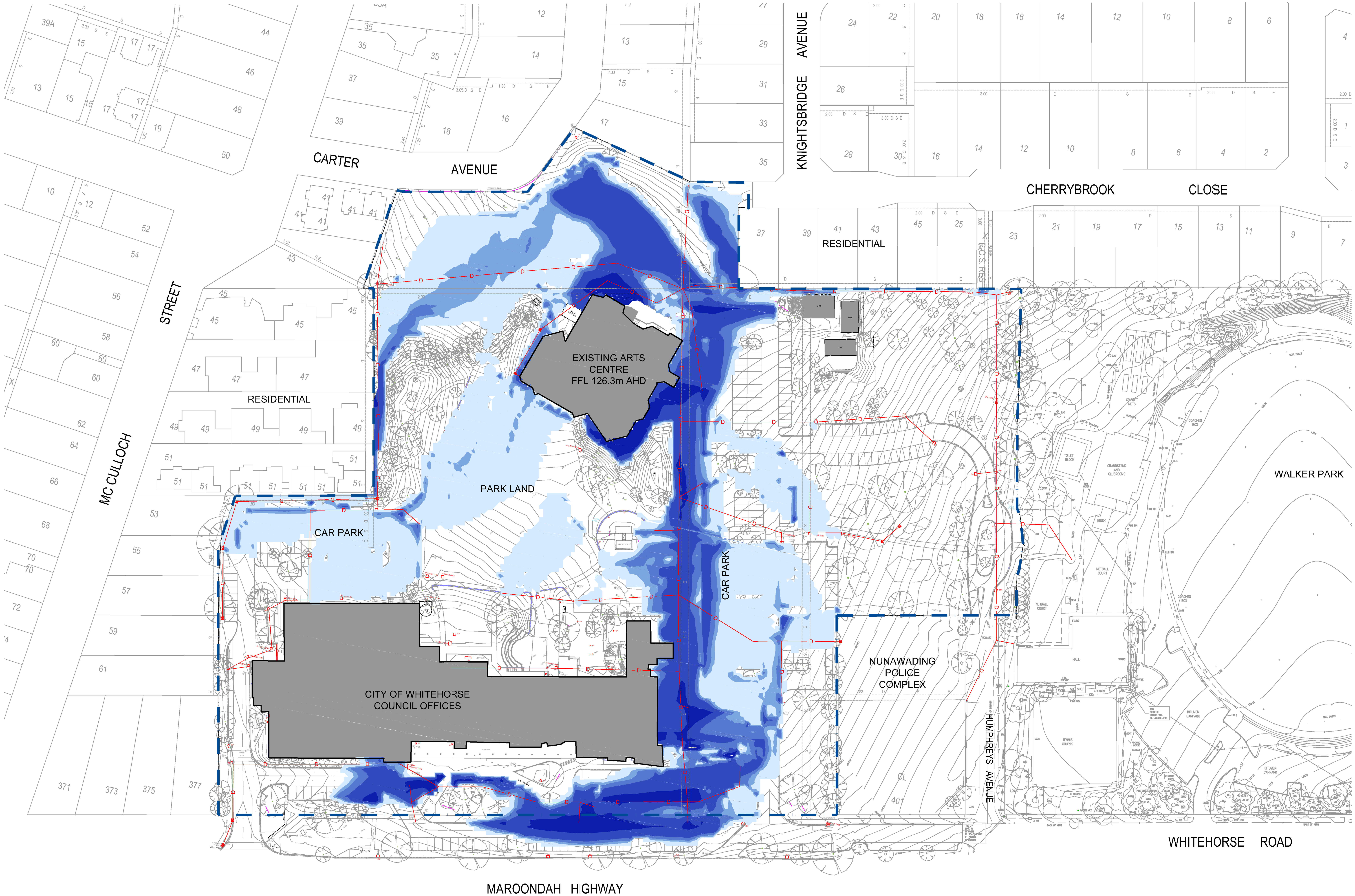
TITLE
GENERAL ARRANGEMENT PLAN

CLIENT
CITY OF WHITEHORSE

DATE	DESIGNER	DRAWN	CHECKED	APPROVED
Sep, 2014	PLM	PK	LOT	PLM

SCALE AT A1	JOB No.	DRAWING No.	ISSUE
1:500	12ME0460	CSK006	P1

DATE PLOTTED: 16 September 2014 2:27 PM BY : PETRA KENNA



LEGEND

Existing 100 Year ARI Max. Depth

Lower value		Upper value		Colour
0	to	25	mm	
25	to	50	mm	
50	to	100	mm	
100	to	250	mm	
250	to	500	mm	

