Penrith CBD Detailed Overland Flow Flood Study-Final Report

W4735

Prepared for Penrith City Council

7 July 2015

Cardno (NSW/ACT) Pty Ltd
ABN 95 001 145 035

Level 9 The Forum
203 Pacific Highway
St Leonards NSW 2065
Australia

Telephone: 02 9496 7700
Facsimile: 02 9439 5170
International: +61 2 9496 7700

sydney@cardno.com.au
www.cardno.com.au

Report No ______________

Document Control:

Version	Status	Date	Author		Reviewer	
			Name	Initials	Name	Initials
1	Draft	9 February 2011	Stephen Yu Tina Fang	SY TF	Rhys Thomson	RST
2	Draft	24 February 2011	Stephen Yu Tina Fang	SY TF	Rhys Thomson	RST
3	Draft	4 March 2013	Stephen Yu Tina Fang	SY TF	Rhys Thomson	RST
4	Draft	10 September 2013	Stephen Yu Tina Fang	SY TF	Rhys Thomson	RST
5	Draft	28 November 2013	Stephen Yu Tina Fang	SY TF	Rhys Thomson Andrew Reid	RST AR
6	Draft	6 March 2014	Stephen Yu Tina Fang	SY TF	Rhys Thomson	RST
7	Draft	27 May 2014	Stephen Yu Tina Fang	SY TF	Rhys Thomson	RST
8	Draft Exhibition	25 June 2014	Stephen Yu Tina Fang	SY TF	Rhys Thomson	RST
9	Final Draft	25 June 2014	Stephen Yu Tina Fang	SY TF	Rhys Thomson	RST
10	Final	7 July 2015	Stephen Yu Tina Fang	SY TF	Rhys Thomson	RST

File Ref: W:_Current Projects\4735 Penrith Detailed Studies\Reports\Penrith CBD\PenCBD-Final Report V10\W4735-Penrith CBD Final Report.doc

Note: The Study has been adopted by Council in its Ordinary Meeting on 25 May 2015

DISCLAIMER AND COPYRIGHT

TABLE OF CONTENTS

TABLES

FIGURES

APPENDICES

GLOSSARY

* Many terms in this Glossary have been derived or adapted from the NSW Government *Floodplain Development Manual*, 2005.

Australian Height Datum (AHD)	A common national surface level datum approximately corresponding to mean sea level.
Average recurrence interval (ARI)	The long-term average number of years between the occurrences of a flood as big as or larger than the selected event. For example, floods with a discharge as great as or greater than the 20 year ARI flood event will occur on average once every 20 years. ARI is another way of expressing the likelihood of occurrence of a flood event.
Cadastre, cadastral base	Information in map or digital form showing the extent and usage of land, including streets, lot boundaries, water courses etc.
Catchment	The land area draining through the main stream, as well as tributary streams, to a particular site. It always relates to an area above a specific location.
Creek Rehabilitation	Rehabilitating the natural 'biophysical' (i.e. geomorphic and ecological) functions of the creek.
Creek Modification	Widening or altering the creek channel in an environmentally compatible manner (i.e. including weed removal and stabilisation with suitable native endemic vegetation) to allow for additional conveyance.
Design flood	A significant event to be considered in the design process; various works within the floodplain may have different design events, e.g. some roads may be designed to be overtopped in the 1 year ARI flood event.

Development	Is defined in Part 4 of the EP&A Act. Infill development: refers to the development of vacant blocks of land that are generally surrounded by developed properties and is permissible under the current zoning of the land. Conditions such as minimum floor levels may be imposed on infill development new development: refers to development of a completely different nature to that associated with the former landuse. E.g., the urban subdivision of an area previously used for rural purposes. New developments involve re-zoning and typically require major extensions of existing urban services, such as roads, water supply, sewerage and electric power. Redevelopment: refers to rebuilding in an area. E.g., as urban areas age, it may become necessary to demolish and reconstruct buildings on a relatively large scale. Redevelopment generally does not require either re-zoning or major extensions to urban services.
Discharge	The rate of flow of water measured in terms of volume per unit time, for example, cubic metres per second (m^3/s). Discharge is different from the speed or velocity of flow, which is a measure of how fast the water is moving for example, metres per second (m/s).
Flash flooding	Flooding which is sudden and unexpected. It is often caused by sudden local or nearby heavy rainfall. Often defined as flooding which peaks within six hours of the causative rain.
Flood	Relatively high stream flow which overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam, and/or local overland flooding associated with major drainage before entering a watercourse, and/or coastal inundation resulting from super-elevated sea levels and/or waves overtopping coastline defenses excluding tsunami.
Flood fringe	The remaining area of flood-prone land after floodway and flood storage areas have been defined.
Flood hazard	A source of potential harm or a situation with a potential to cause loss. In relation to this manual the hazard is flooding which has the potential to cause damage to the community. Definitions of high and low provisional hazard categories are provided in Appendix L of the Floodplain Development Manual (NSW Government, 2005).

Flood-prone land	Land susceptible to inundation by the probable maximum flood (PMF) event, i.e. the maximum extent of flood liable land.
Floodplain	Area of land which is subject to inundation by floods up to the probable maximum flood event, i.e. flood prone land.
Floodplain risk management options	The measures that might be feasible for the management of a particular area of the floodplain. Preparation of a floodplain risk management plan requires a detailed evaluation of floodplain risk management options.
Flood planning area	The area of land below the FPL and thus subject to flood related development controls.
Flood planning levels	Are the combinations of flood levels (derived from significant historical flood events or floods of specific ARIs) and freeboards selected for floodplain risk management purposes, as determined in management studies and incorporated in management plans.
Flood Risk	Potential danger to personal safety and potential damage to property resulting from flooding. The degree of risk varies with circumstances across the full range of floods. Flood risk in this manual is divided into 3 types, existing, future and continuing risks. They are described below: ▪ Existing flood risk: the risk a community is exposed to as a result of its location on the floodplain. ▪ Future flood risk: the risk a community may be exposed to as a result of new development on the floodplain. ▪ Continuing flood risk: the risk a community is exposed to after floodplain risk management measures have been implemented. For a town protected by levees, the continuing flood risk is the consequences of the levees being overtopped. For an area without any floodplain risk management measures, the continuing flood risk is simply the existence of its flood exposure.
Flood storage areas	Those parts of the floodplain that are important for the temporary storage of floodwaters during the passage of a flood. The extent and behaviour of flood storage areas may change with flood severity, and loss of flood storage can increase the severity of flood impacts by reducing natural flood attenuation. Hence, it is necessary to investigate a range of flood sizes before defining flood storage areas.

Floodway areas	Those areas of the floodplain where a significant discharge of water occurs during floods. They are often aligned with naturally defined channels. Floodways are areas that, even if only partially blocked, would cause a significant redistribution of flood flow, or a significant increase in flood levels.
Freeboard	Provides reasonable certainty that the risk exposure selected in deciding on a particular flood chosen as the basis for the FPL is actually provided. It is a factor of safety typically used in relation to the setting of floor levels, levee crest levels, etc. (See Section K5). Freeboard is included in the flood planning level.
Geographical information systems (GIS)	A system of software and procedures designed to support the management, manipulation, analysis and display of spatially referenced data.
High hazard	Flood conditions that pose a possible danger to personal safety; evacuation by trucks difficult; able-bodied adults would have difficulty wading to safety; potential for significant structural damage to buildings.
Hydraulics	The term given to the study of water flow in a river, channel or pipe, in particular, the evaluation of flow parameters such as stage and velocity.
Hydrograph	A graph that shows how the discharge changes with time at any particular location.
Hydrology	The term given to the study of the rainfall and runoff process as it relates to the derivation of hydrographs for given floods.
Local overland flooding	Inundation by local runoff rather than overbank discharge from a stream, river, estuary, lake or dam.
Low hazard	Flood conditions such that should it be necessary, people and their possessions could be evacuated by trucks; able-bodied adults would have little difficulty wading to safety.
Mainstream flooding	Inundation of normally dry land occurring when water overflows the natural or artificial banks of a stream, river, estuary, lake or dam.

Management plan	A document including, as appropriate, both written and diagrammatic information describing how a particular area of land is to be used and managed to achieve defined objectives. With regard to flooding, the objective of the management plan is to minimise and mitigate the risk of flooding to the community. It may also include description and discussion of various issues, special features and values of the area, the specific management measures which are to apply and the means and timing by which the plan will be implemented.
Mathematical/computer models	The mathematical representation of the physical processes involved in runoff and stream flow. These models are often run on computers due to the complexity of the mathematical relationships. In this report, the models referred to are mainly involved with rainfall, runoff, pipe and overland stream flow.
NPER	National Professional Engineers Register. Maintained by the Institution of Engineers, Australia.
Peak discharge	The maximum discharge occurring during a flood event.
Probable maximum flood	The PMF is the largest flood that could conceivably occur at a particular location, usually estimated from probable maximum precipitation, and where applicable, snow melt, coupled with the worst flood producing catchment conditions. Generally, it is not physically or economically possible to provide complete protection against this event. The PMF defines the extent of flood prone land, that is, the floodplain. The extent, nature and potential consequences of flooding associated with a range of events rarer than the flood used for designing mitigation works and controlling development, up to and including the PMF event should be addressed in a floodplain risk management study.
Probable Maximum Precipitation	The PMP is the greatest depth of precipitation for a given duration meteorologically possible over a given size storm area at a particular location at a particular time of the year, with no allowance made for long-term climatic trends (World Meteorological Organisation, 1986). It is the primary input to PMF estimation.
Probability	A statistical measure of the expected frequency or occurrence of flooding.

Risk	Chance of something happening that will have an impact. It is measured in terms of consequences and likelihood. For this study, it is the likelihood of consequences arising from the interaction of floods, communities and the environment.
Runoff	The amount of rainfall that actually ends up as stream or pipe flow, also known as rainfall excess.
Stage	Equivalent to 'water level'. Both are measured with reference to a specified datum.
Stage hydrograph	A graph that shows how the water level changes with time. It must be referenced to a particular location and datum.
Stormwater flooding	Inundation by local runoff. Stormwater flooding can be caused by local runoff exceeding the capacity of an urban stormwater drainage system or by the backwater effects of mainstream flooding causing the urban stormwater drainage system to overflow.
Topography	A surface which defines the ground level of a chosen area.

List of Abbreviations

1D	One Dimensional
2D	Two Dimensional
AHD	Australian Height Datum
ARI	Average Recurrence Interval
BoM	Bureau of Meteorology
DECCW	Department of Environment, Climate Change & Water (now OEH)
FPL	Flood Planning Level
FRMP	Floodplain Risk Management Plan
FRMS	Floodplain Risk Management Study
km	kilometres
km^2	Square kilometres
LGA	Local Government Area
m	metre
m^2	Square metres
m^3	Cubic metres
mAHD	Metres to Australian Height Datum
mm	millimetres
m/s	metres per second
NSW	New South Wales
OSD	On-site Detention
OEH	Office of Environment and Heritage
PMF	Probable Maximum Flood
PMP	Probable Maximum Precipitation
SES	State Emergency Service
SWC	Sydney Water Corporation

Foreword

The NSW Government's Flood Prone Lands Policy is directed towards providing solutions to existing flood problems in developed areas utilising ecologically positive methods wherever possible and ensuring that new development is compatible with the flood hazard and does not create additional flooding problems in other areas.

Under the policy, the management of flood prone land is the responsibility of Local Government. To achieve its primary objective, the policy provides for State Government financial assistance to Councils for actions to alleviate existing flooding problems. The policy also provides for State Government technical assistance to Councils to ensure that the management of flood prone land is consistent with the flood hazard and that future development does not create or increase flooding problems in flood prone areas.

The Policy provides for technical and financial support by the State Government through the following sequential stages:

1. Data Collection	Collect all data required for flood studies, including ground survey, historical rainfall and flood levels data.
2. Flood Study	Determines the nature and extent of the flood problem.
3. Floodplain Risk Management Study	Evaluates management options for the floodplain in respect of both existing and proposed development.
4. Floodplain Risk Management Plan	Involves formal adoption by Council of a plan of management for the floodplain.
5. Implementation of the Plan	Implementation of actions to manage flood risks for existing and new development.

Penrith CBD Detailed Overland Flow Flood Study is the first and second stages of the management for Penrith CBD and surrounding suburbs and has been prepared for Penrith Council by Cardno to define flood behaviour under existing catchment conditions.

EXECUTIVE SUMMARY

Cardno was commissioned by Penrith Council to undertake Penrith CBD Detailed Overland Flow Flood Study. The study area lies to the west of Sydney, east of Nepean River and north of the M4. It comprises the Penrith Central Business District (CBD) and the surrounding suburbs. This area is located on the southern side of the railway, and is bounded by Parker Street in the east, Jamison Road in the south, and Mulgoa Road in the west.

An extensive data compilation and review was undertaken in the study. This included an extensive survey exercise which required the collection of data for over 920 pits within the study area, together with cross sections of stormwater channels and details of hydraulic structures such as culverts.

The data compilation also included a resident survey of approximately 2075 properties. This survey targeted local residents' experience with flooding in the study area to collect the historical flooding information for the model calibration and validation. All survey data has been complied into a GIS database for Council.

A fully dynamitic 1D/2D hydraulic TUFLOW model was established. The TUFLOW model incorporated a detailed one dimensional (1D) network (drainage system, including channels in the study area) with a fine 1 metre terrain grid. Hydrological modelling was undertaken utilising a combination of Direct Rainfall within the study area and traditional hydrological modelling for catchments external to the study area.

Calibration and validation are two important processes to ensure the feasibility of the hydraulic model. However, it is difficult to directly calibrate the hydraulic model in this study due to scarce calibration data, such as the historical flood levels, representative rainfall and localised storm events. Therefore, the robustness and reliability of the hydraulic model was tested by an indirect validation. The validation results suggest that the hydraulic model is capable of reasonably simulating the hydrological and hydraulic processes of the catchment.

The primary objective of the study is to define flood behaviour for the study area under existing conditions that represent the features of overland flowpaths and the drainage system. The study provides information on flood extents, flood levels, depths, and flood velocities for a full range of design storm events, including 1 year, 2 year, 5 year, 10 year, 20 year, 50 year, 100 year, and 200 year ARI storm events together with the Probable Maximum Flood (PMF) event. This study also defines provisional hazards and hydraulic categories for the study area, as well as a preliminary flood damage assessment.

The outcomes of this study can be used for future Floodplain Risk Management and Plan for the study area to investigate various management and flood mitigation options under the existing catchment conditions.

1 INTRODUCTION

1.1 Background

Penrith City Council completed a broad-scale overland flow flood study (”Overview Study”) in October 2006 (Cardno Lawson Treloar, 2006) in order to prioritise future detailed overland flow flood studies for all catchments within the Penrith Local Government Area (LGA) in according with the NSW Government’s Floodplain Development Manual, 2005.

Penrith CBD Detailed Overland Flow Flood Study is an outcome of that process. Compared with previous “Overview Study”, the key features associated with Penrith CBD Detailed Overland Flow Flood Study are:

- A fine 1m grid was applied within the study area in order to identify the overland flow paths in detail; and
- Detailed 1D components were incorporated within the 2D grids, including pits, pipes, channels, and other hydraulic control structures.

The primary objective of the study is to define the flood behaviour, the flood hazard, and to quantify flood damages under existing conditions. The outcome of this study could be utilised in a Floodplain Risk Management Study and Plan.

1.2 Study Area

The study area lies approximately 54 kilometres to the west of Sydney CBD, east of Nepean River and north of the M4 (**Figure 1.1**). The study area comprises the Penrith Central Business District (CBD) and the surrounding suburbs as shown in **Figure 1.2**. This area is located on the southern side of the railway, and is bounded by Parker Street in the east, Jamison Road in the south, and Mulgoa road in the west.

The study area covers an area of approximate 340 hectares, and is highly urbanised. The eastern parts of the study area are relatively steep compared to the western portion and rise up to 69.5m AHD. Key features of the study area include the Penrith showground, the shopping district including the Westfield Plaza, the Centro Nepean and the Penrith Stadium.

The study area has approximately 14 kilometres of drainage pipelines. In addition, there are 2 main drainage channels in the study area, including one in the north of the showground and one on the Jamison Road, near to the boundary of the study area.

The catchment itself extends beyond the study area, with a small portion to the north of the railway and a larger portion to the south of Jamison Road. The area to the south extends as far as approximately 2.9 kilometres, represents approximately 365 hectares upstream of Jamison road.

1.3 Study Objectives

The primary objective of the study is to define flood behaviour for the study area under existing conditions that represent the features of overland flowpaths and the drainage system. The study provides information on flood extents, flood levels, flows, depths, and flood velocities for a full range of design storm events, including 1 year, 2 year, 5 year, 10 year, 20 year, 50 year, 100 year, and 200 year ARI storm events together with the Probable Maximum Flood (PMF) event. This study also defines provisional hazards, hydraulic categories and quantifies the flood damages for the study area. The results of the study may form the basis for subsequent Floodplain Risk Management and Plan for the study area.

In order to achieve these objectives, the following tasks have been undertaken:

- Compile and review all relevant information to enhance Council's existing drainage infrastructure database (**Section 2**);
- Investigate the likely extent and nature of flooding under the existing conditions and identify potential hydraulic control structures through a detailed site inspection (**Section 2**);
- Develop a hydrological model to obtain upstream input hydrographs into the 1D/2D hydraulic model for the study area (**Section 5**);
- Establish a 1D/2D hydraulic model to investigate the flood behaviour for the full range of design storm events (**Section 6**);
- Undertake a validation process to test the robustness and reliability of the 1D/2D hydraulic model (**Section 7**);
- Define the flood extents, flood levels, flows, velocities and depths for the study area (**Section 8**);
- Define Provisional Flood Hazard for flood-affected areas (**Section 9**);
- Define the Hydraulic Categories for flood-affected areas (**Section 10**);
- Estimate flood damage costs (**Section 11**);
- Undertake sensitivity analysis on key model parameters (**Section 12**), and
- Identify preliminary flood mitigation options (**Section 13**).

2 DATA COMPILATION

Quality data is one of the essential factors for undertaking an overland flow flood study. In general, data includes information required for inputs to the hydrological and hydraulic models, such as existing drainage system, hydraulic control structures and terrain (ALS) data. Data also includes information required for calibration and validation of models, such as historical rainfall and flood levels data.

The data were obtained from the following sources:

- Previous flood study reports relevant to the current study area (**Section 2.1**);
- Ground and property survey and aerial survey information (**Section 2.2**);
- Pit and Pipe Survey (**Section 2.2**);
- Aerial photography taken in 2008 from Penrith Council;
- General GIS information (such as cadastre, street names, and etc.) from Penrith Council;
- Proposed Stormwater Trunk Drainage Augmentation and Jane Street Realignment Drawings from Penrith Council, and
- Rainfall data from Sydney Water (**Section 2.5**).

2.1 Previous Studies and Reports

2.1.1 Penrith Overland Flow Study –"Overview Study"

Penrith Overland Flow Flood Study –"Overview Study" was undertaken by Cardno Lawson Treloar in 2006. This study developed a two-dimensional (2D) hydraulic model to determine the overland flow behaviour for the entire LGA excluding areas defined by South Creek or Nepean River flood extents. Due to the computer limitations at the time, a course/fine grid combination was applied in the study, where a coarse 45m grid was established for the entire LGA and finer 3m grids or 9m grids were then nested within the coarse grid. Only significant culverts/bridges in the study area were included as one-dimensional (1D) components within the fine grid. In addition, a few critical control structures identified by the Council were also included as 1D components in the grid.

This study investigated the overland flow behaviour throughout the LGA by defining the flood extents, flood velocities, flood levels and flow rates for the 20 year and 100 year ARIs along with the PMF design flood events. The results of this study were used as a guide for the Council to identify and prioritise areas for future detailed overland flow flood studies.

2.1.2 Other Previous Studies

A number of flood studies have been undertaken for the Nepean River and Peachtree Creek, including:

- Peachtree Creek Flood Study (LMCE, 1994);

- Upper Nepean Flood Study (DLWC, 1995);
- Nepean River at Penrith Flood Study (Lawson & Treloar, 1995);
- Penrith RUBICON Modelling (Webb and Mckeown, 2005), and
- Nepean River RMA-2 Model (Worley Parsons, 2008).

The majority of these studies focus on mainstream Nepean River flooding and do not directly influence this study. However, the flood levels for the Peachtree Creek study were reviewed for their influence on the downstream boundary levels of the study area. A sensitivity analysis on the effects of the downstream boundary will be discussed in **Section 12**.

2.2 Survey Information

Penrith City Council provided a substantial amount of the data required for the study. An additional survey was undertaken by Cardno's own in-house team of surveyors to obtain detailed information regarding pits, pipes, channel cross sections and hydraulic control structures within the study area. In addition, a property survey was also conducted by Penrith City Council to collect property floor levels data and other relevant data for estimating property damage costs.

2.2.1 Topographic Survey

Airborne Laser Scanning (ALS) based on a survey undertaken on 7-9 November 2002 was supplied by Penrith City Council. Generally, the accuracy of ALS data is +/- 0.15m to one standard deviation on hard surfaces. The ALS data defines the topographic features in the study area. It is noted that features such as channels and culverts are generally not well defined in the ALS data. These features were picked up through ground survey, discussed in section 2.2.2.

2.2.2 Ground Survey

A detailed field survey undertaken by "Cardno's in-house" surveyors was completed in October 2008. The survey provided information that is sufficient to set up 1D/2D hydraulic models for the study area, including pits, pipes, hydraulic control structures and the creek cross sections. The layout of surveyed drainage system for the study area is displayed in **Figure 2.1**.

The following survey details were obtained within the study areas:

- Pit and Pipe Field Survey – Approximately 920 pits and 960 pipes were surveyed for the study area. This generates a 'pit and pipe GIS database' which identifies the dimensions and locations of all surveyed pits and pipes. The surface levels and invert levels of pits in the 'database' were directly measured by the surveyors. A small portion of pits and pipes have incomplete information due to the difficulty in accessing some of these pits and pipes.

- Cross Sections and Culvert Dimensions – cross sections of the open channels and culvert dimensions within the study area were obtained (see **Figure 2.1**). These details are generally not adequately defined in the aerial survey described in **Section 2.2.1** and were therefore obtained as supplementary information.

2.2.3 Property Survey

A property survey was arranged by Penrith City Council and supplied to Cardno in February 2010. The data includes floor level and a representative ground level along with other details of the property such as building type, number of storeys etc. Information obtained by property survey was used to assess the flood damage for various design flood events.

2.3 Site Inspections

The site inspections were undertaken by Cardno's experienced hydraulic engineers. The site visits provided the opportunity to fine tune the modelling approach to capture various street drainage features, and to visually identify likely flood behaviour in the field GIS Data.

2.4 General Data

The following Geographic Information System (GIS) data were provided by Council for this study:

- The study area catchment plans with minor and major contours (0.5m and 5m intervals respectively);
- Existing pits and pipes layout plan;
- Cadastre for the study area;
- Flood extents from Penrith Overland Flood Flow Study;
- Landuse map, and
- Digital ortho-rectified aerial images of the study area taken in 2008

2.5 Historical Rainfall Information

Figure 2.2 shows the rain gauges in the surrounding areas. The details of these rain gauges are listed in **Table 2.1**.

It is noted that due to the short critical duration for the study area, only the Pluviometer rainfall data is appropriate for the study. Therefore, rainfall data was obtained for these historical events from the Sydney Water gauge at the Penrith STP. This rain gauge (567107) at Penrith is approximately 1.5 kilometres away from the centre of the study area.

Table 2.1 Rain Gauge Information

Station No.	Station Name	Source	Longitude (oE)	Latitude (oS)	Type
567107	Penrith STP	Sydney Water	150.696	-33.7417	Pluviometer (6min interval)
67018	Penrith Ladbury Avenue	BOM	150.678	-33.7542	Hourly Interval
567047	Penrith (Nepean River)	BOM	150.683	-33.748	Hourly Interval
67096	Glenroy	BOM	150.7	-33.7667	Hourly Interval

There are four rain gauges in the surrounding areas. According to Bureau of Meteorology (http://www.bom.gov.au), the rain gauge (67096) closed in December 1923, whilst the rain gauge (67018) closed in December 1994. However, all recorded historical storm events occurred after 1998 (referred to Section 5.4). Therefore, insufficient rainfall data (where at least three rain gauges are required) can be used to undertake rainfall isohyet analysis in this study.

2.6 Historical Flood Levels

Information regarding historical flood levels is usually used to calibrate or validate the hydraulic model. In this study, only limited information on historical flood levels was reported by the Community Survey, which is further described in **Section 3**.

3 COMMUNITY CONSULTATION

3.1 Overview

A residential survey has been undertaken to collect the historical flooding information for the model calibration and validation. A questionnaire was prepared in consultation with Council to seek information regarding whether residents have experienced flooding, the nature and depth of flooding and the timing of such floods.

The questionnaires were sent in the post to all residents in the study area in March 2008 by Council. Approximately 2075 properties were contacted. It is noted that the number of questionnaires delivered would be larger than this as the properties include units and multi-dwelling developments.

The questionnaire featured eight questions, which were directed at understanding of community awareness of flooding as well as historical flood information which would be used for the model calibration and validation (**Section 7**). A copy of the questionnaire and associated figures are attached in **Appendix A**. The data received are summarised in this report, with a complete detailed list of responses provided to Council separately.

A summary of the responses to each question can be found in **Sections 3.3 – 3.7**.

3.2 Response Rate

A total of 193 respondents were received, indicating a response rate of approximately 9%. This represents a mid-range response rate in comparison to similar studies undertaken by Cardno (as a guide a low return rate is 5% or less and a high return rate is around 15%). It is also noted that the survey was delivered to the entire study area, with many residents likely outside of the floodplain extent.

3.3 Duration of Residence

The duration of residency reported by the respondents is shown in **Table 3.1** and **Figure 3.1**.

Table 3.1 Duration of Residence of Respondents

Period of Residence	Number of Respondents	Percentage (%)
Less than 1 year	2	1.1
1 to 2 years	14	7.5
2 to 5 years	25	13.4
5 to 10 years	30	16.0
10 to 20 years	27	14.4
20 to 30 years	28	15.0
30 to 40 Years	24	12.8
More than 40 Years	37	19.8
Total	**187**	

Note: 7 respondents did not mention the duration of residency.

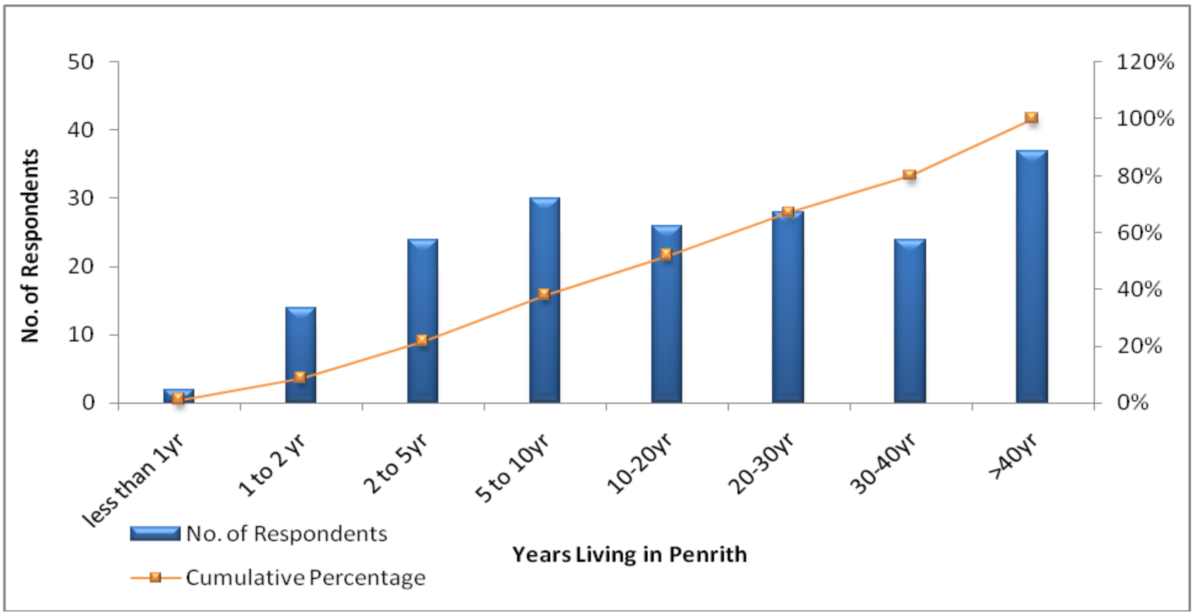


Figure 3.1 Duration of Residence of Respondents

Approximately 40 % Tuof the respondents have lived in the study area for less than 10 years, while approximate 30% respondents have lived here for more than 20 years. Generally, there is a fairly even spread in regards to the duration of residence.

3.4 Flood Awareness

There was considerable awareness of flooding amongst the respondents. A total of 120 out of the 193 (approximately 62%) respondents indicated awareness or some knowledge of flooding in the study area.

3.5 Flood Impacts

The respondents provided information as to where their properties were flooded, and which areas they have seen flooded. Around 45 respondents reported to have driveway flooding, whilst seven respondents experienced over floor flooding. The response results are summarised in **Table 3.2**.

Table 3.2 Summary of Responses on Flood Impact

Location	No. Responses	Location	No. Response
Driveway	45	Garage	25
Backyard	39	Building (below floor level)	9
Front yard	29	Building (above floor level)	7
Shed	13		

3.6 Events Experienced

A number of flooding events have been experienced by respondents in the study area in the past. It is expected that residents will be unlikely to recall the specific timing of all of these events, particularly the more distant events. More respondents may experience recent events whereas only longer term residents may recall events which occurred further in the past. In general, the responses were skewed towards more recent events.

Only 14 respondents provided information when the historical flooding events occurred. According to the survey respondents, a number of historical flooding events may have occurred in 2008, 2007, 2006, 2005, 2004, 1998, and 1990**.** **Table 3.3** shows the possible historical flooding events and the number of respondents who remember these events. **Table 3.3** indicates that the survey results only provided scarce timing information about the historical flood events.

2006 reported the greater number of responses, and this also correlates to the largest event in recent times, as discussed in **Section 5.4**. It is also noted that it can commonly be difficult to recall exact dates of events. For example, the respondent who reported on event in 2005 may in fact be referring to 2006.

Table 3.3 Inferred Flood Experience of Respondents Based on Time of Residency

Storm Events	Respondents that may have been present	
	Percentage	Number
2008	1.6%	3
2007	1.0%	2
2006	4.7%	9
2005	0.5%	1
2004	1.0%	2
1998	0.5%	1
1990	0.5%	1

3.7 Verification Data

Few respondents provided information about historical flood levels in detail. Therefore, the primary information was through which property had over ground flooding or over floor flooding. A property which occurred flooding either in Driveway, Backyard, Frontyard, or Garage is classified as over ground flooding. The properties that experienced flooding based on the survey information are shown in **Figure 3.2**.

4 METHODOLOGY

Two numerical modelling tools were utilised to assess flood behaviour in the Penrith CBD study area:

- Hydrological model (XP-RAFTS)
- Hydraulic model (TUFLOW).

Both models are described in general below, and in detail in **Sections 5** and **6** respectively.

4.1 Hydrological Model

A hydrological model simulates the complicated hydrological processes of the catchment by converting rainfall into runoff. A traditional hydrological XP-RAFTS model was developed through the entire catchment, including the upstream area of 2D domain. The primary purpose of this traditional hydrological model is to generate input hydrographs to the 1D/2D hydraulic model in the study area.

The 'Direct Rainfall' method (also known as 'rainfall on the grids') was used for areas within the 2D domain. Refer to **Section 6** for more detailed information.

4.2 Hydraulic Model

A hydraulic model produces water levels and velocities by converting runoff (traditional from a hydrological model) throughout the major drainage/creek systems in the study area. The model simulates the hydraulic behaviour of the water within the study area by accounting for flow in the major channels as well as potential flow paths, which develop when the capacity of the channels is exceeded. It relies on boundary conditions, which include the runoff hydrographs produced by the hydrological model and the appropriate downstream boundary.

A dynamic hydraulic modelling system TUFLOW was applied in this study. As a widely used hydraulic modelling system in Australia, TUFLOW has been shown to provide reliable, robust simulation of flood behaviour in urban and rural areas through a vast number of applications. TUFLOW incorporates a one dimensional (1D) network (drainage system, including channels in the study area) with a two dimensional (2D) domain (representing the study area topography) to fully simulate the catchment hydrological and hydraulic responses to rainfall.

Stormwater drainage pits, pipes and channels are represented in the model as one-dimensional elements which are dynamically linked to the water conveyed across the elevation grids. An important feature of the model is the ability to model the hydraulic structures in the 1D component rather than in the 2D domain. The benefit of this approach is that structure hydraulics are modelled more precisely than the approximate representation possible in a 2D domain.

5 HYDROLOGICAL MODELLING

Hydrological modelling was undertaken using two methods:

- Traditional hydrological modelling using XP-RAFTS - The hydrological modelling was undertaken to develop catchment runoff hydrographs through the entire catchment, including upstream area of the 2D model domain. These hydrographs generated from the upstream area of the 2D model domain were used as inflow boundaries for the 1D/2D hydraulic modelling.
- Direct Rainfall Method, where rainfall is applied directly to the 2D hydraulic model grids and routing occurs within the hydraulic model.

5.1 Traditional Hydrological Modelling (XP-RAFTS)

An XP-RAFTS hydrological model was established for the entire catchment, including the upstream area of Penrith CBD. The landuse within the catchment is highly urbanised with predominantly residential areas and some business/commercial areas. The following attributes were considered in the hydrological analysis of the catchment:

- Rainfall intensity-frequency-duration (IFD) relationships;
- Sub-catchment divisions;
- Slopes and overland flowpath lengths; and
- Landuse (pervious and impervious areas).

5.1.1 Sub-Catchment Delineation

Sub-catchment delineation is a preparation step for establishing the hydrological model. The total area for the XP-RAFTS model is 7.38 km^2, with elevation varied from 91m AHD in the upper reaches of the catchment to 22m AHD at the catchment outlet.

The catchment was divided into 36 sub-catchments based on the topographic features (using the 0.5-metre contour data supplied by the Council), the likely flowpaths and the input requirements of the hydraulic model. The sub-catchment layout is presented in **Figure 5.1** and the details of these sub-catchments are provided in **Table 5.1**.

Pervious and impervious fractions for each sub-catchment were estimated based on aerial photography and site inspections. For each sub-catchment, the major landuses were identified and the area of each landuse was estimated using GIS. The following impervious fractions were used for different types of landuse.

- Highly urbanised residential: 60%
- Industrial/Commercial: 90%
- Open Space: 5%

The study catchment has an estimated 58.4% of impervious area, which represents approximately 431 hectares.

Table 5.1 Sub-catchment details

Sub-catchment ID	Area (ha)	Catchment Slope (%)	(%) Impervious
C1	15.3	4.1	17
C2	15.3	3.4	28
C3	13.1	3.2	40
C4	24.6	1.6	56
C5	10.0	3.2	60
C6	12.6	2.2	60
C7	4.7	1.6	45
C8	11.4	2.2	60
C9	10.7	1.8	60
C10	17.9	2.3	60
C11	17.6	2.0	53
C12	33.7	1.7	73
C13	13.2	1.2	50
C14	18.0	1.9	60
C15	22.2	1.8	60
C16	43.2	0.3	59
C17	52.5	1.5	67
C18	100.0	1.3	58
C19	40.7	2.0	60
C20	28.9	1.3	90
C21	55.1	0.4	90
C22	48.2	0.3	48
C23	14.5	0.5	42
C24	18.1	0.4	60
C25	26.5	1.6	30
C30	10.5	0.4	30
C31	15.0	0.3	59
basin0	9.6	3.5	49
basin1	3.5	3.7	54
basin2	3.5	5.0	55
basin3	3.1	3.7	54
basin4	2.7	3.0	52
basin5	1.6	2.8	45
basin6	2.2	2.7	50
basin7	3.0	2.4	51
basin8	15.3	2.2	48
Total Area	737.8		58.4

**See Figure 5.1 for the location of each sub-catchment*

5.1.2 Detention Basins

There are 9 detention basins identified in the study area based on the terrain data. The stage-storage relationship for each basin was generated by 12D modelling using the terrain data. The details of stage-storage relationship for these basins are provided in **Appendix B**.

The information regarding the spillway of the basins was obtained using the basin design drawings provided by the Council.

5.1.3 Hydrological Model Parameters

A number of parameters are required in the development of the RAFTS model. The important parameters include initial and continuing rainfall loss rate, and Manning roughness.

A split sub-catchment approach was applied to develop the RAFTS model. Manning's roughness values for impervious and pervious area were set as 0.015 and 0.04 respectively.

The initial and continuing rainfall lost rates for impervious/pervious areas are presented in **Table 5.2**.

Table 5.2 Rainfall Loss Rate

Rainfall Loss Rate	Impervious Area	Pervious Area
Initial loss (mm)	1.5	10
Continuing loss (mm/hr)	0	2.5

5.2 Direct Rainfall

Direct Rainfall Method was applied directly within the 2D domain in this study. In the application of Direct Rainfall Method, the hydrology and the hydraulics are undertaken in the same modelling package TUFLOW.

In the 2D model, rainfall is applied directly to the 2D terrain, and the hydraulic model automatically routes the flow using the same computation process that controls the routing of all other flows through the model. This means that catchment outlets do not have to be predefined, and flowpaths are identified by the model, rather than being assumed.

There are a number of advantages of the modelling approach, particularly given the nature of the study area. In flat areas, such as the west parts of the study area, overland flow paths are not obvious. Furthermore, additional and unexpected 'cross-catchment' flows may activate in larger events. The rainfall on the grid approach overcomes these issues, as the model will automatically divert flood waters along different flowpaths (based on the terrain and the roughness) during high flow events.

For a flood study dealing with a large number of stormwater pits and pipes, it can be difficult to determine the catchment that applies to a particular pit in using a traditional hydrological modelling approach. With the Direct Rainfall method, flows are automatically routed to the pit. This can provide a significant saving in time, as well as reduce potential errors in the application of flow.

5.3 Design Rainfall

5.3.1 Standard Design Rainfall Information

A uniform rainfall distribution was assumed for the study area due to its relatively small size. The rainfall intensities provided by the Council were applied in this study.

Table 5.3 lists the rainfall intensities for a full range of design events. The design rainfall for the 9 hour events was developed using standard techniques provided in *Australian Rainfall and Runoff* (AR&R) (Engineers Australia, 1999).

Table 5.3 Design Rainfall Intensities (mm/hr)*

Time	Return Period (Years)							
hr min	1	2	5	10	20	50	100	200+
0 15	47.5	61.5	80.2	91.2	105.8	125.0	139.7	153.0
0 30	33.5	43.4	56.5	64.3	74.6	88.0	98.4	107.3
0 45	26.8	34.7	45.2	51.5	59.7	70.5	78.8	85.5
1 00	22.7	29.4	38.4	43.7	50.6	59.8	66.8	72.3
1 30	17.9	23.2	30.2	34.4	39.9	47.1	52.6	56.5
2 00	15.1	19.6	25.4	28.9	33.5	39.6	44.2	47.3
3 00	11.9	15.3	19.9	22.6	26.2	30.9	34.5	36.7
4 30	9.3	12.0	15.6	17.7	20.4	24.1	26.9	28.4
6 00	7.8	10.1	13.1	14.8	17.2	20.2	22.5	23.7
9 00+	6.4	8.2	10.3	11.5	13.2	16.3	16.9	18.4
12 00	5.1	6.6	8.5	9.5	11.0	12.8	14.2	15.3

* Data supplied by Penrith City Council
+ Values derived from AR&R IFD calculations

5.3.2 Probable Maximum Precipitation

The Probable Maximum Precipitation (PMP) was estimated according to the publication *The Estimation of Probable Maximum Precipitation in Australia: Generalised Short - Duration Method (Bureau of Meteorology, 2003)*. The PMP ellipses to generate PMP spatial distribution for this study area are shown in **Appendix C**.

The values of the key parameters for generating PMP are shown in **Table 5.4**. The PMP rainfall intensities for a range of critical durations are shown in **Table 5.5**.

Table 5.4 Values of the Key Parameters for Estimating PMP

Study Area	PMP Ellipse	Area Enclosed	Area Between	Moisture Adjustment Factor	Elevation Adjustment Factor	Percentage Rough
CBD	A	2.34	2.34	0.72	1	0
	B	4.87	2.53	0.72	1	0

Table 5.5 Rainfall Intensities of PMP Events (mm/hr)

Study Area	Duration						
	15mins	30mins	45mins	60mins	90mins	120mins	180mins
CBD	640	460	400	350	260	220	163

5.4 Historical Rainfall Analysis

Seven historical events were reported through the community consultation (**Section 3**), including January1998, October 2004, January 2005, February 2006, November 2007 and April 2008. The daily rainfall depth for these historical storm events are summarised in **Table 5.6**.

Table 5.6 Daily Rainfall for Historical Storm Events

Events	Total Daily Rainfall (mm)
6 Apr. 2008	37
22 Nov. 2007	38.5
26 Feb. 2006	82
23 Jan.2005	57
21 Oct. 2004	60.5
18 Jan.1998	46
1990	-

Sources: Sydney Water Rain Gauge (567107). Rainfall data in 1990 is not available.

The intensities for these historical storm events and their approximate ARIs are summarised in **Table 5.7**.

Table 5.7 Approximate ARI of Historical Rainfall Events

Event	Details	Duration (mins)								
		15	30	45	60	90	120	180	360	540
Apr.2008	Intensity	40	*	29.3	*	20	16	10.7	6	*
	Approx.ARI	<1yr	*	1-2yr	*	1-2yr	~1yr	~1yr	<1yr	*
Nov.2007	Intensity	*	40	36	28	20.7	16	10.7	*	*
	Approx.ARI	*	1-2yr	2-5yr	~2yr	1-2yr	~1yr	~1yr	*	*

Event	Details	Duration (mins)								
		15	30	45	60	90	120	180	360	540
Feb.2006	Intensity	48	44	34.7	35	36	29.5	24.7	*	8.4
	Approx.ARI	~1yr	~2yr	2yr	2-5yr	10-20yr	~10yr	10-20yr	*	~2yr
Jan.2005	Intensity	64	56	42.7	38	29.3	23	15.3	9.5	6.3
	Approx.ARI	2-5yr	~5yr	2-5yr	~5yr	~5yr	2-5yr	2yr	2-5yr	1yr
Oct.2004	Intensity	*	*	*	*	*	*	*	*	*
	Approx.ARI	*	*	*	*	*	*	*	*	*
Jan.1998	Intensity	*	40	29.3	22	18	14	11	6.8	5.1
	Approx.ARI	*	1-2yr	1-2yr	~1yr	~1yr	~1yr	~1yr	~1yr	~1yr

Note: * indicates that the storm intensity (mm/hr) is less than the intensity of 1 year ARI design storm.

From **Table 5.7**, it can be seen that the storm event on February 2006 was the largest historical event recalled by residents, which is roughly equivalent to 20 year ARI with the duration of 90 minutes based on the rainfall intensity.

The temporal patterns of 2006 event and the 20 year design event (90 minute duration) are overlaid in **Figure 5.2**.

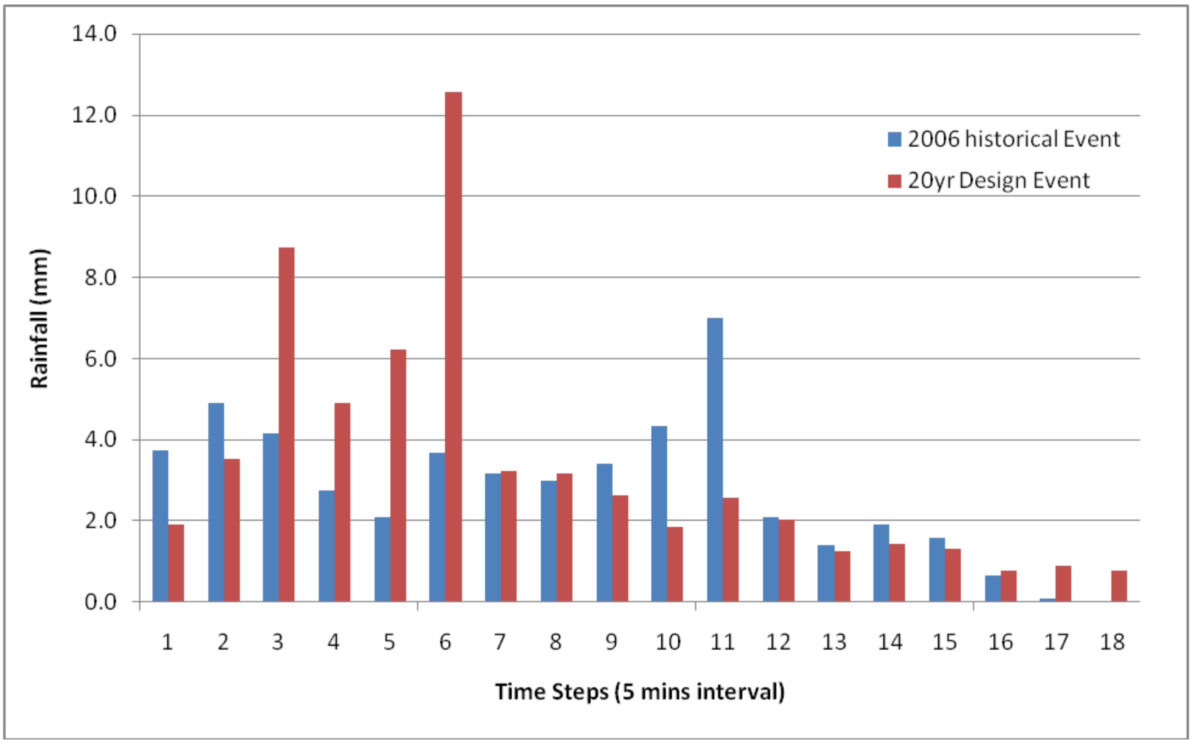


Figure 5.2 Temporal Patterns of 2006 Event and 20 Year ARI Design Event

Figure 5.2 indicates that 2006 historical event spreads more evenly than the design event. The peak rainfall (5 minute interval) of 2006 is smaller than one in 20 year ARI design event.

There are two important points to note in regard to this analysis. Firstly, a rainfall analysis such as this is not always indicative of the ARI of the flood event, due to such effects as preceding rainfall. Furthermore, the storm patterns affecting the CBD may be localised and may not be registered at the STP gauge which is 1.5km away. Therefore, this analysis should be considered indicative.

5.5 Hydrological Model Validation

As is common for most urban areas, there are no flow gauges in the study area (i.e. gauges that measure actual water flows, commonly in a channel) and hence the hydrological model could not be calibrated directly. Instead, the hydrological model was validated by comparing the XP-Rafts results with the Rational Method, and the Direct Rainfall methods from alternative modelling software SOBEK.

5.5.1 Validation using the Rational Method

In order to validate the hydrological model, the Rational Method was used to estimate the peak flows at the outlet for a number of design events. The detailed procedures of the Rational Method are defined in Australian Rainfall and Runoff (AR&R) (Pilgrim (ed), 1999).

The peak flows based on the Rational Method were calculated as following steps:

i. Determine the critical duration as the time of concentration $t_c = 0.76A^{0.38} = 0.76*7.38^{0.38} = 1.63hr \approx 1.5hr$

ii. Calculate the runoff coefficient C_{10} for urban areas (AR&R, Book VIII)

The runoff coefficient for the pervious area: $C^1_{10} = 0.1+(0.7-0.1)\times({}^{10}I_1-25)/(70-25) = 0.35$

10 year ARI runoff coefficient $C_{10} = 0.9\times f + C^1_{10}\times(1-f) = 0.65$

The fraction of impervious areas was estimated as 59% (**Section 5.1.1**).

iii. Determine the frequency factor $FF_{100} = 2.57-0.588\times I_{12,50}/ I_{12,2} = 1.43$

$FF_{50} = 1.99-0.366\times I_{12,50}/ I_{12,2} = 1.28$

$FF_{20} = 1.12$

iv. Estimate the peak flows: $Q_y = 0.278\times C_y\times I_{tc,Y}\times A$

$Q_{100} = 103.40\ m^3/s$

$Q_{50} = 82.87\ m^3/s$

$Q_{20} = 61.42\ m^3/s$

The peak flow values at the outlet based on the RAFTS model and the Rational Method for 100 year, 50 year and 20 year ARI events are presented in **Table 5.8**.

Table 5.8 Comparison of RAFTS model and Rational Method (Peak Flow, m³/s)

Storm (ARI)	Rational Method	RAFTS	Difference (%)
100 Year	103.40	95.88	-7.27
50 Year	82.87	84.98	2.55
20 Year	61.42	73.95	20.40

In term of 100 year and 50 year ARI event, the differences of the peak flows based on these two approaches are within ±10%. For 20 year ARI, the peak flow at the outlet based on the RAFTS model is approximately 20% higher than one calculated by the Rational Method.

5.5.2 Validation using the SOBEK Model

An additional validation was conducted by establishing a 2D hydraulic model of the catchment and applying the Direct Rainfall methodology. The SOBEK modelling system developed by Deltares was adopted for the validation and has been used in a number of studies, including “Overview Study” (Cardno Lawson Treloar, 2006).

In the validation process, the SOBEK 2D model was developed for the entire catchment. A terrain grid with 5m×5m grid cell was used to develop the SOBEK 2D model.

The 2D model was simulated using two design storm events, the 100 year ARI 2 hour duration and 100 year ARI 9 hour duration. The locations for comparing hydrographs based on XP-RAFTS and SOBEK model are shown in **Figure 5.1**.

The hydrograph comparisons at node C8 and C5 are shown in **Figure 5.3** and **5.4** respectively.

Modelled results for the two storm events at these locations are listed in **Table 5.9**.

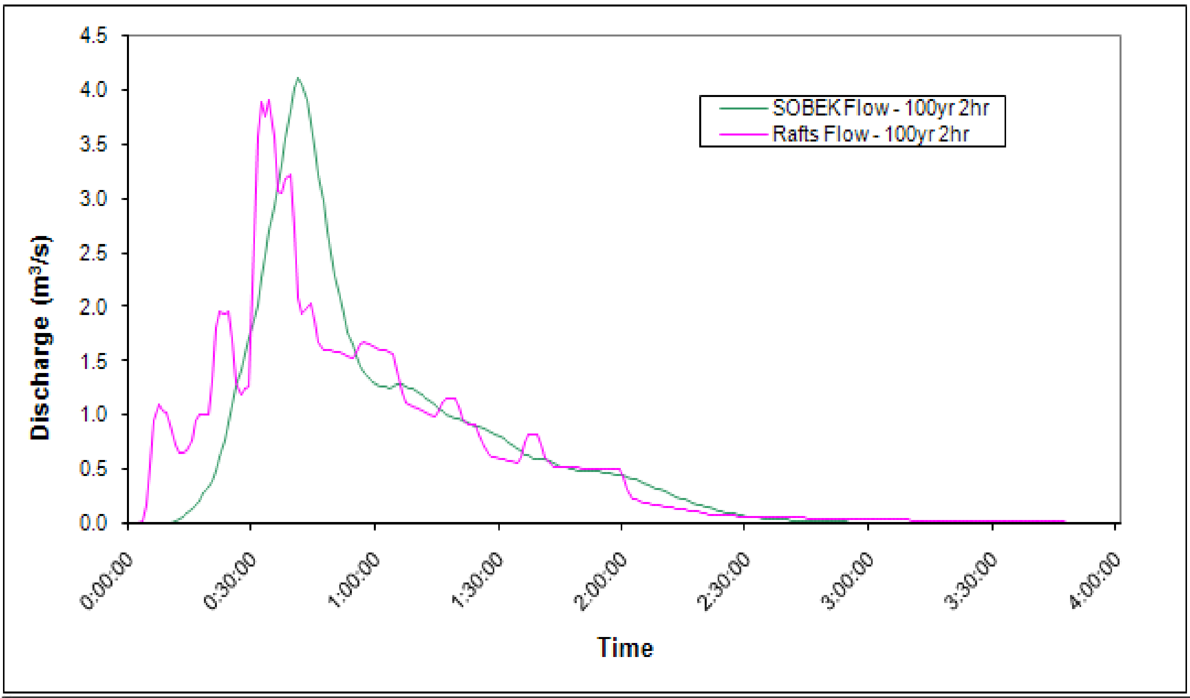
Table 5.9 Results Comparison for RAFTS and SOBEK

Location ID	Storm Event	Peak Flow (m3/s)		Peak Flow Difference (%)	Total Volume (m3)		Volume Difference (%)
		SOBEK	RAFTS		SOBEK	RAFTS	
C8	100yr, 2hr	4.12	3.91	-5.10	8913	9267	3.97
	100yr, 9hr	1.66	1.57	-5.42	15118	15755	4.21
C5	100yr, 2hr	3.24	3.31	2.16	7900	8139	3.03
	100yr, 9hr	1.47	1.33	-9.52	13510	13821	2.30

It is not always expected that the two models will fully match. In fact two separate traditional hydrological models with similar parameters may result in significantly different results. The peak flow from RAFTS at C8 for two design events is approximately 5.5% lower than the flow determined in the SOBEK model respectively. The total volume based on RAFTS model for these two design events is approximately 4.2% higher than the total volume based on the SOBEK model respectively.

It was found that the total volume difference generated by these two models at C5 for the two design events is within 3%. The peak flow based on RAFTS model for the design event of100 year ARI, 2 hours duration is only approximately 2.2% higher than the peak flow based on the SOBEK model. The largest flow difference occurs at C5 for the storm event of 100 year ARI with 9 hours duration. However, this peak flow difference is still within 10%.

The results indicate that the RAFTS model is capable of simulating the hydrological process of the catchment.



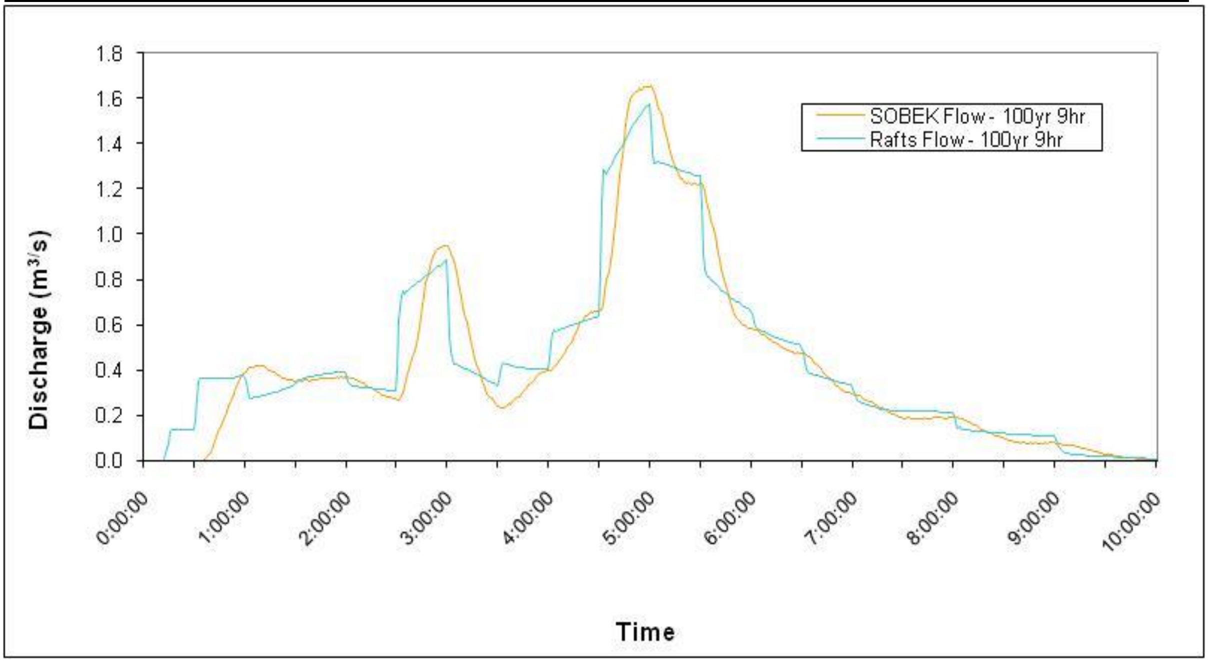
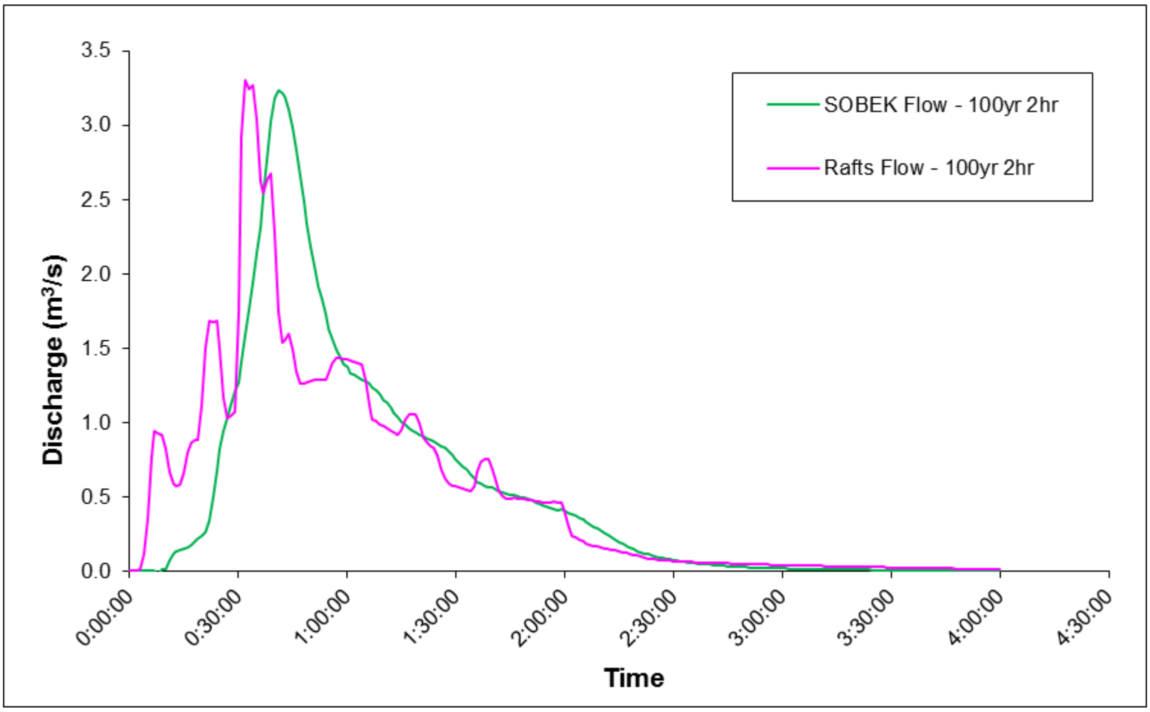


Figure 5.3 Hydrograph Comparison for RAFTS and SOBEK model at Node C8



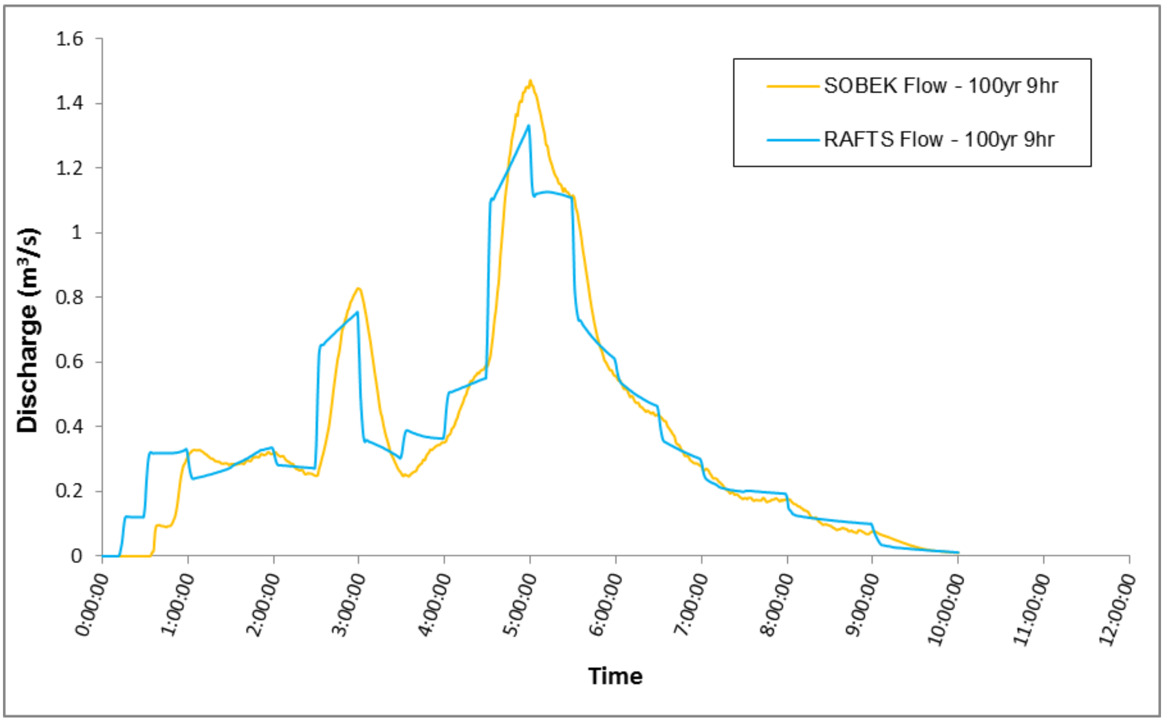


Figure 5.4 Hydrograph Comparison for RAFTS and SOBEK model at Node C5

5.6 Runoff Hydrographs

The RAFTS model was used to produce the runoff hydrographs for inputs to the 1D/2D hydraulic model. The model runs were carried out for a full range of design storms.

Design storm rainfall intensities for the full range of storm frequencies and duration were discussed in **Section 5.3**. The peak flows from the RAFTS model at the input nodes to the 1D/2D hydraulic model for the design events are presented in **Table 5.10**. The locations of input nodes to the 2D domain are referred to **Figure 5.1**.

Table 5.10 Peak Flows of Input Nodes to 1D/2D Hydraulic Model

ARI	Duration (mins)	C16	C25	C12	A1	A2
1 year	15	4.6	2.9	4.9	1.9	0.6
	30	4.5	3.0	6.6	1.8	0.6
	45	3.9	2.9	7.0	1.6	0.5
	60	4.1	3.1	7.1	1.7	0.5
	90	4.4	3.2	8.6	1.9	0.6
	120	4.1	3.2	8.1	1.8	0.6
	180	2.6	2.3	6.9	1.0	0.3
	360	1.7	1.8	5.9	0.8	0.3
	540	1.7	2.0	6.0	0.8	0.3
2 year	15	6.2	3.8	6.4	2.5	0.8
	30	5.9	4.1	7.8	2.3	0.7
	45	5.1	3.8	8.5	2.1	0.7
	60	5.4	4.2	9.6	2.3	0.7
	90	5.8	4.3	10.9	2.5	0.8
	120	5.5	4.3	10.4	2.4	0.8
	180	3.3	3.0	8.3	1.4	0.5
	360	2.3	2.5	7.3	1.1	0.4
	540	2.3	2.7	7.2	1.1	0.4
5 year	15	8.3	5.1	8.4	3.2	1
	30	7.8	5.6	9.9	3.1	1
	45	6.8	5.1	10.3	2.7	0.9
	60	7.3	5.7	12.2	3.1	1
	90	7.8	5.9	13.7	3.4	1.1
	120	7.3	6	12.7	3.2	1.1
	180	4.4	4.2	10.1	2	0.7
	360	3.1	3.6	9.2	1.6	0.5
	540	3	3.5	9.8	1.4	0.5

ARI	Duration (mins)	C16	C25	C12	A1	A2
10 year	15	9.5	5.9	9.6	3.7	1.2
	30	9.0	6.5	11.5	3.6	1.2
	45	7.8	5.9	11.3	3.1	1.0
	60	8.4	6.7	13.6	3.5	1.2
	90	9.0	7.0	15.2	4.0	1.3
	120	8.4	7.0	14.1	3.7	1.2
	180	5.0	4.9	11.2	2.4	0.8
	360	3.5	4.3	10.2	1.8	0.6
	540	3.4	4.0	10.6	1.6	0.5
20 year	15	11.1	7.0	11.1	4.4	1.4
	30	10.5	7.7	13.6	4.2	1.4
	45	9.1	7.0	12.6	3.6	1.2
	60	9.8	7.9	15.4	4.2	1.4
	90	10.6	8.3	17.3	4.7	1.6
	120	9.9	8.3	15.9	4.4	1.4
	180	5.9	5.9	12.7	2.8	0.9
	360	4.1	5.2	12.2	2.1	0.7
	540	4.0	4.6	12.9	1.8	0.6
50 year	15	12.4	8.2	12.4	4.9	1.6
	30	11.3	8.8	15.2	4.6	1.5
	45	10.3	8.1	14.0	4.1	1.3
	60	10.9	9.2	17.1	4.8	1.6
	90	11.7	9.6	19.0	5.3	1.8
	120	10.9	9.4	18.7	4.9	1.6
	180	6.5	6.7	16.9	3.2	1.1
	360	4.6	6.0	16.6	2.4	0.8
	540	4.7	5.5	19.3	2.1	0.7
100 year	15	13.9	9.3	13.9	5.5	1.8
	30	12.7	10	16.9	5.3	1.7
	45	11.6	9.2	15.2	4.6	1.5
	60	12.3	10.6	18.8	5.4	1.8
	90	13.3	11	21.6	6	2
	120	12.3	10.7	22.8	5.5	1.8
	180	7.3	7.7	21.4	3.7	1.2
	360	5.2	6.9	21	2.6	0.9
	540	4.9	5.8	20.3	2.2	0.7

ARI	Duration (mins)	C16	C25	C12	A1	A2
200 year	15	15.3	10.4	15.4	6.1	2.0
	30	13.8	11.0	18.2	5.8	1.9
	45	12.6	10.1	17.8	5.0	1.7
	60	13.4	11.7	22.2	5.9	2.0
	90	14.3	12.0	25.4	6.5	2.2
	120	13.3	11.6	26.4	6.0	2.0
	180	7.8	8.3	23.7	3.9	1.3
	360	5.5	7.3	23.2	2.8	0.9
	540	5.3	6.3	23.2	2.4	0.8
PMF	15	66.1	57.1	101.4	26.1	8.4
	30	48.6	52	144.4	30.1	10.1
	45	43.4	56.9	172.6	28	9.4
	60	39.3	55.1	183.4	21.1	6.8
	90	31.4	45.1	165.5	15.8	5.1
	120	28.9	40.1	151.4	13.5	4.3
	180	38.1	50.4	160.2	10	3.3

6 HYDRAULIC MODELLING

It is a complex task to define overland flows in an urban environment. A number of features associated with urban development have a significant impact on flood behaviour, including:

- In many developed areas, the natural creek systems have been replaced with underground pipe drainage, which has a limited capacity; and
- The complexity of overland flowpaths is increased as a result of the development of the area.

A reasonably accurate assessment of flooding in urban areas requires a two-dimensional approach in modelling the flood behaviour.

6.1 Model Schematisation

A fully dynamic one and two dimensional (1D/2D) hydraulic model was developed for the study area using the TUFLOW modelling system (version 2010-10-AD). The drainage system layout is shown in **Figure 6.1**.

Channels have been modelled as one-dimensional (1D) elements, where the cross-sections were surveyed to define the channel geometry. Once the channel capacity is exceeded, flow is able to spill into the two-dimensional (2D) grid and simulated as overland flow.

Stormwater drainage pits and pipes, shown in **Figure 6.1** have also been incorporated into the model as 1D elements. Once the pipe capacity is exceeded, excess flow spills into the 2D domain via the pits. Similarly, overland flow is able to enter the pipe network through the relevant pit when the drainage system at that location is not at capacity.

6.2 1D Model Set-up

1D components of the hydraulic model consists of pipes, pits, open channels and other hydraulic structures.

6.2.1 Piped Drainage Systems

Piped drainage systems are incorporated into the TUFLOW model as distinct 1D elements connected to the terrain grid. Approximately 14 kilometres of pipes and 2 kilometres of channels are modelled in this study. Detailed field survey by Cardno's surveyors (**Section 2.2**) was primarily utilised for the modelling.

It is noted that the drainage system along Jane Street (shown in **Figure 6.1**) was based on Proposed Stormwater Trunk Drainage Augmentation and Jane Street Realignment Drawings provided by the Council.

The detailed information of pits and pipes in the TUFLOW model is provided in **Appendix D**.

Some of the surveyed pits and pipes have incomplete information, thus assumptions are made for compiling the pit and pipe data to the TUFLOW model. The main assumptions are:

- Missing data for some pits and pipes, such as inlet size and pipe diameter, were determined by reviewing the pit and pipe dimensions in the vicinity;

- Inconsistencies between pit inverts and their respective pipe inverts were corrected. For example, pit inverts were lowered to match pipe inverts;
- Ground survey was not able to provide detailed information on junction pits, thus the invert of junction pits is interpolated between known upstream and downstream pits;
- Pit inverts were corrected where the downstream pit invert is higher than the upstream pit invert;
- Pit surface levels were estimated using the terrain grid in locations where a detailed survey level was not available; and
- Pit surface levels (in 1D) were adjusted in the model to match the terrain grid level (2D) to allow efficient inflow of surface runoff into the piped drainage system.

6.2.2 Open Channels and other Hydraulic Control Structures

The channel features were determined by the representative cross sections. These cross sections were located such that all flow controls were captured, and so that the cross sections adequately represented variations in the channel definition. Details of structures within the study area (such as bridges and culverts) were also gathered, and included in the model.

There are a series of channel crossings along Jamison Road between York Road and Mulgoa Road. Culverts were applied at these locations in the TUFLOW model.

6.2.3 Inlet Capacity

Inlet capacity is one of the key factors that may constrain flows into the drainage system in urban hydraulic modelling. The capacity of inlets depends on the depth and velocity of approaching run-off and the configuration of the inlets.

The pit types and inlet openings were surveyed by Cardno's surveyors. The inlets were modelled in TUFLOW by using inlet capacity curves in accordance with inlet pit types. Inlet pits were classified into 18 categories, which are shown in **Table 6.1**, whist the details of the inlet curves are provided in **Appendix E**. Inlet curves were developed for the 18 types of inlet pits according to corresponding pit inlet curves from the DRAINS (ref).

Table 6.1 Inlet Types Applied in the TUFLOW Model

Inlet Type	Grate		Inlet
	Length (m)	Width (m)	Length (m)
1	≤0.7		-
2	0.7<x≤1.1		-
3	1.1<x≤1.6		-
4	1.95	0.9	-
5	4.0	2.0	-

Inlet Type	Grate		Inlet
	Length (m)	Width (m)	Length (m)
6	5.0	5.0	-
7	-	-	≤1.5
8	-	-	1.5<x≤2.1
9	-	-	2.1<x≤2.7
10	-	-	2.7<x≤3.3
11	-	-	3.3<x≤3.9
12	0.9	0.45	≤1.5
13	0.9	0.45	1.5<x≤2.1
14	0.9	0.45	2.1<x≤2.7
15	0.9	0.45	2.7<x≤3.3
16	0.9	0.45	3.3<x≤3.9
17	0.9	0.45	3.9<x≤4.5
18	0.9	0.45	>4.5

6.2.4 Blockage

The capacity of a drainage system is directly impacted by blockages to the pits and pipes. This study adopted 50% blockage to all inlet pits and no blockage in pipes for design events in accordance with Council's blockage policies. A sensitivity assessment simulation with 0% pit blockage was undertaken to investigate the impact to flood behaviour in the study area if all pits are at capacity, and this is detailed in **Section 12**.

6.3 2D Model Set-up

Two-dimensional (2D) hydraulic modelling was developed to define the flood behaviour for the study area. The 'Direct Rainfall' method (also known as 'rainfall on the grid') was used for areas within the 2D Domain. The inflow hydrographs at the five locations to the 1D/2D hydraulic model in the study area were generated by the traditional hydrological model XP-RAFTS (see **Figure 5.1**).

A fine grid size (1m x 1m) was used to simulate the overland flow behaviour in the study area in detail. The TUFLOW model incorporates all 1D components with a two dimensional (2D) domain (representing the study area topography) to simulate the flood behaviour in the study area.

6.3.1 Model Terrain

A terrain grid (also referred to as a 'topographic' grid) was developed to represent ground elevations based on aerial laser scanning data provided by Council (**Section 2**), with some modifications based on the cross-section ground survey.

The model terrain is shown in **Figure 6.2**. The terrain grid for the TUFLOW model was developed at 1mx1m comprising about 9 million grid points.

6.3.2 Buildings

Buildings within the floodplain in the study area were conservatively assumed to completely block overland flow, and were modelled as raised blocks in the topographic grids. The floodplain covers the areas affected by the flood extent in a PMF event defined in the "Overview Study" (Cardno Lawson Treloar, 2006).

The building outlines used in the "Overview Study" (Cardno Lawson Treloar, 2006) were modified (based on 2008 Aerial photographs provided by the Council) to include buildings recently developed in the downstream of the study area. The buildings layout is shown in **Figure 6.3**. There are 2256 buildings raised within the TUFLOW model boundary in this study.

Buildings outside of the floodplain were modelled using a high roughness value of 0.1. Syme (2008) undertook analysis on different methodologies for incorporating buildings in 2D models, including blocking of the buildings and modelling them with high roughness. The testing indicated that both approaches resulted in similar upstream water levels, although local velocity behaviour could potentially differ. This suggests that the approach of modelling buildings as high roughness provides sufficient detail, particularly outside of the primary floodplain.

Additional sensitivity testing was also undertaken on buildings by lowering the roughness on roofs to 0.02. This is discussed in **Section 12.6**.

A number of shopping arcades were also included in the TUFLOW model. The locations of shopping arcades modelled in the TUFLOW are shown in **Figure 6.4**. The detailed information about these shopping arcades was provided by the Council, whilst the arcade opening widths and the blockage policies are given below:

- Arcade A (50% block) – 3.1 m
- Arcade B (open), 564 High St – 4.2 m
- Arcade C (50% block), 518 High St – 3.35 m

All other arcades within the study area were assumed to be closed or blocked to flow. Refer to **Section 12.3** for a sensitivity test on arcades blocked.

6.4 Specific Features and Revisions to the Modelling

Following review of the modelling by Council and Cardno, the TUFLOW model was revised to include the following key features based on additional information supplied by Penrith City Council. The main features and revisions are as follows:

- Building outlines were modified based on the 2008 aerial photographs provided by Council.
- Pits and pipes along Jane Street, Henry Street, and the bus stop area (highlighted in cyan colour in **Figure 6.1**) were updated according to Proposed Stormwater Trunk Drainage Augmentation and Jane Street Realignment Drawings provided by Council (dated on 19 August 2011) and as discussed with Council in November 2011.

- A section of the existing concrete-lined open channel positioned about 35m south from the south-western corner of the intersection of Lethbridge and Evan Street, and 25m west immediately downstream of Evan Street was amended in the TUFLOW model. This section is now modelled as a 1D channel element based on the channel cross-sections surveyed by Penrith City Council (provided to Cardno on 29th July 2011).

- An existing solid brick fence (about 1m high) at the frontage of 51-57 Henry Street was explicitly included as a blockage to refine modelling of overland flow coming down from the Evan Street ramp at the intersection of Evan and Henry Street.

- Overland flowpaths between current building layouts and flood storage in car park areas at Belmore Street and Station Street in Penrith CBD have been identified and incorporated into the TUFLOW model.

- Overland flow from the northside of Henry Street would enter the car park area of the Good Guys shopping complex from an eastern vehicular entrance, and then exit to Lawson Street. The entrance and exit were modelled as a combination of box culvert and weir based on details from Council (dated 11th October 2011) after detailed site investigations. The eastern entrance was modelled as a 7m wide x 0.3m high box culvert with invert level at RL33mAHD and a 7m wide overflow weir with crest level RL33.6mAHD. The western exit was modelled as a 7m wide x 0.4m high box culvert with invert RL31.8mAHD and a 7m wide overflow weir of crest level RL32.6mAHD.

- The existing stormwater drainage connection near the Target store at the intersection of Henry and High Streets was revised based on information from the 2007-08 drainage survey. The system was modelled as a 0.9m wide x 0.6m high box culvert connected to a 1.55m wide x 0.5m high box culvert which is then connected to a 1.35m diameter pipe.

- A large square-shaped stormwater inlet of 20m perimeter located in the north-western corner of the Western Sydney Institute's car park off Belmore Street was modelled as a broad-crested weir with half its perimeter length allowing for 50% blockage.

- Overland flow at the intersection of Haynes Street and The Crescent is captured by a 900mm diameter pipe which runs underneath the Railway line and connects to the 1.5m diameter pipe in Henry Street. The alignment of this drain is assumed as detailed survey information was not obtained for this line.

- Overland flow at the intersection of Blaxland Avenue and The Crescent is captured by a 750mm diameter pipe which runs underneath the Railway line and connects to the 1.5m diameter pipe in Henry Street. The alignment of this drain is assumed as detailed survey information was not obtained for this line.

- The existing stormwater drainage behind Coles along Woodriff Street, and at the intersection of Woodriff and Stafford Street, was revised based on investigations by Council in October 2011. The system comprises of an existing 1.4m wide x 0.9m high box culvert in Stafford Street connected to a 1.8m wide x 1.25m high box culvert in Woodriff Street. Also, two separate parallel stormwater pipes of sizes 600mm and 675mm diameter are located outside Coles in Woodriff Street.

- The existing ground level at the historic amphitheatre south-east of Penrith Council's main entrance was revised based on information supplied by Penrith Council in August 2011. The base of the former amphitheatre was modelled as filled to RL27.05mAHD to eliminate previously modelled ponding outside Penrith Council's main entrance.

6.5 Hydraulic Roughness

A hydraulic roughness map is required for 2D modelling to classify the surface roughness for various landuses. The roughness map was determined using both aerial photography supplied by Council (**Section 2.2**) and site inspections carried out during the study (**Section 2.3**).

There is no standard reference that provides guidelines on estimating the hydraulic roughness for overland flow in 2D models in urban areas. Previous experience gained from calibrating the catchments with similar landuse and topography usually provides a better guide to determine the roughness values.

The hydraulic roughness map used in the "Overview Study" (Cardno Lawson Treloar, 2006) has been used as a 'base' roughness map in this study, with modifications reflecting the current land development. Fences were modelled in the TUFLOW model using a very high roughness value. **Figure 6.5** shows the hydraulic roughness layout applied in the 2D model.

The roughness values adopted for the 2D and 1D elements are listed in **Table 6.2**.

Table 6.2 Roughness Values for 2D and 1D Elements

Classification	Adopted Roughness Value
2D Roughness Values	
Grass	0.030
Roads	0.015
Residential/Urban Areas	0.100
Forest/Bushland	0.100
Creeks/Waterways	0.030
Open Bushland/Shrubs	0.050
Fences (highly impermeable)	1.00
1D Roughness Values	
Pipe	0.015
Culvert	0.015
Natural Open Channel	0.035
Concrete Open Channel	0.020

It is noted that a uniform high roughness value of 0.1 was applied in residential/urban areas in this study, which is consistent to the SOBEK model adopted in Penrith Overland Flow Study –"Overview Study" (Cardno, 2006). It means that a high roughness value of 0.1 was also applied for raised buildings. A sensitivity analysis has been undertaken to evaluate the potential flood impact by a different roughness value (0.02) for raised buildings. This is discussed in **Section 12.6.4**.

6.6 Boundary Conditions

6.6.1 Model Inflows

As discussed in **Section 4**, the 'Direct Rainfall' method was applied for areas within the 2D domain. Thus rainfall-runoff routing for the modelled area was directly carried out in the hydraulic model.

However, a large volume of runoff was generated by the upstream areas of 2D domain. The hydrographs generated by the traditional hydrological model XP-RAFTS were used as inflows to the 1D/2D model at five locations (see **Figure 5.1**).

6.6.2 Downstream Boundary

A sensitivity analysis has been performed to determine the potential impact of the 20 year ARI Peachtree Creek tailwater condition on water level for the study area. This is further discussed in **Section 12.6.1**. As the influence of the 20 year ARI Peachtree Creek tailwater level has an insignificant impact on the water level within the Penrith CBD study area, a free outfall downstream boundary condition has been adopted by Cardno and agreed with Penrith City Council.

7 MODEL CALIBRATION AND VALIDATION

Calibration and validation are two important processes to ensure that the hydraulic model is capable of simulating the catchment natural responses to the rainfall effectively. Calibration is usually conducted by adjusting the model parameters within acceptable ranges so that the modelled flood levels reasonably match the recorded flood levels at calibration locations. As discussed in **Section 3**, the information regarding the historical flood levels is scarce and the rainfall data may not be representative, making it difficult to calibrate the hydraulic model in this study. Therefore, the robustness and reliability of the hydraulic model was tested by an indirect verification.

The results of community survey (**Section 3**) indicate that seven properties experienced over floor flooding, and 52 properties experienced over ground flooding (see **Figure 3.2**).

The validation was undertaken according to the following steps:

- Determine whether properties that experienced flooding are within the 20 year flood extents; and
- Examine whether the hydraulic model is capable of identifying those properties experienced over floor flooding.

7.1 Validation Based on the Flood Extents

The historical rainfall analysis in **Section 2.5** suggests that the event in February 2006 was the largest historical storm event reported by the community survey, which is roughly equivalent to a 20 year design storm based on the rainfall intensity. However, the storm patterns affecting the CBD may be localised and may not be registered at the STP gauge which is 1.5km away. Therefore, the validation was undertaken using 20 year, 50 year and 100 year ARI design events. The validation results are shown in **Figure 7.1**. A summary of the validation results is presented in **Table 7.1**.

Table 7.1 Validation Results Based on Flood Extents

Property ID	Flood Flag	100yr Extent	50yr Extent	20yr Extent
Impacted by 20 year ARI Extent				
A1	1	1	1	1
A2	2	1	1	1
A3	2	1	1	1
A4	2	1	1	1
A5	2	1	1	1
A6	2	1	1	1
A7	1	1	1	1
A8	1	1	1	1
A9	2	1	1	1
A10	2	1	1	1
A11	2	1	1	1
A12	2	1	1	1

Property ID	Flood Flag	100yr Extent	50yr Extent	20yr Extent
A13	2	1	1	1
A14	2	1	1	1
A15	2	1	1	1
A16	2	1	1	1
A17	2	1	1	1
A18	2	1	1	1
A19	2	1	1	1
A20	2	1	1	1
A21	2	1	1	1
A22	2	1	1	1
A23	2	1	1	1
A24	2	1	1	1
A25	1	1	1	1
A26	2	1	1	1
A27	2	1	1	1
A28	2	1	1	1
A29	2	1	1	1
A30	1	1	1	1
Impacted by 50 year ARI Extent				
A31	2	1	1	0
A32	2	1	1	0
A33	2	1	1	0
A34	2	1	1	0
A35	2	1	1	0
A36	1	1	1	0
Impacted by 100 year ARI Extent				
A37	2	1	0	0
A38	2	1	0	0
A39	2	1	0	0
A40	2	1	0	0
Not Impacted by 100 Year ARI Extent				
A41	2	0	0	0
A42	1	0	0	0
A43	2	0	0	0
A44	2	0	0	0
A45	2	0	0	0
A46	2	0	0	0
A47	2	0	0	0

Property ID	Flood Flag	100yr Extent	50yr Extent	20yr Extent
A48	2	0	0	0
A49	2	0	0	0
A50	2	0	0	0
A51	2	0	0	0
A52	2	0	0	0
A53	2	0	0	0
A54	2	0	0	0
A55	2	0	0	0
A56	2	0	0	0
A57	2	0	0	0
A58	2	0	0	0
A59	2	0	0	0

Note: flood flag column: 1 – over floor flooding, 2 – over ground flooding. For flood extent column, 1 indicates that it was impacted by flood extent.