ISSUE	DESCRIPTION	BY	DATE	ISSUE	DESCRIPTION	BY	DATE
P1	PRELIMINARY ISSUE	PK	NYI				

STATUS

PRELIMINARY ISSUE

NOT TO BE USED FOR CONSTRUCTION PURPOSES

SCALE 15 7.5 0 15 30 45m

H 1:750 AT

SCALE INDICATED FOR REFERENCE ONLY. DO NOT SCALE DRAWING.

irwinconsult
Level 3, 289 Wellington Parade South
East Melbourne VIC 3002
t +61 3 9622 9700 f +61 3 9650 6664
mlb@irwinconsult.com.au ABN 89 050 214 894

PROJECT
WHITEHORSE CIVIC CENTRE

CLIENT
CITY OF WHITEHORSE

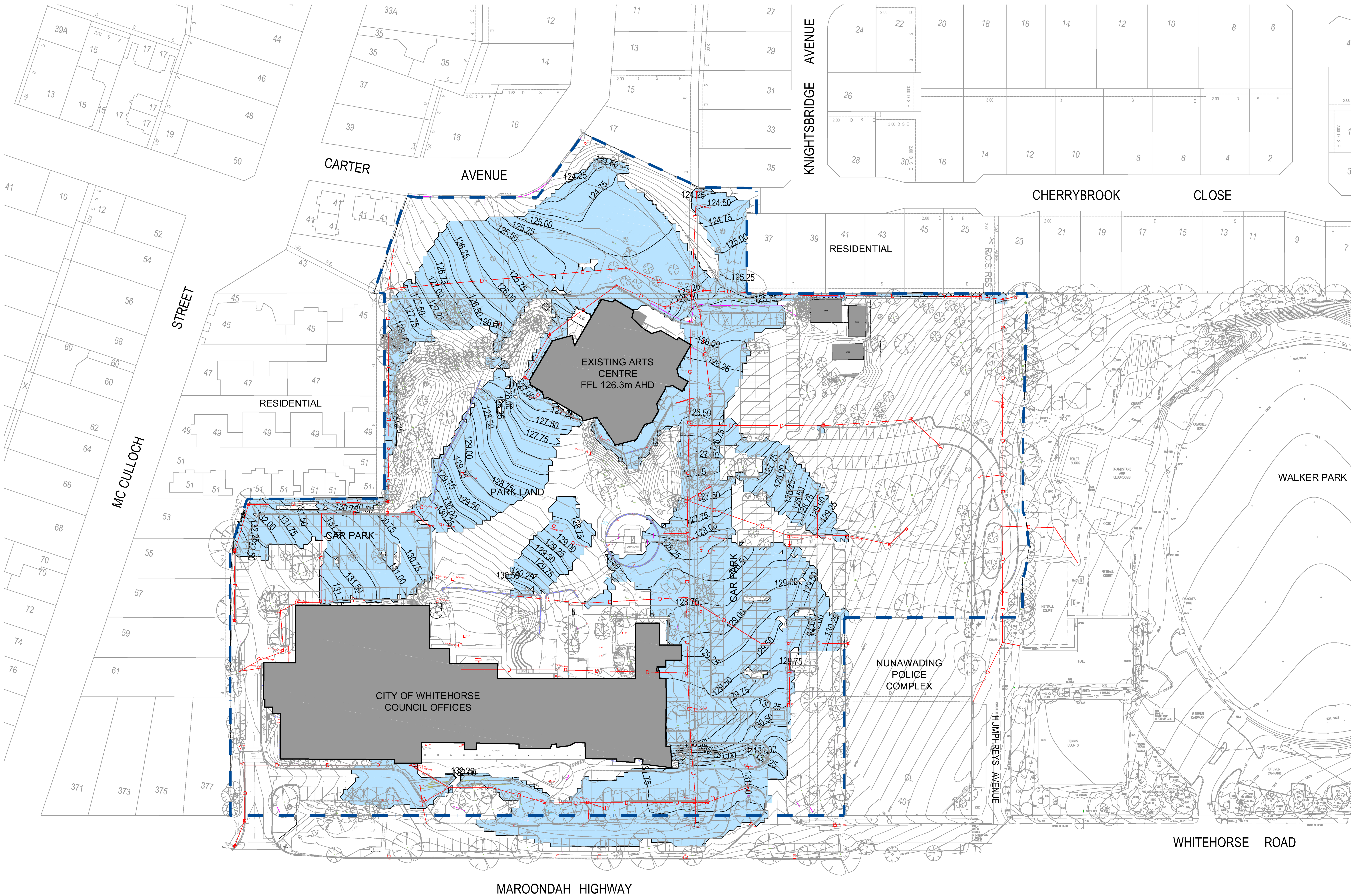
TITLE
EXISTING SITE FLOOD PLAN
MAXIMUM WATER DEPTHS
1% AEP CRITICAL STORM EVENT

DATE	DESIGNER	DRAWN	CHECKED	APPROVED
Sep, 2014	PLM	PK	LOT	PLM

SCALE AT A1	JOB No.	DRAWING No.	ISSUE
1:750	12ME0460	CSK007	P1

CAD FILE: 12ME0460-CSK007-CSK009.DWG

DATE PLOTTED: 16 September 2014 2:30 PM BY : PETRA KENNA



NOTES:

1. ALL FLOOD LEVEL CONTOURS ARE MEASURED IN METRES ABOVE AUSTRALIAN HEIGHT DATUM (m AHD)

CAD FILE : 12ME0460-CSK007-CSK009.DWG

ISSUE	DESCRIPTION	BY	DATE
P1	PRELIMINARY ISSUE	PK	NYI

STATUS

PRELIMINARY ISSUE

NOT TO BE USED FOR CONSTRUCTION PURPOSES

SCALE 15 7.5 0 15 30 45m
H 1:750 AT

SCALE INDICATED FOR REFERENCE ONLY. DO NOT SCALE DRAWING.

irwinconsult
Level 3, 289 Wellington Parade South
East Melbourne VIC 3002
t +61 3 9622 9700 f +61 3 9650 6664
mlb@irwinconsult.com.au ABN 89 050 214 894

PROJECT
WHITEHORSE CIVIC CENTRE

CLIENT
CITY OF WHITEHORSE

TITLE
EXISTING SITE FLOOD PLAN
MAXIMUM SURFACE CONTOURS
1% AEP CRITICAL STORM EVENT

DATE	DESIGNER	DRAWN	CHECKED	APPROVED
Sep, 2014	PLM	PK	LOT	PLM

SCALE AT A1	JOB No.	DRAWING No.	ISSUE
1:750	12ME0460	CSK008	P1

DATE PLOTTED: 16 September 2014 2:30 PM BY : PETRA KENNA

LEGEND

Existing 100 Year ARI Max Hazard VxD

Lower value		Uppervalue	Colour
0.0000001	to	.05	m^2/sec
.05	to	.1	m^2/sec
.1	to	.15	m^2/sec
.15	to	.2	m^2/sec
.2	to	.25	m^2/sec
.25	to	.3	m^2/sec
.3	to	.35	m^2/sec
.35	to	.4	m^2/sec
.4	to	1.5	m^2/sec

CAD FILE : 12ME0460-CSK007-CSK009.DWG

ISSUE	DESCRIPTION	BY	DATE
P1	PRELIMINARY ISSUE	PK	NYI

STATUS

PRELIMINARY ISSUE

NOT TO BE USED FOR CONSTRUCTION PURPOSES

SCALE 15 7.5 0 15 30 45m
H 1:750 AT

SCALE INDICATED FOR REFERENCE ONLY. DO NOT SCALE DRAWING.

irwinconsult
Level 3, 289 Wellington Parade South
East Melbourne VIC 3002
t +61 3 9622 9700 f +61 3 9650 6664
mlb@irwinconsult.com.au ABN 89 050 214 894

PROJECT
WHITEHORSE CIVIC CENTRE

CLIENT
CITY OF WHITEHORSE

TITLE
EXISTING SITE FLOOD PLAN
HAZARD ASSESSMENT VxD
1% AEP CRITICAL STORM EVENT

DATE	DESIGNER	DRAWN	CHECKED	APPROVED
Sep, 2014	PLM	PK	LOT	PLM

SCALE AT A1	JOB No.	DRAWING No.	ISSUE
1:750	12ME0460	CSK009	P1

DATE PLOTTED: 16 September 2014 2:32 PM BY : PETRA KENNA

CAD FILE: 12ME0460-CSK010-CSK012.DWG

ISSUE	DESCRIPTION	BY	DATE
P1	PRELIMINARY ISSUE	PK	NYI

STATUS

PRELIMINARY ISSUE

NOT TO BE USED FOR CONSTRUCTION PURPOSES

SCALE 15 7.5 0 15 30 45m

H 1:750 AT

SCALE INDICATED FOR REFERENCE ONLY. D) NOT SCALE DRAWING.

irwinconsult
Level 3, 289 Wellington Parade South
East Melbourne VIC 3002
t +61 3 9622 9700 f +61 3 9650 6664
mlb@irwinconsult.com.au ABN 89 050 214 894