The community survey (**Section 3**) indicates that 52 properties experienced over ground flooding, and 7 properties experienced over floor flooding. From **Table 7.1**, it was found that 30 out of 59 properties were within the flood extent for a 20 year ARI event. It was also found 6 properties impacted by 50 year ARI flood extent, and 4 properties impacted by 100 year ARI flood extent.

The hydraulic model results do not match the survey results for 19 properties. These properties are generally located at the eastern parts of the study area, which in general are in the upper portions of the floodplain. Nine of these properties are located near a pipeline (as shown on **Figure 7.1**) indicating these sites may have experienced inundation due to a localised pit blockage or localised drainage issues.

One issue is the property at 12 Rosedale Avenue, which was reported to have over-floor flooding. However, the hydraulic model results did not identify flooding in this property. ALS data indicates that the ground levels of this property are approximately 3m higher than the ground levels at 11 Rosedale Avenue, which is currently located within the flood extent. The analysis on ALS data supports the model results for the property at 12 Rosedale Avenue.

In general, the validation results suggest that the flood events were reasonably defined by the hydraulic model.

7.2 Validation Based on Over Floor Flooding

This validation was undertaken by testing whether the hydraulic model is capable of defining the properties being affected by over floor flooding.

The community survey reported seven properties which experienced over floor flooding. A floor level survey that was conducted by Council (**Section 2.2.3**) provided floor levels for six properties, excluding the property at 12 Rosedale Avenue. **Table 7.2** shows the validation results based on testing over floor flooding.

Table 7.2 Validation Results Based on Testing Over Floor Flooding

Property ID	Floor Levels Surveyed (mAHD)	Flood Levels Modelled (mAHD)			Difference (m)		
		20yr	50yr	100yr	20yr	50yr	100yr
A7	36.74	36.73	36.77	36.83	-0.01	0.03	0.09
A1	30.70	30.29	30.31	30.33	-0.41	-0.39	-0.37
A30	36.15	36.17	36.25	36.32	0.02	0.1	0.17
A8	43.70	43.65	43.69	43.78	-0.05	-0.01	0.08
A25	32.73	33.10	33.19	33.26	0.37	0.46	0.53
A36	29.26	-	29.23	29.31	-	-0.03	0.05

The flood levels in Table 7.2 were obtained based on flood damage estimation in **Section 11**. It is referred to **Section 11** for details.

Table 7.2 indicates that the hydraulic model identifies over floor flooding occurred for five properties. However, the A1 property was not identified as over floor flooding. For flood damage estimation (**Section 11**), the flood level for each property was estimated as the sum of the surveyed ground level and the average flood depth within the flood extent for this property. The floor level is about 0.7m higher than the surveyed ground level at A1 property. This may explain why this property was not identified as over floor flooding.

8 DESIGN FLOOD MODELLING RESULTS

8.1 Flood Extents

As discussed in **Section 4**, rainfall was applied directly to the 2D domain, using the 'Direct Rainfall' approach. This approach results in every 2D cell being inundated with some flood depth. In order to create model extents and provide reasonable results, a filter was applied to separate what is normal catchment runoff and what is flooding. The flood extents were drawn only for depths greater than 0.15m, consistent with Cardno (2006). In addition, flood extents do not include isolated water ponding areas outside of major overland flowpaths which are smaller than 100 m^2. Flood extents for PMF, 200 year, 100 year, 50 year, 20 year, 10 year, 5 year, 2 year and 1 year ARI are shown in **Figures 8.1-8.9**.

8.2 Critical Duration

Table 8.1 lists a range of the design events utilised in the TUFLOW model in this study.

Table 8.1 Design Strom Events Utilised in the TUFLOW Model

Design Event	Durations (minutes)
100 year, 20 year and 5 year ARI	15, 30, 45, 60, 90, 120, 180, 360, 540
1 year, 2 year, 10 year, 50 year and 200 year ARI	120, 540
PMF	15, 30

A number of durations, as identified in **Table 8.1**, were analysed for the 100 year, 20 year and 5 year ARI eevnts. This was undertaken to determine the representative critical durations for the catchment.

Critical durations for 100 year ARI and 5 year ARI events are shown in **Figures 8.10-8.11**. A 2 hour duration is critical in a 100 year ARI event in the majority of the study area. The critical duration is 9 hours for some significant ponding locations in the western part of the study area.

Similarly, the 2 hour storm is the critical duration for a 5 year ARI in the eastern part of the study area. In the western part of the study area, the critical durations are 2 hours and 9 hours for the 5 year ARI event.

In general, the 2 hour storm is results in the maximum flood levels across the floodplain. There are some isolated areas with longer critical durations, but these are generally associated with isolated ponding locations.

Other ARIs (with the exception of the PMF) were therefore analysed with the 2 hour and 9 hour events, based on the critical durations for the 5 year and 100 year ARI.

8.3 Peak Flood Levels, Depths, and Velocities

Model results for the flood peak depth, level and velocity were processed within the flood extents. These represent the envelope of the results, being the maximum of all durations analysed. Peak flood depths for PMF, 200 year, 100 year, 50 year, 20 year, 10 year, 5 year, 2 year and 1 year ARI are shown in **Figures 8.12-8.20**. The peak flood levels for these design events are shown in **Figures 8.21-8.29**, whilst the peak flood velocities for the design events are shown in **Figure 8.30-8.38**.

Water levels for design storms at a number of reference points are provided in **Appendix F**, and the locations of these reference points are shown in **Figure 8.39**.

8.4 Peak Flows of Pipes and Open Channels

The peak flows for pipes which are greater than 600mm diameter are provided in **Appendix G**. The results of pipe capacity analysis are also shown in **Appendix G** (**Section 8.8** for details).

The peak flows for open channel are also provided in **Appendix H**.

8.5 2D Peak Flows

2D peak flows at reference locations for a full range of design events are provided in **Appendix I**, whilst these reference locations are shown in **Figure 8.40**.

8.6 Discussion of Results

The following discussion is based primarily on the results of 100 year ARI events, unless otherwise stated.

8.6.1 Flood Behaviour in the East of the Study Area

The eastern parts of the study area are relatively steep with elevations in the range of 30.5 and 69.5 mAHD. Runoff in the eastern parts of the study area is generated by the local catchment. Residential properties are the primary land-use in these areas.

The modelling (**Figure 8.3**) indicates that two overland flow tributaries start from Parker Street, and converge near the corner of Doonmore Street and Hope Street. This flow continues draining down to the corner of Lethbridge Street and Castlereagh Street, where a flow tributary down from Evan Street mergers.

The flowpaths in the upper portions are primarily overland flow, and proceed between the houses and across the roads in these areas. Significant ponding occurs at a trapped low point surrounded by Lethbridge Street, Castlereagh Street and Derby Street, as well as at the corner of Henry Street and Evan Street. Peak depths of ponding in both of these locations exceed 1m for the 100 year ARI event.

8.6.2 Flood Behaviour in the West of the Study Area

The western parts of the study area are located at the lower and flat portion of the study area. The area incorporates a mix of residential and industrial properties.

Flooding in this area consists of three sources, including local runoff, the upstream runoff from a large catchment area to the south of Jamison Road, and runoff from the east of the study area. The upstream runoff is the dominant portion, which is generated based on a catchment area of approximate 365 hectares.

Some ponding occurs in the residential areas between Castlereagh Street and Woodriff Street. The flood depths for a number of properties are up to 0.5m for 100 year ARI events.

This study includes a small portion of area that is located on the north side of railway and between Mulgoa Road and Nepean River. In this area, overland flows are primarily confined to road.

8.6.3 Flood Behaviour North Side of Railway

The railway provides a barrier to overland flows from the upstream catchment. From the models, it was found that over-topping does not occur in the eastern part of railway as it is elevated sufficiently above the flood levels. However, over- topping occurs in the vicinity of Crescent Bridge for the PMF. The railway over-topping location is shown in **Figure 8.41**.

8.7 Major Access Road Flooding

There are a number of major roads in the study area, including Henry Street, High Street, Lethbridge Street, and Woodriff Street. Road flooding not only directly impacts on local traffic, but also hinders the access of emergency vehicles using the road network in the study area.

A summary of major access road flooding is provided in **Table 8.2,** with the locations shown in **Figure 8.42**. This table provides indicative flood depths at a number of locations. The actual depth may vary depending on the location on the road. It should be noted that, in general, the critical duration for flooding in the study area ranges from 2 to 9 hours, therefore, road inundation may occur over a relatively long timeframe, particular, in the western portions of the catchment.

Table 8.2 Major Access Road Flooding - Indicative Depths (metres)*

Location ID	PMF	200yr	100yr	50yr	20yr	10yr	5yr	2yr	1yr
B1	0.60	0.33	0.33	0.31	0.30	0.29	0.27	0.25	0.23
B2	0.76	0.36	0.35	0.34	0.32	0.31	0.29	0.26	0.24
B3	1.94	0.52	0.50	0.47	0.43	0.40	0.38	0.33	0.30
B4	0.89	0.31	0.30	0.27	0.24	0.22	0.20	0.17	-
B5	1.37	0.63	0.61	0.56	0.51	0.43	0.35	0.24	0.17
B6	0.57	0.26	0.25	0.26	0.22	0.20	0.16	-	-
B7	1.64	0.47	0.45	0.41	0.37	0.31	0.25	-	-
B8	1.54	0.47	0.45	0.42	0.38	0.35	0.31	0.20	-
B9	0.55	0.38	0.38	0.36	0.33	0.28	0.23	-	-
B10	0.55	0.41	0.40	0.39	0.35	0.30	0.26	0.18	-
B11	0.97	0.36	0.34	0.31	0.29	0.26	0.24	-	-
B12	0.50	0.32	0.32	0.31	0.31	0.30	0.30	0.28	0.25
B13	0.61	0.35	0.34	0.33	0.30	0.25	0.22	-	-
B14	1.11	0.35	0.33	0.31	0.28	0.25	0.21	-	-
B15	1.04	0.48	0.46	0.45	0.43	0.41	0.39	0.35	0.31
B16	1.25	0.32	0.30	0.28	0.26	0.24	0.22	0.16	-
B17	1.98	0.56	0.49	0.37	0.23	0.16	-	-	-
B18	1.27	0.41	0.32	0.24	0.16	-	-	-	-
B19	0.73	0.31	0.29	0.24	0.21	0.18	0.18	0.16	-
B20	1.09	0.34	0.32	0.28	0.24	0.17	-	-	-

Note: only depths greater than 0.15m are shown in the table.

The model results indicate a potential road flooding along Jamison Road which is between Brown Street and Woodriff Street. The peak flood depth in a 100 year ARI event is approximately 0.3 metres in this area.

There are two road flooding spots along Mulgoa Road in the study area. The first spot is in the corner of Mulgoa Road and Jamison Road, whilst the second spot is in the west side of Mulgoa Road near Rodley Avenue. The peak flood depth is approximately 0.3m for a 100 year ARI in these two locations.

8.8 Pipe Capacity Assessment

A pipe capacity assessment was undertaken for the trunk drainage system for the study area, for pipes of greater than 600mm in diameter. Pipe attributes (upper invert, lower invert, pipe length, slope, pipe diameter) were extracted from the TUFLOW hydraulic model.

This assessment was undertaken by comparing the nominal pipe capacity based on a Mannings equation against the modelled pipe capacity. The nominal pipe capacity and the modelled peak flows for design events are provided in **Appendix G**. The ARI rating of the pipes (Nominal return period) were calculated by determining the design event in which the pipe was running full.

The nominal return period for these pipes are shown in **Figure 8.43**, which clearly identify which pipe sizes are not sufficient to convey flows in the study area. The flow capacity for 217 pipes of greater than 600mm in diameter was analysed. The nominal capacity of 52 pipes (in **Figure 8.43**) is not greater than a 5 year ARI. The modelled peak flows of open channels for design events are provided in **Appendix H**.

8.9 Mass Balance in TUFLOW Models

A mass balance check was carried out during each model run as it indicated the healthiness of the model. In terms of TUFLOW modelling, a cumulative mass error in a range of ± 2% would suggest a robust model. This is also noted in Engineers Australia (2012). However, for rainfall on grid models, the cumulative mass error is generally slightly higher due to the fact that water might be retained in the model due to terrain effect coupled with rapid wetting and drying in steep areas. In the Penrith models, the cumulative mass errors for each storm return and duration are summarised in **Table 8.3**. These errors are well within the expected range.

Table 8.3 Cumulative Mass Errors (ME) for Design Events

Design Event	Duration	ME%
PMF	30 mins	-0.9
200 Year ARI	2 hours	-1.7
	9 hours	-2.1
100 Year ARI	2 hours	-2.0
	9 hours	-2.4
50 Year ARI	2 hours	-2.0
	9 hours	-2.4
20 Year ARI	2 hours	-2.2
	9 hours	-2.5

Design Event	Duration	ME%
10 Year ARI	2 hours	-2.1
	9 hours	-2.6
5 Year ARI	2 hours	-2.2
	9 hours	-2.7
2 Year ARI	2 hours	-1.8
	9 hours	-2.5
1 Year ARI	2 hours	-2.5
	9 hours	-2.9

In addition, for comparison purpose, cumulative mass errors in a 100 year ARI, 2 hours duration were obtained from models of using 2m grid, 3m grid and 4m grid. These cumulative mass errors are summarised in **Table 8.4**.

Table 8.4 Comparison of Cumulative Mass Errors for Models using Different Grid Sizes

Model	1m Grid	2m Grid	3m Grid	4m Grid
ME (%)	-2.0	-0.9	-1.3	-0.8

9 PROVISIONAL FLOOD HAZARD

9.1 General

Flood hazard can be defined as the risk to life and limb caused by a flood. The hazard caused by a flood varies both in time and place across the floodplain.

The *Floodplain Development Manual* (NSW Government, 2005) describes various factors to be considered in determining the degree of hazard. These factors are:

- Size of the flood
- Depth and velocity of floodwaters
- Effective warning time
- Flood awareness
- Rate of rise of floodwaters
- Duration of flooding
- Evacuation problems
- Access.

Hazard categorisation based on all the above factors is often referred to as 'true hazard'. The scope of the present study is to determine 'provisional' flood hazards only. The provisional flood hazard is generally considered in conjunction with the above listed factors as part of the Floodplain Risk Management Study (the next stage of the Floodplain Risk Management process after the Flood Study) to provide a comprehensive analysis of the overall flood hazard.

9.2 Provisional Flood Hazard

Provisional flood hazard is determined through a relationship developed between the depth and velocity of floodwaters (NSW Government, 2005). The two categories for provisional hazard are defined as High and Low shown in **Figure 9.1**.

The hazard results were directly generated by the TUFLOW model, which utilises the model results of flood depth and velocity. In this study, high hazard includes the high and medium hazard zones shown in **Figure 9.1**.

Provisional flood hazard for PMF, 200 year,100 year, 50 year, 20 year, 10 year, 5 year, 2 year and 1 year ARI design events is shown in **Figures 9.2-9.10**.

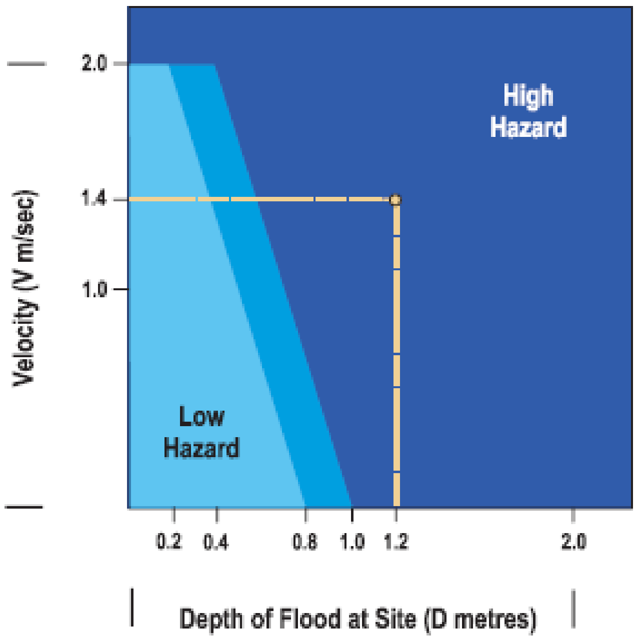


Figure 9.1 Provisional Hazard Classifications (NSW Government, 2005)

9.3 Discussion

Generally high hazard in the 200 year ARI and 100 year ARI events is limited to the channels and some localised ponding at the following locations:

- Corner of Henry Street and Evan Street;
- Corner of Lethbridge Street and Castlereagh Street;
- Two ponding areas in the north-western corner of the study area.

High hazard conditions for the 20 year, 10 year and 5 year ARI events is primarily limited to the channels and two ponding areas in the north-western corner of the study area. In a 1 year ARI event the high hazard is limited to the channels.

In general, the high hazard for the study area is primarily defined by water depth rather than velocity.

10 HYDRAULIC CATEGORIES

10.1 General

The damages and disruption caused by floodwaters depend on the extent and duration of flood inundation, and on the depth and the velocity of flow. The hydraulic categories (floodway, flood storage and flood fringe) are typically defined in accordance with the NSW Government's *Floodplain Development Manual (April 2005)* as follows:

- Floodways tend to be aligned with natural channels and carry the main volumes of water during floods, often at substantial flow velocities;
- Flood storage areas become filled with water for temporary storage during floods;
- Flood fringe areas are those remaining after floodways and storage areas have been defined.

Hydraulic categories for the study area have been provided for a full range of design storms. The method of mapping the hydraulic categories is as follows (Howells et al, 2003):

- Floodways include creek and channels. Floodways are also defined following depth and velocity criteria:
  - Velocity-depth product must be greater than 0.25m^2/s and velocity must be greater than 0.25 m/s or
  - Velocity is greater than 1m/s.
- Flood storage is the remaining area where flood depth is greater than 0.2 m; and
- Flood fringe is the remaining area within the flood extent which is not either Floodway or Flood Fringe.

The hydraulic categories for the full range of design events are shown in **Figures 10.1 to 10.9**.

10.2 Discussion

Overland flow between Parker Street and Woodriff Street is categorised as floodway along most of its length in the 200 year ARI, 100 year and 50 year ARI events, This flowpath extends from Woodriff Street to High Street which is close to the Westfield Shopping Centre. A flowpath at the corner of Henry Street and Evan Street is also categorised as floodway. The majority of the western portion of the catchment is dominated by storage

The floodway is limited to the channels and some upstream flowpaths for 20 year and 10 year ARI. For 5 year, 2 year and 1 year ARI events, the floodway is generally limited to the channels. The floodplain is predominately classified as flood storage.

11 FLOOD DAMAGE ESTIMATION

11.1 Background

Flooding is likely to cause significant social and economic damages to the communities. The flood damages are classified into different categories, which are summarised in **Table 11.1**.

Table 11.1 Types of Flood Damages

Type of Flood Damage	Description
Direct	Building contents (internal) Structure (building repair and clean) External items (vehicles, contents of sheds etc)
Indirect	Clean-up (immediate removal of debris) Financial (loss of revenue, extra expenditure) Opportunity (non-provision of public services)
Intangible	Social – increased levels of insecurity, depression, stress General inconvenience in post-flood stage

The direct damage costs, as indicated in the above table, are just one component of the entire cost of a flood event. There are also indirect costs. Both direct and indirect costs are referred to as 'tangible' costs. In addition to this there are also 'intangible' costs such as social distress. The flood damage values discussed in this report are the tangible damages and do not include an assessment of the intangible costs which are difficult to calculate in economic terms.

Flood damages can be assessed by a number of methods including the use of computer programs such as FLDAMAGE or ANUFLOOD or via more generic methods using spreadsheets. For the purposes of this project, generic spreadsheets have been used with assistance from DECCW (now OEH) Damage Curves on the adoption of appropriate damage curves.

11.2 Floor Level and Property Survey

A detailed floor level and property survey spreadsheet and GIS data were provided by Council in August, 2011. The floor survey data includes details of a property including the type of a property (residential, commercial, Industrial, car park, or vacant), the ground and floor levels, the floor area of commercial/industrial buildings etc.

The floor level and property survey GIS data provided survey information about 1704 properties, although 112 of these have duplicated data. Removing the duplications, there are a total of 1592 properties for flood damage estimation. Some properties have incomplete survey data in the floor survey GIS data, including:

- 61 properties were not provided information regarding the type of property (residential, commercial, Industrial, car park, or vacant);
- 158 properties do not have ground levels;

- 57 commercial/industrial properties do not have information regarding the floor area, and
- There are significant inconsistencies between the floor level survey GIS data provided and the spreadsheet data that was provided. For example, the floor level data in the survey spreadsheet was recorded as the ground level in the GIS data for 235 properties. In this study, it was assumed that the spreadsheet data was the most representative and therefore this data was used to update the GIS information.

11.3 Assumptions

The following assumptions were applied for flood damage estimation since the floor level and property survey data provided incomplete information. These assumptions are:

i. The flood level for each property was estimated as the sum of the surveyed ground level and the average flood depth.

ii. For 158 properties without surveyed ground levels, the average ground level within PMF flood extent for this property was assumed to be the ground level for this property.

iii. For 314 properties without surveyed floor levels (based on the survey spreadsheet data), the floor levels for these properties were assumed to be 0.3m higher than the surveyed ground levels.

iv. For 57 commercial/industrial properties without floor area, the floor areas were estimated from aerial photographs.

v. For 61 properties without information regarding the type of property, the type of this property was identified (Residential, Commercial/Industrial, Car Park or Vacant) from aerial photographs.

vi. For 75 properties, the surveyed floor level is significant lower than the surveyed ground level. It results in unrealistic estimates of damage, e.g., up to 2m of flood depth for 1 year ARI event at some properties. It was assumed that the floor levels for these properties were 0.3m higher than the surveyed ground levels.

vii. In damage calculation spreadsheet, the damage costs caused by flooding were only estimated for properties which building outline (1m buffer) was affected by flood extents.

11.4 Damage Analysis

A flood damage assessment for the existing catchment and floodplain conditions has been undertaken as part of the current study. The assessment is based on damage curves that relate the depth of flooding on a property, to the potential damage within the property.

Ideally, the damage curves should be prepared for the particular catchment for which the study is being carried out. However, damage data in most catchments is not available and recourse is generally made to damage curves from other catchments. OEH has carried out research and prepared a methodology (draft) to develop damage curves based on state-wide historical data. This methodology is only for residential properties and does not cover industrial or commercial properties.

The OEH methodology is only a recommendation and there are currently no strict guidelines regarding the use of damage curves in NSW. However, correspondence at the outset of this project with OEH confirmed that the use of OEH curves was appropriate.

The following sections set out the methodology for the determination of damages within the Penrith CBD floodplain.

11.4.1 Residential Damage Curves

The draft DNR (now OEH) Floodplain Management Guideline No. 4 Residential Flood Damage Calculation (2004) was used in the creation of the residential damage curves. These guidelines include a template spreadsheet program that determines damage curves for three types of residential buildings:

- Single storey, slab-on-ground
- Two storey, slab-on-ground
- Single storey, high-set (i.e. on piers)

Two types of these properties were adopted for this study, including the single storey slab-on-ground and the two storey slab-on-ground. No single storey high-set houses, apartment buildings or townhouses were identified in the survey therefore no additional costs were apportioned based on these landuses.

Damages are generally incurred on a property prior to any over-floor flooding. The OEH curves allow for a damage of $10,452 (May 2012 dollars) to be incurred when the water level reaches the base of the house (the base of the house is determined by 0.3m below the floor level for slab on ground). Damages of this type are generally direct external damages (sheds, gardens), direct structural damages (foundational damage) or indirect damages (garden amenity and debris clean-up). According to the damage curves this amount of damage remains constant from the base of the house to the floor level of the house.

As mentioned in Section 11.3, the floor levels for these properties were assumed to be 0.3m higher than the surveyed ground levels for 314 properties without surveyed floor levels (based on the survey spreadsheet).

Given some of the inconsistencies in the data set, the following was assumed:

- When the depth of flooding on the property exceeded 0.3 metres, a nominal $3000 of garden damage was assumed;
- When the flood level is a 0.1 metres below the floor level, then a damage of $10,452 is incurred, as per the OEH damage curves.

There are a number of input parameters required for the OEH curves, such as floor area and level of flood awareness. The following parameters were adopted:

- Based on interrogation of the aerial photos a value of 200m^2 was adopted as a conservative estimate of the floor area for residential dwellings for the floodplain. With a floor area of 200m^2, the default contents value is $50,000 (November 2001 dollars).

- The effective warning time has been assumed to be zero due to the absence of any flood warning systems in the catchment. A long effective warning time allows residents to prepare for flooding by moving valuable household contents (e.g. the placement of valuables on top of tables and benches).
- The Penrith CBD catchment is within a large metropolitan area, and as such is not likely to cause any post-flood inflation. These inflation costs are generally experienced in remote areas, where re-construction resources are limited and large floods can cause a strain on these resources.

Average Weekly Earnings

The OEH curves are derived for late 2001, and were updated to represent May 2012 dollars. General recommendations by OEH are to adjust values in residential damage curves by Average Weekly Earnings (AWE), rather than by the inflation rate as measured by the Consumer Price Index (CPI). OEH proposes that AWE is a better representation of societal wealth, and hence an indirect measure of the building and contents value of a home. The most recent data for AWE from the Australian Bureau of Statistics at the time of the assessment was for May 2012. Therefore all ordinates in the residential flood damage curves were updated to May 2012 dollars.

While not specified, it has been assumed that the curves provided by OEH were derived in November 2001, which allows the use of November 2001 AWE statistics (issued quarterly) for comparison purposes. November 2001 AWE and May 2012 AWE were taken from the Australian Bureau of Statistics website (www.abs.gov.au).

Table 11.2 AWE Statistics (source from www.abs.gov.au)

Month	Year	AWE
November	2001	$676.40
May	2012	$1057.30
Change	56.31%	

Consequently, all ordinates on the damage curves were increased by 56.31%.

11.4.2 Commercial Damage Curves

Commercial damage curves have been adopted from the FLDamage Manual, Water Studies Pty Ltd (1992). FLDamage allows for three types of commercial properties:

- Low value commercial;
- Medium value commercial; and
- High value commercial.

In determining these damage curves, it has been assumed that the effective warning time is approximately zero, and the loss of trading days as a result of the flooding has been taken as 10 days.

These curves are determined based on the floor area of the property. The floor level survey provides an estimate of the floor area of the individual properties. For some commercial properties without the surveyed floor area, the floor area was estimated from aerial photographs.

The Consumer Price Index (CPI) was used to bring the 1990 data to March 2012 dollars (this data was obtained from the Australian Bureau of Statistics website (www.abs.gov.au). The CPI data is shown in **Table 11.3**.

Table 11.3 CPI Statistics for Commercial Property Damage Estimation

Month	Year	CPI
June	1990	102.50
March	2012	178.80
Change	74.44%	

Consequently, damages have been increased by 74.44%.

11.4.3 Industrial Damage Curves

Cardno, as a part of the Allans Creek Floodplain Management Study, conducted a survey of industrial properties in 1998 for Wollongong City Council (Cardno Lawson Treloar, 2006). The damage curves derived from this survey are more recent than those presented in FLDamage and have been used in a number of previous studies. Therefore Cardno feels these damage curves are adequate for use in this study.

The curves were prepared for three categories:

- Low value industrial (e.g. small factories and workshops)
- Medium value industrial (e.g. large industrial properties in the corner of Castlereagh Road and Railway)
- High value industrial (e.g. BHP steelworks in Wollongong).

Within the catchment, there are no properties considered to be representative of high value industrial properties, and hence these curves were not used.

The survey conducted only accounts for structural and contents damage to the property. Clean up costs and indirect financial costs were estimated based on FLDamage Manual. Actual internal damage could be estimated, along with potential internal damage, using various factors within FLDamage. Using both the actual and potential internal damages, estimation of both the cleanup costs and indirect financial costs could be made. The values were adjusted to March 2012 dollars using the CPI statistics shown in **Table 11 4**.

Table 11.4 CPI Statistics for Industrial Property Damage Estimation

Month	Year	CPI
June	1998	121.00
March	2012	178.80
Change	47.77%	

Consequently, damages have been increased by 47.77%.

11.4.4 Car Park Damage Curves

The floor level and property survey data indicate that there are a number of car parks in the study area. Flooding may cause significant car damage costs, including clean-up, repairs, and disposal costs.

There are no standard damage curves for car parks in the current application in New South Wales. Damage curves for car park were derived by Cardno for this study following the assumptions as below:

- Approximately 70% of the total area is used for carspace lots;
- The area of a carspace is approximately 15m^2 (5.5m*2.6m);
- Approximately 80% of carspaces are occupied;
- Proportional damage costs between $3,000 and $10,000 per car are estimated when the flood depths are in a range of 0.3-1.0m;
- The assumed average disposal cost is $10,000 per car when the flood depths are higher than 1.0m, and
- Note that the estimates for the disposals and damages are likely to be on the low end, and hence provide a conservative estimate.

11.4.5 Adopted Damage Curves

The adopted damage curves are shown in **Figure 11.1**. The commercial and industrial damage curves are for a property with a floor area of 100m^2. The car park damage curves are estimated per car.

To normalise the damages for property size, the curves have been factored to account for floor area. The floor level survey provided an estimate of the floor area of commercial\ industrial properties. For some commercial\industrial properties without the surveyed floor area, the floor area was estimated from aerial photographs.

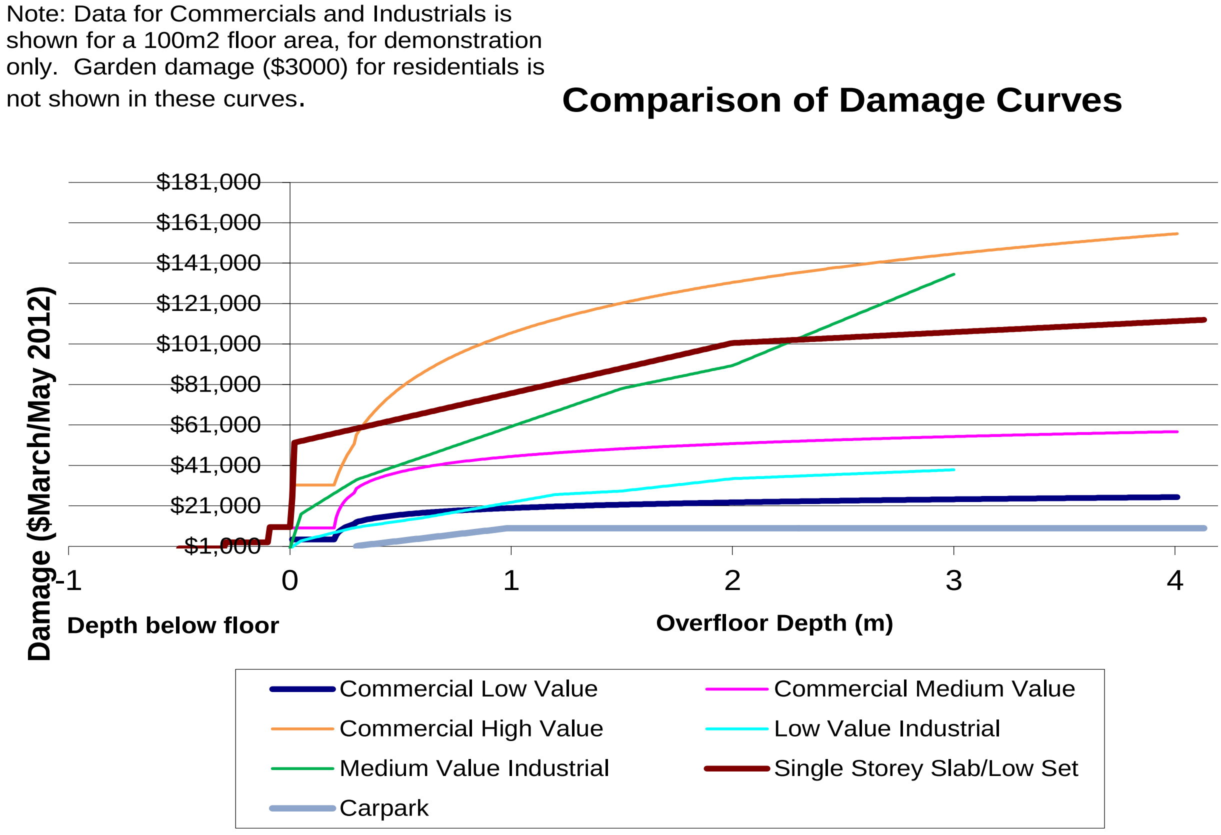


Figure 11.1 Damage Curves Developed for Penrith CBD

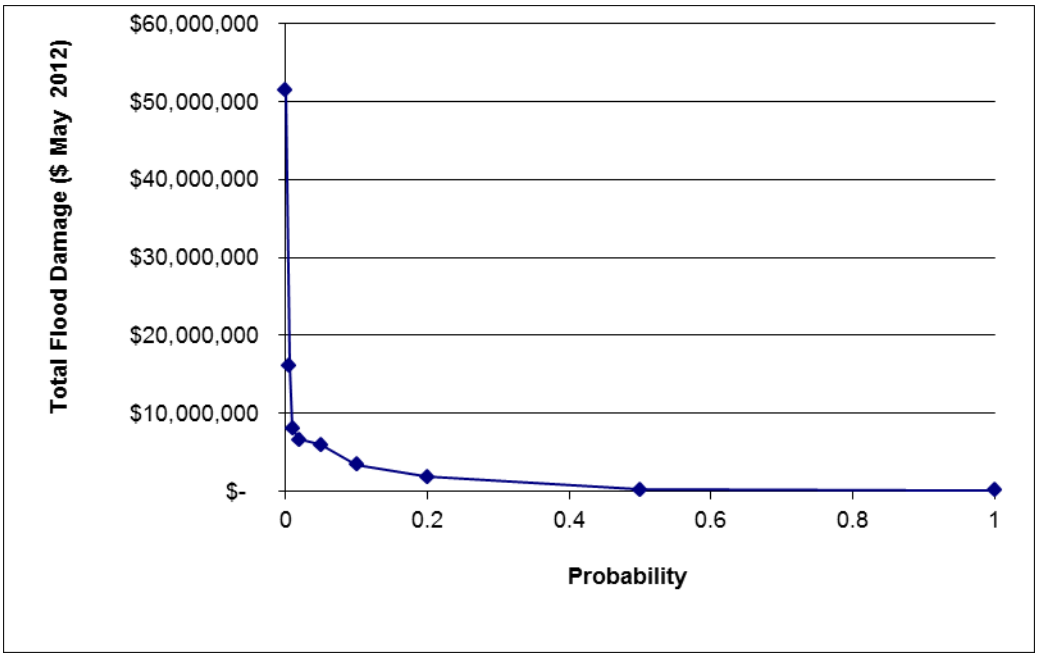
11.5 Average Annual Damage

Average Annual Damage (AAD) is calculated on a probability approach, using the flood damages calculated for each design event.

Flood damages (for a design event) are calculated by using the 'damage curves' described in the sections above. These damage curves define the damage experienced on a property for varying depths of flooding. The total damage for a design event is determined by adding all the individual property damages for that event.

AAD attempts to quantify the flood damage that a floodplain would receive on average during a single year. It does this using a probability approach. A probability curve is drawn, based on the flood damages calculated for each design event (**Figure 11.2**). For example, the 100 year ARI design event has a probability of occurring of 1% in any given year, and as such the 100 year ARI flood damage is plotted at this point on the AAD curve (Figure 11.2). AAD is then calculated by determining the area under this curve.

Further information on the calculation of AAD is provided in Appendix M of the Floodplain Development Manual (NSW Government, 2005).



Note: The probability of the PMF occurring is assumed as 0.0001%

Figure 11.2 Flood Damage Variation with AEP for Penrith CBD

11.6 Results

Table 11.5 shows the results of the flood damage assessments. Based on the analysis described in **Section 11.4**, the total average annual damage for all events up to and including the PMF estimated for the Penrith CBD floodplain under the existing conditions is approximately $1.4 million.

The average annual damage reflects of the likelihood of each design flood event in one year and the damages likely to occur as a result of that event. Whilst this is a useful tool for evaluating the benefit of flood management options and assessing the flood damage to an area over a long period of time, it is also important to note the actual damages estimated to occur as a result of each design flood event. The cost to the community of flood damage is not incurred as an average annual amount. The costs will be borne at one time by the damage incurred by a specific flood event.

Financial and community attitude surveys and analysis undertaken in other areas of Sydney (e.g. the Hawkesbury Nepean Valley) (Gillespie et al, 2002) suggests that many people would have real difficulties dealing with the cost of recovering from severe flooding.

Table 11.5 Flood Damage Assessment Summary

Property Type	Properties with Overfloor Flooding	Average Overfloor Flooding Depth (m)	Maximum Overfloor Flooding Depth (m)	Properties with Overground Flooding	Total Damage ($May 2012)
			PMF		
Residential	446	0.42	1.77	771	$28,332,136
Commercial	266	0.45	1.93	365	$16,584,490
Industry	12	0.12	0.32	15	$1,853,985
Car Park				10	$4,674,377
PMF Total	724			1161	$51,444,989
			200 Year ARI		
Residential	150	0.34	0.80	377	$8,799,777
Commercial	115	0.30	0.63	178	$7,049,031
Industry	2	0.17	0.22	3	$75,706
Car Park				3	$172,006
200 Year ARI Total	267			561	$16,096,520
			100 Year ARI		
Residential	107	0.25	0.62	344	$4,960,583
Commercial	96	0.26	0.62	165	$3,028,816
Industrial	-	-	-	2	Nil
Car Park				1	$45,440
100 Year ARI Total	204			512	$8,034,840
			50 Year ARI		
Residential	98	0.24	0.61	331	$4,198,814
Commercial	82	0.24	0.61	147	$2,399,087
Industrial	-	-	-	1	Nil
Car Park				1	$42,560
50 Year ARI Total	180			480	$6,640,461
			20 Year ARI		
Residential	65	0.26	0.60	286	$4,000,682
Commercial	63	0.19	0.58	140	$1,855,020
Industrial	-	-	-	1	Nil
Car Park				1	$36,800
20 Year ARI Total	128			428	$5,892,502
			10 Year ARI		
Residential	48	0.32	0.60	251	$2,984,061
Commercial	21	0.24	0.58	100	$377,002
Industry	-	-	-	1	Nil
Car Park				1	$28,160
10 Year ARI Total	69			353	$3,389,222

Property Type	Properties with Overfloor Flooding	Average Overfloor Flooding Depth (m)	Maximum Overfloor Flooding Depth (m)	Properties with Overground Flooding	Total Damage ($May 2012)
5 Year ARI					
Residential	25	0.34	0.58	142	$1,591,001
Commercial	11	0.22	0.54	75	$205,133
Industry	-	-	-	1	Nil
Car Park				1	$28,160
5 Year ARI Total	36			219	$1,824,294
2 Year ARI					
Residential	3	0.20	0.26	73	$210,684
Commercial				44	Nil
Industrial					
Car Park					
2 Year ARI Total	3			117	$210,684
1 Year ARI					
Residential	2	0.23	0.24	47	$149,184
Commercial				39	
Industry					
Car Park					
1 Year ARI Total	2				$149,184

Note: damage costs exclude GST. Garden damages for commercial/industrial properties were not considered.

12 SENSITIVITY ANALYSIS

A sensitivity analysis was undertaken to investigate the flood impact of the key model parameters, including:

- Rainfall – increase and decrease by 20%;
- Hydraulic roughness – increase and decrease by 20%.
- Arcades blocked – assuming all arcades were fully blocked;
- Downstream boundary conditions;
- Pits and pipes blocked; and

The base case for the sensitivity analysis is 100 year ARI with 2 hour duration, which is the critical event for 100 year ARI.

12.1 Rainfall

An analysis of the sensitivity of the model to rainfall is also an indication of the sensitivity of the study area to potential impacts for climate change. The 20% increase in rainfall assessed here is in the middle of the recommended DECCW (now OEH) climate change guidelines of 10 – 30% rainfall increases.

The flood level impact of an increase\decrease of rainfall by 20% is shown in **Figure 12.1-12.2** respectively. An increase in peak rainfall of 20% results in a general increase in peak water levels throughout the study area. For the majority of the overland flow areas, these increases are typically less than 0.1 metres. The flood levels increase by up to 0.2m along the major flowpath starting from the corner of Doonmore Street and Derby Street to the corner of Lethbridge Street and Castlereagh Street. The flood levels increase by up to 0.25m in a number of ponding areas, e.g., in the corner of Castlereagh Street and Stafford Street, in the corner of Henry Street and Evan Street.

A reduction in peak rainfall of 20% results in reductions in peak flood levels generally within 0 to 0.2 metres. Decreases of flood levels by approximately 0.3m were observed in a number of small ponding areas.

Changes in rainfall also impact on the showground channel flow. The showground channel flow is 6.4m^3/s under the existing conditions. The showground channel flow reaches 7.4m3/s due to the 20% increase in rainfall, indicating approximately 16% increase in the channel flow. The water levels increase in a range of 0.2m-0.3m along the showground channel due to the 20% increase in rainfall.

A 20% decrease in rainfall generates showground channel flow of 6.0m^3/s, indicating approximately 6% decrease in the showground channel flow. This results in a decrease in water levels in a range of 0.1m-0.2m along the showground channel.

12.2 Hydraulic Roughness

The flood level impact of an increase\decrease of hydraulic roughness is shown in **Figure 12.3-12.4** respectively. Varying in hydraulic roughness has a relatively minor impact on the predicted flood levels in the 100 year ARI event.

In general, the 20% increase in hydraulic roughness results in an increase of water levels by less than 0.02m in the east part of the study area, and a decrease of water levels by less than 0.1m in the west part of the study area.

The 20% decrease of hydraulic roughness results in a decrease of water levels by less than 0.02m in the east part of the study area, and an increase of water levels generally by less than 0.05m in the west part of the study area.

12.3 Arcades Blocked

As discussed in **Section 6.3.2**, three shopping arcades were included in the TUFLOW model, which were assumed to be 50% blocked.

A sensitivity analysis was undertaken to test the flood impact of fully blocked arcades, which is shown in **Figure 12.5**.

The scenario with fully blocked arcades results in increases in peak flood levels within 0.1 metres immediately upstream of arcades. The peak flood levels in immediately downstream of arcades decrease by approximately 0.1 metres.

12.4 Downstream Boundary Conditions

The modelling undertaken in this study assumes that there is no flooding occurring within Peachtree Creek at the same time as a local flood event within the Penrith CBD catchment.

A sensitivity model run was carried out in order to test the effect of flooding influence of Peachtree Creek to Penrith CBD. The results from the Peachtree Creek Flood Study (Lyall & Macoun Consulting Engineering, 1994) were used.

A fixed tailwater level of 25.66 mAHD in Mulgoa and Jamison Road in the event of a 100yr ARI flood event in Peachtree Creek was adopted as downstream boundary conditions in the sensitivity test run.

Figure 12.6 shows that the flood levels were significantly impacted by raising downstream boundary level in two areas. The results indicate that the water levels increased by up to 2.4m in the industrial areas west of Castlereagh Road. The water level increased by up to 0.5m in the ponding area along High Street near the Westfield Shopping Centre.

A slight increase in water levels (less than 0.05m) occurs along the main overland flow path staring from the showground channel towards High Street via the car park.

12.5 Pit and Pipe Blockage

As discussed in **Section 6.2.4**, this study adopted 50% blockage to all inlet pits and no blockage in pipes for design events in accordance with Council's blockage policies. A sensitivity analysis with 0% pit blockage was undertaken to investigate the impact to flood behaviour in the study area if all pits are at capacity.

The flood level impact of 0% pit blockage is shown in **Figure 12.7**. It results in reductions in peak flood levels generally within 0 to 0.1 meters. A more significant decrease in peak flood levels (in a range of 0.1-0.2m) occurs in the ponding area along High Street near the Westfield Shopping Centre.

The model results indicate that the flood levels increase by approximately 0.16m along the showground channel due to a 0% pit blockage.

12.6 Additional Sensitivity Tests Using 3m Grid Models

Additional sensitivity testing was undertaken in this study to assess further input configurations of the models. This was undertaken using a 3 metre grid model, to provide an indication of the relative differences. These tests included:

- Peachtree Creek Tailwater Conditions;
- Hydraulic roughness - modification of roughness value in car parks and concrete ground;
- Incorporation of a missing building – a building was identified as missing in the 1 metre models;
- Roof roughness;
- Major culverts blocked;
- Sensitivity to rainfall for 20 year ARI and
- Sensitivity to roughness for 20 year ARI.

It is noted that these sensitivity tests were based on 3m grid models due to consideration of computer simulation time. The critical events in a 100 year ARI, including 2 hours and 9 hours duration were used for these sensitivity tests. The 1D components were included during the additional sensitivity analysis. It is noted that the existing model using the comparison was also based on 3m grid model.

12.6.1 Peachtree Creek Tailwater Conditions

The flood modelling undertaken for this study has assumed that the flooding behaviour in Peachtree Creek and Surveyor Creek would not be flooding at the same time as a local flood event in the Penrith CBD catchment.

As a further test of the analysis undertaken in Section 12.4, a sensitivity analysis were carried out using a 100yr ARI local catchment flood coupled with a fixed 20yr ARI Peachtree Creek/Surveyor Creek flood levels. This assumes that a 20 year ARI flood occurs within Peachtree and Surveyor Creeks at the same time as a 100 year ARI flood in the local catchment.

Peachtree Creek Flood Study (Lyall & Macoun Consulting Engineering, 1994) only reported estimated 100yr ARI flood levels in Peachtree Creek, and not for more frequent flood events. Therefore, in the absence of other frequent flood levels in Peachtree Creek/Surveyor Creek, the 20yr ARI Peachtree Creek flood level was estimated based on estimated flows from the two creek systems. The combined 20yr ARI peak flow from Peachtree Creek/Surveyor Creek systems at the Racecourse Channel outlet was estimated to be approximately 150m^3/s as agreed with Penrith City Council. Then, a one dimensional XP-SWMM hydraulic model was then developed for Peachtree Creek commencing from the confluence of Race Course Channel to downstream of the railway line north of High Street in order to estimate 20yr ARI flood levels in Peachtree Creek.

The results of 1D XP-SWMM model indicated that the estimated 20yr ARI flood levels in Peachtree Creek varied from RL24.16mAHD at the confluence of Race Course channel, to RL23.6mAHD at the confluence of Showground channel, and to RL23.0mAHD downstream of the Railway Line.

In order to test the flood impacts of the 20yr ARI Peachtree creek flood on the study areas, three tailwater conditions were inserted into the 1D/2D TUFLOW model. In the model, three fixed tailwater boundary conditions were adopted at the locations mentioned above.

The 1D/2D TUFLOW model was then run for 2hr and 9hr storm durations.

The results of these TUFLOW models were compared against results without Peachtree creek tailwater conditions. **Figure 12.8** and **12.9** shows the 20yr ARI Peachtree Creek/Surveyor Creek tailwater levels adopted in the sensitivity run for 100 year ARI with 2 hours duration and 9 hours duration respectively. The flood affected areas by adopting fixed 20 year ARI Peachtree Creek/Surveyor Creek tailwater conditions are also shown in **Figure 12.8-12.9**.

It was found that in both 2hr and 9hr runs, the 20yr ARI Peachtree creek flood levels would have insignificant impact to the study areas. For the 2hr flood, it was estimated that Mulgoa Road would have minor impact in a range of 0.01 to 0.02m in a 2hr flood, and 0.01 to 0.03m in a 9hr flood due to the influence of Peachtree Creek.

12.6.2 Modification of Roughness Values in Car Parks and Concrete Ground

This study adopted a uniform hydraulic roughness value (0.1) for all residential, commercial and industrial blocks, which were generally based on the Penrith Overland Flow Flood "Overview Study" (Cardno Lawson Treloar, 2006). A refinement of roughness map for car parks and concrete ground in the study area was undertaken to assess the flood impacts by the modified roughness map. The refined roughness map for car parks and concrete ground is presented in **Figure 12.10**. The modified roughness value 0.02 was adopted for car parks and concrete ground showing in **Figure 12.10**.

The first run only considered the roughness value 0.02 for Kmart car park. The second run considered the roughness value 0.02 for all the car parks and concrete ground showing in **Figure 12.10**. The flood impacts of these two sensitivity runs are shown in **Figure 12.11** and **12.12** respectively.

The results of the first run indicate that the water levels decreased by less than 0.03m in the Kmart car park. **Figure 12.12** indicates that the water levels decreased by less than 0.02m for the majority of refined roughness areas. In a few of concrete ground areas, e.g. in the corner of Union Road and Station Street, in the corner of Henry Street and Evan Street, the water levels decreased by up to 0.15m. The water level increased by less than 0.1m in the ponding area located at the intersection of Henry Street and High Street. Water level increased by approximately 0.15m in a small ponding spot at 570-578 Union Lane. In general, the refine of roughness map does not have significant flood impacts on any property in the study area.

12.6.3 Incorporation of Missing Building

In this study, buildings within the floodplain in the study area were conservatively assumed to completely block overland flow, and were modelled as raised blocks in the topographic grids. However, a building along an overland flowpath was not included in the building outlines utilised in the current study.

A sensitivity test run was undertaken to investigate the flood impacts by raising this additional building. The water level impacts of this sensitivity run and the location of this missing building are shown in **Figure 12.13**.

It was found that raising this building results in an increase in upstream water levels by approximately 0.1m and a decrease in downstream water levels by approximately 0.15.

12.6.4 Roof Roughness

As discussed in **Section 6.5**, a uniform high roughness value of 0.1 was applied in residential/urban areas in this study, indicating a high roughness value of 0.1 applied for raised buildings in this study.

A sensitivity analysis has been undertaken to evaluate the potential flood impact by using roughness value of 0.02 for all raised buildings within the TUFLOW model boundary. The flood impact of using roughness value of 0.02 for raised buildings is shown in **Figure 12.14**.

The results indicate that the water levels decrease by less than 0.04m along the overland flowpath from the corner of Doonmore Street and Derby Street towards the corner of High Street and Henry Street by using a roughness value of 0.02 for raised buildings, including the Showground Channel water levels. A slight increase in water levels (less than 0.02m) in the ponding area located at the industrial area west of Castlereagh Road. The assumption of a high uniform high roughness value of 0.1 applied in residential/urban areas in this study does not cause a significant flood impact in the study area.

12.6.5 Major Culverts Blocked

A sensitivity test of the flood impact of major culverts becoming blocked was undertaken. Major culverts were identified on main flowpaths in conjunction with Council, and are shown in **Figure 12.15**. The locations of the major culverts blocked are summarised in **Table 12.1**.

Table 12.1 A Summary of Locations of the Major Culverts Blocked

Location ID	Location ID	%Blocked
L1	2893	50%
L2	2890	50%
L3	B1_2 B1_3 B1_1 R1_4	50%
L4	B2_1 B2_2	50%
L5	O1_1 O1_b	50%
L6	7104	50%

The level of blockage assumed was based on *Penrith CBD Stormwater Design Standards Review* (Cardno, 2012), which assigns a certain amount of blockage based on the size of the culvert. The recommendations from this report were applied as follows:

- Culverts with a diagonal opening less than 6m, 50% blocked; and
- Culverts with a diagonal opening greater or equal to 6m, 25% blocked.

The water level impacts of these major culverts blocked for 100 year and 20 year ARI are shown in **Figure 12.16** and **Figure 12.17** respectively.

The results indicate that the potential blockage of culverts has a large flood impact in the immediate vicinity of each of the culverts. This results in an increased in the water levels in a range of 0.1m-0.2m in the vicinity of these blocked culverts.

12.6.6 Sensitivity to Rainfall for 20 Year ARI

A sensitivity analysis has been undertaken to investigate the flood impact by a varied rainfall for 20 year ARI. The flood level impact of an increase\decrease of rainfall by 20% is shown in **Figure 12.18-12.19** respectively.

A 20% rainfall increase results in an increase in water levels in a range 0.02m-0.2m along the overland flowpaths, whilst a 20% rainfall decrease results in a decrease in water levels in a range 0.02m-0.2m along the overland flowpaths.

12.6.7 Sensitivity to Roughness for 20 Year ARI

The flood level impact of an increase\decrease of hydraulic roughness of 20% for 20 year ARI is shown in **Figure 12.20-12.21** respectively. Varying in hydraulic roughness has a relatively minor impact on the predicted flood levels in the 20 year ARI event. The results show that the flood levels only varied by less than 0.02m for the 20 year ARI due to varying in hydraulic roughness by 20%.

13 PRELIMINARY FLOOD MITIGATION OPTIONS

The results of flood damage estimation indicate that flooding may cause significant economic damage costs in the Penrith CBD study area. This study provides some preliminary flood mitigation options to Council based on the hydraulic modelling results. It is recommended to undertake a flood risk management study and plan to investigate the effectiveness of flood mitigation options in detail.

13.1 Detention Basin Modification

The major existing informal basins within the catchment include Howell Oval, Penrith Park and Penrith Showground. Reconfiguring of these informal basins is recommended for further investigation since it may improve the flooding conditions downstream. Sites suitable for other detention basins within the catchment are limited. A small basin in Spence Park may result in a slight reduction of flood levels downstream.

13.2 Pipes and Culverts Upgrades

The study area is highly urbanised. Upgrading pipes and culverts is a primary flood mitigation option for this area. The results of pipe capacity assessment (**Figure 8.33**) indicate that 52 pipes have flow capacity which is not greater than 5 year ARI. These pipes are generally in the eastern side of the study area. Upgrading pipes and culverts requires consideration of pipe network rather than individual pipes.

The assessment of flood behaviour under existing conditions for the Penrith CBD catchment indicates that the following areas exposure a significant flood risk (see **Figure 8.12**):

- The area bounded by Doonmore Street to the east, Derby to the south, and Castlereagh Street to the west;
- A large ponding area in the corner of Union Lane and Station Street, and
- Ponding area in the corner of Evan Street and Henry Street

The three preliminary flood mitigation options in this study focus on decrease flood risk in these three areas.

13.2.1 Flood Mitigation Option 1

Significant water ponding occurs in the area bounded by Doonmore Street to the east, and Castlereagh Street to the west (shown in **Figure 8.12**). Pipe capacity analysis indicates that a number of pipes have a low capacity (up to 5yr ARI) in this area.

Flood mitigation option 1(shown in Figure 13.1) suggests construction of an additional pipe in this area to convey flows from the upstream open channel to a downstream pipe which still has sufficient capacity.

13.2.2 Flood Mitigation Option 2

Figure 13.2 shows flood mitigation option 2 which aims at decreasing flood risk in the large ponding area in the corner of Union Lane and Station Street. Option 2 suggests two additional pipes which can be constructed in different stages based on the availability of Council funding. Pipe 1 runs along Union Lane and Station Street towards the open channel, conveying flows in the corner of Union Lane and Station Street. The design of pipe 1 should consider the additional capacity to convey flows between Woodriff Street and Station Street. This provides potential capacity for Council to upgrade drainage system in this area.

Pipe 2 was designed along Rodley Avenue to the downstream of open channel. It is expected that Pipe 2 can decrease flood risk for properties along Rodley Avenue.

This report only provides the preliminary concept design of Option 1 and 2. It is noted that detailed studies of flood mitigation option 1 and 2 are required to investigate the effectiveness of flood mitigation options and flood impact on downstream drainage system.

Effective drainage maintenance is an essential factor to ensure the performance of drainage system. It requires cleaning curb/gutters to remove an obstruction to drainage system. It is also a challenge to keep inlet pits and the outlets in efficient working conditions to decrease the blockage risk.

Careful maintenance is required for open ditches to improve the flow conveyance by removing debris and brush. Brush, weeds, and other debris should be cleared from open channel to keep its capacity. It is important to keep culverts in function since the culvert blockage may cause a real hazard.

14 CONCLUSIONS

This report has been prepared for Penrith City Council to define the nature and extent of flooding for Penrith CBD study area. Flood modelling was completed to define flood behaviour under existing conditions for a full range of design events. Information provided in this report includes flood extents, flood levels, depths, and flood velocities for these design events. This study also defines provisional hazards and hydraulic categories for the study area.

The investigation and modelling procedures adopted for this study follow current best practice and considerable care has been applied to the preparation of the results. It is known that uncertainty is always associated with the model results due to the input data quality and other systematic errors. In particular, the hydraulic model was not fully calibrated due to scarce calibration data. Instead, the robustness and reliability of the hydraulic model was tested by an indirect validation. This should be considered in the future application of the model results.

15 ACKNOWLEDGEMENTS

The Penrith CBD Detailed Overland Flow Flood Study was prepared by Cardno (NSW/ACT) Pty Ltd on behalf of Penrith City Council and NSW Office of Environment and Heritage (OEH). The study has been prepared with the technical guidance and financial assistance from the New South Wales Government through its Floodplain Management Program.

16 REFERENCES

Bureau of Meteorology (2003), *The Estimation of Probable Maximum Precipitation in Australia: Generalised Short-Duration Method*, June.

Cardno (2012). *Penrith CBD Stormwater Design Standards Review*, prepared for Penrith City Council, version 1, November.

Cardno Lawson Treloar (2006), *Penrith Overland Flow Study –"Overview Study"*, Prepared for Penrith City Council.

Cardno Lawson Treloar (2006), *Allans Creek Floodplain Management Study*.

Engineers Australia (1999), Australia Rainfall and Runoff [AR&R].

Engineers Australia (2012). *Australian Rainfall and Runoff – Project 15 – 2D Modelling in Urban Environments*, Stage 1 & 2, November.

Howells L., McLuckie D., Collings G. & Lawson N (2003), *Defining the Floodway – Can One Size Fit All?* Proceedings of 43rd Floodplain Management Authority of New South Wales Annual Conference, Forbes.

Land & Water Conservation (1995) (Report No NSWPW 95052), *Upper Nepean River Flood Study*, Prepared for Wollondilly Shire Council, Campbelltown City Council, The Council of Camden, Liverpool City Council & Penrith City Council.

Lyall & Macoun Consulting Engineering (1994), *Peacktree Creek Flood Study*, prepared for Penrith City Council, NSW Public Works and NSW Department of Water Resources.

NSW Government (2005), *Floodplain Development Manual* – The Management of Food-Liable Land.

Office of Environment and Heritage (2004), *The draft DNR Floodplain Management Guideline No. 4 Residential Flood Damage Calculation.*

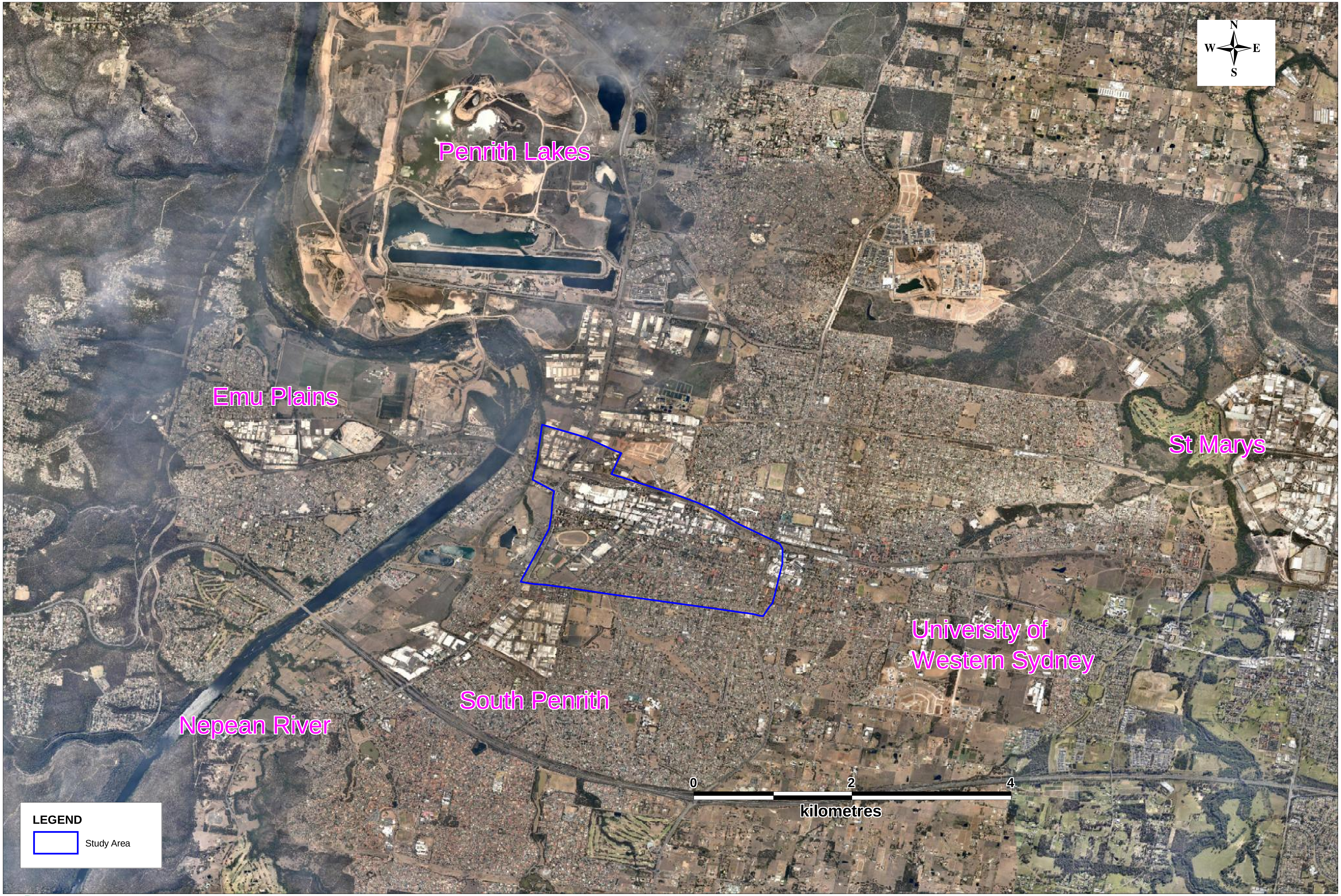
Syme.W.J (2008), *Flooding in Urban Areas – 2D Modelling Approaches for Buildings and Fence*, BMT WBM Pty Ltd, Proceedings of Engineering Australia, 9th National Conference on Hydraulics in Water Engineering.

Water Studies Pty Ltd (1992*), FLDamage Manual*.

Webb McKeown & Associates (2005), *Penrith RUBICON Modelling*.

Worley Parsons (2008), *Nepean River RMA-2 Model*, Draft Report, Rev C, prepared for Penrith City Council.

Figures



Cardno

W4735
July 2015

Penrith CBD Detailed Overland Flow Flood Study

FIGURE 1.1
LOCALITY OF STUDY AREA

Cardno

W4735
July 2015

Penrith CBD Detailed Overland Flow Flood Study

FIGURE 1.2
THE STUDY AREA

Cardno

W4735
July 2015

Penrith CBD Detailed Overland Flow Flood Study

FIGURE 2.1
SURVEYED DRAINAGE LAYOUT

Cardno

W4735
July 2015

Penrith CBD Detailed Overland Flow Flood Study

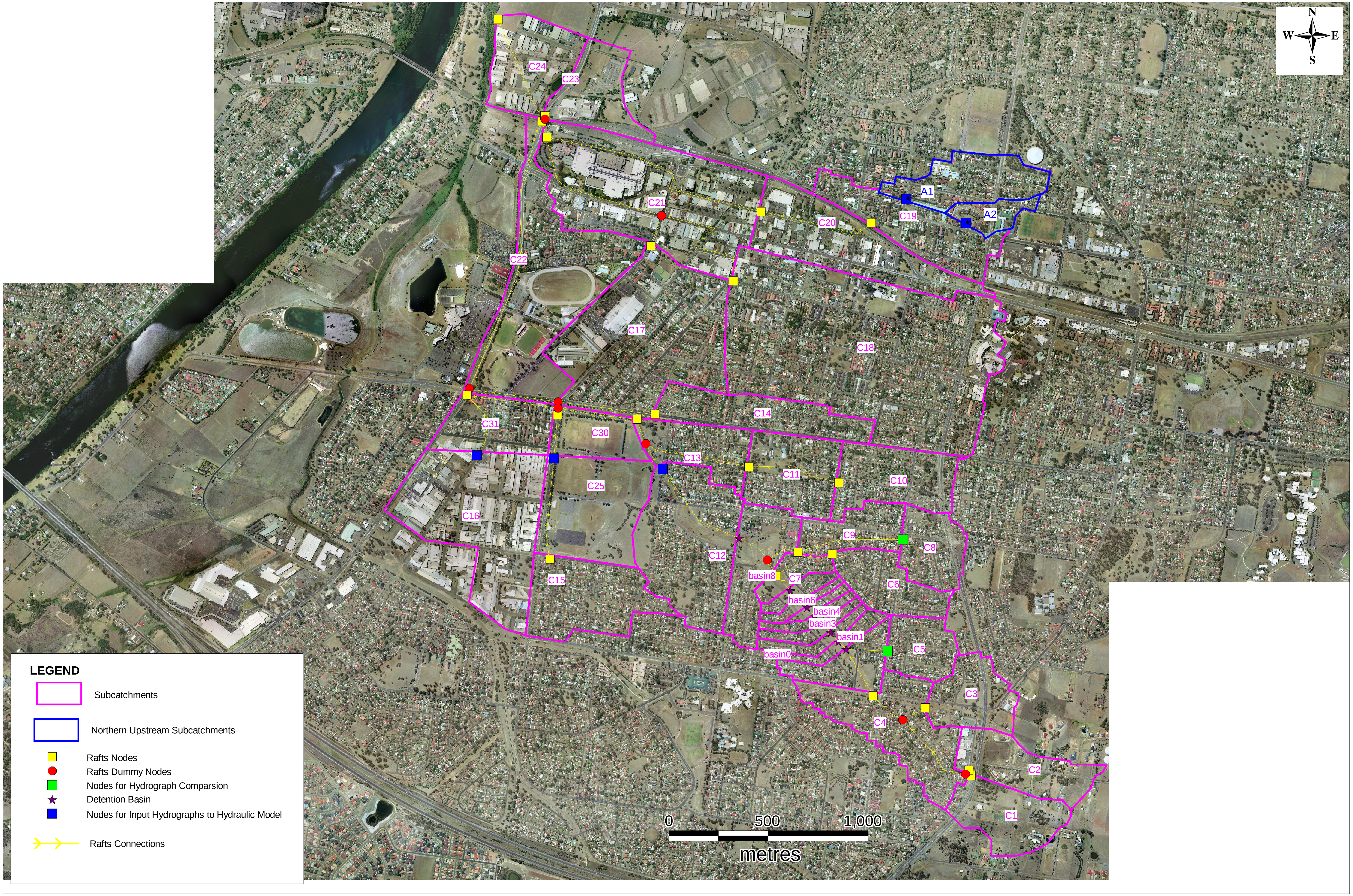
FIGURE 2.2
RAIN GAUGES

FIGURE 3.2
PROPERTIES EXPERIENCED FLOODING
- FROM COMMUNITY SURVEY

Penrith CBD Detailed Overland Flow Flood Study

Cardno

W4735
July 2015

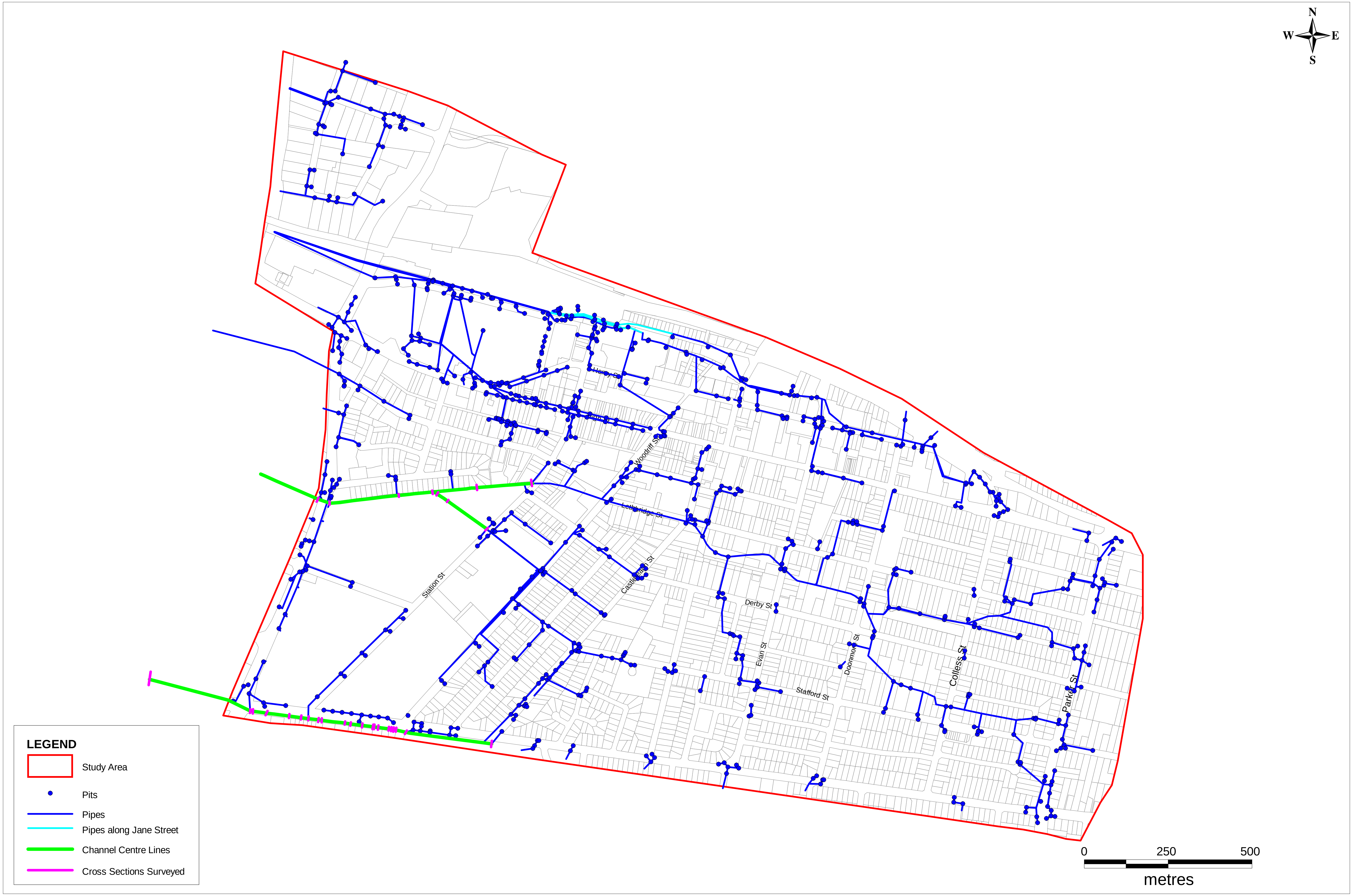


Cardno

W4735
July 2015

Penrith CBD Detailed Overland Flow Flood Study

FIGURE 5.1
RAFTS SUBCATCHMENTS

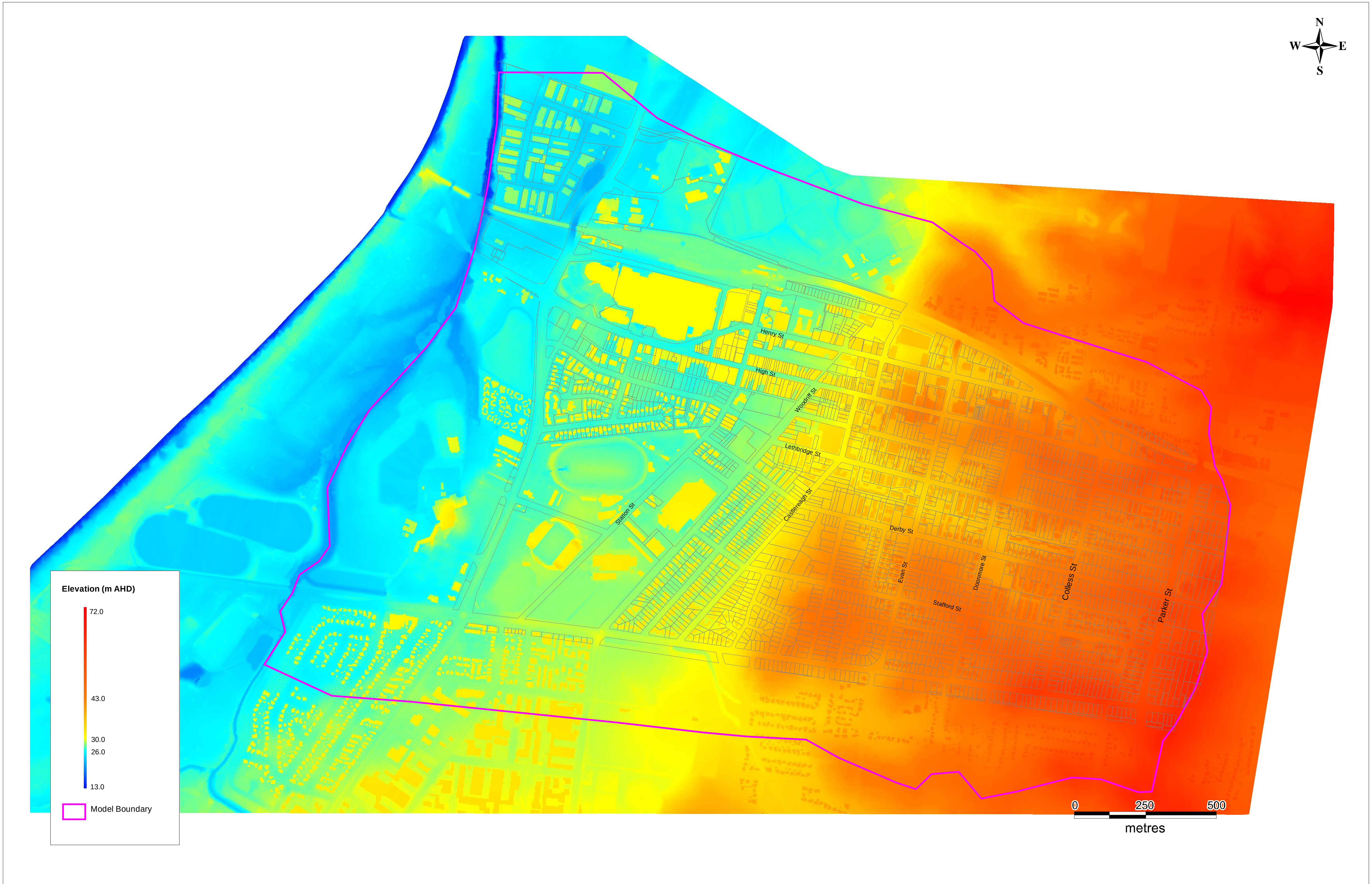


Cardno

W4735
July 2015

Penrith CBD Detailed Overland Flow Flood Study

FIGURE 6.1
1D COMPONENTS OF HYDRAULIC MODEL



W4735
July 2015

Penrith CBD Detailed Overland Flow Flood Study

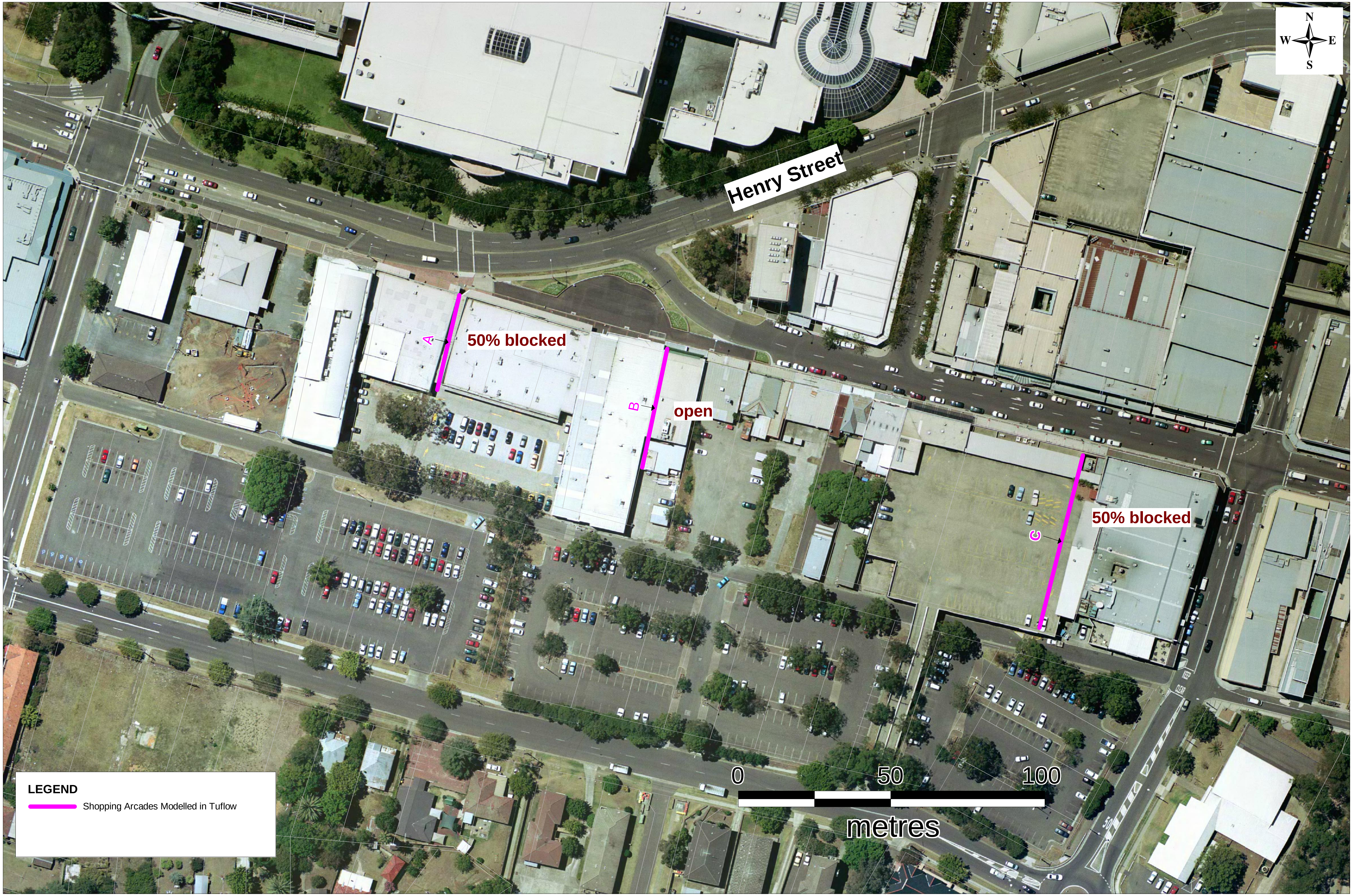
FIGURE 6.2
TUFLOW MODEL TERRAIN

Penrith CBD Detailed Overland Flow Flood Study

FIGURE 6.3
BUILDINGS LAYOUT

Cardno

W4735
July 2015



Cardno

W4735
July 2015

Penrith CBD Detailed Overland Flow Flood Study

FIGURE 6.4
SHOPPING ARCADES MODELLED IN TUFLOW

Cardno

W4735
July 2015

Penrith CBD Detailed Overland Flow Flood Study

FIGURE 6.5
2D ROUGHNESS MAPPING

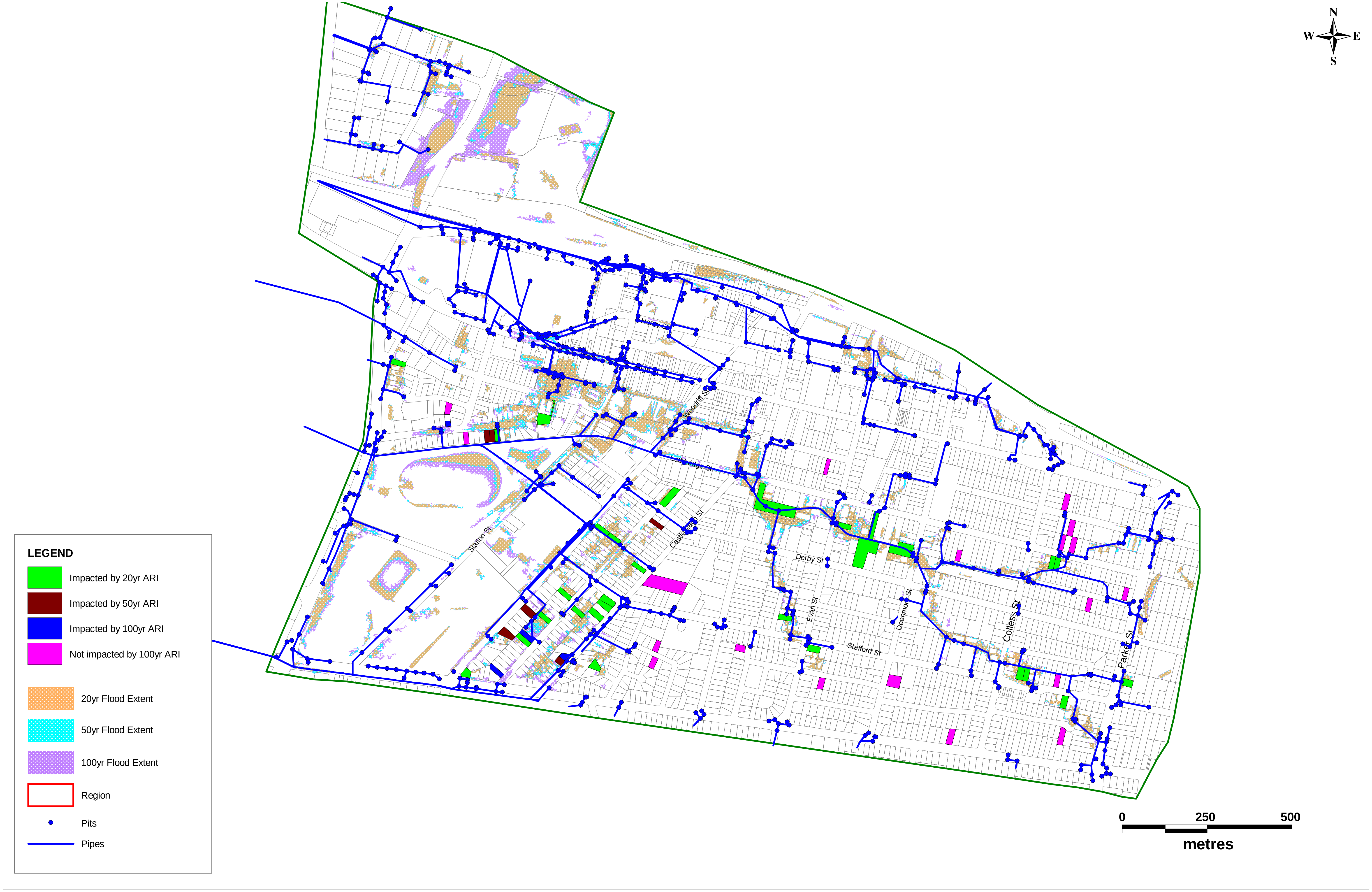


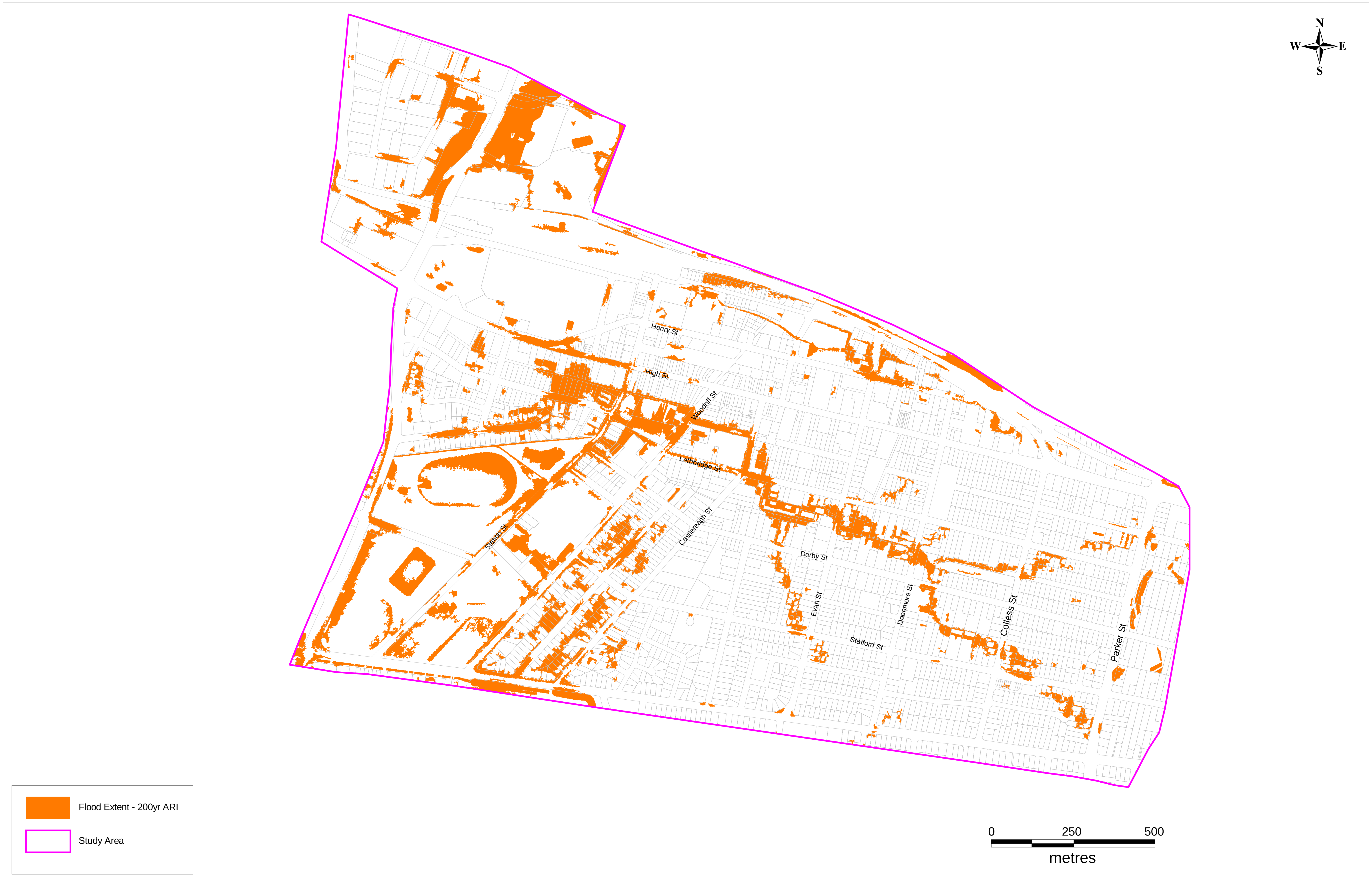
FIGURE 7.1
VALIDATION RESULTS

FIGURE 8.1
PMF FLOOD EXTENT

Penrith CBD Detailed Overland Flow Flood Study

Cardno

W4735
July 2015



Cardno

W4735
July 2015

Penrith CBD Detailed Overland Flow Flood Study

FIGURE 8.2
FLOOD EXTENT- 200 YEAR ARI

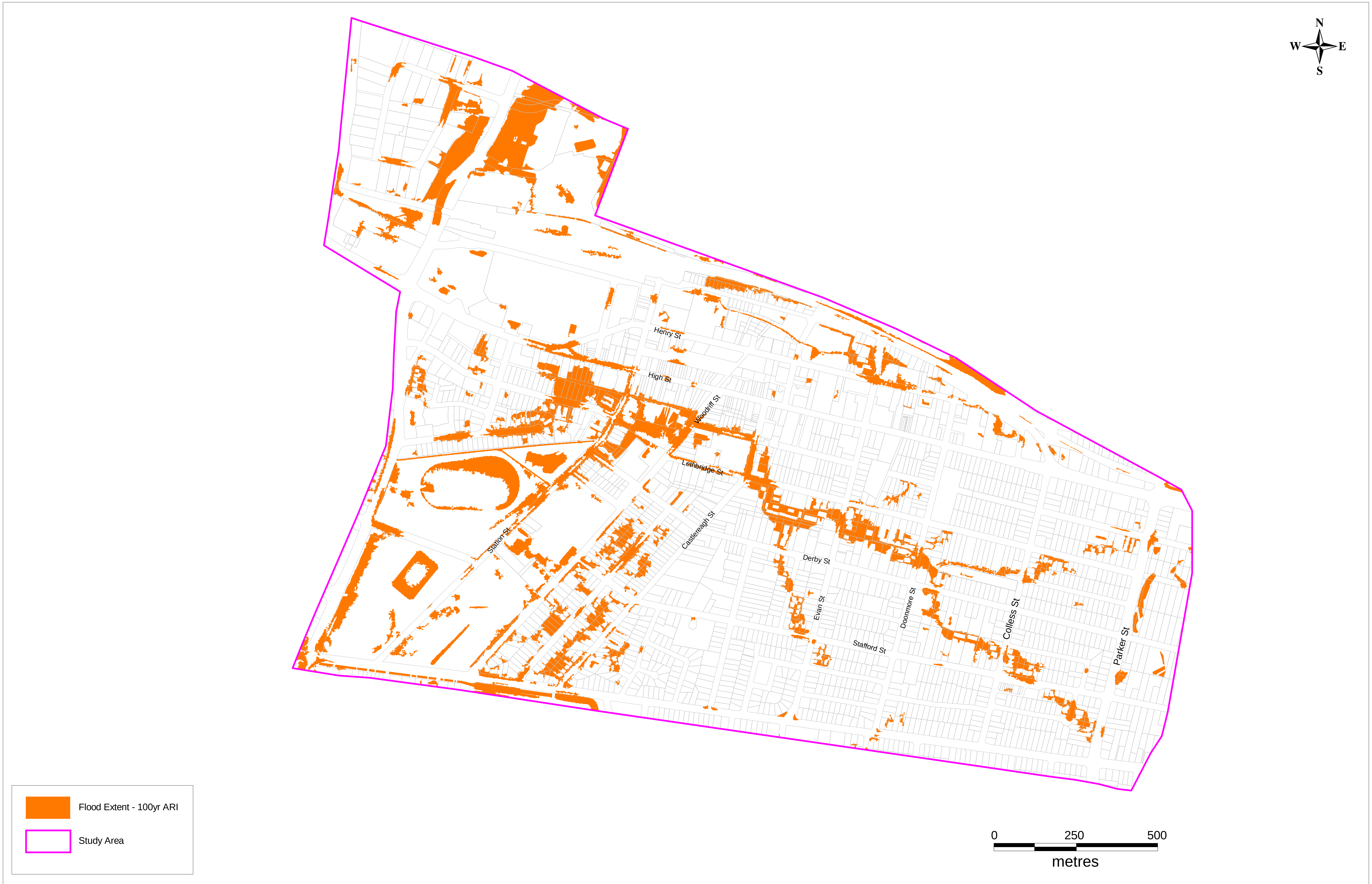
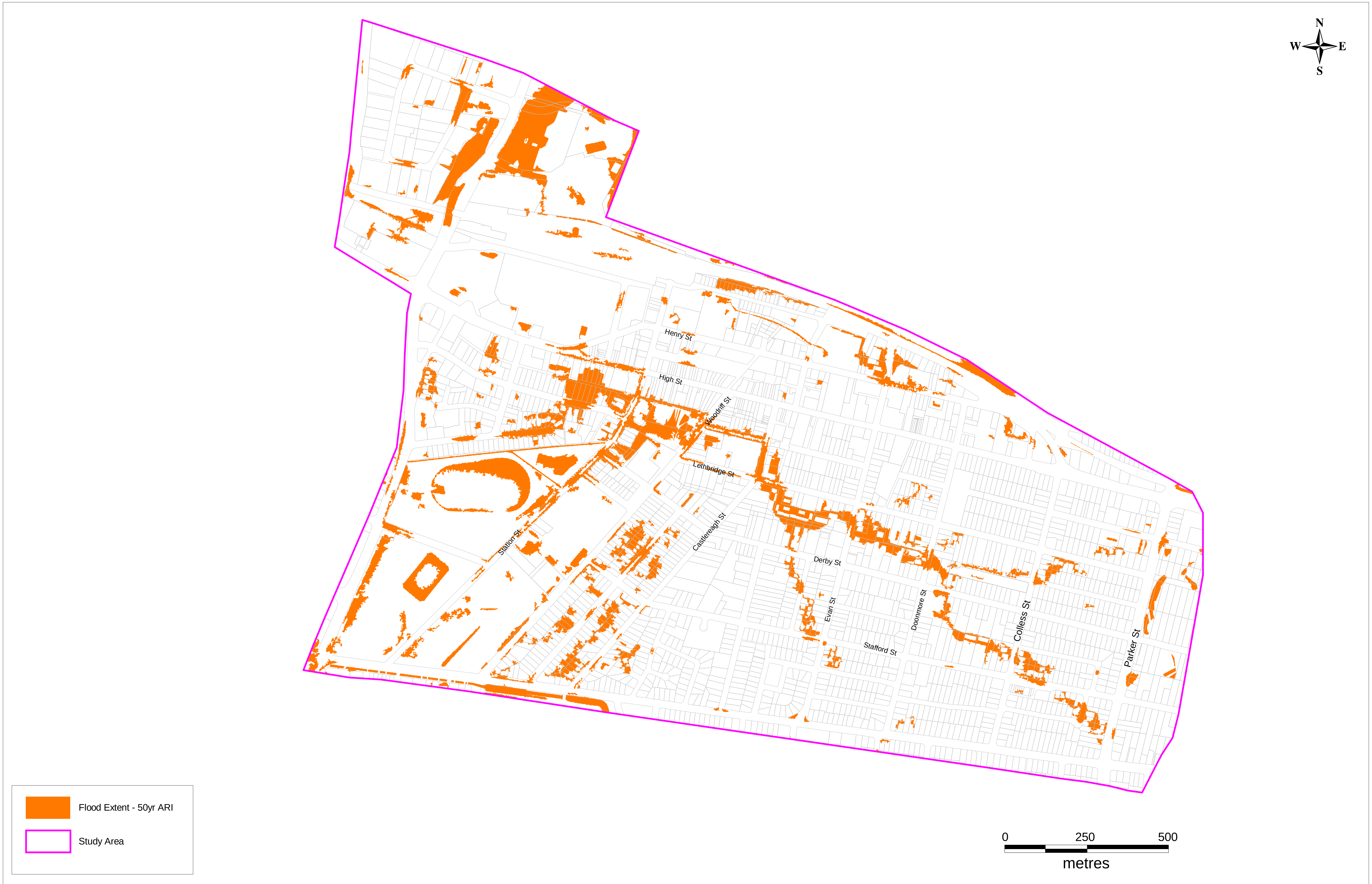


FIGURE 8.3
FLOOD EXTENT- 100 YEAR ARI

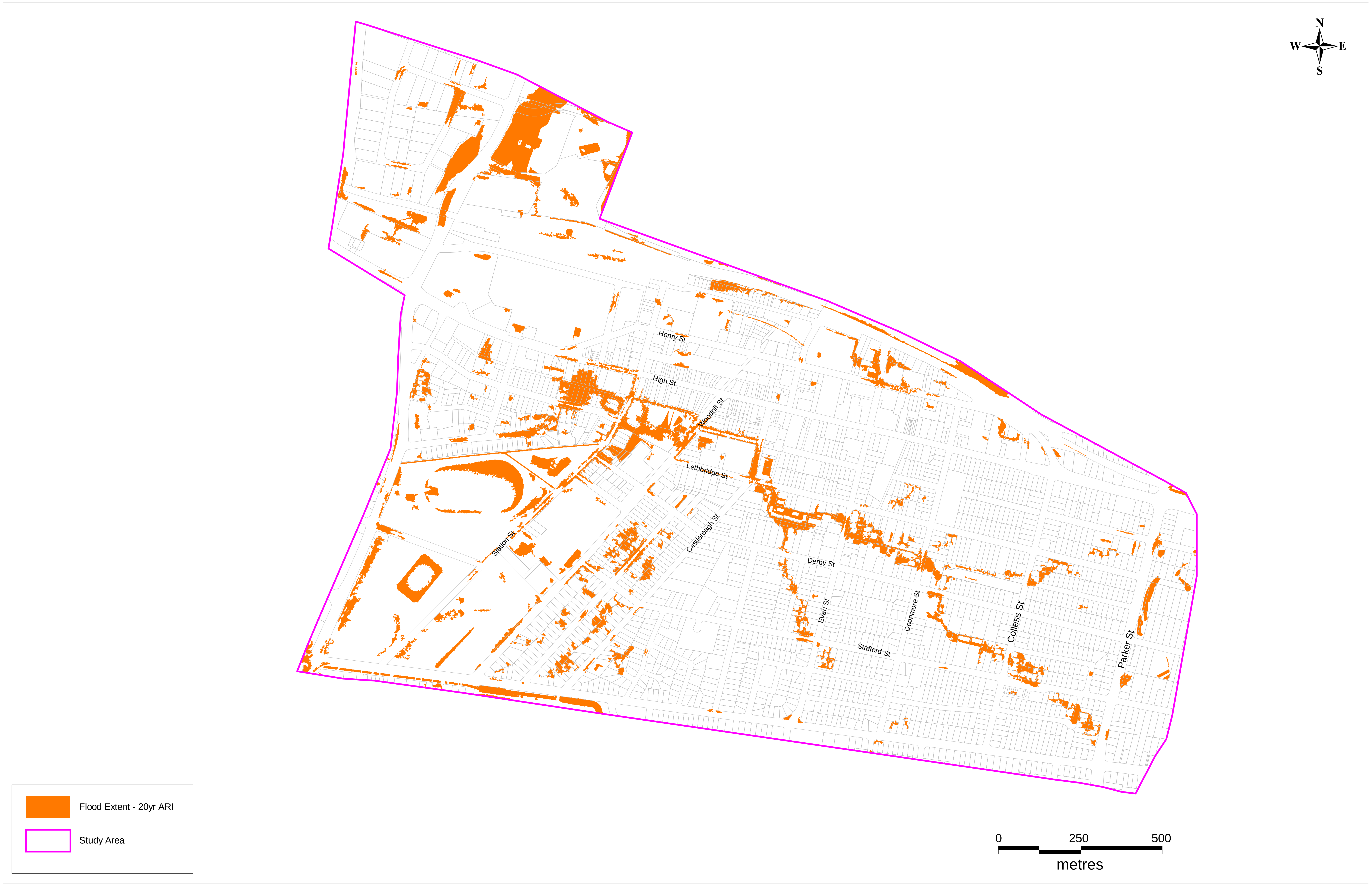


Cardno

W4735
July 2015

Penrith CBD Detailed Overland Flow Flood Study

FIGURE 8.4
FLOOD EXTENT- 50 YEAR ARI

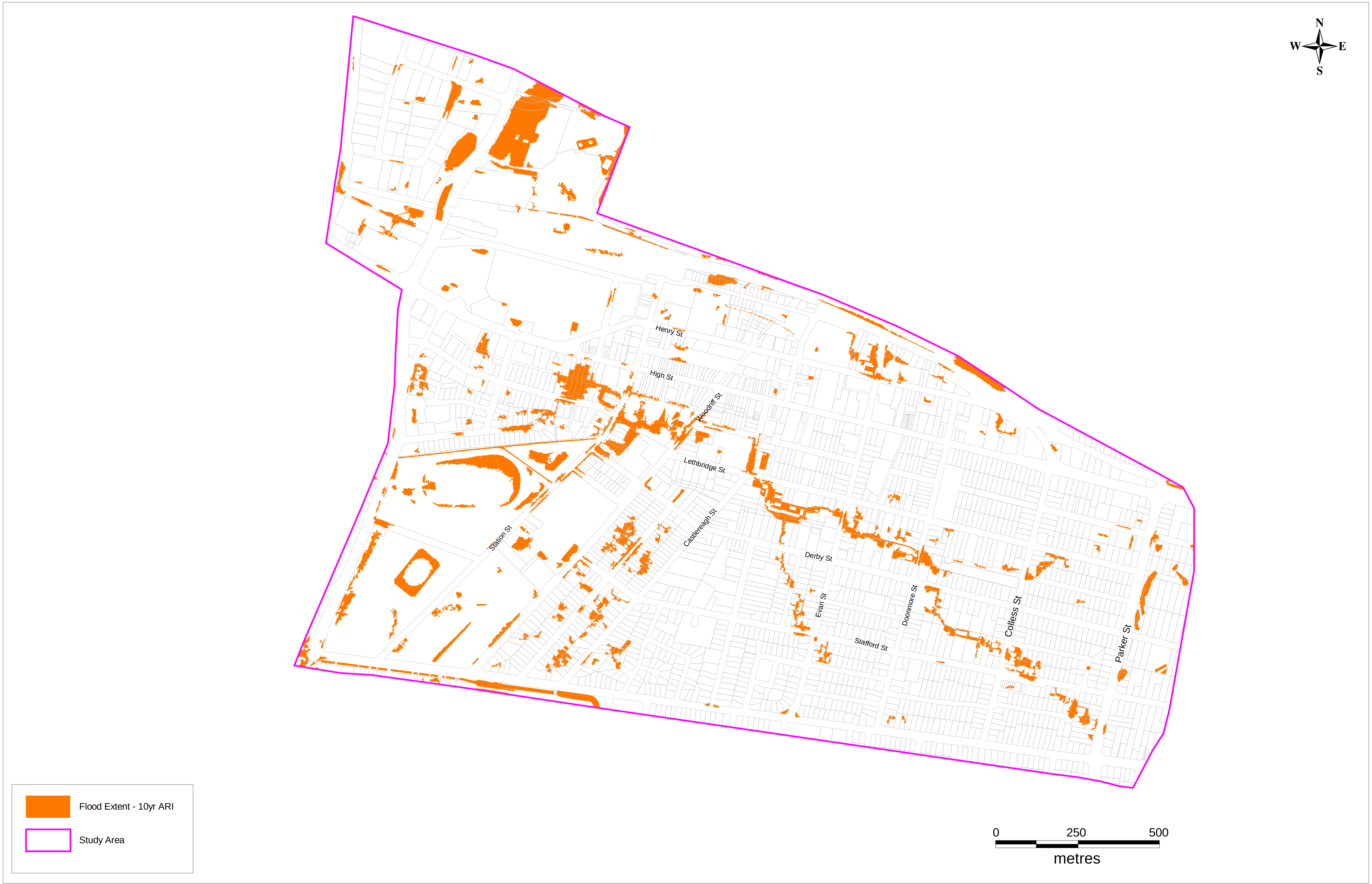


Cardno

W4735
July 2015

Penrith CBD Detailed Overland Flow Flood Study

FIGURE 8.5
FLOOD EXTENT- 20 YEAR ARI

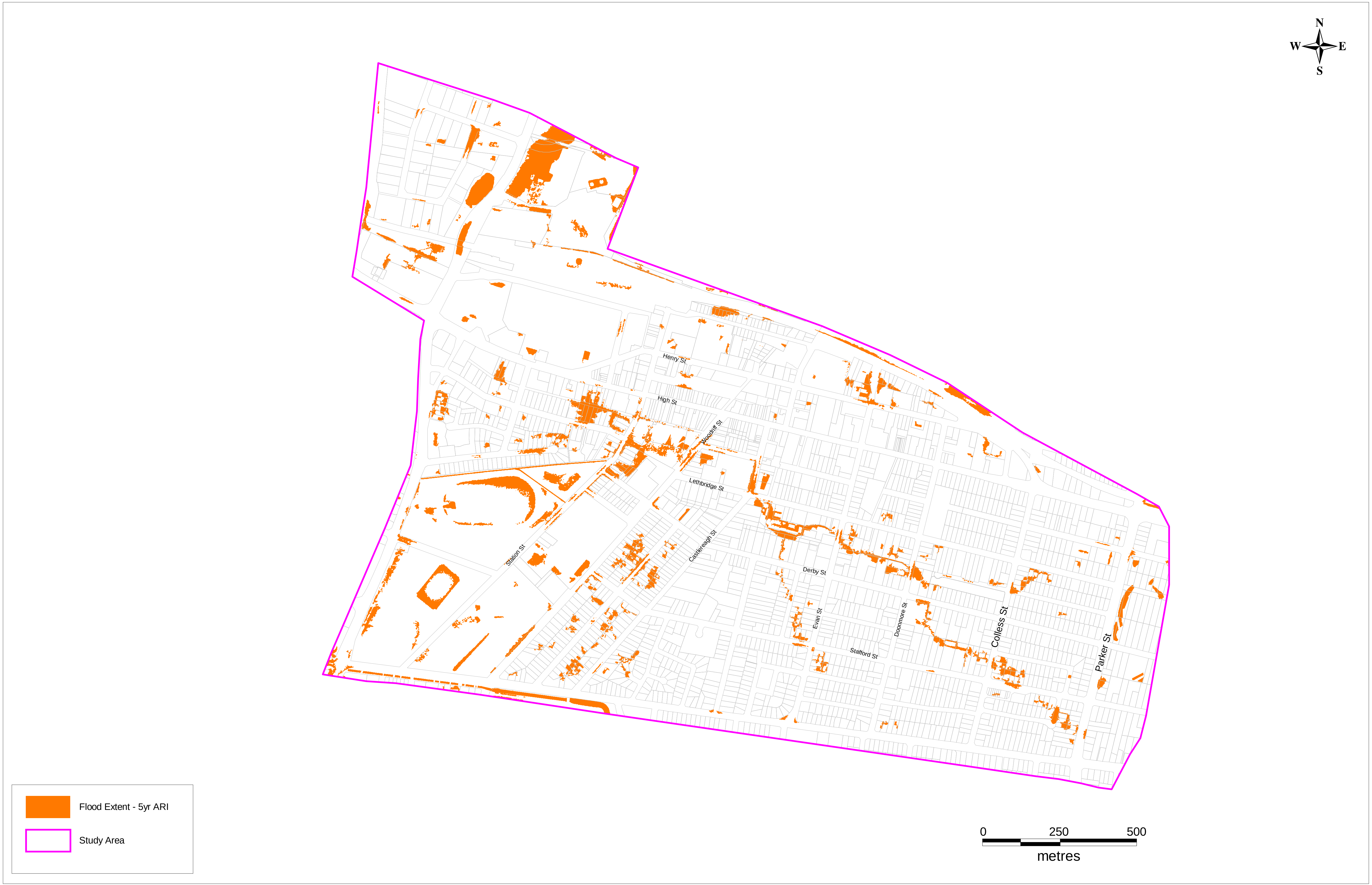


Cardno

W4735
July 2015

Penrith CBD Detailed Overland Flow Flood Study

FIGURE 8.6
FLOOD EXTENT- 10 YEAR ARI

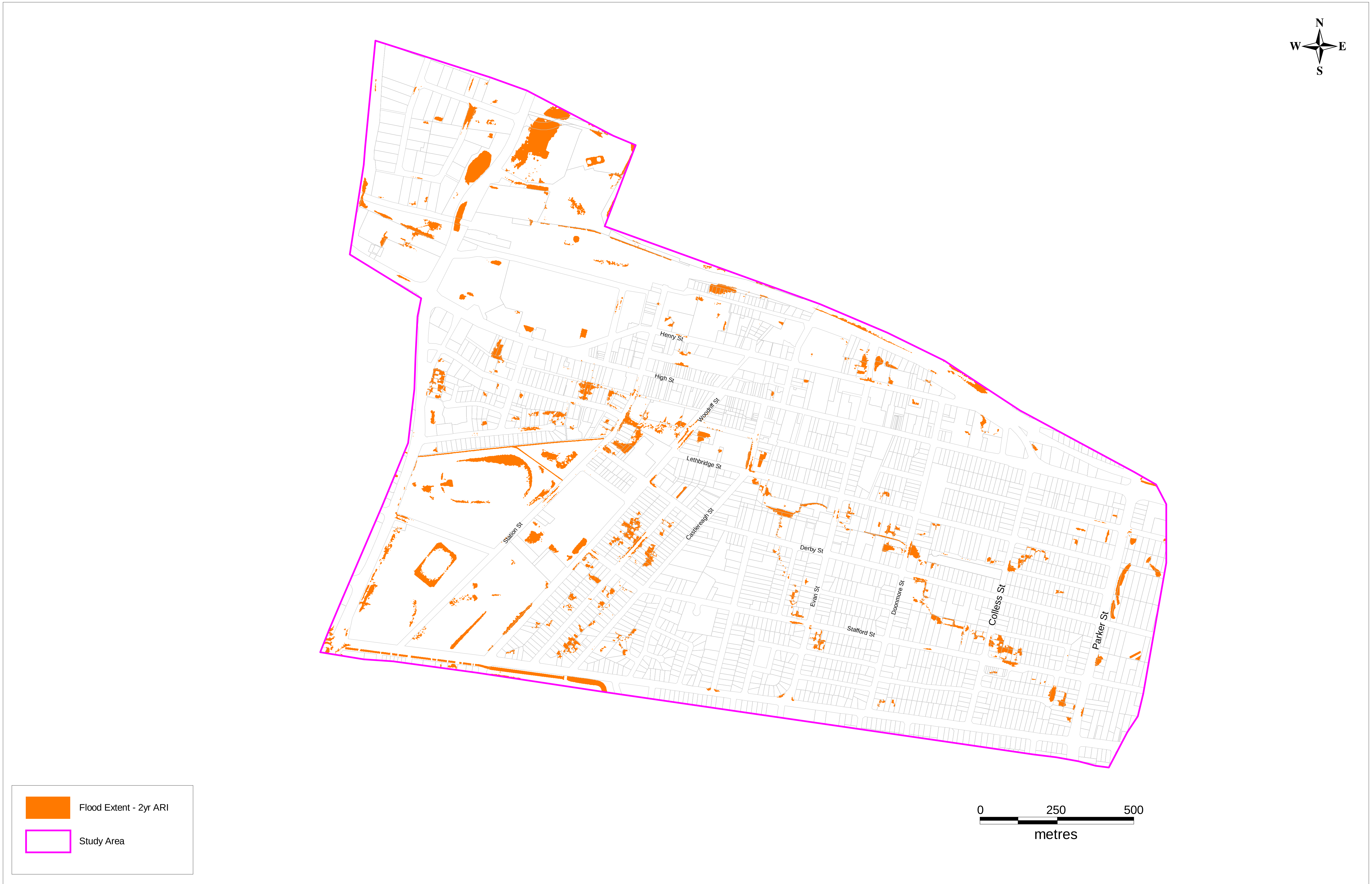


Cardno

W4735
July 2015

Penrith CBD Detailed Overland Flow Flood Study

FIGURE 8.7
FLOOD EXTENT- 5 YEAR ARI

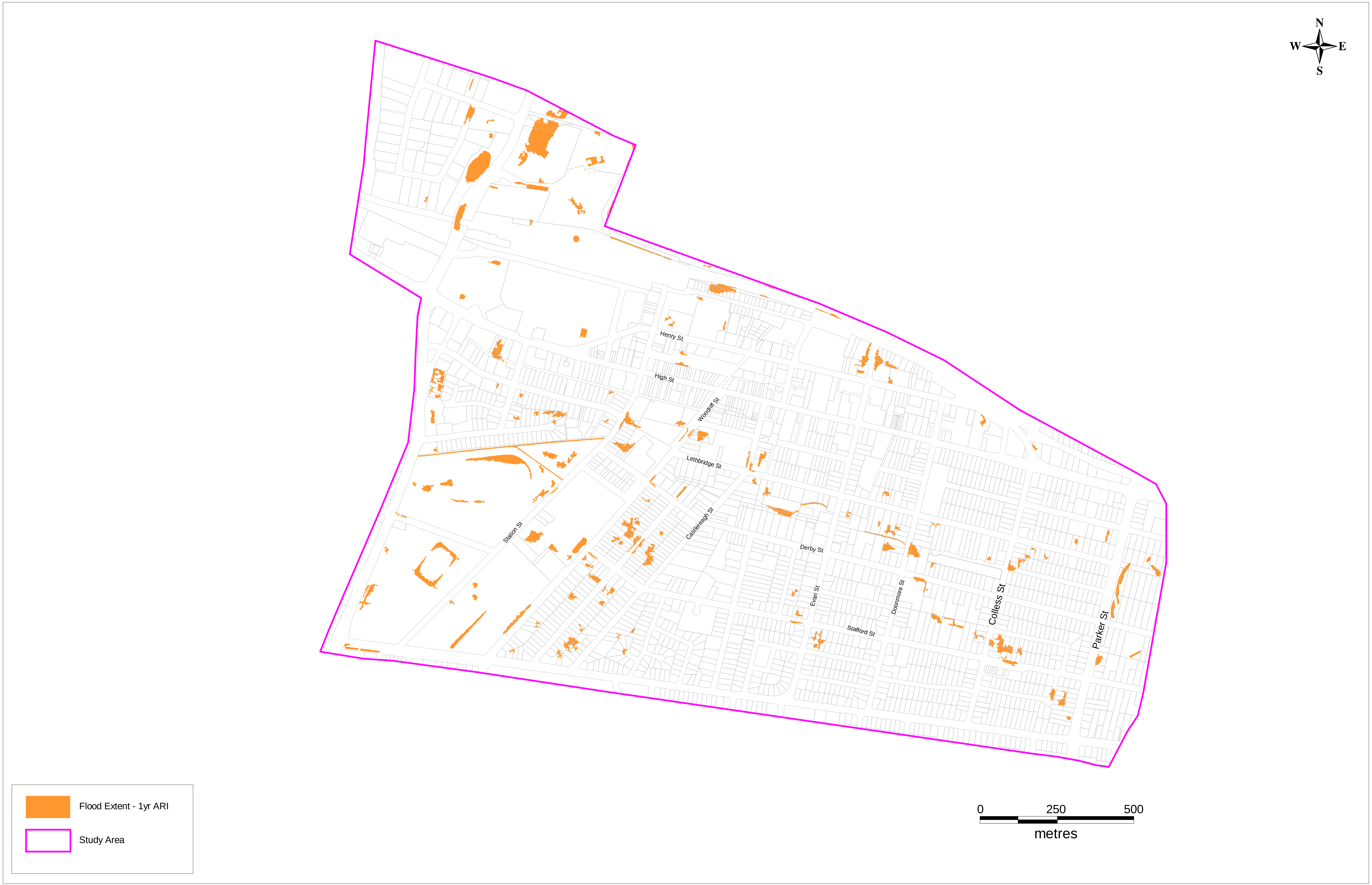


Cardno

W4735
July 2015

Penrith CBD Detailed Overland Flow Flood Study

FIGURE 8.8
FLOOD EXTENT- 2 YEAR ARI



Cardno

W4735
July 2015

Penrith CBD Detailed Overland Flow Flood Study

FIGURE 8.9
FLOOD EXTENT- 1 YEAR ARI

Cardno

W4735
July 2015

Penrith CBD Detailed Overland Flow Flood Study

FIGURE 8.10
CRITICAL DURATIONS - 100YR ARI

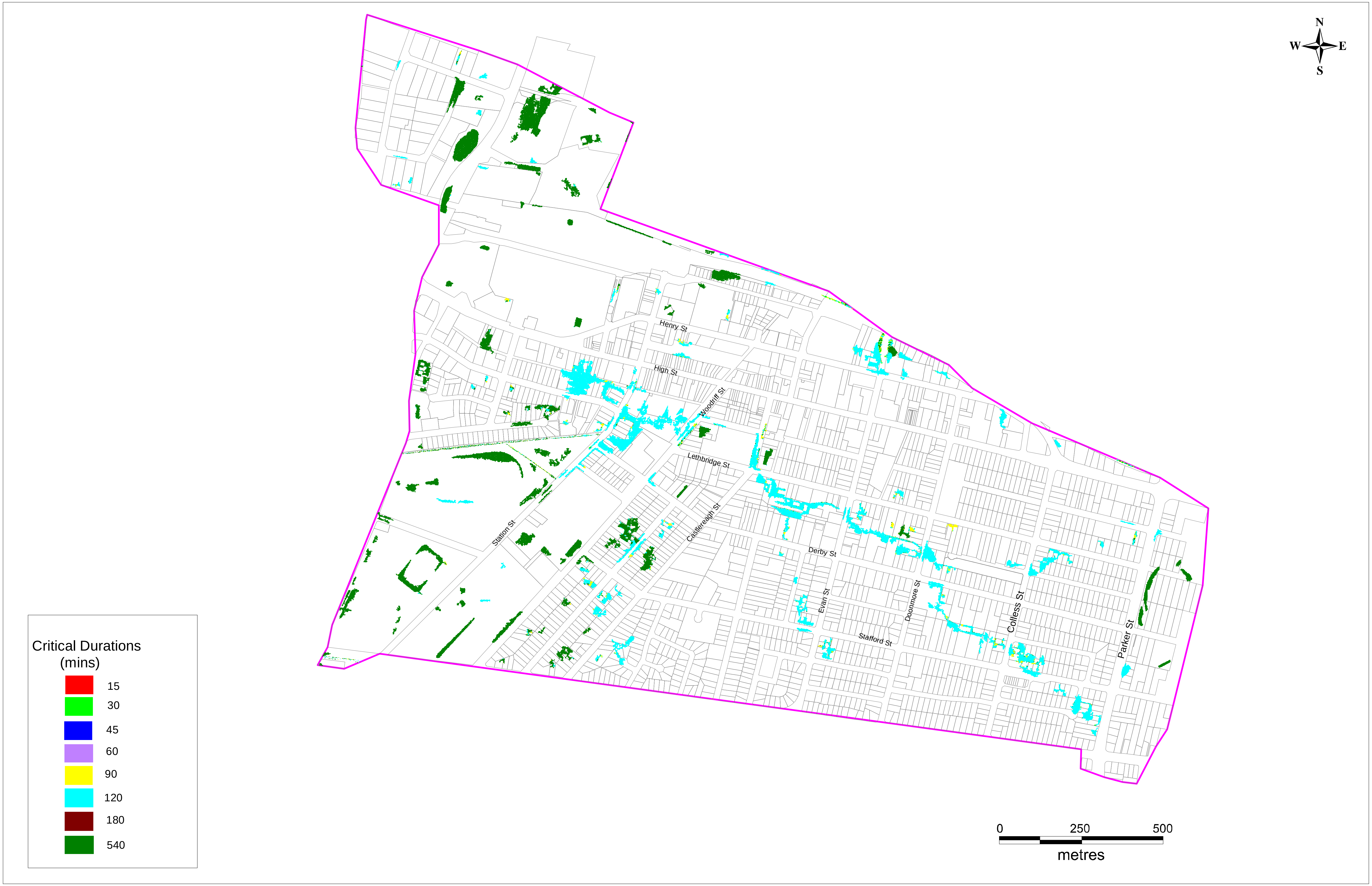


FIGURE 8.11
CRITICAL DURATIONS - 5YR ARI

Penrith CBD Detailed Overland Flow Flood Study

Cardno

W4735
July 2015

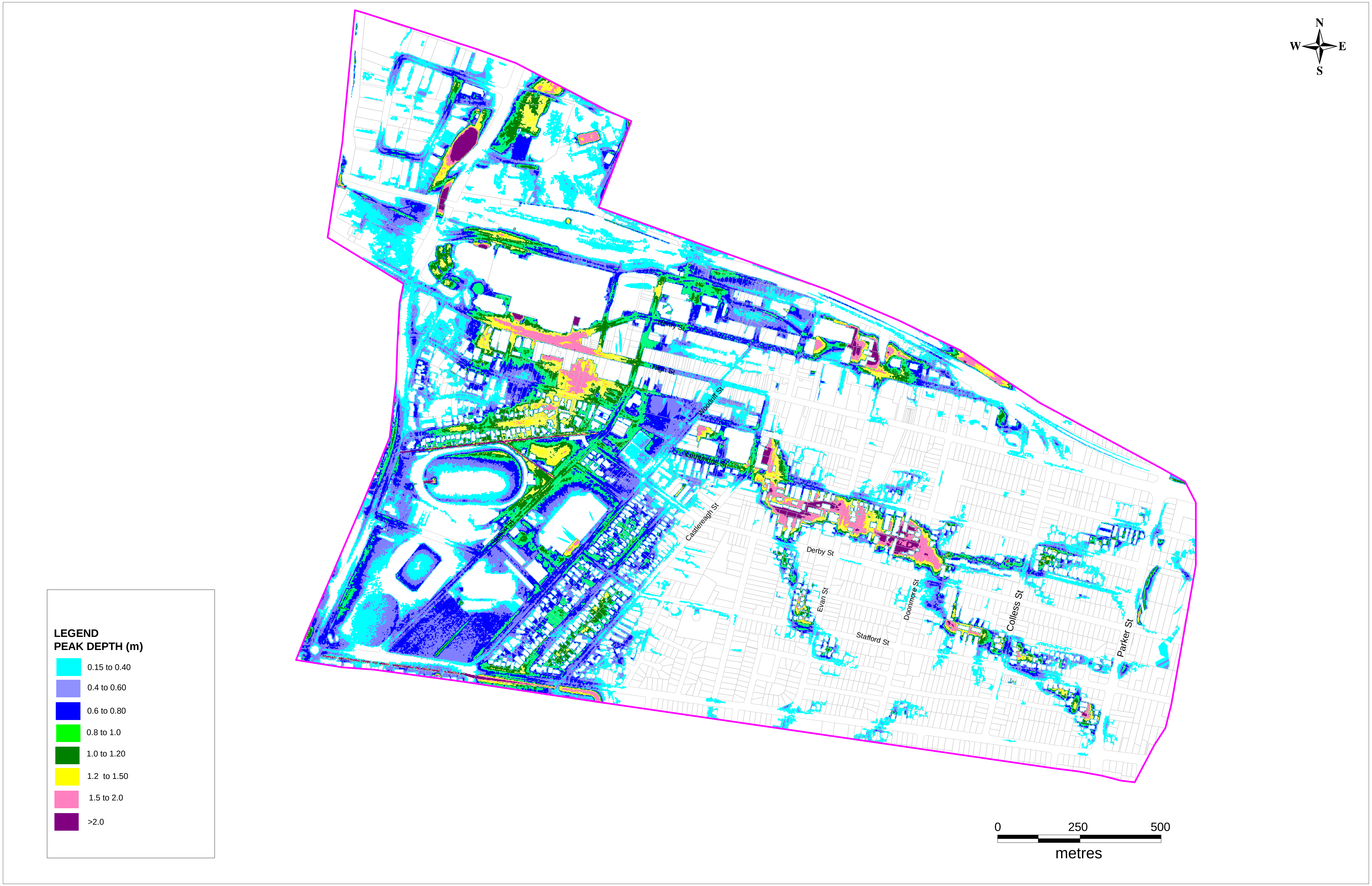


FIGURE 8.12
PMF PEAK FLOOD DEPTHS

Penrith CBD Detailed Overland Flow Flood Study

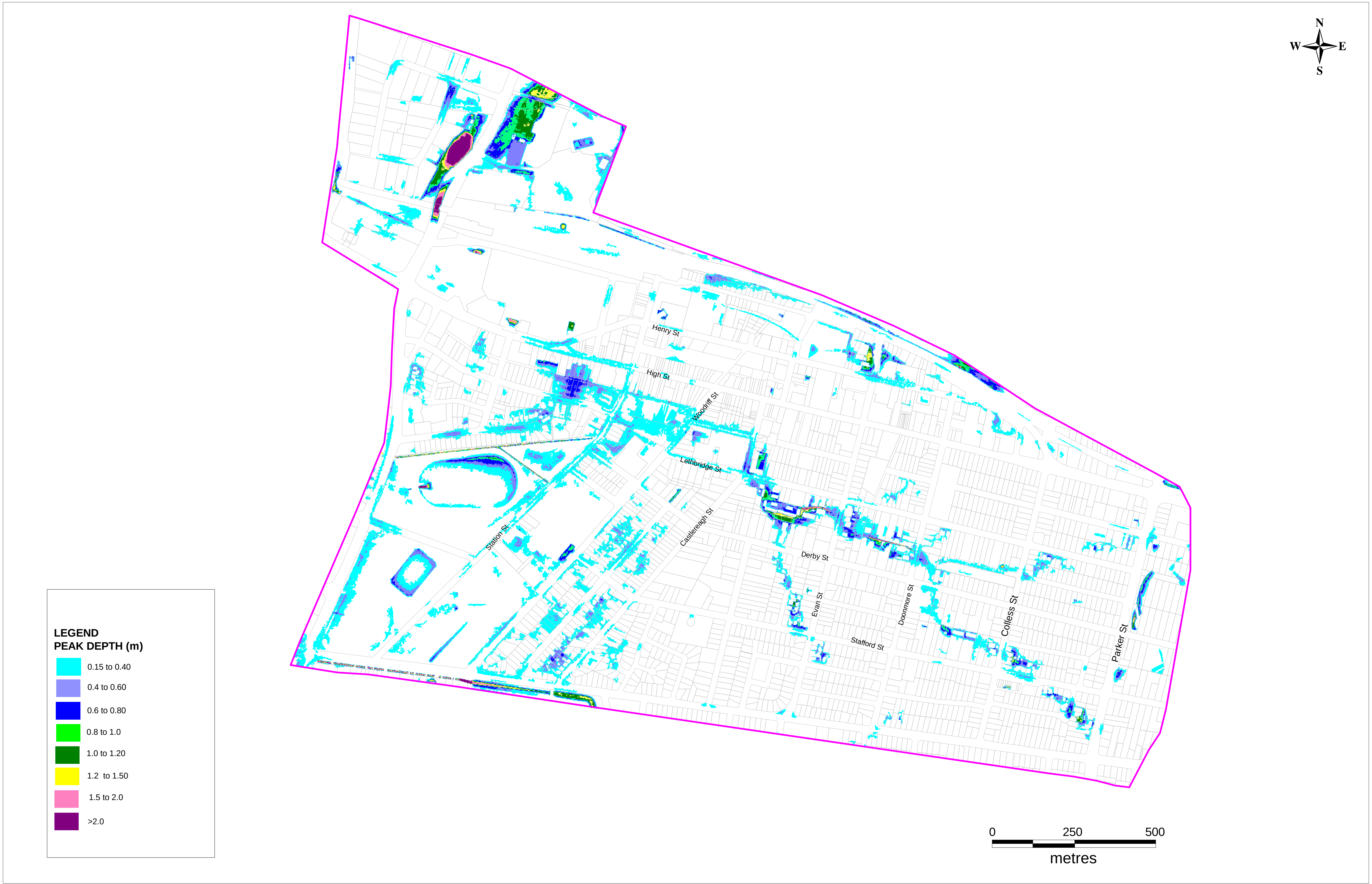
W4735
July 2015

Cardno

W4735
July 2015

Penrith CBD Detailed Overland Flow Flood Study

FIGURE 8.13
200 YEAR ARI PEAK FLOOD DEPTHS



Cardno

W4735
July 2015

Penrith CBD Detailed Overland Flow Flood Study

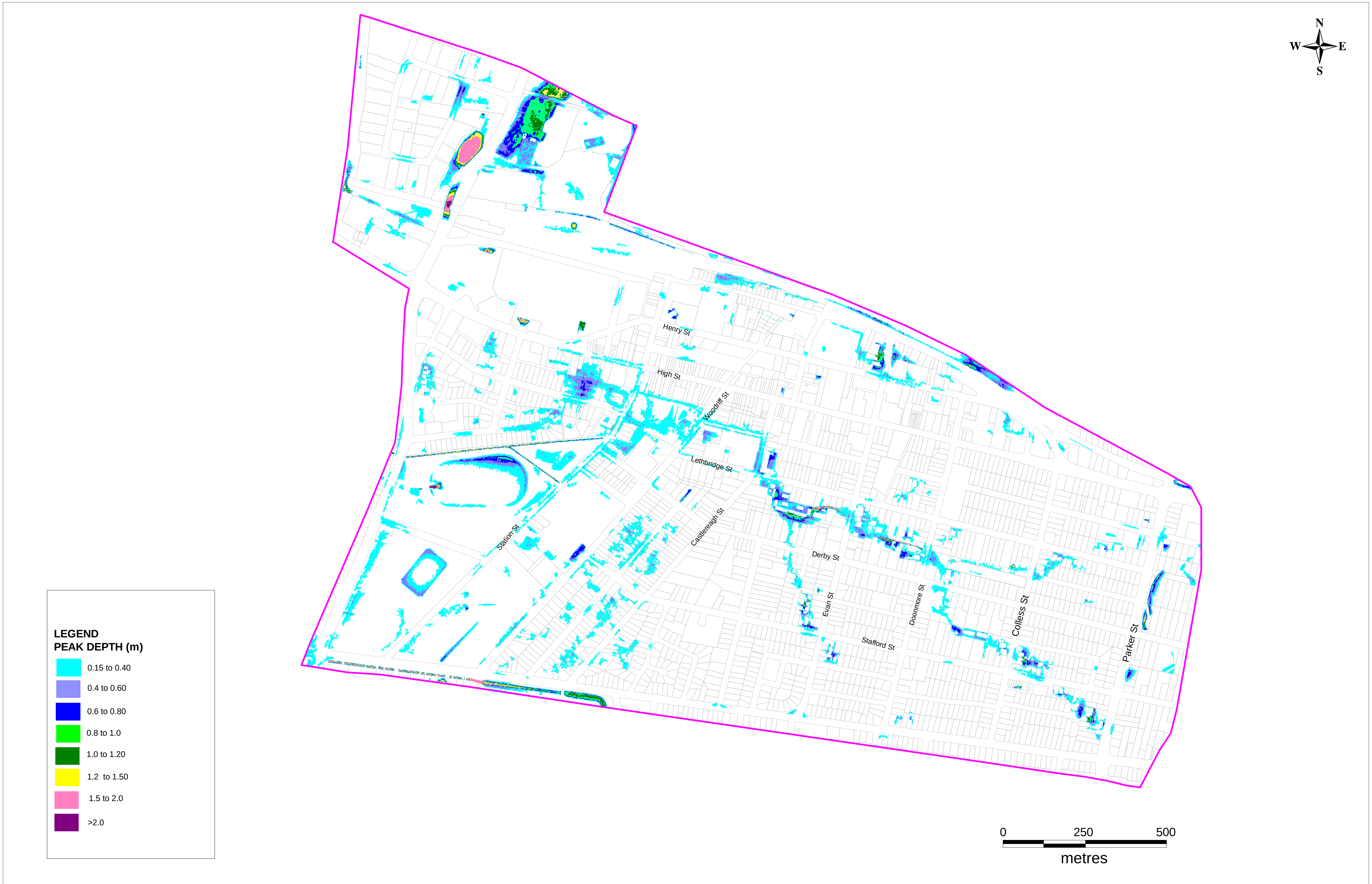
FIGURE 8.14
100 YEAR ARI PEAK FLOOD DEPTHS

Cardno

W4735
July 2015

Penrith CBD Detailed Overland Flow Flood Study

FIGURE 8.15
50 YEAR ARI PEAK FLOOD DEPTHS

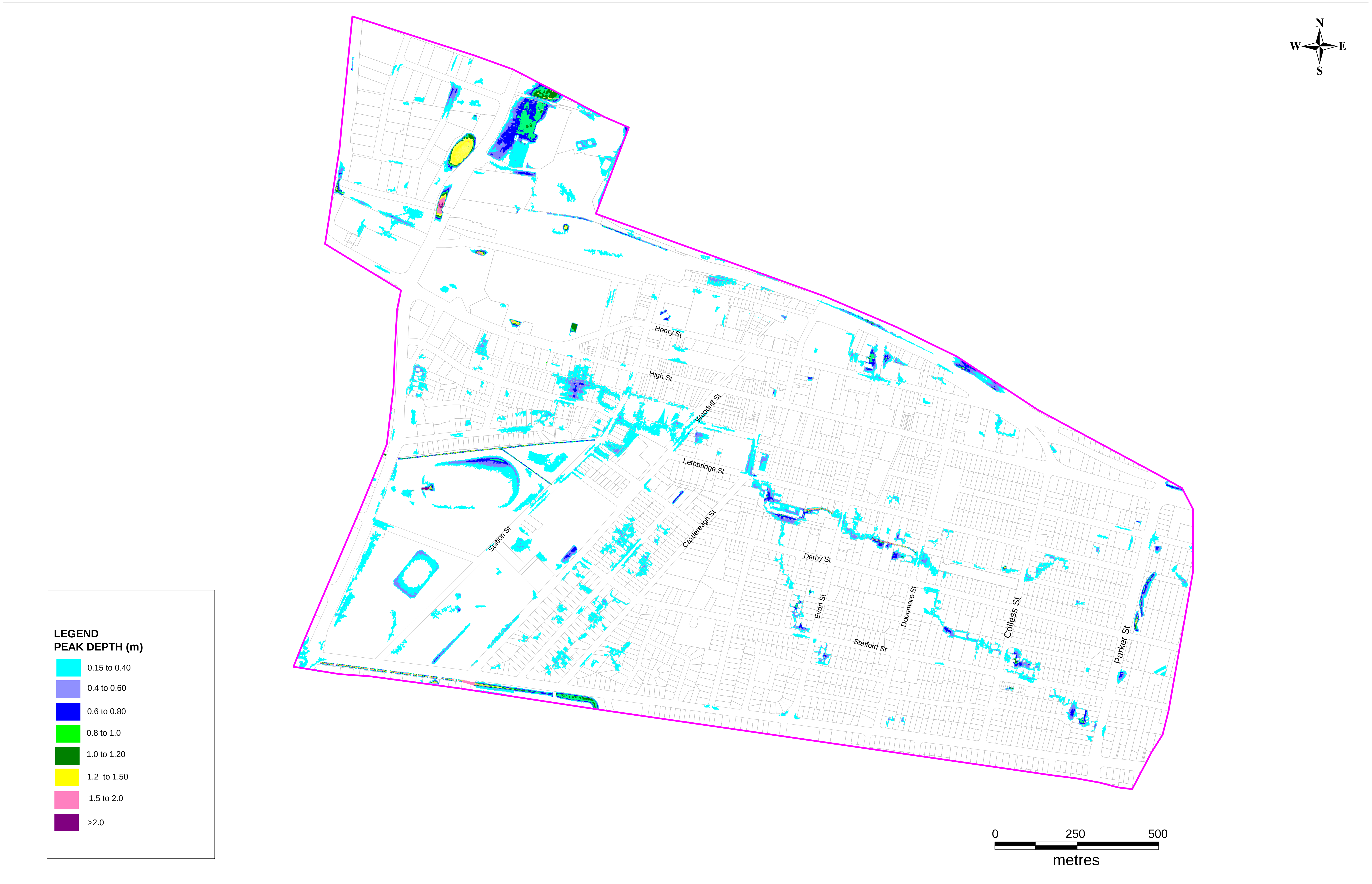


Cardno

W4735
July 2015

Penrith CBD Detailed Overland Flow Flood Study

FIGURE 8.16
20 YEAR ARI PEAK FLOOD DEPTHS

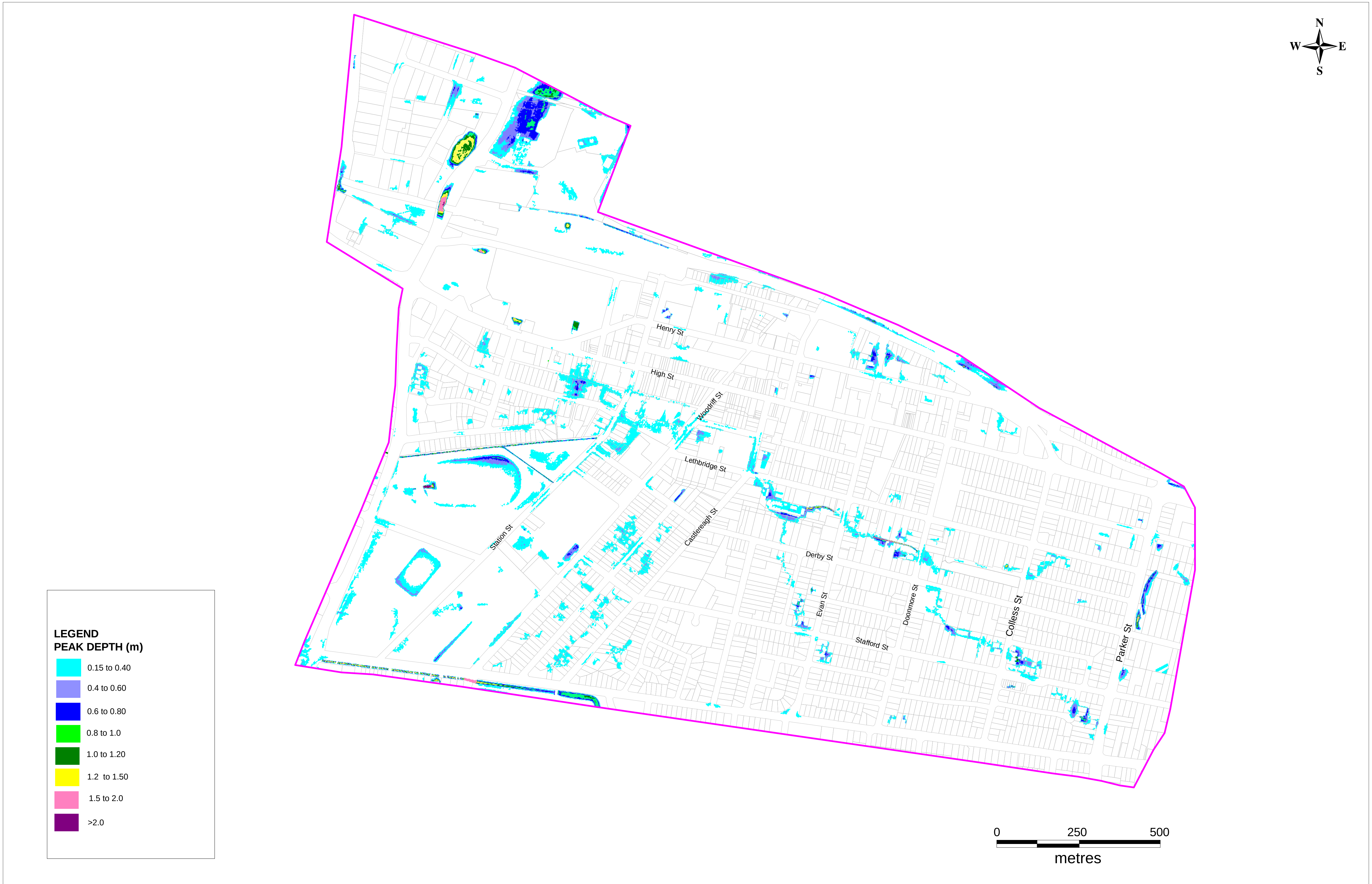


Cardno

W4735
July 2015

Penrith CBD Detailed Overland Flow Flood Study

FIGURE 8.17
10 YEAR ARI PEAK FLOOD DEPTHS

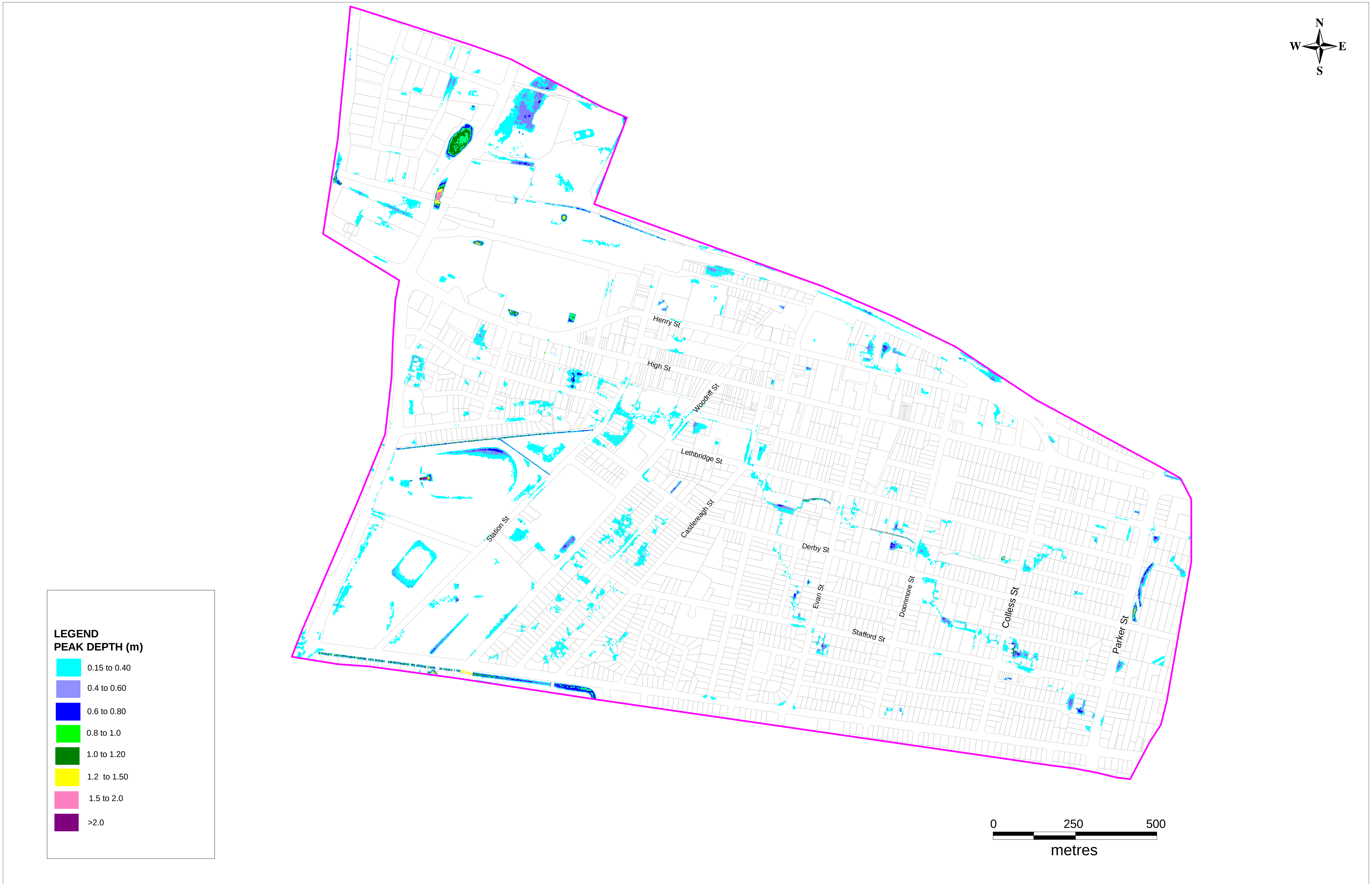


Cardno

W4735
July 2015

Penrith CBD Detailed Overland Flow Flood Study

FIGURE 8.18
5 YEAR ARI PEAK FLOOD DEPTHS



Cardno

W4735
July 2015

Penrith CBD Detailed Overland Flow Flood Study

FIGURE 8.19
2 YEAR ARI PEAK FLOOD DEPTHS

Cardno

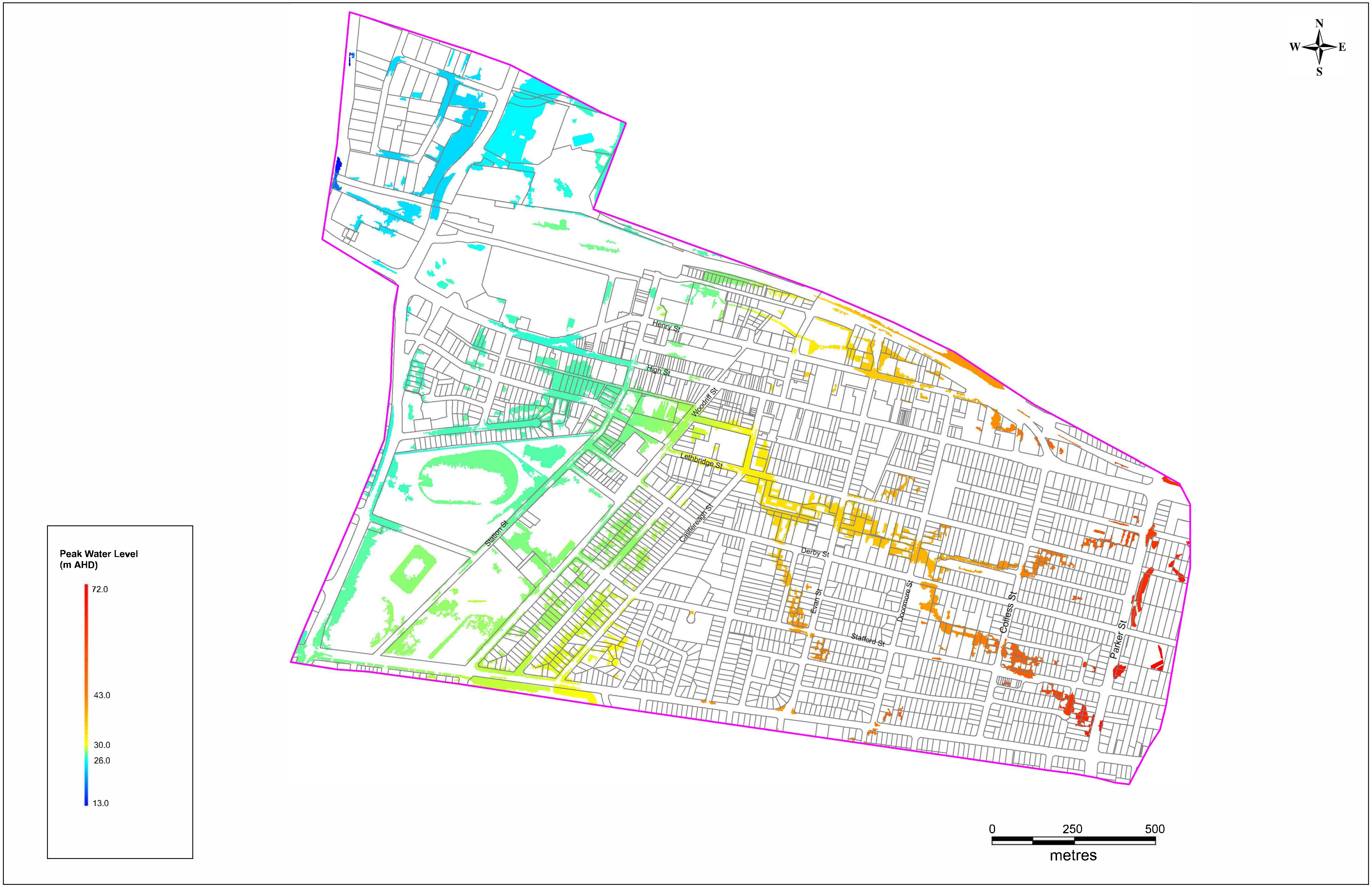
W4735
July 2015

Penrith CBD Detailed Overland Flow Flood Study

FIGURE 8.20
1 YEAR ARI PEAK FLOOD DEPTHS

Penrith CBD Detailed Overland Flow Flood Study

FIGURE 8.21
PMF PEAK FLOOD LEVELS

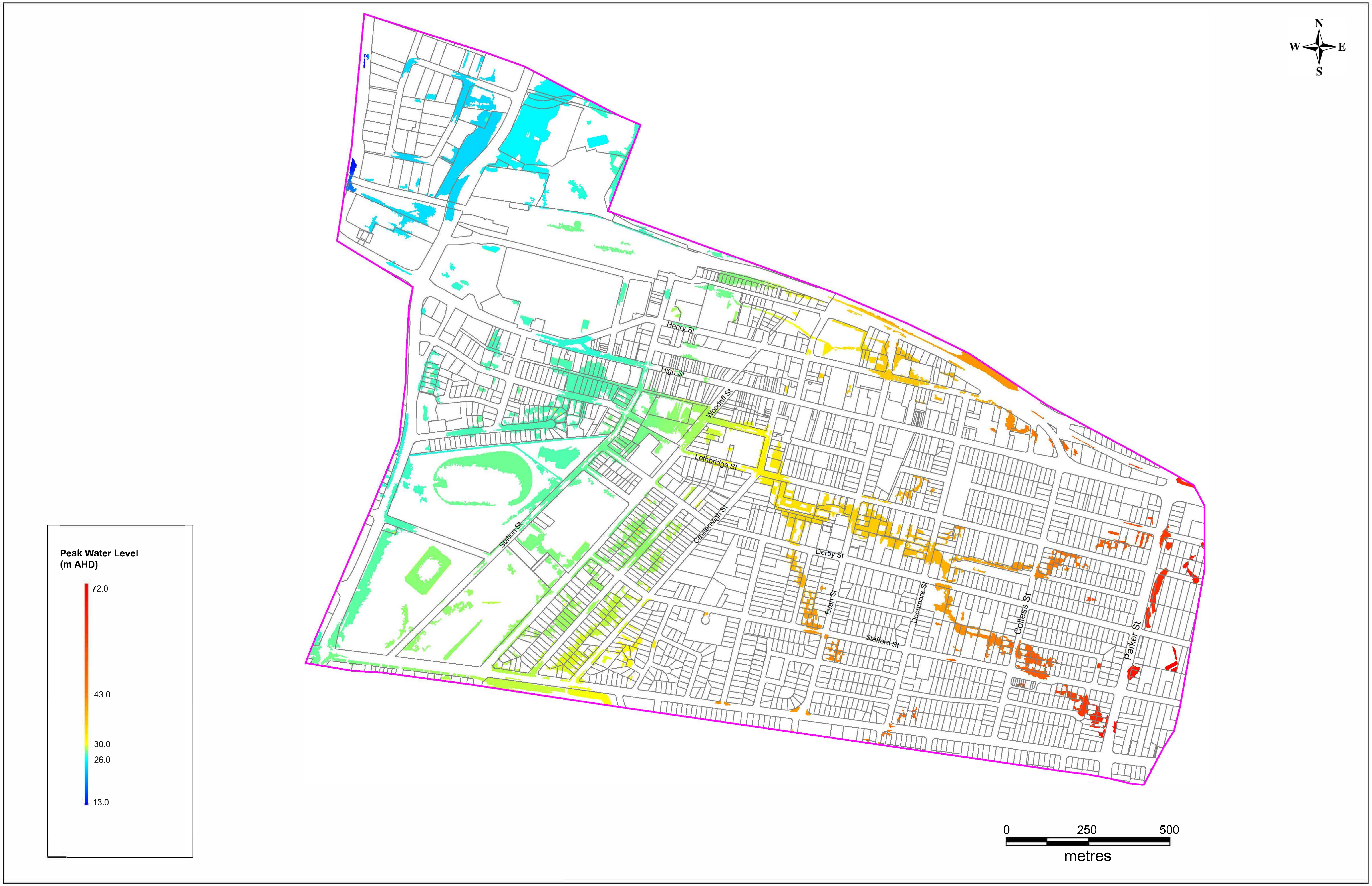


Cardno

W4735
July 2015

Penrith CBD Detailed Overland Flow Flood Study

FIGURE 8.22
200 YEAR ARI PEAK FLOOD LEVELS

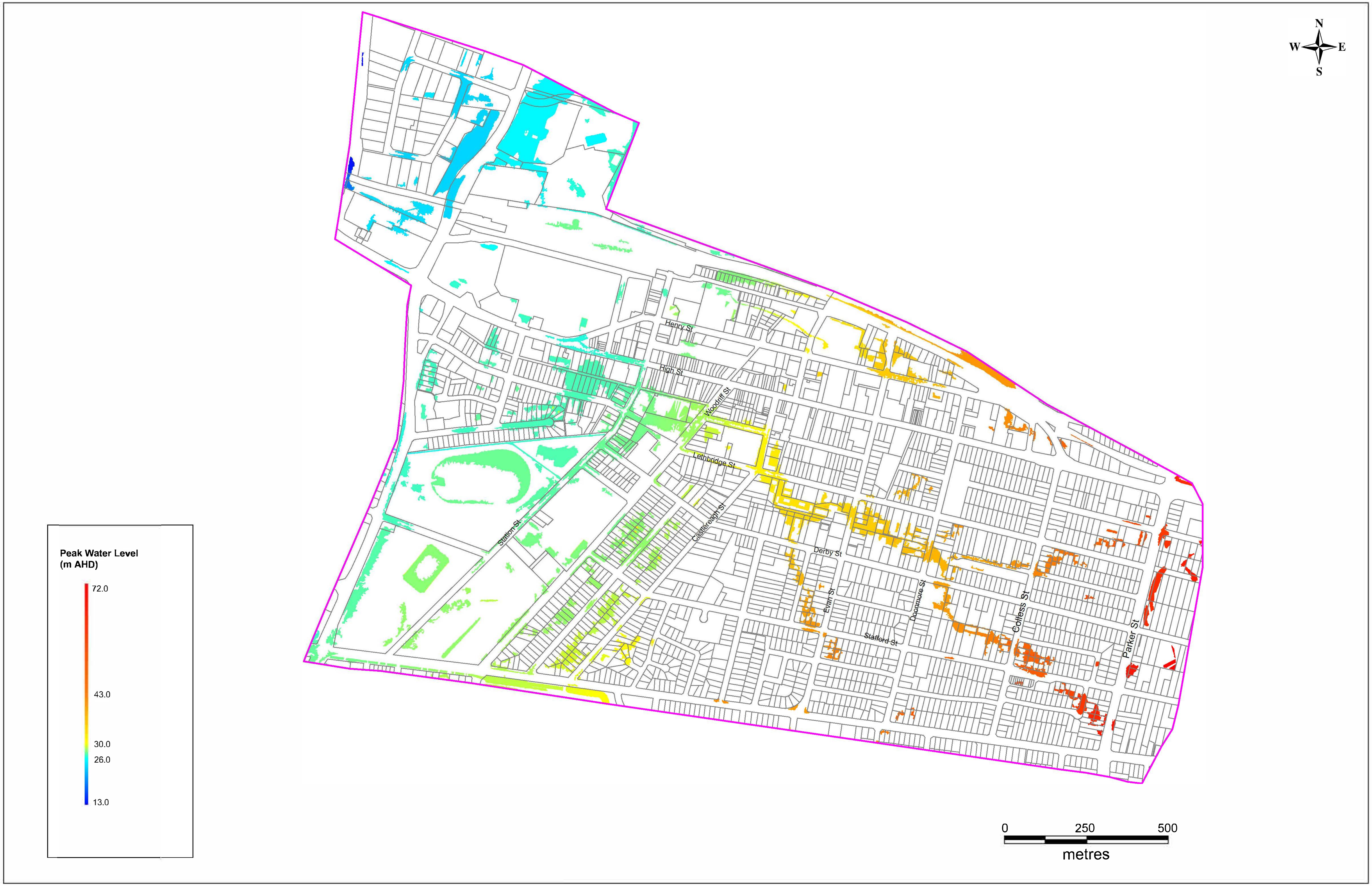


Cardno

W4735
July 2015

Penrith CBD Detailed Overland Flow Flood Study

FIGURE 8.23
100 YEAR ARI PEAK FLOOD LEVELS

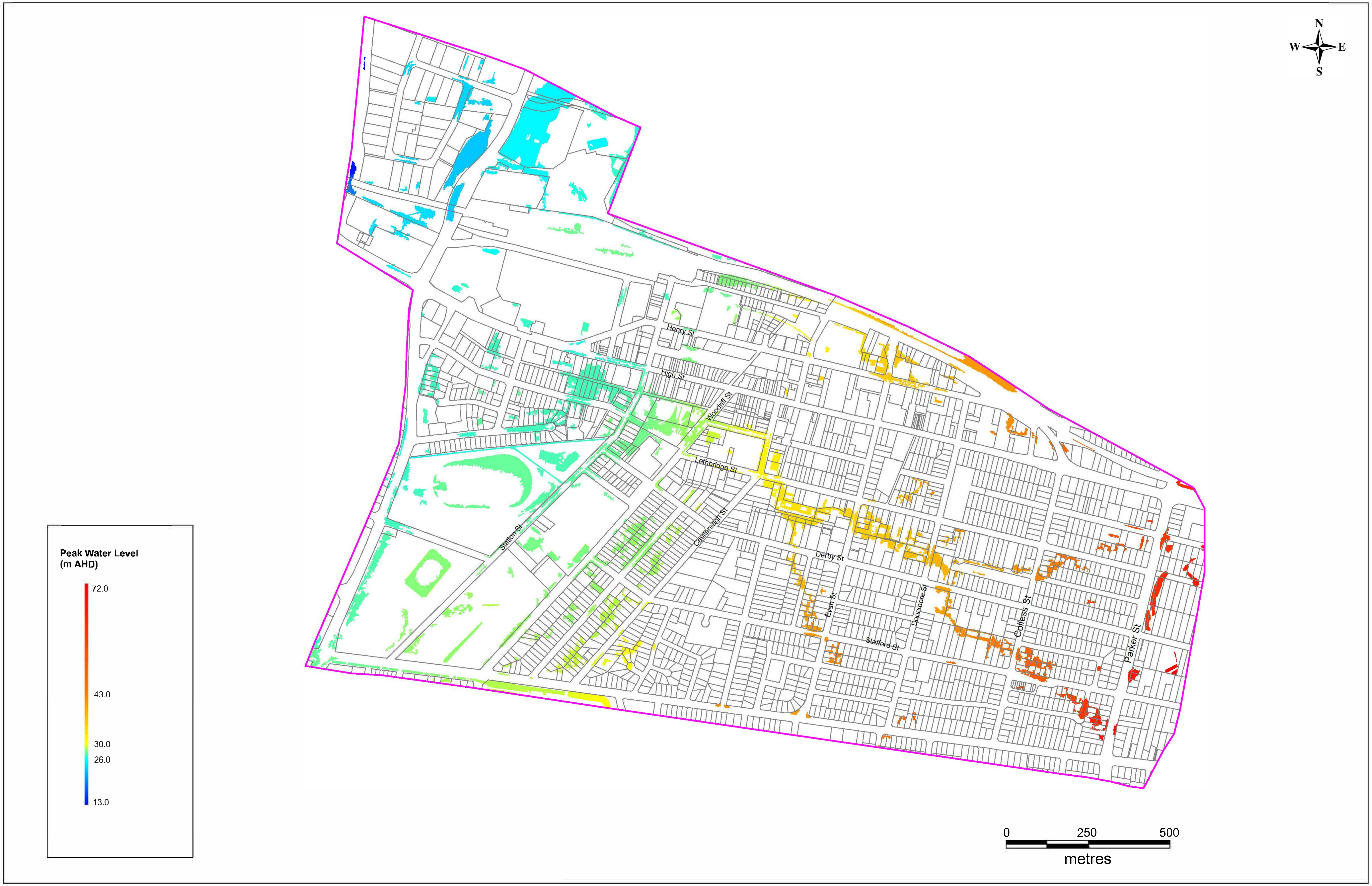


Cardno

W4735
July 2015

Penrith CBD Detailed Overland Flow Flood Study

FIGURE 8.24
50 YEAR ARI PEAK FLOOD LEVELS



Cardno

W4735
July 2015

Penrith CBD Detailed Overland Flow Flood Study

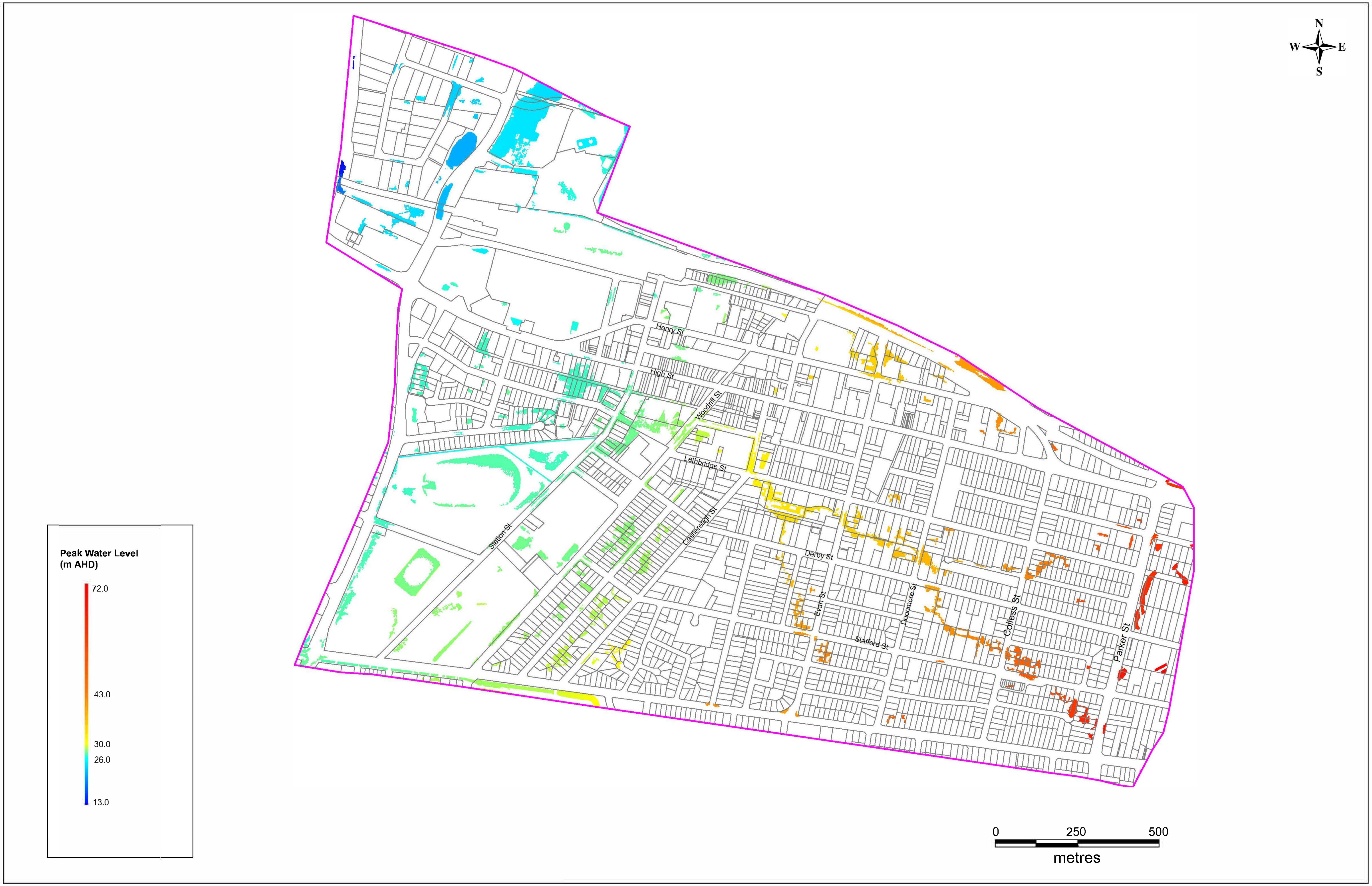
FIGURE 8.25
20 YEAR ARI PEAK FLOOD LEVELS