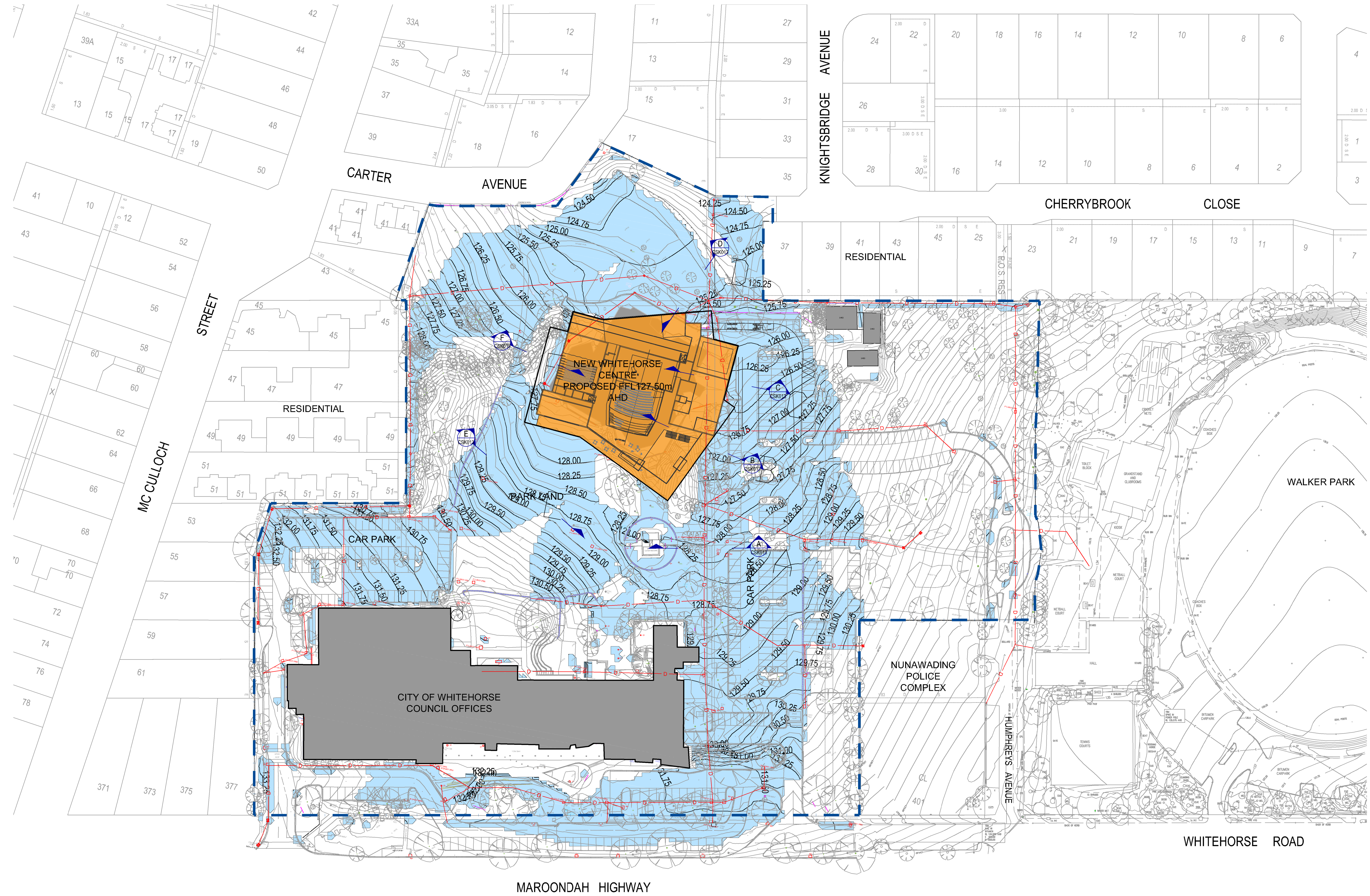
PROJECT
WHITEHORSE CIVIC CENTRE

CLIENT
CITY OF WHITEHORSE

TITLE
DEVELOPED SITE FLOOD PLAN
MAXIMUM WATER DEPTHS
1% AEP CRITICAL STORM EVENT

DATE	DESIGNER	DRAWN	CHECKED	APPROVED
Sep, 2014	PLM	PK	LOT	PLM

SCALE AT A1	JOB No.	DRAWING No.	ISSUE
1:750	12ME0460	CSK010	P1



NOTES:

1. ALL FLOOD LEVEL CONTOURS ARE MEASURED IN METRES ABOVE AUSTRALIAN HEIGHT DATUM (m AHD)

DATE PLOTTED: 16 September 2014 2:33 PM BY : PETRA KENNA

CAD FILE: 12ME0460-CSK010-CSK012.DWG

ISSUE	DESCRIPTION	BY	DATE	ISSUE	DESCRIPTION	BY	DATE
P1	PRELIMINARY ISSUE	PK	NYI				

STATUS

PRELIMINARY ISSUE

NOT TO BE USED FOR CONSTRUCTION PURPOSES

SCALE 15 7.5 0 15 30 45m

H 1:750 AT

SCALE INDICATED FOR REFERENCE ONLY. DO NOT SCALE DRAWING.

irwinconsult

Level 3, 289 Wellington Parade South
East Melbourne VIC 3002
t +61 3 9622 9700 f +61 3 9650 6664
mlb@irwinconsult.com.au ABN 89 050 214 894

PROJECT
WHITEHORSE CIVIC CENTRE

CLIENT
CITY OF WHITEHORSE

TITLE
DEVELOPED SITE FLOOD PLAN
MAXIMUM SURFACE CONTOURS
1% AEP CRITICAL STORM EVENT

DATE	DESIGNER	DRAWN	CHECKED	APPROVED
Sep, 2014	PLM	PK	LOT	PLM

SCALE AT A1	JOB No.	DRAWING No.	ISSUE
1:750	12ME0460	CSK011	P1

LEGEND

Developed 100 Year ARI Max Hazard VxD

Lower value		Upper value	Colour
0.0000001	to	.05	m^2/sec
.05	to	.1	m^2/sec
.1	to	.15	m^2/sec
.15	to	.2	m^2/sec
.2	to	.25	m^2/sec
.25	to	.3	m^2/sec
.3	to	.35	m^2/sec
.35	to	.4	m^2/sec
.4	to	1.5	m^2/sec

DATE PLOTTED: 16 September 2014 2:35 PM BY : PETRA KENNA

CAD FILE: 12ME0460-CSK010-CSK012.DWG

ISSUE	DESCRIPTION	BY	DATE
P1	PRELIMINARY ISSUE	PK	NYI

STATUS

PRELIMINARY ISSUE

NOT TO BE USED FOR CONSTRUCTION PURPOSES

SCALE 15 7.5 0 15 30 45m
H 1:750 AT

SCALE INDICATED FOR REFERENCE ONLY. DO NOT SCALE DRAWING.

irwinconsult
Level 3, 289 Wellington Parade South
East Melbourne VIC 3002
t +61 3 9622 9700 f +61 3 9650 6664
mlb@irwinconsult.com.au ABN 89 050 214 894