Cardno

W4735
July 2015

Penrith CBD Detailed Overland Flow Flood Study

FIGURE 8.26
10 YEAR ARI PEAK FLOOD LEVELS

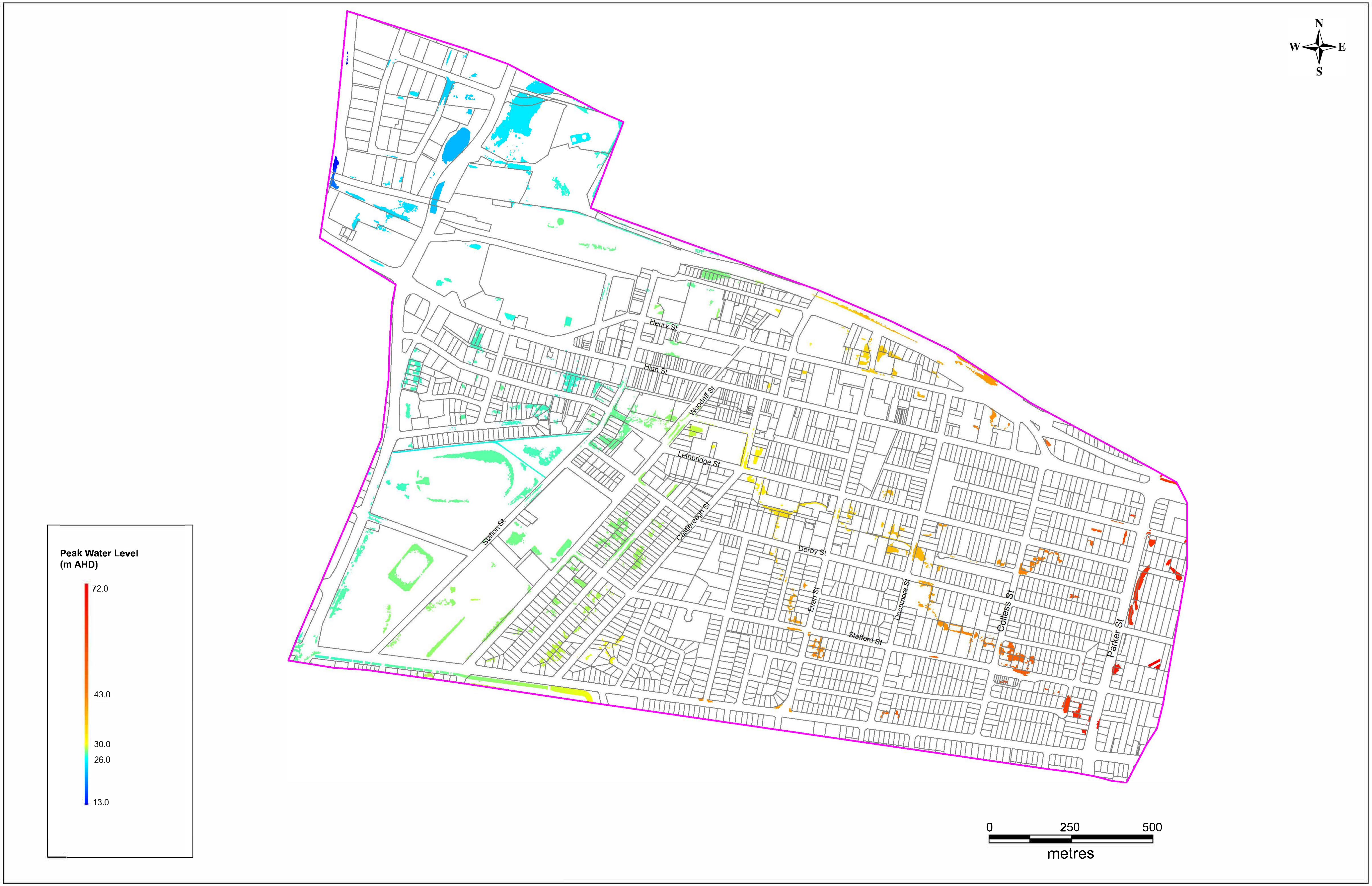


Cardno

W4735
July 2015

Penrith CBD Detailed Overland Flow Flood Study

FIGURE 8.27
5 YEAR ARI PEAK FLOOD LEVELS

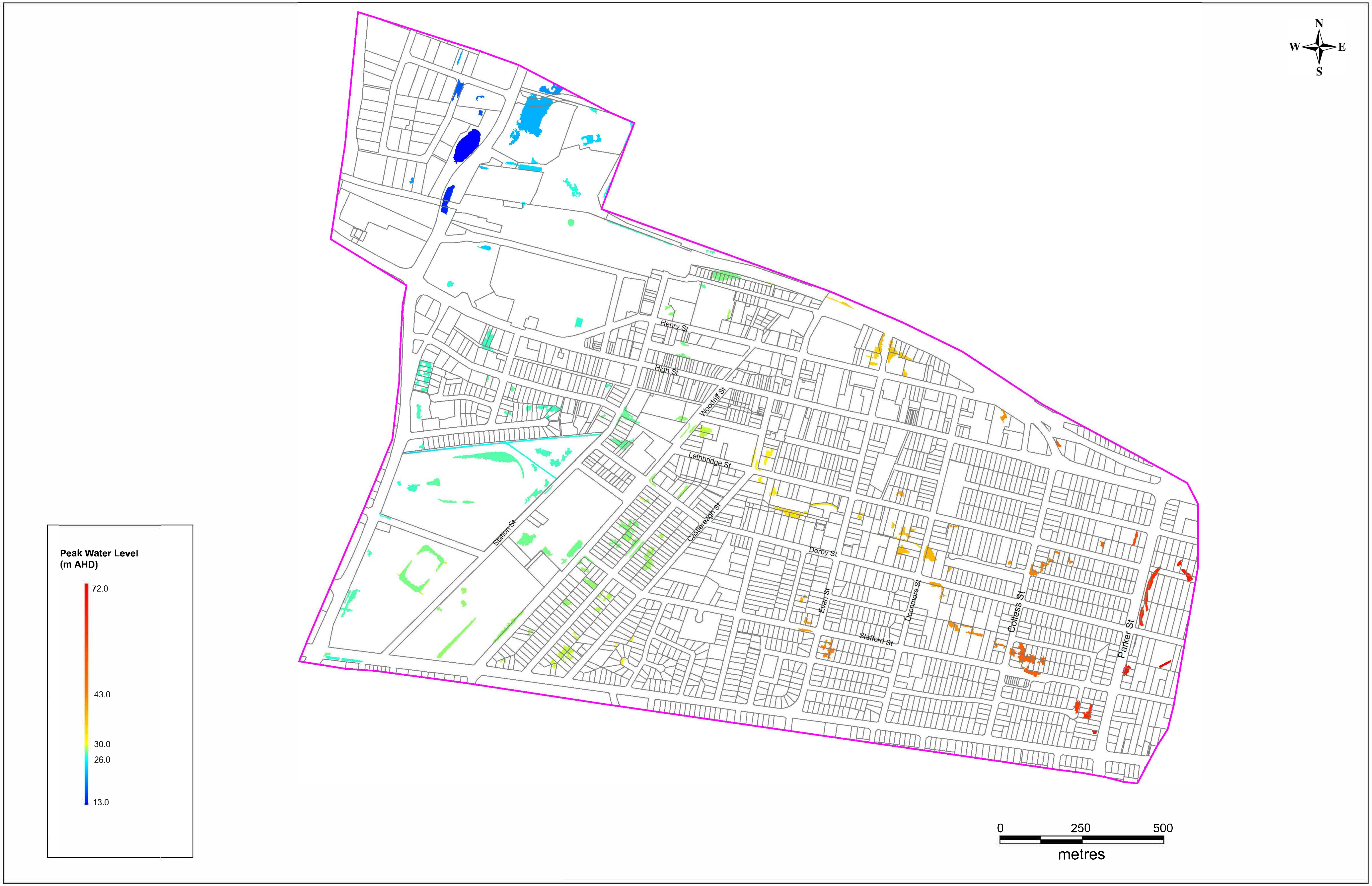


Cardno

W4735
July 2015

Penrith CBD Detailed Overland Flow Flood Study

FIGURE 8.28
2 YEAR ARI PEAK FLOOD LEVELS



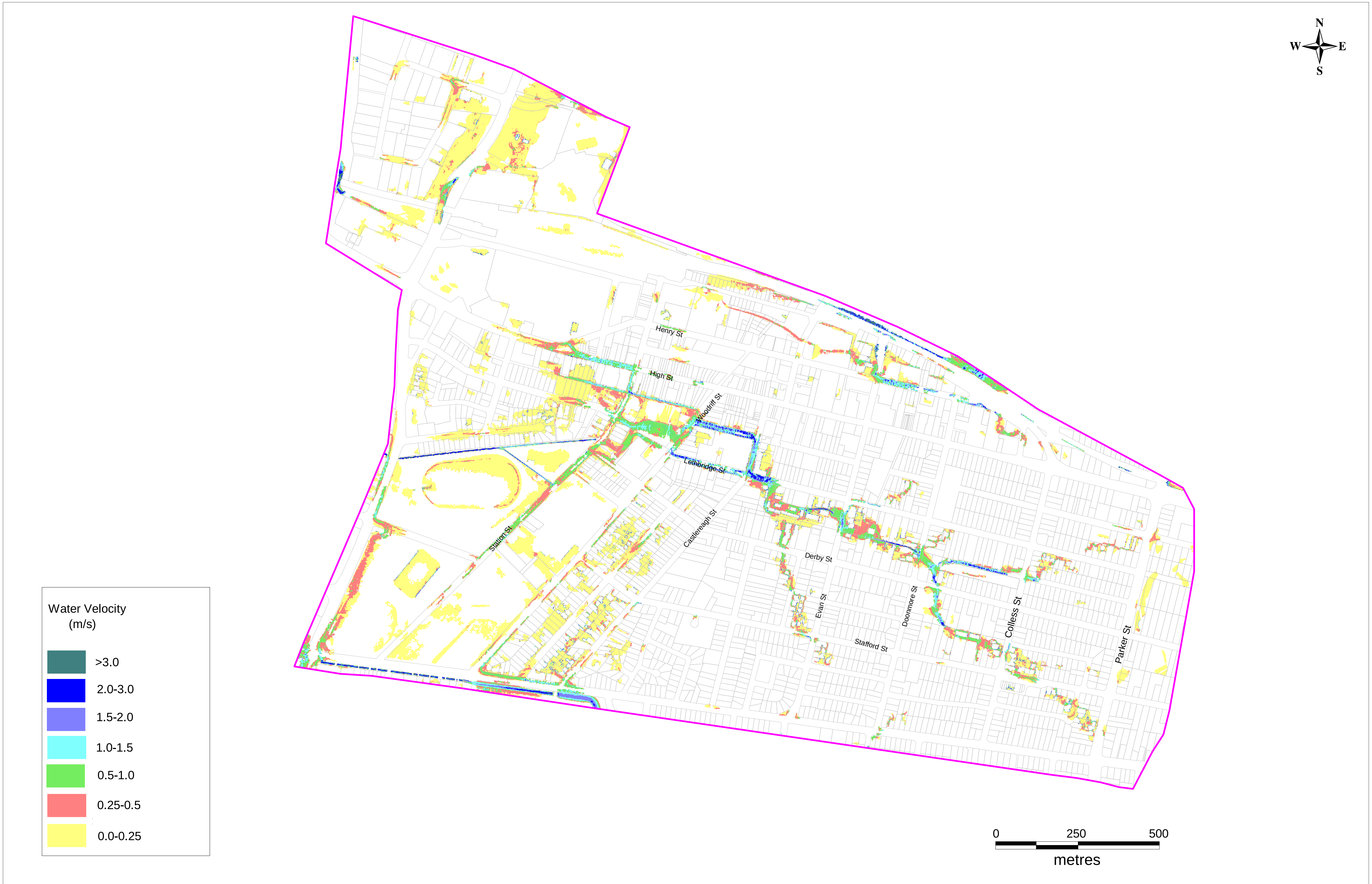
Cardno

W4735
July 2015

Penrith CBD Detailed Overland Flow Flood Study

FIGURE 8.29
1 YEAR ARI PEAK FLOOD LEVELS

FIGURE 8.30
PMF PEAK FLOOD VELOCITY

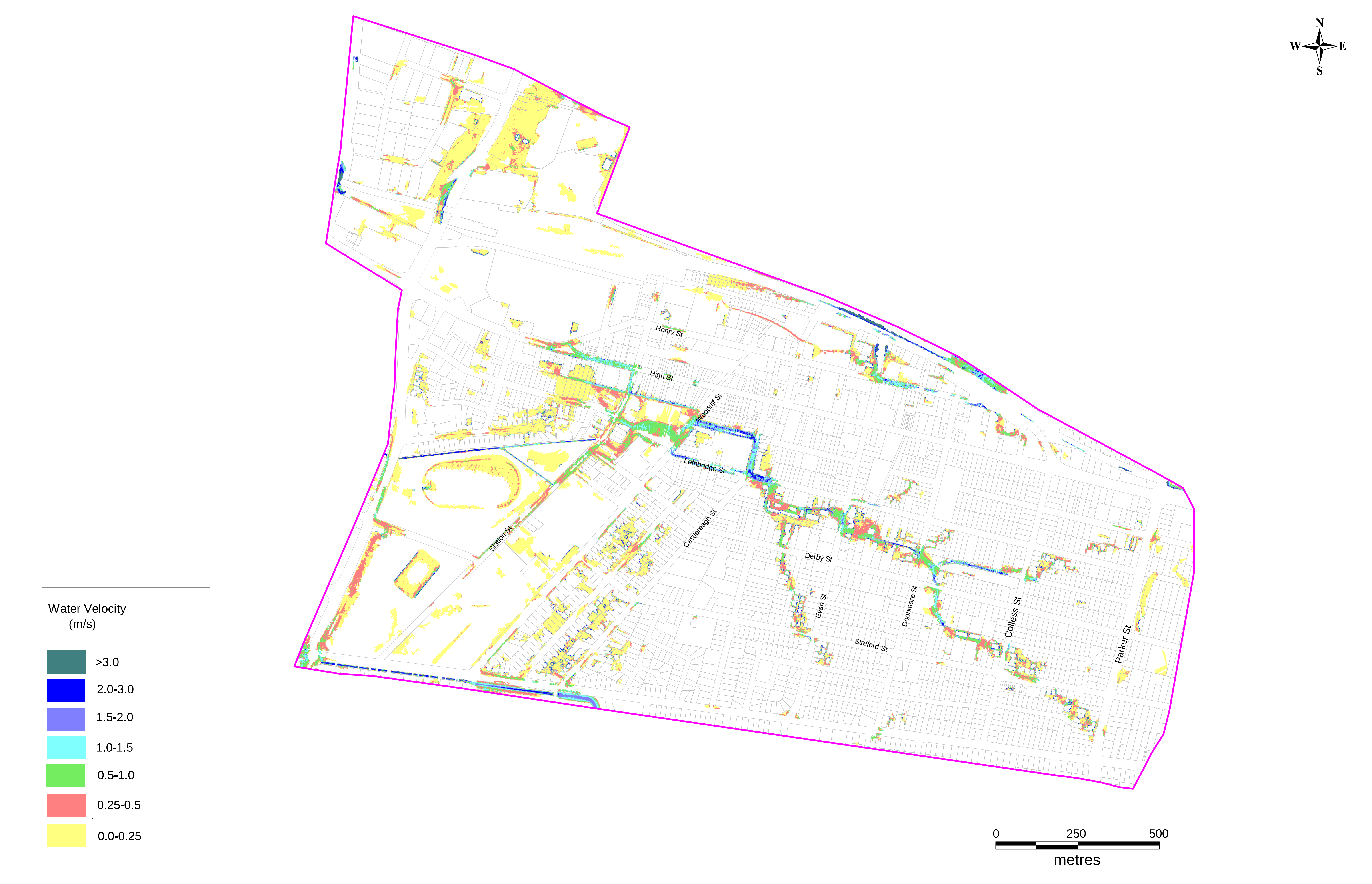


Cardno

W4735
July 2015

Penrith CBD Detailed Overland Flow Flood Study

FIGURE 8.31
200 YEAR ARI PEAK FLOOD VELOCITY

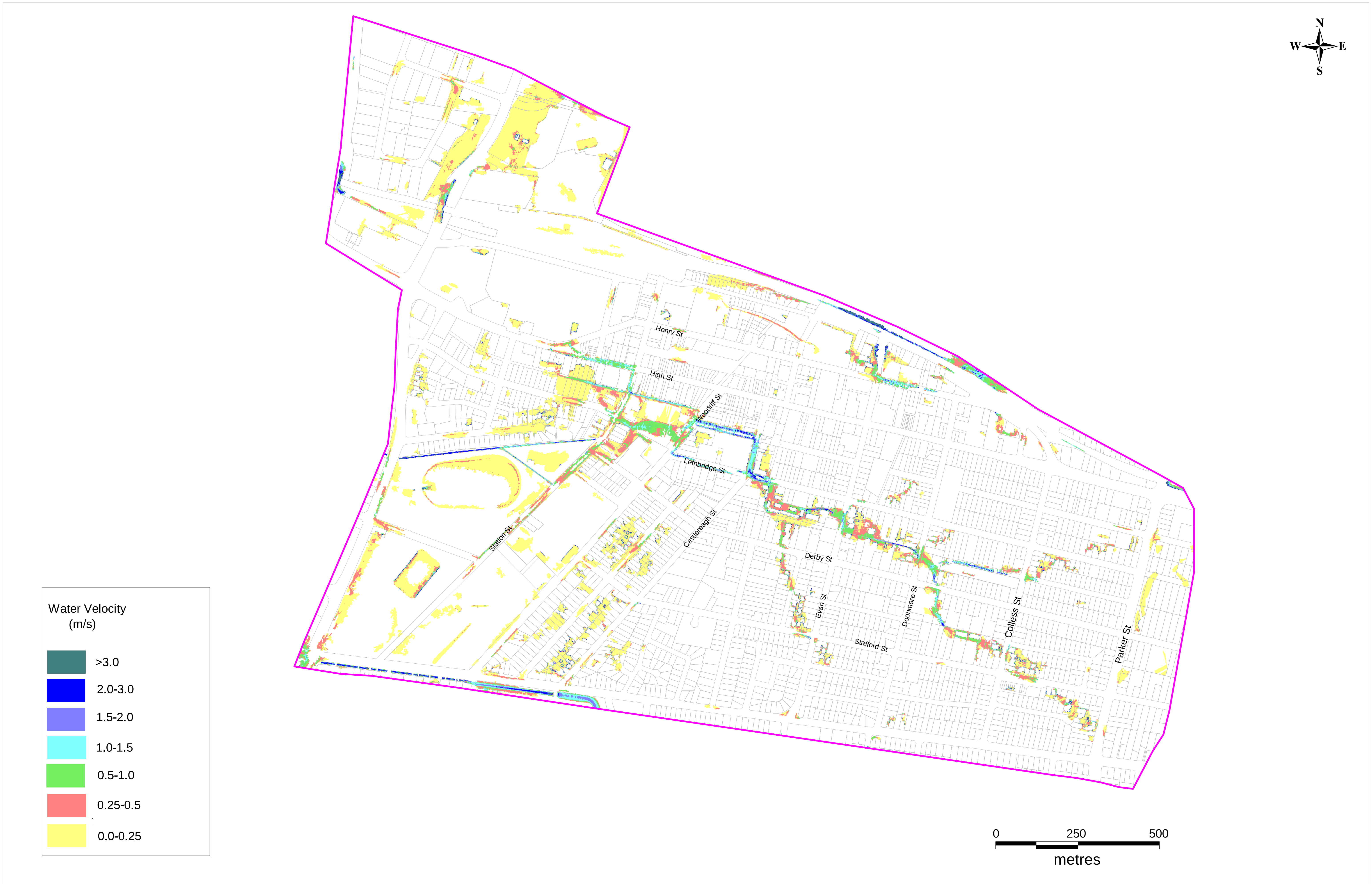


Cardno

W4735
July 2015

Penrith CBD Detailed Overland Flow Flood Study

FIGURE 8.32
100 YEAR ARI PEAK FLOOD VELOCITY

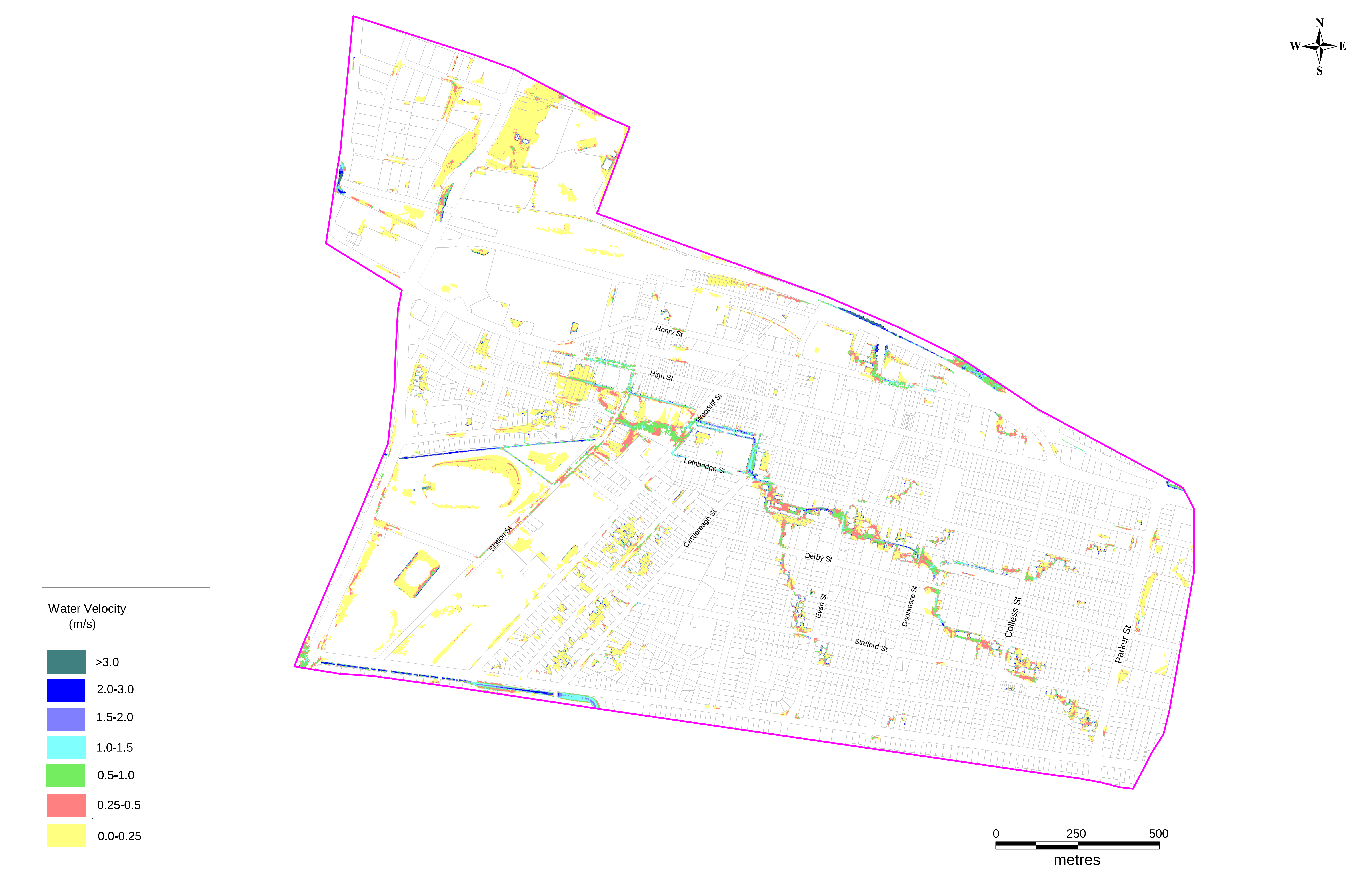


Cardno

W4735
July 2015

Penrith CBD Detailed Overland Flow Flood Study

FIGURE 8.33
50 YEAR ARI PEAK FLOOD VELOCITY

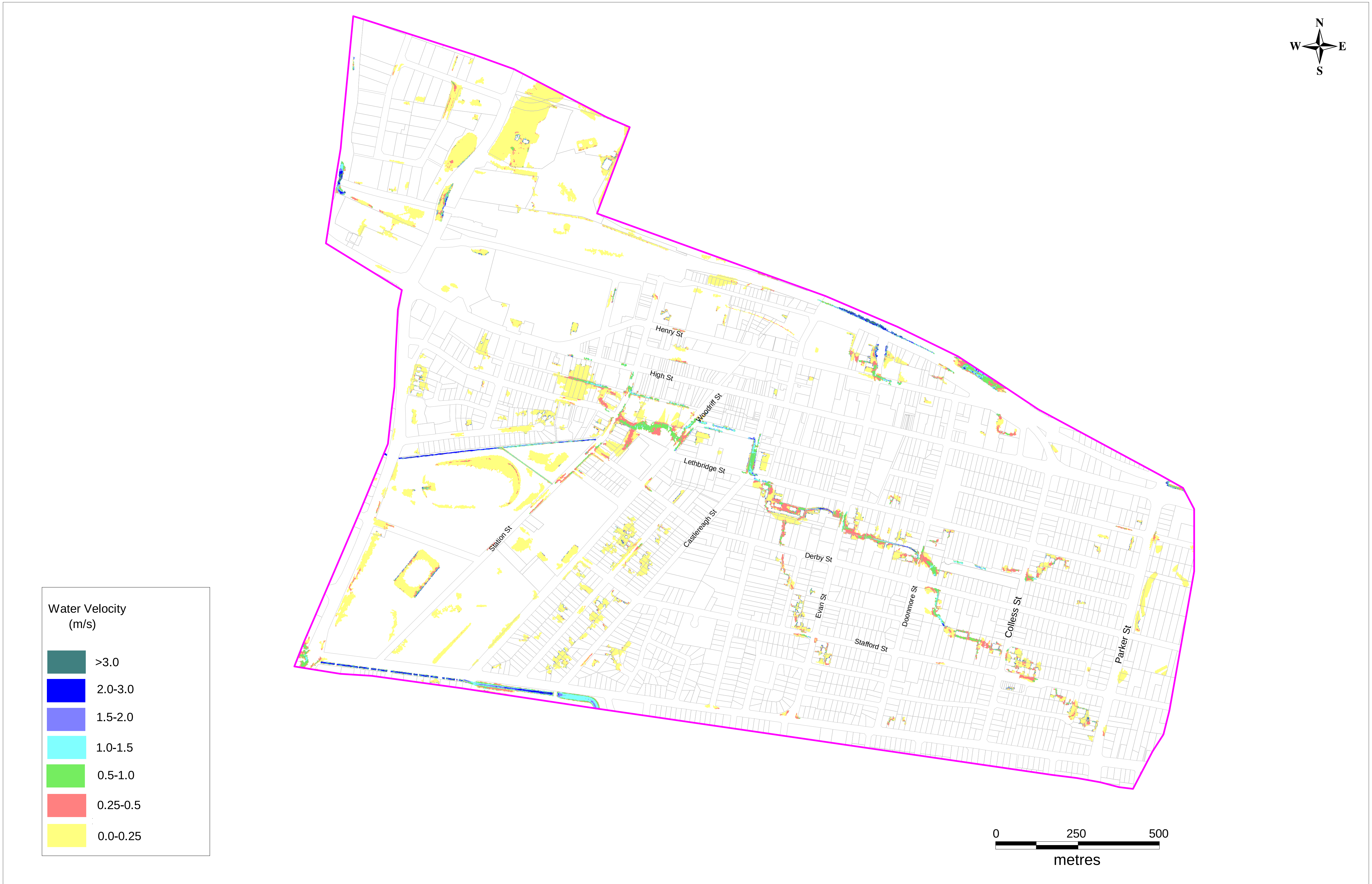


Cardno

W4735
July 2015

Penrith CBD Detailed Overland Flow Flood Study

FIGURE 8.34
20 YEAR ARI PEAK FLOOD VELOCITY



Cardno

W4735
July 2015

Penrith CBD Detailed Overland Flow Flood Study

FIGURE 8.35
10 YEAR ARI PEAK FLOOD VELOCITY

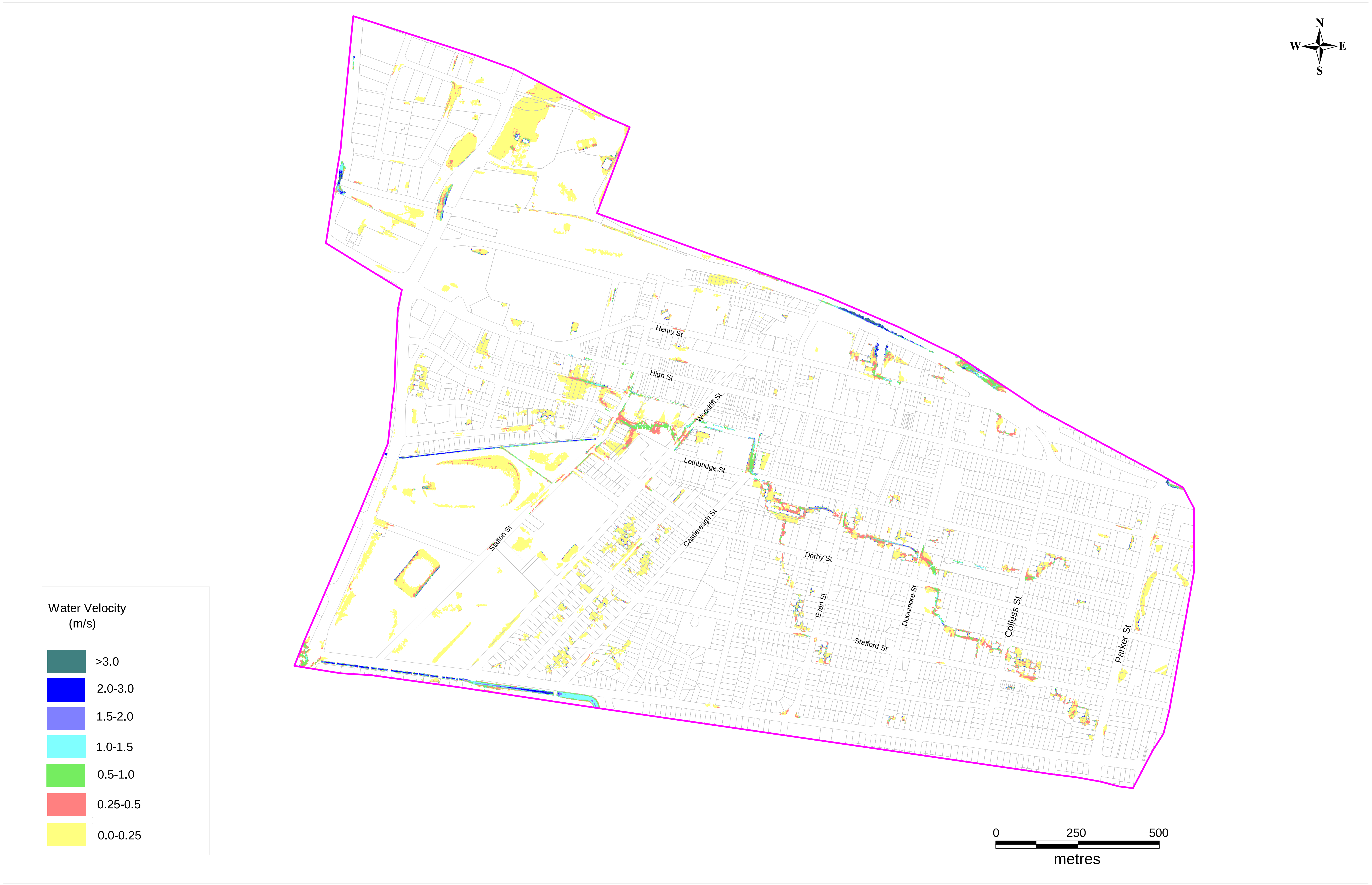
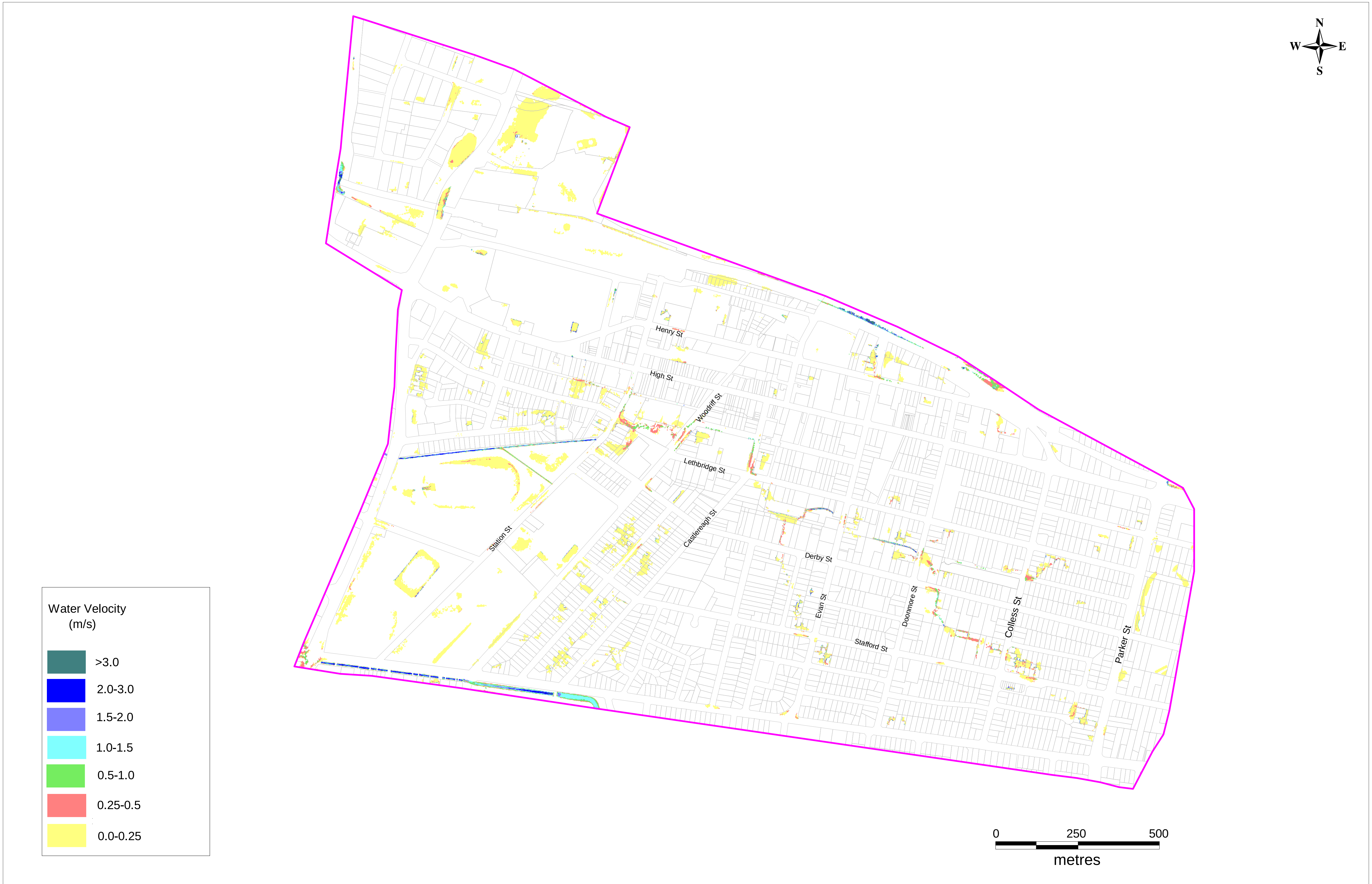


FIGURE 8.36
5 YEAR ARI PEAK FLOOD VELOCITY

Cardno

Penrith CBD Detailed Overland Flow Flood Study

W4735
July 2015

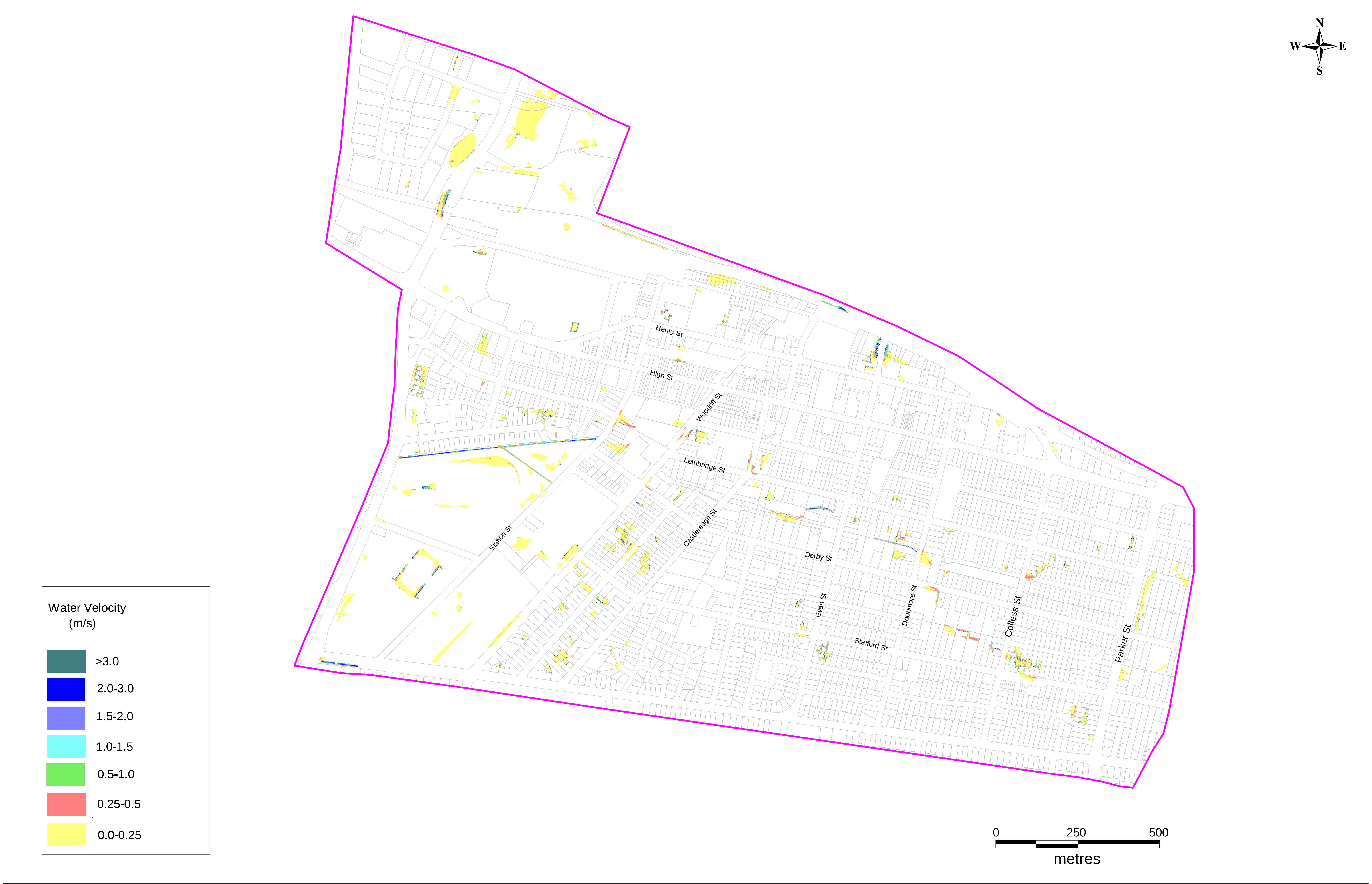


Cardno

W4735
July 2015

Penrith CBD Detailed Overland Flow Flood Study

FIGURE 8.37
2 YEAR ARI PEAK FLOOD VELOCITY

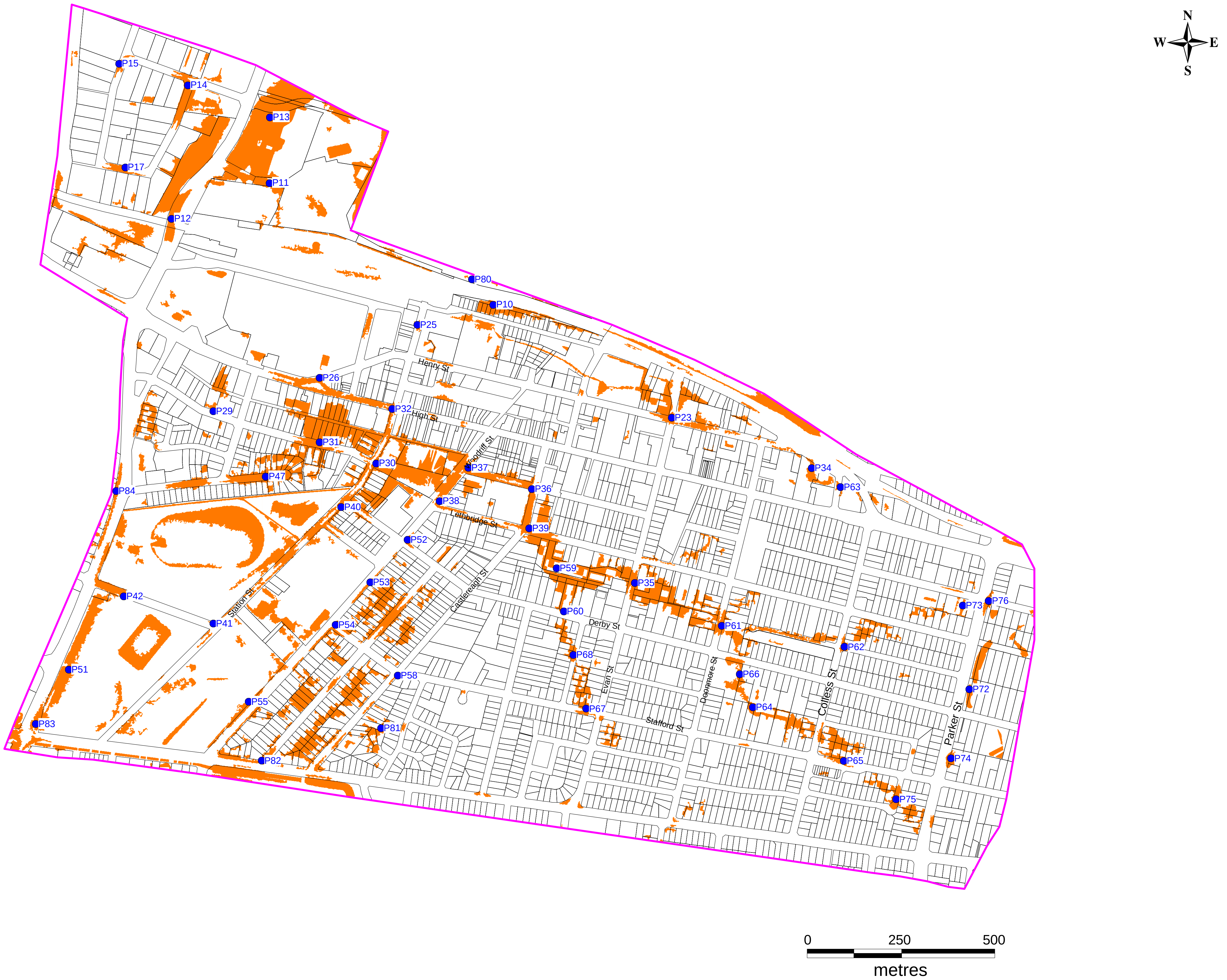


Cardno

W4735
July 2015

Penrith CBD Detailed Overland Flow Flood Study

FIGURE 8.38
1 YEAR ARI PEAK FLOOD VELOCITY



	Flood Extent - 100yr ARI
●	Reference Points for Water Levels

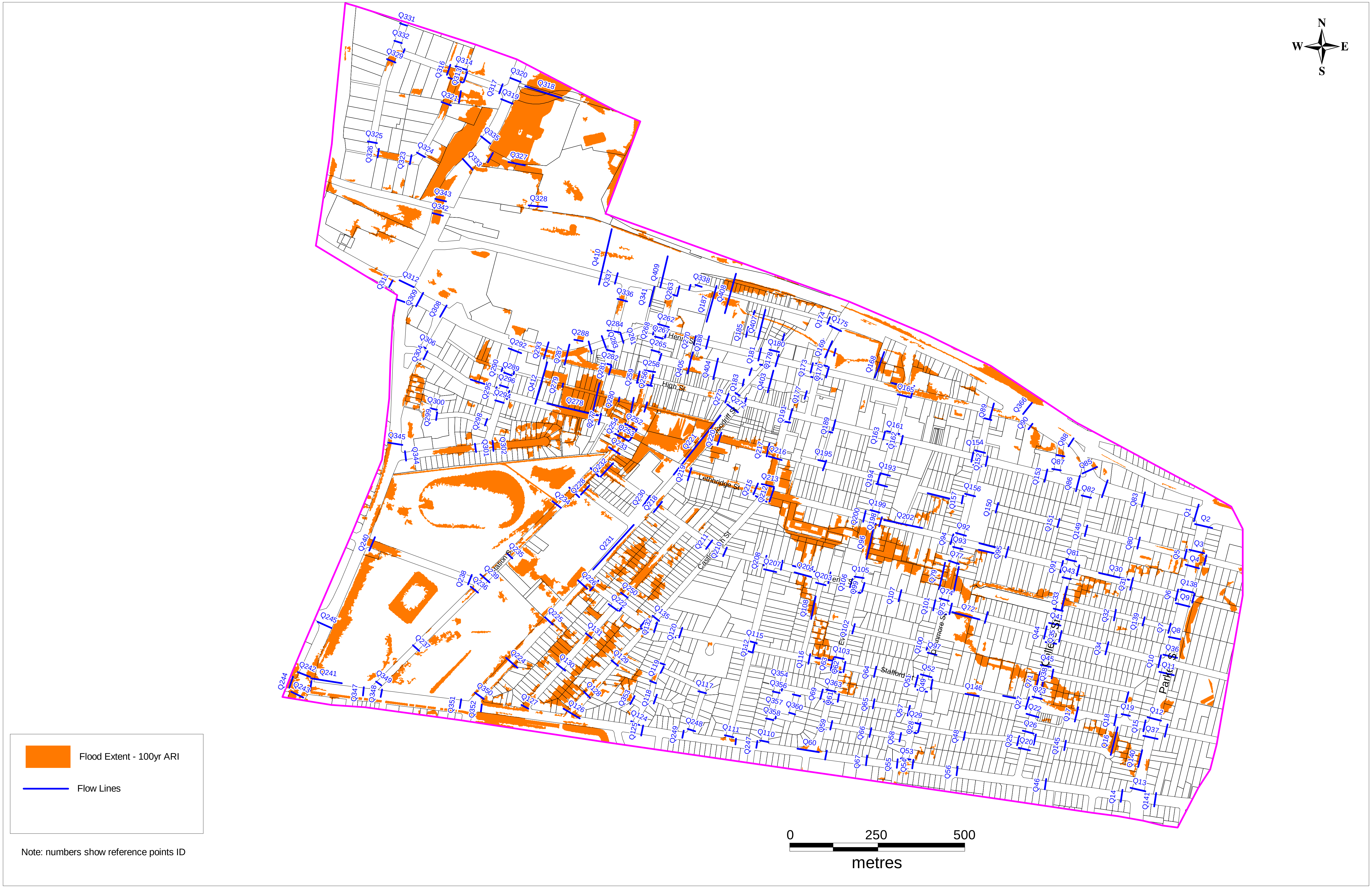
Note: numbers show reference points ID

Cardno

W4735
July 2015

Penrith CBD Detailed Overland Flow Flood Study

FIGURE 8.39
REFERENCE POINTS FOR PEAK WATER LEVELS

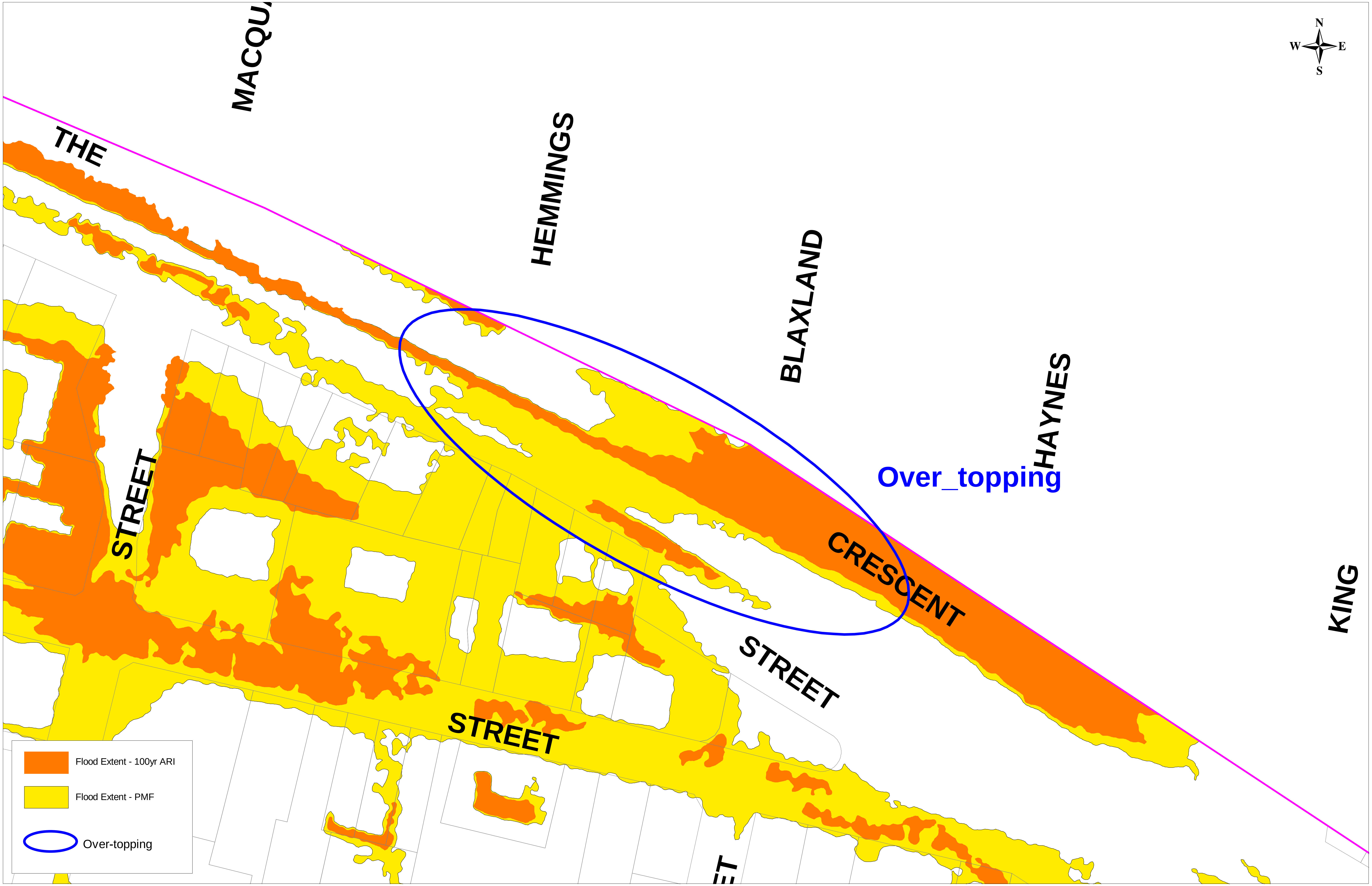


Cardno

Penrith CBD Detailed Overland Flow Flood Study

FIGURE 8.40
REFERENCE LOCATIONS FOR 2D PEAK FLOWS

W4735
July 2015

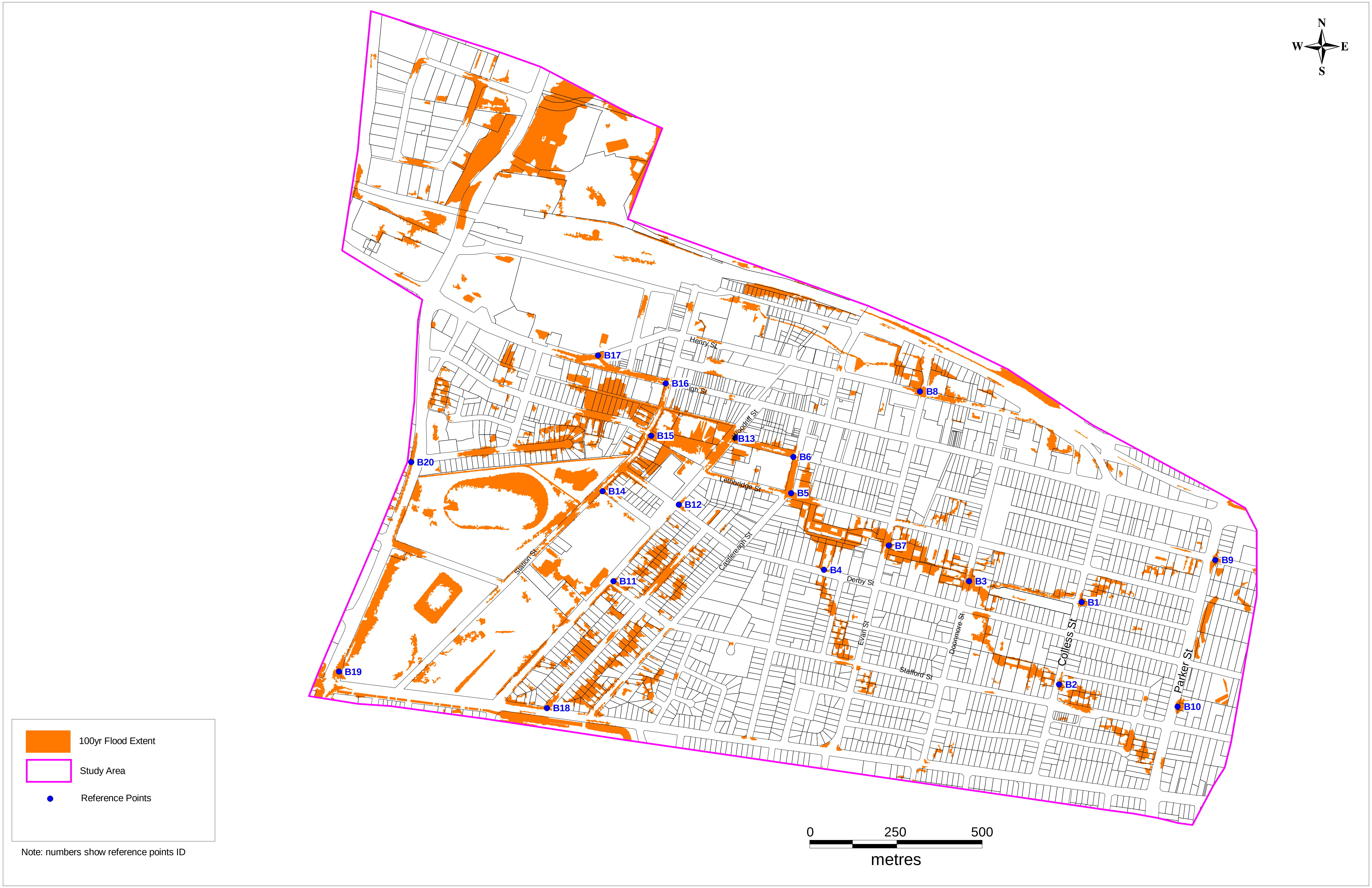


Cardno

W4735
July 2015

Penrith CBD Detailed Overland Flow Flood Study

FIGURE 8.41
RAILWAY OVER-TOPPING - PMF



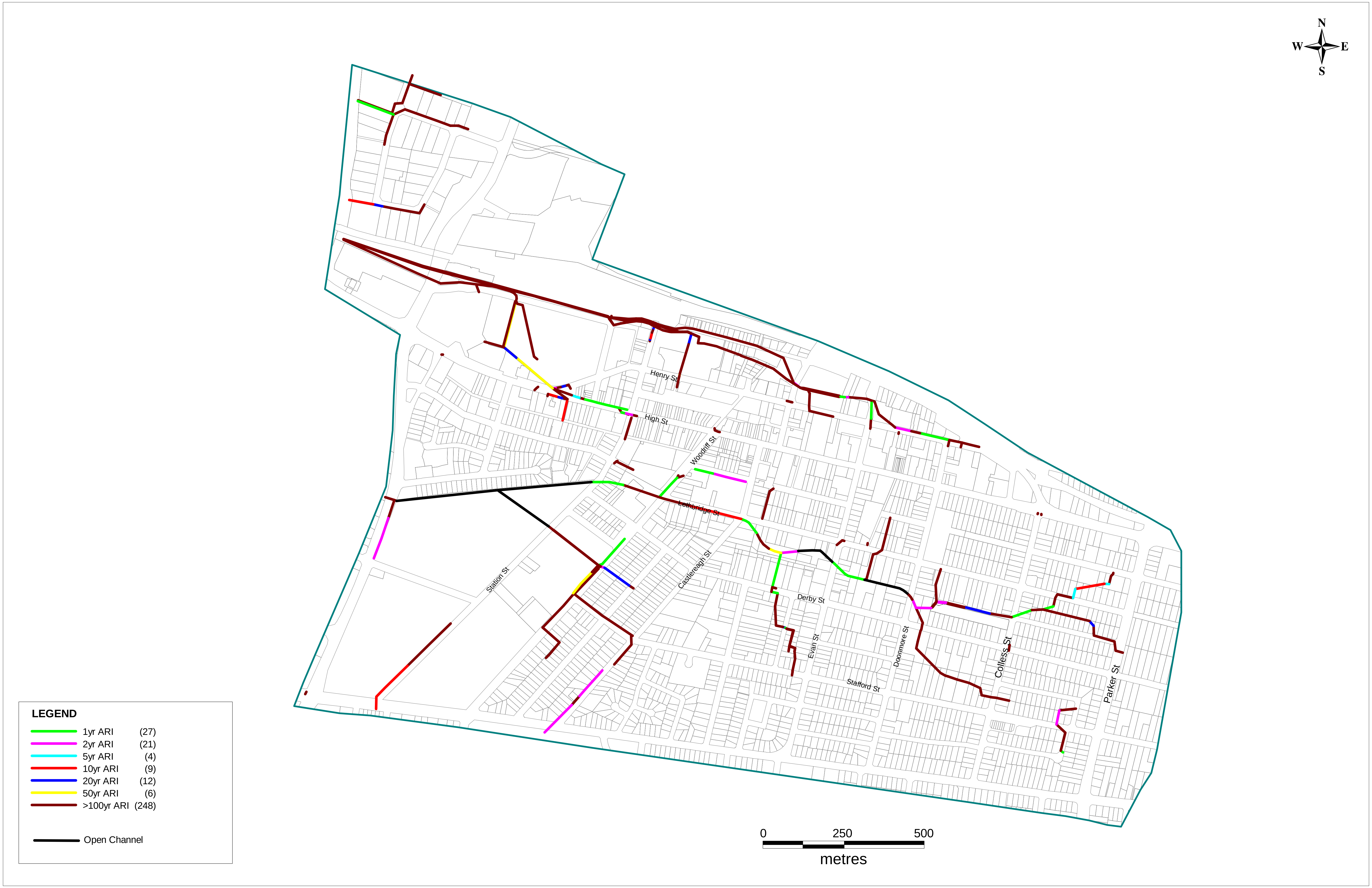
Note: numbers show reference points ID

Cardno

Penrith CBD Detailed Overland Flow Flood Study

W4735
July 2015

FIGURE 8.42
REFERENCE POINTS-ROAD ACCESS FLOODING



Cardno

W4735
June 2014

Penrith CBD Detailed Overland Flow Flood Study

FIGURE 8.43
PIPE CAPACITY ASSESSMENT
NOMINAL RETURN PERIOD (ARI)

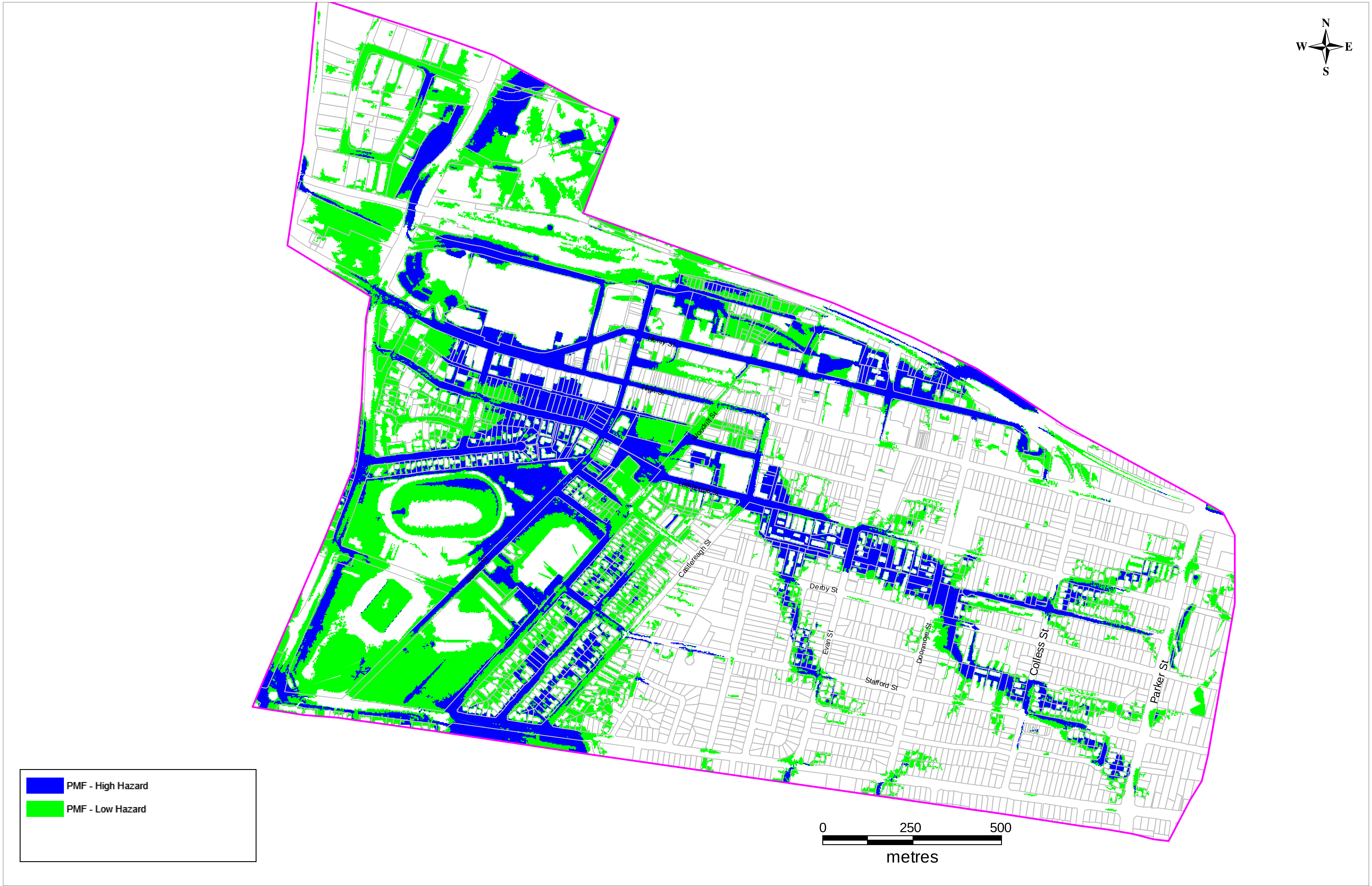


FIGURE 9.2
PROVISIONAL HAZARD- PMF

Penrith CBD Detailed Overland Flow Flood Study

Cardno

W4735
July 2015

Cardno

W4735
July 2015

Penrith CBD Detailed Overland Flow Flood Study

FIGURE 9.3
PROVISIONAL HAZARD- 200 YEAR ARI

FIGURE 9.4
PROVISIONAL HAZARD- 100 YEAR ARI

Cardno

W4735
July 2015

Penrith CBD Detailed Overland Flow Flood Study

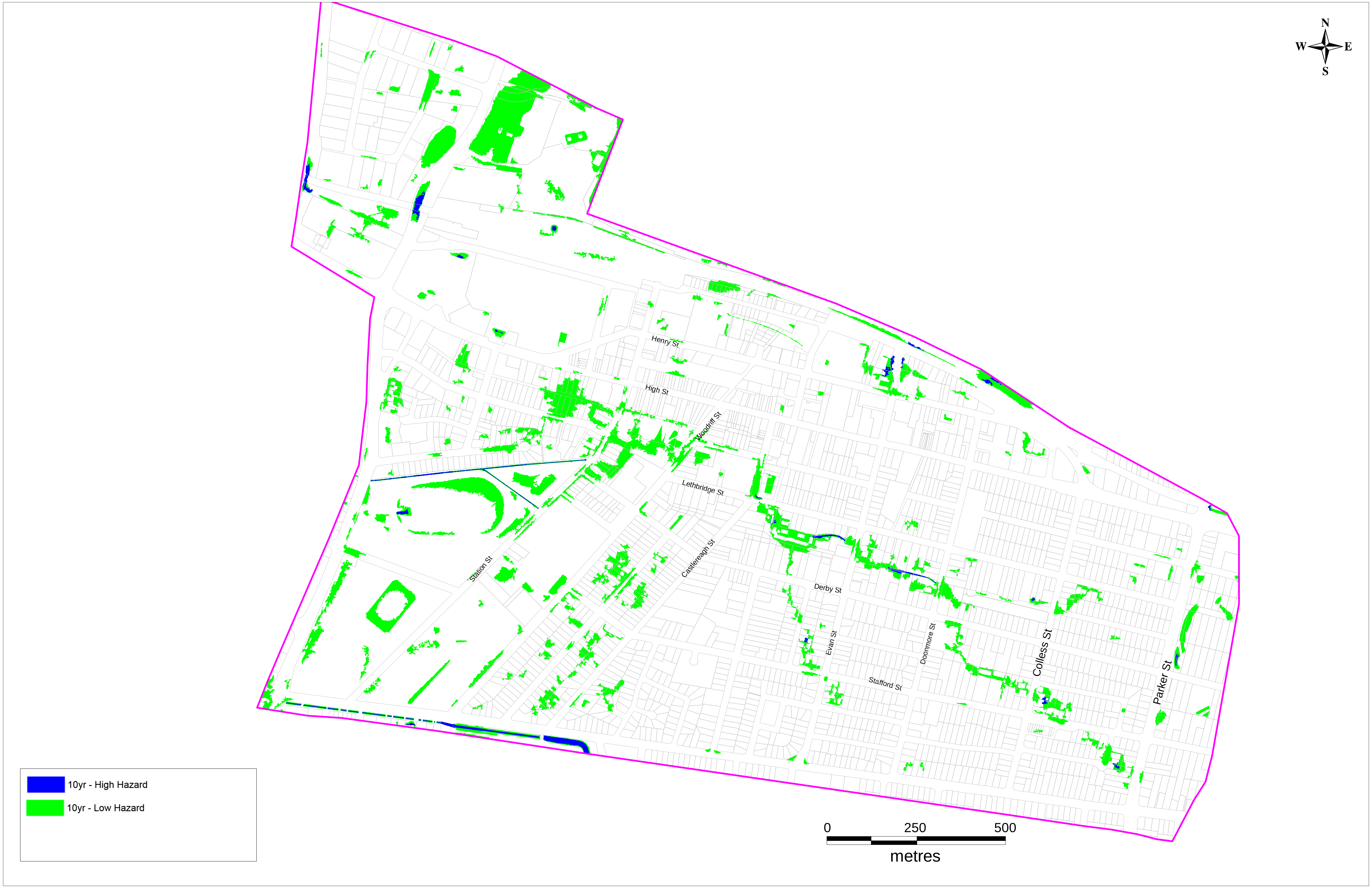
FIGURE 9.5
PROVISIONAL HAZARD- 50 YEAR ARI

Cardno

W4735
July 2015

Penrith CBD Detailed Overland Flow Flood Study

FIGURE 9.6
PROVISIONAL HAZARD- 20 YEAR ARI



Cardno

W4735
July 2015

Penrith CBD Detailed Overland Flow Flood Study

FIGURE 9.7
PROVISIONAL HAZARD- 10 YEAR ARI

Cardno

W4735
July 2015

Penrith CBD Detailed Overland Flow Flood Study

FIGURE 9.8
PROVISIONAL HAZARD- 5 YEAR ARI

FIGURE 9.9
PROVISIONAL HAZARD- 2 YEAR ARI

Cardno

Penrith CBD Detailed Overland Flow Flood Study

W4735
July 2015

Cardno

W4735
July 2015

Penrith CBD Detailed Overland Flow Flood Study

FIGURE 9.10
PROVISIONAL HAZARD- 1 YEAR ARI

Cardno

W4735
July 2015

Penrith CBD Detailed Overland Flow Flood Study

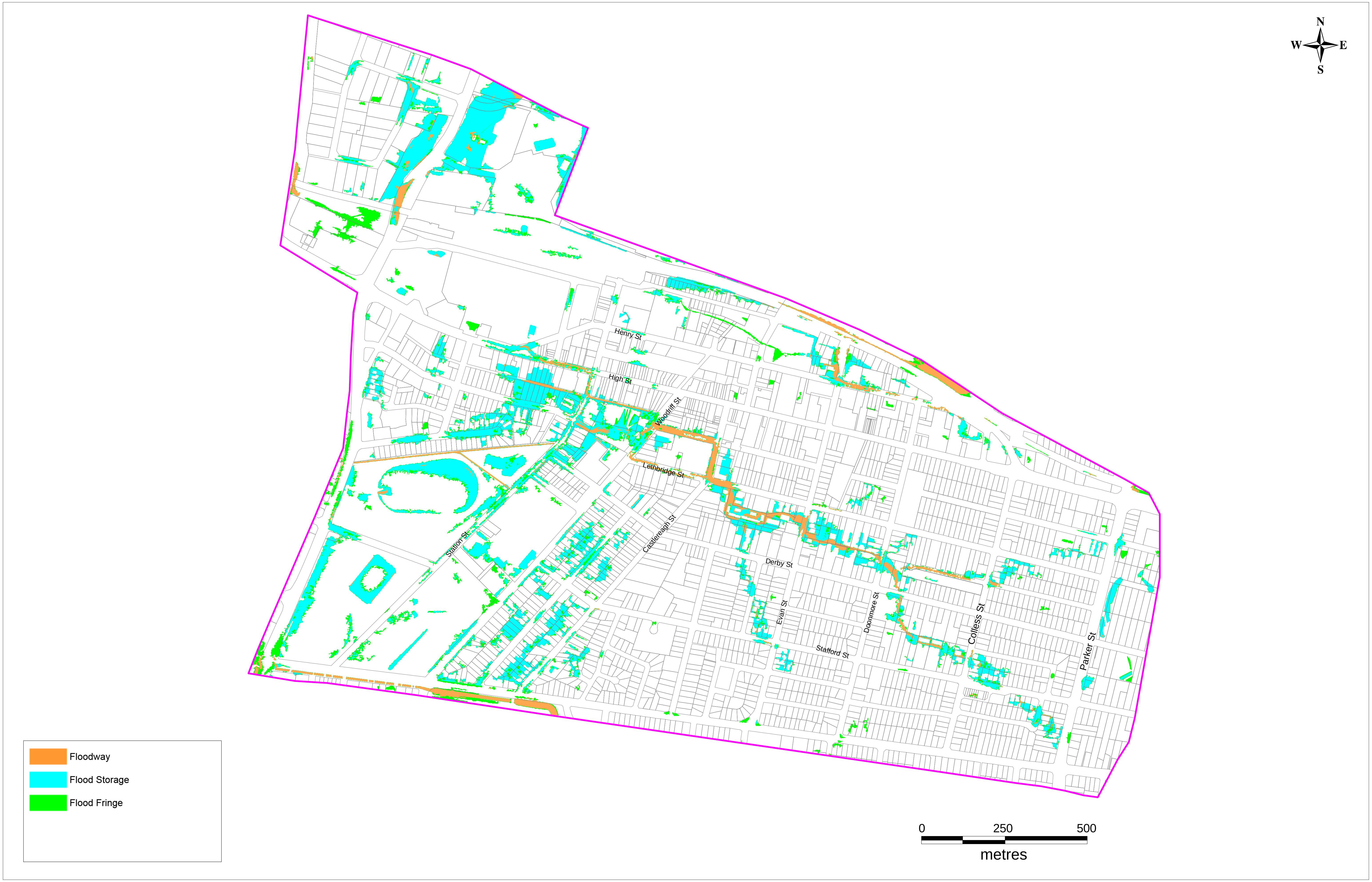
FIGURE 10.1
HYDRAULIC CATEGORIES - PMF

Cardno

W4735
July 2015

Penrith CBD Detailed Overland Flow Flood Study

FIGURE 10.2
HYDRAULIC CATEGORIES - 200 YEAR ARI



Cardno

W4735
July 2015

Penrith CBD Detailed Overland Flow Flood Study

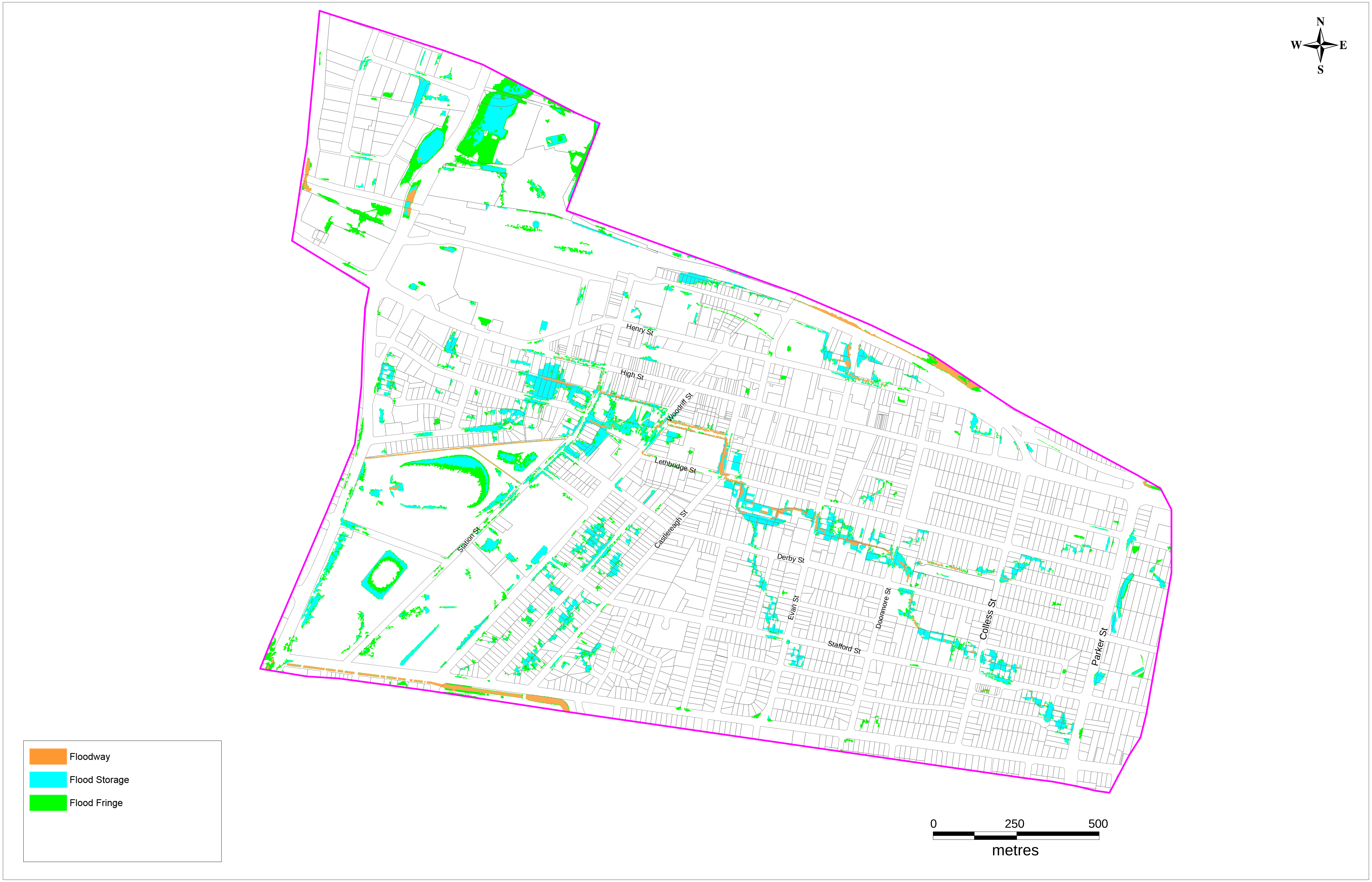
FIGURE 10.3
HYDRAULIC CATEGORIES - 100 YEAR ARI

Cardno

W4735
July 2015

Penrith CBD Detailed Overland Flow Flood Study

FIGURE 10.4
HYDRAULIC CATEGORIES - 50 YEAR ARI

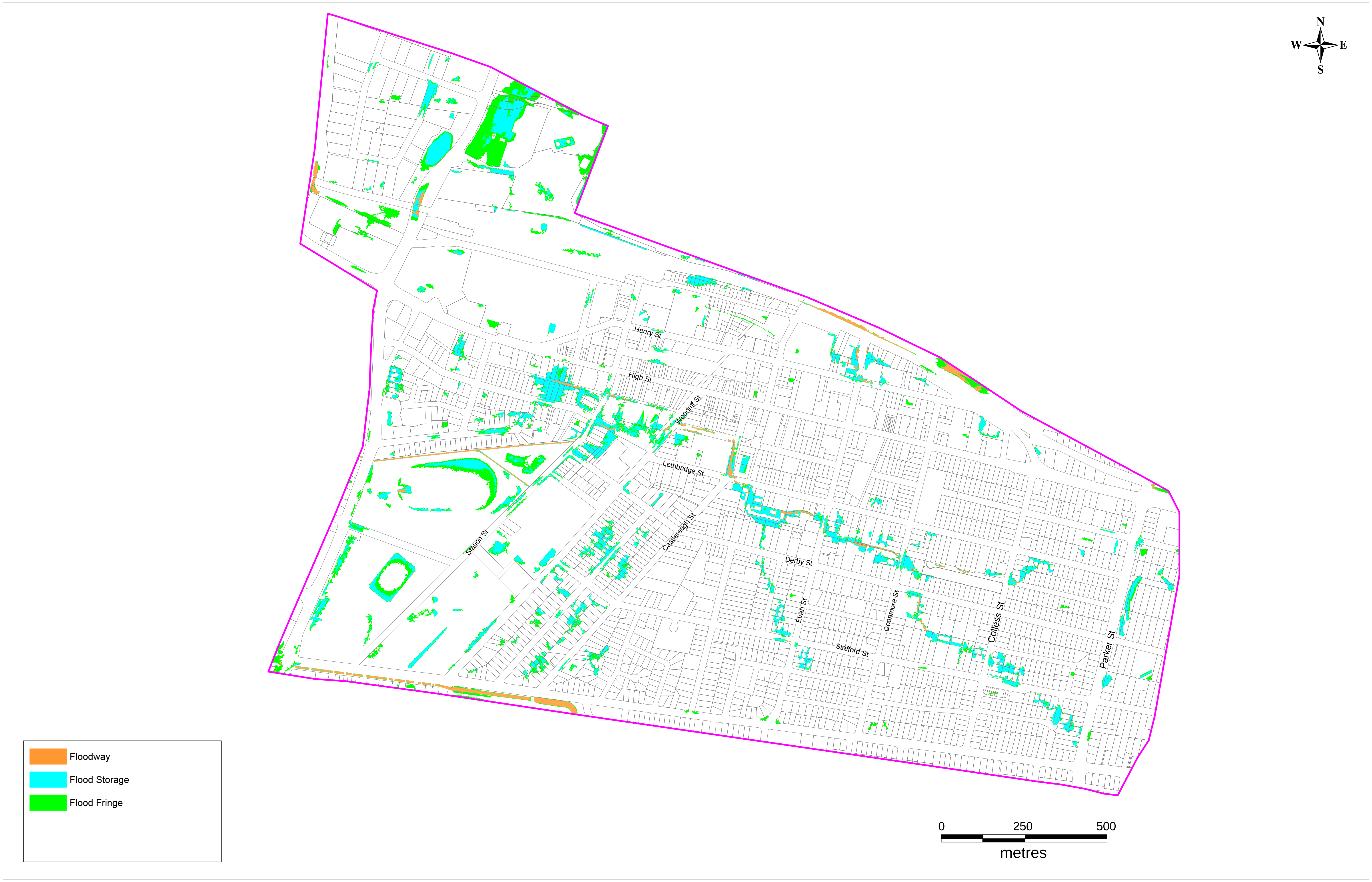


Cardno

W4735
July 2015

Penrith CBD Detailed Overland Flow Flood Study

FIGURE 10.5
HYDRAULIC CATEGORIES - 20 YEAR ARI



Cardno

W4735
July 2015

Penrith CBD Detailed Overland Flow Flood Study

FIGURE 10.6
HYDRAULIC CATEGORIES - 10 YEAR ARI

Cardno

W4735
July 2015

Penrith CBD Detailed Overland Flow Flood Study

FIGURE 10.7
HYDRAULIC CATEGORIES - 5 YEAR ARI

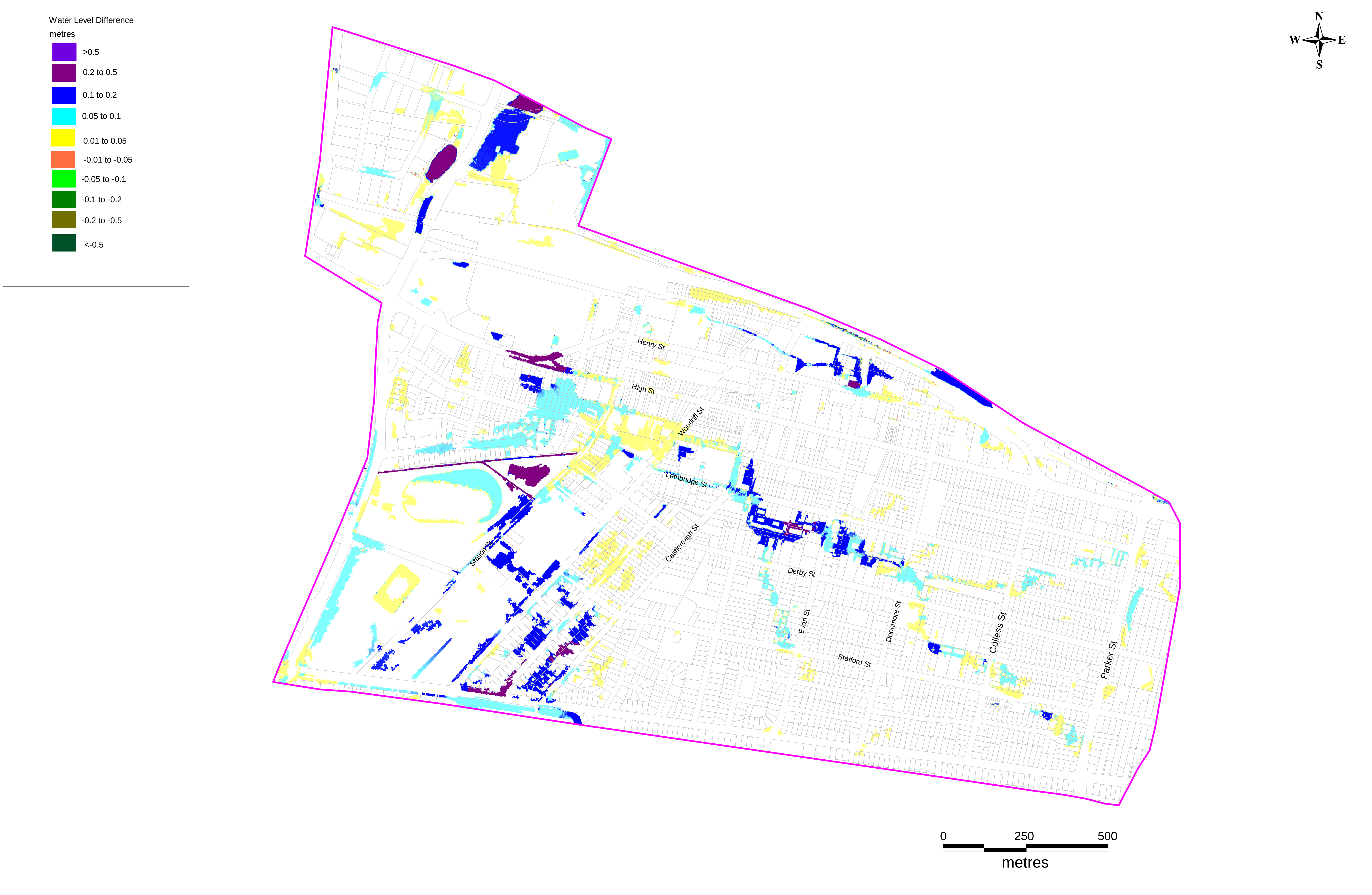
Cardno

W4735
July 2015

Penrith CBD Detailed Overland Flow Flood Study

FIGURE 10.8
HYDRAULIC CATEGORIES - 2 YEAR ARI

FIGURE 10.9
HYDRAULIC CATEGORIES - 1 YEAR ARI



Cardno

W4735
July 2015

Penrith CBD Detailed Overland Flow Flood Study

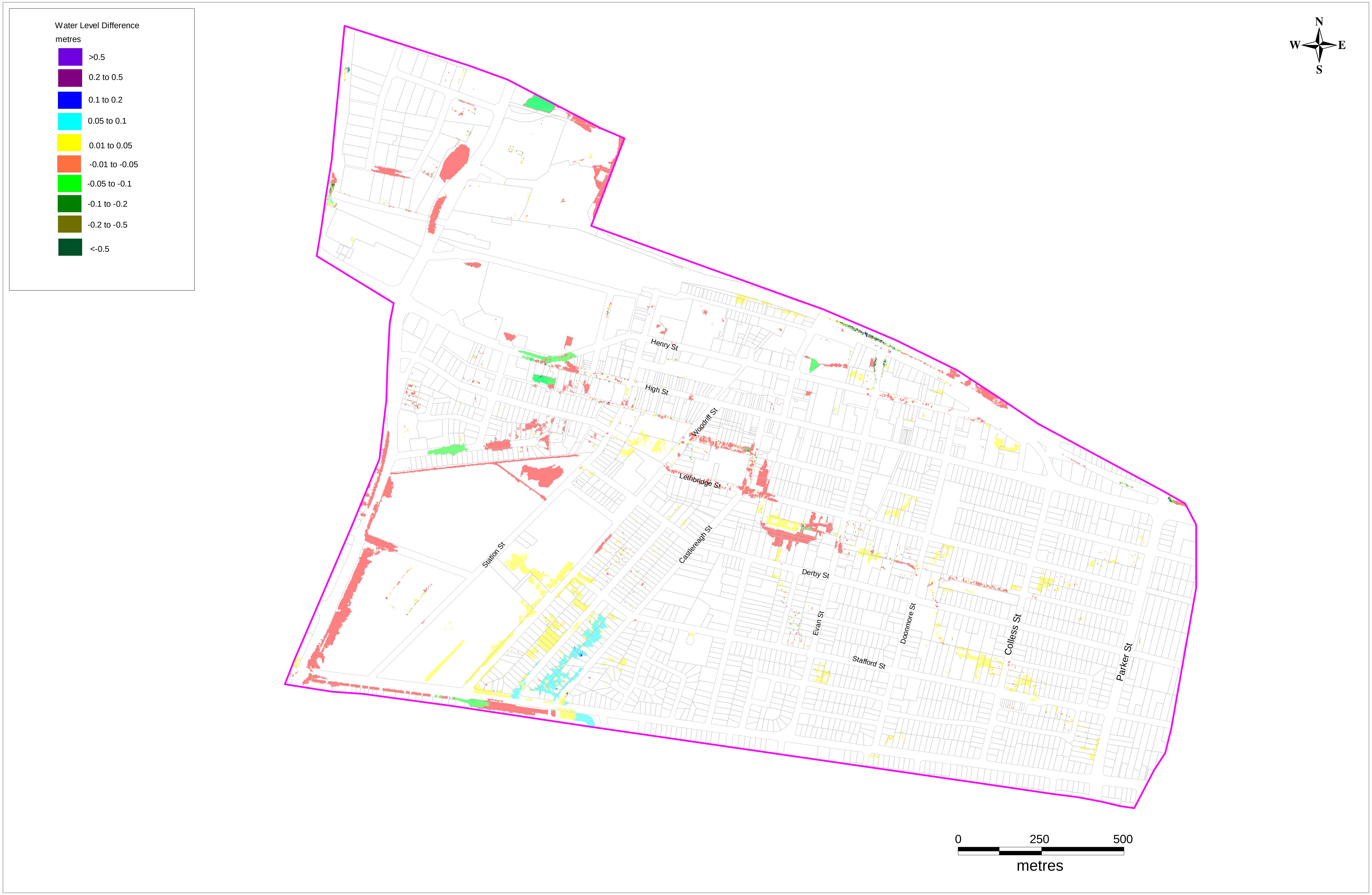
FIGURE 12.1
PEAK WATER LEVEL IMPACT - RAINFALL INCREASED BY 20%
100 YEAR ARI - 2 HOUR DURATION