PROJECT
WHITEHORSE CIVIC CENTRE

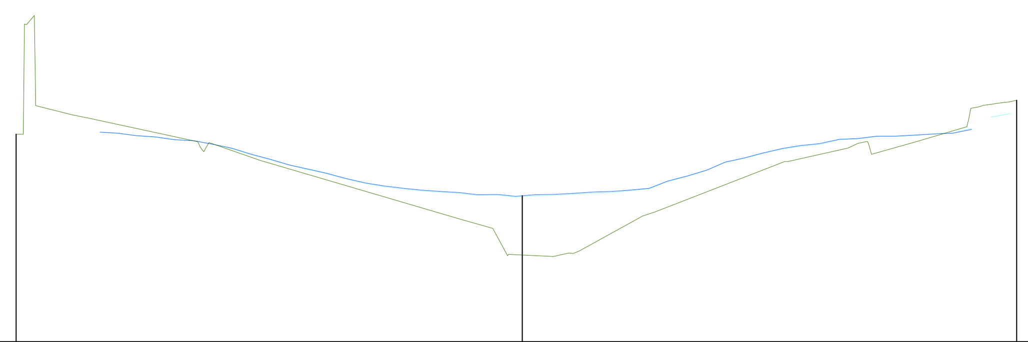
CLIENT
CITY OF WHITEHORSE

TITLE
DEVELOPED SITE FLOOD PLAN HAZARD ASSESSMENT VxD 1% AEP CRITICAL STORM EVENT

DATE	DESIGNER	DRAWN	CHECKED	APPROVED
Sep, 2014	PLM	PK	LOT	PLM

SCALE AT A1	JOB No.	DRAWING No.	ISSUE
1:750	12ME0460	CSK012	P1

DATE PLOTTED: 11 September 2014 4:27 PM BY : DAVID GROS

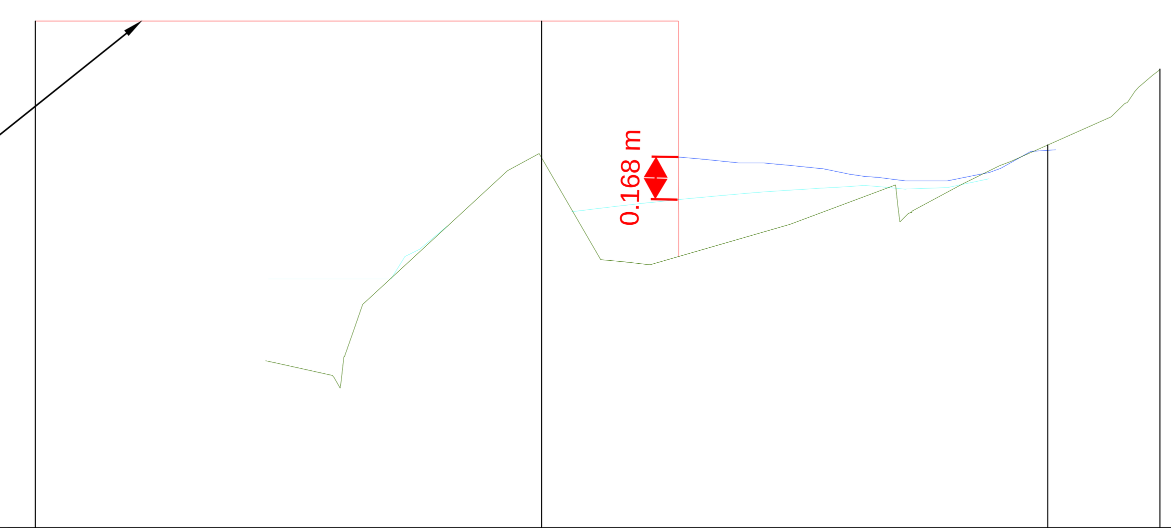


DATUM 127.500

DEVELOPED 100 YEAR ARI FLOOD WATER LEVEL		128.078	
EXISTING 100 YEAR ARI FLOOD WATER LEVEL		128.074	
EXISTING SURFACE	128.322	127.843	128.456
OFFSET	0.000	20.000	39.536

SECTION SECTION A-A

HORIZONTAL SCALE 1 : 250
VERTICAL SCALE 1 : 25

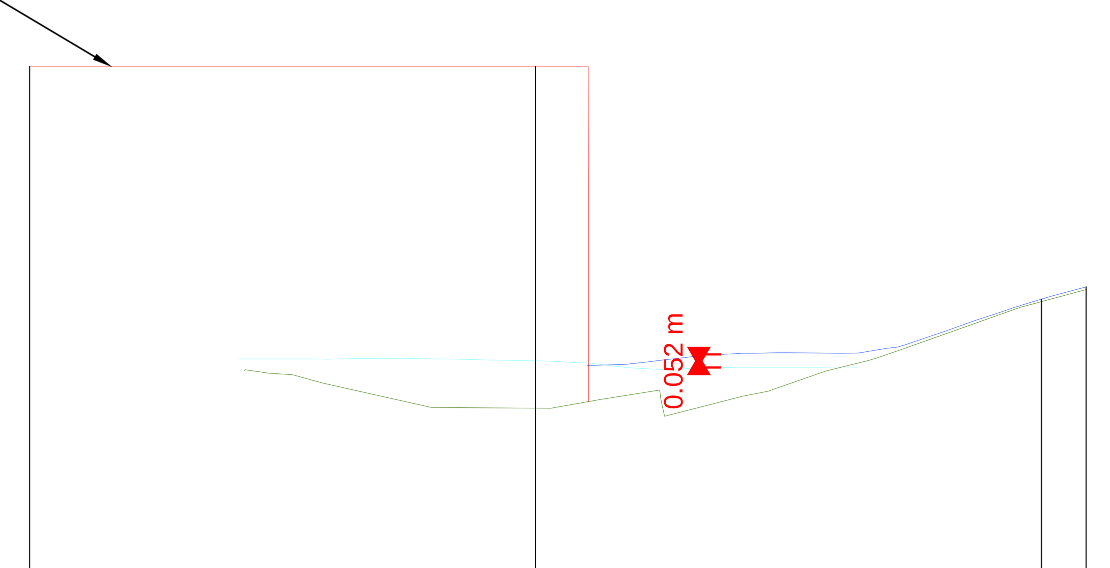


DATUM 125.500

DEVELOPED 100 YEAR ARI FLOOD WATER LEVEL			126.990	
EXISTING 100 YEAR ARI FLOOD WATER LEVEL				
EXISTING SURFACE		126.961	127.011	127.311
OFFSET	0.000	20.000	40.000	44.431