FIGURE 12.2
PEAK WATER LEVEL IMPACT - RAINFALL DECREASED BY 20%
100 YEAR ARI - 2 HOUR DURATION

Penrith CBD Detailed Overland Flow Flood Study

Cardno

W4735
July 2015

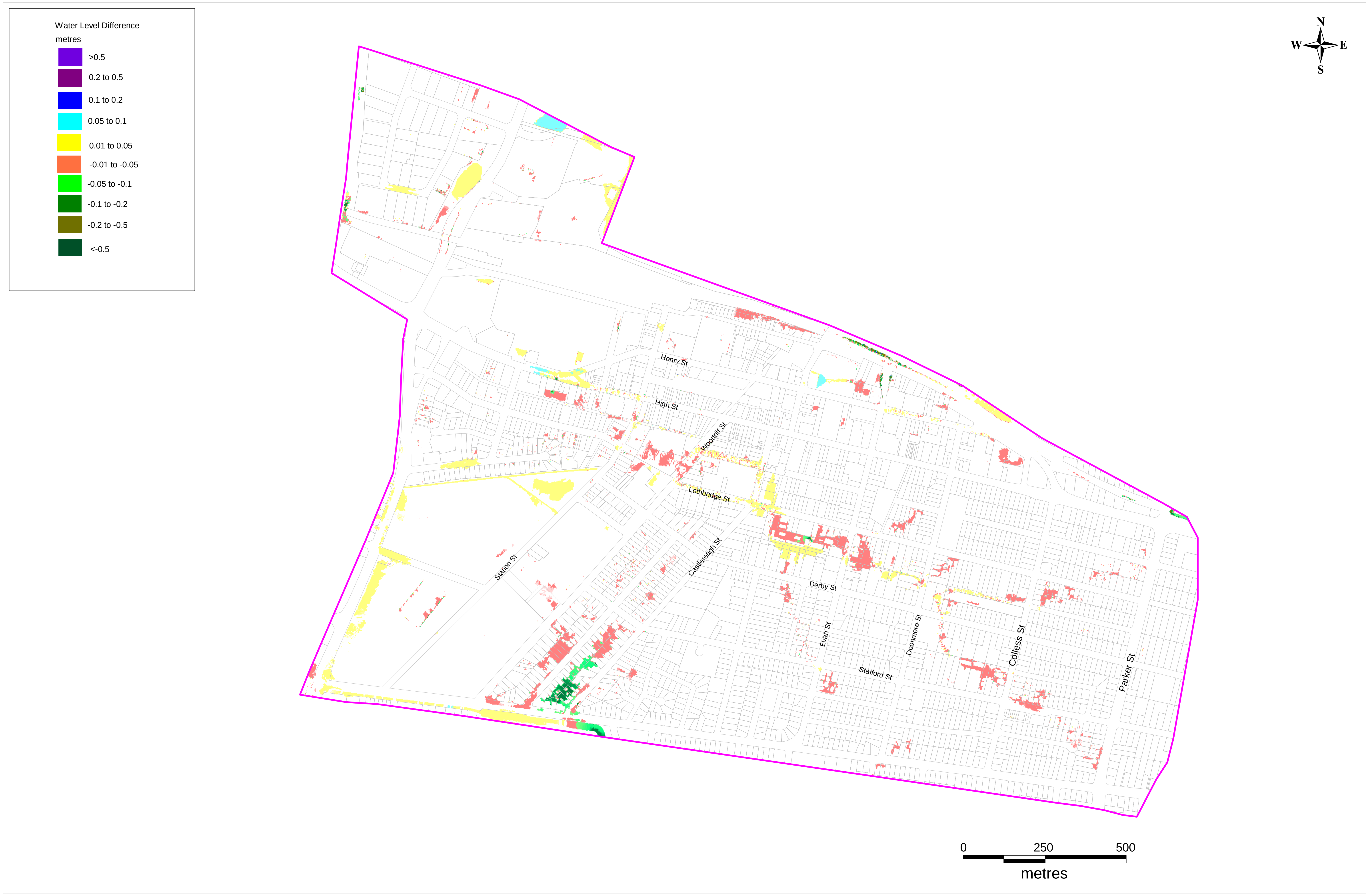


Cardno

W4735
July 2015

Penrith CBD Detailed Overland Flow Flood Study

FIGURE 12.3
PEAK WATER LEVEL IMPACT - ROUGHNESS INCREASED BY 20%
100 YEAR ARI - 2 HOUR DURATION



Cardno

W4735
July 2015

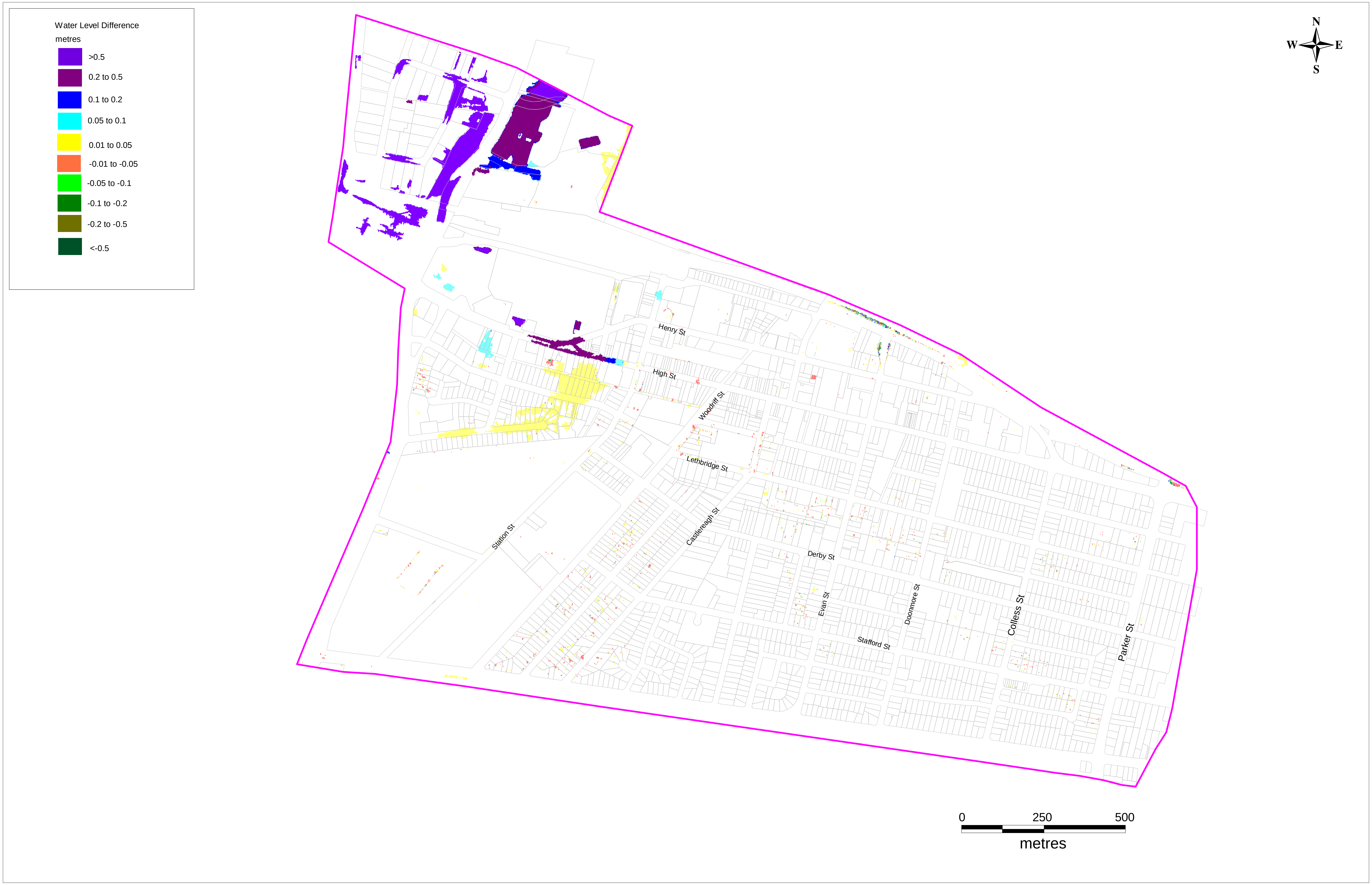
Penrith CBD Detailed Overland Flow Flood Study

FIGURE 12.4
PEAK WATER LEVEL IMPACT - ROUGHNESS DECREASED BY 20%
100 YEAR ARI - 2 HOUR DURATION

W4735
July 2015

Penrith CBD Detailed Overland Flow Flood Study

FIGURE 12.5
PEAK WATER LEVEL IMPACT - ARCADES BLOCKED
100 YEAR ARI - 2 HOUR DURATION



Cardno

W4735
July 2015

Penrith CBD Detailed Overland Flow Flood Study

FIGURE 12.6
PEAK WATER LEVEL IMPACT - DOWNSTREAM BOUNDARY
100 YEAR ARI - 2 HOUR DURATION

Cardno

W4735
July 2015

Penrith CBD Detailed Overland Flow Flood Study

FIGURE 12.7
PEAK WATER LEVEL IMPACT - NO PIT BLOCKAGE
100 YEAR ARI - 2 HOUR DURATION

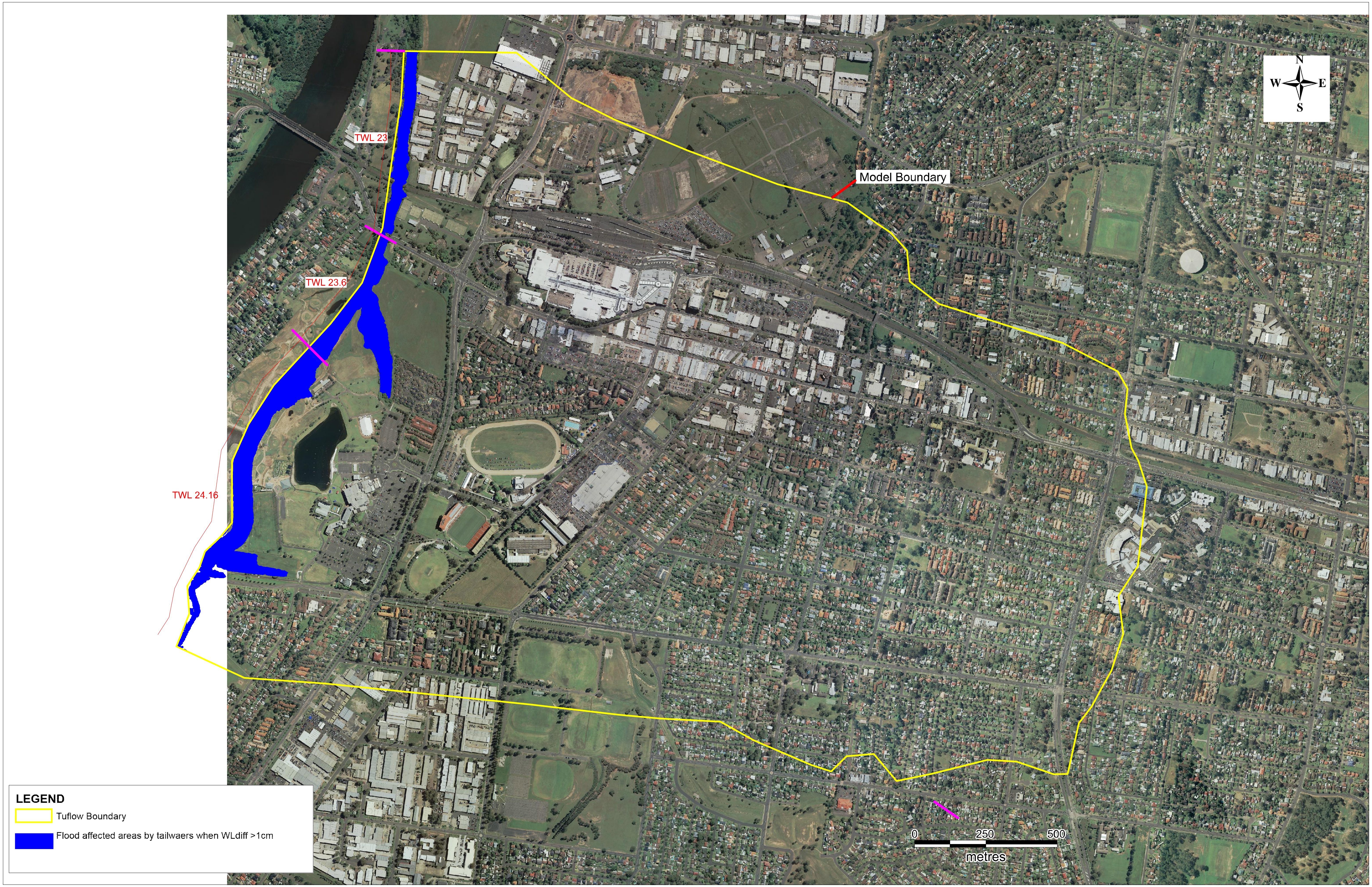


FIGURE 12.8
FLOOD AFFECTED AREAS BY 20YR ARI PEACH TREE CREEK TAILWATER CONDITIONS
100 YEA ARI (2 HOURS) LOCAL CATCHMENT FLOOD

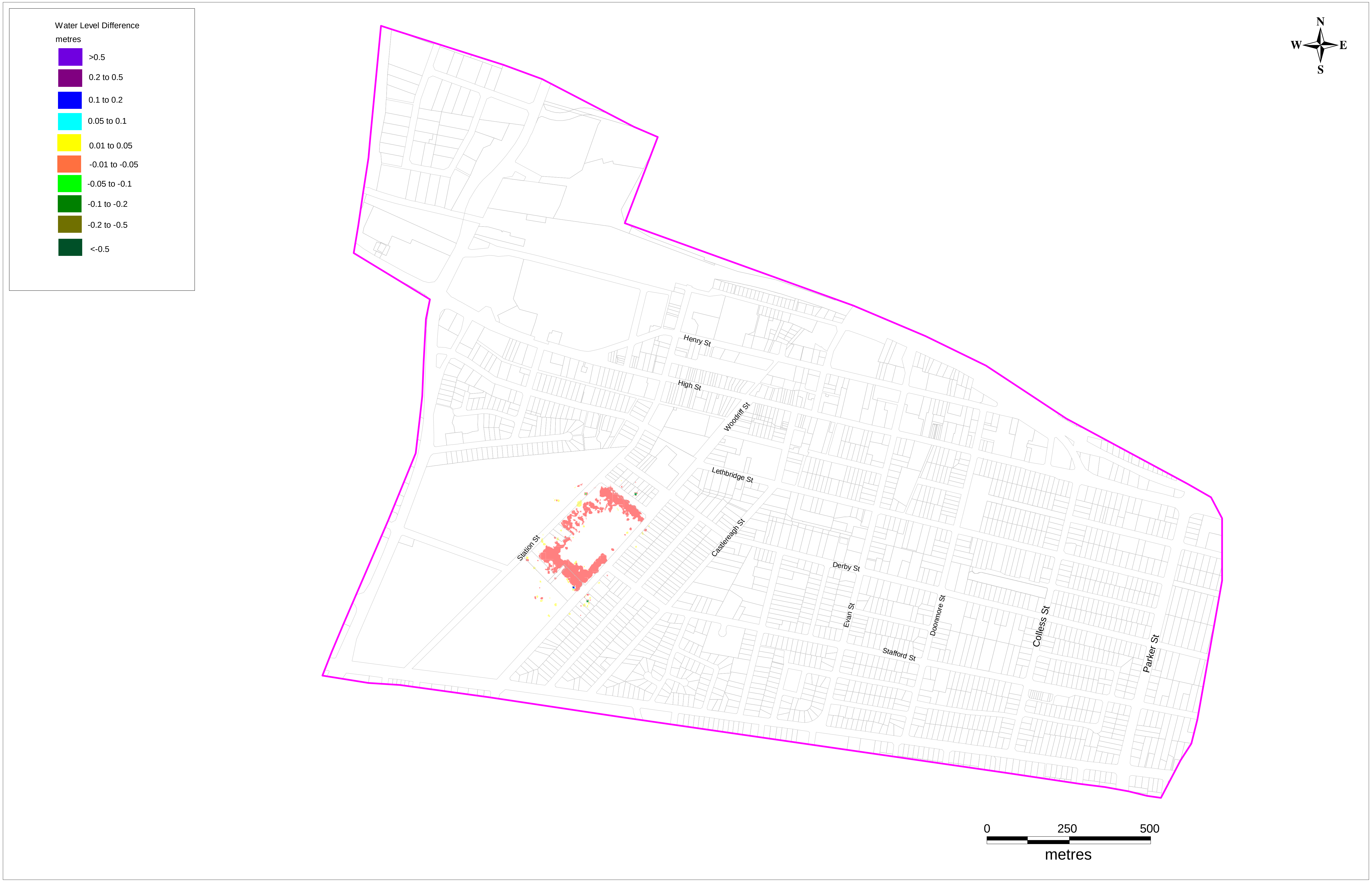
Cardno

W4735
July 2015

Penrith CBD Detailed Overland Flow Flood Study

FIGURE 12.9
FLOOD AFFECTED AREAS BY 20YR ARI PEACH TREE CREEK TAILWATER CONDITIONS
100 YEA ARI (9 HOURS) LOCAL CATCHMENT FLOOD

FIGURE 12.10
REFINED ROUGHNESS MAP FOR CARPARKS AND CONCRETE GROUND



W4735
July 2015

Penrith CBD Detailed Overland Flow Flood Study

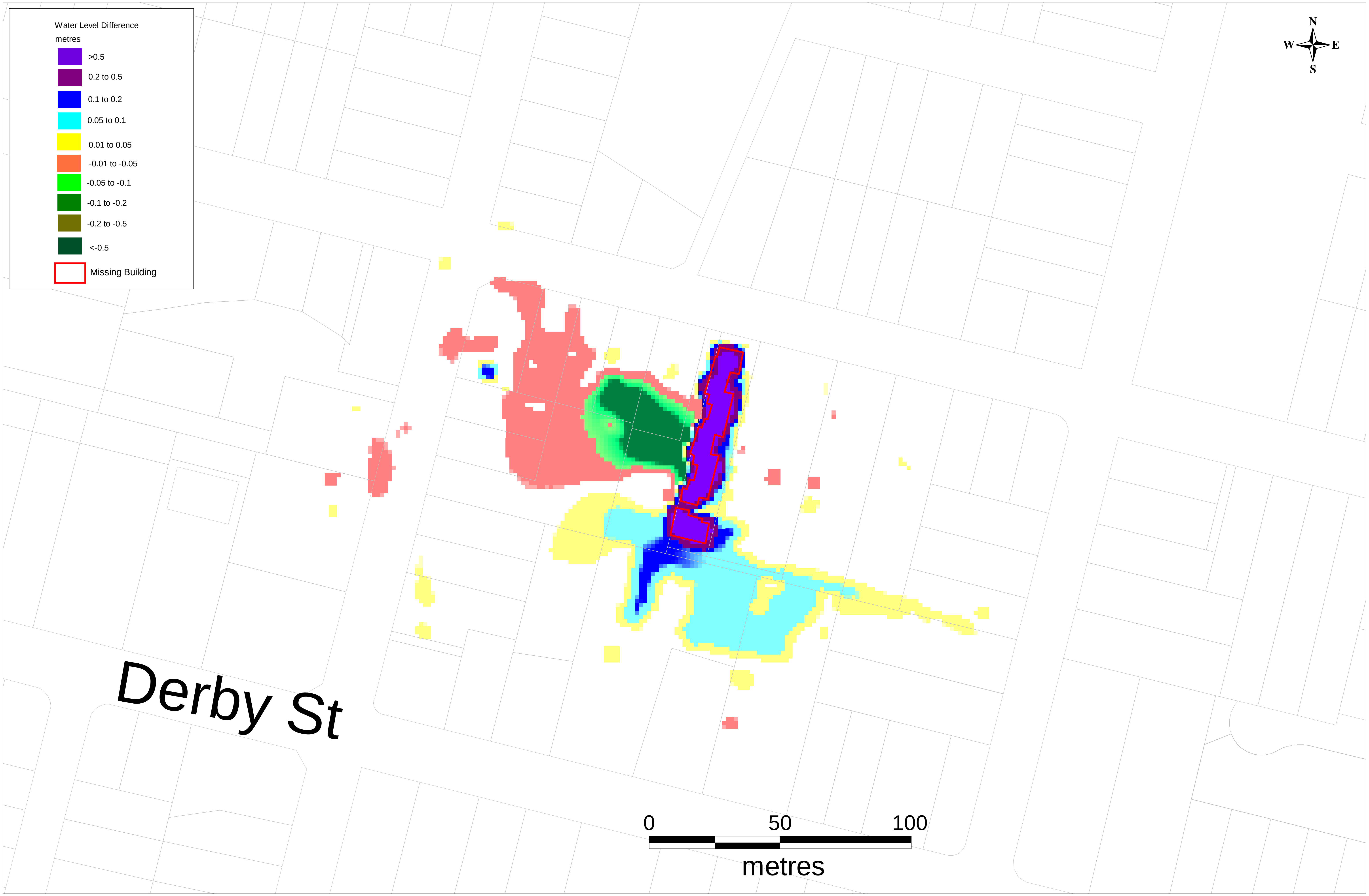
FIGURE 12.11
PEAK WATER LEVEL IMPACT - 100 YEAR ARI
CASE WITH MODIFIED ROUGHNESS AT KMART CARPARK LESS EXISTING

Cardno

W4735
July 2015

Penrith CBD Detailed Overland Flow Flood Study

FIGURE 12.12
PEAK WATER LEVEL IMPACT - 100 YEAR ARI
MODIFIED ROUGHNESS FOR ALL CARPARKS LESS EXISTING



Cardno

W4735
July 2015

Penrith CBD Detailed Overland Flow Flood Study

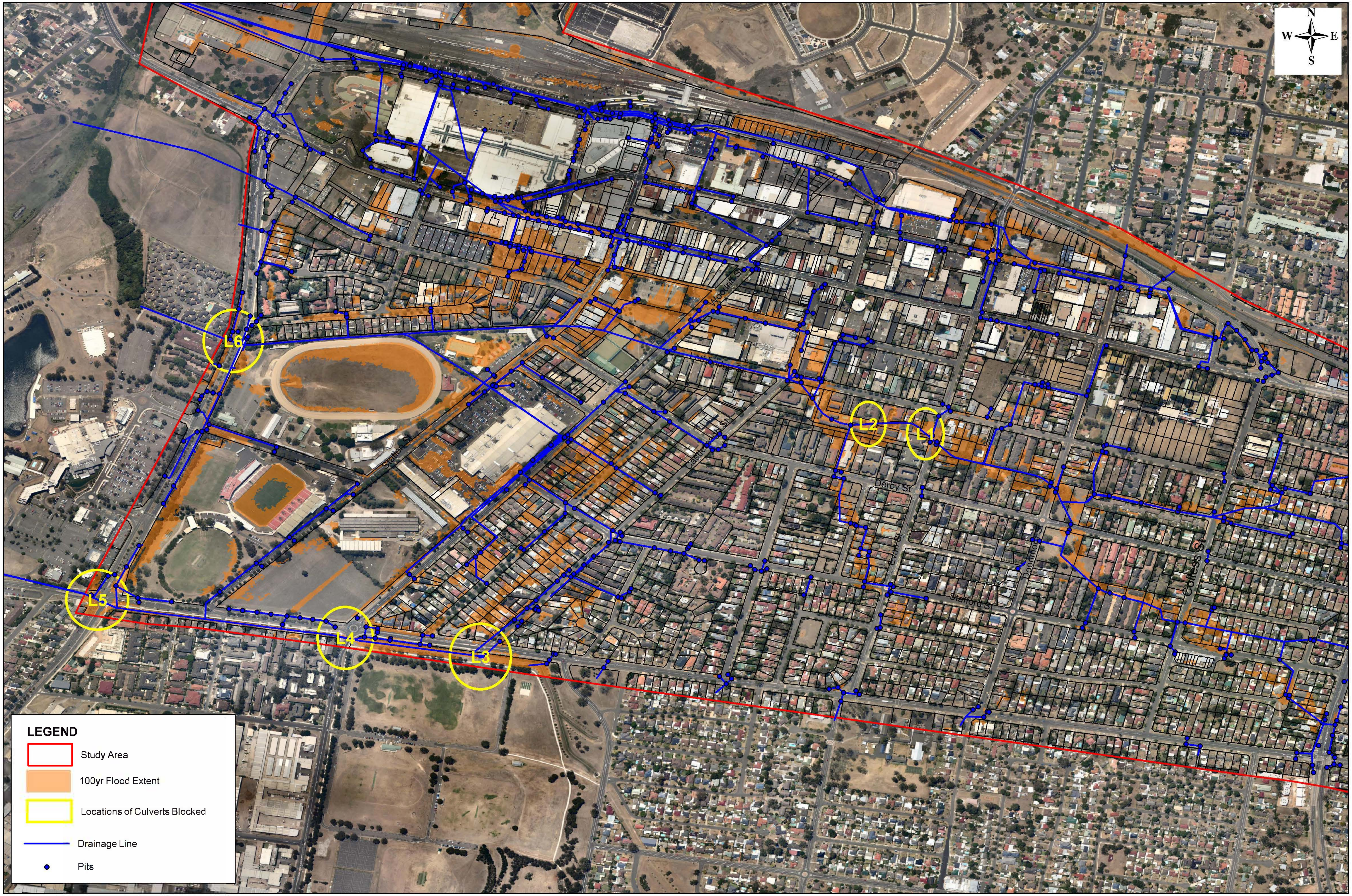
FIGURE 12.13
PEAK WATER LEVEL IMPACT - 100 YEAR ARI
CASE WITH RAISED MISSING BUILDING LESS EXIST

Cardno

W4735
July 2015

Penrith CBD Detailed Overland Flow Flood Study

FIGURE 12.14
PEAK WATER LEVEL IMPACTS - 100 YEAR ARI
ROOF ROUGHNESS (0.02) -LESS-EXISTING

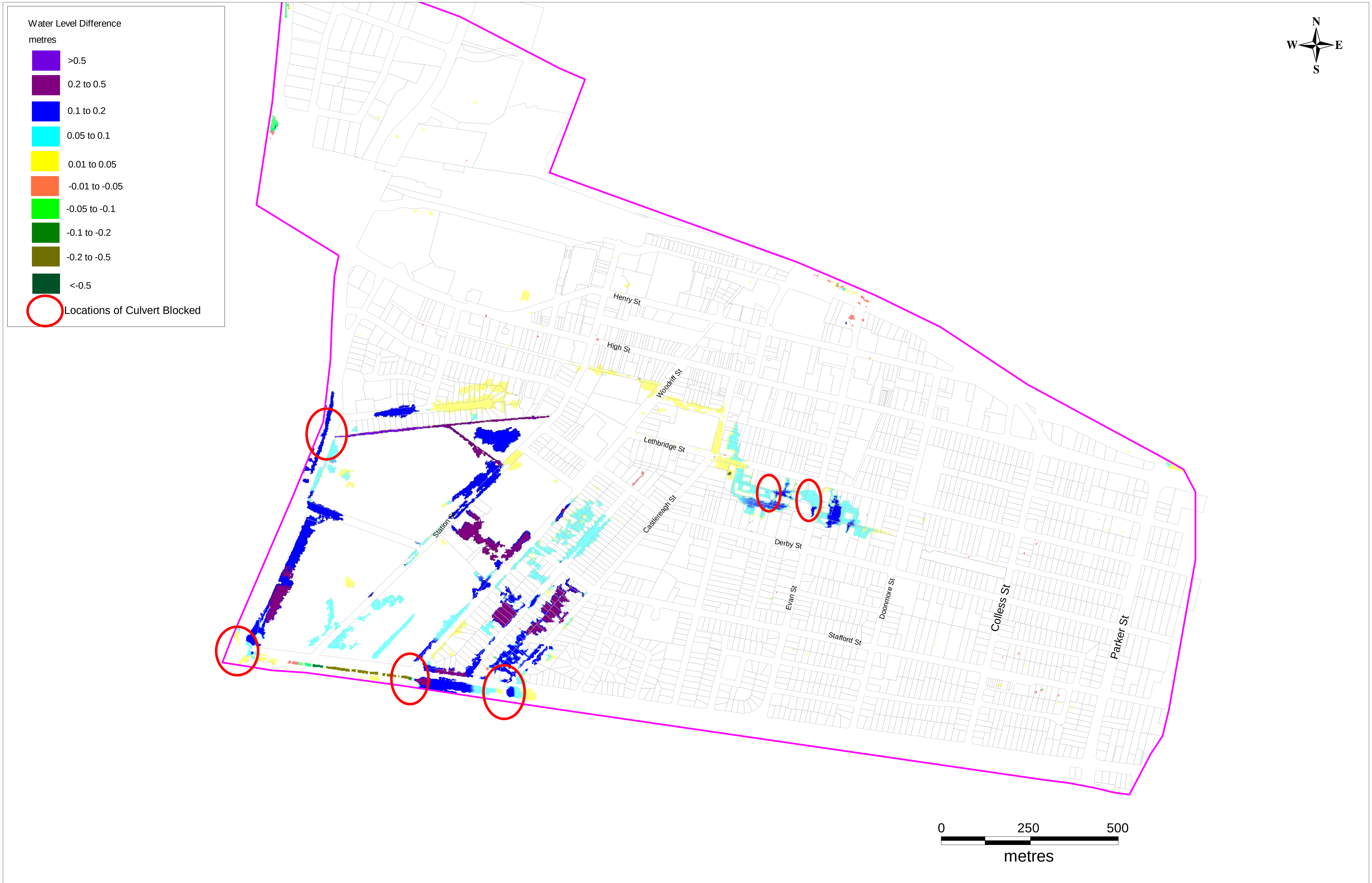


Cardno

W4735
July 2015

Penrith CBD Detailed Overland Flow Flood Study

FIGURE 12.15
LOCATIONS OF MAJOR CULVERTS BLOCKED

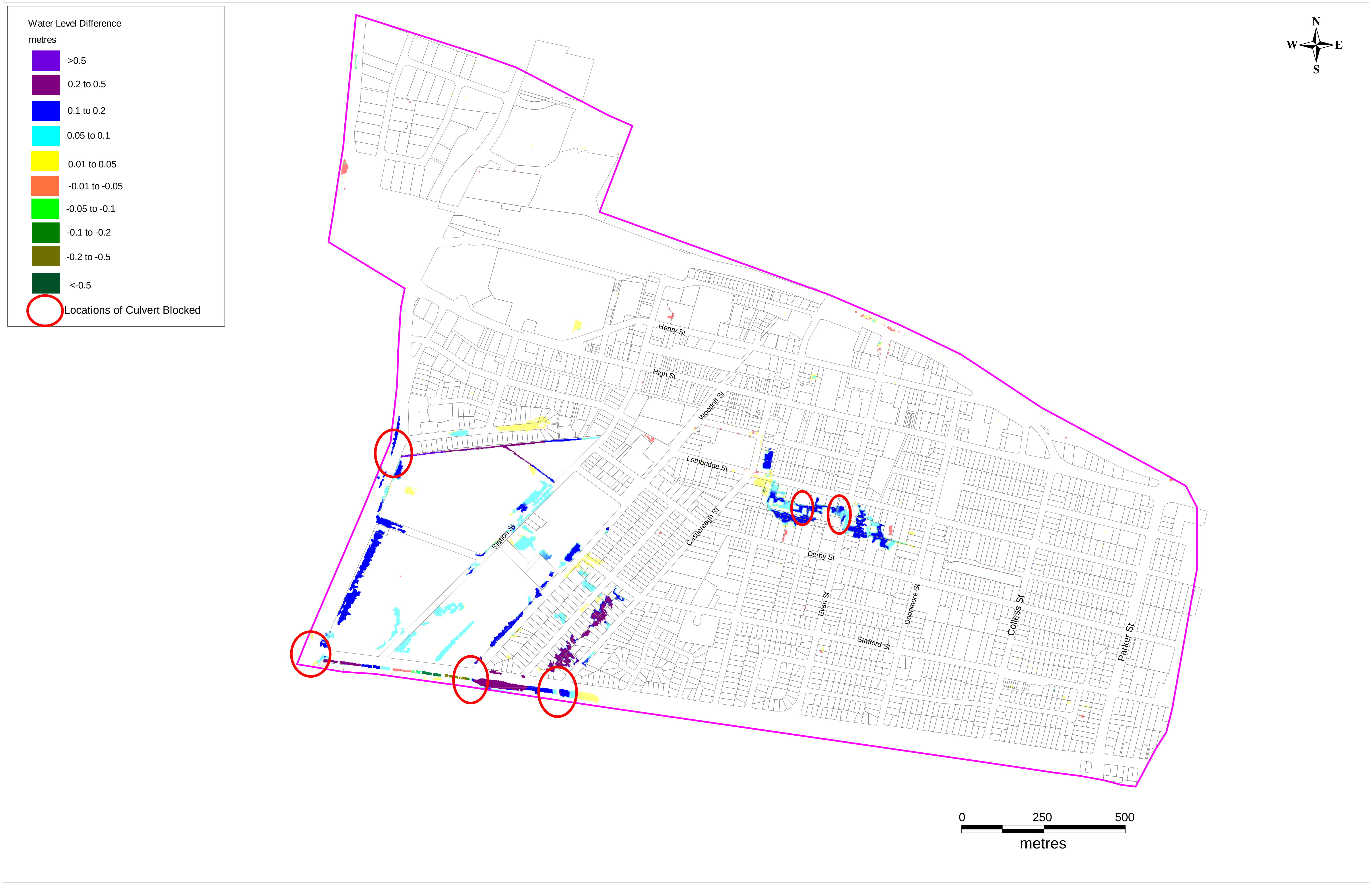


Cardno

W4735
July 2015

Penrith CBD Detailed Overland Flow Flood Study

FIGURE 12.16
PEAK WATER LEVEL IMPACTS - 100 YEAR ARI
MAJOR CULVERTS BLOCKED -LESS-EXISTING



Cardno

W4735
July 2015

Penrith CBD Detailed Overland Flow Flood Study

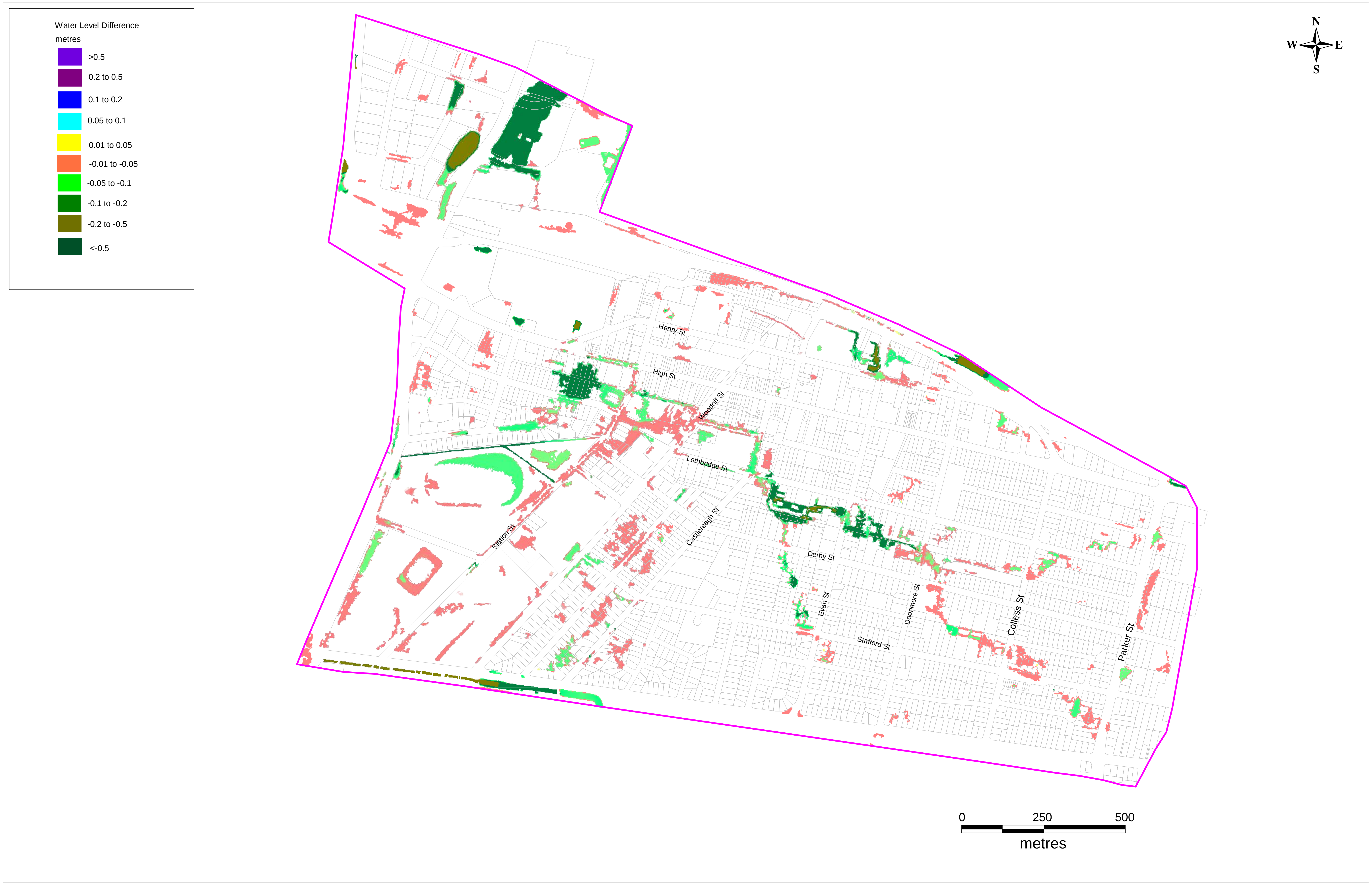
FIGURE 12.17
PEAK WATER LEVEL IMPACTS - 20 YEAR ARI
MAJOR CULVERTS BLOCKED -LESS-EXISTING

Cardno

W4735
July 2015

Penrith CBD Detailed Overland Flow Flood Study

FIGURE 12.18
PEAK WATER LEVEL IMPACTS - 20 YEAR ARI
RAINFALL INCREASED BY 20% -LESS-EXISTING

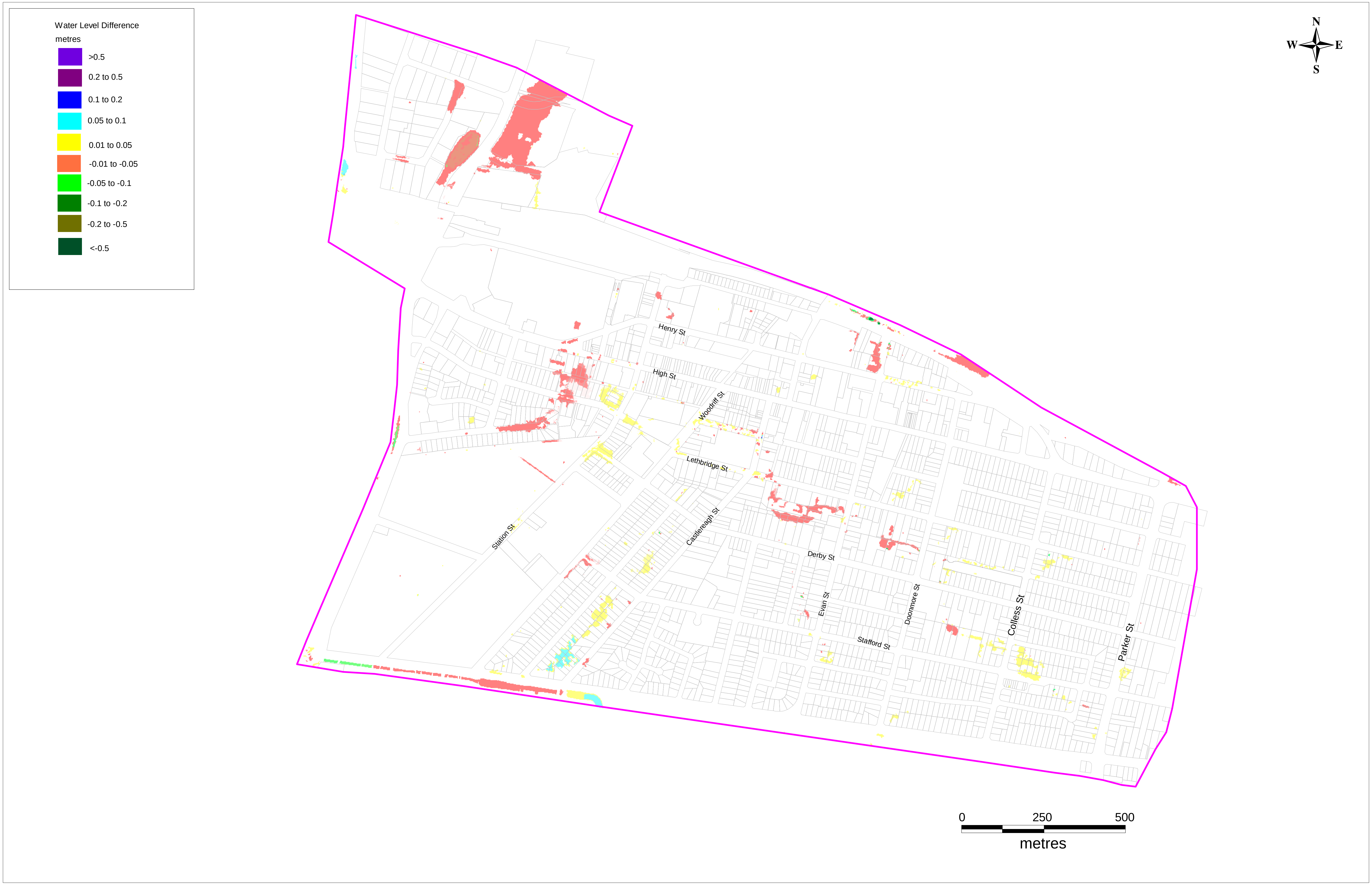


Cardno

W4735
July 2015

Penrith CBD Detailed Overland Flow Flood Study

FIGURE 12.19
PEAK WATER LEVEL IMPACTS - 20 YEAR ARI
RAINFALL DECREASED BY 20% -LESS-EXISTING

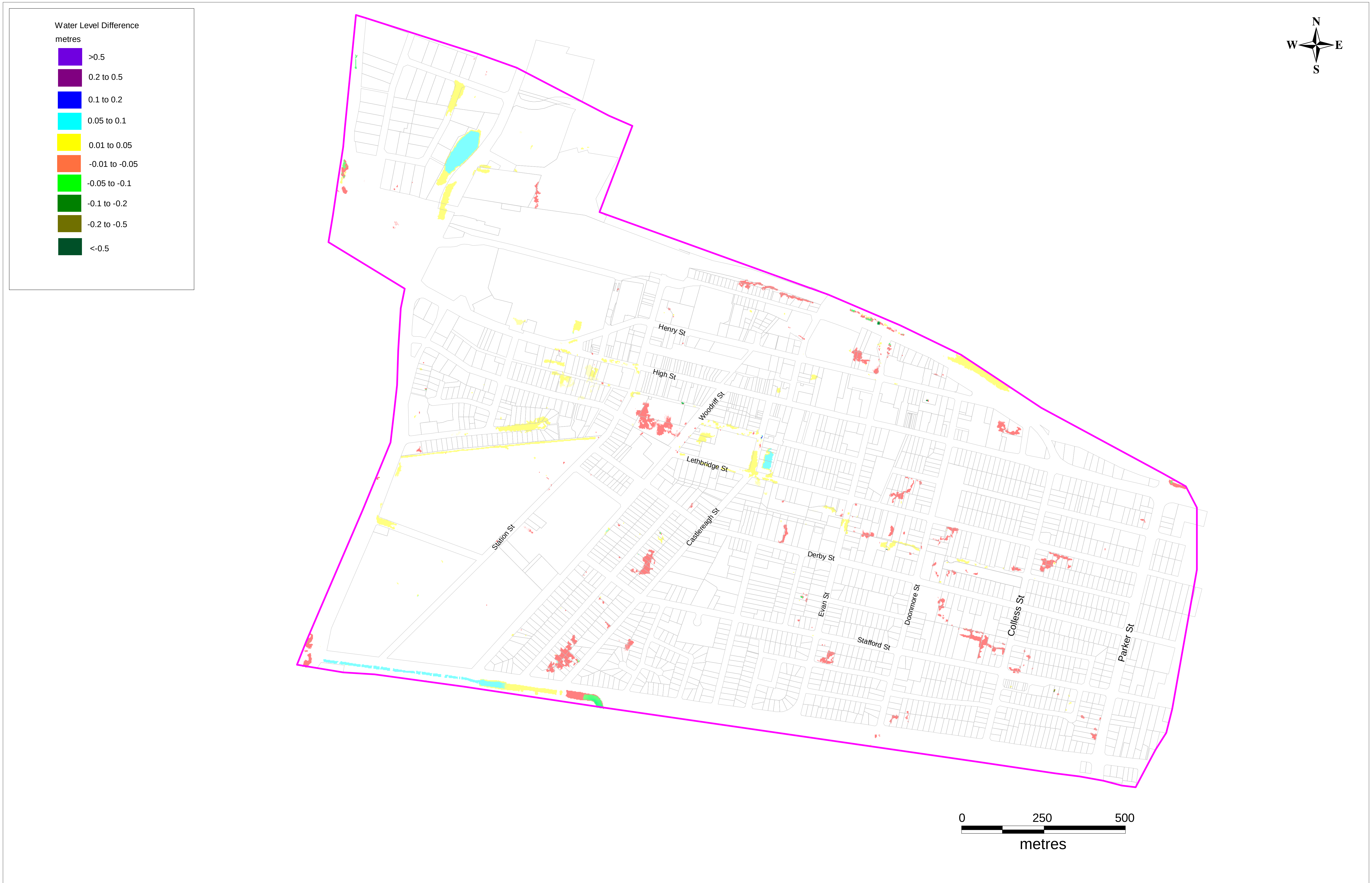


Cardno

W4735
July 2015

Penrith CBD Detailed Overland Flow Flood Study

FIGURE 12.20
PEAK WATER LEVEL IMPACTS - 20 YEAR ARI
ROUGHNESS IECREASED BY 20% -LESS-EXISTING

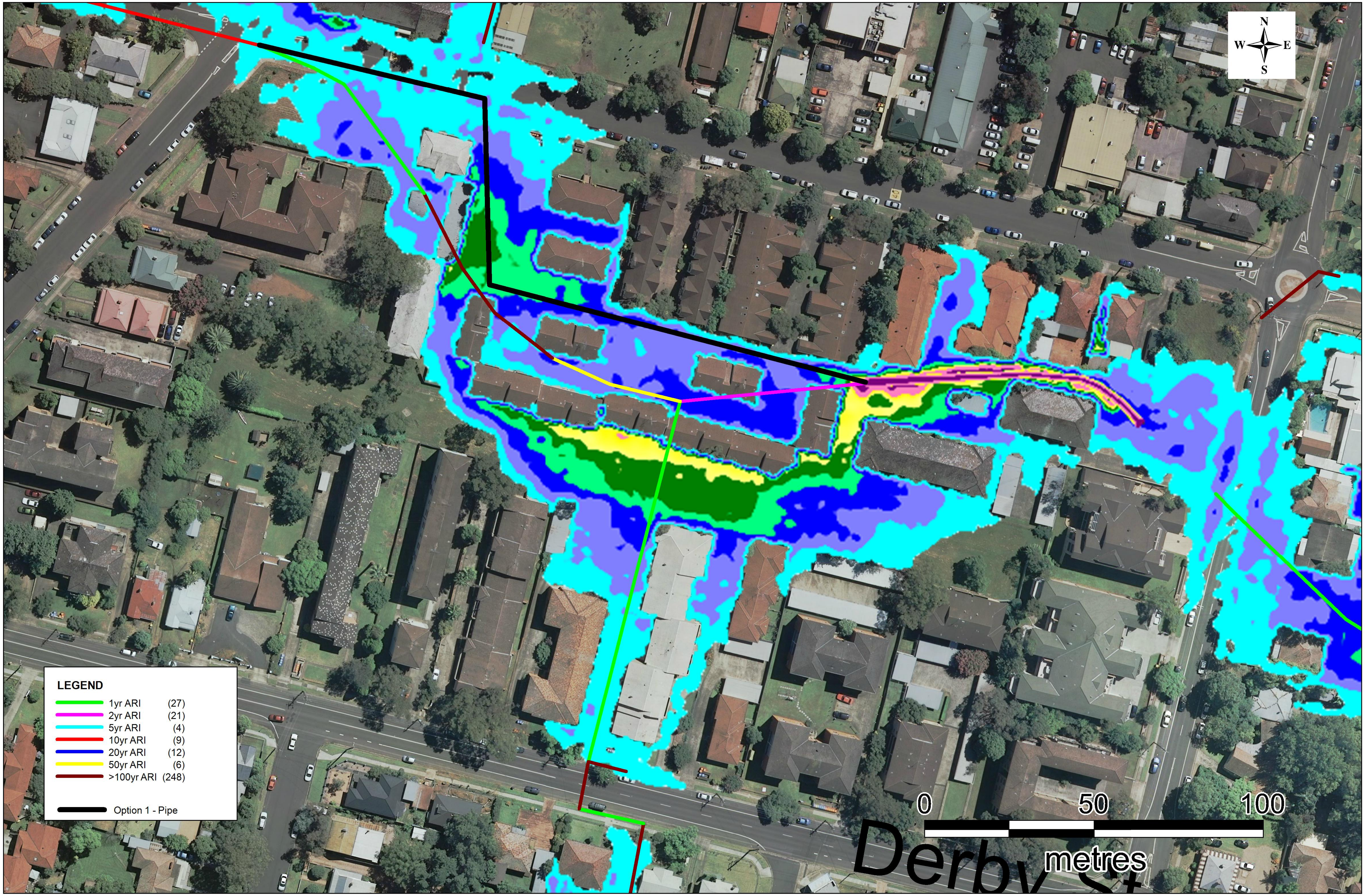


Cardno

W4735
July 2014

Penrith CBD Detailed Overland Flow Flood Study

FIGURE 12.21
PEAK WATER LEVEL IMPACTS - 20 YEAR ARI
ROUGHNESS DECREASED BY 20% -LESS-EXISTING

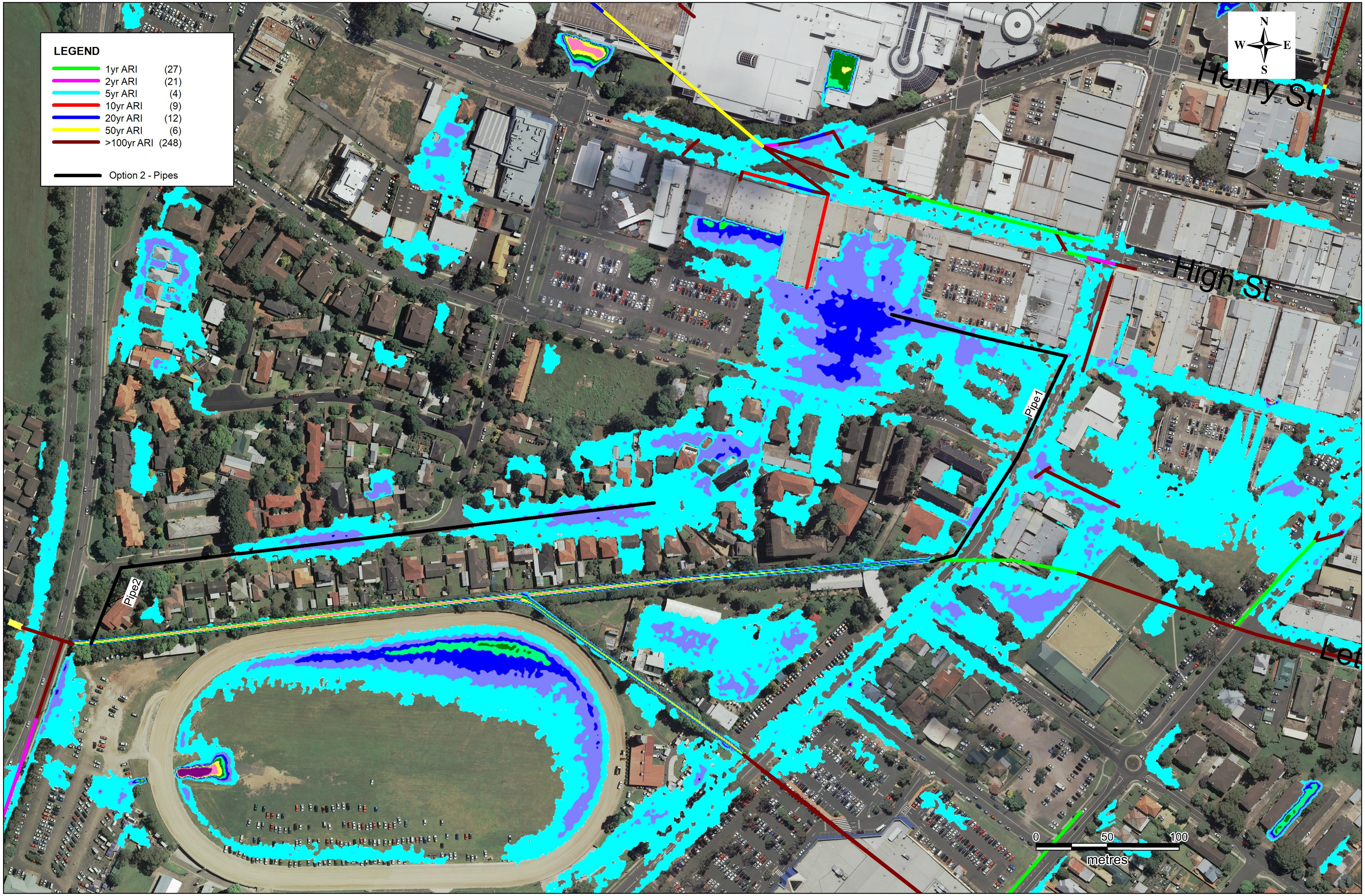


Cardno

W4735
July 2015

Penrith CBD Detailed Overland Flow Flood Study

FIGURE 13.1
FLOOD MITIGATION OPTION 1



Cardno

Penrith CBD Detailed Overland Flow Flood Study

FIGURE 13.2
FLOOD MITIGATION OPTION 2

W4735
July 2015

Appendix A

Consultation Materials

PENRITH OVERLAND FLOW FLOOD STUDY: COMMUNITY QUESTIONNAIRE

Penrith City Council has engaged Consultants Cardno Lawson Treloar to undertake a Detailed Overland Flow Flood Study to identify areas that are at risk of flooding during heavy rainfall. You have received this questionnaire because you live within the study area that may have experienced flooding.

By understanding the extent of the flooding risks, Council can develop strategies to reduce the future occurrence of flooding and minimise the costs and damages incurred by the community.

The study involves sophisticated computer modelling, which is fine tuned by correlating it with historical flood records. Although Council has access to some such records, the recollections of members of the community who have seen or experienced flooding can be valuable for this purpose.

Please consider setting aside around ten minutes to complete the questionnaire below, either on this form and return in the enclosed "reply paid" envelope, or by entering Council's website **http://www.penrithcity.nsw.gov.au/index.asp?id=4916**

YOUR PERSONAL INFORMATION WILL REMAIN COMPLETELY CONFIDENTIAL AND WILL ONLY BE USED IF WE NEED TO CONTACT YOU TO FURTHER CLARIFY THE DETAILS YOU HAVE PROVIDED.

If you have any queries related to this questionnaire, please contact:

Ratnam Thilliyar – PENRITH CITY COUNCIL Ph: **4732 7777**,

Question 1
Can you please provide us with the following details? We may wish to contact you to discuss some of the information that you provide in this questionnaire.

Name: ……………………………………………………………… Daytime Ph: ……………………………………………………

Address: …………………………………………………………… Email: ……………………………………………………………

……………………………………………………………………

Question 2
How long have you lived, worked, or shopped in this locality?

…………Months …………Years

Question 3
How aware are you of stormwater flooding from streets or channels in the catchment? (*Please tick one*)

…………… Aware
…………… Some knowledge
…………… Not aware

Question 4
Has your property been flooded because of floodwater/stormwater from streets or channels in this locality?

YES ………… NO …………

If YES, where was your property flooded, and when did it occur? (*You may tick more than one*)

	Location	Dates/ Times/ Description
☐	Driveway	……………………………………………………………………………………
☐	Backyard	……………………………………………………………………………………
☐	Front yard	……………………………………………………………………………………
☐	Shed	……………………………………………………………………………………
☐	Garage	……………………………………………………………………………………
☐	Building (below floor level)	……………………………………………………………………………………
☐	Building (above floor level)	……………………………………………………………………………………
☐	Other (please specify) …………………………………………………………………………………… ……………………………………………………………………………………………………	

PENRITH CITY COUNCIL Serving Our Community · SES STATE EMERGENCY SERVICE · Department of Environment & Climate Change NSW · Cardno Lawson Treloar

Question 5

If you have experienced flooding, what other areas have you seen flooded? (*You may tick more than one)*

	Location	Location/Address	Description (incl. Date/Time if known)
☐	Residential	…………………………………… …………………………………… ……………………………………	…………………………………………… …………………………………………… ……………………………………………
☐	Commercial	…………………………………… …………………………………… ……………………………………	…………………………………………… …………………………………………… ……………………………………………
☐	Parks	…………………………………… …………………………………… ……………………………………	…………………………………………… …………………………………………… ……………………………………………
☐	Roads and paths	…………………………………… …………………………………… ……………………………………	…………………………………………… …………………………………………… ……………………………………………
☐	Other (*please specify*)	…………………………………… …………………………………… ……………………………………	…………………………………………… …………………………………………… ……………………………………………

Question 6

Do you have any evidence of past flood events (eg photos, video footage, watermarks on walls or posts)?

YES ………... NO ………...

If YES, please give as much detail as possible:

………………………………………………………………………………………………………

………………………………………………………………………………………………………

………………………………………………………………………………………………………

………………………………………………………………………………………………………

………………………………………………………………………………………………………

………………………………………………………………………………………………………

………………………………………………………………………………………………………

………………………………………………………………………………………………………

………………………………………………………………………………………………………

………………………………………………………………………………………………………

………………………………………………………………………………………………………

………………………………………………………………………………………………………

Question 7

If you have any other information that would help facilitate the Penrith Overland Flow Flood Study including any ideas on potential solutions to the flooding problem, please provide it in the space below:

………………………………………………………………………………………………………

………………………………………………………………………………………………………

………………………………………………………………………………………………………

………………………………………………………………………………………………………

………………………………………………………………………………………………………

………………………………………………………………………………………………………

………………………………………………………………………………………………………

Thankyou for providing this information. Please remember to place all pages in the reply paid envelope and send to Council by Monday 21st April 2008. A representative from Council or the Consultant Cardno Lawson Treloar may contact you in the near future to discuss your response.

Council will keep any persons who respond to the questionnaire included in future mail outs that are related to the project.

PENRITH CITY COUNCIL Serving Our Community | SES STATE EMERGENCY SERVICE | Department of Environment & Climate Change NSW | Cardno Lawson Treloar

Appendix B

Stage-Storage Relationship

APPENDIX B

Stage - Storage Relationship for the Detention Basins

Basin 0	
Reference Level (m AHD)	Volume (m3)
43.8	0.00
43.9	0.0
44	0.0
44.1	0.2
44.2	9.6
44.3	81.3
44.4	255.3
44.5	493.2
44.6	772.8
44.7	1082.5
44.8	1416.8
44.9	1772.9
45	2149.9
45.1	2542.4
45.2	2945.8
45.3	3358.2
45.4	3774.6
45.5	4191.8
45.6	4608.9
45.7	5026.1
45.8	5443.2
45.9	5860.4
46	6277.5

Basin 1	
Reference Level (m AHD)	Volume (m3)
43.1	0.0
43.2	0.0
43.3	0.6
43.4	6.4
43.5	34.8
43.6	101.7
43.7	219.5
43.8	384.0
43.9	589.7
44	831.7
44.1	1108.5
44.2	1413.6
44.3	1737.0
44.4	2067.3
44.5	2400.9
44.6	2736.0
44.7	3071.2
44.8	3406.4
44.9	3741.6
45	4076.7

Basin 2	
Reference Level (m AHD)	Volume (m3)
42.4	0.0
42.5	0.0
42.6	1.3
42.7	12.8
42.8	46.4
42.9	120.9
43	250.5
43.1	434.2
43.2	655.7
43.3	902.4
43.4	1169.6
43.5	1457.2
43.6	1764.7
43.7	2093.0
43.8	2438.0
43.9	2793.6
44	3155.3

Basin 3

Reference Level (m AHD)	Volume (m3)
41.7	0.0
41.8	0.0
41.9	0.0
42	1.0
42.1	8.6
42.2	47.8
42.3	143.7
42.4	288.4
42.5	468.6
42.6	683.4
42.7	929.8
42.8	1199.1
42.9	1486.2
43	1787.2
43.1	2097.8
43.2	2413.8
43.3	2732.4
43.4	3052.9
43.5	3374.4
43.6	3696.3
43.7	4018.3
43.8	4340.3
43.9	4662.3
44	4984.3

Basin 4

Reference Level (m AHD)	Volume (m3)
41.4	0.0
41.5	0.0
41.6	0.0
41.7	2.9
41.8	29.1
41.9	135.5
42	323.3
42.1	564.1
42.2	841.7
42.3	1142.6
42.4	1463.3
42.5	1799.7
42.6	2145.7
42.7	2495.5
42.8	2846.2
42.9	3197.2
43	3548.1
43.1	3899.1
43.2	4250.1
43.3	4601.0
43.4	4952.0
43.5	5302.9
43.6	5653.9
43.7	6004.9
43.8	6355.8
43.9	6706.8
44	7057.7

Basin 5

Reference Level (m AHD)	Volume (m3)
40.5	0.0
40.6	0.0
40.7	0.1
40.8	1.9
40.9	9.8
41	33.5
41.1	88.6
41.2	191.1
41.3	349.4
41.4	554.3
41.5	787.9
41.6	1039.0
41.7	1301.8
41.8	1572.8
41.9	1849.8
42	2131.1
42.1	2415.1
42.2	2700.6
42.3	2986.6
42.4	3272.6
42.5	3558.5
42.6	3844.5
42.7	4130.5
42.8	4416.5
42.9	4702.4
43	4988.4

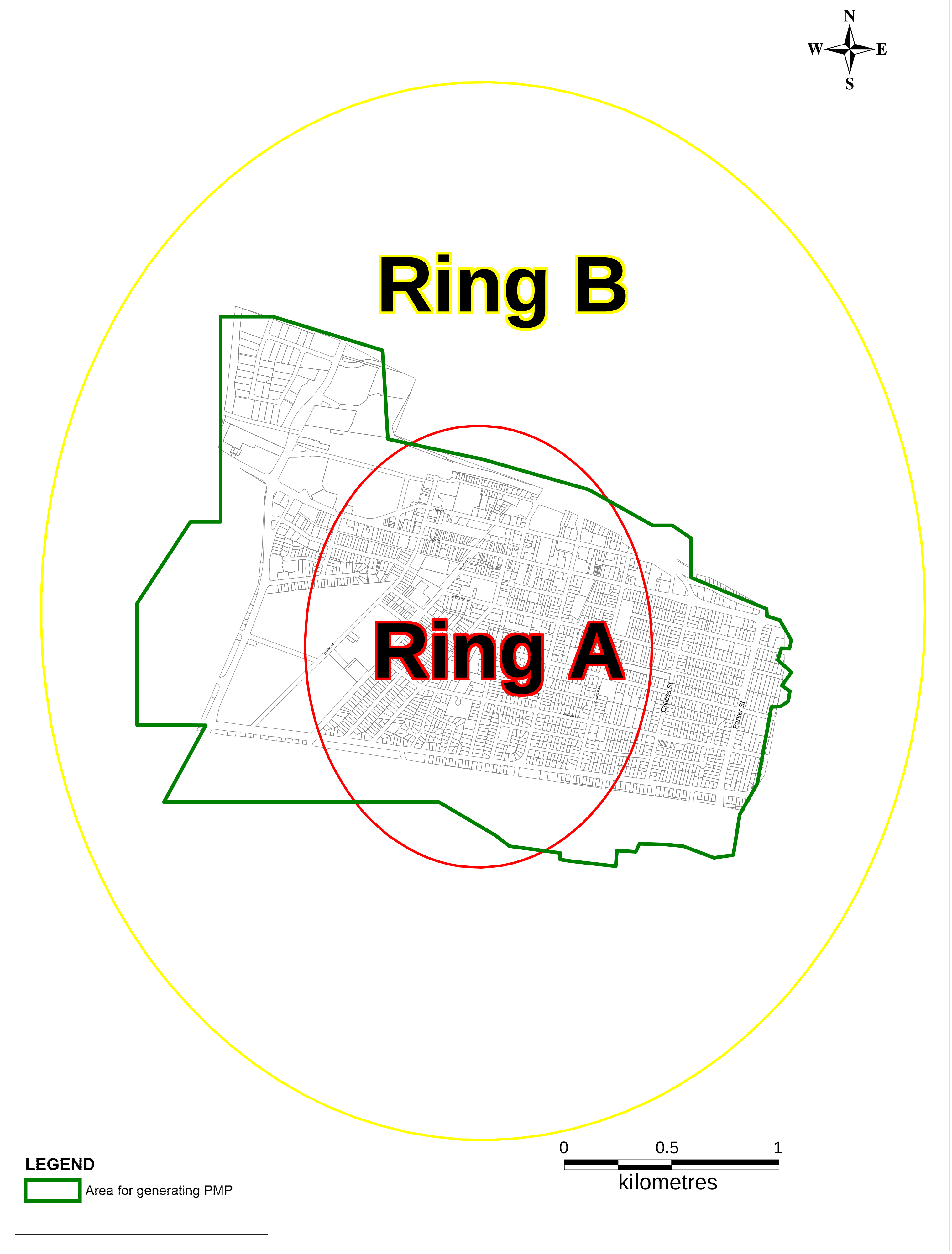
Basin 6	
Reference Level (m AHD)	Volume (m3)
40	0.0
40.1	0.0
40.2	0.5
40.3	5.8
40.4	26.5
40.5	83.3
40.6	195.0
40.7	360.3
40.8	560.1
40.9	781.7
41	1022.4
41.1	1280.2
41.2	1552.7
41.3	1837.7
41.4	2133.6
41.5	2438.8
41.6	2752.2
41.7	3073.1
41.8	3398.0
41.9	3724.2
42	4050.8
42.1	4377.3
42.2	4703.9
42.3	5030.4
42.4	5357.0
42.5	5683.5
42.6	6010.1
42.7	6336.6
42.8	6663.2
42.9	6989.7
43	7316.3

Basin 7	
Reference Level (m AHD)	Volume (m3)
39.3	0.0
39.4	0.0
39.5	0.3
39.6	8.1
39.7	52.7
39.8	166.5
39.9	347.5
40	568.7
40.1	818.6
40.2	1092.4
40.3	1386.5
40.4	1698.6
40.5	2026.8
40.6	2370.8
40.7	2729.9
40.8	3104.5
40.9	3495.2
41	3902.3
41.1	4322.0
41.2	4747.5
41.3	5175.1
41.4	5602.9
41.5	6030.8
41.6	6458.6
41.7	6886.4
41.8	7314.3
41.9	7742.1
42	8169.9

Basin 8	
Reference Level (m AHD)	Volume (m3)
36.4	0.0
36.5	0.0
36.6	0.0
36.7	1.9
36.8	20.1
36.9	88.6
37	238.7
37.1	489.9
37.2	842.5
37.3	1299.3
37.4	1856.0
37.5	2501.3
37.6	3221.9
37.7	4027.6
37.8	4933.4
37.9	5945.9
38	7086.7
38.1	8389.3
38.2	9897.8
38.3	11588.9
38.4	13436.0
38.5	15443.9
38.6	17607.8
38.7	19893.3
38.8	22278.6
38.9	24754.3
39	27303.5
39.1	27687.7
39.2	28080.0
39.3	28477.2
39.4	28877.9
39.5	29280.0
39.6	29682.5
39.7	30085.3
39.8	30488.2
39.9	30891.0
39	31293.8

Appendix C

PMP Ellipses


N
W
E
S
Ring B
Ring A
Colless St
Parker St
LEGEND
Area for generating PMP
0
0.5
1
kilometres

Appendix D

Pit and Pipe Data in the TUFLOW

APPENDIX D

Detailed Information of Pipes in the Tuflow Model

Pipe ID	Type	Length	Manning's n	US_Invert	DS_Invert	Width_or_Dia	Height_or_WF	Number_of Conduit	Entry_Loss	Exis_Loss
2454	C	10.5	0.015	47.34	47.23	0.45	0	1	0.3	0.2
2680	C	37.8	0.015	50.67	49.27	0.375	0	1	0.3	0.2
2474	C	10.9	0.015	46.65	46.41	0.3	0	1	0.3	0.2
2683	C	25.2	0.015	50.1	49.62	0.45	0	1	0.3	0.2
2669	C	12.9	0.015	52.46	52.38	0.375	0	1	0.3	0.2
2668	C	15.6	0.015	52.47	52.15	0.375	0	1	0.3	0.2
2665	C	15.5	0.015	54.06	53.78	0.375	0	1	0.3	0.2
2663	C	17.2	0.015	53.74	53.43	0.375	0	1	0.3	0.2
2661	C	11.2	0.015	53.47	52.61	0.375	0	1	0.3	0.2
2660	C	43.4	0.015	52.57	51.99	0.375	0	1	0.3	0.2
2659	C	12.4	0.015	51.97	51.72	0.375	0	1	0.3	0.2
2657	C	10.7	0.015	51.72	51.47	0.375	0	1	0.3	0.2
2338	C	68.4	0.015	51.44	48.29	0.375	0	1	0.3	0.2
2656	C	11.9	0.015	52.45	51.69	0.375	0	1	0.3	0.2
2658	C	32	0.015	52.48	51.99	0.375	0	1	0.3	0.2
2866	C	6.5	0.015	41.98	41.75	0.3	0	1	0.3	0.2
2867	C	29.8	0.015	41.73	41.47	0.3	0	1	0.3	0.2
2314	C	7.9	0.015	39.9	39.67	0.375	0	1	0.3	0.2
2926	C	22.3	0.015	40.51	40.29	0.375	0	1	0.3	0.2
2969	C	11	0.015	38.97	38.92	0.45	0	1	0.3	0.2
2966	C	16.9	0.015	38.69	38.47	0.525	0	1	0.3	0.2
2853	C	25.3	0.015	31.43	30.43	0.375	0	1	0.3	0.2
2852	C	8	0.015	30.88	30.44	0.3	0	1	0.3	0.2
2862	C	61.2	0.015	28.6	28.53	0.45	0	1	0.3	0.2
2295	C	80.2	0.015	28.35	28.1	0.6	0	1	0.3	0.2
2389	C	14.3	0.015	28.48	28.47	0.525	0	1	0.3	0.2
2278	C	25.3	0.015	27.4	26.82	0.45	0	1	0.3	0.2
2275	R	20.7	0.015	26.86	26.83	1.4	0.9	1	0.3	0.2
2277	R	88.6	0.015	26.82	26.68	1.4	0.9	1	0.3	0.2
2271	C	7.4	0.015	27.75	27.62	0.3	0	1	0.3	0.2
2272	C	58.7	0.015	27.62	27.44	0.375	0	1	0.3	0.2
2273	C	58.5	0.015	27.44	27.43	0.375	0	1	0.3	0.2
2266	C	24.9	0.015	27.55	27.47	0.3	0	1	0.3	0.2
2904	C	13.5	0.015	27.3	27.24	0.375	0	1	0.3	0.2
2254	C	150.7	0.015	27.27	27.17	0.45	0	1	0.3	0.2
2252	R	13.7	0.015	27.74	27.55	0.7	0.35	1	0.3	0.2
2253	R	9.4	0.015	27.53	27.29	0.5	0.4	1	0.3	0.2
2592	C	51.4	0.015	27	26.85	0.45	0	1	0.3	0.2
2590	C	98.1	0.015	26.85	26.55	0.6	0	1	0.3	0.2
2591	C	88.5	0.015	26.55	26.29	0.6	0	1	0.3	0.2
2595	C	98.1	0.015	26.29	25.98	0.6	0	1	0.3	0.2
2596	C	37.7	0.015	25.98	25.95	0.75	0	1	0.3	0.2
2441	C	14.5	0.015	27	26.85	0.525	0	1	0.3	0.2
3000	C	11.3	0.015	26.78	26.54	0.375	0	1	0.3	0.2
2250	C	22.6	0.015	27.76	27.57	0.375	0	1	0.3	0.2
2249	C	26.4	0.015	27.54	27.43	0.375	0	1	0.3	0.2
2248	C	24.9	0.015	27.43	27.35	0.375	0	1	0.3	0.2
2246	C	26.2	0.015	27.34	27.22	0.375	0	1	0.3	0.2
2242	C	26.5	0.015	27.96	27.85	0.375	0	1	0.3	0.2
2833	C	8.1	0.015	26.73	26.68	0.375	0	1	0.3	0.2
2831	C	46.2	0.015	26.67	26.47	0.375	0	1	0.3	0.2
2830	C	46.6	0.015	26.44	26.33	0.375	0	1	0.3	0.2
2829	C	45.2	0.015	26.31	26.29	0.375	0	1	0.3	0.2

Pipe ID	Type	Length	Manning's n	US_Invert	DS_Invert	Width_or_Dia	Height_or_WF	Number_of Conduit	Entry_Loss	Exis_Loss
2910	C	10.3	0.015	26.65	26.55	0.3	0	1	0.3	0.2
2911	C	106.1	0.015	26.55	26.4	0.375	0	1	0.3	0.2
2828	C	6.4	0.015	26.31	26.29	0.375	0	1	0.3	0.2
2832	C	8.7	0.015	26.6	26.6	0.375	0	1	0.3	0.2
2812	C	7.3	0.015	26.27	26.1	0.375	0	1	0.3	0.2
2570	C	4.2	0.015	26.53	26.5	0.45	0	1	0.3	0.2
2574	C	26	0.015	26.5	26.41	0.45	0	1	0.3	0.2
2575	C	46.1	0.015	26.41	26.27	0.45	0	1	0.3	0.2
2579	C	3	0.015	26.27	26.25	0.45	0	1	0.3	0.2
2580	C	6.3	0.015	26.25	26.22	0.525	0	1	0.3	0.2
2586	C	3.7	0.015	26.55	26.4	0.375	0	1	0.3	0.2
2583	C	51	0.015	26.55	26.51	0.45	0	1	0.3	0.2
2572	C	21.3	0.015	26.47	26.32	0.375	0	1	0.3	0.2
2877	C	8.3	0.015	35.64	35.48	0.65	0	1	0.3	0.2
2416	C	19.5	0.015	34.09	33.79	0.6	0	1	0.3	0.2
2417	C	14.2	0.015	33.75	33.2	0.6	0	1	0.3	0.2
2283	C	4.6	0.015	27.72	27.7	0.45	0	1	0.3	0.2
2287	C	5.9	0.015	28.47	28.44	0.375	0	1	0.3	0.2
2291	C	3.4	0.015	28.69	28.58	0.375	0	1	0.3	0.2
2303	C	10.4	0.015	36.32	36.16	0.375	0	1	0.3	0.2
2300	C	33.5	0.015	36.14	35.4	0.375	0	1	0.3	0.2
2307	C	11.5	0.015	41.58	41.45	0.375	0	1	0.3	0.2
2306	R	24.5	0.015	41.54	41.45	0.5	0.35	1	0.3	0.2
2868	C	2.9	0.015	44.03	43.78	0.3	0	1	0.3	0.2
2308	C	42	0.015	43.77	43.04	0.3	0	1	0.3	0.2
2855	C	8.5	0.015	31.45	31.44	0.375	0	1	0.3	0.2
2010	C	15.6	0.015	30.69	29.8	0.375	0	1	0.3	0.2
2011	C	91.2	0.015	29.72	27.55	0.375	0	1	0.3	0.2
2555	C	38.9	0.015	27.53	27.15	0.375	0	1	0.3	0.2
2557	C	70.6	0.015	27.14	27	0.45	0	1	0.3	0.2
2558	C	20.3	0.015	26.97	26.9	0.375	0	1	0.3	0.2
2559	R	29.7	0.015	26.99	26.9	0.45	0.3	1	0.3	0.2
2556	C	22.5	0.015	27.45	27.15	0.375	0	1	0.3	0.2
2819	C	12.2	0.015	25.69	25.66	0.375	0	1	0.3	0.2
2816	C	13.1	0.015	25.65	25.53	0.375	0	1	0.3	0.2
2824	C	12.8	0.015	25.89	25.75	0.525	0	1	0.3	0.2
2825	C	46.3	0.015	26.29	25.95	0.45	0	1	0.3	0.2
2797	C	31.9	0.015	26.01	25.47	0.375	0	1	0.3	0.2
2784	R	11	0.015	26.3	26.18	0.45	0.3	1	0.3	0.2
2783	R	26	0.015	26.17	25.89	0.45	0.3	1	0.3	0.2
2782	R	17.9	0.015	25.89	25.84	0.45	0.3	1	0.3	0.2
2014	C	5.9	0.015	25.96	25.78	0.35	0	1	0.3	0.2
2015	C	2.1	0.015	25.68	25.68	0.35	0	1	0.3	0.2
2016	C	3.4	0.015	25.68	25.61	0.35	0	1	0.3	0.2
2017	C	4.6	0.015	25.61	25.35	0.35	0	1	0.3	0.2
2814	C	11	0.015	26.07	25.94	0.375	0	1	0.3	0.2
2788	C	29.1	0.015	26.16	26.11	0.375	0	1	0.3	0.2
2789	C	69.4	0.015	26.09	25.82	0.375	0	1	0.3	0.2
2795	C	16.2	0.015	25.8	25.66	0.375	0	1	0.3	0.2
2951	C	32.9	0.015	25.64	24.78	0.375	0	1	0.3	0.2
2232	C	25.4	0.015	25.68	25.51	0.375	0	1	0.3	0.2
2233	C	21.5	0.015	25.48	25.4	0.375	0	1	0.3	0.2
2954	C	19	0.015	25.39	25.38	0.375	0	1	0.3	0.2
2953	C	17.7	0.015	25.36	25.24	0.375	0	1	0.3	0.2
2941	C	21.1	0.015	25.23	25.18	0.375	0	1	0.3	0.2
2952	C	18.7	0.015	25.35	25.24	0.375	0	1	0.3	0.2
2240	C	13.4	0.015	25.95	25.72	0.375	0	1	0.3	0.2

Pipe ID	Type	Length	Manning's n	US_Invert	DS_Invert	Width_or_Dia	Height_or_WF	Number_of Conduit	Entry_Loss	Exis_Loss
2752	C	24.9	0.015	25.92	25.67	0.375	0	1	0.3	0.2
2753	C	38.4	0.015	25.63	25.32	0.375	0	1	0.3	0.2
2754	C	25.2	0.015	25.18	24.98	0.375	0	1	0.3	0.2
2755	C	78.7	0.015	23.62	23.2	0.375	0	1	0.3	0.2
2759	C	29.8	0.015	25	24.5	0.375	0	1	0.3	0.2
2037	C	196.1	0.015	23.56	22.84	1.35	0	1	0.3	0.2
2045	R	34	0.015	25.45	25.44	0.8	0.35	1	0.3	0.2
2046	R	18.1	0.015	25.42	25.39	0.8	0.35	1	0.3	0.2
2047	R	10	0.015	25.36	24.48	0.8	0.35	1	0.3	0.2
2655	C	18	0.015	57.03	56.42	0.375	0	1	0.3	0.2
2654	C	26	0.015	56.35	55.35	0.375	0	1	0.3	0.2
2652	C	14.7	0.015	55.81	55.65	0.3	0	1	0.3	0.2
2653	C	29.4	0.015	55.56	55.35	0.375	0	1	0.3	0.2
3013	C	27.1	0.015	53.4	53.35	0.375	0	1	0.3	0.2
2651	C	8.2	0.015	54.81	54.4	0.375	0	1	0.3	0.2
2640	C	14.8	0.015	56.73	56.19	0.45	0	1	0.3	0.2
2642	C	16.7	0.015	56.16	55.84	0.45	0	1	0.3	0.2
2643	C	16.1	0.015	55.78	54.48	0.45	0	1	0.3	0.2
2644	C	40.1	0.015	54.43	53.66	0.45	0	1	0.3	0.2
2645	C	24.8	0.015	53.63	53.35	0.45	0	1	0.3	0.2
2916	C	23	0.015	52.6	51.79	0.375	0	1	0.3	0.2
2673	C	50.6	0.015	50.8	48.92	0.375	0	1	0.3	0.2
2672	C	22.5	0.015	48.92	48.82	0.375	0	1	0.3	0.2
2679	C	36	0.015	49.23	48.87	0.375	0	1	0.3	0.2
3035	C	47.6	0.015	52.98	52.88	0.375	0	1	0.3	0.2
2973	C	3.1	0.015	43.27	43.19	0.375	0	1	0.3	0.2
2974	C	14.7	0.015	42.93	42.46	0.525	0	1	0.3	0.2
2975	C	35	0.015	42.42	42.4	0.525	0	1	0.3	0.2
2367	C	6.1	0.015	36.25	36.08	1.35	0	1	0.3	0.2
2366	C	13.7	0.015	36.06	36.04	1.35	0	1	0.3	0.2
2603	C	6	0.015	36.02	35.8	1.35	0	1	0.3	0.2
2364	C	51	0.015	35.8	35.62	1.35	0	1	0.3	0.2
2371	C	14.2	0.015	39.06	38.96	0.45	0	1	0.3	0.2
2370	C	48.4	0.015	38.94	36.9	0.45	0	1	0.3	0.2
2318	C	13.6	0.015	43.89	43.75	0.525	0	1	0.3	0.2
2319	C	83.9	0.015	43.73	39.82	0.525	0	1	0.3	0.2
2323	C	70.9	0.015	43.8	41.74	0.375	0	1	0.3	0.2
2869	C	4.6	0.015	46.3	46.05	0.375	0	1	0.3	0.2
2870	C	17.5	0.015	46	45.52	0.375	0	1	0.3	0.2
2347	C	58.9	0.015	45.46	43.53	0.375	0	1	0.3	0.2
2322	C	14.1	0.015	44.16	43.82	0.375	0	1	0.3	0.2
2341	C	3.3	0.015	45.43	45.35	0.375	0	1	0.3	0.2
2342	C	7.3	0.015	45.32	45.19	0.375	0	1	0.3	0.2
2343	C	41.3	0.015	45.14	44.08	0.375	0	1	0.3	0.2
3037	C	8.8	0.015	45.74	44.47	0.375	0	1	0.3	0.2
2331	C	1.9	0.015	45.47	45.41	0.375	0	1	0.3	0.2
2329	C	11.6	0.015	45.41	45.07	0.45	0	1	0.3	0.2
2330	C	10	0.015	45.63	45.41	0.375	0	1	0.3	0.2
2690	C	2.2	0.015	49	48.74	0.45	0	1	0.3	0.2
2350	C	4.7	0.015	41.09	41	0.3	0	1	0.3	0.2
2443	C	12.4	0.015	42.98	42.78	0.76	0	1	0.3	0.2
2415	R	20.6	0.015	38.71	38.28	0.6	0.3	1	0.3	0.2
2479	C	20.9	0.015	41.67	41.62	0.225	0	1	0.3	0.2
2013	C	12.7	0.015	30.94	30.84	0.375	0	1	0.3	0.2
2012	C	36.5	0.015	30.6	29.77	0.375	0	1	0.3	0.2
2003	C	21.8	0.015	29.75	29.65	0.3	0	1	0.3	0.2
2421	C	3.4	0.015	34.91	34.7	0.3	0	1	0.3	0.2

Pipe ID	Type	Length	Manning's n	US_Invert	DS_Invert	Width_or_Dia	Height_or_WF	Number_of Conduit	Entry_Loss	Exis_Loss
2423	C	18.2	0.015	34.64	34.08	0.375	0	1	0.3	0.2
2424	C	46.1	0.015	34.04	32.96	0.45	0	1	0.3	0.2
2427	C	13.8	0.015	32.89	31.19	0.6	0	1	0.3	0.2
2425	C	25.9	0.015	34.32	33.53	0.3	0	1	0.3	0.2
2426	C	13.2	0.015	33.5	33.11	0.3	0	1	0.3	0.2
2432	C	42.1	0.015	30.52	30.42	0.45	0	1	0.3	0.2
2430	C	5.8	0.015	31.07	30.93	0.375	0	1	0.3	0.2
2406	C	13	0.015	35.14	35.02	0.375	0	1	0.3	0.2
2407	C	8.8	0.015	34.91	34.8	0.375	0	1	0.3	0.2
2409	R	21.6	0.015	34.78	33.92	0.6	0.45	1	0.3	0.2
2410	C	53.7	0.015	33.78	33.28	0.525	0	1	0.3	0.2
2414	C	6.6	0.015	32.94	32.4	0.45	0	1	0.3	0.2
2411	C	9.8	0.015	32.87	32.77	0.45	0	1	0.3	0.2
2408	R	6.2	0.015	34.88	34.8	0.9	0.3	1	0.3	0.2
2395	C	10.7	0.015	39.4	39.27	0.375	0	1	0.3	0.2
2396	C	15.9	0.015	38.79	38.58	0.375	0	1	0.3	0.2
2436	C	8.4	0.015	40.23	40.09	0.375	0	1	0.3	0.2
3041	C	53.3	0.015	36.92	35.99	0.375	0	1	0.3	0.2
2375	C	3.8	0.015	35.99	35.45	0.375	0	1	0.3	0.2
2373	C	6.3	0.015	35.95	35.85	0.3	0	1	0.3	0.2
2360	C	29.7	0.015	36.97	36.82	0.9	0	1	0.3	0.2
2458	C	12.8	0.015	34.3	33.83	0.375	0	1	0.3	0.2
2459	C	34.5	0.015	33.8	32.97	0.375	0	1	0.3	0.2
2516	C	13.1	0.015	36.9	36.86	0.375	0	1	0.3	0.2
2917	C	157.2	0.015	42.22	38.14	0.525	0	1	0.3	0.2
2482	C	3.6	0.015	42.55	42.45	0.375	0	1	0.3	0.2
2491	C	13.1	0.015	44.56	44.27	0.375	0	1	0.3	0.2
2494	C	14.2	0.015	45.13	44.18	0.375	0	1	0.3	0.2
2501	C	14.3	0.015	43.78	43.41	0.375	0	1	0.3	0.2
2502	C	60.4	0.015	43.33	42.22	0.375	0	1	0.3	0.2
3024	C	15.5	0.015	44.33	44.23	0.375	0	1	0.3	0.2
2715	C	14.3	0.015	32.1	31.52	0.6	0	1	0.3	0.2
2713	C	39.8	0.015	31.52	30.58	0.6	0	1	0.3	0.2
2112	C	22.4	0.015	28.02	27.92	0.375	0	1	0.3	0.2
2113	C	12.3	0.015	27.82	27.66	0.375	0	1	0.3	0.2
2108	C	4.5	0.015	28.1	28	0.375	0	1	0.3	0.2
2082	C	53	0.015	27.22	26.89	0.375	0	1	0.3	0.2
2081	C	51.1	0.015	26.85	26.64	0.45	0	1	0.3	0.2
2080	C	31.4	0.015	26.6	26.47	0.45	0	1	0.3	0.2
2079	C	49.2	0.015	26.44	26.35	0.45	0	1	0.3	0.2
2069	C	36.3	0.015	26.31	26.17	0.525	0	1	0.3	0.2
2068	C	11.1	0.015	26.16	26.12	0.45	0	1	0.3	0.2
2064	C	11	0.015	26.12	26.08	0.525	0	1	0.3	0.2
2058	R	26.6	0.015	26.03	25.91	0.6	0.35	1	0.3	0.2
2083	C	33.4	0.015	27.16	26.95	0.375	0	1	0.3	0.2
2078	C	50.9	0.015	26.9	26.62	0.375	0	1	0.3	0.2
2077	C	30.5	0.015	26.58	26.43	0.525	0	1	0.3	0.2
2075	C	56.7	0.015	26.38	26.22	0.525	0	1	0.3	0.2
2072	C	25.4	0.015	26.2	26.16	0.375	0	1	0.3	0.2
2071	C	15.5	0.015	26.15	26.14	0.375	0	1	0.3	0.2
2060	R	8.5	0.015	26.1	26.04	0.6	0.5	1	0.3	0.2
2059	R	15.2	0.015	26.03	26.02	0.8	0.5	1	0.3	0.2
2057	R	16.4	0.015	26	25.91	0.8	0.5	1	0.3	0.2
2055	R	42.6	0.015	25.89	25.74	0.8	0.5	1	0.3	0.2
2551	C	27.9	0.015	27.36	27.19	0.45	0	1	0.3	0.2
2550	C	6.9	0.015	27.14	27.06	0.6	0	1	0.3	0.2
2547	C	11.9	0.015	27.48	27.06	0.45	0	1	0.3	0.2

Pipe ID	Type	Length	Manning's n	US_Invert	DS_Invert	Width_or_ Dia	Height_ or_WF	Number_of Conduit	Entry_Loss	Exis_Loss
2546	C	19.5	0.015	27.23	27.06	0.6	0	1	0.3	0.2
2004	C	44.2	0.015	29.91	29.62	0.375	0	1	0.3	0.2
2005	C	20.7	0.015	29.39	28.86	0.375	0	1	0.3	0.2
2601	R	7	0.015	30.25	29.76	0.45	0.3	1	0.3	0.2
2600	R	17.8	0.015	29.74	29.55	0.45	0.3	1	0.3	0.2
2535	C	49.4	0.015	28.78	28.63	0.45	0	1	0.3	0.2
2779	C	26.2	0.015	26.29	25.95	0.3	0	1	0.3	0.2
2781	C	67.1	0.015	25.93	25.87	0.375	0	1	0.3	0.2
2101	R	68.9	0.015	26.52	26.21	0.6	0.35	1	0.3	0.2
2727	C	21.8	0.015	24.71	24.43	0.375	0	1	0.3	0.2
2733	C	149.4	0.015	23.16	22.52	1.35	0	1	0.3	0.2
2139	C	19.8	0.015	25.86	25.73	0.375	0	1	0.3	0.2
3052	C	16.7	0.015	25.73	25.6	0.375	0	1	0.3	0.2
2734	C	30.1	0.015	25.13	24.75	0.375	0	1	0.3	0.2
2730	C	23.1	0.015	24.72	24.59	0.375	0	1	0.3	0.2
2214	C	13.7	0.015	23.3	23.02	0.375	0	1	0.3	0.2
2212	C	13.4	0.015	22.97	22.63	0.375	0	1	0.3	0.2
2210	C	13.5	0.015	23.19	21.62	0.375	0	1	0.3	0.2
2207	C	13.5	0.015	23.79	23.7	0.375	0	1	0.3	0.2
2204	C	48.7	0.015	23.7	23.4	0.45	0	1	0.3	0.2
2203	C	29.9	0.015	23.4	23.15	0.45	0	1	0.3	0.2
2202	C	13.4	0.015	23.65	23.4	0.375	0	1	0.3	0.2
2195	C	13.4	0.015	22.94	22.61	0.375	0	1	0.3	0.2
3027	C	45.5	0.015	24.2	23.96	0.375	0	1	0.3	0.2
2205	C	85.7	0.015	23.96	22.9	0.525	0	1	0.3	0.2
2201	C	28.9	0.015	22.87	22.55	0.6	0	1	0.3	0.2
2220	C	13.6	0.015	22.72	22.58	0.375	0	1	0.3	0.2
2221	C	20.3	0.015	22.43	22.33	0.525	0	1	0.3	0.2
2222	C	13.6	0.015	22.26	22.07	0.525	0	1	0.3	0.2
2227	C	59.5	0.015	23.31	22.62	0.375	0	1	0.3	0.2
2218	C	13.5	0.015	23.3	23.06	0.375	0	1	0.3	0.2
3009	C	36.2	0.015	26.38	25.6	0.375	0	1	0.3	0.2
2627	C	18.1	0.015	26.1	25.99	0.375	0	1	0.3	0.2
2628	C	30.8	0.015	25.96	25.81	0.375	0	1	0.3	0.2
2065	C	8.3	0.015	26.08	26.03	0.525	0	1	0.3	0.2
2053	R	25.5	0.015	25.71	25.64	1.3	0.4	1	0.3	0.2
2040	C	18.7	0.015	24.54	24.3	0.45	0	1	0.3	0.2
2018	R	1.4	0.015	25.61	25.5	0.35	0.8	1	0.3	0.2
2019	C	17.7	0.015	25.6	25.45	0.375	0	1	0.3	0.2
2001	C	8.3	0.015	30.12	29.88	0.375	0	1	0.3	0.2
2002	C	18.2	0.015	29.63	29.53	0.45	0	1	0.3	0.2
2007	C	4.9	0.015	29.97	29.9	0.375	0	1	0.3	0.2
2006	C	33	0.015	29.68	29.53	0.3	0	1	0.3	0.2
2020	C	5.9	0.015	25.64	25.61	0.525	0	1	0.3	0.2
2021	C	67	0.015	25.35	25.06	0.825	0	1	0.3	0.2
2022	C	67.1	0.015	25.45	25.06	0.525	0	1	0.3	0.2
2023	C	6	0.015	25.7	25.6	0.3	0	1	0.3	0.2
2026	R	1.9	0.015	25.9	25.87	0.3	0.4	1	0.3	0.2
2786	C	18	0.015	25.76	25.7	0.375	0	1	0.3	0.2
2029	R	2.2	0.015	25.83	25.75	0.3	0.45	1	0.3	0.2
2041	C	15.3	0.015	24.08	24.07	0.375	0	1	0.3	0.2
2042	C	36.5	0.015	24.05	24	0.45	0	1	0.3	0.2
2085	R	21.3	0.015	25.65	25.57	0.45	0.3	1	0.3	0.2
2086	C	5.4	0.015	25.77	25.73	0.3	0	1	0.3	0.2
2087	R	21.6	0.015	25.58	25.53	0.9	0.5	1	0.3	0.2
2088	C	6.9	0.015	26.07	25.9	0.3	0	1	0.3	0.2
2089	C	4.1	0.015	26.05	26	0.3	0	1	0.3	0.2

Pipe ID	Type	Length	Manning's n	US_Invert	DS_Invert	Width_or_Dia	Height_or_WF	Number_of Conduit	Entry_Loss	Exis_Loss
2090	R	18.9	0.015	25.51	25.35	0.9	0.6	1	0.3	0.2
2091	R	10.2	0.015	25.34	25.31	1.8	0.5	1	0.3	0.2
2092	R	14.6	0.015	25.34	25.27	1.55	0.5	1	0.3	0.2
2097	R	57	0.015	26.38	26.21	0.45	0.45	1	0.3	0.2
2098	R	25.8	0.015	26.2	26.16	0.45	0.45	1	0.3	0.2
2099	R	18.4	0.015	26.09	26.03	0.8	0.5	1	0.3	0.2
2100	C	7.4	0.015	26.2	26.14	0.375	0	1	0.3	0.2
2110	R	5	0.015	28.08	27.89	0.45	0.2	1	0.3	0.2
2111	C	8.4	0.015	28	27.95	0.375	0	1	0.3	0.2
2114	C	177	0.015	27.27	25.71	0.45	0	1	0.3	0.2
2119	C	16	0.015	26.37	26.3	0.375	0	1	0.3	0.2
2120	C	16	0.015	26.92	26.24	0.375	0	1	0.3	0.2
2121	C	14.8	0.015	26.24	26.21	0.375	0	1	0.3	0.2
2118	C	5.6	0.015	26.55	26.38	0.375	0	1	0.3	0.2
2122	C	17.5	0.015	26.58	26.41	0.375	0	1	0.3	0.2
2125	C	1.8	0.015	26.66	26.64	0.375	0	1	0.3	0.2
2124	C	6.9	0.015	26.64	26.59	0.375	0	1	0.3	0.2
2123	C	19.1	0.015	26.61	26.41	0.375	0	1	0.3	0.2
2084	C	11	0.015	26.92	26.82	0.375	0	1	0.3	0.2
2127	C	1	0.015	26.4	25.5	0.375	0	1	0.3	0.2
2128	C	3.9	0.015	25.97	25.3	0.375	0	1	0.3	0.2
2131	C	1.9	0.015	25.98	25.1	0.375	0	1	0.3	0.2
2132	C	7.4	0.015	24.2	24	1.95	0	1	0.3	0.2
2133	C	10.4	0.015	26.04	25.88	0.375	0	1	0.3	0.2
2134	C	5.7	0.015	25.76	25.3	0.375	0	1	0.3	0.2
2135	C	4.7	0.015	25.98	25.79	0.375	0	1	0.3	0.2
2136	C	16.8	0.015	26.2	26.1	0.375	0	1	0.3	0.2
2137	C	5.1	0.015	26.1	25.95	0.375	0	1	0.3	0.2
2140	C	10.8	0.015	25.6	25	0.375	0	1	0.3	0.2
2143	C	4.1	0.015	25.53	25.44	0.375	0	1	0.3	0.2
2144	C	8	0.015	25.44	24.6	0.375	0	1	0.3	0.2
2145	C	14.4	0.015	25.27	24	0.375	0	1	0.3	0.2
2146	C	30	0.015	22.67	22.54	2.15	0	1	0.3	0.2
2148	C	29.7	0.015	22.54	22.39	2.15	0	1	0.3	0.2
2149	C	30.1	0.015	22.39	22.24	2.15	0	1	0.3	0.2
2150	C	30.2	0.015	22.24	22.11	2.15	0	1	0.3	0.2
2151	C	493.5	0.015	22.11	19.62	2.15	0	1	0.3	0.2
2337	C	3.3	0.015	48.65	48.27	0.375	0	1	0.3	0.2
2943	C	17.3	0.015	25.16	25.09	0.375	0	1	0.3	0.2
2944	C	13.4	0.015	25.21	25.09	0.375	0	1	0.3	0.2
2675	C	35.9	0.015	49.48	49.38	0.375	0	1	0.3	0.2
2564	C	13	0.015	26.34	26.3	0.6	0	1	0.3	0.2
2191	C	8.6	0.015	20.96	20.88	1.2	0	1	0.3	0.2
2190	C	13.9	0.015	21.09	21.07	1.2	0	1	0.3	0.2
2196	C	5.2	0.015	23.06	20.15	0.375	0	1	0.3	0.2
3017	C	30.3	0.015	20.88	20.68	1.2	0	1	0.3	0.2
3018	C	111.8	0.015	20.64	20.55	1.2	0	1	0.3	0.2
2198	C	4	0.015	23.5	23.21	0.225	0	1	0.3	0.2
2199	C	5.5	0.015	23.44	23.38	0.3	0	1	0.3	0.2
2206	C	4.7	0.015	24.17	24.09	0.3	0	1	0.3	0.2
2225	C	18.2	0.015	22.26	22	0.75	0	1	0.3	0.2
2223	C	45.2	0.015	21.55	20.84	0.9	0	1	0.3	0.2
2234	C	400	0.015	25.34	21.45	0.525	0	1	0.3	0.2
2238	C	2.9	0.015	25.67	25.65	0.375	0	1	0.3	0.2
2247	C	21.5	0.015	26.82	26.75	1.05	0	1	0.3	0.2
3001	C	10.2	0.015	26.74	26.7	1.05	0	1	0.3	0.2
2251	C	5.4	0.015	27.61	27.5	0.3	0	1	0.3	0.2

Pipe ID	Type	Length	Manning's n	US_Invert	DS_Invert	Width_or_ Dia	Height_ or_WF	Number_of Conduit	Entry_Loss	Exis_Loss
2255	C	22.8	0.015	27.95	27.77	0.375	0	1	0.3	0.2
2256	C	24.1	0.015	27.74	27.46	0.375	0	1	0.3	0.2
2257	C	19.8	0.015	27.46	27.35	0.6	0	1	0.3	0.2
2258	C	22	0.015	27.33	27.27	0.6	0	1	0.3	0.2
2260	C	59.8	0.015	27.1	27.06	0.45	0	1	0.3	0.2
2261	C	4.2	0.015	28.19	28.09	0.45	0	1	0.3	0.2
2262	C	28.9	0.015	27.03	27.03	0.6	0	1	0.3	0.2
2263	C	14.7	0.015	27.61	27.44	0.525	0	1	0.3	0.2
2264	C	21.4	0.015	26.99	26.92	0.6	0	1	0.3	0.2
2265	C	22.1	0.015	26.9	26.87	0.6	0	1	0.3	0.2
2274	C	1.6	0.015	27.14	27.04	0.375	0	1	0.3	0.2
2279	C	2.6	0.015	26.98	26.68	0.45	0	1	0.3	0.2
2282	C	5.1	0.015	27.22	27.11	0.3	0	1	0.3	0.2
2284	C	4.7	0.015	27.72	27.7	0.45	0	1	0.3	0.2
2290	C	6.6	0.015	28.83	28.72	0.375	0	1	0.3	0.2
2294	C	25.9	0.015	28.1	27.62	0.6	0	1	0.3	0.2
2309	C	37.9	0.015	38.81	38.05	0.6	0	1	0.3	0.2
2311	C	6.5	0.015	40.1	39.76	0.375	0	1	0.3	0.2
2312	C	5.1	0.015	39.71	39.41	0.375	0	1	0.3	0.2
2313	C	5.6	0.015	39.99	39.67	0.375	0	1	0.3	0.2
2324	C	29.5	0.015	40.39	39.64	1.05	0	1	0.3	0.2
2326	C	15.6	0.015	39.45	39.29	1.05	0	1	0.3	0.2
2327	C	23.7	0.015	39.29	39	1.05	0	1	0.3	0.2
2391	R	17.6	0.015	45.15	44.7	0.6	0.3	1	0.3	0.2
2340	R	5.1	0.015	44.72	44.47	0.8	0.2	1	0.3	0.2
2351	C	4.3	0.015	41.15	41.05	0.3	0	1	0.3	0.2
2349	C	18.5	0.015	41.24	41.14	0.45	0	1	0.3	0.2
2355	C	4	0.015	38.97	38.94	0.375	0	1	0.3	0.2
2356	C	6.9	0.015	38.89	38.88	0.375	0	1	0.3	0.2
2359	C	65.1	0.015	37.64	37.01	0.9	0	1	0.3	0.2
2361	C	30.3	0.015	36.97	36.82	0.9	0	1	0.3	0.2
2633	C	26.6	0.015	36.82	35.75	0.9	0	1	0.3	0.2
2377	C	22.7	0.015	35.62	35.45	1.35	0	1	0.3	0.2
2374	R	4.8	0.015	35.45	34.94	1.6	1.4	1	0.3	0.2
2372	C	3.8	0.015	35.64	35.54	0.375	0	1	0.3	0.2
2376	C	3.5	0.015	36.02	36.01	0.375	0	1	0.3	0.2
2381	C	35.9	0.015	28.37	28.33	0.9	0	1	0.3	0.2
2379	C	14.7	0.015	28.39	28.26	0.45	0	1	0.3	0.2
2380	C	118.9	0.015	28.33	28.22	0.9	0	1	0.3	0.2
2384	C	25.8	0.015	28.39	28.37	0.75	0	1	0.3	0.2
2385	C	28.7	0.015	28.55	28.52	0.375	0	1	0.3	0.2
2387	C	16	0.015	28.5	28.47	0.45	0	1	0.3	0.2
2390	C	18.5	0.015	28.47	28.45	0.7	0	1	0.3	0.2
3053	C	61.5	0.015	28.45	28.39	0.7	0	1	0.3	0.2
2393	C	95.3	0.015	29.23	27.24	0.45	0	1	0.3	0.2
2402	C	15.9	0.015	36.3	36.27	0.3	0	1	0.3	0.2
2403	R	5.9	0.015	36.25	36.2	0.7	0.35	1	0.3	0.2
2404	C	103.2	0.015	37.98	34.96	0.7	0	1	0.3	0.2
3015	C	95.2	0.015	34.9	32.6	0.75	0	1	0.3	0.2
2412	C	6.8	0.015	32.74	32.4	0.45	0	1	0.3	0.2
2413	C	9.4	0.015	33.01	32.75	0.45	0	1	0.3	0.2
2420	C	109.8	0.015	33.19	31.34	0.6	0	1	0.3	0.2
2431	C	5.7	0.015	30.5	30.4	0.373	0	1	0.3	0.2
2435	C	2.1	0.015	41.31	41.27	0.375	0	1	0.3	0.2
2434	C	42.7	0.015	41.05	40.5	0.375	0	1	0.3	0.2
2433	C	6.1	0.015	40.38	40.35	0.525	0	1	0.3	0.2
2438	C	50.8	0.015	40.04	38.4	0.6	0	1	0.3	0.2

Pipe ID	Type	Length	Manning's n	US_Invert	DS_Invert	Width_or_Dia	Height_or_WF	Number_of Conduit	Entry_Loss	Exis_Loss
2439	R	18.9	0.015	44.59	43.66	0.35	0.25	1	0.3	0.2
2452	C	64.7	0.015	48.74	47.15	0.45	0	1	0.3	0.2
2465	C	5.4	0.015	33.09	33.07	0.75	0	1	0.3	0.2
2464	C	55.6	0.015	33.04	33	0.75	0	1	0.3	0.2
2462	C	8	0.015	33.75	33.65	0.375	0	1	0.3	0.2
2463	C	4.8	0.015	34.31	34.21	0.375	0	1	0.3	0.2
2455	C	46.6	0.015	35.65	34.65	0.375	0	1	0.3	0.2
2460	C	11.7	0.015	32.96	32.93	0.45	0	1	0.3	0.2
2461	C	7.8	0.015	32.92	32.82	0.45	0	1	0.3	0.2
2467	C	2.4	0.015	33.42	33.32	0.375	0	1	0.3	0.2
2468	C	5	0.015	33.36	33.28	0.3	0	1	0.3	0.2
2470	C	9.6	0.015	33.49	32.92	0.45	0	1	0.3	0.2
2473	C	114.3	0.015	47.94	43.71	0.3	0	1	0.3	0.2
2476	C	29.8	0.015	46.16	45.56	0.6	0	1	0.3	0.2
2477	C	20.3	0.015	45.53	45.49	0.6	0	1	0.3	0.2
3029	C	146.9	0.015	45.09	42.49	0.6	0	1	0.3	0.2
2480	C	23.5	0.015	53.13	52.98	0.375	0	1	0.3	0.2
2481	C	9.1	0.015	42.65	42.24	0.45	0	1	0.3	0.2
2493	C	13.5	0.015	45.71	45.44	0.375	0	1	0.3	0.2
2495	C	15.5	0.015	44.77	44.18	0.375	0	1	0.3	0.2
2497	R	3.4	0.015	46.16	46.11	0.9	0.15	1	0.3	0.2
2496	R	3	0.015	46.01	45.98	0.9	0.15	1	0.3	0.2
2503	C	5.3	0.015	37.4	37	0.375	0	1	0.3	0.2
2504	C	4.7	0.015	37.44	37.26	0.375	0	1	0.3	0.2
2506	C	13.9	0.015	36.93	36.8	0.375	0	1	0.3	0.2
2512	C	48.1	0.015	37.88	34.89	0.375	0	1	0.3	0.2
2511	R	4.5	0.015	34.48	34.48	0.6	0.3	1	0.3	0.2
2510	C	7.8	0.015	34.65	34.48	0.375	0	1	0.3	0.2
2508	C	24	0.015	34.45	34.07	0.375	0	1	0.3	0.2
2509	C	16.4	0.015	34.03	34	0.45	0	1	0.3	0.2
2515	R	52.2	0.015	34.3	33.98	1.5	1.2	1	0.3	0.2
2513	C	12.5	0.015	34.4	34.3	0.375	0	1	0.3	0.2
2517	R	13.5	0.015	36.6	36.2	0.9	0.2	1	0.3	0.2
2518	C	4.5	0.015	36.7	36.6	0.375	0	1	0.3	0.2
2520	C	5.8	0.015	38.24	38.14	0.375	0	1	0.3	0.2
2519	C	13.9	0.015	36.9	36.45	0.6	0	1	0.3	0.2
2522	C	57.1	0.015	42.58	39.31	0.375	0	1	0.3	0.2
2523	C	64.7	0.015	39.27	38.03	0.375	0	1	0.3	0.2
2524	C	12.5	0.015	38.01	37.92	0.375	0	1	0.3	0.2
2525	C	20.6	0.015	37.88	37.61	0.375	0	1	0.3	0.2
2526	C	20.4	0.015	37.59	37.09	0.45	0	1	0.3	0.2
2527	C	5.4	0.015	37.9	37.71	0.45	0	1	0.3	0.2
2528	C	3.1	0.015	37.69	37.6	0.375	0	1	0.3	0.2
2529	C	20.8	0.015	37.08	36.63	0.45	0	1	0.3	0.2
2530	C	8.2	0.015	36.61	36.41	0.45	0	1	0.3	0.2
2534	C	12.2	0.015	28.94	28.85	0.375	0	1	0.3	0.2
2544	C	9	0.015	27.55	27.46	0.525	0	1	0.3	0.2
2548	C	54.5	0.015	27.05	27	0.6	0	1	0.3	0.2
3016	C	4.6	0.015	27.5	27.29	0.375	0	1	0.3	0.2
2554	C	8.5	0.015	28.7	28.2	0.3	0	1	0.3	0.2
2562	C	14.2	0.015	26.54	26.51	0.6	0	1	0.3	0.2
2563	C	13.7	0.015	26.54	26.52	0.6	0	1	0.3	0.2
2566	C	7.9	0.015	26.49	26.4	0.9	0	1	0.3	0.2
2567	C	7.7	0.015	26.46	26.4	0.9	0	1	0.3	0.2
2571	C	9.3	0.015	26.52	26.32	0.375	0	1	0.3	0.2
2573	C	14.3	0.015	26.31	26.08	0.375	0	1	0.3	0.2
2578	C	9.4	0.015	26.4	26.23	0.525	0	1	0.3	0.2

Pipe ID	Type	Length	Manning's n	US_Invert	DS_Invert	Width_or_Dia	Height_or_WF	Number_of Conduit	Entry_Loss	Exis_Loss
2581	C	15.3	0.015	26.53	26.43	0.45	0	1	0.3	0.2
2587	C	26.5	0.015	26.4	26.2	0.45	0	1	0.3	0.2
2588	C	32	0.015	26.63	26.2	0.375	0	1	0.3	0.2
2589	C	12.5	0.015	27.08	26.55	0.375	0	1	0.3	0.2
2593	C	15.8	0.015	27.2	27.1	0.375	0	1	0.3	0.2
2594	C	13.3	0.015	27.02	26.92	0.375	0	1	0.3	0.2
2597	C	38.1	0.015	25.95	25.92	0.75	0	1	0.3	0.2
2605	C	5.2	0.015	27.7	27.6	0.375	0	1	0.3	0.2
2606	C	35.8	0.015	30.38	30.05	0.45	0	1	0.3	0.2
2895	R	13.7	0.015	29.73	29.63	0.8	0.4	1	0.3	0.2
2607	C	7.9	0.015	30.33	30.23	0.45	0	1	0.3	0.2
2608	C	13.7	0.015	30.47	30.23	0.3	0	1	0.3	0.2
2613	R	26.5	0.015	29.55	29.49	1.45	1.2	1	0.3	0.2
2027	R	66.8	0.015	29.3	28.42	2.15	1.2	1	0.3	0.2
2615	C	8.6	0.015	29.93	29.83	0.375	0	1	0.3	0.2
2614	C	23.1	0.015	30.27	30.17	0.375	0	1	0.3	0.2
2617	C	35.6	0.015	29.39	29.02	0.375	0	1	0.3	0.2
2618	C	63	0.015	28.97	28.4	0.375	0	1	0.3	0.2
2619	C	103.4	0.015	28.34	28.1	0.45	0	1	0.3	0.2
2620	C	12.3	0.015	27.2	27	0.375	0	1	0.3	0.2
2621	C	69.9	0.015	27	26.35	0.45	0	1	0.3	0.2
2622	C	5.7	0.015	26.33	26.23	0.45	0	1	0.3	0.2
2624	C	8.3	0.015	26.86	26.53	0.225	0	1	0.3	0.2
2625	C	29.1	0.015	26.28	26.1	0.3	0	1	0.3	0.2
2630	C	48.8	0.015	26.32	26.02	0.3	0	1	0.3	0.2
2631	C	4.7	0.015	25.33	25.2	0.7	0	1	0.3	0.2
2626	C	4.1	0.015	25.2	25.18	0.7	0	1	0.3	0.2
2635	C	14.6	0.015	26.04	25.03	0.375	0	1	0.3	0.2
2634	C	18.4	0.015	25.17	25.06	0.7	0	1	0.3	0.2
2636	C	7.2	0.015	25.06	24.94	0.7	0	1	0.3	0.2
2637	C	13.7	0.015	24.94	24.84	0.7	0	1	0.3	0.2
2638	C	4.2	0.015	25.58	25.48	0.45	0	1	0.3	0.2
2639	C	7.05	0.015	26.36	26	0.375	0	1	0.3	0.2
2662	C	11.2	0.015	54.42	54.03	0.375	0	1	0.3	0.2
2693	C	8	0.015	28.17	28.07	0.45	0	1	0.3	0.2
2695	C	10.4	0.015	27.4	27.25	0.375	0	1	0.3	0.2
2696	C	8.2	0.015	27.11	27.01	0.375	0	1	0.3	0.2
2697	R	19.23	0.015	25.63	25.3	2.4	1.5	1	0.3	0.2
2699	C	24.61	0.015	25.3	25.2	1.8	0	1	0.3	0.2
2702	C	2.1	0.015	26.34	26.24	0.3	0	1	0.3	0.2
2701	C	1.3	0.015	26.6	26.5	0.3	0	1	0.3	0.2
2700	R	56.8	0.015	26.52	25.64	1.8	1.5	1	0.3	0.2
2698	R	54.9	0.015	25.52	25.47	2.4	1.5	1	0.3	0.2
2707	C	3.8	0.015	29.32	29.22	0.3	0	1	0.3	0.2
2706	C	3.7	0.015	28.35	28.25	0.375	0	1	0.3	0.2
2612	R	31	0.015	27.49	27.12	1.8	1.2	1	0.3	0.2
2609	C	127.9	0.015	31.21	29.57	1.2	0	1	0.3	0.2
2611	C	102.8	0.015	31.21	30	1.2	0	1	0.3	0.2
2709	C	15	0.015	31.8	31.73	0.3	0	1	0.3	0.2
2710	C	13	0.015	31.71	31.48	0.3	0	1	0.3	0.2
2714	C	11.9	0.015	30.58	30.1	0.6	0	1	0.3	0.2
2718	C	2.7	0.015	32.72	32.42	0.3	0	1	0.3	0.2
2720	C	493.5	0.015	22.11	19.62	2.15	0	1	0.3	0.2
2722	C	12.3	0.015	22.08	22.05	2.15	0	1	0.3	0.2
2723	C	50.3	0.015	22.05	21.77	2.15	0	1	0.3	0.2
2726	C	5.5	0.015	25.36	24.99	0.25	0	1	0.3	0.2
2729	C	7.8	0.015	22.43	22.39	2.15	0	1	0.3	0.2

Pipe ID	Type	Length	Manning's n	US_Invert	DS_Invert	Width_or_Dia	Height_or_WF	Number_of Conduit	Entry_Loss	Exis_Loss
2721	C	28.7	0.015	22.39	22.28	2.15	0	1	0.3	0.2
2744	C	9.5	0.015	24.05	22.28	0.375	0	1	0.3	0.2
2735	C	8	0.015	25.09	24.75	0.375	0	1	0.3	0.2
2736	C	7.7	0.015	25.3	25.13	0.375	0	1	0.3	0.2
2738	C	5.5	0.015	22.84	22.71	1.25	0	1	0.3	0.2
2739	C	20	0.015	22.71	22.6	2.15	0	1	0.3	0.2
2740	C	60.3	0.015	21.51	21.23	2.15	0	1	0.3	0.2
2742	C	328	0.015	21.23	19.62	2.15	0	1	0.3	0.2
2749	C	13.6	0.015	25.16	24.8	0.375	0	1	0.3	0.2
2747	C	78.8	0.015	25.36	25	0.45	0	1	0.3	0.2
2746	R	12.7	0.015	26.15	25.94	0.35	0.15	1	0.3	0.2
2748	R	4.2	0.015	26.33	26.17	0.35	0.15	1	0.3	0.2
2745	R	4.2	0.015	26.42	26.39	0.6	0.25	1	0.3	0.2
2750	R	1.9	0.015	26.45	26.39	0.4	0.15	1	0.3	0.2
2751	R	23.6	0.015	26.36	26.15	0.35	0.15	1	0.3	0.2
2756	C	7.5	0.015	25.01	24.77	0.375	0	1	0.3	0.2
2757	C	6.7	0.015	24.7	24.4	0.375	0	1	0.3	0.2
2758	C	13	0.015	25.15	24.76	0.375	0	1	0.3	0.2
2760	C	50.1	0.015	23.98	23.42	0.525	0	1	0.3	0.2
2762	C	8.8	0.015	24.2	24.1	0.45	0	1	0.3	0.2
2038	C	146.3	0.015	23.56	23.26	1.35	0	1	0.3	0.2
2766	C	22.3	0.015	24.64	24.53	0.45	0	1	0.3	0.2
2767	C	22.9	0.015	24.29	24.21	0.45	0	1	0.3	0.2
2768	C	24.3	0.015	26.15	25.81	0.225	0	1	0.3	0.2
2771	C	22.4	0.015	25.42	25.32	0.375	0	1	0.3	0.2
2772	C	9.6	0.015	24.68	24.33	0.45	0	1	0.3	0.2
2774	C	14.6	0.015	26.35	26.01	0.375	0	1	0.3	0.2
2776	C	30.4	0.015	26.29	26.18	0.3	0	1	0.3	0.2
2777	C	42.2	0.015	26.16	26.03	0.3	0	1	0.3	0.2
2778	C	4.1	0.015	26.41	26.36	0.3	0	1	0.3	0.2
2780	C	4.6	0.015	26	25.95	0.375	0	1	0.3	0.2
2785	R	27	0.015	25.84	25.81	0.45	0.3	1	0.3	0.2
2787	C	47.6	0.015	25.65	24.49	0.375	0	1	0.3	0.2
2793	C	18.9	0.015	26.52	26.45	0.375	0	1	0.3	0.2
2792	C	19.3	0.015	26.52	26.45	0.225	0	1	0.3	0.2
2790	C	46.4	0.015	26.42	26.17	0.375	0	1	0.3	0.2
2791	C	46.7	0.015	26.46	26.17	0.225	0	1	0.3	0.2
2801	C	13.9	0.015	25.68	25.47	0.375	0	1	0.3	0.2
2798	C	9.3	0.015	25.97	25.92	0.3	0	1	0.3	0.2
2934	C	6.1	0.015	24.92	24.7	0.375	0	1	0.3	0.2
2804	C	11.8	0.015	26.12	25.98	0.3	0	1	0.3	0.2
2805	C	3.8	0.015	25.97	25.18	0.3	0	1	0.3	0.2
2807	C	10.8	0.015	25.86	25.1	0.45	0	1	0.3	0.2
2806	C	7.2	0.015	25.47	25.37	0.3	0	1	0.3	0.2
2809	C	21.6	0.015	26.24	26.06	0.3	0	1	0.3	0.2
2811	C	47.2	0.015	25.81	25	0.375	0	1	0.3	0.2
2813	C	48.1	0.015	26.1	25.97	0.375	0	1	0.3	0.2
2815	C	88.3	0.015	25.92	25.68	0.525	0	1	0.3	0.2
2818	C	66	0.015	25.53	25.25	0.6	0	1	0.3	0.2
2820	C	8.5	0.015	26.09	25.92	0.3	0	1	0.3	0.2
2821	R	15.1	0.015	25.89	25.71	0.5	0.35	1	0.3	0.2
2826	C	9.5	0.015	26.3	25.93	0.375	0	1	0.3	0.2
2834	C	6.7	0.015	26.62	26.57	0.375	0	1	0.3	0.2
2835	C	55.7	0.015	26.57	26.45	0.375	0	1	0.3	0.2
2836	C	48.7	0.015	26.44	26.21	0.375	0	1	0.3	0.2
2838	C	14	0.015	26.46	26.3	0.3	0	1	0.3	0.2
2839	C	49.4	0.015	26.28	26.16	0.375	0	1	0.3	0.2

Pipe ID	Type	Length	Manning's n	US_Invert	DS_Invert	Width_or_Dia	Height_or_WF	Number_of Conduit	Entry_Loss	Exis_Loss
2840	C	8.7	0.015	26.15	26.1	0.525	0	1	0.3	0.2
2841	C	5	0.015	26.13	25.98	0.375	0	1	0.3	0.2
2842	C	37.5	0.015	25.98	25.67	0.375	0	1	0.3	0.2
2846	C	7.6	0.015	26.8	26.65	0.525	0	1	0.3	0.2
2845	C	23.4	0.015	26.65	26.52	0.525	0	1	0.3	0.2
2843	C	17.2	0.015	26.51	26.44	0.525	0	1	0.3	0.2
2848	R	3.8	0.015	26.57	26.47	0.8	0.3	1	0.3	0.2
2849	R	8.1	0.015	26.62	26.52	0.8	0.3	1	0.3	0.2
2851	C	78.9	0.015	26.58	26.3	0.375	0	1	0.3	0.2
2850	C	55.2	0.015	26.39	26.21	0.525	0	1	0.3	0.2
2854	C	101.2	0.015	30.4	28.59	0.45	0	1	0.3	0.2
2856	C	2.5	0.015	28.67	28.39	0.375	0	1	0.3	0.2
2858	C	48.1	0.015	28.6	28.37	0.65	0	1	0.3	0.2
2859	C	2.3	0.015	28.57	28.5	0.375	0	1	0.3	0.2
2863	C	1.8	0.015	28.53	28.5	0.45	0	1	0.3	0.2
3032	R	117.3	0.015	27	26.21	1.8	1.3	1	0.3	0.2
2875	C	4.7	0.015	35.69	35.66	0.65	0	1	0.3	0.2
2874	C	18.8	0.015	36.02	35.71	0.825	0	1	0.3	0.2
2878	C	21.8	0.015	35.46	35.21	0.75	0	1	0.3	0.2
2887	C	59.9	0.015	35.21	34.54	0.75	0	1	0.3	0.2
2879	C	17.2	0.015	37.46	36.51	0.6	0	1	0.3	0.2
2889	R	39.9	0.015	30.74	30.4	1.8	1.4	1	0.3	0.2
2888	R	62.9	0.015	30.4	29.73	1.8	1.4	1	0.3	0.2
2890	R	55.27	0.015	31.01	30.74	1.8	1.4	1	0.3	0.2
2893	R	117.8	0.015	32.44	31.8	1.6	1	1	0.3	0.2
2883	R	165.5	0.015	29.33	28.16	1.8	1.3	1	0.3	0.2
2896	C	9.5	0.015	29.99	29.89	0.3	0	1	0.3	0.2
2903	C	195.9	0.015	26.3	25.8	1.05	0	1	0.3	0.2
2905	C	7.2	0.015	27.23	27.13	0.375	0	1	0.3	0.2
2906	C	69.8	0.015	27.06	26.85	0.7	0	1	0.3	0.2
3050	R	45.3	0.015	53.52	53.42	0.4	0.35	1	0.3	0.2
2914	C	18.9	0.015	54.64	53.52	0.375	0	1	0.3	0.2
2915	C	63.6	0.015	53.4	51.2	0.375	0	1	0.3	0.2
2918	C	58.9	0.015	35.76	34.44	0.375	0	1	0.3	0.2
2919	C	4.6	0.015	29.39	29.34	0.375	0	1	0.3	0.2
2920	C	17.2	0.015	29.32	29.08	0.375	0	1	0.3	0.2
2921	C	9.8	0.015	29.07	28.8	0.45	0	1	0.3	0.2
2922	C	34.5	0.015	28.5	27.9	0.6	0	1	0.3	0.2
2923	C	17.2	0.015	32.58	32.25	0.45	0	1	0.3	0.2
2924	C	27.9	0.015	32.25	32.15	0.45	0	1	0.3	0.2
2928	C	28.8	0.015	39.91	38.84	0.45	0	1	0.3	0.2
2930	C	13.3	0.015	25.87	25.79	0.375	0	1	0.3	0.2
2931	C	11.7	0.015	25.95	25.87	0.375	0	1	0.3	0.2
2933	R	11.2	0.015	25.63	25.5	0.5	0.5	1	0.3	0.2
2935	C	18.3	0.015	25.05	24.93	0.375	0	1	0.3	0.2
2937	C	54.7	0.015	25.18	25.07	0.375	0	1	0.3	0.2
2940	C	54.7	0.015	25.38	25.18	0.375	0	1	0.3	0.2
2942	C	35.3	0.015	24.99	24.41	0.375	0	1	0.3	0.2
2945	C	66.4	0.015	24.36	24.25	0.45	0	1	0.3	0.2
2946	C	23	0.015	24.77	24.36	0.45	0	1	0.3	0.2
2955	C	33.1	0.015	24.3	23.9	0.45	0	1	0.3	0.2
2957	C	2.4	0.015	26.09	26.08	0.375	0	1	0.3	0.2
2959	C	3.6	0.015	26.16	26.1	0.375	0	1	0.3	0.2
2958	R	8.3	0.015	26.08	26.03	0.35	0.6	1	0.3	0.2
2961	R	21.7	0.015	26.15	26.08	0.35	0.6	1	0.3	0.2
2962	C	2.5	0.015	26.14	26.04	0.375	0	1	0.3	0.2
2963	C	2.7	0.015	26.14	26.04	0.375	0	1	0.3	0.2

Pipe ID	Type	Length	Manning's n	US_Invert	DS_Invert	Width_or_Dia	Height_or_WF	Number_of Conduit	Entry_Loss	Exis_Loss
2964	C	19.2	0.015	26.36	26.2	0.375	0	1	0.3	0.2
2967	R	20.2	0.015	38.46	38.35	0.3	1.2	1	0.3	0.2
2970	C	45.6	0.015	38.16	37.83	0.7	0	1	0.3	0.2
2977	C	28.1	0.015	55.86	55.61	0.375	0	1	0.3	0.2
2978	C	20.9	0.015	55.6	55	0.45	0	1	0.3	0.2
2980	C	3.4	0.015	26.39	26.35	0.3	0	1	0.3	0.2
2981	C	4	0.015	25.97	25.74	0.375	0	1	0.3	0.2
2984	C	2.6	0.015	26.4	26.19	0.375	0	1	0.3	0.2
2983	C	6.1	0.015	25.88	25.73	0.375	0	1	0.3	0.2
2982	C	7.56	0.015	26.48	26.46	0.375	0	1	0.3	0.2
2989	C	5.9	0.015	25.87	25.59	0.375	0	1	0.3	0.2
2987	C	3.71	0.015	26.37	26.32	0.375	0	1	0.3	0.2
2988	C	3.6	0.015	26.22	26.12	0.375	0	1	0.3	0.2
2990	C	2.2	0.015	26.41	26.31	0.375	0	1	0.3	0.2
2992	C	7.9	0.015	24.1	24	1.8	0	1	0.3	0.2
2991	C	8.1	0.015	25.01	24.82	0.45	0	1	0.3	0.2
2998	C	3.1	0.015	29.37	29.27	0.375	0	1	0.3	0.2
2129	C	14.8	0.015	24.31	24.22	1.95	0	1	0.3	0.2
2985	C	25	0.015	24.85	24.74	1.8	0	1	0.3	0.2
3002	C	31	0.015	25.85	25.8	0.375	0	1	0.3	0.2
3004	C	19.6	0.015	26.47	26.15	0.45	0	1	0.3	0.2
3005	C	5.3	0.015	26.79	26.5	0.3	0	1	0.3	0.2
3006	C	0.6	0.015	26.04	26.02	0.3	0	1	0.3	0.2
3003	C	16	0.015	26.01	25.6	0.375	0	1	0.3	0.2
3034	C	9.3	0.015	26.38	26.28	0.375	0	1	0.3	0.2
3020	C	25.5	0.015	24.52	24.29	0.45	0	1	0.3	0.2
2623	C	9.4	0.015	26.51	26.01	0.45	0	1	0.3	0.2
7000	C	6.6	0.015	48.97	48.94	0.375	0	1	0.3	0.2
7001	C	46.4	0.015	53.31	53.24	0.375	0	1	0.3	0.2
7003	C	21.6	0.015	40.88	40.5	0.45	0	1	0.3	0.2
7004	C	34.7	0.015	36.48	36.28	1.35	0	1	0.3	0.2
7006	R	15	0.015	35.3	35.1	1.6	1.4	1	0.3	0.2
7005	R	1.5	0.015	35.37	35.3	1.6	1.4	1	0.3	0.2
7094	R	7.8	0.015	35.1	34.94	1.6	1.4	1	0.3	0.2
7008	C	3.3	0.015	38.88	38.82	0.6	0	1	0.3	0.2
7009	R	50.1	0.015	29.73	29.58	1.8	1.3	1	0.3	0.2
7010	R	17	0.015	29.58	29.53	1.8	1.3	1	0.3	0.2
7096	R	78.4	0.015	28.16	27.29	1.8	1.3	1	0.3	0.2
7018	R	25.1	0.015	36.36	35.95	1.5	1.2	1	0.3	0.2
7019	R	39.2	0.015	35.95	35.36	1.5	1.2	1	0.3	0.2
7020	R	93.4	0.015	35.36	34.96	1.5	1.2	1	0.3	0.2
7021	R	6	0.015	36.86	36.6	0.9	0.2	1	0.3	0.2
7022	R	26.8	0.015	34.96	34.3	1.5	1.2	1	0.3	0.2
7023	C	15.2	0.015	44.23	44.18	0.525	0	1	0.3	0.2
7024	C	8.2	0.015	42.66	42.45	0.45	0	1	0.3	0.2
7025	C	3.8	0.015	42.23	42.2	0.525	0	1	0.3	0.2
7026	R	10.1	0.015	33.98	33.85	1.5	1.2	1	0.3	0.2
7027	R	15.7	0.015	32.3	32.07	1.5	1.2	1	0.3	0.2
7028	C	4.4	0.015	33.06	33.02	0.75	0	1	0.3	0.2
7029	C	12.6	0.015	33.02	32.91	0.75	0	1	0.3	0.2
7030	C	9	0.015	32.91	32.83	0.75	0	1	0.3	0.2
7031	C	25.3	0.015	30	29.55	1.2	0	1	0.3	0.2
3051	R	16.2	0.015	32.07	31.87	1.5	1.2	1	0.3	0.2
7033	R	7.4	0.015	29.49	29.39	2.15	1.2	1	0.3	0.2
7034	R	6.7	0.015	29.39	29.3	2.15	1.2	1	0.3	0.2
7035	R	75.7	0.015	28.42	27.55	2.1	1.85	1	0.3	0.2
7036	R	110.6	0.015	27.55	26.63	2.1	1.85	1	0.3	0.2

Pipe ID	Type	Length	Manning's n	US_Invert	DS_Invert	Width_or_ Dia	Height_ or_WF	Number_of Conduit	Entry_Loss	Exis_Loss
7037	R	169.7	0.015	26.63	25.79	2.1	1.85	1	0.3	0.2
7038	R	40.9	0.015	25.79	25.7	2.1	1.85	1	0.3	0.2
7039	R	22.7	0.015	25.35	24.1	2.1	1.85	1	0.3	0.2
7045	C	205.8	0.015	24	23	2.15	0	1	0.3	0.2
7046	R	92.3	0.015	29.55	28.48	1.8	1.2	1	0.3	0.2
7047	R	5.8	0.015	28.48	28.41	1.8	1.2	1	0.3	0.2
7048	R	60.5	0.015	28.41	27.71	1.8	1.2	1	0.3	0.2
7049	R	19	0.015	27.71	27.49	1.8	1.2	1	0.3	0.2
7050	R	2.2	0.015	27.12	26.52	1.8	1.2	1	0.3	0.2
7051	R	62.1	0.015	26.52	26.1	1.8	1.5	1	0.3	0.2
7052	R	18.5	0.015	25.78	25.64	1.8	1.5	1	0.3	0.2
7053	R	3.8	0.015	30.05	30.23	0.8	0.4	1	0.3	0.2
7054	C	11.1	0.015	25.55	25.5	0.9	0	1	0.3	0.2
7055	C	5.3	0.015	25.5	25.49	0.9	0	1	0.3	0.2
7056	C	1.6	0.015	26.51	26.47	0.45	0	1	0.3	0.2
7057	C	3.2	0.015	26.15	26.01	0.45	0	1	0.3	0.2
7058	C	32.7	0.015	25.3	25.2	0.9	0	1	0.3	0.2
7059	C	1.9	0.015	25.35	25.33	0.375	0	1	0.3	0.2
7060	C	7.2	0.015	25.6	25.38	0.375	0	1	0.3	0.2
7061	C	7.2	0.015	25.6	25.38	0.375	0	1	0.3	0.2
7063	C	50.2	0.015	25.2	25	1.8	0	1	0.3	0.2
7064	C	30	0.015	25	24.85	1.8	0	1	0.3	0.2
7065	C	10.6	0.015	24.73	24.69	1.95	0	1	0.3	0.2
7066	C	69	0.015	24.69	24.41	1.95	0	1	0.3	0.2
7077	C	27.3	0.015	24.41	24.31	1.95	0	1	0.3	0.2
7068	S	132.4	1	34.94	32.44	0	0	1	0.3	0.2
7069	R	15.6	0.015	26.15	26.09	0.8	0.5	1	0.3	0.2
7070	R	6.7	0.015	25.64	25.6	0.9	0.5	1	0.3	0.2
7071	R	9.9	0.015	25.6	25.58	0.9	0.5	1	0.3	0.2
7072	C	6.7	0.015	25.87	25.81	0.375	0	1	0.3	0.2
7073	C	10.1	0.015	25.81	25.75	0.375	0	1	0.3	0.2
7074	C	3.1	0.015	27.3	27.27	0.45	0	1	0.3	0.2
7075	C	23.8	0.015	26.11	25.96	0.3	0	1	0.3	0.2
7076	C	15.1	0.015	24.21	24	0.45	0	1	0.3	0.2
7083	C	46.4	0.015	23.9	23.26	0.45	0	1	0.3	0.2
7078	C	50.8	0.015	23.26	23.16	1.35	0	1	0.3	0.2
7079	C	49	0.015	22.28	22.08	2.15	0	1	0.3	0.2
7080	C	49.7	0.015	21.77	21.52	2.15	0	1	0.3	0.2
7081	C	91.4	0.015	53.24	49.01	0.45	0	1	0.3	0.2
7082	C	22.5	0.015	42.4	41.82	0.7	0	1	0.3	0.2
7086	R	19.7	0.015	26.68	26.6	1.4	0.9	1	0.3	0.2
7087	R	5.9	0.015	26	25.93	2.4	1.1	1	0.3	0.2
7088	R	17.1	0.015	25.93	25.79	2.4	1.1	1	0.3	0.2
7091	C	15.3	0.015	26.4	26.3	0.375	0	1	0.3	0.2
7092	C	66.8	0.015	41	40.5	0.75	0	1	0.3	0.2
7093	C	51.8	0.015	38.4	37	0.6	0	1	0.3	0.2
7097	C	8.8	0.015	26.1	25.9	0.675	0	1	0.3	0.2
7098	C	52	0.015	26.2	26	0.525	0	1	0.3	0.2
7099	C	16.3	0.015	27.04	26.9	0.6	0	1	0.3	0.2
7100	C	57.2	0.015	25.25	24.56	0.6	0	1	0.3	0.2
7101	R	7.9	0.015	24.59	24.56	5	1.6	1	0.3	0.2
3021	R	29.5	0.015	24.56	24.5	5	1.6	1	0.3	0.2
B2_1	R	30.7	0.02	26.86	26.58	3.11	2.12	1	0.3	0.2
9012	S	7.2	0.02	26.58	26.51	0	0	1	0.3	0.2
9013	S	6.9	0.02	26.51	26.49	0	0	1	0.3	0.2
9014	S	7.8	0.02	26.49	26.49	0	0	1	0.3	0.2
9015	S	31.3	0.02	26.49	26.42	0	0	1	0.3	0.2

Pipe ID	Type	Length	Manning's n	US_Invert	DS_Invert	Width_or_Dia	Height_or_WF	Number_of Conduit	Entry_Loss	Exis_Loss
9016	S	12	0.02	26.42	26.39	0	0	1	0.3	0.2
9018	S	32	0.02	26.38	26.34	0	0	1	0.3	0.2
9020	S	17.3	0.02	26.31	26.21	0	0	1	0.3	0.2
9021	S	69.4	0.02	26.21	26.06	0	0	1	0.3	0.2
J1_1	R	9.7	0.02	26.06	26.03	6.19	2.15	1	0.3	0.2
9023	S	30.4	0.02	26.03	25.91	0	0	1	0.3	0.2
9024	S	20.9	0.02	25.91	25.9	0	0	1	0.3	0.2
9025	S	36.6	0.02	25.9	25.84	0	0	1	0.3	0.2
9026	S	68.1	0.02	25.84	25.66	0	0	1	0.3	0.2
9027	S	41	0.02	25.66	25.55	0	0	1	0.3	0.2
9028	S	7.9	0.02	25.55	25.55	0	0	1	0.3	0.2
9002	S	100.5	0.02	25.09	24.85	0	0	1	0.3	0.2
9006	S	139.5	0.02	25.64	25.57	0	0	1	0.3	0.2
9007	N	41.9	0.02	25.57	25.51	0	0	1	0.3	0.2
9008	N	14.6	0.02	25.51	25.09	0	0	1	0.3	0.2
B1_2	R	9.66	0.02	28.37	28.21	2.82	1.4	1	0.3	0.2
B1_1	R	9.66	0.02	28.37	28.21	3.02	1.44	1	0.3	0.2
B1_3	R	9.66	0.02	28.37	28.21	3.14	1.44	1	0.3	0.2
R1_4	R	9.66	0.02	28.37	28.21	3.25	1.49	1	0.3	0.2
B3_1	R	4	0.02	26.49	26.49	6.22	2.27	1	0.3	0.2
D1_1	R	4	0.02	26.49	26.49	6.12	2.14	1	0.3	0.2
E1_1	R	4	0.02	26.42	26.42	6.29	2.2	1	0.3	0.2
F1_1	R	12	0.02	26.39	26.38	6.19	2.24	1	0.3	0.2
G1_1	R	4	0.02	26.34	26.34	6.17	2.13	1	0.3	0.2
H1_1	R	4	0.02	26.31	26.31	6.17	2.24	1	0.3	0.2
I1_1	R	4	0.02	26.21	26.21	6.27	2.28	1	0.3	0.2
K1_1	R	4	0.02	25.91	25.91	6.23	2.16	1	0.3	0.2
L1_1	R	5	0.02	25.9	25.9	6.25	2.13	1	0.3	0.2
M1_1	R	4	0.02	25.84	25.84	6.25	2.13	1	0.3	0.2
N1_1	R	5	0.02	25.66	25.66	6.66	2.26	1	0.3	0.2
B2_2	R	30.7	0.02	26.86	26.58	3.04	2.19	1	0.3	0.2
O1_1b	R	306.6	0.015	25.55	23.25	2.9	1.6	1	0.3	0.2
2674	C	12.3	0.015	49.42	49.07	0.375	0	1	0.3	0.2
2676	C	2.5	0.015	49.07	48.97	0.375	0	1	0.3	0.2
2677	C	14	0.015	48.94	48.85	0.375	0	1	0.3	0.2
2678	C	25	0.015	48.81	48.74	0.45	0	1	0.3	0.2
2671	C	8	0.015	48.98	48.82	0.375	0	1	0.3	0.2
2453	C	64.4	0.015	48.74	47.15	0.45	0	1	0.3	0.2
2451	C	3.4	0.015	47.22	47.14	0.45	0	1	0.3	0.2
2450	C	8.9	0.015	47.12	46.87	0.65	0	1	0.3	0.2
2449	C	25.3	0.015	46.81	46.26	0.65	0	1	0.3	0.2
2448	C	13.6	0.015	46.23	46.07	0.65	0	1	0.3	0.2
2447	C	91.4	0.015	46.04	44.79	0.65	0	1	0.3	0.2
2446	C	29.3	0.015	44.76	44.42	0.65	0	1	0.3	0.2
2444	C	50.2	0.015	44.15	43.29	0.7	0	1	0.3	0.2
2440	C	25.8	0.015	43.04	42.93	0.45	0	1	0.3	0.2
2442	C	23.9	0.015	43.27	42.93	0.3	0	1	0.3	0.2
2445	C	26.8	0.015	42.78	42.27	0.75	0	1	0.3	0.2
3040	C	33	0.015	42.27	42.17	0.75	0	1	0.3	0.2
3039	C	34.4	0.015	42.17	41	0.75	0	1	0.3	0.2
2666	C	10.2	0.015	52.38	52.3	0.45	0	1	0.3	0.2
2667	C	14.6	0.015	52.28	52.12	0.375	0	1	0.3	0.2
2685	C	80.2	0.015	52.15	49.63	0.45	0	1	0.3	0.2
2681	C	19.7	0.015	50.31	49.99	0.375	0	1	0.3	0.2
2682	C	24.3	0.015	49.96	49.69	0.375	0	1	0.3	0.2
2684	C	22.8	0.015	49.6	49.21	0.6	0	1	0.3	0.2
2687	C	14.1	0.015	50.32	49.43	0.375	0	1	0.3	0.2

Pipe ID	Type	Length	Manning's n	US_Invert	DS_Invert	Width_or_Dia	Height_or_WF	Number_of Conduit	Entry_Loss	Exis_Loss
2686	C	28.5	0.015	49.2	48.65	0.6	0	1	0.3	0.2
2475	C	66.5	0.015	48.63	46.19	0.6	0	1	0.3	0.2
2478	C	9	0.015	45.06	44.85	0.3	0	1	0.3	0.2
2353	C	118.8	0.015	44.83	41.28	0.3	0	1	0.3	0.2
2352	C	13	0.015	41.06	41.05	0.375	0	1	0.3	0.2
2354	C	68.4	0.015	40.5	38.3	1.05	0	1	0.3	0.2
2357	C	74.4	0.015	38.26	37.64	1.05	0	1	0.3	0.2
2358	C	64.6	0.015	37.64	37.01	0.9	0	1	0.3	0.2
2437	C	13	0.015	40.3	40.09	0.525	0	1	0.3	0.2
2632	C	26.2	0.015	36.82	35.75	0.9	0	1	0.3	0.2
2378	C	47.1	0.015	35.76	35.62	1.35	0	1	0.3	0.2
2641	C	12	0.015	56.51	56.21	0.375	0	1	0.3	0.2
2648	C	32.9	0.015	53.58	53.31	0.45	0	1	0.3	0.2
2647	C	10.8	0.015	53.4	53.35	0.45	0	1	0.3	0.2
2646	C	23.6	0.015	53.32	53.24	0.45	0	1	0.3	0.2
2649	C	13.7	0.015	53.4	53.33	0.375	0	1	0.3	0.2
2650	C	10.8	0.015	53.32	53.24	0.375	0	1	0.3	0.2
2664	C	87.8	0.015	56.5	53.68	0.375	0	1	0.3	0.2
2336	C	7.7	0.015	48.25	47.91	0.525	0	1	0.3	0.2
2335	C	51.2	0.015	47.89	47.5	0.6	0	1	0.3	0.2
2688	C	2.1	0.015	48.74	48.69	0.525	0	1	0.3	0.2
2689	C	2.2	0.015	48.67	48.63	0.525	0	1	0.3	0.2
2691	C	8.5	0.015	48.6	48.57	0.65	0	1	0.3	0.2
2692	C	57.4	0.015	48.55	48.04	0.65	0	1	0.3	0.2
2333	C	37.1	0.015	48.04	47.68	0.6	0	1	0.3	0.2
2334	C	43.9	0.015	47.64	47.5	0.6	0	1	0.3	0.2
3038	C	105.5	0.015	47.5	45.42	0.375	0	1	0.3	0.2
2328	C	13.7	0.015	45.3	45.07	0.375	0	1	0.3	0.2
2332	C	41.5	0.015	45.07	44.97	0.45	0	1	0.3	0.2
3036	C	52.4	0.015	44.97	43.85	0.375	0	1	0.3	0.2
2344	C	40.7	0.015	43.85	42.33	0.9	0	1	0.3	0.2
2345	C	15.2	0.015	42.32	42.04	1.05	0	1	0.3	0.2
2346	C	30.2	0.015	42.02	41.75	1.05	0	1	0.3	0.2
2348	C	22.7	0.015	41.75	41.25	1.05	0	1	0.3	0.2
3042	C	37.9	0.015	41.25	41.06	1.05	0	1	0.3	0.2
2325	C	38.9	0.015	41.06	40.42	1.05	0	1	0.3	0.2
2320	C	9.8	0.015	39.64	39.45	1.05	0	1	0.3	0.2
2369	C	83.2	0.015	39	36.91	1.35	0	1	0.3	0.2
2368	C	20.5	0.015	36.9	36.48	1.35	0	1	0.3	0.2
2472	C	9.9	0.015	48.26	47.96	0.3	0	1	0.3	0.2
2533	C	5.5	0.015	43.33	43.32	0.375	0	1	0.3	0.2
2532	C	111.3	0.015	43.3	41.45	0.375	0	1	0.3	0.2
2531	C	12.4	0.015	41.44	41.35	0.375	0	1	0.3	0.2
2397	C	77.1	0.015	40.69	38.87	0.45	0	1	0.3	0.2
2398	C	13.4	0.015	38.86	38.78	0.45	0	1	0.3	0.2
2399	C	14.3	0.015	38.72	38.55	0.45	0	1	0.3	0.2
2400	C	21.7	0.015	38.55	37.98	0.525	0	1	0.3	0.2
2405	C	18.9	0.015	34.94	34.91	0.75	0	1	0.3	0.2
2317	C	70.3	0.015	41.27	40.02	0.375	0	1	0.3	0.2
2315	C	13.3	0.015	39.67	39.41	0.375	0	1	0.3	0.2
2310	C	10.4	0.015	38.98	38.88	0.6	0	1	0.3	0.2
2316	C	50.6	0.015	39.41	38.88	0.375	0	1	0.3	0.2
2886	C	22.6	0.015	38.05	37.66	0.6	0	1	0.3	0.2
2884	C	10.3	0.015	37.64	37.47	0.825	0	1	0.3	0.2
2880	C	18.9	0.015	37.07	36.51	0.825	0	1	0.3	0.2
2881	C	19.1	0.015	37.07	36.51	0.825	0	1	0.3	0.2
2882	C	51.7	0.015	36.44	36.04	0.825	0	1	0.3	0.2

Pipe ID	Type	Length	Manning's n	US_Invert	DS_Invert	Width_or_Dia	Height_or_WF	Number_of Conduit	Entry_Loss	Exis_Loss
2872	C	53	0.015	36.44	36.04	0.825	0	1	0.3	0.2
2873	C	18.5	0.015	36.02	35.71	0.825	0	1	0.3	0.2
2418	C	40.3	0.015	34.54	34.09	0.75	0	1	0.3	0.2
2419	C	11.5	0.015	33.88	33.83	0.6	0	1	0.3	0.2
2422	C	8.8	0.015	34.85	34.73	0.3	0	1	0.3	0.2
2428	C	87.2	0.015	31.11	30.64	0.6	0	1	0.3	0.2
2429	C	5.9	0.015	30.59	30.51	0.375	0	1	0.3	0.2
2000	C	34.6	0.015	30.4	30.15	0.3	0	1	0.3	0.2
2602	R	5.6	0.015	30.6	30.25	0.45	0.3	1	0.3	0.2
2536	C	29.3	0.015	28.63	28.29	0.525	0	1	0.3	0.2
2537	C	6.5	0.015	28.29	28.11	0.525	0	1	0.3	0.2
2538	C	13.2	0.015	28.1	28.03	0.525	0	1	0.3	0.2
2539	C	63.8	0.015	28.01	27.84	0.6	0	1	0.3	0.2
2540	C	40.9	0.015	27.82	27.59	0.6	0	1	0.3	0.2
2541	C	56	0.015	27.59	27.55	0.6	0	1	0.3	0.2
2542	C	12.7	0.015	27.8	27.59	0.375	0	1	0.3	0.2
2543	C	8.9	0.015	27.55	27.46	0.525	0	1	0.3	0.2
2552	C	23.7	0.015	27.5	27.38	0.45	0	1	0.3	0.2
2545	C	54.3	0.015	27.45	27.06	0.375	0	1	0.3	0.2
2549	C	27.5	0.015	27.06	27.05	0.6	0	1	0.3	0.2
2553	C	13	0.015	27.65	27.55	0.525	0	1	0.3	0.2
7012	R	17.4	0.015	27.29	27	1.8	1.3	1	0.3	0.2
2847	R	51.7	0.015	26.47	26.41	0.6	0.35	1	0.3	0.2
2844	R	5.5	0.015	26.41	26.39	0.6	0.35	1	0.3	0.2
7013	R	98.7	0.015	26.21	26.1	1.8	1.3	1	0.3	0.2
2302	C	7.2	0.015	36	35.7	0.375	0	1	0.3	0.2
2301	C	4.8	0.015	35.7	35.5	0.375	0	1	0.3	0.2
2298	C	14.2	0.015	35.5	35.33	0.375	0	1	0.3	0.2
2297	C	26.6	0.015	35.3	33.82	0.375	0	1	0.3	0.2
2296	C	32.6	0.015	33.53	31.76	0.375	0	1	0.3	0.2
2289	C	68.6	0.015	31.6	28.9	0.375	0	1	0.3	0.2
2288	C	7	0.015	28.63	28.44	0.375	0	1	0.3	0.2
2292	C	15.8	0.015	28.49	28.44	0.45	0	1	0.3	0.2
2285	C	15.1	0.015	28.36	27.76	0.45	0	1	0.3	0.2
2293	C	4.2	0.015	28.64	28.46	0.375	0	1	0.3	0.2
2305	C	13.5	0.015	41.41	41.07	0.375	0	1	0.3	0.2
2304	R	12.6	0.015	41.04	40.5	0.8	0.18	1	0.3	0.2
2386	C	28.6	0.015	28.52	28.49	0.375	0	1	0.3	0.2
2388	C	8.9	0.015	28.49	28.48	0.45	0	1	0.3	0.2
2865	C	30.5	0.015	28.5	28.35	0.45	0	1	0.3	0.2
2864	C	3	0.015	28.49	28.48	0.45	0	1	0.3	0.2
2857	C	15.7	0.015	29	28.71	0.45	0	1	0.3	0.2
2860	C	5.8	0.015	28.62	28.58	0.375	0	1	0.3	0.2
2383	C	6.4	0.015	28.6	28.5	0.375	0	1	0.3	0.2
2382	C	15.9	0.015	28.5	28.37	0.45	0	1	0.3	0.2
2259	C	18.6	0.015	27.25	27.12	0.45	0	1	0.3	0.2
2008	C	16.4	0.015	31.41	30.98	0.375	0	1	0.3	0.2
2009	C	24.6	0.015	30.73	29.8	0.375	0	1	0.3	0.2
2560	C	29.8	0.015	27.22	26.9	0.45	0	1	0.3	0.2
2897	C	34.1	0.015	26.9	26.6	0.525	0	1	0.3	0.2
2565	C	103.7	0.015	26.6	26.37	0.6	0	1	0.3	0.2
2392	C	3.7	0.015	27.28	27.18	0.3	0	1	0.3	0.2
2394	C	93.4	0.015	26.9	26.57	0.6	0	1	0.3	0.2
2561	C	8.8	0.015	26.83	26.59	0.375	0	1	0.3	0.2
2276	C	89.8	0.015	27.6	26.86	0.9	0	1	0.3	0.2
2599	C	3.4	0.015	29.73	29.68	0.375	0	1	0.3	0.2
2598	C	12.5	0.015	29.67	29.33	0.375	0	1	0.3	0.2

Pipe ID	Type	Length	Manning's n	US_Invert	DS_Invert	Width_or_ Dia	Height_ or_WF	Number_of Conduit	Entry_Loss	Exis_Loss
2902	C	7.6	0.015	26.72	26.5	0.525	0	1	0.3	0.2
2270	C	26.1	0.015	28	27.59	0.525	0	1	0.3	0.2
2267	C	45.4	0.015	27.58	27.47	0.525	0	1	0.3	0.2
2268	C	15.2	0.015	27.28	27.25	0.7	0	1	0.3	0.2
2269	C	48.2	0.015	27.23	27.06	0.7	0	1	0.3	0.2
7085	C	92.8	0.015	26.85	26.7	0.675	0	1	0.3	0.2
7095	C	186.1	0.015	26.7	26.4	0.675	0	1	0.3	0.2
2576	C	36.4	0.015	26.8	26.68	0.6	0	1	0.3	0.2
2569	C	50.9	0.015	26.68	26.5	0.6	0	1	0.3	0.2
2568	C	28.9	0.015	26.5	26.4	0.6	0	1	0.3	0.2
2900	R	119.6	0.015	26.6	26.4	1.8	1.25	1	0.3	0.2
2584	C	94.9	0.015	27.1	26.55	0.375	0	1	0.3	0.2
2582	C	42.6	0.015	26.67	26.57	0.3	0	1	0.3	0.2
2577	C	32.2	0.015	26.7	26.4	0.45	0	1	0.3	0.2
2585	C	17.7	0.015	26.58	26.4	0.375	0	1	0.3	0.2
2109	C	14	0.015	27.95	27.89	0.375	0	1	0.3	0.2
7015	C	4.4	0.015	27.89	27.83	0.375	0	1	0.3	0.2
2107	C	12.8	0.015	27.83	27.76	0.45	0	1	0.3	0.2
2106	C	4.5	0.015	27.76	27.62	0.6	0	1	0.3	0.2
2105	R	11.8	0.015	27.62	27.6	0.7	0.5	1	0.3	0.2
3007	C	6.5	0.015	27.6	27.57	0.6	0	1	0.3	0.2
2115	C	45.3	0.015	27.57	27.3	0.45	0	1	0.3	0.2
3023	C	24.8	0.015	25.6	25.55	0.9	0	1	0.3	0.2
2629	C	51.4	0.015	26.57	26.32	0.3	0	1	0.3	0.2
2703	C	98.9	0.015	25.49	25.3	0.9	0	1	0.3	0.2
2604	C	13.4	0.015	26.26	25.45	0.375	0	1	0.3	0.2
3028	C	6.6	0.015	26.38	26.38	0.375	0	1	0.3	0.2
3010	C	17.5	0.015	26.38	25.38	0.375	0	1	0.3	0.2
3011	C	17.4	0.015	26.38	25.38	0.375	0	1	0.3	0.2
2103	C	14.9	0.015	26.71	26.49	0.375	0	1	0.3	0.2
2104	C	28.6	0.015	26.49	26.3	0.375	0	1	0.3	0.2
2102	C	30.5	0.015	26.28	26.21	0.375	0	1	0.3	0.2
2074	C	6.4	0.015	26.18	26.14	0.375	0	1	0.3	0.2
2073	C	19.3	0.015	26.33	26.1	0.375	0	1	0.3	0.2
2067	R	30.3	0.015	26.3	26.12	0.4	0.6	1	0.3	0.2
2066	C	7.8	0.015	26.14	26.12	0.375	0	1	0.3	0.2
2960	C	7.9	0.015	26.15	26.12	0.375	0	1	0.3	0.2
2979	C	20	0.015	26.45	26.39	0.3	0	1	0.3	0.2
2063	C	12.3	0.015	26.35	26.17	0.3	0	1	0.3	0.2
2062	C	3.6	0.015	26.16	26.1	0.375	0	1	0.3	0.2
2061	C	2.3	0.015	26.09	26.08	0.375	0	1	0.3	0.2
2056	C	25	0.015	26.01	25.89	0.3	0	1	0.3	0.2
2054	C	18	0.015	25.87	25.82	0.3	0	1	0.3	0.2
2052	C	15.5	0.015	25.8	25.8	0.3	0	1	0.3	0.2
2051	C	5.3	0.015	25.76	25.73	0.375	0	1	0.3	0.2
2050	R	21.6	0.015	25.71	25.67	0.45	0.3	1	0.3	0.2
2049	R	22.1	0.015	25.55	25.46	0.45	0.3	1	0.3	0.2
2048	R	18.7	0.015	25.44	25.26	0.45	0.3	1	0.3	0.2
2024	C	8.1	0.015	25.75	25.7	0.375	0	1	0.3	0.2
2028	C	9.6	0.015	25.86	25.76	0.375	0	1	0.3	0.2
2025	C	20.3	0.015	26.39	26.1	0.15	0	1	0.3	0.2
2036	C	63	0.015	23.72	23.57	1.35	0	1	0.3	0.2
2035	C	56.7	0.015	24.45	23.55	1.35	0	1	0.3	0.2
2117	C	10.7	0.015	26.4	26.36	0.375	0	1	0.3	0.2
2116	C	4.5	0.015	26.34	26.27	0.375	0	1	0.3	0.2
3014	C	10.5	0.015	26.29	26.1	0.375	0	1	0.3	0.2
2095	C	46.8	0.015	25.96	25.67	0.3	0	1	0.3	0.2

Pipe ID	Type	Length	Manning's n	US_Invert	DS_Invert	Width_or_Dia	Height_or_WF	Number_of Conduit	Entry_Loss	Exis_Loss
2096	C	49.6	0.015	25.64	24.95	0.45	0	1	0.3	0.2
2094	C	54.9	0.015	26	25.74	0.3	0	1	0.3	0.2
2093	C	52.4	0.015	25.71	25.34	0.3	0	1	0.3	0.2
2030	R	13.1	0.015	25.31	24.99	1.6	0.4	1	0.3	0.2
2031	C	5	0.015	24.68	24.62	0.6	0	1	0.3	0.2
2032	C	20.4	0.015	24.6	24.45	0.6	0	1	0.3	0.2
2033	C	14.9	0.015	24.41	24.09	0.6	0	1	0.3	0.2
2034	C	10	0.015	24.07	24.05	0.6	0	1	0.3	0.2
2765	C	10.8	0.015	24.8	24.68	0.375	0	1	0.3	0.2
2043	R	9.2	0.015	25.6	25.36	0.65	0.4	1	0.3	0.2
2956	R	5.6	0.015	25.36	25.18	0.6	0.4	1	0.3	0.2
2039	C	7.5	0.015	25.16	24.49	0.45	0	1	0.3	0.2
2763	C	79.5	0.015	23.6	23.4	0.525	0	1	0.3	0.2
2731	C	201.9	0.015	23.39	22.52	1.2	0	1	0.3	0.2
2286	C	29.2	0.015	24.12	24	1.65	0	1	0.3	0.2
2299	C	29.7	0.015	24.12	24	1.65	0	1	0.3	0.2
2929	C	6.5	0.015	25.78	24	0.375	0	1	0.3	0.2
7040	C	22.3	0.015	24	23.89	2.15	0	1	0.3	0.2
7041	C	84.6	0.015	23.89	23.46	2.15	0	1	0.3	0.2
7042	C	50.5	0.015	23.46	23.26	2.15	0	1	0.3	0.2
2142	C	20	0.015	25.26	25.17	0.375	0	1	0.3	0.2
2141	C	14.7	0.015	25.17	24.7	0.375	0	1	0.3	0.2
7043	C	26.2	0.015	23.26	23.13	2.15	0	1	0.3	0.2
7044	C	29.1	0.015	23.13	22.99	2.15	0	1	0.3	0.2
2147	C	26.4	0.015	22.99	22.67	2.15	0	1	0.3	0.2
2719	C	153.9	0.015	23	22.11	2.15	0	1	0.3	0.2
2769	C	35.3	0.015	25.79	25.49	0.375	0	1	0.3	0.2
2773	C	32	0.015	25.2	24.69	0.375	0	1	0.3	0.2
2775	C	61.3	0.015	23.16	23.08	0.9	0	1	0.3	0.2
2770	C	29	0.015	23.08	22.98	0.45	0	1	0.3	0.2
2737	C	146.3	0.015	22.98	22.84	0.525	0	1	0.3	0.2
2725	C	14.4	0.015	24.97	24.81	0.375	0	1	0.3	0.2
2724	C	8.4	0.015	24.79	24.77	0.375	0	1	0.3	0.2
2743	C	13.7	0.015	25.47	25.31	0.375	0	1	0.3	0.2
2741	C	9.4	0.015	25.29	25.13	0.375	0	1	0.3	0.2
2794	C	27.3	0.015	26.01	25.82	0.375	0	1	0.3	0.2
2241	C	83.7	0.015	25.66	25.47	0.525	0	1	0.3	0.2
2236	C	71.7	0.015	25.46	25.34	0.525	0	1	0.3	0.2
2237	C	11.9	0.015	25.63	25.59	0.375	0	1	0.3	0.2
2235	C	26.7	0.015	25.57	25.37	0.375	0	1	0.3	0.2
2947	C	25	0.015	25.72	25.51	0.375	0	1	0.3	0.2
2948	C	25	0.015	25.49	25.29	0.375	0	1	0.3	0.2
2949	C	31.1	0.015	25.27	24.78	0.375	0	1	0.3	0.2
2950	C	34	0.015	24.9	24.78	0.45	0	1	0.3	0.2
2908	C	11.6	0.015	26.14	26	0.375	0	1	0.3	0.2
2909	C	142.3	0.015	26	25.75	0.375	0	1	0.3	0.2
2823	C	10.3	0.015	25.72	25.7	0.525	0	1	0.3	0.2
2827	C	18.7	0.015	26.55	26.4	0.375	0	1	0.3	0.2
2822	C	27.9	0.015	26.22	25.7	0.45	0	1	0.3	0.2
2817	C	66.4	0.015	25.68	25.53	0.6	0	1	0.3	0.2
2808	C	4.5	0.015	25.84	25.68	0.3	0	1	0.3	0.2
2938	C	39.2	0.015	25.51	25.2	0.375	0	1	0.3	0.2
2799	C	8	0.015	25.91	25.9	0.375	0	1	0.3	0.2
2800	C	13	0.015	25.86	25.7	0.375	0	1	0.3	0.2
2802	C	35.9	0.015	25.45	24.56	0.375	0	1	0.3	0.2
2803	C	5.2	0.015	26.23	26.13	0.3	0	1	0.3	0.2
2936	C	10.3	0.015	25.5	25.29	0.375	0	1	0.3	0.2