SECTION SECTION B-B

HORIZONTAL SCALE 1 : 250
VERTICAL SCALE 1 : 25

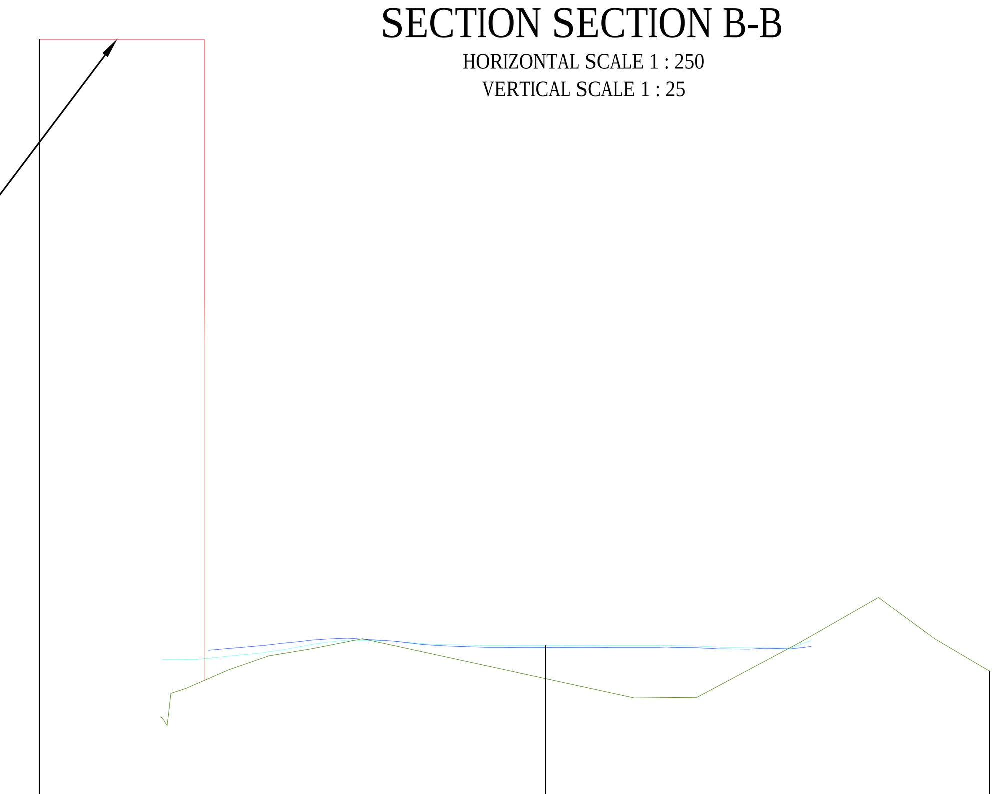


DATUM 125.500

DEVELOPED 100 YEAR ARI FLOOD WATER LEVEL			126.582	126.631
EXISTING 100 YEAR ARI FLOOD WATER LEVEL		126.338		
EXISTING SURFACE		126.151	126.572	126.620
OFFSET	0.000	20.000	40.000	41.771