Pipe ID	Type	Length	Manning's n	US_Invert	DS_Invert	Width_or_Dia	Height_or_WF	Number_of Conduit	Entry_Loss	Exis_Loss
2243	C	28.8	0.015	27.83	27.72	0.375	0	1	0.3	0.2
2244	C	27.6	0.015	27.71	27.63	0.375	0	1	0.3	0.2
2245	C	31.1	0.015	27.62	27.52	0.375	0	1	0.3	0.2
2999	C	66.8	0.015	26.99	26.54	0.375	0	1	0.3	0.2
2837	C	50.9	0.015	26.53	26.19	0.375	0	1	0.3	0.2
2971	C	12.7	0.015	43.08	42.76	0.375	0	1	0.3	0.2
2972	C	20.7	0.015	42.66	42.6	0.375	0	1	0.3	0.2
2976	C	14.4	0.015	56.1	55.87	0.375	0	1	0.3	0.2
2965	C	17.6	0.015	38.7	38.7	0.375	0	1	0.3	0.2
2968	C	31.6	0.015	38.9	38.47	0.525	0	1	0.3	0.2
2925	C	12	0.015	40.51	40.29	0.375	0	1	0.3	0.2
2927	C	16.3	0.015	40.27	39.93	0.375	0	1	0.3	0.2
2498	C	12.9	0.015	45.9	45.71	0.375	0	1	0.3	0.2
2492	C	31.2	0.015	45.44	44.62	0.375	0	1	0.3	0.2
2490	C	12.1	0.015	44.18	44.12	0.525	0	1	0.3	0.2
2489	C	8.9	0.015	44.11	43.98	0.525	0	1	0.3	0.2
2488	C	27.8	0.015	43.94	43.89	0.525	0	1	0.3	0.2
2487	C	26.8	0.015	43.89	43.69	0.525	0	1	0.3	0.2
2486	C	23.8	0.015	43.69	43.43	0.525	0	1	0.3	0.2
2485	C	25.1	0.015	43.41	42.67	0.525	0	1	0.3	0.2
2484	C	13.9	0.015	42.67	42.45	0.525	0	1	0.3	0.2
2483	C	159.8	0.015	42.22	38.14	0.525	0	1	0.3	0.2
2499	C	17.4	0.015	44.33	44.1	0.3	0	1	0.3	0.2
2500	C	13.9	0.015	44.08	43.8	0.3	0	1	0.3	0.2
2505	C	2.5	0.015	38	37.54	0.375	0	1	0.3	0.2
2514	R	29.6	0.015	38.14	36.36	1.5	1.2	1	0.3	0.2
2507	C	29.7	0.015	34.31	34.07	0.375	0	1	0.3	0.2
2521	R	105.1	0.015	33.85	32.3	1.5	1.2	1	0.3	0.2
2466	C	80.4	0.015	36.39	33.41	0.45	0	1	0.3	0.2
2456	C	12.9	0.015	33.94	33.41	0.375	0	1	0.3	0.2
2457	C	13.6	0.015	33.21	32.97	0.45	0	1	0.3	0.2
2717	R	42.4	0.015	31.87	31.33	1.5	1.2	1	0.3	0.2
2939	R	9.8	0.015	31.33	31.26	1.5	1.2	1	0.3	0.2
2711	R	13.2	0.015	31.26	31.21	1.5	1.2	1	0.3	0.2
2712	R	25.4	0.015	31.21	30.88	1.5	1.2	1	0.3	0.2
2610	R	102.2	0.015	30.88	29.57	1.45	1.2	1	0.3	0.2
2469	C	15.8	0.015	33.28	32.92	0.375	0	1	0.3	0.2
2471	C	74.6	0.015	32.91	32.1	0.6	0	1	0.3	0.2
3026	C	26.2	0.015	21.8	21.77	0.525	0	1	0.3	0.2
2215	C	55.2	0.015	21.77	21.72	0.525	0	1	0.3	0.2
2216	C	30.1	0.015	21.72	21.69	0.6	0	1	0.3	0.2
2213	C	50.1	0.015	21.69	21.64	0.6	0	1	0.3	0.2
2211	C	25.4	0.015	21.64	21.61	0.6	0	1	0.3	0.2
2209	C	41	0.015	21.64	21.57	0.65	0	1	0.3	0.2
2208	C	28.9	0.015	21.57	21.54	0.8	0	1	0.3	0.2
3025	C	75.1	0.015	21.54	21.45	0.8	0	1	0.3	0.2
2217	C	69.7	0.015	23.31	22.86	0.375	0	1	0.3	0.2
2219	C	63.5	0.015	22.79	22.46	0.525	0	1	0.3	0.2
2231	C	16.7	0.015	22.96	22.75	0.375	0	1	0.3	0.2
2230	C	8.1	0.015	22.71	22.65	0.45	0	1	0.3	0.2
2229	C	13.4	0.015	22.61	22.55	0.45	0	1	0.3	0.2
2228	C	8.4	0.015	22.53	22.47	0.45	0	1	0.3	0.2
2226	C	13.3	0.015	22.39	22.26	0.6	0	1	0.3	0.2
2224	C	25.8	0.015	22	21.55	0.75	0	1	0.3	0.2
2188	C	27.5	0.015	21.6	21.5	1.05	0	1	0.3	0.2
3019	C	103.2	0.015	22.96	21.58	0.75	0	1	0.3	0.2
2189	C	63.5	0.015	21.47	21.13	1.2	0	1	0.3	0.2

Pipe ID	Type	Length	Manning's n	US_Invert	DS_Invert	Width_or_Dia	Height_or_WF	Number_of Conduit	Entry_Loss	Exis_Loss
2193	C	103.2	0.015	20.82	20.58	0.9	0	1	0.3	0.2
2192	C	38.6	0.015	20.38	20.2	0.9	0	1	0.3	0.2
2200	C	13.4	0.015	23.25	23.1	0.375	0	1	0.3	0.2
2197	C	68.5	0.015	22.45	22.01	0.6	0	1	0.3	0.2
2194	C	118	0.015	20.05	20	1.05	0	1	0.3	0.2
2280	C	14.1	0.015	27.14	26.98	0.45	0	1	0.3	0.2
2810	R	8.3	0.015	26.03	25.98	0.5	0.3	1	0.3	0.2
2044	R	5.8	0.015	25.5	25.47	0.6	0.25	1	0.3	0.2
2130	C	8.9	0.015	26.1	25.99	0.375	0	1	0.3	0.2
2885	C	10.6	0.015	37.62	37.47	0.825	0	1	0.3	0.2
2898	R	172.9	0.015	26.3	26	2.4	1.1	1	0.3	0.2
7002	C	5.2	0.015	53.51	53.2	0.375	0	1	0.3	0.2
7089	C	32.6	0.015	27.1	27	0.45	0	1	0.3	0.2
2894	R	19.39	0.015	31.8	31.76	1.8	1.3	1	0.3	0.2
Evan_Box	R	39.76	0.015	31.76	31.7	1.8	1.3	1	0.3	0.2
Evan_Ch1	S	34.36	0.02	31.7	31.64	0	0	0	0	0
Evan_Ch2	S	33.47	0.02	31.64	31.58	0	0	0	0	0
van_Ch2_1	S	25.61	0.02	31.58	31.34	0	0	0	0	0
Evan_Ch4	S	20.42	0.02	31.34	31.01	0	0	0	0	0
104	R	70.4	0.015	25.24	25.1	2.4	1.5	1	0.3	0.2
10	C	12.5	0.015	26.56	25.97	0.375	0	1	0.3	0.2
11	C	7.4	0.015	26.19	25.87	0.375	0	1	0.3	0.2
100	R	10.6	0.015	25.47	25.45	2.4	1.5	1	0.3	0.2
101	R	55.5	0.015	25.45	25.31	2.4	1.5	1	0.3	0.2
106	R	50.5	0.015	25.06	24	2.4	1.5	1	0.3	0.2
102	R	23	0.015	25.31	25.25	2.4	1.5	1	0.3	0.2
103	R	8.4	0.015	25.25	25.24	2.4	1.5	1	0.3	0.2
13	C	2.6	0.015	26.35	26.24	0.375	0	1	0.3	0.2
105	R	15.6	0.015	25.1	25.06	2.4	1.5	1	0.3	0.2
14	C	2.3	0.015	26.22	26.08	0.375	0	1	0.3	0.2
15	C	2.3	0.015	26.16	26.04	0.375	0	1	0.3	0.2
2732	C	147.4	0.015	22.84	22.52	1.5	0	1	0.3	0.2
9000a	S	21.2	0.02	26.1	25.99	0	0	1	0.3	0.2
9000	S	142	0.02	25.99	25.32	0	0	1	0.3	0.2
9001a	S	72.1	0.02	25.32	25.19	0	0	1	0.3	0.2
9001	S	61	0.02	25.19	25.09	0	0	1	0.3	0.2
9003a	S	5.35	0.02	24.85	24.84	0	0	1	0.3	0.2
9003	S	202.05	0.02	24.84	24.59	0	0	1	0.3	0.2
9019a	S	34.9	0.02	26.34	26.33	0	0	1	0.3	0.2
9019	S	26.08	0.02	26.33	26.31	0	0	1	0.3	0.2
9010a	S	15.95	0.02	28.21	28.13	0	0	1	0.3	0.2
9010	S	241.35	0.02	28.13	26.86	0	0	1	0.3	0.2
Cor1	R	17.1	0.015	25.8	25.79	1.1	1.1	1	0.3	0.2
DwChan	S	11.3	0.02	25.79	25.64	0	0	0	0	0
BusPip1	C	12.48	0.015	26.82	25.5	0.375	0	1	0.3	0.2
2932a	R	31.31	0.015	25.7	25.61	2.1	1.85	1	0.3	0.2
2932b	R	47.62	0.015	25.61	25.49	2.1	1.85	1	0.3	0.2
2932	R	53.99	0.015	25.49	25.35	2.1	1.85	1	0.3	0.2
TarPip1	C	172.2	0.015	27.17	26.8	0.6	0	1	0.3	0.2
O1_1	R	51.65	0.015	25.55	25.35	2.87	1.6	1	0.3	0.2
O1_1a	R	254.95	0.015	25.35	23.25	2.87	1.6	1	0.3	0.2
BigInletw	W	1	0.02	27.55	25.63	13	0	1	0	0
9005	S	99.6	0.02	24.49	24.388	0	0	1	0.3	0.2
9005_a	S	10.4	0.02	24.388	24.377	0	0	1	0.3	0.2
9005_b	S	75.6	0.02	24.377	24.3	0	0	1	0.3	0.2
P2898w	W	1	0.02	31.25	29.55	7.8	0	1	0	0
NorthC1	C	27.62	0.014	38.9	37.68	0.9	0	1	0.5	0.5

Pipe ID	Type	Length	Manning's n	US_Invert	DS_Invert	Width_or_Dia	Height_or_WF	Number_of Conduit	Entry_Loss	Exis_Loss
NorthC1a	C	29.9	0.014	37.68	36.36	0.9	0	1	0.5	0.5
NorthC2	R	25.8	0.014	37.5	36.85	0.75	0.75	1	0.5	0.5
NorthC2a	R	60	0.014	36.85	35.36	0.75	0.75	1	0.5	0.5
GGuys_E	R	1.5	0.015	33	33	7	0.3	1	0.3	0.2
GGuys_W	R	1.5	0.015	31.8	31.8	7	0.4	1	0.3	0.2

Detailed Information of Pits in the Tuflow Model

Pit ID	Surface_level	Inlet_Type
P2405	25.27	Type_2
P2403	25.28	Type_13
P2372	51.79	Type_12
P2370	50.19	Type_12
P2692	48.18	Type_8
P2691	48.18	Type_10
P2690	47.41	Type_12
P2366	49.72	Type_12
P2365	49.97	Type_12
P2367	49.70	Type_12
P2368	49.71	Type_12
P2369	49.92	Type_12
P2373	54.22	Type_13
P2379	54.16	Type_13
P2633	38.76	Type_8
P2634	39.05	Type_8
P2635	38.92	Type_12
P2629	40.04	Type_7
P2630	40.00	Type_8
P2605	44.78	Type_7
P2604	45.00	Type_8
P2621	44.44	Type_8
P2607	44.96	Type_8
P2606	44.99	Type_7
P2610	46.73	Type_9
P2609	47.16	Type_8
P2608	47.45	Type_8
P2712	46.29	Type_12
P2711	46.27	Type_12
P2710	46.41	Type_13
P2611	45.99	Type_12
P2620	44.29	Type_8
P2613	46.23	Type_12
P2616	46.33	Type_12
P2614	46.30	Type_12
P2615	46.54	Type_12
P2702	48.91	Type_12
P2706	49.89	Type_14
P2704	49.90	Type_2
P2917	49.72	Type_12
P2916	49.34	Type_12
P2918	49.80	Type_12
P2919	49.72	Type_10
P2668	39.12	Type_16
P2669	40.08	Type_16
P2671	41.99	Type_13
P2673	41.91	Type_8
P2672	41.77	Type_10
P2676	42.21	Type_12
P2683	44.20	Type_10
P2681	44.31	Type_10
P2685	44.06	Type_15
P2684	43.93	Type_10
P2677	45.90	Type_7
P2678	45.69	Type_8

Pit ID	Surface_level	Inlet_Type
P2682	45.01	Type_8
P2695	49.08	Type_10
P2696	49.31	Type_10
P2600	42.50	Type_8
P2599	42.33	Type_8
P2598	41.52	Type_7
P2588	40.04	Type_8
P2589	40.06	Type_8
P2595	40.73	Type_13
P2597	40.69	Type_13
P2594	42.80	Type_13
P2592	40.79	Type_8
P2590	40.92	Type_12
P2571	36.89	Type_8
P2572	36.84	Type_8
P2518	34.81	Type_7
P2517	34.79	Type_7
P2520	35.31	Type_7
P2519	35.20	Type_7
P2521	38.59	Type_8
P2522	39.15	Type_13
P2627	42.47	Type_8
P2504	29.04	Type_8
P2506	29.37	Type_13
P2507	29.73	Type_13
P2511	29.47	Type_14
P2573	32.67	Type_10
P2574	34.59	Type_10
P2575	36.00	Type_10
P2578	37.15	Type_8
P2579	37.13	Type_8
P2576	36.16	Type_12
P2577	36.80	Type_2
P2582	41.97	Type_10
P2583	42.40	Type_7
P2584	42.25	Type_10
P2581	41.71	Type_10
P2580	40.86	Type_9
P2587	44.28	Type_7
P2585	43.20	Type_7
P2469	28.14	Type_12
P2470	28.14	Type_13
P2471	28.09	Type_13
P2882	28.35	Type_8
P2883	28.78	Type_8
P2014	28.74	Type_8
P2011	31.25	Type_2
P2009	32.27	Type_15
P2010	31.34	Type_2
P3024	32.27	Type_16
P2012	31.40	Type_16
P2013	31.84	Type_16
P2472	27.85	Type_12
P2475	27.64	Type_12
P2733	27.90	Type_7
P2734	27.94	Type_7
P2513	29.97	Type_12
P2514	30.20	Type_13

Pit ID	Surface_level	Inlet_Type
P2515	30.37	Type_12
P2467	28.41	Type_16
P2468	28.14	Type_16
P2881	29.49	Type_8
P2006	30.66	Type_8
P2002	30.49	Type_13
P2007	30.91	Type_8
P2534	35.73	Type_13
P2536	35.60	Type_13
P2535	35.10	Type_13
P2533	34.85	Type_12
P2532	35.09	Type_2
P2531	34.19	Type_2
P2530	33.92	Type_16
P2529	32.65	Type_13
P2527	31.65	Type_16
P2528	31.63	Type_2
P2738	31.17	Type_2
P2562	36.31	Type_16
P2563	36.03	Type_16
P2564	35.45	Type_16
P2566	35.06	Type_2
P2570	33.76	Type_7
P2569	33.96	Type_7
P2568	34.02	Type_12
P2567	33.92	Type_17
P2561	36.42	Type_8
P2560	36.80	Type_8
P2555	39.91	Type_7
P2554	40.09	Type_8
P2553	40.06	Type_8
P2552	39.89	Type_7
P2551	40.02	Type_9
P2550	42.23	Type_8
P2549	42.31	Type_7
P2547	44.37	Type_13
P2840	41.08	Type_8
P2841	40.86	Type_13
P2842	40.92	Type_10
P2716	37.69	Type_2
P2663	37.02	Type_8
P2637	36.97	Type_9
P2662	36.92	Type_9
P2661	36.82	Type_10
P2666	37.67	Type_14
P2667	38.34	Type_16
P2807	35.31	Type_12
P2808	35.03	Type_13
P2809	34.84	Type_8
P2810	34.93	Type_9
P2812	35.17	Type_8
P2811	35.16	Type_7
P2817	34.78	Type_8
P2872	35.24	Type_13
P2873	35.51	Type_13
P2820	36.09	Type_12
P2822	36.89	Type_13
P2824	37.82	Type_10

Pit ID	Surface_level	Inlet_Type
P2825	37.88	Type_10
P2539	38.99	Type_13
P2838	43.39	Type_15
P2839	43.48	Type_2
P2862	45.64	Type_7
P2864	45.73	Type_15
P2863	45.80	Type_7
P2860	45.45	Type_7
P2859	45.10	Type_12
P2858	44.98	Type_12
P2857	44.81	Type_12
P2865	45.90	Type_7
P2384	46.27	Type_7
P2385	46.06	Type_12
P2866	44.76	Type_7
P2867	44.73	Type_9
P2804	32.75	Type_13
P2646	32.32	Type_11
P2645	31.48	Type_2
P2805	34.91	Type_13
P2806	35.11	Type_2
P2091	28.63	Type_16
P2090	28.65	Type_16
P2089	28.61	Type_16
P2088	28.50	Type_16
P2087	28.60	Type_13
P2101	28.79	Type_2
P2102	28.98	Type_13
P2103	28.57	Type_13
P2084	28.34	Type_2
P2081	27.84	Type_13
P2079	27.67	Type_13
P2078	27.53	Type_13
P2075	27.42	Type_13
P2071	27.19	Type_13
P2065	27.09	Type_2
P2060	26.84	Type_13
P2756	27.09	Type_2
P2073	27.11	Type_13
P2755	27.09	Type_8
P2754	27.06	Type_13
P2083	27.66	Type_2
P2082	27.94	Type_13
P2080	27.69	Type_13
P2077	27.57	Type_13
P2074	27.37	Type_13
P2070	27.21	Type_13
P2066	27.00	Type_2
P2061	26.98	Type_14
P2057	26.73	Type_13
P2059	26.82	Type_14
P2058	26.74	Type_14
P2055	26.48	Type_14
P2054	26.56	Type_14
P2053	26.60	Type_14
P2052	26.45	Type_14
P2771	26.72	Type_2
P2772	26.81	Type_9

Pit ID	Surface_level	Inlet_Type
P2104	27.04	Type_2
P2069	27.16	Type_13
P2107	27.24	Type_13
P2110	27.20	Type_10
P2108	26.90	Type_16
P2109	27.31	Type_14
P2462	27.44	Type_15
P2463	27.28	Type_15
P2464	27.19	Type_15
P2465	26.80	Type_2
P2466	27.65	Type_13
P2098	28.12	Type_16
P2099	28.12	Type_12
P2095	28.29	Type_13
P2096	27.69	Type_13
P2094	28.43	Type_8
P2093	28.47	Type_10
P2092	28.52	Type_13
P2765	30.20	Type_8
P2005	30.23	Type_8
P2766	29.18	Type_13
P2767	28.78	Type_13
P2004	30.66	Type_8
P2003	30.31	Type_12
P2764	30.37	Type_8
P2763	30.48	Type_8
P2762	30.32	Type_8
P2761	30.74	Type_10
P2760	31.14	Type_7
P2781	26.80	Type_8
P2780	26.64	Type_10
P2779	26.19	Type_2
P2778	26.23	Type_2
P2015	26.75	Type_13
P2016	26.71	Type_15
P2017	26.74	Type_15
P2018	26.74	Type_15
P2019	26.61	Type_15
P2024	26.53	Type_7
P2428	27.01	Type_9
P2429	27.11	Type_9
P2195	26.19	Type_12
P2196	26.01	Type_13
P2194	26.16	Type_12
P2193	26.34	Type_12
P2192	26.46	Type_12
P2787	27.02	Type_13
P2786	26.80	Type_13
P2784	26.38	Type_13
P2785	26.38	Type_13
P2783	26.16	Type_15
P2040	26.48	Type_2
P2033	26.30	Type_17
P2106	26.69	Type_12
P2105	26.81	Type_12
P2028	26.31	Type_15
P2029	26.21	Type_2
P2032	26.23	Type_14

Pit ID	Surface_level	Inlet_Type
P2031	26.25	Type_14
P2030	26.17	Type_2
P2042	26.46	Type_2
P2044	26.38	Type_2
P2043	26.22	Type_2
P2045	26.40	Type_2
P2046	26.35	Type_16
P2035	26.37	Type_18
P2133	25.71	Type_13
P2132	25.23	Type_12
P2131	26.10	Type_13
P2150	26.06	Type_15
P2149	25.82	Type_15
P2143	25.79	Type_13
P2142	25.88	Type_8
P2141	25.88	Type_1
P2144	25.89	Type_13
P2145	25.98	Type_12
P2148	26.32	Type_12
P2147	25.69	Type_2
P8133	26.38	Type_2
P2174	25.86	Type_12
P2134	25.99	Type_1
P2130	26.42	Type_13
P2127	26.48	Type_13
P2126	26.38	Type_15
P2125	26.63	Type_13
P2123	26.44	Type_13
P2387	24.10	Type_11
P2388	24.46	Type_10
P2386	24.39	Type_10
P2390	24.64	Type_10
P2391	24.72	Type_10
P2425	24.03	Type_11
P2424	24.09	Type_10
P2427	24.11	Type_11
P2426	24.11	Type_9
P2421	24.51	Type_9
P2401	24.38	Type_11
P2394	24.56	Type_9
P2395	24.48	Type_9
P2393	24.64	Type_2
P3016	25.32	Type_10
P2406	24.43	Type_10
P2407	24.17	Type_10
P2409	24.53	Type_13
P2410	24.53	Type_13
P2416	24.66	Type_13
P2411	24.35	Type_9
P2412	24.41	Type_8
P2413	24.08	Type_2
P2648	24.21	Type_2
P2408	24.01	Type_10
P2414	23.71	Type_10
P2415	23.65	Type_10
P2420	24.41	Type_10
P2312	57.26	Type_15
P2311	56.73	Type_8

Pit ID	Surface_level	Inlet_Type
P2310	56.61	Type_7
P2313	58.00	Type_13
P2317	58.07	Type_13
P2318	56.82	Type_12
P2319	57.54	Type_13
P2320	56.97	Type_12
P2321	56.25	Type_12
P2323	54.81	Type_13
P2324	54.34	Type_12
P2322	55.63	Type_12
P2326	54.22	Type_12
P2327	54.29	Type_12
P2328	54.06	Type_12
P2329	54.71	Type_12
P2364	50.39	Type_12
P2363	51.50	Type_12
P2680	47.47	Type_8
P2679	47.36	Type_8
P2355	50.32	Type_13
P2356	50.99	Type_12
P2353	51.35	Type_12
P2352	51.39	Type_12
P2354	51.20	Type_12
P2357	51.25	Type_12
P2351	53.66	Type_12
P2349	54.02	Type_12
P2347	53.17	Type_12
P2340	53.57	Type_12
P2341	53.48	Type_12
P2338	53.59	Type_12
P2343	53.92	Type_12
P2336	54.37	Type_12
P2335	55.03	Type_12
P2334	55.03	Type_12
P2333	55.06	Type_12
P2337	58.99	Type_12
P2304	43.78	Type_10
P2305	44.09	Type_10
P2306	44.18	Type_10
P2303	44.09	Type_8
P2302	44.10	Type_8
P2430	26.79	Type_13
P2216	26.78	Type_8
P2217	26.67	Type_13
P2214	26.78	Type_8
P2215	26.88	Type_13
P2213	26.90	Type_8
P2197	26.22	Type_12
P2802	26.11	Type_13
P2202	26.27	Type_12
P2203	26.39	Type_12
P2204	26.17	Type_2
P2205	26.43	Type_14
P2206	26.60	Type_13
P2207	26.30	Type_14
P2208	26.47	Type_14
P2211	26.82	Type_8
P2212	27.01	Type_8

Pit ID	Surface_level	Inlet_Type
P2295	40.69	Type_8
P2296	40.90	Type_7
P2297	41.17	Type_8
P2294	41.07	Type_7
P2995	39.16	Type_10
P2299	39.84	Type_2
P2298	39.68	Type_11
P2300	39.75	Type_11
P2301	39.91	Type_10
P2510	29.43	Type_12
P2970	31.71	Type_10
P2969	31.85	Type_10
P2968	32.19	Type_8
P2967	32.20	Type_9
P2660	29.28	Type_13
P2731	28.76	Type_14
P2730	29.24	Type_16
P2498	28.18	Type_7
P2499	28.38	Type_10
P2478	27.78	Type_7
P2480	27.94	Type_8
P2497	28.44	Type_8
P2496	28.28	Type_10
P2495	28.27	Type_10
P2493	28.07	Type_2
P2490	28.20	Type_1
P2491	28.13	Type_3
P2719	29.09	Type_16
P2720	29.24	Type_16
P2721	29.30	Type_14
P2485	28.00	Type_9
P2486	28.12	Type_8
P2489	28.31	Type_7
P2488	28.35	Type_9
P2443	27.80	Type_16
P2650	28.05	Type_13
P2440	28.10	Type_13
P2438	28.16	Type_13
P2437	28.42	Type_13
P2442	27.99	Type_16
P2267	27.84	Type_2
P2266	27.41	Type_13
P2269	28.25	Type_13
P2275	28.65	Type_12
P2278	28.63	Type_16
P2277	28.67	Type_12
P2276	28.66	Type_12
P2271	29.01	Type_12
P2272	28.67	Type_12
P2273	28.45	Type_12
P2274	28.11	Type_12
P2234	26.82	Type_2
P2233	26.71	Type_8
P2435	27.50	Type_12
P2436	27.47	Type_7
P2241	26.75	Type_8
P2240	26.83	Type_8
P2242	27.33	Type_7

Pit ID	Surface_level	Inlet_Type
P2243	27.38	Type_7
P2250	27.15	Type_13
P2252	27.88	Type_8
P2254	27.44	Type_8
P2434	26.69	Type_15
P2433	26.53	Type_15
P2432	26.56	Type_10
P2431	26.57	Type_10
P2226	26.57	Type_7
P2225	26.56	Type_7
P2223	26.91	Type_8
P2224	26.89	Type_8
P2222	26.90	Type_8
P2219	26.80	Type_8
P2455	26.74	Type_13
P2456	27.03	Type_13
P2453	27.07	Type_13
P2451	27.37	Type_2
P2450	27.43	Type_2
P2447	27.33	Type_13
P2445	27.11	Type_13
P2449	27.06	Type_7
P2448	27.26	Type_8
P2889	27.16	Type_8
P2474	27.42	Type_16
P2473	27.37	Type_18
P2476	27.69	Type_16
P2457	27.36	Type_15
P2948	27.05	Type_2
P2642	26.83	Type_12
P2640	27.34	Type_8
P2888	27.68	Type_13
P2309	57.08	Type_7
P2308	56.92	Type_8
P2307	57.16	Type_9
P2644	27.22	Type_10
P2643	27.27	Type_12
P2638	27.25	Type_13
P2062	27.04	Type_2
P2056	26.62	Type_16
P2049	26.46	Type_12
P2048	26.39	Type_16
P2047	26.41	Type_1
P2050	26.65	Type_2
P2051	26.87	Type_13
P2085	28.55	Type_13
P2100	28.23	Type_2
P2000	30.56	Type_12
P2001	30.71	Type_12
P2525	31.20	Type_8
P2020	26.55	Type_8
P2021	26.61	Type_8
P2022	26.54	Type_2
P2023	26.42	Type_13
P2026	26.48	Type_8
P2025	26.42	Type_7
P2027	26.46	Type_7
P2036	26.30	Type_13

Pit ID	Surface_level	Inlet_Type
P2038	26.54	Type_1
P2039	26.38	Type_18
P2116	26.94	Type_2
P2117	27.01	Type_12
P2118	27.11	Type_12
P2119	27.37	Type_12
P2120	27.04	Type_12
P2121	26.95	Type_12
P2122	27.09	Type_12
P2114	26.85	Type_13
P2113	26.35	Type_12
P2112	26.75	Type_12
P2111	27.04	Type_12
P2129	25.78	Type_1
P2128	26.33	Type_13
P2136	25.82	Type_1
P2137	25.62	Type_1
P2138	25.58	Type_3
P2139	25.42	Type_3
P2140	25.63	Type_3
P2171	27.00	Type_12
P2170	26.95	Type_13
P2167	26.91	Type_13
P2164	27.11	Type_2
P2158	27.52	Type_14
P2159	27.61	Type_12
P2163	27.19	Type_13
P2161	27.30	Type_13
P2152	27.78	Type_2
P2153	27.43	Type_2
P2156	27.73	Type_12
P2155	27.72	Type_2
P2151	28.01	Type_13
P2168	26.99	Type_2
P2173	26.02	Type_13
P2705	49.17	Type_12
P2245	27.05	Type_14
P2198	25.97	Type_13
P2231	26.43	Type_14
P2236	26.59	Type_13
P2237	26.85	Type_1
P2238	26.80	Type_13
P2256	27.52	Type_8
P2258	27.22	Type_13
P2259	27.32	Type_2
P2260	27.32	Type_13
P2261	27.29	Type_13
P2262	27.27	Type_13
P2709	44.52	Type_10
P2707	45.79	Type_7
P2544	40.56	Type_13
P2543	39.27	Type_13
P2538	38.69	Type_12
P2540	39.11	Type_13
P2280	28.67	Type_13
P2281	28.69	Type_12
P2282	28.53	Type_12
P2283	28.95	Type_7

Pit ID	Surface_level	Inlet_Type
P2439	28.22	Type_13
P2286	28.54	Type_13
P2287	28.62	Type_12
P2284	28.87	Type_13
P2285	28.74	Type_1
P2288	29.53	Type_11
P2718	29.28	Type_16
P2722	29.33	Type_16
P2732	29.27	Type_14
P2227	26.25	Type_13
P2228	26.35	Type_14
P2218	26.27	Type_13
P2235	26.78	Type_13
P2558	36.24	Type_10
P2404	25.06	Type_13
P2199	25.88	Type_13
P2200	25.73	Type_8
P2201	25.86	Type_13
P2209	26.46	Type_2
P2293	33.19	Type_12
P2292	33.73	Type_11
P2371	50.88	Type_12
P2374	55.21	Type_7
P2375	55.32	Type_13
P2376	54.88	Type_7
P2378	53.89	Type_12
P2380	46.44	Type_1
P2382	46.01	Type_1
P2392	24.81	Type_2
P2396	24.57	Type_1
P2397	24.41	Type_2
P2398	24.18	Type_10
P2399	24.26	Type_11
P2400	24.49	Type_1
P2402	25.05	Type_14
P2418	23.96	Type_10
P2419	23.98	Type_9
P2444	27.90	Type_12
P2446	27.12	Type_7
P2452	27.25	Type_2
P2477	27.66	Type_16
P2483	28.05	Type_7
P2501	28.24	Type_7
P2512	29.76	Type_10
P2526	31.74	Type_2
P2545	42.88	Type_13
P2647	24.20	Type_2
P2651	28.78	Type_16
P2652	29.01	Type_2
P2653	28.82	Type_1
P2654	28.89	Type_1
P2655	28.69	Type_2
P2656	29.32	Type_14
P2745	27.98	Type_14
P2743	27.44	Type_15
P2741	27.34	Type_15
P2742	27.41	Type_13
P2740	27.62	Type_13

Pit ID	Surface_level	Inlet_Type
P2739	27.63	Type_12
P2753	27.29	Type_12
P2752	27.14	Type_12
P2751	27.46	Type_12
P2749	27.95	Type_13
P2750	28.03	Type_13
P2748	29.37	Type_13
P2747	30.77	Type_12
P2675	40.11	Type_13
P2674	40.20	Type_2
P2694	47.87	Type_3
P2700	41.25	Type_2
P2699	41.89	Type_2
P2701	40.94	Type_1
P2726	29.32	Type_14
P2727	29.33	Type_13
P2728	29.28	Type_16
P2729	29.02	Type_16
P2735	36.98	Type_13
P2791	26.52	Type_15
P2789	26.63	Type_13
P2788	26.64	Type_13
P2792	27.16	Type_1
P2793	26.94	Type_8
P2798	26.85	Type_2
P2800	26.55	Type_12
P2803	26.09	Type_13
P2813	34.68	Type_8
P2815	34.99	Type_7
P2816	35.14	Type_7
P2818	35.64	Type_1
P2819	35.92	Type_13
P2821	36.45	Type_8
P2826	37.75	Type_13
P2827	37.92	Type_12
P2828	38.47	Type_9
P2830	40.37	Type_9
P2833	43.41	Type_10
P2843	45.15	Type_7
P2844	44.06	Type_9
P2845	41.35	Type_2
P2846	41.94	Type_2
P2848	47.03	Type_3
P2850	36.23	Type_13
P2851	35.61	Type_2
P2852	35.33	Type_2
P2856	44.58	Type_13
P2870	38.36	Type_12
P2874	35.98	Type_1
P2875	39.05	Type_2
P2876	35.61	Type_8
P2879	30.80	Type_16
P2880	28.21	Type_13
P2885	28.16	Type_2
P2886	28.17	Type_2
P2887	27.41	Type_7
P2890	28.20	Type_13
P2893	31.00	Type_13

Pit ID	Surface_level	Inlet_Type
P2901	31.24	Type_13
P2899	31.09	Type_2
P2900	31.32	Type_13
P2896	31.16	Type_8
P2894	30.97	Type_8
P2891	28.32	Type_15
P2892	28.62	Type_1
P2897	31.12	Type_2
P2902	30.16	Type_13
P2903	27.57	Type_7
P2904	27.59	Type_7
P2906	26.90	Type_13
P2907	26.95	Type_12
P2908	27.01	Type_13
P2910	27.13	Type_12
P2909	27.06	Type_8
P2912	27.96	Type_13
P2914	55.42	Type_12
P2915	49.69	Type_12
P2920	30.35	Type_12
P2921	29.23	Type_16
P2922	27.98	Type_10
P2926	27.46	Type_12
P2925	27.59	Type_12
P2928	30.02	Type_1
P2929	29.10	Type_1
P2930	32.85	Type_5
P2931	33.03	Type_1
P2932	32.95	Type_2
P2933	32.97	Type_2
P2934	32.77	Type_2
P2935	32.92	Type_1
P2936	34.04	Type_8
P2937	33.44	Type_2
P2938	26.19	Type_2
P2939	26.29	Type_13
P2940	26.41	Type_2
P2942	27.05	Type_2
P2944	26.90	Type_2
P2945	26.95	Type_2
P2946	26.74	Type_2
P2947	27.07	Type_1
P2949	27.05	Type_1
P2951	27.03	Type_2
P2950	27.09	Type_2
P2952	27.13	Type_2
P2953	26.81	Type_2
P2957	26.95	Type_13
P2958	26.80	Type_7
P2962	27.06	Type_1
P2963	27.49	Type_8
P2964	26.97	Type_14
P2966	27.92	Type_2
P2971	29.39	Type_14
P2974	37.01	Type_2
P2975	37.52	Type_1
P2977	38.26	Type_1
P2978	38.62	Type_1

Pit ID	Surface_level	Inlet_Type
P2979	38.76	Type_1
P2980	38.81	Type_4
P2984	32.30	Type_2
P2983	32.24	Type_2
P2990	30.33	Type_11
P2991	30.27	Type_16
P2989	30.25	Type_11
P2992	30.38	Type_2
P2993	25.85	Type_12
P2955	26.42	Type_13
P2994	27.26	Type_13
P2996	27.15	Type_2
P2997	27.58	Type_12
P2999	27.33	Type_13
P2998	27.53	Type_12
P3005	30.51	Type_8
P3009	27.43	Type_12
P3008	27.27	Type_12
P3007	27.31	Type_12
P3020	26.84	Type_2
P8000	25.16	Type_12
P8003	22.56	Type_9
P8138	52.05	Type_12
P8135	28.59	Type_13
P8032	28.00	Type_2
P8034	38.89	Type_12
P8040	46.49	Type_7
P8075	27.82	Type_13
P8082	27.12	Type_8
P8129	26.54	Type_7
P8097	27.26	Type_2
P8098	26.52	Type_2
P8099	26.79	Type_2
P8101	26.88	Type_12
P8108	39.95	Type_11
P8109	29.42	Type_14
P8110	29.42	Type_14
P8111	29.12	Type_12
P8112	28.83	Type_2
P8118	27.71	Type_2
P8119	27.36	Type_12
P8125	27.17	Type_2
P8128	27.10	Type_8
P8136	26.66	Type_13
P9137	37.01	Type_2
P2861	45.20	Type_7
NEW1	27.59	Type_12
NEW2	27.69	Type_12
NEW3	27.46	Type_12
NEW4	27.38	Type_12
addPt1	27.65	Type_15
BusPit2	27.14	Type_7
P2034	26.26	Type_4
P2817a	34.80	Type_8
NorthP1	40.10	Type_9
NorthP2	38.28	Type_9

Note: Pit surface levels were modified based on the terrain grid

Appendix E

Inlet Curves Applied in the TUFLOW

APPENDIX E

Inlet Curves

Depth	Type_1	Type_2	Type_3	Type_4	Type_5	Type_6	Type_7	Type_8	Type_9	Type_10	Type_11	Type_12	Type_13	Type_14	Type_15	Type_16	Type_17	Type_18
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.025	0.034	0.068	0.102	0.136	1.088	3.400	0.004	0.008	0.011	0.014	0.016	0.072	0.076	0.079	0.082	0.084	0.087	0.100
0.050	0.048	0.096	0.144	0.192	1.536	4.800	0.012	0.023	0.031	0.039	0.047	0.108	0.119	0.127	0.135	0.143	0.150	0.190
0.075	0.059	0.118	0.177	0.236	1.888	5.900	0.021	0.043	0.057	0.071	0.086	0.139	0.161	0.175	0.189	0.204	0.218	0.290
0.100	0.068	0.136	0.204	0.272	2.176	6.800	0.033	0.066	0.088	0.110	0.132	0.169	0.202	0.224	0.246	0.268	0.290	0.400
0.125	0.076	0.152	0.228	0.304	2.432	7.600	0.046	0.092	0.123	0.154	0.184	0.198	0.244	0.275	0.306	0.336	0.367	0.520
0.150	0.083	0.167	0.249	0.334	2.672	8.350	0.061	0.121	0.162	0.202	0.242	0.228	0.288	0.329	0.369	0.409	0.450	0.651
0.175	0.090	0.180	0.270	0.360	2.880	9.000	0.076	0.153	0.204	0.255	0.306	0.256	0.333	0.384	0.435	0.486	0.536	0.792
0.200	0.096	0.193	0.288	0.386	3.088	9.650	0.093	0.187	0.249	0.311	0.373	0.286	0.380	0.442	0.504	0.566	0.628	0.939
0.225	0.102	0.204	0.306	0.408	3.264	10.200	0.111	0.223	0.297	0.371	0.445	0.315	0.427	0.501	0.575	0.649	0.724	1.094
0.250	0.108	0.215	0.324	0.430	3.440	10.750	0.13	0.261	0.348	0.435	0.522	0.345	0.476	0.563	0.650	0.737	0.824	1.259
0.275	0.113	0.226	0.339	0.452	3.616	11.300	0.15	0.301	0.401	0.502	0.602	0.376	0.527	0.627	0.728	0.828	0.928	1.430
0.300	0.118	0.236	0.354	0.472	3.776	11.800	0.171	0.343	0.457	0.571	0.686	0.407	0.579	0.693	0.807	0.922	1.036	1.608
0.325	0.123	0.245	0.369	0.490	3.920	12.250	0.193	0.387	0.515	0.644	0.773	0.438	0.632	0.760	0.889	1.018	1.147	1.791
0.350	0.127	0.255	0.381	0.510	4.080	12.750	0.216	0.432	0.576	0.720	0.864	0.471	0.687	0.831	0.975	1.119	1.263	1.983
0.375	0.132	0.264	0.396	0.528	4.224	13.200	0.24	0.479	0.639	0.799	0.958	0.504	0.743	0.903	1.063	1.222	1.382	2.180
0.400	0.136	0.272	0.408	0.544	4.352	13.600	0.264	0.528	0.704	0.880	1.056	0.536	0.800	0.976	1.152	1.328	1.504	2.384
0.425	0.140	0.281	0.420	0.562	4.496	14.050	0.289	0.578	0.771	0.964	1.156	0.570	0.859	1.052	1.245	1.437	1.630	2.593
0.450	0.144	0.289	0.432	0.578	4.624	14.450	0.315	0.630	0.840	1.050	1.260	0.604	0.919	1.129	1.339	1.549	1.759	2.809
0.475	0.148	0.297	0.444	0.594	4.752	14.850	0.342	0.683	0.911	1.138	1.366	0.639	0.980	1.208	1.435	1.663	1.891	3.029
0.500	0.152	0.304	0.456	0.608	4.864	15.200	0.369	0.738	0.984	1.230	1.475	0.673	1.042	1.288	1.534	1.779	2.025	3.254
0.525	0.156	0.312	0.468	0.624	4.992	15.600	0.397	0.794	1.058	1.323	1.587	0.709	1.106	1.370	1.635	1.899	2.164	3.486
0.550	0.160	0.319	0.480	0.638	5.104	15.950	0.426	0.851	1.135	1.418	1.702	0.745	1.170	1.454	1.737	2.021	2.305	3.723
0.575	0.163	0.326	0.489	0.652	5.216	16.300	0.455	0.910	1.213	1.516	1.820	0.781	1.236	1.539	1.842	2.146	2.449	3.966
0.600	0.167	0.333	0.501	0.666	5.328	16.650	0.485	0.970	1.293	1.616	1.939	0.818	1.303	1.626	1.949	2.272	2.596	4.211
0.625	0.170	0.340	0.510	0.680	5.440	17.000	0.515	1.031	1.375	1.718	2.062	0.855	1.371	1.715	2.058	2.402	2.746	4.464
0.650	0.174	0.347	0.522	0.694	5.552	17.350	0.547	1.093	1.458	1.822	2.187	0.894	1.440	1.805	2.169	2.534	2.898	4.721
0.675	0.177	0.354	0.531	0.708	5.664	17.700	0.579	1.157	1.543	1.929	2.314	0.933	1.511	1.897	2.283	2.668	3.054	4.982
0.700	0.180	0.360	0.540	0.720	5.760	18.000	0.611	1.222	1.629	2.037	2.444	0.971	1.582	1.989	2.397	2.804	3.211	5.248
0.725	0.183	0.367	0.549	0.734	5.872	18.350	0.644	1.288	1.717	2.174	2.576	1.011	1.655	2.084	2.541	2.943	3.372	5.519
0.750	0.186	0.373	0.558	0.746	5.968	18.650	0.678	1.355	1.807	2.259	2.711	1.051	1.728	2.180	2.632	3.084	3.535	5.795
0.775	0.190	0.379	0.570	0.758	6.064	18.950	0.712	1.424	1.898	2.373	2.847	1.091	1.803	2.277	2.752	3.226	3.701	6.073
0.800	0.193	0.385	0.579	0.770	6.160	19.250	0.747	1.493	1.991	2.488	2.986	1.132	1.878	2.376	2.873	3.371	3.869	6.357
0.825	0.196	0.391	0.588	0.782	6.256	19.550	0.782	1.564	2.085	2.606	3.127	1.173	1.955	2.476	2.997	3.518	4.039	6.645
0.850	0.198	0.397	0.594	0.794	6.352	19.850	0.818	1.635	2.180	2.725	3.270	1.215	2.032	2.577	3.122	3.667	4.212	6.937
0.875	0.201	0.403	0.603	0.806	6.448	20.150	0.854	1.708	2.277	2.846	3.416	1.257	2.111	2.680	3.249	3.819	4.388	7.235
0.900	0.204	0.408	0.612	0.816	6.528	20.400	0.891	1.782	2.375	2.969	3.563	1.299	2.190	2.783	3.377	3.971	4.565	7.534
0.925	0.207	0.414	0.621	0.828	6.624	20.700	0.928	1.856	2.475	3.094	3.713	1.342	2.270	2.889	3.508	4.127	4.745	7.840
0.950	0.210	0.420	0.630	0.840	6.720	21.000	0.966	1.932	2.576	3.220	3.864	1.386	2.352	2.996	3.640	4.284	4.928	8.148
0.975	0.213	0.425	0.639	0.850	6.800	21.250	1.004	2.009	2.678	3.348	4.018	1.429	2.434	3.103	3.773	4.443	5.112	8.461
1.000	0.216	0.431	0.648	0.862	6.896	21.550	1.043	2.087	2.782	3.478	4.173	1.474	2.518	3.213	3.909	4.604	5.300	8.777

Appendix F

Peak Water Levels at Reference Points

APPENDIX F

Peak Water Depths for Design Events at Reference Points

Reference ID	Peak Water Depths (m)								
	PMF	200yr ARI	100yr ARI	50yr ARI	20yr ARI	10yr ARI	5yr ARI	2yr ARI	1yr ARI
P10	0.87	0.40	0.40	0.38	0.35	0.29	0.27	0.25	0.20
P11	0.99	0.80	0.78	0.56	0.55	0.53	0.52	0.50	0.48
P12	2.86	2.50	2.44	1.68	1.50	1.36	1.24	0.99	0.84
P13	1.31	1.13	1.11	0.54	0.46	0.39	0.33	0.21	-
P14	1.06	0.64	0.62	0.58	0.54	0.47	0.42	0.26	0.19
P15	0.81	0.44	0.42	0.39	0.35	0.31	0.29	-	-
P17	0.84	0.35	0.32	0.27	0.22	-	-	-	-
P23	1.54	0.47	0.45	0.43	0.40	0.36	0.32	0.22	-
P25	1.35	0.26	0.24	0.21	0.19	0.16	0.15	-	-
P26	1.96	0.53	0.46	0.34	0.21	-	-	-	-
P29	1.03	0.23	0.21	0.18	-	-	-	-	-
P30	0.86	0.32	0.30	0.29	0.27	0.25	0.23	0.20	0.16
P31	1.41	0.41	0.39	0.34	0.28	0.22	0.15	-	-
P32	1.27	0.33	0.31	0.29	0.28	-	-	-	-
P34	1.20	0.61	0.58	0.55	0.51	0.47	0.43	0.36	0.33
P35	1.58	0.41	0.38	0.34	0.31	0.26	0.20	-	-
P36	0.61	0.32	0.31	0.30	0.24	0.19	-	-	-
P37	0.58	0.34	0.33	0.32	0.30	0.25	0.22	-	-
P38	0.53	0.31	0.30	0.27	0.27	0.27	0.24	-	-
P39	1.52	0.72	0.69	0.64	0.58	0.49	0.39	0.26	0.19
P40	1.01	0.37	0.35	0.33	0.30	0.27	0.24	0.00	0.00
P41	0.83	0.27	0.24	0.21	-	-	-	-	-
P42	0.79	0.34	0.31	0.24	-	-	-	-	-
P47	1.40	0.40	0.39	0.34	0.27	0.19	-	-	-
P51	0.84	0.37	0.34	0.27	0.23	0.20	0.17	-	-
P52	0.53	0.35	0.34	0.34	0.34	0.33	0.33	0.31	0.28
P53	1.22	0.54	0.52	0.47	-	-	-	-	-
P54	0.97	0.36	0.33	0.31	0.29	0.26	-	-	-
P55	0.91	0.43	0.38	0.34	0.32	0.31	0.30	0.25	0.20
P58	0.42	0.31	0.31	0.31	0.30	-	-	-	-
P59	1.45	0.50	0.45	0.38	0.30	0.24	-	-	-
P60	0.86	0.28	0.27	0.23	0.20	-	-	-	-
P61	1.78	0.37	0.34	0.31	0.28	0.25	0.23	0.19	0.16
P62	0.62	0.33	0.32	0.31	0.30	0.29	0.28	0.25	0.23
P63	0.52	0.30	0.29	0.27	0.26	-	-	-	-
P64	1.97	0.88	0.83	0.76	0.69	0.62	0.57	0.48	0.41
P65	0.81	0.44	0.44	0.41	0.39	0.37	0.35	0.33	0.32
P66	0.89	0.51	0.49	0.46	0.42	0.39	0.36	0.32	0.28
P67	0.99	0.39	0.36	0.32	0.27	0.22	-	-	-
P68	0.95	0.52	0.49	0.45	0.37	0.29	0.23	-	-
P72	0.83	0.64	0.64	0.62	0.59	0.49	0.38	0.18	-
P73	0.82	0.54	0.51	0.45	0.42	0.38	0.36	0.32	0.32
P74	1.01	0.88	0.87	0.85	0.81	0.76	0.72	0.64	0.60
P75	1.32	0.85	0.83	0.80	0.77	0.73	0.69	0.56	0.38
P76	0.54	0.38	0.37	0.35	0.33	0.28	0.22	-	-
P80	0.48	0.24	0.24	0.23	0.22	0.21	0.20	0.19	-
P81	0.64	0.30	0.28	0.27	0.25	0.22	0.20	0.17	-
P82	1.22	0.36	0.27	0.19	-	-	-	-	-
P83	0.63	0.22	0.19	0.15	-	-	-	-	-
P84	1.05	0.33	0.31	0.26	0.22	-	-	-	-

Note: "-" indicates the water depth recorded outside the flood extent

APPENDIX F

Peak Water Levels for Design Events at Reference Points

Reference ID	Peak Water Levels (m AHD)								
	PMF	200yr ARI	100yr ARI	50yr ARI	20yr ARI	10yr ARI	5yr ARI	2yr ARI	1yr ARI
P10	28.57	28.10	28.10	28.08	28.05	27.99	27.97	27.95	27.90
P11	26.02	25.83	25.81	25.59	25.58	25.56	25.55	25.53	25.51
P12	24.97	24.61	24.55	23.79	23.61	23.47	23.35	23.10	22.95
P13	26.01	25.83	25.81	25.24	25.16	25.09	25.03	24.91	-
P14	24.91	24.49	24.47	24.43	24.39	24.32	24.27	24.11	24.04
P15	24.96	24.59	24.57	24.54	24.50	24.46	24.44	-	-
P17	24.90	24.41	24.38	24.33	24.28	-	-	-	-
P23	36.35	35.28	35.26	35.24	35.21	35.17	35.13	35.03	-
P25	28.27	27.18	27.16	27.13	27.11	27.08	27.06	-	-
P26	28.13	26.70	26.63	26.51	26.38	-	-	-	-
P29	28.06	27.26	27.24	27.21	-	-	-	-	-
P30	28.31	27.77	27.75	27.74	27.72	27.70	27.68	27.65	27.61
P31	28.21	27.21	27.19	27.14	27.08	27.02	26.93	-	-
P32	28.21	27.27	27.25	27.23	27.22	-	-	-	-
P34	42.02	41.43	41.40	41.37	41.33	41.29	41.25	41.18	41.15
P35	35.69	34.52	34.49	34.45	34.42	34.37	34.31	-	-
P36	31.15	30.86	30.85	30.84	30.78	30.73	-	-	-
P37	29.04	28.80	28.79	28.78	28.76	28.71	28.68	-	-
P38	28.80	28.58	28.57	28.54	28.54	28.54	28.51	-	-
P39	32.17	31.37	31.34	31.29	31.23	31.14	31.04	30.91	30.84
P40	28.32	27.68	27.66	27.64	27.61	27.58	27.55	-	-
P41	28.54	27.98	27.95	27.92	-	-	-	-	-
P42	27.64	27.19	27.16	27.09	-	-	-	-	-
P47	28.15	27.15	27.14	27.09	27.02	26.94	-	-	-
P51	27.95	27.48	27.45	27.38	27.34	27.31	27.28	-	-
P52	28.64	28.46	28.45	28.45	28.45	28.44	28.44	28.42	28.39
P53	28.57	27.89	27.87	27.82	-	-	-	-	-
P54	28.80	28.19	28.16	28.14	28.12	28.09	-	-	-
P55	28.95	28.47	28.42	28.38	28.36	28.35	28.34	28.29	28.24
P58	29.77	29.66	29.66	29.66	29.65	-	-	-	-
P59	33.95	33.00	32.95	32.88	32.80	32.74	-	-	-
P60	35.68	35.10	35.09	35.05	35.02	-	-	-	-
P61	38.91	37.50	37.47	37.44	37.41	37.38	37.36	37.32	37.29
P62	42.64	42.35	42.34	42.33	42.32	42.31	42.30	42.27	42.25
P63	43.88	43.66	43.65	43.63	43.62	-	-	-	-
P64	42.50	41.41	41.36	41.29	41.22	41.15	41.10	41.01	40.94
P65	46.87	46.50	46.50	46.47	46.45	46.43	46.41	46.39	46.38
P66	40.13	39.75	39.73	39.70	39.66	39.63	39.60	39.56	39.52
P67	41.02	40.42	40.39	40.35	40.30	40.25	-	-	-
P68	37.84	37.41	37.38	37.34	37.26	37.18	37.12	-	-
P72	51.77	51.58	51.58	51.56	51.53	51.43	51.32	51.12	-
P73	48.77	48.49	48.46	48.40	48.37	48.33	48.31	48.27	48.27
P74	54.06	53.93	53.92	53.90	53.86	53.81	53.77	53.69	53.65
P75	51.04	50.57	50.55	50.52	50.49	50.45	50.41	50.28	50.10
P76	50.46	50.30	50.29	50.27	50.25	50.20	50.14	-	-
P80	27.56	27.32	27.32	27.31	27.30	27.29	27.28	27.27	-
P81	30.44	30.10	30.08	30.07	30.05	30.02	30.00	29.97	-
P82	29.86	29.00	28.91	28.83	-	-	-	-	-
P83	28.01	27.60	27.57	27.52	-	-	-	-	-
P84	27.32	26.60	26.58	26.53	26.49	-	-	-	-

Note: "-" indicates the water level recorded outside the flood extent

Appendix G

Conduit Peak Flows

APPENDIX G

Pipe Capacity Analysis

Pipe/Culvert ID	Type	LENGTH	US INVERT	DS INVERT	Diameter/ Width	Height	SLOPE	Mannings (n)	Nominal Capacity*	Max Modelled Flow	Nominal Return Period^	Modelled Peak Flows: PMF	200yr ARI	100yr ARI	50yr ARI	20yr ARI	10yr ARI	5yrARI	2yr ARI	1yrARI
		m	m AHD	m AHD	m	m	m/m		(m^3/s)	m3/s	ARI									
2021	Pipe	67.0	25.35	25.06	0.825	-	0.004	0.015	0.82	1.20	10yr	1.20	1.17	1.09	1.05	0.97	0.84	0.70	0.24	0.05
2031	Pipe	5.0	24.68	24.62	0.6	-	0.012	0.015	0.58	0.47	PMF	0.47	0.47	0.46	0.45	0.37	0.28	0.26	0.19	0.14
2032	Pipe	20.4	24.6	24.45	0.6	-	0.007	0.015	0.46	0.57	20yr	0.57	0.57	0.56	0.56	0.46	0.35	0.32	0.23	0.17
2033	Pipe	14.9	24.41	24.09	0.6	-	0.021	0.015	0.78	0.74	PMF	0.74	0.74	0.74	0.73	0.57	0.37	0.32	0.23	0.17
2034	Pipe	10.0	24.07	24.05	0.6	-	0.002	0.015	0.24	1.13	2yr	1.13	1.08	1.08	1.03	0.70	0.41	0.35	0.25	0.18
2035	Pipe	56.7	24.45	23.55	1.35	-	0.016	0.015	5.83	2.40	PMF	2.40	2.35	2.35	2.27	2.11	1.84	1.49	0.65	0.31
2036	Pipe	63.0	23.72	23.57	1.35	-	0.002	0.015	2.26	2.59	100yr	2.59	2.40	2.09	1.86	1.56	1.38	1.17	0.82	0.65
2037	Pipe	196.1	23.56	22.84	1.35	-	0.004	0.015	2.80	3.57	50yr	3.57	3.45	3.25	2.88	2.29	1.71	1.30	0.73	0.54
2038	Pipe	146.3	23.56	23.26	1.35	-	0.002	0.015	2.09	2.93	20yr	2.93	2.88	2.72	2.50	1.96	1.56	1.50	0.73	0.54
2106	Pipe	4.5	27.76	27.62	0.6	-	0.031	0.015	0.94	0.25	PMF	0.25	0.16	0.15	0.14	0.17	0.15	0.14	0.14	0.15
2129	Pipe	14.8	24.31	24.22	1.8	-	0.006	0.015	7.77	7.02	PMF	7.02	4.51	4.40	3.89	3.65	3.27	3.02	2.19	1.62
2132	Pipe	7.4	24.2	24	1.85	-	0.027	0.015	17.62	7.07	PMF	7.07	4.62	4.72	3.88	3.98	3.54	3.22	2.25	1.85
2146	Pipe	30.0	22.67	22.54	2.15	-	0.004	0.015	10.53	11.90	>200yr	11.90	7.25	6.79	6.12	5.51	4.92	4.49	3.46	2.31
2147	Pipe	26.4	22.99	22.67	2.15	-	0.012	0.015	17.62	11.83	PMF	11.83	7.21	6.75	6.08	5.48	4.90	4.47	3.45	2.30
2148	Pipe	29.7	22.54	22.39	2.15	-	0.005	0.015	11.37	12.28	>200yr	12.28	7.31	6.84	6.18	5.55	4.95	4.51	3.48	2.32
2149	Pipe	30.1	22.39	22.24	2.15	-	0.005	0.015	11.30	12.38	>200yr	12.38	7.33	6.86	6.19	5.57	4.96	4.52	3.49	2.33
2150	Pipe	30.2	22.24	22.11	2.15	-	0.004	0.015	10.50	12.49	>200yr	12.49	7.35	6.88	6.22	5.58	4.97	4.53	3.49	2.33
2151	Pipe	493.5	22.11	19.62	2.15	-	0.005	0.015	11.37	12.88	>200yr	12.88	7.39	6.91	6.27	5.61	4.99	4.54	3.45	2.33
2188	Pipe	27.5	21.6	21.5	1.05	-	0.004	0.015	1.43	0.08	PMF	0.03	0.03	0.05	0.03	0.05	0.08	0.04	0.00	0.00
2189	Pipe	63.5	21.47	21.13	1.2	-	0.005	0.015	2.47	0.58	PMF	0.32	0.32	0.50	0.26	0.41	0.58	0.40	0.03	0.01
2190	Pipe	13.9	21.09	21.07	1.2	-	0.001	0.015	1.28	0.97	PMF	0.13	0.05	0.05	0.05	0.64	0.97	0.79	0.13	0.02
2191	Pipe	8.6	20.96	20.88	1.2	-	0.009	0.015	3.26	0.95	PMF	0.13	0.05	0.05	0.04	0.70	0.78	0.95	0.16	0.02
2192	Pipe	38.6	20.38	20.2	0.9	-	0.005	0.015	1.07	0.69	PMF	0.69	0.53	0.53	0.51	0.44	0.43	0.36	0.31	0.26
2193	Pipe	103.2	20.82	20.58	0.9	-	0.002	0.015	0.76	0.52	PMF	0.49	0.52	0.52	0.49	0.43	0.42	0.35	0.29	0.27
2194	Pipe	118.0	20.05	20	1.05	-	0.000	0.015	0.49	1.54	1yr	1.54	1.10	1.06	1.02	0.93	0.85	0.73	0.54	0.39
2197	Pipe	68.5	22.45	22.01	0.6	-	0.006	0.015	0.43	0.28	PMF	0.28	0.17	0.15	0.14	0.13	0.11	0.10	0.09	0.07
2201	Pipe	28.9	22.87	22.55	0.6	-	0.011	0.015	0.56	0.14	PMF	0.14	0.11	0.09	0.13	0.10	0.09	0.10	0.08	0.12
2208	Pipe	28.9	21.57	21.54	0.8	-	0.001	0.015	0.37	0.69	20yr	0.69	0.45	0.43	0.40	0.33	0.27	0.18	0.10	0.10
2209	Pipe	41.0	21.64	21.57	0.65	-	0.002	0.015	0.27	0.37	>200yr	0.37	0.21	0.21	0.21	0.19	0.17	0.10	0.08	0.09
2211	Pipe	25.4	21.64	21.61	0.6	-	0.001	0.015	0.18	0.39	<1yr	0.39	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21
2213	Pipe	50.1	21.69	21.64	0.6	-	0.001	0.015	0.17	0.67	<1yr	0.67	0.34	0.34	0.33	0.32	0.31	0.29	0.27	0.25
2216	Pipe	30.1	21.72	21.69	0.6	-	0.001	0.015	0.17	0.90	<1yr	0.90	0.34	0.34	0.33	0.32	0.31	0.29	0.27	0.25
2223	Pipe	45.2	21.55	20.84	0.9	-	0.016	0.015	1.97	0.71	PMF	0.71	0.51	0.52	0.50	0.42	0.42	0.35	0.35	0.29
2224	Pipe	25.8	22	21.55	0.75	-	0.017	0.015	1.27	0.31	PMF	0.25	0.23	0.24	0.31	0.19	0.23	0.13	0.14	0.12
2225	Pipe	18.2	22.26	22	0.75	-	0.014	0.015	1.15	0.28	PMF	0.24	0.18	0.19	0.28	0.15	0.19	0.10	0.12	0.10
2226	Pipe	13.3	22.39	22.26	0.6	-	0.010	0.015	0.53	0.25	PMF	0.22	0.14	0.14	0.25	0.11	0.17	0.09	0.12	0.10

Pipe/Culvert ID	Type	LENGTH	US INVERT	DS INVERT	Diameter/ Width	Height	SLOPE	Mannings (n)	Nominal Capacity*	Max Modelled Flow	Nominal Return Period^	Modelled Peak Flows PMF	200yr ARI	100yr ARI	50yr ARI	20yr ARI	10yr ARI	5yrARI	2yr ARI	1yrARI
		m	m AHD	m AHD	m	m	m/m		(m^3/s)	m3/s	ARI									
2247	Pipe	21.5	26.82	26.75	1.05	-	0.003	0.015	1.35	0.27	PMF	0.12	0.02	0.05	0.19	0.27	0.05	0.05	0.07	0.04
2257	Pipe	19.8	27.46	27.35	0.6	-	0.006	0.015	0.40	0.11	PMF	0.11	0.07	0.10	0.07	0.07	0.06	0.06	0.04	0.04
2258	Pipe	22.0	27.33	27.27	0.6	-	0.003	0.015	0.28	0.26	PMF	0.26	0.16	0.17	0.17	0.17	0.16	0.14	0.09	0.05
2262	Pipe	28.9	27.04	27.03	0.6	-	0.000	0.015	0.60	0.34	PMF	0.34	0.21	0.21	0.22	0.21	0.18	0.15	0.10	0.05
2264	Pipe	21.4	26.99	26.92	0.6	-	0.003	0.015	0.30	0.33	>200yr	0.33	0.21	0.21	0.22	0.21	0.18	0.15	0.11	0.06
2265	Pipe	22.1	26.9	26.87	0.6	-	0.001	0.015	0.20	0.53	5yr	0.53	0.30	0.30	0.30	0.29	0.25	0.22	0.14	0.08
2268	Pipe	15.2	27.28	27.25	0.7	-	0.002	0.015	0.36	0.26	PMF	0.26	0.22	0.23	0.21	0.13	0.06	0.03	0.02	0.01
2269	Pipe	48.2	27.23	27.06	0.7	-	0.004	0.015	0.48	0.37	PMF	0.37	0.33	0.35	0.32	0.22	0.14	0.09	0.05	0.03
2276	Pipe	89.8	27.6	26.86	0.9	-	0.008	0.015	1.42	1.30	PMF	1.30	0.98	0.97	0.96	0.94	0.85	0.86	0.84	0.72
2286	Pipe	29.2	24.12	24	1.65	-	0.004	0.015	5.06	3.55	PMF	3.55	2.33	2.32	1.94	1.98	1.82	1.60	1.12	1.10
2294	Pipe	25.9	28.1	27.62	0.6	-	0.019	0.015	0.72	0.51	PMF	0.51	0.49	0.49	0.49	0.49	0.42	0.44	0.41	0.31
2295	Pipe	80.2	28.35	28.1	0.6	-	0.003	0.015	0.30	0.26	PMF	0.25	0.26	0.26	0.26	0.26	0.19	0.20	0.21	0.16
2299	Pipe	29.7	24.12	24	1.65	-	0.004	0.015	5.02	3.52	PMF	3.52	2.31	2.30	1.93	1.97	1.85	1.78	1.11	1.13
2309	Pipe	37.9	38.81	38.05	0.6	-	0.020	0.015	0.75	0.86	>200yr	0.86	0.73	0.70	0.65	0.60	0.54	0.52	0.46	0.40
2310	Pipe	10.4	38.98	38.88	0.6	-	0.010	0.015	0.52	0.32	PMF	0.32	0.28	0.27	0.26	0.25	0.24	0.22	0.19	0.18
2320	Pipe	9.8	39.64	39.45	1.05	-	0.019	0.015	3.30	2.59	PMF	2.59	1.08	1.05	1.01	0.93	0.88	0.84	0.75	0.68
2324	Pipe	29.5	40.39	39.64	1.05	-	0.025	0.015	3.77	2.33	PMF	2.33	0.95	0.93	0.90	0.83	0.79	0.75	0.68	0.61
2325	Pipe	38.9	41.06	40.42	1.05	-	0.016	0.015	3.04	2.04	PMF	2.04	0.82	0.79	0.78	0.72	0.69	0.67	0.61	0.56
2326	Pipe	15.6	39.45	39.29	1.05	-	0.010	0.015	2.40	2.59	>200yr	2.59	1.08	1.05	1.01	0.93	0.88	0.84	0.75	0.68
2327	Pipe	23.7	39.29	39	1.05	-	0.012	0.015	2.62	2.97	>200yr	2.97	1.29	1.25	1.21	1.12	1.06	1.00	0.87	0.78
2333	Pipe	37.1	48.04	47.68	0.6	-	0.010	0.015	0.52	0.53	>200yr	0.53	0.46	0.46	0.45	0.45	0.45	0.46	0.46	0.42
2334	Pipe	43.9	47.64	47.5	0.6	-	0.003	0.015	0.30	0.38	2yr	0.26	0.35	0.35	0.35	0.38	0.38	0.36	0.29	0.28
2335	Pipe	51.2	47.89	47.5	0.6	-	0.008	0.015	0.46	0.41	PMF	0.41	0.38	0.38	0.38	0.38	0.37	0.37	0.28	0.20
2344	Pipe	40.7	43.85	42.33	0.9	-	0.037	0.015	3.03	0.57	PMF	0.57	0.43	0.43	0.42	0.41	0.40	0.39	0.37	0.35
2345	Pipe	15.2	42.32	42.04	1.05	-	0.018	0.015	3.21	1.33	PMF	1.33	0.70	0.69	0.67	0.63	0.59	0.58	0.54	0.51
2346	Pipe	30.2	42.02	41.75	1.05	-	0.009	0.015	2.24	1.95	PMF	1.95	0.78	0.76	0.75	0.69	0.66	0.64	0.59	0.55
2348	Pipe	22.7	41.75	41.25	1.05	-	0.022	0.015	3.51	1.95	PMF	1.95	0.78	0.76	0.75	0.69	0.66	0.64	0.59	0.54
2354	Pipe	68.4	40.5	38.3	1.05	-	0.032	0.015	4.24	2.11	PMF	2.11	1.81	1.79	1.77	1.73	1.67	1.59	1.37	1.13
2357	Pipe	74.4	38.26	37.64	1.05	-	0.008	0.015	2.16	2.68	20yr	2.68	2.46	2.40	2.30	2.19	2.07	1.94	1.61	1.26
2358	Pipe	64.6	37.64	37.01	0.9	-	0.010	0.015	1.55	1.45	PMF	1.45	1.31	1.28	1.22	1.15	1.07	1.03	0.82	0.65
2359	Pipe	65.1	37.64	37.01	0.9	-	0.010	0.015	1.54	1.44	PMF	1.44	1.31	1.27	1.21	1.15	1.07	1.04	0.82	0.67
2360	Pipe	29.7	36.97	36.82	0.9	-	0.005	0.015	1.12	1.55	2yr	1.55	1.47	1.44	1.41	1.37	1.30	1.24	0.96	0.71
2361	Pipe	30.3	36.97	36.82	0.9	-	0.005	0.015	1.10	1.54	2yr	1.54	1.45	1.43	1.40	1.36	1.26	1.23	0.95	0.71
2364	Pipe	51.0	35.8	35.62	1.35	-	0.004	0.015	2.75	3.15	>200yr	3.15	1.83	1.78	1.71	1.63	1.58	1.55	1.33	1.20
2366	Pipe	13.7	36.06	36.04	1.35	-	0.001	0.015	1.77	3.24	200yr	3.24	1.77	1.72	1.65	2.22	1.58	1.73	1.58	1.26
2367	Pipe	6.1	36.25	36.08	1.35	-	0.028	0.015	7.72	3.17	PMF	3.17	2.00	1.57	1.55	2.27	1.51	2.07	1.55	1.09
2368	Pipe	20.5	36.9	36.48	1.35	-	0.020	0.015	6.62	2.97	PMF	2.97	1.29	1.25	1.21	1.12	1.06	1.00	0.87	0.78
2369	Pipe	83.2	39	36.91	1.35	-	0.025	0.015	7.33	2.97	PMF	2.97	1.29	1.25	1.20	1.12	1.06	1.00	0.87	0.78

Pipe/Culvert ID	Type	LENGTH	US INVERT	DS INVERT	Diameter/ Width	Height	SLOPE	Mannings (n)	Nominal Capacity*	Max Modelled Flow	Nominal Return Period^	Modelled Peak Flows PMF	200yr ARI	100yr ARI	50yr ARI	20yr ARI	10yr ARI	5yrARI	2yr ARI	1yrARI
		m	m AHD	m AHD	m	m	m/m		(m^3/s)	m3/s	ARI									
2377	Pipe	22.7	35.62	35.45	1.35	-	0.007	0.015	4.00	6.28	2yr	6.28	5.23	5.14	5.01	4.83	4.56	4.27	3.48	2.70
2378	Pipe	47.1	35.76	35.62	1.35	-	0.003	0.015	2.52	3.75	2yr	3.75	3.41	3.37	3.31	3.24	3.06	2.94	2.26	1.63
2380	Pipe	118.9	28.33	28.22	0.9	-	0.001	0.015	0.48	0.89	2yr	0.84	0.83	0.80	0.80	0.76	0.89	0.83	0.47	0.26
2381	Pipe	35.9	28.37	28.33	0.9	-	0.001	0.015	0.52	0.55	100yr	0.45	0.53	0.52	0.53	0.51	0.55	0.54	0.33	0.24
2384	Pipe	25.8	28.39	28.37	0.75	-	0.001	0.015	0.27	0.32	2yr	0.25	0.30	0.29	0.31	0.32	0.32	0.32	0.26	0.20
2390	Pipe	18.5	28.47	28.45	0.7	-	0.001	0.015	0.26	0.36	2yr	0.36	0.32	0.32	0.34	0.34	0.34	0.33	0.27	0.21
2394	Pipe	93.4	26.9	26.57	0.6	-	0.004	0.015	0.32	0.40	20yr	0.40	0.38	0.38	0.38	0.33	0.29	0.26	0.19	0.15
2404	Pipe	103.2	37.98	34.96	0.7	-	0.029	0.015	1.37	0.42	PMF	0.42	0.21	0.20	0.19	0.18	0.17	0.16	0.13	0.11
2405	Pipe	18.9	34.94	34.91	0.75	-	0.002	0.015	0.38	0.52	>200yr	0.52	0.27	0.24	0.22	0.20	0.19	0.17	0.14	0.12
2416	Pipe	19.5	34.09	33.79	0.6	-	0.015	0.015	0.66	0.84	1yr	0.84	0.81	0.81	0.81	0.80	0.79	0.79	0.75	0.63
2417	Pipe	14.2	33.75	33.2	0.6	-	0.039	0.015	1.05	0.86	>200yr	0.86	0.82	0.81	0.80	0.81	0.81	0.80	0.79	0.65
2418	Pipe	40.3	34.54	34.09	0.75	-	0.011	0.015	1.02	1.10	200yr	1.10	1.02	1.01	0.99	0.96	0.93	0.92	0.78	0.62
2419	Pipe	11.5	33.88	33.83	0.6	-	0.004	0.015	0.35	0.07	PMF	0.06	0.07	0.05	0.06	0.06	0.04	0.05	0.05	0.03
2420	Pipe	109.8	33.19	31.34	0.6	-	0.017	0.015	0.69	0.88	1yr	0.88	0.86	0.86	0.85	0.82	0.82	0.82	0.83	0.68
2427	Pipe	13.8	32.89	31.19	0.6	-	0.123	0.015	1.87	0.66	PMF	0.66	0.30	0.28	0.24	0.22	0.18	0.17	0.11	0.08
2428	Pipe	87.2	31.11	30.64	0.6	-	0.005	0.015	0.39	0.51	>200yr	0.51	0.30	0.28	0.25	0.22	0.20	0.18	0.11	0.08
2438	Pipe	50.8	40.04	38.4	0.6	-	0.032	0.015	0.96	0.65	PMF	0.65	0.34	0.33	0.32	0.31	0.28	0.27	0.23	0.20
2443	Pipe	12.4	42.98	42.78	0.76	-	0.016	0.015	1.27	0.88	PMF	0.88	0.88	0.87	0.86	0.84	0.81	0.74	0.58	0.46
2444	Pipe	50.2	44.15	43.29	0.7	-	0.017	0.015	1.05	0.90	PMF	0.90	0.81	0.81	0.80	0.79	0.78	0.71	0.56	0.44
2445	Pipe	26.8	42.78	42.27	0.75	-	0.019	0.015	1.33	1.04	PMF	1.04	1.04	1.03	1.02	1.00	0.98	0.94	0.79	0.62
2446	Pipe	29.3	44.76	44.42	0.65	-	0.012	0.015	0.71	0.95	5yr	0.95	0.83	0.82	0.81	0.80	0.78	0.71	0.56	0.44
2447	Pipe	91.4	46.04	44.79	0.65	-	0.014	0.015	0.77	0.95	10yr	0.95	0.83	0.82	0.81	0.80	0.78	0.71	0.56	0.44
2448	Pipe	13.6	46.23	46.07	0.65	-	0.012	0.015	0.71	1.01	5yr	1.01	0.93	0.92	0.89	0.85	0.76	0.71	0.56	0.44
2449	Pipe	25.3	46.81	46.26	0.65	-	0.022	0.015	0.97	0.88	PMF	0.88	0.87	0.87	0.86	0.83	0.75	0.70	0.55	0.43
2450	Pipe	8.9	47.12	46.87	0.65	-	0.028	0.015	1.10	0.80	PMF	0.80	0.78	0.79	0.77	0.76	0.71	0.68	0.55	0.42
2451	Pipe	3.4	47.22	47.14	0.7	-	0.024	0.015	1.23	0.36	PMF	0.35	0.36	0.36	0.36	0.36	0.36	0.36	0.26	0.18
2464	Pipe	55.6	33.04	33	0.75	-	0.001	0.015	0.26	1.08	<1yr	1.08	0.86	0.86	0.86	0.88	0.88	0.86	0.67	0.56
2465	Pipe	5.4	33.09	33.07	0.75	-	0.004	0.015	0.59	0.53	PMF	0.53	0.47	0.47	0.45	0.44	0.41	0.39	0.29	0.20
2471	Pipe	74.6	32.91	32.1	0.6	-	0.011	0.015	0.55	0.60	>200yr	0.60	0.17	0.17	0.16	0.15	0.14	0.12	0.09	0.07
2475	Pipe	66.5	48.63	46.19	0.6	-	0.037	0.015	1.02	0.86	PMF	0.86	0.29	0.28	0.25	0.23	0.19	0.17	0.12	0.09
2476	Pipe	29.8	46.16	45.56	0.6	-	0.020	0.015	0.76	0.72	PMF	0.72	0.33	0.31	0.27	0.25	0.21	0.18	0.14	0.10
2477	Pipe	20.3	45.53	45.49	0.6	-	0.002	0.015	0.24	0.72	20yr	0.72	0.32	0.30	0.27	0.25	0.21	0.18	0.14	0.10
2519	Pipe	13.9	36.9	36.45	0.6	-	0.032	0.015	0.96	0.17	PMF	0.16	0.14	0.14	0.17	0.17	0.13	0.14	0.10	0.09
2539	Pipe	63.8	28.01	27.84	0.6	-	0.003	0.015	0.27	0.56	2yr	0.56	0.53	0.52	0.52	0.51	0.48	0.41	0.28	0.12
2540	Pipe	40.9	27.82	27.59	0.6	-	0.006	0.015	0.40	0.48	2yr	0.48	0.48	0.48	0.47	0.47	0.46	0.45	0.40	0.29
2541	Pipe	56.0	27.59	27.55	0.6	-	0.001	0.015	0.14	0.44	<1yr	0.44	0.43	0.43	0.42	0.42	0.41	0.40	0.38	0.33
2546	Pipe	19.5	27.23	27.06	0.6	-	0.009	0.015	0.50	0.08	PMF	0.08	0.03	0.05	0.05	0.04	0.04	0.04	0.03	0.05
2548	Pipe	54.5	27.05	27	0.6	-	0.001	0.015	0.16	0.51	<1yr	0.51	0.36	0.36	0.33	0.34	0.34	0.31	0.36	0.31

Pipe/Culvert ID	Type	LENGTH	US INVERT	DS INVERT	Diameter/ Width	Height	SLOPE	Mannings (n)	Nominal Capacity*	Max Modelled Flow	Nominal Return Period^	Modelled Peak Flows								
												PMF	200yr ARI	100yr ARI	50yr ARI	20yr ARI	10yr ARI	5yrARI	2yr ARI	1yrARI
		m	m AHD	m AHD	m	m	m/m		(m^3/s)	m3/s	ARI									
2549	Pipe	27.5	27.06	27.05	0.6	-	0.000	0.015	0.10	0.38	<1yr	0.38	0.33	0.33	0.31	0.31	0.28	0.29	0.31	0.25
2550	Pipe	6.9	27.14	27.06	0.6	-	0.012	0.015	0.57	0.15	PMF	0.14	0.15	0.15	0.13	0.12	0.12	0.12	0.11	0.06
2562	Pipe	14.2	26.54	26.51	0.6	-	0.002	0.015	0.24	0.70	2yr	0.70	0.67	0.64	0.62	0.58	0.35	0.29	0.17	0.11
2563	Pipe	13.7	26.54	26.52	0.6	-	0.001	0.015	0.20	0.67	2yr	0.67	0.63	0.62	0.63	0.47	0.35	0.29	0.16	0.11
2564	Pipe	13.0	26.34	26.3	0.6	-	0.003	0.015	0.30	0.59	<1yr	0.59	0.55	0.54	0.53	0.51	0.46	0.44	0.41	0.35
2565	Pipe	103.7	26.6	26.37	0.6	-	0.002	0.015	0.25	0.45	<1yr	0.45	0.45	0.45	0.45	0.44	0.43	0.42	0.45	0.39
2566	Pipe	7.9	26.49	26.4	0.9	-	0.011	0.015	1.67	1.04	PMF	1.04	0.80	0.76	0.66	0.57	0.36	0.30	0.17	0.12
2567	Pipe	7.7	26.46	26.4	0.9	-	0.008	0.015	1.38	1.02	PMF	1.02	0.74	0.85	0.82	0.59	0.36	0.30	0.17	0.12
2568	Pipe	28.9	26.5	26.4	0.65	-	0.003	0.015	0.39	0.38	PMF	0.38	0.33	0.35	0.33	0.26	0.20	0.17	0.10	0.07
2569	Pipe	50.9	26.68	26.5	0.6	-	0.004	0.015	0.32	0.35	50yr	0.34	0.33	0.35	0.32	0.25	0.20	0.16	0.09	0.07
2576	Pipe	36.4	26.8	26.68	0.6	-	0.003	0.015	0.31	0.35	50yr	0.32	0.33	0.35	0.32	0.25	0.20	0.16	0.09	0.07
2590	Pipe	98.1	26.85	26.55	0.6	-	0.003	0.015	0.29	0.28	PMF	0.28	0.15	0.15	0.16	0.17	0.15	0.13	0.08	0.05
2591	Pipe	88.5	26.55	26.29	0.6	-	0.003	0.015	0.29	0.33	>200yr	0.33	0.25	0.25	0.26	0.25	0.23	0.18	0.10	0.07
2595	Pipe	98.1	26.29	25.98	0.6	-	0.003	0.015	0.30	0.53	10yr	0.53	0.34	0.34	0.33	0.32	0.29	0.23	0.12	0.08
2596	Pipe	37.7	25.98	25.95	0.75	-	0.001	0.015	0.27	0.57	10yr	0.57	0.35	0.35	0.35	0.33	0.29	0.23	0.12	0.08
2597	Pipe	38.1	25.95	25.92	0.75	-	0.001	0.015	0.27	0.58	10yr	0.58	0.35	0.35	0.35	0.33	0.29	0.23	0.12	0.08
2603	Pipe	6.0	36.02	35.8	1.35	-	0.037	0.015	8.86	3.15	PMF	3.15	1.83	1.78	1.71	2.00	1.62	1.56	1.45	1.34
2609	Pipe	127.9	31.21	29.57	1.2	-	0.013	0.015	3.83	3.53	PMF	3.53	2.52	2.52	2.35	2.17	1.97	1.80	1.41	0.95
2611	Pipe	102.8	31.21	30	1.2	-	0.012	0.015	3.67	3.33	PMF	3.33	2.50	2.44	2.35	2.17	1.97	1.80	1.41	0.95
2626	Pipe	4.1	25.2	25.18	0.7	-	0.005	0.015	0.56	0.77	20yr	0.77	0.68	0.67	0.62	0.56	0.49	0.44	0.35	0.25
2631	Pipe	4.7	25.33	25.2	0.7	-	0.028	0.015	1.33	0.60	PMF	0.60	0.53	0.52	0.49	0.44	0.39	0.38	0.27	0.21
2632	Pipe	26.2	36.82	35.75	0.9	-	0.041	0.015	3.17	1.88	PMF	1.88	1.72	1.69	1.66	1.62	1.53	1.45	1.13	0.80
2633	Pipe	26.6	36.82	35.75	0.9	-	0.040	0.015	3.15	1.87	PMF	1.87	1.71	1.68	1.65	1.61	1.53	1.45	1.13	0.80
2634	Pipe	18.4	25.17	25.06	0.7	-	0.006	0.015	0.62	1.02	10yr	1.02	0.83	0.81	0.74	0.66	0.56	0.50	0.34	0.25
2636	Pipe	7.2	25.06	24.94	0.7	-	0.017	0.015	1.04	1.24	>200yr	1.24	0.92	0.87	0.77	0.68	0.56	0.50	0.36	0.26
2637	Pipe	13.7	24.94	24.84	0.7	-	0.007	0.015	0.69	1.44	20yr	1.44	0.92	0.87	0.77	0.68	0.56	0.50	0.33	0.25
2684	Pipe	22.8	49.6	49.21	0.6	-	0.017	0.015	0.70	0.71	>200yr	0.71	0.29	0.27	0.24	0.22	0.18	0.16	0.12	0.09
2686	Pipe	28.5	49.2	48.65	0.6	-	0.019	0.015	0.74	0.73	PMF	0.73	0.29	0.27	0.24	0.22	0.18	0.16	0.12	0.09
2691	Pipe	8.5	48.6	48.57	0.65	-	0.004	0.015	0.39	0.55	1yr	0.55	0.43	0.42	0.42	0.42	0.42	0.42	0.41	0.39
2692	Pipe	57.4	48.55	48.04	0.65	-	0.009	0.015	0.62	0.64	>200yr	0.64	0.46	0.46	0.45	0.45	0.46	0.47	0.46	0.42
2699	Pipe	24.6	25.3	25.2	1.8	-	0.004	0.015	6.35	5.27	PMF	5.27	2.97	2.77	2.35	2.12	1.88	1.71	1.33	0.95
2703	Pipe	98.9	25.49	25.3	0.9	-	0.002	0.015	0.69	0.96	100yr	0.96	0.71	0.69	0.66	0.64	0.60	0.57	0.48	0.45
2713	Pipe	39.8	31.52	30.58	0.6	-	0.024	0.015	0.82	0.53	PMF	0.53	0.27	0.26	0.24	0.22	0.20	0.18	0.14	0.10
2714	Pipe	11.9	30.58	30.1	0.6	-	0.040	0.015	1.07	0.70	PMF	0.70	0.40	0.39	0.37	0.33	0.31	0.27	0.22	0.17
2715	Pipe	14.3	32.1	31.52	0.6	-	0.041	0.015	1.07	0.48	PMF	0.48	0.21	0.20	0.19	0.18	0.16	0.14	0.11	0.08
2719	Pipe	153.9	23	22.11	2.15	-	0.006	0.015	12.17	12.19	>200yr	12.19	6.08	5.60	5.18	4.55	4.06	3.65	3.01	2.26
2720	Pipe	493.5	22.11	19.62	2.15	-	0.005	0.015	11.37	12.59	>200yr	12.59	6.13	5.64	5.15	4.59	4.06	3.65	2.79	2.14
2721	Pipe	28.7	22.39	22.28	2.15	-	0.004	0.015	9.91	9.37	PMF	9.37	7.43	6.97	5.99	4.51	3.50	2.68	1.65	1.23