SECTION SECTION C-C

HORIZONTAL SCALE 1 : 250
VERTICAL SCALE 1 : 25

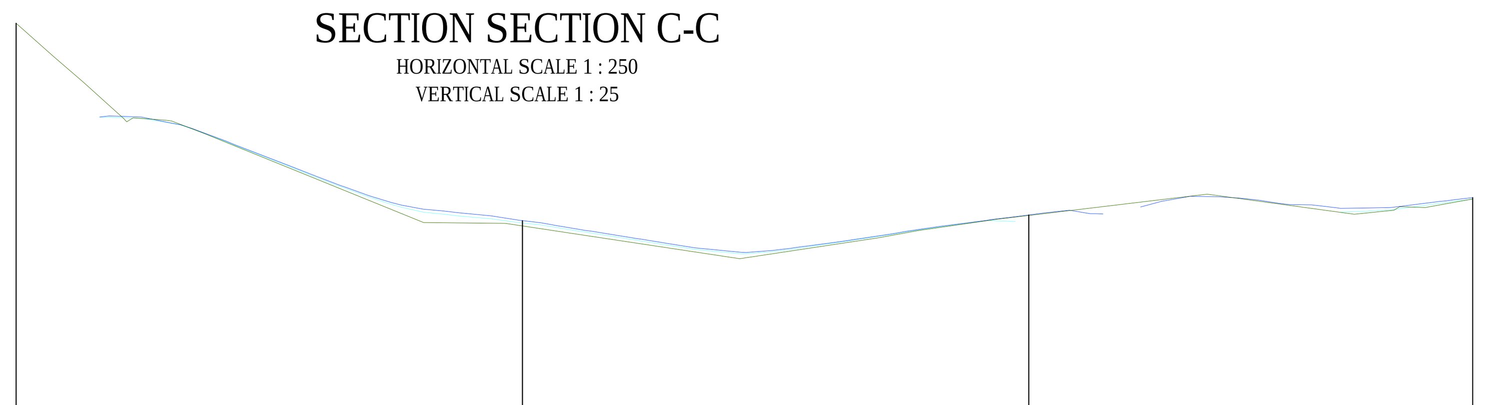


DATUM 124.500

DEVELOPED 100 YEAR ARI FLOOD WATER LEVEL		125.098	
EXISTING 100 YEAR ARI FLOOD WATER LEVEL		125.106	
EXISTING SURFACE		124.975	125.005
OFFSET	0.000	20.000	37.554

SECTION SECTION D-D

HORIZONTAL SCALE 1 : 250
VERTICAL SCALE 1 : 25

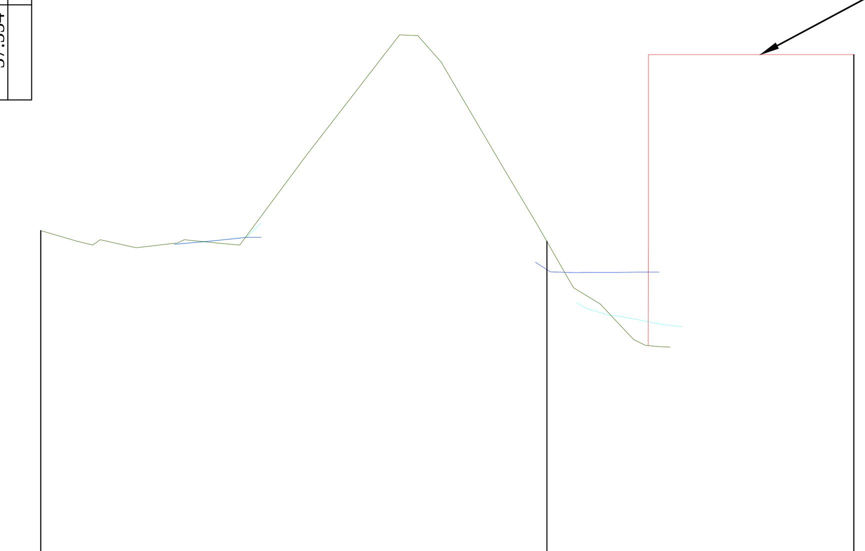


DATUM 128.000

DEVELOPED 100 YEAR ARI FLOOD WATER LEVEL		128.768	128.790	128.858
EXISTING 100 YEAR ARI FLOOD WATER LEVEL		128.759		128.852
EXISTING SURFACE	129.547	128.747	128.788	128.853
OFFSET	0.000	20.000	40.000	57.537

SECTION SECTION E-E

HORIZONTAL SCALE 1 : 250
VERTICAL SCALE 1 : 25



DATUM 125.500

DEVELOPED 100 YEAR ARI FLOOD WATER LEVEL		126.651	
EXISTING 100 YEAR ARI FLOOD WATER LEVEL			
EXISTING SURFACE	126.805	126.762	
OFFSET	0.000	20.000	32.124

SECTION SECTION F-F

HORIZONTAL SCALE 1 : 250
VERTICAL SCALE 1 : 25

ISSUE	DESCRIPTION	BY	DATE
P1	PRELIMINARY ISSUE	PK	NYI

ISSUE	DESCRIPTION	BY	DATE

STATUS

PRELIMINARY ISSUE

NOT TO BE USED FOR CONSTRUCTION PURPOSES

SCALE 5 2.5 0 5 10 15m
0.5 0.25 0 0.5 1 1.5
H 1:250, V 1:25

SCALE INDICATED FOR REFERENCE ONLY. DO NOT SCALE DRAWING.

irwinconsult
Level 3, 289 Wellington Parade South
East Melbourne VIC 3002
t +61 3 9622 9700 f +61 3 9650 6664
mlb@irwinconsult.com.au ABN 89 050 214 894

PROJECT
WHITEHORSE CIVIC CENTRE

CLIENT
CITY OF WHITEHORSE

TITLE
DEVELOPED SITE FLOOD PLAN
CROSS SECTIONS

DATE	DESIGNER	DRAWN	CHECKED	APPROVED
Sep, 2014	AC	DG	LOT	PLM

SCALE AT A1	JOB No.	DRAWING No.	ISSUE
AS SHOWN	12ME0460	CSK013	P1

CAD FILE: 12ME0460-CSK013.DWG