Pipe/Culvert ID	Type	LENGTH	US INVERT	DS INVERT	Diameter/ Width	Height	SLOPE	Mannings (n)	Nominal Capacity*	Max Modelled Flow	Nominal Return Period^	Modelled Peak Flows: PMF	200yr ARI	100yr ARI	50yr ARI	20yr ARI	10yr ARI	5yrARI	2yr ARI	1yrARI
		m	m AHD	m AHD	m	m	m/m		(m^3/s)	m3/s	ARI									
2722	Pipe	12.3	22.08	22.05	2.15	-	0.002	0.015	7.90	10.13	>200yr	10.13	7.48	7.02	6.36	4.54	3.53	2.70	1.67	1.24
2723	Pipe	50.3	22.05	21.77	2.15	-	0.006	0.015	11.94	10.60	PMF	10.60	7.52	7.06	6.11	4.57	3.56	2.72	1.70	1.26
2729	Pipe	7.8	22.43	22.39	2.15	-	0.005	0.015	11.46	9.22	PMF	9.22	7.43	6.98	5.99	4.51	3.50	2.68	1.65	1.23
2731	Pipe	201.9	23.39	22.52	1.2	-	0.004	0.015	2.22	0.97	PMF	0.97	0.54	0.53	0.41	0.26	0.21	0.17	0.11	0.07
2732	Pipe	147.4	22.84	22.52	1.5	-	0.002	0.015	2.85	3.57	50yr	3.57	3.45	3.25	2.90	2.29	1.71	1.28	0.72	0.53
2733	Pipe	149.4	23.16	22.52	1.35	-	0.004	0.015	3.03	3.73	100yr	3.73	3.31	3.10	2.64	2.20	2.00	1.47	0.82	0.60
2738	Pipe	5.5	22.84	22.71	1.25	-	0.024	0.015	5.79	0.38	PMF	0.38	0.38	0.34	0.34	0.26	0.25	0.24	0.18	0.16
2739	Pipe	20.0	22.71	22.6	2.15	-	0.005	0.015	11.87	1.83	PMF	1.83	0.35	0.36	0.34	0.27	0.25	0.24	0.19	0.16
2740	Pipe	60.3	21.51	21.23	2.15	-	0.005	0.015	10.90	13.00	>200yr	13.00	7.97	7.49	6.47	4.88	3.84	2.99	1.94	1.46
2742	Pipe	328.0	21.23	19.62	2.15	-	0.005	0.015	11.21	13.17	>200yr	13.17	7.97	7.49	6.46	4.87	3.84	2.97	1.91	1.43
2775	Pipe	61.3	23.16	23.08	0.9	-	0.001	0.015	0.57	0.15	PMF	0.15	0.15	0.15	0.13	0.12	0.12	0.14	0.11	0.11
2817	Pipe	66.4	25.68	25.53	0.6	-	0.002	0.015	0.25	0.33	2yr	0.28	0.32	0.33	0.32	0.33	0.33	0.33	0.23	0.16
2818	Pipe	66.0	25.53	25.25	0.6	-	0.004	0.015	0.35	0.49	2yr	0.49	0.44	0.44	0.44	0.44	0.45	0.40	0.26	0.17
2858	Pipe	48.1	28.6	28.37	0.65	-	0.005	0.015	0.46	0.05	PMF	0.01	0.05	0.04	0.03	0.02	0.02	0.02	0.02	0.01
2872	Pipe	53.0	36.44	36.04	0.825	-	0.008	0.015	1.08	0.79	PMF	0.79	0.61	0.58	0.55	0.49	0.44	0.41	0.31	0.28
2873	Pipe	18.5	36.02	35.71	0.825	-	0.017	0.015	1.61	0.76	PMF	0.76	0.60	0.58	0.56	0.51	0.46	0.42	0.33	0.27
2874	Pipe	18.8	36.02	35.71	0.825	-	0.016	0.015	1.60	0.76	PMF	0.76	0.59	0.58	0.56	0.50	0.45	0.42	0.33	0.27
2875	Pipe	4.7	35.69	35.66	0.65	-	0.006	0.015	0.53	1.34	1yr	1.34	1.06	1.03	1.00	0.92	0.84	0.80	0.67	0.55
2877	Pipe	8.3	35.64	35.48	0.65	-	0.019	0.015	0.91	1.12	20yr	1.12	1.00	0.98	0.96	0.91	0.85	0.82	0.73	0.59
2878	Pipe	21.8	35.46	35.21	0.75	-	0.011	0.015	1.03	1.10	200yr	1.10	1.02	1.01	0.99	0.96	0.93	0.92	0.78	0.62
2879	Pipe	17.2	37.46	36.51	0.6	-	0.055	0.015	1.25	0.13	PMF	0.06	0.03	0.13	0.08	0.00	0.00	0.00	0.00	0.00
2880	Pipe	18.9	37.07	36.51	0.825	-	0.030	0.015	2.14	0.73	PMF	0.73	0.56	0.53	0.51	0.44	0.39	0.36	0.28	0.23
2881	Pipe	19.1	37.07	36.51	0.825	-	0.029	0.015	2.13	0.72	PMF	0.72	0.55	0.53	0.51	0.44	0.39	0.36	0.28	0.23
2882	Pipe	51.7	36.44	36.04	0.825	-	0.008	0.015	1.09	0.80	PMF	0.80	0.61	0.59	0.55	0.49	0.44	0.41	0.31	0.30
2884	Pipe	10.3	37.64	37.47	0.825	-	0.017	0.015	1.60	0.68	PMF	0.68	0.52	0.49	0.46	0.42	0.38	0.35	0.27	0.22
2885	Pipe	10.6	37.62	37.47	0.825	-	0.014	0.015	1.48	0.67	PMF	0.67	0.55	0.53	0.49	0.45	0.41	0.38	0.29	0.25
2886	Pipe	22.6	38.05	37.66	0.6	-	0.017	0.015	0.70	0.86	100yr	0.86	0.73	0.70	0.65	0.60	0.54	0.52	0.46	0.40
2887	Pipe	59.9	35.21	34.54	0.75	-	0.011	0.015	1.02	1.10	200yr	1.10	1.02	1.01	0.99	0.96	0.93	0.92	0.81	0.63
2903	Pipe	195.9	26.3	25.8	1.05	-	0.003	0.015	1.20	0.91	PMF	0.91	0.78	0.69	0.66	0.65	0.61	0.52	0.39	0.30
2906	Pipe	69.8	27.06	26.85	0.7	-	0.003	0.015	0.44	0.37	PMF	0.37	0.33	0.35	0.33	0.22	0.14	0.09	0.05	0.03
2922	Pipe	34.5	28.5	27.9	0.6	-	0.017	0.015	0.70	0.35	PMF	0.35	0.30	0.30	0.30	0.30	0.30	0.30	0.27	0.22
2970	Pipe	45.6	38.16	37.83	0.7	-	0.007	0.015	0.68	0.67	PMF	0.67	0.60	0.60	0.59	0.57	0.56	0.55	0.51	0.42
2985	Pipe	25.0	24.85	24.74	1.8	-	0.004	0.015	6.61	5.92	PMF	5.92	4.00	3.75	3.15	2.86	2.55	2.31	1.86	1.39
2991	Pipe	8.1	25.01	24.82	1.8	-	0.023	0.015	15.26	0.20	PMF	0.20	0.07	0.07	0.06	0.05	0.05	0.04	0.02	0.02
2992	Pipe	7.9	24.1	24	1.8	-	0.013	0.015	11.21	8.48	PMF	8.48	4.66	4.26	4.11	3.69	3.32	3.06	2.36	1.68
3001	Pipe	10.2	26.74	26.7	1.05	-	0.004	0.015	1.48	0.13	PMF	0.13	0.02	0.11	0.04	0.03	0.07	0.05	0.13	0.08
3007	Pipe	6.5	27.6	27.57	0.6	-	0.005	0.015	0.36	0.24	PMF	0.24	0.18	0.20	0.18	0.19	0.18	0.18	0.17	0.17
3015	Pipe	95.2	34.9	32.6	0.75	-	0.024	0.015	1.50	0.55	PMF	0.55	0.24	0.23	0.21	0.20	0.19	0.17	0.14	0.12

Pipe/Culvert ID	Type	LENGTH	US INVERT	DS INVERT	Diameter/ Width	Height	SLOPE	Mannings (n)	Nominal Capacity*	Max Modelled Flow	Nominal Return Period^	Modelled Peak Flows								
												PMF	200yr ARI	100yr ARI	50yr ARI	20yr ARI	10yr ARI	5yrARI	2yr ARI	1yrARI
		m	m AHD	m AHD	m	m	m/m		(m^3/s)	m3/s	ARI									
3017	Pipe	30.3	20.88	20.68	1.2	-	0.007	0.015	2.75	0.97	PMF	0.33	0.30	0.08	0.30	0.60	0.86	0.97	0.33	0.01
3018	Pipe	111.8	20.64	20.55	1.2	-	0.001	0.015	0.96	0.27	PMF	0.27	0.15	0.15	0.11	0.11	0.11	0.11	0.10	0.10
3019	Pipe	103.2	22.96	21.58	0.75	-	0.013	0.015	1.12	0.01	PMF	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3023	Pipe	24.8	25.6	25.55	0.9	-	0.002	0.015	0.70	0.41	PMF	0.41	0.34	0.39	0.34	0.33	0.32	0.31	0.29	0.28
3025	Pipe	75.1	21.54	21.45	0.8	-	0.001	0.015	0.40	0.91	10yr	0.91	0.59	0.57	0.54	0.48	0.41	0.31	0.13	0.12
3029	Pipe	146.9	45.09	42.49	0.6	-	0.018	0.015	0.71	0.72	>200yr	0.72	0.32	0.30	0.27	0.24	0.21	0.18	0.13	0.10
3039	Pipe	34.4	42.17	41	0.75	-	0.034	0.015	1.78	1.48	PMF	1.48	1.28	1.27	1.26	1.24	1.19	1.11	0.92	0.72
3040	Pipe	33.0	42.27	42.17	0.75	-	0.003	0.015	0.53	1.04	<1yr	0.85	1.04	1.03	1.02	1.00	0.98	0.94	0.79	0.62
3042	Pipe	37.9	41.25	41.06	1.05	-	0.005	0.015	1.68	1.95	>200yr	1.95	0.78	0.76	0.75	0.69	0.66	0.64	0.58	0.54
3053	Pipe	61.5	28.45	28.39	0.7	-	0.001	0.015	0.25	0.32	2yr	0.32	0.30	0.29	0.32	0.32	0.32	0.32	0.26	0.21
7004	Pipe	34.7	36.48	36.28	1.35	-	0.006	0.015	3.51	3.07	PMF	3.07	1.34	1.30	1.25	1.58	1.12	1.36	0.95	0.80
7008	Pipe	3.3	38.88	38.82	0.6	-	0.018	0.015	0.72	0.52	PMF	0.52	0.49	0.49	0.48	0.47	0.46	0.44	0.41	0.37
7028	Pipe	4.4	33.06	33.02	0.75	-	0.009	0.015	0.92	0.57	PMF	0.57	0.51	0.49	0.47	0.45	0.44	0.40	0.28	0.20
7029	Pipe	12.6	33.02	32.91	0.75	-	0.009	0.015	0.90	0.60	PMF	0.60	0.54	0.52	0.51	0.49	0.46	0.42	0.30	0.22
7030	Pipe	9.0	32.91	32.83	0.75	-	0.009	0.015	0.91	0.60	PMF	0.60	0.54	0.53	0.51	0.49	0.46	0.43	0.29	0.22
7031	Pipe	25.3	30	29.55	1.2	-	0.018	0.015	4.51	4.03	PMF	4.03	2.82	2.76	2.62	2.40	2.17	1.98	1.58	1.05
7040	Pipe	22.3	24	23.89	2.15	-	0.005	0.015	11.24	11.29	>200yr	11.29	7.08	6.64	5.98	5.40	4.84	4.42	3.42	2.27
7041	Pipe	84.6	23.89	23.46	2.15	-	0.005	0.015	11.41	11.32	PMF	11.32	7.09	6.65	5.99	5.40	4.84	4.42	3.42	2.27
7042	Pipe	50.5	23.46	23.26	2.15	-	0.004	0.015	10.07	11.42	>200yr	11.42	7.17	6.72	6.05	5.46	4.88	4.46	3.44	2.29
7043	Pipe	26.2	23.26	23.13	2.15	-	0.005	0.015	11.27	11.53	>200yr	11.53	7.20	6.75	6.08	5.48	4.89	4.47	3.45	2.30
7044	Pipe	29.1	23.13	22.99	2.15	-	0.005	0.015	11.10	11.69	>200yr	11.69	7.21	6.76	6.08	5.48	4.90	4.47	3.45	2.30
7045	Pipe	205.8	24	23	2.15	-	0.005	0.015	11.15	12.13	>200yr	12.13	6.07	5.59	5.10	4.57	4.03	3.67	2.88	2.27
7054	Pipe	11.1	25.55	25.5	0.9	-	0.005	0.015	1.05	0.60	PMF	0.60	0.47	0.47	0.47	0.46	0.44	0.43	0.37	0.33
7055	Pipe	5.3	25.5	25.49	0.9	-	0.002	0.015	0.68	0.97	50yr	0.97	0.71	0.69	0.67	0.64	0.61	0.57	0.48	0.45
7058	Pipe	32.7	25.3	25.2	0.9	-	0.003	0.015	0.87	1.27	20yr	1.27	1.00	0.98	0.94	0.89	0.81	0.74	0.58	0.51
7063	Pipe	50.2	25.2	25	1.8	-	0.004	0.015	6.29	5.56	PMF	5.56	3.77	3.54	3.07	2.79	2.52	2.30	1.86	1.39
7064	Pipe	30.0	25	24.85	1.8	-	0.005	0.015	7.04	5.82	PMF	5.82	4.00	3.74	3.14	2.83	2.54	2.31	1.86	1.39
7065	Pipe	10.6	24.73	24.69	1.8	-	0.004	0.015	6.12	7.09	>200yr	7.09	4.61	4.25	3.82	3.45	3.11	2.78	2.18	1.62
7066	Pipe	69.0	24.69	24.41	1.8	-	0.004	0.015	6.35	7.01	>200yr	7.01	4.50	4.23	3.82	3.42	3.03	2.78	2.18	1.62
7077	Pipe	27.3	24.41	24.31	1.8	-	0.004	0.015	6.03	7.06	>200yr	7.06	4.51	4.38	3.82	3.42	3.02	2.78	2.19	1.62
7078	Pipe	50.8	23.26	23.16	1.35	-	0.002	0.015	2.05	3.22	PMF	3.04	3.22	3.04	2.66	2.01	1.66	1.53	0.79	0.62
7079	Pipe	49.0	22.28	22.08	2.15	-	0.004	0.015	10.22	9.78	>200yr	9.78	7.49	7.02	6.05	4.54	3.53	2.70	1.67	1.24
7080	Pipe	49.7	21.77	21.52	2.15	-	0.005	0.015	11.35	12.35	>200yr	12.35	7.84	7.38	6.36	4.82	3.79	2.95	1.88	1.42
7082	Pipe	22.5	42.4	41.82	0.7	-	0.026	0.015	1.29	0.26	PMF	0.26	0.19	0.20	0.19	0.18	0.18	0.17	0.16	0.14
7092	Pipe	66.8	41	40.5	0.75	-	0.007	0.015	0.83	1.48	1yr	1.48	1.28	1.27	1.26	1.24	1.19	1.11	0.92	0.72
7093	Pipe	51.8	38.4	37	0.6	-	0.027	0.015	0.87	0.65	PMF	0.65	0.34	0.33	0.32	0.31	0.28	0.27	0.23	0.20
7097	Pipe	8.8	26.1	25.9	0.675	-	0.023	0.015	1.10	0.52	PMF	0.52	0.32	0.34	0.30	0.29	0.26	0.26	0.20	0.15
7099	Pipe	16.3	27.04	26.9	0.6	-	0.009	0.015	0.49	0.33	PMF	0.33	0.28	0.27	0.25	0.23	0.21	0.19	0.15	0.12

Pipe/Culvert ID	Type	LENGTH	US INVERT	DS INVERT	Diameter/ Width	Height	SLOPE	Mannings (n)	Nominal Capacity*	Max Modelled Flow	Nominal Return Period^	Modelled Peak Flows PMF	200yr ARI	100yr ARI	50yr ARI	20yr ARI	10yr ARI	5yrARI	2yr ARI	1yrARI
		m	m AHD	m AHD	m	m	m/m		(m^3/s)	m3/s	ARI									
7100	Pipe	57.2	25.25	24.56	0.6	-	0.012	0.015	0.58	0.70	200yr	0.70	0.57	0.57	0.57	0.58	0.55	0.49	0.31	0.21
NorthC1	Pipe	27.6	38.9	37.68	0.9	-	0.044	0.015	3.30	2.75	PMF	2.75	2.23	2.21	2.15	2.09	2.05	1.99	1.84	1.70
2027	Culvert	66.8	29.3	28.42	2.15	1.2	0.013	0.015	10.45	6.89	PMF	6.89	4.32	4.02	3.94	3.55	3.19	2.89	2.32	1.59
2030	Culvert	13.1	25.31	24.99	1.6	0.4	0.024	0.015	1.97	0.33	PMF	0.21	0.23	0.23	0.33	0.15	0.08	0.07	0.05	0.03
2043	Culvert	9.2	25.6	25.36	0.65	0.4	0.026	0.015	0.70	0.27	PMF	0.27	0.23	0.23	0.18	0.13	0.11	0.09	0.07	0.04
2044	Culvert	5.8	25.5	25.47	0.6	0.25	0.005	0.015	0.14	0.12	PMF	0.12	0.10	0.10	0.10	0.10	0.10	0.11	0.10	0.10
2045	Culvert	34.0	25.45	25.44	0.8	0.35	0.000	0.015	0.08	0.20	10yr	0.20	0.13	0.12	0.09	0.09	0.05	0.05	0.04	0.04
2046	Culvert	18.1	25.42	25.39	0.8	0.35	0.002	0.015	0.19	0.30	20yr	0.30	0.27	0.25	0.22	0.20	0.15	0.09	0.05	0.04
2047	Culvert	10.0	25.36	24.48	0.8	0.35	0.088	0.015	1.36	0.43	PMF	0.43	0.39	0.36	0.31	0.29	0.22	0.09	0.05	0.04
2053	Culvert	25.5	25.71	25.64	1.3	0.4	0.003	0.015	0.52	0.73	<1yr	0.73	0.73	0.73	0.72	0.72	0.73	0.73	0.72	0.63
2055	Culvert	42.6	25.89	25.74	0.8	0.5	0.004	0.015	0.45	0.66	<1yr	0.61	0.66	0.66	0.66	0.65	0.66	0.66	0.66	0.57
2057	Culvert	16.4	26	25.91	0.8	0.5	0.005	0.015	0.57	0.46	PMF	0.44	0.44	0.43	0.44	0.44	0.45	0.45	0.46	0.41
2058	Culvert	26.6	26.03	25.91	0.6	0.35	0.005	0.015	0.22	0.31	<1yr	0.29	0.31	0.31	0.31	0.30	0.31	0.31	0.30	0.27
2059	Culvert	15.2	26.03	26.02	0.8	0.5	0.001	0.015	0.20	0.48	<1yr	0.48	0.48	0.48	0.48	0.47	0.48	0.48	0.41	0.38
2060	Culvert	8.5	26.1	26.04	0.6	0.5	0.007	0.015	0.45	0.11	PMF	0.05	0.09	0.10	0.10	0.11	0.09	0.09	0.09	0.08
2087	Culvert	21.6	25.58	25.53	0.9	0.5	0.002	0.015	0.43	0.89	<1yr	0.89	0.88	0.88	0.87	0.87	0.87	0.87	0.79	0.65
2090	Culvert	18.9	25.51	25.35	0.9	0.6	0.008	0.015	1.06	1.07	>200yr	1.07	1.04	1.03	1.01	0.99	0.97	0.94	0.80	0.65
2091	Culvert	10.2	25.34	25.31	1.8	0.5	0.003	0.015	1.10	1.66	5yr	1.66	1.44	1.38	1.32	1.26	1.19	1.10	0.81	0.65
2092	Culvert	14.6	25.34	25.27	1.55	0.5	0.005	0.015	1.18	1.72	5yr	1.72	1.50	1.43	1.36	1.29	1.22	1.12	0.80	0.65
2099	Culvert	18.4	26.09	26.03	0.8	0.5	0.003	0.015	0.44	0.51	2yr	0.50	0.51	0.51	0.51	0.51	0.51	0.51	0.41	0.27
2101	Culvert	68.9	26.52	26.21	0.6	0.35	0.004	0.015	0.22	0.16	>200yr	0.05	0.13	0.14	0.14	0.16	0.13	0.12	0.11	0.07
2105	Culvert	11.8	27.62	27.6	0.7	0.5	0.002	0.015	0.27	0.29	PMF	0.29	0.19	0.19	0.19	0.21	0.20	0.19	0.18	0.19
2252	Culvert	13.7	27.74	27.55	0.7	0.35	0.014	0.015	0.46	0.12	PMF	0.06	0.06	0.12	0.12	0.03	0.03	0.02	0.02	0.02
2275	Culvert	20.7	26.86	26.83	1.4	0.9	0.001	0.015	1.35	1.41	>200yr	1.41	1.03	1.02	1.00	0.98	0.87	0.85	0.85	0.72
2277	Culvert	88.6	26.82	26.68	1.4	0.9	0.002	0.015	1.41	1.74	>200yr	1.74	1.16	1.14	1.11	1.08	0.94	0.89	0.90	0.75
2304	Culvert	12.6	41.04	40.5	0.8	0.18	0.043	0.015	0.35	0.21	PMF	0.21	0.11	0.10	0.10	0.09	0.08	0.08	0.06	0.05
2340	Culvert	5.1	44.72	44.47	0.8	0.2	0.049	0.015	0.44	0.01	PMF	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2374	Culvert	4.8	35.45	34.94	1.6	1.4	0.106	0.015	25.24	6.27	PMF	6.27	5.27	5.14	5.01	4.83	4.56	4.27	3.47	2.70
2391	Culvert	17.6	45.15	44.7	0.6	0.3	0.026	0.015	0.41	0.01	PMF	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2403	Culvert	5.9	36.25	36.2	0.7	0.35	0.008	0.015	0.36	0.11	PMF	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2408	Culvert	6.2	34.88	34.8	0.9	0.3	0.013	0.015	0.48	0.40	PMF	0.38	0.40	0.39	0.38	0.37	0.34	0.34	0.29	0.26
2409	Culvert	21.6	34.78	33.92	0.6	0.45	0.040	0.015	0.91	0.46	PMF	0.46	0.40	0.39	0.38	0.36	0.34	0.33	0.29	0.26
2415	Culvert	20.6	38.71	38.28	0.6	0.3	0.021	0.015	0.37	0.16	PMF	0.16	0.12	0.11	0.11	0.11	0.10	0.09	0.08	0.07
2496	Culvert	3.0	46.01	45.98	0.9	0.15	0.010	0.015	0.14	0.04	PMF	0.03	0.03	0.03	0.03	0.04	0.03	0.04	0.02	0.02
2497	Culvert	3.4	46.16	46.11	0.9	0.15	0.015	0.015	0.18	0.00	PMF	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2511	Culvert	4.5	34.48	34.48	0.6	0.3	0.000	0.015	0.12	0.07	PMF	0.07	0.04	0.04	0.03	0.03	0.03	0.02	0.02	0.01

Pipe/Culvert ID	Type	LENGTH	US INVERT	DS INVERT	Diameter/ Width	Height	SLOPE	Mannings (n)	Nominal Capacity*	Max Modelled Flow	Nominal Return Period^	Modelled Peak Flows								
												PMF	200yr ARI	100yr ARI	50yr ARI	20yr ARI	10yr ARI	5yrARI	2yr ARI	1yrARI
		m	m AHD	m AHD	m	m	m/m		(m^3/s)	m3/s	ARI									
2514	Culvert	29.6	38.14	36.36	1.5	1.2	0.060	0.015	14.15	0.86	PMF	0.86	0.79	0.79	0.78	0.77	0.75	0.73	0.64	0.50
2515	Culvert	52.2	34.3	33.98	1.5	1.2	0.006	0.015	4.52	5.53	2yr	5.53	5.19	5.16	5.10	5.03	4.93	4.83	4.32	2.87
2517	Culvert	13.5	36.6	36.2	0.9	0.2	0.030	0.015	0.39	0.29	PMF	0.29	0.20	0.20	0.20	0.19	0.17	0.15	0.16	0.11
2521	Culvert	105.1	33.85	32.3	1.5	1.2	0.015	0.015	7.01	5.41	PMF	5.41	5.09	5.05	5.01	4.94	4.87	4.79	4.34	2.95
2610	Culvert	102.2	30.88	29.57	1.45	1.2	0.013	0.015	6.25	5.73	PMF	5.73	3.82	3.81	3.47	3.14	2.85	2.60	2.06	1.51
2612	Culvert	31.0	27.49	27.12	1.8	1.2	0.012	0.015	7.96	7.51	PMF	7.51	5.48	5.28	4.87	4.45	4.02	3.64	2.92	2.04
2613	Culvert	26.5	29.55	29.49	1.45	1.2	0.002	0.015	2.63	6.12	2yr	6.12	4.06	3.84	3.77	3.44	3.13	2.84	2.27	1.56
2697	Culvert	19.2	25.63	25.3	2.1	1.6	0.017	0.015	17.33	7.67	PMF	7.67	5.96	5.67	5.19	4.73	4.25	3.83	3.01	2.09
2698	Culvert	54.9	25.52	25.47	2.5	1.5	0.001	0.015	4.55	7.57	>200yr	7.57	3.78	3.55	3.05	2.74	2.44	2.19	1.72	1.17
2700	Culvert	56.8	26.52	25.64	1.8	1.5	0.015	0.015	12.35	7.73	PMF	7.73	5.70	5.41	4.96	4.53	4.08	3.69	2.97	2.06
2711	Culvert	13.2	31.26	31.21	1.5	1.2	0.004	0.015	3.55	7.20	1yr	7.20	6.10	6.14	6.07	5.78	5.66	5.67	4.83	3.37
2712	Culvert	25.4	31.21	30.88	1.5	1.2	0.013	0.015	6.58	5.52	PMF	5.52	3.63	3.63	3.39	3.13	2.84	2.60	2.06	1.51
2717	Culvert	42.4	31.87	31.33	1.5	1.2	0.013	0.015	6.51	6.91	>200yr	6.91	6.25	6.34	6.25	5.92	5.79	5.82	4.88	3.35
2745	Culvert	4.2	26.42	26.39	0.6	0.25	0.007	0.015	0.17	0.06	PMF	0.06	0.05	0.05	0.05	0.04	0.04	0.04	0.03	0.02
2844	Culvert	5.5	26.41	26.39	0.6	0.35	0.004	0.015	0.19	0.30	>200yr	0.30	0.11	0.11	0.12	0.11	0.12	0.11	0.09	0.12
2847	Culvert	51.7	26.47	26.41	0.6	0.35	0.001	0.015	0.11	0.22	>200yr	0.22	0.08	0.08	0.09	0.09	0.09	0.09	0.07	0.10
2848	Culvert	3.8	26.57	26.47	0.8	0.3	0.026	0.015	0.59	0.16	PMF	0.12	0.04	0.04	0.16	0.04	0.07	0.05	0.03	0.05
2849	Culvert	8.1	26.62	26.52	0.8	0.3	0.012	0.015	0.41	0.11	PMF	0.10	0.06	0.05	0.11	0.06	0.08	0.06	0.05	0.05
2883	Culvert	165.5	29.33	28.16	1.8	1.3	0.007	0.015	6.85	8.18	10yr	8.18	7.33	7.29	7.19	7.07	6.85	6.72	6.24	5.18
2888	Culvert	62.9	30.4	29.73	1.8	1.4	0.011	0.015	9.31	9.28	PMF	9.28	8.41	8.34	8.25	8.08	7.67	7.48	6.61	5.03
2889	Culvert	39.9	30.74	30.4	1.8	1.4	0.009	0.015	8.33	9.40	50yr	9.40	8.46	8.42	8.30	8.13	7.62	7.41	6.61	5.03
2890	Culvert	55.3	31.01	30.74	1.8	1.4	0.005	0.015	6.31	9.07	2yr	9.07	7.89	7.86	7.72	7.53	6.98	6.73	5.88	4.37
2893	Culvert	117.8	32.44	31.8	1.6	1	0.005	0.015	3.58	5.83	1yr	5.81	5.83	5.83	5.83	5.82	5.79	5.71	4.78	3.48
2894	Culvert	19.4	31.8	31.76	1.8	1.3	0.002	0.015	3.70	6.38	1yr	6.27	6.34	6.35	6.37	6.38	6.37	6.27	5.39	3.85
2895	Culvert	13.7	29.73	29.63	0.8	0.4	0.007	0.015	0.48	0.33	PMF	0.33	0.15	0.20	0.19	0.12	0.19	0.20	0.10	0.27
2898	Culvert	172.9	26.3	26	2.4	1.1	0.002	0.015	3.83	3.57	PMF	3.57	3.24	3.10	2.61	2.20	1.80	1.60	1.29	1.04
2900	Culvert	119.6	26.6	26.4	1.8	1.25	0.002	0.015	3.15	1.97	PMF	1.97	1.36	1.34	1.29	1.23	1.11	1.13	1.10	0.79
2932	Culvert	54.0	25.49	25.35	2.4	1.5	0.003	0.015	7.30	8.41	>200yr	8.41	4.68	4.24	4.09	3.66	3.29	3.05	2.35	1.64
2939	Culvert	9.8	31.33	31.26	1.5	1.2	0.007	0.015	4.88	6.99	2yr	6.99	6.18	6.27	6.18	5.87	5.73	5.76	4.86	3.36
2956	Culvert	5.6	25.36	25.18	0.6	0.4	0.032	0.015	0.70	0.26	PMF	0.26	0.22	0.23	0.17	0.13	0.11	0.09	0.06	0.04
3021	Culvert	29.5	24.56	24.5	5	1.6	0.002	0.015	17.23	29.13	>200yr	29.13	15.95	14.98	13.38	11.57	10.18	9.06	7.54	6.28
3032	Culvert	117.3	27	26.21	1.8	1.3	0.007	0.015	6.69	6.81	>200yr	6.81	6.06	6.03	5.98	5.91	5.78	5.69	5.43	4.92
3051	Culvert	16.2	32.07	31.87	1.5	1.2	0.012	0.015	6.41	6.79	>200yr	6.79	6.23	6.17	6.07	5.95	5.81	5.64	4.88	3.35
7005	Culvert	1.5	35.37	35.3	1.6	1.4	0.047	0.015	16.73	6.41	PMF	6.41	5.53	5.36	5.23	5.05	4.79	4.52	3.75	2.93
7006	Culvert	15.0	35.3	35.1	1.6	1.4	0.013	0.015	8.94	6.59	PMF	6.59	5.69	5.59	5.46	5.28	5.03	4.76	3.94	3.09
7009	Culvert	50.1	29.73	29.58	1.8	1.3	0.003	0.015	4.46	8.99	<1yr	8.99	8.03	7.95	7.87	7.71	7.34	7.17	6.52	5.14

Pipe/Culvert ID	Type	LENGTH	US INVERT	DS INVERT	Diameter/ Width	Height	SLOPE	Mannings (n)	Nominal Capacity*	Max Modelled Flow	Nominal Return Period^	Modelled Peak Flows								
												PMF	200yr ARI	100yr ARI	50yr ARI	20yr ARI	10yr ARI	5yrARI	2yr ARI	1yrARI
		m	m AHD	m AHD	m	m	m/m		(m^3/s)	m3/s	ARI									
7010	Culvert	17.0	29.58	29.53	1.8	1.3	0.003	0.015	4.42	8.86	<1yr	8.86	7.97	7.91	7.76	7.60	7.26	7.09	6.47	5.15
7012	Culvert	17.4	27.29	27	1.8	1.3	0.017	0.015	10.52	7.25	PMF	7.25	6.46	6.42	6.37	6.28	6.13	6.03	5.71	4.90
7013	Culvert	98.7	26.21	26.1	1.8	1.3	0.001	0.015	2.72	6.66	<1yr	6.66	5.80	5.76	5.71	5.63	5.50	5.42	5.15	4.57
7018	Culvert	25.1	36.36	35.95	1.5	1.2	0.016	0.015	7.37	3.87	PMF	3.87	3.15	3.11	3.05	2.99	2.91	2.83	2.50	2.18
7019	Culvert	39.2	35.95	35.36	1.5	1.2	0.015	0.015	7.08	3.87	PMF	3.87	3.29	3.24	3.17	3.11	3.03	2.92	2.62	2.27
7020	Culvert	93.4	35.36	34.96	1.5	1.2	0.004	0.015	3.78	5.70	1yr	5.70	5.34	5.30	5.23	5.14	5.01	4.86	4.28	2.81
7021	Culvert	6.0	36.86	36.6	0.9	0.2	0.043	0.015	0.47	0.11	PMF	0.11	0.07	0.06	0.07	0.07	0.06	0.04	0.06	0.03
7022	Culvert	26.8	34.96	34.3	1.5	1.2	0.025	0.015	9.05	5.58	PMF	5.58	5.19	5.15	5.10	5.02	4.92	4.80	4.25	2.81
7026	Culvert	10.1	33.98	33.85	1.5	1.2	0.013	0.015	6.55	5.45	PMF	5.45	5.14	5.10	5.05	4.99	4.90	4.81	4.32	2.87
7027	Culvert	15.7	32.3	32.07	1.5	1.2	0.015	0.015	6.98	6.17	PMF	6.17	5.92	5.93	5.87	5.82	5.68	5.56	4.89	3.35
7033	Culvert	7.4	29.49	29.39	2.15	1.2	0.014	0.015	10.58	6.31	PMF	6.31	4.15	3.90	3.83	3.46	3.14	2.85	2.28	1.56
7034	Culvert	6.7	29.39	29.3	2.15	1.2	0.013	0.015	10.55	6.64	PMF	6.64	4.26	3.96	3.91	3.52	3.18	2.89	2.31	1.59
7035	Culvert	75.7	28.42	27.55	2.4	1.5	0.011	0.015	15.37	7.61	PMF	7.61	4.38	4.05	3.97	3.57	3.21	2.91	2.34	1.60
7036	Culvert	110.6	27.55	26.63	2.4	1.5	0.008	0.015	13.07	7.82	PMF	7.82	4.47	4.07	3.99	3.58	3.22	2.99	2.35	1.61
7037	Culvert	169.7	26.63	25.79	2.4	1.5	0.005	0.015	10.08	7.91	PMF	7.91	4.45	4.11	4.01	3.60	3.24	3.32	2.49	1.62
7038	Culvert	40.9	25.79	25.7	2.4	1.5	0.002	0.015	6.72	7.99	>200yr	7.99	4.72	4.29	4.13	3.69	3.29	3.16	2.39	1.64
7039	Culvert	22.7	25.35	24.1	2.4	1.5	0.055	0.015	33.64	8.39	PMF	8.39	4.64	4.24	4.08	3.66	3.29	3.05	2.35	1.64
7046	Culvert	92.3	29.55	28.48	1.8	1.2	0.012	0.015	7.85	7.53	PMF	7.53	5.27	5.10	4.68	4.27	3.87	3.52	2.79	1.95
7047	Culvert	5.8	28.48	28.41	1.8	1.2	0.012	0.015	8.01	7.54	PMF	7.54	5.27	5.10	4.68	4.28	3.87	3.52	2.78	1.95
7048	Culvert	60.5	28.41	27.71	1.8	1.2	0.012	0.015	7.84	7.51	PMF	7.51	5.32	5.13	4.70	4.30	3.89	3.53	2.80	1.96
7049	Culvert	19.0	27.71	27.49	1.8	1.2	0.012	0.015	7.84	7.46	PMF	7.46	5.35	5.14	4.73	4.33	3.92	3.56	2.82	1.97
7050	Culvert	2.2	27.12	26.52	1.8	1.2	0.273	0.015	38.06	7.46	PMF	7.46	5.51	5.31	4.91	4.49	4.05	3.67	2.94	2.05
7051	Culvert	62.1	26.52	26.1	1.8	1.5	0.007	0.015	8.16	7.77	PMF	7.77	5.71	5.41	4.93	4.49	4.05	3.67	2.94	2.05
7052	Culvert	18.5	25.78	25.64	1.8	1.5	0.008	0.015	8.63	7.67	PMF	7.67	5.96	5.67	5.20	4.73	4.25	3.83	3.01	2.09
7053	Culvert	3.8	30.23	30.05	0.8	0.4	0.047	0.015	1.21	0.27	PMF	0.09	0.00	0.21	0.22	0.05	0.18	0.27	0.02	0.27
7069	Culvert	15.6	26.15	26.09	0.8	0.5	0.004	0.015	0.47	0.36	PMF	0.36	0.36	0.35	0.35	0.35	0.36	0.35	0.27	0.14
7070	Culvert	6.7	25.64	25.6	0.9	0.5	0.006	0.015	0.69	0.84	1yr	0.80	0.83	0.82	0.82	0.83	0.83	0.84	0.79	0.65
7071	Culvert	9.9	25.6	25.58	0.9	0.5	0.002	0.015	0.40	0.84	<1yr	0.81	0.83	0.82	0.83	0.84	0.84	0.84	0.79	0.64
7085	Culvert	92.8	26.85	26.7	1.8	1.25	0.002	0.015	3.10	0.37	PMF	0.37	0.34	0.35	0.33	0.23	0.14	0.09	0.05	0.03
7086	Culvert	19.7	26.68	26.6	1.4	0.9	0.004	0.015	2.26	2.08	PMF	2.08	1.39	1.35	1.30	1.23	1.06	0.95	0.95	0.78
7087	Culvert	5.9	26	25.93	2.4	1.1	0.012	0.015	10.01	3.56	PMF	3.56	3.41	3.29	2.78	2.29	1.84	1.64	1.31	1.08
7088	Culvert	17.1	25.93	25.79	2.4	1.1	0.008	0.015	8.31	3.82	PMF	3.82	3.76	3.67	3.14	2.59	2.14	1.92	1.47	1.20
7094	Culvert	7.8	35.1	34.94	1.6	1.4	0.021	0.015	11.09	6.88	PMF	6.88	6.03	5.94	5.80	5.62	5.37	5.08	4.19	3.25
7095	Culvert	186.1	26.7	26.4	1.8	1.25	0.002	0.015	3.10	0.37	PMF	0.34	0.36	0.37	0.35	0.24	0.14	0.09	0.05	0.03
7096	Culvert	78.4	28.16	27.29	1.8	1.3	0.011	0.015	8.58	8.10	PMF	8.10	7.18	7.13	7.07	6.95	6.74	6.61	6.16	5.16
7101	Culvert	7.9	24.59	24.56	5	1.6	0.004	0.015	23.54	29.13	>200yr	29.13	15.48	14.61	12.96	11.11	9.74	8.70	7.28	6.10

Pipe/Culvert ID	Type	LENGTH	US INVERT	DS INVERT	Diameter/ Width	Height	SLOPE	Mannings (n)	Nominal Capacity*	Max Modelled Flow	Nominal Return Period^	Modelled Peak Flows PMF	200yr ARI	100yr ARI	50yr ARI	20yr ARI	10yr ARI	5yrARI	2yr ARI	1yrARI
		m	m AHD	m AHD	m	m	m/m		(m^3/s)	m3/s	ARI									
2932a	Culvert	31.3	25.7	25.61	2.1	1.85	0.003	0.015	23.54	8.64	PMF	8.64	4.64	4.24	4.08	3.66	3.28	3.09	2.36	1.64
2932b	Culvert	47.6	25.61	25.49	2.1	1.85	0.003	0.015	23.54	8.55	PMF	8.55	4.69	4.25	4.09	3.65	3.28	3.06	2.35	1.64
100	Culvert	10.6	25.47	25.45	2.4	1.5	0.002	0.015	23.54	7.36	PMF	7.36	3.85	3.62	3.12	2.79	2.48	2.22	1.77	1.20
101	Culvert	55.5	25.45	25.31	2.4	1.5	0.003	0.015	23.54	7.36	PMF	7.36	3.82	3.55	3.05	2.73	2.44	2.19	1.71	1.17
102	Culvert	23.0	25.31	25.25	2.4	1.5	0.003	0.015	23.54	7.60	PMF	7.60	3.79	3.55	3.06	2.74	2.45	2.25	1.75	1.19
103	Culvert	8.4	25.25	25.24	2.4	1.5	0.001	0.015	23.54	7.61	PMF	7.61	3.79	3.56	3.09	2.77	2.47	2.21	1.74	1.18
104	Culvert	70.4	25.24	25.1	2.4	1.5	0.002	0.015	23.54	7.89	PMF	7.89	3.98	3.70	3.22	2.89	2.58	2.28	1.79	1.27
105	Culvert	15.6	25.1	25.06	2.4	1.5	0.003	0.015	23.54	7.89	PMF	7.89	3.82	3.58	3.09	2.77	2.48	2.23	1.73	1.18
106	Culvert	50.5	25.06	24	2.4	1.5	0.021	0.015	23.54	8.02	PMF	8.02	3.82	3.58	3.09	2.77	2.47	2.21	1.72	1.18
B1_1	Culvert	9.66	28.37	28.21	3.02	1.44	0.017	0.015	23.11	10.15	PMF	10.15	6.81	6.39	5.94	5.27	4.68	4.12	2.99	2.30
B1_2	Culvert	9.66	28.37	28.21	2.82	1.40	0.017	0.015	20.41	9.36	PMF	9.36	6.35	5.96	5.55	4.92	4.37	3.85	2.79	2.15
B1_3	Culvert	9.66	28.37	28.21	3.14	1.44	0.017	0.015	24.23	10.56	PMF	10.56	7.08	6.64	6.18	5.48	4.87	4.29	3.11	2.39
B2_1	Culvert	30.7	26.86	26.58	3.11	2.12	0.009	0.015	30.86	20.05	PMF	20.05	14.86	14.55	13.76	12.47	11.02	9.68	6.87	5.12
B2_2	Culvert	30.7	26.86	26.58	3.04	2.19	0.009	0.015	31.36	20.32	PMF	20.32	14.52	14.22	13.45	12.18	10.77	9.46	6.72	5.01
B3_1	Culvert	4	26.49	26.486	6.22	2.27	0.001	0.015	26.32	43.68	20yr	43.68	29.64	28.93	27.23	24.67	21.81	19.17	13.60	10.13
D1_1	Culvert	4	26.49	26.486	6.12	2.14	0.001	0.015	23.65	40.21	10yr	40.21	29.72	28.99	27.29	24.70	21.84	19.20	13.61	10.14
E1_1	Culvert	4	26.42	26.416	6.29	2.20	0.001	0.015	25.45	37.08	20yr	37.08	30.08	29.41	27.33	24.74	21.89	19.58	13.61	10.14
F1_1	Culvert	12	26.39	26.38	6.19	2.24	0.001	0.015	23.42	37.36	10yr	37.36	30.79	29.40	27.31	24.76	21.90	19.47	13.61	10.15
G1_1	Culvert	4	26.34	26.336	6.17	2.13	0.001	0.015	23.71	35.93	10yr	35.93	29.83	29.12	27.34	24.81	21.88	19.24	13.62	10.15
H1_1	Culvert	4	26.31	26.306	6.17	2.24	0.001	0.015	25.56	39.47	20yr	39.47	30.17	29.36	27.49	24.96	22.22	19.23	14.65	10.98
I1_1	Culvert	4	26.21	26.206	6.27	2.28	0.001	0.015	26.75	41.39	20yr	41.39	30.30	29.47	27.58	25.03	22.27	19.25	13.68	10.29
J1_1	Culvert	9.7	26.06	26.03	6.19	2.15	0.003	0.015	42.45	45.18	200yr	45.18	31.19	30.20	28.40	25.74	22.55	19.59	13.72	10.39
K1_1	Culvert	4	25.91	25.91	6.23	2.16	0.000	0.015	24.49	48.66	10yr	48.66	30.69	29.95	28.02	25.45	22.40	19.55	13.72	10.39
L1_1	Culvert	5	25.90	25.9	6.25	2.13	0.001	0.015	24.07	51.06	10yr	51.06	30.74	29.85	27.94	25.58	22.37	19.52	13.72	10.37
M1_1	Culvert	4	25.84	25.84	6.25	2.13	0.001	0.015	24.07	73.05	10yr	73.05	30.66	29.78	27.86	25.41	22.30	19.45	13.71	10.34
N1_1	Culvert	5	25.66	25.66	6.66	2.26	0.001	0.015	28.33	52.95	50yr	52.95	30.60	29.79	27.80	25.39	22.25	19.40	13.70	10.32
NorthC2	Culvert	25.8	37.50	36.85	0.75	0.75	0.025	0.015	1.95	2.71	2yr	2.71	2.43	2.41	2.38	2.33	2.28	2.18	1.76	0.60
O1_1	Culvert	51.65	25.55	25.35	2.87	1.60	0.004	0.015	12.22	14.70	10yr	14.70	13.67	13.58	13.36	12.41	11.18	9.78	6.87	5.31
O1_1b	Culvert	306.6	25.55	23.25	2.90	1.60	0.004	0.015	17.22	15.67	PMF	15.67	14.31	14.23	13.98	12.91	11.32	9.88	6.95	5.36
R1_4	Culvert	9.66	28.37	28.21	3.25	1.49	0.017	0.015	26.55	10.93	PMF	10.93	7.32	6.87	6.39	5.67	5.04	4.44	3.22	2.48

Only pipes greater than 600mm in diameter have been included in the analysis

Appendix H

Peak Flows of Open Channels

APPENDIX H

Channel Peak Flows

Channel ID	Type	Modelled Flows								
		PMF	200yr ARI	100yr ARI	50yr ARI	20yr ARI	10yr ARI	5yrARI	2yr ARI	1yrARI
7068	Channel	59.5	14.2	13.1	11.4	9.7	8.0	6.5	4.4	3.3
9000	Channel	14.7	7.7	7.3	6.8	6.3	6.0	5.8	5.2	4.6
9001	Channel	20.0	7.8	7.4	6.9	6.4	6.1	5.9	5.3	4.7
9002	Channel	35.0	15.3	14.3	12.7	10.9	9.5	8.5	7.2	6.0
9003	Channel	35.3	15.4	14.4	12.8	11.0	9.6	8.6	7.3	6.1
9005	Channel	39.0	17.2	16.0	14.0	11.9	10.3	9.2	7.6	6.3
9006	Channel	14.4	7.2	6.6	5.6	4.3	3.3	2.7	1.9	1.4
9010	Channel	40.7	24.8	24.2	22.5	21.3	19.2	17.1	12.3	9.5
9012	Channel	37.3	29.4	28.8	27.2	24.7	21.8	19.2	13.6	10.1
9013	Channel	38.2	29.6	28.9	27.2	24.7	21.8	19.2	13.6	10.1
9014	Channel	38.4	29.7	28.9	27.2	24.7	21.8	19.1	13.6	10.1
9015	Channel	38.0	29.9	29.2	27.3	24.7	21.9	19.3	13.6	10.1
9016	Channel	37.4	30.5	29.7	27.3	24.8	22.1	19.7	13.6	10.1
9018	Channel	36.7	30.0	29.2	27.3	24.8	21.9	19.3	13.6	10.2
9019	Channel	38.7	30.0	29.2	27.4	24.9	22.2	19.2	13.7	10.2
9020	Channel	40.7	30.3	29.4	27.5	25.0	22.3	19.2	13.7	10.3
9021	Channel	41.8	30.5	29.7	27.6	25.2	22.1	19.3	13.7	10.1
9023	Channel	46.7	30.6	29.8	27.8	25.3	22.3	19.4	13.6	10.1
9024	Channel	47.5	30.9	30.0	27.8	25.6	22.4	19.6	13.7	10.2
9025	Channel	48.1	30.7	29.9	27.7	25.6	22.4	19.5	13.7	10.2
9026	Channel	50.8	30.4	29.5	27.6	25.4	22.3	19.4	13.7	10.1
9027	Channel	42.6	30.4	29.7	27.6	25.5	22.3	19.4	13.7	10.1
9028	Channel	35.1	29.5	29.1	27.5	25.3	22.4	19.5	13.7	10.1
9000a	Channel	11.8	6.6	6.4	6.2	5.9	5.7	5.5	5.2	4.6
9001a	Channel	20.2	7.7	7.3	6.8	6.3	6.0	5.8	5.2	4.6
9003a	Channel	35.7	15.3	14.3	12.7	10.9	9.5	8.6	7.2	6.0
9005_a	Channel	39.2	17.2	16.0	14.0	11.9	10.3	9.2	7.6	6.3
9005_b	Channel	38.9	17.8	16.4	14.3	12.1	10.4	9.3	7.7	6.4
9010a	Channel	37.9	27.6	25.9	23.1	21.3	18.9	16.7	12.1	9.3
9019a	Channel	36.9	29.9	29.2	27.4	24.8	21.9	19.2	13.6	10.2
DwChan	Channel	14.5	7.2	6.6	5.6	4.3	3.3	2.7	1.9	1.5
Evan_Ch1	Channel	26.2	12.1	11.5	10.7	9.5	8.2	7.0	5.6	4.0
Evan_Ch2	Channel	46.3	14.7	13.6	11.9	10.1	8.5	7.2	5.7	4.2
Evan_Ch2_1	Channel	29.7	11.8	10.9	9.9	8.8	7.5	6.4	5.1	4.5
Evan_Ch4	Channel	24.1	21.7	19.0	17.5	14.3	6.8	5.9	5.2	4.0

Appendix I

2D Peak Flows at Reference Locations

APPENDIX I

2D Peak Flows at Reference Locations

Reference ID	Peak Flows (m^3/s)								
	PMF	200yr ARI	100yr ARI	50yr ARI	20yr ARI	10yr ARI	5yr ARI	2yr ARI	1yr ARI
Q1	0.15	0.04	0.04	0.03	0.03	0.03	0.02	0.02	0.01
Q2	1.14	0.23	0.20	0.17	0.16	0.13	0.11	0.08	0.08
Q3	2.18	0.43	0.41	0.36	0.33	0.27	0.23	0.17	0.12
Q4	0.36	0.06	0.05	0.06	0.06	0.06	0.05	0.04	0.03
Q5	3.10	0.20	0.18	0.16	0.14	0.12	0.10	0.06	0.04
Q6	0.31	0.06	0.06	0.05	0.05	0.04	0.04	0.03	0.02
Q7	2.41	0.03	0.03	0.03	0.02	0.02	0.02	0.01	0.01
Q8	1.44	0.17	0.14	0.09	0.07	0.06	0.05	0.03	0.02
Q9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Q10	0.18	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.01
Q11	0.34	0.07	0.06	0.05	0.05	0.04	0.04	0.03	0.02
Q12	1.12	0.15	0.14	0.13	0.10	0.08	0.07	0.05	0.03
Q13	2.39	0.17	0.15	0.13	0.11	0.09	0.08	0.05	0.04
Q14	0.26	0.04	0.04	0.03	0.03	0.02	0.02	0.01	0.01
Q15	0.27	0.04	0.04	0.04	0.03	0.03	0.02	0.02	0.01
Q16	10.03	1.65	1.46	1.16	0.89	0.60	0.42	0.09	0.05
Q17	14.39	2.18	1.95	1.66	1.37	1.10	0.84	0.48	0.38
Q18	5.92	0.04	0.03	0.03	0.03	0.02	0.02	0.02	0.01
Q19	0.22	0.04	0.04	0.03	0.03	0.03	0.03	0.02	0.01
Q20	0.91	0.19	0.21	0.20	0.13	0.14	0.12	0.08	0.06
Q21	2.15	0.44	0.41	0.36	0.32	0.27	0.24	0.18	0.13
Q22	3.03	0.68	0.63	0.56	0.50	0.42	0.37	0.26	0.20
Q23	8.91	0.80	0.72	0.64	0.56	0.48	0.40	0.26	0.18
Q24	2.88	2.03	1.90	1.56	1.26	1.01	0.79	0.39	0.26
Q25	0.06	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00
Q26	3.49	0.70	0.65	0.59	0.49	0.43	0.37	0.28	0.21
Q27	0.52	0.05	0.05	0.05	0.04	0.03	0.03	0.02	0.02
Q28	0.32	0.08	0.08	0.07	0.07	0.06	0.05	0.04	0.03
Q29	0.40	0.07	0.07	0.06	0.06	0.04	0.04	0.03	0.02
Q30	10.46	1.31	1.12	0.88	0.62	0.46	0.38	0.22	0.17
Q31	4.40	0.29	0.27	0.25	0.21	0.18	0.15	0.11	0.08
Q32	6.72	0.88	0.80	0.71	0.63	0.53	0.47	0.36	0.27
Q33	23.32	2.93	2.58	2.11	1.64	1.23	0.93	0.44	0.19
Q34	0.81	0.18	0.17	0.14	0.13	0.11	0.09	0.07	0.06
Q35	0.76	0.27	0.25	0.24	0.22	0.20	0.18	0.15	0.12
Q36	1.23	0.27	0.25	0.22	0.18	0.14	0.12	0.06	0.04
Q37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Q38	13.65	1.62	1.43	1.13	0.91	0.69	0.53	0.29	0.23
Q39	6.10	0.47	0.37	0.31	0.23	0.13	0.03	0.00	0.00
Q40	0.32	0.06	0.05	0.05	0.04	0.04	0.03	0.02	0.02
Q41	1.36	0.38	0.36	0.33	0.30	0.26	0.23	0.19	0.15
Q42	4.75	0.85	0.80	0.71	0.63	0.54	0.46	0.33	0.26
Q43	4.87	0.32	0.30	0.27	0.22	0.18	0.16	0.12	0.09
Q44	0.21	0.05	0.04	0.04	0.03	0.03	0.02	0.02	0.01
Q45	0.38	0.07	0.07	0.06	0.06	0.05	0.04	0.03	0.03
Q46	0.34	0.10	0.10	0.09	0.08	0.07	0.06	0.05	0.04
Q47	0.92	0.19	0.18	0.16	0.15	0.12	0.10	0.08	0.06
Q48	0.92	0.19	0.17	0.15	0.13	0.11	0.10	0.07	0.05
Q49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Q50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Q51	0.12	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.01
Q52	0.18	0.03	0.03	0.03	0.03	0.02	0.02	0.01	0.01
Q53	1.97	0.35	0.33	0.30	0.25	0.21	0.17	0.12	0.09

Reference ID	Peak Flows (m^3/s)								
	PMF	200yr ARI	100yr ARI	50yr ARI	20yr ARI	10yr ARI	5yr ARI	2yr ARI	1yr ARI
Q54	4.54	0.72	0.66	0.57	0.50	0.40	0.33	0.21	0.15
Q55	0.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Q56	0.31	0.09	0.07	0.08	0.17	0.07	0.05	0.04	0.09
Q57	0.60	0.12	0.12	0.11	0.09	0.08	0.07	0.05	0.04
Q58	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Q59	0.36	0.10	0.09	0.08	0.07	0.06	0.05	0.04	0.03
Q60	5.67	0.99	0.89	0.77	0.63	0.45	0.31	0.02	0.00
Q61	1.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Q62	4.76	0.96	0.88	0.79	0.67	0.53	0.45	0.26	0.16
Q63	10.11	1.88	1.72	1.47	1.20	0.90	0.70	0.29	0.16
Q64	1.13	0.24	0.22	0.19	0.17	0.15	0.13	0.09	0.07
Q65	2.81	0.51	0.48	0.42	0.38	0.32	0.27	0.20	0.15
Q66	0.51	0.11	0.10	0.08	0.07	0.06	0.06	0.04	0.03
Q67	0.29	0.05	0.05	0.04	0.04	0.03	0.03	0.02	0.01
Q68	3.94	0.70	0.66	0.57	0.51	0.43	0.37	0.27	0.20
Q69	0.93	0.19	0.18	0.16	0.14	0.12	0.10	0.07	0.06
Q70	5.98	1.10	0.98	0.85	0.71	0.57	0.46	0.27	0.19
Q71	16.34	3.13	2.80	2.25	1.81	1.35	1.03	0.47	0.30
Q72	24.44	4.44	3.93	3.18	2.55	1.97	1.54	0.86	0.51
Q73	4.32	0.39	0.36	0.32	0.29	0.23	0.20	0.14	0.10
Q74	0.61	0.15	0.15	0.13	0.11	0.10	0.09	0.07	0.05
Q75	0.97	0.12	0.12	0.10	0.09	0.08	0.06	0.05	0.03
Q76	0.75	0.20	0.20	0.18	0.17	0.15	0.13	0.09	0.07
Q77	1.91	0.67	0.63	0.57	0.49	0.41	0.34	0.22	0.15
Q78	65.87	8.31	7.25	5.81	4.47	3.29	2.40	1.10	0.63
Q79	82.59	2.68	2.32	1.87	1.43	1.05	0.74	0.29	0.14
Q80	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.02	0.00
Q81	0.84	0.17	0.16	0.14	0.12	0.09	0.08	0.06	0.05
Q82	0.84	0.16	0.15	0.14	0.12	0.11	0.09	0.06	0.04
Q83	1.62	0.32	0.36	0.27	0.25	0.21	0.19	0.11	0.09
Q84	4.44	0.88	0.81	0.73	0.64	0.53	0.45	0.33	0.24
Q85	5.27	0.70	0.64	0.55	0.46	0.37	0.29	0.20	0.14
Q86	2.19	0.71	0.71	0.67	0.62	0.52	0.46	0.34	0.26
Q87	5.13	1.27	1.21	1.05	0.92	0.79	0.68	0.48	0.34
Q88	4.35	0.27	0.23	0.16	0.10	0.05	0.02	0.01	0.01
Q89	19.72	2.44	2.17	1.82	1.42	1.05	0.80	0.39	0.23
Q90	11.82	2.15	1.96	1.63	1.33	0.98	0.73	0.40	0.26
Q91	0.32	0.07	0.06	0.06	0.05	0.05	0.04	0.03	0.02
Q92	0.12	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.01
Q93	0.32	0.05	0.05	0.04	0.03	0.04	0.03	0.02	0.02
Q94	0.20	0.04	0.04	0.04	0.04	0.03	0.03	0.02	0.02
Q95	2.39	0.43	0.40	0.35	0.32	0.27	0.23	0.17	0.13
Q96	55.32	10.30	9.05	6.84	4.65	2.71	1.33	0.40	0.24
Q97	0.69	0.14	0.13	0.11	0.10	0.09	0.08	0.06	0.05
Q98	0.39	0.15	0.14	0.13	0.12	0.11	0.09	0.08	0.06
Q99	1.13	0.43	0.41	0.37	0.33	0.29	0.25	0.18	0.13
Q100	0.94	0.22	0.21	0.19	0.17	0.15	0.13	0.10	0.08
Q101	0.14	0.02	0.02	0.01	0.01	0.01	0.02	0.01	0.01
Q102	0.61	0.12	0.11	0.10	0.09	0.08	0.07	0.05	0.03
Q103	0.30	0.06	0.06	0.05	0.04	0.03	0.03	0.02	0.01
Q104	1.04	0.22	0.21	0.18	0.16	0.14	0.12	0.09	0.07
Q105	2.08	0.60	0.55	0.50	0.45	0.39	0.34	0.26	0.18
Q106	0.46	0.06	0.06	0.05	0.04	0.03	0.03	0.02	0.01
Q107	0.21	0.09	0.08	0.07	0.06	0.05	0.05	0.03	0.02
Q108	9.92	1.80	1.48	1.10	0.73	0.43	0.21	0.00	0.00
Q109	5.66	2.01	1.80	1.51	1.24	0.92	0.68	0.22	0.11
Q110	0.77	0.16	0.15	0.13	0.12	0.11	0.09	0.07	0.05

Reference ID	Peak Flows (m3/s)								
	PMF	200yr ARI	100yr ARI	50yr ARI	20yr ARI	10yr ARI	5yr ARI	2yr ARI	1yr ARI
Q111	1.45	0.30	0.27	0.25	0.22	0.18	0.16	0.12	0.09
Q112	0.48	0.11	0.10	0.09	0.09	0.07	0.06	0.04	0.03
Q113	1.37	0.31	0.28	0.25	0.22	0.18	0.16	0.11	0.09
Q114	1.91	0.35	0.33	0.28	0.24	0.20	0.16	0.11	0.07
Q115	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Q116	1.50	0.28	0.25	0.23	0.20	0.18	0.13	0.11	0.08
Q117	1.36	0.30	0.28	0.25	0.22	0.19	0.17	0.13	0.10
Q118	0.69	0.14	0.15	0.13	0.14	0.10	0.10	0.06	0.09
Q119	4.67	0.85	0.82	0.69	0.61	0.55	0.50	0.37	0.24
Q120	6.72	1.06	0.96	0.83	0.68	0.55	0.46	0.28	0.20
Q121	0.64	0.22	0.21	0.19	0.17	0.14	0.12	0.09	0.07
Q122	0.60	0.25	0.24	0.22	0.19	0.17	0.14	0.11	0.08
Q123	0.34	0.08	0.07	0.07	0.06	0.05	0.04	0.03	0.02
Q124	1.07	0.25	0.25	0.21	0.19	0.16	0.15	0.10	0.08
Q125	1.72	0.37	0.78	0.55	0.32	0.69	0.23	0.14	0.11
Q126	2.91	1.54	1.04	0.36	0.14	0.10	0.07	0.05	0.02
Q127	7.18	0.36	0.22	0.01	0.00	0.00	0.00	0.00	0.00
Q128	6.16	0.55	0.27	0.10	0.11	0.09	0.06	0.03	0.02
Q129	5.09	0.11	0.10	0.09	0.09	0.07	0.05	0.02	0.01
Q130	11.31	0.04	0.04	0.04	0.03	0.02	0.02	0.01	0.01
Q131	0.52	0.32	0.27	0.21	0.16	0.13	0.09	0.04	0.03
Q132	7.32	1.35	1.24	1.08	0.93	0.69	0.59	0.40	0.26
Q133	7.93	0.76	0.63	0.49	0.39	0.28	0.19	0.07	0.01
Q134	1.22	0.04	0.04	0.04	0.05	0.05	0.06	0.05	0.04
Q135	1.22	0.32	0.30	0.27	0.24	0.22	0.19	0.12	0.09
Q136	2.74	0.40	0.36	0.27	0.20	0.17	0.14	0.09	0.06
Q137	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Q138	0.11	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01
Q139	5.94	0.70	0.66	0.57	0.50	0.40	0.34	0.24	0.18
Q140	6.96	1.13	1.02	0.88	0.74	0.56	0.44	0.17	0.12
Q141	1.21	0.22	0.22	0.19	0.16	0.13	0.11	0.08	0.08
Q142	0.68	0.16	0.15	0.13	0.12	0.11	0.09	0.07	0.05
Q143	5.59	0.90	0.82	0.72	0.64	0.55	0.46	0.34	0.24
Q144	0.32	0.05	0.05	0.04	0.04	0.03	0.03	0.02	0.01
Q145	0.44	0.07	0.06	0.05	0.04	0.04	0.03	0.02	0.01
Q146	2.44	0.48	0.45	0.40	0.35	0.30	0.26	0.20	0.15
Q147	4.49	0.75	0.69	0.58	0.49	0.40	0.33	0.21	0.14
Q148	7.15	1.08	0.99	0.84	0.72	0.58	0.48	0.30	0.19
Q149	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Q150	0.12	0.03	0.03	0.03	0.03	0.02	0.02	0.01	0.01
Q151	0.07	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02
Q152	0.57	0.11	0.11	0.10	0.09	0.07	0.06	0.04	0.03
Q153	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Q154	0.34	0.04	0.04	0.04	0.03	0.02	0.02	0.01	0.01
Q155	3.37	0.61	0.54	0.51	0.42	0.35	0.28	0.20	0.14
Q156	1.15	0.27	0.24	0.23	0.20	0.17	0.14	0.11	0.08
Q157	1.69	0.26	0.24	0.20	0.17	0.14	0.12	0.07	0.05
Q158	4.72	0.73	0.67	0.58	0.50	0.42	0.35	0.24	0.17
Q159	0.13	0.02	0.02	0.01	0.01	0.01	0.01	0.00	0.00
Q160	0.08	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Q161	3.30	0.34	0.28	0.19	0.11	0.07	0.06	0.04	0.04
Q162	2.49	0.39	0.34	0.25	0.16	0.06	0.02	0.01	0.01
Q163	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Q164	0.42	0.09	0.09	0.08	0.09	0.09	0.05	0.04	0.03
Q165	6.55	0.78	0.69	0.55	0.48	0.42	0.33	0.30	0.18
Q166	45.69	4.53	4.11	3.44	2.75	1.99	1.53	0.64	0.35
Q167	16.54	4.31	3.81	3.21	2.50	1.82	1.28	0.41	0.18

Reference ID	Peak Flows (m^3/s)								
	PMF	200yr ARI	100yr ARI	50yr ARI	20yr ARI	10yr ARI	5yr ARI	2yr ARI	1yr ARI
Q168	26.41	3.22	2.77	2.25	1.70	1.19	0.73	0.14	0.08
Q169	13.54	0.12	0.03	0.03	0.03	0.02	0.02	0.01	0.01
Q170	26.10	0.51	0.48	0.37	0.30	0.27	0.23	0.15	0.11
Q171	1.28	0.21	0.24	0.17	0.15	0.13	0.11	0.08	0.07
Q172	0.12	0.01	0.01	0.02	0.03	0.02	0.09	0.01	0.05
Q173	28.92	0.78	0.69	0.61	0.52	0.45	0.37	0.27	0.21
Q174	0.85	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00
Q175	15.90	0.72	0.63	0.41	0.24	0.11	0.09	0.06	0.04
Q176	14.29	0.63	0.44	0.25	0.12	0.07	0.05	0.03	0.02
Q177	0.45	0.09	0.09	0.08	0.07	0.06	0.06	0.04	0.03
Q178	27.88	0.84	0.77	0.65	0.58	0.48	0.39	0.28	0.20
Q179	2.65	0.10	0.09	0.08	0.07	0.06	0.05	0.03	0.03
Q180	0.85	0.12	0.11	0.10	0.09	0.07	0.98	0.05	0.04
Q181	25.91	0.92	0.84	0.71	0.60	0.49	0.40	0.28	0.20
Q182	1.07	0.07	0.06	0.05	0.04	0.03	0.03	0.01	0.03
Q183	1.99	0.35	0.31	0.25	0.20	0.14	0.10	0.04	0.02
Q184	6.88	0.16	0.15	0.13	0.11	0.09	0.07	0.05	0.03
Q185	4.01	0.24	0.23	0.20	0.17	0.14	0.11	0.07	0.05
Q186	6.59	0.31	0.23	0.13	0.10	0.07	0.05	0.02	0.02
Q187	16.17	0.48	0.39	0.27	0.16	0.06	0.04	0.02	0.00
Q188	25.55	1.06	0.96	0.80	0.68	0.55	0.44	0.28	0.19
Q189	1.03	0.20	0.22	0.17	0.15	0.14	0.13	0.09	0.06
Q190	0.00	0.01	0.01	0.00	0.02	0.00	0.00	0.00	0.01
Q191	2.55	0.51	0.46	0.40	0.42	0.32	0.33	0.20	0.17
Q192	0.01	0.02	0.04	0.08	0.04	0.02	0.02	0.01	0.01
Q193	0.31	0.06	0.06	0.05	0.05	0.04	0.04	0.03	0.02
Q194	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Q195	0.70	0.11	0.10	0.09	0.07	0.06	0.05	0.04	0.02
Q196	1.13	0.10	0.09	0.08	0.07	0.05	0.05	0.03	0.02
Q197	0.68	0.14	0.13	0.12	0.10	0.09	0.08	0.06	0.04
Q198	14.65	1.60	1.43	1.14	0.96	0.83	0.73	0.54	0.40
Q199	1.28	0.27	0.25	0.23	0.20	0.17	0.15	0.11	0.09
Q200	0.14	0.02	0.02	0.02	0.01	0.02	0.03	0.01	0.03
Q201	7.18	0.25	0.22	0.20	0.17	0.13	0.10	0.04	0.02
Q202	8.53	1.15	1.00	0.83	0.72	0.48	0.35	0.16	0.09
Q203	2.71	0.06	0.06	0.05	0.05	0.04	0.03	0.03	0.02
Q204	12.83	2.02	1.71	1.27	0.84	0.50	0.36	0.25	0.18
Q205	16.99	2.55	2.24	1.70	1.20	0.93	0.77	0.41	0.26
Q206	1.08	0.17	0.16	0.14	0.12	0.11	0.09	0.06	0.04
Q207	1.54	0.30	0.28	0.25	0.23	0.19	0.16	0.12	0.09
Q208	0.61	0.15	0.14	0.12	0.11	0.09	0.08	0.06	0.04
Q209	1.10	0.22	0.21	0.18	0.16	0.14	0.12	0.09	0.07
Q210	2.25	0.49	0.44	0.40	0.36	0.31	0.26	0.20	0.15
Q211	2.91	0.46	0.40	0.34	0.27	0.20	0.17	0.14	0.09
Q212	65.65	10.78	9.14	7.07	5.08	3.39	2.11	0.57	0.30
Q213	25.23	7.27	6.96	5.75	4.49	3.25	2.04	0.72	0.22
Q214	2.48	0.25	0.23	0.20	0.18	0.15	0.13	0.09	0.06
Q215	47.23	4.37	3.27	2.19	1.29	0.68	0.34	0.06	0.04
Q216	25.10	7.27	6.71	5.63	4.34	3.01	1.95	0.65	0.23
Q217	17.90	6.83	6.35	5.48	4.06	2.85	1.74	0.59	0.19
Q218	4.26	0.75	0.71	0.64	0.53	0.45	0.37	0.27	0.20
Q219	39.30	4.51	3.66	2.53	1.57	0.86	0.52	0.21	0.15
Q220	23.04	7.14	6.53	5.55	4.21	2.94	1.83	0.58	0.08
Q221	59.57	12.55	11.04	9.08	6.83	4.94	3.48	1.70	0.69
Q222	2.06	0.23	0.20	0.15	0.12	0.10	0.08	0.04	0.03
Q223	9.40	1.18	1.02	0.82	0.65	0.47	0.34	0.11	0.04
Q224	8.03	1.18	0.72	0.35	0.16	0.08	0.06	0.04	0.03

Reference ID	Peak Flows (m^3/s)								
	PMF	200yr ARI	100yr ARI	50yr ARI	20yr ARI	10yr ARI	5yr ARI	2yr ARI	1yr ARI
Q225	8.09	0.71	0.37	0.16	0.09	0.06	0.04	0.01	0.01
Q226	3.12	0.46	0.40	0.27	0.21	0.16	0.13	0.07	0.04
Q227	11.06	0.51	0.41	0.28	0.16	0.11	0.10	0.04	0.03
Q228	10.82	0.41	0.29	0.22	0.14	0.08	0.08	0.10	0.03
Q229	6.80	2.67	2.28	1.85	1.34	0.87	0.51	0.01	0.00
Q230	2.87	0.53	0.48	0.41	0.32	0.24	0.17	0.05	0.01
Q231	12.22	0.86	0.52	0.03	0.01	0.00	0.00	0.00	0.00
Q232	14.66	1.98	1.63	1.23	0.81	0.51	0.34	0.10	0.07
Q233	0.56	0.21	0.20	0.19	0.19	0.19	0.16	0.05	0.01
Q234	8.61	1.03	0.46	0.35	0.23	0.14	0.09	0.02	0.01
Q235	9.00	1.55	0.86	0.70	0.52	0.41	0.33	0.20	0.15
Q236	7.73	1.01	0.46	0.26	0.11	0.09	0.07	0.04	0.03
Q237	0.01	0.03	0.02	0.01	0.00	0.00	0.00	0.00	0.00
Q238	1.70	0.36	0.33	0.29	0.27	0.22	0.18	0.12	0.09
Q239	8.41	1.13	0.66	0.52	0.40	0.30	0.25	0.16	0.11
Q240	8.77	2.28	1.88	1.06	0.63	0.32	0.23	0.12	0.08
Q241	16.78	1.58	1.08	0.33	0.14	0.11	0.11	0.12	0.09
Q242	8.12	1.42	1.17	0.55	0.27	0.22	0.21	0.16	0.14
Q243	23.21	4.02	3.73	3.13	2.49	1.97	1.65	0.99	0.45
Q244	16.56	2.17	1.81	1.29	0.80	0.52	0.39	0.33	0.17
Q245	1.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Q246	1.12	0.27	0.25	0.24	0.20	0.18	0.16	0.12	0.09
Q247	0.54	0.15	0.14	0.12	0.11	0.10	0.09	0.07	0.05
Q248	0.11	0.03	0.03	0.02	0.02	0.02	0.02	0.01	0.01
Q249	0.42	0.08	0.07	0.07	0.06	0.05	0.05	0.03	0.03
Q250	3.85	0.46	0.39	0.33	0.30	0.21	0.14	0.03	0.01
Q251	25.08	5.39	4.74	4.03	3.20	2.48	1.96	1.10	0.48
Q252	9.11	2.72	2.42	2.10	1.75	1.44	1.19	0.79	0.48
Q253	0.39	0.10	0.11	0.10	0.09	0.08	0.07	0.04	0.04
Q254	12.75	2.34	2.05	1.71	1.37	1.07	0.83	0.31	0.06
Q255	12.79	3.32	3.02	2.53	1.88	1.24	0.75	0.18	0.10
Q256	9.64	1.30	1.15	0.89	0.67	0.42	0.22	0.04	0.03
Q257	3.26	2.22	2.07	1.86	1.56	1.19	0.83	0.34	0.13
Q258	12.02	0.97	0.85	0.67	0.51	0.32	0.19	0.05	0.04
Q259	20.41	3.15	2.76	2.23	1.69	1.20	0.82	0.28	0.10
Q260	11.95	2.69	2.38	1.84	1.31	0.85	0.58	0.25	0.10
Q261	16.30	0.38	0.32	0.23	0.13	0.10	0.08	0.05	0.62
Q262	1.55	0.53	0.49	0.41	0.35	0.28	0.24	0.16	0.10
Q263	9.42	0.06	0.04	0.03	0.02	0.03	0.01	0.01	0.01
Q264	4.74	0.77	0.69	0.57	0.45	0.32	0.25	0.10	0.07
Q265	8.86	0.26	0.32	0.15	0.12	0.07	0.10	0.03	1.37
Q266	20.15	0.98	0.88	0.70	0.57	0.44	0.35	0.23	0.15
Q267	8.83	0.17	0.15	0.12	0.10	0.06	0.02	0.00	0.00
Q268	16.77	0.33	0.27	0.19	0.13	0.07	0.05	0.02	0.01
Q269	0.51	0.02	0.01	0.01	0.01	0.00	0.01	0.05	0.00
Q270	20.24	1.06	0.99	0.80	0.67	0.54	0.44	0.27	0.18
Q271	4.70	0.85	0.78	0.69	0.63	0.56	0.44	0.34	0.25
Q272	2.19	0.23	0.22	0.19	0.17	0.14	0.12	0.08	0.06
Q273	7.03	1.17	1.06	0.93	0.80	0.67	0.53	0.34	0.22
Q274	0.78	0.04	0.04	0.03	0.03	0.03	0.03	0.02	0.03
Q275	4.34	0.53	0.51	0.43	0.39	0.31	0.30	0.22	0.19
Q276	8.31	2.65	2.33	1.92	1.44	1.60	0.88	0.57	0.22
Q277	16.40	1.20	1.00	0.76	0.55	0.39	0.29	0.08	0.02
Q278	2.55	0.67	0.65	0.58	0.47	0.38	0.26	0.06	0.02
Q279	2.10	0.85	0.74	0.48	0.26	0.09	0.00	0.00	0.00
Q280	7.23	1.41	1.24	0.97	0.66	0.37	0.22	0.03	0.04
Q281	20.81	3.38	2.97	2.39	1.77	1.16	0.71	0.04	0.02

Reference ID	Peak Flows (m^3/s)								
	PMF	200yr ARI	100yr ARI	50yr ARI	20yr ARI	10yr ARI	5yr ARI	2yr ARI	1yr ARI
Q282	1.72	0.06	0.05	0.05	0.04	0.03	0.03	0.02	0.02
Q283	10.79	0.36	0.28	0.13	0.05	0.05	0.03	0.02	0.01
Q284	7.86	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Q285	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Q286	10.55	0.34	0.25	0.12	0.11	0.09	0.08	0.05	0.03
Q287	25.28	1.28	0.78	0.56	0.19	0.02	0.01	0.01	0.01
Q288	0.36	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Q289	0.68	0.11	0.10	0.09	0.07	0.06	0.05	0.04	0.03
Q290	2.78	0.05	0.04	0.04	0.03	0.03	0.03	0.02	0.12
Q291	0.82	0.15	0.14	0.12	0.10	0.09	0.07	0.05	0.03
Q292	1.79	0.28	0.25	0.22	0.18	0.15	0.12	0.06	0.03
Q293	24.99	1.04	0.88	0.35	0.07	0.03	0.03	0.02	0.02
Q294	0.25	0.05	0.04	0.05	0.03	0.05	0.03	0.02	0.02
Q295	1.45	0.08	0.08	0.07	0.06	0.05	0.04	0.02	0.01
Q296	0.32	0.04	0.03	0.03	0.02	0.02	0.02	0.01	0.01
Q297	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Q298	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Q299	0.70	0.11	0.10	0.08	0.07	0.05	0.04	0.03	0.02
Q300	0.21	0.05	0.05	0.04	0.04	0.03	0.03	0.02	0.01
Q301	13.16	0.46	0.36	0.12	0.06	0.05	0.04	0.03	0.02
Q302	13.53	0.48	0.34	0.10	0.00	0.00	0.00	0.00	0.00
Q303	1.08	0.12	0.09	0.03	0.01	0.01	0.01	0.01	0.01
Q304	1.39	0.24	0.22	0.17	0.13	0.10	0.08	0.05	0.03
Q305	0.58	0.07	0.06	0.06	0.05	0.04	0.03	0.02	0.01
Q306	0.40	0.06	0.05	0.04	0.04	0.02	0.02	0.01	0.01
Q307	0.55	0.04	0.03	0.02	0.01	0.01	0.01	0.00	0.00
Q308	6.99	0.12	0.10	0.08	0.06	0.05	0.04	0.02	0.02
Q309	6.45	0.23	0.20	0.17	0.15	0.14	0.11	0.08	0.06
Q310	1.80	0.13	0.09	0.07	0.04	0.02	0.01	0.01	0.00
Q311	2.15	0.35	0.32	0.25	0.20	0.15	0.11	0.05	0.03
Q312	1.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Q313	2.61	0.48	0.41	0.26	0.25	0.11	0.13	0.04	0.02
Q314	1.04	0.24	0.22	0.19	0.15	0.13	0.11	0.07	0.05
Q315	5.95	0.77	0.69	0.51	0.41	0.22	0.19	0.09	0.04
Q316	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Q317	0.53	0.10	0.09	0.08	0.08	0.06	0.06	0.04	0.03
Q318	1.46	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.01
Q319	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Q320	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Q321	1.86	0.34	0.33	0.31	0.27	0.22	0.19	0.13	0.09
Q322	0.11	0.04	0.04	0.15	0.04	0.57	0.06	0.01	0.58
Q323	0.80	0.23	0.21	0.19	0.16	0.13	0.12	0.08	0.06
Q324	0.51	0.12	0.11	0.10	0.09	0.07	0.06	0.04	0.03
Q325	1.94	0.25	0.22	0.18	0.15	0.12	0.09	0.05	0.04
Q326	2.04	0.46	0.42	0.37	0.31	0.25	0.20	0.11	0.09
Q327	5.45	0.87	0.75	0.59	0.43	0.31	0.23	0.11	0.02
Q328	1.84	0.20	0.17	0.13	0.10	0.09	0.06	0.03	0.02
Q329	2.56	0.34	0.33	0.29	0.27	0.23	0.20	0.14	0.09
Q330	0.45	0.17	0.16	0.15	0.14	0.11	0.09	0.05	0.03
Q331	0.90	0.17	0.16	0.14	0.12	0.10	0.08	0.05	0.03
Q332	0.04	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
Q333	1.06	0.19	0.17	0.15	0.12	0.08	0.07	0.03	0.02
Q334	0.06	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00
Q335	0.20	0.05	0.05	0.04	0.04	0.03	0.03	0.02	0.01
Q336	7.42	0.15	0.21	0.13	0.11	0.10	0.12	0.05	0.04
Q337	8.62	0.06	0.03	0.02	0.03	0.01	0.01	0.01	0.01
Q338	2.43	0.15	0.14	0.12	0.10	0.08	0.06	0.04	0.02

Reference ID	Peak Flows (m^3/s)								
	PMF	200yr ARI	100yr ARI	50yr ARI	20yr ARI	10yr ARI	5yr ARI	2yr ARI	1yr ARI
Q339	9.78	0.07	0.04	0.01	0.00	0.00	0.00	0.00	0.00
Q340	1.07	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Q341	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Q342	1.35	0.35	0.33	0.27	0.27	0.20	0.22	0.17	0.16
Q343	0.82	0.01	0.06	0.07	0.08	0.05	0.11	0.05	0.08
Q344	6.93	0.09	0.04	0.04	0.03	0.03	0.02	0.01	0.01
Q345	0.73	0.14	0.12	0.09	0.06	0.04	0.03	0.02	0.02
Q346	8.96	1.54	1.17	0.04	0.04	0.03	0.02	0.01	0.01
Q347	0.08	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00
Q348	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Q349	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Q350	13.72	1.50	0.59	0.13	0.03	0.03	0.02	0.01	0.01
Q351	0.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Q352	0.03	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00
Q353	1.12	0.21	0.19	0.15	0.14	0.12	0.10	0.08	0.06
Q354	0.27	0.05	0.05	0.04	0.04	0.03	0.03	0.02	0.02
Q355	0.10	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01
Q356	0.12	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01
Q357	0.16	0.04	0.04	0.03	0.03	0.03	0.02	0.02	0.01
Q358	0.45	0.09	0.09	0.08	0.07	0.06	0.05	0.04	0.03
Q359	0.09	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01
Q360	0.33	0.07	0.06	0.05	0.05	0.04	0.04	0.02	0.02
Q361	0.14	0.03	0.03	0.03	0.02	0.02	0.02	0.01	0.01
Q362	0.77	0.18	0.16	0.15	0.14	0.12	0.09	0.07	0.05
Q363	2.31	0.29	0.26	0.23	0.20	0.17	0.14	0.10	0.08
Q364	0.27	0.06	0.05	0.05	0.04	0.03	0.03	0.02	0.02
Q365	4.70	1.08	1.02	0.90	0.79	0.65	0.55	0.39	0.27
Q366	1.66	0.22	0.25	0.22	0.18	0.18	0.14	0.10	0.09
Q401	20.69	0.60	0.45	0.20	0.10	0.00	0.10	0.05	0.24
Q402	12.03	0.47	0.14	0.03	0.03	0.02	0.02	0.02	0.01
Q403	2.19	0.41	0.38	0.36	0.30	0.25	0.23	0.17	0.15
Q404	4.15	0.62	0.56	0.46	0.37	0.28	0.22	0.11	0.09
Q405	2.76	0.50	0.44	0.36	0.29	0.20	0.17	0.06	0.05
Q406	3.08	0.15	0.14	0.12	0.10	0.08	0.05	0.03	0.03
Q407	13.05	0.37	0.31	0.26	0.21	0.17	0.13	0.07	0.05
Q408	23.42	1.80	1.60	1.14	0.69	0.37	0.30	0.18	0.13
Q409	2.87	0.02	0.02	0.77	0.01	0.02	0.04	0.18	0.02
Q410	8.43	0.09	0.10	0.08	0.05	0.06	0.09	0.03	0.07
Q411	30.76	5.60	4.96	3.93	2.96	2.17	1.60	0.62	0.12
Q412	6.14	0.01	0.14	0.01	0.00	0.00	0.00	0.00	0.00